Red Hat Enterprise Linux 8

Configuring and managing virtualization

Setting up your host, creating and administering virtual machines, and understanding virtualization features in Red Hat Enterprise Linux 8

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Legal Notice

Abstract

This document describes how to manage virtualization in Red Hat Enterprise Linux 8 (RHEL 8). In addition to general information about virtualization, it describes how to manage virtualization using command-line utilities, as well as using the web console.

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MAKING OPEN SOURCE MORE INCLUSIVE

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

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We appreciate your input on our documentation. Please let us know how we could make it better. To do so:

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  2. Use your mouse cursor to highlight the part of text that you want to comment on.
  3. Click the **Add Feedback** pop-up that appears below the highlighted text.
  4. Follow the displayed instructions.
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  1. Go to the Bugzilla website.
  2. As the Component, use **Documentation**.
  3. Fill in the **Description** field with your suggestion for improvement. Include a link to the relevant part(s) of documentation.
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CHAPTER 1. INTRODUCING VIRTUALIZATION IN RHEL

If you are unfamiliar with the concept of virtualization or its implementation in Linux, the following sections provide a general overview of virtualization in RHEL 8: its basics, advantages, components, and other possible virtualization solutions provided by Red Hat.

1.1. WHAT IS VIRTUALIZATION?

RHEL 8 provides the *virtualization* functionality, which enables a machine running RHEL 8 to *host* multiple virtual machines (VMs), also referred to as *guests*. VMs use the host's physical hardware and computing resources to run a separate, virtualized operating system (*guest OS*) as a user-space process on the host's operating system.

In other words, virtualization makes it possible to have operating systems within operating systems.

VMs enable you to safely test software configurations and features, run legacy software, or optimize the workload efficiency of your hardware. For more information on the benefits, see Section 1.2, "Advantages of virtualization".

For more information on what virtualization is, see the Red Hat Customer Portal .

Additional resources

- To try out virtualization in Red Hat Enterprise Linux 8, see Chapter 2, *Getting started with virtualization*.
- In addition to Red Hat Enterprise Linux 8 virtualization, Red Hat offers a number of specialized virtualization solutions, each with a different user focus and features. For more information, see Section 1.5, "Red Hat virtualization solutions" .

1.2. ADVANTAGES OF VIRTUALIZATION

Using virtual machines (VMs) has the following benefits in comparison to using physical machines:

- **Flexible and fine-grained allocation of resources**
  A VM runs on a host machine, which is usually physical, and physical hardware can also be assigned for the guest OS to use. However, the allocation of physical resources to the VM is done on the software level, and is therefore very flexible. A VM uses a configurable fraction of the host memory, CPUs, or storage space, and that configuration can specify very fine-grained resource requests.

  For example, what the guest OS sees as its disk can be represented as a file on the host file system, and the size of that disk is less constrained than the available sizes for physical disks.

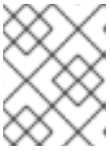
- **Software-controlled configurations**
  The entire configuration of a VM is saved as data on the host, and is under software control. Therefore, a VM can easily be created, removed, cloned, migrated, operated remotely, or connected to remote storage.

- **Separation from the host**
  A guest OS runs on a virtualized kernel, separate from the host OS. This means that any OS can be installed on a VM, and even if the guest OS becomes unstable or is compromised, the host is not affected in any way.

- **Space and cost efficiency**

A single physical machine can host a large number of VMs. Therefore, it avoids the need for multiple physical machines to do the same tasks, and thus lowers the space, power, and maintenance requirements associated with physical hardware.

- **Software compatibility**
  Because a VM can use a different OS than its host, virtualization makes it possible to run applications that were not originally released for your host OS. For example, using a RHEL 7 guest OS, you can run applications released for RHEL 7 on a RHEL 8 host system.



NOTE

Not all operating systems are supported as a guest OS in a RHEL 8 host. For details, see Section 20.2, “Recommended features in RHEL 8 virtualization” .

1.3. VIRTUAL MACHINE COMPONENTS AND THEIR INTERACTION

Virtualization in RHEL 8 consists of the following principal software components:

Hypervisor

The basis of creating virtual machines (VMs) in RHEL 8 is the *hypervisor*, a software layer that controls hardware and enables running multiple operating systems on a host machine.

The hypervisor includes the **Kernel-based Virtual Machine (KVM)**module and virtualization kernel drivers, such as **virtio** and **vfio**. These components ensure that the Linux kernel on the host machine provides resources for virtualization to user-space software.

At the user-space level, the **QEMU** emulator simulates a complete virtualized hardware platform that the guest operating system can run in, and manages how resources are allocated on the host and presented to the guest.

In addition, the **libvirt** software suite serves as a management and communication layer, making QEMU easier to interact with, enforcing security rules, and providing a number of additional tools for configuring and running VMs.

XML configuration

A host-based XML configuration file (also known as a *domain XML* file) determines all settings and devices in a specific VM. The configuration includes:

- Metadata such as the name of the VM, time zone, and other information about the VM.
- A description of the devices in the VM, including virtual CPUs (vCPUS), storage devices, input/output devices, network interface cards, and other hardware, real and virtual.
- VM settings such as the maximum amount of memory it can use, restart settings, and other settings about the behavior of the VM.

For more information on the contents of an XML configuration, see Section 6.3, “Sample virtual machine XML configuration”.

Component interaction

When a VM is started, the hypervisor uses the XML configuration to create an instance of the VM as a user-space process on the host. The hypervisor also makes the VM process accessible to the host-based interfaces, such as the **virsh**, **virt-install**, and **guestfish** utilities, or the web console GUI.

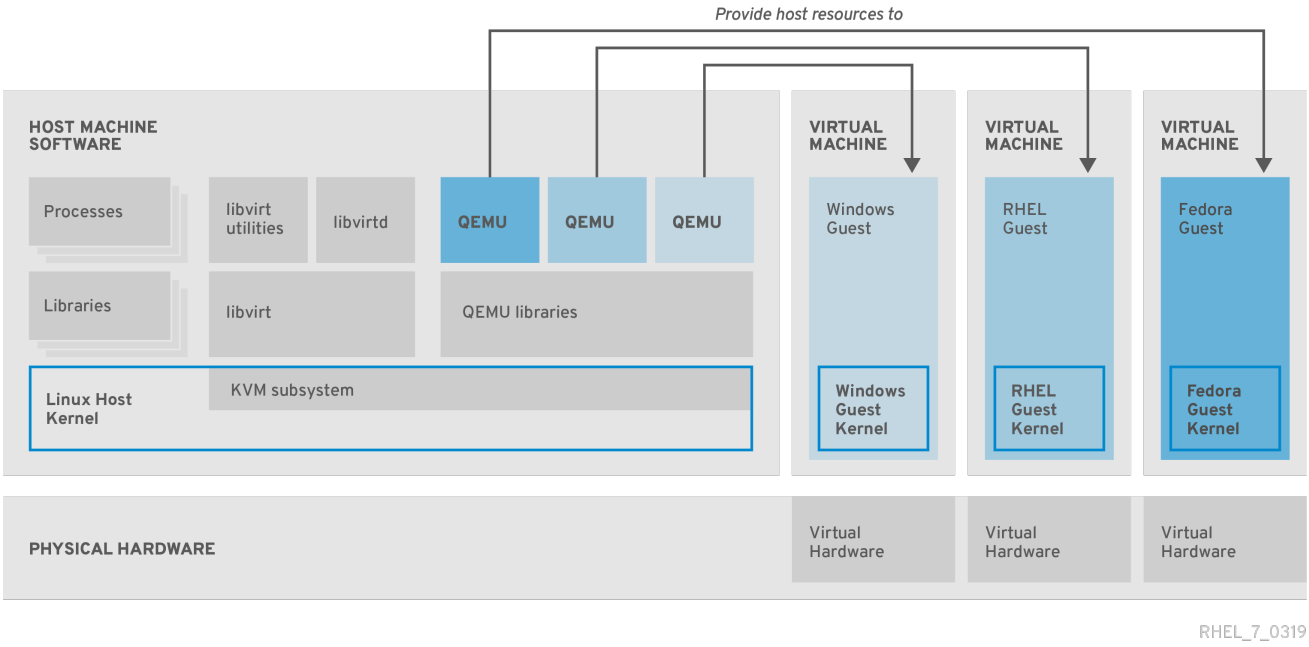
When these virtualization tools are used, libvirt translates their input into instructions for QEMU. QEMU communicates the instructions to KVM, which ensures that the kernel appropriately assigns the resources necessary to carry out the instructions. As a result, QEMU can execute the corresponding user-space changes, such as creating or modifying a VM, or performing an action in the VM's guest operating system.

NOTE

While QEMU is an essential component of the architecture, it is not intended to be used directly on RHEL 8 systems, due to security concerns. Therefore, using **qemu-*** commands is not supported by Red Hat, and it is highly recommended to interact with QEMU using libvirt.

For more information on the host-based interfaces, see Section 1.4, "Tools and interfaces for virtualization management".

Figure 1.1. RHEL 8 virtualization architecture



1.4. TOOLS AND INTERFACES FOR VIRTUALIZATION MANAGEMENT

You can manage virtualization in RHEL 8 using the command-line interface (CLI) or several graphical user interfaces (GUIs).

Command-line interface

The CLI is the most powerful method of managing virtualization in RHEL 8. Prominent CLI commands for virtual machine (VM) management include:

- **virsh** - A versatile virtualization command-line utility and shell with a great variety of purposes, depending on the provided arguments. For example:
  - Starting and shutting down a VM - **virsh start** and **virsh shutdown**
  - Listing available VMs - **virsh list**
  - Creating a VM from a configuration file - **virsh create**

- Entering a virtualization shell - **virsh**

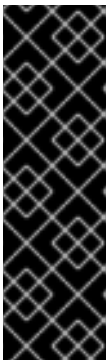
For more information, see the **virsh(1)** man page.

- **virt-install** - A CLI utility for creating new VMs. For more information, see the **virt-install(1)** man page.
- **virt-xml** - A utility for editing the configuration of a VM.
- **guestfish** - A utility for examining and modifying VM disk images. For more information, see the **guestfish(1)** man page.

Graphical interfaces

You can use the following GUIs to manage virtualization in RHEL 8:

- The **RHEL 8 web console**, also known as *Cockpit*, provides a remotely accessible and easy to use graphical user interface for managing VMs and virtualization hosts.
  For instructions on basic virtualization management with the web console, see Chapter 5, *Managing virtual machines in the web console* .
- The Virtual Machine Manager (**virt-manager**) application provides a specialized GUI for managing VMs and virtualization hosts.



IMPORTANT

Although still supported in RHEL 8, **virt-manager** has been deprecated. The web console is intended to become its replacement in a subsequent release. It is, therefore, recommended that you get familiar with the web console for managing virtualization in a GUI.

However, in RHEL 8, some features may only be accessible from either **virt-manager** or the command line. For details, see Section 5.4, "Differences between virtualization features in Virtual Machine Manager and the web console".

- The **Gnome Boxes** application is a lightweight graphical interface to view and access VMs and remote systems. Gnome Boxes is primarily designed for use on desktop systems.

IMPORTANT

Gnome Boxes is provided as a part of the GNOME desktop environment and is supported on RHEL 8, but Red Hat recommends that you use the web console for managing virtualization in a GUI.

Additional resources

- For instructions on basic virtualization management using CLI and GUI, see Chapter 2, *Getting started with virtualization*.

1.5. RED HAT VIRTUALIZATION SOLUTIONS

The following Red Hat products are built on top of RHEL 8 virtualization features and expand the KVM virtualization capabilities available in RHEL 8. In addition, many limitations of RHEL 8 virtualization do not apply to these products:

Red Hat Virtualization (RHV)

RHV is designed for enterprise-class scalability and performance, and enables the management of your entire virtual infrastructure, including hosts, virtual machines, networks, storage, and users from a centralized graphical interface.
Red Hat Virtualization can be used by enterprises running large deployments or mission-critical applications. Examples of large deployments suited to Red Hat Virtualization include databases, trading platforms, and messaging systems that must run continuously without any downtime.

For more information about Red Hat Virtualization, see the Red Hat Customer Portal or the Red Hat Virtualization documentation suite.

To download a fully supported 60-day evaluation version of Red Hat Virtualization, see the Red Hat Customer Portal.

Red Hat OpenStack Platform (RHOSP)

Red Hat OpenStack Platform offers an integrated foundation to create, deploy, and scale a secure and reliable public or private OpenStack cloud.
For more information about Red Hat OpenStack Platform, see the Red Hat Customer Portal or the Red Hat OpenStack Platform documentation suite .

NOTE

For details on virtualization features not supported on RHEL but supported on RHV or RHOSP, see Section 20.3, “Unsupported features in RHEL 8 virtualization” .

In addition, specific Red Hat products provide *operating-system-level virtualization*, also known as **containerization**:

- Containers are isolated instances of the host OS and operate on top of an existing OS kernel. For more information on containers, see the Red Hat Customer Portal .
- Containers do not have the versatility of KVM virtualization, but are more lightweight and flexible to handle. For a more detailed comparison, see the Introduction to Linux Containers .

CHAPTER 2. GETTING STARTED WITH VIRTUALIZATION

To start using virtualization in RHEL 8 , follow the steps below. The default method for this is using the command-line interface (CLI), but for user convenience, some of the steps can be completed in the web console GUI.

1. Enable the virtualization module and install the virtualization packages - see Section 2.1, "Enabling virtualization".
2. Create a virtual machine (VM):
   - For CLI, see Section 2.2.1, "Creating virtual machines using the command-line interface" .
   - For GUI, see Section 2.2.2, "Creating virtual machines and installing guest operating systems using the web console".
3. Start the VM:
   - For CLI, see Section 2.3.1, "Starting a virtual machine using the command-line interface" .
   - For GUI, see Section 2.3.2, "Starting virtual machines using the web console" .
4. Connect to the VM:
   - For CLI, see Section 2.4.3, "Connecting to a virtual machine using SSH" or Section 2.4.2, "Opening a virtual machine graphical console using Virt Viewer".
   - For GUI, see Section 2.4.1, "Interacting with virtual machines using the web console" .

NOTE

The web console currently provides only a subset of VM management functions, so using the command line is recommended for advanced use of virtualization in RHEL 8.

2.1. ENABLING VIRTUALIZATION

To use virtualization in RHEL 8, you must enable the virtualization module, install virtualization packages, and ensure your system is configured to host virtual machines (VMs).

Prerequisites

- Red Hat Enterprise Linux 8 is installed and registered on your host machine.
- Your system meets the following hardware requirements to work as a virtualization host:
  - The following minimum system resources are available:
    - 6 GB free disk space for the host, plus another 6 GB for each intended VM.
    - 2 GB of RAM for the host, plus another 2 GB for each intended VM.
    - 4 CPUs on the host. VMs can generally run with a single assigned vCPU, but Red Hat recommends assigning 2 or more vCPUs per VM to avoid VMs becoming unresponsive during high load.
  - The architecture of your host machine supports KVM virtualization.

- Notably, RHEL 8 does not support virtualization on the 64-bit ARM architecture (ARM 64).
- The procedure below applies to the AMD64 and Intel 64 architecture (x86_64). To enable virtualization on a host with a different supported architecture, see one of the following sections:
  - Section 3.1, "Enabling virtualization on IBM POWER"
  - Section 4.1, "Enabling virtualization on IBM Z"

Procedure

1. Install the packages in the RHEL 8 virtualization module:

```
# yum module install virt
```

2. Install the **virt-install** and **virt-viewer** packages:

```
# yum install virt-install virt-viewer
```

3. Start the **libvirtd** service.

```
# systemctl start libvirtd
```

Verification

1. Verify that your system is prepared to be a virtualization host:

```
# virt-host-validate
[...]
QEMU: Checking for device assignment IOMMU support         : PASS
QEMU: Checking if IOMMU is enabled by kernel               : WARN (IOMMU appears to be disabled in kernel. Add intel_iommu=on to kernel cmdline arguments)
LXC: Checking for Linux >= 2.6.26                          : PASS
[...]
LXC: Checking for cgroup 'blkio' controller mount-point    : PASS
LXC: Checking if device /sys/fs/fuse/connections exists    : FAIL (Load the 'fuse' module to enable /proc/ overrides)
```

2. If all **virt-host-validate** checks return a **PASS** value, your system is prepared for creating VMs. If any of the checks return a **FAIL** value, follow the displayed instructions to fix the problem.

   If any of the checks return a **WARN** value, consider following the displayed instructions to improve virtualization capabilities.

Additional information

- Note that if virtualization is not supported by your host CPU, **virt-host-validate** generates the following output:

```
QEMU: Checking for hardware virtualization: FAIL (Only emulated CPUs are available, performance will be significantly limited)
```

However, attempting to create VMs on such a host system will fail, rather than have performance problems.

2.2. CREATING VIRTUAL MACHINES

To create a virtual machine (VM) in RHEL 8, use the command-line interface or the RHEL 8 web console.

2.2.1. Creating virtual machines using the command-line interface

To create a virtual machine (VM) on your RHEL 8 host using the **virt-install** utility, follow the instructions below.

Prerequisites

- Virtualization is enabled on your host system.
- You have sufficient a amount of system resources to allocate to your VMs, such as disk space, RAM, or CPUs. The recommended values may vary significantly depending on the intended tasks and workload of the VMs.
- An operating system (OS) installation source is available locally or on a network. This can be one of the following:
  - An ISO image of an installation medium
  - A disk image of an existing VM installation

WARNING

Installing from a host CD-ROM or DVD-ROM device is not possible in RHEL 8. If you select a CD-ROM or DVD-ROM as the installation source when using any VM installation method available in RHEL 8, the installation will fail. For more information, see the Red Hat Knowledgebase.

- Optional: A Kickstart file can be provided for faster and easier configuration of the installation.

Procedure

To create a VM and start its OS installation, use the **virt-install** command, along with the following mandatory arguments:

- The name of the new machine (**--name**)
- The amount of allocated memory (**--memory**)
- The number of allocated virtual CPUs (**--vcpus**)
- The type and size of the allocated storage (**--disk**)

- The type and location of the OS installation source (**--cdrom** or **--location**)

Based on the chosen installation method, the necessary options and values can vary. See below for examples:

- The following creates a VM named **demo-guest1** that installs the Windows 10 OS from an ISO image locally stored in the **/home/username/Downloads/Win10install.iso** file. This VM is also allocated with 2048 MiB of RAM and 2 vCPUs, and an 80 GiB qcow2 virtual disk is automatically configured for the VM.

```
# virt-install --name demo-guest1 --memory 2048 --vcpus 2 --disk size=80 --os-variant
win10 --cdrom /home/username/Downloads/Win10install.iso
```

- The following creates a VM named **demo-guest2** that uses the **/home/username/Downloads/rhel8.iso** image to run a RHEL 8 OS from a live CD. No disk space is assigned to this VM, so changes made during the session will not be preserved. In addition, the VM is allocated with 4096 MiB of RAM and 4 vCPUs.

```
# virt-install --name demo-guest2 --memory 4096 --vcpus 4 --disk none --livecd --os-
variant rhel8.0 --cdrom /home/username/Downloads/rhel8.iso
```

- The following creates a RHEL 8 VM named **demo-guest3** that connects to an existing disk image, **/home/username/backup/disk.qcow2**. This is similar to physically moving a hard drive between machines, so the OS and data available to demo-guest3 are determined by how the image was handled previously. In addition, this VM is allocated with 2048 MiB of RAM and 2 vCPUs.

```
# virt-install --name demo-guest3 --memory 2048 --vcpus 2 --os-variant rhel8.0 --import
--disk /home/username/backup/disk.qcow2
```

  Note that the **--os-variant** option is highly recommended when importing a disk image. If it is not provided, the performance of the created VM will be negatively affected.

- The following creates a VM named **demo-guest4** that installs from the **http://example.com/OS-install** URL. For the installation to start successfully, the URL must contain a working OS installation tree. In addition, the OS is automatically configured using the **/home/username/ks.cfg** kickstart file. This VM is also allocated with 2048 MiB of RAM, 2 vCPUs, and a 160 GiB qcow2 virtual disk.

```
# virt-install --name demo-guest4 --memory 2048 --vcpus 2 --disk size=160 --os-variant
rhel8.0 --location http://example.com/OS-install --initrd-inject /home/username/ks.cfg --
extra-args="inst.ks=file:/ks.cfg console=tty0 console=ttyS0,115200n8"
```

- The following creates a VM named **demo-guest5** that installs from a **RHEL8.iso** image file in text-only mode, without graphics. It connects the guest console to the serial console. The VM has 16384 MiB of memory, 16 vCPUs, and 280 GiB disk. This kind of installation is useful when connecting to a host over a slow network link.

```
# virt-install --name demo-guest5 --memory 16384 --vcpus 16 --disk size=280 --os-
variant rhel8.0 --location RHEL8.iso --graphics none --extra-args='console=ttyS0'
```

- The following creates a VM named **demo-guest6**, which has the same configuration as demo-guest5, but resides on the 10.0.0.1 remote host.

```
# virt-install --connect qemu+ssh://root@10.0.0.1/system --name demo-guest6 --memory 16384 --vcpus 16 --disk size=280 --os-variant rhel8.0 --location RHEL8.iso --graphics none --extra-args='console=ttyS0'
```

Verification

- If the VM is created successfully, a virt-viewer window opens with a graphical console of the VM and starts the guest OS installation.

Troubleshooting

- If **virt-install** fails with a **cannot find default network** error:

  a. Ensure that the *libvirt-daemon-config-network* package is installed:

  ```
  # yum info libvirt-daemon-config-network
  Installed Packages
  Name        : libvirt-daemon-config-network
  [...]
  ```

  b. Verify that the **libvirt** default network is active and configured to start automatically:

  ```
  # virsh net-list --all
   Name      State    Autostart   Persistent
  ----------------------------------------------
   default   active   yes         yes
  ```

  c. If it is not, activate the default network and set it to auto-start:

  ```
  # virsh net-autostart default
  Network default marked as autostarted

  # virsh net-start default
  Network default started
  ```

  i. If activating the default network fails with the following error, the *libvirt-daemon-config-network* package has not been installed correctly.

  ```
  error: failed to get network 'default'
  error: Network not found: no network with matching name 'default'
  ```

  To fix this, re-install *libvirt-daemon-config-network*.

  ```
  # yum reinstall libvirt-daemon-config-network
  ```

  ii. If activating the default network fails with an error similar to the following, a conflict has occurred between the default network's subnet and an existing interface on the host.

  ```
  error: Failed to start network default
  error: internal error: Network is already in use by interface ens2
  ```

  To fix this, use the **virsh net-edit default** command and change the **192.168.122.*** values in the configuration to a subnet not already in use on the host.

Additional resources

- A number of other options can be specified for **virt-install** to further configure the VM and its OS installation. For details, see the **virt-install** man page.
- If you already have a functional VM, you can clone it to quickly create a new VM with the same configuration and data. For details, see Chapter 8, *Cloning virtual machines*.

2.2.2. Creating virtual machines and installing guest operating systems using the web console

To manage virtual machines (VMs) in a GUI on a RHEL 8 host, use the web console. The following sections provide information on how to use the RHEL 8 web console to create VMs and install guest operating systems on them.

2.2.2.1. Creating virtual machines using the web console

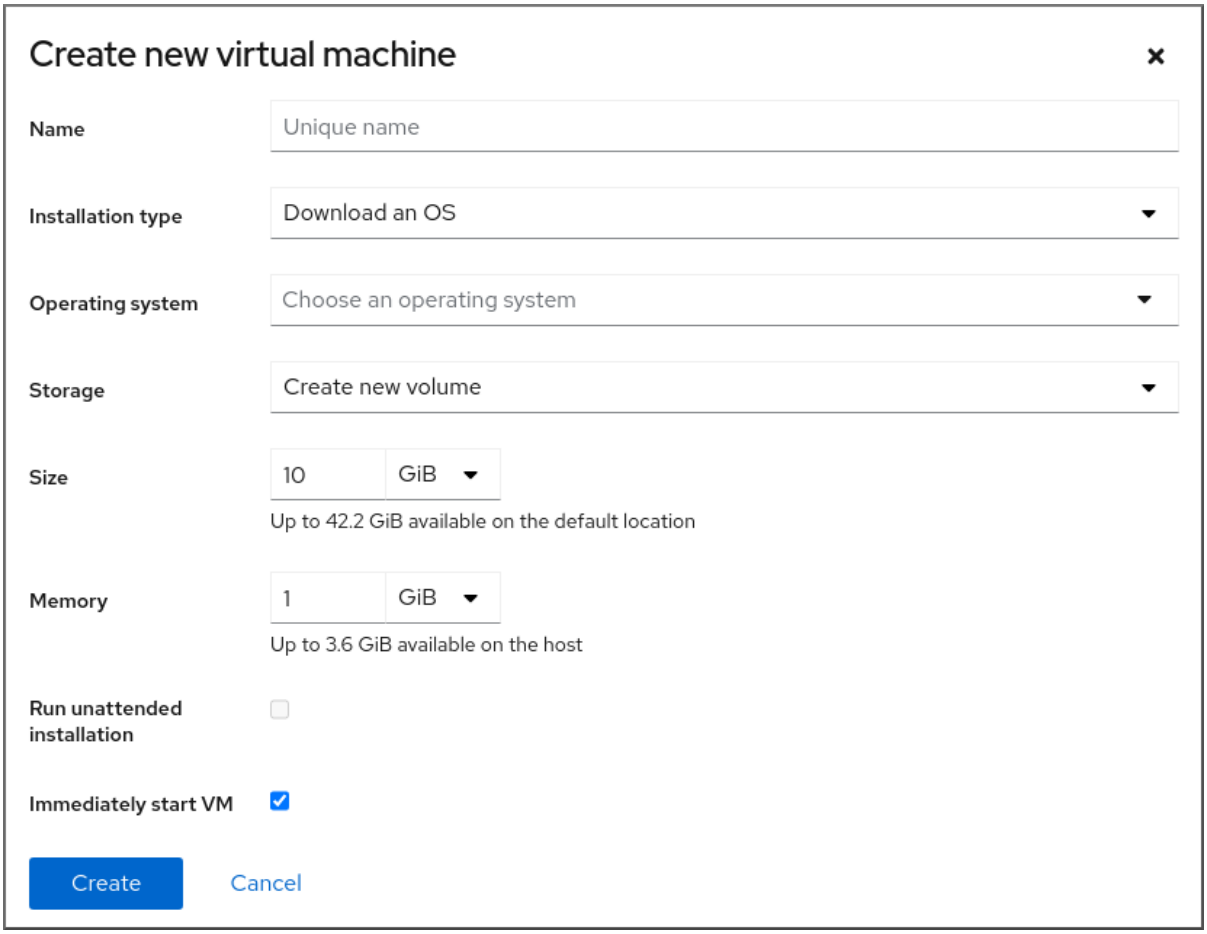
To create a virtual machine (VM) on the host machine to which the web console is connected, follow the instructions below.

Prerequisites

- Virtualization is enabled on your host system.
- The web console VM plug-in is installed on your system.
- You have sufficient a amount of system resources to allocate to your VMs, such as disk space, RAM, or CPUs. The recommended values may vary significantly depending on the intended tasks and workload of the VMs.

Procedure

1. In the **Virtual Machines** interface of the web console, click **Create VM**.
   The Create new virtual machine dialog appears.



2. Enter the basic configuration of the VM you want to create.
   - **Name** - The name of the VM.
   - **Connection** - The type of libvirt connection, system or session. For more details, see System and session connections.
   - **Installation type** - The installation can use a local installation medium, a URL, a PXE network boot, or download an OS from a limited set of operating systems.
   - **Operating system** - The VM's operating system. Note that Red Hat provides support only for a limited set of guest operating systems .
   - **Storage** - The type of storage with which to configure the VM.
   - **Size** - The amount of storage space with which to configure the VM.
   - **Memory** - The amount of memory with which to configure the VM.
   - **Run unattended installation** - Whether or not to run the installation unattended. This option is available only when the **Installation type** is **Download an OS**.
   - **Immediately Start VM** - Whether or not the VM will start immediately after it is created.
3. Click **Create**.
   The VM is created. If the **Immediately Start VM** checkbox is selected, the VM will immediately start and begin installing the guest operating system.

Additional resources

- For information on installing an operating system on a VM, see Section 2.2.2.3, “Installing guest operating systems using the web console”.

2.2.2.2. Creating virtual machines by importing disk images using the web console

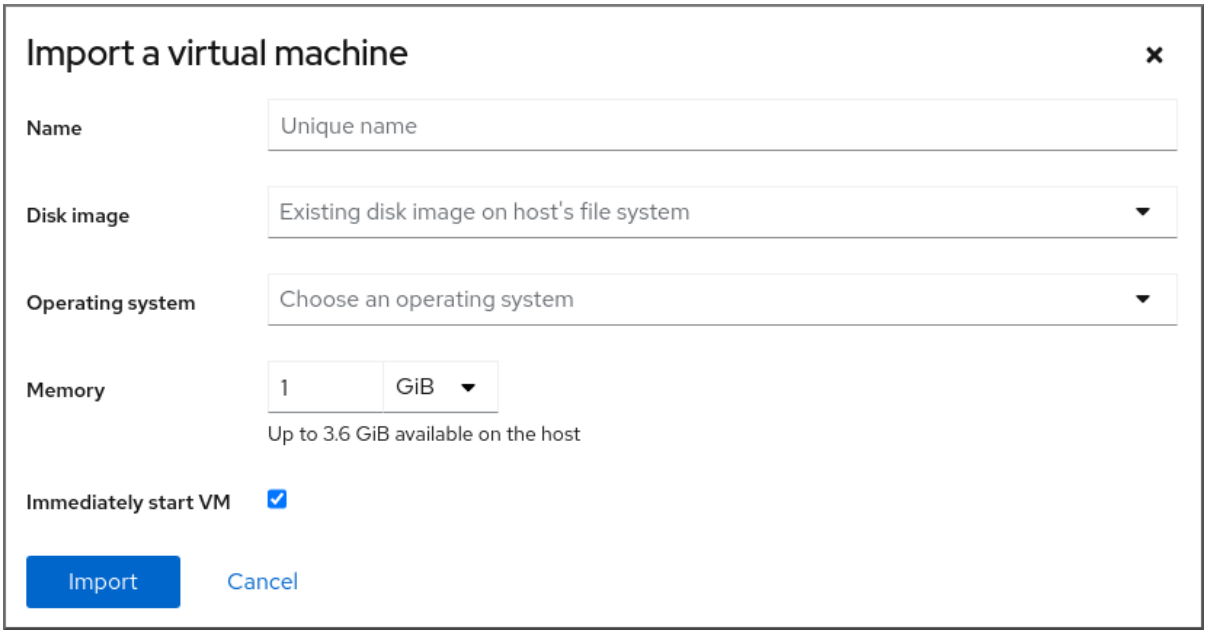
To create a virtual machine (VM) by importing a disk image of an existing VM installation, follow the instructions below.

Prerequisites

- The web console VM plug-in is installed on your system.
- You have sufficient a amount of system resources to allocate to your VMs, such as disk space, RAM, or CPUs. The recommended values can vary significantly depending on the intended tasks and workload of the VMs.
- Make sure you have a disk image of an existing VM installation

Procedure

1. In the **Virtual Machines** interface of the web console, click **Import VM**.
The Import a virtual machine dialog appears.



2. Enter the basic configuration of the VM you want to create.
   - **Name** - The name of the VM.
   - **Connection** - The type of libvirt connection, system or session. For more details, see System and session connections.
   - **Disk image** - The path to the existing disk image of a VM on the host system.
   - **Operating system** - The VM’s operating system. Note that Red Hat provides support only for a limited set of guest operating systems.
   - **Memory** - The amount of memory with which to configure the VM.
   - **Immediately start VM** - Whether or not the VM will start immediately after it is created.

3. Click **Import**.

2.2.2.3. Installing guest operating systems using the web console

The first time a virtual machine (VM) loads, you must install an operating system on the VM.

NOTE

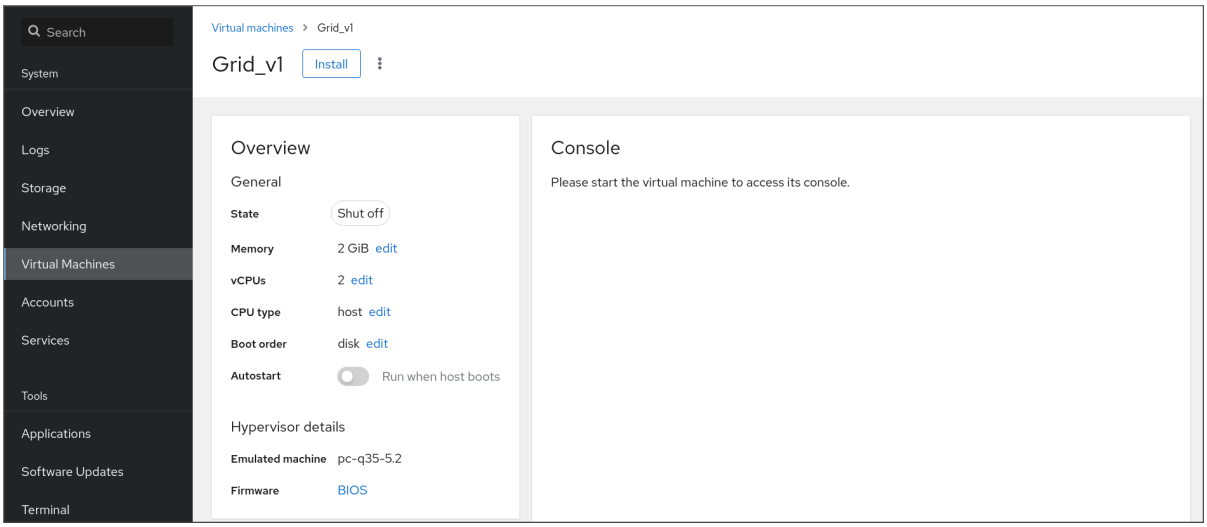
If the *Immediately Start VM* checkbox in the Create New Virtual Machine dialog is checked, the installation routine of the operating system starts automatically when the VM is created.

Prerequisites

- The web console VM plug-in is installed on your system.
- A VM on which to install an operating system must be available.

Procedure

1. In the **Virtual Machines** interface, click the VM on which you want to install a guest OS.
   A new page opens with basic information about the selected VM and controls for managing various aspects of the VM.



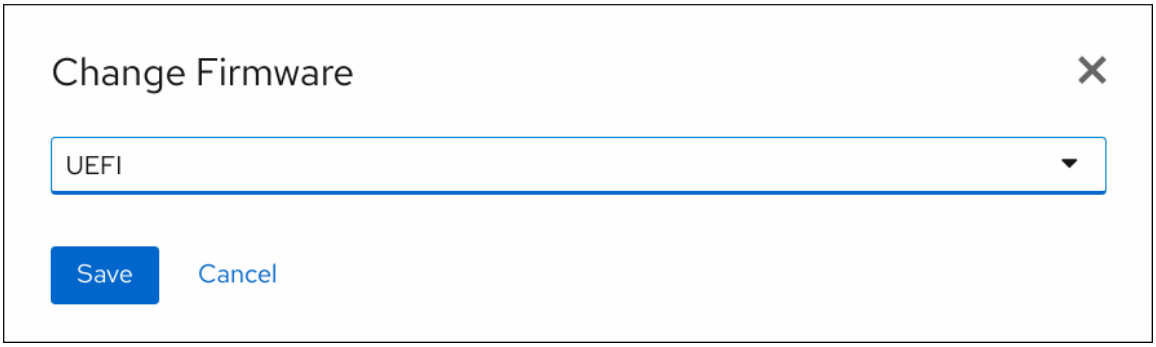
2. **Optional**: Change the firmware.

NOTE

You can change the firmware only if you had not selected the *Immediately Start VM* check box in the **Create New Virtual Machine**dialog, and the OS has not already been installed on the VM.

   a. Click the firmware.

   b. In the Change Firmware window, select the desired firmware.



c. Click **Save**.

3. Click **Install**.
The installation routine of the operating system runs in the VM console.

Troubleshooting

- If the installation routine fails, the VM must be deleted and recreated.

2.3. STARTING VIRTUAL MACHINES

To start a virtual machine (VM) in RHEL 8, you can use the command line interface or the web console GUI.

Prerequisites

- Before a VM can be started, it must be created and, ideally, also installed with an OS. For instruction to do so, see Section 2.2, "Creating virtual machines".

2.3.1. Starting a virtual machine using the command-line interface

You can use the command line interface to start a shut-down virtual machine (VM) or restore a saved VM. Follow the procedure below.

Prerequisites

- An inactive VM that is already defined.
- The name of the VM.
- For remote VMs:
  - The IP address of the host where the VM is located.
  - Root access privileges to the host.

Procedure

- For a local VM, use the **virsh start** utility.
For example, the following command starts the *demo-guest1* VM.

```
# virsh start demo-guest1
Domain demo-guest1 started
```

- For a VM located on a remote host, use the **virsh start** utility along with the QEMU+SSH connection to the host.
  For example, the following command starts the *demo-guest1* VM on the 192.168.123.123 host.

```
# virsh -c qemu+ssh://root@192.168.123.123/system start demo-guest1

root@192.168.123.123's password:
Last login: Mon Feb 18 07:28:55 2019

Domain demo-guest1 started
```

Additional Resources

- For more **virsh start** arguments, use **virsh start --help**.
- For simplifying VM management on remote hosts, see modifying your libvirt and SSH configuration.
- You can use the **virsh autostart** utility to configure a VM to start automatically when the host boots up. For more information about autostart, see starting virtual machines automatically when the host starts.

2.3.2. Starting virtual machines using the web console

If a virtual machine (VM) is in the **shut off** state, you can start it using the RHEL 8 web console.

Prerequisites

- The web console VM plug-in is installed on your system .
- An inactive VM that is already defined.
- The name of the VM.

Procedure

1. In the **Virtual Machines** interface, click the VM you want to start.
   A new page opens with detailed information about the selected VM and controls for shutting down and deleting the VM.
2. Click **Run**.
   The VM starts, and you can connect to its console or graphical output .
3. **Optional:** To set up the VM to start automatically when the host starts, click the **Autostart** checkbox.
   If you use network interfaces that are not managed by libvirt, you must also make additional changes to the systemd configuration. Otherwise, the affected VMs might fail to start, see starting virtual machines automatically when the host starts .

Additional resources

- For information on shutting down a VM, see Section 2.5.2.1, “Shutting down virtual machines in the web console”.

- For information on restarting a VM, see Section 2.5.2.2, "Restarting virtual machines using the web console".

2.3.3. Starting virtual machines automatically when the host starts

When a host with a running virtual machine (VM) restarts, the VM must be started again manually by default. However, you might want your VM to be always available when the host is running. In that case, you can use the **virsh autostart** utility to configure the VM to be started automatically.

Prerequisites

- A created VM, for more information see creating virtual machines.

Procedure

1. Use the **virsh autostart** utility to configure the VM to start automatically when the host starts. For example, the following command configures the *demo-guest1* VM to start automatically.

```
# virsh autostart demo-guest1
Domain demo-guest1 marked as autostarted
```

2. If you use network interfaces that are not managed by libvirt, you must also make additional changes to the systemd configuration. Otherwise, the affected VMs might fail to start.

NOTE

These interfaces include for example:

- Bridge devices created by **NetworkManager**
- Networks configured to use **<forward mode='bridge'/>**

   a. In the systemd configuration directory tree, create a **libvirtd.service.d** directory if it does not exist yet.

```
# mkdir -p /etc/systemd/system/libvirtd.service.d/
```

   b. Create a **10-network-online.conf** systemd unit override file in the previously created directory. The content of this file overrides the default systemd configuration for libvirtd service.

```
# touch /etc/systemd/system/libvirtd.service.d/10-network-online.conf
```

   c. Add the following lines to the **10-network-online.conf** file. This configuration change ensures systemd starts libvirtd service only after the network on the host is ready.

```
[Unit]
After=network-online.target
```

Verification

1. View the VM configuration, and check that the *autostart* option is enabled.

For example, the following command displays basic information about the *demo-guest1* VM, including the *autostart* option.

```
# virsh dominfo demo-guest1
Id:             2
Name:           demo-guest1
UUID:           e46bc81c-74e2-406e-bd7a-67042bae80d1
OS Type:        hvm
State:          running
CPU(s):         2
CPU time:       385.9s
Max memory:     4194304 KiB
Used memory:    4194304 KiB
Persistent:     yes
Autostart:      enable
Managed save:   no
Security model: selinux
Security DOI:   0
Security label: system_u:system_r:svirt_t:s0:c873,c919 (enforcing)
```

2. If you use network interfaces that are not managed by libvirt, check if the content of the **10-network-online.conf** file matches the following output.

```
$ cat /etc/systemd/system/libvirtd.service.d/10-network-online.conf
[Unit]
After=network-online.target
```

Additional resources

- **$ virsh autostart --help**
- You can also enable autostart using the web console, see starting virtual machines using the web console.

2.4. CONNECTING TO VIRTUAL MACHINES

To interact with a virtual machine (VM) in RHEL 8, you need to connect to it by doing one of the following:

- When using the web console interface, use the Virtual Machines pane in the web console interface. For more information, see Section 2.4.1, “Interacting with virtual machines using the web console”.
- If you need to interact with a VM graphical display without using the web console, use the Virt Viewer application. For details, see Section 2.4.2, “Opening a virtual machine graphical console using Virt Viewer”.
- When a graphical display is not possible or not necessary, use an SSH terminal connection .
- When the virtual machine is not reachable from your system by using a network, use the virsh console.

If the VMs to which you are connecting are on a remote host rather than a local one, you can optionally configure your system for more convenient access to remote hosts .

Prerequisites

- The VMs you want to interact with are installed and started.

2.4.1. Interacting with virtual machines using the web console

To interact with a virtual machine (VM) in the RHEL 8 web console, you need to connect to the VM's console. These include both graphical and serial consoles.

- To interact with the VM's graphical interface in the web console, use the graphical console.
- To interact with the VM's graphical interface in a remote viewer, use the graphical console in remote viewers.
- To interact with the VM's CLI in the web console, use the serial console.

2.4.1.1. Viewing the virtual machine graphical console in the web console

Using the virtual machine (VM) console interface, you can view the graphical output of a selected VM in the RHEL 8 web console.

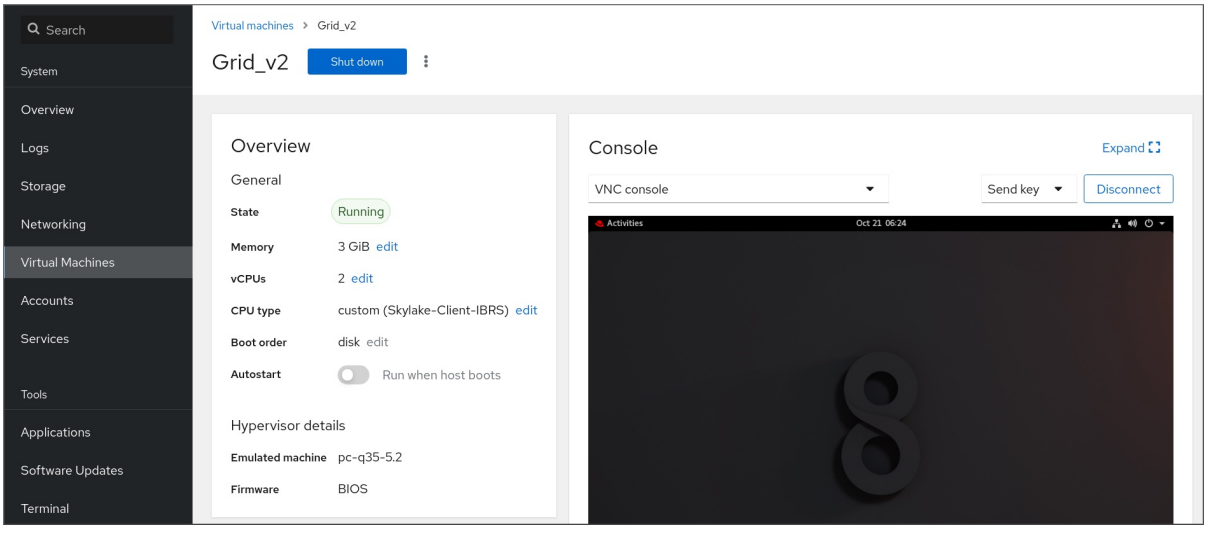
Prerequisites

- The web console VM plug-in is installed on your system.
- Ensure that both the host and the VM support a graphical interface.

Procedure

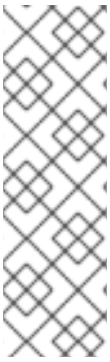
1. In the **Virtual Machines** interface, click the VM whose graphical console you want to view.
   A new page opens with an **Overview** and a **Console** section for the VM.
2. Select **VNC console** in the console drop down menu.
   The VNC console appears below the menu in the web interface.

   The graphical console appears in the web interface.



3. Click **Expand**

You can now interact with the VM console using the mouse and keyboard in the same manner you interact with a real machine. The display in the VM console reflects the activities being performed on the VM.



NOTE

The host on which the web console is running may intercept specific key combinations, such as **Ctrl**+**Alt**+**Del**, preventing them from being sent to the VM.

To send such key combinations, click the **Send key** menu and select the key sequence to send.

For example, to send the **Ctrl**+**Alt**+**Del** combination to the VM, click the **Send key** and select the **Ctrl+Alt+Del** menu entry.

Additional resources

- For instructions on viewing the graphical console in a remote viewer, see Section 2.4.1.2, "Viewing the graphical console in a remote viewer using the web console".
- For instructions on viewing the serial console in the web console, see Section 2.4.1.3, "Viewing the virtual machine serial console in the web console".

2.4.1.2. Viewing the graphical console in a remote viewer using the web console

Using the web console interface, you can display the graphical console of a selected virtual machine (VM) in a remote viewer, such as Virt Viewer.

NOTE

You can launch Virt Viewer from within the web console. Other VNC and SPICE remote viewers can be launched manually.

Prerequisites

- The web console VM plug-in is installed on your system.
- Ensure that both the host and the VM support a graphical interface.
- Before you can view the graphical console in Virt Viewer, you must install Virt Viewer on the machine to which the web console is connected.

1. Click **Launch remote viewer**.
   A **.vv** file downloads.
2. Open the file to launch Virt Viewer.

NOTE

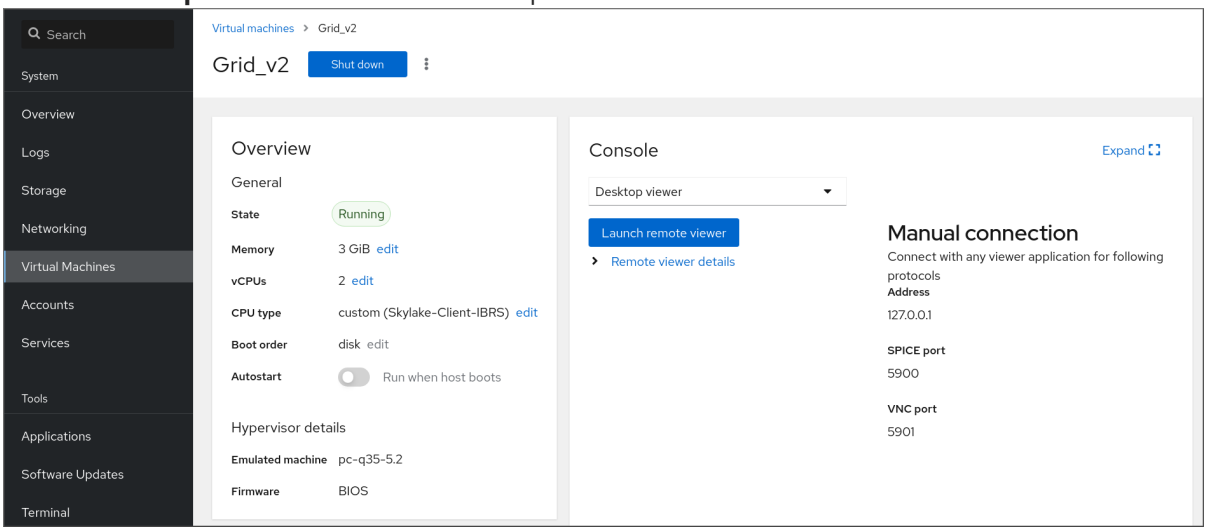
Remote Viewer is available on most operating systems. However, some browser extensions and plug-ins do not allow the web console to open Virt Viewer.

Procedure

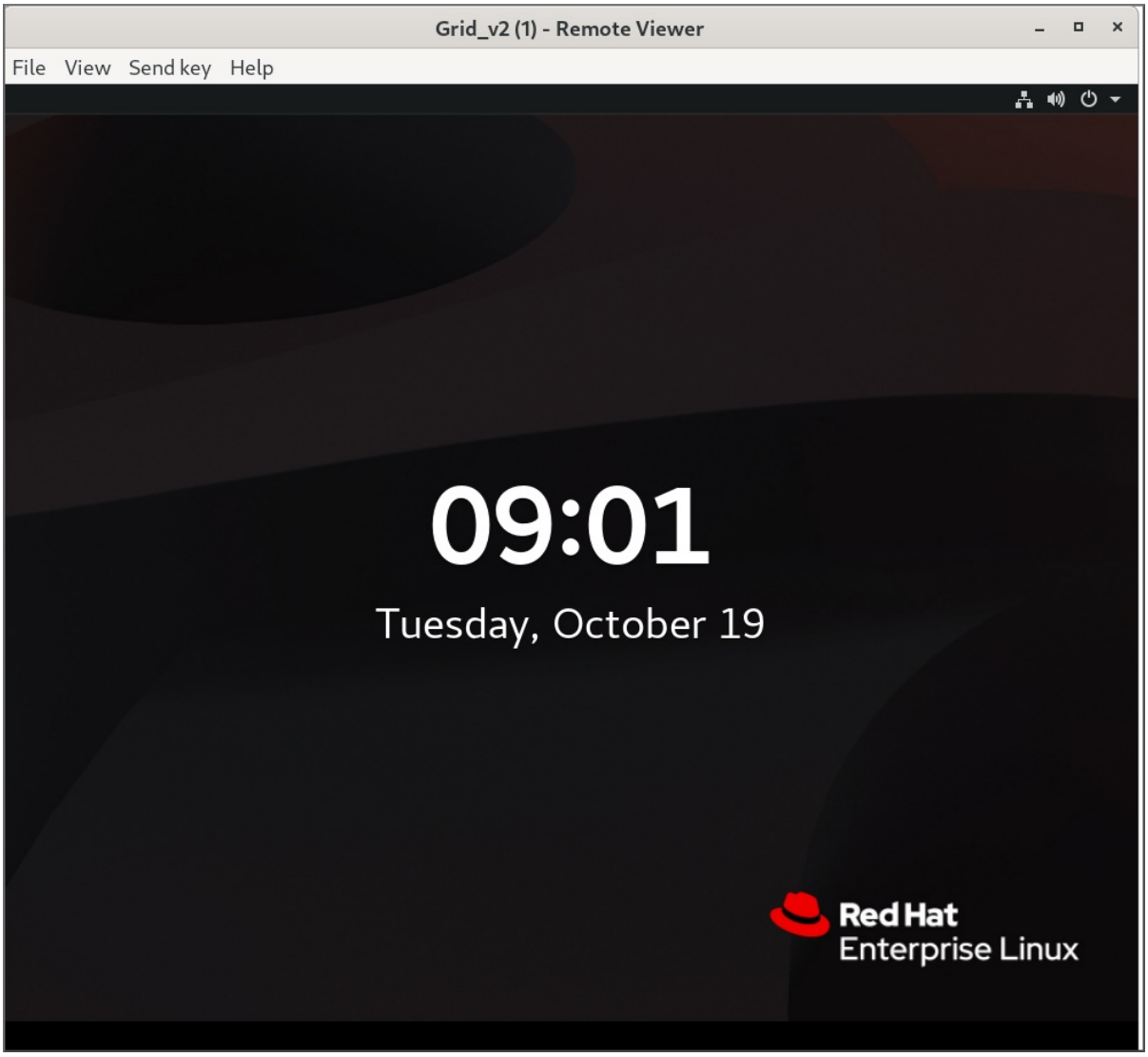
1. In the **Virtual Machines** interface, click the VM whose graphical console you want to view.

A new page opens with an **Overview** and a **Console** section for the VM.

2. Select **Desktop Viewer** in the console drop down menu.



3. Click **Launch Remote Viewer**.
The graphical console opens in Virt Viewer.



You can interact with the VM console using the mouse and keyboard in the same manner you interact with a real machine. The display in the VM console reflects the activities being performed on the VM.

NOTE

The server on which the web console is running can intercept specific key combinations, such as **Ctrl**+**Alt**+**Del**, preventing them from being sent to the VM.

To send such key combinations, click the **Send key** menu and select the key sequence to send.

For example, to send the **Ctrl**+**Alt**+**Del** combination to the VM, click the **Send key** menu and select the **Ctrl+Alt+Del** menu entry.

Troubleshooting

- If launching the Remote Viewer in the web console does not work or is not optimal, you can manually connect with any viewer application using the following protocols:
  - **Address** - The default address is **127.0.0.1**. You can modify the **vnc_listen** or the **spice_listen** parameter in **/etc/libvirt/qemu.conf** to change it to the host's IP address.
  - **SPICE port** - 5900
  - **VNC port** - 5901

Additional resources

- For instructions on viewing the graphical console in the web console, see Section 2.4.1.1, "Viewing the virtual machine graphical console in the web console".
- For instructions on viewing the serial console in the web console, see Section 2.4.1.3, "Viewing the virtual machine serial console in the web console".

2.4.1.3. Viewing the virtual machine serial console in the web console

You can view the serial console of a selected virtual machine (VM) in the RHEL 8 web console. This is useful when the host machine or the VM is not configured with a graphical interface.

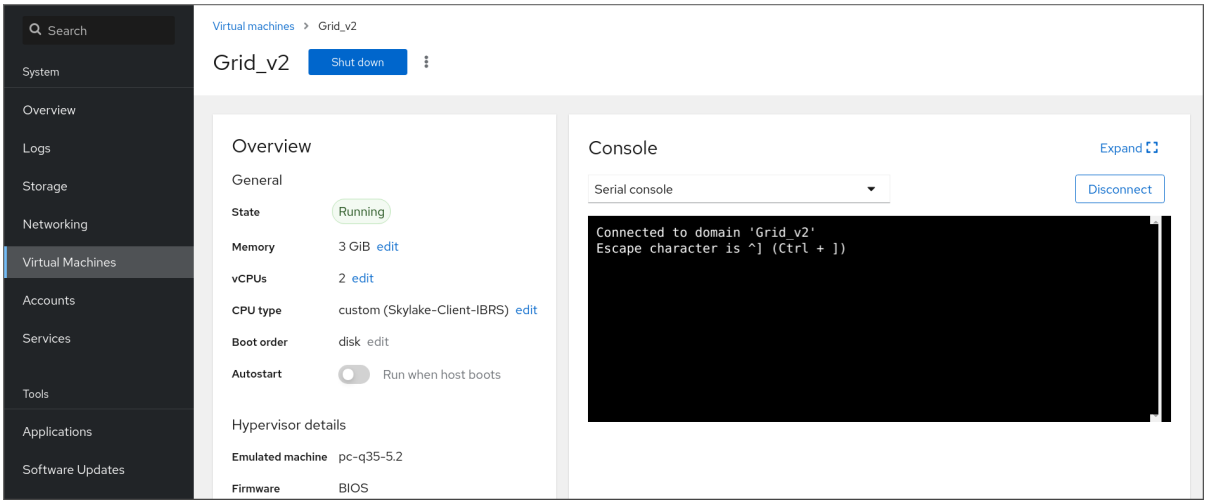
For more information about the serial console, see Section 2.4.4, "Opening a virtual machine serial console".

Prerequisites

- The web console VM plug-in is installed on your system.

Procedure

1. In the **Virtual Machines** pane, click the VM whose serial console you want to view.
   A new page opens with an **Overview** and a **Console** section for the VM.
2. Select **Serial console** in the console drop down menu.
   The graphical console appears in the web interface.



You can disconnect and reconnect the serial console from the VM.

- To disconnect the serial console from the VM, click **Disconnect**.
- To reconnect the serial console to the VM, click **Reconnect**.

Additional resources

- For instructions on viewing the graphical console in the web console, see Section 2.4.1.1, "Viewing the virtual machine graphical console in the web console".
- For instructions on viewing the graphical console in a remote viewer, see Section 2.4.1.2, "Viewing the graphical console in a remote viewer using the web console".

2.4.2. Opening a virtual machine graphical console using Virt Viewer

To connect to a graphical console of a KVM virtual machine (VM) and open it in the **Virt Viewer** desktop application, follow the procedure below.

Prerequisites

- Your system, as well as the VM you are connecting to, must support graphical displays.
- If the target VM is located on a remote host, connection and root access privileges to the host are needed.
- **Optional:** If the target VM is located on a remote host, set up your libvirt and SSH for more convenient access to remote hosts.

Procedure

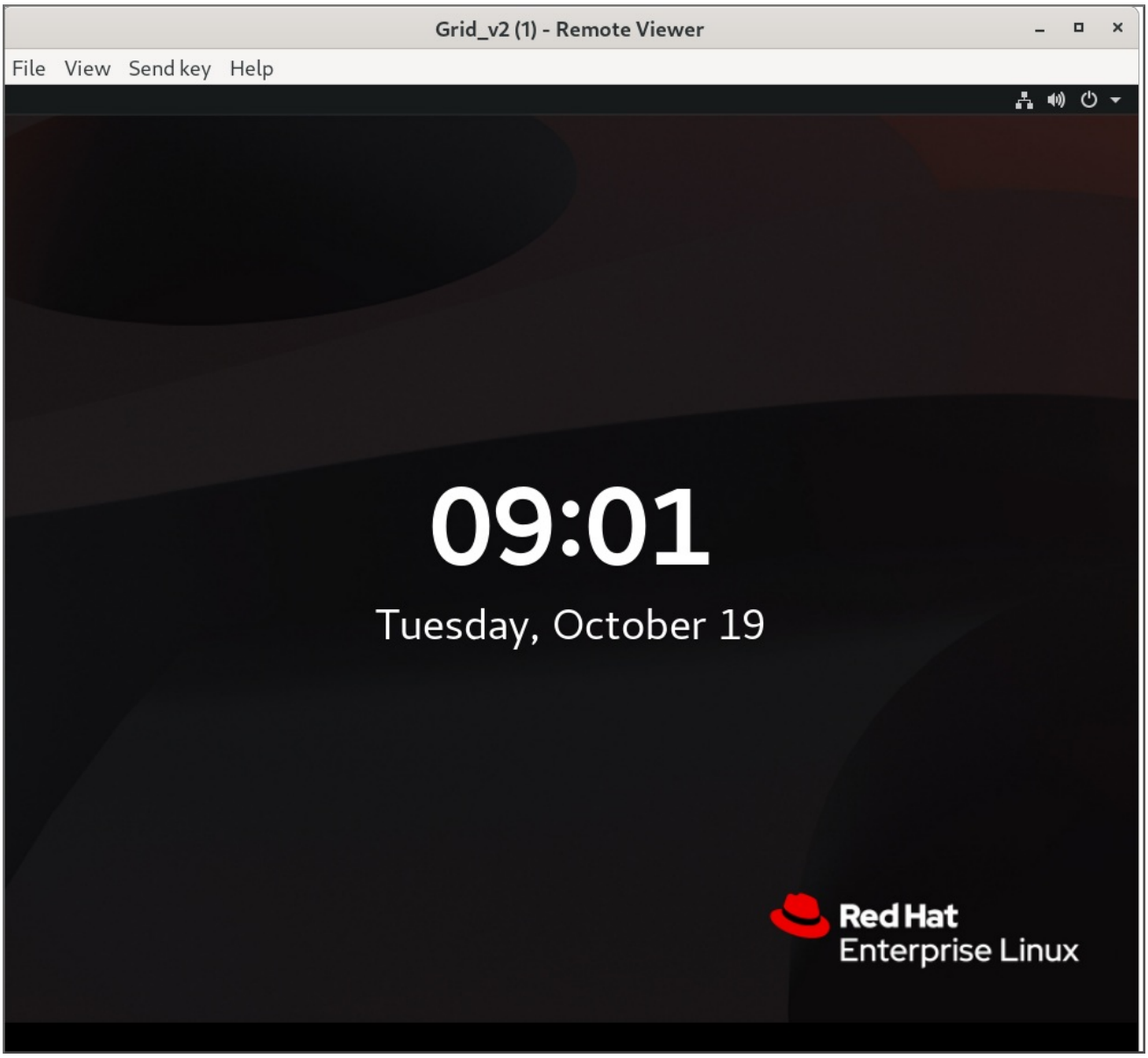
- To connect to a local VM, use the following command and replace *guest-name* with the name of the VM you want to connect to:

```
# virt-viewer guest-name
```

- To connect to a remote VM, use the **virt-viewer** command with the SSH protocol. For example, the following command connects as root to a VM called *guest-name*, located on remote system 10.0.0.1. The connection also requires root authentication for 10.0.0.1.

```
# virt-viewer --direct --connect qemu+ssh://root@10.0.0.1/system guest-name
root@10.0.0.1's password:
```

If the connection works correctly, the VM display is shown in the **Virt Viewer** window.



You can interact with the VM console using the mouse and keyboard in the same manner you interact with a real machine. The display in the VM console reflects the activities being performed on the VM.

Additional resources

- For more information on using Virt Viewer, see the **virt-viewer** man page.
- Connecting to VMs on a remote host can be simplified by modifying your libvirt and SSH configuration.
- For management of VMs in an interactive GUI in RHEL 8, you can use the web console interface. For more information, see Section 2.4.1, “Interacting with virtual machines using the web console”.

2.4.3. Connecting to a virtual machine using SSH

To interact with the terminal of a virtual machine (VM) using the SSH connection protocol, follow the procedure below:

Prerequisites

- You have network connection and root access privileges to the target VM.
- If the target VM is located on a remote host, you also have connection and root access privileges to that host.
- The **libvirt-nss** component is installed and enabled on the VM's host. If it is not, do the following:

  a. Install the **libvirt-nss** package:

  ```
  # yum install libvirt-nss
  ```

  b. Edit the **/etc/nsswitch.conf** file and add **libvirt_guest** to the **hosts** line:

  ```
  [...]
  passwd:     compat
  shadow:     compat
  group:      compat
  hosts:      files libvirt_guest dns
  [...]
  ```

Procedure

1. **Optional**: When connecting to a remote VM, SSH into its physical host first. The following example demonstrates connecting to a host machine 10.0.0.1 using its root credentials:

   ```
   # ssh root@10.0.0.1
   root@10.0.0.1's password:
   Last login: Mon Sep 24 12:05:36 2018
   root~#
   ```

2. Use the VM's name and user access credentials to connect to it. For example, the following connects to to the "testguest1" VM using its root credentials:

   ```
   # ssh root@testguest1
   root@testguest1's password:
   Last login: Wed Sep 12 12:05:36 2018
   root~]#
   ```

Troubleshooting

- If you do not know the VM's name, you can list all VMs available on the host using the **virsh list --all** command:

  ```
  # virsh list --all
  Id    Name                           State
  ----------------------------------------------------
  2     testguest1                     running
  -     testguest2                     shut off
  ```

2.4.4. Opening a virtual machine serial console

Using the **virsh console** command, it is possible to connect to the serial console of a virtual machine (VM).

This is useful when the VM:

- Does not provide VNC or SPICE protocols, and thus does not offer video display for GUI tools.
- Does not have a network connection, and thus cannot be interacted with using SSH.

Prerequisites

- The VM must have the serial console configured in its kernel command line. To verify this, the **cat /proc/cmdline** command output on the VM should include *console=ttyS0*. For example:

```
# cat /proc/cmdline
BOOT_IMAGE=/vmlinuz-3.10.0-948.el7.x86_64 root=/dev/mapper/rhel-root ro console=tty0
console=ttyS0,9600n8 rd.lvm.lv=rhel/root rd.lvm.lv=rhel/swap rhgb
```

  If the serial console is not set up properly on a VM, using **virsh console** to connect to the VM connects you to an unresponsive guest console. However, you can still exit the unresponsive console by using the **Ctrl+]** shortcut.

- To set up serial console on the VM, do the following:

  a. On the VM, edit the **/etc/default/grub** file and add **console=ttyS0** to the line that starts with **GRUB_CMDLINE_LINUX**.

  b. Clear the kernel options that may prevent your changes from taking effect.

```
# grub2-editenv - unset kernelopts
```

  c. Reload the Grub configuration:

```
# grub2-mkconfig -o /boot/grub2/grub.cfg
Generating grub configuration file ...
Found linux image: /boot/vmlinuz-3.10.0-948.el7.x86_64
Found initrd image: /boot/initramfs-3.10.0-948.el7.x86_64.img
[...]
done
```

  d. Reboot the VM.

Procedure

1. On your host system, use the **virsh console** command. The following example connects to the *guest1* VM, if the libvirt driver supports safe console handling:

```
# virsh console guest1 --safe
Connected to domain guest1
Escape character is ^]

Subscription-name
```

```
Kernel 3.10.0-948.el7.x86_64 on an x86_64

localhost login:
```

2. You can interact with the virsh console in the same way as with a standard command-line interface.

Additional resources

- For more information about the VM serial console, see the virsh man page.

2.4.5. Setting up easy access to remote virtualization hosts

When managing VMs on a remote host system using libvirt utilities, it is recommended to use the **-c qemu+ssh://root@hostname/system** syntax. For example, to use the **virsh list** command as root on the 10.0.0.1 host:

```
# virsh -c qemu+ssh://root@10.0.0.1/system list

root@10.0.0.1's password:
Last login: Mon Feb 18 07:28:55 2019

 Id   Name            State
--------------------------------
 1    remote-guest    running
```

However, for convenience, you can remove the need to specify the connection details in full by modifying your SSH and libvirt configuration. For example, you will be able to do:

```
# virsh -c remote-host list

root@10.0.0.1's password:
Last login: Mon Feb 18 07:28:55 2019

 Id   Name            State
--------------------------------
 1    remote-guest    running
```

To enable this improvement, follow the instructions below.

Procedure

1. Edit or create the **~/.ssh/config** file and add the following to it, where *host-alias* is a shortened name associated with a specific remote host, and *hosturl* is the URL address of the host.

```
Host host-alias
    User            root
    Hostname        hosturl
```

For example, the following sets up the *tyrannosaurus* alias for root@10.0.0.1:

```
Host tyrannosaurus
    User            root
    Hostname        10.0.0.1
```

2. Edit or create the **/etc/libvirt/libvirt.conf** file, and add the following, where *qemu-host-alias* is a host alias that QEMU and libvirt utilities will associate with the intended host:

```
uri_aliases = [
  "qemu-host-alias=qemu+ssh://host-alias/system",
]
```

For example, the following uses the *tyrannosaurus* alias configured in the previous step to set up the *t-rex* alias, which stands for **qemu+ssh://10.0.0.1/system**:

```
uri_aliases = [
  "t-rex=qemu+ssh://tyrannosaurus/system",
]
```

3. As a result, you can manage remote VMs by using libvirt-based utilities on the local system with an added **-c *qemu-host-alias*** parameter. This automatically performs the commands over SSH on the remote host.
For example, the following lists VMs on the 10.0.0.1 remote host, the connection to which was set up as *t-rex* in the previous steps:

```
$ virsh -c t-rex list

root@10.0.0.1's password:
Last login: Mon Feb 18 07:28:55 2019

 Id   Name           State
--------------------------------
 1    velociraptor   running
```

4. **Optional:** If you want to use libvirt utilities exclusively on a single remote host, you can also set a specific connection as the default target for libvirt-based utilities. To do so, edit the **/etc/libvirt/libvirt.conf** file and set the value of the **uri_default** parameter to *qemu-host-alias*. For example, the following uses the *t-rex* host alias set up in the previous steps as a default libvirt target.

```
# These can be used in cases when no URI is supplied by the application
# (@uri_default also prevents probing of the hypervisor driver).
#
uri_default = "t-rex"
```

As a result, all libvirt-based commands will automatically be performed on the specified remote host.

```
$ virsh list
root@10.0.0.1's password:
Last login: Mon Feb 18 07:28:55 2019

 Id   Name           State
--------------------------------
 1    velociraptor   running
```

However, this is not recommended if you also want to manage VMs on your local host or on different remote hosts.

Additional resources

- When connecting to a remote host, you can avoid having to provide the root password to the remote system. To do so, use one or more of the following methods:
  - Set up key-based SSH access to the remote host .
  - Use SSH connection multiplexing to connect to the remote system.
  - Set up a kerberos authentication ticket on the remote system. For instructions, see Kerberos authentication in Identity Management .
- Utilities that can use the **-c** (or **--connect**) option and the remote host access configuration described above include:
  - virt-install
  - virt-viewer
  - virsh
  - virt-manager

2.5. SHUTTING DOWN VIRTUAL MACHINES

To shut down a running virtual machine hosted on RHEL 8, use the command line interface or the web console GUI.

2.5.1. Shutting down a virtual machine using the command-line interface

To shut down a responsive virtual machine (VM), do one of the following:

- Use a shutdown command appropriate to the guest OS while connected to the guest .
- Use the **virsh shutdown** command on the host:
  - If the VM is on a local host:

```
# virsh shutdown demo-guest1
Domain demo-guest1 is being shutdown
```

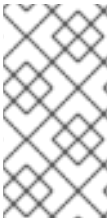
  - If the VM is on a remote host, in this example 10.0.0.1:

```
# virsh -c qemu+ssh://root@10.0.0.1/system shutdown demo-guest1

root@10.0.0.1's password:
Last login: Mon Feb 18 07:28:55 2019
Domain demo-guest1 is being shutdown
```

To force a VM to shut down, for example if it has become unresponsive, use the **virsh destroy** command on the host:

```
# virsh destroy demo-guest1
Domain demo-guest1 destroyed
```



NOTE

The **virsh destroy** command does not actually delete or remove the VM configuration or disk images. It only destroys the running VM instance. However, in rare cases, this command may cause corruption of the VM's file system, so using **virsh destroy** is only recommended if all other shutdown methods have failed.

2.5.2. Shutting down and restarting virtual machines using the web console

Using the RHEL 8 web console, you can shut down or restart running virtual machines. You can also send a non-maskable interrupt to an unresponsive virtual machine.

2.5.2.1. Shutting down virtual machines in the web console

If a virtual machine (VM) is in the **running** state, you can shut it down using the RHEL 8 web console.

Prerequisites

- The web console VM plug-in is installed on your system.

Procedure

1. In the **Virtual Machines** interface, click the row of the VM you want to shut down.
   The row expands to reveal the Overview pane with basic information about the selected VM and controls for shutting down and deleting the VM.

2. Click **Shut Down**.
   The VM shuts down.

Troubleshooting

- If the VM does not shut down, click the Menu button ⋮ next to the **Shut Down** button and select **Force Shut Down**.

- To shut down an unresponsive VM, you can also send a non-maskable interrupt. For more information, see Section 2.5.2.3, "Sending non-maskable interrupts to VMs using the web console".

Additional resources

- For information on starting a VM, see Section 2.3.2, "Starting virtual machines using the web console".

- For information on restarting a VM, see Section 2.5.2.2, "Restarting virtual machines using the web console".

2.5.2.2. Restarting virtual machines using the web console

If a virtual machine (VM) is in the **running** state, you can restart it using the RHEL 8 web console.

Prerequisites

- The web console VM plug-in is installed on your system.

Procedure

Procedure

1. In the **Virtual Machines** interface, click the row of the VM you want to restart.
   The row expands to reveal the Overview pane with basic information about the selected VM and controls for shutting down and deleting the VM.

2. Click **Restart**.
   The VM shuts down and restarts.

Troubleshooting

- If the VM does not restart, click the Menu button ⋮ next to the **Restart** button and select **Force Restart**.

- To restart an unresponsive VM, you can also send a non-maskable interrupt. For more information, see Section 2.5.2.3, "Sending non-maskable interrupts to VMs using the web console".

Additional resources

- For information on starting a VM, see Section 2.3.2, "Starting virtual machines using the web console".

- For information on shutting down a VM, see Section 2.5.2.1, "Shutting down virtual machines in the web console".

2.5.2.3. Sending non-maskable interrupts to VMs using the web console

Sending a non-maskable interrupt (NMI) may cause an unresponsive running virtual machine (VM) to respond or shut down. For example, you can send the **Ctrl**+**Alt**+**Del** NMI to a VM that is not responding to standard input.

Prerequisites

- The web console VM plug-in is installed on your system.

Procedure

1. In the **Virtual Machines** interface, click the row of the VM to which you want to send an NMI.
   The row expands to reveal the Overview pane with basic information about the selected VM and controls for shutting down and deleting the VM.

2. Click the Menu button ⋮ next to the **Shut Down** button and select **Send Non-Maskable Interrupt**.
   An NMI is sent to the VM.

Additional resources

- For information on starting a VM, see Section 2.3.2, "Starting virtual machines using the web console".

- For information on restarting a VM, see Section 2.5.2.2, "Restarting virtual machines using the web console".

- For information on shutting down a VM, see Section 2.5.2.1, "Shutting down virtual machines in the web console".

2.6. DELETING VIRTUAL MACHINES

To delete virtual machines in RHEL 8, use the command line interface or the web console GUI.

2.6.1. Deleting virtual machines using the command line interface

To delete a virtual machine (VM), you can remove its XML configuration and associated storage files from the host using the command line. Follow the procedure below:

Prerequisites

- Back up important data from the VM.
- Shut down the VM.
- Make sure no other VMs use the same associated storage.

Procedure

- Use the **virsh undefine** utility.
  For example, the following command removes the *guest1* VM, its associated storage volumes, and non-volatile RAM, if any.

```
# virsh undefine guest1 --remove-all-storage --nvram
Domain guest1 has been undefined
Volume 'vda'(/home/images/guest1.qcow2) removed.
```

Additional resources

- For other **virsh undefine** arguments, use **virsh undefine --help** or see the **virsh** man page.

2.6.2. Deleting virtual machines using the web console

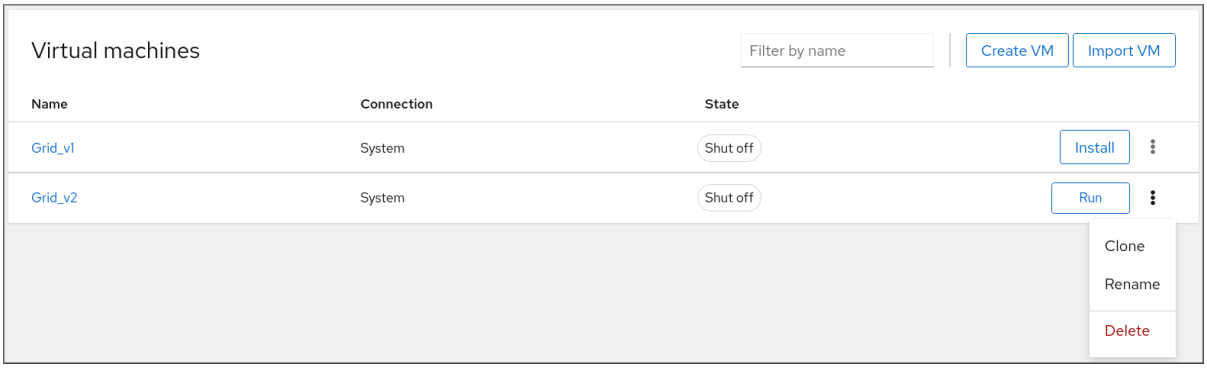
To delete a virtual machine (VM) and its associated storage files from the host to which the RHEL 8 web console is connected with, follow the procedure below:

Prerequisites

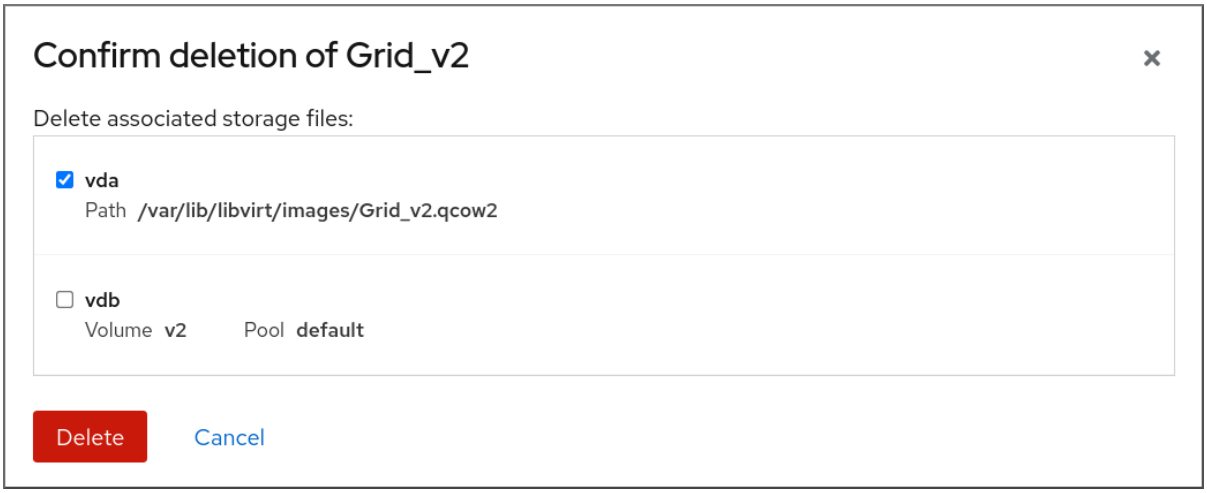
- The web console VM plug-in is installed on your system.
- Back up important data from the VM.
- Make sure no other VM uses the same associated storage.
- **Optional:** Shut down the VM.

Procedure

1. In the **Virtual Machines** interface, click the Menu button ⋮ of the VM that you want to delete.
   A drop down menu appears with controls for various VM operations.



2. Click **Delete**.
A confirmation dialog appears.



3. **Optional:** To delete all or some of the storage files associated with the VM, select the checkboxes next to the storage files you want to delete.

4. Click **Delete**.
The VM and any selected storage files are deleted.

2.7. RELATED INFORMATION

- The information above apply to the AMD64 and Intel 64 architectures. If you want to use RHEL 8 virtualization on other supported architectures, different setup procedures are needed and certain features may be restricted or work differently. For details, see the appropriate section below:
  - Chapter 3, *Getting started with virtualization on IBM POWER*
  - Chapter 4, *Getting started with virtualization on IBM Z*

CHAPTER 3. GETTING STARTED WITH VIRTUALIZATION ON IBM POWER

You can use KVM virtualization when using RHEL 8 on IBM POWER8 or POWER9 hardware. However, enabling the KVM hypervisor on your system requires extra steps compared to virtualization on AMD64 and Intel64 architectures. Certain RHEL 8 virtualization features also have different or restricted functionality on IBM POWER.

Apart from the information in the following sections, using virtualization on IBM POWER works the same as on AMD64 and Intel 64. Therefore, you can see other RHEL 8 virtualization documentation for more information when using virtualization on IBM POWER.

3.1. ENABLING VIRTUALIZATION ON IBM POWER

To set up a KVM hypervisor and create virtual machines (VMs) on an IBM POWER8 or IBM POWER9 system running RHEL 8, follow the instructions below.

Prerequisites

- RHEL 8 is installed and registered on your host machine.
- The following minimum system resources are available:
  - 6 GB free disk space for the host, plus another 6 GB for each intended VM.
  - 2 GB of RAM for the host, plus another 2 GB for each intended VM.
  - 4 CPUs on the host. VMs can generally run with a single assigned vCPU, but Red Hat recommends assigning 2 or more vCPUs per VM to avoid VMs becoming unresponsive during high load.
- Your CPU machine type must support IBM POWER virtualization.
  To verify this, query the platform information in your **/proc/cpuinfo** file.

```
# grep ^platform /proc/cpuinfo/
platform        : PowerNV
```

  If the output of this command includes the **PowerNV** entry, you are running a PowerNV machine type and can use virtualization on IBM POWER.

Procedure

1. Load the KVM-HV kernel module

```
# modprobe kvm_hv
```

2. Verify that the KVM kernel module is loaded

```
# lsmod | grep kvm
```

   If KVM loaded successfully, the output of this command includes **kvm_hv**.

3. Install the packages in the virtualization module:

```
# yum module install virt
```

4. Install the **virt-install** package:

```
# yum install virt-install
```

5. Start the **libvirtd** service.

```
# systemctl start libvirtd
```

Verification

1. Verify that your system is prepared to be a virtualization host:

```
# virt-host-validate
[...]
QEMU: Checking if device /dev/vhost-net exists                  : PASS
QEMU: Checking if device /dev/net/tun exists                    : PASS
QEMU: Checking for cgroup 'memory' controller support           : PASS
QEMU: Checking for cgroup 'memory' controller mount-point       : PASS
[...]
QEMU: Checking for cgroup 'blkio' controller support            : PASS
QEMU: Checking for cgroup 'blkio' controller mount-point        : PASS
QEMU: Checking if IOMMU is enabled by kernel                    : PASS
```

2. If all **virt-host-validate** checks return a **PASS** value, your system is prepared for creating VMs. If any of the checks return a **FAIL** value, follow the displayed instructions to fix the problem.

   If any of the checks return a **WARN** value, consider following the displayed instructions to improve virtualization capabilities.

Additional information

- Note that if virtualization is not supported by your host CPU, **virt-host-validate** generates the following output:

```
QEMU: Checking for hardware virtualization: FAIL (Only emulated CPUs are available, performance will be significantly limited)
```

  However, attempting to create VMs on such a host system will fail, rather than have performance problems.

3.2. HOW VIRTUALIZATION ON IBM POWER DIFFERS FROM AMD64 AND INTEL 64

KVM virtualization in RHEL 8 on IBM POWER systems is different from KVM on AMD64 and Intel 64 systems in a number of aspects, notably:

Memory requirements

VMs on IBM POWER consume more memory. Therefore, the recommended minimum memory allocation for a virtual machine (VM) on an IBM POWER host is 2GB RAM.

Display protocols

The SPICE protocol is not supported on IBM POWER systems. To display the graphical output of a VM, use the **VNC** protocol. In addition, only the following virtual graphics card devices are supported:

- **vga** - only supported in **-vga std** mode and not in **-vga cirrus** mode.
- **virtio-vga**
- **virtio-gpu**

SMBIOS

SMBIOS configuration is not available.

Memory allocation errors

POWER8 VMs, including compatibility mode VMs, may fail with an error similar to:

```
qemu-kvm: Failed to allocate KVM HPT of order 33 (try smaller maxmem?): Cannot allocate memory
```

This is significantly more likely to occur on VMs that use RHEL 7.3 and prior as the guest OS.

To fix the problem, increase the CMA memory pool available for the guest's hashed page table (HPT) by adding **kvm_cma_resv_ratio=*memory*** to the host's kernel command line, where *memory* is the percentage of the host memory that should be reserved for the CMA pool (defaults to 5).

Huge pages

Transparent huge pages (THPs) do not provide any notable performance benefits on IBM POWER8 VMs. However, IBM POWER9 VMs can benefit from THPs as expected.

In addition, the size of static huge pages on IBM POWER8 systems are 16 MiB and 16 GiB, as opposed to 2 MiB and 1 GiB on AMD64, Intel 64, and IBM POWER9. As a consequence, to migrate a VM configured with static huge pages from an IBM POWER8 host to an IBM POWER9 host, you must first set up 1GiB huge pages on the VM.

kvm-clock

The **kvm-clock** service does not have to be configured for time management in VMs on IBM POWER9.

pvpanic

IBM POWER9 systems do not support the **pvpanic** device. However, an equivalent functionality is available and activated by default on this architecture. To enable it in a VM, use the **<on_crash>** XML configuration element with the **preserve** value.

In addition, make sure to remove the **<panic>** element from the **<devices>** section, as its presence can lead to the VM failing to boot on IBM POWER systems.

Single-threaded host

On IBM POWER8 systems, the host machine must run in **single-threaded mode** to support VMs. This is automatically configured if the *qemu-kvm* packages are installed. However, VMs running on single-threaded hosts can still use multiple threads.

Peripheral devices

A number of peripheral devices supported on AMD64 and Intel 64 systems are not supported on IBM POWER systems, or a different device is supported as a replacement.

- Devices used for PCI-E hierarchy, including **ioh3420** and **xio3130-downstream**, are not supported. This functionality is replaced by multiple independent PCI root bridges provided by the **spapr-pci-host-bridge** device.

- UHCI and EHCI PCI controllers are not supported. Use OHCI and XHCI controllers instead.
- IDE devices, including the virtual IDE CD-ROM (**ide-cd**) and the virtual IDE disk (**ide-hd**), are not supported. Use the **virtio-scsi** and **virtio-blk** devices instead.
- Emulated PCI NICs (**rtl8139**) are not supported. Use the **virtio-net** device instead.
- Sound devices, including **intel-hda**, **hda-output**, and **AC97**, are not supported.
- USB redirection devices, including **usb-redir** and **usb-tablet**, are not supported.

v2v and p2v

The **virt-v2v** and **virt-p2v** utilities are only supported on the AMD64 and Intel 64 architecture, and are not provided on IBM POWER.

Additional sources

- For a comparison of selected supported and unsupported virtualization features across system architectures supported by Red Hat, see Section 20.5, “An overview of virtualization features support”.

CHAPTER 4. GETTING STARTED WITH VIRTUALIZATION ON IBM Z

You can use KVM virtualization when using RHEL 8 on IBM Z hardware. However, enabling the KVM hypervisor on your system requires extra steps compared to virtualization on AMD64 and Intel 64 architectures. Certain RHEL 8 virtualization features also have different or restricted functionality on IBM Z.

Apart from the information in the following sections, using virtualization on IBM Z works the same as on AMD64 and Intel 64. Therefore, you can see other RHEL 8 virtualization documentation for more information when using virtualization on IBM Z.

4.1. ENABLING VIRTUALIZATION ON IBM Z

To set up a KVM hypervisor and create virtual machines (VMs) on an IBM Z system running RHEL 8, follow the instructions below.

Prerequisites

- RHEL 8 is installed and registered on your host machine.
- The following minimum system resources are available:
  - 6 GB free disk space for the host, plus another 6 GB for each intended VM.
  - 2 GB of RAM for the host, plus another 2 GB for each intended VM.
  - 4 CPUs on the host. VMs can generally run with a single assigned vCPU, but Red Hat recommends assigning 2 or more vCPUs per VM to avoid VMs becoming unresponsive during high load.
- Your IBM Z host system is using a z13 CPU or later.
- RHEL 8 is installed on a logical partition (LPAR). In addition, the LPAR supports the *start-interpretive execution* (SIE) virtualization functions.
  To verify this, search for **sie** in your **/proc/cpuinfo** file.

```
# grep sie /proc/cpuinfo/
features       : esan3 zarch stfle msa ldisp eimm dfp edat etf3eh highgprs te sie
```

- *Red Hat Enterprise Linux Advanced Virtualization for IBM Z* repository is enabled:

```
# subscription-manager repos --enable advanced-virt-for-rhel-8-s390x-rpms
```

Procedure

1. Load the KVM kernel module:

```
# modprobe kvm
```

2. Verify that the KVM kernel module is loaded:

```
# lsmod | grep kvm
```

If KVM loaded successfully, the output of this command includes **kvm**.

3. Remove any pre-existing virtualization packages and modules that your system already contains:

```
# yum remove -y libvirt* qemu* @virt
# yum module reset virt
```

4. Install the packages in the **virt:av/common** module:

```
# yum module install virt:av/common
```

5. Start the **libvirtd** service.

```
# systemctl start libvirtd
```

Verification

1. Verify that your system is prepared to be a virtualization host:

```
# virt-host-validate
[...]
QEMU: Checking if device /dev/kvm is accessible                 : PASS
QEMU: Checking if device /dev/vhost-net exists                  : PASS
QEMU: Checking if device /dev/net/tun exists                    : PASS
QEMU: Checking for cgroup 'memory' controller support           : PASS
QEMU: Checking for cgroup 'memory' controller mount-point       : PASS
[...]
```

2. If all **virt-host-validate** checks return a **PASS** value, your system is prepared for creating VMs. If any of the checks return a **FAIL** value, follow the displayed instructions to fix the problem.

   If any of the checks return a **WARN** value, consider following the displayed instructions to improve virtualization capabilities.

Additional information

- Note that if virtualization is not supported by your host CPU, **virt-host-validate** generates the following output:

```
QEMU: Checking for hardware virtualization: FAIL (Only emulated CPUs are available, performance will be significantly limited)
```

  However, attempting to create VMs on such a host system will fail, rather than have performance problems.

4.2. HOW VIRTUALIZATION ON IBM Z DIFFERS FROM AMD64 AND INTEL 64

KVM virtualization in RHEL 8 on IBM Z systems differs from KVM on AMD64 and Intel 64 systems in the following:

PCI and USB devices

Virtual PCI and USB devices are not supported on IBM Z. This also means that **virtio-*-pci** devices are unsupported, and **virtio-*-ccw** devices should be used instead. For example, use **virtio-net-ccw** instead of **virtio-net-pci**.

Note that direct attachment of PCI devices, also known as PCI passthrough, is supported.

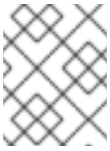
Supported guest OS

Red Hat only supports VMs hosted on IBM Z if they use RHEL 7 or RHEL 8 as their guest operating system.

Device boot order

IBM Z does not support the **<boot dev='*device*'>** XML configuration element. To define device boot order, use the **<boot order='*number*'>** element in the **<devices>** section of the XML. For example:

```
<disk type='file' device='disk'>
  <driver name='qemu' type='qcow2'/>
  <source file='/path/to/qcow2'/>
  <target dev='vda' bus='virtio'/>
  <address type='ccw' cssid='0xfe' ssid='0x0' devno='0x0000'/>
  <boot order='2'>
</disk>
```



NOTE

Using **<boot order='*number*'>** for boot order management is also preferred on AMD64 and Intel 64 hosts.

Memory hot plug

Adding memory to a running VM is not possible on IBM Z. Note that removing memory from a running VM (*memory hot unplug*) is also not possible on IBM Z, as well as on AMD64 and Intel 64.

NUMA topology

Non-Uniform Memory Access (NUMA) topology for CPUs is not supported by **libvirt** on IBM Z. Therefore, tuning vCPU performance using NUMA is not possible on these systems.

vfio-ap

VMs on an IBM Z host can use the *vfio-ap* cryptographic device passthrough, which is not supported on any other architectures.

SMBIOS

SMBIOS configuration is not available on IBM Z.

Watchdog devices

If using watchdog devices in your VM on an IBM Z host, use the **diag288** model. For example:

```
<devices>
  <watchdog model='diag288' action='poweroff'/>
</devices>
```

kvm-clock

The **kvm-clock** service is specific to AMD64 and Intel 64 systems, and does not have to be configured for VM time management on IBM Z.

v2v and p2v

The **virt-v2v** and **virt-p2v** utilities are supported only on the AMD64 and Intel 64 architecture, and are not provided on IBM Z.

Nested virtualization

Creating nested VMs requires different settings on IBM Z than on AMD64 and Intel 64. For details, see Chapter 18, *Creating nested virtual machines*.

No graphical output in earlier releases

When using RHEL 8.3 or an earlier minor version on your host, displaying the VM graphical output is not possible when connecting to the VM using the VNC protocol. This is because the **gnome-desktop** utility was not supported in earlier RHEL versions on IBM Z. In addition, the SPICE display protocol does not work on IBM Z.

Migrations

To successfully migrate to a newer machine or to update the hypervisor, it is recommended to use the **host-model** CPU mode. The **host-passthrough** and **maximum** CPU mode should be used with care, as they are in general not migration-safe.
If you want to specify an explicit CPU model in the **custom** CPU mode, make sure to follow these guidelines:

- Do not use CPU models that end with **-base**.
- Do not use the **qemu**, **max** or **host** CPU model.

To successfully migrate to an older machine or QEMU/KVM/kernel version, it's recommended to use the CPU model of the oldest machine without **-base** at the end.

If you have both the machines running, you can use the **virsh cpu-baseline** command to choose a suitable CPU model.

Additional resources

- For a comparison of selected supported and unsupported virtualization features across system architectures supported by Red Hat, see Section 20.5, "An overview of virtualization features support".

4.3. RELATED INFORMATION

- When setting up a VM on an IBM Z system, it is recommended to protect the guest OS from the "Spectre" vulnerability. To do so, use the **virsh edit** command to modify the VM's XML configuration and configure its CPU in one of the following ways:
  - Use the host CPU model, for example as follows:

```
<cpu mode='host-model' check='partial'>
  <model fallback='allow'/>
</cpu>
```

    This makes the **ppa15** and **bpb** features available to the guest if the host supports them.

  - If using a specific host model, add the **ppa15** and **pbp** features. The following example uses the zEC12 CPU model:

```
<cpu mode='custom' match='exact' check='partial'>
    <model fallback='allow'>zEC12</model>
    <feature policy='force' name='ppa15'/>
```

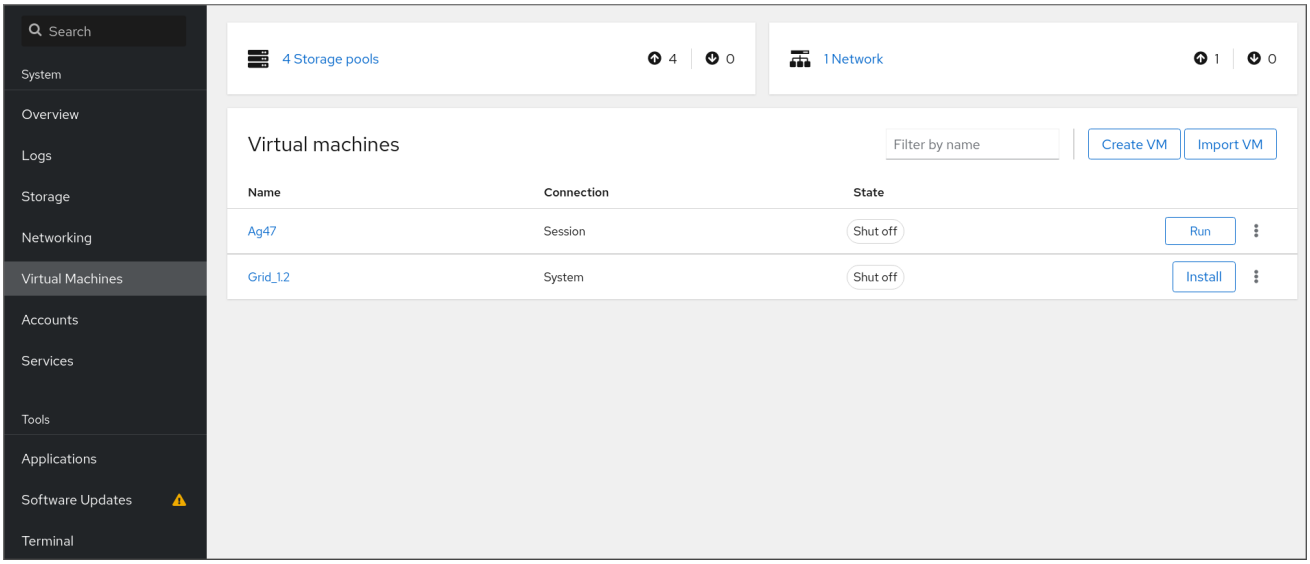
```
    <feature policy='force' name='bpb'/>
</cpu>
```

Note that when using the **ppa15** feature with the **z114** and **z196** CPU models on a host machine that uses a z12 CPU, you also need to use the latest microcode level (bundle 95 or later).

- Note that running KVM on the z/VM OS is not supported.
- For information on attaching DASD devices to VMs on IBM Z hosts, see Section 10.10, “Attaching DASD devices to virtual machines on IBM Z”.
- For instructions on using IBM Z hardware encryption in VMs, see Section 15.8, “Attaching cryptographic coprocessors to virtual machines on IBM Z”.
- For instructions on configuring IBM Z Secure Execution for your VMs, see Section 15.7, “Setting up IBM Secure Execution on IBM Z”.
- For information on configuring nested virtualization on IBM Z hosts, see Section 18.3, “Creating a nested virtual machine on IBM Z”.

CHAPTER 5. MANAGING VIRTUAL MACHINES IN THE WEB CONSOLE

To manage virtual machines in a graphical interface on a RHEL 8 host, you can use the **Virtual Machines** pane in the RHEL 8 web console.



5.1. OVERVIEW OF VIRTUAL MACHINE MANAGEMENT USING THE WEB CONSOLE

The RHEL 8 web console is a web-based interface for system administration. As one of its features, the web console provides a graphical view of virtual machines (VMs) on the host system, and makes it possible to create, access, and configure these VMs.

Note that to use the web console to manage your VMs on RHEL 8, you must first install a web console plug-in for virtualization.

Next steps

- For instructions on enabling VMs management in your web console, see Setting up the web console to manage virtual machines.
- For a comprehensive list of VM management actions that the web console provides, see Virtual machine management features available in the web console.
- For a list of features that are currently not available in the web console but can be used in the **virt-manager** application, see Differences between virtualization features in Virtual Machine Manager and the web console.

5.2. SETTING UP THE WEB CONSOLE TO MANAGE VIRTUAL MACHINES

Before using the RHEL 8 web console to manage virtual machines (VMs), you must install the web console virtual machine plug-in on the host.

Prerequisites

- Ensure that the web console is installed and enabled on your machine.

```
# systemctl status cockpit.socket
cockpit.socket - Cockpit Web Service Socket
Loaded: loaded (/usr/lib/systemd/system/cockpit.socket
[...]
```

If this command returns **Unit cockpit.socket could not be found**, follow the Installing the web console document to enable the web console.

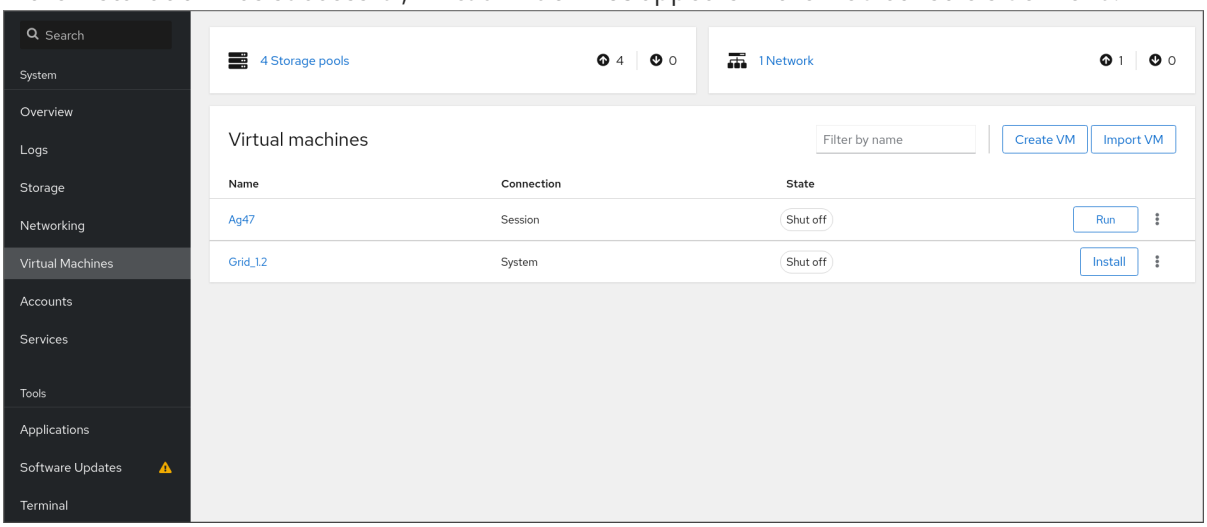
Procedure

- Install the **cockpit-machines** plug-in.

```
# yum install cockpit-machines
```

Verification

1. Access the web console, for example by entering the **https://localhost:9090** address in your browser.
2. Log in.
3. If the installation was successful, **Virtual Machines** appears in the web console side menu.



Additional resources

- For instructions on connecting to the web console, as well as other information on using the web console, see the *Managing systems using the RHEL 8 web console* document.

5.3. VIRTUAL MACHINE MANAGEMENT FEATURES AVAILABLE IN THE WEB CONSOLE

Using the RHEL 8 web console, you can perform the following actions to manage the virtual machines (VMs) on your system.

Table 5.1. VM management tasks that can be performed in the RHEL 8 web console

Task	For details, see
Create a VM and install it with a guest operating system	Creating virtual machines and installing guest operating systems using the web console
Delete a VM	Deleting virtual machines using the web console
Start, shut down, and restart the VM	Starting virtual machines using the web consoleand Shutting down and restarting virtual machines using the web console
Connect to and interact with a VM using a variety of consoles	Interacting with virtual machines using the web console
View a variety of information about the VM	Viewing virtual machine information using the web console
Adjust the host memory allocated to a VM	Adding and removing virtual machine memory using the web console
Manage network connections for the VM	Using the web console for managing virtual machine network interfaces
Manage the VM storage available on the host and attach virtual disks to the VM	Managing storage for virtual machines using the web console
Configure the virtual CPU settings of the VM	Section 16.5.2, “Managing virtual CPUs using the web console”
Live migrate a VM	Section 9.6, “Live migrating a virtual machine using the web console”

5.4. DIFFERENCES BETWEEN VIRTUALIZATION FEATURES IN VIRTUAL MACHINE MANAGER AND THE WEB CONSOLE

The Virtual Machine Manager (**virt-manager**) application is supported in RHEL 8, but has been deprecated. The web console is intended to become its replacement in a subsequent major release. It is, therefore, recommended that you get familiar with the web console for managing virtualization in a GUI.

However, in RHEL 8, some VM management tasks can only be performed in **virt-manager** or the command line. The following table highlights the features that are available in **virt-manager** but not available in the RHEL 8.0 web console.

If a feature is available in a later minor version of RHEL 8, the minimum RHEL 8 version appears in the *Support in web console introduced* column.

Table 5.2. VM managemennt tasks that cannot be performed using the web console in RHEL 8.0

Task	Support in web console introduced	Alternative method using CLI
Setting a virtual machine to start when the host boots	RHEL 8.1	**virsh autostart**
Suspending a virtual machine	RHEL 8.1	**virsh suspend**
Resuming a suspended virtual machine	RHEL 8.1	**virsh resume**
Creating file-system directory storage pools	RHEL 8.1	**virsh pool-define-as**
Creating NFS storage pools	RHEL 8.1	**virsh pool-define-as**
Creating physical disk device storage pools	RHEL 8.1	**virsh pool-define-as**
Creating LVM volume group storage pools	RHEL 8.1	**virsh pool-define-as**
Creating partition-based storage pools	*CURRENTLY UNAVAILABLE*	**virsh pool-define-as**
Creating GlusterFS-based storage pools	*CURRENTLY UNAVAILABLE*	**virsh pool-define-as**
Creating vHBA-based storage pools with SCSI devices	*CURRENTLY UNAVAILABLE*	**virsh pool-define-as**
Creating Multipath-based storage pools	*CURRENTLY UNAVAILABLE*	**virsh pool-define-as**
Creating RBD-based storage pools	*CURRENTLY UNAVAILABLE*	**virsh pool-define-as**
Creating a new storage volume	RHEL 8.1	**virsh vol-create**
Adding a new virtual network	RHEL 8.1	**virsh net-create** or **virsh net-define**
Deleting a virtual network	RHEL 8.1	**virsh net-undefine**
Creating a bridge from a host machine's interface to a virtual machine	*CURRENTLY UNAVAILABLE*	**virsh iface-bridge**
Creating a snapshot	*CURRENTLY UNAVAILABLE*	**virsh snapshot-create-as**

Task	Support in web console introduced	Alternative method using CLI
Reverting to a snapshot	*CURRENTLY UNAVAILABLE*	**virsh snapshot-revert**
Deleting a snapshot	*CURRENTLY UNAVAILABLE*	**virsh snapshot-delete**
Cloning a virtual machine	RHEL 8.4	**virt-clone**
Migrating a virtual machine to another host machine	RHEL 8.5	**virsh migrate**

Additional resources

- For information on the Virtual Machine Manager, see RHEL 7 documentation.

CHAPTER 6. VIEWING INFORMATION ABOUT VIRTUAL MACHINES

When you need to adjust or troubleshoot any aspect of your virtualization deployment on RHEL 8, the first step you need to perform usually is to view information about the current state and configuration of your virtual machines. To do so, you can use the command-line interface or the web console. You can also view the information in the VM's XML configuration.

6.1. VIEWING VIRTUAL MACHINE INFORMATION USING THE COMMAND-LINE INTERFACE

To retrieve information about virtual machines (VMs) on your host and their configurations, use one or more of the following commands.

Procedure

- To obtain a list of VMs on your host:

```
# virsh list --all
 Id   Name            State
----------------------------------
 1    testguest1      running
 -    testguest2      shut off
 -    testguest3      shut off
 -    testguest4      shut off
```

- To obtain basic information about a specific VM:

```
# virsh dominfo testguest1
Id:             1
Name:           testguest1
UUID:           a973666f-2f6e-415a-8949-75a7a98569e1
OS Type:        hvm
State:          running
CPU(s):         2
CPU time:       188.3s
Max memory:     4194304 KiB
Used memory:    4194304 KiB
Persistent:     yes
Autostart:      disable
Managed save:   no
Security model: selinux
Security DOI:   0
Security label: system_u:system_r:svirt_t:s0:c486,c538 (enforcing)
```

- To obtain the complete XML configuration of a specific VM:

```
# virsh dumpxml testguest2

<domain type='kvm' id='1'>
  <name>testguest2</name>
```

```
  <uuid>a973434f-2f6e-4ěša-8949-76a7a98569e1</uuid>
  <metadata>
[...]
```

- For information about a VM's disks and other block devices:

```
# virsh domblklist testguest3
 Target   Source
------------------------------------------------------------
 vda      /var/lib/libvirt/images/testguest3.qcow2
 sda      -
 sdb      /home/username/Downloads/virt-p2v-1.36.10-1.el7.iso
```

  For instructions on managing a VM's storage, see Chapter 11, *Managing storage for virtual machines*.

- To obtain information about a VM's file systems and their mountpoints:

```
# virsh domfsinfo testguest3
Mountpoint   Name   Type   Target
-----------------------------------
 /           dm-0   xfs
 /boot       vda1   xfs
```

- To obtain more details about the vCPUs of a specific VM:

```
# virsh vcpuinfo testguest4
VCPU:           0
CPU:            3
State:          running
CPU time:       103.1s
CPU Affinity:   yyyy

VCPU:           1
CPU:            0
State:          running
CPU time:       88.6s
CPU Affinity:   yyyy
```

  To configure and optimize the vCPUs in your VM, see Section 16.5, "Optimizing virtual machine CPU performance".

- To list all virtual network interfaces on your host:

```
# virsh net-list --all
 Name       State    Autostart   Persistent
----------------------------------------------
 default    active   yes         yes
 labnet     active   yes         yes
```

  For information about a specific interface:

```
# virsh net-info default
Name:           default
```

```
UUID:           c699f9f6-9202-4ca8-91d0-6b8cb9024116
Active:         yes
Persistent:     yes
Autostart:      yes
Bridge:         virbr0
```

For details about network interfaces, VM networks, and instructions for configuring them, see Chapter 13, *Configuring virtual machine network connections* .

- For instructions on viewing information about storage pools and storage volumes on your host, see Section 11.2, “Viewing virtual machine storage information using the CLI” .

6.2. VIEWING VIRTUAL MACHINE INFORMATION USING THE WEB CONSOLE

Using the RHEL 8 web console, you can view information about the virtual storage and VMs to which the web console is connected.

6.2.1. Viewing a virtualization overview in the web console

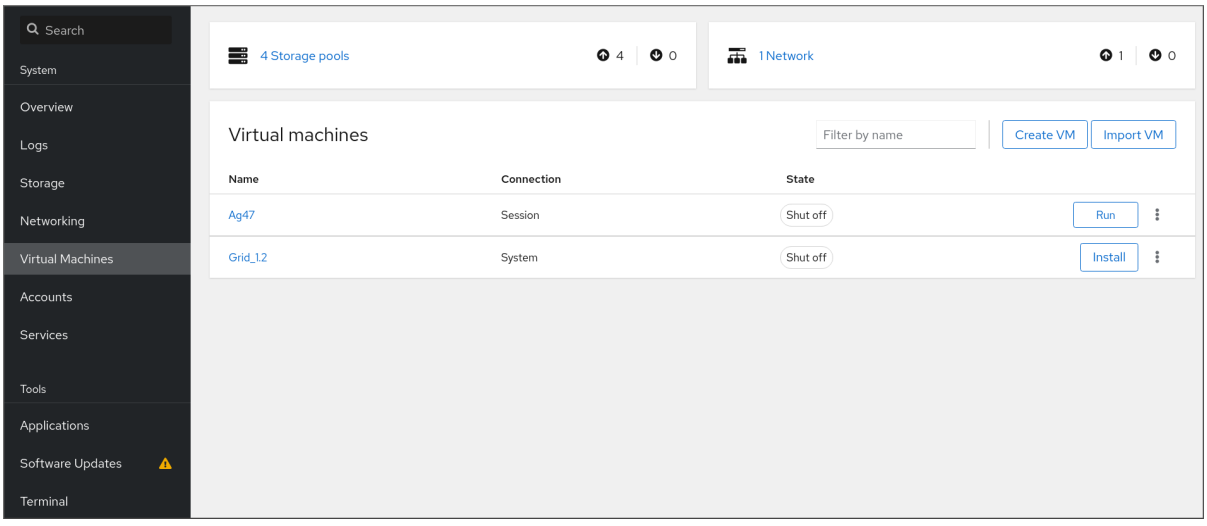
Using the web console, you can access a virtualization overview that contains summarized information about available virtual machines (VMs), storage pools, and networks.

Prerequisites

- The web console VM plug-in is installed on your system .

Procedure

- Click **Virtual Machines** in the web console’s side menu.
  A dialog box appears with information about the available storage pools, available networks, and the VMs to which the web console is connected.



The information includes the following:

- **Storage Pools** - The number of storage pools, active or inactive, that can be accessed by the web console and their state.

- **Networks** - The number of networks, active or inactive, that can be accessed by the web console and their state.
- **Name** - The name of the VM.
- **Connection** - The type of libvirt connection, system or session.
- **State** - The state of the VM.

Additional resources

- For instructions on viewing detailed information about the storage pools the web console session can access, see Section 6.2.2, "Viewing storage pool information using the web console" .
- For instructions on viewing basic information about a selected VM to which the web console session is connected, see Section 6.2.3, "Viewing basic virtual machine information in the web console".
- For instructions on viewing resource usage for a selected VM to which the web console session is connected, see Section 6.2.4, "Viewing virtual machine resource usage in the web console" .
- For instructions on viewing disk information about a selected VM to which the web console session is connected, see Section 6.2.5, "Viewing virtual machine disk information in the web console".
- For instructions on viewing virtual network interface information about a selected VM to which the web console session is connected, see Section 6.2.6, "Viewing and editing virtual network interface information in the web console".

6.2.2. Viewing storage pool information using the web console

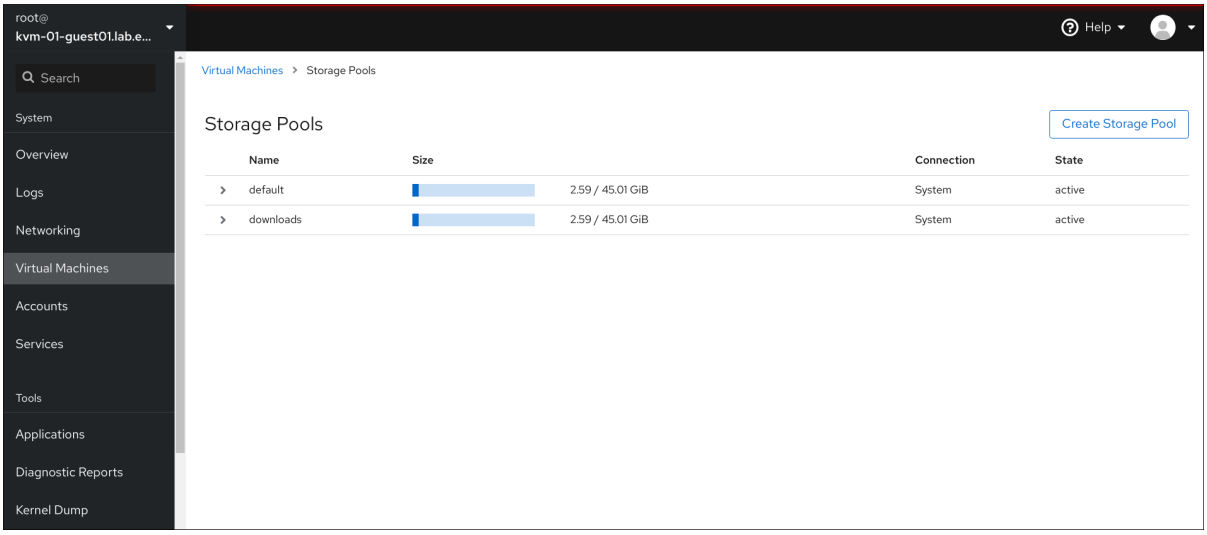
Using the web console, you can view detailed information about storage pools available on your system. Storage pools can be used to create disk images for your virtual machines.

Prerequisites

- The web console VM plug-in is installed on your system .

Procedure

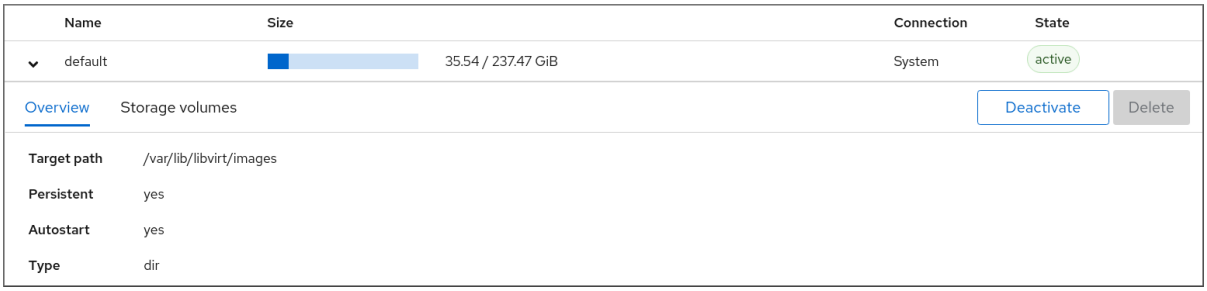
1. Click **Storage Pools** at the top of the **Virtual Machines** interface.
   The Storage Pools window appears, showing a list of configured storage pools.



The information includes the following:

- **Name** - The name of the storage pool.
- **Size** - The current allocation and the total capacity of the storage pool.
- **Connection** - The connection used to access the storage pool.
- **State** - The state of the storage pool.

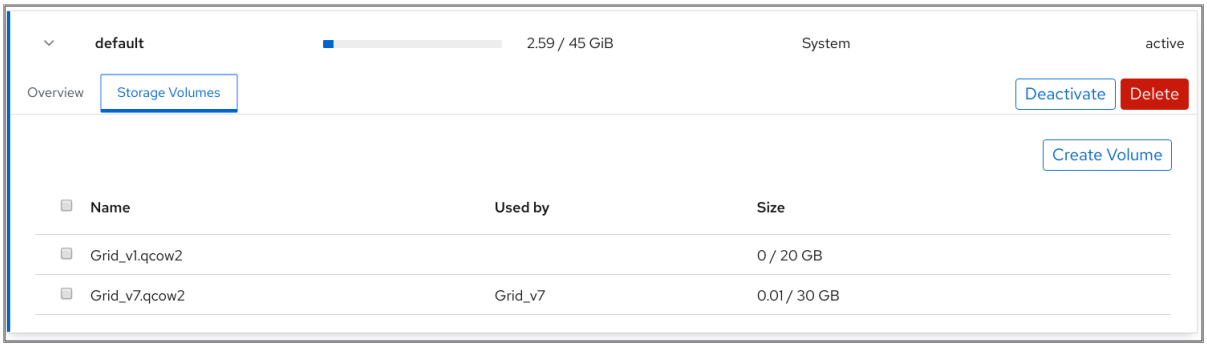
2. Click the row of the storage whose information you want to see.
The row expands to reveal the Overview pane with detailed information about the selected storage pool.



The information includes:

- **Target path** - The source for the types of storage pools backed by directories, such as **dir** or **netfs**.
- **Persistent** - Indicates whether or not the storage pool has a persistent configuration.
- **Autostart** - Indicates whether or not the storage pool starts automatically when the system boots up.
- **Type** - The type of the storage pool.

3. To view a list of storage volumes associated with the storage pool, click **Storage Volumes**.
The Storage Volumes pane appears, showing a list of configured storage volumes.



The information includes:

- **Name** - The name of the storage volume.
- **Used by** - The VM that is currently using the storage volume.
- **Size** - The size of the volume.

Additional resources

- For instructions on viewing information about all of the VMs to which the web console session is connected, see Section 6.2.1, "Viewing a virtualization overview in the web console" .
- For instructions on viewing basic information about a selected VM to which the web console session is connected, see Section 6.2.3, "Viewing basic virtual machine information in the web console".
- For instructions on viewing resource usage for a selected VM to which the web console session is connected, see Section 6.2.4, "Viewing virtual machine resource usage in the web console" .
- For instructions on viewing disk information about a selected VM to which the web console session is connected, see Section 6.2.5, "Viewing virtual machine disk information in the web console".
- For instructions on viewing virtual network interface information about a selected VM to which the web console session is connected, see Section 6.2.6, "Viewing and editing virtual network interface information in the web console".

6.2.3. Viewing basic virtual machine information in the web console

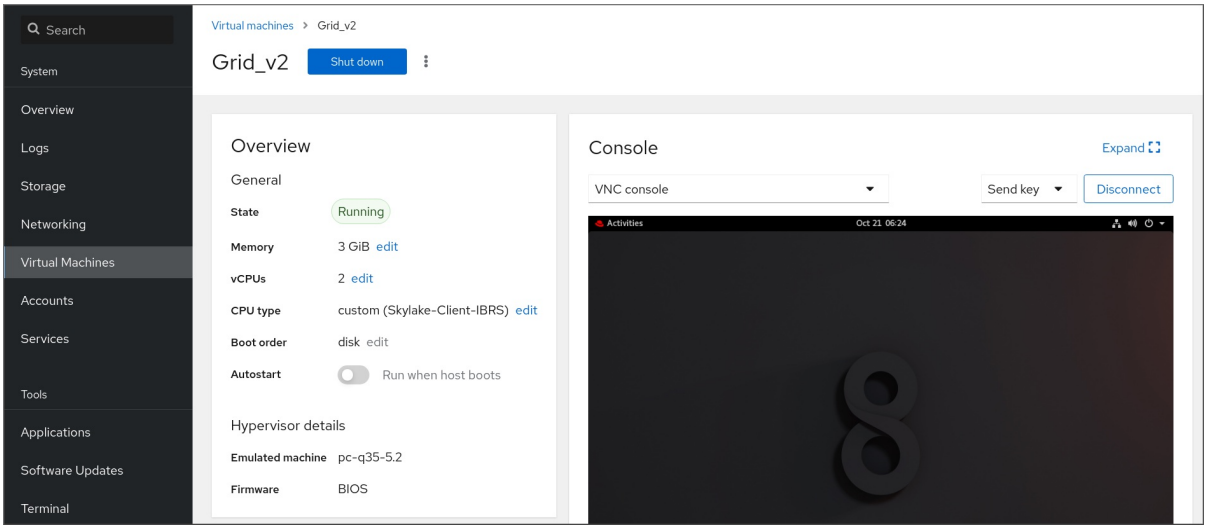
Using the web console, you can view basic information, such as assigned resources or hypervisor details, about a selected virtual machine (VM).

Prerequisites

- The web console VM plug-in is installed on your system .

Procedure

1. Click **Virtual Machines** in the web console side menu.
2. Click the VM whose information you want to see.
   A new page opens with an Overview section with basic information about the selected VM and a Console section to access the VM's graphical interface.



The Overview section includes the following general VM details:

- **State** - The VM state, Running or Shut off.
- **Memory** - The amount of memory assigned to the VM.
- **vCPUs** - The number of virtual CPUs configured for the VM.
- **CPU Type** - The architecture of the virtual CPUs configured for the VM.
- **Boot Order** - The boot order configured for the VM.
- **Autostart** - Whether or not autostart is enabled for the VM.

The information also includes the following hypervisor details:

- **Emulated Machine** - The machine type emulated by the VM.
- **Firmware** - The firmware of the VM.

Additional resources

- For instructions on viewing information about all of the VMs to which the web console session is connected, see Section 6.2.1, “Viewing a virtualization overview in the web console” .
- For instructions on viewing information about the storage pools to which the web console session is connected, see Section 6.2.2, “Viewing storage pool information using the web console”.
- For instructions on viewing resource usage for a selected VM to which the web console session is connected, see Section 6.2.4, “Viewing virtual machine resource usage in the web console” .
- For instructions on viewing disk information about a selected VM to which the web console session is connected, see Section 6.2.5, “Viewing virtual machine disk information in the web console”.
- For instructions on viewing virtual network interface information about a selected VM to which the web console session is connected, see Section 6.2.6, “Viewing and editing virtual network interface information in the web console”.

- To see more detailed virtual CPU information and configure the virtual CPUs configured for a VM, see Section 16.5.2, “Managing virtual CPUs using the web console” .

6.2.4. Viewing virtual machine resource usage in the web console

Using the web console, you can view memory and virtual CPU usage of a selected virtual machine (VM).

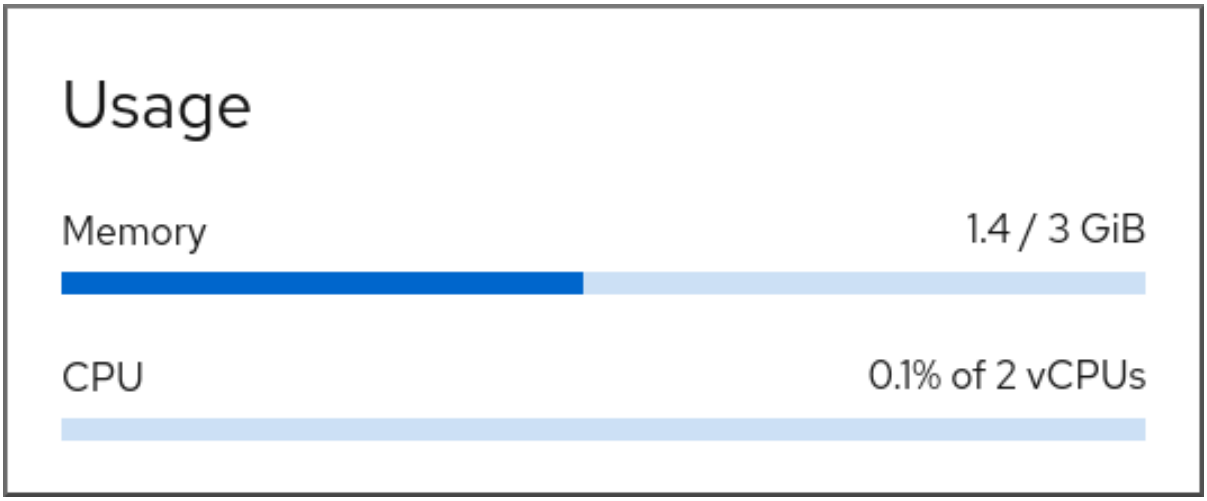
Prerequisites

- The web console VM plug-in is installed on your system .

Procedure

1. In the **Virtual Machines** interface, click the VM whose information you want to see.
   A new page opens with an Overview section with basic information about the selected VM and a Console section to access the VM’s graphical interface.

2. Scroll to **Usage**.
   The Usage section displays information about the memory and virtual CPU usage of the VM.



Additional resources

- For instructions on viewing information about all of the VMs to which the web console session is connected, see Section 6.2.1, “Viewing a virtualization overview in the web console” .
- For instructions on viewing information about the storage pools to which the web console session is connected, see Section 6.2.2, “Viewing storage pool information using the web console”.
- For instructions on viewing basic information about a selected VM to which the web console session is connected, see Section 6.2.3, “Viewing basic virtual machine information in the web console”.
- For instructions on viewing disk information about a selected VM to which the web console session is connected, see Section 6.2.5, “Viewing virtual machine disk information in the web console”.
- For instructions on viewing virtual network interface information about a selected VM to which the web console session is connected, see Section 6.2.6, “Viewing and editing virtual network interface information in the web console”.

6.2.5. Viewing virtual machine disk information in the web console

Using the web console, you can view detailed information about disks assigned to a selected virtual machine (VM).

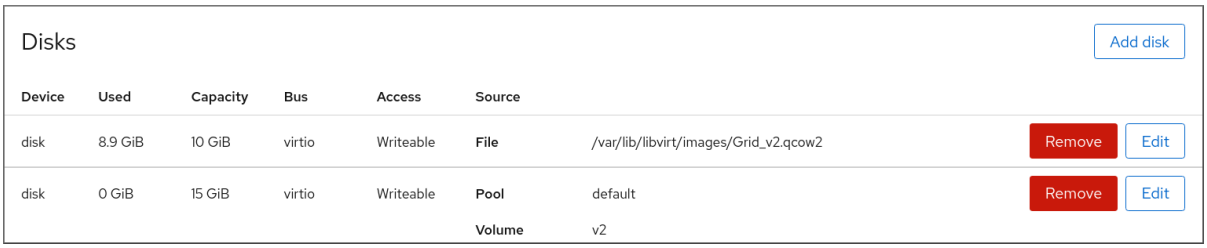
Prerequisites

- The web console VM plug-in is installed on your system.

Procedure

1. Click the VM whose information you want to see.
   A new page opens with an Overview section with basic information about the selected VM and a Console section to access the VM's graphical interface.

2. Scroll to **Disks**.
   The Disks section displays information about the disks assigned to the VM as well as options to **Add**, **Remove**, or **Edit** disks.



The information includes the following:

- **Device** - The device type of the disk.
- **Used** - The amount of disk currently allocated.
- **Capacity** - The maximum size of the storage volume.
- **Bus** - The type of disk device that is emulated.
- **Access** - Whether the disk is **Writeable** or **Read-only**. For **raw** disks, you can also set the access to **Writeable and shared**.
- **Source** - The disk device or file.

Additional resources

- For instructions on viewing information about all of the VMs to which the web console session is connected, see Section 6.2.1, "Viewing a virtualization overview in the web console" .
- For instructions on viewing information about the storage pools to which the web console session is connected, see Section 6.2.2, "Viewing storage pool information using the web console".
- For instructions on viewing basic information about a selected VM to which the web console session is connected, see Section 6.2.3, "Viewing basic virtual machine information in the web console".

- For instructions on viewing resource usage for a selected VM to which the web console session is connected, see Section 6.2.4, "Viewing virtual machine resource usage in the web console" .
- For instructions on viewing virtual network interface information about a selected VM to which the web console session is connected, see Section 6.2.6, "Viewing and editing virtual network interface information in the web console".

6.2.6. Viewing and editing virtual network interface information in the web console

Using the RHEL 8 web console, you can view and modify the virtual network interfaces on a selected virtual machine (VM):

Prerequisites

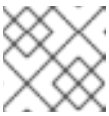
- The web console VM plug-in is installed on your system .

Procedure

1. In the **Virtual Machines** interface, click the VM whose information you want to see.
   A new page opens with an Overview section with basic information about the selected VM and a Console section to access the VM's graphical interface.
2. Scroll to **Network Interfaces**.
   The Networks Interfaces section displays information about the virtual network interface configured for the VM as well as options to **Add**, **Delete**, **Edit**, or **Unplug** network interfaces.

   + The information includes the following:

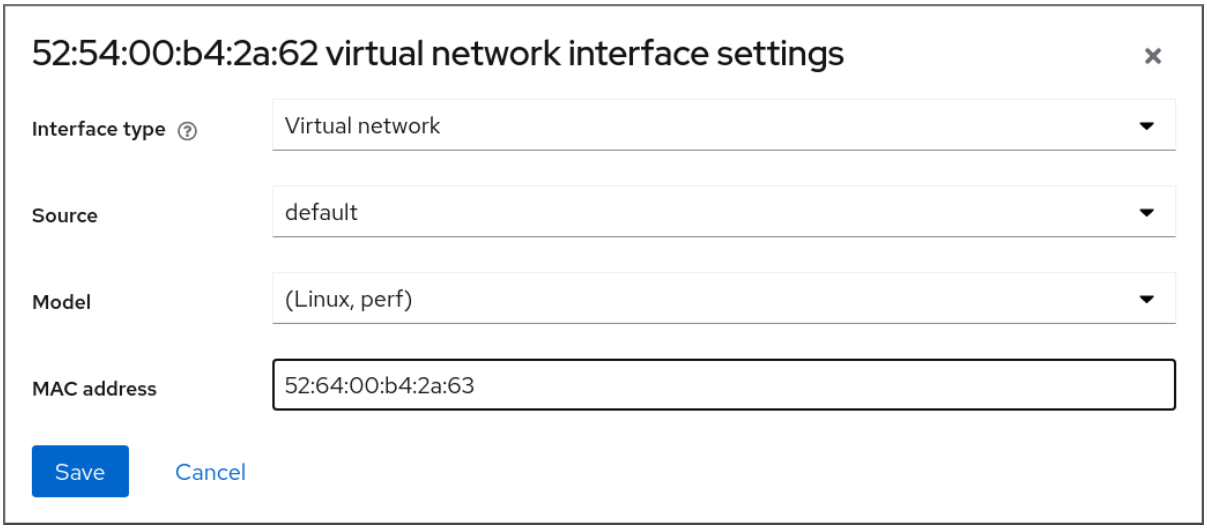
   - **Type** - The type of network interface for the VM. The types include virtual network, bridge to LAN, and direct attachment.



     NOTE

     Generic Ethernet connection is not supported in RHEL 8 and later.

   - **Model type** - The model of the virtual network interface.
   - **MAC Address** - The MAC address of the virtual network interface.
   - **IP Address** - The IP address of the virtual network interface.
   - **Source** - The source of the network interface. This is dependent on the network type.
   - **State** - The state of the virtual network interface.
3. To edit the virtual network interface settings, Click **Edit**. The Virtual Network Interface Settings dialog opens.



4. Change the interface type, source, model, or MAC address.
5. Click **Save**. The network interface is modified.

NOTE

Changes to the virtual network interface settings take effect only after restarting the VM.

Additionally, MAC address can only be modified when the VM is shut off.

6.3. SAMPLE VIRTUAL MACHINE XML CONFIGURATION

The XML configuration of a VM, also referred to as a *domain XML*, determines the VM's settings and components. The following table shows sections of a sample XML configuration of a virtual machine (VM) and explains the contents.

To obtain the XML configuration of a VM, you can use the **virsh dumpxml** command followed by the VM's name.

```
# virsh dumpxml testguest1
```

Table 6.1. Sample XML configuration

Domain XML Section	Description
<domain type='kvm'> <name>Testguest1</name> <uuid>ec6fbaa1-3eb4-49da-bf61-bb02fbec4967</uuid> <memory unit='KiB'>1048576</memory> <currentMemory unit='KiB'>1048576</currentMemory>	This is a KVM virtual machine called *Testguest1*, with 1024 MiB allocated RAM.

Domain XML Section	Description
`<vcpu placement='static'>1</vcpu>`	The VM is allocated with a single virtual CPU (vCPU). For information about configuring vCPUs, see Section 16.5, "Optimizing virtual machine CPU performance".

`<os>`
`<type arch='x86_64' machine='pc-q35-4.1'>hvm</type>`
`<boot dev='hd'/>`
`</os>`
	The machine architecture is set to the AMD64 and Intel 64 architecture, and uses the Intel Q35 machine type to determine feature compatibility. The OS is set to be booted from the hard drive.
	
	For information about creating a VM with an installed OS, see Section 2.2.2, "Creating virtual machines and installing guest operating systems using the web console".

`<features>`
`<acpi/>`
`<apic/>`
`<vmport state='off'/>`
`</features>`
	The **acpi** and **apic** hypervisor features are disabled and the VMWare IO port is turned off.

`<cpu mode='host-model' check='partial'>`	The host CPU definitions from capabilities XML (obtainable with **virsh capabilities**) are automatically copied into the VM's XML configuration. Therefore, when the VM is booted, **libvirt** picks a CPU model that is similar to the host CPU, and then adds extra features to approximate the host model as closely as possible.

`<clock offset='utc'>`
`<timer name='rtc' tickpolicy='catchup'/>`
`<timer name='pit' tickpolicy='delay'/>`
`<timer name='hpet' present='no'/>`
`</clock>`
	The VM's virtual hardware clock uses the UTC time zone. In addition, three different timers are set up for synchronization with the QEMU hypervisor.

Domain XML Section	Description
<on_poweroff>destroy</on_poweroff> <on_reboot>restart</on_reboot> <on_crash>destroy</on_crash>	When the VM powers off, or its OS terminates unexpectedly, **libvirt** terminates the VM and releases all its allocated resources. When the VM is rebooted, **libvirt** restarts it with the same configuration.
<pm> <suspend-to-mem enabled='no'/> <suspend-to-disk enabled='no'/> </pm>	The S3 and S4 ACPI sleep states are disabled for this VM.
<devices> <emulator>/usr/bin/qemu-kvm</emulator> <disk type='file' device='disk'> <driver name='qemu' type='qcow2'/> <source file='/var/lib/libvirt/images/Testguest.qcow2'/> <target dev='hda' bus='ide'/> <address type='drive' controller='0' bus='0' target='0' unit='0'/> </disk> <disk type='file' device='cdrom'> <driver name='qemu' type='raw'/> <target dev='hdb' bus='ide'/> <readonly/> <address type='drive' controller='0' bus='0' target='0' unit='1'/> </disk>	The VM uses the **/usr/bin/qemu-kvm** binary file for emulation. In addition, it has two disks attached. The first disk is a virtualized hard-drive based on the **/var/lib/libvirt/images/Testguest.qcow2** stored on the host, and its logical device name is set to **hda**.
<controller type='usb' index='0' model='qemu-xhci' ports='15'> <address type='pci' domain='0x0000' bus='0x02' slot='0x00' function='0x0'/> </controller> <controller type='sata' index='0'> <address type='pci' domain='0x0000' bus='0x00' slot='0x1f' function='0x2'/> </controller> <controller type='pci' index='0' model='pcie-root'/> <controller type='pci' index='1' model='pcie-root-port'> <model name='pcie-root-port'/> <target chassis='1' port='0x10'/> <address type='pci' domain='0x0000' bus='0x00' slot='0x02' function='0x0' multifunction='on'/> </controller> <controller type='pci' index='2' model='pcie-root-port'> <model name='pcie-root-port'/> <target chassis='2' port='0x11'/>	The VM uses a single controller for attaching USB devices, and a root controller for PCI-Express (PCIe) devices. In addition, a **virtio-serial** controller is available, which enables the VM to interact with the host in a variety of ways, such as the serial console. For more information about virtual devices, see Section 10.6, “Types of virtual devices”.

Domain XML Section	Description
<address type='pci' domain='0x0000' bus='0x00' slot='0x02' function='0x1'/> </controller> <controller type='pci' index='3' model='pcie-root-port'> <model name='pcie-root-port'/> <target chassis='3' port='0x12'/> <address type='pci' domain='0x0000' bus='0x00' slot='0x02' function='0x2'/> </controller> <controller type='pci' index='4' model='pcie-root-port'> <model name='pcie-root-port'/> <target chassis='4' port='0x13'/> <address type='pci' domain='0x0000' bus='0x00' slot='0x02' function='0x3'/> </controller> <controller type='pci' index='5' model='pcie-root-port'> <model name='pcie-root-port'/> <target chassis='5' port='0x14'/> <address type='pci' domain='0x0000' bus='0x00' slot='0x02' function='0x4'/> </controller> <controller type='pci' index='6' model='pcie-root-port'> <model name='pcie-root-port'/> <target chassis='6' port='0x15'/> <address type='pci' domain='0x0000' bus='0x00' slot='0x02' function='0x5'/> </controller> <controller type='pci' index='7' model='pcie-root-port'> <model name='pcie-root-port'/> <target chassis='7' port='0x16'/> <address type='pci' domain='0x0000' bus='0x00' slot='0x02' function='0x6'/> </controller> <controller type='virtio-serial' index='0'> <address type='pci' domain='0x0000' bus='0x03' slot='0x00' function='0x0'/> </controller>	
<interface type='network'> <mac address='52:54:00:65:29:21'/> <source network='default'/> <model type='rtl8139'/> <address type='pci' domain='0x0000' bus='0x00' slot='0x03' function='0x0'/> </interface>	A network interface is set up in the VM that uses the **default** virtual network and the **rtl8139** network device model. For information about configuring the network interface, see Section 16.6, “Optimizing virtual machine network performance”.

Domain XML Section	Description
<serial type='pty'> <target type='isa-serial' port='0'> <model name='isa-serial'/> </target> </serial> <console type='pty'> <target type='serial' port='0'/> </console> <channel type='unix'> <target type='virtio' name='org.qemu.guest_agent.0'/> <address type='virtio-serial' controller='0' bus='0' port='1'/> </channel> <channel type='spicevmc'> <target type='virtio' name='com.redhat.spice.0'/> <address type='virtio-serial' controller='0' bus='0' port='2'/> </channel>	A **pty** serial console is set up on the VM, which enables rudimentary VM communication with the host. The console uses the **UNIX** channel on port 1, and the paravirtualized **SPICE** on port 2. This is set up automatically and changing these settings is not recommended. For more information about interacting with VMs, see Section 2.4.1, “Interacting with virtual machines using the web console”.
<input type='tablet' bus='usb'> <address type='usb' bus='0' port='1'/> </input> <input type='mouse' bus='ps2'/> <input type='keyboard' bus='ps2'/>	The VM uses a virtual **usb** port, which is set up to receive tablet input, and a virtual **ps2** port set up to receive mouse and keyboard input. This is set up automatically and changing these settings is not recommended.
<graphics type='spice' autoport='yes' listen='127.0.0.1'> <listen type='address' address='127.0.0.1'/> <image compression='off'/> </graphics> <graphics type='vnc' port='-1' autoport='yes' listen='127.0.0.1'> <listen type='address' address='127.0.0.1'/> </graphics>	The VM uses the **vnc** and **SPICE** protocols for rendering its graphical output, and image compression is turned off.
<sound model='ich6'> <address type='pci' domain='0x0000' bus='0x00' slot='0x04' function='0x0'/> </sound> <video> <model type='qxl' ram='65536' vram='65536' vgamem='16384' heads='1' primary='yes'/> <address type='pci' domain='0x0000' bus='0x00' slot='0x02' function='0x0'/> </video>	An **ICH6** HDA sound device is set up for the VM, and the QEMU **QXL** paravirtualized framebuffer device is set up as the video accelerator. This is set up automatically and changing these settings is not recommended.

Domain XML Section	Description
<redirdev bus='usb' type='spicevmc'> <address type='usb' bus='0' port='1'/> </redirdev> <redirdev bus='usb' type='spicevmc'> <address type='usb' bus='0' port='2'/> </redirdev> <memballoon model='virtio'> <address type='pci' domain='0x0000' bus='0x00' slot='0x07' function='0x0'/> </memballoon> </devices> </domain>	The VM has two re-directors for attaching USB devices remotely, and memory ballooning is turned on. This is set up automatically and changing these settings is not recommended.

CHAPTER 7. SAVING AND RESTORING VIRTUAL MACHINES

To free up system resources, you can shut down a virtual machine (VM) running on that system. However, when you require the VM again, you must boot up the guest operating system (OS) and restart the applications, which may take a considerable amount of time. To reduce this downtime and enable the VM workload to start running sooner, you can use the save and restore feature to avoid the OS shutdown and boot sequence entirely.

This section provides information about saving VMs, as well as about restoring them to the same state without a full VM boot-up.

7.1. HOW SAVING AND RESTORING VIRTUAL MACHINES WORKS

Saving a virtual machine (VM) saves its memory and device state to the host's disk, and immediately stops the VM process. You can save a VM that is either in a running or paused state, and upon restoring, the VM will return to that state.

This process frees up RAM and CPU resources on the host system in exchange for disk space, which may improve the host system performance. When the VM is restored, because the guest OS does not need to be booted, the long boot-up period is avoided as well.

To save a VM, you can use the command-line interface (CLI). For instructions, see Saving virtual machines using the command line interface.

To restore a VM you can use the CLI or the web console GUI.

7.2. SAVING A VIRTUAL MACHINE USING THE COMMAND LINE INTERFACE

To save a virtual machine (VM) using the command line, follow the procedure below.

Prerequisites

- Make sure you have sufficient disk space to save the VM and its configuration. Note that the space occupied by the VM depends on the amount of RAM allocated to that VM.
- Make sure the VM is persistent.
- **Optional:** Back up important data from the VM if required.

Procedure

- Use the **virsh managedsave** utility.
  For example, the following command stops the *demo-guest1* VM and saves its configuration.

  ```
  # virsh managedsave demo-guest1
  Domain demo-guest1 saved by libvirt
  ```

  The saved VM file is located by default in the **/var/lib/libvirt/qemu/save** directory as **demo-guest1.save**.

  The next time the VM is started, it will automatically restore the saved state from the above file.

Verification

- You can make sure that the VM is in a saved state or shut off using the **virsh list** utility.
  To list the VMs that have managed save enabled, use the following command. The VMs listed as *saved* have their managed save enabled.

```
# virsh list --managed-save --all
 Id    Name                           State
----------------------------------------------------
 -     demo-guest1                    saved
 -     demo-guest2                    shut off
```

  To list the VMs that have a managed save image:

```
# virsh list --with-managed-save --all
 Id    Name                           State
----------------------------------------------------
 -     demo-guest1                    shut off
```

  Note that to list the saved VMs that are in a shut off state, you must use the **--all** or **--inactive** options with the command.

Troubleshooting

- If the saved VM file becomes corrupted or unreadable, restoring the VM will initiate a standard VM boot instead.

Additional resources

- For more **virsh managedsave** arguments, use **virsh managedsave --help** or see the **virsh** man page.
- For instructions on restoring a saved VM using the command-line interface, see Section 7.3, “Starting a virtual machine using the command-line interface”.
- For instructions on restoring a saved VM using the web console, see Section 7.4, “Starting virtual machines using the web console”.

7.3. STARTING A VIRTUAL MACHINE USING THE COMMAND-LINE INTERFACE

You can use the command line interface to start a shut-down virtual machine (VM) or restore a saved VM. Follow the procedure below.

Prerequisites

- An inactive VM that is already defined.
- The name of the VM.
- For remote VMs:
  - The IP address of the host where the VM is located.

- Root access privileges to the host.

Procedure

- For a local VM, use the **virsh start** utility.
  For example, the following command starts the *demo-guest1* VM.

```
# virsh start demo-guest1
Domain demo-guest1 started
```

- For a VM located on a remote host, use the **virsh start** utility along with the QEMU+SSH connection to the host.
  For example, the following command starts the *demo-guest1* VM on the 192.168.123.123 host.

```
# virsh -c qemu+ssh://root@192.168.123.123/system start demo-guest1

root@192.168.123.123's password:
Last login: Mon Feb 18 07:28:55 2019

Domain demo-guest1 started
```

Additional Resources

- For more **virsh start** arguments, use **virsh start --help**.
- For simplifying VM management on remote hosts, see modifying your libvirt and SSH configuration.
- You can use the **virsh autostart** utility to configure a VM to start automatically when the host boots up. For more information about autostart, see starting virtual machines automatically when the host starts.

7.4. STARTING VIRTUAL MACHINES USING THE WEB CONSOLE

If a virtual machine (VM) is in the **shut off** state, you can start it using the RHEL 8 web console.

Prerequisites

- The web console VM plug-in is installed on your system .
- An inactive VM that is already defined.
- The name of the VM.

Procedure

1. In the **Virtual Machines** interface, click the VM you want to start.
   A new page opens with detailed information about the selected VM and controls for shutting down and deleting the VM.
2. Click **Run**.
   The VM starts, and you can connect to its console or graphical output .

3. **Optional:** To set up the VM to start automatically when the host starts, click the **Autostart** checkbox.
   If you use network interfaces that are not managed by libvirt, you must also make additional changes to the systemd configuration. Otherwise, the affected VMs might fail to start, see starting virtual machines automatically when the host starts .

Additional resources

- For information on shutting down a VM, see Section 2.5.2.1, “Shutting down virtual machines in the web console”.
- For information on restarting a VM, see Section 2.5.2.2, “Restarting virtual machines using the web console”.

CHAPTER 8. CLONING VIRTUAL MACHINES

To quickly create a new virtual machine (VM) with a specific set of properties, you can *clone* an existing VM.

Cloning creates a new VM that uses its own disk image for storage, but most of the clone's configuration and stored data is identical to the source VM. This makes it possible to prepare a number of VMs optimized for a certain task without the need to optimize each VM individually.

8.1. HOW CLONING VIRTUAL MACHINES WORKS

Cloning a virtual machine (VM) copies the XML configuration of the source VM and its disk images, and makes adjustments to the configurations to ensure the uniqueness of the new VM. This includes changing the name of the VM and ensuring it uses the disk image clones. Nevertheless, the data stored on the clone's virtual disks is identical to the source VM.

This process is faster than creating a new VM and installing it with a guest operating system, and can be used to rapidly generate VMs with a specific configuration and content.

If you are planning to create multiple clones of a VM, first create a VM *template* that does not contain:

- Unique settings, such as persistent network MAC configuration, which can prevent the clones from working correctly.
- Sensitive data, such as SSH keys and password files.

For instructions, see Section 8.2, "Creating virtual machine templates" .

To clone a VM, you can use the RHEL 8 CLI. For details, see Section 8.3, "Cloning a virtual machine using the command-line interface".

8.2. CREATING VIRTUAL MACHINE TEMPLATES

To create multiple clone virtual machines (VMs) that work correctly, you can remove information and configurations that are unique to a source VM, such as SSH keys or persistent network MAC configuration. This creates a VM *template*, which you can use to easily and safely create VM clones.

You can create VM templates using the **virt-sysrep** utility or you can create them manually based on your requirements.

8.2.1. Creating a virtual machine template using virt-sysrep

To create a template from an existing virtual machine (VM), you can use the **virt-sysrep** utility to quickly unconfigure a guest VM to prepare it for cloning.

Prerequisites

- The **virt-sysprep** utility is installed on your host:

```
# yum install /usr/bin/virt-sysprep
```

- The VM intended as a template is shut down.

- You must know where the disk image for the source VM is located, and be the owner of the VM's disk image file.
  Note that disk images for VMs created in the system connection of libvirt are by default located in the **/var/lib/libvirt/images** directory and owned by the root user:

```
# ls -la /var/lib/libvirt/images
-rw-------.  1 root root  9665380352 Jul 23 14:50 a-really-important-vm.qcow2
-rw-------.  1 root root  8591507456 Jul 26  2017 an-actual-vm-that-i-use.qcow2
-rw-------.  1 root root  8591507456 Jul 26  2017 totally-not-a-fake-vm.qcow2
-rw-------.  1 root root 10739318784 Sep 20 17:57 another-vm-example.qcow2
```

- **Optional:** Any important data on the VM's disk has been backed up. If you want to preserve the source VM intact, clone it first and edit the clone to create a template.

Procedure

1. Ensure you are logged in as the owner of the VM's disk image:

```
# whoami
root
```

2. **Optional:** Copy the disk image of the VM.

```
# cp /var/lib/libvirt/images/a-really-important-vm.qcow2 /var/lib/libvirt/images/a-really-important-vm-original.qcow2
```

   This is used later to verify the VM was successfully turned into a template.

3. Use the following command, and replace */var/lib/libvirt/images/a-really-important-vm.qcow2* with the path to the disk image of the source VM.

```
# virt-sysprep -a /var/lib/libvirt/images/a-really-important-vm.qcow2
[   0.0] Examining the guest ...
[   7.3] Performing "abrt-data" ...
[   7.3] Performing "backup-files" ...
[   9.6] Performing "bash-history" ...
[   9.6] Performing "blkid-tab" ...
[...]
```

Verification

- To confirm that the process was successful, compare the modified disk image to the original one. The following example shows a successful creation of a template:

```
# virt-diff -a /var/lib/libvirt/images/a-really-important-vm-orig.qcow2 -A
/var/lib/libvirt/images/a-really-important-vm.qcow2
- - 0644       1001 /etc/group-
- - 0000        797 /etc/gshadow-
= - 0444         33 /etc/machine-id
[...]
- - 0600        409 /home/username/.bash_history
- d 0700          6 /home/username/.ssh
- - 0600        868 /root/.bash_history
[...]
```

Additional resources

- Using the **virt-sysprep** command as shown above performs the standard VM template preparation. For more information, see the **OPERATIONS** section in the **virt-sysprep** man page.
  To customize which specific operations you want **virt-sysprep** to perform, use the **--operations** option, and specify the intended operations as a comma-separated list.

- For instructions on cloning a VM template, see Section 8.3, "Cloning a virtual machine using the command-line interface".

8.2.2. Creating a virtual machine template manually

To create a template from an existing virtual machine (VM), you can manually reset or unconfigure a guest VM to prepare it for cloning.

Prerequisites

- Ensure that you know the location of the disk image for the source VM and are the owner of the VM's disk image file.
  Note that disk images for VMs created in the system connection of libvirt are by default located in the **/var/lib/libvirt/images** directory and owned by the root user:.

```
# ls -la /var/lib/libvirt/images
-rw-------. 1 root root  9665380352 Jul 23 14:50 a-really-important-vm.qcow2
-rw-------. 1 root root  8591507456 Jul 26  2017 an-actual-vm-that-i-use.qcow2
-rw-------. 1 root root  8591507456 Jul 26  2017 totally-not-a-fake-vm.qcow2
-rw-------. 1 root root 10739318784 Sep 20 17:57 another-vm-example.qcow2
```

- Ensure that the VM is shut down.

- **Optional:** Any important data on the VM's disk has been backed up. If you want to preserve the source VM intact, clone it first and edit the clone to create a template.

Procedure

1. Configure the VM for cloning:

   a. Install any software needed on the clone.

   b. Configure any non-unique settings for the operating system.

   c. Configure any non-unique application settings.

2. Remove the network configuration:

   a. Remove any persistent udev rules using the following command:

```
# rm -f /etc/udev/rules.d/70-persistent-net.rules
```

NOTE

If udev rules are not removed, the name of the first NIC might be **eth1** instead of **eth0**.

b. Remove unique network details from ifcfg scripts by editing **/etc/sysconfig/network-scripts/ifcfg-eth[x]** as follows:

i. Remove the HWADDR and Static lines:

NOTE

If the HWADDR does not match the new guest's MAC address, the **ifcfg** will be ignored.

```
DEVICE=eth[x] BOOTPROTO=none ONBOOT=yes #NETWORK=10.0.1.0 <- REMOVE #NETMASK=255.255.255.0 <- REMOVE #IPADDR=10.0.1.20 <- REMOVE #HWADDR=xx:xx:xx:xx:xx <- REMOVE #USERCTL=no <- REMOVE # Remove any other *unique or non-desired settings, such as UUID.*
```

ii. Configure DHCP but do not include HWADDR or any other unique information:

```
DEVICE=eth[x] BOOTPROTO=dhcp ONBOOT=yes
```

c. Ensure the following files also contain the same content, if they exist on your system:

- **/etc/sysconfig/networking/devices/ifcfg-eth[x]**
- **/etc/sysconfig/networking/profiles/default/ifcfg-eth[x]**

NOTE

If you had used **NetworkManager** or any special settings with the VM, ensure that any additional unique information is removed from the **ifcfg** scripts.

3. Remove registration details:

- For VMs registered on the Red Hat Network (RHN):

```
# rm /etc/sysconfig/rhn/systemid
```

- For VMs registered with Red Hat Subscription Manager (RHSM):
  - If you do not plan to use the original VM:

```
# subscription-manager unsubscribe --all # subscription-manager unregister # subscription-manager clean
```

  - If you plan to use the original VM:

```
# subscription-manager clean
```

NOTE

The original RHSM profile remains in the Portal along with your ID code. Use the following command to reactivate your RHSM registration on the VM after it is cloned:

```
#subscription-manager register --consumerid=71rd64fx-6216-4409-bf3a-e4b7c7bd8ac9
```

4. Remove other unique details:

   a. Remove ssh public/private key pairs:

   ```
   # rm -rf /etc/ssh/ssh_host_example
   ```

   b. Remove any other application-specific identifiers or configurations that might cause conflicts if running on multiple machines.

5. Remove the **gnome-initial-setup-done** file to configure the VM to run the configuration wizard on the next boot:

   ```
   # rm ~/.config/gnome-initial-setup-done
   ```

NOTE

The wizard that runs on the next boot depends on the configurations that have been removed from the VM. In addition, on the first boot of the clone, it is recommended that you change the hostname.

8.3. CLONING A VIRTUAL MACHINE USING THE COMMAND-LINE INTERFACE

To quickly create a new virtual machine (VM) with a specific set of properties, for example for testing purposes, you can clone an existing VM. To do so using the CLI, follow the instructions below.

Prerequisites

- The source VM is shut down.
- Ensure that there is sufficient disk space to store the cloned disk images.
- **Optional:** When creating multiple VM clones, remove unique data and settings from the source VM to ensure the cloned VMs work properly. For instructions, see Section 8.2, “Creating virtual machine templates”.

Procedure

1. Use the **virt-clone** utility with options that are appropriate for your environment and use case.
   Sample use cases

   - The following command clones a local VM named *doppelganger* and creates the *doppelganger-clone* VM. It also creates the *doppelganger-clone.qcow2* disk image in the same location as the disk image of the original VM, and with the same data:

```
# virt-clone --original doppelganger --auto-clone
Allocating 'doppelganger-clone.qcow2'                    | 50.0 GB  00:05:37

Clone 'doppelganger-clone' created successfully.
```

- The following command clones a VM named *geminus1*, and creates a local VM named *geminus2*, which uses only two of *geminus1*'s multiple disks.

```
# virt-clone --original geminus1 --name geminus2 --file
/var/lib/libvirt/images/disk1.qcow2 --file /var/lib/libvirt/images/disk2.qcow2
Allocating 'disk1-clone.qcow2'                           | 78.0 GB  00:05:37
Allocating 'disk2-clone.qcow2'                           | 80.0 GB  00:05:37

Clone 'geminus2' created successfully.
```

- To clone your VM to a different host, migrate the VM without undefining it on the local host. For example, the following commands clone the previously created *geminus2* VM to the 10.0.0.1 remote system, including its local disks. Note that using these commands also requires root privileges for 10.0.0.1.

```
# virsh migrate --offline --persistent geminus2 qemu+ssh://root@10.0.0.1/system
root@10.0.0.1's password:

# scp /var/lib/libvirt/images/disk1-clone.qcow2
root@10.0.0.1/user@remote_host.com://var/lib/libvirt/images/

# scp /var/lib/libvirt/images/disk2-clone.qcow2
root@10.0.0.1/user@remote_host.com://var/lib/libvirt/images/
```

Verification

To verify the VM has been successfully cloned and is working correctly:

1. Confirm the clone has been added to the list of VMs on your host.

```
# virsh list --all
 Id   Name                State
----------------------------------------
 -    doppelganger        shut off
 -    doppelganger-clone  shut off
```

2. Start the clone and observe if it boots up.

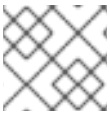
```
# virsh start doppelganger-clone
Domain doppelganger-clone started
```

Additional resources

- For additional options for cloning VMs, see the **virt-clone** man page.
- For details on moving the VM clones to a different host, including troubleshooting information, see Chapter 9, *Migrating virtual machines*.

8.4. CLONING A VIRTUAL MACHINE USING THE WEB CONSOLE

To quickly create new virtual machines (VMs) with a specific set of properties, you can clone a VM that you had previously configured. The following instructions explain how to do so using the web console.



NOTE

Cloning a VM also clones the disks associated with that VM.

Prerequisites

- The web console VM plug-in is installed on your system.
- Ensure that the VM you want to clone is shut down.

Procedure

1. In the Virtual Machines interface of the web console, click the Menu button ⋮ of the VM that you want to clone.
   A drop down menu appears with controls for various VM operations.

2. Click **Clone**.
   The Create a clone VM dialog appears.

3. **Optional:** Enter a new name for the VM clone.
4. Click **Clone**.
   A new VM is created based on the source VM.

Verification

- Confirm whether the cloned VM appears in the list of VMs available on your host.

CHAPTER 9. MIGRATING VIRTUAL MACHINES

If the current host of a virtual machine (VM) becomes unsuitable or cannot be used anymore, or if you want to redistribute the hosting workload, you can migrate the VM to another KVM host.

9.1. HOW MIGRATING VIRTUAL MACHINES WORKS

The essential part of virtual machine (VM) migration is copying the XML configuration of a VM to a different host machine. If the migrated VM is not shut down, the migration also transfers the state of the VM's memory and any virtualized devices to a destination host machine. For the VM to remain functional on the destination host, the VM's disk images must remain available to it.

By default, the migrated VM is transient on the destination host, and remains defined also on the source host.

You can migrate a running VM using *live* or *non-live* migrations. To migrate a shut-off VM, you must use an *offline* migration. For details, see the following table.

Table 9.1. VM migration types

Migration type	Description	Use case	Storage requirements
Live migration	The VM continues to run on the source host machine while KVM is transferring the VM's memory pages to the destination host. When the migration is nearly complete, KVM very briefly suspends the VM, and resumes it on the destination host.	Useful for VMs that require constant uptime. However, VMs that modify memory pages faster than KVM can transfer them, such as VMs under heavy I/O load, cannot be live-migrated, and *non-live migration* must be used instead.	The VM's disk images must be located on a shared network, accessible both to the source host and the destination host.
Non-live migration	Suspends the VM, copies its configuration and its memory to the destination host, and resumes the VM.	Creates downtime for the VM, but is generally more reliable than live migration. Recommended for VMs under heavy I/O load.	The VM's disk images must be located on a shared network, accessible both to the source host and the destination host.
Offline migration	Moves the VM's configuration to the destination host	Recommended for shut-off VMs.	The VM's disk images do not have to be available on a shared network, and can be copied or moved manually to the destination host instead.

Additional resources

- For more information on the benefits of VM migration, see Section 9.2, "Benefits of migrating virtual machines".

- For instructions on setting up shared storage for migrating VMs, see Section 9.4, "Sharing virtual machine disk images with other hosts".

9.2. BENEFITS OF MIGRATING VIRTUAL MACHINES

Migrating virtual machines (VMs) can be useful for:

Load balancing

VMs can be moved to host machines with lower usage if their host becomes overloaded, or if another host is under-utilized.

Hardware independence

When you need to upgrade, add, or remove hardware devices on the host machine, you can safely relocate VMs to other hosts. This means that VMs do not experience any downtime for hardware improvements.

Energy saving

VMs can be redistributed to other hosts, and the unloaded host systems can thus be powered off to save energy and cut costs during low usage periods.

Geographic migration

VMs can be moved to another physical location for lower latency or when required for other reasons.

9.3. LIMITATIONS FOR MIGRATING VIRTUAL MACHINES

Before migrating virtual machines (VMs) in RHEL 8, ensure you are aware of the migration's limitations.

- Live storage migration cannot be performed on RHEL 8, but you can migrate storage while the VM is powered down. Note that live storage migration is available on Red Hat Virtualization.
- Migrating VMs from or to a session connection of **libvirt** is unreliable and therefore not recommended.
- VMs that use certain features and configurations will not work correctly if migrated, or the migration will fail. Such features include:
  - Device passthrough
  - SR-IOV device assignment
  - Mediated devices, such as vGPUs
  - Non-Uniform Memory Access (NUMA) pinning

9.4. SHARING VIRTUAL MACHINE DISK IMAGES WITH OTHER HOSTS

To perform a live migration of a virtual machine (VM) between supported KVM hosts, shared VM storage is required. This section provides instructions for sharing a locally stored VM image with the source host and the destination host using the NFS protocol.

Prerequisites

- The VM intended for migration is shut down.

- **Optional:** A host system is available for hosting the storage that is not the source or destination host, but both the source and the destination host can reach it through the network. This is the optimal solution for shared storage and is recommended by Red Hat.
- Make sure that NFS file locking is not used as it is not supported in KVM.
- The NFS is installed and enabled on the source and destination hosts. If it is not:

  a. Install the NFS packages:

  ```
  # yum install nfs-utils
  ```

  b. Make sure that the ports for NFS, such as 2049, are open in the firewall.

  ```
  # firewall-cmd --permanent --add-service=nfs
  # firewall-cmd --permanent --add-service=mountd
  # firewall-cmd --permanent --add-service=rpc-bind
  # firewall-cmd --permanent --add-port=2049/tcp
  # firewall-cmd --permanent --add-port=2049/udp
  # firewall-cmd --reload
  ```

  c. Start the NFS service.

  ```
  # systemctl start nfs-server
  ```

Procedure

1. Connect to the host that will provide shared storage. In this example, it is the **cargo-bay** host:

```
# ssh root@cargo-bay
root@cargo-bay's password:
Last login: Mon Sep 24 12:05:36 2019
root~#
```

2. Create a directory that will hold the disk image and will be shared with the migration hosts.

```
# mkdir /var/lib/libvirt/shared-images
```

3. Copy the disk image of the VM from the source host to the newly created directory. For example, the following copies the disk image of the **wanderer1** VM to the **/var/lib/libvirt/shared-images/** directory on the`cargo-bay` host:

```
# scp /var/lib/libvirt/images/wanderer1.qcow2 root@cargo-bay:/var/lib/libvirt/shared-images/wanderer1.qcow2
```

4. On the host that you want to use for sharing the storage, add the sharing directory to the **/etc/exports** file. The following example shares the **/var/lib/libvirt/shared-images** directory with the **source-example** and **dest-example** hosts:

```
/var/lib/libvirt/shared-images source-example(rw,no_root_squash) dest-example(rw,no_root_squash)
```

5. On both the source and destination host, mount the shared directory in the **/var/lib/libvirt/images** directory:

```
# mount cargo-bay:/var/lib/libvirt/shared-images /var/lib/libvirt/images
```

Verification

- To verify the process was successful, start the VM on the source host and observe if it boots correctly.

Additional resources

- For detailed information on configuring NFS and firewall rules, see Exporting NFS shares.

9.5. MIGRATING A VIRTUAL MACHINE USING THE COMMAND-LINE INTERFACE

If the current host of a virtual machine (VM) becomes unsuitable or cannot be used anymore, or if you want to redistribute the hosting workload, you can migrate the VM to another KVM host. This section provides instructions and examples for various scenarios of such migrations.

Prerequisites

- The source host and the destination host both use the KVM hypervisor.
- The source host and the destination host are able to reach each other over the network. Use the **ping** utility to verify this.
- For the migration to be supportable by Red Hat, the source host and destination host must be using specific operating systems and machine types. To ensure this is the case, see the VM migration compatibility table.
- The disk images of VMs that will be migrated are located on a separate networked location accessible to both the source host and the destination host. This is optional for offline migration, but required for migrating a running VM.
  For instructions to set up such shared VM storage, see Section 9.4, "Sharing virtual machine disk images with other hosts".
- When migrating a running VM, your network bandwidth must be higher than the rate in which the VM generates dirty memory pages.
  To obtain the dirty page rate of your VM before you start the live migration, do the following:

  a. Monitor the rate of dirty page generation of the VM for a short period of time.

```
# virsh domdirtyrate-calc vm-name 30
```

  b. After the monitoring finishes, obtain its results:

```
# virsh domstats vm-name --dirtyrate
Domain: 'vm-name'
  dirtyrate.calc_status=2
  dirtyrate.calc_start_time=200942
  dirtyrate.calc_period=30
  dirtyrate.megabytes_per_second=2
```

In this example, the VM is generating 2 MB of dirty memory pages per second. Attempting to live-migrate such a VM on a network with a bandwidth of 2 MB/s or less will cause the live migration not to progress if you do not pause the VM or lower its workload.

To ensure that the live migration finishes successfully, Red Hat recommends that your network bandwidth is significantly greater than the VM's dirty page generation rate.

- When migrating an existing VM in a public bridge tap network, the source and destination hosts must be located on the same network. Otherwise, the VM network will not operate after migration.

Procedure

1. Ensure that the **libvirtd** service is enabled and running.

```
# systemctl enable libvirtd.service
# systemctl restart libvirtd.service
```

2. Use the **virsh migrate** command with options appropriate for your migration requirements.

   - The following migrates the **wanderer1** VM from your local host to the system connection of the **dest-example** host. The VM will remain running during the migration.

```
# virsh migrate --persistent --live wanderer1 qemu+ssh://dest-example/system
```

   - The following enables you to make manual adjustments to the configuration of the **wanderer2** VM running on your local host, and then migrates the VM to the **dest-example** host. The migrated VM will automatically use the updated configuration.

```
# virsh dumpxml --migratable wanderer2 >wanderer2.xml
# vi wanderer2.xml
# virsh migrate --live --persistent --xml wanderer2.xml wanderer2 qemu+ssh://dest-example/system
```

     This procedure can be useful for example when the destination host needs to use a different path to access the shared VM storage or when configuring a feature specific to the destination host.

   - The following suspends the **wanderer3** VM from the **source-example** host, migrates it to the **dest-example** host, and instructs it to use the adjusted XML configuration, provided by the **wanderer3-alt.xml** file. When the migration is completed, **libvirt** resumes the VM on the destination host.

```
# virsh migrate wanderer3 qemu+ssh://source-example/system qemu+ssh://dest-example/system --xml wanderer3-alt.xml
```

     After the migration, the VM remains in the suspended state on the source host, and the migrated copy is deleted after it is shut down.

   - The following deletes the shut-down **wanderer4** VM from the **source-example** host, and moves its configuration to the **dest-example** host.

```
# virsh migrate --offline --persistent --undefinesource wanderer4 qemu+ssh://source-example/system qemu+ssh://dest-example/system
```

Note that this type of migration does not require moving the VM's disk image to shared storage. However, for the VM to be usable on the destination host, you need to migrate the VM's disk image. For example:

```
# scp root@source-example:/var/lib/libvirt/images/wanderer4.qcow2 root@dest-example:/var/lib/libvirt/images/wanderer4.qcow2
```

3. Wait for the migration to complete. The process may take some time depending on network bandwidth, system load, and the size of the VM. If the **--verbose** option is not used for **virsh migrate**, the CLI does not display any progress indicators except errors.
When the migration is in progress, you can use the **virsh domjobinfo** utility to display the migration statistics.

Verification

- On the destination host, list the available VMs to verify if the VM has been migrated:

```
# virsh list
 Id Name                State
----------------------------------
 10 wanderer1           running
```

If the migration is still running, this command will list the VM state as **paused**.

Troubleshooting

- In some cases, the target host will not be compatible with certain values of the migrated VM's XML configuration, such as the network name or CPU type. As a result, the VM will fail to boot on the target host. To fix these problems, you can update the problematic values by using the **virsh edit** command.

- If a live migration is taking a long time to complete, this may be because the VM is under heavy load and too many memory pages are changing for live migration to be possible. To fix this problem, change the migration to a non-live one by suspending the VM.

```
# virsh suspend wanderer1
```

Additional resources

- For further options and examples for virtual machine migration, use **virsh migrate --help** or see the **virsh** man page.

9.6. LIVE MIGRATING A VIRTUAL MACHINE USING THE WEB CONSOLE

If you wish to migrate a virtual machine (VM) that is performing tasks which require it to be constantly running, you can migrate that VM to another KVM host without shutting it down. This is also known as live migration. The following instructions explain how to do so using the web console.

WARNING

For tasks that modify memory pages faster than KVM can transfer them, such as heavy I/O load tasks, it is recommended that you do not live migrate the VM.

Prerequisites

- The web console VM plug-in is installed on your system.
- The source and destination hosts are running.
- The VM's disk images are located on a shared storage that is accessible to the source host as well as the destination host.
- When migrating a running VM, your network bandwidth must be higher than the rate in which the VM generates dirty memory pages.
  To obtain the dirty page rate of your VM before you start the live migration, do the following in your command-line interface:

  a. Monitor the rate of dirty page generation of the VM for a short period of time.

  ```
  # virsh domdirtyrate-calc vm-name 30
  ```

  b. After the monitoring finishes, obtain its results:

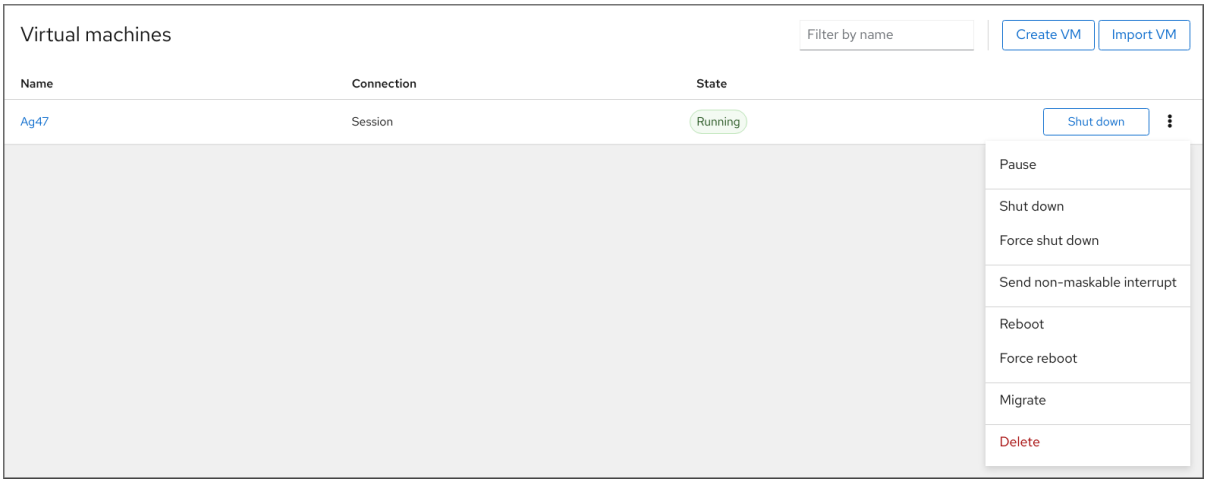
  ```
  # virsh domstats vm-name --dirtyrate
  Domain: 'vm-name'
    dirtyrate.calc_status=2
    dirtyrate.calc_start_time=200942
    dirtyrate.calc_period=30
    dirtyrate.megabytes_per_second=2
  ```

  In this example, the VM is generating 2 MB of dirty memory pages per second. Attempting to live-migrate such a VM on a network with a bandwidth of 2 MB/s or less will cause the live migration not to progress if you do not pause the VM or lower its workload.

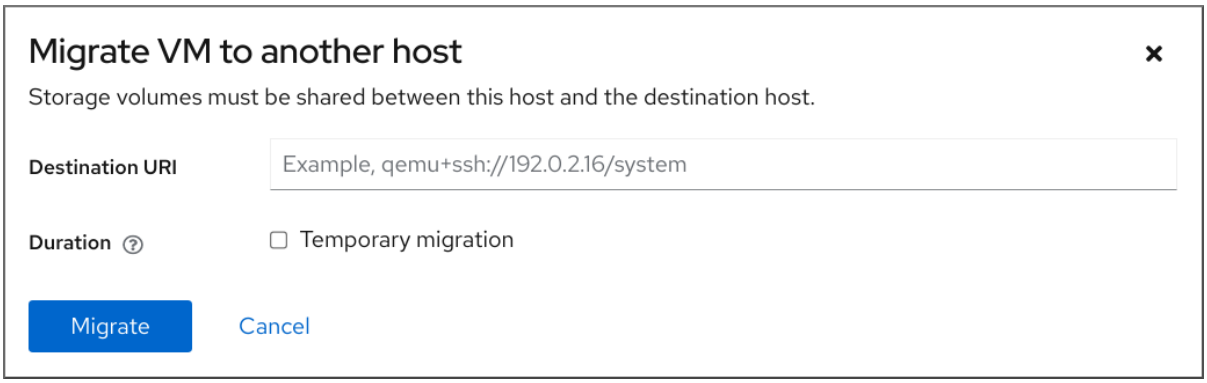
  To ensure that the live migration finishes successfully, Red Hat recommends that your network bandwidth is significantly greater than the VM's dirty page generation rate.

Procedure

1. In the Virtual Machines interface of the web console, click the Menu button ⋮ of the VM that you want to migrate.
   A drop down menu appears with controls for various VM operations.



2. Click **Migrate**
The Migrate VM to another host dialog appears.



3. Enter the URI of the destination host.

4. Configure the duration of the migration:

   - **Permanent** - Do not check the box if you wish to migrate the VM permanently. Permanent migration completely removes the VM configuration from the source host.

   - **Temporary** - Temporary migration migrates a copy of the VM to the destination host. This copy is deleted from the destination host when the VM is shut down. The original VM remains on the source host.

5. Click **Migrate**
Your VM is migrated to the destination host.

Verification

To verify whether the VM has been successfully migrated and is working correctly:

- Confirm whether the VM appears in the list of VMs available on the destination host.

- Start the migrated VM and observe if it boots up.

9.7. SUPPORTED HOSTS FOR VIRTUAL MACHINE MIGRATION

For the virtual machine (VM) migration to work properly and be supported by Red Hat, the source and destination hosts must be specific RHEL versions and machine types. The following table shows supported VM migration paths.

Table 9.2. Live migration compatibility

Migration method	Release type	Example	Support status
Forward	Major release	7.6+ → 8.1	On supported RHEL 7 systems: machine types **i440fx** and **q35**
Backward	Major release	8.1 → 7.6+	On supported RHEL 8 systems: machine types **i440fx** and **q35**
Forward	Minor release	8.0.1+ → 8.1+	On supported RHEL 7 systems: machine types **i440fx** and **q35** on RHEL 7.6.0 and later. On supported RHEL 8 systems: machine type **q35**.
Backward	Minor release	8.1 → 8.0.1	On supported RHEL 7 systems. Fully supported for machine types **i440fx** and **q35**. On supported RHEL 8 systems: machine type **q35**.

Additional resources

- For information on the currently supported versions of RHEL 7 and RHEL 8, see Red Hat Knowledgebase.

9.8. ADDITIONAL RESOURCES

- You can also migrate VMs from a non-KVM hypervisor to a RHEL 7 or RHEL 8 host. This is also referred to as a **V2V conversion**, and you can find additional information and instructions in the Red Hat Knowledgebase .

CHAPTER 10. MANAGING VIRTUAL DEVICES

One of the most effective ways to manage the functionality, features, and performance of a virtual machine (VM) is to adjust its *virtual devices*.

The following sections provide a general overview of what virtual devices are, and instructions on how they can be attached, modified, or removed from a VM.

10.1. HOW VIRTUAL DEVICES WORK

The basics

Just like physical machines, virtual machines (VMs) require specialized devices to provide functions to the system, such as processing power, memory, storage, networking, or graphics. Physical systems usually use hardware devices for these purposes. However, because VMs work as software implements, they need to use software abstractions of such devices instead, referred to as *virtual devices*.

Virtual devices attached to a VM can be configured when creating the VM, and can also be managed on an existing VM. Generally, virtual devices can be attached or detached from a VM only when the VM is shut off, but some can be added or removed when the VM is running. This feature is referred to as device *hot plug* and *hot unplug*.

When creating a new VM, **libvirt** automatically creates and configures a default set of essential virtual devices, unless specified otherwise by the user. These are based on the host system architecture and machine type, and usually include:

- the CPU
- memory
- a keyboard
- a network interface controller (NIC)
- various device controllers
- a video card
- a sound card

To manage virtual devices after the VM is created, use the command-line interface (CLI). However, to manage virtual storage devices and NICs, you can also use the RHEL 8 web console.

Performance or flexibility

For some types of devices, RHEL 8 supports multiple implementations, often with a trade-off between performance and flexibility.

For example, the physical storage used for virtual disks can be represented by files in various formats, such as **qcow2** or **raw**, and presented to the VM using a variety of controllers:

- an emulated controller
- **virtio-scsi**
- **virtio-blk**

An emulated controller is slower than a **virtio** controller, because **virtio** devices are designed specifically for virtualization purposes. On the other hand, emulated controllers make it possible to run operating systems that have no drivers for **virtio** devices. Similarly, **virtio-scsi** offers a more complete support for SCSI commands, and makes it possible to attach a larger number of disks to the VM. Finally, **virtio-blk** provides better performance than both **virtio-scsi** and emulated controllers, but a more limited range of use-cases. For example, attaching a physical disk as a LUN device to a VM is not possible when using **virtio-blk**.

For more information on types of virtual devices, see Section 10.6, "Types of virtual devices".

Additional resources

- For instructions how to attach, remove, or modify VM storage devices using the CLI, see Chapter 11, *Managing storage for virtual machines*.
- For instructions how to manage VM disks using the web console, see Section 11.7, "Managing storage for virtual machines using the web console".
- For instructions how to manage VM NICs using the web console, see Section 13.2, "Using the web console for managing virtual machine network interfaces".
- For instructions how to create and manage NVIDIA vGPUs, see Section 12.2, "Managing NVIDIA vGPU devices".

10.2. VIEWING DEVICES ATTACHED TO VIRTUAL MACHINES USING THE WEB CONSOLE

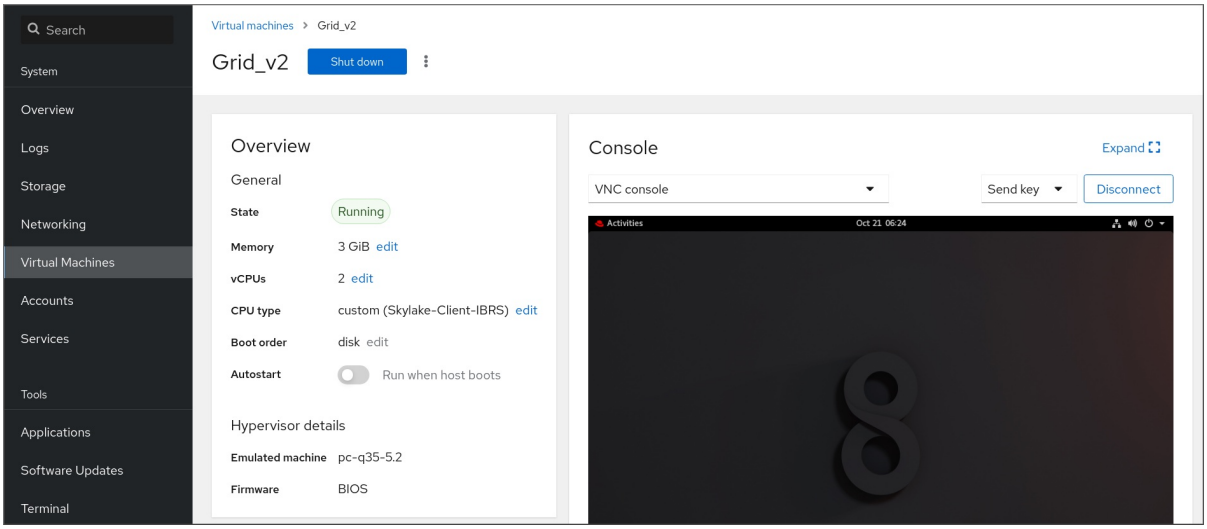
Before adding or modifying the devices attached to your virtual machine (VM), you may want to view the devices that are already attached to your VM. The following procedure provides instructions for viewing such devices using the web console.

Prerequisites

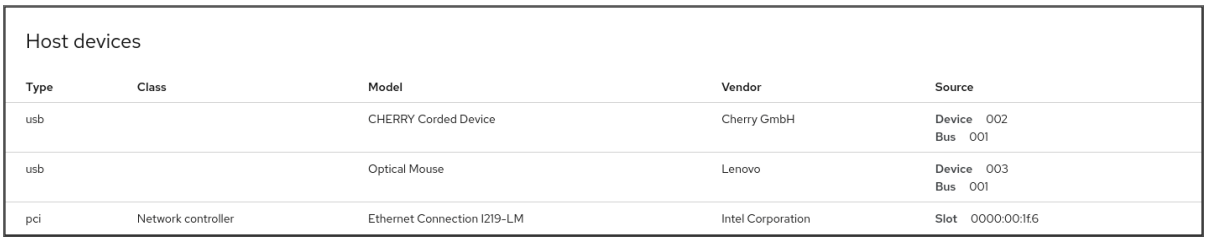
- The web console VM plug-in is installed on your system.

Procedure

1. In the **Virtual Machines** interface, click the VM whose information you want to see.
   A new page opens with detailed information about the VM.



2. Scroll to the **Host devices** section.



Host devices

Type	Class	Model	Vendor	Source
usb		CHERRY Corded Device	Cherry GmbH	Device 002 Bus 001
usb		Optical Mouse	Lenovo	Device 003 Bus 001
pci	Network controller	Ethernet Connection I219-LM	Intel Corporation	Slot 0000:00:1f.6

Additional resources

- For information about attaching or removing virtual devices, see Chapter 10, *Managing virtual devices*.

10.3. ATTACHING DEVICES TO VIRTUAL MACHINES

You can add a specific functionality to your virtual machines (VMs) by attaching a new virtual device. For example, you can increase the storage capacity of a VM by attaching a new virtual disk device to it.

The following procedure demostrates how to create and attach virtual devices to your virtual machines (VMs) using the command-line interface (CLI). Some devices can also be attached to VMs using the RHEL 8 web console.

Prerequisites

- Obtain the required options for the device you intend to attach to a VM. To see the available options for a specific device, use the **virt-xml --*device*=?** command. For example:

```
# virt-xml --network=?
--network options:
[...]
address.unit
boot_order
clearxml
driver_name
[...]
```

Procedure

1. To attach a device to a VM, use the **virt-xml --add-device** command, including the definition of the device and the required options:

   - For example, the following command creates a 20GB *newdisk* qcow2 disk image in the **/var/lib/libvirt/images/** directory, and attaches it as a virtual disk to the running *testguest* VM on the next start-up of the VM:

```
# virt-xml testguest --add-device --disk
/var/lib/libvirt/images/newdisk.qcow2,format=qcow2,size=20
Domain 'testguest' defined successfully.
Changes will take effect after the domain is fully powered off.
```

   - The following attaches a USB flash drive, attached as device 004 on bus 002 on the host, to the *testguest2* VM while the VM is running:

```
# virt-xml testguest2 --add-device --update --hostdev 002.004
Device hotplug successful.
Domain 'testguest2' defined successfully.
```

The bus-device combination for defining the USB can be obtained using the **lsusb** command.

Verification

To verify the device has been added, do any of the following:

- Use the **virsh dumpxml** command and see if the device's XML definition has been added to the **<devices>** section in the VM's XML configuration.
  For example, the following output shows the configuration of the *testguest* VM and confirms that the 002.004 USB flash disk device has been added.

```
# virsh dumpxml testguest
[...]
<hostdev mode='subsystem' type='usb' managed='yes'>
  <source>
    <vendor id='0x4146'/>
    <product id='0x902e'/>
    <address bus='2' device='4'/>
  </source>
  <alias name='hostdev0'/>
  <address type='usb' bus='0' port='3'/>
</hostdev>
[...]
```

- Run the VM and test if the device is present and works properly.

Additional resources

- For further information on using the **virt-xml** command, use **man virt-xml**.

10.4. MODIFYING DEVICES ATTACHED TO VIRTUAL MACHINES

You can change the functionality of your virtual machines (VMs) by editing a configuration of the attached virtual devices. For example, if you want to optimize the performance of your VMs, you can change their virtual CPU models to better match the CPUs of the hosts.

The following procedure provides general instructions for modifying virtual devices using the command-line interface (CLI). Some devices attached to your VM, such as disks and NICs, can also be modified using the RHEL 8 web console .

Prerequisites

- Obtain the required options for the device you intend to attach to a VM. To see the available options for a specific device, use the **virt-xml --*device*=?** command. For example:

```
# virt-xml --network=?
--network options:
[...]
address.unit
```

```
boot_order
clearxml
driver_name
[...]
```

- **Optional:** Back up the XML configuration of your VM by using **virsh dumpxml *vm-name*** and sending the output to a file. For example, the following backs up the configuration of your *Motoko* VM as the **motoko.xml** file:

```
# virsh dumpxml Motoko > motoko.xml
# cat motoko.xml
<domain type='kvm' xmlns:qemu='http://libvirt.org/schemas/domain/qemu/1.0'>
  <name>Motoko</name>
  <uuid>ede29304-fe0c-4ca4-abcd-d246481acd18</uuid>
  [...]
</domain>
```

Procedure

1. Use the **virt-xml --edit** command, including the definition of the device and the required options:
   For example, the following clears the *<cpu>* configuration of the shut-off *testguest* VM and sets it to *host-model*:

```
# virt-xml testguest --edit --cpu host-model,clearxml=yes
Domain 'testguest' defined successfully.
```

Verification

To verify the device has been modified, do any of the following:

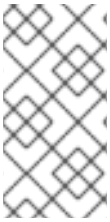
- Run the VM and test if the device is present and reflects the modifications.
- Use the **virsh dumpxml** command and see if the device's XML definition has been modified in the VM's XML configuration.
  For example, the following output shows the configuration of the *testguest* VM and confirms that the CPU mode has been configured as *host-model*.

```
# virsh dumpxml testguest
[...]
<cpu mode='host-model' check='partial'>
  <model fallback='allow'/>
</cpu>
[...]
```

Troubleshooting

- If modifying a device causes your VM to become unbootable, use the **virsh define** utility to restore the XML configuration by reloading the XML configuration file you backed up previously.

```
# virsh define testguest.xml
```



NOTE

For small changes to the XML configuration of your VM, you can use the **virsh edit** command - for example **virsh edit testguest**. However, do not use this method for more extensive changes, as it is more likely to break the configuration in ways that could prevent the VM from booting.

Additional resources

- For details on using the **virt-xml** command, use **man virt-xml**.

10.5. REMOVING DEVICES FROM VIRTUAL MACHINES

You can change the functionality of your virtual machines (VMs) by removing a virtual device. For example, you can remove a virtual disk device from one of your VMs if it is no longer needed.

The following procedure demonstrates how to remove virtual devices from your virtual machines (VMs) using the command-line interface (CLI). Some devices, such as disks or NICs, can also be removed from VMs using the RHEL 8 web console .

Prerequisites

- **Optional:** Back up the XML configuration of your VM by using **virsh dumpxml *vm-name*** and sending the output to a file. For example, the following backs up the configuration of your *Motoko* VM as the **motoko.xml** file:

```
# virsh dumpxml Motoko > motoko.xml
# cat motoko.xml
<domain type='kvm' xmlns:qemu='http://libvirt.org/schemas/domain/qemu/1.0'>
  <name>Motoko</name>
  <uuid>ede29304-fe0c-4ca4-abcd-d246481acd18</uuid>
  [...]
</domain>
```

Procedure

1. Use the **virt-xml --remove-device** command, including a definition of the device. For example:

   - The following removes the storage device marked as *vdb* from the running *testguest* VM after it shuts down:

     ```
     # virt-xml testguest --remove-device --disk target=vdb
     Domain 'testguest' defined successfully.
     Changes will take effect after the domain is fully powered off.
     ```

   - The following immediately removes a USB flash drive device from the running *testguest2* VM:

     ```
     # virt-xml testguest2 --remove-device --update --hostdev type=usb
     Device hotunplug successful.
     Domain 'testguest2' defined successfully.
     ```

Troubleshooting

- If removing a device causes your VM to become unbootable, use the **virsh define** utility to restore the XML configuration by reloading the XML configuration file you backed up previously.

```
# virsh define testguest.xml
```

Additional resources

- For details on using the **virt-xml** command, use **man virt-xml**.

10.6. TYPES OF VIRTUAL DEVICES

Virtualization in RHEL 8 can present several distinct types of virtual devices that you can attach to virtual machines (VMs):

Emulated devices

Emulated devices are software implementations of widely used physical devices. Drivers designed for physical devices are also compatible with emulated devices. Therefore, emulated devices can be used very flexibly.
However, since they need to faithfully emulate a particular type of hardware, emulated devices may suffer a significant performance loss compared with the corresponding physical devices or more optimized virtual devices.

The following types of emulated devices are supported:

- Virtual CPUs (vCPUs), with a large choice of CPU models available. The performance impact of emulation depends significantly on the differences between the host CPU and the emulated vCPU.
- Emulated system components, such as PCI bus controllers
- Emulated storage controllers, such as SATA, SCSI or even IDE
- Emulated sound devices, such as ICH9, ICH6 or AC97
- Emulated graphics cards, such as VGA or QXL cards
- Emulated network devices, such as rtl8139

Paravirtualized devices

Paravirtualization provides a fast and efficient method for exposing virtual devices to VMs. Paravirtualized devices expose interfaces that are designed specifically for use in VMs, and thus significantly increase device performance. RHEL 8 provides paravirtualized devices to VMs using the *virtio* API as a layer between the hypervisor and the VM. The drawback of this approach is that it requires a specific device driver in the guest operating system.
It is recommended to use paravirtualized devices instead of emulated devices for VM whenever possible, notably if they are running I/O intensive applications. Paravirtualized devices decrease I/O latency and increase I/O throughput, in some cases bringing them very close to bare-metal performance. Other paravirtualized devices also add functionality to VMs that is not otherwise available.

The following types of paravirtualized devices are supported:

- The paravirtualized network device (**virtio-net**).
- Paravirtualized storage controllers:

- **virtio-blk** - provides block device emulation.
- **virtio-scsi** - provides more complete SCSI emulation.

- The paravirtualized clock.
- The paravirtualized serial device (**virtio-serial**).
- The balloon device (**virtio-balloon**), used to share information about guest memory usage with the hypervisor.
  Note, however, that the balloon device also requires the balloon service to be installed.
- The paravirtualized random number generator (**virtio-rng**).
- The paravirtualized graphics card (**QXL**).

Physically shared devices

Certain hardware platforms enable VMs to directly access various hardware devices and components. This process is known as *device assignment* or *passthrough*.
When attached in this way, some aspects of the physical device are directly available to the VM as they would be to a physical machine. This provides superior performance for the device when used in the VM. However, devices physically attached to a VM become unavailable to the host, and also cannot be migrated.

Nevertheless, some devices can be *shared* across multiple VMs. For example, a single physical device can in certain cases provide multiple *mediated devices*, which can then be assigned to distinct VMs.

The following types of passthrough devices are supported:

- Virtual Function I/O (VFIO) device assignment - safely exposes devices to applications or VMs using hardware-enforced DMA and interrupt isolation.
- USB, PCI, and SCSI passthrough - expose common industry standard buses directly to VMs in order to make their specific features available to guest software.
- Single-root I/O virtualization (SR-IOV) - a specification that enables hardware-enforced isolation of PCI Express resources. This makes it safe and efficient to partition a single physical PCI resource into virtual PCI functions. It is commonly used for network interface cards (NICs).
- N_Port ID virtualization (NPIV) - a Fibre Channel technology to share a single physical host bus adapter (HBA) with multiple virtual ports.
- GPUs and vGPUs - accelerators for specific kinds of graphic or compute workloads. Some GPUs can be attached directly to a VM, while certain types also offer the ability to create virtual GPUs (vGPUs) that share the underlying physical hardware.

10.7. MANAGING VIRTUAL USB DEVICES

When using a virtual machine (VM), you can access and control a USB device, such as a flash drive or a web camera, that is attached to the host system. In this scenario, the host system passes control of the device to the VM. This is also known as a USB-passthrough.

The following sections provide information about using the command line to:

- Attach a USB device to a VM
- Remove a USB device from a VM

10.7.1. Attaching USB devices to virtual machines

To attach a USB device to a virtual machine (VM), you can include the USB device information in the XML configuration file of the VM.

Prerequisites

- Ensure the device you want to pass through to the VM is attached to the host.

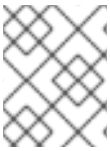
Procedure

1. Locate the bus and device values of the USB that you want to attach to the VM.
   For example, the following command displays a list of USB devices attached to the host. The device we will use in this example is attached on bus 001 as device 005.

```
# lsusb
[...]
Bus 001 Device 003: ID 2567:0a2b Intel Corp.
Bus 001 Device 005: ID 0407:6252 Kingston River 2.0
[...]
```

2. Use the **virt-xml** utility along with the **--add-device** argument.
   For example, the following command attaches a USB flash drive to the **Library** VM.

```
# virt-xml Library --add-device --hostdev 001.005
Domain 'Library' defined successfully.
```



NOTE

To attach a USB device to a running VM, add the **--update** argument to the previous command.

Verification

- Run the VM and test if the device is present and works as expected.
- Use the **virsh dumpxml** command to see if the device's XML definition has been added to the <devices> section in the VM's XML configuration file.

```
# virsh dumpxml Library
[...]
<hostdev mode='subsystem' type='usb' managed='yes'>
  <source>
    <vendor id='0x0407'/>
    <product id='0x6252'/>
    <address bus='1' device='5'/>
  </source>
  <alias name='hostdev0'/>
```

```
  <address type='usb' bus='0' port='3'/>
</hostdev>
[...]
```

Additional resources

- For other arguments, see the virt-xml(1) man page.

10.7.2. Removing USB devices from virtual machines

To remove a USB device from a virtual machine (VM), you can remove the USB device information from the XML configuration of the VM.

Procedure

1. Locate the bus and device values of the USB that you want to remove from the VM.
   For example, the following command displays a list of USB devices attached to the host. The device we will use in this example is attached on bus 001 as device 005.

```
# lsusb
[...]
Bus 001 Device 003: ID 2567:0a2b Intel Corp.
Bus 001 Device 005: ID 0407:6252 Kingston River 2.0
[...]
```

2. Use the **virt-xml** utility along with the **--remove-device** argument.
   For example, the following command removes a USB flash drive, attached to the host as device 005 on bus 001, from the **Library** VM.

```
# virt-xml Library --remove-device --hostdev 001.005
Domain 'Library' defined successfully.
```

NOTE

To remove a USB device from a running VM, add the **--update** argument to the previous command.

Verification

- Run the VM and check if the device has been removed from the list of devices.

Additional resources

- For other arguments, see the virt-xml(1) man page.

10.7.3. Additional resources

- For information about managing other types of devices, see Section 10.3, “Attaching devices to virtual machines”.

10.8. MANAGING VIRTUAL OPTICAL DRIVES

When using a virtual machine (VM), you can access information stored in an ISO image on the host. To do so, attach the ISO image to the VM as a virtual optical drive, such as a CD drive or a DVD drive.

The following sections provide information about using the command line to:

- Attach a drive and an ISO image to a VM
- Replace an ISO image in a virtual optical drive
- Remove an ISO image from a virtual optical drive
- Remove a drive from the VM

10.8.1. Attaching optical drives to virtual machines

To attach an ISO image as a virtual optical drive, edit the XML configuration file of the virtual machine (VM) and add the new drive.

Prerequisites

- You must store the ISO image on the local host.
- You must know the path to the ISO image.

Procedure

- Use the **virt-xml** utility with the **--add-device** argument.
  For example, the following command attaches the **Doc10** ISO image, stored in the **/MC/tank/** directory, to the **DN1** VM.

```
# virt-xml DN1 --add-device --disk /MC/tank/Doc10.iso,device=cdrom
Domain 'DN1' defined successfully.
```

Verification

- Run the VM and test if the device is present and works as expected.

Additional resources

- For other arguments, see the virt-xml(1) man page.

10.8.2. Replacing ISO images in virtual optical drives

To replace an ISO image attached as a virtual optical drive to a virtual machine (VM), edit the XML configuration file of the VM and specify the replacement.

Prerequisites

- You must store the ISO image on the local host.
- You must know the path to the ISO image.

Procedure

1. Locate the target device where the CD-ROM is attached to the VM. You can find this information in the VM's XML configuration file.
   For example, the following command displays the **DN1** VM's XML configuration file, where the target device for CD-ROM is **sda**.

```
# virsh dumpxml DN1
...
<disk>
  ...
  <source file='/MC/tank/Doc10.iso'/>
  <target dev='sda' bus='sata'/>
  ...
</disk>
...
```

2. Use the **virt-xml** utility with the **--edit** argument.
   For example, the following command replaces the **Doc10** ISO image, attached to the **DN1** VM at target **sda**, with the **DrDN** ISO image stored in the **/Dvrs/current/** directory.

```
# virt-xml DN1 --edit target=sda --disk /Dvrs/current/DrDN.iso
Domain 'DN1' defined successfully.
```

Verification

- Run the VM and test if the device is replaced and works as expected.

Additional resources

- For other arguments, see the virt-xml(1) man page.

10.8.3. Removing ISO images from virtual optical drives

To remove an ISO image from a virtual optical drive attached to a virtual machine (VM), edit the XML configuration file of the VM.

Procedure

1. Locate the target device where the CD-ROM is attached to the VM. You can find this information in the VM's XML configuration file.
   For example, the following command displays the **DN1** VM's XML configuration file, where the target device for CD-ROM is **sda**.

```
# virsh dumpxml DN1
...
<disk>
  ...
  <source file='/Dvrs/current/DrDN'/>
  <target dev='sda' bus='sata'/>
  ...
</disk>
...
```

2. Use the **virt-xml** utility with the **--edit** argument.

For example, the following command removes the **DrDN** ISO image from the CD drive attached to the **DN1** VM.

```
# virt-xml DN1 --edit target=sda --disk path=
Domain 'DN1' defined successfully.
```

Verification

- Run the VM and check that image is no longer available.

Additional resources

- For other arguments, see the virt-xml(1) man page.

10.8.4. Removing optical drives from virtual machines

To remove an optical drive attached to a virtual machine (VM), edit the XML configuration file of the VM.

Procedure

1. Locate the target device where the CD-ROM is attached to the VM. You can find this information in the VM's XML configuration file.
   For example, the following command displays the **DN1** VM's XML configuration file, where the target device for CD-ROM is **sda**.

```
# virsh dumpxml DN1
...
<disk type='file' device='cdrom'>
  <driver name='qemu' type='raw'/>
  <target dev='sda' bus='sata'/>
  ...
</disk>
...
```

2. Use the **virt-xml** utility with the **--remove-device** argument.
   For example, the following command removes the optical drive attached as target **sda** from the **DN1** VM.

```
# virt-xml DN1 --remove-device --disk target=sda
Domain 'DN1' defined successfully.
```

Verification

- Confirm that the device is no longer listed in the XML configuration file of the VM.

Additional resources

- For other arguments, see the virt-xml(1) man page.

10.8.5. Additional resources

- For information about managing other types of devices, see Section 10.3, "Attaching devices to virtual machines".

10.9. MANAGING SR-IOV DEVICES

An emulated virtual device often uses more CPU and memory than a hardware network device. This can limit the performance of a virtual machine (VM). However, if any devices on your virtualization host support Single Root I/O Virtualization (SR-IOV), you can use this feature to improve the device performance, and possibly also the overall performance of your VMs.

10.9.1. What is SR-IOV?

Single-root I/O virtualization (SR-IOV) is a specification that enables a single PCI Express (PCIe) device to present multiple separate PCI devices, called *virtual functions* (VFs), to the host system. Each of these devices:

- Is able to provide the same or similar service as the original PCIe device.
- Appears at a different address on the host PCI bus.
- Can be assigned to a different VM using VFIO assignment.

For example, a single SR-IOV capable network device can present VFs to multiple VMs. While all of the VFs use the same physical card, the same network connection, and the same network cable, each of the VMs directly controls its own hardware network device, and uses no extra resources from the host.

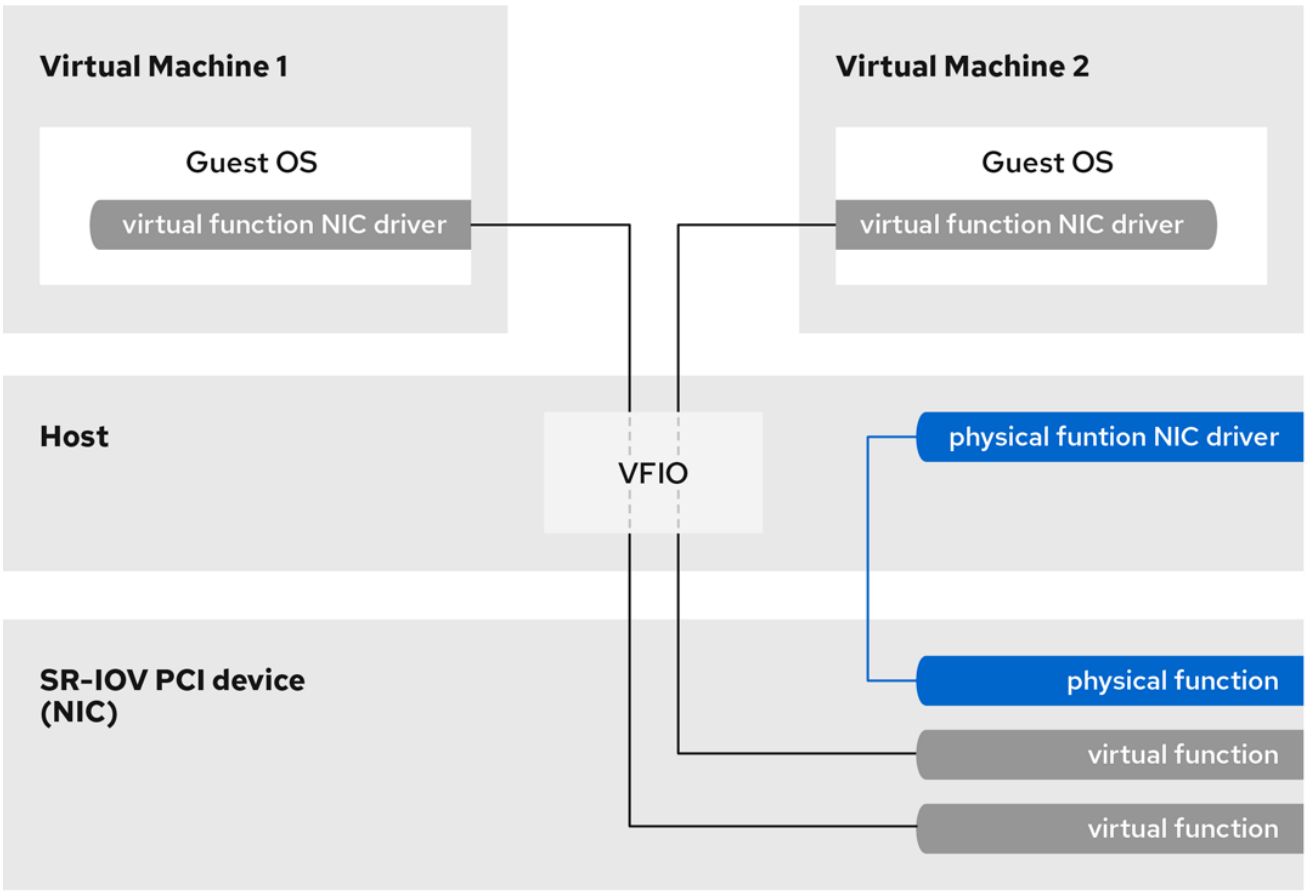
How SR-IOV works

The SR-IOV functionality is possible thanks to the introduction of the following PCIe functions:

- **Physical functions (PFs)** - A PCIe function that provides the functionality of its device (for example networking) to the host, but can also create and manage a set of VFs. Each SR-IOV capable device has one or more PFs.
- **Virtual functions (VFs)** - Lightweight PCIe functions that behave as independent devices. Each VF is derived from a PF. The maximum number of VFs a device can have depends on the device hardware. Each VF can be assigned only to a single VM at a time, but a VM can have multiple VFs assigned to it.

VMs recognize VFs as virtual devices. For example, a VF created by an SR-IOV network device appears as a network card to a VM to which it is assigned, in the same way as a physical network card appears to the host system.

Figure 10.1. SR-IOV architecture



Benefits

The primary advantages of using SR-IOV VFs rather than emulated devices are:

- Improved performance
- Reduced use of host CPU and memory resources

For example, a VF attached to a VM as a vNIC performs at almost the same level as a physical NIC, and much better than paravirtualized or emulated NICs. In particular, when multiple VFs are used simultaneously on a single host, the performance benefits can be significant.

Disadvantages

- To modify the configuration of a PF, you must first change the number of VFs exposed by the PF to zero. Therefore, you also need to remove the devices provided by these VFs from the VM to which they are assigned.
- A VM with an VFIO-assigned devices attached, including SR-IOV VFs, cannot be migrated to another host. In some cases, you can work around this limitation by pairing the assigned device with an emulated device. For example, you can bond an assigned networking VF to an emulated vNIC, and remove the VF before the migration.
- In addition, VFIO-assigned devices require pinning of VM memory, which increases the memory consumption of the VM and prevents the use of memory ballooning on the VM.

Additional resources

- For a list of device types that support SR-IOV, see Section 10.9.3, "Supported devices for SR-IOV assignment".

10.9.2. Attaching SR-IOV networking devices to virtual machines

To attach an SR-IOV networking device to a virtual machine (VM) on an Intel or AMD host, you must create a virtual function (VF) from an SR-IOV capable network interface on the host and assign the VF as a device to a specified VM. For details, see the following instructions.

Prerequisites

- The CPU and the firmware of your host support the I/O Memory Management Unit (IOMMU).
  - If using an Intel CPU, it must support the Intel Virtualization Technology for Directed I/O (VT-d).
  - If using an AMD CPU, it must support the AMD-Vi feature.
- The host system uses Access Control Service (ACS) to provide direct memory access (DMA) isolation for PCIe topology. Verify this with the system vendor.
  For additional information, see Hardware Considerations for Implementing SR-IOV .
- The physical network device supports SR-IOV. To verify if any network devices on your system support SR-IOV, use the **lspci -v** command and look for **Single Root I/O Virtualization (SR-IOV)** in the output.

```
# lspci -v
[...]
02:00.0 Ethernet controller: Intel Corporation 82576 Gigabit Network Connection (rev 01)
 Subsystem: Intel Corporation Gigabit ET Dual Port Server Adapter
 Flags: bus master, fast devsel, latency 0, IRQ 16, NUMA node 0
 Memory at fcba0000 (32-bit, non-prefetchable) [size=128K]
[...]
 Capabilities: [150] Alternative Routing-ID Interpretation (ARI)
 Capabilities: [160] Single Root I/O Virtualization (SR-IOV)
 Kernel driver in use: igb
 Kernel modules: igb
[...]
```

- The host network interface you want to use for creating VFs is running. For example, to activate the *eth1* interface and verify it is running:

```
# ip link set eth1 up
# ip link show eth1
8: eth1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc mq state UP mode
DEFAULT qlen 1000
  link/ether a0:36:9f:8f:3f:b8 brd ff:ff:ff:ff:ff:ff
  vf 0 MAC 00:00:00:00:00:00, spoof checking on, link-state auto
  vf 1 MAC 00:00:00:00:00:00, spoof checking on, link-state auto
  vf 2 MAC 00:00:00:00:00:00, spoof checking on, link-state auto
  vf 3 MAC 00:00:00:00:00:00, spoof checking on, link-state auto
```

- For SR-IOV device assignment to work, the IOMMU feature must be enabled in the host BIOS and kernel. To do so:

- On an Intel host, enable VT-d:
  - If your Intel host uses multiple boot entries:
    A. Edit the **/etc/default/grub** file and add the **intel_iommu=on** and **iommu=pt** parameters at the end of the *GRUB_CMDLINE_LINUX* line:

```
GRUB_CMDLINE_LINUX="crashkernel=auto resume=/dev/mapper/rhel_dell-per730-27-swap rd.lvm.lv=rhel_dell-per730-27/root rd.lvm.lv=rhel_dell-per730-27/swap console=ttyS0,115200n81 intel_iommu=on iommu=pt"
```

    B. Regenerate the GRUB configuration:

```
# grub2-mkconfig -o /boot/grub2/grub.cfg
```

    C. Reboot the host.
  - If your Intel host uses a single boot entry:
    A. Regenerate the GRUB configuration with the **intel_iommu=on** parameter:

```
# grubby --args="intel_iommu=on" --update-kernel DEFAULT
```

    B. Reboot the host.
- On an AMD host, enable AMD-Vi:
  - If your AMD host uses multiple boot entries:
    A. Edit the **/etc/default/grub** file and add the **iommu=pt** and **amd_iommu=on** parameters at the end of the *GRUB_CMDLINE_LINUX* line:

```
GRUB_CMDLINE_LINUX="crashkernel=auto resume=/dev/mapper/rhel_dell-per730-27-swap rd.lvm.lv=rhel_dell-per730-27/root rd.lvm.lv=rhel_dell-per730-27/swap console=ttyS0,115200n81 iommu=pt amd_iommu=on"
```

    B. Regenerate the GRUB configuration:

```
# grub2-mkconfig -o /boot/grub2/grub.cfg
```

    C. Reboot the host.
  - If your AMD host uses a single boot entry:
    A. Regenerate the GRUB configuration with the **iommu=pt** parameter:

```
# grubby --args="iommu=pt" --update-kernel DEFAULT
```

    B. Reboot the host.

Procedure

1. **Optional:** Confirm the maximum number of VFs your network device can use. To do so, use the following command and replace *eth1* with your SR-IOV compatible network device.

```
# cat /sys/class/net/eth1/device/sriov_totalvfs
7
```

2. Use the following command to create a virtual function (VF):

```
# echo VF-number > /sys/class/net/network-interface/device/sriov_numvfs
```

In the command, replace:

- *VF-number* with the number of VFs you want to create on the PF.
- *network-interface* with the name of the network interface for which the VFs will be created.

The following example creates 2 VFs from the eth1 network interface:

```
# echo 2 > /sys/class/net/eth1/device/sriov_numvfs
```

3. Verify the VFs have been added:

```
# lspci | grep Ethernet
01:00.0 Ethernet controller: Intel Corporation Ethernet Controller 10-Gigabit X540-AT2 (rev
01)
01:00.1 Ethernet controller: Intel Corporation Ethernet Controller 10-Gigabit X540-AT2 (rev
01)
07:00.0 Ethernet controller: Intel Corporation I350 Gigabit Network Connection (rev 01)
07:00.1 Ethernet controller: Intel Corporation I350 Gigabit Network Connection (rev 01)
```

4. Make the created VFs persistent by creating a udev rule for the network interface you used to create the VFs. For example, for the *eth1* interface, create the **/etc/udev/rules.d/eth1.rules** file, and add the following line:

```
ACTION=="add", SUBSYSTEM=="net", ENV{ID_NET_DRIVER}=="ixgbe",
ATTR{device/sriov_numvfs}="2"
```

This ensures that the two VFs that use the **ixgbe** driver will automatically be available for the **eth1** interface when the host starts.

WARNING

Currently, this command does not work correctly when attempting to make VFs persistent on Broadcom NetXtreme II BCM57810 adapters. In addition, attaching VFs based on these adapters to Windows VMs is currently not reliable.

5. Use the **virsh nodedev-list** command to verify that *libvirt* recognizes the added VF devices. For example, the following shows that the 01:00.0 and 07:00.0 PFs from the previous example have been successfully converted into VFs:

```
# virsh nodedev-list | grep pci_
```

```
pci_0000_01_00_0
pci_0000_01_00_1
pci_0000_07_10_0
pci_0000_07_10_1
[...]
```

6. Obtain the **bus**, **slot**, and **function** values of a PF and one of its corresponding VFs. For example, for **pci_0000_01_00_0** and **pci_0000_01_00_1**:

```
# virsh nodedev-dumpxml pci_0000_01_00_0
<device>
  <name>pci_0000_01_00_0</name>
  <path>/sys/devices/pci0000:00/0000:00:01.0/0000:01:00.0</path>
  <parent>pci_0000_00_01_0</parent>
  <driver>
    <name>ixgbe</name>
  </driver>
  <capability type='pci'>
    <domain>0</domain>
    <bus>1</bus>
    <slot>0</slot>
    <function>0</function>
[...]
# virsh nodedev-dumpxml pci_0000_01_00_1
<device>
  <name>pci_0000_01_00_1</name>
  <path>/sys/devices/pci0000:00/0000:00:01.0/0000:01:00.1</path>
  <parent>pci_0000_00_01_0</parent>
  <driver>
    <name>vfio-pci</name>
  </driver>
  <capability type='pci'>
    <domain>0</domain>
    <bus>1</bus>
    <slot>0</slot>
    <function>1</function>
[...]
```

7. Create a temporary XML file and add a configuration into using the **bus**, **slot**, and **function** values you obtained in the previous step. For example:

```
<interface type='hostdev' managed='yes'>
  <source>
    <address type='pci' domain='0x0000' bus='0x03' slot='0x10' function='0x2'/>
  </source>
</interface>
```

8. Add the VF to a VM using the temporary XML file. For example, the following attaches a VF saved in the **/tmp/holdmyfunction.xml** to a running *testguest1* VM and ensures it is available after the VM restarts:

```
# virsh attach-device testguest1 /tmp/holdmyfunction.xml --live --config
Device attached successfully.
```

Verification

- If the procedure is successful, the guest operating system detects a new network interface card.

10.9.3. Supported devices for SR-IOV assignment

Not all devices can be used for SR-IOV. The following devices have been tested and verified as compatible with SR-IOV in RHEL 8.

Networking devices

- Intel 82599ES 10 Gigabit Ethernet Controller - uses the **ixgbe** driver
- Intel Ethernet Controller XL710 Series - uses the **i40e** driver
- Mellanox ConnectX-5 Ethernet Adapter Cards - use the **mlx5_core** driver
- Intel Ethernet Network Adapter XXV710 - uses the **i40e** driver
- Intel 82576 Gigabit Ethernet Controller - uses the **igb** driver
- Broadcom NetXtreme II BCM57810 - uses the **bnx2x** driver

10.10. ATTACHING DASD DEVICES TO VIRTUAL MACHINES ON IBM Z

Direct-access storage devices (DASDs) provide a number of specific storage features. Using the **vfio-ccw** feature, you can assign DASDs as mediated devices to your virtual machines (VMs) on IBM Z hosts. This for example makes it possible for the VM to access a z/OS dataset, or to share the assigned DASDs with a z/OS machine.

Prerequisites

- Your host system is using the IBM Z hardware architecture and supports the FICON protocol.
- The target VM is using a Linux guest operating system.
- The *mdevctl* package is installed.

```
# yum install mdevctl
```

- The *driverctl* package is installed.

```
# yum install driverctl
```

- The necessary kernel modules have been loaded on the host. To verify, use:

```
# lsmod | grep vfio
```

  The output should contain the following modules:

  - **vfio_ccw**
  - **vfio_mdev**
  - **vfio_iommu_type1**

- You have a spare DASD device for exclusive use by the VM, and you know the device's identifier.
  This procedure uses **0.0.002c** as an example. When performing the commands, replace **0.0.002c** with the identifier of your DASD device.

Procedure

1. Obtain the subchannel identifier of the DASD device.

```
# lscss -d 0.0.002c
Device   Subchan.  DevType CU Type Use  PIM PAM POM  CHPIDs
------------------------------------------------------------------------
0.0.002c 0.0.29a8  3390/0c 3990/e9 yes  f0  f0  ff   02111221 00000000
```

   In this example, the subchannel identifier is detected as **0.0.29a8**. In the following commands of this procedure, replace **0.0.29a8** with the detected subchannel identifier of your device.

2. If the **lscss** command in the previous step only displayed the header output and no device information, perform the following steps:

   a. Remove the device from the **cio_ignore** list.

```
# cio_ignore -r 0.0.002c
```

   b. Edit the kernel command line of the VM and add the device identifier with a **!** mark to the line that starts with **cio_ignore=**, if it is not present already.

```
cio_ignore=all,!condev,!0.0.002c
```

   c. Repeat the previous step to obtain the subchannel identifier.

3. Bind the subchannel to the **vfio_ccw** passthrough driver.

```
# driverctl -b css set-override 0.0.29a8 vfio_ccw
```

NOTE

This binds the *0.0.29a8* subchannel to **vfio_ccw** persistently, which means the DASD will not be usable on the host. If you need to use the device on the host, you must first remove the automatic binding to 'vfio_ccw' and rebind the subchannel to the default driver:

```
# driverctl -b css unset-override0.0.29a8
```

4. Generate an UUID.

```
# uuidgen
30820a6f-b1a5-4503-91ca-0c10ba12345a
```

5. Create the DASD mediated device using the generated UUID.

```
# mdevctl start --uuid 30820a6f-b1a5-4503-91ca-0c10ba12345a --parent 0.0.29a8 --type
vfio_ccw-io
```

6. Make the mediated device persistent.

```
# mdevctl define --auto --uuid 30820a6f-b1a5-4503-91ca-0c10ba12345a
```

7. Attach the mediated device to the VM. To do so, use the **virsh edit** utility to edit the XML configuration of the VM, add the following section to the XML, and replace the **uuid** value with the UUID you generated in the previous step.

```
<hostdev mode='subsystem' type='mdev' model='vfio-ccw'>
  <source>
    <address uuid="30820a6f-b1a5-4503-91ca-0c10ba12345a"/>
  </source>
</hostdev>
```

Verification

1. Obtain the identifier that **libvirt** assigned to the mediated DASD device. To do so, display the XML configuration of the VM and look for a **vfio-ccw** device.

```
# virsh dumpxml vm-name

<domain>
[...]
    <hostdev mode='subsystem' type='mdev' managed='no' model='vfio-ccw'>
      <source>
        <address uuid='10620d2f-ed4d-437b-8aff-beda461541f9'/>
      </source>
      <alias name='hostdev0'/>
      <address type='ccw' cssid='0xfe' ssid='0x0' devno='0x0009'/>
    </hostdev>
[...]
</domain>
```

   In this example, the assigned identifier of the device is **0.0.0009**.

2. Log in to the guest operating system of the VM and confirm that the device is listed. For example:

```
# lscss | grep 0.0.0009
0.0.0009 0.0.0007  3390/0c 3990/e9      f0  f0  ff   12212231 00000000
```

3. Set the device online. For example:

```
# chccwdev -e 0.0009
Setting device 0.0.0009 online
Done
```

Additional resources

- For more information on **cio_ignore**, see the IBM documentation.

CHAPTER 11. MANAGING STORAGE FOR VIRTUAL MACHINES

A virtual machine (VM), just like a physical machine, requires storage for data, program, and system files. As a VM administrator, you can assign physical or network-based storage to your VMs as virtual storage. You can also modify how the storage is presented to a VM regardless of the underlying hardware.

The following sections provide information about the different types of VM storage, how they work, and how you can manage them using the CLI or the web console.

11.1. UNDERSTANDING VIRTUAL MACHINE STORAGE

If you are new to virtual machine (VM) storage, or are unsure about how it works, the following sections provide a general overview about the various components of VM storage, how it works, management basics, and the supported solutions provided by Red Hat.

You can find information about:

- Storage pools
- Storage volumes
- Managing storage using libvirt
- Overview of VM storage
- Supported and unsupported storage pool types

11.1.1. Introduction to storage pools

A storage pool is a file, directory, or storage device, managed by **libvirt** to provide storage for virtual machines (VMs). You can divide storage pools into storage volumes, which store VM images or are attached to VMs as additional storage.

Furthermore, multiple VMs can share the same storage pool, allowing for better allocation of storage resources.

- Storage pools can be persistent or transient:
  - A persistent storage pool survives a system restart of the host machine. You can use the **virsh pool-define** to create a persistent storage pool.
  - A transient storage pool only exists until the host reboots. You can use the **virsh pool-create** command to create a transient storage pool.

Storage pool storage types

Storage pools can be either local or network-based (shared):

- **Local storage pools**
  Local storage pools are attached directly to the host server. They include local directories, directly attached disks, physical partitions, and Logical Volume Management (LVM) volume groups on local devices.

  Local storage pools are useful for development, testing, and small deployments that do not require migration or have a large number of VMs.

- **Networked (shared) storage pools**
  Networked storage pools include storage devices shared over a network using standard protocols.

11.1.2. Introduction to storage volumes

Storage pools are divided into **storage volumes**. Storage volumes are abstractions of physical partitions, LVM logical volumes, file-based disk images, and other storage types handled by **libvirt**. Storage volumes are presented to VMs as local storage devices, such as disks, regardless of the underlying hardware.

On the host machine, a storage volume is referred to by its name and an identifier for the storage pool from which it derives. On the **virsh** command line, this takes the form **--pool *storage_pool* *volume_name***.

For example, to display information about a volume named *firstimage* in the *guest_images* pool.

```
# virsh vol-info --pool guest_images firstimage
 Name:           firstimage
 Type:           block
 Capacity:       20.00 GB
 Allocation:     20.00 GB
```

11.1.3. Storage management using libvirt

Using the **libvirt** remote protocol, you can manage all aspects of VM storage. These operations can also be performed on a remote host. Consequently, a management application that uses **libvirt**, such as the RHEL web console, can be used to perform all the required tasks of configuring the storage of a VM.

You can use the **libvirt** API to query the list of volumes in a storage pool or to get information regarding the capacity, allocation, and available storage in that storage pool. For storage pools that support it, you can also use the **libvirt** API to create, clone, resize, and delete storage volumes. Furthermore, you can use the **libvirt** API to upload data to storage volumes, download data from storage volumes, or wipe data from storage volumes.

11.1.4. Overview of storage management

To illustrate the available options for managing storage, the following example talks about a sample NFS server that uses **mount -t nfs nfs.example.com:/path/to/share /path/to/data**.

As a storage administrator:

- You can define an NFS storage pool on the virtualization host to describe the exported server path and the client target path. Consequently, **libvirt** can mount the storage either automatically when **libvirt** is started or as needed while **libvirt** is running.

- You can simply add the storage pool and storage volume to a VM by name. You do not need to add the target path to the volume. Therefore, even if the target client path changes, it does not affect the VM.

- You can configure storage pools to autostart. When you do so, **libvirt** automatically mounts the NFS shared disk on the directory which is specified when **libvirt** is started. **libvirt** mounts the share on the specified directory, similar to the command **mount nfs.example.com:/path/to/share /vmdata**.

- You can query the storage volume paths using the **libvirt** API. These storage volumes are basically the files present in the NFS shared disk. You can then copy these paths into the section of a VM's XML definition that describes the source storage for the VM's block devices.

- In the case of NFS, you can use an application that uses the **libvirt** API to create and delete storage volumes in the storage pool (files in the NFS share) up to the limit of the size of the pool (the storage capacity of the share).
  Note that, not all storage pool types support creating and deleting volumes.

- You can stop a storage pool when no longer required. Stopping a storage pool (**pool-destroy**) undoes the start operation, in this case, unmounting the NFS share. The data on the share is not modified by the destroy operation, despite what the name of the command suggests. For more information, see **man virsh**.

11.1.5. Supported and unsupported storage pool types

Supported storage pool types

The following is a list of storage pool types supported by RHEL:

- Directory-based storage pools
- Disk-based storage pools
- Partition-based storage pools
- GlusterFS storage pools
- iSCSI-based storage pools
- LVM-based storage pools
- NFS-based storage pools
- SCSI-based storage pools with vHBA devices
- Multipath-based storage pools
- RBD-based storage pools

Unsupported storage pool types

The following is a list of **libvirt** storage pool types not supported by RHEL:

- Sheepdog-based storage pools
- Vstorage-based storage pools
- ZFS-based storage pools

11.2. VIEWING VIRTUAL MACHINE STORAGE INFORMATION USING THE CLI

Before you can modify or troubleshoot your VM storage, you may want to view the current state and configuration of your storage. The following provides information about viewing information about storage pools and storage volumes using the CLI.

11.2.1. Viewing storage pool information using the CLI

Using the CLI, you can view a list of all storage pools with limited or full details about the storage pools. You can also filter the storage pools listed.

Procedure

- Use the **virsh pool-list** command to view storage pool information.

```
# virsh pool-list --all --details
 Name                State    Autostart  Persistent    Capacity  Allocation   Available
 default             running  yes        yes           48.97 GiB   23.93 GiB   25.03 GiB
 Downloads           running  yes        yes          175.62 GiB   62.02 GiB  113.60 GiB
 RHEL8-Storage-Pool  running  yes        yes          214.62 GiB   93.02 GiB  168.60 GiB
```

Additional resources

- For information on the available **virsh pool-list** options, use the **virsh pool-list --help** command.

11.2.2. Viewing storage volume information using the CLI

Using the command line, you can view a list of all storage pools available on your host, as well as details about a specified storage pool

Procedure

1. Use the **virsh vol-list** command to list the storage volumes in a specified storage pool.

```
# virsh vol-list --pool RHEL8-Storage-Pool --details
 Name                Path                                       Type   Capacity  Allocation
--------------------------------------------------------------------------------------------
 .bash_history       /home/VirtualMachines/.bash_history        file  18.70 KiB   20.00 KiB
 .bash_logout        /home/VirtualMachines/.bash_logout         file    18.00 B    4.00 KiB
 .bash_profile       /home/VirtualMachines/.bash_profile        file   193.00 B    4.00 KiB
 .bashrc             /home/VirtualMachines/.bashrc              file   1.29 KiB    4.00 KiB
 .git-prompt.sh      /home/VirtualMachines/.git-prompt.sh       file  15.84 KiB   16.00 KiB
 .gitconfig          /home/VirtualMachines/.gitconfig           file   167.00 B    4.00 KiB
 RHEL8_Volume.qcow2  /home/VirtualMachines/RHEL8_Volume.qcow2  file  60.00 GiB
13.93 GiB
```

2. Use the **virsh vol-info** command to list the storage volumes in a specified storage pool.

```
# vol-info --pool RHEL8-Storage-Pool --vol RHEL8_Volume.qcow2
Name:           RHEL8_Volume.qcow2
Type:           file
Capacity:       60.00 GiB
Allocation:     13.93 GiB
```

11.3. CREATING AND ASSIGNING STORAGE POOLS FOR VIRTUAL MACHINES USING THE CLI

You can create one or more storage pools from available storage media. For a list of supported storage pool types, see Supported storage pool types .

- To create persistent storage pools, use the **virsh pool-define-as** and **virsh pool-define** commands.
  The **virsh pool-define-as** command places the options in the command line. The **virsh pool-define** command uses an XML file for the pool options.

- To create temporary storage pools, use the **virsh pool-create** and **virsh pool-create-as** commands.
  The **virsh pool-create-as** command places the options in the command line. The **virsh pool-create** command uses an XML file for the pool options.

The following sections provide information on creating and assigning various types of storage pools using the CLI:

11.3.1. Creating directory-based storage pools using the CLI

A directory-based storage pool is based on a directory in an existing mounted file system. This is useful, for example, when you want to use the remaining space on the file system for other purposes. You can use the **virsh** utility to create directory-based storage pools.

Prerequisites

- Ensure your hypervisor supports directory storage pools:

  ```
  # virsh pool-capabilities | grep "'dir' supported='yes'"
  ```

  If the command displays any output, directory pools are supported.

Procedure

1. **Create a storage pool**
   Use the **virsh pool-define-as** command to define and create a directory-type storage pool. For example, to create a storage pool named **guest_images_dir** that uses the **/guest_images** directory:

   ```
   # virsh pool-define-as guest_images_dir dir --target "/guest_images"
   Pool guest_images_dir defined
   ```

   If you already have an XML configuration of the storage pool you want to create, you can also define the pool based on the XML. For details, see Section 11.4.1, “Directory-based storage pool parameters”.

2. **Create the storage pool target path**
   Use the **virsh pool-build** command to create a storage pool target path for a pre-formatted file system storage pool, initialize the storage source device, and define the format of the data.

   ```
   # virsh pool-build guest_images_dir
     Pool guest_images_dir built

   # ls -la /guest_images
     total 8
     drwx------.  2 root root 4096 May 31 19:38 .
     dr-xr-xr-x. 25 root root 4096 May 31 19:38 ..
   ```

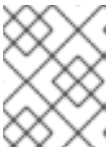
3. **Verify that the pool was created**
   Use the **virsh pool-list** command to verify that the pool was created.

```
# virsh pool-list --all

 Name               State      Autostart
-------------------------------------------
 default            active     yes
 guest_images_dir   inactive   no
```

4. **Start the storage pool**
   Use the **virsh pool-start** command to mount the storage pool.

```
# virsh pool-start guest_images_dir
 Pool guest_images_dir started
```



NOTE

The **virsh pool-start** command is only necessary for persistent storage pools. Transient storage pools are automatically started when they are created.

5. **[Optional] Turn on autostart**
   By default, a storage pool defined with the **virsh** command is not set to automatically start each time libvirtd starts. Use the **virsh pool-autostart** command to configure the storage pool to autostart.

```
# virsh pool-autostart guest_images_dir
 Pool guest_images_dir marked as autostarted
```

Verification

- Use the **virsh pool-info** command to verify that the storage pool is in the ***running*** state. Check if the sizes reported are as expected and if autostart is configured correctly.

```
# virsh pool-info guest_images_dir
 Name:           guest_images_dir
 UUID:           c7466869-e82a-a66c-2187-dc9d6f0877d0
 State:          running
 Persistent:     yes
 Autostart:      yes
 Capacity:       458.39 GB
 Allocation:     197.91 MB
 Available:      458.20 GB
```

11.3.2. Creating disk-based storage pools using the CLI

In a disk-based storage pool, the pool is based on a disk partition. This is useful, for example, when you want to have an entire disk partition assigned as a storage pool. You can use the **virsh** utility to create disk-based storage pools.

Recommendations

Be aware of the following before creating a disk-based storage pool:

- Depending on the version of **libvirt** being used, dedicating a disk to a storage pool may reformat and erase all data currently stored on the disk device. It is strongly recommended that you back up the data on the storage device before creating a storage pool.
- VMs should not be given write access to whole disks or block devices (for example, **/dev/sdb**). Use partitions (for example, **/dev/sdb1**) or LVM volumes.
  If you pass an entire block device to a VM, the VM will likely partition it or create its own LVM groups on it. This can cause the host machine to detect these partitions or LVM groups and cause errors.

Prerequisites

- Ensure your hypervisor supports disk-based storage pools:

```
# virsh pool-capabilities | grep "'disk' supported='yes'"
```

  If the command displays any output, disk-based pools are supported.

Procedure

1. **Create a storage pool**
   Use the **virsh pool-define-as** command to define and create a disk-type storage pool. For example, to create a storage pool named **guest_images_disk** that uses the **/dev/sdb1** partition, and is mounted on the /dev directory:

```
# virsh pool-define-as guest_images_disk disk --source-format=gpt --source-
dev=/dev/sdb1 --target /dev
Pool guest_images_disk defined
```

   If you already have an XML configuration of the storage pool you want to create, you can also define the pool based on the XML. For details, see Section 11.4.2, "Disk-based storage pool parameters".

2. **Create the storage pool target path**
   Use the **virsh pool-build** command to create a storage pool target path for a pre-formatted file-system storage pool, initialize the storage source device, and define the format of the data.

```
# virsh pool-build guest_images_disk
  Pool guest_images_disk built
```

   NOTE

   Building the target path is only necessary for disk-based, file system-based, and logical storage pools. If **libvirt** detects that the source storage device's data format differs from the selected storage pool type, the build fails, unless the ***overwrite*** option is specified.

3. **Verify that the pool was created**
   Use the **virsh pool-list** command to verify that the pool was created.

```
# virsh pool-list --all
```

```
Name                 State      Autostart
-----------------------------------------
default              active     yes
guest_images_disk    inactive   no
```

4. **Start the storage pool**
   Use the **virsh pool-start** command to mount the storage pool.

```
# virsh pool-start guest_images_disk
  Pool guest_images_disk started
```

NOTE

The **virsh pool-start** command is only necessary for persistent storage pools. Transient storage pools are automatically started when they are created.

5. **[Optional] Turn on autostart**
   By default, a storage pool defined with the **virsh** command is not set to automatically start each time libvirtd starts. Use the **virsh pool-autostart** command to configure the storage pool to autostart.

```
# virsh pool-autostart guest_images_disk
  Pool guest_images_disk marked as autostarted
```

Verification

- Use the **virsh pool-info** command to verify that the storage pool is in the ***running*** state. Check if the sizes reported are as expected and if autostart is configured correctly.

```
# virsh pool-info guest_images_disk
  Name:           guest_images_disk
  UUID:           c7466869-e82a-a66c-2187-dc9d6f0877d0
  State:          running
  Persistent:     yes
  Autostart:      yes
  Capacity:       458.39 GB
  Allocation:     197.91 MB
  Available:      458.20 GB
```

11.3.3. Creating filesystem-based storage pools using the CLI

When you want to create a storage pool on a file system that is not mounted, use the filesystem-based storage pool. This storage pool is based on a given file-system mountpoint. You can use the **virsh** utility to create filesystem-based storage pools.

Recommendations

Do not use this procedure to assign an entire disk as a storage pool (for example, **/dev/sdb**). VMs should not be given write access to whole disks or block devices. This method should only be used to assign partitions (for example, **/dev/sdb1**) to storage pools.

Prerequisites

- Ensure your hypervisor supports filesystem-based storage pools:

```
# virsh pool-capabilities | grep "'fs' supported='yes'"
```

If the command displays any output, file-based pools are supported.

Procedure

1. **Create a storage pool**
Use the **virsh pool-define-as** command to define and create a filesystem-type storage pool. For example, to create a storage pool named **guest_images_fs** that uses the **/dev/sdc1** partition, and is mounted on the /guest_images directory:

```
# virsh pool-define-as guest_images_fs fs --source-dev /dev/sdc1 --target
/guest_images
Pool guest_images_fs defined
```

If you already have an XML configuration of the storage pool you want to create, you can also define the pool based on the XML. For details, see Section 11.4.3, "Filesystem-based storage pool parameters".

2. **Define the storage pool target path**
Use the **virsh pool-build** command to create a storage pool target path for a pre-formatted file-system storage pool, initialize the storage source device, and define the format of the data.

```
# virsh pool-build guest_images_fs
  Pool guest_images_fs built

# ls -la /guest_images
  total 8
  drwx------.  2 root root 4096 May 31 19:38 .
  dr-xr-xr-x. 25 root root 4096 May 31 19:38 ..
```

3. **Verify that the pool was created**
Use the **virsh pool-list** command to verify that the pool was created.

```
# virsh pool-list --all

  Name                 State      Autostart
  -----------------------------------------
  default              active     yes
  guest_images_fs      inactive   no
```

4. **Start the storage pool**
Use the **virsh pool-start** command to mount the storage pool.

```
# virsh pool-start guest_images_fs
  Pool guest_images_fs started
```

NOTE

The **virsh pool-start** command is only necessary for persistent storage pools. Transient storage pools are automatically started when they are created.

5. **[Optional] Turn on autostart**
   By default, a storage pool defined with the **virsh** command is not set to automatically start each time libvirtd starts. Use the **virsh pool-autostart** command to configure the storage pool to autostart.

```
# virsh pool-autostart guest_images_fs
  Pool guest_images_fs marked as autostarted
```

Verification

1. Use the **virsh pool-info** command to verify that the storage pool is in the ***running*** state. Check if the sizes reported are as expected and if autostart is configured correctly.

```
# virsh pool-info guest_images_fs
  Name:           guest_images_fs
  UUID:           c7466869-e82a-a66c-2187-dc9d6f0877d0
  State:          running
  Persistent:     yes
  Autostart:      yes
  Capacity:       458.39 GB
  Allocation:     197.91 MB
  Available:      458.20 GB
```

2. Verify there is a **lost+found** directory in the target path on the file system, indicating that the device is mounted.

```
# mount | grep /guest_images
  /dev/sdc1 on /guest_images type ext4 (rw)

# ls -la /guest_images
  total 24
  drwxr-xr-x.  3 root root  4096 May 31 19:47 .
  dr-xr-xr-x. 25 root root  4096 May 31 19:38 ..
  drwx------.  2 root root 16384 May 31 14:18 lost+found
```

11.3.4. Creating GlusterFS-based storage pools using the CLI

GlusterFS is a user-space file system that uses the File System in Userspace (FUSE) software interface. If you want to have a storage pool on a Gluster server, you can use the **virsh** utility to create GlusterFS-based storage pools.

Prerequisites

- Before you can create GlusterFS-based storage pool on a host, prepare a Gluster.

  a. Obtain the IP address of the Gluster server by listing its status with the following command:

```
# gluster volume status
Status of volume: gluster-vol1
Gluster process                         Port Online Pid
------------------------------------------------------------
Brick 222.111.222.111:/gluster-vol1     49155   Y    18634
```

```
Task Status of Volume gluster-vol1
------------------------------------------------------------
There are no active volume tasks
```

b. If not installed, install the **glusterfs-fuse** package.

c. If not enabled, enable the **virt_use_fusefs** boolean. Check that it is enabled.

```
# setsebool virt_use_fusefs on
# getsebool virt_use_fusefs
virt_use_fusefs --> on
```

- Ensure your hypervisor supports GlusterFS-based storage pools:

```
# virsh pool-capabilities | grep "'gluster' supported='yes'"
```

If the command displays any output, GlusterFS-based pools are supported.

Procedure

1. **Create a storage pool**
Use the **virsh pool-define-as** command to define and create a GlusterFS-based storage pool. For example, to create a storage pool named **guest_images_glusterfs** that uses a Gluster server named **gluster-vol1** with IP **111.222.111.222**, and is mounted on the root directory of the Gluster server:

```
# virsh pool-define-as --name guest_images_glusterfs --type gluster --source-host
111.222.111.222 --source-name gluster-vol1 --source-path /
Pool guest_images_glusterfs defined
```

If you already have an XML configuration of the storage pool you want to create, you can also define the pool based on the XML. For details, see Section 11.4.4, "GlusterFS-based storage pool parameters".

2. **Verify that the pool was created**
Use the **virsh pool-list** command to verify that the pool was created.

```
# virsh pool-list --all

 Name                 State      Autostart
-------------------------------------------
 default              active     yes
 guest_images_glusterfs  inactive   no
```

3. **Start the storage pool**
Use the **virsh pool-start** command to mount the storage pool.

```
# virsh pool-start guest_images_glusterfs
 Pool guest_images_glusterfs started
```

NOTE

The **virsh pool-start** command is only necessary for persistent storage pools. Transient storage pools are automatically started when they are created.

4. **[Optional] Turn on autostart**
   By default, a storage pool defined with the **virsh** command is not set to automatically start each time libvirtd starts. Use the **virsh pool-autostart** command to configure the storage pool to autostart.

```
# virsh pool-autostart guest_images_glusterfs
  Pool guest_images_glusterfs marked as autostarted
```

Verification

- Use the **virsh pool-info** command to verify that the storage pool is in the ***running*** state. Check if the sizes reported are as expected and if autostart is configured correctly.

```
# virsh pool-info guest_images_glusterfs
  Name:           guest_images_glusterfs
  UUID:           c7466869-e82a-a66c-2187-dc9d6f0877d0
  State:          running
  Persistent:     yes
  Autostart:      yes
  Capacity:       458.39 GB
  Allocation:     197.91 MB
  Available:      458.20 GB
```

11.3.5. Creating iSCSI-based storage pools using the CLI

Internet Small Computer Systems Interface (iSCSI) is an IP-based storage networking standard for linking data storage facilities. If you want to have a storage pool on an iSCSI server, you can use the **virsh** utility to create iSCSI-based storage pools.

Prerequisites

- Ensure your hypervisor supports iSCSI-based storage pools:

```
# virsh pool-capabilities | grep "'iscsi' supported='yes'"
```

  If the command displays any output, iSCSI-based pools are supported.

Procedure

1. **Create a storage pool**
   Use the **virsh pool-define-as** command to define and create an iSCSI-type storage pool. For example, to create a storage pool named **guest_images_iscsi** that uses the **iqn.2010-05.com.example.server1:iscsirhel7guest** IQN on the **server1.example.com**, and is mounted on the **/dev/disk/by-path** path:

```
# virsh pool-define-as --name guest_images_iscsi --type iscsi --source-host
server1.example.com --source-dev iqn.2010-05.com.example.server1:iscsirhel7guest --
target /dev/disk/by-path
```

```
Pool guest_images_iscsi defined
```

If you already have an XML configuration of the storage pool you want to create, you can also define the pool based on the XML. For details, see Section 11.4.5, "iSCSI-based storage pool parameters".

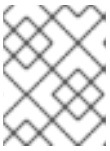
2. **Verify that the pool was created**
   Use the **virsh pool-list** command to verify that the pool was created.

```
# virsh pool-list --all

 Name                 State      Autostart
 -----------------------------------------
 default              active     yes
 guest_images_iscsi   inactive   no
```

3. **Start the storage pool**
   Use the **virsh pool-start** command to mount the storage pool.

```
# virsh pool-start guest_images_iscsi
 Pool guest_images_iscsi started
```



NOTE

The **virsh pool-start** command is only necessary for persistent storage pools. Transient storage pools are automatically started when they are created.

4. **[Optional] Turn on autostart**
   By default, a storage pool defined with the **virsh** command is not set to automatically start each time libvirtd starts. Use the **virsh pool-autostart** command to configure the storage pool to autostart.

```
# virsh pool-autostart guest_images_iscsi
 Pool guest_images_iscsi marked as autostarted
```

Verification

- Use the **virsh pool-info** command to verify that the storage pool is in the ***running*** state. Check if the sizes reported are as expected and if autostart is configured correctly.

```
# virsh pool-info guest_images_iscsi
 Name:           guest_images_iscsi
 UUID:           c7466869-e82a-a66c-2187-dc9d6f0877d0
 State:          running
 Persistent:     yes
 Autostart:      yes
 Capacity:       458.39 GB
 Allocation:     197.91 MB
 Available:      458.20 GB
```

11.3.6. Creating LVM-based storage pools using the CLI

If you want to have a storage pool that is part of an LVM volume group, you can use the **virsh** utility to create LVM-based storage pools.

Recommendations

Be aware of the following before creating an LVM-based storage pool:

- LVM-based storage pools do not provide the full flexibility of LVM.
- **libvirt** supports thin logical volumes, but does not provide the features of thin storage pools.
- LVM-based storage pools are volume groups. You can create volume groups using the **virsh** utility, but this way you can only have one device in the created volume group. To create a volume group with multiple devices, use the LVM utility instead, see How to create a volume group in Linux with LVM.
  For more detailed information about volume groups, refer to the *Red Hat Enterprise Linux Logical Volume Manager Administration Guide*.
- LVM-based storage pools require a full disk partition. If you activate a new partition or device using **virsh** commands, the partition will be formatted and all data will be erased. If you are using a host's existing volume group, as in these procedures, nothing will be erased.

Prerequisites

- Ensure your hypervisor supports LVM-based storage pools:

  ```
  # virsh pool-capabilities | grep "'logical' supported='yes'"
  ```

  If the command displays any output, LVM-based pools are supported.

Procedure

1. **Create a storage pool**
   Use the **virsh pool-define-as** command to define and create an LVM-type storage pool. For example, the following command creates a storage pool named **guest_images_lvm** that uses the **lvm_vg** volume group and is mounted on the **/dev/lvm_vg** directory:

   ```
   # virsh pool-define-as guest_images_lvm logical --source-name lvm_vg --target
   /dev/lvm_vg
   Pool guest_images_lvm defined
   ```

   If you already have an XML configuration of the storage pool you want to create, you can also define the pool based on the XML. For details, see Section 11.4.6, "LVM-based storage pool parameters".

2. **Verify that the pool was created**
   Use the **virsh pool-list** command to verify that the pool was created.

   ```
   # virsh pool-list --all

    Name                 State      Autostart
   -----------------------------------------
   default              active     yes
   guest_images_lvm     inactive   no
   ```

3. **Start the storage pool**
   Use the **virsh pool-start** command to mount the storage pool.

```
# virsh pool-start guest_images_lvm
  Pool guest_images_lvm started
```

NOTE

The **virsh pool-start** command is only necessary for persistent storage pools. Transient storage pools are automatically started when they are created.

4. **[Optional] Turn on autostart**
   By default, a storage pool defined with the **virsh** command is not set to automatically start each time libvirtd starts. Use the **virsh pool-autostart** command to configure the storage pool to autostart.

```
# virsh pool-autostart guest_images_lvm
  Pool guest_images_lvm marked as autostarted
```

Verification

- Use the **virsh pool-info** command to verify that the storage pool is in the ***running*** state. Check if the sizes reported are as expected and if autostart is configured correctly.

```
# virsh pool-info guest_images_lvm
  Name:           guest_images_lvm
  UUID:           c7466869-e82a-a66c-2187-dc9d6f0877d0
  State:          running
  Persistent:     yes
  Autostart:      yes
  Capacity:       458.39 GB
  Allocation:     197.91 MB
  Available:      458.20 GB
```

11.3.7. Creating NFS-based storage pools using the CLI

If you want to have a storage pool on a Network File System (NFS) server, you can use the **virsh** utility to create NFS-based storage pools.

Prerequisites

- Ensure your hypervisor supports NFS-based storage pools:

```
# virsh pool-capabilities | grep "<value>nfs</value>"
```

  If the command displays any output, NFS-based pools are supported.

Procedure

1. **Create a storage pool**
   Use the virsh **pool-define-as** command to define and create an NFS-type storage pool. For example, to create a storage pool named **guest_images_netfs** that uses a NFS server with IP

111.222.111.222 mounted on the server directory **/home/net_mount** using the target directory **/var/lib/libvirt/images/nfspool**:

```
# virsh pool-define-as --name guest_images_netfs --type netfs --source-
host='111.222.111.222' source-path='/home/net_mount' --source-format='nfs' --
target='/var/lib/libvirt/images/nfspool'
```

If you already have an XML configuration of the storage pool you want to create, you can also define the pool based on the XML. For details, see Section 11.4.7, "NFS-based storage pool parameters".

2. **Verify that the pool was created**
   Use the **virsh pool-list** command to verify that the pool was created.

```
# virsh pool-list --all

 Name                 State      Autostart
-------------------------------------------
 default              active     yes
 guest_images_netfs   inactive   no
```

3. **Start the storage pool**
   Use the **virsh pool-start** command to mount the storage pool.

```
# virsh pool-start guest_images_netfs
 Pool guest_images_netfs started
```

NOTE

The **virsh pool-start** command is only necessary for persistent storage pools. Transient storage pools are automatically started when they are created.

4. **[Optional] Turn on autostart**
   By default, a storage pool defined with the **virsh** command is not set to automatically start each time libvirtd starts. Use the **virsh pool-autostart** command to configure the storage pool to autostart.

```
# virsh pool-autostart guest_images_netfs
 Pool guest_images_netfs marked as autostarted
```

Verification

- Use the **virsh pool-info** command to verify that the storage pool is in the ***running*** state. Check if the sizes reported are as expected and if autostart is configured correctly.

```
# virsh pool-info guest_images_netfs
 Name:           guest_images_netfs
 UUID:           c7466869-e82a-a66c-2187-dc9d6f0877d0
 State:          running
 Persistent:     yes
 Autostart:      yes
```

```
Capacity:       458.39 GB
Allocation:     197.91 MB
Available:      458.20 GB
```

11.3.8. Creating SCSI-based storage pools with vHBA devices using the CLI

If you want to have a storage pool on a Small Computer System Interface (SCSI) device, your host must be able to connect to the SCSI device using a virtual host bus adapter (vHBA). You can then use the **virsh** utility to create SCSI-based storage pools.

Prerequisites

- Ensure your hypervisor supports SCSI-based storage pools:

  ```
  # virsh pool-capabilities | grep "'scsi' supported='yes'"
  ```

  If the command displays any output, SCSI-based pools are supported.

- Before creating a SCSI-based storage pools with vHBA devices, create a vHBA. For more information, see Creating vHBAs.

Procedure

1. **Create a storage pool**
   Use the **virsh pool-define-as** command to define and create SCSI storage pool using a vHBA. For example, the following creates a storage pool named **guest_images_vhba** that uses a vHBA identified by the **scsi_host3** parent adapter, world-wide port number **5001a4ace3ee047d**, and world-wide node number **5001a4a93526d0a1**. The storage pool is mounted on the **/dev/disk/** directory:

   ```
   # virsh pool-define-as guest_images_vhba scsi --adapter-parent scsi_host3 --adapter-wwnn 5001a4a93526d0a1 --adapter-wwpn 5001a4ace3ee047d --target /dev/disk/
   Pool guest_images_vhba defined
   ```

   If you already have an XML configuration of the storage pool you want to create, you can also define the pool based on the XML. For details, see Section 11.4.8, “Parameters for SCSI-based storage pools with vHBA devices”.

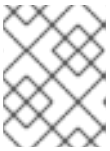
2. **Verify that the pool was created**
   Use the **virsh pool-list** command to verify that the pool was created.

   ```
   # virsh pool-list --all

    Name               State      Autostart
   -----------------------------------------
   default            active     yes
   guest_images_vhba  inactive   no
   ```

3. **Start the storage pool**
   Use the **virsh pool-start** command to mount the storage pool.

   ```
   # virsh pool-start guest_images_vhba
    Pool guest_images_vhba started
   ```



NOTE

The **virsh pool-start** command is only necessary for persistent storage pools. Transient storage pools are automatically started when they are created.

4. **[Optional] Turn on autostart**
   By default, a storage pool defined with the **virsh** command is not set to automatically start each time libvirtd starts. Use the **virsh pool-autostart** command to configure the storage pool to autostart.

```
# virsh pool-autostart guest_images_vhba
  Pool guest_images_vhba marked as autostarted
```

Verification

- Use the **virsh pool-info** command to verify that the storage pool is in the ***running*** state. Check if the sizes reported are as expected and if autostart is configured correctly.

```
# virsh pool-info guest_images_vhba
  Name:           guest_images_vhba
  UUID:           c7466869-e82a-a66c-2187-dc9d6f0877d0
  State:          running
  Persistent:     yes
  Autostart:      yes
  Capacity:       458.39 GB
  Allocation:     197.91 MB
  Available:      458.20 GB
```

11.4. PARAMETERS FOR CREATING STORAGE POOLS

Based on the type of storage pool you require, you can modify its XML configuration file and define a specific type of storage pool. This section provides information about the XML parameters required for creating various types of storage pools along with examples.

11.4.1. Directory-based storage pool parameters

When you want to create or modify a directory-based storage pool using an XML configuration file, you must include certain required parameters. See the following table for more information about these parameters.

You can use the **virsh pool-define** command to create a storage pool based on the XML configuration in a specified file. For example:

```
# virsh pool-define ~/guest_images.xml
  Pool defined from guest_images_dir
```

Parameters

The following table provides a list of required parameters for the XML file for a directory-based storage pool.

Table 11.1. Directory-based storage pool parameters

Description	XML
The type of storage pool	**<pool type='dir'>**
The name of the storage pool	**<name>*name*</name>**
The path specifying the target. This will be the path used for the storage pool.	**<target>** **<path>*target_path*</path>** **</target>**

Example

The following is an example of an XML file for a storage pool based on the **/guest_images** directory:

```
<pool type='dir'>
  <name>dirpool</name>
  <target>
    <path>/guest_images</path>
  </target>
</pool>
```

Additional resources

For more information on creating directory-based storage pools, see Section 11.3.1, "Creating directory-based storage pools using the CLI".

11.4.2. Disk-based storage pool parameters

When you want to create or modify a disk-based storage pool using an XML configuration file, you must include certain required parameters. See the following table for more information about these parameters.

You can use the **virsh pool-define** command to create a storage pool based on the XML configuration in a specified file. For example:

```
# virsh pool-define ~/guest_images.xml
  Pool defined from guest_images_disk
```

Parameters

The following table provides a list of required parameters for the XML file for a disk-based storage pool.

Table 11.2. Disk-based storage pool parameters

Description	XML
The type of storage pool	**<pool type='disk'>**
The name of the storage pool	**<name>*name*</name>**

Description	XML
The path specifying the storage device. For example, **/dev/sdb**.	**<source>** **<path>*source_path*</path>** **</source>**
The path specifying the target device. This will be the path used for the storage pool.	**<target>** **<path>*target_path*</path>** **</target>**

Example

The following is an example of an XML file for a disk-based storage pool:

```
<pool type='disk'>
  <name>phy_disk</name>
  <source>
    <device path='/dev/sdb'/>
    <format type='gpt'/>
  </source>
  <target>
    <path>/dev</path>
  </target>
</pool>
```

Additional resources

For more information on creating disk-based storage pools, see Section 11.3.2, “Creating disk-based storage pools using the CLI”.

11.4.3. Filesystem-based storage pool parameters

When you want to create or modify a filesystem-based storage pool using an XML configuration file, you must include certain required parameters. See the following table for more information about these parameters.

You can use the **virsh pool-define** command to create a storage pool based on the XML configuration in a specified file. For example:

```
# virsh pool-define ~/guest_images.xml
  Pool defined from guest_images_fs
```

Parameters

The following table provides a list of required parameters for the XML file for a filesystem-based storage pool.

Table 11.3. Filesystem-based storage pool parameters

Description	XML
The type of storage pool	**<pool type='fs'>**
The name of the storage pool	**<name>*name*</name>**
The path specifying the partition. For example, **/dev/sdc1**	**<source>** ** <device path=*device_path* />**
The file system type, for example **ext4**.	** <format type=*fs_type* />** **</source>**
The path specifying the target. This will be the path used for the storage pool.	**<target>** ** <path>*path-to-pool*</path>** **</target>**

Example

The following is an example of an XML file for a storage pool based on the **/dev/sdc1** partition:

```
<pool type='fs'>
  <name>guest_images_fs</name>
  <source>
    <device path='/dev/sdc1'/>
    <format type='auto'/>
  </source>
  <target>
    <path>/guest_images</path>
  </target>
</pool>
```

Additional resources

For more information on creating filesystem-based storage pools, see Section 11.3.3, “Creating filesystem-based storage pools using the CLI”.

11.4.4. GlusterFS-based storage pool parameters

When you want to create or modify a GlusterFS-based storage pool using an XML configuration file, you must include certain required parameters. See the following table for more information about these parameters.

You can use the **virsh pool-define** command to create a storage pool based on the XML configuration in a specified file. For example:

```
# virsh pool-define ~/guest_images.xml
  Pool defined from guest_images_glusterfs
```

Parameters

The following table provides a list of required parameters for the XML file for a GlusterFS-based storage pool.

Table 11.4. GlusterFS-based storage pool parameters

Description	XML
The type of storage pool	**<pool type='gluster'>**
The name of the storage pool	**<name>*name*</name>**
The hostname or IP address of the Gluster server	**<source>** **<name=*gluster-name* />**
The path on the Gluster server used for the storage pool.	**<dir path=*gluster-path* />** **</source>**

Example

The following is an example of an XML file for a storage pool based on the Gluster file system at 111.222.111.222:

```
<pool type='gluster'>
  <name>Gluster_pool</name>
  <source>
    <host name='111.222.111.222'/>
    <dir path='/'/>
    <name>gluster-vol1</name>
  </source>
</pool>
```

For more information on creating filesystem-based storage pools, see Section 11.3.4, “Creating GlusterFS-based storage pools using the CLI”.

11.4.5. iSCSI-based storage pool parameters

When you want to create or modify an iSCSI-based storage pool using an XML configuration file, you must include certain required parameters. See the following table for more information about these parameters.

You can use the **virsh pool-define** command to create a storage pool based on the XML configuration in a specified file. For example:

```
# virsh pool-define ~/guest_images.xml
  Pool defined from guest_images_iscsi
```

Parameters

The following table provides a list of required parameters for the XML file for an iSCSI-based storage pool.

Table 11.5. iSCSI-based storage pool parameters

Description	XML
The type of storage pool	**<pool type='iscsi'>**
The name of the storage pool	**<name>*name*</name>**
The name of the host	**<source>** **<host name=*hostname* />**
The iSCSI IQN	**<device path= *iSCSI_IQN* />** **</source>**
The path specifying the target. This will be the path used for the storage pool.	**<target>** **<path>*/dev/disk/by-path*</path>** **</target>**
[Optional] The IQN of the iSCSI initiator. This is only needed when the ACL restricts the LUN to a particular initiator.	**<initiator>** **<iqn name='*initiator0*' />** **</initiator>**

NOTE

The IQN of the iSCSI initiator can be determined using the **virsh find-storage-pool-sources-as** iscsi command.

Example

The following is an example of an XML file for a storage pool based on the specified iSCSI device:

```
<pool type='iscsi'>
  <name>iSCSI_pool</name>
  <source>
    <host name='server1.example.com'/>
    <device path='iqn.2010-05.com.example.server1:iscsirhel7guest'/>
  </source>
  <target>
    <path>/dev/disk/by-path</path>
  </target>
</pool>
```

Additional resources

For more information on creating iSCSCI-based storage pools, see Section 11.3.5, “Creating iSCSI-based storage pools using the CLI”.

11.4.6. LVM-based storage pool parameters

When you want to create or modify an LVM-based storage pool using an XML configuration file, you must include certain required parameters. See the following table for more information about these parameters.

You can use the **virsh pool-define** command to create a storage pool based on the XML configuration in a specified file. For example:

```
# virsh pool-define ~/guest_images.xml
  Pool defined from guest_images_logical
```

Parameters

The following table provides a list of required parameters for the XML file for a LVM-based storage pool.

Table 11.6. LVM-based storage pool parameters

Description	XML
The type of storage pool	**<pool type='logical'>**
The name of the storage pool	**<name>*name*</name>**
The path to the device for the storage pool	**<source>** **<device path='*device_path*' />`**
The name of the volume group	**<name>*VG-name*</name>**
The virtual group format	**<format type='lvm2' />** **</source>**
The target path	**<target>** **<path=*target_path* />** **</target>**

NOTE

If the logical volume group is made of multiple disk partitions, there may be multiple source devices listed. For example:

```
<source>
  <device path='/dev/sda1'/>
  <device path='/dev/sdb3'/>
  <device path='/dev/sdc2'/>
  ...
</source>
```

Example

The following is an example of an XML file for a storage pool based on the specified LVM:

```
<pool type='logical'>
  <name>guest_images_lvm</name>
  <source>
    <device path='/dev/sdc'/>
    <name>libvirt_lvm</name>
```

```
    <format type='lvm2'/>
  </source>
  <target>
    <path>/dev/libvirt_lvm</path>
  </target>
</pool>
```

Additional resources

For more information on creating iSCSCI-based storage pools, see Section 11.3.6, "Creating LVM-based storage pools using the CLI".

11.4.7. NFS-based storage pool parameters

When you want to create or modify an NFS-based storage pool using an XML configuration file, you must include certain required parameters. See the following table for more information about these parameters.

You can use the **virsh pool-define** command to create a storage pool based on the XML configuration in a specified file. For example:

```
# virsh pool-define ~/guest_images.xml
  Pool defined from guest_images_netfs
```

Parameters

The following table provides a list of required parameters for the XML file for an NFS-based storage pool.

Table 11.7. NFS-based storage pool parameters

Description	XML
The type of storage pool	**<pool type='netfs'>**
The name of the storage pool	**<name>*name*</name>**
The hostname of the network server where the mount point is located. This can be a hostname or an IP address.	**<source>** **<host name=*hostname*/>**
The format of the storage pool	One of the following: **<format type='nfs' />** **<format type='glusterfs' />** **<format type='cifs' />**
The directory used on the network server	**<dir path=*source_path*/>** **</source>**

Description	XML
The path specifying the target. This will be the path used for the storage pool.	**<target>** **<path>*target_path*</path>** **</target>**

Example

The following is an example of an XML file for a storage pool based on the **/home/net_mount** directory of the **file_server** NFS server:

```
<pool type='netfs'>
  <name>nfspool</name>
  <source>
    <host name='file_server'/>
    <format type='nfs'/>
    <dir path='/home/net_mount'/>
  </source>
  <target>
    <path>/var/lib/libvirt/images/nfspool</path>
  </target>
</pool>
```

Additional resources

For more information on creating NFS-based storage pools, see Section 11.3.7, "Creating NFS-based storage pools using the CLI".

11.4.8. Parameters for SCSI-based storage pools with vHBA devices

To create or modify an XML configuration file for a SCSi-based storage pool that uses a virtual host adapter bus (vHBA) device, you must include certain required parameters in the XML configuration file. See the following table for more information about the required parameters.

You can use the **virsh pool-define** command to create a storage pool based on the XML configuration in a specified file. For example:

```
# virsh pool-define ~/guest_images.xml
  Pool defined from guest_images_vhba
```

Parameters

The following table provides a list of required parameters for the XML file for a SCSI-based storage pool with vHBA.

Table 11.8. Parameters for SCSI-based storage pools with vHBA devices

Description	XML
The type of storage pool	**<pool type='scsi'>**

Description	XML
The name of the storage pool	**<name>*name*</name>**
The identifier of the vHBA. The **parent** attribute is optional.	**<source>** **<adapter type='fc_host'** **[parent=*parent_scsi_device*]** **wwnn='*WWNN*'** **wwpn='*WWPN*' />** **</source>**
The target path. This will be the path used for the storage pool.	**<target>** **<path=*target_path* />** **</target>**

IMPORTANT

When the **<path>** field is **/dev/**, **libvirt** generates a unique short device path for the volume device path. For example, **/dev/sdc**. Otherwise, the physical host path is used. For example, **/dev/disk/by-path/pci-0000:10:00.0-fc-0x5006016044602198-lun-0**. The unique short device path allows the same volume to be listed in multiple virtual machines (VMs) by multiple storage pools. If the physical host path is used by multiple VMs, duplicate device type warnings may occur.

NOTE

The **parent** attribute can be used in the **<adapter>** field to identify the physical HBA parent from which the NPIV LUNs by varying paths can be used. This field, **scsi_hostN**, is combined with the **vports** and **max_vports** attributes to complete the parent identification. The **parent**, **parent_wwnn**, **parent_wwpn**, or **parent_fabric_wwn** attributes provide varying degrees of assurance that after the host reboots the same HBA is used.

- If no **parent** is specified, **libvirt** uses the first **scsi_hostN** adapter that supports NPIV.
- If only the **parent** is specified, problems can arise if additional SCSI host adapters are added to the configuration.
- If **parent_wwnn** or **parent_wwpn** is specified, after the host reboots the same HBA is used.
- If **parent_fabric_wwn** is used, after the host reboots an HBA on the same fabric is selected, regardless of the **scsi_hostN** used.

Examples

The following are examples of XML files for SCSI-based storage pools with vHBA.

- A storage pool that is the only storage pool on the HBA:

```
<pool type='scsi'>
  <name>vhbapool_host3</name>
```

```
  <source>
    <adapter type='fc_host' wwnn='5001a4a93526d0a1' wwpn='5001a4ace3ee047d'/>
  </source>
  <target>
    <path>/dev/disk/by-path</path>
  </target>
</pool>
```

- A storage pool that is one of several storage pools that use a single vHBA and uses the **parent** attribute to identify the SCSI host device:

```
<pool type='scsi'>
  <name>vhbapool_host3</name>
  <source>
    <adapter type='fc_host' parent='scsi_host3' wwnn='5001a4a93526d0a1'
wwpn='5001a4ace3ee047d'/>
  </source>
  <target>
    <path>/dev/disk/by-path</path>
  </target>
</pool>
```

Additional resources

For more information on creating SCSI-based storage pools with vHBA, see Section 11.3.8, “Creating SCSI-based storage pools with vHBA devices using the CLI”.

11.5. CREATING AND ASSIGNING STORAGE VOLUMES USING THE CLI

To obtain a disk image and attach it to a virtual machine (VM) as a virtual disk, create a storage volume and assign its XML configuration to a the VM.

Prerequisites

- A storage pool with unallocated space is present on the host.
  - To verify, list the storage pools on the host:

```
# virsh pool-list --details

Name            State     Autostart   Persistent   Capacity     Allocation   Available
-------------------------------------------------------------------------------------------
default         running   yes         yes          48.97 GiB    36.34 GiB    12.63 GiB
Downloads       running   yes         yes          175.92 GiB   121.20 GiB   54.72 GiB
VM-disks        running   yes         yes          175.92 GiB   121.20 GiB   54.72 GiB
```

  - If you do not have an existing storage pool, create one. For more information, see Section 11.3, “Creating and assigning storage pools for virtual machines using the CLI”

Procedure

1. Create a storage volume using the **virsh vol-create-as** command. For example, to create a 20 GB qcow2 volume based on the **guest-images-fs** storage pool:

```
# virsh vol-create-as --pool guest-images-fs --name vm-disk1 --capacity 20 --format
qcow2
```

Important: Specific storage pool types do not support the **virsh vol-create-as** command and instead require specific processes to create storage volumes:

- **GlusterFS-based** - Use the **qemu-img** command to create storage volumes.
- **iSCSI-based** - Prepare the iSCSI LUNs in advance on the iSCSI server.
- **Multipath-based** - Use the **multipathd** command to prepare or manage the multipath.
- **vHBA-based** - Prepare the fibre channel card in advance.

2. Create an XML file, and add the following lines in it. This file will be used to add the storage volume as a disk to a VM.

```
<disk type='volume' device='disk'>
   <driver name='qemu' type='qcow2'/>
   <source pool='guest-images-fs' volume='vm-disk1'/>
   <target dev='hdk' bus='ide'/>
</disk>
```

This example specifies a virtual disk that uses the **vm-disk1** volume, created in the previous step, and sets the volume to be set up as disk **hdk** on an **ide** bus. Modify the respective parameters as appropriate for your environment.

Important: With specific storage pool types, you must use different XML formats to describe a storage volume disk.

- For *GlusterFS-based* pools:

```
<disk type='network' device='disk'>
  <driver name='qemu' type='raw'/>
  <source protocol='gluster' name='Volume1/Image'>
    <host name='example.org' port='6000'/>
  </source>
  <target dev='vda' bus='virtio'/>
  <address type='pci' domain='0x0000' bus='0x00' slot='0x03' function='0x0'/>
</disk>
```

- For *multipath-based* pools:

```
<disk type='block' device='disk'>
<driver name='qemu' type='raw'/>
<source dev='/dev/mapper/mpatha' />
<target dev='sda' bus='scsi'/>
</disk>
```

- For *RBD-based storage* pools:

```
<disk type='network' device='disk'>
  <driver name='qemu' type='raw'/>
  <source protocol='rbd' name='pool/image'>
    <host name='mon1.example.org' port='6321'/>
```

```
  </source>
  <target dev='vdc' bus='virtio'/>
</disk>
```

3. Use the XML file to assign the storage volume as a disk to a VM. For example, to assign a disk defined in ~/**vm-disk1.xml** to the **testguest1** VM:

```
# attach-device --config testguest1 ~/vm-disk1.xml
```

Verification

- In the guest operating system of the VM, confirm that the disk image has become available as an un-formatted and un-allocated disk.

11.6. DELETING STORAGE FOR VIRTUAL MACHINES USING THE CLI

You can delete storage associated with you virtual machines (VMs) to free up system resources, or to assign them to other VMs. You can also delete storage that you had assigned to defunct VMs. The following provides information about deleting storage pools and storage volumes using the CLI.

11.6.1. Deleting storage pools using the CLI

To remove a storage pool from your host system, you must stop the pool and remove its XML definition.

Procedure

1. List the defined storage pools using the **virsh pool-list** command.

```
# virsh pool-list --all
Name                 State      Autostart
-----------------------------------------
default              active     yes
Downloads            active     yes
RHEL8-Storage-Pool   active     yes
```

2. Stop the storage pool you want to delete using the **virsh pool-destroy** command.

```
# virsh pool-destroy Downloads
Pool Downloads destroyed
```

3. **Optional**: For some types of storage pools, you can remove the directory where the storage pool resides using the **virsh pool-delete** command. Note that to do so, the directory must be empty.

```
# virsh pool-delete Downloads
Pool Downloads deleted
```

4. Delete the definition of the storage pool using the **virsh pool-undefine** command.

```
# virsh pool-undefine Downloads
Pool Downloads has been undefined
```

Verification

- Confirm that the storage pool was deleted.

```
# virsh pool-list --all
Name                 State      Autostart
-----------------------------------------
default              active     yes
RHEL8-Storage-Pool   active     yes
```

11.6.2. Deleting storage volumes using the CLI

To remove a storage volume from your host system, you must stop the pool and remove its XML definition.

Prerequisites

- Any virtual machine that uses the storage volume you want to delete is shut down.

Procedure

1. Use the **virsh vol-list** command to list the storage volumes in a specified storage pool.

```
# virsh vol-list --pool RHEL-SP
 Name                 Path
------------------------------------------------------------------
 .bash_history        /home/VirtualMachines/.bash_history
 .bash_logout         /home/VirtualMachines/.bash_logout
 .bash_profile        /home/VirtualMachines/.bash_profile
 .bashrc              /home/VirtualMachines/.bashrc
 .git-prompt.sh       /home/VirtualMachines/.git-prompt.sh
 .gitconfig           /home/VirtualMachines/.gitconfig
 vm-disk1             /home/VirtualMachines/vm-disk1
```

2. **Optional**: Use the **virsh vol-wipe** command to wipe a storage volume. For example, to wipe a storage volume named **vm-disk1** associated with the storage pool **RHEL-SP**:

```
# virsh vol-wipe --pool RHEL-SP vm-disk1
Vol vm-disk1 wiped
```

3. Use the **virsh vol-delete** command to delete a storage volume. For example, to delete a storage volume named **vm-disk1** associated with the storage pool **RHEL-SP**:

```
# virsh vol-delete --pool RHEL-SP vm-disk1
Vol vm-disk1 deleted
```

Verification

- Use the **virsh vol-list** command again to verify that the storage volume was deleted.

```
# virsh vol-list --pool RHEL-SP
 Name                 Path
------------------------------------------------------------------
```

```
.bash_history       /home/VirtualMachines/.bash_history
.bash_logout        /home/VirtualMachines/.bash_logout
.bash_profile       /home/VirtualMachines/.bash_profile
.bashrc             /home/VirtualMachines/.bashrc
.git-prompt.sh      /home/VirtualMachines/.git-prompt.sh
.gitconfig          /home/VirtualMachines/.gitconfig
```

11.7. MANAGING STORAGE FOR VIRTUAL MACHINES USING THE WEB CONSOLE

Using the RHEL 8 web console, you can manage various aspects of a virtual machine's (VM's) storage. You can use the web console to:

- View storage pool information.
- Create storage pools.
- Remove storage pools.
- Deactivate storage pools.
- Create storage volumes.
- Remove storage volumes.
- View VM disk information.
- Add new disks to a VM.
- Attach disks to a VM.
- Detach disks from a VM.

11.7.1. Viewing storage pool information using the web console

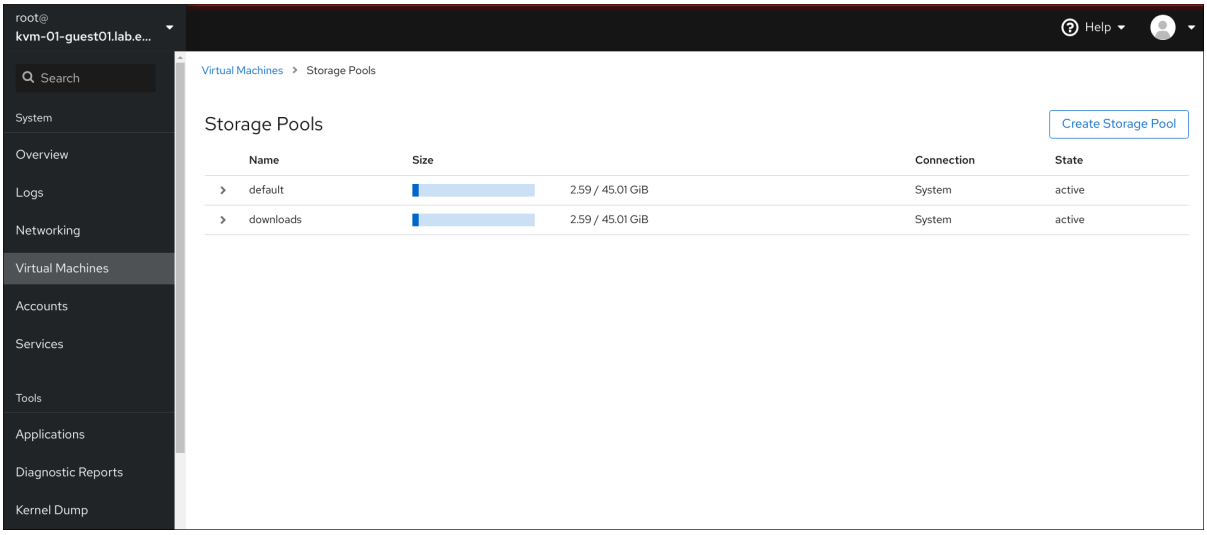
Using the web console, you can view detailed information about storage pools available on your system. Storage pools can be used to create disk images for your virtual machines.

Prerequisites

- The web console VM plug-in is installed on your system.

Procedure

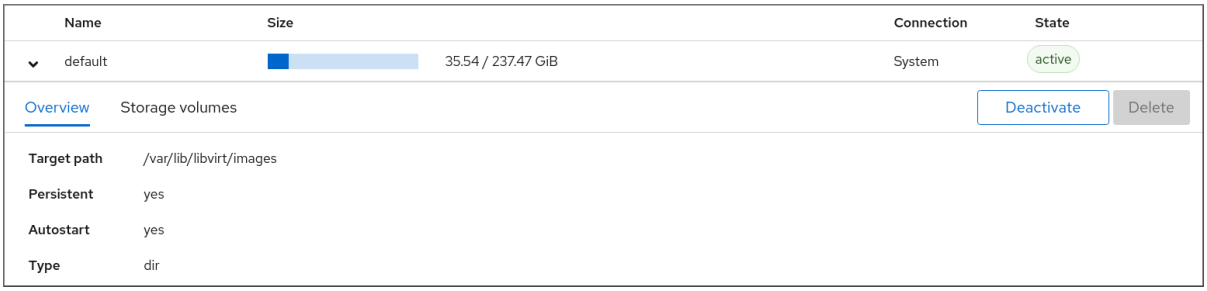
1. Click **Storage Pools** at the top of the **Virtual Machines** interface.
   The Storage Pools window appears, showing a list of configured storage pools.



The information includes the following:

- **Name** - The name of the storage pool.
- **Size** - The current allocation and the total capacity of the storage pool.
- **Connection** - The connection used to access the storage pool.
- **State** - The state of the storage pool.

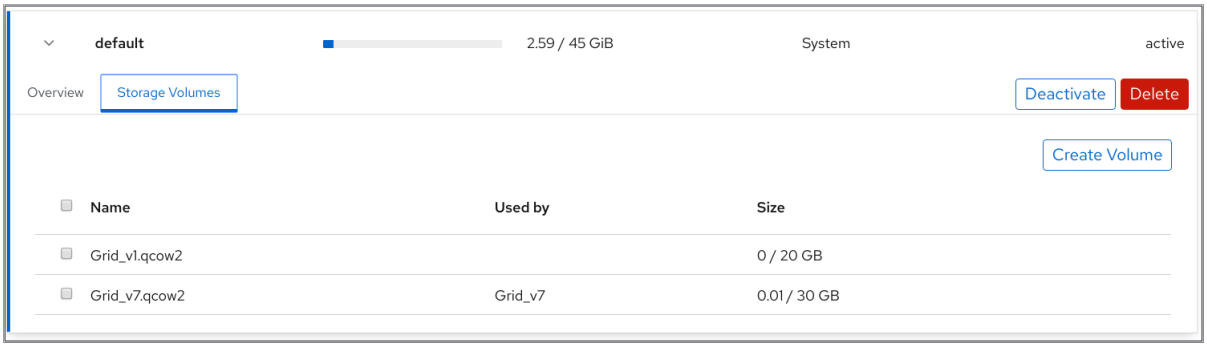
2. Click the row of the storage whose information you want to see.
The row expands to reveal the Overview pane with detailed information about the selected storage pool.



The information includes:

- **Target path** - The source for the types of storage pools backed by directories, such as **dir** or **netfs**.
- **Persistent** - Indicates whether or not the storage pool has a persistent configuration.
- **Autostart** - Indicates whether or not the storage pool starts automatically when the system boots up.
- **Type** - The type of the storage pool.

3. To view a list of storage volumes associated with the storage pool, click **Storage Volumes**.
The Storage Volumes pane appears, showing a list of configured storage volumes.



The information includes:

- **Name** - The name of the storage volume.
- **Used by** - The VM that is currently using the storage volume.
- **Size** - The size of the volume.

Additional resources

- For instructions on viewing information about all of the VMs to which the web console session is connected, see Section 6.2.1, “Viewing a virtualization overview in the web console” .
- For instructions on viewing basic information about a selected VM to which the web console session is connected, see Section 6.2.3, “Viewing basic virtual machine information in the web console”.
- For instructions on viewing resource usage for a selected VM to which the web console session is connected, see Section 6.2.4, “Viewing virtual machine resource usage in the web console” .
- For instructions on viewing disk information about a selected VM to which the web console session is connected, see Section 6.2.5, “Viewing virtual machine disk information in the web console”.
- For instructions on viewing virtual network interface information about a selected VM to which the web console session is connected, see Section 6.2.6, “Viewing and editing virtual network interface information in the web console”.

11.7.2. Creating storage pools using the web console

A virtual machine (VM) requires a file, directory, or storage device that can be used to create storage volumes to store the VM image or act as additional storage. You can create storage pools from local or network-based resources that you can then use to create the storage volumes.

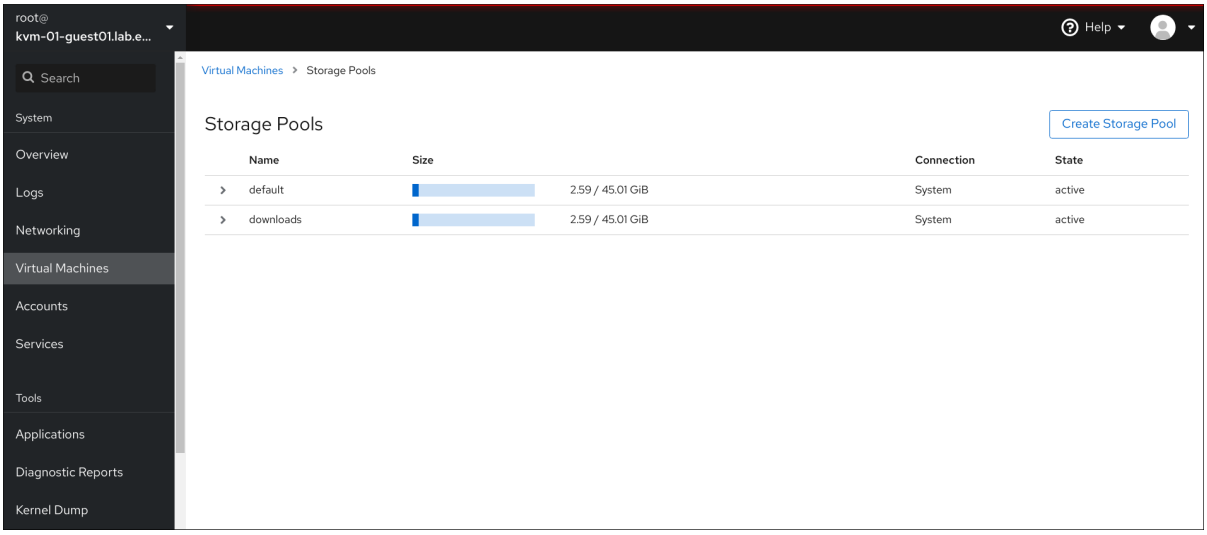
To create storage pools using the RHEL web console, see the following procedure.

Prerequisites

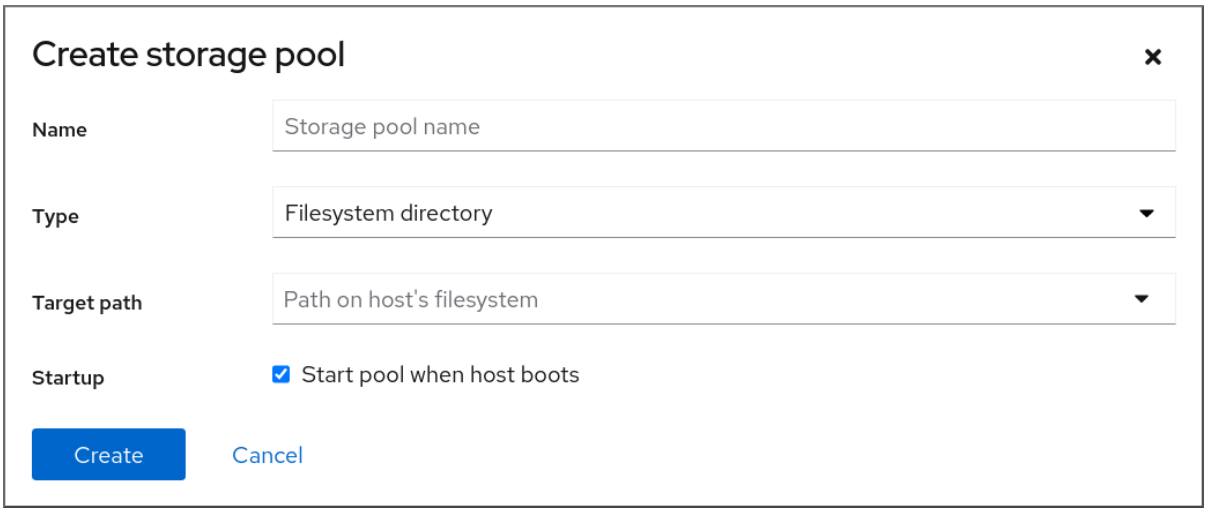
- The web console VM plug-in is installed on your system .

Procedure

1. Click **Storage Pools** at the top of the Virtual Machines tab. The Storage Pools window appears, showing a list of configured storage pools.



2. Click **Create Storage Pool**.
The Create Storage Pool dialog appears.



3. Enter the following information in the Create Storage Pool dialog:

   - **Name** - The name of the storage pool.
   - **Type** - The type of the storage pool. This can be a file-system directory, a network file system, an iSCSI target, a physical disk drive, or an LVM volume group.
   - **Target Path** - The source for the types of storage pools backed by directories, such as **dir** or **netfs**.
   - **Startup** - Whether or not the storage pool starts when the host boots.

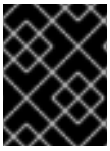
4. Click **Create**. The storage pool is created, the Create Storage Pool dialog closes, and the new storage pool appears in the list of storage pools.

Additional resources

- For more information about storage pools, see Understanding storage pools .
- For instructions on viewing information about storage pools using the web console, see Viewing storage pool information using the web console.

11.7.3. Removing storage pools using the web console

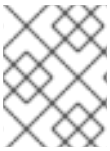
You can remove storage pools to free up resources on the host or on the network to improve system performance. Deleting storage pools also frees up resources that can then be used by other virtual machines (VMs).



IMPORTANT

Unless explicitly specified, deleting a storage pool does not simultaneously delete the storage volumes inside that pool.

To delete a storage pool using the RHEL web console, see the following procedure.



NOTE

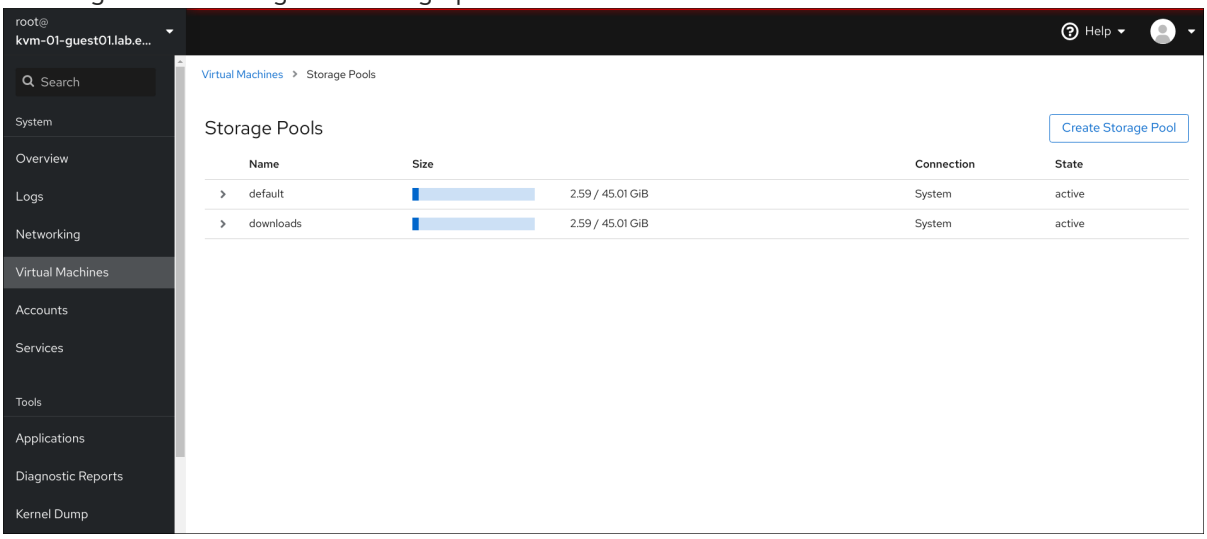
If you want to temporarily deactivate a storage pool instead of deleting it, see Deactivating storage pools using the web console

Prerequisites

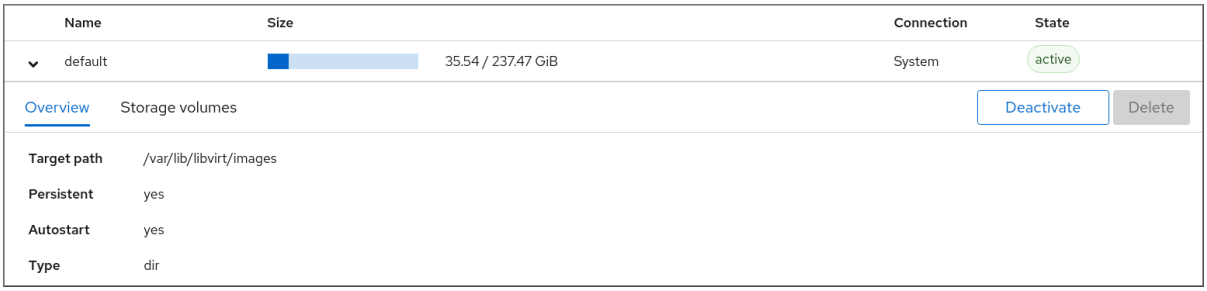
- The web console VM plug-in is installed on your system.
- If you want to delete a storage volume along with the pool, you must first detach the disk from the VM.

Procedure

1. Click **Storage Pools** at the top of the Virtual Machines tab. The Storage Pools window appears, showing a list of configured storage pools.



2. In the **Storage Pools** window, click the storage pool you want to delete.
The row expands to reveal the Overview pane with basic information about the selected storage pool and controls for deactivating or deleting the storage pool.



3. Click **Delete**.
   A confirmation dialog appears.

4. **Optional:** To delete the storage volumes inside the pool, select the check box in the dialog.

5. Click **Delete**.
   The storage pool is deleted. If you had selected the checkbox in the previous step, the associated storage volumes are deleted as well.

Additional resources

- For more information about storage pools, see Understanding storage pools .
- For instructions on viewing information about storage pools using the web console, see viewing storage pool information using the web console.

11.7.4. Deactivating storage pools using the web console

If you do not want to permanently delete a storage pool, you can temporarily deactivate it instead.

When you deactivate a storage pool, no new volumes can be created in that pool. However, any virtual machines (VMs) that have volumes in that pool will continue to run. This is useful for a number of reasons, for example, you can limit the number of volumes that can be created in a pool to increase system performance.

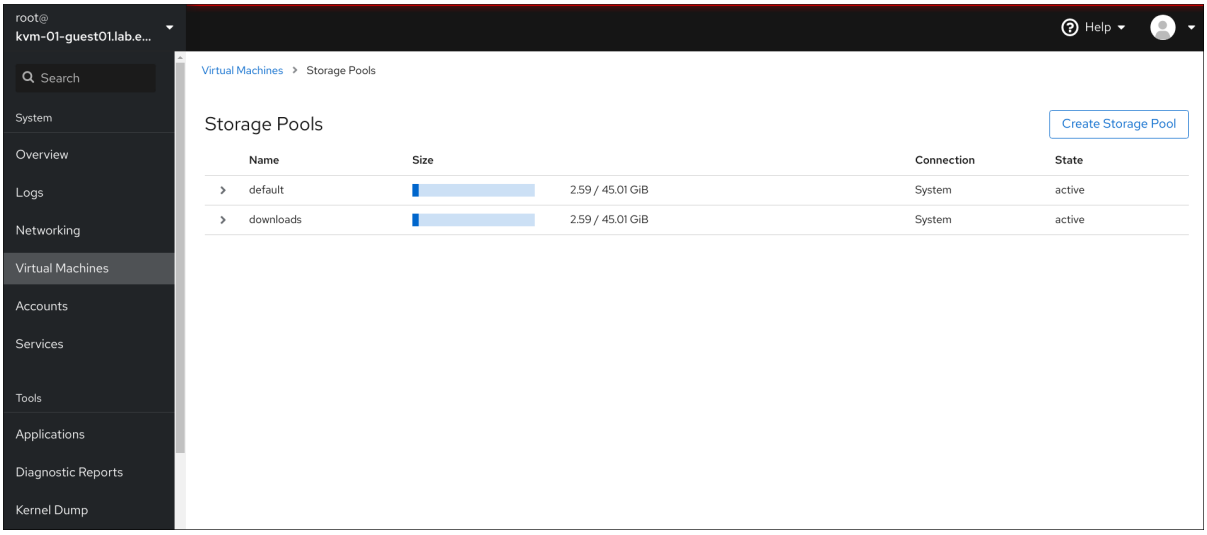
To deactivate a storage pool using the RHEL web console, see the following procedure.

Prerequisites

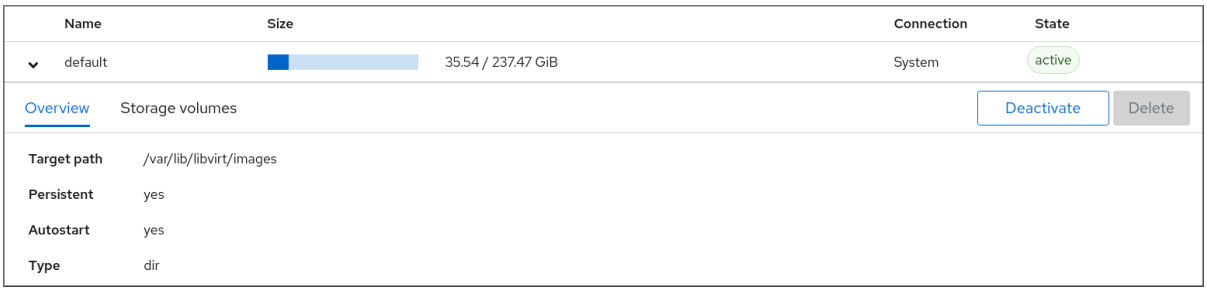
- The web console VM plug-in is installed on your system .

Procedure

1. Click **Storage Pools** at the top of the Virtual Machines tab. The Storage Pools window appears, showing a list of configured storage pools.



2. In the **Storage Pools** window, click the storage pool you want to deactivate.
The row expands to reveal the Overview pane with basic information about the selected storage pool and controls for deactivating and deleting the VM.



3. Click **Deactivate**.
The storage pool is deactivated.

Additional resources

- For more information about storage pools, see Understanding storage pools .
- For instructions on viewing information about storage pools using the web console, see Viewing storage pool information using the web console.

11.7.5. Creating storage volumes using the web console

To create a functioning virtual machine (VM) you require a local storage device assigned to the VM that can store the VM image and VM-related data. You can create a storage volume in a storage pool and assign it to a VM as a storage disk.

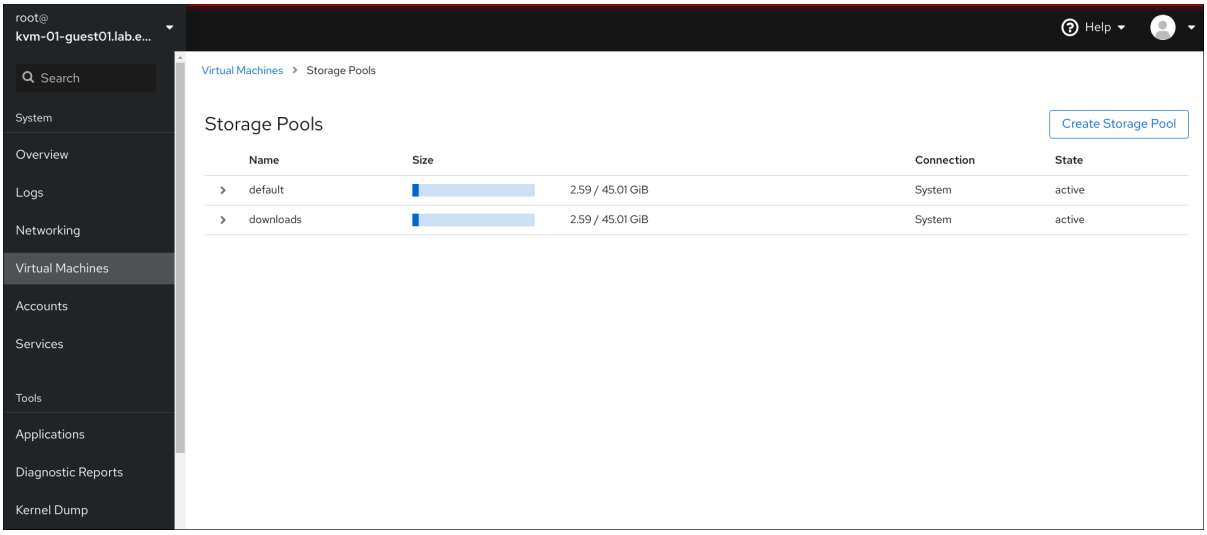
To create storage volumes using the web console, see the following procedure.

Prerequisites

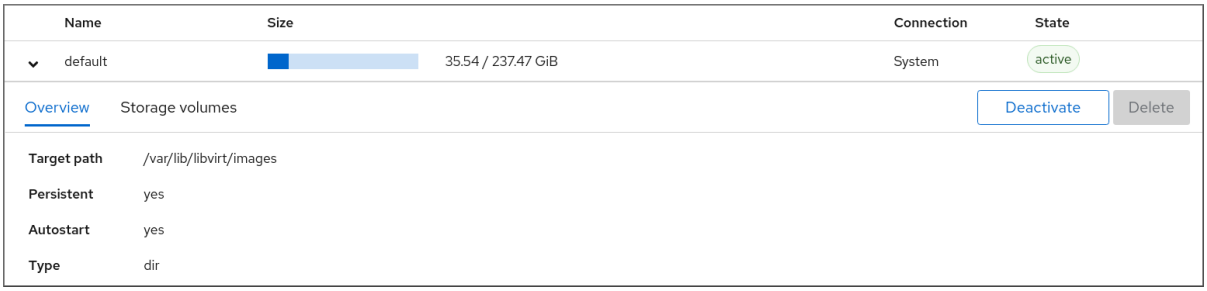
- The web console VM plug-in is installed on your system .

Procedure

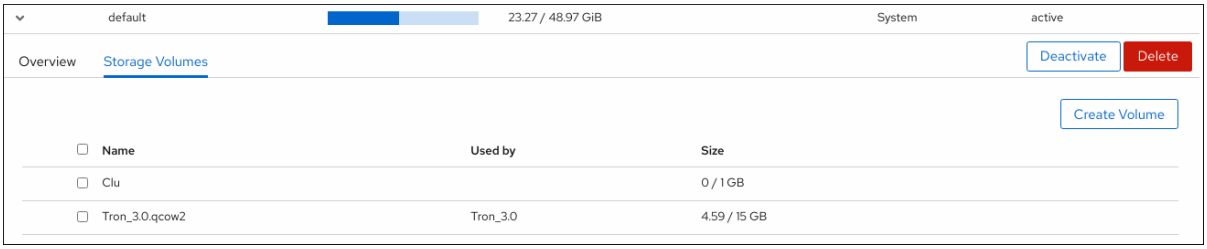
1. Click **Storage Pools** at the top of the Virtual Machines tab. The Storage Pools window appears, showing a list of configured storage pools.



2. In the **Storage Pools** window, click the storage pool from which you want to create a storage volume.
The row expands to reveal the Overview pane with basic information about the selected storage pool.



3. Click **Storage Volumes** next to the Overview tab in the expanded row.
The Storage Volume tab appears with basic information about existing storage volumes, if any.



4. Click **Create Volume**.
The Create Storage Volume dialog appears.

5. Enter the following information in the Create Storage Volume dialog:

- **Name** – The name of the storage volume

- **Name** - The name of the storage volume.
- **Size** - The size of the storage volume in MiB or GiB.
- **Format** - The format of the storage volume. The supported types are **qcow2** and **raw**.

6. Click **Create**.
   The storage volume is created, the Create Storage Volume dialog closes, and the new storage volume appears in the list of storage volumes.

Additional resources

- For more information about storage volumes, see Understanding storage volumes .
- For information about adding disks to VMs using the web console, see Adding new disks to virtual machines using the web console.

11.7.6. Removing storage volumes using the web console

You can remove storage volumes to free up space in the storage pool, or to remove storage items associated with defunct virtual machines (VMs).

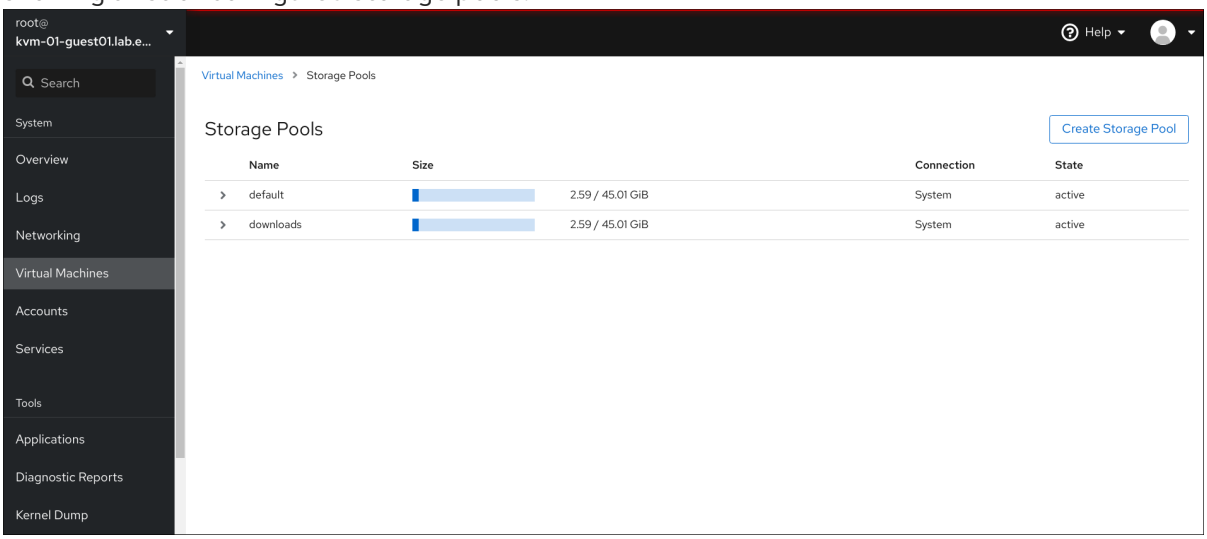
To remove storage volumes using the RHEL web console, see the following procedure.

Prerequisites

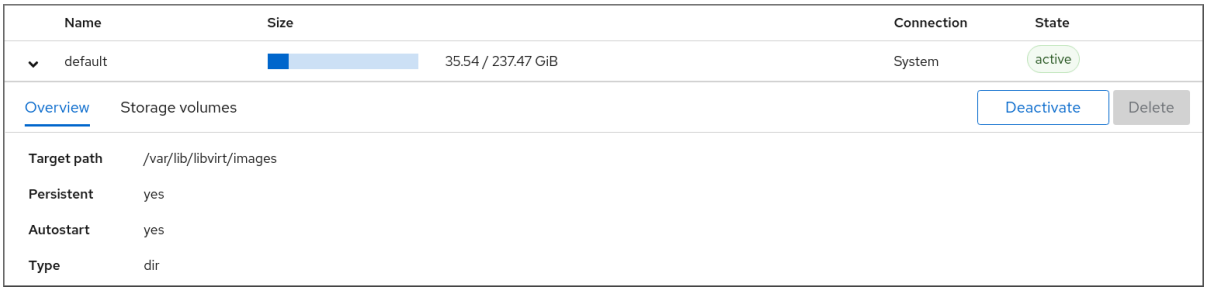
- The web console VM plug-in is installed on your system .
- You must detach the volume from the VM.

Procedure

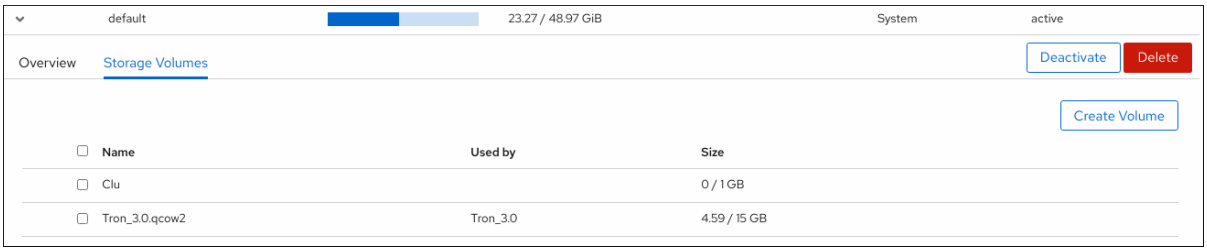
1. Click **Storage Pools** at the top of the Virtual Machines tab. The Storage Pools window appears, showing a list of configured storage pools.



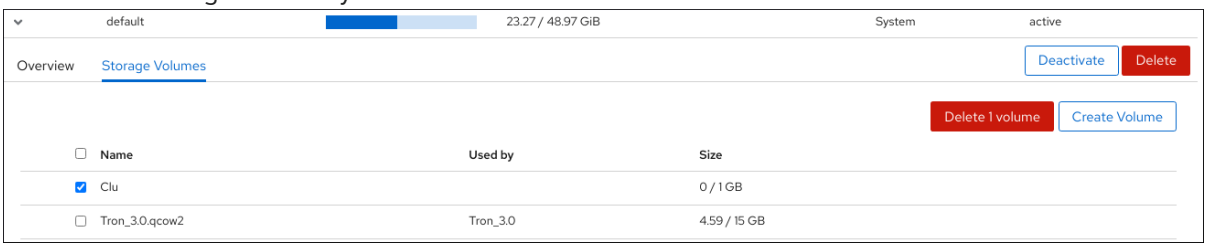
2. In the **Storage Pools** window, click the storage pool from which you want to remove a storage volume.
   The row expands to reveal the Overview pane with basic information about the selected storage pool.



3. Click **Storage Volumes** next to the Overview tab in the expanded row.
The Storage Volume tab appears with basic information about existing storage volumes, if any.



4. Select the storage volume you want to remove.



5. Click **Delete 1 Volume**

Additional resources

- For more information about storage volumes, see Understanding storage volumes .

11.7.7. Viewing virtual machine disk information in the web console

Using the web console, you can view detailed information about disks assigned to a selected virtual machine (VM).

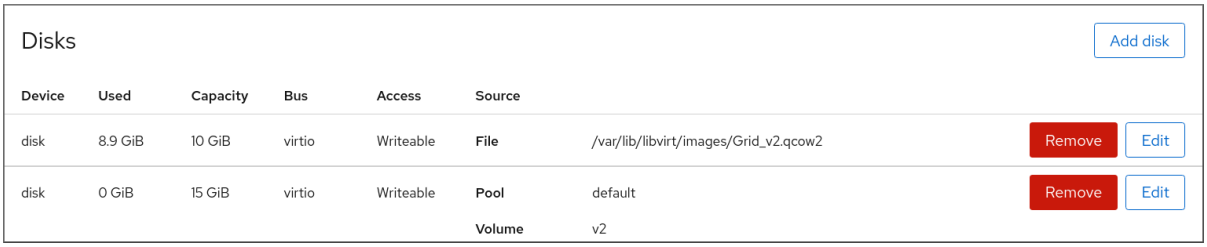
Prerequisites

- The web console VM plug-in is installed on your system .

Procedure

1. Click the VM whose information you want to see.
A new page opens with an Overview section with basic information about the selected VM and a Console section to access the VM's graphical interface.

2. Scroll to **Disks**.
The Disks section displays information about the disks assigned to the VM as well as options to **Add**, **Remove**, or **Edit** disks.



The information includes the following:

- **Device** - The device type of the disk.
- **Used** - The amount of disk currently allocated.
- **Capacity** - The maximum size of the storage volume.
- **Bus** - The type of disk device that is emulated.
- **Access** - Whether the disk is **Writeable** or **Read-only**. For **raw** disks, you can also set the access to **Writeable and shared**.
- **Source** - The disk device or file.

Additional resources

- For instructions on viewing information about all of the VMs to which the web console session is connected, see Section 6.2.1, "Viewing a virtualization overview in the web console" .
- For instructions on viewing information about the storage pools to which the web console session is connected, see Section 6.2.2, "Viewing storage pool information using the web console".
- For instructions on viewing basic information about a selected VM to which the web console session is connected, see Section 6.2.3, "Viewing basic virtual machine information in the web console".
- For instructions on viewing resource usage for a selected VM to which the web console session is connected, see Section 6.2.4, "Viewing virtual machine resource usage in the web console" .
- For instructions on viewing virtual network interface information about a selected VM to which the web console session is connected, see Section 6.2.6, "Viewing and editing virtual network interface information in the web console".

11.7.8. Adding new disks to virtual machines using the web console

You can add new disks to virtual machines (VMs) by creating a new storage volume and attaching it to a VM using the RHEL 8 web console.

Prerequisites

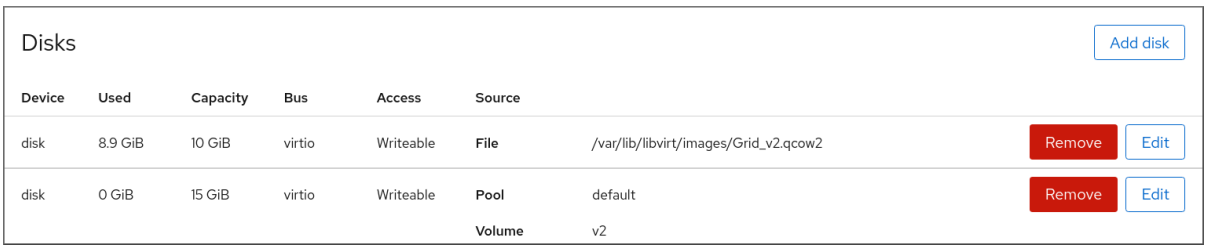
- The web console VM plug-in is installed on your system.

Procedure

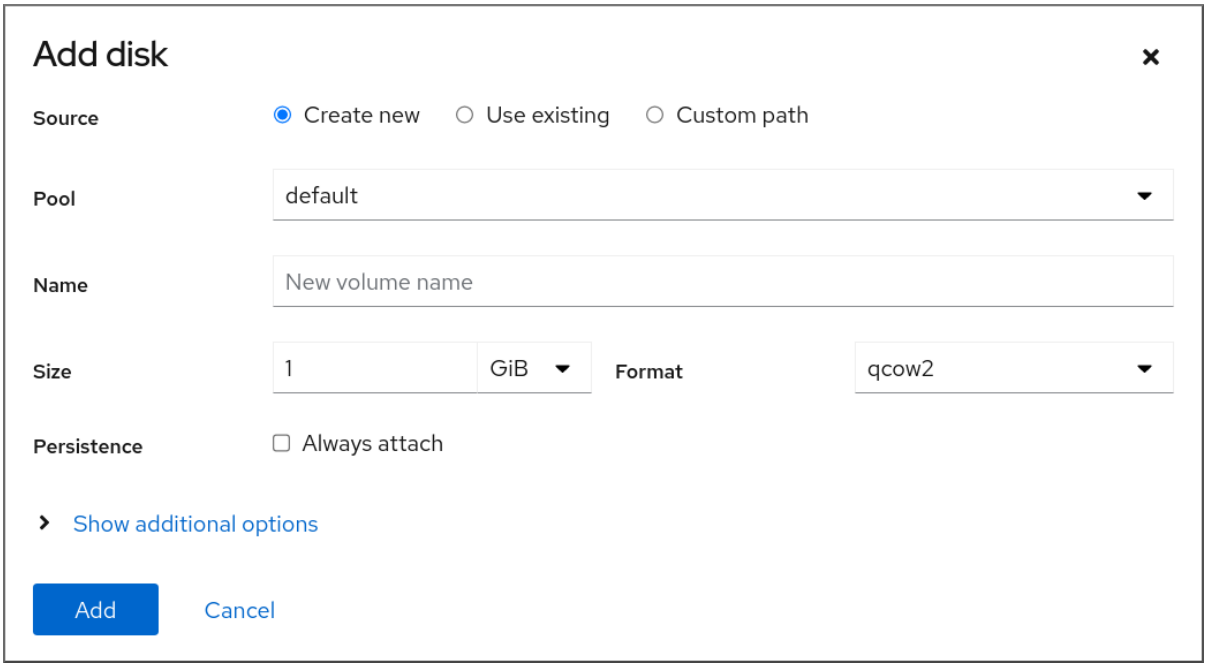
1. In the **Virtual Machines** interface, click the VM for which you want to create and attach a new disk.

A new page opens with an Overview section with basic information about the selected VM and a Console section to access the VM's graphical interface.

2. Scroll to **Disks**.
   The Disks section displays information about the disks assigned to the VM as well as options to **Add**, **Remove**, or **Edit** disks.



3. Click **Add Disk**.
   The Add Disk dialog appears.



4. Select the *Create New* option.

5. Configure the new disk.

   - **Pool** - Select the storage pool from which the virtual disk will be created.
   - **Name** - Enter a name for the virtual disk that will be created.
   - **Size** - Enter the size and select the unit (MiB or GiB) of the virtual disk that will be created.
   - **Format** - Select the format for the virtual disk that will be created. The supported types are **qcow2** and **raw**.
   - **Persistence** - If checked, the virtual disk is persistent. If not checked, the virtual disk is transient.

NOTE

Transient disks can only be added to VMs that are running.

- **Additional Options** - Set additional configurations for the virtual disk.
  - **Cache** - Select the cache mechanism.
  - **Bus** - Select the type of disk device to emulate.

6. Click **Add**.
   The virtual disk is created and connected to the VM.

Additional resources

- For instructions on viewing disk information about a selected VM to which the web console session is connected, see Section 11.7.7, "Viewing virtual machine disk information in the web console".
- For information on attaching existing disks to VMs, see Section 11.7.9, "Attaching existing disks to virtual machines using the web console".
- For information on detaching disks from VMs, see Section 11.7.10, "Detaching disks from virtual machines using the web console".

11.7.9. Attaching existing disks to virtual machines using the web console

Using the web console, you can attach existing storage volumes as disks to a virtual machine (VM).

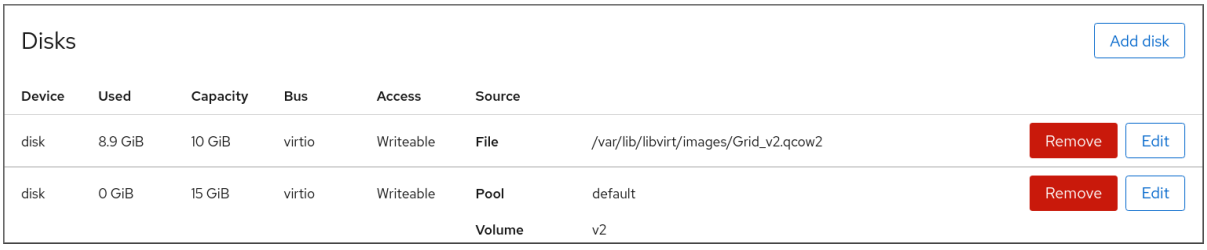
Prerequisites

- The web console VM plug-in is installed on your system.

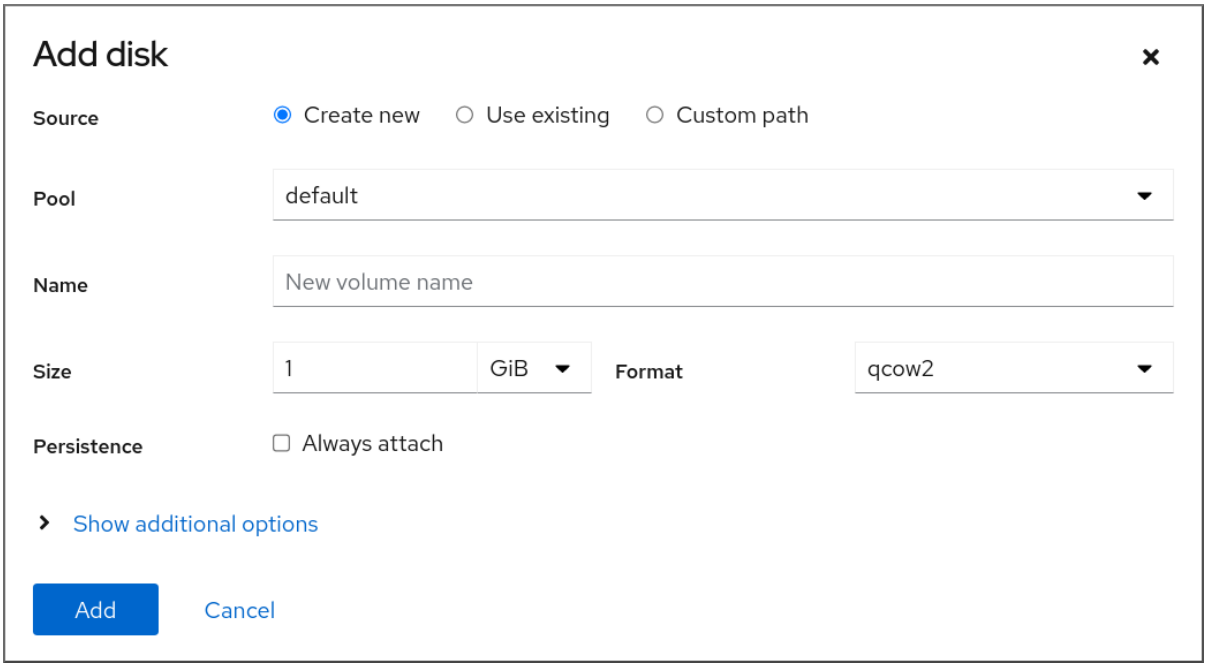
Procedure

1. In the **Virtual Machines** interface, click the VM for which you want to create and attach a new disk.
   A new page opens with an Overview section with basic information about the selected VM and a Console section to access the VM's graphical interface.

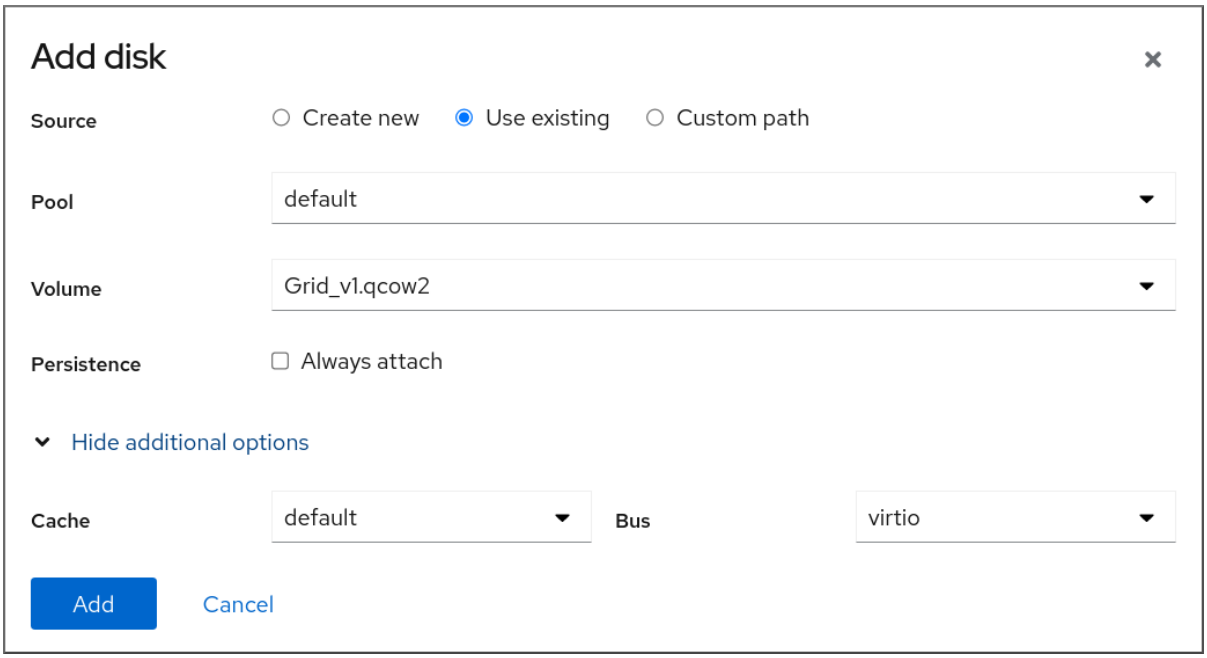
2. Scroll to **Disks**.
   The Disks section displays information about the disks assigned to the VM as well as options to **Add**, **Remove**, or **Edit** disks.



3. Click **Add Disk**.
   The Add Disk dialog appears.



4. Click the **Use Existing** radio button.
The appropriate configuration fields appear in the Add Disk dialog.



5. Configure the disk for the VM.

- **Pool** - Select the storage pool from which the virtual disk will be attached.
- **Volume** - Select the storage volume that will be attached.
- **Persistence** - Check to make the virtual disk persistent. Clear to make the virtual disk transient.
- **Additional Options** - Set additional configurations for the virtual disk.
  - **Cache** - Select the cache mechanism.
  - **Bus** - Select the type of disk device to emulate.

6. Click **Add**
   The selected virtual disk is attached to the VM.

Additional resources

- For instructions on viewing disk information about a selected VM to which the web console session is connected, see Section 11.7.7, "Viewing virtual machine disk information in the web console".
- For information on creating new disks and attaching them to VMs, see Section 11.7.8, "Adding new disks to virtual machines using the web console".
- For information on detaching disks from VMs, see Section 11.7.10, "Detaching disks from virtual machines using the web console".

11.7.10. Detaching disks from virtual machines using the web console

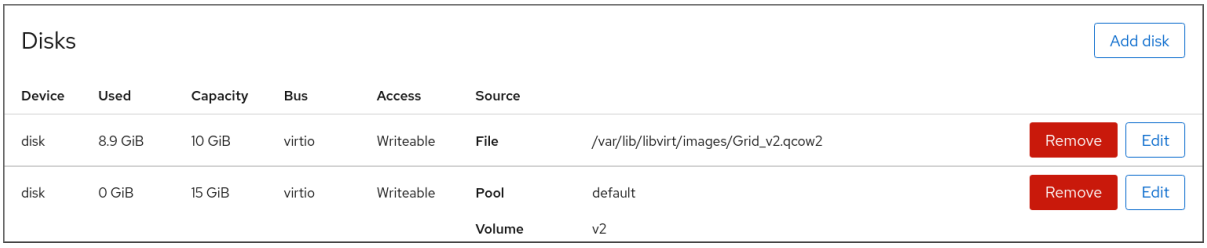
Using the web console, you can detach disks from virtual machines (VMs).

Prerequisites

- The web console VM plug-in is installed on your system.

Procedure

1. In the **Virtual Machines** interface, click the VM from which you want to detach a disk.
   A new page opens with an Overview section with basic information about the selected VM and a Console section to access the VM's graphical interface.
2. Scroll to **Disks**.
   The Disks section displays information about the disks assigned to the VM as well as options to **Add**, **Remove**, or **Edit** disks.



3. Click the **Remove** button next to the disk you want to detach from the VM. A **Remove Disk** confirmation dialog box appears.
4. In the confirmation dialog box, click **Remove**.
   The virtual disk is detached from the VM.

Additional resources

- For instructions on viewing disk information about a selected VM to which the web console session is connected, see Section 11.7.7, "Viewing virtual machine disk information in the web console".
- For information on creating new disks and attaching them to VMs, see Section 11.7.8, "Adding new disks to virtual machines using the web console".

- For information on attaching existing disks to VMs, see Section 11.7.9, “Attaching existing disks to virtual machines using the web console”.

11.8. SECURING ISCSI STORAGE POOLS WITH LIBVIRT SECRETS

User name and password parameters can be configured with **virsh** to secure an iSCSI storage pool. You can configure this before or after you define the pool, but the pool must be started for the authentication settings to take effect.

The following provides instructions for securing iSCSI-based storage pools with **libvirt** secrets.

NOTE

This procedure is required if a ***user_ID*** and ***password*** were defined when creating the iSCSI target.

Prerequisites

- Ensure that you have created an iSCSI-based storage pool. For more information, see Section 11.3.5, “Creating iSCSI-based storage pools using the CLI”

Procedure

1. Create a libvirt secret file with a challenge-handshake authentication protocol (CHAP) user name. For example:

```
<secret ephemeral='no' private='yes'>
   <description>Passphrase for the iSCSI example.com server</description>
   <usage type='iscsi'>
      <target>iscsirhel7secret</target>
   </usage>
</secret>
```

2. Define the libvirt secret with the **virsh secret-define** command.
 # virsh secret-define *secret.xml*

3. Verify the UUID with the **virsh secret-list** command.

```
# virsh secret-list
UUID                                   Usage
--------------------------------------------------------------------------------
2d7891af-20be-4e5e-af83-190e8a922360  iscsi iscsirhel7secret
```

4. Assign a secret to the UUID in the output of the previous step using the **virsh secret-set-value** command. This ensures that the CHAP username and password are in a libvirt-controlled secret list. For example:

```
# virsh secret-set-value --interactive 2d7891af-20be-4e5e-af83-190e8a922360
Enter new value for secret:
Secret value set
```

5. Add an authentication entry in the storage pool’s XML file using the **virsh edit** command, and add an **<auth>** element, specifying **authentication type**, **username**, and **secret usage**.

For example:

```
<pool type='iscsi'>
  <name>iscsirhel7pool</name>
    <source>
      <host name='192.168.122.1'/>
      <device path='iqn.2010-05.com.example.server1:iscsirhel7guest'/>
      <auth type='chap' username='redhat'>
        <secret usage='iscsirhel7secret'/>
      </auth>
    </source>
  <target>
    <path>/dev/disk/by-path</path>
  </target>
</pool>
```

NOTE

The **<auth>** sub-element exists in different locations within the virtual machine's **<pool>** and **<disk>** XML elements. For a **<pool>**, **<auth>** is specified within the **<source>** element, as this describes where to find the pool sources, since authentication is a property of some pool sources (iSCSI and RBD). For a **<disk>**, which is a sub-element of a domain, the authentication to the iSCSI or RBD disk is a property of the disk. In addition, the **<auth>** sub-element for a disk differs from that of a storage pool.

```
<auth username='redhat'>
  <secret type='iscsi' usage='iscsirhel7secret'/>
</auth>
```

6. To activate the changes, activate the storage pool. If the pool has already been started, stop and restart the storage pool:

```
# virsh pool-destroy iscsirhel7pool
# virsh pool-start iscsirhel7pool
```

11.9. CREATING VHBAS

A virtual host bus adapter (vHBA) device connects the host system to an SCSI device and is required for creating an SCSI-based storage pool.

You can create a vHBA device by defining it in an XML configuration file.

Procedure

1. Locate the HBAs on your host system, using the **virsh nodedev-list --cap vports** command. The following example shows a host that has two HBAs that support vHBA:

```
# virsh nodedev-list --cap vports
scsi_host3
scsi_host4
```

2. View the HBA's details, using the **virsh nodedev-dumpxml *HBA_device*** command.

```
# virsh nodedev-dumpxml scsi_host3
```

The output from the command lists the **<name>**, **<wwnn>**, and **<wwpn>** fields, which are used to create a vHBA. **<max_vports>** shows the maximum number of supported vHBAs. For example:

```
<device>
  <name>scsi_host3</name>
  <path>/sys/devices/pci0000:00/0000:00:04.0/0000:10:00.0/host3</path>
  <parent>pci_0000_10_00_0</parent>
  <capability type='scsi_host'>
    <host>3</host>
    <unique_id>0</unique_id>
    <capability type='fc_host'>
      <wwnn>20000000c9848140</wwnn>
      <wwpn>10000000c9848140</wwpn>
      <fabric_wwn>2002000573de9a81</fabric_wwn>
    </capability>
    <capability type='vport_ops'>
      <max_vports>127</max_vports>
      <vports>0</vports>
    </capability>
  </capability>
</device>
```

In this example, the **<max_vports>** value shows there are a total 127 virtual ports available for use in the HBA configuration. The **<vports>** value shows the number of virtual ports currently being used. These values update after creating a vHBA.

3. Create an XML file similar to one of the following for the vHBA host. In these examples, the file is named **vhba_host3.xml**.
This example uses **scsi_host3** to describe the parent vHBA.

```
<device>
  <parent>scsi_host3</parent>
  <capability type='scsi_host'>
    <capability type='fc_host'>
    </capability>
  </capability>
</device>
```

This example uses a WWNN/WWPN pair to describe the parent vHBA.

```
<device>
  <name>vhba</name>
  <parent wwnn='20000000c9848140' wwpn='10000000c9848140'/>
  <capability type='scsi_host'>
    <capability type='fc_host'>
    </capability>
  </capability>
</device>
```

NOTE

The WWNN and WWPN values must match those in the HBA details seen in the previous step.

The **<parent>** field specifies the HBA device to associate with this vHBA device. The details in the **<device>** tag are used in the next step to create a new vHBA device for the host. For more information on the **nodedev** XML format, see the libvirt upstream pages.

NOTE

The **virsh** command does not provide a way to define the **parent_wwnn**, **parent_wwpn**, or **parent_fabric_wwn** attributes.

4. Create a VHBA based on the XML file created in the previous step using the **virsh nodev-create** command.

```
# virsh nodedev-create vhba_host3
Node device scsi_host5 created from vhba_host3.xml
```

Verification

- Verify the new vHBA's details (scsi_host5) using the **virsh nodedev-dumpxml** command:

```
# virsh nodedev-dumpxml scsi_host5
<device>
  <name>scsi_host5</name>
  <path>/sys/devices/pci0000:00/0000:00:04.0/0000:10:00.0/host3/vport-3:0-0/host5</path>
  <parent>scsi_host3</parent>
  <capability type='scsi_host'>
    <host>5</host>
    <unique_id>2</unique_id>
    <capability type='fc_host'>
      <wwnn>5001a4a93526d0a1</wwnn>
      <wwpn>5001a4ace3ee047d</wwpn>
      <fabric_wwn>2002000573de9a81</fabric_wwn>
    </capability>
  </capability>
</device>
```

Additional resources

- For information about creating SCSI-based storage pools with vHBA devices, see Section 11.3.8, "Creating SCSI-based storage pools with vHBA devices using the CLI".

CHAPTER 12. MANAGING GPU DEVICES IN VIRTUAL MACHINES

To enhance the graphical performance of your virtual machine (VMs) on a RHEL 8 host, you can assign a host GPU to a VM.

- You can detach the GPU from the host and pass full control of the GPU directly to the VM.
- You can create multiple mediated devices from a physical GPU, and assign these devices as virtual GPUs (vGPUs) to multiple guests. This is currently only supported on selected NVIDIA GPUs, and only one mediated device can be assigned to a single guest.

12.1. ASSIGNING A GPU TO A VIRTUAL MACHINE

To access and control GPUs that are attached to the host system, you must configure the host system to pass direct control of the GPU to the virtual machine (VM).

NOTE

If you are looking for information about assigning a virtual GPU, see Managing NVIDIA vGPU devices.

Prerequisites

- You must enable IOMMU support on the host machine kernel.
  - On an Intel host, you must enable VT-d:
    1. Regenerate the GRUB configuration with the **intel_iommu=on** parameter:

       ```
       # grubby --args="intel_iommu=on" --update-kernel DEFAULT
       ```

    2. If **intel_iommu=on** works, you can try replacing it with **iommu=pt** to switch it to passthrough mode.

       ```
       # grubby --args="iommu=pt" --update-kernel DEFAULT
       ```

       NOTE

       The **pt** option only enables IOMMU for devices used in pass-through mode and provides better host performance. However, not all hardware supports the option. Revert to the **intel_iommu=on** option if the **iommu=pt** option does not work on your host.

    3. Reboot the host.
  - On an AMD host, you must enable AMD-Vi.
    Note that on AMD hosts, IOMMU is enabled by default, you can add **iommu=pt** to switch it to pass-through mode:
    1. Regenerate the GRUB configuration with the **iommu=pt** parameter:

       ```
       # grubby --args="iommu=pt" --update-kernel DEFAULT
       ```

NOTE

The **pt** option only enables IOMMU for devices used in pass-through mode and provides better host performance. However, not all hardware supports the option. You can still assign devices irrespective of whether this option is enabled.

2. Reboot the host.

Procedure

1. Prevent the driver from binding to the GPU.

   a. Identify the PCI bus address to which the GPU is attached.

   ```
   # lspci -Dnn | grep VGA
   0000:02:00.0 VGA compatible controller [0300]: NVIDIA Corporation GK106GL [Quadro K4000] [10de:11fa] (rev a1)
   ```

   b. Prevent the host's graphics driver from using the GPU. To do so, use the GPU's PCI ID with the pci-stub driver.
   For example, the following command prevents the driver from binding to the GPU attached at the **10de:11fa** bus:

   ```
   # grubby --args="pci-stub.ids=10de:11fa" --update-kernel DEFAULT
   ```

   c. Reboot the host.

2. **Optional:** If certain GPU functions, such as audio, cannot be passed through to the VM due to support limitations, you can modify the driver bindings of the endpoints within an IOMMU group to pass through only the necessary GPU functions.

   a. Convert the GPU settings to XML and note the PCI address of the endpoints that you want to prevent from attaching to the host drivers.
   To do so, convert the GPU's PCI bus address to a libvirt-compatible format by adding the **pci_** prefix to the address, and converting the delimiters to underscores.

   For example, the following command displays the XML configuration of the GPU attached at the **0000:02:00.0** bus address.

   ```
   # virsh nodedev-dumpxml pci_0000_02_00_0
   ```

   ```
   <device>
    <name>pci_0000_02_00_0</name>
    <path>/sys/devices/pci0000:00/0000:00:03.0/0000:02:00.0</path>
    <parent>pci_0000_00_03_0</parent>
    <driver>
     <name>pci-stub</name>
    </driver>
    <capability type='pci'>
     <domain>0</domain>
     <bus>2</bus>
     <slot>0</slot>
     <function>0</function>
   ```

```
 <product id='0x11fa'>GK106GL [Quadro K4000]</product>
 <vendor id='0x10de'>NVIDIA Corporation</vendor>
 <iommuGroup number='13'>
  <address domain='0x0000' bus='0x02' slot='0x00' function='0x0'/>
  <address domain='0x0000' bus='0x02' slot='0x00' function='0x1'/>
 </iommuGroup>
 <pci-express>
  <link validity='cap' port='0' speed='8' width='16'/>
  <link validity='sta' speed='2.5' width='16'/>
 </pci-express>
</capability>
</device>
```

b. Prevent the endpoints from attaching to the host driver.
In this example, to assign the GPU to a VM, prevent the endpoints that correspond to the audio function, **<address domain='0x0000' bus='0x02' slot='0x00' function='0x1'/>**, from attaching to the host audio driver, and instead attach the endpoints to VFIO-PCI.

```
# driverctl set-override 0000:02:00.1 vfio-pci
```

3. Attach the GPU to the VM

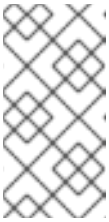
a. Create an XML configuration file for the GPU by using the PCI bus address.
For example, you can create the following XML file, GPU-Assign.xml, by using parameters from the GPU's bus address.

```
<hostdev mode='subsystem' type='pci' managed='yes'>
 <driver name='vfio'/>
 <source>
  <address domain='0x0000' bus='0x02' slot='0x00' function='0x0'/>
 </source>
</hostdev>
```

b. Save the file on the host system.

c. Merge the file with the VM's XML configuration.
For example, the following command merges the GPU XML file, GPU-Assign.xml, with the XML configuration file of the **System1** VM.

```
# virsh attach-device System1 --file /home/GPU-Assign.xml --persistent
Device attached successfully.
```



NOTE

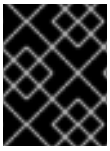
The GPU is attached as a secondary graphics device to the VM. Assigning a GPU as the primary graphics device is not supported, and Red Hat does not recommend removing the primary emulated graphics device in the VM's XML configuration.

Verification

- The device appears under the **<devices>** section in VM's XML configuration. For more information, see Sample virtual machine XML configuration.

12.2. MANAGING NVIDIA VGPU DEVICES

The vGPU feature makes it possible to divide a physical NVIDIA GPU device into multiple virtual devices, referred to as **mediated devices**. These mediated devices can then be assigned to multiple virtual machines (VMs) as virtual GPUs. As a result, these VMs can share the performance of a single physical GPU.



IMPORTANT

Assigning a physical GPU to VMs, with or without using mediated devices, makes it impossible for the host to use the GPU.

12.2.1. Setting up NVIDIA vGPU devices

To set up the NVIDIA vGPU feature, you need to download NVIDIA vGPU drivers for your GPU device, create mediated devices, and assign them to the intended virtual machines. For detailed instructions, see below.

Prerequisites

- The *mdevctl* package is installed.

```
# yum install mdevctl
```

- Your GPU supports vGPU mediated devices. For an up-to-date list of NVIDIA GPUs that support creating vGPUs, see the NVIDIA GPU Software Documentation .
  - If you do not know which GPU your host is using, install the *lshw* package and use the **lshw -C display** command. The following example shows the system is using an NVIDIA Tesla P4 GPU, compatible with vGPU.

```
# lshw -C display

*-display
       description: 3D controller
       product: GP104GL [Tesla P4]
       vendor: NVIDIA Corporation
       physical id: 0
       bus info: pci@0000:01:00.0
       version: a1
       width: 64 bits
       clock: 33MHz
       capabilities: pm msi pciexpress cap_list
       configuration: driver=vfio-pci latency=0
       resources: irq:16 memory:f6000000-f6ffffff memory:e0000000-efffffff
memory:f0000000-f1ffffff
```

Procedure

1. Download the NVIDIA vGPU drivers and install them on your system. For instructions, see the NVIDIA documentation.

2. If the NVIDIA software installer did not create the **/etc/modprobe.d/nvidia-installer-disable-nouveau.conf** file, create a **conf** file of any name in **/etc/modprobe.d/**, and add the following lines in the file:

```
blacklist nouveau
options nouveau modeset=0
```

3. Regenerate the initial ramdisk for the current kernel, then reboot.

```
# dracut --force
# reboot
```

4. Check that the kernel has loaded the **nvidia_vgpu_vfio** module and that the **nvidia-vgpu-mgr.service** service is running.

```
# lsmod | grep nvidia_vgpu_vfio
nvidia_vgpu_vfio 45011 0
nvidia 14333621 10 nvidia_vgpu_vfio
mdev 20414 2 vfio_mdev,nvidia_vgpu_vfio
vfio 32695 3 vfio_mdev,nvidia_vgpu_vfio,vfio_iommu_type1

# systemctl status nvidia-vgpu-mgr.service
nvidia-vgpu-mgr.service - NVIDIA vGPU Manager Daemon
   Loaded: loaded (/usr/lib/systemd/system/nvidia-vgpu-mgr.service; enabled; vendor preset:
disabled)
   Active: active (running) since Fri 2018-03-16 10:17:36 CET; 5h 8min ago
 Main PID: 1553 (nvidia-vgpu-mgr)
 [...]
```

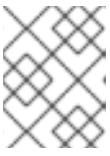
5. Generate a device UUID.

```
# uuidgen
30820a6f-b1a5-4503-91ca-0c10ba58692a
```

6. Create a mediated device from the GPU hardware that you detected in the prerequisites, and assign the generated UUID to the device.

   The following example shows how to create a mediated device of the **nvidia-63** vGPU type on an NVIDIA Tesla P4 card that runs on the 0000:01:00.0 PCI bus:

```
# mdevctl start -u 30820a6f-b1a5-4503-91ca-0c10ba58692a -p 0000:01:00.0 --type
nvidia-63
```



NOTE

For the vGPU type values for specific GPU devices, see the Virtual GPU software documentation.

7. Make the mediated device persistent:

```
# mdevctl define --auto --uuid 30820a6f-b1a5-4503-91ca-0c10ba58692a
```

8. Attach the mediated device to a VM that you want to share the vGPU resources. To do so, add the following lines, along with the previously genereated UUID, to the **<devices/>** sections in the XML configuration of the VM.

```
<hostdev mode='subsystem' type='mdev' managed='no' model='vfio-pci'>
  <source>
    <address uuid='30820a6f-b1a5-4503-91ca-0c10ba58692a'/>
  </source>
</hostdev>
```

   Note that each UUID can only be assigned to one VM at a time.

9. For full functionality of the vGPU mediated devices to be available on the assigned VMs, set up NVIDIA vGPU guest software licensing on the VMs. For further information and instructions, see the NVIDIA Virtual GPU Software License Server User Guide .

Verification

- List the active mediated devices on your host. If the output displays a defined device with the UUID used in the procedure, NVIDIA vGPU has been configured correctly. For example:

```
# mdevctl list
85006552-1b4b-45ef-ad62-de05be9171df 0000:01:00.0 nvidia-63
30820a6f-b1a5-4503-91ca-0c10ba58692a 0000:01:00.0 nvidia-63 (defined)
```

Additional resources

- For more information on using the **mdevctl** utility, use **man mdevctl**.

12.2.2. Removing NVIDIA vGPU devices

To change the configuration of assigned vGPU mediated devices, you need to remove the existing devices from the assigned VMs. For instructions, see below:

Prerequisites

- The *mdevctl* package is installed.

```
# yum install mdevctl
```

- The VM from which you want to remove the device is shut down.

Procedure

1. Obtain the UUID of the mediated device that you want to remove. To do so, use the **mdevctl list** command:

```
# mdevctl list
85006552-1b4b-45ef-ad62-de05be9171df 0000:01:00.0 nvidia-63 (defined)
30820a6f-b1a5-4503-91ca-0c10ba58692a 0000:01:00.0 nvidia-63 (defined)
```

2. Stop the running instance of the mediated vGPU device. To do so, use the **mdevctl stop** command with the UUID of the device. For example, to stop the **30820a6f-b1a5-4503-91ca-0c10ba58692a** device:

```
# mdevctl stop -u 30820a6f-b1a5-4503-91ca-0c10ba58692a
```

3. Remove the device from the XML configuration of the VM. To do so, use the **virsh edit** utility to edit the XML configuration of the VM, and remove the mdev's configuration segment. The segment will look similar to the following:

```
<hostdev mode='subsystem' type='mdev' managed='no' model='vfio-pci'>
  <source>
    <address uuid='30820a6f-b1a5-4503-91ca-0c10ba58692a'/>
  </source>
</hostdev>
```

Note that stopping and detaching the mediated device does not delete it, but rather keeps it as **defined**. As such, you can restart and attach the device to a different VM.

4. **Optional:** To delete the stopped mediated device, remove its definition:

```
# mdevctl undefine -u 30820a6f-b1a5-4503-91ca-0c10ba58692a
```

Verification

- If you only stopped and detached the device, list the active mediated devices and the defined mediated devices.

```
# mdevctl list
85006552-1b4b-45ef-ad62-de05be9171df 0000:01:00.0 nvidia-63 (defined)
# mdevctl list --defined
85006552-1b4b-45ef-ad62-de05be9171df 0000:01:00.0 nvidia-63 auto (active)
30820a6f-b1a5-4503-91ca-0c10ba58692a 0000:01:00.0 nvidia-63 manual
```

If the first command does not display the device but the second command does, the procedure was successful.

- If you also deleted the device, the second command should not display the device.

```
# mdevctl list
85006552-1b4b-45ef-ad62-de05be9171df 0000:01:00.0 nvidia-63 (defined)
# mdevctl list --defined
85006552-1b4b-45ef-ad62-de05be9171df 0000:01:00.0 nvidia-63 auto (active)
```

Additional resources

- For more information on using the **mdevctl** utility, use **man mdevctl**.

12.2.3. Obtaining NVIDIA vGPU information about your system

To evaluate the capabilities of the vGPU features available to you, you can obtain additional information about the mediated devices on your system, such as:

- How many mediated devices of a given type can be created

- What mediated devices are already configured on your system.

Prerequisites

- The *mdevctl* package is installed.

```
# yum install mdevctl
```

Procedure

- To see the available vGPU types on your host, use the **mdevctl types** command.
  For example, the following shows the information for a system that uses a physical Tesla T4 card under the 0000:41:00.0 PCI bus:

```
# mdevctl types
0000:41:00.0
  nvidia-222
    Available instances: 0
    Device API: vfio-pci
    Name: GRID T4-1B
    Description: num_heads=4, frl_config=45, framebuffer=1024M,
max_resolution=5120x2880, max_instance=16
  nvidia-223
    Available instances: 0
    Device API: vfio-pci
    Name: GRID T4-2B
    Description: num_heads=4, frl_config=45, framebuffer=2048M,
max_resolution=5120x2880, max_instance=8
  nvidia-224
    Available instances: 0
    Device API: vfio-pci
    Name: GRID T4-2B4
    Description: num_heads=4, frl_config=45, framebuffer=2048M,
max_resolution=5120x2880, max_instance=8
  nvidia-225
    Available instances: 0
    Device API: vfio-pci
    Name: GRID T4-1A
    Description: num_heads=1, frl_config=60, framebuffer=1024M,
max_resolution=1280x1024, max_instance=16
    [...]
```

- To see the active vGPU devices on your host, including their types, UUIDs, and PCI buses of parent devices, use the **mdevctl list** command:

```
# mdevctl list
85006552-1b4b-45ef-ad62-de05be9171df 0000:41:00.0 nvidia-223
83c32df7-d52e-4ec1-9668-1f3c7e4df107 0000:41:00.0 nvidia-223 (defined)
```

  This example shows that the **85006552-1b4b-45ef-ad62-de05be9171df** device is running but not defined, and the **83c32df7-d52e-4ec1-9668-1f3c7e4df107** is both defined and running.

Additional resources

- For more information on using the **mdevctl** utility, use **man mdevctl**.

12.2.4. Remote desktop streaming services for NVIDIA vGPU

The following remote desktop streaming services have been successfully tested for use with the NVIDIA vGPU feature in RHEL 8 hosts:

- **HP-RGS** - Note that it is currently not possible to use HP-RGS with RHEL 8 VMs.
- **Mechdyne TGX** - Note that it is currently not possible to use Mechdyne TGX with Windows Server 2016 VMs.
- **NICE DCV** - When using this desktop streaming service, use fixed resolution settings. Using dynamic resolution in some cases results in a black screen. In addition, it is currently not possible to use NICE DCV with RHEL 8 VMs.

12.2.5. Related information

- For further information on using NVIDIA vGPU on RHEL with KVM, see the NVIDIA GPU Software Documentation.

CHAPTER 13. CONFIGURING VIRTUAL MACHINE NETWORK CONNECTIONS

For your virtual machines (VMs) to connect over a network to your host, to other VMs on your host, and to locations on an external network, the VM networking must be configured accordingly. To provide VM networking, the RHEL 8 hypervisor and newly created VMs have a default network configuration, which can also be modified further. For example:

- You can enable the VMs on your host to be discovered and connected to by locations outside the host, as if the VMs were on the same network as the host.
- You can partially or completely isolate a VM from inbound network traffic to increase its security and minimize the risk of any problems with the VM impacting the host.

The following sections explain the various types of VM network configuration and provide instructions for setting up selected VM network configurations.

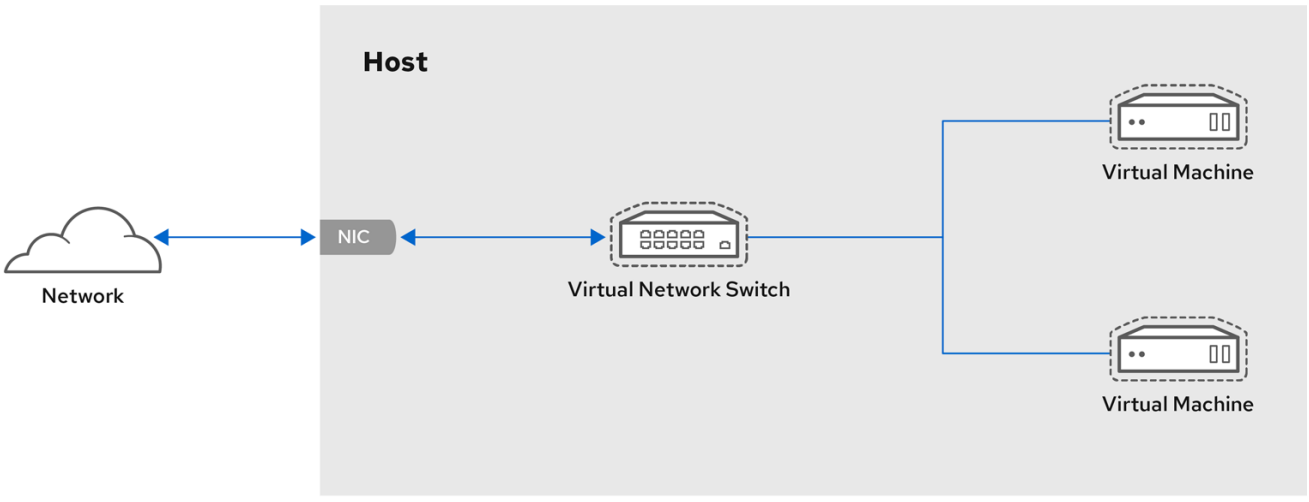
13.1. UNDERSTANDING VIRTUAL NETWORKING

The connection of virtual machines (VMs) to other devices and locations on a network has to be facilitated by the host hardware. The following sections explain the mechanisms of VM network connections and describe the default VM network setting.

13.1.1. How virtual networks work

Virtual networking uses the concept of a virtual network switch. A virtual network switch is a software construct that operates on a host machine. VMs connect to the network through the virtual network switch. Based on the configuration of the virtual switch, a VM can use an existing virtual network managed by the hypervisor, or a different network connection method.

The following figure shows a virtual network switch connecting two VMs to the network:



From the perspective of a guest operating system, a virtual network connection is the same as a physical network connection. Host machines view virtual network switches as network interfaces. When the **libvirtd** service is first installed and started, it creates **virbr0**, the default network interface for VMs.

To view information about this interface, use the **ip** utility on the host.

```
$ ip addr show virbr0
3: virbr0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc noqueue state
 UNKNOWN link/ether 1b:c4:94:cf:fd:17 brd ff:ff:ff:ff:ff:ff
 inet 192.168.122.1/24 brd 192.168.122.255 scope global virbr0
```

By default, all VMs on a single host are connected to the same NAT-type virtual network, named **default**, which uses the **virbr0** interface. For details, see Section 13.1.2, "Virtual networking default configuration".

For basic outbound-only network access from VMs, no additional network setup is usually needed, because the default network is installed along with the **libvirt** package, and is automatically started when the **libvirtd** service is started.

If a different VM network functionality is needed, you can create additional virtual networks and network interfaces and configure your VMs to use them. In addition to the default NAT, these networks and interfaces can be configured to use one of the following modes:

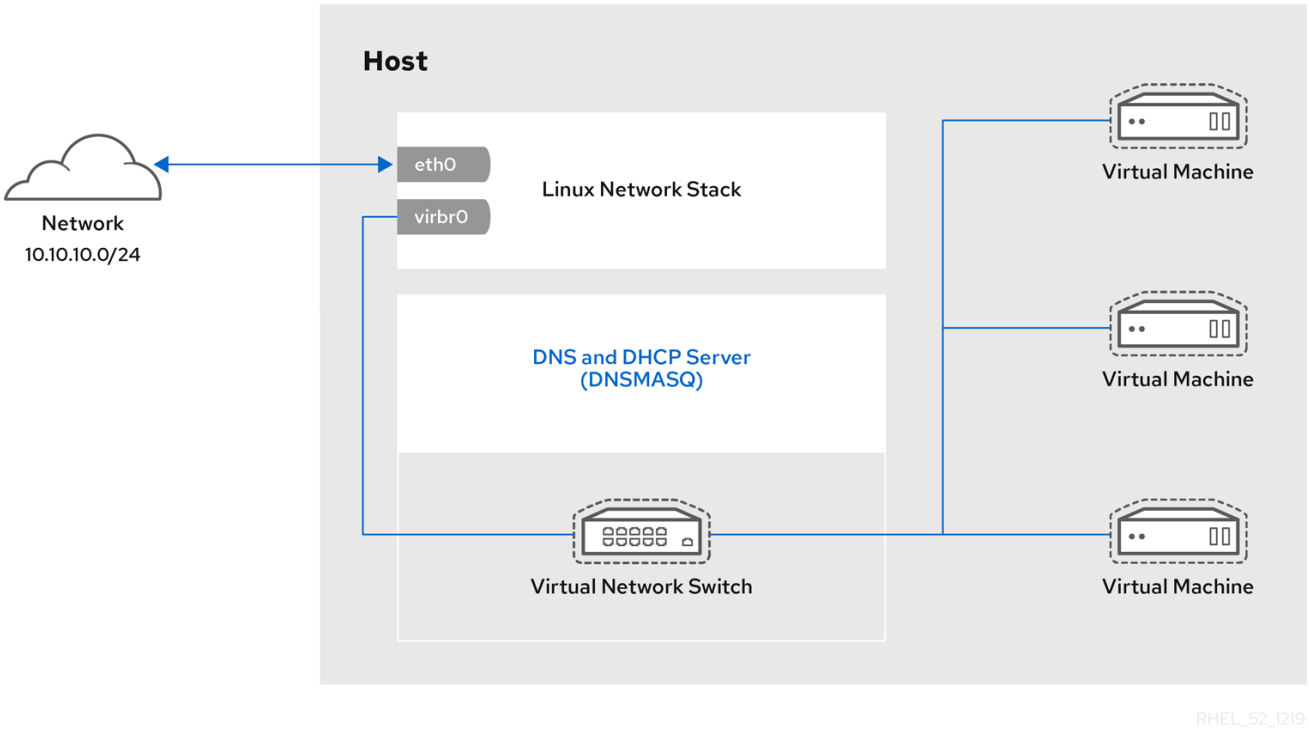
- Routed mode
- Bridged mode
- Isolated mode
- Open mode

13.1.2. Virtual networking default configuration

When the **libvirtd** service is first installed on a virtualization host, it contains an initial virtual network configuration in network address translation (NAT) mode. By default, all VMs on the host are connected to the same **libvirt** virtual network, named **default**. VMs on this network can connect to locations both on the host and on the network beyond the host, but with the following limitations:

- VMs on the network are visible to the host and other VMs on the host, but the network traffic is affected by the firewalls in the guest operating system's network stack and by the **libvirt** network filtering rules attached to the guest interface.
- VMs on the network can connect to locations outside the host but are not visible to them. Outbound traffic is affected by the NAT rules, as well as the host system's firewall.

The following diagram illustrates the default VM network configuration:



13.2. USING THE WEB CONSOLE FOR MANAGING VIRTUAL MACHINE NETWORK INTERFACES

Using the RHEL 8 web console, you can manage the virtual network interfaces for the virtual machines to which the web console is connected. You can:

- View information about network interfaces and edit them .
- Add network interfaces to virtual machines , and disconnect or delete the interfaces.

13.2.1. Viewing and editing virtual network interface information in the web console

Using the RHEL 8 web console, you can view and modify the virtual network interfaces on a selected virtual machine (VM):

Prerequisites

- The web console VM plug-in is installed on your system .

Procedure

1. In the **Virtual Machines** interface, click the VM whose information you want to see.
   A new page opens with an Overview section with basic information about the selected VM and a Console section to access the VM's graphical interface.

2. Scroll to **Network Interfaces**.
   The Networks Interfaces section displays information about the virtual network interface configured for the VM as well as options to **Add**, **Delete**, **Edit**, or **Unplug** network interfaces.

+ The information includes the following:

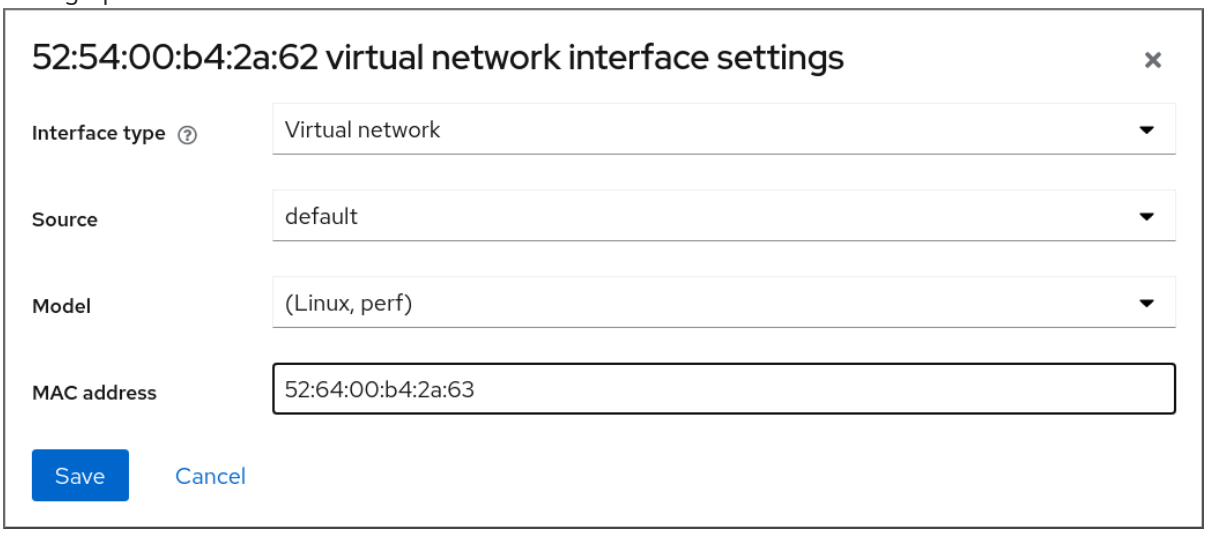
- **Type** - The type of network interface for the VM. The types include virtual network, bridge to LAN, and direct attachment.

NOTE

Generic Ethernet connection is not supported in RHEL 8 and later.

- **Model type** - The model of the virtual network interface.
- **MAC Address** - The MAC address of the virtual network interface.
- **IP Address** - The IP address of the virtual network interface.
- **Source** - The source of the network interface. This is dependent on the network type.
- **State** - The state of the virtual network interface.

3. To edit the virtual network interface settings, Click **Edit**. The Virtual Network Interface Settings dialog opens.



4. Change the interface type, source, model, or MAC address.
5. Click **Save**. The network interface is modified.

NOTE

Changes to the virtual network interface settings take effect only after restarting the VM.

Additionally, MAC address can only be modified when the VM is shut off.

13.2.2. Adding and connecting virtual network interfaces in the web console

Using the RHEL 8 web console, you can create a virtual network interface and connect a virtual machine (VM) to it.

Prerequisites

- The web console VM plug-in is installed on your system.

Procedure

1. In the **Virtual Machines** interface, click the VM whose information you want to see.
   A new page opens with an Overview section with basic information about the selected VM and a Console section to access the VM's graphical interface.

2. Scroll to **Network Interfaces**.
   The Networks Interfaces section displays information about the virtual network interface configured for the VM as well as options to **Add**, **Delete**, **Edit**, or **Plug** network interfaces.

3. Click **Plug** in the row of the virtual network interface you want to connect.
   The selected virtual network interface connects to the VM.

13.2.3. Disconnecting and removing virtual network interfaces in the web console

Using the RHEL 8 web console, you can disconnect the virtual network interfaces connected to a selected virtual machine (VM).

Prerequisites

- The web console VM plug-in is installed on your system.

Procedure

1. In the **Virtual Machines** interface, click the VM whose information you want to see.
   A new page opens with an Overview section with basic information about the selected VM and a Console section to access the VM's graphical interface.

2. Scroll to **Network Interfaces**.
   The Networks Interfaces section displays information about the virtual network interface configured for the VM as well as options to **Add**, **Delete**, **Edit**, or **Unplug** network interfaces.

3. Click **Unplug** in the row of the virtual network interface you want to disconnect.
   The selected virtual network interface disconnects from the VM.

13.3. RECOMMENDED VIRTUAL MACHINE NETWORKING CONFIGURATIONS USING THE COMMAND-LINE INTERFACE

In many scenarios, the default VM networking configuration is sufficient. However, if adjusting the configuration is required, you can use the command-line interface (CLI) to do so. The following sections describe selected VM network setups for such situations.

13.3.1. Configuring externally visible virtual machines using the command-line interface

By default, a newly created VM connects to a NAT-type network that uses **virbr0**, the default virtual bridge on the host. This ensures that the VM can use the host's network interface controller (NIC) for connecting to outside networks, but the VM is not reachable from external systems.

If you require a VM to appear on the same external network as the hypervisor, you must use bridged mode instead. To do so, attach the VM to a bridge device connected to the hypervisor's physical network device. To use the command-line interface for this, follow the instructions below.

Prerequisites

- A shut-down existing VM with the default NAT setup.
- The IP configuration of the hypervisor. This varies depending on the network connection of the host. As an example, this procedure uses a scenario where the host is connected to the network using an ethernet cable, and the hosts' physical NIC MAC address is assigned to a static IP on a DHCP server. Therefore, the ethernet interface is treated as the hypervisor IP.
  To obtain the IP configuration of the ethernet interface, use the **ip addr** utility:

```
# ip addr
[...]
enp0s25: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP
group default qlen 1000
    link/ether 54:ee:75:49:dc:46 brd ff:ff:ff:ff:ff:ff
    inet 10.0.0.148/24 brd 10.0.0.255 scope global dynamic noprefixroute enp0s25
```

Procedure

1. Create and set up a bridge connection for the physical interface on the host. For instructions, see the Configuring a network bridge .
   Note that in a scenario where static IP assignment is used, you must move the IPv4 setting of the physical ethernet interface to the bridge interface.

2. Modify the VM's network to use the created bridged interface. For example, the following sets *testguest* to use *bridge0*.

```
# virt-xml testguest --edit --network bridge=bridge0
Domain 'testguest' defined successfully.
```

3. Start the VM.

```
# virsh start testguest
```

4. In the guest operating system, adjust the IP and DHCP settings of the system's network interface as if the VM was another physical system in the same network as the hypervisor. The specific steps for this will differ depending on the guest OS used by the VM. For example, if the guest OS is RHEL 8, see Configuring an Ethernet connection.

Verification

1. Ensure the newly created bridge is running and contains both the host's physical interface and the interface of the VM.

```
# ip link show master bridge0
2: enp0s25: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel master
bridge0 state UP mode DEFAULT group default qlen 1000
    link/ether 54:ee:75:49:dc:46 brd ff:ff:ff:ff:ff:ff
10: vnet0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel master
bridge0 state UNKNOWN mode DEFAULT group default qlen 1000
    link/ether fe:54:00:89:15:40 brd ff:ff:ff:ff:ff:ff
```

2. Ensure the VM appears on the same external network as the hypervisor:

   a. In the guest operating system, obtain the network ID of the system. For example, if it is a Linux guest:

```
# ip addr
[...]
enp0s0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state
UP group default qlen 1000
    link/ether 52:54:00:09:15:46 brd ff:ff:ff:ff:ff:ff
    inet 10.0.0.150/24 brd 10.0.0.255 scope global dynamic noprefixroute enp0s0
```

   b. From an external system connected to the local network, connect to the VM using the obtained ID.

```
# ssh root@10.0.0.150
root@10.0.0.150's password:
Last login: Mon Sep 24 12:05:36 2019
root~#*
```

   If the connection works, the network has been configured successfully.

Additional resources

- For instructions on creating an externally visible VM using the web console, see Section 13.4.1, "Configuring externally visible virtual machines using the web console".
- For additional information on bridged mode, see Section 13.5.3, "Virtual networking in bridged mode".
- In certain situations, such as when a using client-to-site VPN while the VM is hosted on the client, using bridged mode for making your VMs available to external locations is not possible. To work around this problem, you can set a destination NAT for the VM. For details, see the Configuring and managing networking document.

13.3.2. Isolating virtual machines from each other using the command-line interface

To prevent a virtual machine (VM) from communicating with other VMs on your host, for example to avoid data sharing or to increase system security, you can completely isolate the VM from host-side network traffic.

By default, a newly created VM connects to a NAT-type network that uses **virbr0**, the default virtual bridge on the host. This ensures that the VM can use the host's NIC for connecting to outside networks, as well as to other VMs on the host. This is a generally secure connection, but in some cases, connectivity to the other VMs may be a security or data privacy hazard. In such situations, you can isolate the VM by using direct **macvtap** connection in private mode instead of the default network.

In private mode, the VM is visible to external systems and can receive a public IP on the host's subnet, but the VM and the host cannot access each other, and the VM is also not visible to other VMs on the host.

For instructions to set up **macvtap** private mode on your VM using the CLI, see below.

Prerequisites

- An existing VM with the default NAT setup.
- The name of the host interface that you want to use for the **macvtap** connection. The interface you must select will vary depending on your use case and the network configuration on your host. As an example, this procedure uses the host's physical ethernet interface.
  To obtain the name of the targeted interface:

```
$ ip addr
[...]
2: enp0s31f6: <NO-CARRIER,BROADCAST,MULTICAST,UP> mtu 1500 qdisc fq_codel
state DOWN group default qlen 1000
    link/ether 54:e1:ad:42:70:45 brd ff:ff:ff:ff:ff:ff
[...]
```

Procedure

- Use the selected interface to set up private **macvtap** on the selected VM. The following example configures **macvtap** in private mode on the **enp0s31f6** interface for the VM named *panic-room*.

```
# virt-xml panic-room --edit --network
type=direct,source=enp0s31f6,source.mode=private
Domain panic-room XML defined successfully
```

Verification

1. Start the updated VM.

```
# virsh start panic-room
Domain panic-room started
```

2. List the interface statistics for the VM.

```
# virsh domstats panic-room --interface
Domain: 'panic-room'
  net.count=1
```

```
net.0.name=macvtap0
net.0.rx.bytes=0
net.0.rx.pkts=0
net.0.rx.errs=0
net.0.rx.drop=0
net.0.tx.bytes=0
net.0.tx.pkts=0
net.0.tx.errs=0
net.0.tx.drop=0
```

If the command displays similar output, the VM has been isolated successfully.

Additional resources

- For instructions on isolating a VM using the web console, see Section 13.4.2, "Isolating virtual machines from each other using the web console".
- For additional information about **macvtap** private mode, see Section 13.5.6, "Direct attachment of the virtual network device".
- For additional security measures that you can set on a VM, see Chapter 15, *Securing virtual machines*.

13.4. RECOMMENDED VIRTUAL MACHINE NETWORKING CONFIGURATIONS USING THE WEB CONSOLE

In many scenarios, the default VM networking configuration is sufficient. However, if adjusting the configuration is required, you can use the RHEL 8 web console to do so. The following sections describe selected VM network setups for such situations.

13.4.1. Configuring externally visible virtual machines using the web console

By default, a newly created VM connects to a NAT-type network that uses **virbr0**, the default virtual bridge on the host. This ensures that the VM can use the host's network interface controller (NIC) for connecting to outside networks, but the VM is not reachable from external systems.

If you require a VM to appear on the same external network as the hypervisor, you must use bridged mode instead. To do so, attach the VM to a bridge device connected to the hypervisor's physical network device. To use the RHEL 8 web console for this, follow the instructions below.

Prerequisites

- The web console VM plug-in is installed on your system.
- A shut-down existing VM with the default NAT setup.
- The IP configuration of the hypervisor. This varies depending on the network connection of the host. As an example, this procedure uses a scenario where the host is connected to the network using an ethernet cable, and the hosts' physical NIC MAC address is assigned to a static IP on a DHCP server. Therefore, the ethernet interface is treated as the hypervisor IP.
  To obtain the IP configuration of the ethernet interface, go to the **Networking** tab in the web console, and see the **Interfaces** section.

Procedure

1. Create and set up a bridge connection for the physical interface on the host. For instructions, see Configuring network bridges in the web console .
   Note that in a scenario where static IP assignment is used, you must move the IPv4 setting of the physical ethernet interface to the bridge interface.

2. Modify the VM's network to use the bridged interface. In the Network Interfaces tab of the VM:

   a. Click **Add Network Interface**

   b. In the **Add Virtual Network Interface** dialog, set:

      - **Interface Type** to **Bridge to LAN**
      - Source to the newly created bridge, for example **bridge0**

   c. Click **Add**

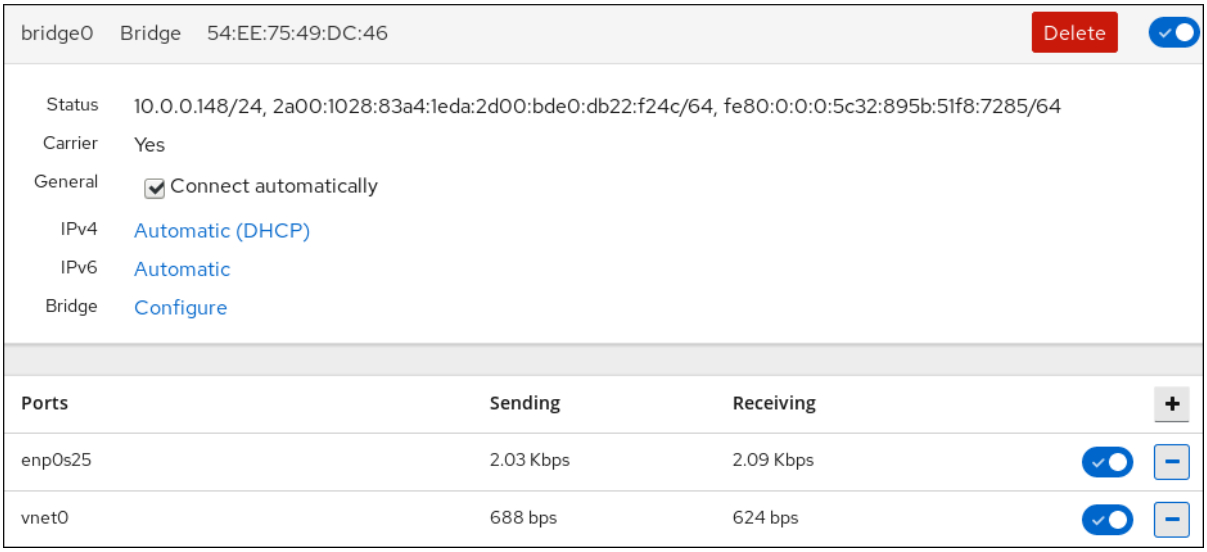
   d. **Optional**: Click **Unplug** for all the other interfaces connected to the VM.

3. Click **Run** to start the VM.

4. In the guest operating system, adjust the IP and DHCP settings of the system's network interface as if the VM was another physical system in the same network as the hypervisor.
   The specific steps for this will differ depending on the guest OS used by the VM. For example, if the guest OS is RHEL 8, see Configuring an Ethernet connection.

Verification

1. In the **Networking** tab of the host's web console, click the row with the newly created bridge to ensure it is running and contains both the host's physical interface and the interface of the VM.



2. Ensure the VM appears on the same external network as the hypervisor.

a. In the guest operating system, obtain the network ID of the system. For example, if it is a Linux guest:

```
# ip addr
[...]
enp0s0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state
UP group default qlen 1000
    link/ether 52:54:00:09:15:46 brd ff:ff:ff:ff:ff:ff
    inet 10.0.0.150/24 brd 10.0.0.255 scope global dynamic noprefixroute enp0s0
```

b. From an external system connected to the local network, connect to the VM using the obtained ID.

```
# ssh root@10.0.0.150
root@110.34.5.18's password:
Last login: Mon Sep 24 12:05:36 2019
root~#*
```

If the connection works, the network has been configured successfully.

Additional resources

- For instructions on creating an externally visible VM using the CLI, see Section 13.3.1, "Configuring externally visible virtual machines using the command-line interface".
- For additional information on bridged mode, see Section 13.5.3, "Virtual networking in bridged mode".
- In certain situations, such as when a using client-to-site VPN while the VM is hosted on the client, using bridged mode for making your VMs available to external locations is not possible. To work around this problem, you can set a destination NAT for the VM. For details, see the Configuring and managing networking document.

13.4.2. Isolating virtual machines from each other using the web console

To prevent a virtual machine (VM) from communicating with other VMs on your host, for example to avoid data sharing or to increase system security, you can completely isolate the VM from host-side network traffic.

By default, a newly created VM connects to a NAT-type network that uses **virbr0**, the default virtual bridge on the host. This ensures that the VM can use the host's NIC for connecting to outside networks, as well as to other VMs on the host. This is a generally secure connection, but in some cases, connectivity to the other VMs may be a security or data privacy hazard. In such situations, you can isolate the VM by using direct **macvtap** connection in private mode instead of the default network.

In private mode, the VM is visible to external systems and can receive a public IP on the host's subnet, but the VM and the host cannot access each other, and the VM is also not visible to other VMs on the host.

For instructions to set up **macvtap** private mode on your VM using the web console, see below.

Prerequisites

- The web console VM plug-in is installed on your system.

- An existing VM with the default NAT setup.

Procedure

1. In the **Virtual Machines** pane, click the row with the virtual machine you want to isolate.
   A pane with the basic information about the VM opens.
2. Click the **Network Interfaces** tab.
3. Click **Edit**.
   The **Virtual Machine Interface Settings** dialog opens.
4. Set **Interface Type** to **Direct Attachment**
5. Set **Source** to the host interface of your choice.
   Note that the interface you select will vary depending on your use case and the network configuration on your host.

Verification

1. Start the VM by clicking **Run**.
2. In the **Terminal** pane of the web console, list the interface statistics for the VM. For example, to view the network interface traffic for the *panic-room* VM:

```
# virsh domstats panic-room --interface
Domain: 'panic-room'
  net.count=1
  net.0.name=macvtap0
  net.0.rx.bytes=0
  net.0.rx.pkts=0
  net.0.rx.errs=0
  net.0.rx.drop=0
  net.0.tx.bytes=0
  net.0.tx.pkts=0
  net.0.tx.errs=0
  net.0.tx.drop=0
```

   If the command displays similar output, the VM has been isolated successfully.

Additional resources

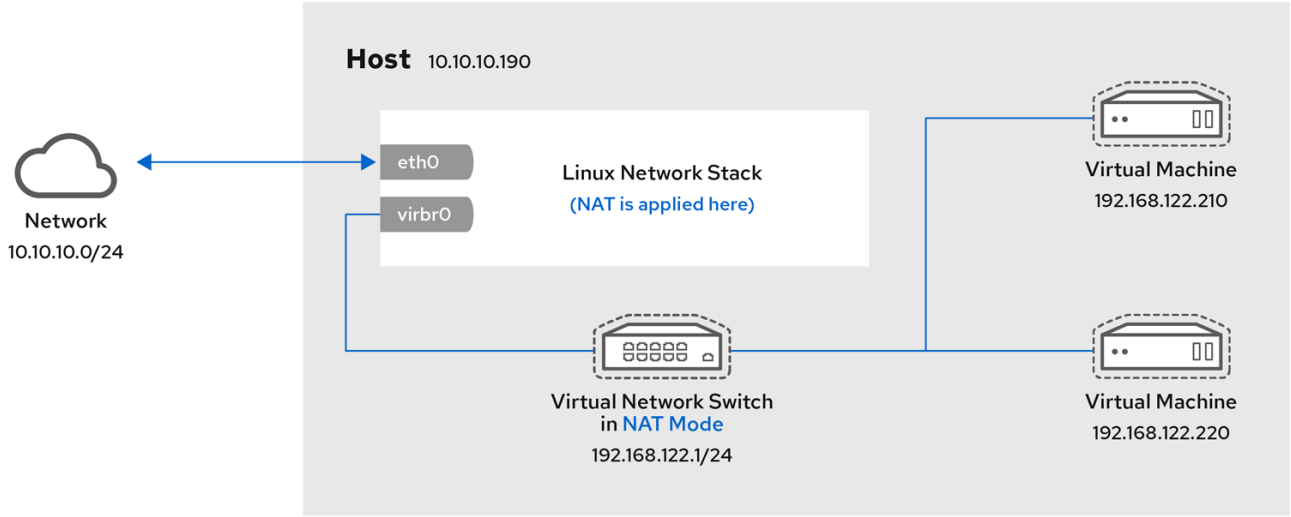
- For instructions on isolating a VM using the command-line, see Section 13.3.2, “Isolating virtual machines from each other using the command-line interface”.
- For additional information about **macvtap** private mode, see Section 13.5.6, “Direct attachment of the virtual network device”.
- For additional security measures that you can set on a VM, see Chapter 15, *Securing virtual machines*.

13.5. TYPES OF VIRTUAL MACHINE NETWORK CONNECTIONS

To modify the networking properties and behavior of your VMs, change the type of virtual network or interface the VMs use. The following sections describe the connection types available to VMs in RHEL 8.

13.5.1. Virtual networking with network address translation

By default, virtual network switches operate in network address translation (NAT) mode. They use IP masquerading rather than Source-NAT (SNAT) or Destination-NAT (DNAT). IP masquerading enables connected VMs to use the host machine's IP address for communication with any external network. When the virtual network switch is operating in NAT mode, computers external to the host cannot communicate with the VMs inside the host.



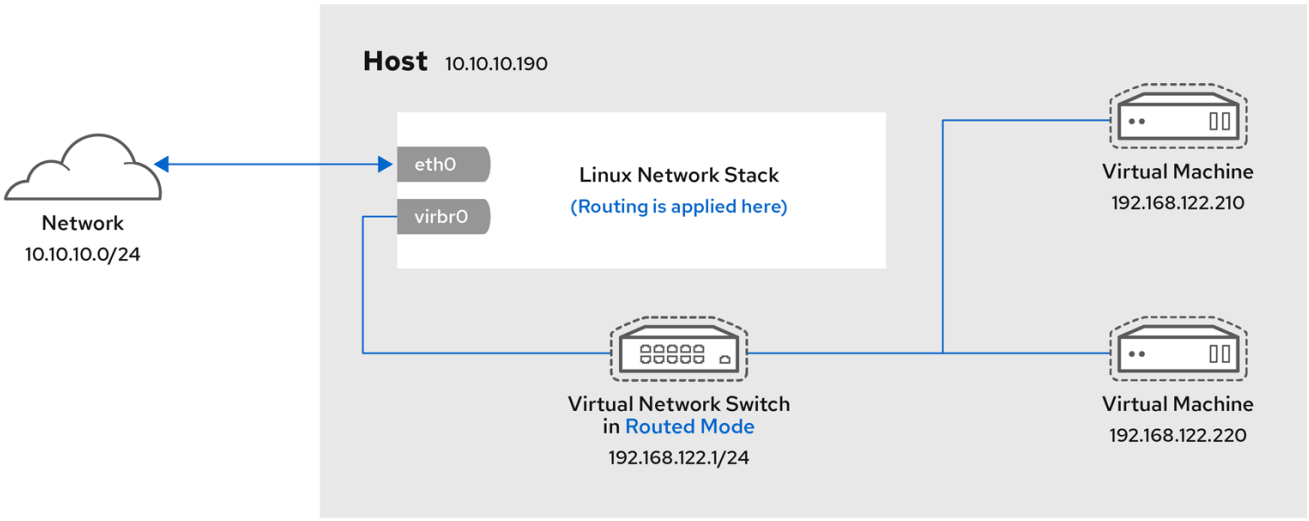
WARNING

Virtual network switches use NAT configured by firewall rules. Editing these rules while the switch is running is not recommended, because incorrect rules may result in the switch being unable to communicate.

13.5.2. Virtual networking in routed mode

When using *Routed* mode, the virtual switch connects to the physical LAN connected to the host machine, passing traffic back and forth without the use of NAT. The virtual switch can examine all traffic and use the information contained within the network packets to make routing decisions. When using this mode, the virtual machines (VMs) are all in a single subnet, separate from the host machine. The VM subnet is routed through a virtual switch, which exists on the host machine. This enables incoming connections, but requires extra routing-table entries for systems on the external network.

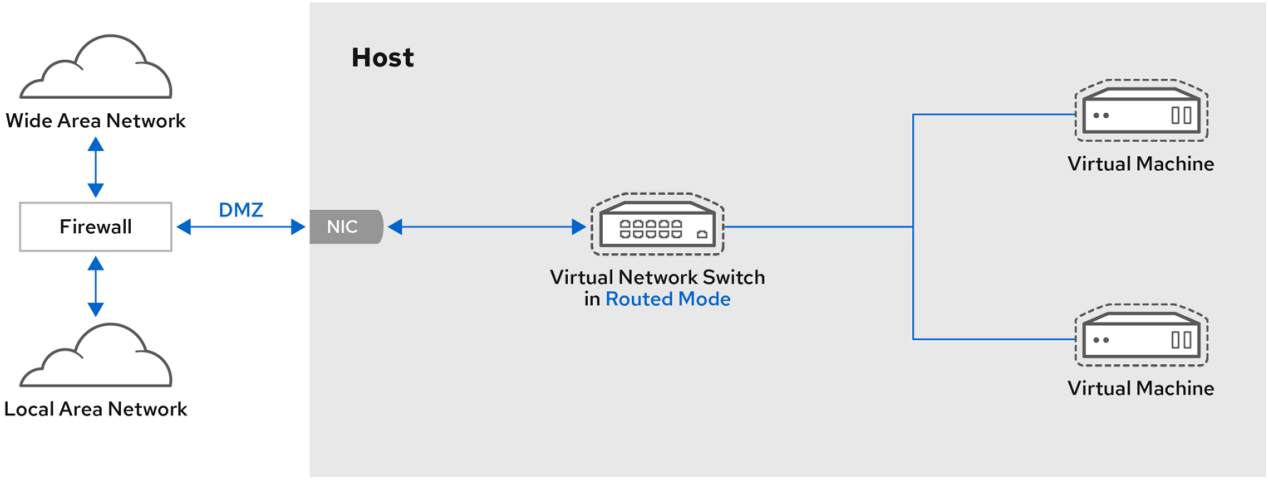
Routed mode uses routing based on the IP address:



Common topologies that use routed mode include DMZs and virtual server hosting.

DMZ

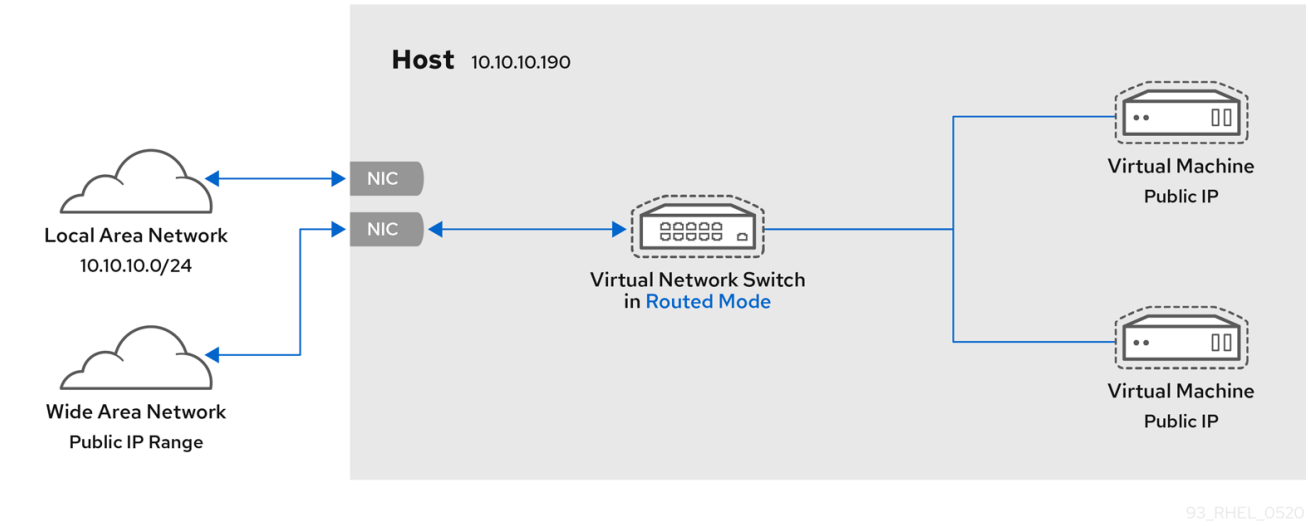
You can create a network where one or more nodes are placed in a controlled sub-network for security reasons. Such a sub-network is known as a demilitarized zone (DMZ).



Host machines in a DMZ typically provide services to WAN (external) host machines as well as LAN (internal) host machines. Since this requires them to be accessible from multiple locations, and considering that these locations are controlled and operated in different ways based on their security and trust level, routed mode is the best configuration for this environment.

Virtual server hosting

A virtual server hosting provider may have several host machines, each with two physical network connections. One interface is used for management and accounting, the other for the VMs to connect through. Each VM has its own public IP address, but the host machines use private IP addresses so that only internal administrators can manage the VMs.



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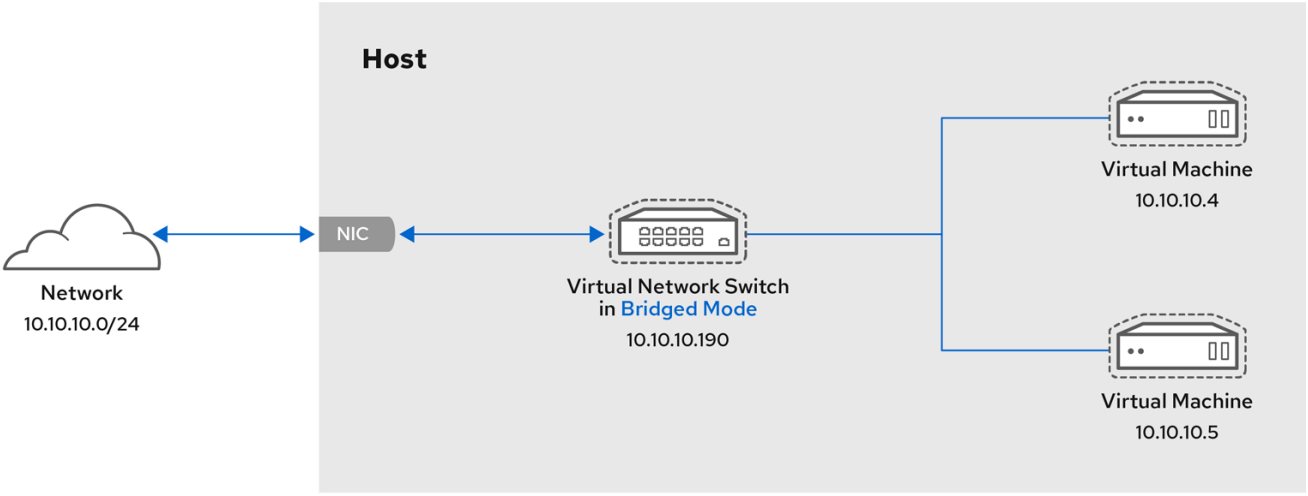
13.5.3. Virtual networking in bridged mode

In most VM networking modes, VMs automatically create and connect to the **virbr0** virtual bridge. In contrast, in *bridged* mode, the VM connects to an existing Linux bridge on the host. As a result, the VM is directly visible on the physical network. This enables incoming connections, but does not require any extra routing-table entries.

Bridged mode uses connection switching based on the MAC address:



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In bridged mode, the VM appear within the same subnet as the host machine. All other physical machines on the same physical network can detect the VM and access it.

Bridged network bonding

It is possible to use multiple physical bridge interfaces on the hypervisor by joining them together with a bond. The bond can then be added to a bridge, after which the VMs can be added to the bridge as well. However, the bonding driver has several modes of operation, and not all of these modes work with a bridge where VMs are in use.

The following bonding modes are usable:

- mode 1

- mode 2
- mode 4

In contrast, using modes 0, 3, 5, or 6 is likely to cause the connection to fail. Also note that media-independent interface (MII) monitoring should be used to monitor bonding modes, as Address Resolution Protocol (ARP) monitoring does not work correctly.

For more information on bonding modes, refer to the Red Hat Knowledgebase .

Common scenarios

The most common use cases for bridged mode include:

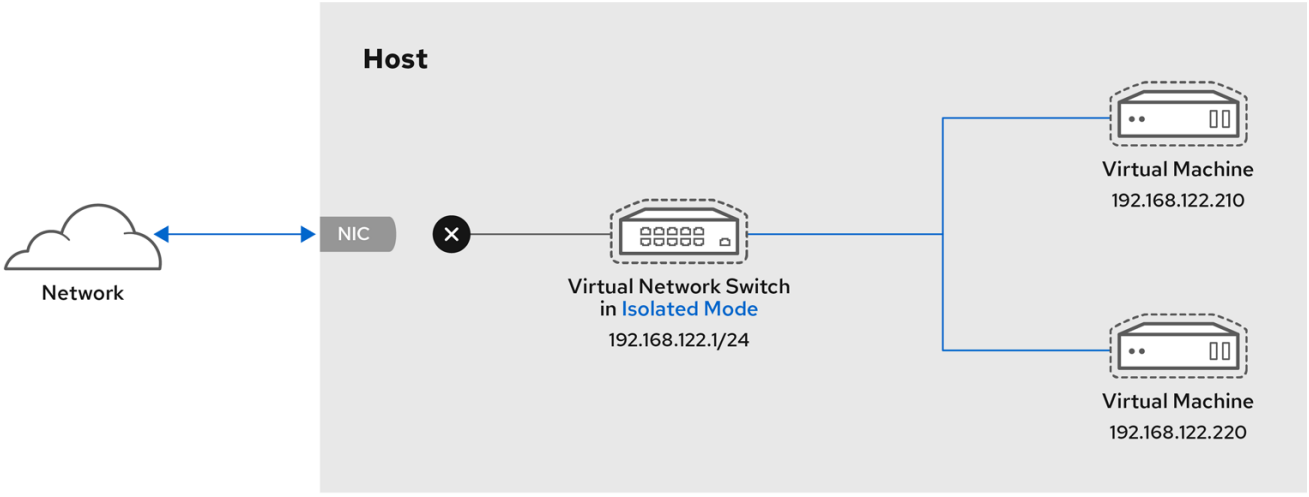
- Deploying VMs in an existing network alongside host machines, making the difference between virtual and physical machines invisible to the end user.
- Deploying VMs without making any changes to existing physical network configuration settings.
- Deploying VMs that must be easily accessible to an existing physical network. Placing VMs on a physical network where they must access DHCP services.
- Connecting VMs to an existing network where virtual LANs (VLANs) are used.

Additional resources

- For instructions on configuring your VMs to use bridged mode, see Section 13.3.1, "Configuring externally visible virtual machines using the command-line interface" or Section 13.4.1, "Configuring externally visible virtual machines using the web console".
- For a detailed explanation of **bridge_opts** parameters, used to configure bridged networking mode, see the Red Hat Virtualization Administration Guide .

13.5.4. Virtual networking in isolated mode

When using *isolated* mode, virtual machines connected to the virtual switch can communicate with each other and with the host machine, but their traffic will not pass outside of the host machine, and they cannot receive traffic from outside the host machine. Using **dnsmasq** in this mode is required for basic functionality such as DHCP.



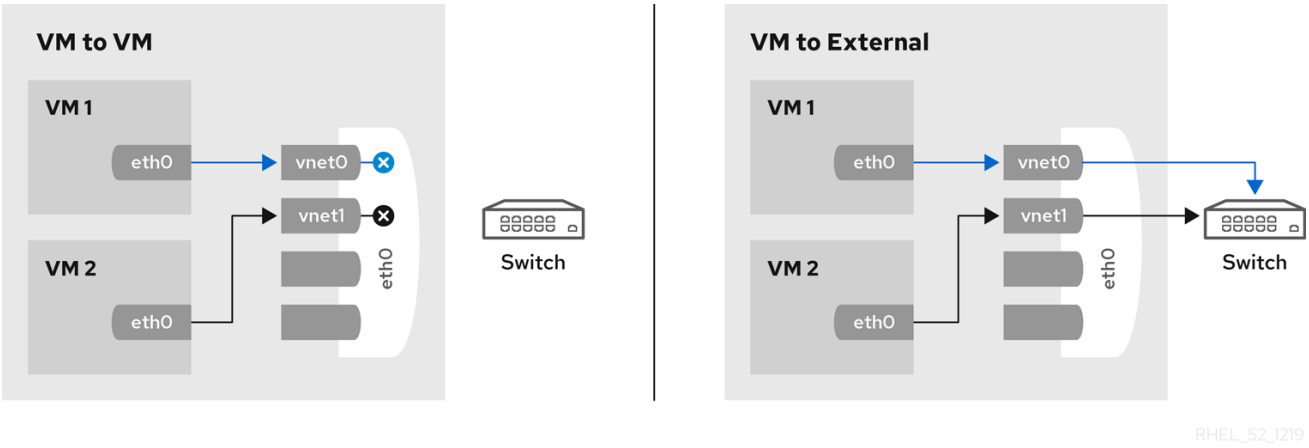
13.5.5. Virtual networking in open mode

When using *open* mode for networking, **libvirt** does not generate any firewall rules for the network. As a result, **libvirt** does not overwrite firewall rules provided by the host, and the user can therefore manually manage the VM's firewall rules.

13.5.6. Direct attachment of the virtual network device

You can use the **macvtap** driver to attach a virtual machine's NIC directly to a specified physical interface of the host machine. The **macvtap** connection has a number of modes, including **private mode**.

In this mode, all packets are sent to the external switch and will only be delivered to a target VM on the same host machine if they are sent through an external router or gateway and these send them back to the host. Private mode can be used to prevent the individual VMs on a single host from communicating with each other.



Additional resources

- For instructions on configuring your VMs to use **macvtap** in private mode, see Section 13.3.2, "Isolating virtual machines from each other using the command-line interface" or Section 13.4.2, "Isolating virtual machines from each other using the web console".

13.5.7. Comparison of virtual machine connection types

The following table provides information about the locations to which selected types of virtual machine (VM) network configurations can connect, and to which they are visible.

Table 13.1. Virtual machine connection types

	Connection to the host	Connection to other VMs on the host	Connection to outside locations	Visible to outside locations
Bridged mode	YES	YES	YES	YES
NAT	YES	YES	YES	*no*
Routed mode	YES	YES	YES	YES

	Connection to the host	Connection to other VMs on the host	Connection to outside locations	Visible to outside locations
Isolated mode	YES	YES	*no*	*no*
Private mode	*no*	*no*	YES	YES
Open mode	*Depends on the host's firewall rules*			

13.6. ADDITIONAL RESOURCES

- For additional information on networking configurations in RHEL 8, see the Configuring and managing networking document.
- Specific network interface cards can be attached to VMs as SR-IOV devices, which increases their performance. For details, see Section 10.9, "Managing SR-IOV devices".

CHAPTER 14. SHARING FILES BETWEEN THE HOST AND ITS VIRTUAL MACHINES

You may frequently require to share data between your host system and the virtual machines (VMs) it runs. To do so quickly and efficiently, you can set up NFS or Samba file shares on your system.

14.1. SHARING FILES BETWEEN THE HOST AND LINUX VIRTUAL MACHINES

For efficient file sharing between your host system and the Linux VMs it is connected to, you can export an NFS share that your VMs can mount and access.

Prerequisites

- The **nfs-utils** package is installed on the host.
- A directory that you want to share with your VMs. If you do not want to share any of your existing directories, create a new one, for example named *shared-files*.

```
# mkdir shared-files
```

- The host is visible and reachable over a network for the VM. This is generally the case if the VM is connected using the *NAT* and *bridge* type of virtual networks. However, for the *macvtap* connection, you must first set up the *macvlan* feature on the host. To do so:

1. Create a network device file in the host's **/etc/systemd/network/** directory, for example called **vm-macvlan.netdev**.

```
# vim /etc/systemd/network/vm-macvlan.netdev
```

2. Edit the network device file to have the following content. You can replace **vm-macvlan** with the name you chose for your network device.

```
[NetDev]
Name=vm-macvlan
Kind=macvlan

[MACVLAN]
Mode=bridge
```

3. Create a network configuration file for your macvlan network device, for example **vm-macvlan.network**.

```
# vim /etc/systemd/network/vm-macvlan.network
```

4. Edit the network configuration file to have the following content. You can replace **vm-macvlan** with the name you chose for your network device.

```
[Match]
Name=_vm-macvlan_

[Network]
```

```
IPForward=yes
Address=192.168.250.33/24
Gateway=192.168.250.1
DNS=192.168.250.1
```

5. Create a network configuration file for your physical network interface. For example, if your interface is **enp4s0**:

```
# vim /etc/systemd/network/enp4s0.network
```

If you are unsure what interface name to use, you can use the **ifconfig** command on your host to obtain the list of active network interfaces.

6. Edit the physical network configuration file to make the physical network a part of the macvlan interface, in this case *vm-macvlan*:

```
[Match]
Name=enp4s0

[Network]
MACVLAN=vm-macvlan
```

7. Reboot your host.

- **Optional:** For improved security, ensure your VMs are compatible with NFS version 4 or later.

Procedure

1. On the host, export a directory with the files you want to share as a network file system (NFS).

a. Obtain the IP address of each virtual machine you want to share files with. The following example obtains the IPs of *testguest1* and *testguest2*.

```
# virsh domifaddr testguest1
Name       MAC address          Protocol     Address
-------------------------------------------------------------------------------
vnet0      52:53:00:84:57:90    ipv4         192.168.124.220/24

# virsh domifaddr testguest2
Name       MAC address          Protocol     Address
-------------------------------------------------------------------------------
vnet1      52:53:00:65:29:21    ipv4         192.168.124.17/24
```

b. Edit the **/etc/exports** file on the host and add a line that includes the directory you want to share, IPs of VMs you want to share with, and sharing options.

```
Shared directory VM1-IP(options) VM2-IP(options) [...]
```

For example, the following shares the **/usr/local/shared-files** directory on the host with *testguest1* and *testguest2*, and enables the VMs to edit the content of the directory:

```
/usr/local/shared-files/ 192.168.124.220(rw,sync) 192.168.124.17(rw,sync)
```

c. Export the updated file system.

```
# exportfs -a
```

d. Ensure the NFS process is started:

```
# systemctl start nfs-server
```

e. Obtain the IP address of the host system. This will be used for mounting the shared directory on the VMs later.

```
# ip addr
[...]
5: virbr0: [BROADCAST,MULTICAST,UP,LOWER_UP] mtu 1500 qdisc noqueue state
UP group default qlen 1000
    link/ether 52:54:00:32:ff:a5 brd ff:ff:ff:ff:ff:ff
    inet 192.168.124.1/24 brd 192.168.124.255 scope global virbr0
       valid_lft forever preferred_lft forever
[...]
```

Note that the relevant network is the one being used use for connection to the host by the VMs you want to share files with. Usually, this is **virbr0**.

2. On the guest OS of a VM specified in the **/etc/exports** file, mount the exported file system.

a. Create a directory you want to use as a mount point for the shared file system, for example **/mnt/host-share**:

```
# mkdir /mnt/host-share
```

b. Mount the directory exported by the host on the mount point. This example mounts the **/usr/local/shared-files** directory exported by the **192.168.124.1** host on **/mnt/host-share** in the guest:

```
# mount 192.168.124.1:/usr/local/shared-files /mnt/host-share
```

Verification

- To verify the mount has succeeded, access and explore the shared directory on the mount point:

```
# cd /mnt/host-share
# ls
shared-file1  shared-file2  shared-file3
```

14.2. SHARING FILES BETWEEN THE HOST AND WINDOWS VIRTUAL MACHINES

For efficient file sharing between your host system and the Windows VMs it is connected to, you can prepare a Samba server that your VMs can access.

Prerequisites

- The **samba** packages are installed on your host. If they are not:

-

```
# yum install samba
```

- The host is visible and reachable over a network for the VM. This is generally the case if the VM is connected using the *NAT* and *bridge* type of virtual networks. However, for the *macvtap* connection, you must first set up the *macvlan* feature on the host. To do so:

  1. Create a network device file, for example called **vm-macvlan.netdev** in the host's **/etc/systemd/network/** directory.

     ```
     # vim /etc/systemd/network/vm-macvlan.netdev
     ```

  2. Edit the network device file to have the following content. You can replace **vm-macvlan** with the name you chose for your network device.

     ```
     [NetDev]
     Name=vm-macvlan
     Kind=macvlan

     [MACVLAN]
     Mode=bridge
     ```

  3. Create a network configuration file for your macvlan network device, for example **vm-macvlan.network**.

     ```
     # vim /etc/systemd/network/vm-macvlan.network
     ```

  4. Edit the network configuration file to have the following content. You can replace **vm-macvlan** with the name you chose for your network device.

     ```
     [Match]
     Name=_vm-macvlan_

     [Network]
     IPForward=yes
     Address=192.168.250.33/24
     Gateway=192.168.250.1
     DNS=192.168.250.1
     ```

  5. Create a network configuration file for your physical network interface. For example, if your interface is **enp4s0**:

     ```
     # vim /etc/systemd/network/enp4s0.network
     ```

     If you are unsure what interface to use, you can use the **ifconfig** command on your host to obtain the list of active network interfaces.

  6. Edit the physical network configuration file to make the physical network a part of the macvlan interface, in this case *vm-macvlan*:

     ```
     [Match]
     Name=enp4s0

     [Network]
     MACVLAN=vm-macvlan
     ```

–

7. Reboot your host.

Procedure

1. On the host, create a Samba share and make it accessible for external systems.

   a. Add firewall permissions for Samba.

   ```
   # firewall-cmd --permanent --zone=public --add-service=samba
   success
   # firewall-cmd --reload
   success
   ```

   b. Edit the **/etc/samba/smb.conf** file:

      i. Add the following to the **[global]** section:

      ```
      map to guest = Bad User
      ```

      ii. Add the following at the end of the file:

      ```
      #=== Share Definitions ===
      [VM-share]
      path = /samba/VM-share
      browsable = yes
      guest ok = yes
      read only = no
      hosts allow = 192.168.122.0/24
      ```

      Note that the **hosts allow** line restricts the accessibility of the share only to hosts on the VM network. If you want the share to be accessible by anyone, remove the line.

   c. Create the **/samba/VM-share** directory.

   ```
   # mkdir -p /samba/VM-share
   ```

   d. Enable the Samba service.

   ```
   # systemctl enable smb.service
   Created symlink /etc/systemd/system/multi-user.target.wants/smb.service →
   /usr/lib/systemd/system/smb.service.
   ```

   e. Restart the Samba service.

   ```
   # systemctl restart smb.service
   ```

   f. Allow the **VM-share** directory to be accessible and modifiable for the VMs.

   ```
   # chmod -R 0755 /samba/VM-share/
   # chown -R nobody:nobody /samba/VM-share/
   ```

   g. Add the SELinux Samba sharing label to **/etc/samba/VM-share/**

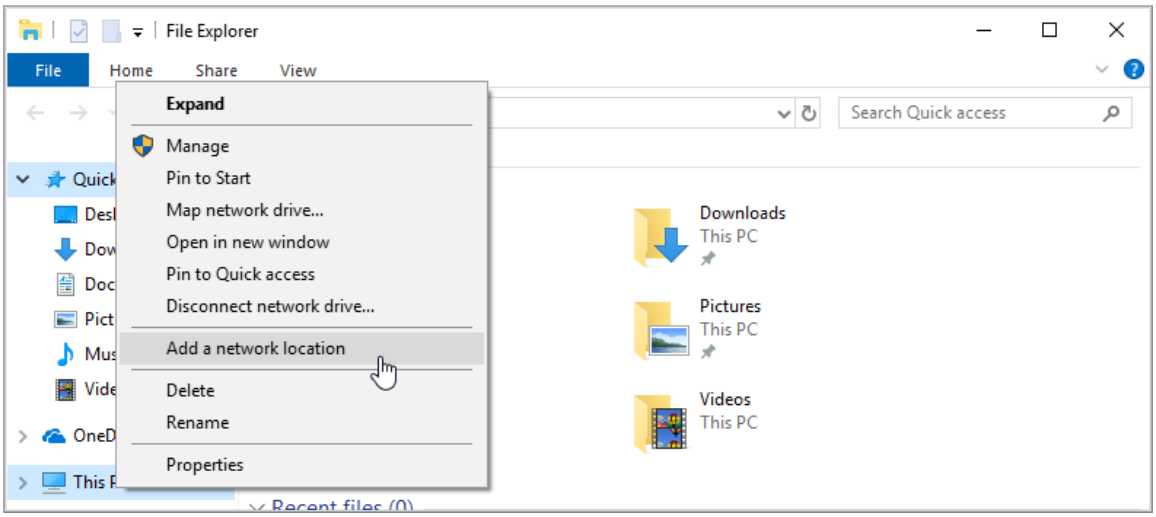
   ■

```
# chcon -t samba_share_t /samba/VM-share/
```

2. On the Windows guest operating system, attach the Samba share as a network location.

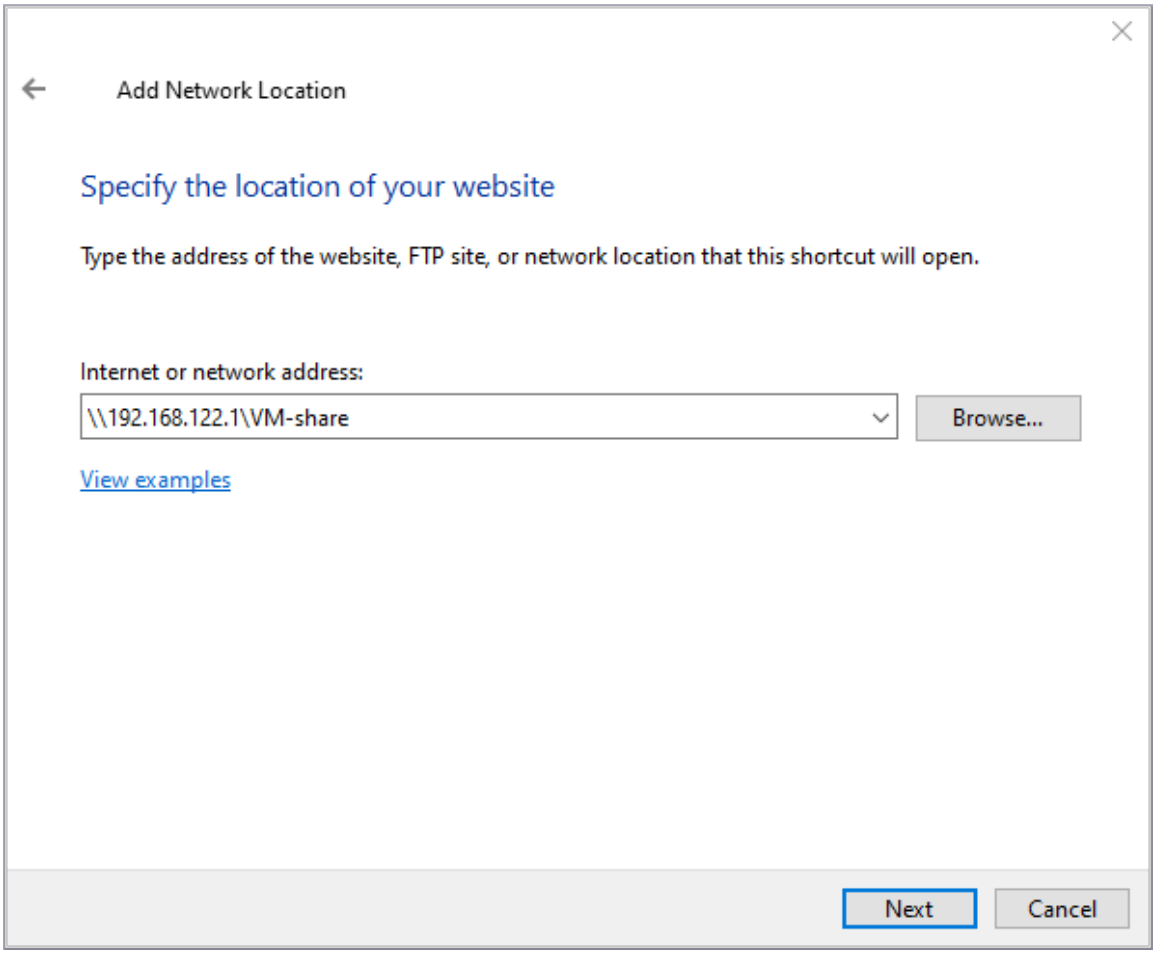
   a. Open the File Explorer and right-click "This PC".

   b. In the context menu, click **Add a network location**.



   c. In the *Add Network Location* wizard that opens, select "Choose a custom network location" and click **Next**.

   d. In the "Internet or network address" field, type *host-IP*/VM-share, where *host-IP* is the IP address of the host. Usually, the host IP is the default gateway of the VM. Afterwards, click **Next**.



e. When the wizard asks if you want to rename the shared directory, keep the default name. This ensures the consistency of file sharing configuration across the VM and the guest. Click **Next**.

f. If accessing the network location was successful, you can now click **Finish** and open the shared directory.

CHAPTER 15. SECURING VIRTUAL MACHINES

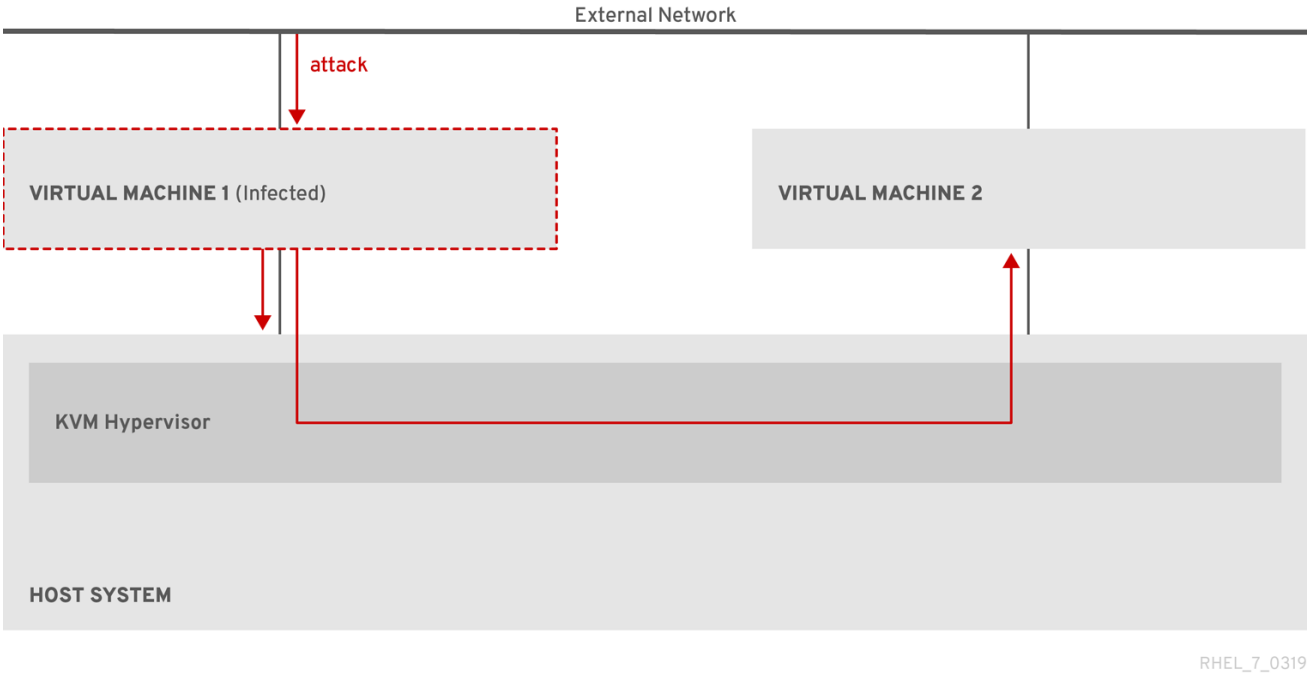
As an administrator of a RHEL 8 system with virtual machines (VMs), ensuring that your VMs are as secure as possible significantly lowers the risk of your guest and host OSs being infected by malicious software.

This document outlines the mechanics of securing VMs on a RHEL 8 host and provides a list of methods to increase the security of your VMs.

15.1. HOW SECURITY WORKS IN VIRTUAL MACHINES

When using virtual machines (VMs), multiple operating systems can be housed within a single host machine. These systems are connected with the host through the hypervisor, and usually also through a virtual network. As a consequence, each VM can be used as a vector for attacking the host with malicious software, and the host can be used as a vector for attacking any of the VMs.

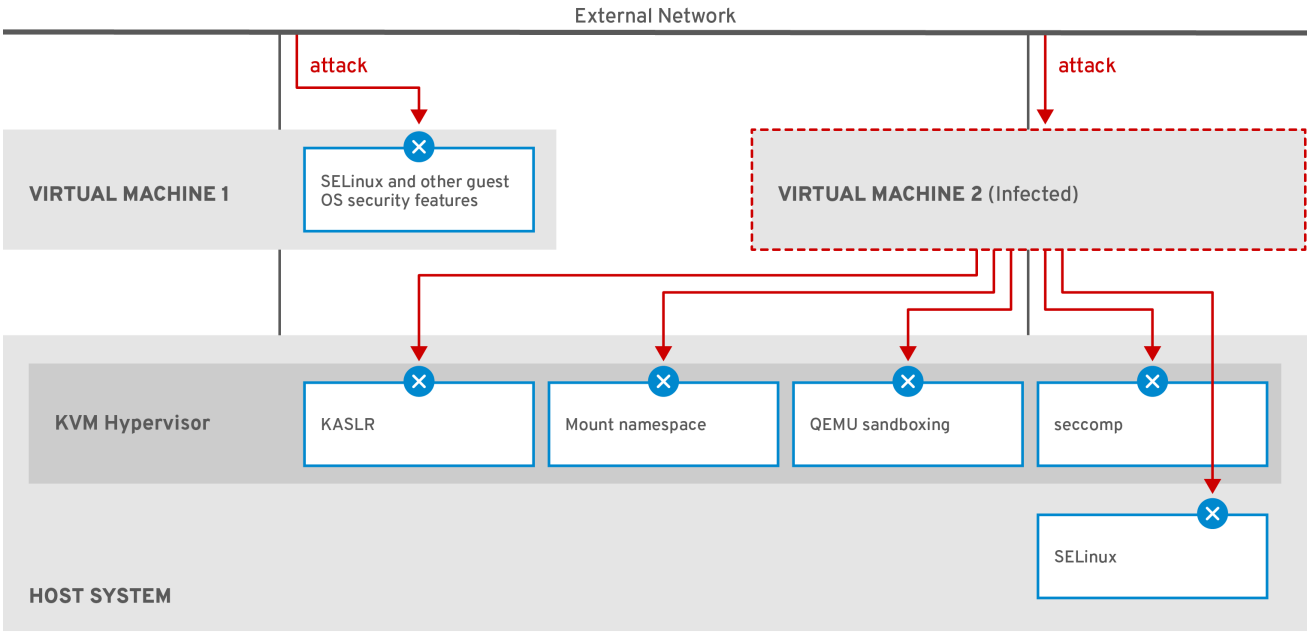
Figure 15.1. A potential malware attack vector on a virtualization host



Because the hypervisor uses the host kernel to manage VMs, services running on the VM's operating system are frequently used for injecting malicious code into the host system. However, you can protect your system against such security threats by using a number of security features on your host and your guest systems.

These features, such as SELinux or QEMU sandboxing, provide various measures that make it more difficult for malicious code to attack the hypervisor and transfer between your host and your VMs.

Figure 15.2. Prevented malware attacks on a virtualization host



Many of the features that RHEL 8 provides for VM security are always active and do not have to be enabled or configured. For details, see Section 15.5, "Automatic features for virtual machine security".

In addition, you can adhere to a variety of best practices to minimize the vulnerability of your VMs and your hypervisor. For more information, see Section 15.2, "Best practices for securing virtual machines".

15.2. BEST PRACTICES FOR SECURING VIRTUAL MACHINES

Following the instructions below significantly decreases the risk of your virtual machines being infected with malicious code and used as attack vectors to infect your host system.

On the guest side:

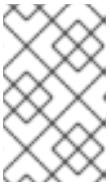
- Secure the virtual machine as if it was a physical machine. The specific methods available to enhance security depend on the guest OS.
  If your VM is running RHEL 8, see Securing Red Hat Enterprise Linux 8 for detailed instructions on improving the security of your guest system.

On the host side:

- When managing VMs remotely, use cryptographic utilities such as **SSH** and network protocols such as **SSL** for connecting to the VMs.
- Ensure SELinux is in Enforcing mode:

  ```
  # getenforce
  Enforcing
  ```

  If SELinux is disabled or in *Permissive* mode, see the Using SELinux document for instructions on activating Enforcing mode.



NOTE

SELinux Enforcing mode also enables the sVirt RHEL 8 feature. This is a set of specialized SELinux booleans for virtualization, which can be manually adjusted for fine-grained VM security management.

- Use VMs with *SecureBoot*:
  SecureBoot is a feature that ensures that your VM is running a cryptographically signed OS. This prevents VMs whose OS has been altered by a malware attack from booting.

  SecureBoot can only be applied when installing a Linux VM that uses OVMF firmware. For instructions, see Section 15.3, "Creating a SecureBoot virtual machine" .

- Do not use **qemu-*** commands, such as **qemu-img**.
  QEMU is an essential component of the virtualization architecture in RHEL 8, but it is difficult to manage manually, and improper QEMU configurations may cause security vulnerabilities. Therefore, using **qemu-*** commands is not supported by Red Hat. Instead, it is highly recommended to interact with QEMU using *libvirt* utilities, such as **virsh**, **virt-install**, and **virt-xml**, as these orchestrate QEMU according to the best practices.

Additional resources

- For detailed information on modifying your virtualization booleans, see Section 15.6, "Virtualization booleans".

15.3. CREATING A SECUREBOOT VIRTUAL MACHINE

You can create a Linux virtual machine (VM) that uses the *SecureBoot* feature, which ensures that your VM is running a cryptographically signed OS. This can be useful if the guest OS of a VM has been altered by malware. In such a scenario, SecureBoot prevents the VM from booting, which stops the potential spread of the malware to your host machine.

Prerequisites

- The VM is using the Q35 machine type.
- The **edk2-OVMF** packages is installed:

```
# yum install edk2-ovmf
```

- An operating system (OS) installation source is available locally or on a network. This can be one of the following formats:
  - An ISO image of an installation medium
  - A disk image of an existing VM installation

WARNING

Installing from a host CD-ROM or DVD-ROM device is not possible in RHEL 8. If you select a CD-ROM or DVD-ROM as the installation source when using any VM installation method available in RHEL 8, the installation will fail. For more information, see the Red Hat Knowledgebase.

- Optional: A Kickstart file can be provided for faster and easier configuration of the installation.

Procedure

1. Use the **virt-install** command to create a VM as detailed in Section 2.2.1, "Creating virtual machines using the command-line interface". For the **--boot** option, use the **uefi,nvram_template=/usr/share/OVMF/OVMF_VARS.secboot.fd** value. This uses the **OVMF_VARS.secboot.fd** and **OVMF_CODE.secboot.fd** files as templates for the VM's non-volatile RAM (NVRAM) settings, which enables the SecureBoot feature.
   For example:

   ```
   # virt-install --name rhel8sb --memory 4096 --vcpus 4 --os-variant rhel8.0 --boot uefi,nvram_template=/usr/share/OVMF/OVMF_VARS.secboot.fd --disk boot_order=2,size=10 --disk boot_order=1,device=cdrom,bus=scsi,path=/images/RHEL-8.0-installation.iso
   ```

2. Follow the OS installation procedure according to the instructions on the screen.

Verification

1. After the guest OS is installed, access the VM's command line by opening the terminal in the graphical guest console or connecting to the guest OS using SSH.

2. To confirm that SecureBoot has been enabled on the VM, use the **mokutil --sb-state** command:

   ```
   # mokutil --sb-state
   SecureBoot enabled
   ```

Additional resources

- For details on the installation process when creating VMs that use RHEL 8 as the guest OS, see Booting the RHEL 8 installation.

15.4. LIMITING WHAT ACTIONS ARE AVAILABLE TO VIRTUAL MACHINE USERS

In some cases, actions that users of virtual machines (VMs) hosted on RHEL 8 can perform by default may pose a security risk. If that is the case, you can limit the actions available to VM users by configuring the **libvirtd** service to use the **polkit** policy toolkit on the host machine.

Procedure

1. **Optional:** Ensure your system's **polkit** control policies related to **libvirt** are set up according to your preferences.

   a. Find all libvirt-related files in the **/usr/share/polkit-1/actions/** and **/usr/share/polkit-1/rules.d/** directories.
   # ls /usr/share/polkit-1/actions | grep libvirt # ls /usr/share/polkit-1/rules.d | grep libvirt

   b. Open the files and review the rule settings.
   For information on reading the syntax of **polkit** control policies, use **man polkit**.

   c. Modify the **libvirt** control policies. To do so:

      i. Create a new **.conf** file in the **/etc/polkit-1/rules.d/** directory.

      ii. Add your custom policies to this file, and save it.
      For further information and examples of **libvirt** control policies, see the **libvirt** upstream documentation.

2. Configure your VMs to use access policies determined by **polkit**.

   a. Open the **/etc/libvirt/libvirtd.conf** file.

   b. Uncomment the **access_drivers = ["polkit"]** line and save the file.

3. Restart the **libvirtd** service.

```
# systemctl restart libvirtd
```

Verification

- As a user whose VM actions you intended to limit, perform one of the restricted actions.
For example, if unprivileged users are restricted from viewing VMs created in the system session:

```
$ virsh -c qemu:///system list --all
 Id   Name           State
--------------------------------
```

If this command does not list any VMs even though one or more VMs exist on your system, **polkit** succesfully restricts the action for unprivileged users.

Troubleshooting

- Currently, configuring **libvirt** to use **polkit** makes it impossible to connect to VMs using the RHEL 8 web console, due to an incompatibility with the **libvirt-dbus** service.
If you require fine-grained access control of VMs in the web console, Red Hat recommends creating a custom D-Bus policy. For instructions, see How to configure fine-grained control of Virtual Machines in Cockpit in the Red Hat Knowledgebase.

15.5. AUTOMATIC FEATURES FOR VIRTUAL MACHINE SECURITY

In addition to manual means of improving the security of your virtual machines listed in Section 15.2, "Best practices for securing virtual machines", a number of security features are provided by the **libvirt** software suite and are automatically enabled when using virtualization in RHEL 8. These include:

System and session connections

To access all the available utilities for virtual machine management in RHEL 8, you need to use the *system connection* of libvirt (**qemu:///system**). To do so, you must have root privileges on the system or be a part of the *libvirt* user group.
Non-root users that are not in the *libvirt* group can only access a *session connection* of libvirt (**qemu:///session**), which has to respect the access rights of the local user when accessing resources. For example, using the session connection, you cannot detect or access VMs created in the system connection or by other users. Also, available VM networking configuration options are significantly limited.

NOTE

The RHEL 8 documentation assumes you have system connection privileges.

Virtual machine separation

Individual VMs run as isolated processes on the host, and rely on security enforced by the host kernel. Therefore, a VM cannot read or access the memory or storage of other VMs on the same host.

QEMU sandboxing

A feature that prevents QEMU code from executing system calls that can compromise the security of the host.

Kernel Address Space Randomization (KASLR)

Enables randomizing the physical and virtual addresses at which the kernel image is decompressed. Thus, KASLR prevents guest security exploits based on the location of kernel objects.

15.6. VIRTUALIZATION BOOLEANS

For fine-grained configuration of virtual machines security on a RHEL 8 system, you can configure SELinux booleans on the host to ensure the hypervisor acts in a specific way.

To list all virtualization-related booleans and their statuses, use the **getsebool -a | grep virt** command:

```
$ getsebool -a | grep virt
[...]
virt_sandbox_use_netlink --> off
virt_sandbox_use_sys_admin --> off
virt_transition_userdomain --> off
virt_use_comm --> off
virt_use_execmem --> off
virt_use_fusefs --> off
[...]
```

To enable a specific boolean, use the **setsebool -P *boolean_name* on** command as root. To disable a boolean, use **setsebool -P *boolean_name* off**.

The following table lists virtualization-related booleans available in RHEL 8 and what they do when enabled:

Table 15.1. SELinux virtualization booleans

SELinux Boolean	Description
staff_use_svirt	Enables non-root users to create and transition VMs to sVirt.
unprivuser_use_svirt	Enables unprivileged users to create and transition VMs to sVirt.
virt_sandbox_use_audit	Enables sandbox containers to send audit messages.
virt_sandbox_use_netlink	Enables sandbox containers to use netlink system calls.
virt_sandbox_use_sys_admin	Enables sandbox containers to use sys_admin system calls, such as mount.
virt_transition_userdomain	Enables virtual processes to run as user domains.
virt_use_comm	Enables virt to use serial/parallel communication ports.
virt_use_execmem	Enables confined virtual guests to use executable memory and executable stack.
virt_use_fusefs	Enables virt to read FUSE mounted files.
virt_use_nfs	Enables virt to manage NFS mounted files.
virt_use_rawip	Enables virt to interact with rawip sockets.
virt_use_samba	Enables virt to manage CIFS mounted files.
virt_use_sanlock	Enables confined virtual guests to interact with the sanlock.
virt_use_usb	Enables virt to use USB devices.
virt_use_xserver	Enables virtual machine to interact with the X Window System.

15.7. SETTING UP IBM SECURE EXECUTION ON IBM Z

When using IBM Z hardware to run a RHEL 8 host, you can improve the security of your virtual machines (VMs) by configuring IBM Secure Execution for the VMs.

IBM Secure Execution, also known as Protected Virtualization, prevents the host system from accessing a VM's state and memory contents. As a result, even if the host is compromised, it cannot be used as a vector for attacking the guest operating system. In addition, Secure Execution can be used to prevent untrusted hosts from obtaining sensitive information from the VM.

The following procedure describes how to convert an existing VM on an IBM Z host into a secured VM.

Prerequisites

- The system hardware is one of the following:
  - IBM z15 or later
  - IBM LinuxONE III or later
- The Secure Execution feature is enabled for your system. To verify, use:

```
# grep facilities /proc/cpuinfo | grep 158
```

  If this command displays any output, your CPU is compatible with Secure Execution.
- The kernel includes support for Secure Execution. To confirm, use:

```
# ls /sys/firmware | grep uv
```

  If the command generates any output, your kernel supports Secure Execution.
- The host CPU model contains the **unpack** facility. To confirm, use:

```
# virsh domcapabilities | grep unpack
<feature policy='require' name='unpack'/>
```

  If the command generates the above output, your CPU host model is compatible with Secure Execution.
- The CPU mode of the VM is set to **host-model**. To confirm this, use the following and replace **vm-name** with the name of your VM.

```
# virsh dumpxml vm-name | grep "<cpu mode='host-model'/>"
```

  If the command generates any output, the VM's CPU mode is set correctly.
- You have obtained and verified the IBM Z host key document. For instructions to do so, see Verifying the host key document in IBM documentation.

Procedure

1. Add the **prot_virt=1** kernel parameter to the boot configuration of the host.

```
# # grubby --update-kernel=ALL --args="prot_virt=1"
```

2. Create a parameter file for the VM you want to secure. For example:

```
# touch ~/secure-parameters
```

3. In the **/boot/loader/entries** directory of the host, identify the boot loader entry with the latest version:

```
# ls /boot/loader/entries -l
```

```
[...]
-rw-r--r--. 1 root root  281 Oct  9 15:51 3ab27a195c2849429927b00679db15c1-4.18.0-
240.el8.s390x.conf
```

4. Retrieve the kernel options line of the boot loader entry:

```
# cat /boot/loader/entries/3ab27a195c2849429927b00679db15c1-4.18.0-
240.el8.s390x.conf | grep options
options root=/dev/mapper/rhel-root crashkernel=auto rd.lvm.lv=rhel/root rd.lvm.lv=rhel/swap
```

5. Add the content of the options line and **swiotlb=262144** to the created parameters file.

```
# echo "root=/dev/mapper/rhel-root crashkernel=auto rd.lvm.lv=rhel/root
rd.lvm.lv=rhel/swap swiotlb=262144" > ~/secure-parameters
```

6. Generate an IBM Secure Execution image for the selected VM.
   For example, the following creates a **/boot/secure-image** secured image based on the **/boot/vmlinuz-4.18.0-240.el8.s390x** image, using the **secure-parameters** file, the **/boot/initramfs-4.18.0-240.el8.s390x.img** initial RAM disk file, and the **HKD-8651-000201C048.crt** host key document.

```
# genprotimg -i /boot/vmlinuz-4.18.0-240.el8.s390x -r /boot/initramfs-4.18.0-
240.el8.s390x.img -p ~/secure-parameters -k HKD-8651-00020089A8.crt -o
/boot/secure-image
```

   Using the **genprotimg** utility creates the secure image, which contains the kernel parameters, initial RAM disk, and boot image.

7. In the guest operating system of the VM, update the VM's boot menu to boot from the secure image. In addition, remove the lines starting with **initrd** and **options**, as they are not needed.
   For example, in a RHEL 8.3 VM, the boot menu can be edited in the **/boot/loader/entries/** directory:

```
# cat /boot/loader/entries/3ab27a195c2849429927b00679db15c1-4.18.0-
240.el8.s390x.conf
title Red Hat Enterprise Linux 8.3
version 4.18.0-240.el8.s390x
linux /boot/secure-image
[...]
```

8. Enable virtio devices to use shared buffers. To do so, use **virsh edit** to modify the XML configuration of the VM, and add **iommu='on'** to the **<driver>** line of all devices that have one.
   For example:

```
<interface type='network'>
  <source network='default'/>
  <model type='virtio'/>
  <driver name='vhost' iommu='on'/>
</interface>
```

   If a device configuration does not contain any **<driver>** line, add **<driver iommu='on'\>** instead.

9. Disable memory ballooning on the VM, as the feature is not compatible with Secure Execution. To do so, add the following line to the VM's XML configuration.

```
<memballoon model='none'/>
```

10. Create the bootable disk image

```
# zipl -V
```

11. Securely remove the original unprotected files. For example:

```
# shred /boot/vmlinuz-4.18.0-240.el8.s390x
# shred /boot/initramfs-4.18.0-240.el8.s390x.img
# shred secure-parameters
```

The original boot image, the initial RAM image, and the kernel parameter file are unprotected, and if they are not removed, VMs with Secure Execution enabled can still be vulnerable to hacking attempts or sensitive data mining.

Verification

- On the host, use the **virsh dumpxml** utility to confirm the XML configuration of the secured VM. The configuration must include the **<driver iommu='on'/>** and **<memballoon model='none'/>** elements.

```
# virsh dumpxml vm-name
[...]
  <cpu mode='host-model'/>
  <devices>
    <disk type='file' device='disk'>
      <driver name='qemu' type='qcow2' cache='none' io='native' iommu='on'>
      <source file='/var/lib/libvirt/images/secure-guest.qcow2'/>
      <target dev='vda' bus='virtio'/>
    </disk>
    <interface type='network'>
      <driver iommu='on'/>
      <source network='default'/>
      <model type='virtio'/>
    </interface>
    <console type='pty'/>
    <memballoon model='none'/>
  </devices>
</domain>
```

Additional resources

- For additonal instructions on modifying the boot configuration of the host, see Configuring kernel command-line parameters.
- For more information on the **genprotimg** utility, see IBM documentation.

15.8. ATTACHING CRYPTOGRAPHIC COPROCESSORS TO VIRTUAL MACHINES ON IBM Z

To use hardware encryption in your virtual machine (VM) on an IBM Z host, create mediated devices from a cryptographic coprocessor device and assign them to the intended VMs. For detailed instructions, see below.

Prerequisites

- Your host is running on IBM Z hardware.
- The cryptographic coprocessor is compatible with device assignment. To confirm this, ensure that the **type** of your coprocessor is listed as **CEX4** or later.

```
# lszcrypt -V

CARD.DOMAIN TYPE  MODE        STATUS  REQUESTS  PENDING HWTYPE QDEPTH
FUNCTIONS  DRIVER
--------------------------------------------------------------------------------
05         CEX5C CCA-Coproc  online       1       0    11     08 S--D--N--  cex4card
05.0004    CEX5C CCA-Coproc  online       1       0    11     08 S--D--N--  cex4queue
05.00ab    CEX5C CCA-Coproc  online       1       0    11     08 S--D--N--  cex4queue
```

- The *mdevctl* package is installed.
- The **vfio_ap** kernel module is loaded. To verify, use:

```
# lsmod | grep vfio_ap
vfio_ap         24576  0
[...]
```

To load the module, use:

```
# modprobe vfio_ap
```

Procedure

1. On the host, reassign your crypto device to the **vfio-ap** drivers. The following example assigns two crypto devices with bitmask IDs **(0x05, 0x0004)** and **(0x05, 0x00ab)** to **vfio-ap**.

```
#  echo -0x05 > /sys/bus/ap/apmask
#  echo -0x0004, -0x00ab > /sys/bus/ap/aqmask
```

For information on identifying the bitmask ID values, see Preparing pass-through devices for cryptographic adapter resources in the KVM Virtual Server Management document from IBM.

2. Verify that the crypto devices have been reassigned correctly.

```
# lszcrypt -V

CARD.DOMAIN TYPE  MODE        STATUS  REQUESTS  PENDING HWTYPE QDEPTH
FUNCTIONS  DRIVER
--------------------------------------------------------------------------------
05         CEX5C CCA-Coproc  -            1       0    11     08 S--D--N--  cex4card
05.0004    CEX5C CCA-Coproc  -            1       0    11     08 S--D--N--  vfio_ap
05.00ab    CEX5C CCA-Coproc  -            1       0    11     08 S--D--N--  vfio_ap
```

If the DRIVER values of the domain queues changed to **vfio_ap**, the reassignment succeeded.

3. Generate a device UUID.

```
# uuidgen
669d9b23-fe1b-4ecb-be08-a2fabca99b71
```

In the following steps of this procedure, replace **669d9b23-fe1b-4ecb-be08-a2fabca99b71** with your generated UUID.

4. Using the UUID, create a new **vfio_ap** device.
The following example shows creating a persistent mediated device and assigning queues to it. For example, the following commands assign domain adapter **0x05** and domain queues **0x0004** and **0x00ab** to device **669d9b23-fe1b-4ecb-be08-a2fabca99b71**.

```
# mdevctl define --uuid 669d9b23-fe1b-4ecb-be08-a2fabca99b71 --parent matrix --type
vfio_ap-passthrough
# mdevctl modify --uuid 669d9b23-fe1b-4ecb-be08-a2fabca99b71 --
addattr=assign_adapter --value=0x05
# mdevctl modify --uuid 669d9b23-fe1b-4ecb-be08-a2fabca99b71 --
addattr=assign_domain --value=0x0004
# mdevctl modify --uuid 669d9b23-fe1b-4ecb-be08-a2fabca99b71 --
addattr=assign_domain --value=0x00ab
```

5. Start the mediated device.

```
# mdevctl start --uuid 669d9b23-fe1b-4ecb-be08-a2fabca99b71
```

6. Check that the configuration has been applied correctly

```
# cat /sys/devices/vfio_ap/matrix/mdev_supported_types/vfio_ap-
passthrough/devices/669d9b23-fe1b-4ecb-be08-a2fabca99b71/matrix
05.0004
05.00ab
```

If the output contains the numerical values of queues that you have previously assigned to **vfio-ap**, the process was successful.

7. Use the **virsh edit** command to open the XML configuration of the VM where you want to use the crypto devices.

```
# virsh edit vm-name
```

8. Add the following lines to the **<devices>** section in the XML configuration, and save it.

```
<hostdev mode='subsystem' type='mdev' managed='no' model='vfio-ap'>
  <source>
    <address uuid='669d9b23-fe1b-4ecb-be08-a2fabca99b71'/>
  </source>
</hostdev>
```

Note that each UUID can only be assigned to one VM at a time.

Verification

1. Start the VM to which you assigned the mediated device.

2. After the guest operating system (OS) boots, ensure that it detects the assigned crypto devices.

```
# lszcrypt -V

CARD.DOMAIN TYPE  MODE        STATUS  REQUESTS  PENDING HWTYPE QDEPTH
FUNCTIONS  DRIVER
--------------------------------------------------------------------------------
05          CEX5C CCA-Coproc  online       1       0    11     08 S--D--N--  cex4card
05.0004     CEX5C CCA-Coproc  online       1       0    11     08 S--D--N--  cex4queue
05.00ab     CEX5C CCA-Coproc  online       1       0    11     08 S--D--N--  cex4queue
```

   The output of this command in the guest OS will be identical to that on a host logical partition with the same cryptographic coprocessor devices available.

15.9. ENABLING STANDARD HARDWARE SECURITY ON WINDOWS VIRTUAL MACHINES

To secure Windows virtual machines (VMs), you can enable basic level security using the standard hardware capabilities of the Windows device.

Prerequisites

- Make sure you have installed the latest WHQL certified VirtIO drivers.
- Make sure the VM's firmware supports UEFI boot.
- Install the **edk2-OVMF** package on your host machine.

```
# yum install edk2-ovmf
```

- Install the **vTPM** packages on your host machine.

```
# yum install swtpm libtpms
```

- Make sure the VM is using the Q35 machine architecture.
- Make sure you have the Windows installation media.

Procedure

1. Enable TPM 2.0 by adding the following parameters to the **<devices>** section in the VM's XML configuration.

```
<devices>
[...]
  <tpm model='tpm-crb'>
    <backend type='emulator' version='2.0'/>
  </tpm>
[...]
</devices>
```

2. Install Windows in UEFI mode. For more information on how to do so, see Creating a SecureBoot virtual machine.

3. Install the VirtIO drivers on the Windows VM. For more information on how to do so, see Installing virtio drivers on a Windows guest .

4. In UEFI, enable Secure Boot. For more information on how to do so, see Secure Boot.

Verification

- Ensure that the **Device Security** page on your Windows machine displays the following message:
  Settings > Update & Security > Windows Security > Device Security

  > **Your device meets the requirements for standard hardware security.**

15.10. ENABLING ENHANCED HARDWARE SECURITY ON WINDOWS VIRTUAL MACHINES

To further secure Windows virtual machines (VMs), you can enable virtualization-based protection of code integrity, also known as Hypervisor-Protected Code Integrity (HVCI).

Prerequisites

- Ensure that standard hardware security is enabled. For more information, see Enabling standard hardware security on Windows virtual machines.
- Ensure that KVM nesting is enabled. For more information, see Creating nested virtual machines.
- On the KVM command line,
  - Specify the CPU model.
  - Enable the Virtual Machine Extensions (VMX) feature.
  - Enable Hyper-V enlightenments.

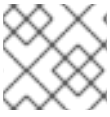
  ```
  # -cpu Skylake-Client-v3,hv_stimer,hv_synic,hv_relaxed,hv_reenlightenment,hv_spinlocks=0xfff,hv_vpindex,hv_vapic,hv_time,hv_frequencies,hv_runtime,+kvm_pv_unhalt,+vmx
  ```

Procedure

1. On your Windows VM, navigate to the **Core isolation details** page:
   Settings > Update & Security > Windows Security > Device Security > Core isolation details

2. Toggle the switch to enable **Memory Integrity**.

3. Reboot the VM.



NOTE

For other methods of enabling HVCI, see the relevant Microsoft documentation.

Verification

- Ensure that the **Device Security** page on your Windows VM displays the following message: **Settings > Update & Security > Windows Security > Device Security**

  > **Your device meets the requirements for enhanced hardware security.**

- Alternatively, check System Information on the Windows VM:

  a. Run **msinfo32.exe** in a command prompt.

  b. Check if **Credential Guard, Hypervisor enforced Code Integrity** is listed under **Virtualization-based security Services Running**.

CHAPTER 16. OPTIMIZING VIRTUAL MACHINE PERFORMANCE

Virtual machines (VMs) always experience some degree of performance deterioration in comparison to the host. The following sections explain the reasons for this deterioration and provide instructions on how to minimize the performance impact of virtualization in RHEL 8, so that your hardware infrastructure resources can be used as efficiently as possible.

16.1. WHAT INFLUENCES VIRTUAL MACHINE PERFORMANCE

VMs are run as user-space processes on the host. The hypervisor therefore needs to convert the host's system resources so that the VMs can use them. As a consequence, a portion of the resources is consumed by the conversion, and the VM therefore cannot achieve the same performance efficiency as the host.

The impact of virtualization on system performance

More specific reasons for VM performance loss include:

- Virtual CPUs (vCPUs) are implemented as threads on the host, handled by the Linux scheduler.
- VMs do not automatically inherit optimization features, such as NUMA or huge pages, from the host kernel.
- Disk and network I/O settings of the host might have a significant performance impact on the VM.
- Network traffic typically travels to a VM through a software-based bridge.
- Depending on the host devices and their models, there might be significant overhead due to emulation of particular hardware.

The severity of the virtualization impact on the VM performance is influenced by a variety factors, which include:

- The number of concurrently running VMs.
- The amount of virtual devices used by each VM.
- The device types used by the VMs.

Reducing VM performance loss

RHEL 8 provides a number of features you can use to reduce the negative performance effects of virtualization. Notably:

- The **tuned** service can automatically optimize the resource distribution and performance of your VMs.
- Block I/O tuning can improve the performances of the VM's block devices, such as disks.
- NUMA tuning can increase vCPU performance.
- Virtual networking can be optimized in various ways.

IMPORTANT

Tuning VM performance can have adverse effects on other virtualization functions. For example, it can make migrating the modified VM more difficult.

16.2. OPTIMIZING VIRTUAL MACHINE PERFORMANCE USING TUNED

The **tuned** utility is a tuning profile delivery mechanism that adapts RHEL for certain workload characteristics, such as requirements for CPU-intensive tasks or storage-network throughput responsiveness. It provides a number of tuning profiles that are pre-configured to enhance performance and reduce power consumption in a number of specific use cases. You can edit these profiles or create new profiles to create performance solutions tailored to your environment, including virtualized environments.

To optimize RHEL 8 for virtualization, use the following profiles:

- For RHEL 8 virtual machines, use the **virtual-guest** profile. It is based on the generally applicable ***throughput-performance*** profile, but also decreases the swappiness of virtual memory.
- For RHEL 8 virtualization hosts, use the **virtual-host** profile. This enables more aggressive writeback of dirty memory pages, which benefits the host performance.

Prerequisites

- The **tuned** service is installed and enabled.

Procedure

To enable a specific **tuned** profile:

1. List the available **tuned** profiles.

```
# tuned-adm list

Available profiles:
- balanced             - General non-specialized tuned profile
- desktop              - Optimize for the desktop use-case
[...]
- virtual-guest        - Optimize for running inside a virtual guest
- virtual-host         - Optimize for running KVM guests
Current active profile: balanced
```

2. **Optional:** Create a new **tuned** profile or edit an existing **tuned** profile.
   For more information, see Customizing tuned profiles.

3. Activate a **tuned** profile.

```
# tuned-adm profile selected-profile
```

   - To optimize a virtualization host, use the *virtual-host* profile.

```
# tuned-adm profile virtual-host
```

   - On a RHEL guest operating system, use the *virtual-guest* profile.

```
# tuned-adm profile virtual-guest
```

Additional resources

- For more information about **tuned** and **tuned** profiles, see Monitoring and managing system status and performance.

16.3. CONFIGURING VIRTUAL MACHINE MEMORY

To improve the performance of a virtual machine (VM), you can assign additional host RAM to the VM. Similarly, you can decrease the amount of memory allocated to a VM so the host memory can be allocated to other VMs or tasks.

To perform these actions, you can use the web console or the command-line interface.

16.3.1. Adding and removing virtual machine memory using the web console

To improve the performance of a virtual machine (VM) or to free up the host resources it is using, you can use the web console to adjust amount of memory allocated to the VM.

Prerequisites

- The guest OS is running the memory balloon drivers. To verify this is the case:
  1. Ensure the VM's configuration includes the **memballoon** device:

     ```
     # virsh dumpxml testguest | grep memballoon
     <memballoon model='virtio'>
       </memballoon>
     ```

     If this commands displays any output and the model is not set to **none**, the **memballoon** device is present.

  2. Ensure the balloon drivers are running in the guest OS.
     - In Windows guests, the drivers are installed as a part of the **virtio-win** driver package. For instructions, see Section 17.2.1, "Installing KVM paravirtualized drivers for Windows virtual machines".
     - In Linux guests, the drivers are generally included by default and activate when the **memballoon** device is present.
- The web console VM plug-in is installed on your system.

Procedure

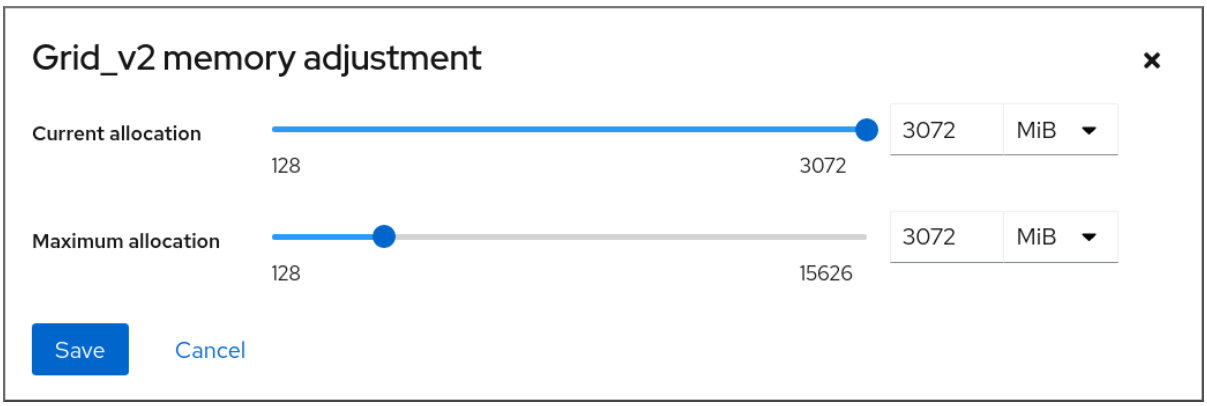
1. **Optional:** Obtain the information about the maximum memory and currently used memory for a VM. This will serve as a baseline for your changes, and also for verification.

   ```
   # virsh dominfo testguest
   Max memory:     2097152 KiB
   Used memory:    2097152 KiB
   ```

2. In the **Virtual Machines** interface, click the VM whose information you want to see.

A new page opens with an Overview section with basic information about the selected VM and a Console section to access the VM's graphical interface.

3. Click **edit** next to the **Memory** line in the Overview pane.
The **Memory Adjustment** dialog appears.



4. Configure the virtual CPUs for the selected VM.

   - **Maximum allocation** - Sets the maximum amount of host memory that the VM can use for its processes. You can specify the maximum memory when creating the VM or increase it later. You can specify memory as multiples of MiB or GiB.
   Adjusting maximum memory allocation is only possible on a shut-off VM.

   - **Current allocation** - Sets the actual amount of memory allocated to the VM. This value can be less than the Maximum allocation but cannot exceed it. You can adjust the value to regulate the memory available to the VM for its processes. You can specify memory as multiples of MiB or GiB.
   If you do not specify this value, the default allocation is the **Maximum allocation** value.

5. Click **Save**.
The memory allocation of the VM is adjusted.

Additional resources

- For instructions for adjusting VM memory setting using the command-line interface, see Section 16.3.2, "Adding and removing virtual machine memory using the command-line interface".

- To optimize how the VM uses the allocated memory, you can modify your vCPU setting. For more information, see Section 16.5, "Optimizing virtual machine CPU performance".

16.3.2. Adding and removing virtual machine memory using the command-line interface

To improve the performance of a virtual machine (VM) or to free up the host resources it is using, you can use the CLI to adjust amount of memory allocated to the VM.

Prerequisites

- The guest OS is running the memory balloon drivers. To verify this is the case:

  1. Ensure the VM's configuration includes the **memballoon** device:

```
# virsh dumpxml testguest | grep memballoon
<memballoon model='virtio'>
  </memballoon>
```

If this commands displays any output and the model is not set to **none**, the **memballoon** device is present.

2. Ensure the ballon drivers are running in the guest OS.
   - In Windows guests, the drivers are installed as a part of the **virtio-win** driver package. For instructions, see Section 17.2.1, "Installing KVM paravirtualized drivers for Windows virtual machines".
   - In Linux guests, the drivers are generally included by default and activate when the **memballoon** device is present.

Procedure

1. **Optional:** Obtain the information about the maximum memory and currently used memory for a VM. This will serve as a baseline for your changes, and also for verification.

```
# virsh dominfo testguest
Max memory:     2097152 KiB
Used memory:    2097152 KiB
```

2. Adjust the maximum memory allocated to a VM. Increasing this value improves the performance potential of the VM, and reducing the value lowers the performance footprint the VM has on your host. Note that this change can only be performed on a shut-off VM, so adjusting a running VM requires a reboot to take effect.
   For example, to change the maximum memory that the *testguest* VM can use to 4096 MiB:

```
# virt-xml testguest --edit --memory memory=4096,currentMemory=4096
Domain 'testguest' defined successfully.
Changes will take effect after the domain is fully powered off.
```

1. **Optional:** You can also adjust the memory currently used by the VM, up to the maximum allocation. This regulates the memory load that the VM has on the host until the next reboot, without changing the maximum VM allocation.

```
# virsh setmem testguest --current 2048
```

Verification

1. Confirm that the memory used by the VM has been updated:

```
# virsh dominfo testguest
Max memory:     4194304 KiB
Used memory:    2097152 KiB
```

2. **Optional:** If you adjusted the current VM memory, you can obtain the memory balloon statistics of the VM to evaluate how effectively it regulates its memory use.

```
# virsh domstats --balloon testguest
```

```
Domain: 'testguest'
  balloon.current=365624
  balloon.maximum=4194304
  balloon.swap_in=0
  balloon.swap_out=0
  balloon.major_fault=306
  balloon.minor_fault=156117
  balloon.unused=3834448
  balloon.available=4035008
  balloon.usable=3746340
  balloon.last-update=1587971682
  balloon.disk_caches=75444
  balloon.hugetlb_pgalloc=0
  balloon.hugetlb_pgfail=0
  balloon.rss=1005456
```

Additional resources

- For instructions for adjusting VM memory setting using the web console, see Section 16.3.1, "Adding and removing virtual machine memory using the web console".
- To optimize how the VM uses the allocated memory, you can modify your vCPU setting. For more information, see Section 16.5, "Optimizing virtual machine CPU performance" .

16.3.3. Additional resources

- To increase the maximum memory of a running VM, you can attach a memory device to the VM. This is also referred to as **memory hot plug**. For details, see Section 10.3, "Attaching devices to virtual machines".
  Note that removing a memory device from a VM, also known as **memory hot unplug**, is not supported in RHEL 8, and Red Hat highly discourages its use.

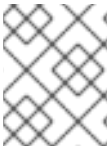
16.4. OPTIMIZING VIRTUAL MACHINE I/O PERFORMANCE

The input and output (I/O) capabilities of a virtual machine (VM) can significantly limit the VM's overall efficiency. To address this, you can optimize a VM's I/O by configuring block I/O parameters.

16.4.1. Tuning block I/O in virtual machines

When multiple block devices are being used by one or more VMs, it might be important to adjust the I/O priority of specific virtual devices by modifying their *I/O weights*.

Increasing the I/O weight of a device increases its priority for I/O bandwidth, and therefore provides it with more host resources. Similarly, reducing a device's weight makes it consume less host resources.



NOTE

Each device's **weight** value must be within the **100** to **1000** range. Alternatively, the value can be **0**, which removes that device from per-device listings.

Procedure

To display and set a VM's block I/O parameters:

1. Display the current **<blkio>** parameters for a VM:
   # virsh dumpxml *VM-name*

```
<domain>
 [...]
 <blkiotune>
  <weight>800</weight>
  <device>
   <path>/dev/sda</path>
   <weight>1000</weight>
  </device>
  <device>
   <path>/dev/sdb</path>
   <weight>500</weight>
  </device>
 </blkiotune>
 [...]
</domain>
```

2. Edit the I/O weight of a specified device:

```
# virsh blkiotune VM-name --device-weights device, I/O-weight
```

   For example, the following changes the weight of the */dev/sda* device in the *liftrul* VM to 500.

```
# virsh blkiotune liftbrul --device-weights /dev/sda, 500
```

16.4.2. Disk I/O throttling in virtual machines

When several VMs are running simultaneously, they can interfere with system performance by using excessive disk I/O. Disk I/O throttling in KVM virtualization provides the ability to set a limit on disk I/O requests sent from the VMs to the host machine. This can prevent a VM from over-utilizing shared resources and impacting the performance of other VMs.

To enable disk I/O throttling, set a limit on disk I/O requests sent from each block device attached to VMs to the host machine.

Procedure

1. Use the **virsh domblklist** command to list the names of all the disk devices on a specified VM.

```
# virsh domblklist rollin-coal
Target     Source
------------------------------------------------
vda        /var/lib/libvirt/images/rollin-coal.qcow2
sda        -
sdb        /home/horridly-demanding-processes.iso
```

2. Find the host block device where the virtual disk that you want to throttle is mounted.
   For example, if you want to throttle the **sdb** virtual disk from the previous step, the following output shows that the disk is mounted on the **/dev/nvme0n1p3** partition.

```
$ lsblk
```

```
NAME                                          MAJ:MIN RM   SIZE RO TYPE  MOUNTPOINT
zram0                                         252:0    0     4G  0 disk  [SWAP]
nvme0n1                                         259:0    0 238.5G  0 disk
├─nvme0n1p1                                     259:1    0   600M  0 part  /boot/efi
├─nvme0n1p2                                     259:2    0     1G  0 part  /boot
└─nvme0n1p3                                     259:3    0 236.9G  0 part
  └─luks-a1123911-6f37-463c-b4eb-fxzy1ac12fea 253:0    0 236.9G  0 crypt /home
```

3. Set I/O limits for the block device using the **virsh blkiotune** command.

```
# virsh blkiotune VM-name --parameter device,limit
```

The following example throttles the **sdb** disk on the **rollin-coal** VM to 1000 read and write I/O operations per second and to 50 MB per second read and write throughput.

```
# virsh blkiotune rollin-coal --device-read-iops-sec /dev/nvme0n1p3,1000 --device-write-iops-sec /dev/nvme0n1p3,1000 --device-write-bytes-sec /dev/nvme0n1p3,52428800 --device-read-bytes-sec /dev/nvme0n1p3,52428800
```

Additional information

- Disk I/O throttling can be useful in various situations, for example when VMs belonging to different customers are running on the same host, or when quality of service guarantees are given for different VMs. Disk I/O throttling can also be used to simulate slower disks.
- I/O throttling can be applied independently to each block device attached to a VM and supports limits on throughput and I/O operations.
- Red Hat does not support using the **virsh blkdeviotune** command to configure I/O throttling in VMs. For more information on unsupported features when using RHEL 8 as a VM host, see Section 20.3, “Unsupported features in RHEL 8 virtualization” .

16.4.3. Enabling multi-queue virtio-scsi

When using **virtio-scsi** storage devices in your virtual machines (VMs), the *multi-queue virtio-scsi* feature provides improved storage performance and scalability. It enables each virtual CPU (vCPU) to have a separate queue and interrupt to use without affecting other vCPUs.

Procedure

- To enable multi-queue virtio-scsi support for a specific VM, add the following to the VM’s XML configuration, where *N* is the total number of vCPU queues:

```
<controller type='scsi' index='0' model='virtio-scsi'>
  <driver queues='N' />
</controller>
```

16.5. OPTIMIZING VIRTUAL MACHINE CPU PERFORMANCE

Much like physical CPUs in host machines, vCPUs are critical to virtual machine (VM) performance. As a result, optimizing vCPUs can have a significant impact on the resource efficiency of your VMs. To optimize your vCPU:

1. Adjust how many host CPUs are assigned to the VM. You can do this using the CLI or the web console.

2. Ensure that the vCPU model is aligned with the CPU model of the host. For example, to set the *testguest1* VM to use the CPU model of the host:

```
# virt-xml testguest1 --edit --cpu host-model
```

3. Deactivate kernel same-page merging (KSM) .

4. If your host machine uses Non-Uniform Memory Access (NUMA), you can also **configure NUMA** for its VMs. This maps the host's CPU and memory processes onto the CPU and memory processes of the VM as closely as possible. In effect, NUMA tuning provides the vCPU with a more streamlined access to the system memory allocated to the VM, which can improve the vCPU processing effectiveness.
   For details, see Section 16.5.3, "Configuring NUMA in a virtual machine" and Section 16.5.4, "Sample vCPU performance tuning scenario".

16.5.1. Adding and removing virtual CPUs using the command-line interface

To increase or optimize the CPU performance of a virtual machine (VM), you can add or remove virtual CPUs (vCPUs) assigned to the VM.

When performed on a running VM, this is also referred to as vCPU hot plugging and hot unplugging. However, note that vCPU hot unplug is not supported in RHEL 8, and Red Hat highly discourages its use.

Prerequisites

- **Optional:** View the current state of the vCPUs in the targeted VM. For example, to display the number of vCPUs on the *testguest* VM:

```
# virsh vcpucount testguest
maximum      config         4
maximum      live           2
current      config         2
current      live           1
```

This output indicates that *testguest* is currently using 1 vCPU, and 1 more vCPu can be hot plugged to it to increase the VM's performance. However, after reboot, the number of vCPUs *testguest* uses will change to 2, and it will be possible to hot plug 2 more vCPUs.

Procedure

1. Adjust the maximum number of vCPUs that can be attached to a VM, which takes effect on the VM's next boot.
   For example, to increase the maximum vCPU count for the *testguest* VM to 8:

```
# virsh setvcpus testguest 8 --maximum --config
```

Note that the maximum may be limited by the CPU topology, host hardware, the hypervisor, and other factors.

2. Adjust the current number of vCPUs attached to a VM, up to the maximum configured in the previous step. For example:

- To increase the number of vCPUs attached to the running *testguest* VM to 4:

```
# virsh setvcpus testguest 4 --live
```

This increases the VM's performance and host load footprint of *testguest* until the VM's next boot.

- To permanently decrease the number of vCPUs attached to the *testguest* VM to 1:

```
# virsh setvcpus testguest 1 --config
```

This decreases the VM's performance and host load footprint of *testguest* after the VM's next boot. However, if needed, additional vCPUs can be hot plugged to the VM to temporarily increase its performance.

Verification

- Confirm that the current state of vCPU for the VM reflects your changes.

```
# virsh vcpucount testguest
maximum      config         8
maximum      live           4
current      config         1
current      live           4
```

Additional resources

- For information on adding and removing vCPUs using the web console, see Section 16.5.2, "Managing virtual CPUs using the web console".

16.5.2. Managing virtual CPUs using the web console

Using the RHEL 8 web console, you can review and configure virtual CPUs used by virtual machines (VMs) to which the web console is connected.

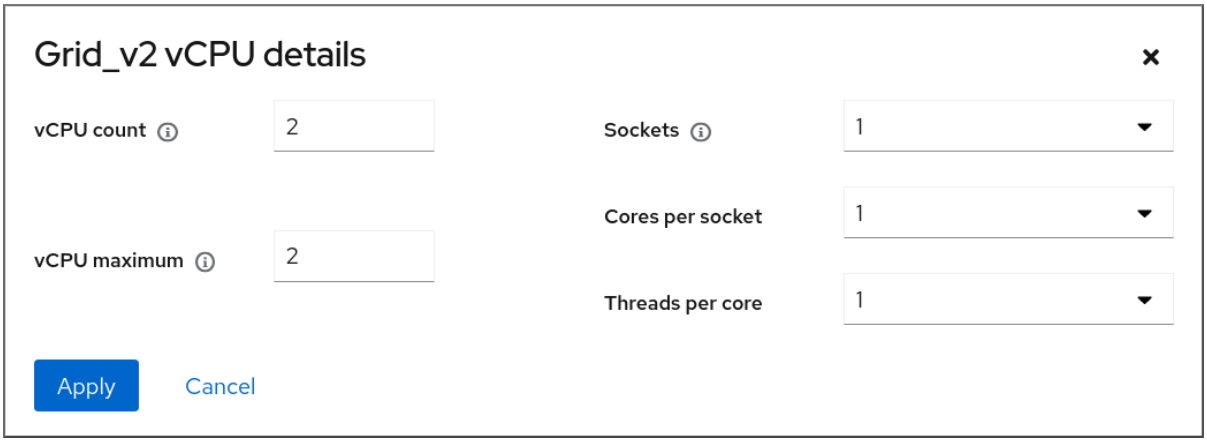
Prerequisites

- The web console VM plug-in is installed on your system.

Procedure

1. In the **Virtual Machines** interface, click the VM whose information you want to see.
   A new page opens with an Overview section with basic information about the selected VM and a Console section to access the VM's graphical interface.

2. Click **edit** next to the number of vCPUs in the Overview pane.
   The vCPU details dialog appears.



1. Configure the virtual CPUs for the selected VM.
   - **vCPU Count** - The number of vCPUs currently in use.

     NOTE

     The vCPU count cannot be greater than the vCPU Maximum.

   - **vCPU Maximum** - The maximum number of virtual CPUs that can be configured for the VM. If this value is higher than the **vCPU Count**, additional vCPUs can be attached to the VM.
   - **Sockets** - The number of sockets to expose to the VM.
   - **Cores per socket** - The number of cores for each socket to expose to the VM.
   - **Threads per core** - The number of threads for each core to expose to the VM.
     Note that the **Sockets**, **Cores per socket**, and **Threads per core** options adjust the CPU topology of the VM. This may be beneficial for vCPU performance and may impact the functionality of certain software in the guest OS. If a different setting is not required by your deployment, keep the default values.
2. Click **Apply**.
   The virtual CPUs for the VM are configured.

   NOTE

   Changes to virtual CPU settings only take effect after the VM is restarted.

Additional resources:

- For information on managing your vCPUs using the command-line interface, see Section 16.5.1, "Adding and removing virtual CPUs using the command-line interface".

16.5.3. Configuring NUMA in a virtual machine

The following methods can be used to configure Non-Uniform Memory Access (NUMA) settings of a virtual machine (VM) on a RHEL 8 host.

Prerequisites

- The host is a NUMA-compatible machine. To detect whether this is the case, use the **virsh nodeinfo** command and see the **NUMA cell(s)** line:

```
# virsh nodeinfo
CPU model:           x86_64
CPU(s):              48
CPU frequency:       1200 MHz
CPU socket(s):       1
Core(s) per socket:  12
Thread(s) per core:  2
NUMA cell(s):        2
Memory size:         67012964 KiB
```

  If the value of the line is 2 or greater, the host is NUMA-compatible.

Procedure

For ease of use, you can set up a VM's NUMA configuration using automated utilities and services. However, manual NUMA setup is more likely to yield a significant performance improvement.

Automatic methods

- Set the VM's NUMA policy to **Preferred**. For example, to do so for the *testguest5* VM:

```
# virt-xml testguest5 --edit --vcpus placement=auto
# virt-xml testguest5 --edit --numatune mode=preferred
```

- Enable automatic NUMA balancing on the host:

```
# echo 1 > /proc/sys/kernel/numa_balancing
```

- Use the **numad** command to automatically align the VM CPU with memory resources.

```
# numad
```

Manual methods

1. Pin specific vCPU threads to a specific host CPU or range of CPUs. This is also possible on non-NUMA hosts and VMs, and is recommended as a safe method of vCPU performance improvement.
   For example, the following commands pin vCPU threads 0 to 5 of the *testguest6* VM to host CPUs 1, 3, 5, 7, 9, and 11, respectively:

```
# virsh vcpupin testguest6 0 1
# virsh vcpupin testguest6 1 3
# virsh vcpupin testguest6 2 5
# virsh vcpupin testguest6 3 7
# virsh vcpupin testguest6 4 9
# virsh vcpupin testguest6 5 11
```

   Afterwards, you can verify whether this was successful:

```
# virsh vcpupin testguest6
VCPU   CPU Affinity
----------------------
```

```
0    1
1    3
2    5
3    7
4    9
5    11
```

2. After pinning vCPU threads, you can also pin QEMU process threads associated with a specified VM to a specific host CPU or range of CPUs. For example, the following commands pin the QEMU process thread of *testguest6* to CPUs 13 and 15, and verify this was successful:

```
# virsh emulatorpin testguest6 13,15
# virsh emulatorpin testguest6
emulator: CPU Affinity
----------------------------------
       *: 13,15
```

3. Finally, you can also specify which host NUMA nodes will be assigned specifically to a certain VM. This can improve the host memory usage by the VM's vCPU. For example, the following commands set *testguest6* to use host NUMA nodes 3 to 5, and verify this was successful:

```
# virsh numatune testguest6 --nodeset 3-5
# virsh numatune testguest6
```

Additional resources

- Note that for best performance results, it is recommended to use all of the manual tuning methods listed above. For an example of such a configuration, see Section 16.5.4, "Sample vCPU performance tuning scenario".
- To see the current NUMA configuration of your system, you can use the **numastat** utility. For details on using **numastat**, see Section 16.7, "Virtual machine performance monitoring tools" .
- NUMA tuning is currently not possible to perform on IBM Z hosts. For further information, see Section 4.2, "How virtualization on IBM Z differs from AMD64 and Intel 64" .

16.5.4. Sample vCPU performance tuning scenario

To obtain the best vCPU performance possible, Red Hat recommends using manual **vcpupin**, **emulatorpin**, and **numatune** settings together, for example like in the following scenario.

Starting scenario

- Your host has the following hardware specifics:
  - 2 NUMA nodes
  - 3 CPU cores on each node
  - 2 threads on each core

  The output of **virsh nodeinfo** of such a machine would look similar to:

```
# virsh nodeinfo
```

```
CPU model:          x86_64
CPU(s):             12
CPU frequency:      3661 MHz
CPU socket(s):      2
Core(s) per socket: 3
Thread(s) per core: 2
NUMA cell(s):       2
Memory size:        31248692 KiB
```

- You intend to modify an existing VM to have 8 vCPUs, which means that it will not fit in a single NUMA node.
  Therefore, you should distribute 4 vCPUs on each NUMA node and make the vCPU topology resemble the host topology as closely as possible. This means that vCPUs that run as sibling threads of a given physical CPU should be pinned to host threads on the same core. For details, see the *Solution* below:

Solution

1. Obtain the information on the host topology:

   ```
   # virsh capabilities
   ```

   The output should include a section that looks similar to the following:

```
<topology>
  <cells num="2">
    <cell id="0">
      <memory unit="KiB">15624346</memory>
      <pages unit="KiB" size="4">3906086</pages>
      <pages unit="KiB" size="2048">0</pages>
      <pages unit="KiB" size="1048576">0</pages>
      <distances>
        <sibling id="0" value="10" />
        <sibling id="1" value="21" />
      </distances>
      <cpus num="6">
        <cpu id="0" socket_id="0" core_id="0" siblings="0,3" />
        <cpu id="1" socket_id="0" core_id="1" siblings="1,4" />
        <cpu id="2" socket_id="0" core_id="2" siblings="2,5" />
        <cpu id="3" socket_id="0" core_id="0" siblings="0,3" />
        <cpu id="4" socket_id="0" core_id="1" siblings="1,4" />
        <cpu id="5" socket_id="0" core_id="2" siblings="2,5" />
      </cpus>
    </cell>
    <cell id="1">
      <memory unit="KiB">15624346</memory>
      <pages unit="KiB" size="4">3906086</pages>
      <pages unit="KiB" size="2048">0</pages>
      <pages unit="KiB" size="1048576">0</pages>
      <distances>
        <sibling id="0" value="21" />
        <sibling id="1" value="10" />
      </distances>
      <cpus num="6">
        <cpu id="6" socket_id="1" core_id="3" siblings="6,9" />
```

```
      <cpu id="7" socket_id="1" core_id="4" siblings="7,10" />
      <cpu id="8" socket_id="1" core_id="5" siblings="8,11" />
      <cpu id="9" socket_id="1" core_id="3" siblings="6,9" />
      <cpu id="10" socket_id="1" core_id="4" siblings="7,10" />
      <cpu id="11" socket_id="1" core_id="5" siblings="8,11" />
    </cpus>
  </cell>
 </cells>
</topology>
```

2. **Optional:** Test the performance of the VM using the applicable tools and utilities.

3. Set up and mount 1 GiB huge pages on the host:

   a. Add the following line to the host's kernel command line:

   ```
   default_hugepagesz=1G hugepagesz=1G
   ```

   b. Create the **/etc/systemd/system/hugetlb-gigantic-pages.service** file with the following content:

   ```
   [Unit]
   Description=HugeTLB Gigantic Pages Reservation
   DefaultDependencies=no
   Before=dev-hugepages.mount
   ConditionPathExists=/sys/devices/system/node
   ConditionKernelCommandLine=hugepagesz=1G

   [Service]
   Type=oneshot
   RemainAfterExit=yes
   ExecStart=/etc/systemd/hugetlb-reserve-pages.sh

   [Install]
   WantedBy=sysinit.target
   ```

   c. Create the **/etc/systemd/hugetlb-reserve-pages.sh** file with the following content:

   ```
   #!/bin/sh

   nodes_path=/sys/devices/system/node/
   if [ ! -d $nodes_path ]; then
    echo "ERROR: $nodes_path does not exist"
    exit 1
   fi

   reserve_pages()
   {
    echo $1 > $nodes_path/$2/hugepages/hugepages-1048576kB/nr_hugepages
   }

   reserve_pages 4 node1
   reserve_pages 4 node2
   ```

   This reserves four 1GiB huge pages from *node1* and four 1GiB huge pages from *node2*.

d. Make the script created in the previous step executable:

```
# chmod +x /etc/systemd/hugetlb-reserve-pages.sh
```

e. Enable huge page reservation on boot:

```
# systemctl enable hugetlb-gigantic-pages
```

4. Use the **virsh edit** command to edit the XML configuration of the VM you wish to optimize, in this example *super-VM*:

```
# virsh edit super-vm
```

5. Adjust the XML configuration of the VM in the following way:

a. Set the VM to use 8 static vCPUs. Use the **<vcpu/>** element to do this.

b. Pin each of the vCPU threads to the corresponding host CPU threads that it mirrors in the topology. To do so, use the **<vcpupin/>** elements in the **<cputune>** section.
Note that, as shown by the **virsh capabilities** utility above, host CPU threads are not ordered sequentially in their respective cores. In addition, the vCPU threads should be pinned to the highest available set of host cores on the same NUMA node. For a table illustration, see the **Additional Resources** section below.

The XML configuration for steps a. and b. can look similar to:

```
<cputune>
  <vcpupin vcpu='0' cpuset='1'/>
  <vcpupin vcpu='1' cpuset='4'/>
  <vcpupin vcpu='2' cpuset='2'/>
  <vcpupin vcpu='3' cpuset='5'/>
  <vcpupin vcpu='4' cpuset='7'/>
  <vcpupin vcpu='5' cpuset='10'/>
  <vcpupin vcpu='6' cpuset='8'/>
  <vcpupin vcpu='7' cpuset='11'/>
  <emulatorpin cpuset='6,9'/>
</cputune>
```

c. Set the VM to use 1 GiB huge pages:

```
<memoryBacking>
  <hugepages>
    <page size='1' unit='GiB'/>
  </hugepages>
</memoryBacking>
```

d. Configure the VM's NUMA nodes to use memory from the corresponding NUMA nodes on the host. To do so, use the **<memnode/>** elements in the **<numatune/>** section:

```
<numatune>
  <memory mode="preferred" nodeset="1"/>
  <memnode cellid="0" mode="strict" nodeset="0"/>
  <memnode cellid="1" mode="strict" nodeset="1"/>
</numatune>
```

e. Ensure the CPU mode is set to **host-passthrough**, and that the CPU uses cache in **passthrough** mode:

```
<cpu mode="host-passthrough">
  <topology sockets="2" cores="2" threads="2"/>
  <cache mode="passthrough"/>
```

Verification

1. Confirm that the resulting XML configuration of the VM includes a section similar to the following:

```
[...]
  <memoryBacking>
    <hugepages>
      <page size='1' unit='GiB'/>
    </hugepages>
  </memoryBacking>
  <vcpu placement='static'>8</vcpu>
  <cputune>
    <vcpupin vcpu='0' cpuset='1'/>
    <vcpupin vcpu='1' cpuset='4'/>
    <vcpupin vcpu='2' cpuset='2'/>
    <vcpupin vcpu='3' cpuset='5'/>
    <vcpupin vcpu='4' cpuset='7'/>
    <vcpupin vcpu='5' cpuset='10'/>
    <vcpupin vcpu='6' cpuset='8'/>
    <vcpupin vcpu='7' cpuset='11'/>
    <emulatorpin cpuset='6,9'/>
  </cputune>
  <numatune>
    <memory mode="preferred" nodeset="1"/>
    <memnode cellid="0" mode="strict" nodeset="0"/>
    <memnode cellid="1" mode="strict" nodeset="1"/>
  </numatune>
  <cpu mode="host-passthrough">
    <topology sockets="2" cores="2" threads="2"/>
    <cache mode="passthrough"/>
    <numa>
      <cell id="0" cpus="0-3" memory="2" unit="GiB">
        <distances>
          <sibling id="0" value="10"/>
          <sibling id="1" value="21"/>
        </distances>
      </cell>
      <cell id="1" cpus="4-7" memory="2" unit="GiB">
        <distances>
          <sibling id="0" value="21"/>
          <sibling id="1" value="10"/>
        </distances>
      </cell>
    </numa>
  </cpu>
</domain>
```

2. **Optional:** Test the performance of the VM using the applicable tools and utilities to evaluate the impact of the VM's optimization.

Additional resources

- The following tables illustrate the connections between the vCPUs and the host CPUs they should be pinned to:

Table 16.1. Host topology

CPU threads	0	3	1	4	2	5	6	9	7	10	8	11
Cores	0		1		2		3		4		5	
Sockets	0						1					
NUMA nodes	0						1					

Table 16.2. VM topology

vCPU threads	0	1	2	3	4	5	6	7
Cores	0		1		2		3	
Sockets	0				1			
NUMA nodes	0				1			

Table 16.3. Combined host and VM topology

vCPU threads			0	1	2	3			4	5	6	7
Host CPU threads	0	3	1	4	2	5	6	9	7	10	8	11
Cores	0		1		2		3		4		5	
Sockets	0						1					
NUMA nodes	0						1					

In this scenario, there are 2 NUMA nodes and 8 vCPUs. Therefore, 4 vCPU threads should be pinned to each node.

In addition, Red Hat recommends leaving at least a single CPU thread available on each node for host system operations.

Because in this example, each NUMA node houses 3 cores, each with 2 host CPU threads, the set for node 0 translates as follows:

```
<vcpupin vcpu='0' cpuset='1'/>
<vcpupin vcpu='1' cpuset='4'/>
<vcpupin vcpu='2' cpuset='2'/>
<vcpupin vcpu='3' cpuset='5'/>
```

16.5.5. Deactivating kernel same-page merging

Although kernel same-page merging (KSM) improves memory density, it increases CPU utilization, and might adversely affect overall performance depending on the workload. In such cases, you can improve the virtual machine (VM) performance by deactivating KSM.

Depending on your requirements, you can either deactivate KSM for a single session or persistently.

Procedure

- To deactivate KSM for a single session, use the **systemctl** utility to stop **ksm** and **ksmtuned** services.

```
# systemctl stop ksm

# systemctl stop ksmtuned
```

- To deactivate KSM persistently, use the **systemctl** utility to disable **ksm** and **ksmtuned** services.

```
# systemctl disable ksm
Removed /etc/systemd/system/multi-user.target.wants/ksm.service.
# systemctl disable ksmtuned
Removed /etc/systemd/system/multi-user.target.wants/ksmtuned.service.
```

NOTE

Memory pages shared between VMs before deactivating KSM will remain shared. To stop sharing, delete all the **PageKSM** pages in the system using the following command:

```
# echo 2 > /sys/kernel/mm/ksm/run
```

After anonymous pages replace the KSM pages, the **khugepaged** kernel service will rebuild transparent hugepages on the VM's physical memory.

16.6. OPTIMIZING VIRTUAL MACHINE NETWORK PERFORMANCE

Due to the virtual nature of a VM's network interface card (NIC), the VM loses a portion of its allocated host network bandwidth, which can reduce the overall workload efficiency of the VM. The following tips can minimize the negative impact of virtualization on the virtual NIC (vNIC) throughput.

Procedure

Use any of the following methods and observe if it has a beneficial effect on your VM network performance:

Enable the vhost_net module

On the host, ensure the **vhost_net** kernel feature is enabled:

```
# lsmod | grep vhost
vhost_net              32768  1
vhost                  53248  1 vhost_net
tap                    24576  1 vhost_net
tun                    57344  6 vhost_net
```

If the output of this command is blank, enable the **vhost_net** kernel module:

```
# modprobe vhost_net
```

Set up multi-queue virtio-net

To set up the *multi-queue virtio-net* feature for a VM, use the **virsh edit** command to edit to the XML configuration of the VM. In the XML, add the following to the **<devices>** section, and replace **N** with the number of vCPUs in the VM, up to 16:

```
<interface type='network'>
    <source network='default'/>
    <model type='virtio'/>
    <driver name='vhost' queues='N'/>
</interface>
```

If the VM is running, restart it for the changes to take effect.

Batching network packets

In Linux VM configurations with a long transmission path, batching packets before submitting them to the kernel may improve cache utilization. To set up packet batching, use the following command on the host, and replace *tap0* with the name of the network interface that the VMs use:

```
# ethtool -C tap0 rx-frames 128
```

SR-IOV

If your host NIC supports SR-IOV, use SR-IOV device assignment for your vNICs. For more information, see Section 10.9, “Managing SR-IOV devices”.

Additional resources

- For additional information on virtual network connection types and tips for usage, see Section 13.1, “Understanding virtual networking”.

16.7. VIRTUAL MACHINE PERFORMANCE MONITORING TOOLS

To identify what consumes the most VM resources and which aspect of VM performance needs optimization, performance diagnostic tools, both general and VM-specific, can be used.

Default OS performance monitoring tools

For standard performance evaluation, you can use the utilities provided by default by your host and guest operating systems:

- On your RHEL 8 host, as root, use the **top** utility or the **system monitor** application, and look for **qemu** and **virt** in the output. This shows how much host system resources your VMs are consuming.

- If the monitoring tool displays that any of the **qemu** or **virt** processes consume a large portion of the host CPU or memory capacity, use the **perf** utility to investigate. For details, see below.
- In addition, if a **vhost_net** thread process, named for example *vhost_net-1234*, is displayed as consuming an excessive amount of host CPU capacity, consider using virtual network optimization features, such as **multi-queue virtio-net**.

- On the guest operating system, use performance utilities and applications available on the system to evaluate which processes consume the most system resources.
  - On Linux systems, you can use the **top** utility.
  - On Windows systems, you can use the **Task Manager** application.

perf kvm

You can use the **perf** utility to collect and analyze virtualization-specific statistics about the performance of your RHEL 8 host. To do so:

1. On the host, install the *perf* package:

```
# yum install perf
```

2. Use one of the **perf kvm stat** commands to display perf statistics for your virtualization host:
   - For real-time monitoring of your hypervisor, use the **perf kvm stat live** command.
   - To log the perf data of your hypervisor over a period of time, activate the logging using the **perf kvm stat record** command. After the command is canceled or interrupted, the data is saved in the **perf.data.guest** file, which can be analyzed using the **perf kvm stat report** command.

3. Analyze the **perf** output for types of **VM-EXIT** events and their distribution. For example, the **PAUSE_INSTRUCTION** events should be infrequent, but in the following output, the high occurrence of this event suggests that the host CPUs are not handling the running vCPUs well. In such a scenario, consider shutting down some of your active VMs, removing vCPUs from these VMs, or tuning the performance of the vCPUs.

```
# perf kvm stat report

Analyze events for all VMs, all VCPUs:


             VM-EXIT    Samples  Samples%     Time%    Min Time    Max Time         Avg time

  EXTERNAL_INTERRUPT     365634    31.59%    18.04%      0.42us  58780.59us    204.08us ( +-   0.99% )
            MSR_WRITE     293428    25.35%     0.13%      0.59us  17873.02us      1.80us ( +-   4.63% )
     PREEMPTION_TIMER     276162    23.86%     0.23%      0.51us  21396.03us      3.38us ( +-   5.19% )
   PAUSE_INSTRUCTION     189375    16.36%    11.75%      0.72us  29655.25us    256.77us ( +-   0.70% )
                 HLT      20440     1.77%    69.83%      0.62us  79319.41us  14134.56us ( +-   0.79% )
             VMCALL      12426     1.07%     0.03%      1.02us   5416.25us      8.77us ( +-   7.36%
```

```
)
     EXCEPTION_NMI        27    0.00%    0.00%      0.69us     1.34us     0.98us ( +-
3.50% )
     EPT_MISCONFIG         5    0.00%    0.00%      5.15us    10.85us     7.88us ( +-
11.67% )

Total Samples:1157497, Total events handled time:413728274.66us.
```

Other event types that can signal problems in the output of **perf kvm stat** include:

- **INSN_EMULATION** - suggests suboptimal VM I/O configuration.

For more information on using **perf** to monitor virtualization performance, see the **perf-kvm** man page.

numastat

To see the current NUMA configuration of your system, you can use the **numastat** utility, which is provided by installing the **numactl** package.

The following shows a host with 4 running VMs, each obtaining memory from multiple NUMA nodes. This is not optimal for vCPU performance, and warrants adjusting:

```
# numastat -c qemu-kvm

Per-node process memory usage (in MBs)
PID              Node 0 Node 1 Node 2 Node 3 Node 4 Node 5 Node 6 Node 7 Total
---------------  ------ ------ ------ ------ ------ ------ ------ ------ -----
51722 (qemu-kvm)     68     16    357   6936      2      3    147    598  8128
51747 (qemu-kvm)    245     11      5     18   5172   2532      1     92  8076
53736 (qemu-kvm)     62    432   1661    506   4851    136     22    445  8116
53773 (qemu-kvm)   1393      3      1      2     12      0      0   6702  8114
---------------  ------ ------ ------ ------ ------ ------ ------ ------ -----
Total              1769    463   2024   7462  10037   2672    169   7837 32434
```

In contrast, the following shows memory being provided to each VM by a single node, which is significantly more efficient.

```
# numastat -c qemu-kvm

Per-node process memory usage (in MBs)
PID              Node 0 Node 1 Node 2 Node 3 Node 4 Node 5 Node 6 Node 7 Total
---------------  ------ ------ ------ ------ ------ ------ ------ ------ -----
51747 (qemu-kvm)      0      0      7      0   8072      0      1      0  8080
53736 (qemu-kvm)      0      0      7      0      0      0   8113      0  8120
53773 (qemu-kvm)      0      0      7      0      0      0      1   8110  8118
59065 (qemu-kvm)      0      0   8050      0      0      0      0      0  8051
---------------  ------ ------ ------ ------ ------ ------ ------ ------ -----
Total                 0      0   8072      0   8072      0   8114   8110 32368
```

16.8. RELATED INFORMATION

- When using Windows as the guest operating system of your VM, Red Hat recommends applying additional optimization measures. For details, see Section 17.2, “Optimizing Windows virtual machines”.

CHAPTER 17. INSTALLING AND MANAGING WINDOWS VIRTUAL MACHINES

To use Microsoft Windows as the guest operating system in your virtual machines (VMs) on a RHEL 8 host, Red Hat recommends taking extra steps to ensure these VMs run correctly.

For this purpose, the following sections provide information on installing and optimizing Windows VMs on the host, as well as installing and configuring drivers in these VMs.

17.1. INSTALLING WINDOWS VIRTUAL MACHINES

You can create a fully-virtualized Windows machine on a RHEL 8 host, launch the graphical Windows installer inside the virtual machine (VM), and optimize the installed Windows guest operating system (OS).

To create the VM and to install the Windows guest OS, use the **virt-install** command or the RHEL 8 web console.

Prerequisites

- A Windows OS installation source, which can be one of the following, and be available locally or on a network:
  - An ISO image of an installation medium
  - A disk image of an existing VM installation
- A storage medium with the KVM **virtio** drivers.
  To create this medium, see Section 17.2.1.2, “Preparing virtio driver installation media on a host machine”.

Procedure

1. Create the VM. For instructions, see Section 2.2, “Creating virtual machines”.
   - If using the **virt-install** utility to create the VM, add the following options to the command:
     - The storage medium with the KVM **virtio** drivers. For example:

       ```
       --disk path=/usr/share/virtio-win/virtio-win.iso,device=disk,bus=virtio
       ```

     - The Windows version you will install. For example, for Windows 10:

       ```
       --os-variant win10
       ```

       For a list of available Windows versions and the appropriate option, use the following command:

       ```
       # osinfo-query os
       ```

   - If using the web console to create the VM, specify your version of Windows in the **Operating System** field of the **Create New Virtual Machine** window. After the VM is created and the guest OS is installed, attach the storage medium with virtio drivers to the

VM using the **Disks** interface. For instructions, see Section 11.7.9, "Attaching existing disks to virtual machines using the web console".

2. Install the Windows OS in the VM.
   For information on how to install a Windows operating system, refer to the relevant Microsoft installation documentation.

3. Configure KVM **virtio** drivers in the Windows guest OS. For details, see Section 17.2.1, "Installing KVM paravirtualized drivers for Windows virtual machines".

Additional resources

- For information on further optimizing Windows VMs, see Section 17.2, "Optimizing Windows virtual machines".

17.2. OPTIMIZING WINDOWS VIRTUAL MACHINES

When using Microsoft Windows as a guest operating system in a virtual machine (VM) hosted in RHEL 8, the performance of the guest may be negatively impacted.

Therefore, Red Hat recommends optimizing your Windows VMs by doing any combination of the following:

- Using paravirtualized drivers. For more information, see Section 17.2.1, "Installing KVM paravirtualized drivers for Windows virtual machines".
- Enabling Hyper-V enlightenments. For more information, see Section 17.2.2, "Enabling Hyper-V enlightenments".
- Configuring NetKVM driver parameters. For more information, see Section 17.2.3, "Configuring NetKVM driver parameters".
- Optimizing or disabling Windows background processes. For more information, see Section 17.2.5, "Optimizing background processes on Windows virtual machines".

17.2.1. Installing KVM paravirtualized drivers for Windows virtual machines

The primary method of improving the performance of your Windows virtual machines (VMs) is to install KVM paravirtualized (**virtio**) drivers for Windows on the guest operating system (OS).

To do so:

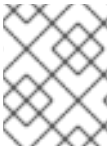
1. Prepare the install media on the host machine. For more information, see Section 17.2.1.2, "Preparing virtio driver installation media on a host machine".
2. Attach the install media to an existing Windows VM, or attach it when creating a new Windows VM.
3. Install the **virtio** drivers on the Windows guest OS. For more information, see Section 17.2.1.3, "Installing virtio drivers on a Windows guest".

17.2.1.1. How Windows virtio drivers work

Paravirtualized drivers enhance the performance of virtual machines (VMs) by decreasing I/O latency and increasing throughput to almost bare-metal levels. Red Hat recommends that you use paravirtualized drivers for VMs that run I/O-heavy tasks and applications.

virtio drivers are KVM's paravirtualized device drivers, available for Windows VMs running on KVM hosts. These drivers are provided by the **virtio-win** package, which includes drivers for:

- Block (storage) devices
- Network interface controllers
- Video controllers
- Memory ballooning device
- Paravirtual serial port device
- Entropy source device
- Paravirtual panic device
- Input devices, such as mice, keyboards, or tablets
- A small set of emulated devices



NOTE

For additional information about emulated, **virtio**, and assigned devices, refer to Chapter 10, *Managing virtual devices*.

Using KVM virtio drivers, the following Microsoft Windows versions are expected to run similarly to physical systems:

- Windows Server versions: See Certified guest operating systems for Red Hat Enterprise Linux with KVM in the Red Hat Knowledgebase.
- Windows Desktop (non-server) versions:
  - Windows 7 (32-bit and 64-bit versions)
  - Windows 8 (32-bit and 64-bit versions)
  - Windows 8.1 (32-bit and 64-bit versions)
  - Windows 10 (32-bit and 64-bit versions)

17.2.1.2. Preparing virtio driver installation media on a host machine

To install KVM virtio drivers on a Windows virtual machine (VM), you must first prepare the installation media for the virtio driver on the host machine. To do so, install the **virtio-win** package on the host machine and use the **.iso** file it provides as storage for the VM.

Prerequisites

- Ensure that virtualization is enabled in your RHEL 8 host system.

Procedure

1. Download the drivers

   a. Browse to Download Red Hat Enterprise Linux.

   b. Select the **Product Variant** relevant for your system architecture. For example, for Intel 64 and AMD64, select **Red Hat Enterprise Linux for x86_64**.

   c. Ensure the **Version** is 8.

   d. In the **Packages**, search for **virtio-win**.

   e. Click **Download Latest** next to the **virtio-win AppStream** package. The **RPM** file downloads.

2. Install the **virtio-win** package from the download directory. For example:

```
# yum install ~/Downloads/virtio-win-1.9.9-3.el8.noarch.rpm
[...]
Installed:
  virtio-win-1.9.9-3.el8.noarch
```

   If the installation succeeds, the **virtio-win** driver files are prepared in the **/usr/share/virtio-win/** directory. These include **ISO** files and a **drivers** directory with the driver files in directories, one for each architecture and supported Windows version.

```
# ls /usr/share/virtio-win/
drivers/  guest-agent/  virtio-win-1.9.9.iso  virtio-win.iso
```

3. Attach the **virtio-win.iso** file to the Windows VM. To do so, do one of the following:

   - Use the file as a disk when creating a new Windows VM .
   - Add the file as a CD-ROM to an existing Windows VM. For example:

```
# virt-xml WindowsVM --add-device --disk virtio-win.iso,device=cdrom
Domain 'WindowsVM' defined successfully.
```

Additional resources

- When **virtio-win.iso** is attached to the Windows VM, you can proceed to installing the virtio driver on the Windows guest operating system. For instructions, see Section 17.2.1.3, “Installing virtio drivers on a Windows guest”.

17.2.1.3. Installing virtio drivers on a Windows guest

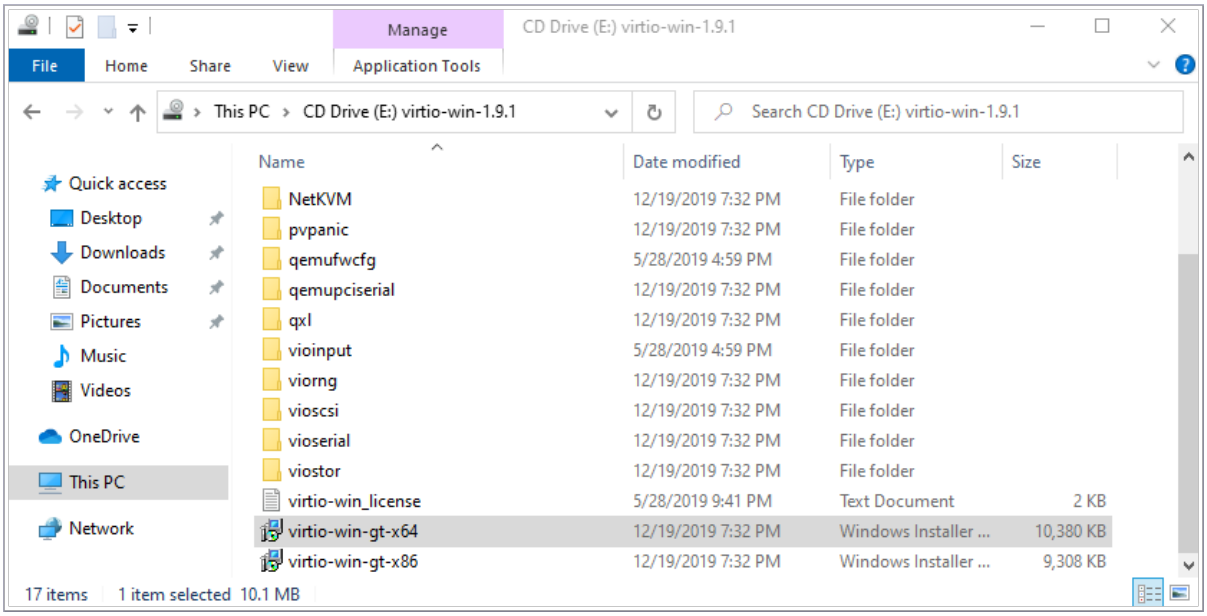
To install KVM **virtio** drivers on a Windows guest operating system (OS), you must add a storage device that contains the drivers - either when creating the virtual machine (VM) or afterwards - and install the drivers in the Windows guest OS.

Prerequisites

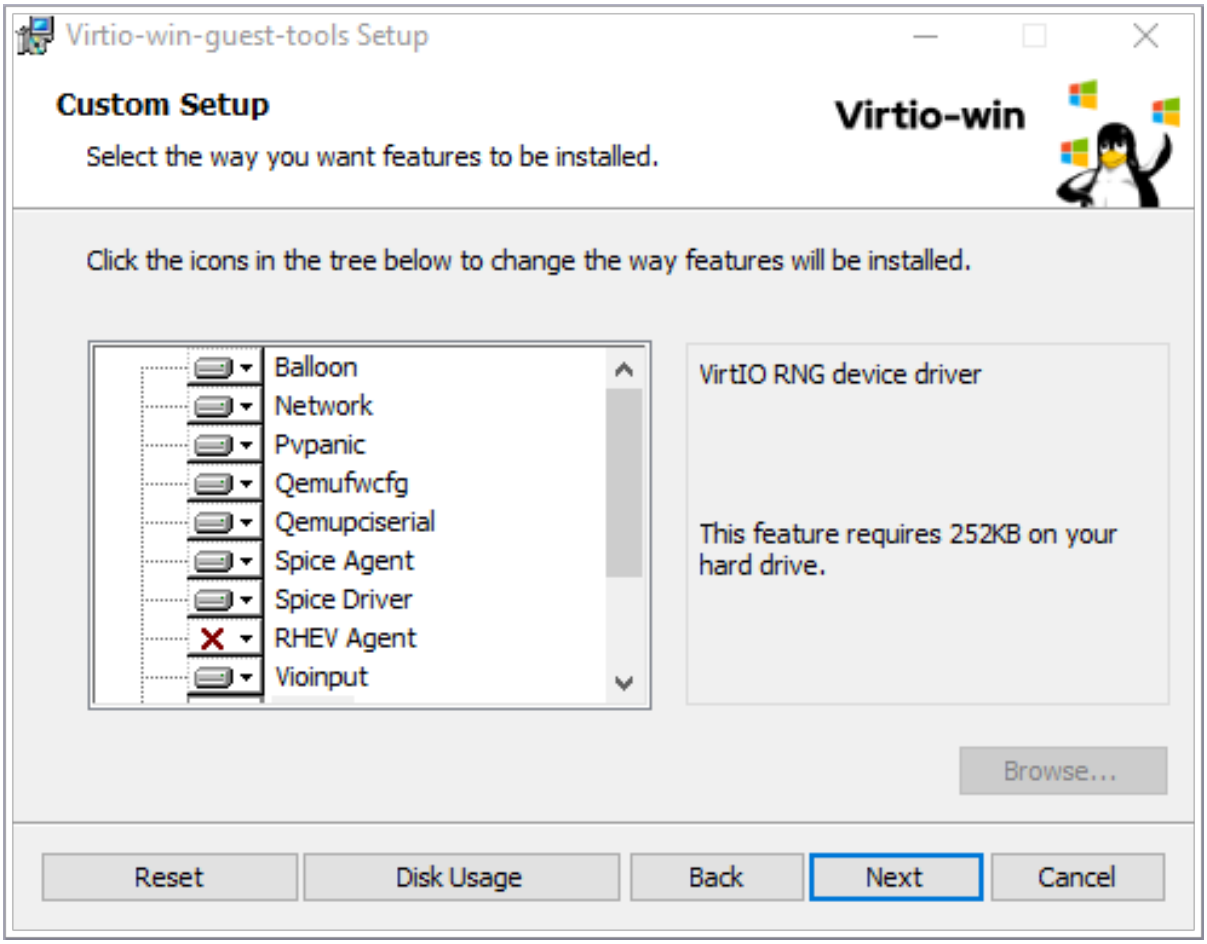
- An installation medium with the KVM **virtio** drivers must be attached to the VM. For instructions on preparing the medium, see Section 17.2.1.2, "Preparing virtio driver installation media on a host machine".

Procedure

1. In the Windows guest OS, open the **File Explorer** application.
2. Click **This PC**.
3. In the **Devices and drives** pane, open the **virtio-win** medium.
4. Based on the architecture of the VM's vCPU, run one of the installers on the medium.
   - If using a 32-bit vCPU, run the **virtio-win-gt-x86** installer.
   - If using a 64-bit vCPU, run the **virtio-win-gt-x64** installer.



5. In the **Virtio-win-guest-tools** setup wizard that opens, follow the displayed instructions until you reach the **Custom Setup** step.



6. In the Custom Setup window, select the device drivers you want to install. The recommended driver set is selected automatically, and the descriptions of the drivers are displayed on the right of the list.

7. Click **next**, then click **Install**.

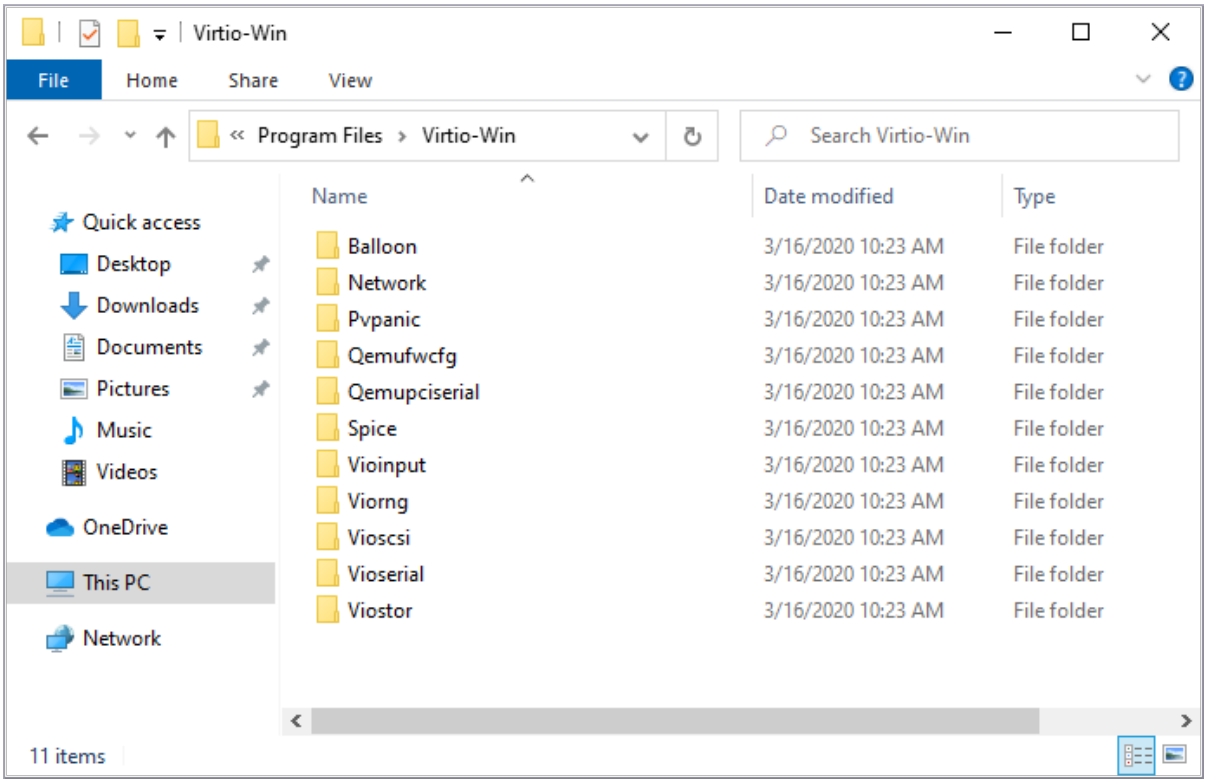
8. After the installation completes, click **Finish**.

9. Reboot the VM to complete the driver installation.

Verification

1. In **This PC**, open the system disk. This is typically **(C:)**.

2. In the **Program Files** directory, open the **Virtio-Win** directory.
   If the **Virtio-Win** directory is present and contains a sub-directory for each of the selected drivers, the installation was successful.



Additional resources

- You can use the Microsoft Windows Installer (MSI) command-line interface (CLI) instead of the graphical interface to install the drivers. For more information about MSI, see the Microsoft documentation.
- If you install the NetKVM driver, you may also need to configure the Windows guest's networking parameters. For instructions, see Section 17.2.3, "Configuring NetKVM driver parameters".

17.2.2. Enabling Hyper-V enlightenments

Hyper-V enlightenments provide a method for KVM to emulate the Microsoft Hyper-V hypervisor. This improves the performance of Windows virtual machines.

The following sections provide information about the supported Hyper-V enlightenments and how to enable them.

17.2.2.1. Enabling Hyper-V enlightenments on a Windows virtual machine

Hyper-V enlightenments provide better performance in a Windows virtual machine (VM) running in a RHEL 8 host. For instructions on how to enable them, see the following.

Procedure

1. Use the **virsh edit** command to open the XML configuration of the VM. For example:

```
# virsh edit windows-vm
```

2. Add the following **<hyperv>** sub-section to the **<features>** section of the XML:

```
<features>
  [...]
```

```
  <hyperv>
    <relaxed state='on'/>
    <vapic state='on'/>
    <spinlocks state='on' retries='8191'/>
    <vpindex state='on'/>
    <runtime state='on' />
    <synic state='on'/>
    <stimer state='on'/>
    <frequencies state='on'/>
  </hyperv>
  [...]
</features>
```

If the XML already contains a **<hyperv>** sub-section, modify it as shown above.

3. Change the **clock** section of the configuration as follows:

```
<clock offset='localtime'>
  <timer name='hypervclock' present='yes'/>
</clock>
```

4. Save and exit the XML configuration.

5. If the VM is running, restart it.

Verification

- Use the **virsh dumpxml** command to display the XML configuration of the running VM. If it includes the following segments, the Hyper-V enlightenments are enabled on the VM.

```
<hyperv>
  <relaxed state='on'/>
  <vapic state='on'/>
  <spinlocks state='on' retries='8191'/>
  <vpindex state='on'/>
  <runtime state='on' />
  <synic state='on'/>
  <stimer state='on'/>
  <frequencies state='on'/>
</hyperv>

<clock offset='localtime'>
  <timer name='hypervclock' present='yes'/>
</clock>
```

17.2.2.2. Configurable Hyper-V enlightenments

You can configure certain Hyper-V features to optimize Windows VMs. The following table provides information about these configurable Hyper-V features and their values.

Table 17.1. Configurable Hyper-V features

Enlightenment	Description	Values
evmcs	Implements paravirtualized protocol between L0 (KVM) and L1 (Hyper-V) hypervisors, which enables faster L2 exits to the hypervisor. This feature is exclusive to Intel processors.	on, off
frequencies	Enables Hyper-V frequency Machine Specific Registers (MSRs).	on, off
ipi	Enables paravirtualized inter processor interrupts (IPI) support.	on, off
no-nonarch-coresharing	Notifies the guest OS that virtual processors will never share a physical core unless they are reported as sibling SMT threads. This information is required by Windows and Hyper-V guests to properly mitigate simultaneous multithreading (SMT) related CPU vulnerabilities.	on, off, auto
reenlightenment	Notifies when there is a time stamp counter (TSC) frequency change which only occurs during migration. It also allows the guest to keep using the old frequency until it is ready to switch to the new one.	on, off
relaxed	Disables a Windows sanity check that commonly results in a BSOD when the VM is running on a heavily loaded host. This is similar to the Linux kernel option no_timer_check, which is automatically enabled when Linux is running on KVM.	on, off
reset	Enables Hyper-V reset.	on, off
runtime	Sets processor time spent on running the guest code, and on behalf of the guest code.	on, off

Enlightenment	Description	Values
spinlock	• Used by a VM's operating system to notify Hyper-V that the calling virtual processor is attempting to acquire a resource that is potentially held by another virtual processor within the same partition. • Used by Hyper-V to indicate to the virtual machine's operating system the number of times a spinlock acquisition should be attempted before indicating an excessive spin situation to Hyper-V.	on, off
stimer	Enables synthetic timers for virtual processors. Note that certain Windows versions revert to using HPET (or even RTC when HPET is unavailable) when this enlightenment is not provided, which can lead to significant CPU consumption, even when the virtual CPU is idle.	on, off
stimer-direct	Enables synthetic timers when an expiration event is delivered via a normal interrupt.	on, off.
synic	Together with stimer, activates the synthetic timer. Windows 8 uses this feature in periodic mode.	on, off

Enlightenment	Description	Values
time	Enables the following Hyper-V-specific clock sources available to the VM, • MSR-based 82 Hyper-V clock source (HV_X64_MSR_TIME_REF_COUNT, 0x40000020) • Reference TSC 83 page which is enabled via MSR (HV_X64_MSR_REFERENCE_TSC, 0x40000021)	on, off
tlbflush	Flushes the TLB of the virtual processors.	on, off
vapic	Enables virtual APIC, which provides accelerated MSR access to the high-usage, memory-mapped Advanced Programmable Interrupt Controller (APIC) registers.	on, off
vendor_id	Sets the Hyper-V vendor id.	• on, off • Id value - string of up to 12 characters
vpindex	Enables virtual processor index.	on, off

17.2.3. Configuring NetKVM driver parameters

After the NetKVM driver is installed, you can configure it to better suit your environment. The parameters listed in this section can be configured using the Windows Device Manager (devmgmt.msc).

IMPORTANT

Modifying the driver's parameters causes Windows to reload that driver. This interrupts existing network activity.

Prerequisites

- The NetKVM driver is installed on the virtual machine.
  For more information, see Section 17.2.1, "Installing KVM paravirtualized drivers for Windows virtual machines".

Procedure

1. Open Windows Device Manager.
   For information on opening Device Manager, refer to the Windows documentation.
2. Locate the Red Hat VirtIO Ethernet Adapter.
   a. In the Device Manager window, click **+** next to Network adapters.
   b. Under the list of network adapters, double-click **Red Hat VirtIO Ethernet Adapter**. The Properties window for the device opens.
3. View the device parameters.
   In the Properties window, click the **Advanced** tab.
4. Modify the device parameters.
   a. Click the parameter you want to modify. Options for that parameter are displayed.
   b. Modify the options as needed.
   For information on the NetKVM parameter options, refer to Section 17.2.4, "NetKVM driver parameters".
   c. Click **OK** to save the changes.

17.2.4. NetKVM driver parameters

The following table provides information on the configurable NetKVM driver logging parameters.

Table 17.2. Logging parameters

Parameter	Description 2
Logging.Enable	A Boolean value that determines whether logging is enabled. The default value is Enabled.
Logging.Level	An integer that defines the logging level. As the integer increases, so does the verbosity of the log. • The default value is 0 (errors only). • 1-2 adds configuration messages. • 3-4 adds packet flow information. • 5-6 adds interrupt and DPC level trace information.  **NOTE** High logging levels will slow down your virtual machine.

The following table provides information on the configurable NetKVM driver initial parameters.

Table 17.3. Initial parameters

Parameter	Description
Assign MAC	A string that defines the locally-administered MAC address for the paravirtualized NIC. This is not set by default.
Init.ConnectionRate(Mb)	An integer that represents the connection rate in megabits per second. The default value for Windows 2008 and later is 10G (10,000 megabits per second).
Init.Do802.1PQ	A Boolean value that enables Priority/VLAN tag population and removal support. The default value is Enabled.
Init.MTUSize	An integer that defines the maximum transmission unit (MTU). The default value is 1500. Any value from 500 to 65500 is acceptable.
Init.MaxTxBuffers	An integer that represents the number of TX ring descriptors that will be allocated. The default value is 1024. Valid values are: 16, 32, 64, 128, 256, 512, and 1024.
Init.MaxRxBuffers	An integer that represents the number of RX ring descriptors that will be allocated. The default value is 256. Valid values are: 16, 32, 64, 128, 256, 512, and 1024.
Offload.Tx.Checksum	Specifies the TX checksum offloading mode. In Red Hat Enterprise Linux 8, the valid values for this parameter are: * All (the default) which enables IP, TCP, and UDP checksum offloading for both IPv4 and IPv6 * TCP/UDP(v4,v6) which enables TCP and UDP checksum offloading for both IPv4 and IPv6 * TCP/UDP(v4) which enables TCP and UDP checksum offloading for IPv4 only * TCP(v4) which enables only TCP checksum offloading for IPv4 only

17.2.5. Optimizing background processes on Windows virtual machines

To optimize the performance of a virtual machine (VM) running a Windows OS, you can configure or disable a variety of Windows processes.

WARNING

Certain processes might not work as expected if you change their configuration.

Procedure

You can optimize your Windows VMs by performing any combination of the following:

- Remove unused devices, such as USBs or CD-ROMs, and disable the ports.
- Disable automatic Windows Update. For more information on how to do so, see Configure Group Policy Settings for Automatic Updates or Configure Windows Update for Business. Note that Windows Update is essential for installing latest updates and hotfixes from Microsoft. As such, Red Hat does not recommend disabling Windows Updates
- Disable background services, such as SuperFetch and Windows Search. For more information about stopping services, see Disabling system services or Stop-Service.
- Disable **useplatformclock**. To do so, run the following command,

```
# bcdedit /set useplatformclock No
```

- Review and disable unnecessary scheduled tasks, such as scheduled disk defragmentation. For more information on how to do so, see Disable Scheduled Tasks.
- Make sure the disks are not encrypted.
- Reduce periodic activity of server applications. You can do so by editing the respective timers. For more information, see Multimedia Timers.
- Close the Server Manager application on the VM.
- Disable the antivirus software. Note that disabling the antivirus might compromise the security of the VM.
- Disable the screen saver.
- Keep the Windows OS on the sign-in screen when not in use.

17.3. SHARING FILES BETWEEN THE HOST AND WINDOWS VIRTUAL MACHINES

For efficient file sharing between your host system and the Windows VMs it is connected to, you can prepare a Samba server that your VMs can access.

Prerequisites

- The **samba** packages are installed on your host. If they are not:

```
# yum install samba
```

- The host is visible and reachable over a network for the VM. This is generally the case if the VM is connected using the *NAT* and *bridge* type of virtual networks. However, for the *macvtap* connection, you must first set up the *macvlan* feature on the host. To do so:

  1. Create a network device file, for example called **vm-macvlan.netdev** in the host's **/etc/systemd/network/** directory.

     ```
     # vim /etc/systemd/network/vm-macvlan.netdev
     ```

  2. Edit the network device file to have the following content. You can replace **vm-macvlan** with the name you chose for your network device.

     ```
     [NetDev]
     Name=vm-macvlan
     Kind=macvlan

     [MACVLAN]
     Mode=bridge
     ```

  3. Create a network configuration file for your macvlan network device, for example **vm-macvlan.network**.

     ```
     # vim /etc/systemd/network/vm-macvlan.network
     ```

  4. Edit the network configuration file to have the following content. You can replace **vm-macvlan** with the name you chose for your network device.

     ```
     [Match]
     Name=_vm-macvlan_

     [Network]
     IPForward=yes
     Address=192.168.250.33/24
     Gateway=192.168.250.1
     DNS=192.168.250.1
     ```

  5. Create a network configuration file for your physical network interface. For example, if your interface is **enp4s0**:

     ```
     # vim /etc/systemd/network/enp4s0.network
     ```

     If you are unsure what interface to use, you can use the **ifconfig** command on your host to obtain the list of active network interfaces.

  6. Edit the physical network configuration file to make the physical network a part of the macvlan interface, in this case *vm-macvlan*:

     ```
     [Match]
     Name=enp4s0

     [Network]
     MACVLAN=vm-macvlan
     ```

  7. Reboot your host.

Procedure

1. On the host, create a Samba share and make it accessible for external systems.

   a. Add firewall permissions for Samba.

   ```
   # firewall-cmd --permanent --zone=public --add-service=samba
   success
   # firewall-cmd --reload
   success
   ```

   b. Edit the **/etc/samba/smb.conf** file:

      i. Add the following to the **[global]** section:

      ```
      map to guest = Bad User
      ```

      ii. Add the following at the end of the file:

      ```
      #=== Share Definitions ===
      [VM-share]
      path = /samba/VM-share
      browsable = yes
      guest ok = yes
      read only = no
      hosts allow = 192.168.122.0/24
      ```

      Note that the **hosts allow** line restricts the accessibility of the share only to hosts on the VM network. If you want the share to be accessible by anyone, remove the line.

   c. Create the **/samba/VM-share** directory.

   ```
   # mkdir -p /samba/VM-share
   ```

   d. Enable the Samba service.

   ```
   # systemctl enable smb.service
   Created symlink /etc/systemd/system/multi-user.target.wants/smb.service →
   /usr/lib/systemd/system/smb.service.
   ```

   e. Restart the Samba service.

   ```
   # systemctl restart smb.service
   ```

   f. Allow the **VM-share** directory to be accessible and modifiable for the VMs.

   ```
   # chmod -R 0755 /samba/VM-share/
   # chown -R nobody:nobody /samba/VM-share/
   ```

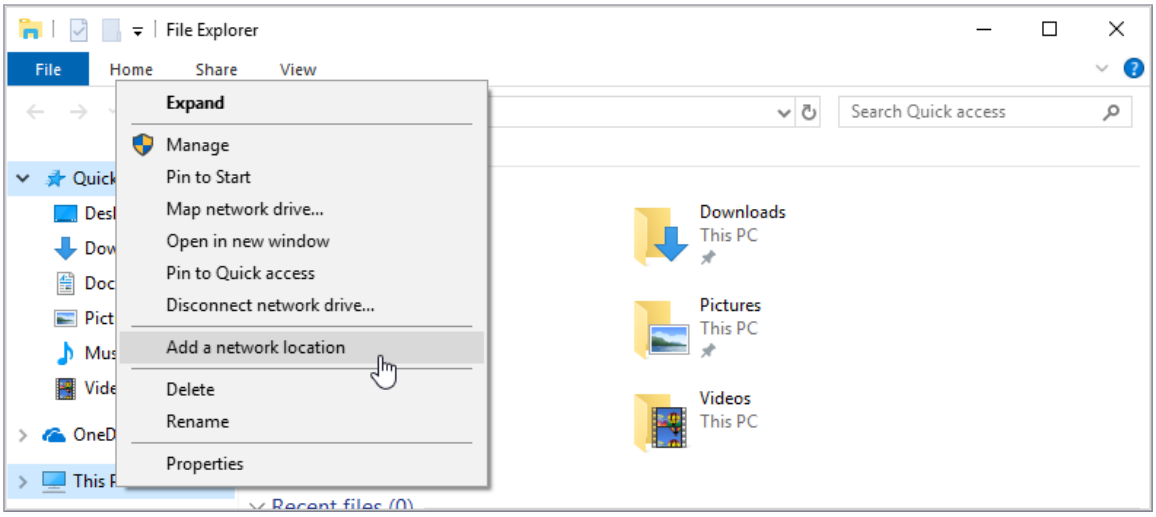
   g. Add the SELinux Samba sharing label to **/etc/samba/VM-share/**

   ```
   # chcon -t samba_share_t /samba/VM-share/
   ```

2. On the Windows guest operating system, attach the Samba share as a network location.

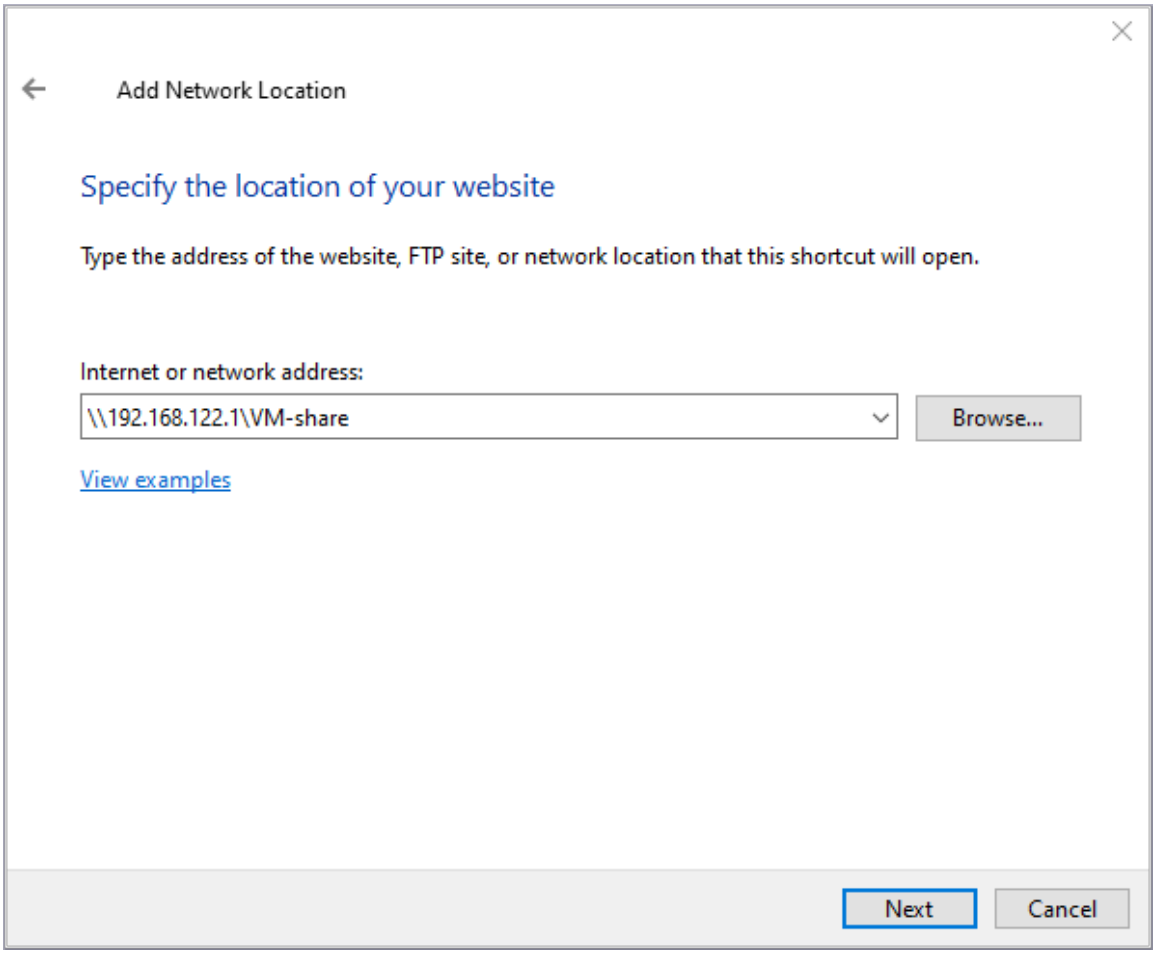
a. Open the File Explorer and right-click "This PC".

b. In the context menu, click **Add a network location**.



c. In the *Add Network Location* wizard that opens, select "Choose a custom network location" and click **Next**.

d. In the "Internet or network address" field, type *host-IP*/VM-share, where *host-IP* is the IP address of the host. Usually, the host IP is the default gateway of the VM. Afterwards, click **Next**.



e. When the wizard asks if you want to rename the shared directory, keep the default name. This ensures the consistency of file sharing configuration across the VM and the guest. Click **Next**.

f. If accessing the network location was successful, you can now click **Finish** and open the shared directory.

17.4. ENABLING STANDARD HARDWARE SECURITY ON WINDOWS VIRTUAL MACHINES

To secure Windows virtual machines (VMs), you can enable basic level security using the standard hardware capabilities of the Windows device.

Prerequisites

- Make sure you have installed the latest WHQL certified VirtIO drivers.
- Make sure the VM's firmware supports UEFI boot.
- Install the **edk2-OVMF** package on your host machine.

```
# yum install edk2-ovmf
```

- Install the **vTPM** packages on your host machine.

```
# yum install swtpm libtpms
```

- Make sure the VM is using the Q35 machine architecture.
- Make sure you have the Windows installation media.

Procedure

1. Enable TPM 2.0 by adding the following parameters to the **<devices>** section in the VM's XML configuration.

```
<devices>
[...]
  <tpm model='tpm-crb'>
    <backend type='emulator' version='2.0'/>
  </tpm>
[...]
</devices>
```

2. Install Windows in UEFI mode. For more information on how to do so, see Creating a SecureBoot virtual machine.
3. Install the VirtIO drivers on the Windows VM. For more information on how to do so, see Installing virtio drivers on a Windows guest .
4. In UEFI, enable Secure Boot. For more information on how to do so, see Secure Boot.

Verification

- Ensure that the **Device Security** page on your Windows machine displays the following message:
  Settings > Update & Security > Windows Security > Device Security

> **Your device meets the requirements for standard hardware security.**

17.5. ENABLING ENHANCED HARDWARE SECURITY ON WINDOWS VIRTUAL MACHINES

To further secure Windows virtual machines (VMs), you can enable virtualization-based protection of code integrity, also known as Hypervisor-Protected Code Integrity (HVCI).

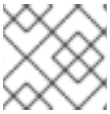
Prerequisites

- Ensure that standard hardware security is enabled. For more information, see Enabling standard hardware security on Windows virtual machines.
- Ensure that KVM nesting is enabled. For more information, see Creating nested virtual machines.
- On the KVM command line,
  - Specify the CPU model.
  - Enable the Virtual Machine Extensions (VMX) feature.
  - Enable Hyper-V enlightenments.

```
# -cpu Skylake-Client-
v3,hv_stimer,hv_synic,hv_relaxed,hv_reenlightenment,hv_spinlocks=0xfff,hv_vpin
dex,hv_vapic,hv_time,hv_frequencies,hv_runtime,+kvm_pv_unhalt,+vmx
```

Procedure

1. On your Windows VM, navigate to the **Core isolation details** page:
   Settings > Update & Security > Windows Security > Device Security > Core isolation details
2. Toggle the switch to enable **Memory Integrity**.
3. Reboot the VM.



NOTE

For other methods of enabling HVCI, see the relevant Microsoft documentation.

Verification

- Ensure that the **Device Security** page on your Windows VM displays the following message:
  Settings > Update & Security > Windows Security > Device Security

> **Your device meets the requirements for enhanced hardware security.**

- Alternatively, check System Information on the Windows VM:
  a. Run **msinfo32.exe** in a command prompt.

b. Check if **Credential Guard, Hypervisor enforced Code Integrity** is listed under **Virtualization-based security Services Running**.

17.6. RELATED INFORMATION

- To use utilities for accessing, editing, and creating virtual machine disks or other disk images for a Windows VM, you must install the **libguestfs-tools** and **libguestfs-winsupport** packages on the host machine.

```
$ sudo yum install libguestfs-tools libguestfs-winsupport
```

CHAPTER 18. CREATING NESTED VIRTUAL MACHINES

On RHEL 8 systems and later, it is possible to create nested virtual machines (VMs). This means that a RHEL 8 VM (also referred to as a **level 1**, or **L1**) that runs on a RHEL 8 physical host (**level 0**, or **L0**) can act as a hypervisor and create its own VMs (**level 2** or **L2**).

In other words, an L0 host can run L1 virtual machines (VMs), and each of these L1 VMs can host their own L2 VMs. Note that, in such cases, both L0 and L1 hosts must be RHEL 8 systems, whereas the L2 guest can be any supported RHEL or Windows system.

WARNING

Red Hat currently provides nested virtualization only as a Technology Preview, and is therefore unsupported.

In addition, Red Hat does not recommend using nested virtualization in production user environments, due to various limitations in functionality . Instead, nested virtualization is primarily intended for development and testing scenarios, such as:

- Debugging hypervisors in a constrained environment
- Testing larger virtual deployments on a limited amount of physical resources

It is also possible to create nested VMs on multiple architectures, such as Intel, AMD, IBM POWER9, and IBM Z. Note that, irrespective of the architecture used, nesting is a Technology Preview, and therefore not supported by Red Hat.

18.1. CREATING A NESTED VIRTUAL MACHINE ON INTEL

Follow the steps below to enable and configure nested virtualization on an Intel host.

WARNING

Nested virtualization is currently provided only as a Technology Preview on the Intel architecture, and is therefore unsupported.

Prerequisites

- An L0 RHEL 8 host running an L1 virtual machine (VM).
- The hypervisor CPU must support nested virtualization. To verify, use the **cat /proc/cpuinfo** command on the L0 hypervisor. If the output of the command includes the **vmx** and **ept** flags, creating L2 VMs is possible. This is generally the case on Intel Xeon v3 cores and later.
- Ensure that nested virtualization is enabled on the L0 host:

```
# cat /sys/module/kvm_intel/parameters/nested
```

- If the command returns **1** or **Y**, the feature is enabled. Skip the remaining prerequisite steps, and continue with the Procedure section.
- If the command returns **0** or **N** but your system supports nested virtualization, use the following steps to enable the feature.

  i. Unload the **kvm_intel** module:

  ```
  # modprobe -r kvm_intel
  ```

  ii. Activate the nesting feature:

  ```
  # modprobe kvm_intel nested=1
  ```

  iii. The nesting feature is now enabled, but only until the next reboot of the L0 host. To enable it permanently, add the following line to the **/etc/modprobe.d/kvm.conf** file:

  ```
  options kvm_intel nested=1
  ```

Procedure

1. Configure your L1 VM for nested virtualization.

   a. Open the XML configuration of the VM. The following example opens the configuration of the *Intel-L1* VM:

   ```
   # virsh edit Intel-L1
   ```

   b. Add the following line to the configuration:

   ```
   <cpu mode='host-passthrough'/>
   ```

   If the VM's XML configuration file already contains a **<cpu>** element, rewrite it.

2. Create an L2 VM within the L1 VM. To do this, follow the same procedure as when creating the L1 VM.

18.2. CREATING A NESTED VIRTUAL MACHINE ON AMD

Follow the steps below to enable and configure nested virtualization on an AMD host.

WARNING

Nested virtualization is currently provided only as a Technology Preview on the AMD64 architecture, and is therefore unsupported.

Prerequisites

- An L0 RHEL 8 host running an L1 virtual machine (VM).
- The hypervisor CPU must support nested virtualization. To verify, use the **cat /proc/cpuinfo** command on the L0 hypervisor. If the output of the command includes the **svm** and **npt** flags, creating L2 VMs is possible. This is generally the case on AMD EPYC cores and later.
- Ensure that nested virtualization is enabled on the L0 host:

```
# cat /sys/module/kvm_amd/parameters/nested
```

  - If the command returns **1** or **Y**, the feature is enabled. Skip the remaining prerequisite steps, and continue with the Procedure section.
  - If the command returns **0** or **N**, use the following steps to enable the feature.
    i. Stop all running VMs on the L0 host.
    ii. Unload the **kvm_amd** module:

```
# modprobe -r kvm_amd
```

    iii. Activate the nesting feature:

```
# modprobe kvm_amd nested=1
```

    iv. The nesting feature is now enabled, but only until the next reboot of the L0 host. To enable it permanently, add the following to the **/etc/modprobe.d/kvm.conf** file:

```
options kvm_amd nested=1
```

Procedure

1. Configure your L1 VM for nested virtualization.
   a. Open the XML configuration of the VM. The following example opens the configuration of the *AMD-L1* VM:

```
# virsh edit AMD-L1
```

   b. Configure the VM's CPU to use **host-passthrough** mode.

```
<cpu mode='host-passthrough'/>
```

   If you require the VM to use a specific CPU instead of **host-passthrough**, add a **<feature policy='require' name='vmx'/>** line to the CPU configuration. For example:

```
<cpu mode ='custom' match ='exact' check='partial'>
<model fallback='allow'>Haswell-noTSX</model>
<feature policy='require' name='vmx'/>
```

2. Create an L2 VM within the L1 VM. To do this, follow the same procedure as when creating the L1 VM.

18.3. CREATING A NESTED VIRTUAL MACHINE ON IBM Z

Follow the steps below to enable and configure nested virtualization on an IBM Z host.

WARNING

Nested virtualization is currently provided only as a Technology Preview on the IBM Z architecture, and is therefore unsupported.

Prerequisites

- An L0 RHEL 8 host running an L1 virtual machine (VM).
- The hypervisor CPU must support nested virtualization. To verify this is the case, use the **cat /proc/cpuinfo** command on the L0 hypervisor. If the output of the command includes the **sie** flag, creating L2 VMs is possible.
- Ensure that nested virtualization is enabled on the L0 host:

```
# cat /sys/module/kvm/parameters/nested
```

  - If the command returns **1** or **Y**, the feature is enabled. Skip the remaining prerequisite steps, and continue with the Procedure section.
  - If the command returns **0** or **N**, use the following steps to enable the feature.
    i. Stop all running VMs on the L0 host.
    ii. Unload the **kvm** module:

```
# modprobe -r kvm
```

    iii. Activate the nesting feature:

```
# modprobe kvm nested=1
```

    iv. The nesting feature is now enabled, but only until the next reboot of the L0 host. To enable it permanently, add the following line to the **/etc/modprobe.d/kvm.conf** file:

```
options kvm nested=1
```

Procedure

- Create an L2 VM within the L1 VM. To do this, follow the same procedure as when creating the L1 VM.

18.4. CREATING A NESTED VIRTUAL MACHINE ON IBM POWER9

Follow the steps below to enable and configure nested virtualization on an IBM POWER9 host.

WARNING

Nested virtualization is currently provided only as a Technology Preview on the IBM POWER9 architecture, and is therefore unsupported. In addition, creating nested virtual machines (VMs) is not possible on previous versions of IBM POWER systems, such as IBM POWER8.

Prerequisites

- An L0 RHEL 8 host is running an L1 VM. The L1 VM is using RHEL 8 as the guest operating system.
- Nested virtualization is enabled on the L0 host:

```
# cat /sys/module/kvm_hv/parameters/nested
```

  - If the command returns **1** or **Y**, the feature is enabled. Skip the remaining prerequisite steps, and continue with the Procedure section.
  - If the command returns **0** or **N**, use the following steps to enable the feature:
    i. Stop all running VMs on the L0 host.
    ii. Unload the **kvm** module:

```
# modprobe -r kvm_hv
```

    iii. Activate the nesting feature:

```
# modprobe kvm_hv nested=1
```

    iv. The nesting feature is now enabled, but only until the next reboot of the L0 host. To enable it permanently, add the following line to the **/etc/modprobe.d/kvm.conf** file:

```
options kvm_hv nested=1
```

Procedure

1. To ensure that the L1 VM can create L2 VMs, add the **cap-nested-hv** parameter to the machine type of the L1 VM. To do so, use the **virsh edit** command to modify the L1 VM's XML configuration, and the following line to the **<features>** section:

```
<nested-hv state='on'/>
```

2. Create an L2 VM within the L1 VM. To do this, follow the same procedure as when creating the L1 VM.
   To significantly improve the performance of L2 VMs, Red Hat recommends adding the `cap-nested-hv` parameter to the XML configurations of L2 VMs as well. For instructions, see the previous step.

Additional information

- Note that using IBM POWER8 as the architecture for the L2 VM currently does not work.

18.5. RESTRICTIONS AND LIMITATIONS FOR NESTED VIRTUALIZATION

Keep the following restrictions in mind when using nested virtualization.

WARNING

Red Hat currently does not support nested virtualization, and only provides nesting as a Technology Preview.

Supported architectures

- The L0 host must be an Intel, AMD, IBM POWER9, or IBM Z system. Nested virtualization currently does not work on other architectures.

Supported guest operating systems

- To create nested VMs, you must use the following guest operating systems (OSs):
  - On the **L0 host** - RHEL 8.2 and later
  - On the **L1 VMs** - RHEL 7.8 and later, or RHEL 8.2 and later

NOTE

This support does not apply to using virtualization offerings based on RHEL 7 and RHEL 8 in L1 VMs. These include:

- Red Hat Virtualization
- Red Hat OpenStack Platform
- OpenShift Virtualization

  - On the **L2 VMs** - you must use one of the following OSs:
    - RHEL 7.8 and later
    - RHEL 8.2 and later
    - Microsoft Windows Server 2016
    - Microsoft Windows Server 2019

- In addition, on IBM POWER9, nested virtualization currently only works under the following circumstances:

- Both the L0 host and the L1 VM use RHEL 8
- The L2 VM uses RHEL 8, or RHEL 7 with a **rhel-alt** kernel.
- The L1 VM and L2 VM are not running in POWER8 compatibility mode.

Hypervisor limitations

- Currently, Red Hat supports nesting only on RHEL-KVM. When RHEL is used as the L0 hypervisor, you can use RHEL 8 or Windows for WSL 2 as the L1 hypervisor.
- When using an L1 RHEL 8 VM on a non-KVM L0 hypervisor, such as VMware ESXi or Amazon Web Services (AWS), creating L2 VMs in the RHEL 8 guest OS may work, but is not supported.

Feature limitations

- Use of L2 VMs as hypervisors and creating L3 guests has not been properly tested and is not expected to work.
- Migrating VMs currently does not work on AMD systems if nested virtualization has been enabled on the L0 host.
- On an IBM Z system, huge-page backing storage and nested virtualization cannot be used at the same time.

```
# modprobe kvm hpage=1 nested=1
modprobe: ERROR: could not insert 'kvm': Invalid argument
# dmesg |tail -1
[90226.508366] kvm-s390: A KVM host that supports nesting cannot back its KVM guests with huge pages
```

- Some features available on the L0 host may be unavailable for the L1 hypervisor.
  For example, on IBM POWER 9 hardware, the External Interrupt Virtualization Engine (XIVE) does not work. However, L1 VMs can use the emulated XIVE interrupt controller to launch L2 VMs.

CHAPTER 19. DIAGNOSING VIRTUAL MACHINE PROBLEMS

When working with virtual machines (VMs), you may encounter problems with varying levels of severity. Some problems may have a quick and easy fix, while for others, you may have to capture VM-related data and logs to report or diagnose the problems.

The following sections provide detailed information about generating logs and diagnosing some common VM problems, as well as about reporting these problems.

19.1. GENERATING VIRTUAL MACHINE DEBUG LOGS

To diagnose virtual machine (VM) problems, it is helpful to generate and review the debug logs. Attaching debug logs is also useful when asking for support to resolve VM-related problems.

The following sections explain what debug logs are, how you can set them to be persistent, enable them during runtime, and attach them when reporting problems.

19.1.1. Understanding virtual machine debug logs

Debug logs are text files that contain data about events that occur during virtual machine (VM) runtime. The logs provide information about fundamental server-side functionalities, such as host libraries and the **libvirtd** service. The log files also contain the standard error output (**stderr**) of all running VMs.

Debug logging is not enabled by default and has to be enabled when libvirt starts. You can enable logging for a single session or persistently. You can also enable logging when a **libvirtd** daemon session is already running by modifying the daemon run-time settings.

Attaching the libvirt debug logs is also useful when requesting support with a VM problem.

19.1.2. Enabling persistent settings for virtual machine debug logs

You can configure virtual machine (VM) debug logging to be automatically enabled whenever libvirt starts by editing the **libvirtd.conf** configuration file which is located in the **/etc/libvirt** directory.

Procedure

1. Open the **libvirtd.conf** file in an editor.
2. Replace or set the filters according to your requirements.

Table 19.1. Debugging filter values

1	logs all messages generated by libvirt.
2	logs all non-debugging information.
3	logs all warning and error messages. This is the default value.
4	logs only error messages.

Example 19.1. Sample libvirtd.conf settings for logging filters

The following settings:

- Log all error and warning messages from the **remote**, **util.json**, and **rpc** layers
- Log only error messages from the **event** layer.
- Save the filtered logs to **/var/log/libvirt/libvirtd.log**

```
log_filters="3:remote 4:event 3:util.json 3:rpc"
log_outputs="1:file:/var/log/libvirt/libvirtd.log"
```

3. Save and exit.
4. Restart the **libvirtd** service.

```
$ systemctl restart libvirtd.service
```

19.1.3. Enabling virtual machine debug logs during runtime

You can modify the libvirt daemon's runtime settings to enable debug logs and save them to an output file.

This is useful when restarting **libvirtd** is not possible because restarting fixes the problem, or because there is another process, such as migration or backup, running at the same time. Modifying runtime settings is also useful if you want to try a command without editing the configuration files or restarting the daemon.

Prerequisites

- Make sure the **libvirt-admin** package is installed.

Procedure

1. **Optional:** Back up the active set of log filters.

```
# virt-admin daemon-log-filters >> virt-filters-backup
```

NOTE

It is recommended that you back up the active set of filters so that you can restore them after generating the logs. If you do not restore the filters, the messages will continue to be logged which may affect system performance.

2. Use the **virt-admin** utility to enable debugging and set the filters according to your requirements.

Table 19.2. Debugging filter values

1	logs all messages generated by libvirt.
2	logs all non-debugging information.

3	logs all warning and error messages. This is the default value.
4	logs only error messages.

Example 19.2. Sample virt-admin setting for logging filters

The following command:

- Logs all error and warning messages from the **remote**, **util.json**, and **rpc** layers
- Logs only error messages from the **event** layer.

```
# virt-admin daemon-log-filters "3:remote 4:event 3:util.json 3:rpc"
```

3. Use the **virt-admin** utility to save the logs to a specific file or directory.
For example, the following command saves the log output to the **libvirt.log** file in the **/var/log/libvirt/** directory.

```
# virt-admin daemon-log-outputs "1:file:/var/log/libvirt/libvirtd.log"
```

4. **Optional:** You can also remove the filters to generate a log file that contains all VM-related information. However, it is not recommended since this file may contain a large amount of redundant information produced by libvirt's modules.
   - Use the **virt-admin** utility to specify an empty set of filters.

```
# virt-admin daemon-log-filters
  Logging filters:
```

5. **Optional:** Restore the filters to their original state using the backup file.
Perform the second step with the saved values to restore the filters.

19.1.4. Attaching virtual machine debug logs to support requests

You may have to request additional support to diagnose and resolve virtual machine (VM) problems. Attaching the debug logs to the support request is highly recommended to ensure that the support team has access to all the information they need to provide a quick resolution of the VM-related problem.

Procedure

- To report a problem and request support, open a support case.
- Based on the encountered problems, attach the following logs along with your report:
  - For problems with the libvirt service, attach the **/var/log/libvirt/libvirtd.log** file from the host.
  - For problems with a specific VM, attach its respective log file.
  For example, for the *testguest1* VM, attach the **testguest1.log** file, which can be found at **/var/log/libvirt/qemu/testguest1.log**.

Additional resources

- For more information about attaching log files, see How to provide files to Red Hat Support?

19.2. DUMPING A VIRTUAL MACHINE CORE

To analyze why a virtual machine (VM) crashed or malfunctioned, you can dump the VM core to a file on disk for later analysis and diagnostics.

This section provides a brief introduction to core dumping and explains how you can dump a VM core to a specific file.

19.2.1. How virtual machine core dumping works

A virtual machine (VM) requires numerous running processes to work accurately and efficiently. In some cases, a running VM may terminate unexpectedly or malfunction while you are using it. Restarting the VM may cause the data to be reset or lost, which makes it difficult to diagnose the exact problem that caused the VM to crash.

In such cases, you can use the **virsh dump** utility to save (or *dump*) the core of a VM to a file before you reboot the VM. The core dump file contains a raw physical memory image of the VM which contains detailed information about the VM. This information can be used to diagnose VM problems, either manually, or by using a tool such as the **crash** utility.

Additional resources

- For information about using the **crash** utility, see the crash man page and the crash utility home page.

19.2.2. Creating a virtual machine core dump file

A virtual machine (VM) core dump contains detailed information about the state of a VM at any given time. This information, which is similar to a snapshot of the VM, can help you detect problems if a VM malfunctions or shuts down suddenly.

Prerequisites

- Make sure you have sufficient disk space to save the file. Note that the space occupied by the VM depends on the amount of RAM allocated to the VM.

Procedure

- Use the **virsh dump** utility.
  For example, the following command dumps the **lander1** VM's cores, its memory and the CPU common register file to **gargantua.file** in the **/core/file** directory.

```
# virsh dump lander1 /core/file/gargantua.file --memory-only
  Domain lander1 dumped to /core/file/gargantua.file
```

IMPORTANT

The **crash** utility no longer supports the default file format of the virsh dump command. To analyze a core dump file using **crash**, you must create the file using the **--memory-only** option.

Additionally, you must use the **--memory-only** option when creating a core dump file to attach to a Red Hat Support Case.

Additional resources

- For other **virsh dump** arguments, use **virsh dump --help** or see the **virsh** man page.
- For information about opening a support case, see Open a Support Case .

19.3. BACKTRACING VIRTUAL MACHINE PROCESSES

When a process related to a virtual machine (VM) malfunctions, you can use the **gstack** command along with the process identifier (PID) to generate an execution stack trace of the malfunctioning process. If the process is a part of a thread group then all the threads are traced as well.

Prerequisites

- Ensure that the **GDB** package is installed.
  For details about installing **GDB** and the available components, see Installing the GNU Debugger.
- Make sure you know the PID of the processes that you want to backtrace.
  You can find the PID by using the **pgrep** command followed by the name of the process. For example:

```
# pgrep libvirt
22014
22025
```

Procedure

- Use the **gstack** utility followed by the PID of the process you wish to backtrace.
  For example, the following command backtraces the libvirt process with the PID 22014.

```
# gstack 22014
Thread 3 (Thread 0x7f33edaf7700 (LWP 22017)):
#0  0x00007f33f81aef21 in poll () from /lib64/libc.so.6
#1  0x00007f33f89059b6 in g_main_context_iterate.isra () from /lib64/libglib-2.0.so.0
#2  0x00007f33f8905d72 in g_main_loop_run () from /lib64/libglib-2.0.so.0
...
```

Additional resources

- For other **gstack** arguments, see the **gstack** man page.
- For more information about **GDB**, see GNU Debugger.

19.4. ADDITIONAL RESOURCES FOR REPORTING VIRTUAL MACHINE PROBLEMS AND PROVIDING LOGS

To request additional help and support, you can:

- Raise a service request using the **redhat-support-tool** command line option, the Red Hat Portal UI, or several different methods using FTP.
  - To report problems and request support, see Open a Support Case .
- Upload the SOS Report and the log files when you submit a service request.
  This ensures that the Red Hat support engineer has all the necessary diagnostic information for reference.
  - For more information about SOS reports, see What is an SOS Report and how to create one in Red Hat Enterprise Linux?
  - For information about attaching log files, see How to provide files to Red Hat Support?

CHAPTER 20. FEATURE SUPPORT AND LIMITATIONS IN RHEL 8 VIRTUALIZATION

This document provides information on feature support and restrictions in Red Hat Enterprise Linux 8 (RHEL 8) virtualization.

20.1. HOW RHEL 8 VIRTUALIZATION SUPPORT WORKS

A set of support limitations applies to virtualization in Red Hat Enterprise Linux 8 (RHEL 8). This means that when you use certain features or exceed a certain amount of allocated resources when using virtual machines in RHEL 8, Red Hat will not support these guests unless you have a specific subscription plan.

Features listed in Section 20.2, "Recommended features in RHEL 8 virtualization" have been tested and certified by Red Hat to work with the KVM hypervisor on a RHEL 8 system. Therefore, they are fully supported and recommended for use in virtualization in RHEL 8.

Features listed in Section 20.3, "Unsupported features in RHEL 8 virtualization" may work, but are not supported and not intended for use in RHEL 8. Therefore, Red Hat strongly recommends not using these features in RHEL 8 with KVM.

Section 20.4, "Resource allocation limits in RHEL 8 virtualization" lists the maximum amount of specific resources supported on a KVM guest in RHEL 8. Guests that exceed these limits are not supported by Red Hat.

In addition, unless stated otherwise, all features and solutions used by the documentation for RHEL 8 virtualization are supported. However, some of these have not been completely tested and therefore may not be fully optimized.

IMPORTANT

Many of these limitations do not apply to other virtualization solutions provided by Red Hat, such as Red Hat Virtualization (RHV), OpenShift Virtualization, or Red Hat OpenStack Platform (RHOSP).

20.2. RECOMMENDED FEATURES IN RHEL 8 VIRTUALIZATION

The following features are recommended for use with the KVM hypervisor included with Red Hat Enterprise Linux 8 (RHEL 8):

Host system architectures

RHEL 8 with KVM is only supported on the following host architectures:

- AMD64 and Intel 64
- IBM Z - IBM z13 systems and later
- IBM POWER8
- IBM POWER9

Any other hardware architectures are not supported for using RHEL 8 as a KVM virtualization host, and Red Hat highly discourages doing so. Notably, this includes the 64-bit ARM architecture (ARM 64).

NOTE

RHEL 8 documentation primarily describes AMD64 and Intel 64 features and usage. For information about the specific of using RHEL 8 virtualization on different architectures, see:

- Chapter 3, *Getting started with virtualization on IBM POWER*
- Chapter 4, *Getting started with virtualization on IBM Z* .

Guest operating systems

Red Hat supports KVM virtual machines that use the following operating systems (OSs):

- Red Hat Enterprise Linux 6 and later
- Microsoft Windows 10 and later
- Microsoft Windows Server 2016 and later

Note, however, that by default, your guest OS does not use the same subscription as your host. Therefore, you must activate a separate licence or subscription for the guest OS to work properly.

Q35 guests

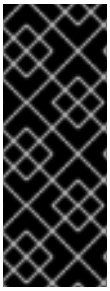
The recommended machine type for KVM virtual machines is QEMU Q35, which emulates the ICH9 chipset.

Additional resources

- For information about unsupported guest OS types and features in RHEL 8 virtualization, see Section 20.3, “Unsupported features in RHEL 8 virtualization” .
- For information about the maximum supported amounts of resources that can be allocated to a virtual machine, see Section 20.4, “Resource allocation limits in RHEL 8 virtualization” .

20.3. UNSUPPORTED FEATURES IN RHEL 8 VIRTUALIZATION

The following features are not supported by the KVM hypervisor included with Red Hat Enterprise Linux 8 (RHEL 8):



IMPORTANT

Many of these limitations may not apply to other virtualization solutions provided by Red Hat, such as Red Hat Virtualization (RHV), OpenShift Virtualization, or Red Hat OpenStack Platform (RHOSP).

Features supported by RHV 4.2 and later, or RHOSP 13 and later, are described as such in the following paragraphs.

Host system architectures

RHEL 8 with KVM is not supported on any host architectures that are not listed in Section 20.2, “Recommended features in RHEL 8 virtualization”.

Notably, Red Hat does not support using systems with the 64-bit ARM architecture (ARM 64) for KVM virtualization on RHEL 8.

Guest operating systems

KVM virtual machines (VMs) using the following guest operating systems (OSs) on a RHEL 8 host are not supported:

- Microsoft Windows 8.1 and earlier
- Microsoft Windows Server 2012 and earlier
- macOS
- Solaris for x86 systems
- Any OS released prior to 2009

For a list of guest OSs supported on RHEL hosts, see Certified guest operating systems for Red Hat Enterprise Linux with KVM.

For a list of guest OSs supported by other virtualization solutions provided by Red Hat, see Certified Guest Operating Systems in Red Hat OpenStack Platform and Red Hat Virtualization.

For a list of guest OSs supported specifically by RHV, see Supported guest operating systems in RHV .

Creating VMs in containers

Red Hat does not support creating KVM virtual machines in any type of container that includes the elements of the RHEL 8 hypervisor (such as the **QEMU** emulator or the **libvirt** package).

To create VMs in containers, Red Hat recommends using the OpenShift Virtualization offering.

vCPU hot unplug

Removing a virtual CPU (vCPU) from a running VM, also referred to as a vCPU hot unplug, is not supported in RHEL 8.

Note that vCPU hot unplugs are supported in RHV. For details, see Hot plugging VCPUs .

Memory hot unplug

Removing a memory device attached to a running VM, also referred to as a memory hot unplug, is unsupported in RHEL 8.

Note that memory hot unplugs are supported in RHV, but only on guest VMs running RHEL with specific guest configurations. For details, see Hot Unplugging Virtual Memory .

QEMU-side I/O throttling

Using the **virsh blkdeviotune** utility to configure maximum input and output levels for operations on virtual disk, also known as QEMU-side I/O throttling, is not supported in RHEL 8.

To set up I/O throttling in RHEL 8, use **virsh blkiotune**. This is also known as libvirt-side I/O throttling. For instructions, see Section 16.4.2, “Disk I/O throttling in virtual machines” .

Note that QEMU-side I/O throttling is supported in RHV. For details, see Storage quality of service .

QEMU-side I/O throttling is also supported in RHOSP. For details, see Setting Resource Limitation on Disk and the **Use Quality-of-Service Specifications** section in the RHOSP Storage Guide.

In addition, OpenShift Virtualizaton supports QEMU-side I/O throttling as well.

Storage live migration

Migrating a disk image of a running VM between hosts is not supported in RHEL 8.

Note that storage live migration is supported in RHV. For details, see Overview of Live Storage Migration.

Storage live migration is also supported in RHOSP, but with some limitations. For details, see Migrate a Volume.

Live snapshots

Creating or loading a snapshot of a running VM, also referred to as a live snapshot, is not supported in RHEL 8.

In addition, note that non-live VM snapshots are deprecated in RHEL 8. Therefore, creating or loading a snapshot of a shut-down VM is supported, but Red Hat recommends not using it.

Note that live snapshots are supported in RHV. For details, see Live snapshots in Red Hat Virtualization .

Live snapshots are also supported in RHOSP. For details, see Importing virtual machines into the overcloud.

vhost-user

RHEL 8 does not support the implementation of a user-space vHost interface.

Note that vhost-user is supported in RHOSP, but only for **virtio-net** interfaces. For details, see virtio-net implementation and vhost user ports.

S3 and S4 system power states

Suspending a VM to the **Suspend to RAM** (S3) or **Suspend to disk** (S4) system power states is not supported. Note that these features are disabled by default, and enabling them will make your VM not supportable by Red Hat.

Note that the S3 and S4 states are currently also not supported in RHV and RHOSP.

S3-PR on a multipathed vDisk

SCSI3 persistent reservation (S3-PR) on a multipathed vDisk is not supported in RHEL 8. As a consequence, Windows Cluster is not supported in RHEL 8.

Note that S3-PR on a multipathed vDisk is supported in RHV. Therefore, if you require Windows Cluster support, Red Hat recommends using RHV as your virtualization solution. For details, see Cluster support on RHV guests.

virtio-crypto

The drivers for the *virtio-crypto* device are available in the RHEL 8.0 kernel, and the device can thus be enabled on a KVM hypervisor under certain circumstances. However, using the *virtio-crypto* device in RHEL 8 is not supported and its use is therefore highly discouraged.

Note that *virtio-crypto* devices are also not supported in RHV or RHOSP.

Incremental live backup

Configuring a VM backup that only saves VM changes since the last backup, also known as incremental live backup, is not supported in RHEL 8, and Red Hat highly discourages its use.

Note that incremental live backup is provided as a Technology Preview in RHV 4.4 and later.

net_failover

Using the **net_failover** driver to set up an automated network device failover mechanism is not supported in RHEL 8.

Note that **net_failover** is currently also not supported in RHV and RHOSP.

Multi-FD migration

Migrating VMs using multiple file descriptors (FDs), also known as multi-FD migration, is not supported in RHEL 8.

Note that multi-FD migrations are currently also not supported in RHV or RHOSP.

virtiofs

Sharing files between the host and its VMs using the **virtiofs** file system is unsupported in RHEL 8.

Note that using **virtiofs** is currently also not supported in RHV or RHOSP.

NVMe devices

Attaching Non-volatile Memory express (NVMe) devices to VMs hosted in RHEL 8 is not supported.

Note that attaching **NVMe** devices to VMs is currently also not supported in RHV or RHOSP.

TCG

QEMU and libvirt include a dynamic translation mode using the QEMU Tiny Code Generator (TCG). This mode does not require hardware virtualization support. However, TCG is not supported by Red Hat.

TCG-based guests can be recognized by examining its XML configuration, for example using the "virsh dumpxml" command.

- The configuration file of a TCG guest contains the following line:

```
<domain type='qemu'>
```

- The configuration file of a KVM guest contains the following line:

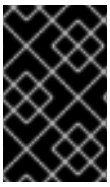
```
<domain type='kvm'>
```

Additional resources

- For information about supported guest OS types and recommended features in RHEL 8 virtualization, see Section 20.2, “Recommended features in RHEL 8 virtualization” .
- For information about the maximum supported amounts of resources that can be allocated to a VM, see Section 20.4, “Resource allocation limits in RHEL 8 virtualization” .

20.4. RESOURCE ALLOCATION LIMITS IN RHEL 8 VIRTUALIZATION

The following limits apply to virtualized resources that can be allocated to a single KVM virtual machine (VM) on a Red Hat Enterprise Linux 8 (RHEL 8) host.



IMPORTANT

Many of these limitations do not apply to other virtualization solutions provided by Red Hat, such as Red Hat Virtualization (RHV), OpenShift Virtualization, or Red Hat OpenStack Platform (RHOSP).

Maximum vCPUs per VM

RHEL 8 supports up to **384** vCPUs allocated to a single VM.

PCI devices per VM

RHEL 8 supports **64** PCI device slots per VM bus, and **8** PCI functions per device slot. This gives a theoretical maximum of 512 PCI functions per bus when multi-function capabilities are enabled in the VM, and no PCI bridges are used.

Each PCI bridge adds a new bus, potentially enabling another 512 device addresses. However, some buses do not make all 512 device addresses available for the user; for example, the root bus has several built-in devices occupying slots.

Virtualized IDE devices

KVM is limited to a maximum of **4** virtualized IDE devices per VM.

20.5. AN OVERVIEW OF VIRTUALIZATION FEATURES SUPPORT

The following tables provide comparative information about the support state of selected virtualization features in RHEL 8 across the supported system architectures.

Table 20.1. Device hot plug and hot unplug

	Intel 64 and AMD64	IBM Z	IBM POWER
CPU hot plug	Supported	Supported	Supported
CPU hot unplug	*UNSUPPORTED*	*UNSUPPORTED*	*UNSUPPORTED*
Memory hot plug	Supported	*UNSUPPORTED*	Supported
Memory hot unplug	*UNSUPPORTED*	*UNSUPPORTED*	*UNSUPPORTED*
PCI hot plug	Supported	Supported [a]	Supported
PCI hot unplug	Supported	Supported [b]	Supported

	Intel 64 and AMD64	IBM Z	IBM POWER

[a] Requires using **virtio-*-ccw** devices instead of **virtio-*-pci**

[b] Requires using **virtio-*-ccw** devices instead of **virtio-*-pci**

Table 20.2. Other selected features

	Intel 64 and AMD64	IBM Z	IBM POWER
NUMA tuning	Supported	*UNSUPPORTED*	Supported
SR-IOV devices	Supported	*UNSUPPORTED*	Supported
virt-v2v and p2v	Supported	*UNSUPPORTED*	*UNSUPPORTED*

Note that some of the unsupported features are supported on other Red Hat products, such as Red Hat Virtualization and Red Hat OpenStack platform. For more information, see Section 20.3, "Unsupported features in RHEL 8 virtualization".

Additional sources

- For a complete list of unsupported features of virtual machines in RHEL 8, see Section 20.3, "Unsupported features in RHEL 8 virtualization".
- For details on the specifics for virtualization on the IBM Z architecture, see Section 4.2, "How virtualization on IBM Z differs from AMD64 and Intel 64".
- For details on the specifics for virtualization on the IBM POWER architecture, see Section 3.2, "How virtualization on IBM POWER differs from AMD64 and Intel 64".