Red Hat Enterprise Linux 6

Virtualization Guide

Guide to Virtualization on Red Hat Enterprise Linux 6

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Edition 3.2

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The *Red Hat Enterprise Linux Virtualization Guide* contains information on installation, configuring, administering, and troubleshooting virtualization technologies included with Red Hat Enterprise Linux.

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Preface

Welcome to the Red Hat Enterprise Linux 6 Virtualization Guide. This guide covers all aspects of using and managing virtualization products included with Red Hat Enterprise Linux 6.

This book is divided into 7 parts:

- System Requirements
- Installation
- Configuration
- Administration
- Reference
- Troubleshooting
- Appendixes

1. Document Conventions

This manual uses several conventions to highlight certain words and phrases and draw attention to specific pieces of information.

In PDF and paper editions, this manual uses typefaces drawn from the *Liberation Fonts*[1] set. The Liberation Fonts set is also used in HTML editions if the set is installed on your system. If not, alternative but equivalent typefaces are displayed. Note: Red Hat Enterprise Linux 5 and later includes the Liberation Fonts set by default.

1.1. Typographic Conventions

Four typographic conventions are used to call attention to specific words and phrases. These conventions, and the circumstances they apply to, are as follows.

`Mono-spaced Bold`

Used to highlight system input, including shell commands, file names and paths. Also used to highlight keycaps and key combinations. For example:

> To see the contents of the file **`my_next_bestselling_novel`** in your current working directory, enter the **`cat my_next_bestselling_novel`** command at the shell prompt and press **`Enter`** to execute the command.

The above includes a file name, a shell command and a keycap, all presented in mono-spaced bold and all distinguishable thanks to context.

Key combinations can be distinguished from keycaps by the hyphen connecting each part of a key combination. For example:

> Press **`Enter`** to execute the command.
>
> Press **`Ctrl`**+**`Alt`**+**`F2`** to switch to the first virtual terminal. Press **`Ctrl`**+**`Alt`**+**`F1`** to return to your X-Windows session.

[1] https://fedorahosted.org/liberation-fonts/

The first paragraph highlights the particular keycap to press. The second highlights two key combinations (each a set of three keycaps with each set pressed simultaneously).

If source code is discussed, class names, methods, functions, variable names and returned values mentioned within a paragraph will be presented as above, in **`mono-spaced bold`**. For example:

> File-related classes include **`filesystem`** for file systems, **`file`** for files, and **`dir`** for directories. Each class has its own associated set of permissions.

Proportional Bold

This denotes words or phrases encountered on a system, including application names; dialog box text; labeled buttons; check-box and radio button labels; menu titles and sub-menu titles. For example:

> Choose **System** → **Preferences** → **Mouse** from the main menu bar to launch **Mouse Preferences**. In the **Buttons** tab, click the **Left-handed mouse** check box and click **Close** to switch the primary mouse button from the left to the right (making the mouse suitable for use in the left hand).
>
> To insert a special character into a **gedit** file, choose **Applications** → **Accessories** → **Character Map** from the main menu bar. Next, choose **Search** → **Find…** from the **Character Map** menu bar, type the name of the character in the **Search** field and click **Next**. The character you sought will be highlighted in the **Character Table**. Double-click this highlighted character to place it in the **Text to copy** field and then click the **Copy** button. Now switch back to your document and choose **Edit** → **Paste** from the **gedit** menu bar.

The above text includes application names; system-wide menu names and items; application-specific menu names; and buttons and text found within a GUI interface, all presented in proportional bold and all distinguishable by context.

`Mono-spaced Bold Italic` or ***`Proportional Bold Italic`***

Whether mono-spaced bold or proportional bold, the addition of italics indicates replaceable or variable text. Italics denotes text you do not input literally or displayed text that changes depending on circumstance. For example:

> To connect to a remote machine using ssh, type **`ssh`** ***`username@domain.name`*** at a shell prompt. If the remote machine is **`example.com`** and your username on that machine is john, type **`ssh john@example.com`**.
>
> The **`mount -o remount`** ***`file-system`*** command remounts the named file system. For example, to remount the **`/home`** file system, the command is **`mount -o remount /home`**.
>
> To see the version of a currently installed package, use the **`rpm -q`** ***`package`*** command. It will return a result as follows: ***`package-version-release`***.

Note the words in bold italics above — username, domain.name, file-system, package, version and release. Each word is a placeholder, either for text you enter when issuing a command or for text displayed by the system.

Aside from standard usage for presenting the title of a work, italics denotes the first use of a new and important term. For example:

> Publican is a *DocBook* publishing system.

1.2. Pull-quote Conventions

Terminal output and source code listings are set off visually from the surrounding text.

Output sent to a terminal is set in **`mono-spaced roman`** and presented thus:

```
books        Desktop   documentation  drafts  mss    photos   stuff  svn
books_tests  Desktop1  downloads      images  notes  scripts  svgs
```

Source-code listings are also set in **`mono-spaced roman`** but add syntax highlighting as follows:

```
package org.jboss.book.jca.ex1;

import javax.naming.InitialContext;

public class ExClient
{
   public static void main(String args[])
       throws Exception
   {
      InitialContext iniCtx = new InitialContext();
      Object         ref    = iniCtx.lookup("EchoBean");
      EchoHome       home   = (EchoHome) ref;
      Echo           echo   = home.create();

      System.out.println("Created Echo");

      System.out.println("Echo.echo('Hello') = " + echo.echo("Hello"));
   }
}
```

1.3. Notes and Warnings

Finally, we use three visual styles to draw attention to information that might otherwise be overlooked.

Note

Notes are tips, shortcuts or alternative approaches to the task at hand. Ignoring a note should have no negative consequences, but you might miss out on a trick that makes your life easier.

Important

Important boxes detail things that are easily missed: configuration changes that only apply to the current session, or services that need restarting before an update will apply. Ignoring a box labeled 'Important' will not cause data loss but may cause irritation and frustration.

Warning

Warnings should not be ignored. Ignoring warnings will most likely cause data loss.

2. We need your feedback

If you find a typographical error in this manual, or if you have thought of a way to make this manual better, we would love to hear from you. Submit a report in Bugzilla: *http://bugzilla.redhat.com/* against the **Red_Hat_Enterprise_Linux** product.

When submitting a bug report, be sure to refer to the correct component: doc-*Virtualization_Guide* and version number: **6**.

If you have a suggestion for improving the documentation, try to be as specific as possible when describing it. If you have found an error, include the section number and some of the surrounding text so we can find it easily.

Introduction

This chapter introduces various virtualization technologies, applications and features, and explains how they work.

1.1. What is virtualization?

Virtualization is a broad computing term for running software, usually operating systems, concurrently and isolated from other programs on one system. Most existing implementations of virtualization use a hypervisor, a software layer or subsystem that controls hardware and provides guest operating systems with access to underlying hardware. The hypervisor allows multiple operating systems to run on the same physical system by offering virtualized hardware to the guest operating system. There are various methods for virtualizing operating systems:

- Full virtualization uses hardware features of the processor to provide total abstraction of the underlying physical system and creates a new virtual machine in which the guest operating systems can run. No modifications are needed in the guest operating system. The guest operating system and any applications on the guest are not aware of the virtualized environment and run normally. Hardware-assisted virtualization is the technique used for full virtualization with KVM (Kernel-based Virtual Machine) in Red Hat Enterprise Linux.
- Para-virtualization uses a collection of software and data structures that are presented to the guest virtual machine, and requires software modifications in the guest to use the para-virtualized environment. Para-virtualization can encompass the entire kernel, as is the case for Xen para-virtualized guests, or simply drivers that virtualize I/O devices, as is the case for the virtio block and network devices.
- Software virtualization (or emulation) uses slower binary translation and other emulation techniques to run unmodified operating systems. Software virtualization is unsupported by Red Hat Enterprise Linux.

1.2. KVM and virtualization in Red Hat Enterprise Linux

What is KVM?

KVM (Kernel-based Virtual Machine) is a full virtualization solution for Linux on AMD64 and Intel 64 hardware that is built into the standard Red Hat Enterprise Linux 6 kernel. It can run multiple, unmodified virtualized guest Windows and Linux operating systems. The KVM hypervisor in Red Hat Enterprise Linux is managed with the libvirt API and tools built for libvirt (such as **`virt-manager`** and **`virsh`**). Virtualized guests are executed and run as Linux processes and threads which are controlled by these modules.

Overcommitting

The KVM hypervisor supports overcommitting of system resources. Overcommitting means allocating more virtualized CPUs or memory than the available resources on the system. Memory overcommitting allows hosts to utilize memory and virtual memory to increase guest densities.

Important

A single guest can **not** use more CPU or memory than physically available. Overcommitting does, however, support the operation of **multiple** guests that have a total CPU and/or memory requirement greater than the physical host.

Overcommitting involves possible risks to system stability. For more information on overcommitting with KVM, and the precautions that should be taken, refer to *Chapter 20, Overcommitting with KVM*.

KSM

Kernel SamePage Merging (KSM) is used by the KVM hypervisor to allow KVM guests to share identical memory pages. These shared pages are usually common libraries or other identical, high-use data. KSM allows for greater guest density of identical or similar guest operating systems by avoiding memory duplication.

For more information on KSM, refer to *Chapter 21, KSM*.

1.3. libvirt and the libvirt tools

Libvirt is a hypervisor-independent virtualization API that is able to interact with the virtualization capabilities of a range of operating systems.

Libvirt provides:

- A common, generic and stable layer to securely manage virtualized guests on a host.
- A common interface for managing local systems and networked hosts.
- All of the APIs required to provision, create, modify, monitor, control, migrate and stop virtualized guests if the hypervisor supports these operations. Although multiple hosts may be accessed with libvirt simultaneously, the APIs are limited to single node operations.

Libvirt is designed as a building block for higher level management tools and applications, for example, **`virt-manager`** and the **`virsh`** command line management tools. Libvirt focuses on managing single hosts, with the exception of migration capabilities and provides APIs to enumerate, monitor and use the resources available on the managed node, including CPUs, memory, storage, networking and Non-Uniform Memory Access (NUMA) partitions. The management tools can be located on separate physical machines from the host using secure protocols.

Red Hat Enterprise Linux 6 supports libvirt and included libvirt-based tools as its default method for virtualization management.

Libvirt is available as free software under the GNU Lesser General Public License. The libvirt project aims to provide a long term stable C API to virtualization management tools, running on top of varying hypervisor technologies. The *libvirt* package supports Xen on Red Hat Enterprise Linux 5, and it supports KVM on both Red Hat Enterprise Linux 5 and Red Hat Enterprise Linux 6.

virsh

The **`virsh`** command-line tool is built on the **`libvirt`** management API and operates as an alternative to the graphical **`virt-manager`** application. The **`virsh`** command can be used in read-only mode by unprivileged users or, with root access, full administration functionality. The **`virsh`** command is ideal for scripting virtualization administration.

The **virsh** tool is included in the *libvirt-client* package.

virt-manager

virt-manager is a graphical desktop tool for managing virtualized guests. It can be used to perform virtualization administration, virtualized guest creation, migration and configuration tasks and allows access to graphical guest consoles. The ability to view virtualized guests, host statistics, device information and performance graphs is also provided. The local hypervisor and remote hypervisors can be managed through a single interface.

RHEV-M

Red Hat Enterprise Virtualization Manager (RHEV-M) provides a graphical user interface to administer the physical and logical resources within the virtual environment infrastructure. It can be used to manage provisioning, connection protocols, user sessions, virtual machine pools, images and high availability/clustering as an alternative to the **virsh** and **virt-manager** tools. It runs on Windows Server 2008 R2 in clustered mode, with active-standby configuration. For more information on RHEV-M, refer to the Red Hat Enterprise Virtualization documentation at *http://docs.redhat.com*.

1.4. Virtualized hardware devices

Virtualization on Red Hat Linux 6 presents three distinct types of system devices to virtualized guests. The three types include:

- Emulated software devices.
- Para-virtualized devices.
- Physically shared devices.

These hardware devices all appear as physically attached hardware devices to the virtualized guest but the device drivers work in different ways.

1.4.1. Virtualized and emulated devices

The QEMU/KVM emulator implements many core devices for virtualized guests in software. These emulated hardware devices are crucial for virtualizing operating systems. This section is provided as an introduction to the emulated devices and emulated device drivers.

Emulated devices are virtual devices which exist entirely in software. The emulated devices do not require a real hardware device to back them.

Emulated drivers may use either a physical device or a virtual software device. Emulated drivers are a translation layer between the guest and the Linux kernel (which manages the source device). The device level instructions are completely translated by the KVM hypervisor. Any device, of the same type, recognized by the Linux kernel may be used as the backing source device for the emulated drivers.

Virtualized CPUs (vCPUs)

A host system has a number of virtual CPUs (vCPUs) that can be presented to guest operating systems for their use. The number of virtual CPUs that can be offered to guests is finite and is determined by the number of physical processor cores on the host. For more information on virtual CPUs, refer to *Section 1.4.4, “Guest CPU models”* and *Section 4.1, “KVM restrictions”*.

Emulated graphics devices

Two emulated graphics devices are provided. These devices can be connected to with the SPICE protocol or with VNC.

- A Cirrus CLGD 5446 PCI VGA card (using the *cirrus* device).
- A standard VGA graphics card with Bochs VESA extensions (hardware level, including all non-standard modes).

Emulated system components

Various core system components are emulated to provide basic system functions.

- An Intel i440FX host PCI bridge.
- PIIX3 PCI to ISA bridge.
- A PS/2 mouse and keyboard.
- An EvTouch USB Graphics Tablet.
- A PCI UHCI USB controller and a virtualized USB hub.
- PCI network adapters.
- Emulated serial ports.

Emulated sound devices

Red Hat Enterprise Linux 6.1 introduces an emulated (Intel) HDA sound device, `intel-hda`. This device is supported on the following guest operating systems:

- Red Hat Enterprise Linux 6, for i386 and x86_64 architectures
- Red Hat Enterprise Linux 5, for i386 and x86_64 architectures
- Red Hat Enterprise Linux 4, for i386 and x86_64 architectures
- Red Hat Enterprise Linux 3.9.z, for i386 architecture
- Windows 2003 with Service Pack 2, for i386 architecture
- Windows 2008, for i386 architecture
- Windows 2008 R2, for x86_64 architecture
- Windows 7, for i386 and x86_64 architectures

The following two emulated sound devices are also available but are not recommended due to compatibility issues with certain guests:

- `ac97`, an emulated Intel 82801AA AC97 Audio compatible sound card.
- `es1370`, an emulated ENSONIQ AudioPCI ES1370 sound card.

Emulated network drivers

There are two emulated network drivers available for network devices:

- The `e1000` driver emulates an Intel E1000 network adaptor (Intel 82540EM, 82573L, 82544GC).
- The `rtl8139` driver emulates a Realtek 8139 network adaptor.

Emulated storage drivers

Storage devices and storage pools can use the emulated drivers to attach storage devices to virtualized guests.

Note that the storage drivers are not storage devices. The drivers are used to attach a backing storage device, file or storage pool volume to a virtualized guest. The backing storage device can be any supported type of storage device, file, or storage pool volume.

The emulated IDE driver
: The QEMU-KVM emulator provides two emulated PCI IDE interfaces. The emulated IDE driver can be used to attach any combination of up to four virtualized IDE hard disks or virtualized IDE CD-ROM drives to each virtualized guest. The emulated IDE driver is used for virtualized CD-ROM and DVD-ROM drives.

The emulated floppy disk drive driver
: The emulated floppy disk drive driver is used for creating virtualized floppy drives.

1.4.2. Para-virtualized drivers

Para-virtualized drivers are device drivers that increase the I/O performance of virtualized guests.

Para-virtualized drivers decrease I/O latency and increase I/O throughput to near bare-metal levels. It is recommended to use the para-virtualized drivers for virtualized guests running I/O intensive applications.

The para-virtualized drivers must be installed on the guest operating system. By default, the para-virtualized drivers are included in Red Hat Enterprise Linux 4.7 and newer, Red Hat Enterprise Linux 5.4 and newer and Red Hat Enterprise Linux 6.0 and newer. The para-virtualized drivers must be manually installed on Windows guests. For more information on using the para-virtualized drivers refer to *Chapter 11, KVM Para-virtualized Drivers*.

Para-virtualized network driver (virtio-net)

The para-virtualized network driver is a Red Hat branded virtual network device. The para-virtualized network driver can be used as the driver for existing network devices or new network devices for virtualized guests.

Para-virtualized block driver (virtio-blk)

The para-virtualized block driver is a driver for all storage devices supported by the hypervisor attached to the virtualized guest (except for floppy disk drives, which must be emulated).

The para-virtualized clock

Guests using the Time Stamp Counter (TSC) as a clock source may suffer timing issues.

KVM works around hosts that do not have a constant Time Stamp Counter by providing guests with a para-virtualized clock.

For more information on the para-virtualized clock refer to *Chapter 14, KVM guest timing management*.

The para-virtualized serial driver

The para-virtualized serial driver (virtio-serial) is a bytestream-oriented, character stream driver. The para-virtualized serial driver provides a simple communication interface between the host's user space and the guest's user space where networking is not available or unusable.

The balloon driver (virtio-balloon)

The balloon driver can mark some part of the guest's RAM as not in use (a process known as balloon *inflation*) so that the memory can be freed for the host (or for other guests on that host) to use. When the guest needs the memory again, the balloon can be *deflated* and the host can distribute the RAM back to the guest.

1.4.3. Physical host devices

Certain hardware platforms allow virtualized guests to directly access various hardware devices and components. This process in virtualization is known as *device assignment*. Device assignment is also known as *passthrough*.

PCI device assignment

The KVM hypervisor supports attaching PCI devices on the host system to virtualized guests. PCI device assignment allows guests to have exclusive access to PCI devices for a range of tasks. It allows PCI devices to appear and behave as if they were physically attached to the guest operating system.

Device assignment is supported on PCI Express devices, with the exception of graphics cards. Parallel PCI devices may be supported as assigned devices, but they have severe limitations due to security and system configuration conflicts. For more information on Device assignment, refer to *Chapter 12, PCI device assignment*.

SR-IOV

SR-IOV (Single Root I/O Virtualization) is a PCI Express standard that extends a single physical PCI function to share its PCI resources as separate, virtual functions (VF). Each of these functions are capable of being used by a different guest via PCI device assignment.

An SR-IOV capable PCI-e device provides a Single Root Function (for example, a single Ethernet port), and presents multiple, separate virtual devices as separate, unique PCI device functions, each with its own unique PCI configuration space, memory-mapped registers and separate (MSI-based) interrupts.

For more information on SR-IOV, refer to *Chapter 13, SR-IOV*.

NPIV

N_Port ID Virtualization (NPIV) is a function available with some Fibre Channel devices. NPIV shares a single physical N_Port as multiple N_Port IDs. NPIV provides similar functionality for Fibre Channel Host Bus Adaptors (HBAs) that SR-IOV provides for PCIe interfaces. With NPIV, virtualized guests can be provided with a virtual Fibre Channel initiator to Storage Area Networks (SANs).

NPIV can provide high density virtualized environments with enterprise-level storage solutions.

For more information on NPIV, refer to *Chapter 29, N_Port ID Virtualization (NPIV)*.

1.4.4. Guest CPU models

Refer to the following table for supported CPU models that can be presented to guests when using Red Hat Enterprise Linux:

Table 1.1. Supported Guest CPU models

CPU Name	Description
Opteron_G3	AMD Opteron 23xx (Gen 3 Class Opteron)
Opteron_G2	AMD Opteron 22xx (Gen 2 Class Opteron)
Opteron_G1	AMD Opteron 240 (Gen 1 Class Opteron)
Westmere	Westmere E56xx/L56xx/X56xx (Nehalem-C)
Nehalem	Intel Core i7 9xx (Nehalem Class Core i7)
Penryn	Intel Core 2 Duo P9xxx (Penryn Class Core 2)
Conroe	Intel Celeron_4x0 (Conroe/Merom Class Core 2)
cpu64-rhel5	Red Hat Enterprise Linux 5 supported QEMU Virtual CPU version (cpu64-rhel5)
cpu64-rhel6	Red Hat Enterprise Linux 6 supported QEMU Virtual CPU version (cpu64-rhel6)

1.5. Storage

Storage for virtualized guests is abstracted from the physical storage used by the guest. Storage is attached to virtualized guests using the para-virtualized (*Section 1.4.2, “Para-virtualized drivers”*) or emulated block device drivers (*Emulated storage drivers*).

1.5.1. Storage pools

A *storage pool* is a file, directory, or storage device managed by libvirt for the purpose of providing storage to virtualized guests. Storage pools are divided into storage *volumes* that store virtualized guest images or are attached to virtualized guests as additional storage.

- **Local storage pools** - Local storage pools are directly attached to the host server. They include local directories, directly attached disks, physical partitions, and LVM volume groups on local devices. Local storage pools are useful for development, testing and small deployments that do not require migration or large numbers of virtualized guests. Local storage pools are not suitable for many production environments as they do not support live migration.

- **Networked (shared) storage pools** - Networked storage pools is a term used for storage devices shared over a network using standard protocols. Networked storage is required for migrating virtualized guests between hosts. Networked storage pools are managed by libvirt.

Storage Volumes

Storage pools are further divided into storage volumes. Storage volumes are an abstraction of physical partitions, LVM logical volumes, file-based disk images and other storage types handled by libvirt. Storage volumes are presented to virtualized guests as local storage devices regardless of the underlying hardware. For more information on storage and virtualization refer to *Part V, “Virtualization storage topics”*.

1.6. Virtualization security features

SELinux

SELinux was developed by the US National Security Agency and others to provide Mandatory Access Control (MAC) for Linux. All processes and files are given a type and access is limited by fine-grained controls. SELinux limits an attackers abilities and works to prevent many common security exploits such as buffer overflow attacks and privilege escalation.

SELinux strengthens the security model of Red Hat Enterprise Linux hosts and virtualized Red Hat Enterprise Linux guests. SELinux is configured and tested to work, by default, with all virtualization tools shipped with Red Hat Enterprise Linux 6.

For more information on SELinux and virtualization, refer to *Section 16.2, “SELinux and virtualization”*.

sVirt

sVirt is a technology included in Red Hat Enterprise Linux 6 that integrates SELinux and virtualization. sVirt applies Mandatory Access Control (MAC) to improve security when using virtualized guests. sVirt improves security and hardens the system against bugs in the hypervisor that might be used as an attack vector for the host or to another virtualized guest.

For more information on sVirt, refer to *Chapter 17, sVirt*.

1.7. Migration

Migration describes the process of moving a virtualized guest from one host to another. This is possible because guests are running in a virtualized environment instead of directly on the hardware.

Migration is useful for:

- Load balancing - guests can be moved to hosts with lower usage when their host becomes overloaded, or another host is being under-utilized.
- Hardware independence - when we need to upgrade, add, or remove hardware devices on the host, we can safely relocate guests to other hosts. This means that guests do not experience any downtime for hardware improvements.
- Energy saving - guests can be redistributed to other hosts and host systems powered off to save energy and cut costs in low usage periods.
- Geographic migration - guests can be moved to another location for lower latency or in serious circumstances.

Migration only moves the virtualized guest's memory. The guest's storage is located on networked storage, which is shared between the source host and destination hosts.

Shared, networked storage must be used for storing guest images. Without shared storage, migration is not possible. It is recommended to use libvirt-managed storage pools for shared storage.

Offline migration

An offline migration suspends the guest, and then moves an image of the guest's memory to the destination host. The guest is then resumed on the destination host and the memory used by the guest on the source host is freed.

Live migration

Live migration is the process of migrating a *running* guest from one physical host to another physical host.

For more information on migration refer to *Chapter 18, KVM live migration*.

1.8. Virtualized to virtualized migration (V2V)

Virtualized to virtualized migration is supported in Red Hat Enterprise Linux 6 for certain virtualized guests.

Red Hat Enterprise Linux 6 provides tools for converting virtualized guests from other types of hypervisor to KVM. The **`virt-v2v`** tool converts and imports virtual machines from Xen, other versions of KVM and VMware ESX.

For more information on using V2V, refer to *Chapter 23, Migrating to KVM from other hypervisors using virt-v2v*

Part I. Requirements and restrictions

System requirements and restrictions for virtualization with Red Hat Enterprise Linux 6

These chapters outline the system requirements and restrictions for virtualization on Red Hat Enterprise Linux 6.

System requirements

This chapter lists system requirements for successfully running virtualized guest operating systems with Red Hat Enterprise Linux 6. Virtualization is available for Red Hat Enterprise Linux 6 on the Intel 64 and AMD64 architecture.

The KVM hypervisor is provided with Red Hat Enterprise Linux 6.

For information on installing the virtualization packages, read *Chapter 5, Installing the virtualization packages*.

Minimum system requirements

- 6GB free disk space
- 2GB of RAM.

Recommended system requirements

- 6GB plus the required disk space recommended by the guest operating system per guest. For most operating systems more than 6GB of disk space is recommended.
- One processor core or hyper-thread for each virtualized CPU and one for the host.
- 2GB of RAM plus additional RAM for virtualized guests.

KVM overcommit

KVM can overcommit physical resources for virtualized guests. Overcommitting resources means the total virtualized RAM and processor cores used by the guests can exceed the physical RAM and processor cores on the host. For information on safely overcommitting resources with KVM refer to *Chapter 20, Overcommitting with KVM*.

KVM requirements

The KVM hypervisor requires:

- an Intel processor with the Intel VT and the Intel 64 extensions, or
- an AMD processor with the AMD-V and the AMD64 extensions.

Refer to *Section 24.3, "Verifying virtualization extensions"* to determine if your processor has the virtualization extensions.

Storage support

The working guest storage methods are:

- files on local storage,
- physical disk partitions,
- locally connected physical LUNs,
- LVM partitions,
- NFS shared file systems,
- iSCSI,

- GFS2 clustered file systems, and
- Fibre Channel-based LUNs
- SRP devices (SCSI RDMA Protocol), the block export protocol used in Infiniband and 10GbE iWARP adapters.

KVM Guest VM limitations and support

To verify whether your processor supports the virtualization extensions and for information on enabling the virtualization extensions if they are disabled, refer to *Section 24.3, “Verifying virtualization extensions”*.

Red Hat Enterprise Linux 6 servers are limited to 256 processor cores or less.

The following URLs explain the processor and memory amount limitations for Red Hat Enterprise Linux:

- For host systems: *http://www.redhat.com/rhel/compare/*
- For hypervisors: *http://www.redhat.com/rhel/virtualization/compare/*

The following URL is a complete chart showing supported operating systems and host and guest combinations:

- *http://www.redhat.com/rhel/server/advanced/virt.html*

Virtualization restrictions

This chapter covers additional support and product restrictions of the virtualization packages in Red Hat Enterprise Linux 6.

4.1. KVM restrictions

The following restrictions apply to the KVM hypervisor:

Maximum VCPUs per guest
: Virtualized guests support up to a maximum of 64 virtualized CPUs in Red Hat Enterprise Linux 6.

Constant TSC bit
: Systems without a Constant Time Stamp Counter require additional configuration. Refer to *Chapter 14, KVM guest timing management* for details on determining whether you have a Constant Time Stamp Counter and configuration steps for fixing any related issues.

Memory overcommit
: KVM supports memory overcommit and can store the memory of guests in swap. A guest will run slower if it is swapped frequently. When KSM is used, make sure that the swap size is the size of the overcommit ratio.

CPU overcommit
: It is not recommended to have more than 10 virtual CPUs per physical processor core. Any number of overcommitted virtual CPUs above the number of physical processor cores may cause problems with certain virtualized guests.

  Refer to *Chapter 20, Overcommitting with KVM* for tips and recommendations on overcommitting CPUs.

Virtualized SCSI devices
: SCSI emulation is not supported with KVM in Red Hat Enterprise Linux.

Virtualized IDE devices
: KVM is limited to a maximum of four virtualized (emulated) IDE devices per guest.

Para-virtualized devices
: Para-virtualized devices, which use the **`virtio`** drivers, are PCI devices. Presently, guests are limited to a supported maximum of 32 PCI devices. Some PCI devices are critical for the guest to run and these devices cannot be removed. The default, required devices are:

  - the host bridge,
  - the ISA bridge and usb bridge (The usb and isa bridges are the same device),
  - the graphics card (using either the Cirrus or qxl driver), and
  - the memory balloon device.

Migration restrictions
: Live migration is only possible with CPUs from the same vendor (that is, Intel to Intel or AMD to AMD only).

  The No eXecution (NX) bit must be set to on or off for both host CPUs for live migration.

Storage restrictions
: Guest should not be given write access to whole disks or block devices (for example, **`/dev/sdb`**). Virtualized guests with access to block devices may be able to access other block devices on the system or modify volume labels which can be used to compromise the host system. Use partitions (for example, **`/dev/sdb1`**) or LVM volumes to prevent this issue.

SR-IOV restrictions
: SR-IOV is only thoroughly tested with the following devices (other SR-IOV devices may work but have not been tested at the time of release):

  Intel® 82576NS Gigabit Ethernet Controller (**`igb`** driver)

  Intel® 82576EB Gigabit Ethernet Controller (**`igb`** driver)

  Neterion X3100 Series 10GbE PCIe (**`vxge`** driver)

  Intel® 82599ES 10 Gigabit Ethernet Controller (**`ixgbe`** driver)

  Intel® 82599EB 10 Gigabit Ethernet Controller (**`ixgbe`** driver)

PCI device assignment restrictions
: PCI device assignment (attaching PCI devices to guests) requires host systems to have AMD IOMMU or Intel VT-d support to enable device assignment of PCI-e devices.

  For parallel/legacy PCI, only single devices behind a PCI bridge are supported.

  Multiple PCIe endpoints connected through a non-root PCIe switch require ACS support in the PCIe bridges of the PCIe switch. This restriction can be disabled in **`/etc/libvirt/qemu.conf`**, setting **relaxed_acs_check=1**

  Red Hat Enterprise Linux 6 has limited PCI configuration space access by guest device drivers. This limitation could cause drivers that are dependent on PCI configuration space to fail configuration.

4.2. Application restrictions

There are aspects of virtualization which make virtualization unsuitable for certain types of applications.

Applications with high I/O throughput requirements should use the para-virtualized drivers for fully virtualized guests. Without the para-virtualized drivers certain applications may be unstable under heavy I/O loads.

The following applications should be avoided for their high I/O requirement reasons:

- **kdump** server
- **netdump** server

You should carefully evaluate applications and tools that heavily utilize I/O (such as databases) or those that require real-time performance. Consider the para-virtualized drivers or PCI device assignment for increased I/O performance. Refer to *Chapter 11, KVM Para-virtualized Drivers* for more information on the para-virtualized drivers for fully virtualized guests. Refer to *Chapter 12, PCI device assignment* for more information on PCI device assignment.

Applications still suffer a small performance loss from running in virtualized environments. The performance benefits of virtualization through consolidating to newer and faster hardware should be evaluated against the potential application performance issues associated with using virtualization.

4.3. Other restrictions

For the list of all other restrictions and issues affecting virtualization read the *Red Hat Enterprise Linux 6 Release Notes*. The *Red Hat Enterprise Linux 6 Release Notes* cover the present new features, known issues and restrictions as they are updated or discovered.

Part II. Installation

Virtualization installation topics

These chapters cover setting up the host and installing virtualized guests with Red Hat Enterprise Linux 6. It is recommended to read these chapters carefully to ensure successful installation of virtualized guest operating systems.

Installing the virtualization packages

Before you can use virtualization, the virtualization packages must be installed on your computer. Virtualization packages can be installed either during the installation sequence or after installation using the **`yum`** command and the Red Hat Network (RHN).

The KVM hypervisor uses the default Red Hat Enterprise Linux kernel with the *kvm* kernel module.

5.1. Installing KVM with a new Red Hat Enterprise Linux installation

This section covers installing virtualization tools and KVM package as part of a fresh Red Hat Enterprise Linux installation.

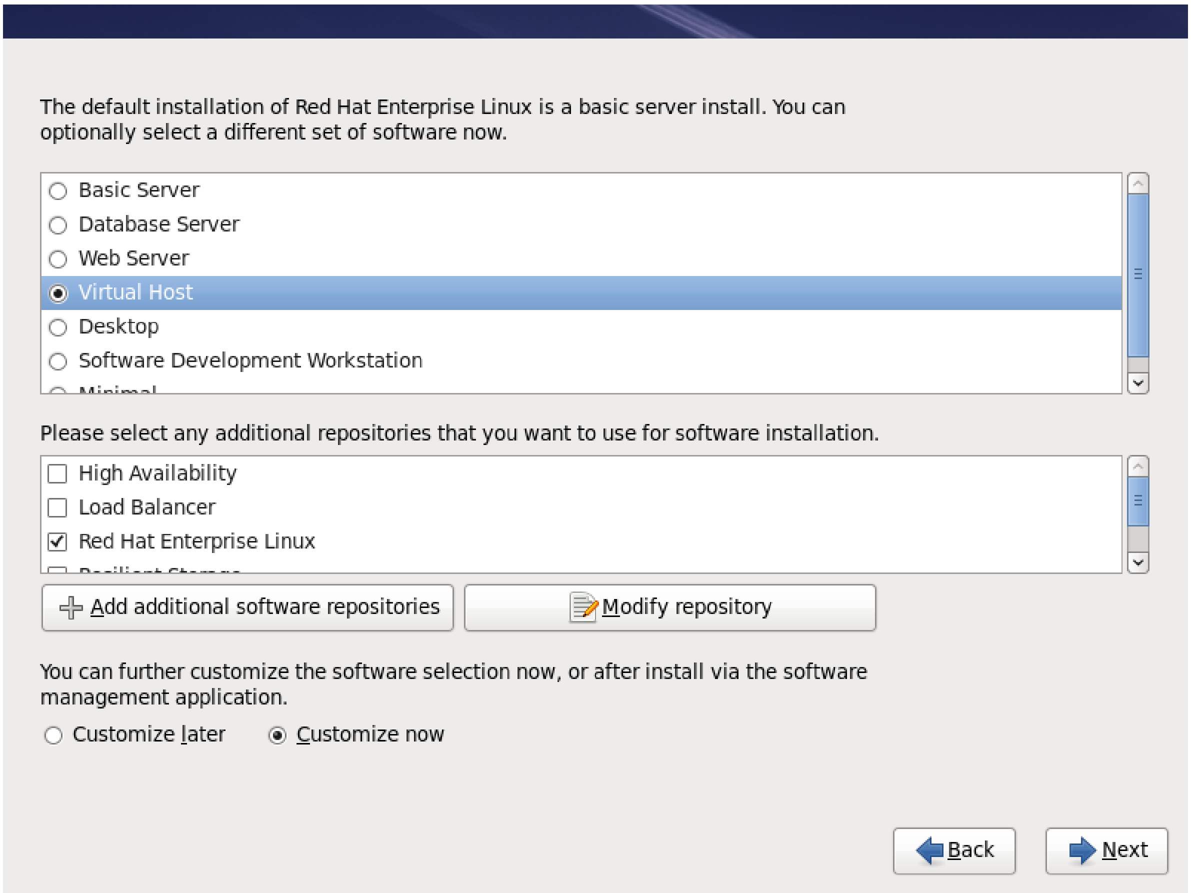
> **Need help installing?**
>
> The *Installation Guide* (available from redhat.com[1]) covers installing Red Hat Enterprise Linux in detail.

1. Start an interactive Red Hat Enterprise Linux installation from the Red Hat Enterprise Linux Installation CD-ROM, DVD or PXE.

2. You must enter a valid installation number when prompted to receive access to the virtualization and other Advanced Platform packages.

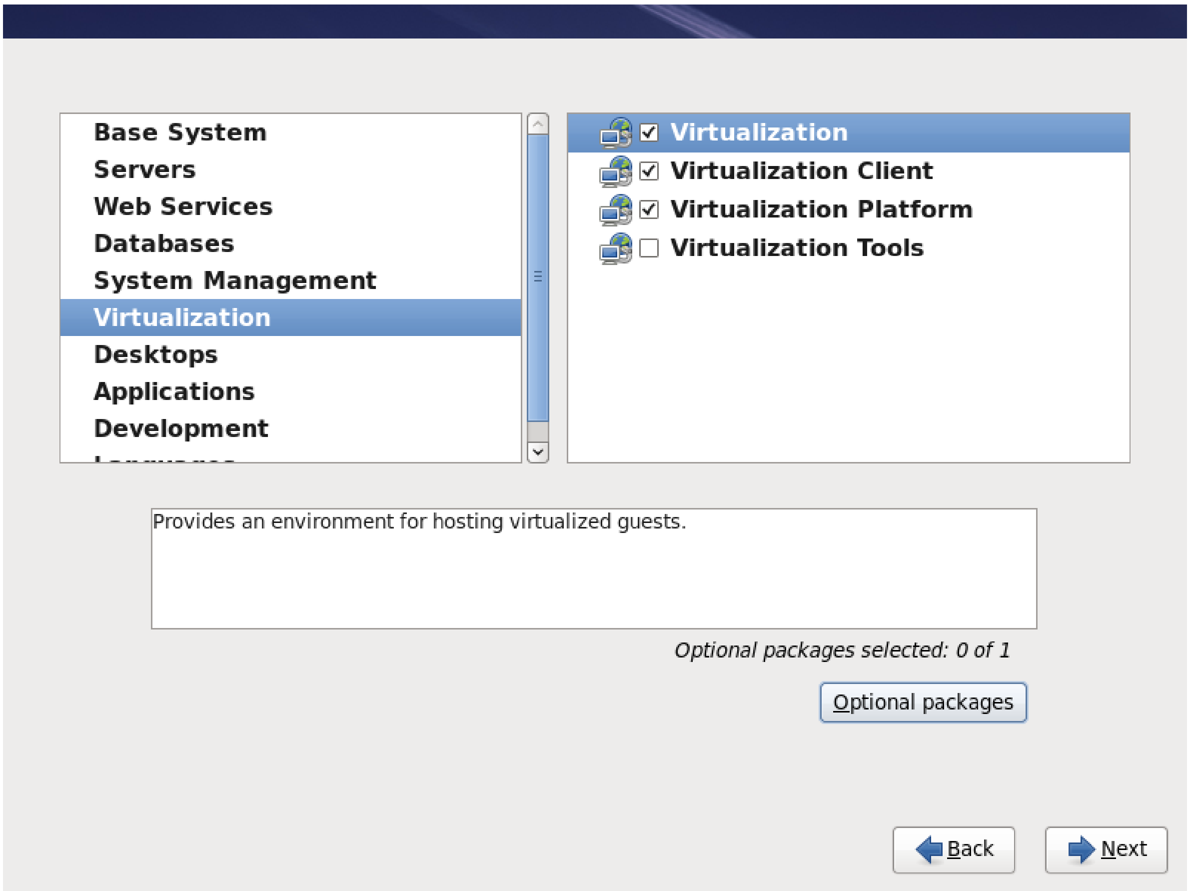
3. Complete the other steps up to the package selection step.

[1] http://www.redhat.com/docs/manuals/enterprise/

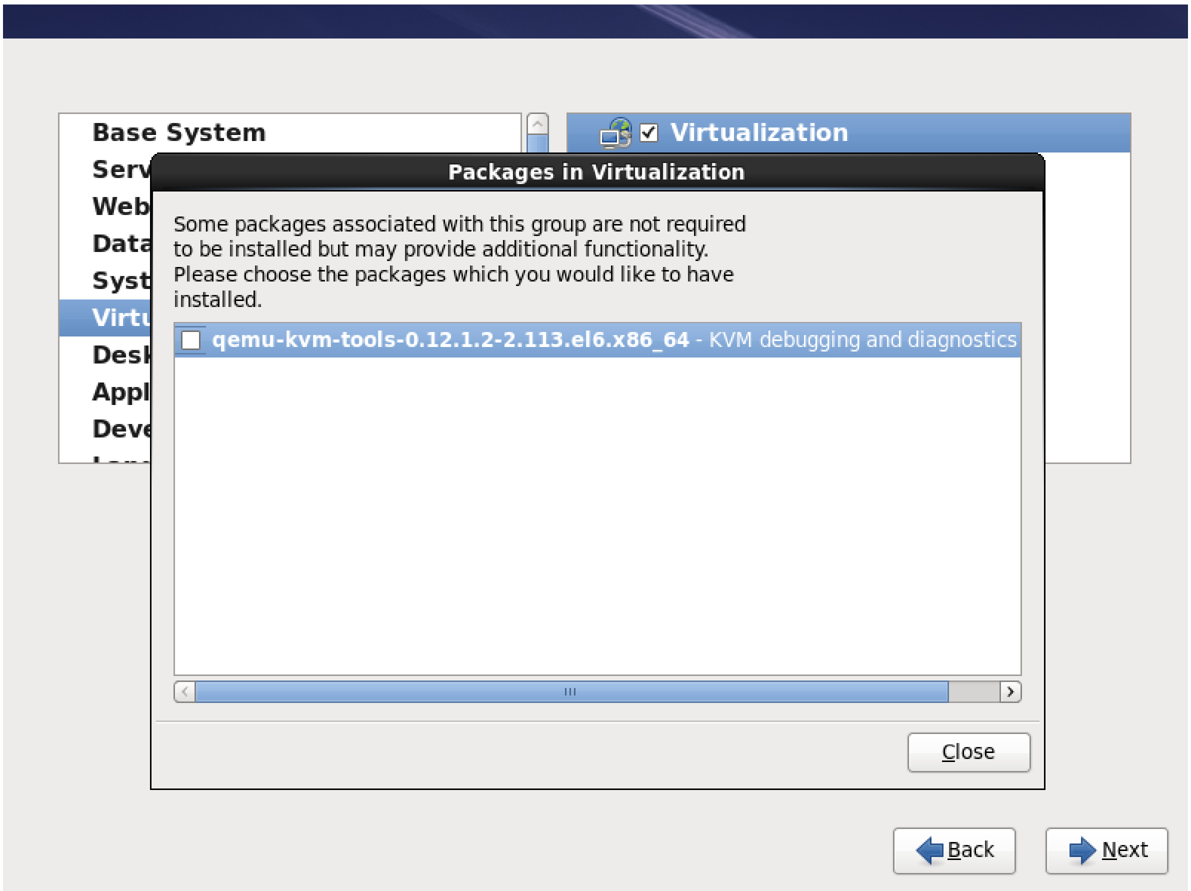


Select the **Virtual Host** server role to install a platform for virtualized guests. Alternatively, select the **Customize Now** radio button to specify individual packages.

4. Select the **Virtualization** package group. This selects the KVM hypervisor, **`virt-manager`**, **`libvirt`** and **`virt-viewer`** for installation.



5. **Customize the packages (if required)**
   Customize the **Virtualization** group if you require other virtualization packages.



Press the **Close** button then the **Next** button to continue the installation.

Note

You require a valid RHN virtualization entitlement to receive updates for the virtualization packages.

Installing KVM packages with Kickstart files

This section describes how to use a Kickstart file to install Red Hat Enterprise Linux with the KVM hypervisor packages. Kickstart files allow for large, automated installations without a user manually installing each individual system. The steps in this section will assist you in creating and using a Kickstart file to install Red Hat Enterprise Linux with the virtualization packages.

In the **%packages** section of your Kickstart file, append the following package group:

```
%packages
@kvm
```

More information on Kickstart files can be found on Red Hat's website, redhat.com[2], in the *Installation Guide*.

[2] http://www.redhat.com/docs/manuals/enterprise/

5.2. Installing KVM packages on an existing Red Hat Enterprise Linux system

The section describes the steps for installing the KVM hypervisor on a working Red Hat Enterprise Linux 6 or newer system.

Adding packages to your list of Red Hat Network entitlements

This section describes how to enable Red Hat Network (RHN) entitlements for the virtualization packages. You need these entitlements enabled to install and update the virtualization packages on Red Hat Enterprise Linux. You require a valid Red Hat Network account in order to install virtualization packages on Red Hat Enterprise Linux.

In addition, your machines must be registered with RHN. To register an unregistered installation of Red Hat Enterprise Linux, run the **`rhn_register`** command and follow the prompts.

If you do not have a valid Red Hat subscription, visit the *Red Hat online store*[3].

Procedure 5.1. Adding the Virtualization entitlement with RHN

1. Log in to *RHN*[4] using your RHN username and password.

2. Select the systems you want to install virtualization on.

3. In the **System Properties** section the present systems entitlements are listed next to the **Entitlements** header. Use the **(Edit These Properties)** link to change your entitlements.

4. Select the **Virtualization** checkbox.

Your system is now entitled to receive the virtualization packages. The next section covers installing these packages.

Installing the KVM hypervisor with `yum`

To use virtualization on Red Hat Enterprise Linux you require the **`kvm`** package. The **`kvm`** package contains the KVM kernel module providing the KVM hypervisor on the default Red Hat Enterprise Linux kernel.

To install the **`kvm`** package, run:

```
# yum install kvm
```

Now, install additional virtualization management packages.

Recommended virtualization packages:

python-virtinst
: Provides the **`virt-install`** command for creating virtual machines.

libvirt
: The *libvirt* package provides the server and host side libraries for interacting with hypervisors and host systems. The *libvirt* package provides the `libvirtd` daemon that handles the library calls, manages virtualizes guests and controls the hypervisor.

[3] https://www.redhat.com/wapps/store/catalog.html

libvirt-python
The *libvirt-python* package contains a module that permits applications written in the Python programming language to use the interface supplied by the *libvirt* API.

virt-manager
`virt-manager`, also known as **Virtual Machine Manager**, provides a graphical tool for administering virtual machines. It uses *libvirt-client* library as the management API.

libvirt-client
The *libvirt-client* package provides the client-side APIs and libraries for accessing *libvirt* servers. The *libvirt-client* package includes the **`virsh`** command line tool to manage and control virtualized guests and hypervisors from the command line or a special virtualization shell.

Install the other recommended virtualization packages:

```
# yum install virt-manager libvirt libvirt-python python-virtinst libvirt-client
```

Virtualized guest installation overview

After you have installed the virtualization packages on the host system you can create guest operating systems. This chapter describes the general processes for installing guest operating systems on virtual machines. You can create guests using the **New** button in **virt-manager** or use the command line interface **`virt-install`**. Both methods are covered by this chapter.

Detailed installation instructions are available for specific versions of Red Hat Enterprise Linux, other Linux distributions, and Windows. Refer to the relevant procedure for you guest operating system:

- Red Hat Enterprise Linux 5.
- Para-virtualized Red Hat Enterprise Linux 6 on Red Hat Enterprise Linux 5: *Chapter 8, Installing Red Hat Enterprise Linux 6 as a Xen para-virtualized guest on Red Hat Enterprise Linux 5*
- Red Hat Enterprise Linux 6: *Chapter 7, Installing Red Hat Enterprise Linux 6 as a fully virtualized guest on Red Hat Enterprise Linux 6*
- Microsoft Windows operating systems: *Chapter 9, Installing a fully-virtualized Windows guest*

6.1. Virtualized guest prerequisites and considerations

Various factors should be considered before creating any virtualized guests. Factors include:

- Performance
- I/O requirements and types of I/O.
- Storage.
- Networking and network infrastructure.
- Guest load and usage for processor and memory resources.

6.2. Creating guests with virt-install

You can use the **`virt-install`** command to create virtualized guests from the command line. **`virt-install`** is used either interactively or as part of a script to automate the creation of virtual machines. Using **`virt-install`** with Kickstart files allows for unattended installation of virtual machines.

The **`virt-install`** tool provides a number of options one can pass on the command line. To see a complete list of options run:

```
$ virt-install --help
```

The **`virt-install`** man page also documents each command option and important variables.

`qemu-img` is a related command which may be used before **`virt-install`** to configure storage options.

An important option is the `--`*vnc* option which opens a graphical window for the guest's installation.

Example 6.1. Using virt-install to install a RHEL 5 guest

This example creates a RHEL 5 guest:

```
virt-install \
   --name=guest1-rhel5-64 \
   --disk path=/var/lib/libvirt/images/guest1-rhel5-64,size=8 \
   --nonsparse --vnc \
   --vcpus=2 --ram=2048 \
   --location=http://example1.com/installation_tree/RHEL5.6-Server-x86_64/os \
   --network bridge=br0 \
   --os-type=linux \
   --os-variant=rhel5.4
```

Note

When installing a Windows guest with **`virt-install`**, the **`--os-type=windows`** option is recommended. This option prevents the CD-ROM from disconnecting when rebooting during the installation procedure. The **`--os-variant`** option further optimizes the configuration for a specific guest operating system.

Refer to **`man virt-install`** for more examples.

6.3. Creating guests with virt-manager

`virt-manager`, also known as Virtual Machine Manager, is a graphical tool for creating and managing virtualized guests.

Procedure 6.1. Creating a virtualized guest with **virt-manager**

1. **Open virt-manager**
   Start **`virt-manager`**. Launch the **Virtual Machine Manager** application from the **Applications** menu and **System Tools** submenu. Alternatively, run the **`virt-manager`** command as root.

2. **Optional: Open a remote hypervisor**
   Refer to *Section 31.5, "Adding a remote connection"*

   Select the hypervisor and press the **Connect** button to connect to the remote hypervisor.

3. **Create a new guest**
   The **virt-manager** window allows you to create a new virtual machine. Click the **Create a new virtual machine** button (*Figure 6.1, "Virtual Machine Manager window"*) to open the **New VM** wizard.

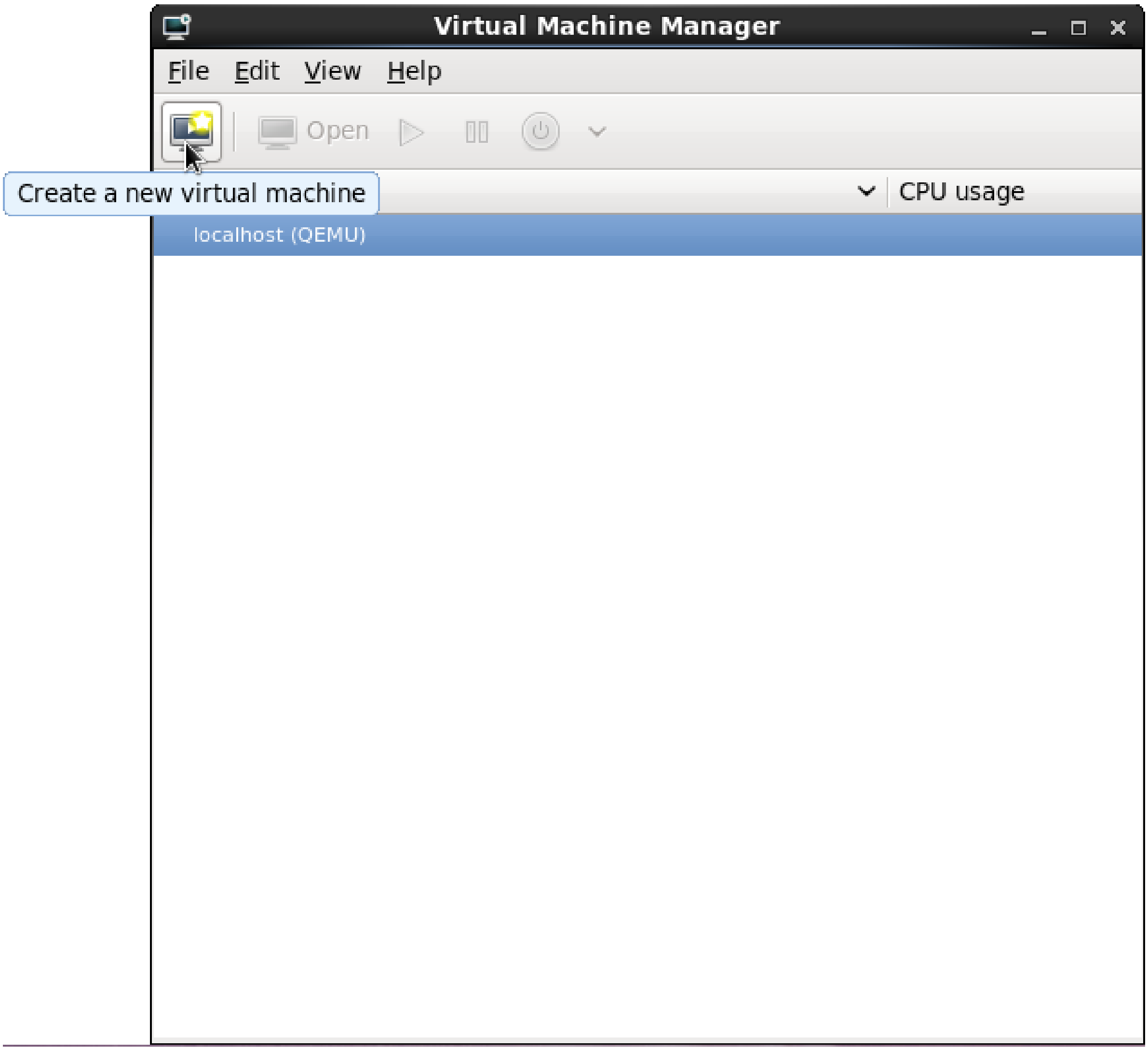


Figure 6.1. Virtual Machine Manager window

4. **New VM wizard**
   The **New VM** wizard breaks down the guest creation process into five steps:

   1. Naming the guest and choosing the installation type
   2. Locating and configuring the installation media
   3. Configuring memory and CPU options
   4. Configuring the guest's storage
   5. Configuring networking, hypervisor type, architecture, and other hardware settings

   Ensure that **`virt-manager`** can access the installation media (whether locally or over the network).

5. **Specify name and installation type**
   The guest creation process starts with the selection of a name and installation type. Virtual machine names can have underscores (_), periods (`.`), and hyphens (`-`).

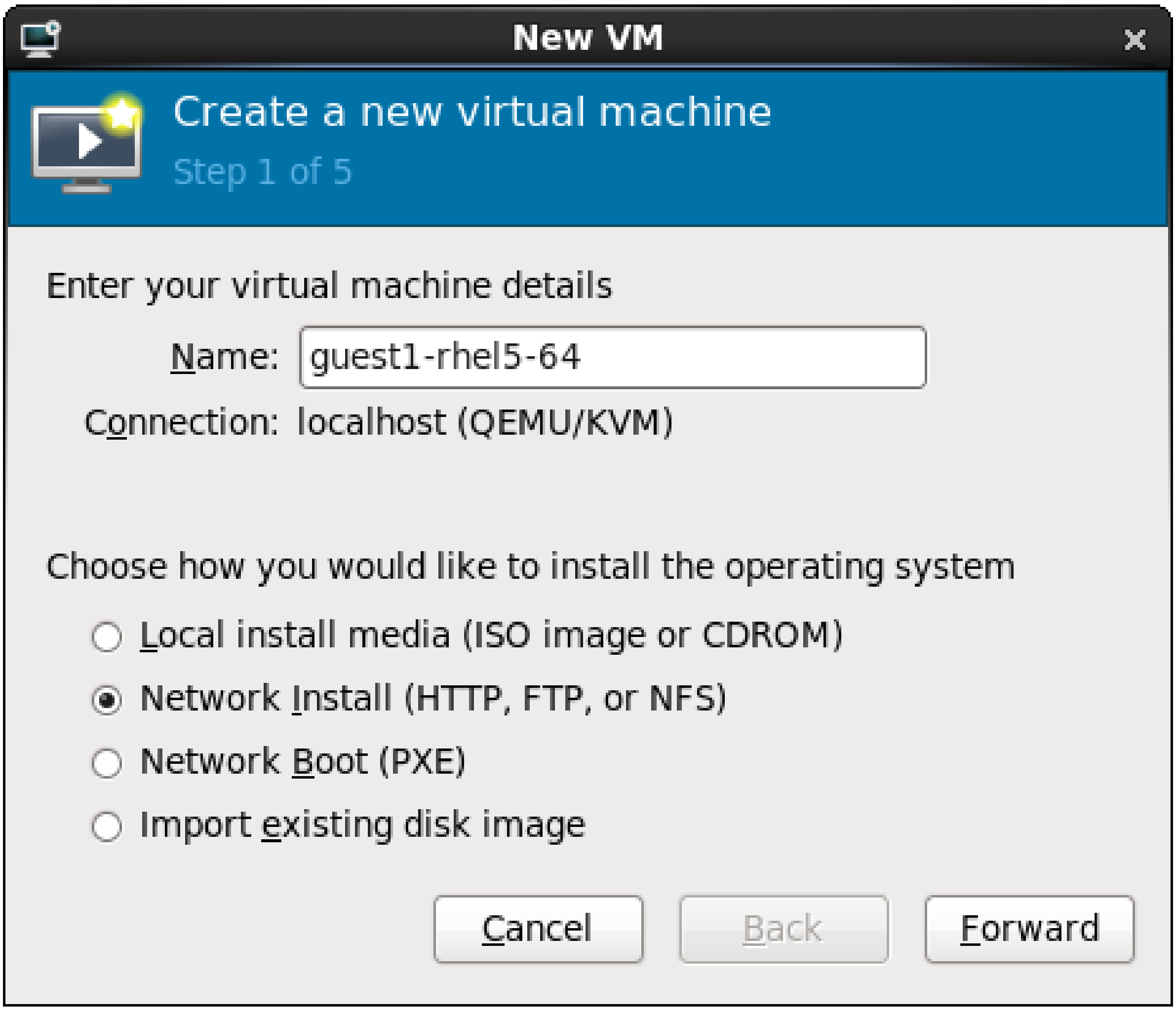


Figure 6.2. Step 1

Type in a virtual machine name and choose an installation type:

Local install media (ISO image or CDROM)
: This method uses a CD-ROM, DVD, or image of an installation disk (e.g. `.iso`).

Network Install (HTTP, FTP, or NFS)
: Network installing involves the use of a mirrored Red Hat Enterprise Linux or Fedora installation tree to install a guest. The installation tree must be accessible through either HTTP, FTP, or NFS.

Network Boot (PXE)
: This method uses a Preboot eXecution Environment (PXE) server to install the guest. Setting up a PXE server is covered in the *Deployment Guide*. To install via network boot, the guest must have a routable IP address or shared network device. For information on the required networking configuration for PXE installation, refer to *Chapter 10, Network Configuration*.

Import existing disk image
: This method allows you to create a new guest and import a disk image (containing a pre-installed, bootable operating system) to it.

Click **Forward** to continue.

6. **Configure installation**
   Next, configure the **OS type** and **Version** of the installation. Depending on the method of installation, provide the install URL or existing storage path.

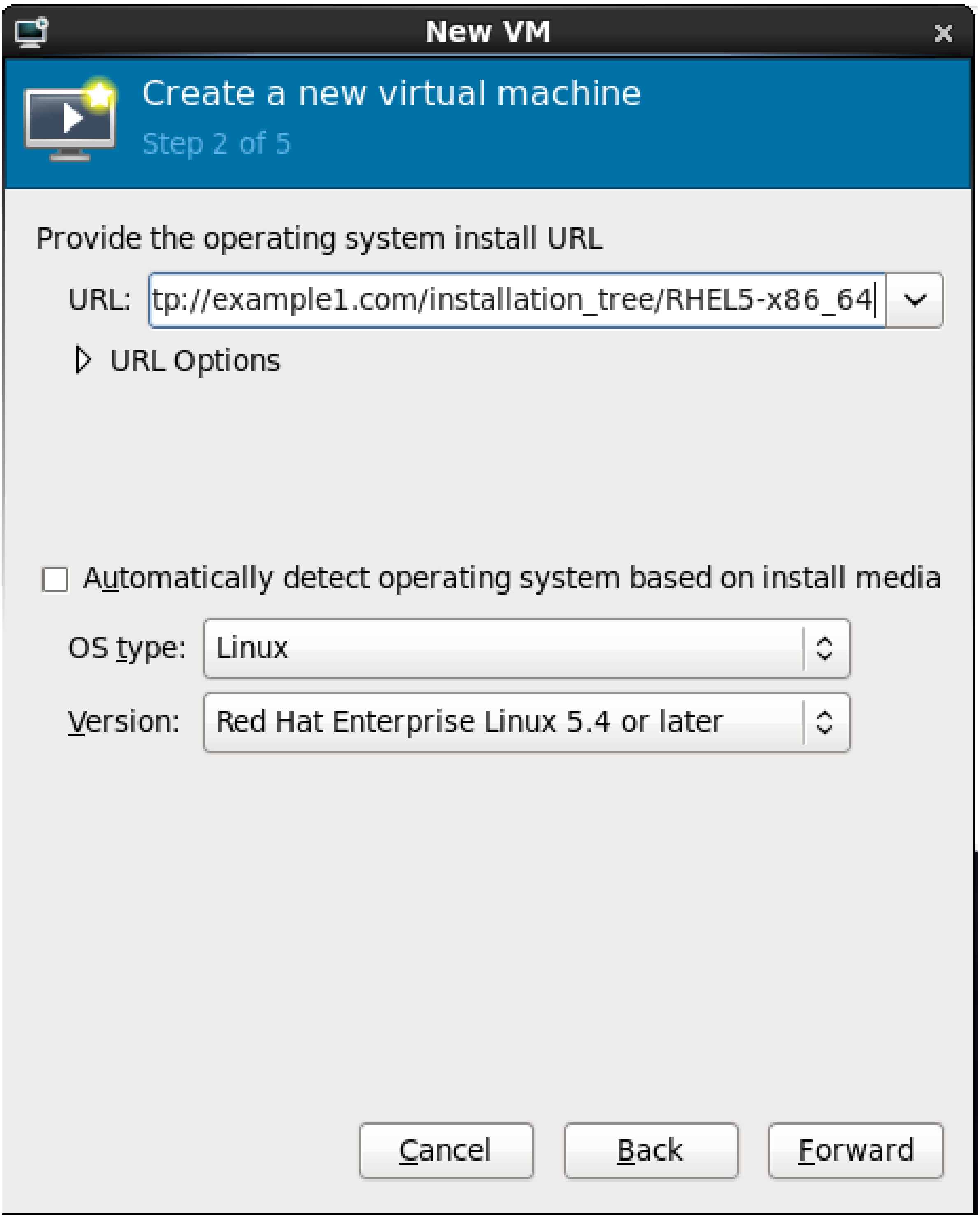


Figure 6.3. Local install media (configuration)

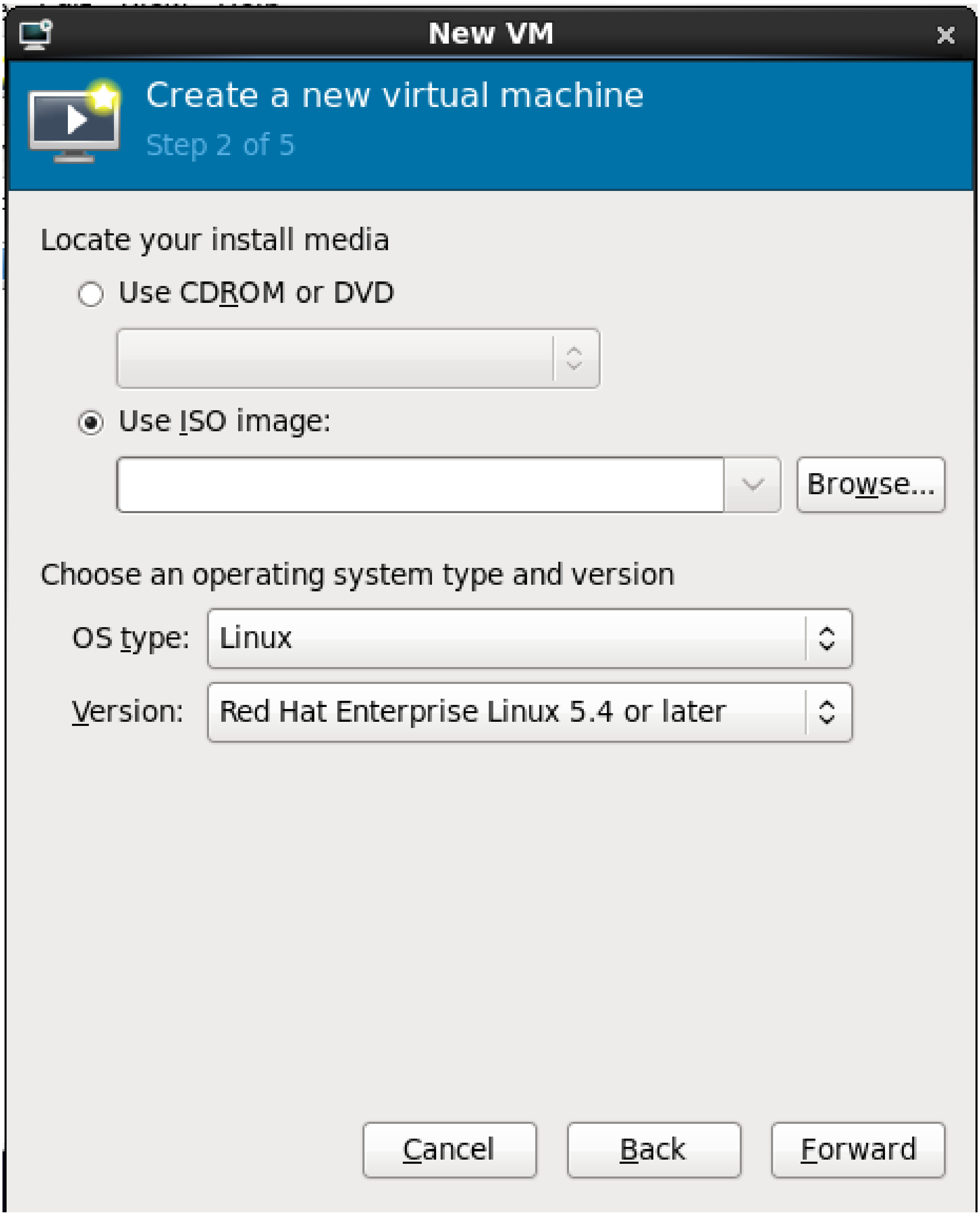


Figure 6.4. Import existing disk image (configuration)

7. **Configure CPU and memory**
   The next step involves configuring the number of CPUs and amount of memory to allocate to the virtual machine. The wizard shows the number of CPUs and amount of memory you can allocate; configure these settings and click **Forward**.

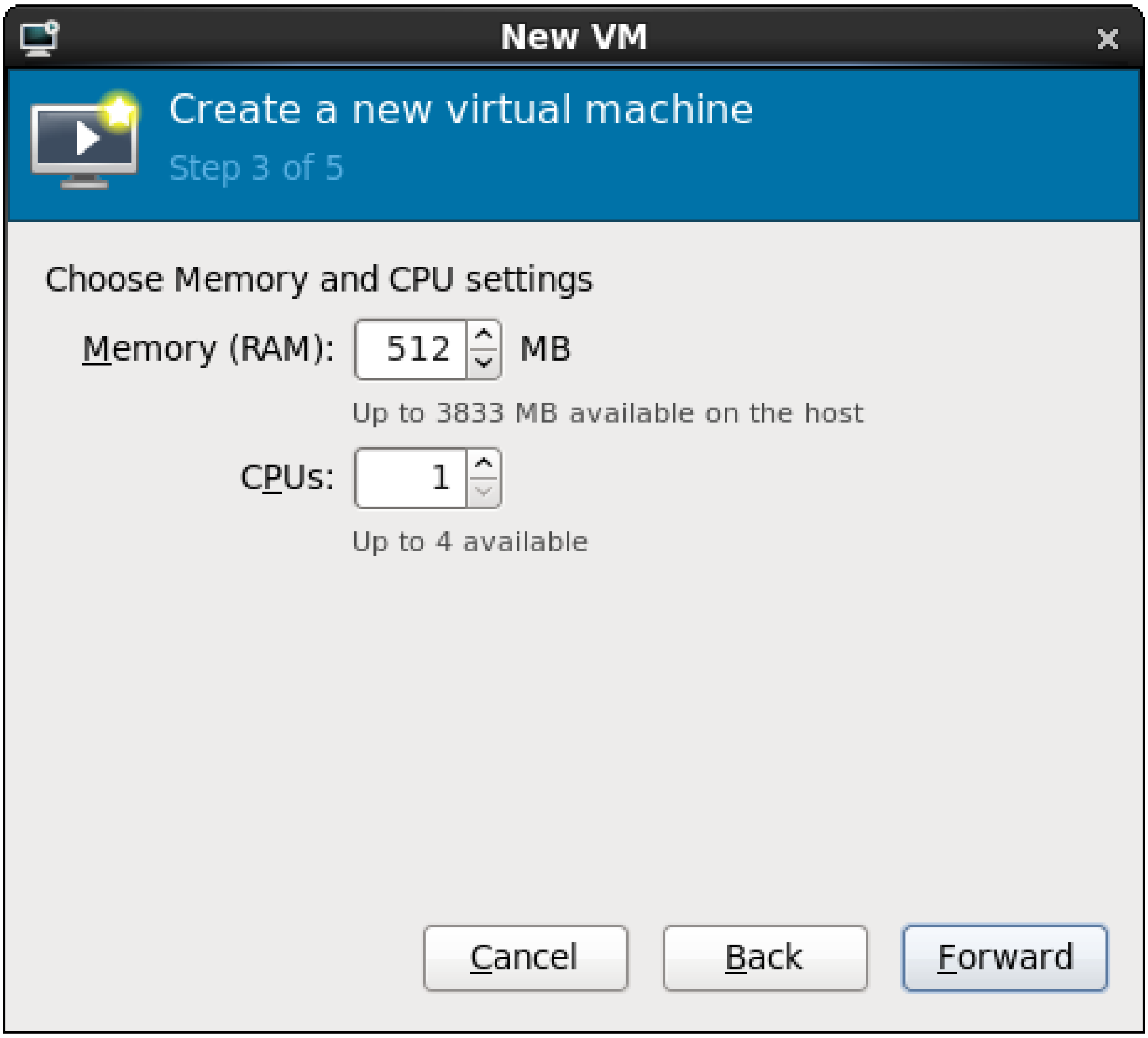


Figure 6.5. Configuring CPU and Memory

8. **Configure storage**
   Assign storage to the guest.

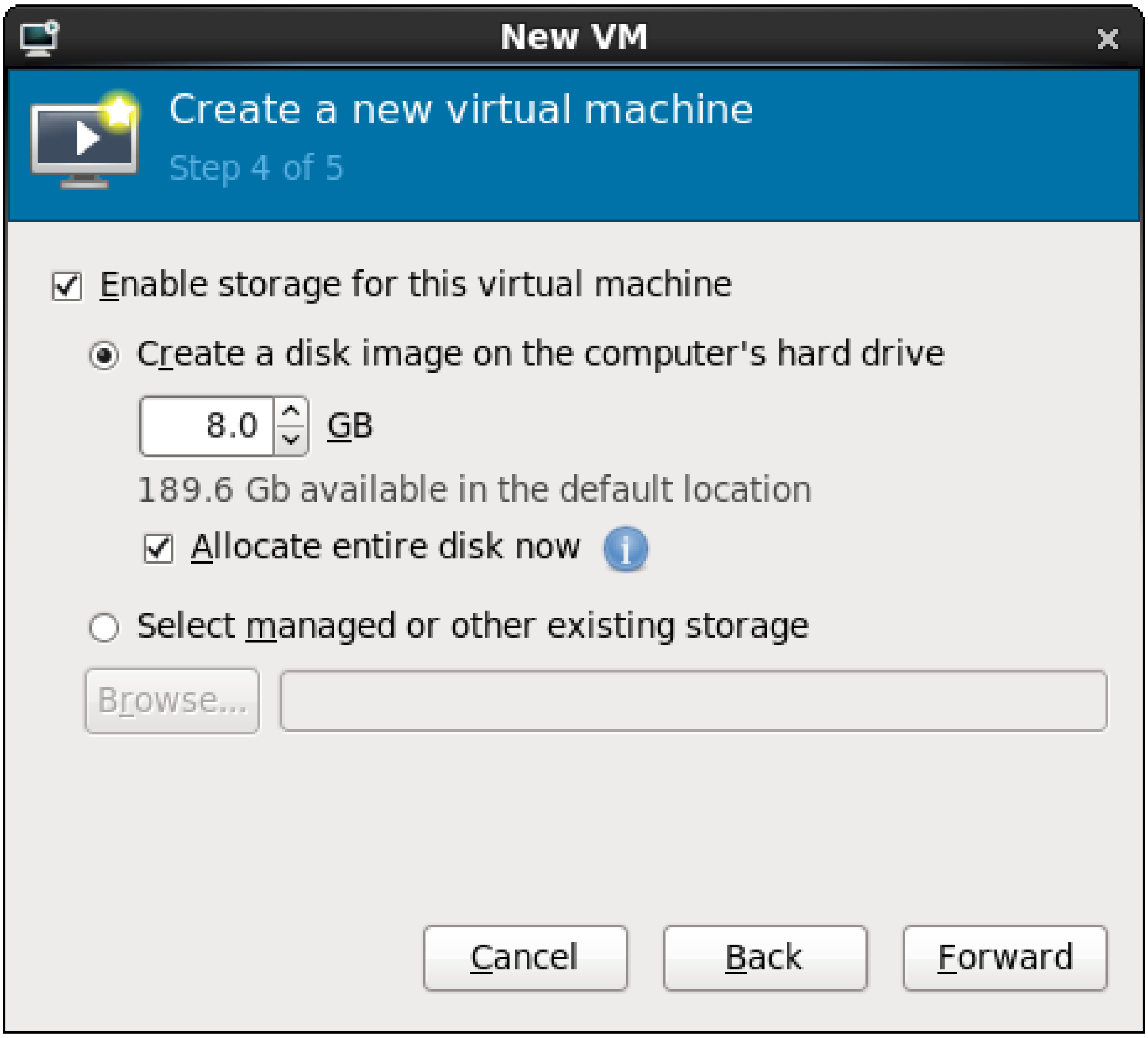


Figure 6.6. Configuring virtual storage

If you chose to import an existing disk image during the first step, **`virt-manager`** will skip this step.

Assign sufficient space for your virtualized guest and any applications the guest requires, then click **Forward** to continue.

9. **Final configuration**
Verify the settings of the virtual machine and click **Finish** when you are satisfied; doing so will create the guest with default networking settings, virtualization type, and architecture.

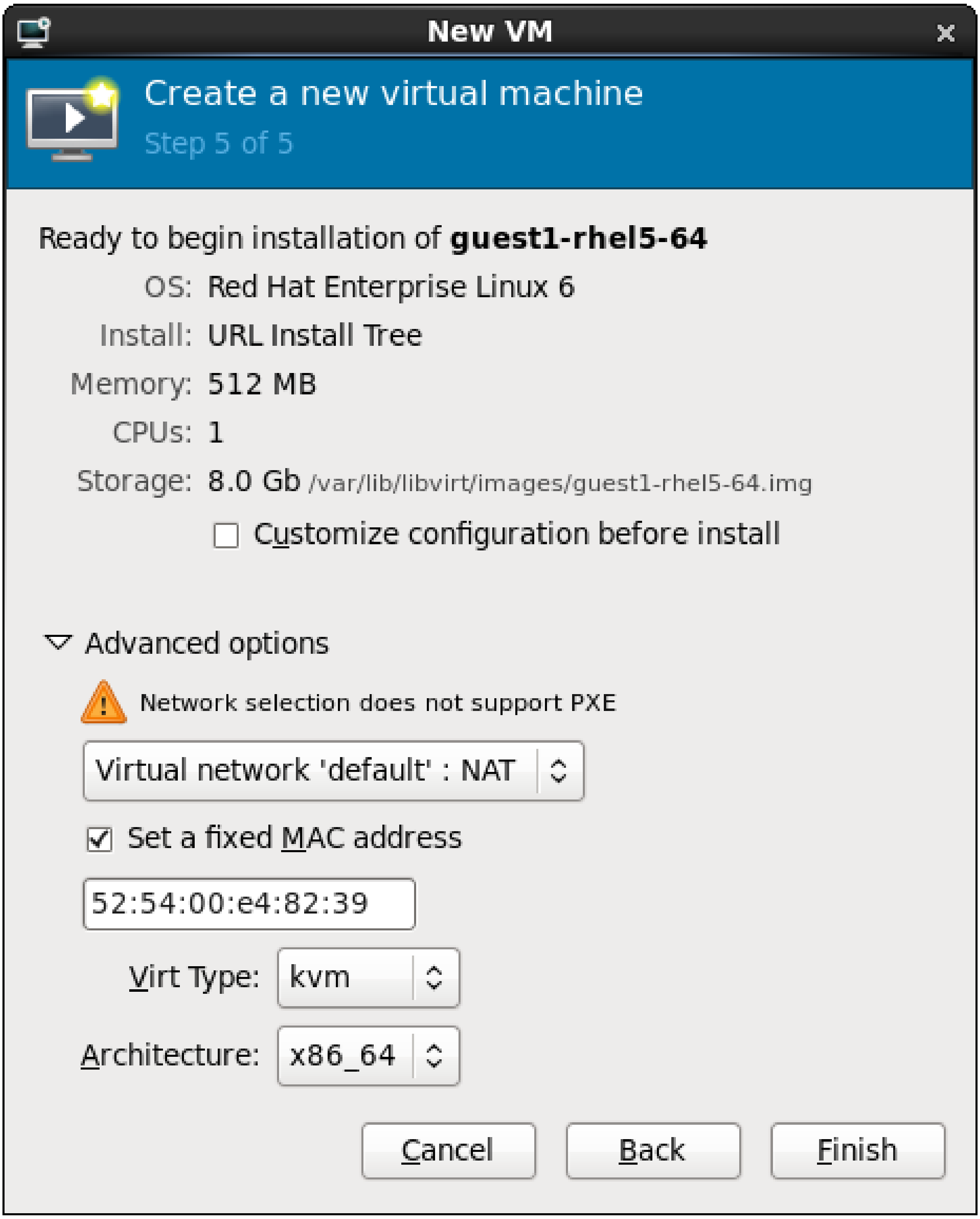


Figure 6.7. Verifying the configuration

If you prefer to further configure the virtual machine's hardware first, check the **Customize configuration before install** box first before clicking **Finish**. Doing so will open another wizard *Figure 6.8, "Virtual hardware configuration"* that will allow you to add, remove, and configure the virtual machine's hardware settings.

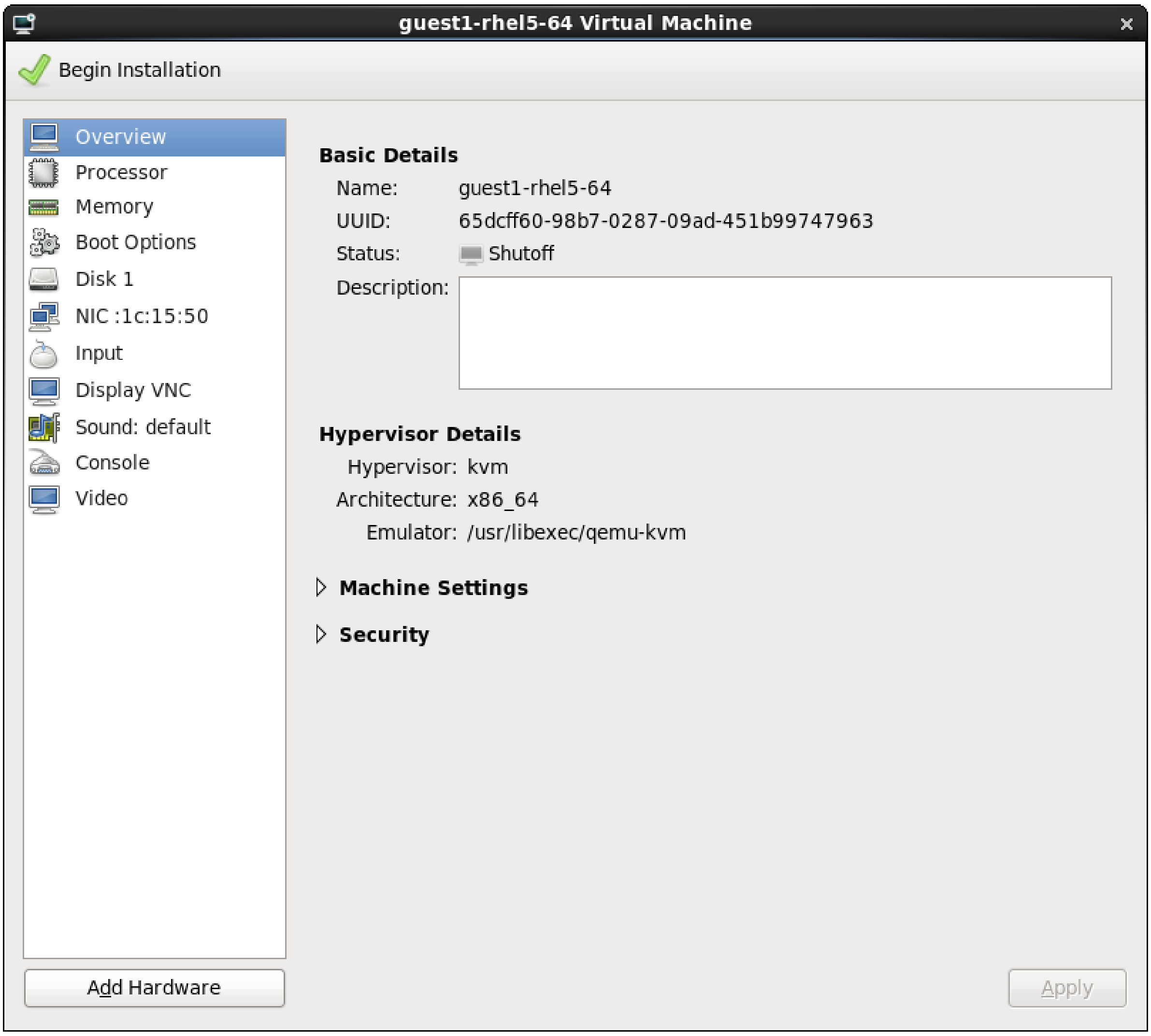


Figure 6.8. Virtual hardware configuration

After configuring the virtual machine's hardware, click **Apply**. **`virt-manager`** will then create the guest with your specified hardware settings.

This concludes the general process for creating guests with **`virt-manager`**. *Chapter 6, Virtualized guest installation overview* contains step-by-step instructions to installing a variety of common operating systems.

6.4. Installing guests with PXE

This section covers the steps required to install guests with PXE. PXE guest installation requires a shared network device, also known as a network bridge. The procedures below covers creating a bridge and the steps required to utilize the bridge for PXE installation.

1. **Create a new bridge**

   a. Create a new network script file in the **`/etc/sysconfig/network-scripts/`** directory. This example creates a file named **`ifcfg-installation`** which makes a bridge named *`installation`*.

   ```
   # cd /etc/sysconfig/network-scripts/
   # vim ifcfg-installation
   DEVICE=installation
   ```

```
TYPE=Bridge
BOOTPROTO=dhcp
ONBOOT=yes
```

Warning

The line, *TYPE=Bridge*, is case-sensitive. It must have uppercase 'B' and lower case 'ridge'.

b. Start the new bridge by restarting the network service. The **ifup installation** command can start the individual bridge but it is safer to test the entire network restarts properly.

```
# service network restart
```

c. There are no interfaces added to the new bridge yet. Use the **brctl show** command to view details about network bridges on the system.

```
# brctl show
bridge name     bridge id               STP enabled     interfaces
installation    8000.000000000000       no
virbr0          8000.000000000000       yes
```

The **virbr0** bridge is the default bridge used by **libvirt** for Network Address Translation (NAT) on the default Ethernet device.

2. **Add an interface to the new bridge**
Edit the configuration file for the interface. Add the **BRIDGE** parameter to the configuration file with the name of the bridge created in the previous steps.

```
# Intel Corporation Gigabit Network Connection
DEVICE=eth1
BRIDGE=installation
BOOTPROTO=dhcp
HWADDR=00:13:20:F7:6E:8E
ONBOOT=yes
```

After editing the configuration file, restart networking or reboot.

```
# service network restart
```

Verify the interface is attached with the **brctl show** command:

```
# brctl show
bridge name     bridge id               STP enabled     interfaces
installation    8000.001320f76e8e       no              eth1
virbr0          8000.000000000000       yes
```

3. **Security configuration**
Configure **iptables** to allow all traffic to be forwarded across the bridge.

```
# iptables -I FORWARD -m physdev --physdev-is-bridged -j ACCEPT
# service iptables save
```

```
# service iptables restart
```

> **Disable iptables on bridges**
>
> Alternatively, prevent bridged traffic from being processed by **`iptables`** rules. In **`/etc/sysctl.conf`** append the following lines:
>
> ```
> net.bridge.bridge-nf-call-ip6tables = 0
> net.bridge.bridge-nf-call-iptables = 0
> net.bridge.bridge-nf-call-arptables = 0
> ```
>
> Reload the kernel parameters configured with **`sysctl`**.
>
> ```
> # sysctl -p /etc/sysctl.conf
> ```

4. **Restart libvirt before the installation**
   Restart the **`libvirt`** daemon.

   ```
   # service libvirtd reload
   ```

The bridge is configured, you can now begin an installation.

PXE installation with virt-install

For **`virt-install`** append the **`--network=bridge:installation`** installation parameter where *`installation`* is the name of your bridge. For PXE installations use the `--pxe` parameter.

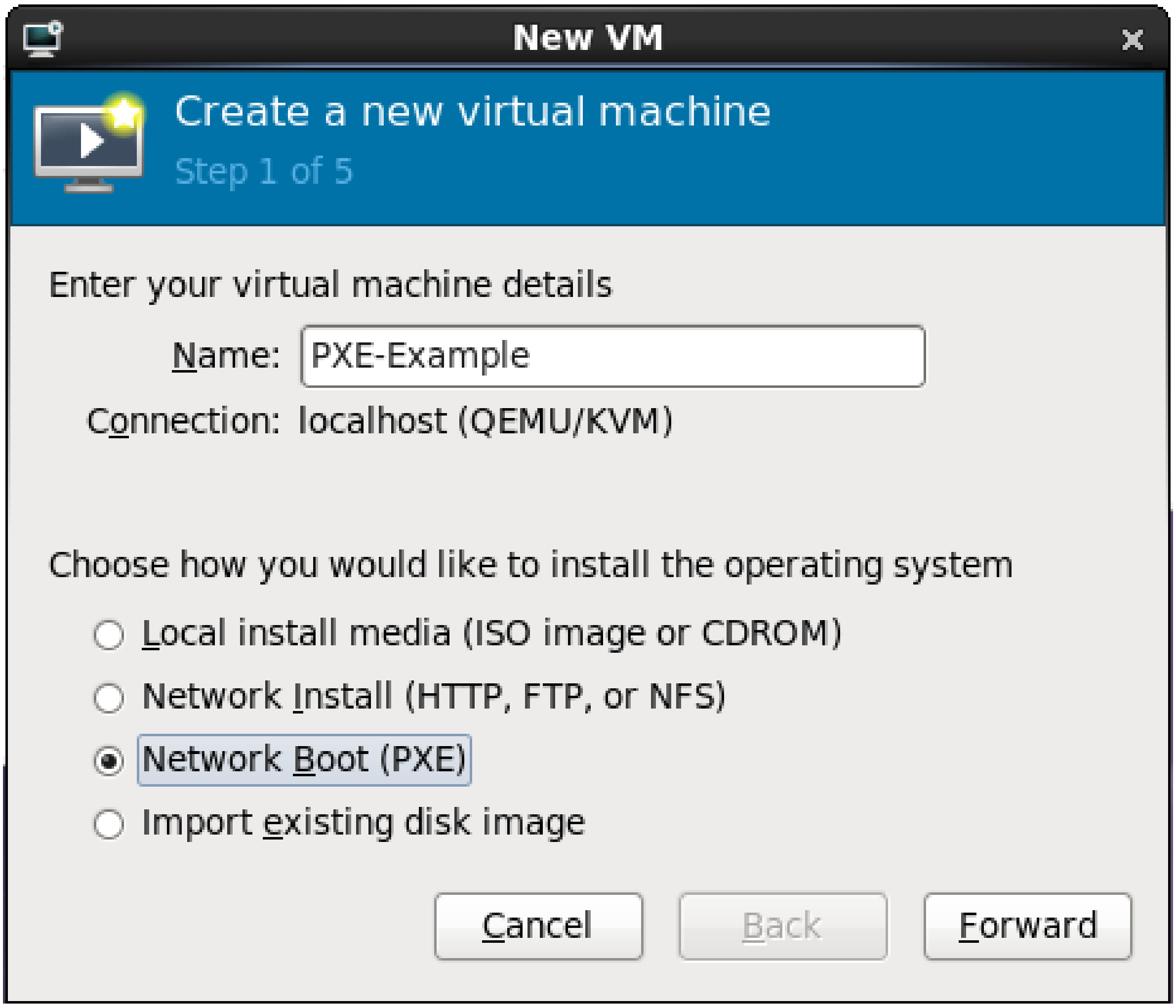
Example 6.2. PXE installation with virt-install

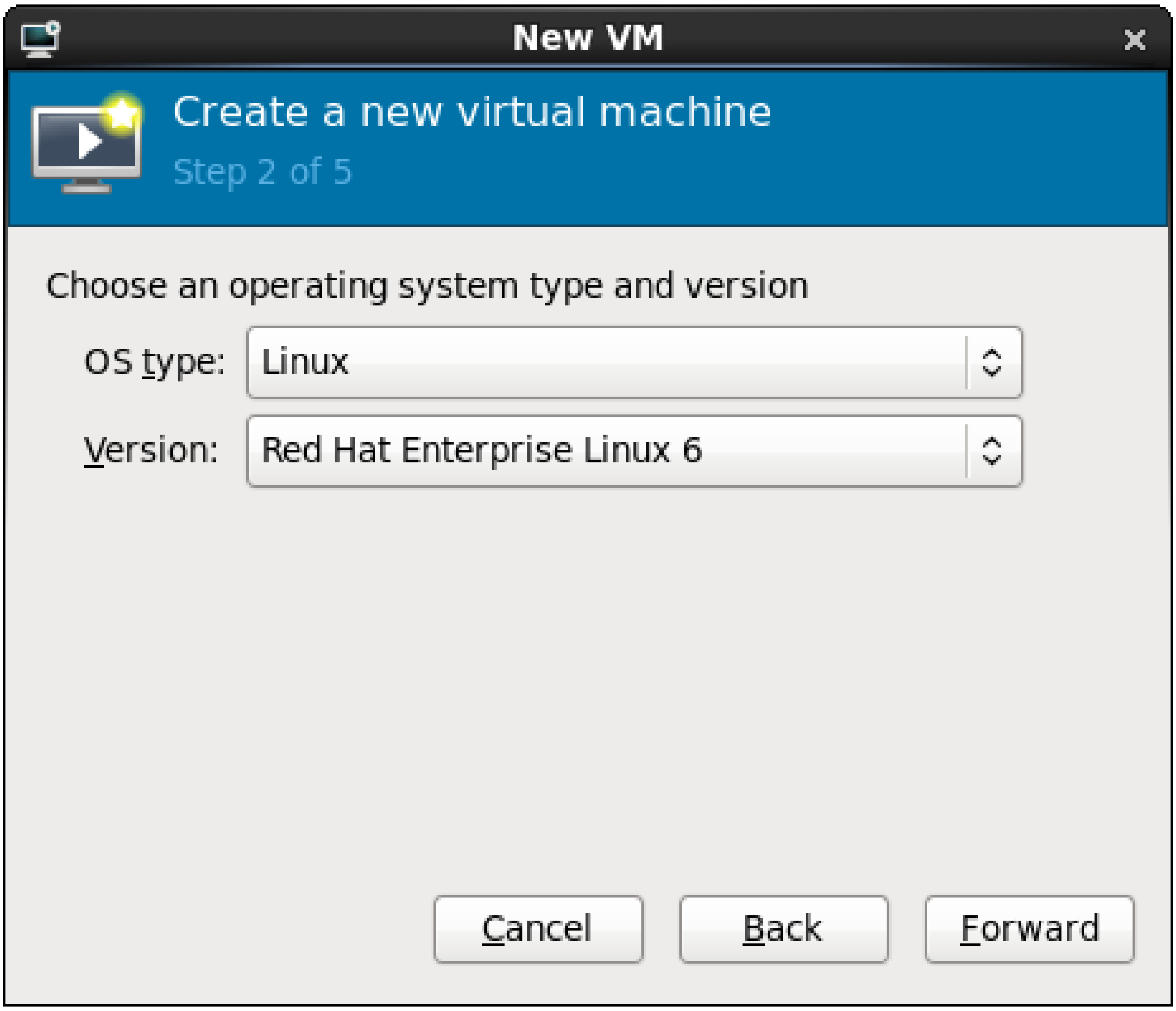
```
# virt-install --hvm --connect qemu:///system \
    --network=bridge:installation --pxe\
    --name EL10 --ram=756 \
    --vcpus=4
    --os-type=linux --os-variant=rhel5
    --file=/var/lib/libvirt/images/EL10.img \
```

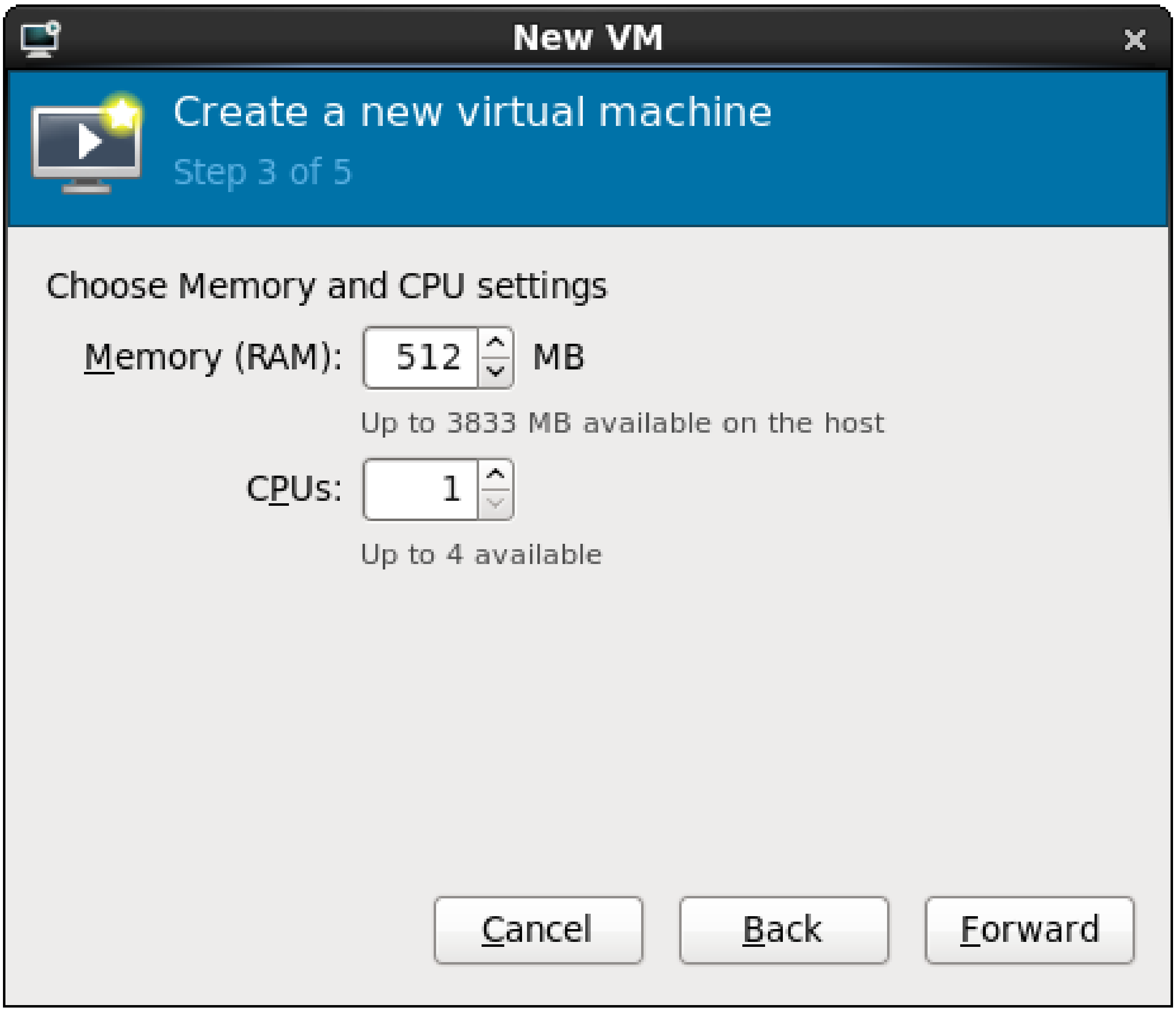
PXE installation with virt-manager

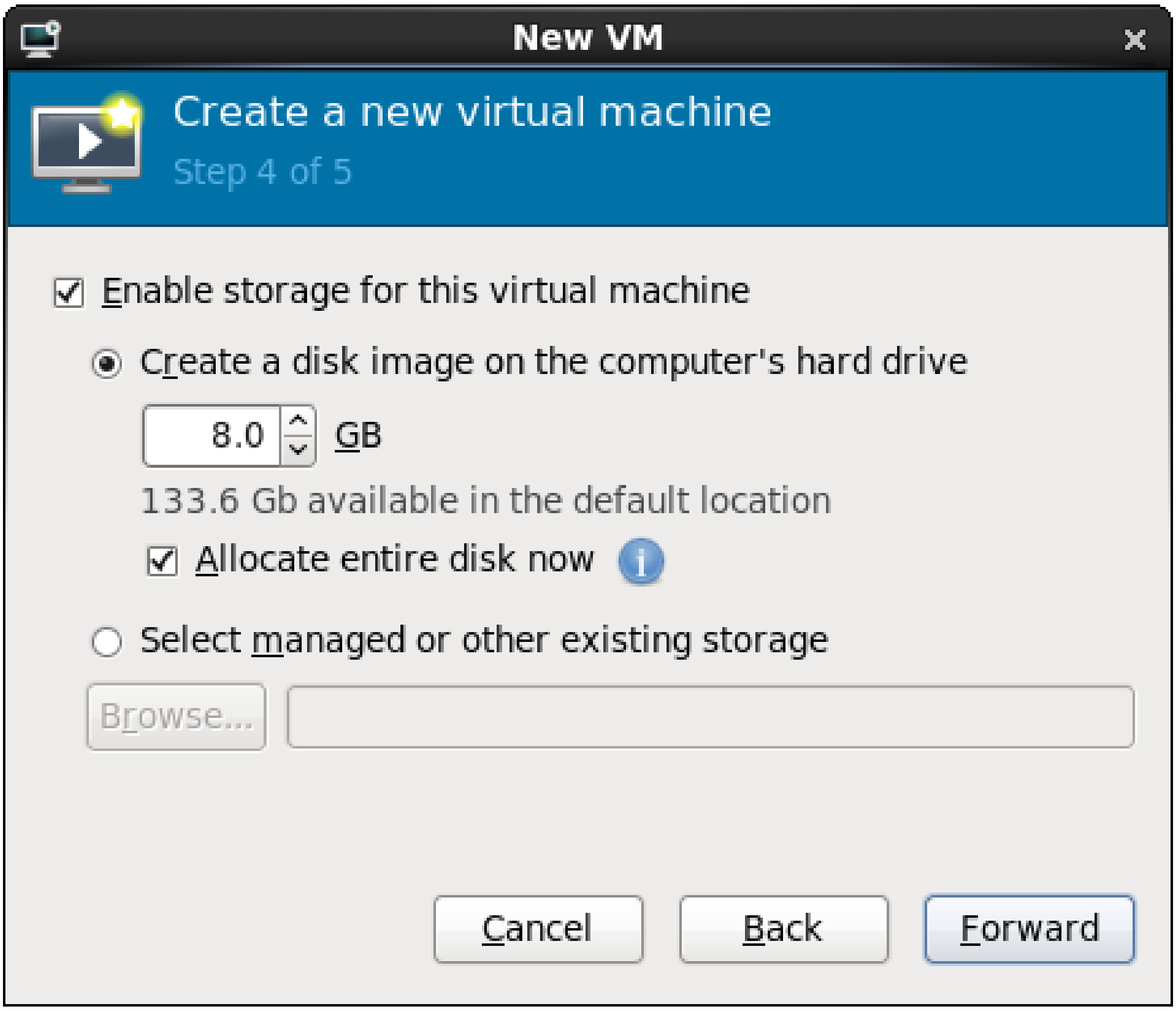
The steps below are the steps that vary from the standard **`virt-manager`** installation procedures.

1. **Select PXE**
   Select PXE as the installation method and follow the rest of the steps to configure the OS type, memory, CPU and storage settings.

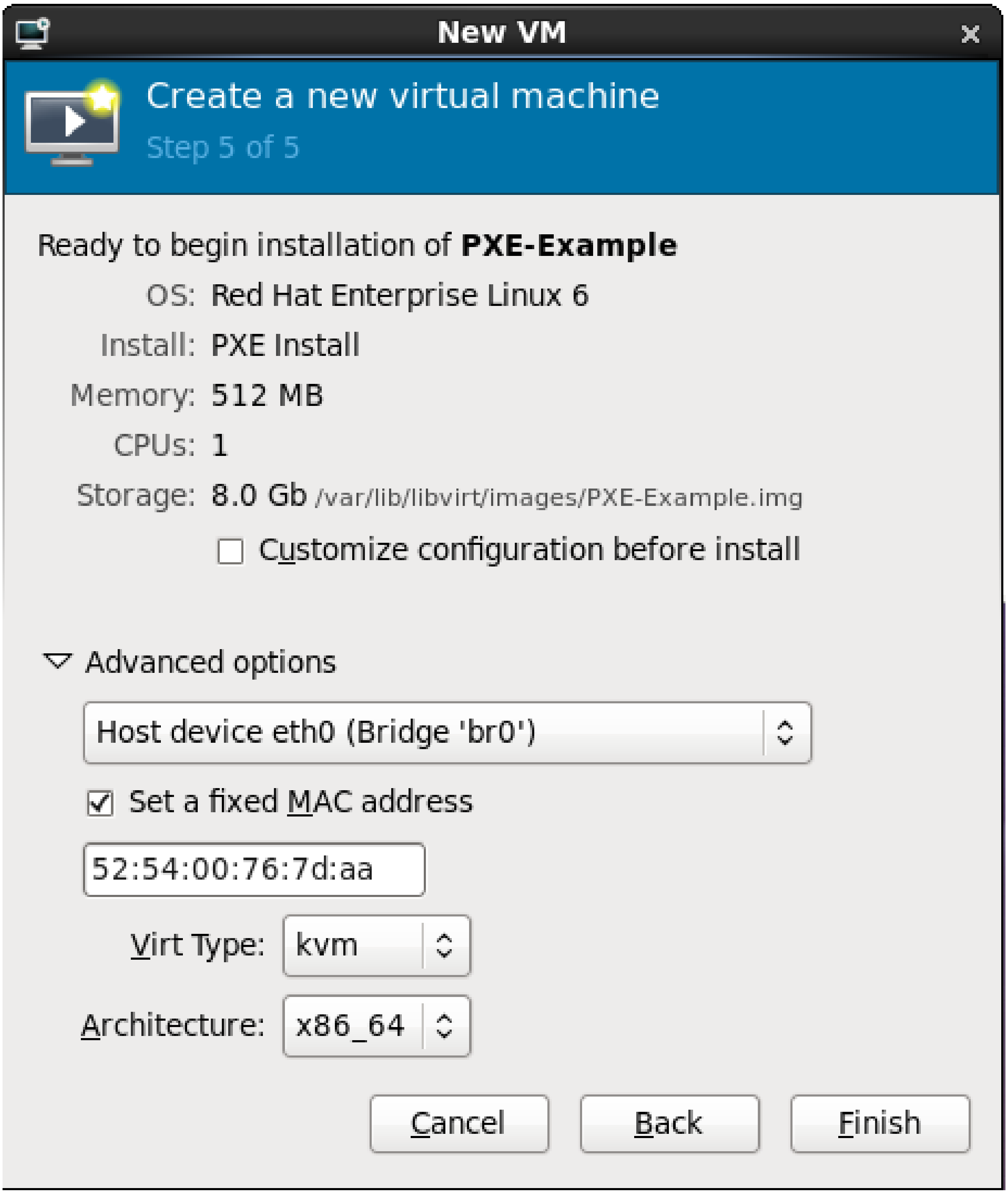

New VM
Create a new virtual machine
Step 1 of 5
Enter your virtual machine details
Name: PXE-Example
Connection: localhost (QEMU/KVM)
Choose how you would like to install the operating system
Local install media (ISO image or CDROM)
Network Install (HTTP, FTP, or NFS)
Network Boot (PXE)
Import existing disk image
Cancel
Back
Forward


New VM
Create a new virtual machine
Step 2 of 5
Choose an operating system type and version
OS type:
Linux
Version:
Red Hat Enterprise Linux 6
Cancel
Back
Forward


New VM
Create a new virtual machine
Step 3 of 5
Choose Memory and CPU settings
Memory (RAM): 512 MB
Up to 3833 MB available on the host
CPUs: 1
Up to 4 available
Cancel
Back
Forward



2. **Start the installation**
   The installation is ready to start.



A DHCP request is sent and if a valid PXE server is found the guest installation processes will start.

Installing Red Hat Enterprise Linux 6 as a fully virtualized guest on Red Hat Enterprise Linux 6

This Chapter covers how to install Red Hat Enterprise Linux 6 as a fully virtualized guest on Red Hat Enterprise Linux 6.

This procedure assumes that the KVM hypervisor and all other required packages are installed and the host is configured for virtualization. For more information on installing the virtualization pacakges, refer to *Chapter 5, Installing the virtualization packages*.

7.1. Creating a Red Hat Enterprise Linux 6 guest with local installation media

This procedure covers creating a virtualized Red Hat Enterprise Linux 6 guest with a locally stored installation DVD or DVD image. DVD images are available from *rhn.redhat.com*[1] for Red Hat Enterprise Linux 6.

Procedure 7.1. Creating a Red Hat Enterprise Linux 6 guest with virt-manager

1. **Optional: Preparation**
   Prepare the storage environment for the virtualized guest. For more information on preparing storage, refer to *Part V, "Virtualization storage topics"*.

   Note

   Various storage types may be used for storing virtualized guests. However, for a guest to be able to use migration features the guest must be created on networked storage.

   Red Hat Enterprise Linux 6 requires at least 1GB of storage space. However, Red Hat recommends at least 5GB of storage space for a Red Hat Enterprise Linux 6 installation and for the procedures in this guide.

2. **Open virt-manager and start the wizard**
   Open virt-manager by executing the virt-manager command as root or opening **Applications** -> **System Tools** -> **Virtual Machine Manager**.

[1] http://www.rhn.redhat.com

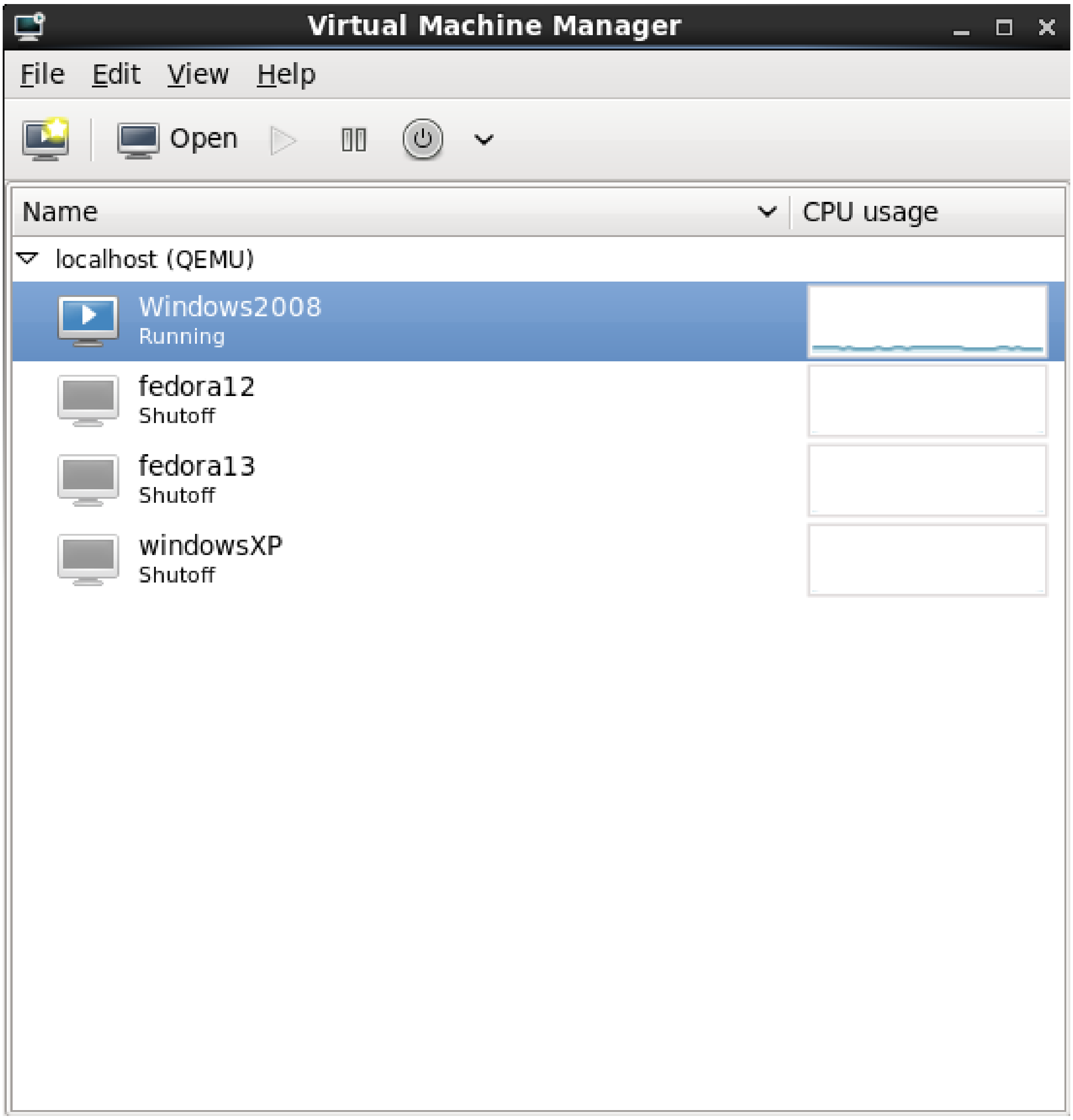


Figure 7.1. The main virt-manager window

Press the **create new virtualized guest button** (see figure *Figure 7.2, “The create new virtualized guest button”*) to start the new virtualized guest wizard.

Figure 7.2. The create new virtualized guest button

The **Create a new virtual machine** window opens.

3. **Name the virtualized guest**
   Guest names can contain letters, numbers and the following characters: '_', '**.**' and '**-**'. Guest names must be unique for migration.

   Choose the **Local install media (ISO image or CDROM)** radio button.

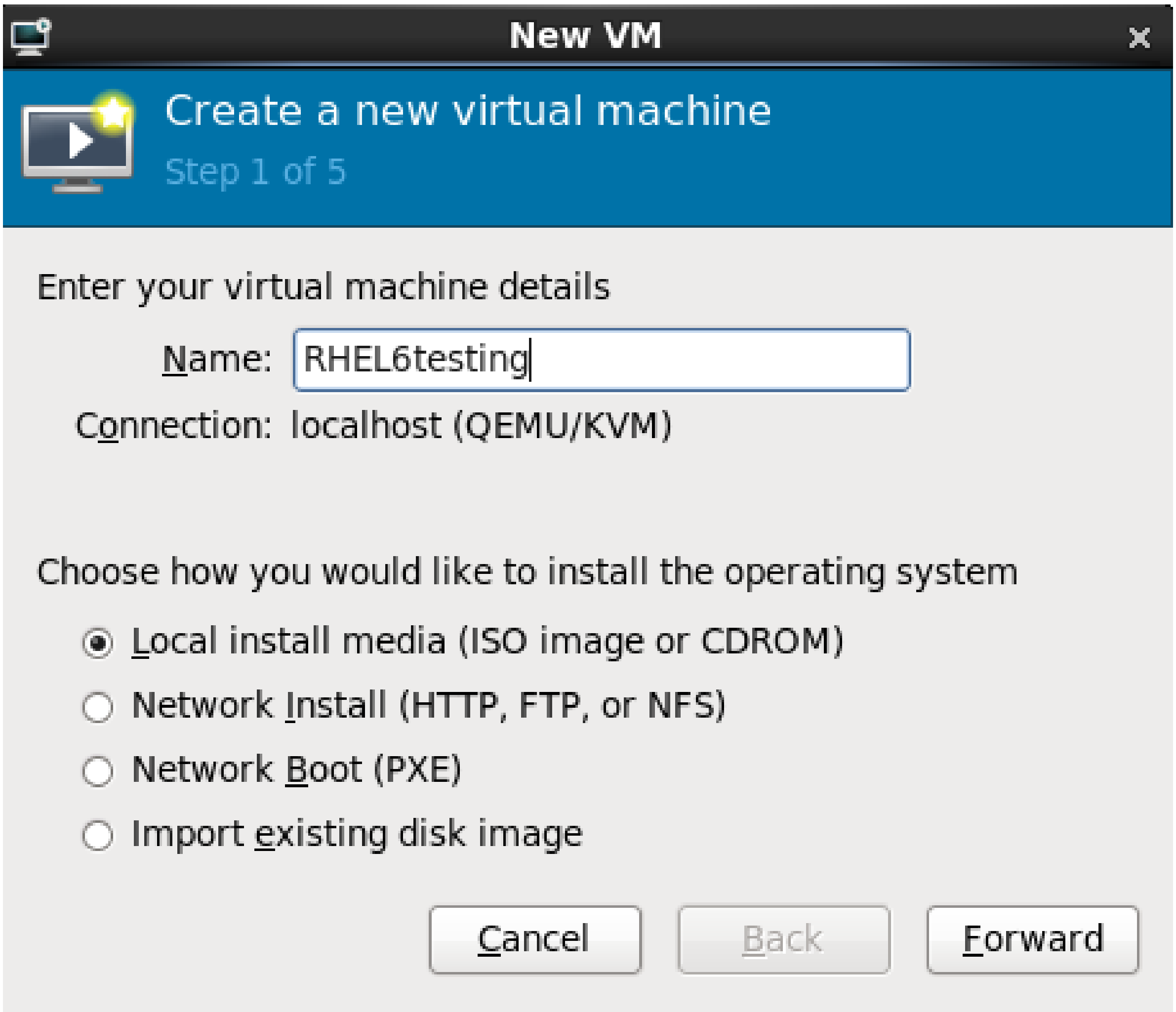


Figure 7.3. The Create a new virtual machine window - Step 1

Press **Forward** to continue.

4. **Select the installation media**
   Select the installation ISO image location or a DVD drive with the installation disc inside. This example uses an ISO file image of the Red Hat Enterprise Linux 6.0 installation DVD image.

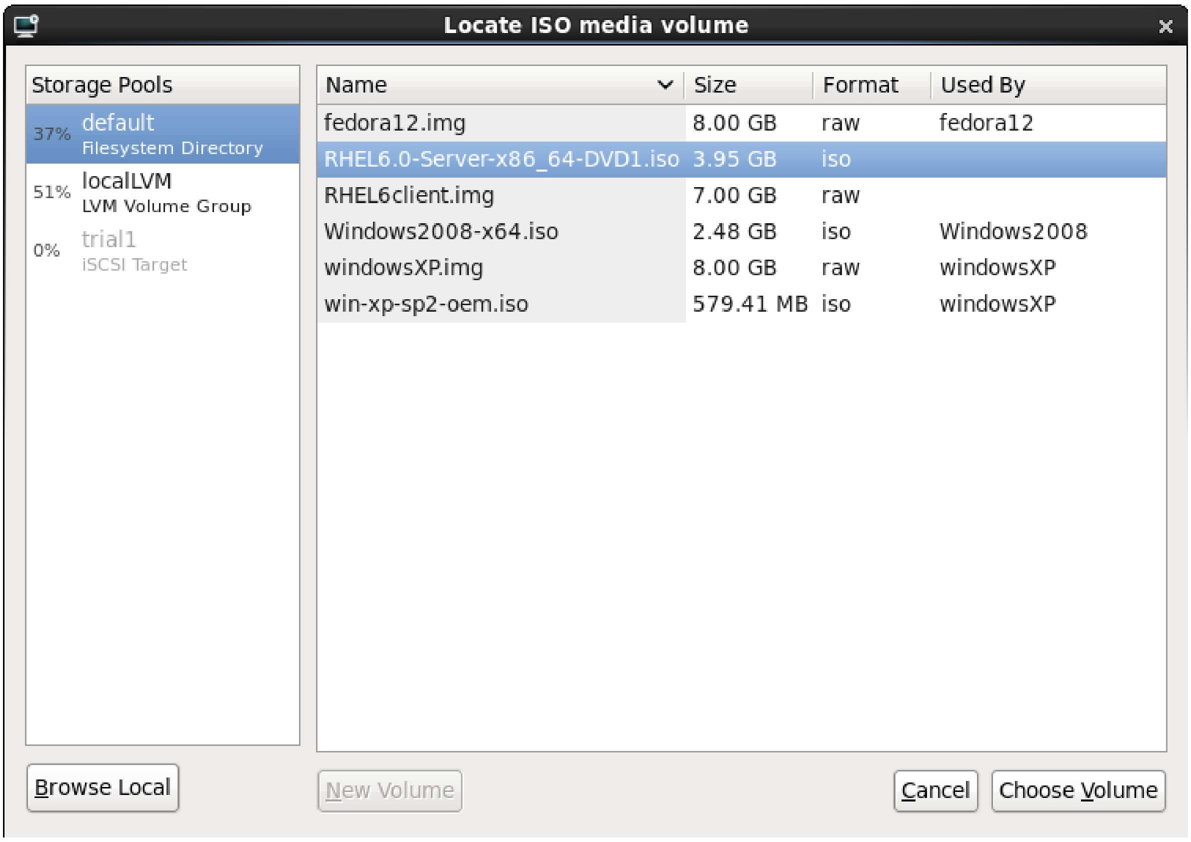


Figure 7.4. The Locate ISO media volume window

Image files and SELinux

For ISO image files and guest storage images, the recommended directory to use is the **`/var/lib/libvirt/images/`** directory. Any other location may require additional configuration for SELinux, refer to *Section 16.2, “SELinux and virtualization”* for details.

Select the operating system type and version which match the installation media you have selected.

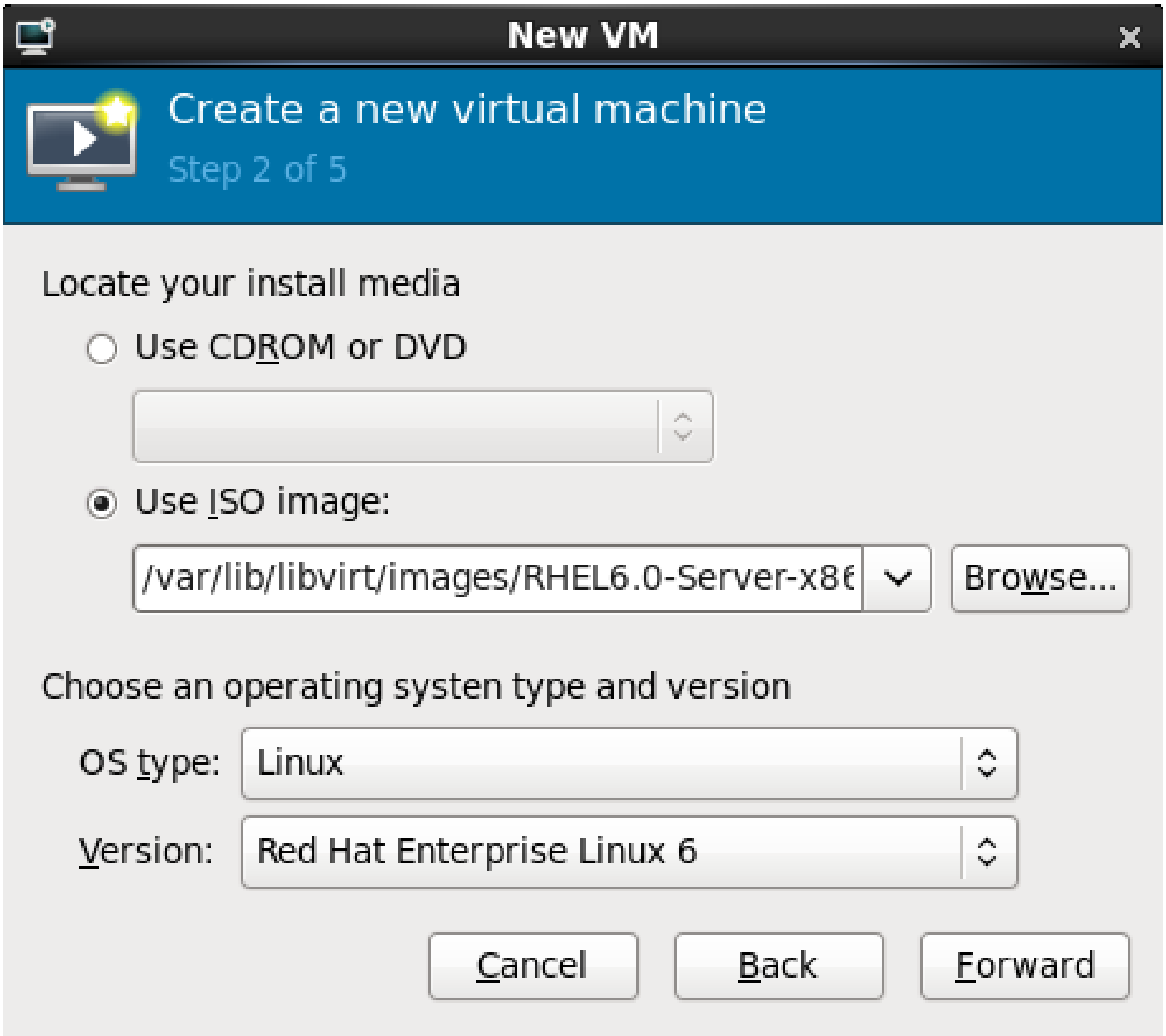


Figure 7.5. The Create a new virtual machine window - Step 2

Press **Forward** to continue.

5. **Set RAM and virtual CPUs**

   Choose appropriate values for the virtualized CPUs and RAM allocation. These values affect the host's and guest's performance. Memory and virtualized CPUs can be overcommitted, for more information on overcommitting refer to *Chapter 20, Overcommitting with KVM*.

   Virtualized guests require sufficient physical memory (RAM) to run efficiently and effectively. Red Hat supports a minimum of 512MB of RAM for a virtualized guest. Red Hat recommends at least 1024MB of RAM for each logical core.

   Assign sufficient virtual CPUs for the virtualized guest. If the guest runs a multithreaded application, assign the number of virtualized CPUs the guest will require to run efficiently.

   You cannot assign more virtual CPUs than there are physical processors (or hyper-threads) available on the host system. The number of virtual CPUs available is noted in the **Up to *X* available** field.

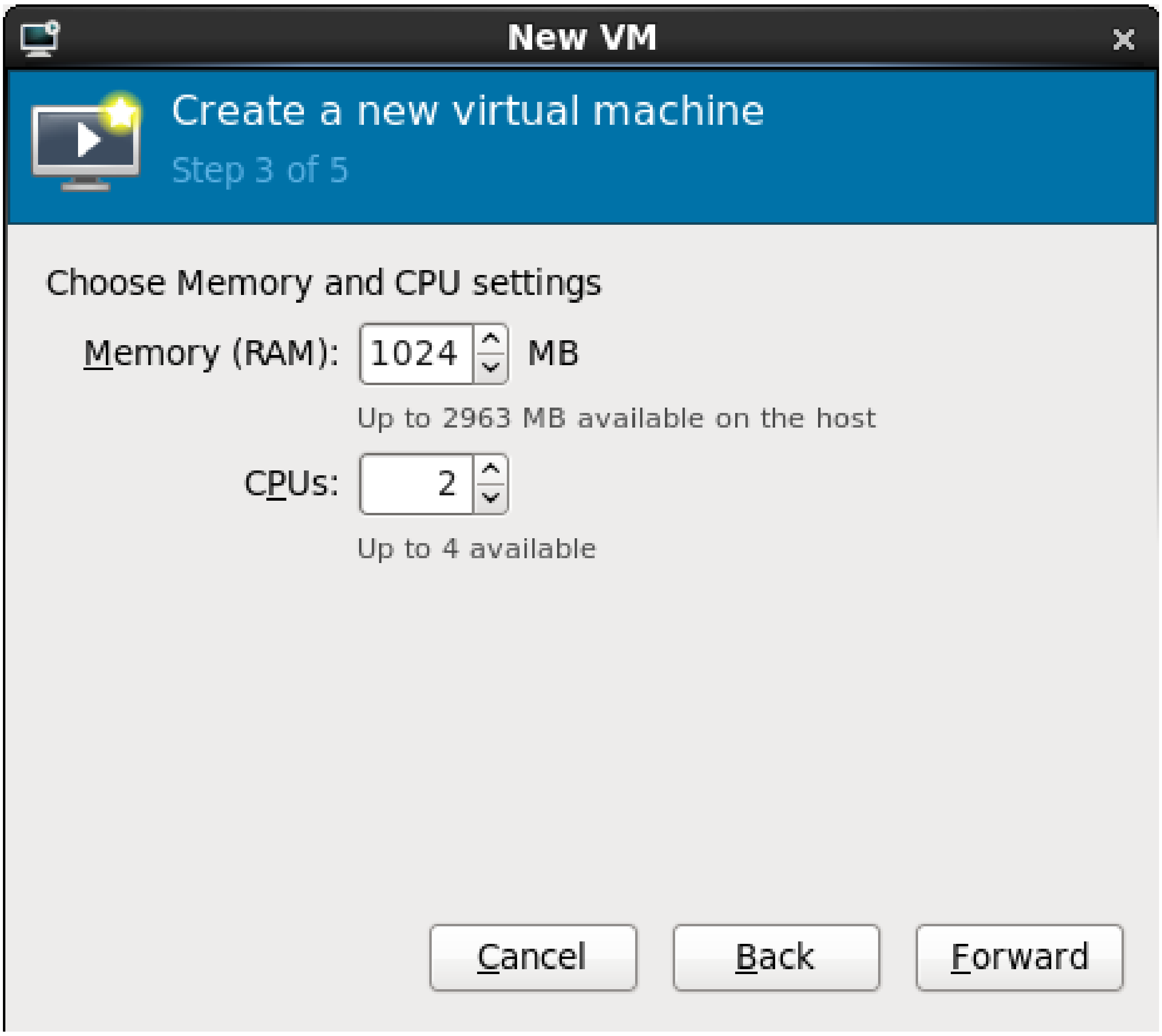


Figure 7.6. The Create a new virtual machine window - Step 3

Press **Forward** to continue.

6. **Storage**
   Enable and assign storage for the Red Hat Enterprise Linux 6 guest. Assign at least 5GB for a desktop installation or at least 1GB for a minimal installation.

   Migration

   Live and offline migrations require guests to be installed on shared network storage. For information on setting up shared storage for guests refer to *Part V, "Virtualization storage topics"*.

   a. **With the default local storage**
      Select the **Create a disk image on the computer's hard drive** radio button to create a file-based image in the default storage pool, the **`/var/lib/libvirt/images/`** directory. Enter the size of the disk image to be created. If the **Allocate entire disk now** check box is selected, a disk image of the size specified will be created immediately. If not, the disk image will grow as it becomes filled.

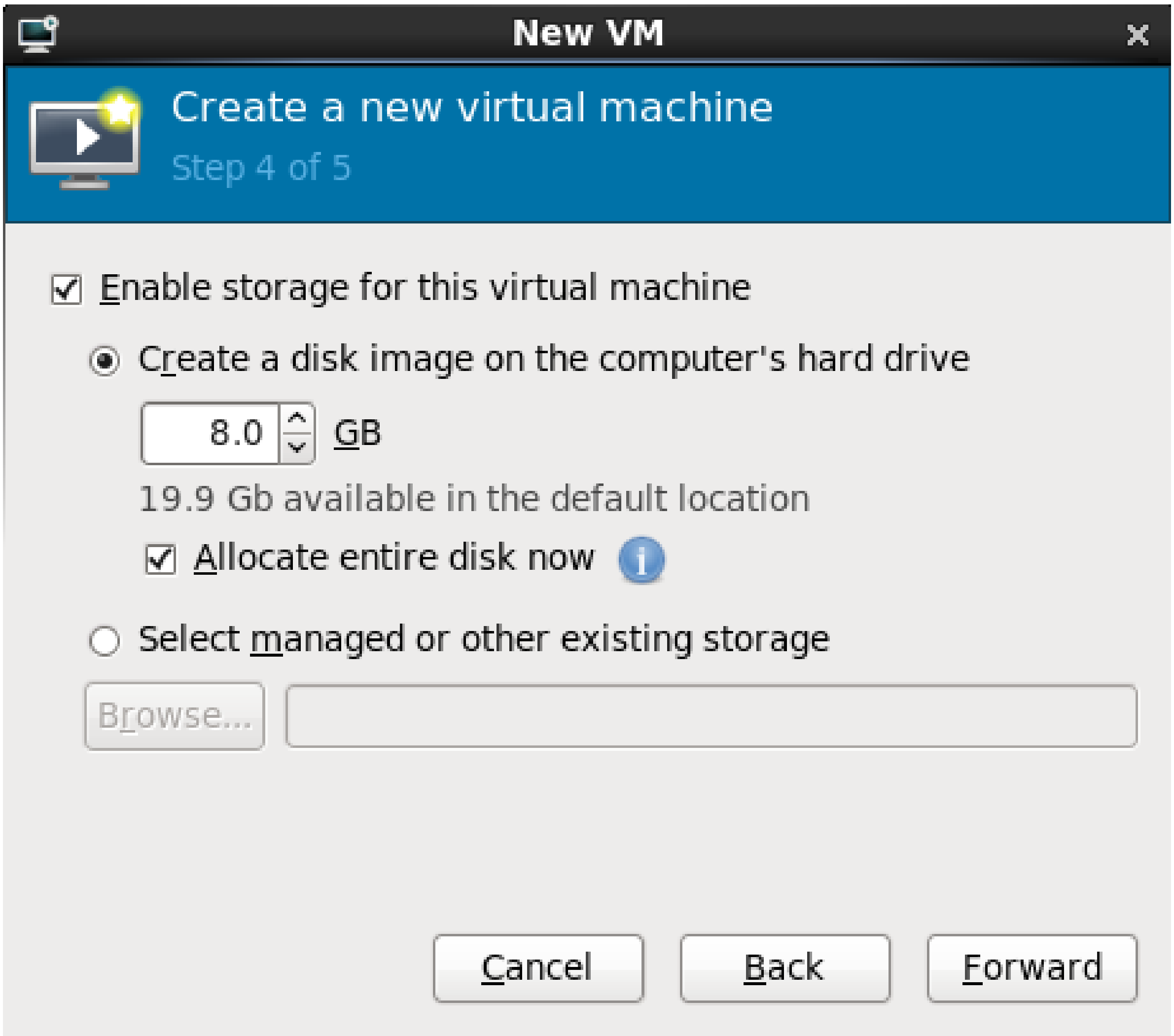


Figure 7.7. The Create a new virtual machine window - Step 4

b. **With a storage pool**

Select **Select managed or other existing storage** to use a storage pool.

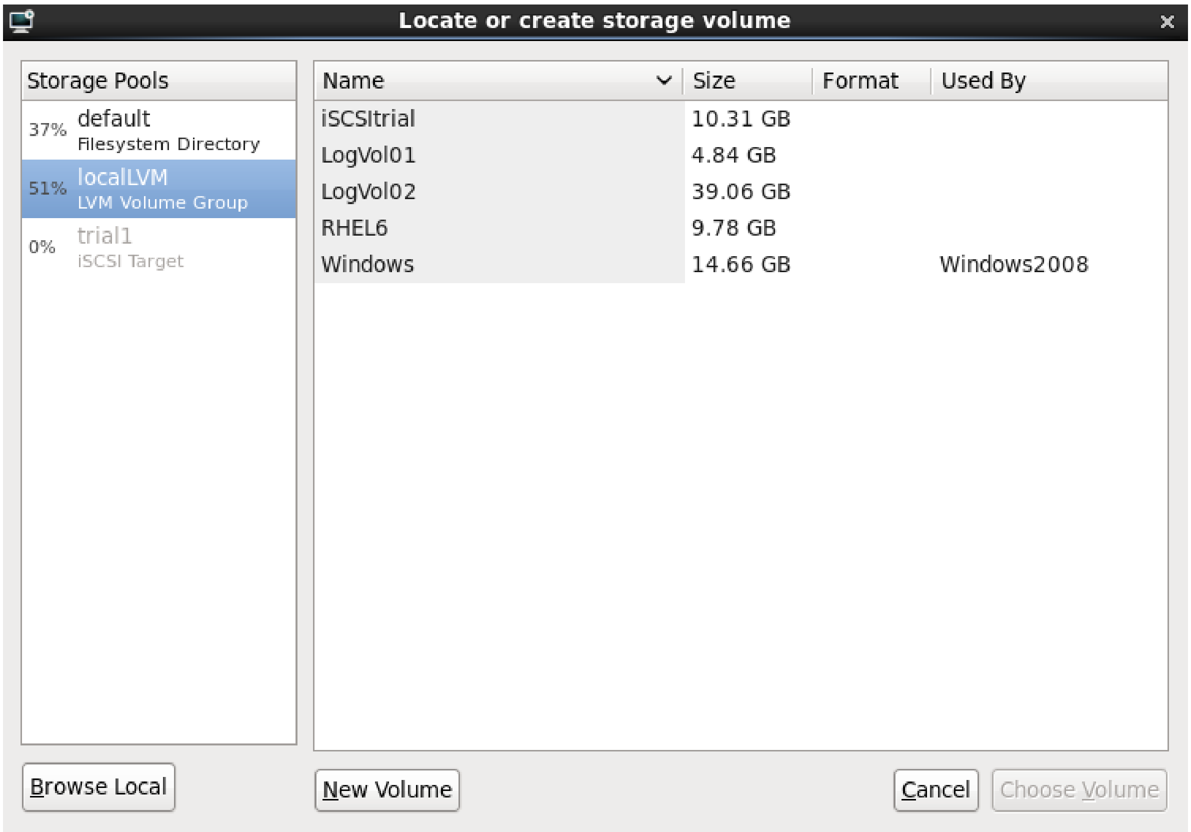


Figure 7.8. The Locate or create storage volume window

i. Press the **browse** button to open the storage pool browser.

ii. Select a storage pool from the **Storage Pools** list.

iii. Optional: Press the **New Volume** button to create a new storage volume. Enter the name of the new storage volume.

iv. Press the **Choose Volume** button to select the volume for the virtualized guest.

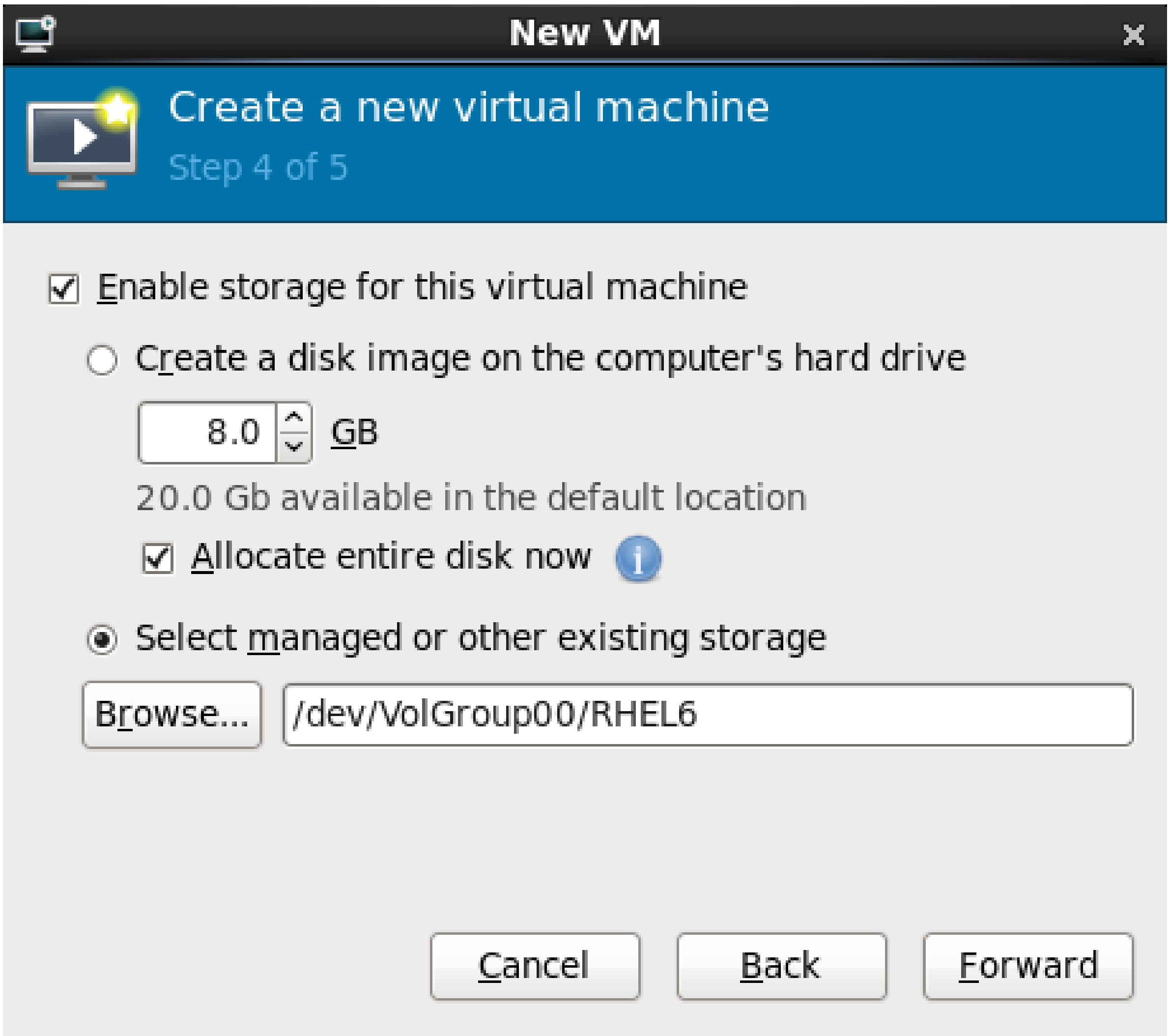


Figure 7.9. The Create a new virtual machine window - Step 4

Press **Forward** to continue.

7. **Verify and finish**

   Verify there were no errors made during the wizard and everything appears as expected.

   Select the **Customize configuration before install** check box to change the guest's storage or network devices, to use the para-virtualized drivers or, to add additional devices.

   Press the Advanced options down arrow to inspect and modify advanced options. For a standard Red Hat Enterprise Linux 6 none of these options require modification.

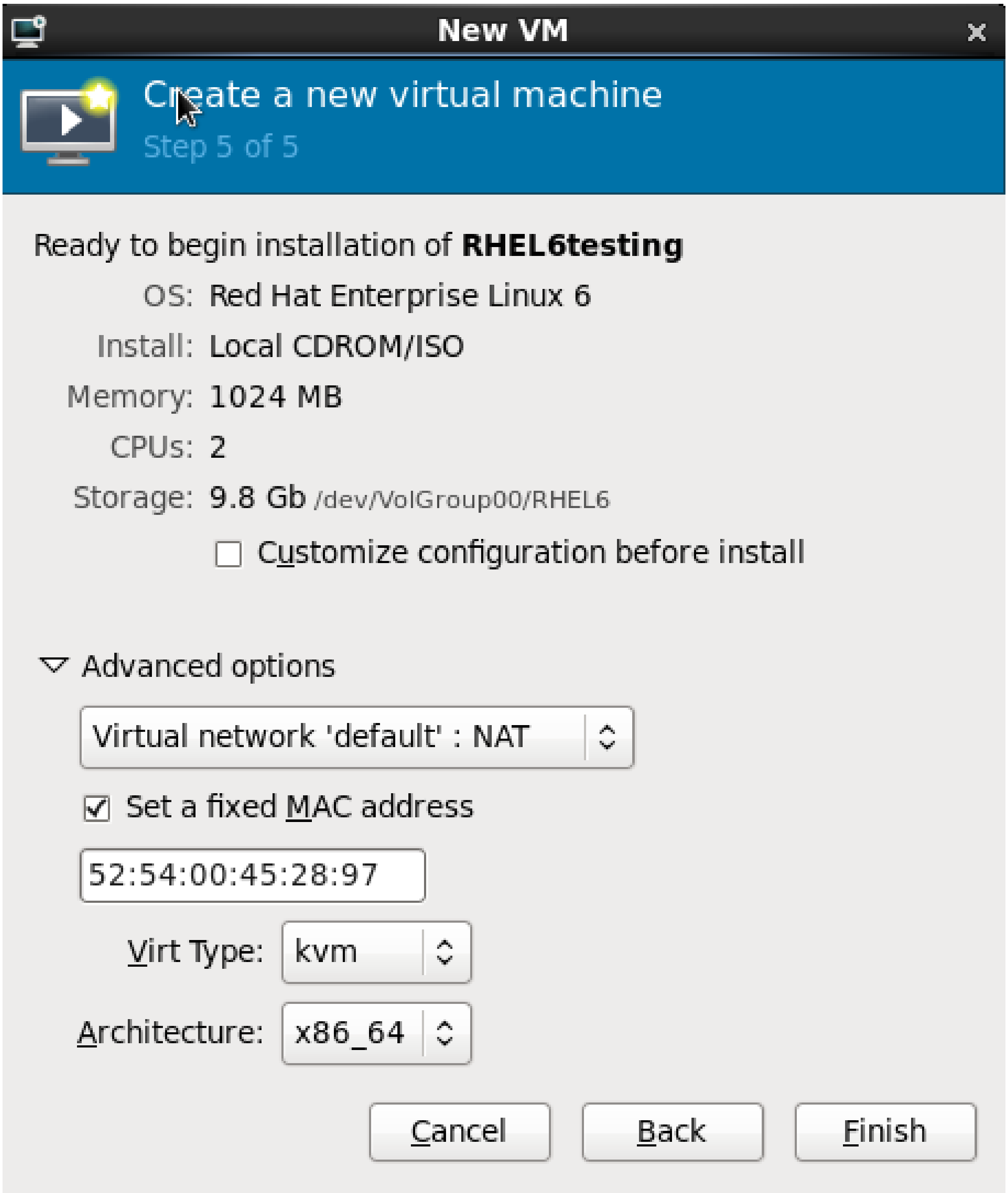


Figure 7.10. The Create a new virtual machine window - Step 5

Press **Finish** to continue into the Red Hat Enterprise Linux installation sequence. For more information on installing Red Hat Enterprise Linux 6 refer to the Red Hat Enterprise Linux 6 *Installation Guide*.

A Red Hat Enterprise Linux 6 guest is now created from a an ISO installation disc image.

7.2. Creating a Red Hat Enterprise Linux 6 guest with a network installation tree

Procedure 7.2. Creating a Red Hat Enterprise Linux 6 guest with virt-manager

1. **Optional: Preparation**
   Prepare the storage environment for the virtualized guest. For more information on preparing storage, refer to *Part V, "Virtualization storage topics"*.

   > **Note**
   >
   > Various storage types may be used for storing virtualized guests. However, for a guest to be able to use migration features the guest must be created on networked storage.

   Red Hat Enterprise Linux 6 requires at least 1GB of storage space. However, Red Hat recommends at least 5GB of storage space for a Red Hat Enterprise Linux 6 installation and for the procedures in this guide.

2. **Open virt-manager and start the wizard**
   Open virt-manager by executing the virt-manager command as root or opening **Applications** -> **System Tools** -> **Virtual Machine Manager**.

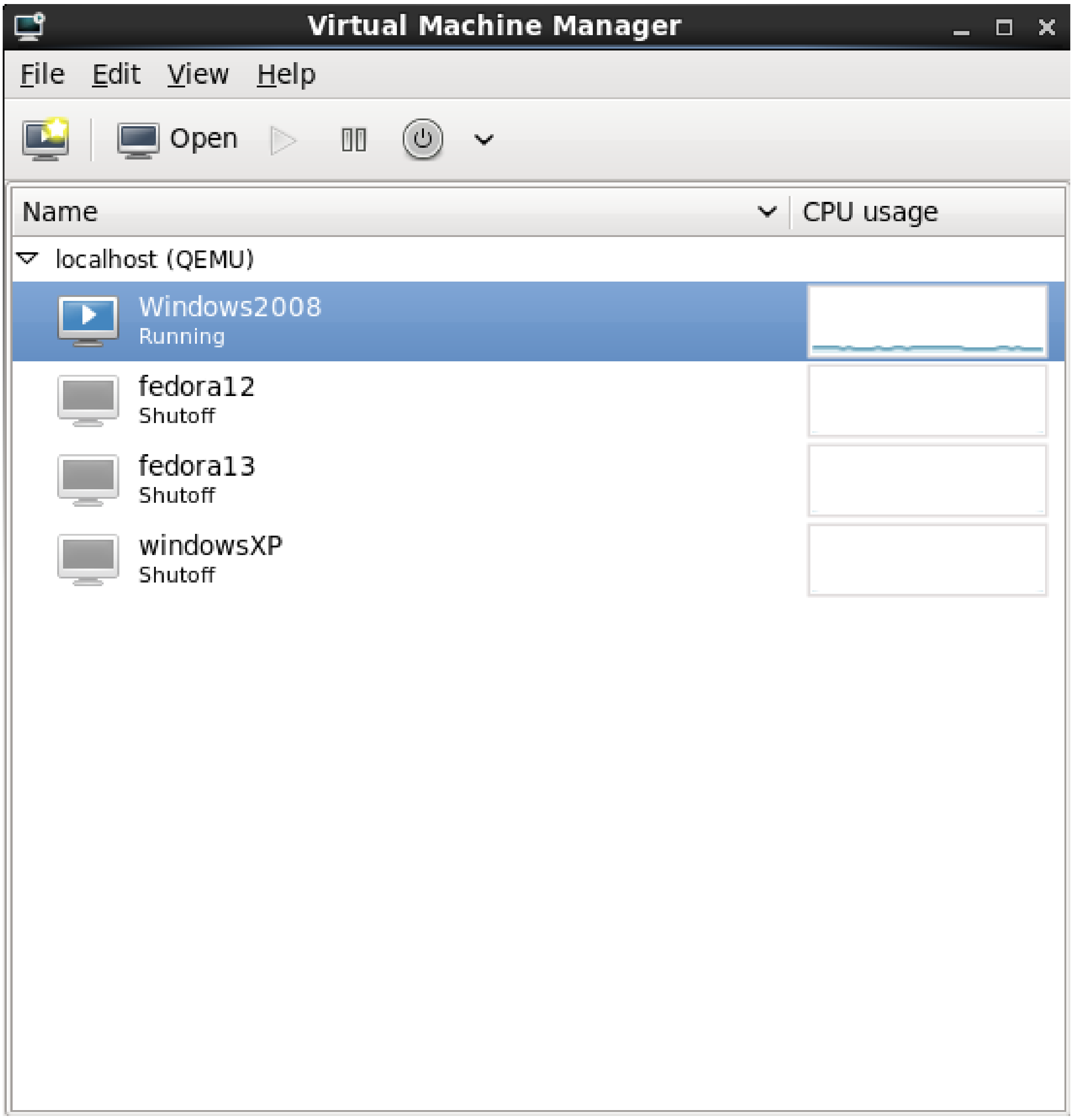


Figure 7.11. The main virt-manager window

Press the **create new virtualized guest button** (see figure *Figure 7.12, “The create new virtualized guest button”*) to start the new virtualized guest wizard.

Figure 7.12. The create new virtualized guest button

The **Create a new virtual machine** window opens.

3. **Name the virtualized guest**
   Guest names can contain letters, numbers and the following characters: '_', '**.**' and '**-**'. Guest names must be unique for migration.

   Choose the installation method from the list of radio buttons.

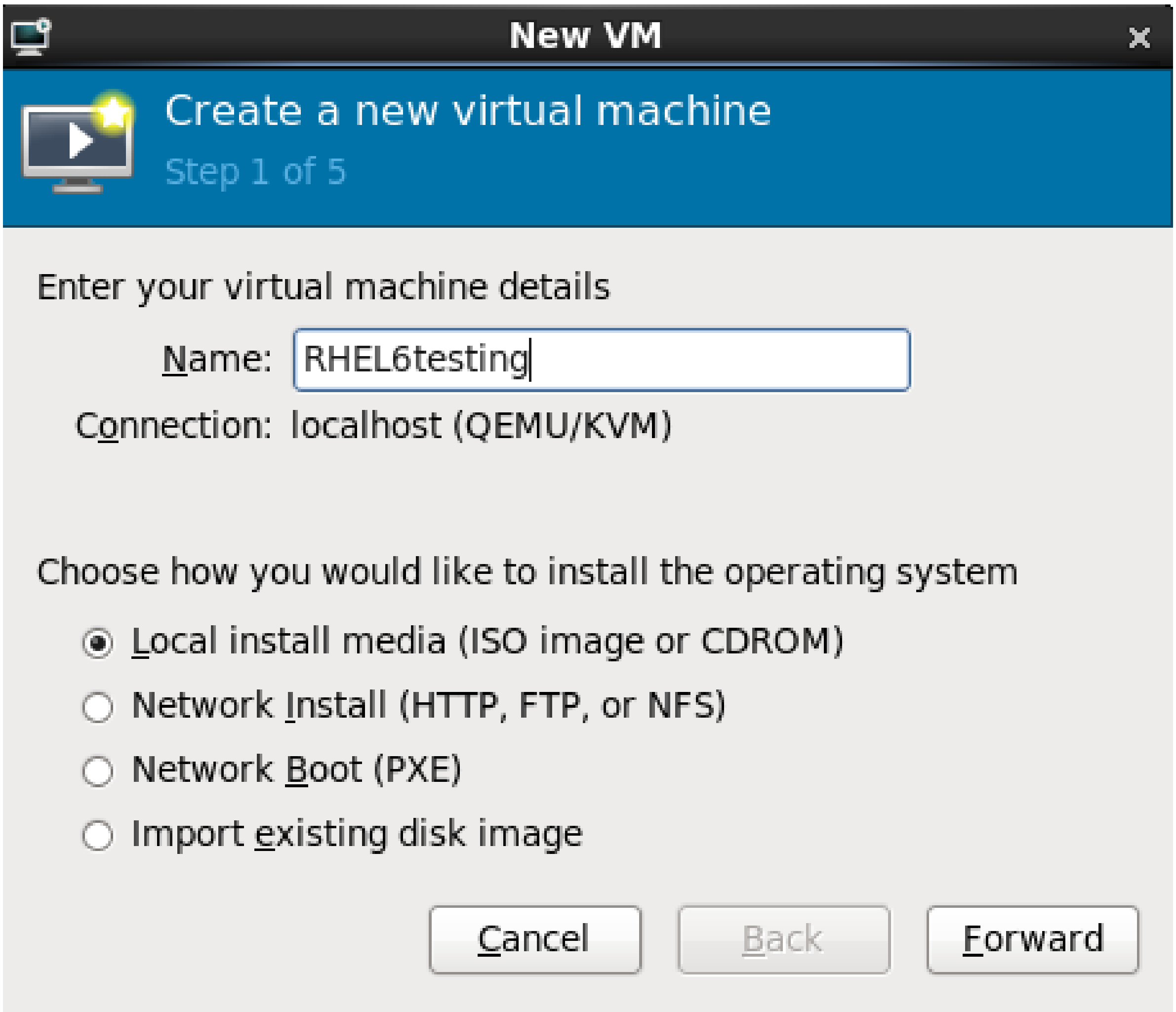


Figure 7.13. The Create a new virtual machine window - Step 1

Press **Forward** to continue.

7.3. Creating a Red Hat Enterprise Linux 6 guest with PXE

Procedure 7.3. Creating a Red Hat Enterprise Linux 6 guest with virt-manager

1. **Optional: Preparation**
   Prepare the storage environment for the virtualized guest. For more information on preparing storage, refer to *Part V, “Virtualization storage topics”*.

   > **Note**
   >
   > Various storage types may be used for storing virtualized guests. However, for a guest to be able to use migration features the guest must be created on networked storage.

   Red Hat Enterprise Linux 6 requires at least 1GB of storage space. However, Red Hat recommends at least 5GB of storage space for a Red Hat Enterprise Linux 6 installation and for the procedures in this guide.

2. **Open virt-manager and start the wizard**
   Open virt-manager by executing the virt-manager command as root or opening **Applications** -> **System Tools** -> **Virtual Machine Manager**.

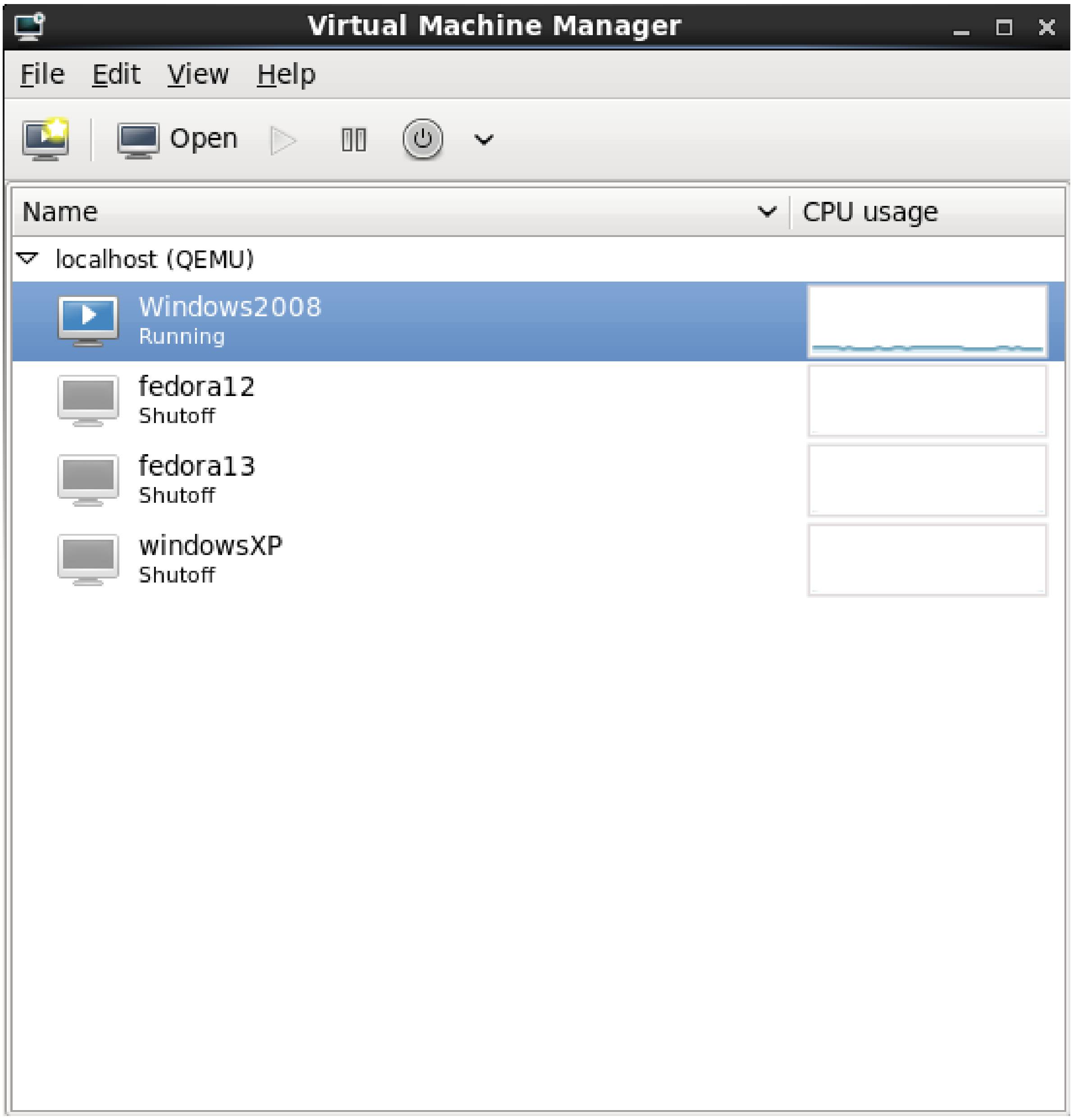


Figure 7.14. The main virt-manager window

Press the **create new virtualized guest button** (see figure *Figure 7.15, “The create new virtualized guest button”*) to start the new virtualized guest wizard.

Figure 7.15. The create new virtualized guest button

The **Create a new virtual machine** window opens.

3. **Name the virtualized guest**
   Guest names can contain letters, numbers and the following characters: '_', '**.**' and '**-**'. Guest names must be unique for migration.

Choose the installation method from the list of radio buttons.

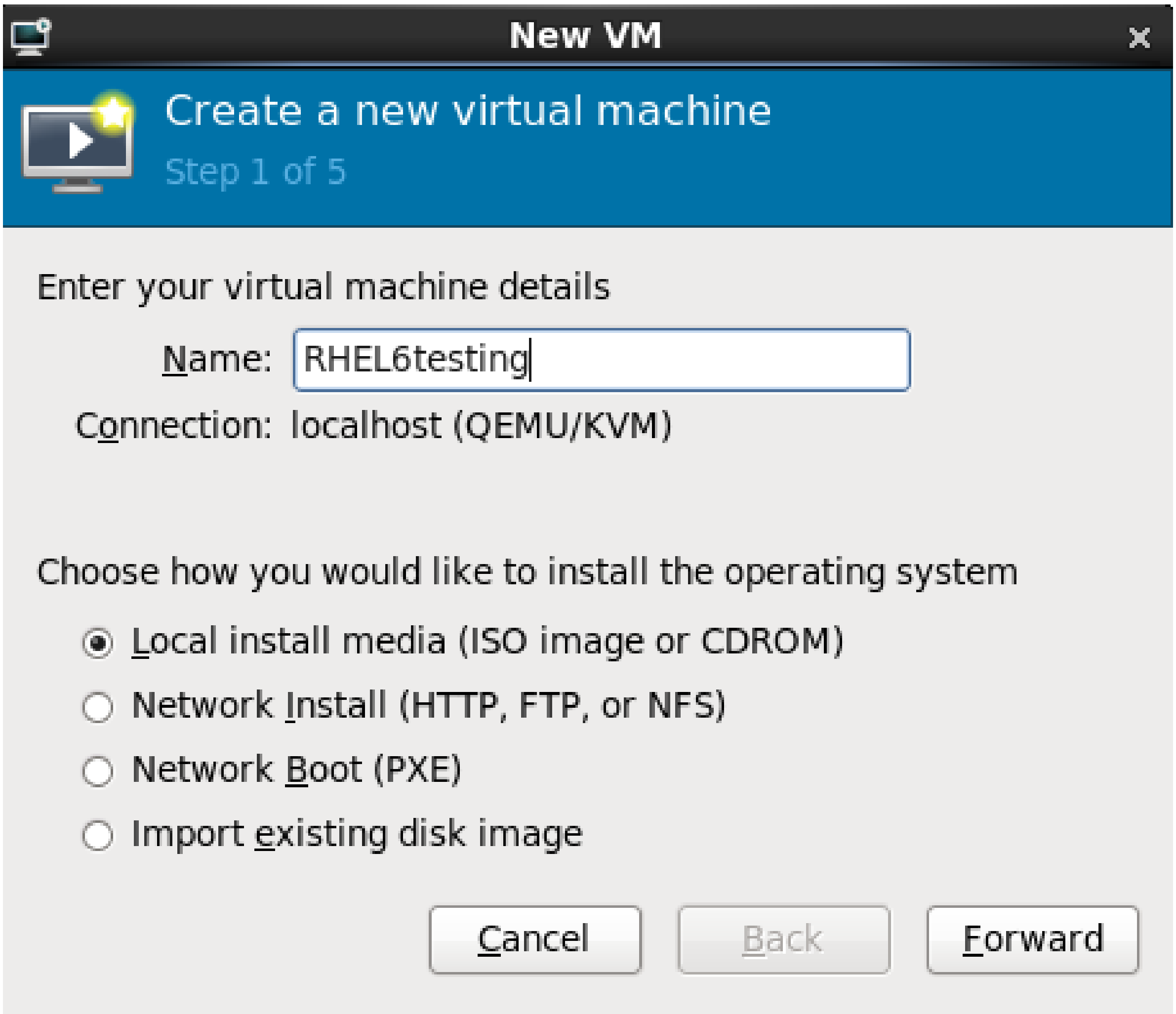


Figure 7.16. The Create a new virtual machine window - Step 1

Press **Forward** to continue.

Installing Red Hat Enterprise Linux 6 as a Xen para-virtualized guest on Red Hat Enterprise Linux 5

This section describes how to install Red Hat Enterprise Linux 6 as a Xen para-virtualized guest on Red Hat Enterprise Linux 5. Para-virtualization is only available for Red Hat Enterprise Linux 5 hosts. Red Hat Enterprise Linux 6 uses the PV-opts features of the Linux kernel to appear as a compatible Xen para-virtualized guest.

8.1. Using virt-install

This section covers creating a Xen para-virtualized Red Hat Enterprise Linux 6 guest on a Red Hat Enterprise Linux 5 host using the **`virt-install`** command. For instructions on **`virt-manager`**, refer to the procedure in *Section 8.2, “Using virt-manager”*.

This method installs Red Hat Enterprise Linux 6 from a remote server hosting the network installation tree. The installation instructions presented in this section are similar to installing from the minimal installation live CD-ROM.

Automating with virt-install

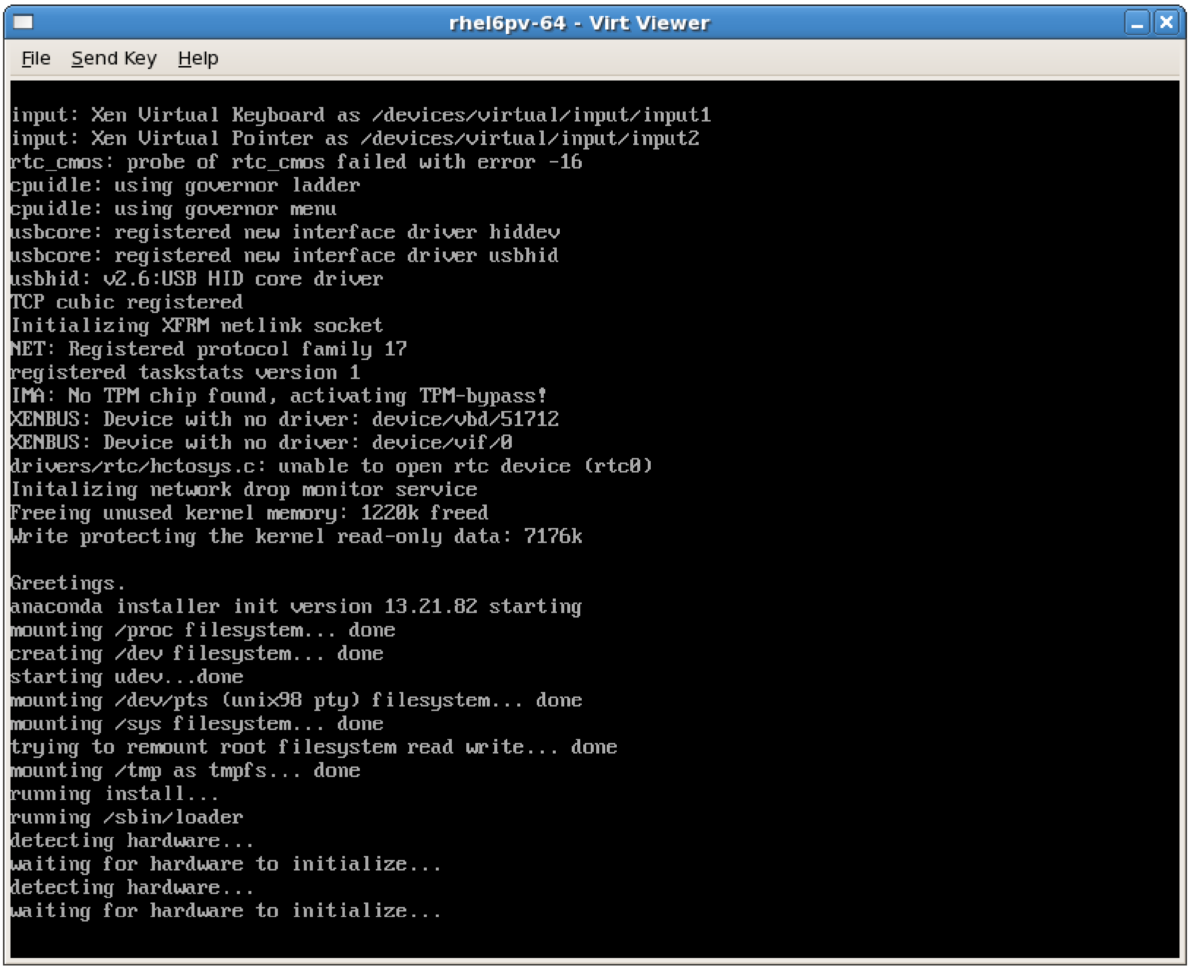
Guests can be created with the command line **`virt-install`** tool. The name of the guest in the example is *`rhel6pv-64`*, the disk image file is *`rhel6pv-64.img`* and a local mirror of the Red Hat Enterprise Linux 6 installation tree is *`http://example.com/installation_tree/RHEL6-x86/`*. Replace those values with values for your system and network.

```
# virt-install --name rhel6pv-64 \
--disk /var/lib/xen/images/rhel6pv-64.img,--file-size=6 \
--nonsparse --vnc --paravirt --vcpus=2 --ram=2048 \
--location=http://example.com/installation_tree/RHEL6-x86/
```

Red Hat Enterprise Linux can be installed without a graphical interface or manual input. Use a Kickstart file to automate the installation process. This example extends the previous example with a Kickstart file, located at **`http://example.com/kickstart/ks.cfg`**, to fully automate the installation.

```
# virt-install --name rhel6pv-64 \
--disk /var/lib/xen/images/rhel6pv-64.img,--file-size=6 \
--nonsparse --nographics --paravirt --vcpus=2 --ram=2048 \
--location=http://example.com/installation_tree/RHEL6-x86/ \
-x "ks=http://example.com/kickstart/ks.cfg"
```

The graphical console opens showing the initial boot phase of the guest:



After your guest has completed its initial boot, the standard installation process for Red Hat Enterprise Linux 6 starts.

Refer to the Red Hat Enterprise Linux 6 Installation Guide for more information on installing Red Hat Enterprise Linux 6.

8.2. Using virt-manager

Procedure 8.1. Creating a Xen para-virtualized Red Hat Enterprise Linux 6 guest with virt-manager

1. **Open virt-manager**

   Start **`virt-manager`**. Launch the **Virtual Machine Manager** application from the **Applications** menu and **System Tools** submenu. Alternatively, run the **`virt-manager`** command as root.

2. **Select the hypervisor**

   Select the Xen hypervisor connection. Note that presently the KVM hypervisor is named **`qemu`**.

   Connect to a hypervisor if you have not already done so. Open the **File** menu and select the **Add Connection...** option. Refer to *Section 31.5, “Adding a remote connection”*.

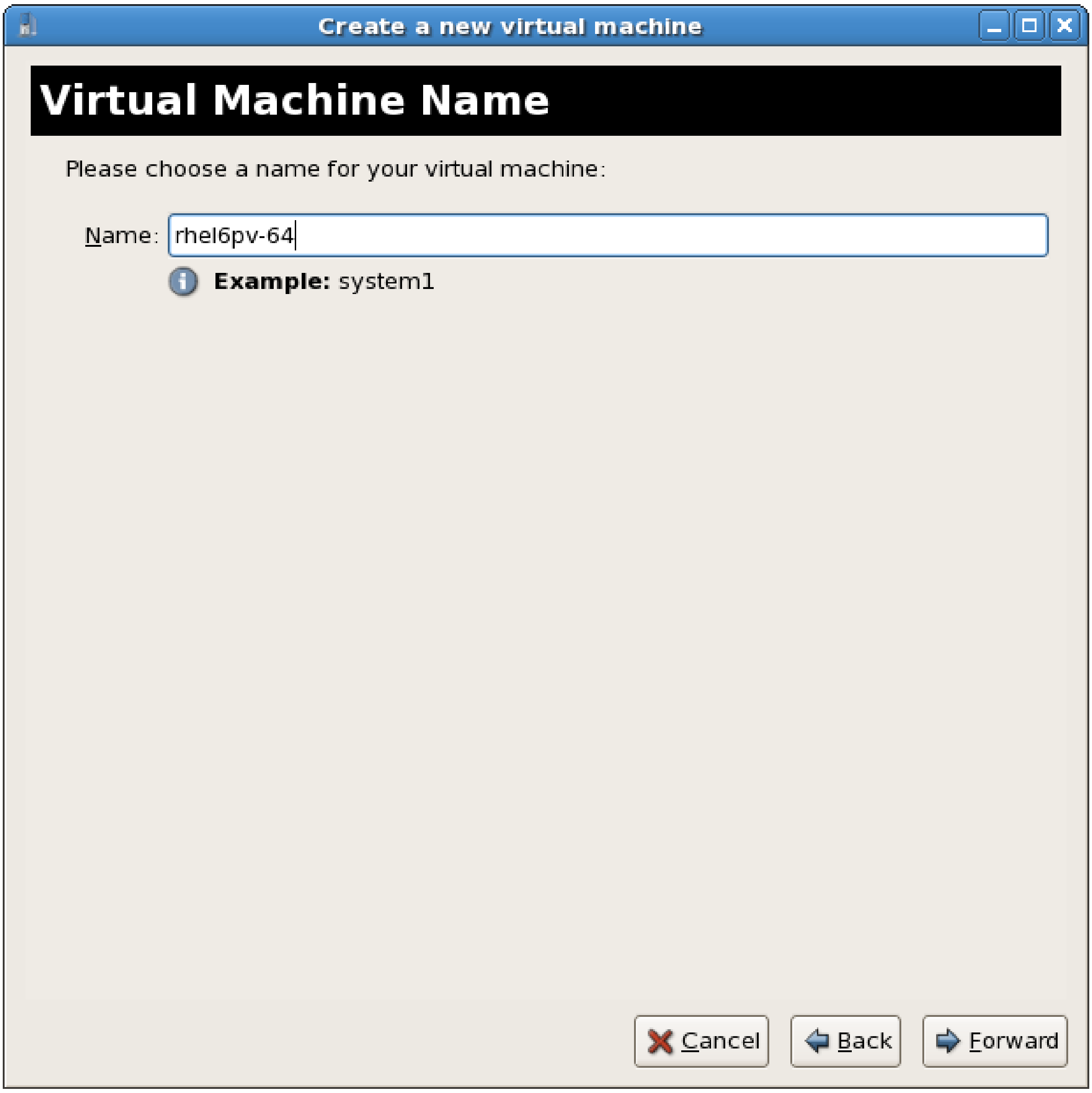
   Once a hypervisor connection is selected the **New** button becomes available. Press the **New** button.

3. **Start the new virtual machine wizard**

   Pressing the **New** button starts the virtual machine creation wizard.

Press **Forward** to continue.

4. **Name the virtual machine**
   Provide a name for your virtualized guest. The following punctuation and whitespace characters are permitted for '_', '**.**' and '**-**' characters.



Press **Forward** to continue.

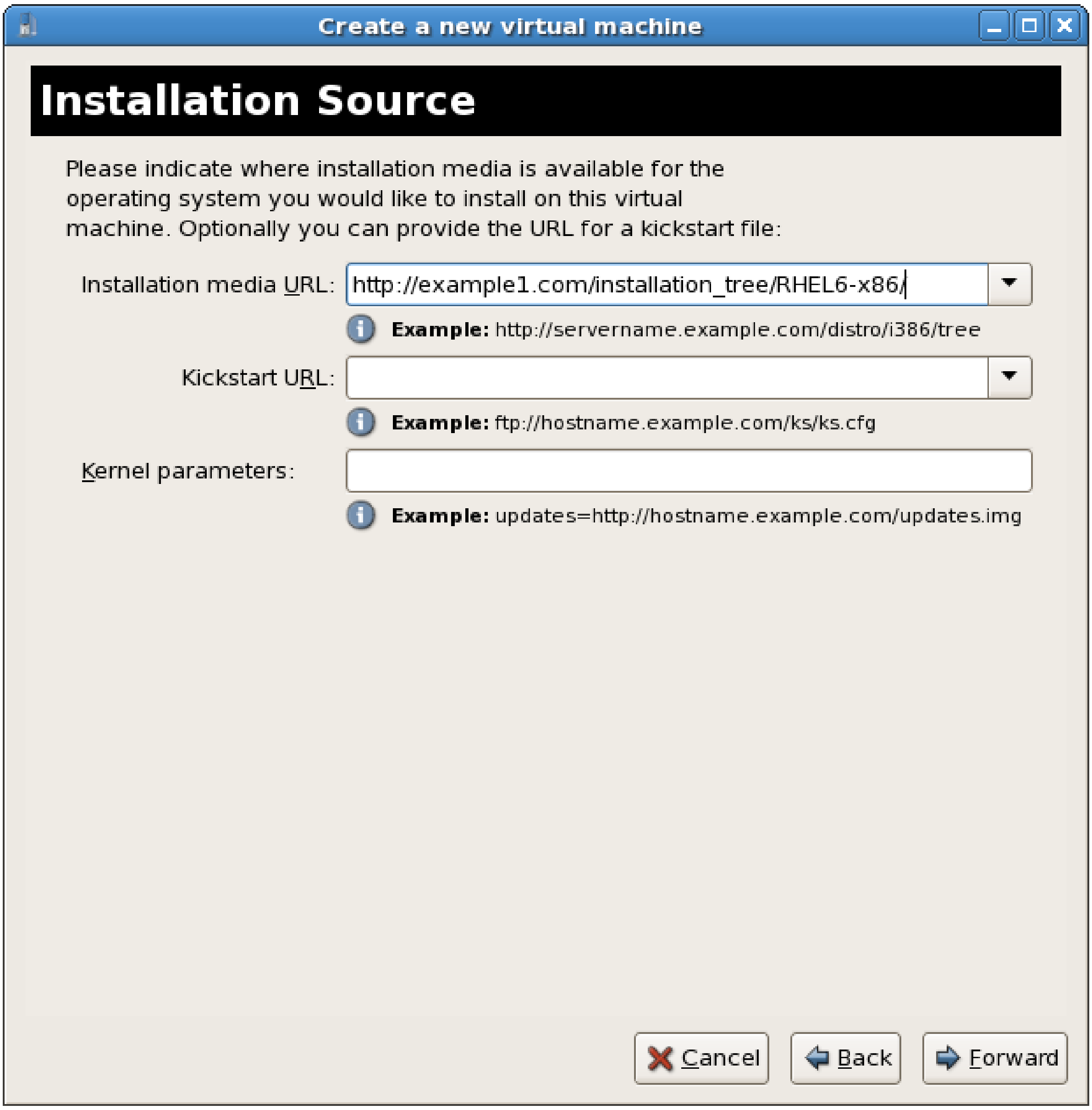
5. **Select the installation method**
   Red Hat Enterprise Linux can be installed using one of the following methods:

   - **local install media**, either an ISO image or physical optical media.
   - Select **Network install tree** if you have the installation tree for Red Hat Enterprise Linux hosted somewhere on your network via HTTP, FTP or NFS.
   - PXE can be used if you have a PXE server configured for booting Red Hat Enterprise Linux installation media. Configuring a sever to PXE boot a Red Hat Enterprise Linux installation is not covered by this guide. However, most of the installation steps are the same after the media boots.

   Set **OS Type** to **Linux** and **OS Variant** to **Red Hat Enterprise Linux 6** as shown in the screenshot.

Press **Forward** to continue.

6. **Locate installation media**
   Enter the location of the installation tree.



Press **Forward** to continue.

Image files and SELinux

Xen file-based images should be stored in the **`/var/lib/xen/images/`** directory. Any other location may require additional configuration for SELinux, refer to *Section 16.2, "SELinux and virtualization"* for details.

7. **Storage setup**
   Assign a physical storage device (**Block device**) or a file-based image (**File**). Assign sufficient space for your virtualized guest and any applications the guest requires.

Press **Forward** to continue.

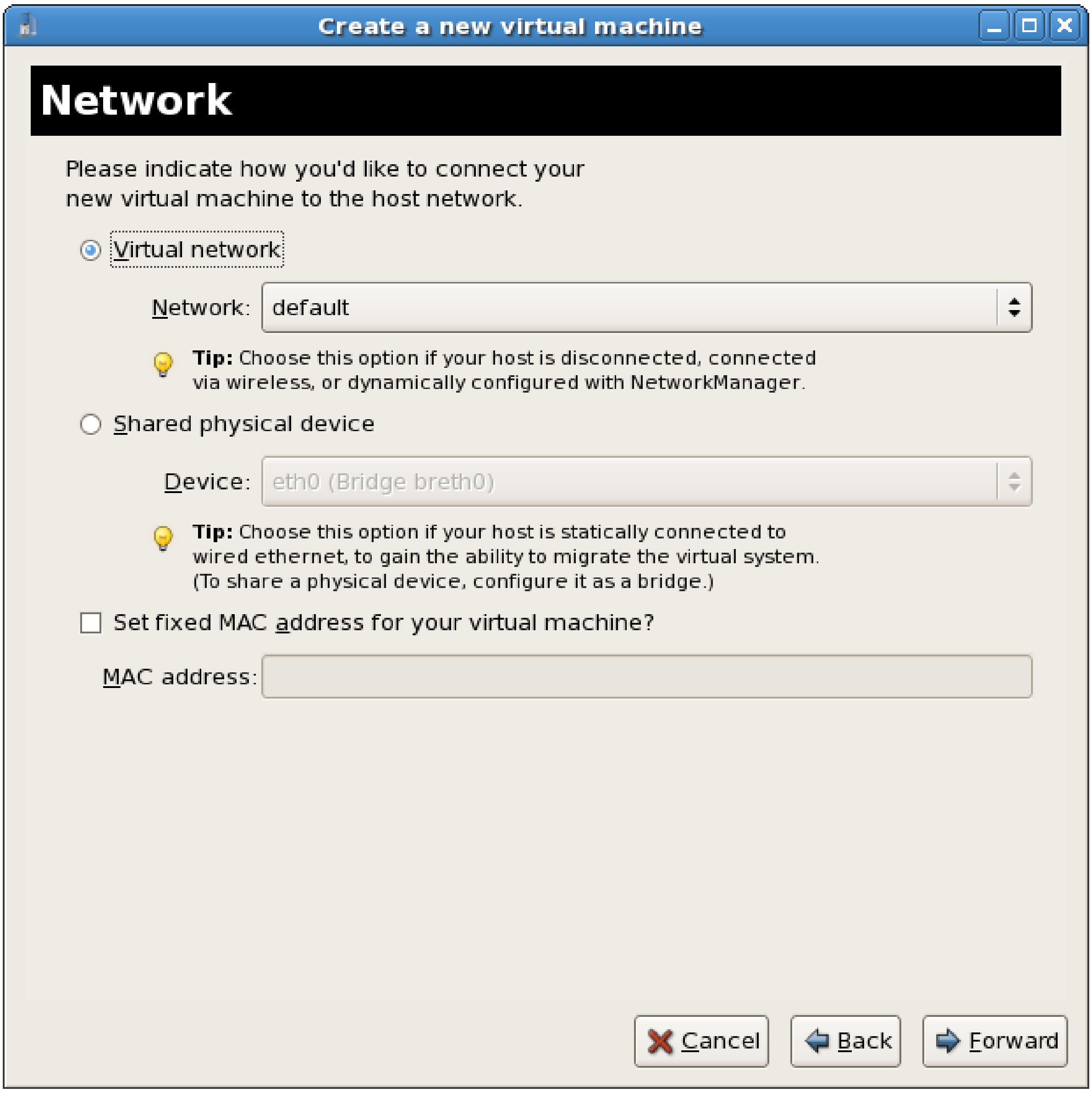
Migration

Live and offline migrations require guests to be installed on shared network storage. For information on setting up shared storage for guests refer to *Part V, "Virtualization storage topics"*.

8. **Network setup**
   Select either **Virtual network** or **Shared physical device**.

   The virtual network option uses Network Address Translation (NAT) to share the default network device with the virtualized guest.

   The shared physical device option uses a network bridge to give the virtualized guest full access to a network device.



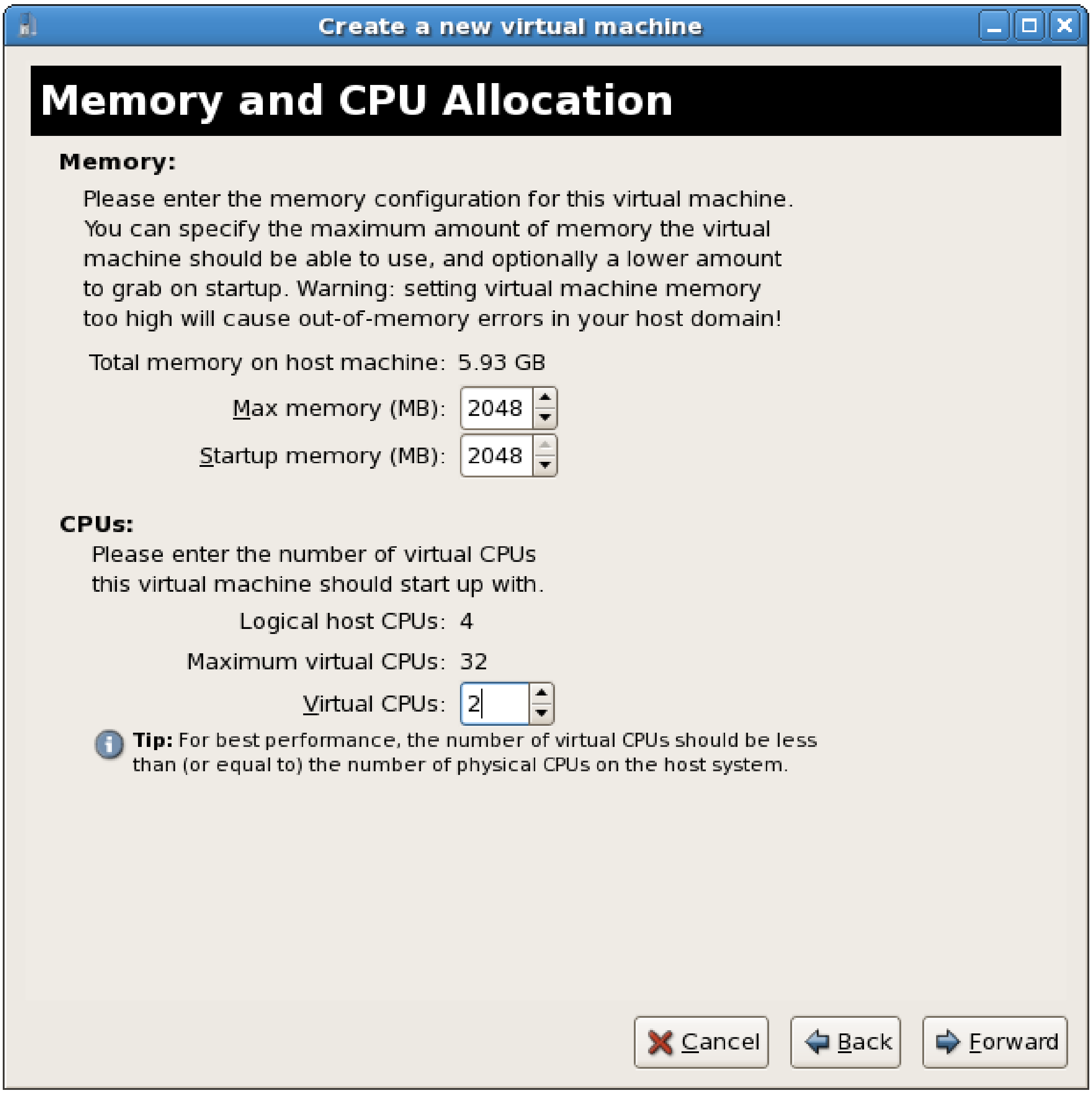
Press **Forward** to continue.

9. **Memory and CPU allocation**

   The **Memory and CPU Allocation** window displays. Choose appropriate values for the virtualized CPUs and RAM allocation. These values affect the host's and guest's performance.

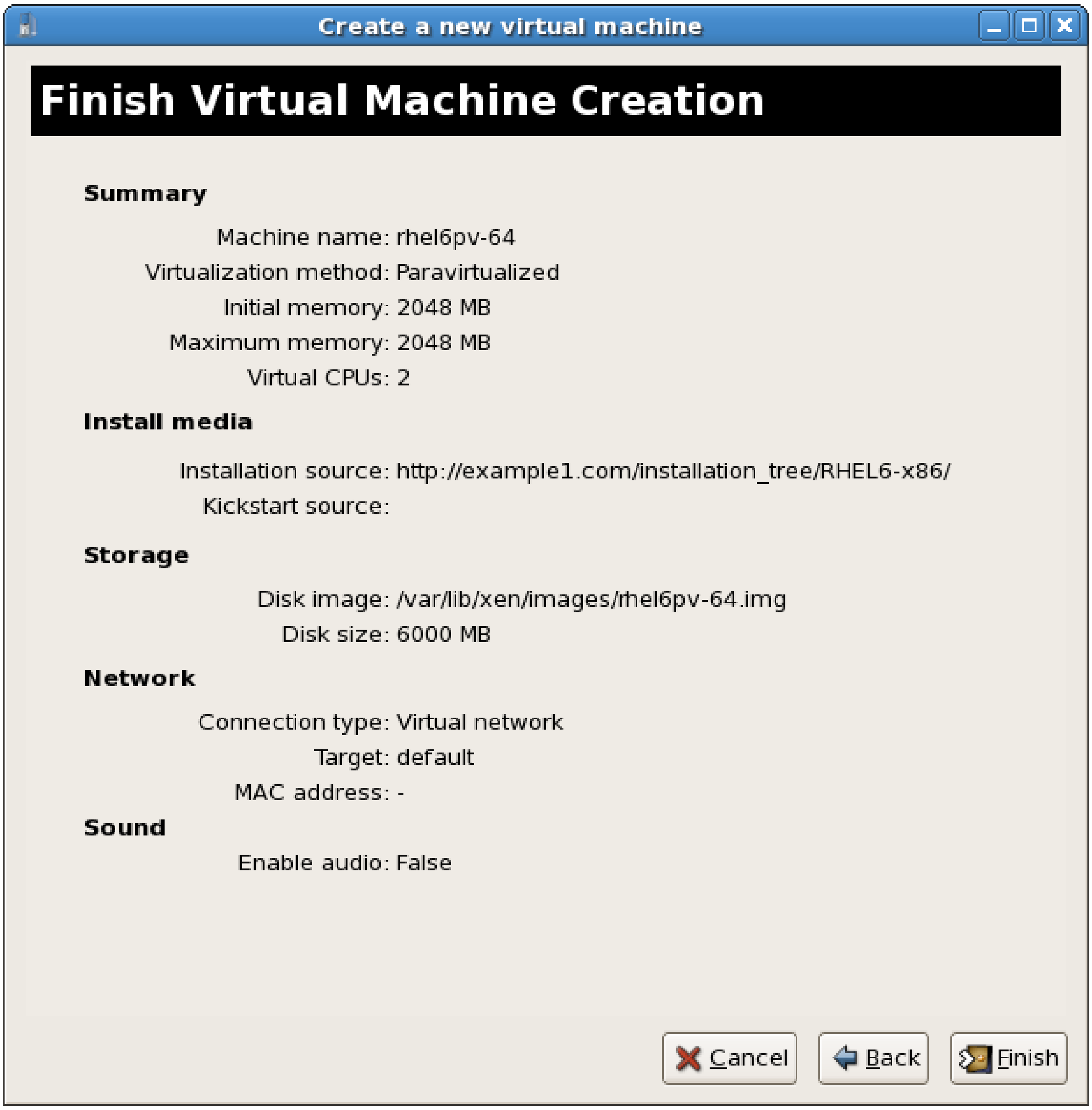
   Virtualized guests require sufficient physical memory (RAM) to run efficiently and effectively. Choose a memory value which suits your guest operating system and application requirements. Remember, Xen guests use physical RAM. Running too many guests or leaving insufficient memory for the host system results in significant usage of virtual memory and swapping. Virtual memory is significantly slower which causes degraded system performance and responsiveness. Ensure you allocate sufficient memory for all guests and the host to operate effectively.

   Assign sufficient virtual CPUs for the virtualized guest. If the guest runs a multithreaded application, assign the number of virtualized CPUs the guest will require to run efficiently. Do not assign more virtual CPUs than there are physical processors (or hyper-threads) available on the host system. It is possible to over allocate virtual processors, however, over allocating VCPUs has a significant, negative effect on Xen guest and host performance.



Press **Forward** to continue.

10. **Verify and start guest installation**
    Verify the configuration.



Press **Finish** to start the guest installation procedure.

11. **Installing Red Hat Enterprise Linux**
Complete the Red Hat Enterprise Linux installation sequence. The installation sequence is covered by the Red Hat Enterprise Linux 6 *Installation Guide*. Refer to Red Hat Documentation[1] for the Red Hat Enterprise Linux 6 *Installation Guide*.

Installing a fully-virtualized Windows guest

Red Hat Enterprise Linux 6 supports the installation of any Microsoft Windows operating system as a fully virtualized guest. This chapter describes how to create a fully virtualized guest using the command-line (**`virt-install`**), launch the operating system's installer inside the guest, and access the installer through **`virt-viewer`**.

To install a Windows operating system on the guest, use the **`virt-viewer`** tool. This tool allows you to display the graphical console of a virtual machine (via the VNC protocol). In doing so, **`virt-viewer`** allows you to install a fully virtualized guest's operating system through that operating system's installer (e.g. the Windows XP installer).

Installing a Windows operating system involves two major steps:

1. Creating the guest (using either **`virt-install`** or **`virt-manager`**)

2. Installing the Windows operating system on the guest (through **`virt-viewer`**)

Note that this chapter does not describe how to install a Windows operating system on a fully-virtualized guest. Rather, it only covers how to create the guest and launch the installer within the guest. For information on how to install a Windows operating system, refer to the relevant Microsoft installation documentation.

9.1. Using virt-install to create a guest

The **`virt-install`** command allows you to create a fully-virtualized guest from a terminal, i.e. without a GUI. If you prefer to use a GUI instead, refer to *Section 6.3, "Creating guests with virt-manager"* for instructions on how to use **`virt-manager`**.

> **Important**
>
> Before creating the guest, consider first if the guest needs to use KVM Windows para-virtualized drivers. If it does, keep in mind that you can do so *during* or *after* installing the Windows operating system on the guest. For more information about para-virtualized drivers, refer to *Chapter 11, KVM Para-virtualized Drivers*.
>
> For instructions on how to install KVM para-virtualized drivers, refer to *Section 11.2, "Installing the KVM Windows para-virtualized drivers"*.

It is possible to create a fully-virtualized guest with only a single command. To do so, simply run the following program (replace the values accordingly):

```
# virt-install \
   --name=guest-name  \
   --network network=default \
   --disk path=path-to-disk \
   --disk size=disk-size \
   --cdrom=path-to-install-disk \
   --vnc --ram=1024
```

The ***`path-to-disk`*** must be a device (e.g. **`/dev/sda3`**) or image file (**`/var/lib/libvirt/images/name.img`**). It must also have enough free space to support the ***`disk-size`***.

Important

All image files should be stored in **`/var/lib/libvirt/images/`**. Other directory locations for file-based images are prohibited by SELinux. If you run SELinux in enforcing mode, refer to *Section 16.2, “SELinux and virtualization”* for more information on installing guests.

You can also run **`virt-install`** interactively. To do so, use the **`--prompt`** command, as in:

```
# virt-install --prompt
```

Once the fully-virtualized guest is created, **`virt-viewer`** will launch the guest and run the operating system's installer. Refer to to the relevant Microsoft installation documentation for instructions on how to install the operating system.

Part III. Configuration

Configuring virtualization in Red Hat Enterprise Linux 6

These chapters cover configuration procedures for various advanced virtualization tasks. These tasks include adding network and storage devices, enhancing security, improving performance, and using the para-virtualized drivers on fully virtualized guests.

Network Configuration

This section provides an introduction to the common networking configurations used by libvirt-based applications. For additional information, consult the libvirt network architecture documentation: *http://libvirt.org/intro.html*.

Red Hat Enterprise Linux 6 supports the following networking setups for virtualization:

- virtual networks using Network Address Translation (*NAT*)
- directly allocated physical devices using PCI device assignment or SR-IOV.
- bridged networks

You must enable NAT, network bridging or directly share a physical device to allow external hosts access to network services on virtualized guests.

10.1. Network Address Translation (NAT) with libvirt

One of the most common methods for sharing network connections is to use Network Address Translation (NAT) forwarding (also know as virtual networks).

Host configuration

Every standard `libvirt` installation provides NAT based connectivity to virtual machines out of the box. This is the so called 'default virtual network'. Verify that it is available with the **`virsh net-list --all`** command.

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

If it is missing, the example XML configuration file can be reloaded and activated:

```
# virsh net-define /usr/share/libvirt/networks/default.xml
```

The default network is defined from **`/usr/share/libvirt/networks/default.xml`**

Mark the default network to automatically start:

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

Start the default network:

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

Once the `libvirt` default network is running, you will see an isolated bridge device. This device does *not* have any physical interfaces added. The new device uses NAT and IP forwarding to connect to outside world. Do not add new interfaces.

```
# brctl show
bridge name     bridge id               STP enabled     interfaces
virbr0          8000.000000000000       yes
```

libvirt adds **iptables** rules which allow traffic to and from guests attached to the virbr0 device in the **INPUT**, **FORWARD**, **OUTPUT** and **POSTROUTING** chains. **libvirt** then attempts to enable the **ip_forward** parameter. Some other applications may disable **ip_forward**, so the best option is to add the following to **/etc/sysctl.conf**.

```
net.ipv4.ip_forward = 1
```

Guest configuration

Once the host configuration is complete, a guest can be connected to the virtual network based on its name. To connect a guest to the 'default' virtual network, the following could be used in the XML configuration file (such as **/etc/libvirtd/qemu/myguest.xml**) for the guest:

```
<interface type='network'>
   <source network='default'/>
</interface>
```

> **Note**
>
> Defining a MAC address is optional. A MAC address is automatically generated if omitted. Manually setting the MAC address may be useful to maintain consistency or easy reference throughout your environment, or to avoid the very small chance of a conflict.
>
> ```
> <interface type='network'>
>   <source network='default'/>
>   <mac address='00:16:3e:1a:b3:4a'/>
> </interface>
> ```

10.2. Using vhost-net to accelerate para-virtualized network drivers

The **vhost-net** module is used to accelerate KVM para-virtualized drivers. It is used by default on guests using Red Hat Enterprise Linux 6 and later, or Windows guests with the virtio network driver installed. It has no effect on guest machines with older operating systems, or other drivers.

10.2.1. Disabling vhost-net

The **vhost-net** module is enabled by default where it is effective, and disabled by default where it is not. However, some workloads can experience a degradation in performance when **vhost-net** is in use.

Specifically, performance degradation can occur when UDP traffic is sent from a host machine to a guest machine running on that host if the guest machine processes incoming data at a rate slower than the host machine sends it. In this situation, enabling **vhost-net** causes the UDP socket's receive buffer to overflow more quickly, which results in greater packet loss. In this case, it is therefore better to disable **vhost-net**, which slows the traffic, but improves overall performance.

To disable **vhost-net**, edit the **<interface>** sub-element in your guest's XML configuration file and define the network as follows:

```
<interface type="network">
   ...
```

```
   <model type="virtio"/>
   <driver name="qemu"/>
   ...
</interface>
```

10.2.1.1. Checksum correction for older DHCP clients

The **vhost-net** module avoids using checksum computations in host to guest communication, and notifies guests that incoming packets do not include the checksum.

Some DHCP clients on Linux guest machines (specifically, guests running versions of Red Hat Enterprise Linux earlier than version 6.0) cannot handle the packets without checksums that are generated by this setup when they are used with a DHCP server running on the same host that is not started by libvirt. In this situation, the DHCP client assumes that the checksum value for these packets is incorrect rather than missing, and discards those packets.

To work around this problem, you can create an iptables CHECKSUM target to compute and fill in the checksum value in packets that lack checksums, for example:

```
iptables -A POSTROUTING -t mangle -p udp --dport 68 -j CHECKSUM --checksum-fill
```

This iptables rule is programmed automatically on the host when the server is started by libvirt, so no further action is required.

10.3. Bridged networking with libvirt

Bridged networking (also known as physical device sharing) is used for dedicating a physical device to a virtual machine. Bridging is often used for more advanced setups and on servers with multiple network interfaces.

Disable NetworkManager

NetworkManager does not support bridging. NetworkManager must be disabled to use networking with the network scripts (located in the **/etc/sysconfig/network-scripts/** directory).

```
# chkconfig NetworkManager off
# chkconfig network on
# service NetworkManager stop
# service network start
```

> **Note**
>
> Instead of turning off **NetworkManager**, add "*NM_CONTROLLED=no*" to the **ifcfg-*** scripts used in the examples.

Creating the bridge

Create or edit the following two network configuration files. These steps can be repeated (with different names) for additional network bridges.

1. **Change to the network scripts directory**
   Change to the **/etc/sysconfig/network-scripts** directory:

   ```
   # cd /etc/sysconfig/network-scripts
   ```

2. **Modify a network interface to make a bridge**
   Edit the network script for the network device you are adding to the bridge. In this example, **`/etc/sysconfig/network-scripts/ifcfg-eth0`** is used. This file defines **`eth0`**, the physical network interface which is set as part of a bridge:

   ```
   DEVICE=eth0
   # change the hardware address to match the hardware address your NIC uses
   HWADDR=00:16:76:D6:C9:45
   ONBOOT=yes
   BRIDGE=br0
   ```

   Tip

   You can configure the device's Maximum Transfer Unit (MTU) by appending an *`MTU`* variable to the end of the configuration file.

   ```
   MTU=9000
   ```

3. **Create the bridge script**
   Create a new network script in the **`/etc/sysconfig/network-scripts`** directory called **`ifcfg-br0`** or similar. The *`br0`* is the name of the bridge, this can be anything as long as the name of the file is the same as the DEVICE parameter, and that it matches the bridge name used in step 2.

   ```
   DEVICE=br0
   TYPE=Bridge
   BOOTPROTO=dhcp
   ONBOOT=yes
   DELAY=0
   ```

   Warning

   The line, *`TYPE=Bridge`*, is case-sensitive. It must have uppercase 'B' and lower case 'ridge'.

4. **Restart the network**
   After configuring, restart networking or reboot.

   ```
   # service network restart
   ```

5. **Configure iptables**
   Configure **`iptables`** to allow all traffic to be forwarded across the bridge.

   ```
   # iptables -I FORWARD -m physdev --physdev-is-bridged -j ACCEPT
   # service iptables save
   # service iptables restart
   ```

Disable iptables on bridges

Alternatively, prevent bridged traffic from being processed by **`iptables`** rules. In **`/etc/sysctl.conf`** append the following lines:

```
net.bridge.bridge-nf-call-ip6tables = 0
net.bridge.bridge-nf-call-iptables = 0
net.bridge.bridge-nf-call-arptables = 0
```

Reload the kernel parameters configured with **`sysctl`**.

```
# sysctl -p /etc/sysctl.conf
```

6. **Restart the libvirt service**
   Restart the **`libvirt`** service with the **`service`** command.

```
# service libvirtd reload
```

7. **Verify the bridge**
   Verify the new bridge is available with the bridge control command (**`brctl`**).

```
# brctl show
bridge name     bridge id               STP enabled     interfaces
virbr0          8000.000000000000       yes
br0             8000.000e0cb30550       no              eth0
```

A "**Shared physical device**" is now available through **`virt-manager`** and libvirt, which guests can be attached and have full network access.

Note, the bridge is completely independent of the **`virbr0`** bridge. Do *not* attempt to attach a physical device to **`virbr0`**. The **`virbr0`** bridge is only for Network Address Translation (NAT) connectivity.

KVM Para-virtualized Drivers

Para-virtualized drivers are available for virtualized Windows guests running on KVM hosts. These para-virtualized drivers are included in the virtio package. The virtio package supports block (storage) devices and network interface controllers.

Para-virtualized drivers enhance the performance of fully virtualized guests. With the para-virtualized drivers guest I/O latency decreases and throughput increases to near bare-metal levels. It is recommended to use the para-virtualized drivers for fully virtualized guests running I/O heavy tasks and applications.

The KVM para-virtualized drivers are automatically loaded and installed on the following:

- Red Hat Enterprise Linux 4.8 and newer
- Red Hat Enterprise Linux 5.3 and newer
- Red Hat Enterprise Linux 6 and newer
- Some versions of Linux based on the 2.6.27 kernel or newer kernel versions.

Versions of Red Hat Enterprise Linux in the list above detect and install the drivers, additional installation steps are not required.

In Red Hat Enterprise Linux 3 (3.9 and above), manual installation is required.

Note

PCI devices are limited by the virtualized system architecture. Out of the 32 available PCI devices for a guest, 4 are not removable. This means there are up to 28 free PCI slots available for additional devices per guest. Each PCI device in a guest can have up to 8 functions.

The following Microsoft Windows versions are expected to function normally using KVM para-virtualized drivers:

- Windows XP (32-bit only)
- Windows Server 2003 (32-bit and 64-bit versions)
- Windows Server 2008 (32-bit and 64-bit versions)
- Windows 7 (32-bit and 64-bit versions)

11.1. Using the para-virtualized drivers with Red Hat Enterprise Linux 3.9 guests

Para-virtualized drivers for Red Hat Enterprise Linux 3.9 consist of five kernel modules: **`virtio`**, **`virtio_blk`**, **`virtio_net`**, **`virtio_pci`** and **`virtio_ring`**. All five modules must be loaded to use both the para-virtualized block and network devices drivers.

> **Note**
>
> For Red Hat Enterprise Linux 3.9 guests, the *kmod-virtio* package is a requirement for the **`virtio`** module.

> **Note**
>
> To use the network device driver only, load the **`virtio`**, **`virtio_net`** and **`virtio_pci`** modules. To use the block device driver only, load the **`virtio`**, **`virtio_ring`**, **`virtio_blk`** and **`virtio_pci`** modules.

> **Modified initrd files**
>
> The *virtio* package modifies the initrd RAM disk file in the **`/boot`** directory. The original initrd file is saved to **`/boot/initrd-`** *`kernel-version`* **`.img.virtio.orig`**. The original initrd file is replaced with a new initrd RAM disk containing the **`virtio`** driver modules. The initrd RAM disk is modified to allow the guest to boot from a storage device using the para-virtualized drivers. To use a different initrd file, you must ensure that drivers are loaded with the **`sysinit`** script (*Loading the para-virtualized drivers with the sysinit script*) or when creating new initrd RAM disk (*Adding the para-virtualized drivers to the initrd RAM disk*).

Loading the para-virtualized drivers with the sysinit script

This procedure covers loading the para-virtualized driver modules during the boot sequence on a Red Hat Enterprise Linux 3.9 or newer guest with the **`sysinit`** script. Note that the guest cannot use the para-virtualized drivers for the default boot disk if the modules are loaded with the **`sysinit`** script.

The drivers must be loaded in the following order:

1. **`virtio`**
2. **`virtio_ring`**
3. **`virtio_blk`**
4. **`virtio_net`**
5. **`virtio_pci`**

Only order of **`virtio_net`** and **`virtio_blk`** can be change. If the drivers are loaded in a different order, drivers will not work.

Configure the modules to . Locate the following section of the **`/etc/rc.d/rc.sysinit`** file.

```
if [ -f /etc/rc.modules ]; then
        /etc/rc.modules
fi
```

```
Append the following lines after that section:
```

```
if [ -f /etc/rc.modules ]; then
```

```
        /etc/rc.modules
fi

modprobe virtio
modprobe virtio_ring # Comment this out if you do not need block driver
modprobe virtio_blk  # Comment this out if you do not need block driver
modprobe virtio_net  # Comment this out if you do not need net driver
modprobe virtio_pci
```

Reboot the guest to load the kernel modules.

Adding the para-virtualized drivers to the initrd RAM disk

This procedure covers loading the para-virtualized driver modules with the kernel on a Red Hat Enterprise Linux 3.9 or newer guest by including the modules in the initrd RAM disk. The mkinitrd tool configures the initrd RAM disk to load the modules. Specify the additional modules with the `--with` parameter for the **`mkinitrd`** command. Append following set of parameters, in the exact order, when using the **`mkinitrd`** command to create a custom initrd RAM disk:

```
--with virtio --with virtio_ring --with virtio_blk --with virtio_net --with virtio_pci
```

AMD64 and Intel 64 issues

Use the **`x86_64`** version of the *virtio* package for AMD64 systems.

Use the **`ia32e`** version of the *virtio* package for Intel 64 systems. Using the **`x86_64`** version of the *virtio* may cause a '**`Unresolved symbol`**' error during the boot sequence on Intel 64 systems.

Network performance issues

If you experience low performance with the para-virtualized network drivers, verify the setting for the GSO, TSO, and LRO features on the host system. The para-virtualized network drivers require that the GSO, TSO and LRO options are disabled for optimal performance.

Verify the status of the GSO, TSO and LRO settings with the following command on the host (replacing *`interface`* with the network interface used by the guest):

```
# ethtool -k interface
```

Disable the GSO, TSO and LRO options with the following commands on the host:

```
# ethtool -K interface gso off
# ethtool -K interface tso off
# ethtool -K interface lro off
```

Para-virtualized driver swap partition issue

After activating the para-virtualized block device driver the swap partition may not be available. This issue is may be caused by a change in disk device name. To fix this issue, open the **`/etc/fstab`** file and locate the lines containing swap partitions, for example:

```
/dev/hda3  swap swap defaults 0 0
```

The para-virtualized drivers use the **`/dev/vd*`** naming convention, not the **`/dev/hd*`** naming convention. To resolve this issue modify the incorrect swap entries in the **`/etc/fstab`** file to use the **`/dev/vd*`** convention, for the example above:

```
/dev/vda3  swap swap defaults 0 0
```

Save the changes and reboot the virtualized guest. The guest should now correctly have swap partitions.

11.2. Installing the KVM Windows para-virtualized drivers

This section covers the installation process for the KVM Windows para-virtualized drivers. The KVM para-virtualized drivers can be loaded during the Windows installation or installed after the guest is installed.

You can install the para-virtualized drivers on your guest by one of the following methods:

- hosting the installation files on a network accessible to the guest,
- using a virtualized CD-ROM device of the driver installation disk .iso file, or
- using a virtualized floppy device to install the drivers during boot time (for Windows guests).

This guide describes installation from the para-virtualized installer disk as a virtualized CD-ROM device.

1. **Download the drivers**
   The *virtio-win* package contains the para-virtualized block and network drivers for all supported Windows guests.

   Download the *virtio-win* package with the **yum** command.

   ```
   # yum install virtio-win
   ```

   The drivers are also from Microsoft (*windowsservercatalog.com*[1]). Note that the Red Hat Enterprise Virtualization Hypervisor and Red Hat Enterprise Linux are created on the same code base so the drivers for the same version (for example, Red Hat Enterprise Virtualization Hypervisor 2.2 and Red Hat Enterprise Linux 5.5) are supported for both environments.

   The *virtio-win* package installs a CD-ROM image, **virtio-win.iso**, in the **/usr/share/virtio-win/** directory.

2. **Install the para-virtualized drivers**
   It is recommended to install the drivers on the guest before attaching or modifying a device to use the para-virtualized drivers.

   For block devices storing root file systems or other block devices required for booting the guest, the drivers must be installed before the device is modified. If the drivers are not installed on the guest and the driver is set to the virtio driver the guest will not boot.

11.2.1. Installing the drivers on an installed Windows guest

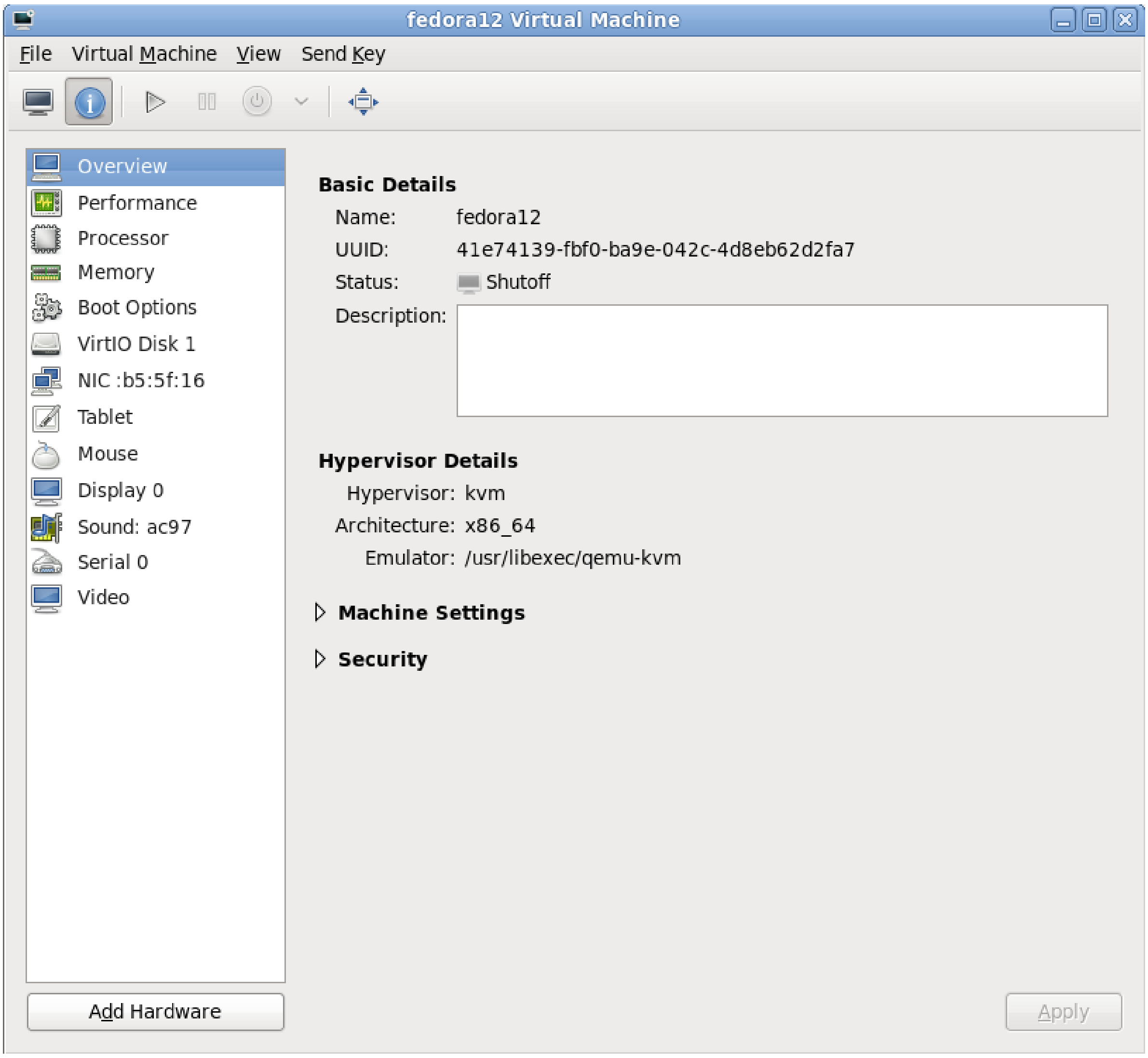
This procedure covers installing the para-virtualized drivers with a virtualized CD-ROM after Windows is installed.

Follow *Procedure 11.1, “Installing from the driver CD-ROM image with virt-manager”* to add a CD-ROM image with **virt-manager** and then install the drivers.

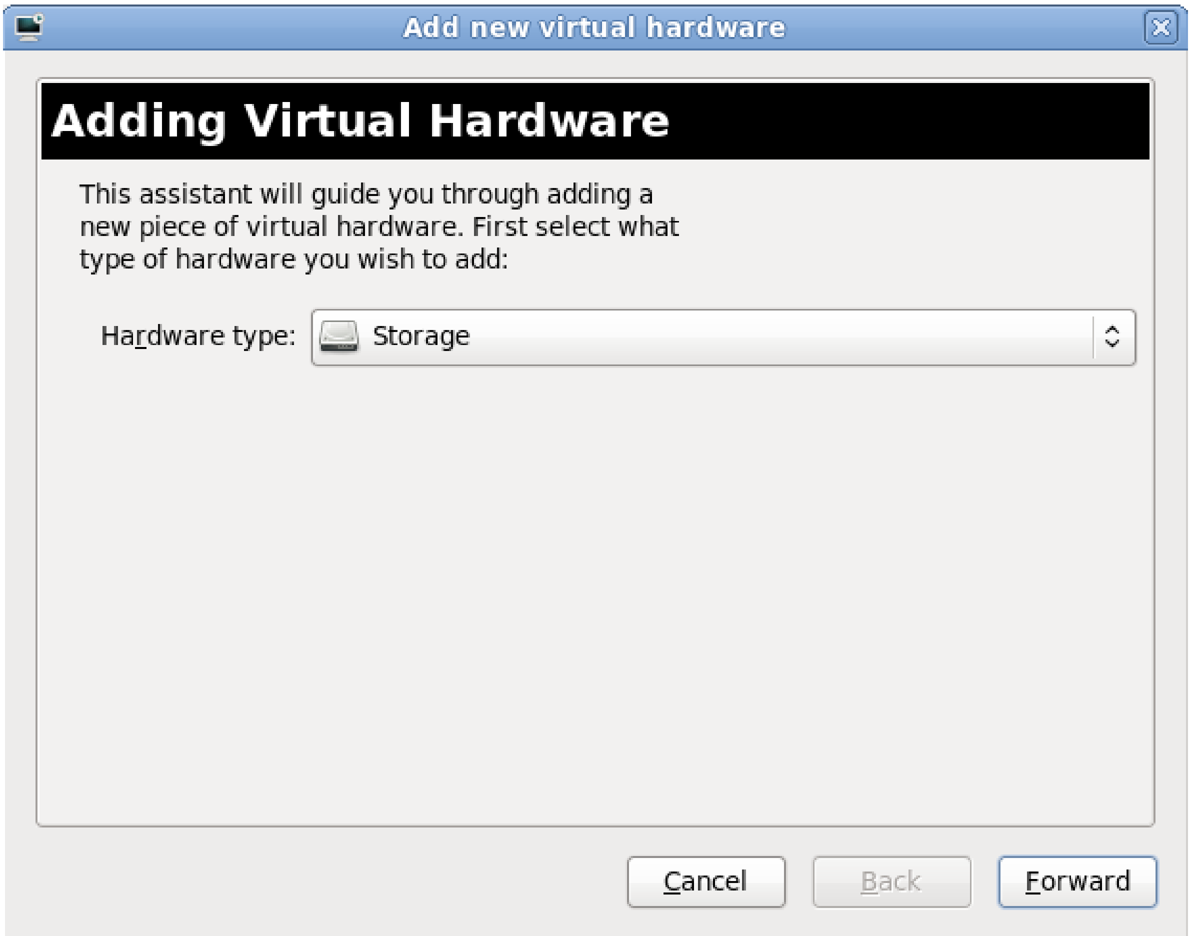
Procedure 11.1. Installing from the driver CD-ROM image with virt-manager

1. **Open virt-manager and the guest**
   Open **`virt-manager`**, select your virtualized guest from the list by double clicking the guest name.

2. **Open the hardware window**
   Click the blue **Information** button at the top to view guest details. Then click the **Add Hardware** button at the bottom of the window.



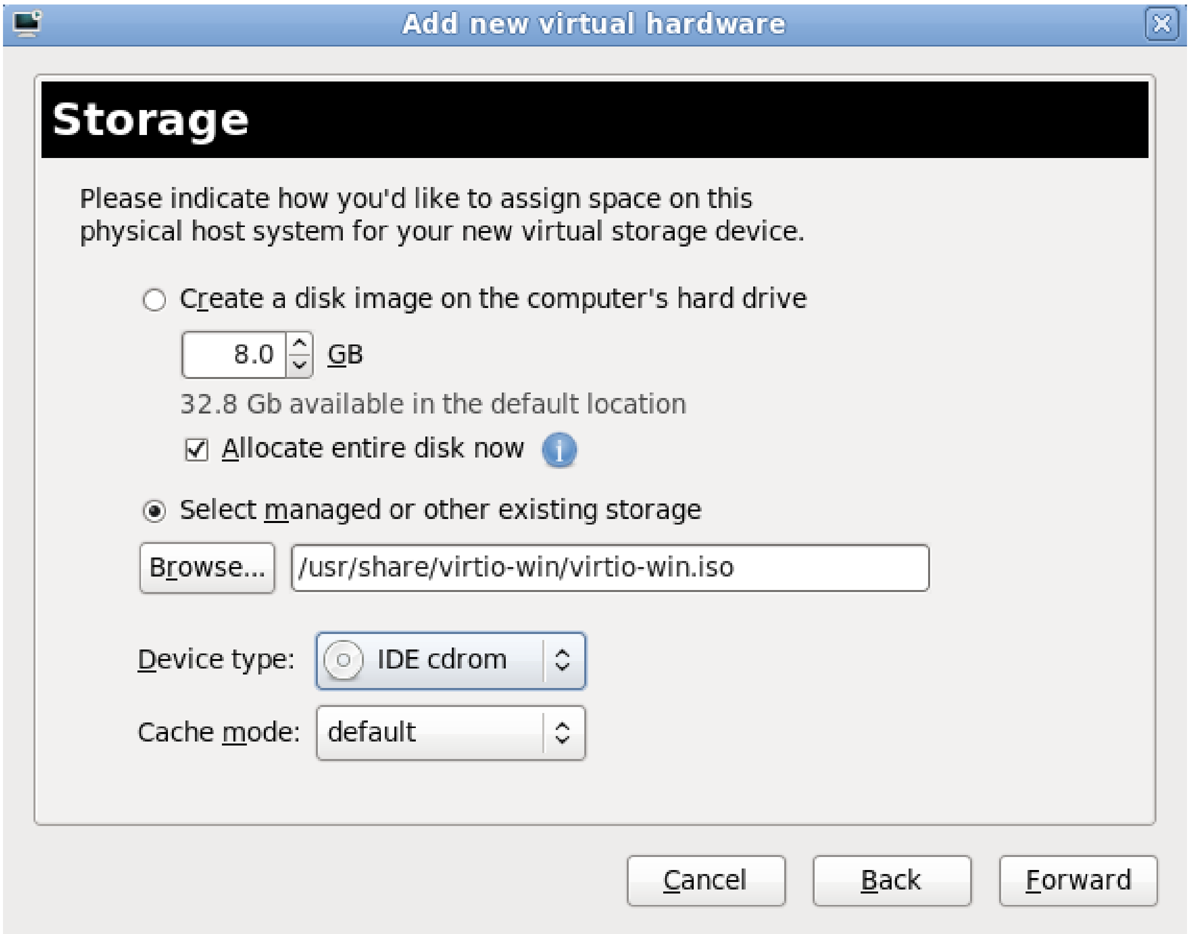
3. **Select the device type**
   This opens a wizard for adding the new device. Select **Storage** from the dropdown menu.



Click the **Forward** button to proceed.

4. **Select the ISO file**
   Select **Select managed or other existing storage** and set the file location of the para-virtualized drivers .iso image file. The default location for the latest version of the drivers is **`/usr/share/virtio-win/virtio-win.iso`**.

   Change the **Device type** to **IDE cdrom** and click the **Forward** button to proceed.



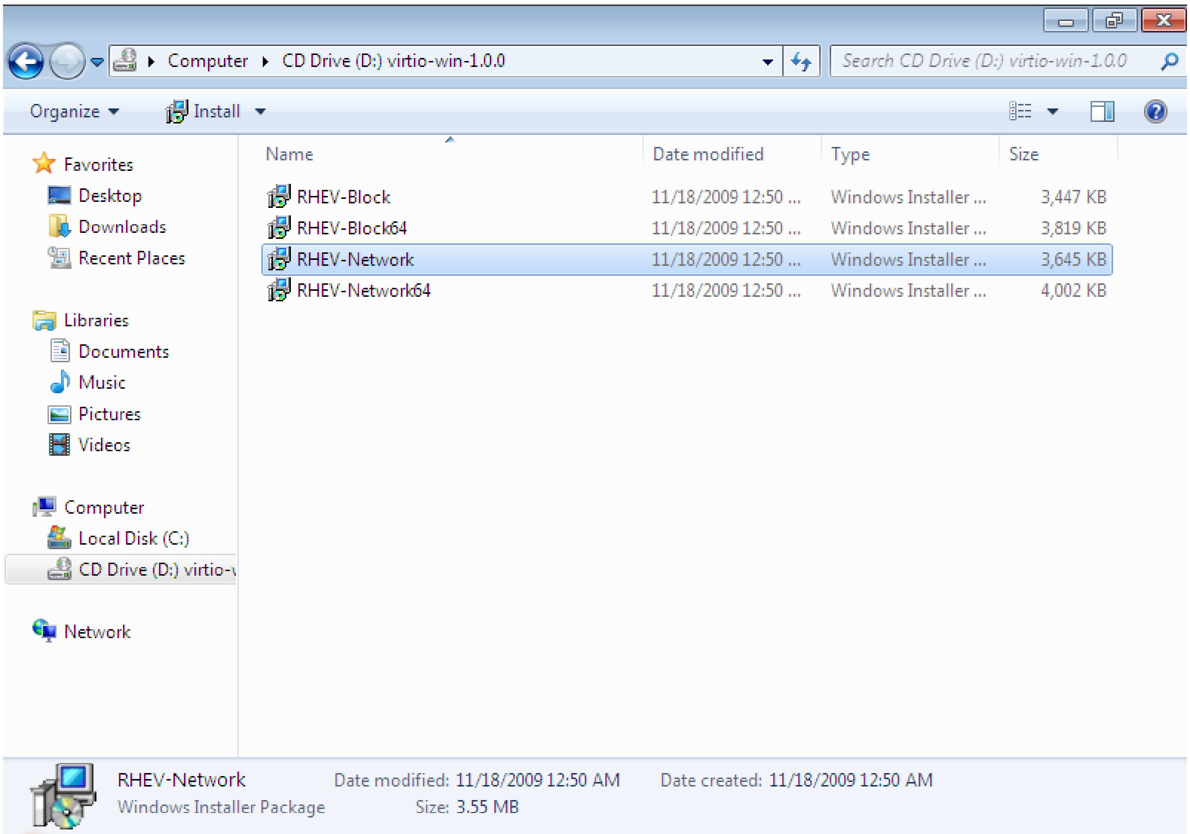
5. **Finish adding virtual hardware**
   Press the **Finish** button to complete the wizard.

6. **Reboot**
   Reboot or start the guest to begin using the driver disc. Virtualized IDE devices require a restart to for the guest to recognize the new device.

Once the CD-ROM with the drivers is attached and the guest has started, proceed with *Procedure 11.2, "Windows installation"*.

Procedure 11.2. Windows installation

1. **Open My Computer**
   On the Windows guest, open **My Computer** and select the CD-ROM drive.



2. **Select the correct installation files**

   There are four files available on the disc. Select the drivers you require for your guest's architecture:

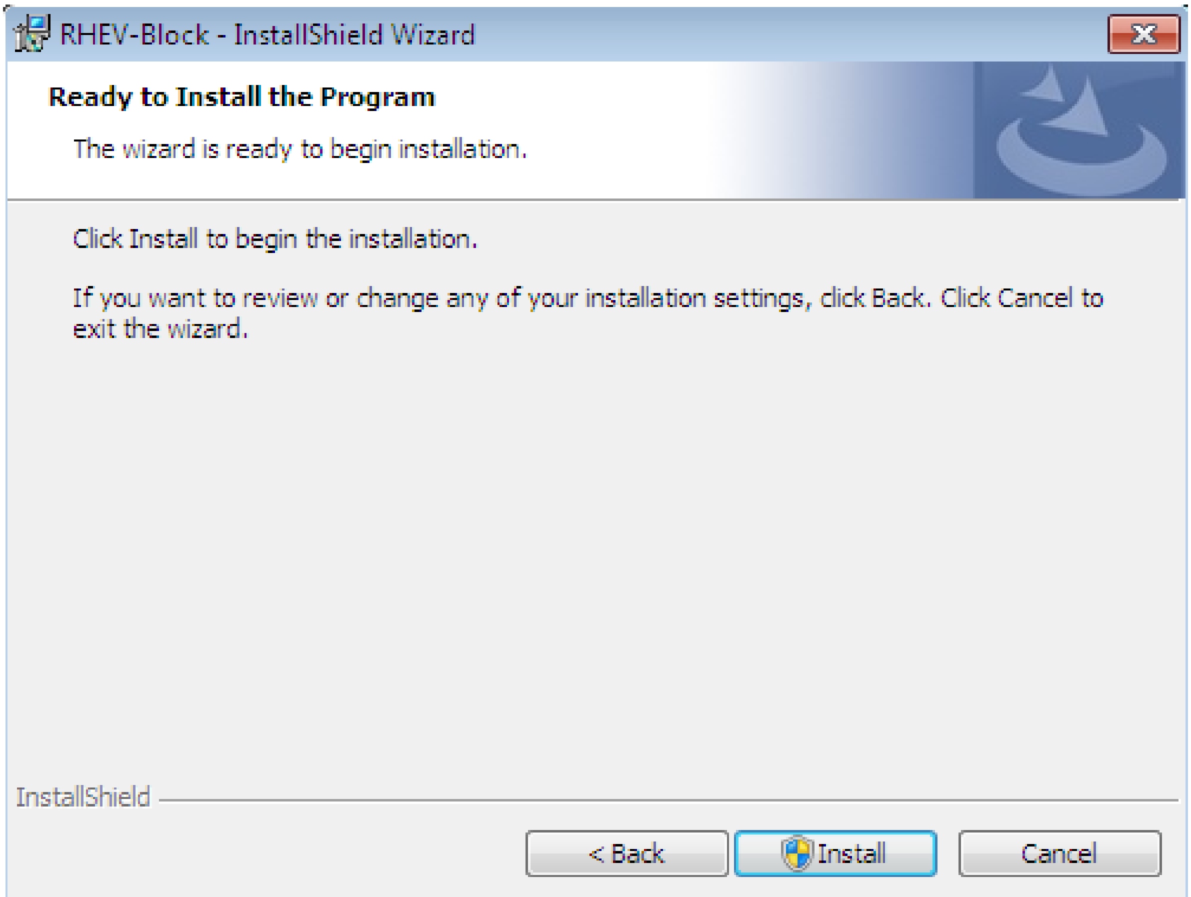
   - the para-virtualized block device driver (**`RHEV-Block.msi`** for 32-bit guests or **`RHEV-Block64.msi`** for 64-bit guests),
   - the para-virtualized network device driver (**`RHEV-Network.msi`** for 32-bit guests or **`RHEV-Block64.msi`** for 64-bit guests),
   - or both the block and network device drivers.

   Double click the installation files to install the drivers.

3. **Install the block device driver**

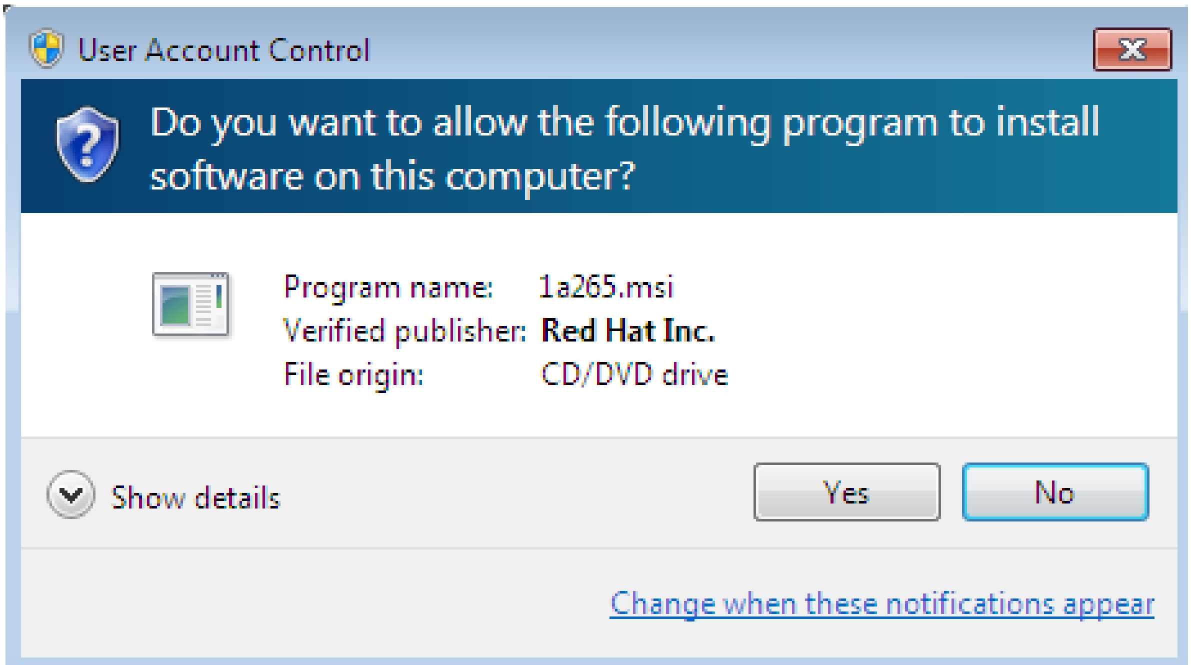
   a. **Start the block device driver installation**

      Double click **`RHEV-Block.msi`** or **`RHEV-Block64.msi`**.



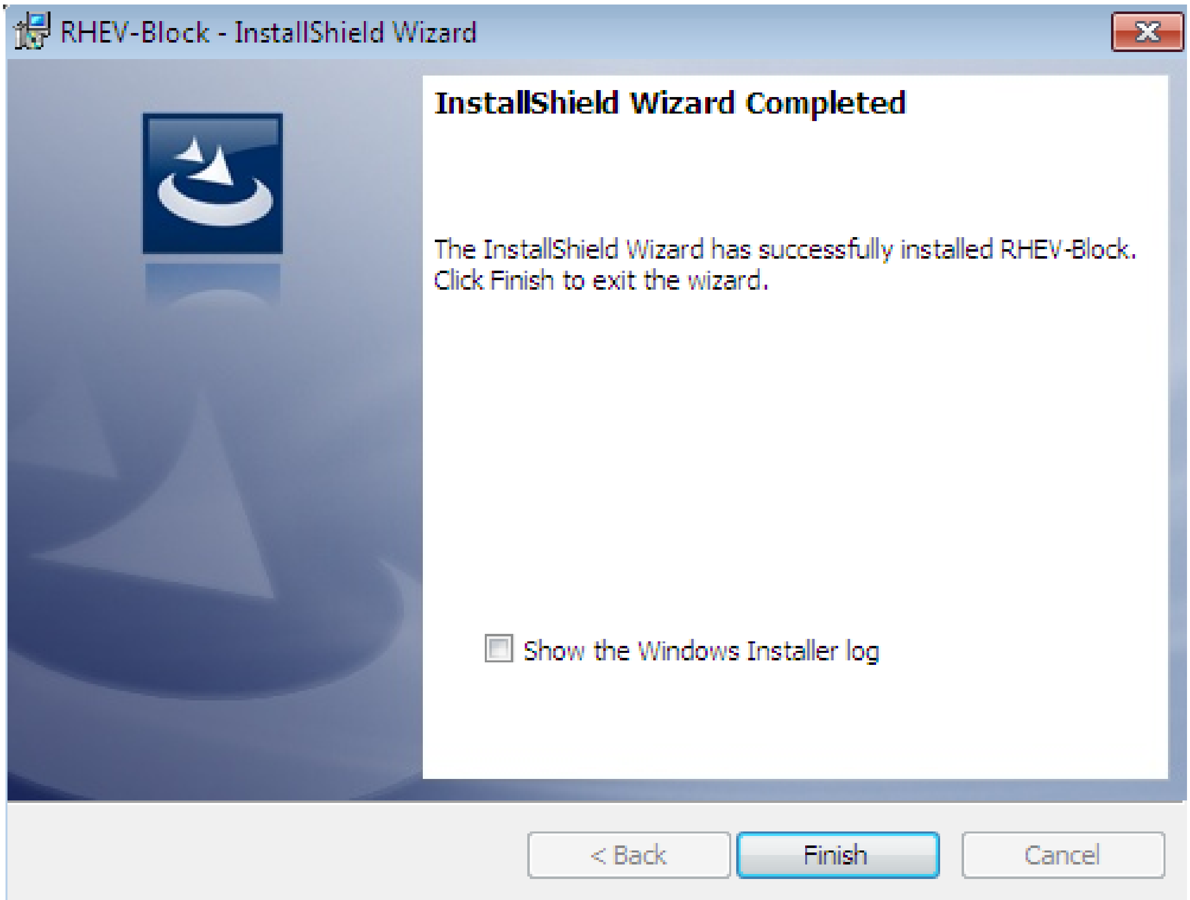
Press **Install** to continue.

b. **Confirm the exception**
Windows may prompt for a security exception.



Press **Yes** if it is correct.

c. **Finish**

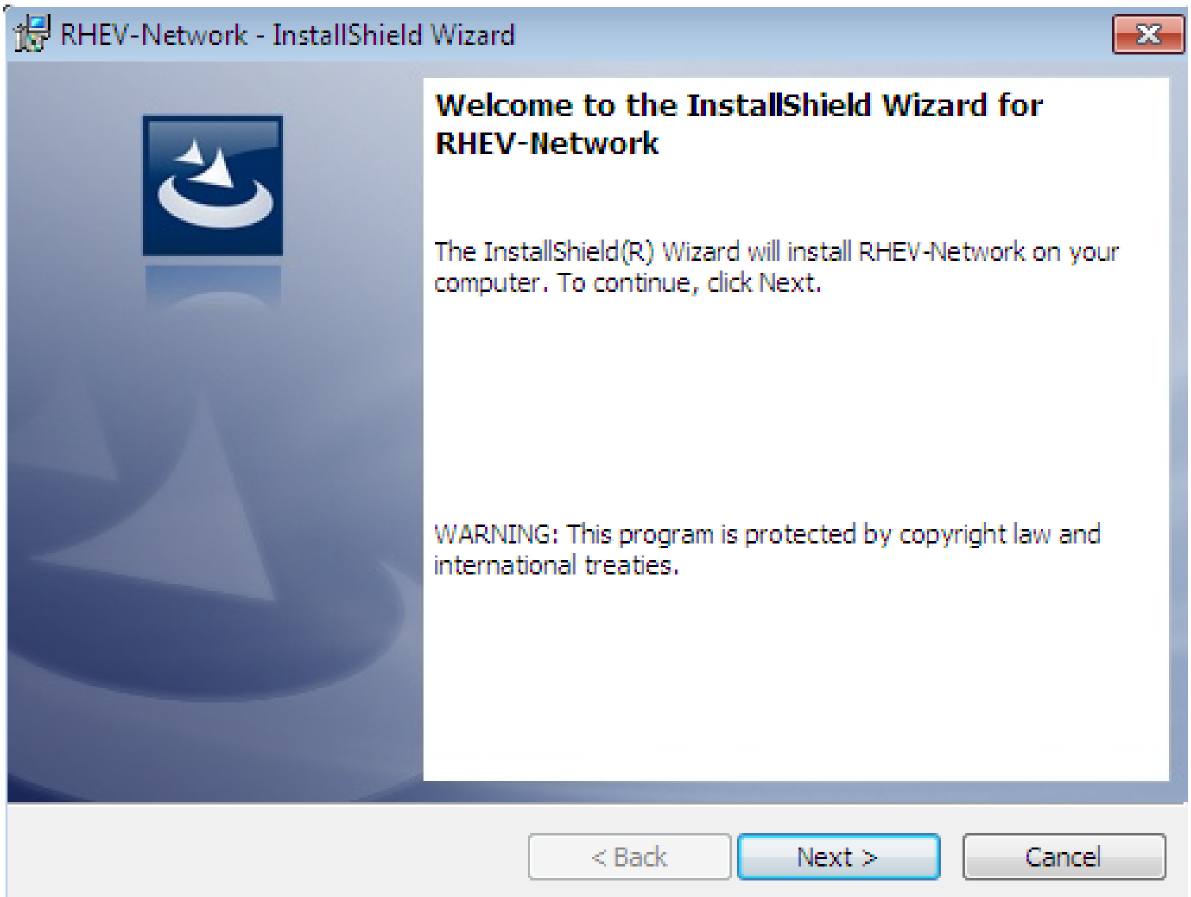


Press **Finish** to complete the installation.

4. **Install the network device driver**

   a. **Start the network device driver installation**

   Double click **`RHEV-Network.msi`** or **`RHEV-Network64.msi`**.



Press **Next** to continue.

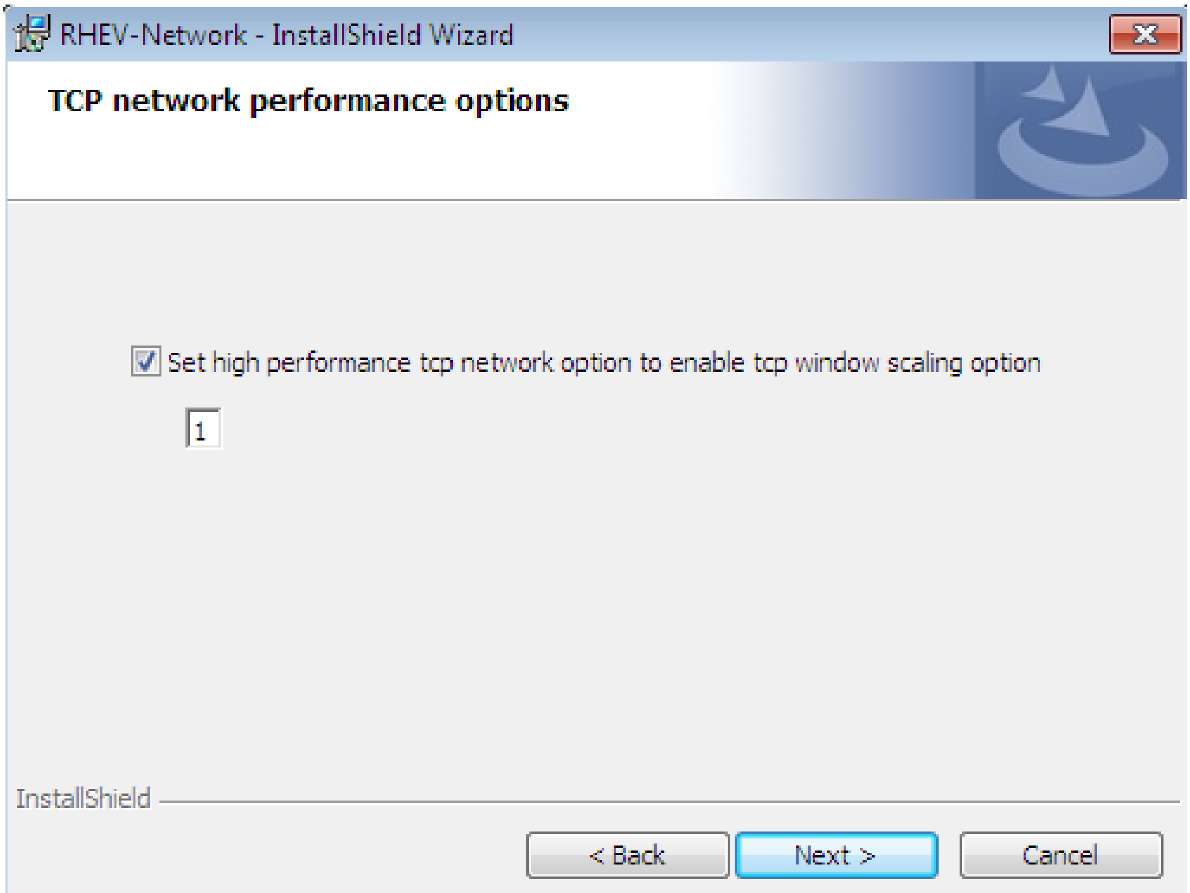
b. **Performance setting**

This screen configures advanced TCP settings for the network driver. TCP timestamps and TCP window scaling can be enabled or disabled. The default is, 1, for window scaling to be enabled.

TCP window scaling is covered by *IETF RFC 1323*[2]. The RFC defines a method of increasing the receive window size to a size greater than the default maximum of 65,535 bytes up to a new maximum of 1 gigabyte (1,073,741,824 bytes). TCP window scaling allows networks to transfer at closer to theoretical network bandwidth limits. Larger receive windows may not be supported by some networking hardware or operating systems.

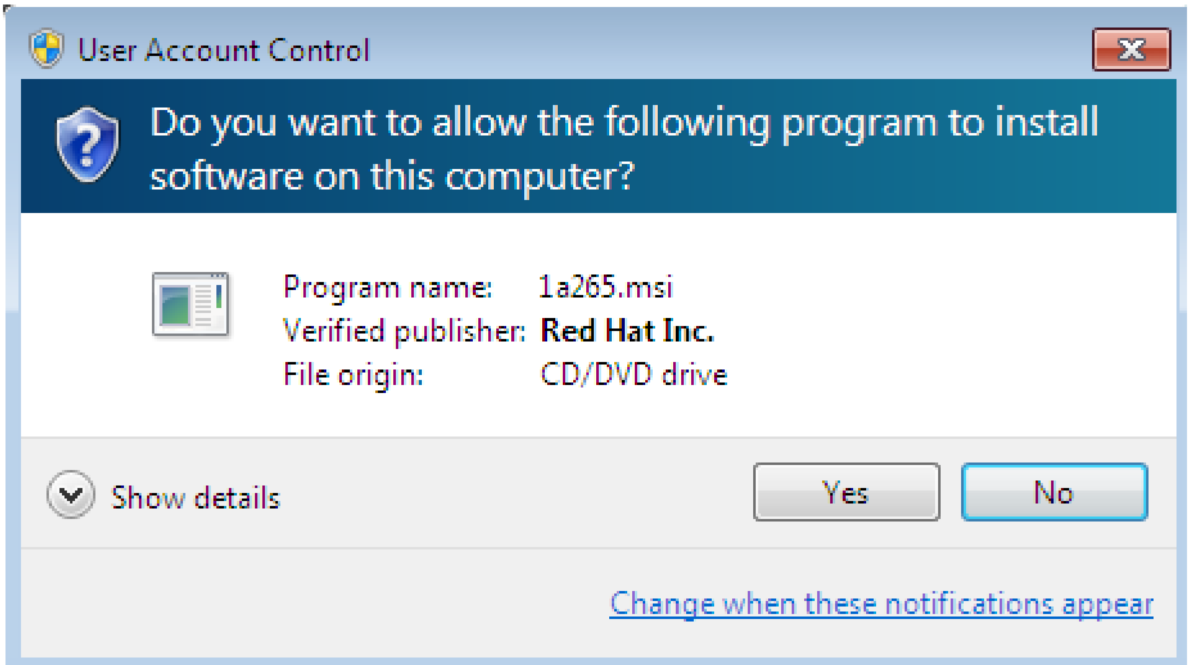
TCP timestamps are also defined by *IETF RFC 1323*[3]. TCP timestamps are used to better calculate Return Travel Time estimates by embedding timing information is embedded in packets. TCP timestamps help the system to adapt to changing traffic levels and avoid congestion issues on busy networks.

Value	Action
0	Disable TCP timestamps and window scaling.
1	Enable TCP window scaling.
2	Enable TCP timestamps.
3	Enable TCP timestamps and window scaling.



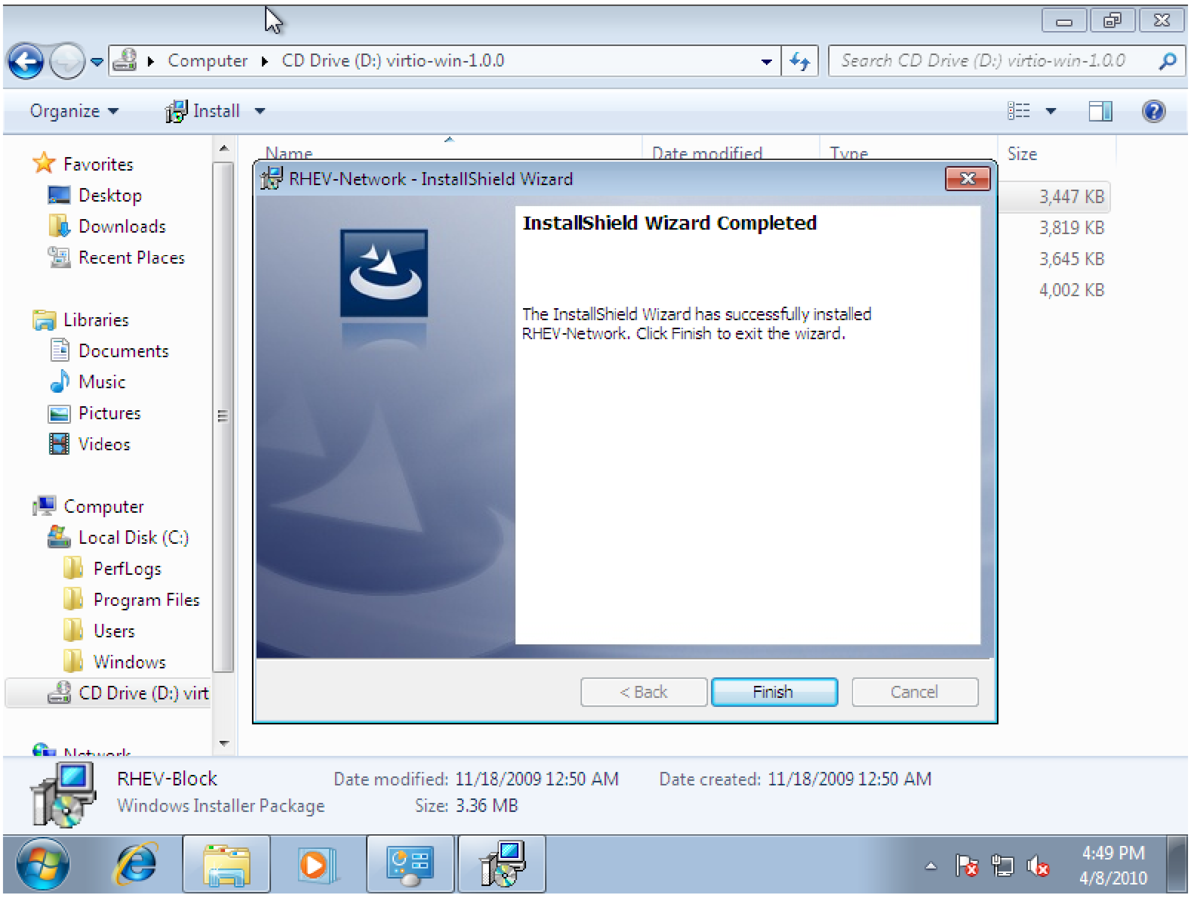
Press **Next** to continue.

c. **Confirm the exception**
Windows may prompt for a security exception.



Press **Yes** if it is correct.

d. **Finish**



Press **Finish** to complete the installation.

5. **Reboot**
   Reboot the guest to complete the driver installation.

Change an existing device to use the para-virtualized drivers (*Section 11.3, “Using KVM para-virtualized drivers for existing devices”*) or install a new device using the para-virtualized drivers (*Section 11.4, “Using KVM para-virtualized drivers for new devices”*).

11.2.2. Installing drivers during the Windows installation

This procedure covers installing the para-virtualized drivers during a Windows installation.

This method allows a Windows guest to use the para-virtualized (**`virtio`**) drivers for the default storage device.

1. Install the virtio-win package:

```
# yum install virtio-win
```

Creating guests

Create the guest, as normal, without starting the guest. Follow one of the procedures below.

2. **Creating the guest with virsh**
   This method attaches the para-virtualized driver floppy disk to a Windows guest *before* the installation.

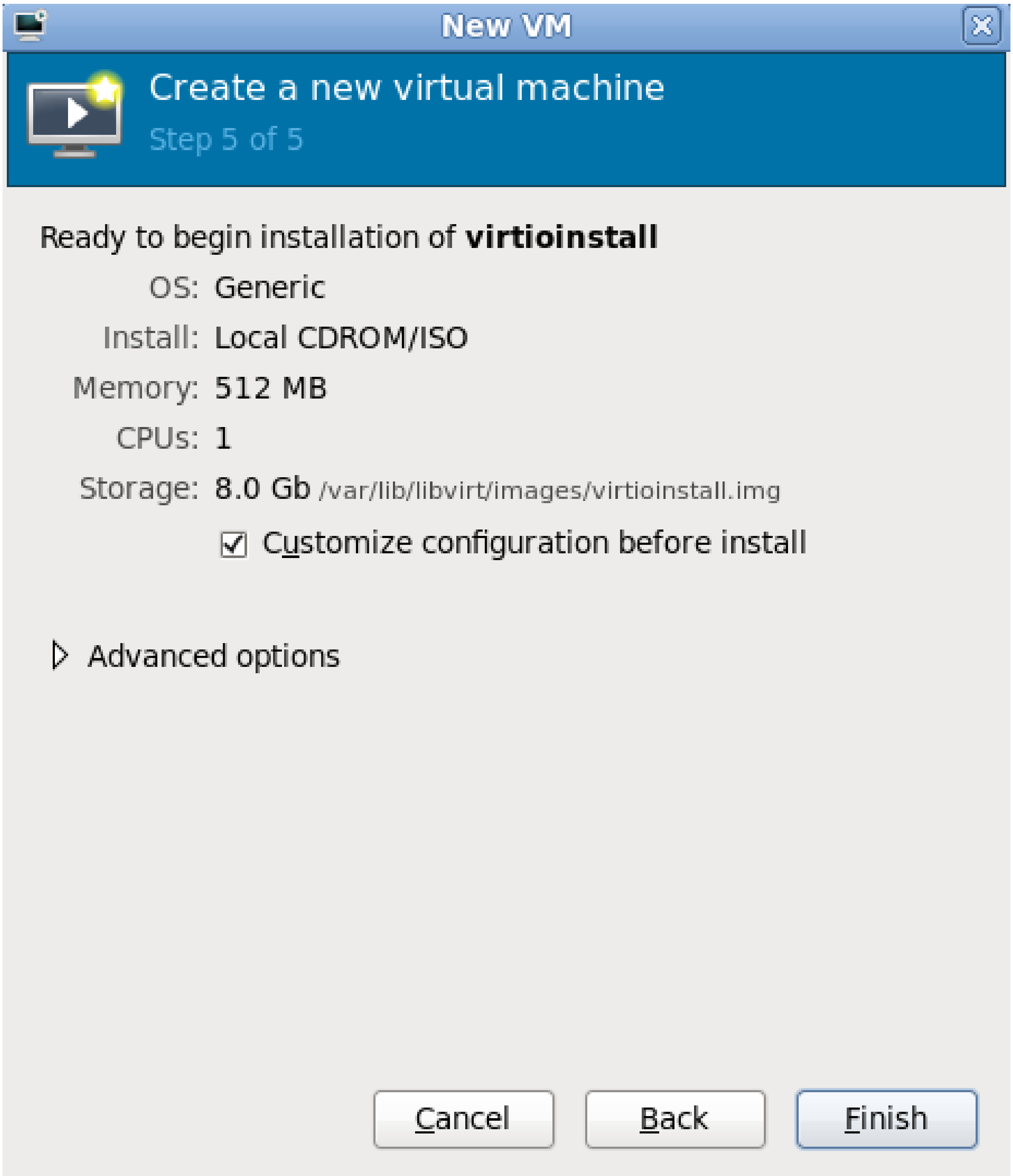
   If the guest is created from an XML definition file with **`virsh`** use the **`virsh define`** command not the **`virsh create`** command.

   a. Create, but do not start, the guest. Refer to *Chapter 30, Managing guests with virsh* for details on creating guests with the **`virsh`** command.

   b. Add the driver disk as a virtualized floppy disk with the **`virsh`** command. This example can be copied and used if there are no other virtualized floppy devices attached to the virtualized guest.

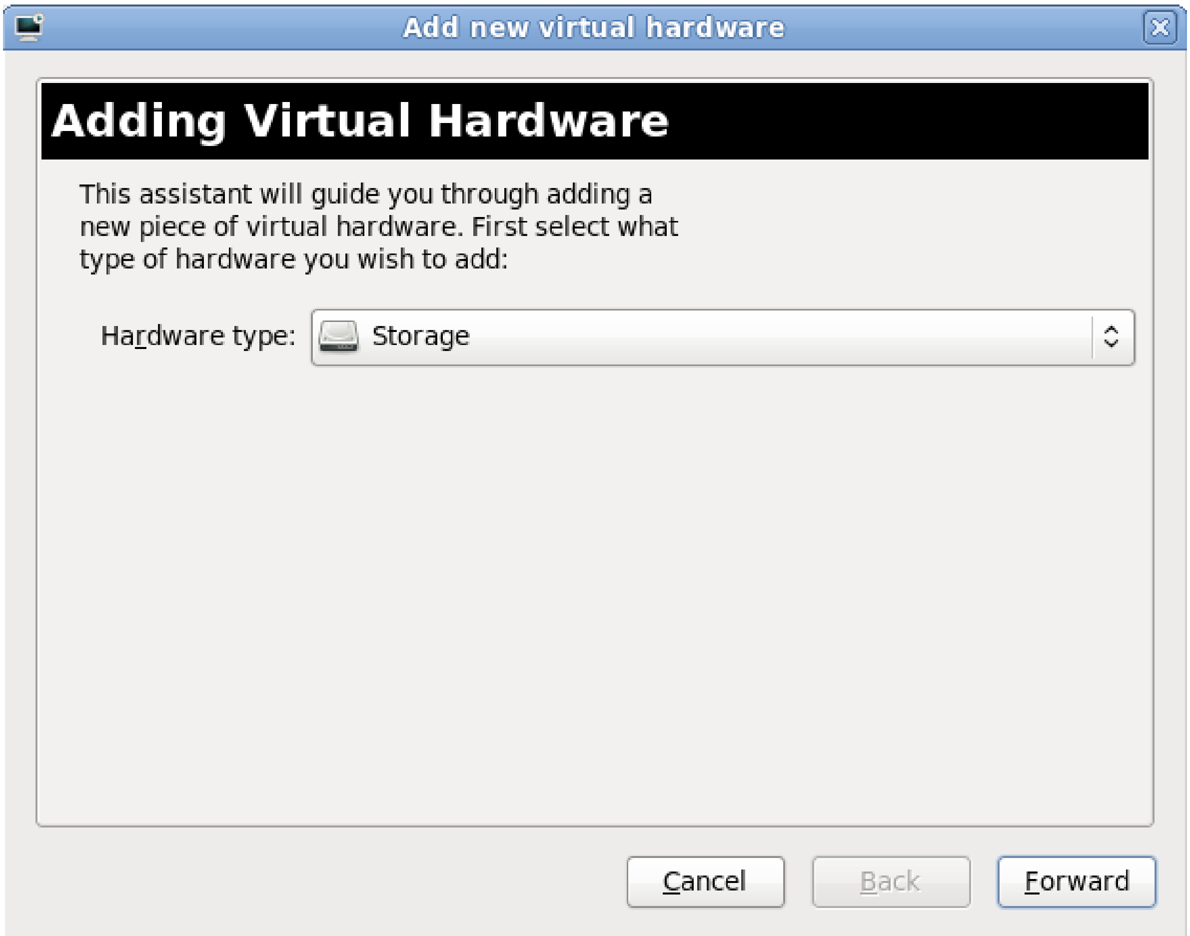
   ```
   # virsh attach-disk guest1 /usr/share/virtio-win/virtio-win.vfd fda --type floppy
   ```

3. **Creating the guest with virt-manager**
   a. At the final step of the virt-manager guest creation wizard, check the **Customize configuration before install** checkbox.



Press the **Finish** button to continue.

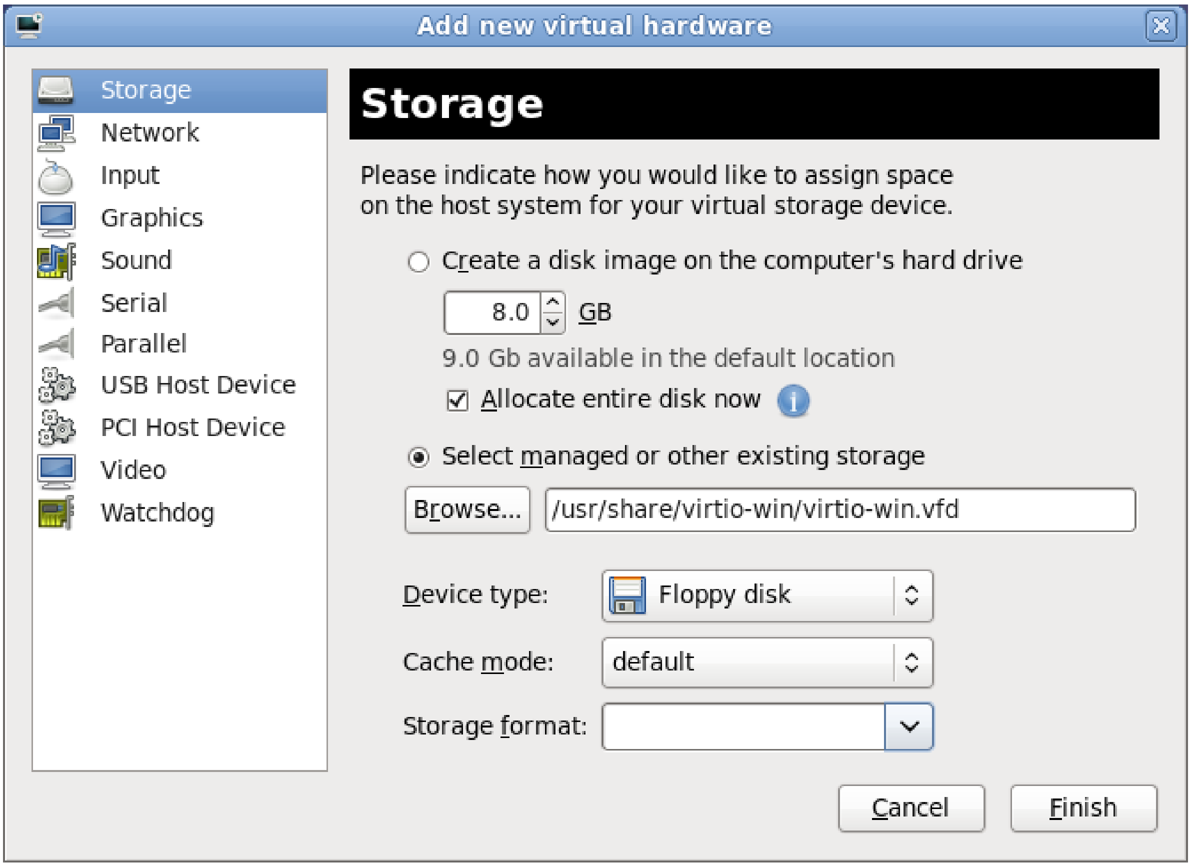
b. **Add the new device**
Select **Storage** from the **Hardware type** list. Click **Forward** to continue.



c. **Select the driver disk**
   Select **Select managed or existing storage**.

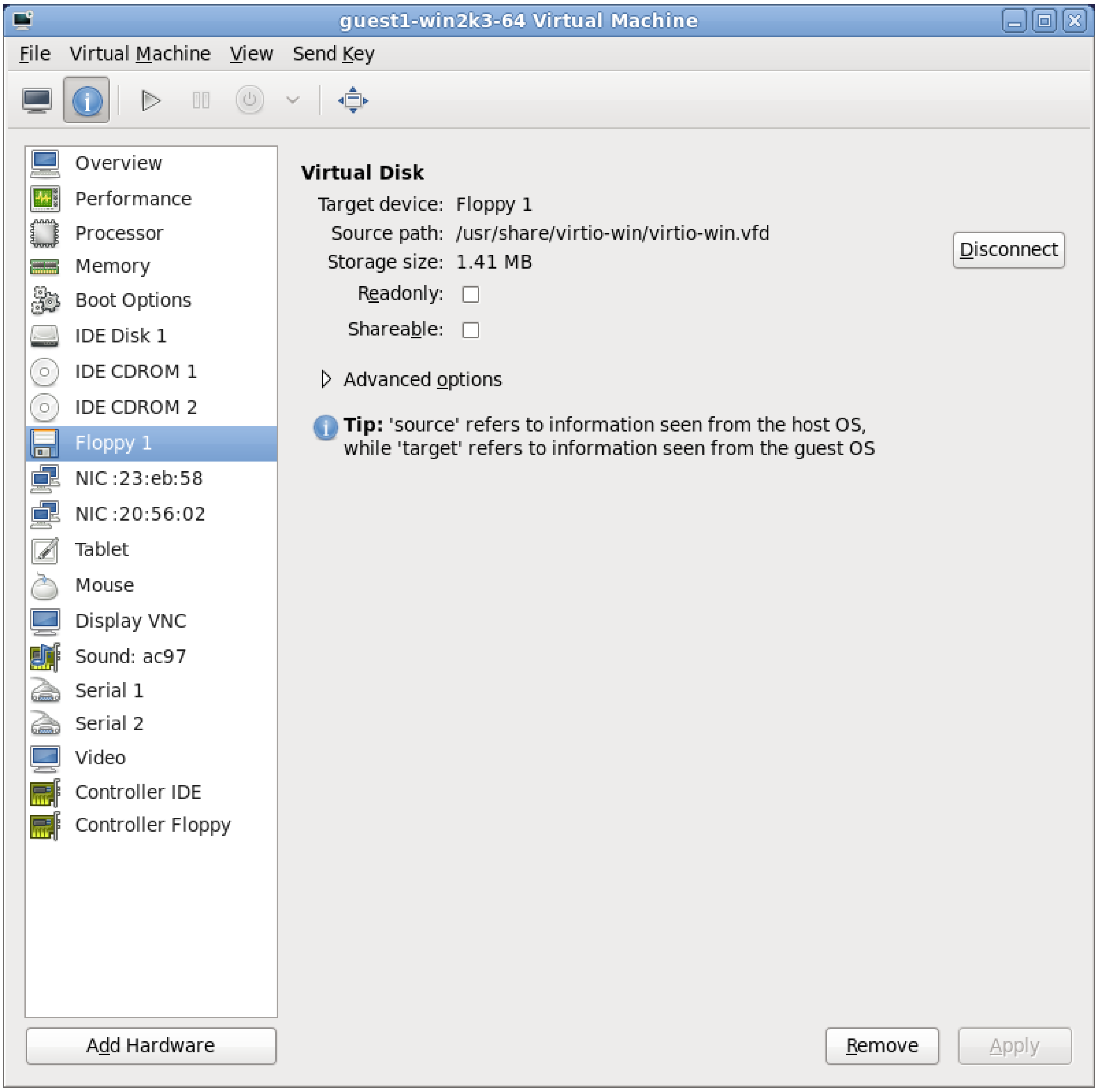
   Set the location to **`/usr/share/virtio-win/virtio-win.vfd`**.

   Change **Device type** to **Floppy disk**.



Press the **Finish** button to continue.

d. **Confirm settings**
   Review the device settings.



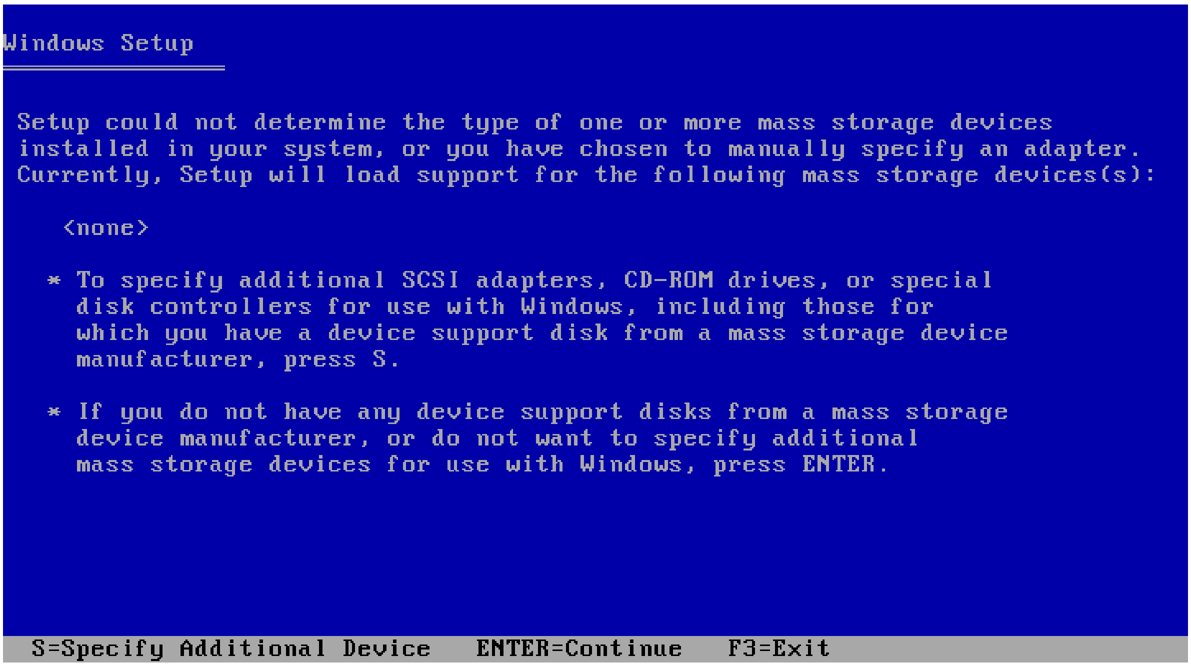
4. **Creating the guest with virt-install**
   Append the following parameter exactly as listed below to add the driver disk to the installation with the **`virt-install`** command :

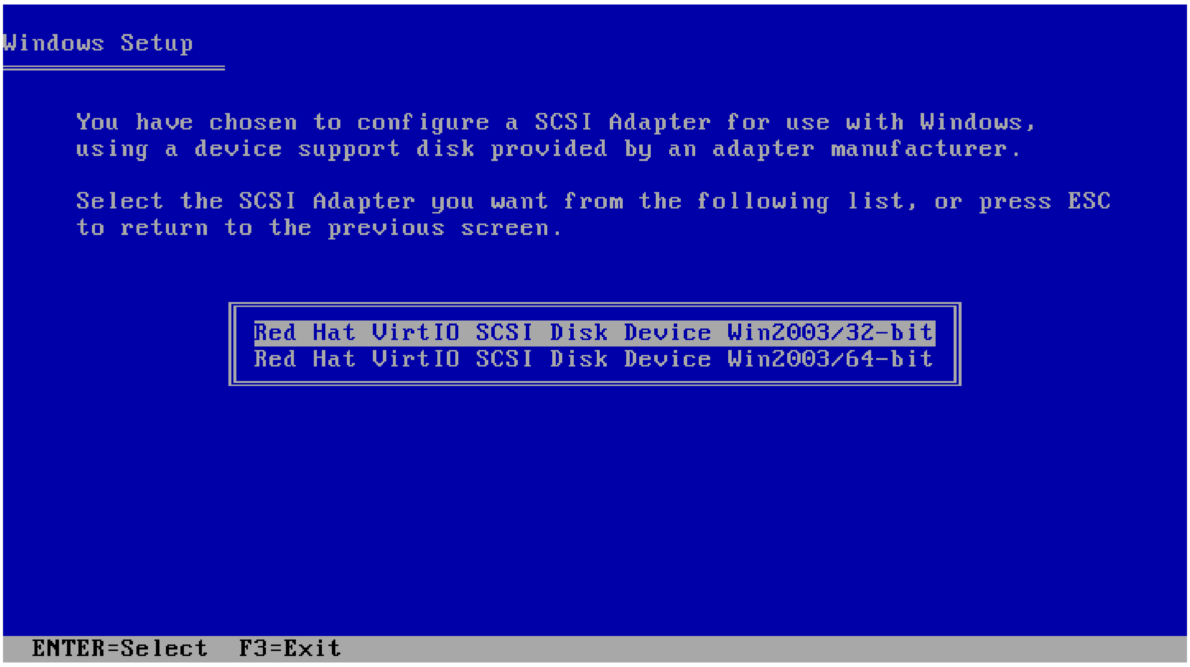
   ```
   --disk path=/usr/share/virtio-win/virtio-win.vfd,device=floppy
   ```

5. During the installation, additional steps are required to install drivers, depending on the type of Windows guest.

   a. **Windows Server 2003 and Windows XP**
      Before the installation blue screen repeatedly press **F6** for third party drivers.

Press S to install additional





Press **`Enter`** to continue the installation.

b. **Windows Server 2008**
Install the guest as described by *Section 9.1, “Using virt-install to create a guest”*

When the installer prompts you for the driver, click on **Load Driver**, point the installer to `Drive A:` and pick the driver that suits your guest operating system and architecture.

11.3. Using KVM para-virtualized drivers for existing devices

You can modify an existing hard disk device attached to the guest to use the **`virtio`** driver instead of the virtualized IDE driver. This example edits libvirt configuration files. Alternatively, **`virt-manager`**, **`virsh attach-disk`** or **`virsh attach-interface`** can add a new device using the para-virtualized drivers *Section 11.4, “Using KVM para-virtualized drivers for new devices”*. Note that the guest does not need to be shut down to perform these steps, however the change will not be applied until the guest is completely shut down and rebooted.

1. Run the **`virsh edit <guestname>`** command to edit the XML configuration file for your device. For example, **`virsh edit guest1`**. The configuration files are located in **`/etc/libvirt/qemu`**.

2. Below is a file-based block device using the virtualized IDE driver. This is a typical entry for a virtualized guest not using the para-virtualized drivers.

```
<disk type='file' device='disk'>
   <source file='/var/lib/libvirt/images/disk1.img'/>
   <target dev='hda' bus='ide'/>
</disk>
```

3. Change the entry to use the para-virtualized device by modifying the **bus=** entry to **`virtio`**. Note that if the disk was previously IDE it will have a target similar to hda, hdb, or hdc and so on. When changing to **bus=virtio** the target needs to be changed to vda, vdb, or vdc accordingly.

```
<disk type='file' device='disk'>
```

```
    <source file='/var/lib/libvirt/images/disk1.img'/>
    <target dev='vda' bus='virtio'/>
</disk>
```

4. Remove the **address** tag inside the **disk** tags. This must be done for this procedure to work. Libvirt will regenerate the **address** tag appropriately the next time the guest is started.

Please refer to the libvirt wiki: *http://wiki.libvirt.org/page/Virtio* for more details on using Virtio.

11.4. Using KVM para-virtualized drivers for new devices

This procedure covers creating new devices using the KVM para-virtualized drivers with **`virt-manager`**.

Alternatively, the **`virsh attach-disk`** or **`virsh attach-interface`** commands can be used to attach devices using the para-virtualized drivers.

Install the drivers first

Ensure the drivers have been installed on the Windows guest before proceeding to install new devices. If the drivers are unavailable the device will not be recognized and will not work.

Procedure 11.3. Starting the new device wizard

1. Open the virtualized guest by double clicking on the name of the guest in **`virt-manager`**.

2. Open the **Information** tab by pressing the **`i`** information button.

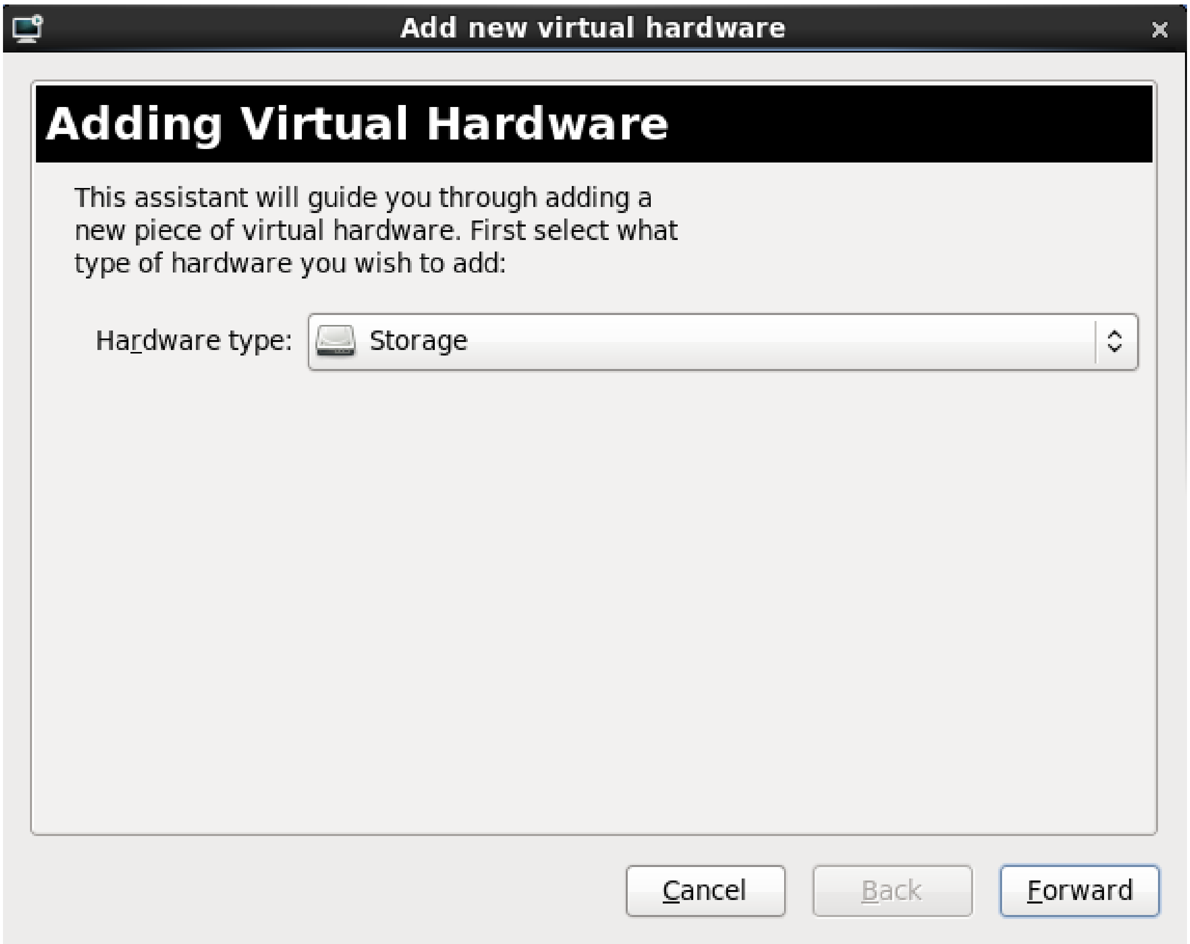
Figure 11.1. The information tab button

3. In the information tab, press the **Add Hardware** button.

4. In the Adding Virtual Hardware tab select **Storage** or **Network** for the type of device. The storage and network device wizards are covered in procedures *Procedure 11.4, "Adding a storage device using the para-virtualized storage driver"* and *Procedure 11.5, "Adding a network device using the para-virtualized network driver"*

Procedure 11.4. Adding a storage device using the para-virtualized storage driver

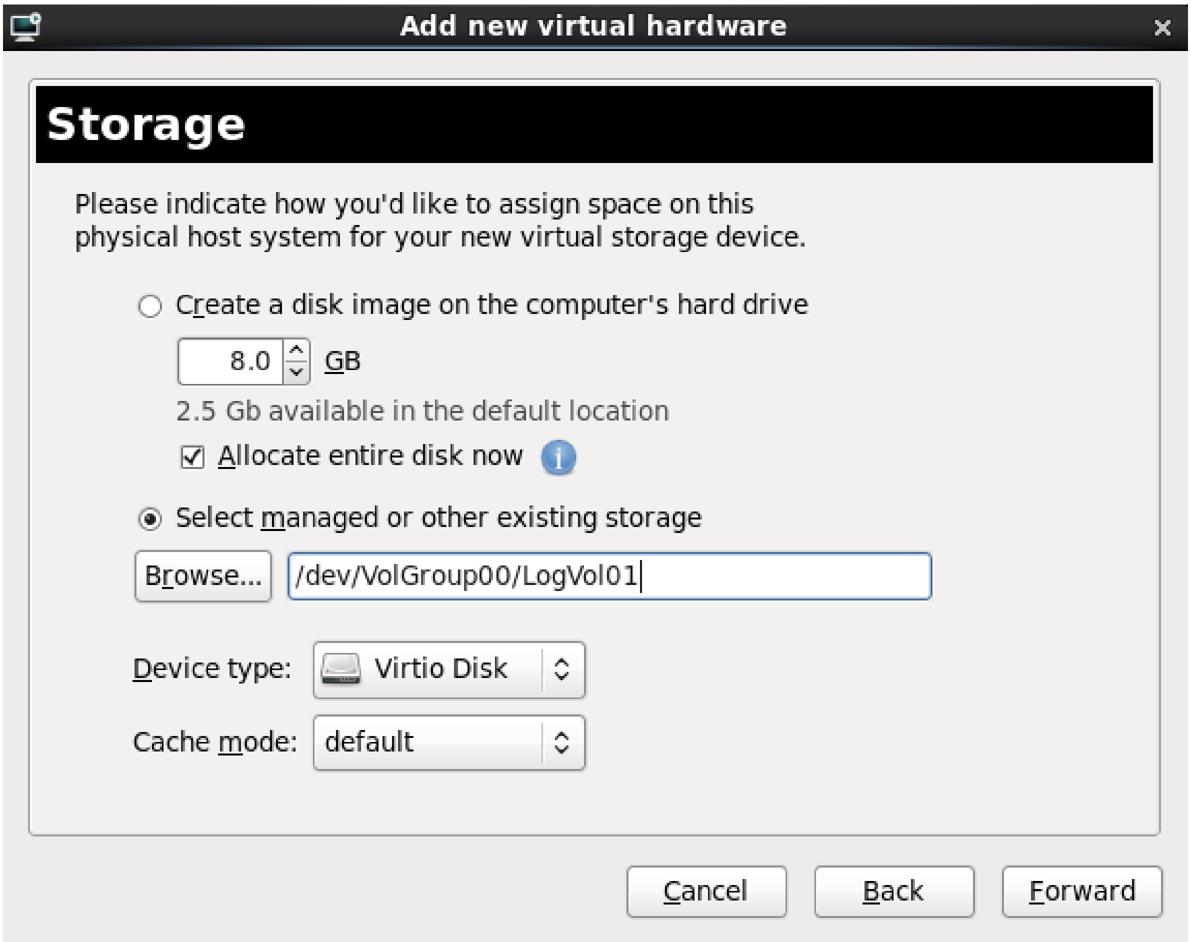
1. **Select hardware type**
   Select **Storage** as the **Hardware type**.



Press **Forward** to continue.

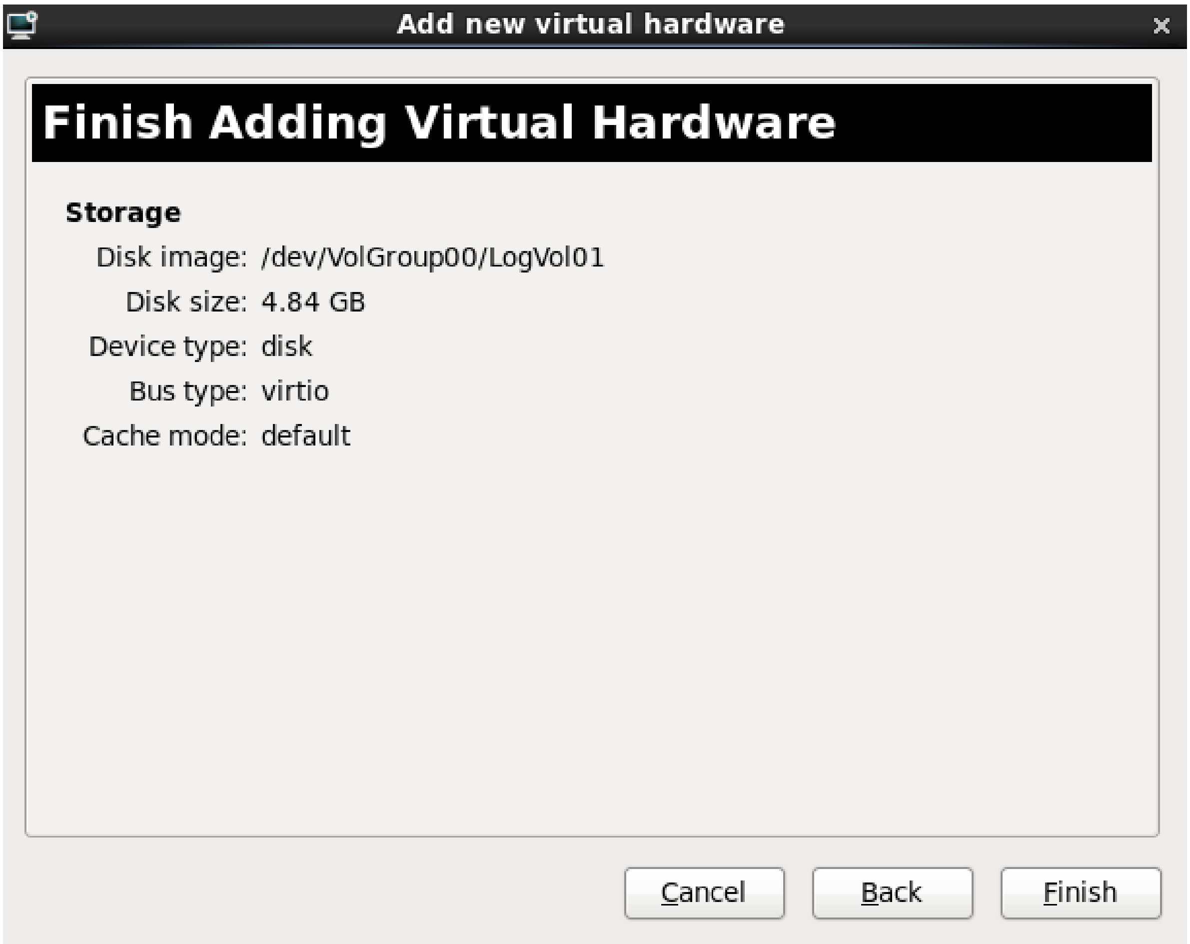
2. **Select the storage device and driver**
   Create a new disk image or select a storage pool volume.

   Set the **Device type** to **Virtio Disk** to use the para-virtualized drivers.



Press **Forward** to continue.

3. **Finish the procedure**
   Confirm the details for the new device are correct.



Press **Finish** to complete the procedure.

Procedure 11.5. Adding a network device using the para-virtualized network driver

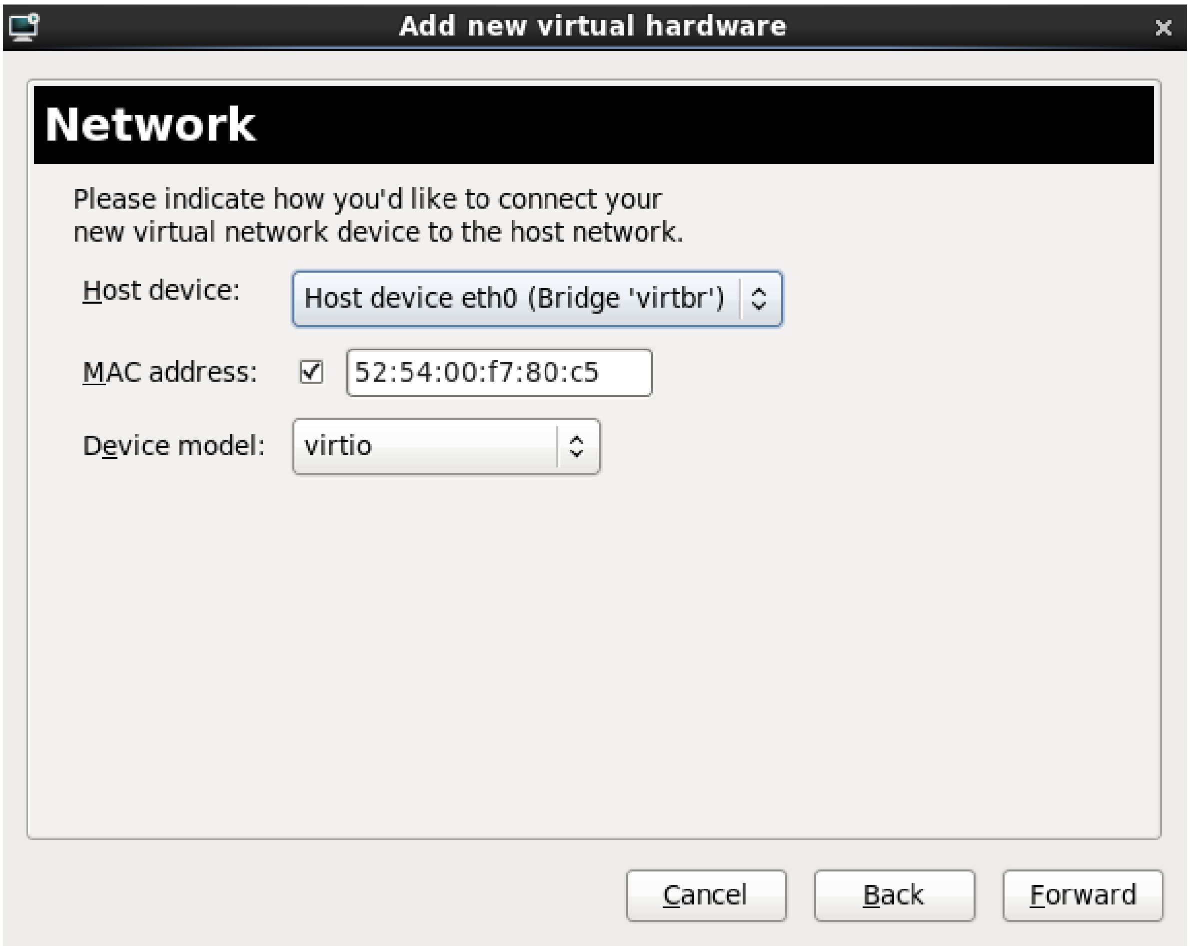
1. **Select hardware type**
   Select **Network** as the **Hardware type**.

Press **Forward** to continue.

2. **Select the network device and driver**
   Select the network device from the **Host device** list.

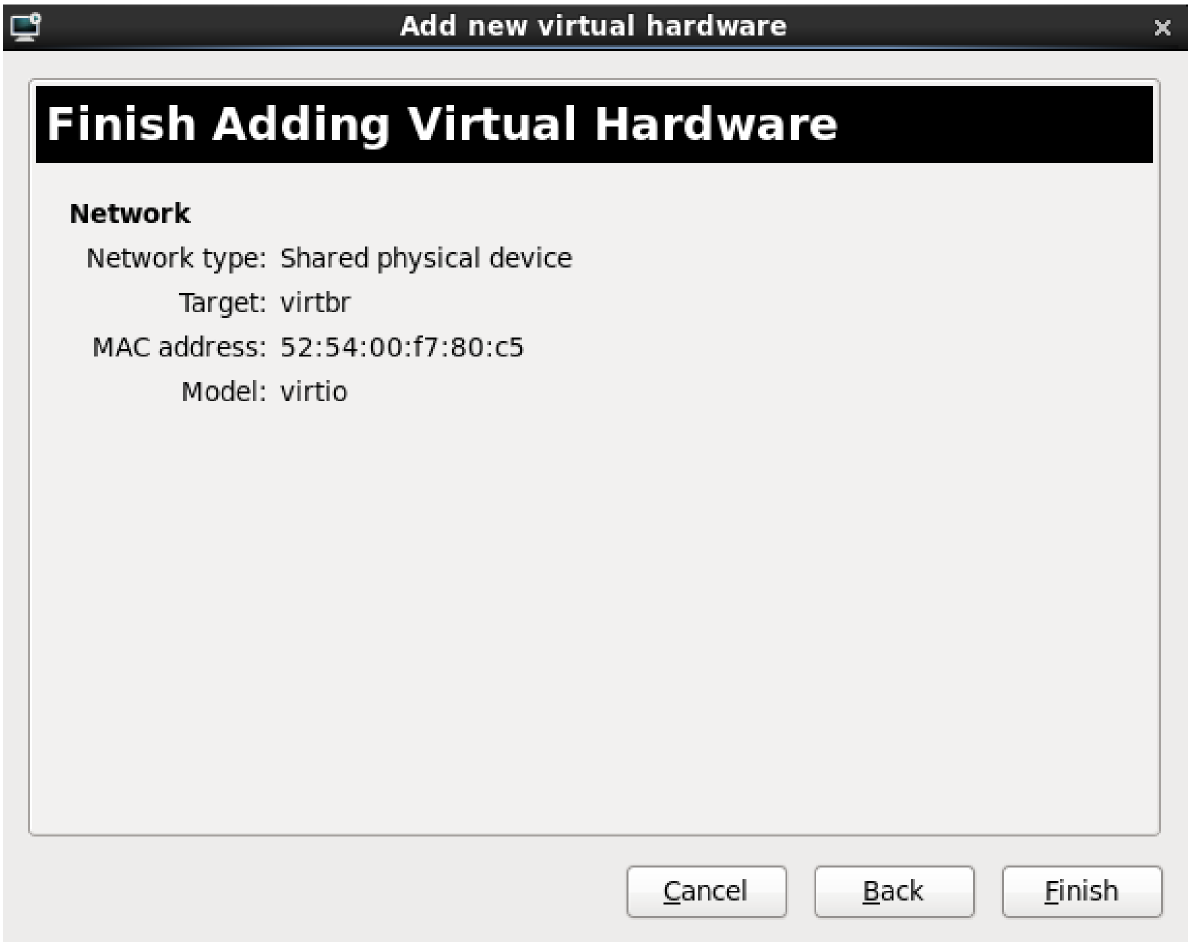
   Create a custom MAC address or use the one provided.

   Set the **Device model** to **virtio** to use the para-virtualized drivers.



Press **Forward** to continue.

3. **Finish the procedure**
   Confirm the details for the new device are correct.



Press **Finish** to complete the procedure.

Once all new devices are added, reboot the guest. Windows guests may may not recognise the devices until the guest is rebooted.

PCI device assignment

This chapter covers using PCI device assignment with KVM.

Certain hardware platforms allow virtualized guests to directly access various hardware devices and components. This process in virtualization is known as *device assignment*. Device assignment is also known as *PCI passthrough*.

The KVM hypervisor supports attaching PCI devices on the host system to virtualized guests. PCI device assignment allows guests to have exclusive access to PCI devices for a range of tasks. PCI device assignment allows PCI devices to appear and behave as if they were physically attached to the guest operating system. PCI device assignment can improve the I/O performance of devices attached to virtualized guests.

Device assignment is supported on PCI Express devices, except graphics cards. Parallel PCI devices may be supported as assigned devices, but they have severe limitations due to security and system configuration conflicts.

> **Note**
>
> The Red Hat Enterprise Linux 6.0 release comes with limitations for operating system drivers of KVM guests to have full access to a device's standard and extended configuration space. The Red Hat Enterprise Linux 6.0 limitations have been significantly reduced in the Red Hat Enterprise Linux 6.1 release and enable a much larger set of PCI Express devices to be successfully assigned to KVM guests.

> **Note**
>
> Because device assignment requires KVM to allocate guest memory from the host, overcommitting memory and guest migration are not currently supported when device assignment is in use.

PCI device assignment is only available on hardware platforms supporting either Intel VT-d or AMD IOMMU. These Intel VT-d or AMD IOMMU extensions must be enabled in BIOS for PCI device assignment to function.

Red Hat Enterprise Linux 6.0 and newer supports hot plugging assigned PCI devices into virtualized guests. Virtualized guests require PCI hot plug support to be enabled in order to hot plug PCI devices from the host to the guest.

Statically defining assigned PCI devices to virtualized guests at startup works the same as any other device presented to the virtualized guest (PCI-IDE, PCI-rtl8139, PCI-e1000e).

Out of the 32 available PCI devices for a guest 4 are not removable. This means there are only 28 PCI slots available for additional devices per guest. Every para-virtualized network or block device uses one slot. Each guest can use up to 28 additional devices made up of any combination of para-virtualized network, para-virtualized disk devices, or other PCI devices using VT-d.

Procedure 12.1. Preparing an Intel system for PCI device assignment

1. **Enable the Intel VT-d extensions**

   The Intel VT-d extensions provides hardware support for directly assigning a physical devices to guest.

The VT-d extensions are required for PCI device assignment with Red Hat Enterprise Linux. The extensions must be enabled in the BIOS. Some system manufacturers disable these extensions by default.

These extensions are often called various terms in BIOS which differ from manufacturer to manufacturer. Consult your system manufacturer's documentation.

2. **Activate Intel VT-d in the kernel**
   Activate Intel VT-d in the kernel by appending the *`intel_iommu=on`* parameter to the kernel line of the kernel line in the **`/boot/grub/grub.conf`** file.

   The example below is a modified **`grub.conf`** file with Intel VT-d activated.

```
default=0
timeout=5
splashimage=(hd0,0)/grub/splash.xpm.gz
hiddenmenu
title Red Hat Enterprise Linux Server (2.6.32-36.x86-645)
        root (hd0,0)
        kernel /vmlinuz-2.6.32-36.x86-64 ro root=/dev/VolGroup00/LogVol00 rhgb
 quiet intel_iommu=on
        initrd /initrd-2.6.32-36.x86-64.img
```

3. **Ready to use**
   Reboot the system to enable the changes. Your system is now PCI device assignment capable.

Procedure 12.2. Preparing an AMD system for PCI

1. **Enable AMD IOMMU extensions**
   The AMD IOMMU extensions are required for PCI device assignment with Red Hat Enterprise Linux. The extensions must be enabled in the BIOS. Some system manufacturers disable these extensions by default.

2. **Enable IOMMU kernel support**
   Add **append amd_iommu=on** to the kernel line so that AMD IOMMU extensions are enabled at boot.

12.1. Adding a PCI device with virsh

These steps cover adding a PCI device to a virtualized guest on a KVM hypervisor using hardware-assisted PCI device assignment.

This example uses a USB controller device with the PCI identifier code, **`pci_8086_3a6c`**, and a fully virtualized guest named *`win2k3`*.

1. **Identify the device**
   Identify the PCI device designated for device assignment to the guest. The **`virsh nodedev-list`** command lists all devices attached to the system. The **`--tree`** option is useful for identifying devices attached to the PCI device (for example, disk controllers and USB controllers).

```
# virsh nodedev-list --tree
```

   For a list of only PCI devices, run the following command:

```
# virsh nodedev-list | grep pci
```

In the output from this command, each PCI device is identified by a string, as shown in the following example output:

```
pci_0000_00_00_0
pci_0000_00_02_0
pci_0000_00_02_1
pci_0000_00_03_0
pci_0000_00_03_2
pci_0000_00_03_3
pci_0000_00_19_0
pci_0000_00_1a_0
pci_0000_00_1a_1
pci_0000_00_1a_2
pci_0000_00_1a_7
pci_0000_00_1b_0
pci_0000_00_1c_0
```

2. Run **`lspci`** and look for (or use the **`grep`** command) to determine the identifier code for your device.

   Tip: determining the PCI device

   Comparing **`lspci`** output to **`lspci -n`** (which turns off name resolution) output can assist in deriving which device has which device identifier code.

   Record the PCI device number; the number is needed in other steps.

3. Convert slot and function values to hexadecimal values (from decimal) to get the PCI bus addresses. Append "0x" to the beginning of the output to tell the computer that the value is a hexadecimal number.

   For example, if bus = 0, slot = 26 and function = 7 run the following:

```
$ printf %x 0
0
$ printf %x 26
1a
$ printf %x 7
7
```

   The values to use:

```
bus='0x00'
slot='0x1a'
function='0x7'
```

4. Run **`virsh edit`** (or virsh attach device) and added a device entry in the **`<devices>`** section to attach the PCI device to the guest.

```
# virsh edit win2k3
<hostdev mode='subsystem' type='pci' managed='yes'>
  <source>
      <address domain='0x0000' bus='0x00' slot='0x1a' function='0x7'/>
  </source>
```

```
</hostdev>
```

5. Toggle an SELinux Boolean to allow the management of the PCI device from the guest:

```
$ setsebool -P virt_use_sysfs 1
```

6. Start the guest system :

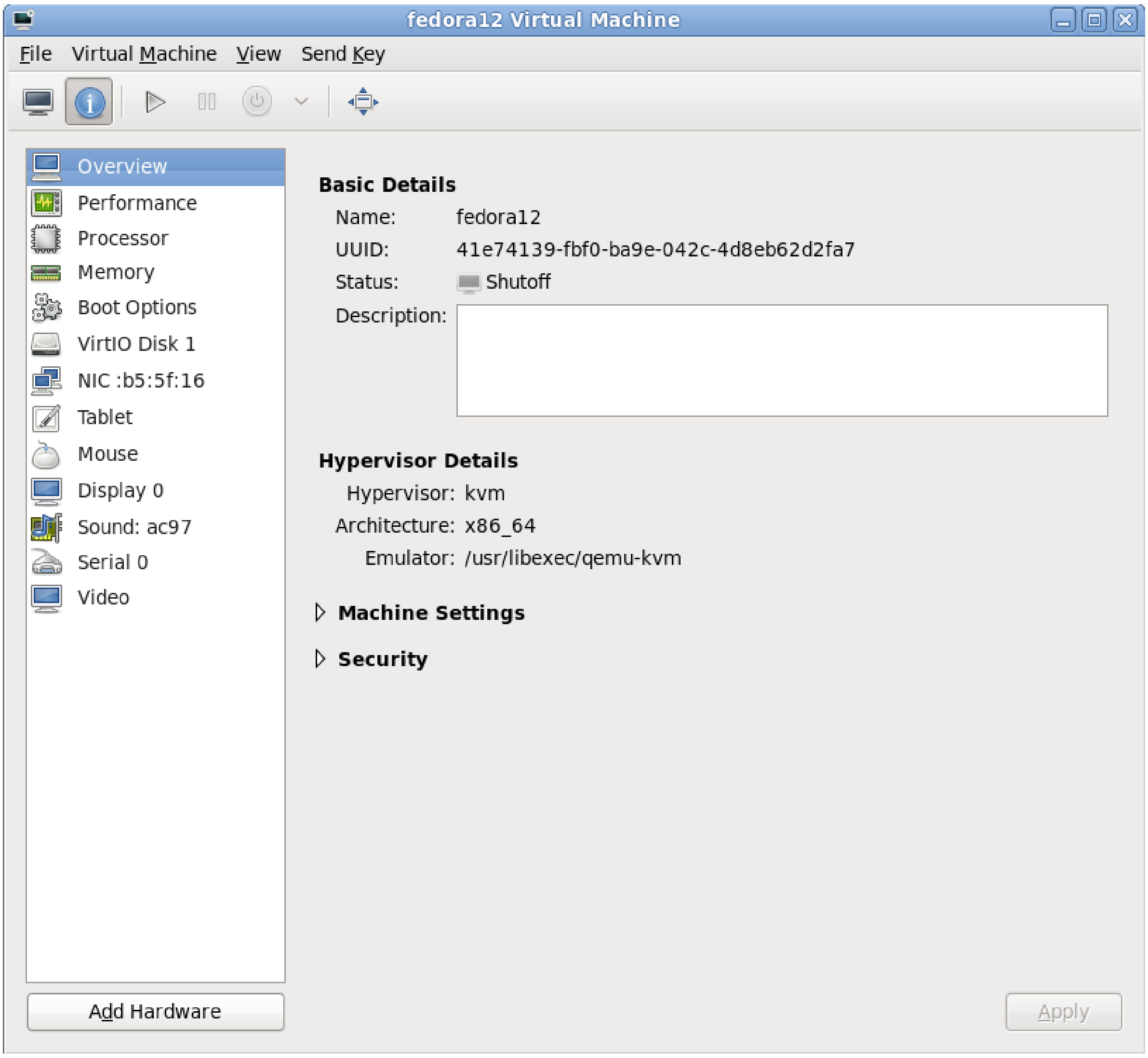
```
# virsh start win2k3
```

The PCI device should now be successfully attached to the guest and accessible to the guest operating system.

12.2. Adding a PCI device with virt-manager

PCI devices can be added to guests using the graphical **`virt-manager`** tool. The following procedure adds a 2 port USB controller to a virtualized guest.

1. **Open the hardware settings**
   Open the virtual machine and click the **Add Hardware** button to add a new device to the guest.



2. **Add the new device**
   Select **Physical Host Device** from the **Hardware type** list. Click **Forward** to continue.

3. **Select a PCI device**
   Select an unused PCI device. Note that selecting PCI devices presently in use on the host causes errors. In this example a PCI to USB interface device is used.

4. **Confirm the new device**
   Click the **Finish** button to confirm the device setup and add the device to the guest.

The setup is complete and the guest can now use the PCI device.

12.3. PCI device assignment with virt-install

To use PCI device assignment with the virt-install parameter, use the additional `--host-device` parameter.

1. **Identify the PCI device**

   Identify the PCI device designated for device assignment to the guest. The **`virsh nodedev-list`** command lists all devices attached to the system. The **`--tree`** option is useful for identifying devices attached to the PCI device (for example, disk controllers and USB controllers).

   ```
   # virsh nodedev-list --tree
   ```

   For a list of only PCI devices, run the following command:

   ```
   # virsh nodedev-list | grep pci
   ```

   In the output from this command, each PCI device is identified by a string, as shown in the following example output:

```
pci_0000_00_00_0
pci_0000_00_02_0
pci_0000_00_02_1
pci_0000_00_03_0
pci_0000_00_03_2
pci_0000_00_03_3
pci_0000_00_19_0
pci_0000_00_1a_0
pci_0000_00_1a_1
pci_0000_00_1a_2
pci_0000_00_1a_7
pci_0000_00_1b_0
pci_0000_00_1c_0
```

Tip: determining the PCI device

Comparing **`lspci`** output to **`lspci -n`** (which turns off name resolution) output can assist in deriving which device has which device identifier code.

2. **Add the device**
   Use the PCI identifier output from the **`virsh nodedev`** command as the value for the *`--host-device`* parameter.

```
# virt-install \
 -n hostdev-test -r 1024 --vcpus 2 \
 --os-variant fedora11 -v \
 -l http://download.fedoraproject.org/pub/fedora/linux/development/x86_64/os \
 -x 'console=ttyS0 vnc' --nonetworks --nographics  \
 --disk pool=default,size=8 \
 --debug --host-device=pci_8086_10bd
```

3. **Complete the installation**
   Complete the guest installation. The PCI device should be attached to the guest.

SR-IOV

13.1. Introduction

The PCI-SIG (PCI Special Interest Group) developed the Single Root I/O Virtualization (SR-IOV) specification. The PCI-SIG Single Root IOV specification is a standard for a type of PCI device assignment which natively shares a single device to multiple guests. SR-IOV reduces hypervisor involvement by specifying virtualization compatible memory spaces, interrupts and DMA streams. SR-IOV improves device performance for virtualized guests.

Note

Because device assignment requires KVM to allocate guest memory from the host, overcommitting memory and guest migration are not currently supported when device assignment is in use.

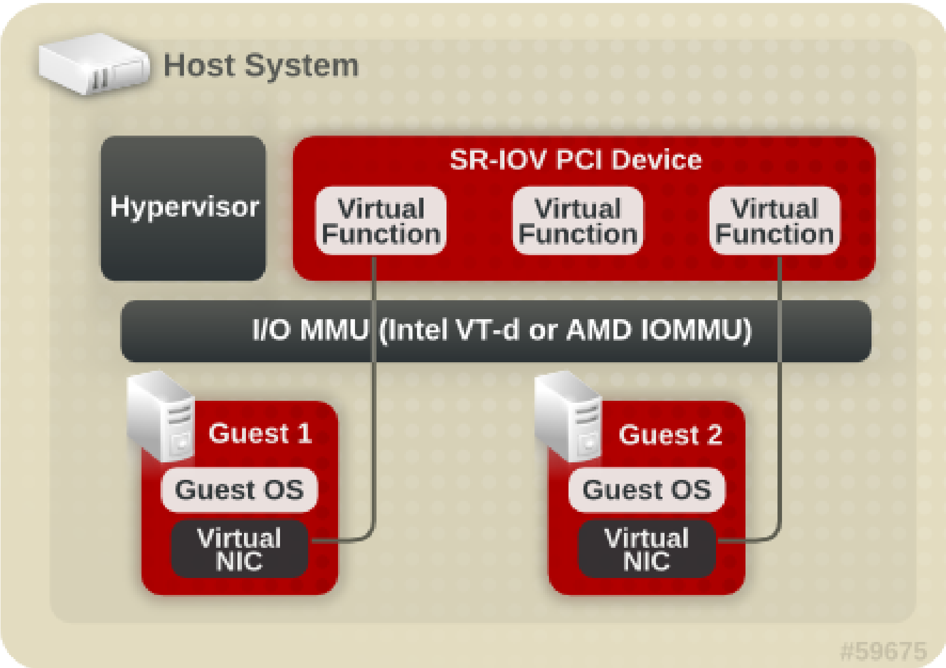


Figure 13.1. How SR-IOV works

SR-IOV enables a Single Root Function (for example, a single Ethernet port), to appear as multiple, separate, physical devices. A physical device with SR-IOV capabilities can be configured to appear in the PCI configuration space as multiple functions, each device has its own configuration space complete with Base Address Registers (BARs) and (MSI-based) interrupts.

SR-IOV uses two new PCI functions:

- Physical Functions (PFs) are full PCIe devices that include the SR-IOV capabilities. Physical Functions are discovered, managed, and configured as normal PCI devices. Physical Functions configure and manage the SR-IOV functionality by instantiating Virtual Functions.
- Virtual Functions (VFs) are simple PCIe functions that only process I/O. Each Virtual Function is derived from a Physical Function. The number of Virtual Functions a device supports is limited by the device hardware. Virtual Functions can be assigned to virtualized guests.

The hypervisor can map one or more Virtual Functions to a virtualized guest. The Virtual Function's configuration space is mapped to the configuration space presented to the virtualized guest by the hypervisor.

Each Virtual Function can only be mapped to a single guest at a time, as Virtual Functions require real hardware resources. A virtualized guest can have multiple Virtual Functions. A Virtual Function appears as a PCI device in the same manner as a normal PCI device would appear to an operating system.

The SR-IOV (VF) drivers are implemented in the guest VM. The core implementation is contained in the PCI subsystem, but there must also be driver support for both the Physical Function (PF) and Virtual Function (VF) devices. With an SR-IOV capable device one can allocate VFs from a PF. The VFs appear as PCI devices which are backed on the physical PCI device by resources (queues, and register sets).

Advantages of SR-IOV

SR-IOV devices can share a single physical port with multiple virtualized guests.

Virtual Functions have near-native performance and provide better performance than para-virtualized drivers and emulated access. Virtual Functions provide data protection between virtualized guests on the same physical server as the data is managed and controlled by the hardware.

These features allow for increased virtualized guest density on hosts within a data center.

SR-IOV is better able to utilize the bandwidth of devices with multiple guests.

13.2. Using SR-IOV

This section covers attaching Virtual Function to a guest as an additional network device.

SR-IOV requires Intel VT-d support.

Procedure 13.1. Attach an SR-IOV network device

1. **Enable Intel VT-d in BIOS and in the kernel**

   Skip this step if Intel VT-d is already enabled and working.

   Enable Intel VT-D in BIOS if it is not enabled already. Refer to *Procedure 12.1, "Preparing an Intel system for PCI device assignment"* for procedural help on enabling Intel VT-d in BIOS and the kernel.

2. **Verify support**

   Verify if the PCI device with SR-IOV capabilities are detected. This example lists an Intel 82576 network interface card which supports SR-IOV. Use the **`lspci`** command to verify if the device was detected.

   ```
   # lspci
   03:00.0 Ethernet controller: Intel Corporation 82576 Gigabit Network Connection (rev 01)
   03:00.1 Ethernet controller: Intel Corporation 82576 Gigabit Network Connection (rev 01)
   ```

   Note that the output has been modified to remove all other devices.

3. **Start the SR-IOV kernel modules and Virtual Functions**

   If the device is supported the driver kernel module should be loaded automatically by the kernel. Optional parameters can be passed to the module using the **`modprobe`** command. The Intel 82576 network interface card uses the **`igb`** driver kernel module.

The *max_vfs* parameter of the **igb** module specifies the maximum number of Virtual Functions. The *max_vfs* parameter causes the driver to spawn Virtual Functions. For this particular card the valid range is *0* to *7*.

Start the module with the *max_vfs* set to *1* or any number of Virtual Functions up to the maximum supported by your device.

```
# modprobe igb max_vfs=7
```

```
# lsmod |grep igb
igb    87592  0
dca    6708    1 igb
```

Note

The *max_vfs* parameter is specific to the **igb** module. Other devices may have other methods of setting the maximum number of Virtual Functions.

4. **Make the Virtual Functions persistent**
   Add the **modprobe** command to the **/etc/modprobe.d/igb.conf** file:

```
options igb max_vfs=7
```

5. **Inspect the new Virtual Functions**
   Using the **lspci** command, list the newly added Virtual Functions attached to the Intel 82576 network device.

```
# lspci | grep 82576
0b:00.0 Ethernet controller: Intel Corporation 82576 Gigabit Network Connection (rev 01)
0b:00.1 Ethernet controller: Intel Corporation 82576 Gigabit Network Connection (rev 01)
0b:10.0 Ethernet controller: Intel Corporation 82576 Virtual Function (rev 01)
0b:10.1 Ethernet controller: Intel Corporation 82576 Virtual Function (rev 01)
0b:10.2 Ethernet controller: Intel Corporation 82576 Virtual Function (rev 01)
0b:10.3 Ethernet controller: Intel Corporation 82576 Virtual Function (rev 01)
0b:10.4 Ethernet controller: Intel Corporation 82576 Virtual Function (rev 01)
0b:10.5 Ethernet controller: Intel Corporation 82576 Virtual Function (rev 01)
0b:10.6 Ethernet controller: Intel Corporation 82576 Virtual Function (rev 01)
0b:10.7 Ethernet controller: Intel Corporation 82576 Virtual Function (rev 01)
0b:11.0 Ethernet controller: Intel Corporation 82576 Virtual Function (rev 01)
0b:11.1 Ethernet controller: Intel Corporation 82576 Virtual Function (rev 01)
0b:11.2 Ethernet controller: Intel Corporation 82576 Virtual Function (rev 01)
0b:11.3 Ethernet controller: Intel Corporation 82576 Virtual Function (rev 01)
0b:11.4 Ethernet controller: Intel Corporation 82576 Virtual Function (rev 01)
0b:11.5 Ethernet controller: Intel Corporation 82576 Virtual Function (rev 01)
```

   The identifier for the PCI device is found with the *-n* parameter of the **lspci** command. The Physical Functions corresponds to **0b:00.0** and **0b:00.1**. All the Virtual Functions have **Virtual Function** in the description.

6. **Add the Virtual Function to the guest**
   a. Shut down the guest.

b. Open the XML configuration file with the **virsh edit** command. This example edits a guest named *MyGuest*.

```
# virsh edit MyGuest
```

c. The default text editor will open the libvirt configuration file for the guest. Add the new device to the **devices** section of the XML configuration file.

```
<hostdev mode='subsystem' type='pci' manage='yes'>
      <source>
        <address bus='0x03' slot='0x10' function='0x01'/>
      </source>
</hostdev>
```

d. Save the configuration.

7. **Restart**
Restart the guest to complete the installation.

```
# virsh start MyGuest
```

The guest should start successfully and detect a new network interface card. This new card is the Virtual Function of the SR-IOV device.

13.3. Troubleshooting SR-IOV

This section contains solutions for problems which may affect SR-IOV.

Error starting the guest

When starting a configured virtual machine, an error occurs as follows:

```
# virsh start test
error: Failed to start domain test
error: internal error unable to start guest: char device redirected to
/dev/pts/2
get_real_device: /sys/bus/pci/devices/0000:03:10.0/config: Permission denied
init_assigned_device: Error: Couldn't get real device (03:10.0)!
Failed to initialize assigned device host=03:10.0
```

This error is often caused by a device that is already assigned to another guest or to the host itself.

KVM guest timing management

Virtualization poses various challenges for guest time keeping. Guests using the Time Stamp Counter (TSC) as a clock source may suffer timing issues as some CPUs do not have a constant Time Stamp Counter. Guests without accurate timekeeping may have issues with some networked applications and processes as the guest will run faster or slower than the actual time and fall out of synchronization.

KVM works around this issue by providing guests with a para-virtualized clock. Alternatively, some guests may use other x86 clock sources for their timing in future versions of those operating systems.

Guests can have several problems caused by inaccurate clocks and counters:

- Clocks can fall out of synchronization with the actual time which invalidates sessions and affects networks.
- Guests with slower clocks may have issues migrating.

These problems exist on other virtualization platforms and timing should always be tested.

> **NTP**
>
> The Network Time Protocol (NTP) daemon should be running on the host and the guests. Enable the `ntpd` service:
>
> ```
> # service ntpd start
> ```
>
> Add the ntpd service to the default startup sequence:
>
> ```
> # chkconfig ntpd on
> ```
>
> Using the `ntpd` service should minimize the affects of clock skew in all cases.

Determining if your CPU has the constant Time Stamp Counter

Your CPU has a constant Time Stamp Counter if the **`constant_tsc`** flag is present. To determine if your CPU has the **`constant_tsc`** flag run the following command:

```
$ grep constant_tsc /proc/cpuinfo
```

If any output is given your CPU has the **`constant_tsc`** bit. If no output is given follow the instructions below.

Configuring hosts without a constant Time Stamp Counter

Systems without constant time stamp counters require additional configuration. Power management features interfere with accurate time keeping and must be disabled for guests to accurately keep time with KVM.

> **Note**
>
> These instructions are for AMD revision F cpus only.

If the CPU lacks the **constant_tsc** bit, disable all power management features (*BZ#513138*[1]). Each system has several timers it uses to keep time. The TSC is not stable on the host, which is sometimes caused by **cpufreq** changes, deep C state, or migration to a host with a faster TSC. Deep C sleep states can stop the TSC. To prevent the kernel using deep C states append **processor.max_cstate=1** to the kernel boot options in the **grub.conf** file on the host:

```
title Red Hat Enterprise Linux (2.6.32-36.x86-64)
        root (hd0,0)
 kernel /vmlinuz-2.6.32-36.x86-64 ro root=/dev/VolGroup00/LogVol00 rhgb
 quiet processor.max_cstate=1
```

Disable **cpufreq** (only necessary on hosts without the **constant_tsc**) by editing the **/etc/sysconfig/cpuspeed** configuration file and change the **MIN_SPEED** and **MAX_SPEED** variables to the highest frequency available. Valid limits can be found in the **/sys/devices/system/cpu/cpu*/cpufreq/scaling_available_frequencies** files.

Using the para-virtualized clock with Red Hat Enterprise Linux guests

For certain Red Hat Enterprise Linux guests, additional kernel parameters are required. These parameters can be set by appending them to the end of the /kernel line in the /boot/grub/grub.conf file of the guest.

The table below lists versions of Red Hat Enterprise Linux and the parameters required for guests on systems without a constant Time Stamp Counter.

Red Hat Enterprise Linux	Additional guest kernel parameters
6.0 AMD64/Intel 64 with the para-virtualized clock	Additional parameters are not required
6.0 AMD64/Intel 64 without the para-virtualized clock	notsc lpj=n
5.5 AMD64/Intel 64 with the para-virtualized clock	Additional parameters are not required[2]
5.5 AMD64/Intel 64 without the para-virtualized clock	divider=10 notsc lpj=n
5.5 x86 with the para-virtualized clock	Additional parameters are not required
5.5 x86 without the para-virtualized clock	divider=10 clocksource=acpi_pm lpj=n
5.4 AMD64/Intel 64	divider=10 notsc
5.4 x86	divider=10 clocksource=acpi_pm
5.3 AMD64/Intel 64	divider=10 notsc
5.3 x86	divider=10 clocksource=acpi_pm
4.8 AMD64/Intel 64	notsc divider=10
4.8 x86	clock=pmtmr divider=10
3.9 AMD64/Intel 64	Additional parameters are not required
3.9 x86	Additional parameters are not required

[1] https://bugzilla.redhat.com/show_bug.cgi?id=513138

Using the Real-Time Clock with Windows Server 2003 and Windows XP guests

Windows uses the both the Real-Time Clock (RTC) and the Time Stamp Counter (TSC). For Windows guests the Real-Time Clock can be used instead of the TSC for all time sources which resolves guest timing issues.

To enable the Real-Time Clock for the **`PMTIMER`** clock source (the **`PMTIMER`** usually uses the TSC) add the following line to the Windows boot settings. Windows boot settings are stored in the boot.ini file. Add the following line to the **`boot.ini`** file:

```
/usepmtimer
```

For more information on Windows boot settings and the pmtimer option, refer to *Available switch options for the Windows XP and the Windows Server 2003 Boot.ini files*[3].

Using the Real-Time Clock with Windows Vista, Windows Server 2008 and Windows 7 guests

Windows uses the both the Real-Time Clock (RTC) and the Time Stamp Counter (TSC). For Windows guests the Real-Time Clock can be used instead of the TSC for all time sources which resolves guest timing issues.

The **`boot.ini`** file is no longer used from Windows Vista and newer. Windows Vista, Windows Server 2008 and Windows 7 use the **Boot Configuration Data Editor** (**`bcdedit.exe`**) to modify the Windows boot parameters.

This procedure is only required if the guest is having time keeping issues. Time keeping issues may not affect guests on all host systems.

1. Open the Windows guest.

2. Open the **Accessories** menu of the **start** menu. Right click on the **Command Prompt** application, select **Run as Administrator**.

3. Confirm the security exception, if prompted.

4. Set the boot manager to use the platform clock. This should instruct Windows to use the PM timer for the primary clock source. The system UUID (*`{default}`* in the example below) should be changed if the system UUID is different than the default boot device.

```
C:\Windows\system32>bcdedit /set {default} USEPLATFORMCLOCK on
The operation completed successfully
```

This fix should improve time keeping for Windows Vista, Windows Server 2008 and Windows 7 guests.

[3] http://support.microsoft.com/kb/833721

Part IV. Administration

Administering virtualized systems

These chapters contain information for administering host and virtualized guests using tools included in Red Hat Enterprise Linux 6.

Server best practices

The following tasks and tips can assist you with securing and ensuring reliability of your Red Hat Enterprise Linux host.

- Run SELinux in enforcing mode. Set SELinux to run in enforcing mode with the **setenforce** command.

```
# setenforce 1
```

- Remove or disable any unnecessary services such as **AutoFS**, **NFS**, **FTP**, **HTTP**, **NIS**, **telnetd**, **sendmail** and so on.

- Only add the minimum number of user accounts needed for platform management on the server and remove unnecessary user accounts.

- Avoid running any unessential applications on your host. Running applications on the host may impact virtual machine performance and can affect server stability. Any application which may crash the server will also cause all virtual machines on the server to go down.

- Use a central location for virtual machine installations and images. Virtual machine images should be stored under **/var/lib/libvirt/images/**. If you are using a different directory for your virtual machine images make sure you add the directory to your SELinux policy and relabel it before starting the installation.

- Installation sources, trees, and images should be stored in a central location, usually the location of your vsftpd server.

Security for virtualization

When deploying virtualization technologies on your corporate infrastructure, you must ensure that the host cannot be compromised. The host is a Red Hat Enterprise Linux system that manages the system, devices, memory and networks as well as all virtualized guests. If the host is insecure, all guests in the system are vulnerable. There are several ways to enhance security on systems using virtualization. You or your organization should create a *Deployment Plan* containing the operating specifications and specifies which services are needed on your virtualized guests and host servers as well as what support is required for these services. Here are a few security issues to consider while developing a deployment plan:

- Run only necessary services on hosts. The fewer processes and services running on the host, the higher the level of security and performance.
- Enable SELinux on the hypervisor. Read *Section 16.2, "SELinux and virtualization"* for more information on using SELinux and virtualization.
- Use a firewall to restrict traffic to the host. You can setup a firewall with default-reject rules that will help secure the host from attacks. It is also important to limit network-facing services.
- Do not allow normal users to access the host. The host is privileged, and granting access to unprivileged accounts may compromise the level of security.

16.1. Storage security issues

Administrators of virtualized guests can change the partitions the host boots in certain circumstances. To prevent this administrators should follow these recommendations:

The host should not use disk labels to identify file systems in the **`fstab`** file, the **`initrd`** file or used by the kernel command line. If less privileged users, especially virtualized guests, have write access to whole partitions or LVM volumes.

Guests 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.

16.2. SELinux and virtualization

Security Enhanced Linux was developed by the NSA with assistance from the Linux community to provide stronger security for Linux. SELinux limits an attackers abilities and works to prevent many common security exploits such as buffer overflow attacks and privilege escalation. It is because of these benefits that all Red Hat Enterprise Linux systems should run with SELinux enabled and in enforcing mode.

Adding LVM based storage with SELinux in enforcing mode

The following section is an example of adding a logical volume to a virtualized guest with SELinux enabled. These instructions also work for hard drive partitions.

Procedure 16.1. Creating and mounting a logical volume on a virtualized guest with SELinux enabled

1. Create a logical volume. This example creates a 5 gigabyte logical volume named *`NewVolumeName`* on the volume group named *`volumegroup`*.

```
# lvcreate -n NewVolumeName -L 5G volumegroup
```

2. Format the *NewVolumeName* logical volume with a file system that supports extended attributes, such as ext3.

```
# mke2fs -j /dev/volumegroup/NewVolumeName
```

3. Create a new directory for mounting the new logical volume. This directory can be anywhere on your file system. It is advised not to put it in important system directories (**/etc**, **/var**, **/sys**) or in home directories (**/home** or **/root**). This example uses a directory called **/virtstorage**

```
# mkdir /virtstorage
```

4. Mount the logical volume.

```
# mount /dev/volumegroup/NewVolumeName /virtstorage
```

5. Set the correct SELinux type for the libvirt image location.

```
# semanage fcontext -a -t virt_image_t "/virtstorage(/.*)?"
```

If the targeted policy is used (targeted is the default policy) the command appends a line to the **/etc/selinux/targeted/contexts/files/file_contexts.local** file which makes the change persistent. The appended line may resemble this:

```
/virtstorage(/.*)?    system_u:object_r:virt_image_t:s0
```

6. Run the command to change the type of the mount point (**/virtstorage**) and all files under it to **virt_image_t** (the **restorecon** and **setfiles** commands read the files in **/etc/selinux/targeted/contexts/files/**).

```
# restorecon -R -v /virtstorage
```

Testing new attributes

Create a new file (using the **touch** command) on the file system.

```
# touch /virtstorage/newfile
```

Verify the file has been relabeled using the following command:

```
# sudo ls -Z /virtstorage
-rw-------. root root system_u:object_r:virt_image_t:s0 newfile
```

The output shows that the new file has the correct attribute, **virt_image_t**.

16.3. SELinux

This section contains topics to consider when using SELinux with your virtualization deployment. When you deploy system changes or add devices, you must update your SELinux policy accordingly. To configure an LVM volume for a guest, you must modify the SELinux context for the respective underlying block device and volume group.

```
# semanage fcontext -a -t virt_image _t -f -b /dev/sda2
# restorecon /dev/sda2
```

KVM and SELinux

The following table shows the SELinux Booleans which affect KVM when launched by libvirt.

KVM SELinux Booleans

SELinux Boolean	Description
virt_use_comm	Allow virt to use serial/parallel communication ports.
virt_use_fusefs	Allow virt to read fuse files.
virt_use_nfs	Allow virt to manage NFS files.
virt_use_samba	Allow virt to manage CIFS files.
virt_use_sysfs	Allow virt to manage device configuration (PCI).
virt_use_xserver	Allow virtual machine to interact with the xserver.
virt_use_usb	Allow virt to use USB devices.

16.4. Virtualization firewall information

Various ports are used for communication between virtualized guests and management utilities.

> **Guest network services**
>
> Any network service on a virtualized guest must have the applicable ports open on the guest to allow external access. If a network service on a guest is firewalled it will be inaccessible. Always verify the guests network configuration first.

- ICMP requests must be accepted. ICMP packets are used for network testing. You cannot ping guests if ICMP packets are blocked.
- Port 22 should be open for SSH access and the initial installation.
- Ports 80 or 443 (depending on the security settings on the RHEV Manager) are used by the vdsm-reg service to communicate information about the host.
- Ports 5634 to 6166 are used for guest console access with the SPICE protocol.
- Ports 49152 to 49216 are used for migrations with KVM. Migration may use any port in this range depending on the number of concurrent migrations occurring.
- Enabling IP forwarding (**`net.ipv4.ip_forward = 1`**) is also required for shared bridges and the default bridge. Note that installing libvirt enables this variable so it will be enabled when the virtualization packages are installed unless it was manually disabled.

> **Note**
>
> Note that enabling IP forwarding is **not** required for physical bridge devices. When a guest is connected through a physical bridge, traffic only operates at a level that does not require IP configuration such as IP forwarding.

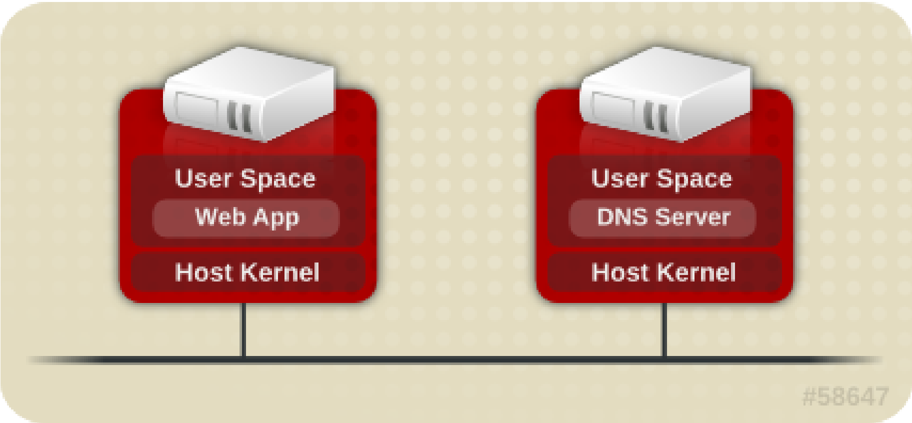
sVirt

sVirt is a technology included in Red Hat Enterprise Linux 6 that integrates SELinux and virtualization. sVirt applies Mandatory Access Control (MAC) to improve security when using virtualized guests. The main reasons for integrating these technologies are to improve security and harden the system against bugs in the hypervisor that might be used as an attack vector aimed toward the host or to another virtualized guest.

This chapter describes how sVirt integrates with virtualization technologies in Red Hat Enterprise Linux 6.

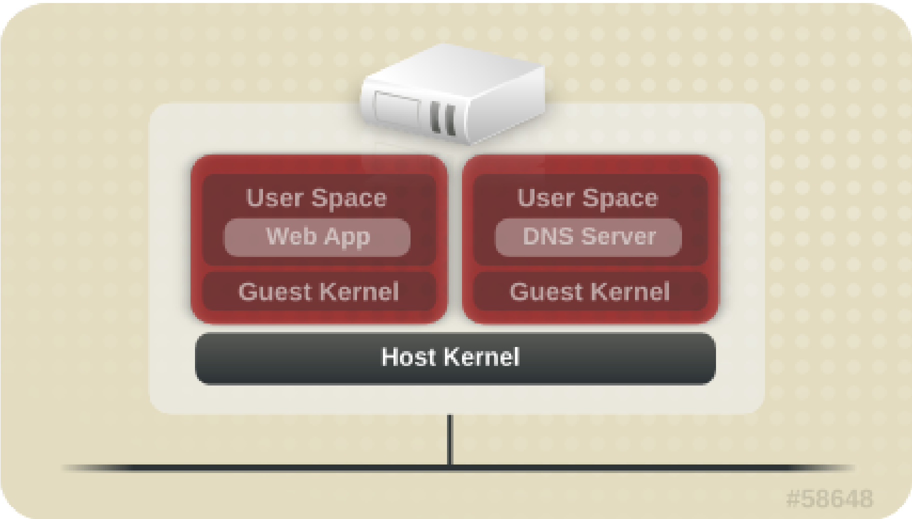
Non-virtualized environments

In a non-virtualized environment, hosts are separated from each other physically and each host has a self-contained environment, consisting of services such as a web server, or a DNS server. These services communicate directly to their own user space, host kernel and physical host, offering their services directly to the network. The following image represents a non-virtualized environment:



Virtualized environments

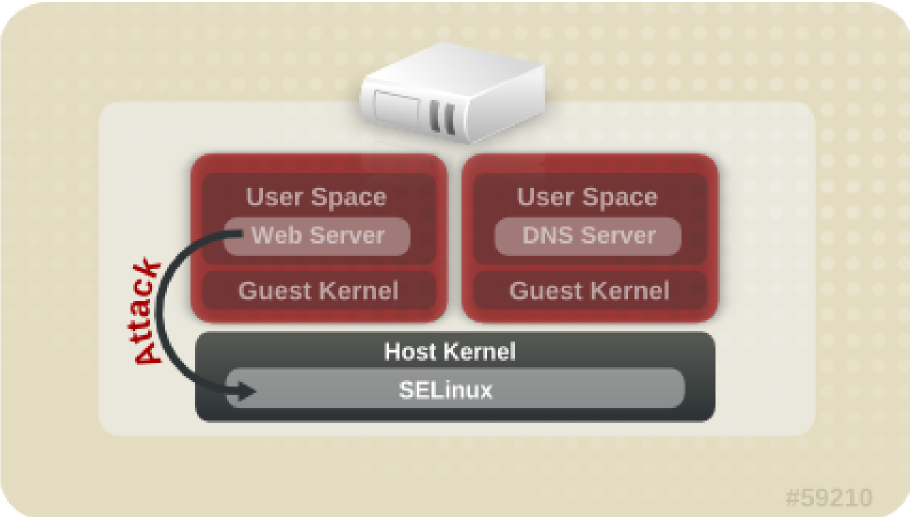
In a virtualized environment, several operating systems can run on a single host kernel and physical host. The following image represents a virtualized environment:



17.1. Security and Virtualization

When services are not virtualized, machines are physically separated. Any exploit is usually contained to the affected machine, with the obvious exception of network attacks. When services are grouped together in a virtualized environment, extra vulnerabilities emerge in the system. If there is a security flaw in the hypervisor that can be exploited by a guest instance, this guest may be able to not only attack the host, but also other guests running on that host. This is not theoretical; attacks already exist on hypervisors. These attacks can extend beyond the guest instance and could expose other guests to attack.

sVirt is an effort to isolate guests and limit their ability to launch further attacks if exploited. This is demonstrated in the following image, where an attack can not break out of the virtualized guest and extend to another guest instance:



SELinux introduces a pluggable security framework for virtualized instances in its implementation of Mandatory Access Control (MAC). The sVirt framework allows guests and their resources to be uniquely labeled. Once labeled, rules can be applied which can reject access between different guests.

17.2. sVirt labeling

Like other services under the protection of SELinux, sVirt uses process-based mechanisms and restrictions to provide an extra layer of security over guest instances. Under typical use, you should not even notice that sVirt is working in the background. This section describes the labeling features of sVirt.

As shown in the following output, when using sVirt, each virtualized guest process is labeled and runs with a dynamically generated level. Each process is isolated from other VMs with different levels:

```
# ps -eZ | grep qemu

system_u:system_r:svirt_t:s0:c87,c520 27950 ?  00:00:17 qemu-kvm
system_u:system_r:svirt_t:s0:c639,c757 27989 ? 00:00:06 qemu-system-x86
```

The actual disk images are automatically labeled to match the processes, as shown in the following output:

```
# ls -lZ /var/lib/libvirt/images/*
```

```
system_u:object_r:svirt_image_t:s0:c87,c520   image1
```

The following table outlines the different labels that can be assigned when using sVirt:

Table 17.1. sVirt labels

Type	SELinux Context	Description
Virtualized guest processes	system_u:system_r:svirt_t:MCS1	MCS1 is a randomly selected MCS field. Currently approximately 500,000 labels are supported.
Virtualized guest images	system_u:object_r:svirt_image_t:MCS1	Only *svirt_t* processes with the same MCS fields are able to read/write these image files and devices.
Virtualized guest shared read/ write content	system_u:object_r:svirt_image_t:s0	All *svirt_t* processes are allowed to write to the svirt_image_t:s0 files and devices.
Virtualized guest shared read only content	system_u:object_r:svirt_content_t:s0	All svirt_t processes are able to read files/devices with this label.
Virtualized guest images	system_u:object_r:virt_content_t:s0	System default label used when an image exits. No *svirt_t* virtual processes are allowed to read files/devices with this label.

It is also possible to perform static labeling when using sVirt. Static labels allow the administrator to select a specific label, including the MCS/MLS field, for a virtualized guest. Administrators who run statically-labeled virtualized guests are responsible for setting the correct label on the image files. The virtualized guest will always be started with that label, and the sVirt system will never modify the label of a statically-labeled virtual machine's content. This allows the sVirt component to run in an MLS environment. You can also run multiple virtualized guests with different sensitivity levels on a system, depending on your requirements.

KVM live migration

This chapter covers migrating guests running on a KVM hypervisor to another KVM host.

Migration describes the process of moving a virtualized guest from one host to another. This is possible because guests are running in a virtualized environment instead of directly on the hardware. Migration is useful for:

- Load balancing - guests can be moved to hosts with lower usage when their host becomes overloaded, or another host is under-utilized.
- Hardware independence - when we need to upgrade, add, or remove hardware devices on the host, we can safely relocate guests to other hosts. This means that guests do not experience any downtime for hardware improvements.
- Energy saving - guests can be redistributed to other hosts and host systems powered off to save energy and cut costs in low usage periods.
- Geographic migration - guests can be moved to another location for lower latency or in serious circumstances.

Migration works by sending the state of the guest's memory and any virtualized devices to a destination host. It requires networked storage to be shared between the source and destination hosts, so that guest storage can be omitted from the migration process.

Migrations can be performed live or offline.

An offline migration suspends the guest, then moves an image of the guest's memory to the destination host. The guest is then resumed on the destination host and the memory the guest used on the source host is freed.

The time an offline migration takes depends on network bandwidth and latency. If the network is experiencing heavy use or low bandwidth, the migration will take much longer.

In a live migration, the guest continues to run on the source host while its memory pages are transferred, in order, to the destination host. During migration, KVM monitors the source for any changes in pages it has already transferred, and begins to transfer these changes when all of the initial pages have been transferred. KVM also estimates transfer speed during migration, so when the remaining amount of data to transfer will take a certain configurable period of time (10ms by default), KVM stops the original guest, transfers the remaining data, and resumes the guest on the destination host.

If the original guest modifies pages faster than KVM can transfer them to the destination host, offline migration must be used, as live migration would never complete.

18.1. Live migration requirements

Migrating guests requires the following:

Migration requirements

- A virtualized guest installed on shared networked storage using one of the following protocols:
  - Fibre Channel
  - iSCSI
  - NFS

  - GFS2

- Two or more Red Hat Enterprise Linux systems of the same version with the same updates.
- Both systems must have the appropriate ports open.
- Both systems must have identical network configurations. All bridging and network configurations must be exactly the same on both hosts.
- Shared storage must mount at the same location on source and destination systems. The mounted directory name must be identical.

Configuring network storage

Configure shared storage and install a guest on the shared storage. For shared storage instructions, refer to *Part V, "Virtualization storage topics"*.

Alternatively, use the NFS example in *Section 18.2, "Shared storage example: NFS for a simple migration"*.

18.2. Shared storage example: NFS for a simple migration

This example uses NFS to share guest images with other KVM hosts. This example is not practical for large installations, this example is only for demonstrating migration techniques and small deployments. Do not use this example for migrating or running more than a few virtualized guests.

For advanced and more robust shared storage instructions, refer to *Part V, "Virtualization storage topics"*

1. **Export your libvirt image directory**
   Add the default image directory to the **`/etc/exports`** file:

   ```
   /var/lib/libvirt/images *.example.com(rw,no_root_squash,sync)
   ```

   Change the hosts parameter as required for your environment.

2. **Start NFS**
   a. Install the NFS packages if they are not yet installed:

      ```
      # yum install nfs
      ```

   b. Open the ports for NFS in **`iptables`** and add NFS to the **`/etc/hosts.allow`** file.

   c. Start the NFS service:

      ```
      # service nfs start
      ```

3. **Mount the shared storage on the destination**
   On the destination system, mount the **`/var/lib/libvirt/images`** directory:

   ```
   # mount source_host:/var/lib/libvirt/images /var/lib/libvirt/images
   ```

Locations must be the same on source and destination

Whichever directory is chosen for the guests must exactly the same on host and guest. This applies to all types of shared storage. The directory must be the same or the migration will fail.

18.3. Live KVM migration with virsh

A guest can be migrated to another host with the **`virsh`** command. The **`migrate`** command accepts parameters in the following format:

```
# virsh migrate --live GuestName DestinationURL
```

The *`GuestName`* parameter represents the name of the guest which you want to migrate.

The *`DestinationURL`* parameter is the URL or hostname of the destination system. The destination system must run the same version of Red Hat Enterprise Linux, be using the same hypervisor and have **`libvirt`** running.

Once the command is entered you will be prompted for the root password of the destination system.

Example: live migration with virsh

This example migrates from `test1.example.com` to `test2.example.com`. Change the host names for your environment. This example migrates a virtual machine named **`RHEL4test`**.

This example assumes you have fully configured shared storage and meet all the prerequisites (listed here: *Migration requirements*).

1. **Verify the guest is running**
   From the source system, `test1.example.com`, verify `RHEL4test` is running:

```
[root@test1 ~]# virsh list
Id Name                 State
----------------------------------
 10 RHEL4test                running
```

2. **Migrate the guest**
   Execute the following command to live migrate the guest to the destination, `test2.example.com`. Append **`/system`** to the end of the destination URL to tell libvirt that you need full access.

```
# virsh migrate --live RHEL4test qemu+ssh://test2.example.com/system
```

   Once the command is entered you will be prompted for the root password of the destination system.

3. **Wait**
   The migration may take some time depending on load and the size of the guest. **`virsh`** only reports errors. The guest continues to run on the source host until fully migrated.

4. **Verify the guest has arrived at the destination host**
   From the destination system, `test2.example.com`, verify `RHEL4test` is running:

```
[root@test2 ~]# virsh list
Id Name                 State
----------------------------------
 10 RHEL4test                running
```

The live migration is now complete.

Other networking methods

libvirt supports a variety of networking methods including TLS/SSL, unix sockets, SSH, and unencrypted TCP. Refer to *Chapter 19, Remote management of virtualized guests* for more information on using other methods.

18.4. Migrating with virt-manager

This section covers migrating KVM based guests with **`virt-manager`**.

1. **Connect to the source and the target hosts**
   Connect to the source and target hosts. On the **File** menu, click **Add Connection**, the **Add Connection** window appears.

   Enter the following details:

   - **Hypervisor**: Select **QEMU**.
   - **Connection**: Select the connection type.
   - **Hostname**: Enter the hostname.

   Press the **Connect** button.

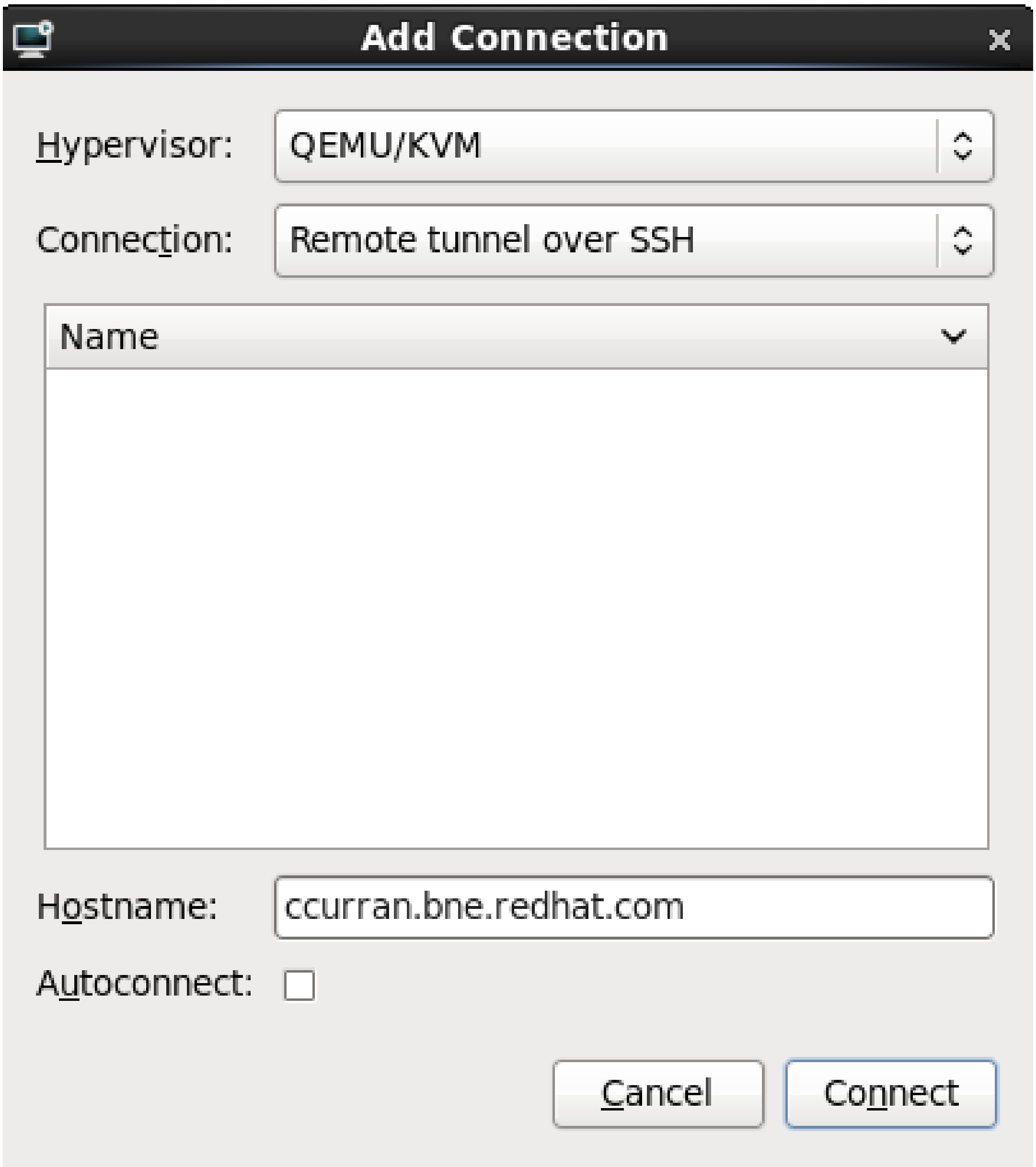


Figure 18.1. Add Connection

`virt-manager` now displays the newly connected host in the list of available hosts.

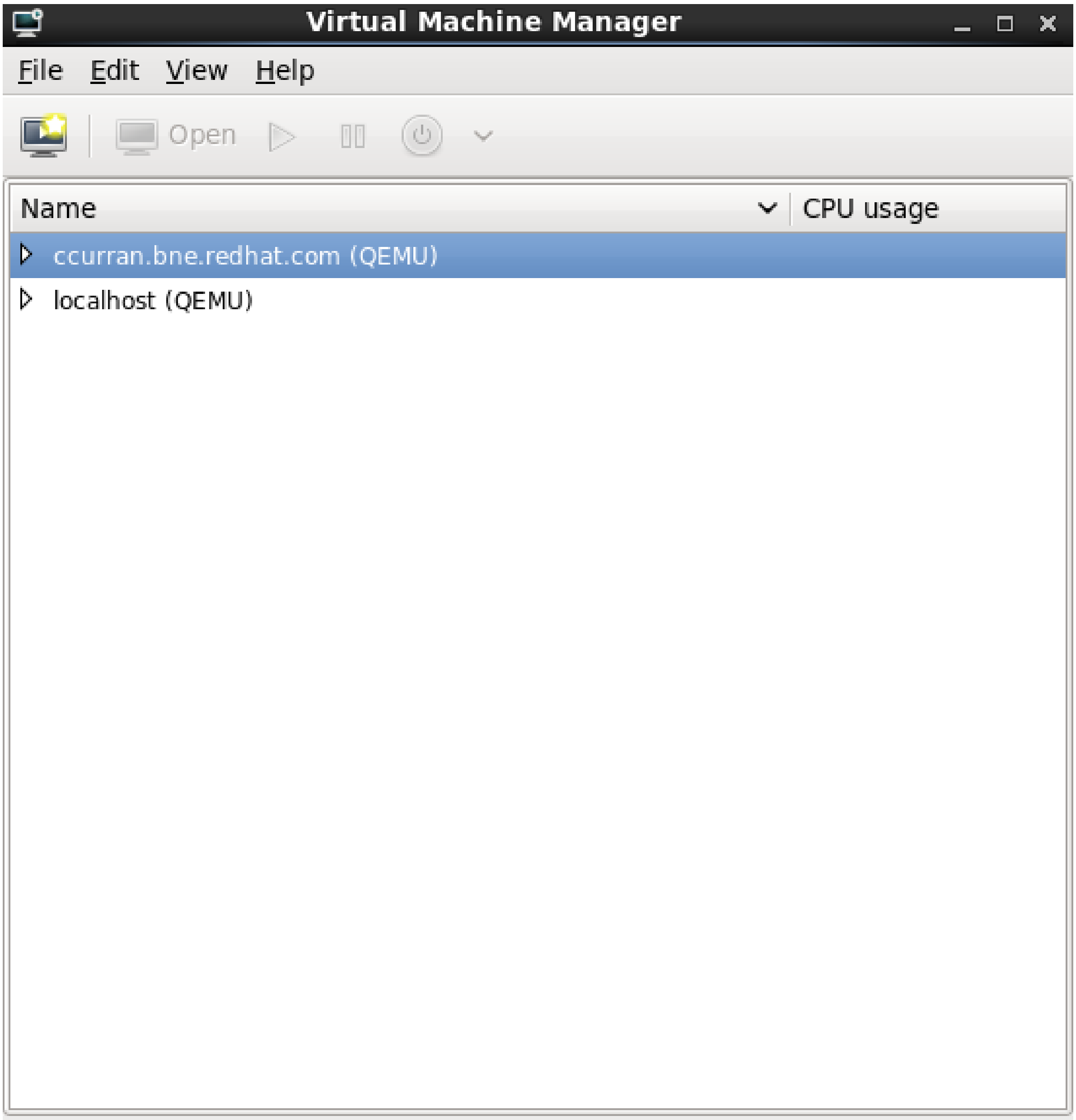


Figure 18.2. Connected Host

2. **Add a storage pool to both hosts**
   Both hosts must be connected to the same storage pool. Create the storage pool on both hosts using the same network storage device. Using a storage pool ensures both servers have identical storage configurations. This procedure uses a NFS server.

   a. **Open the storage tab**
      On the **Edit** menu, click **Host Details**, the Host Details window appears.

      Click the **Storage** tab.

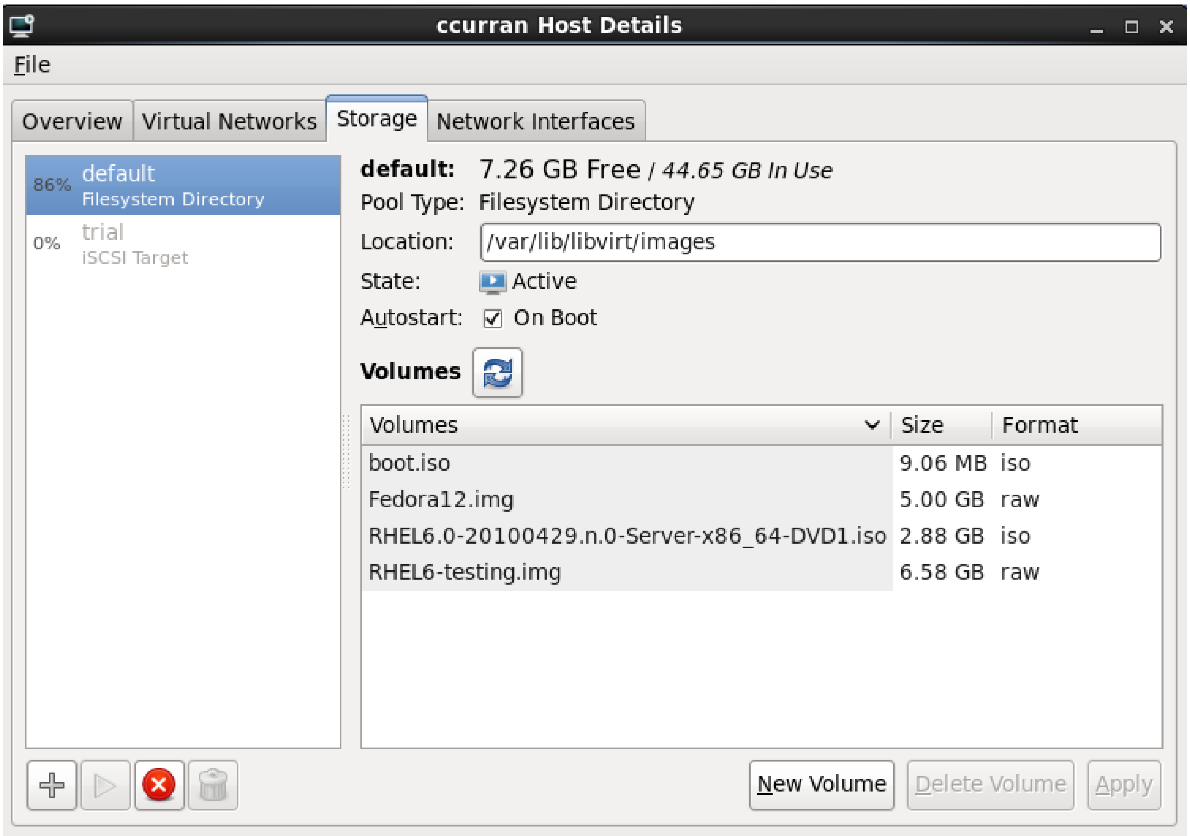


Figure 18.3. Storage tab

b. **Add a storage pool with the same NFS to the source and target hosts.**
Add a new storage pool. In the lower left corner of the window, click the **+** button. The Add a New Storage Pool window appears.

Enter the following details:

- **Name**: Enter the name of the storage pool.
- **Type**: Select **netfs: Network Exported Directory**.

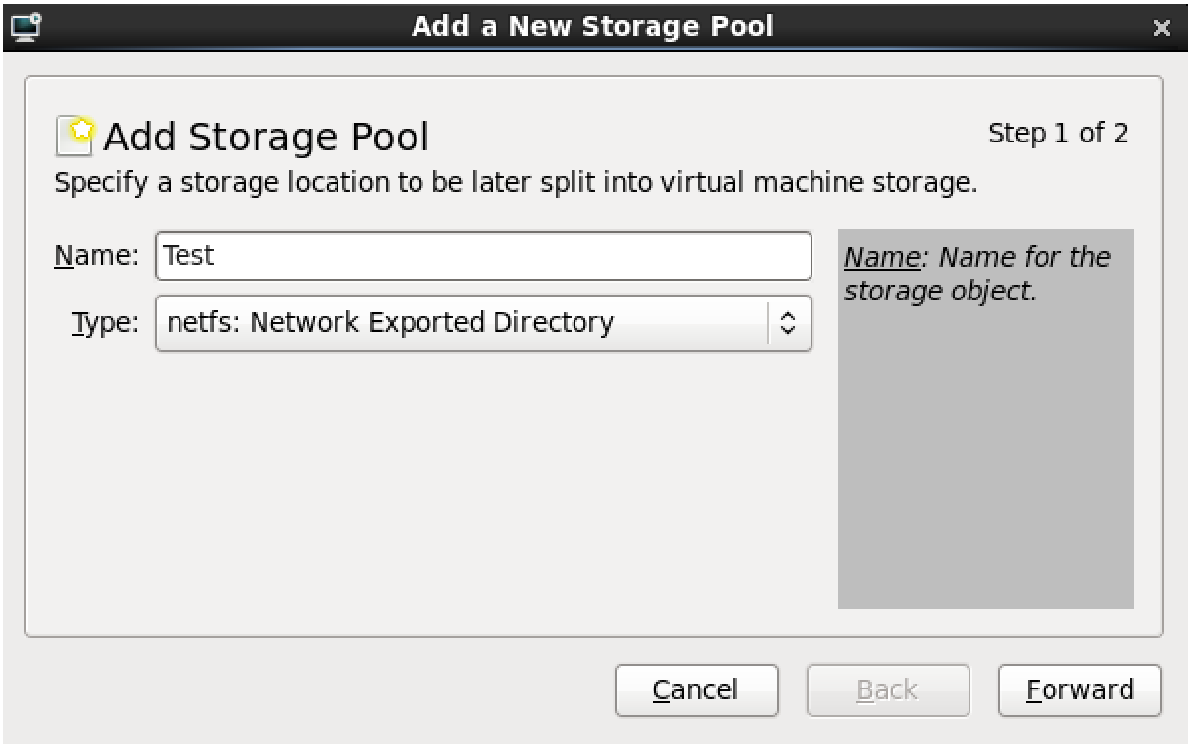


Figure 18.4. Add a new Storage Pool

Press **Forward** to continue.

c. **Specify storage pool details**
Enter the following details:

- **Format**: Select the storage type. This must be NFS or iSCSI for live migrations.
- **Host Name**: Enter the IP address or fully-qualified domain name of the storage server.

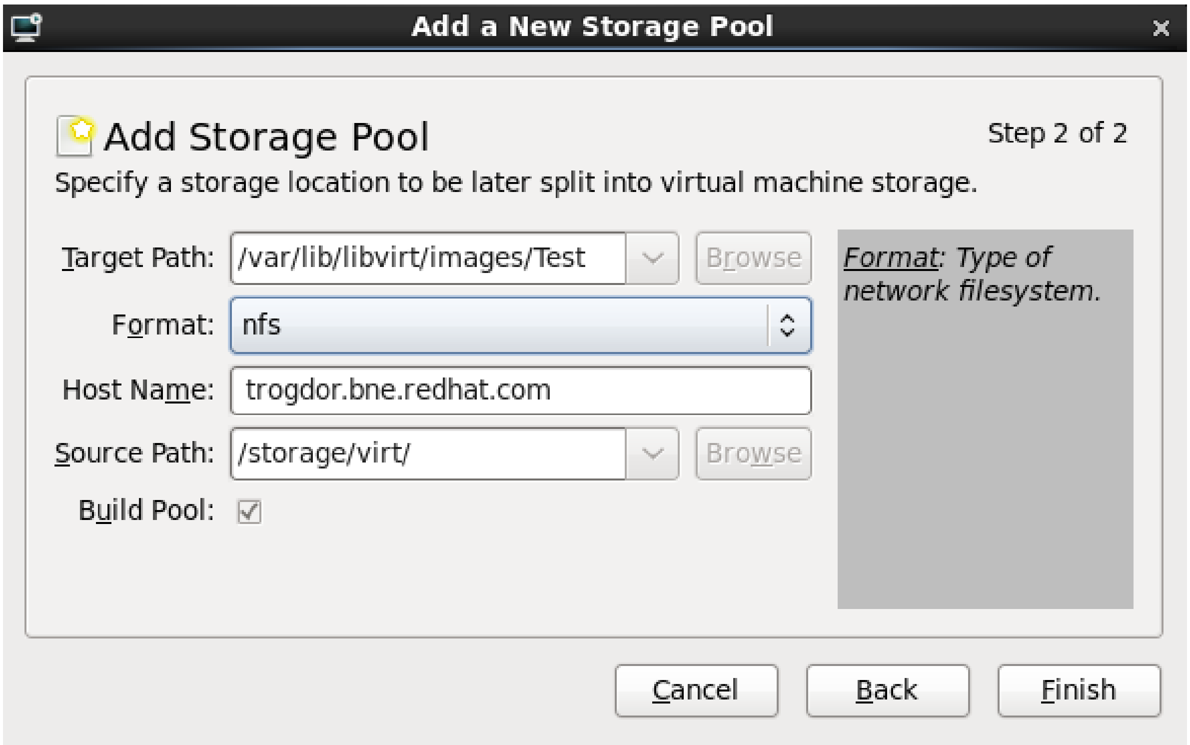


Figure 18.5. Storage pool details

Press the **Finish** button to add the storage pool.

d. **Verify the new storage pool was added sucessfully**
The new storage pool should be visible in the **Storage** tab.

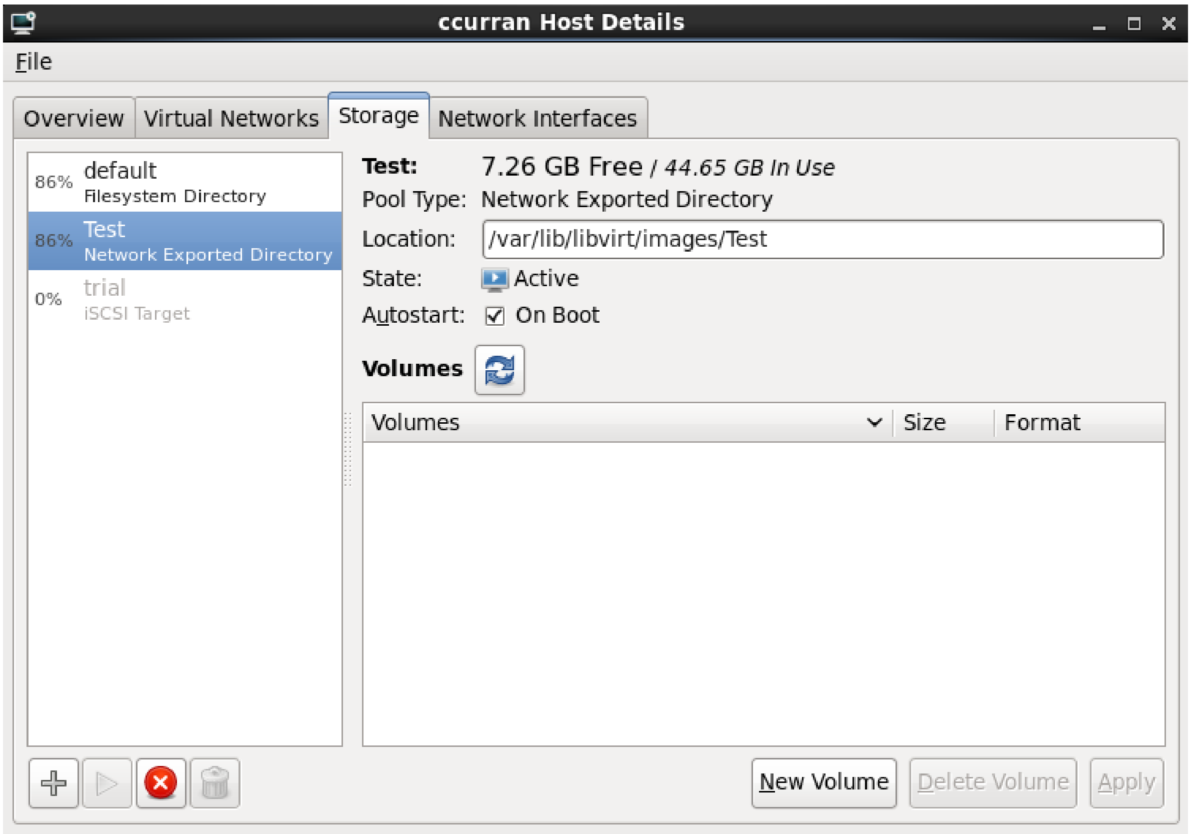


Figure 18.6. New storage pool in the storage tab

Complete these steps on both hosts before proceeding.

3. **Optional: Add a volume to the storage pool**
   Add a volume to the storage pool or create a new virtualized guest on the storage pool. If your storage pool already has virtualized guests, you can skip this step.

   a. Create a new volume in the shared storage pool, click **New Volume**.

      Enter the details, then click **Create Volume**.

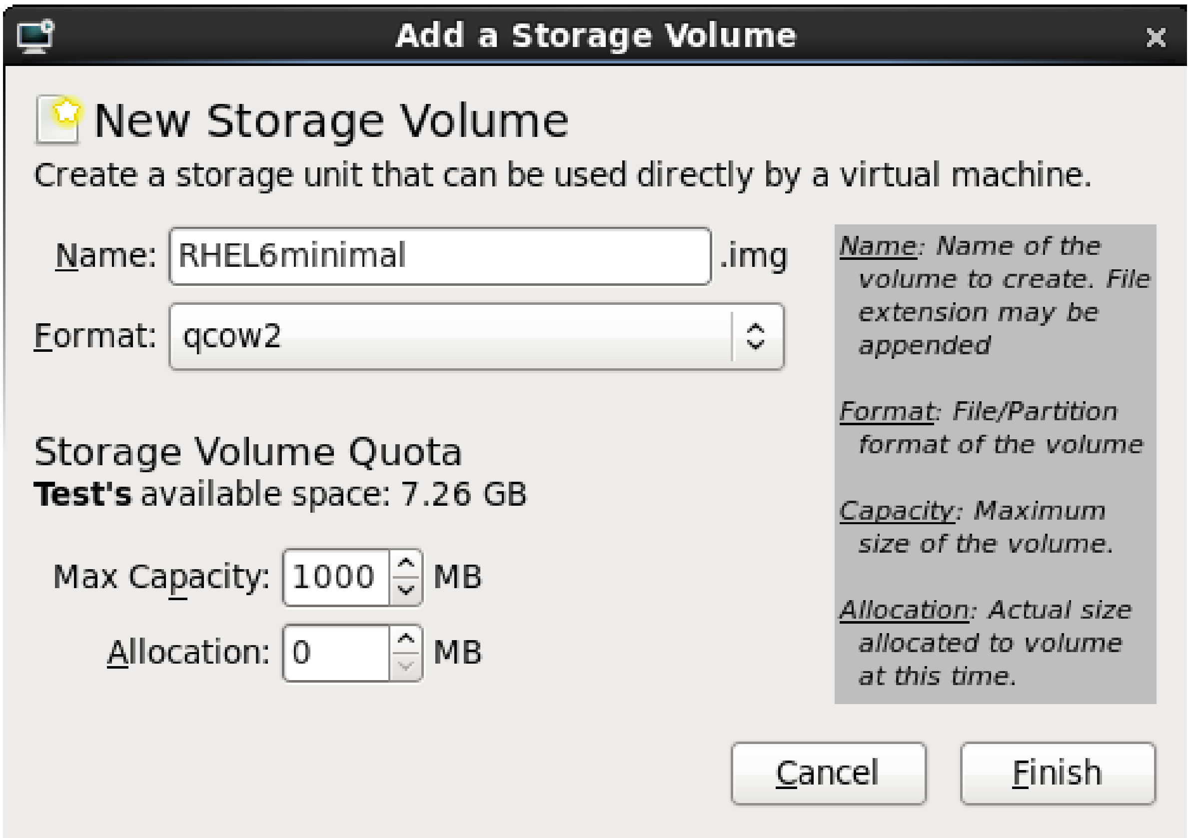


Figure 18.7. Add a storage volume

b. **Create a new virtualized guest on the new volume**
   Create a new virtualized guest that uses the new volume. For information on creating virtualized guests, refer to *Part II, "Installation"*.

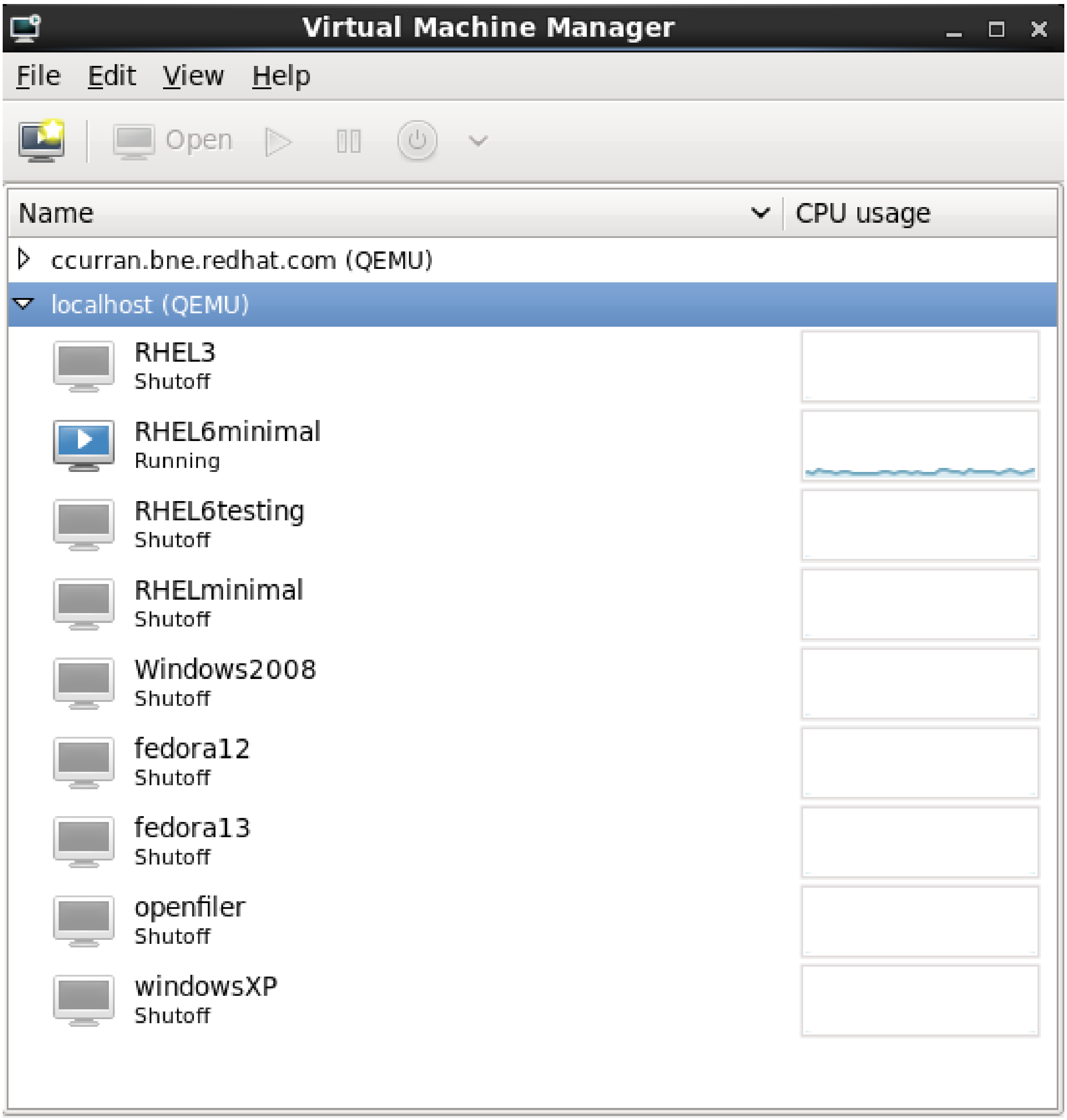


Figure 18.8. New virtualized guest

The Virtual Machine window appears.

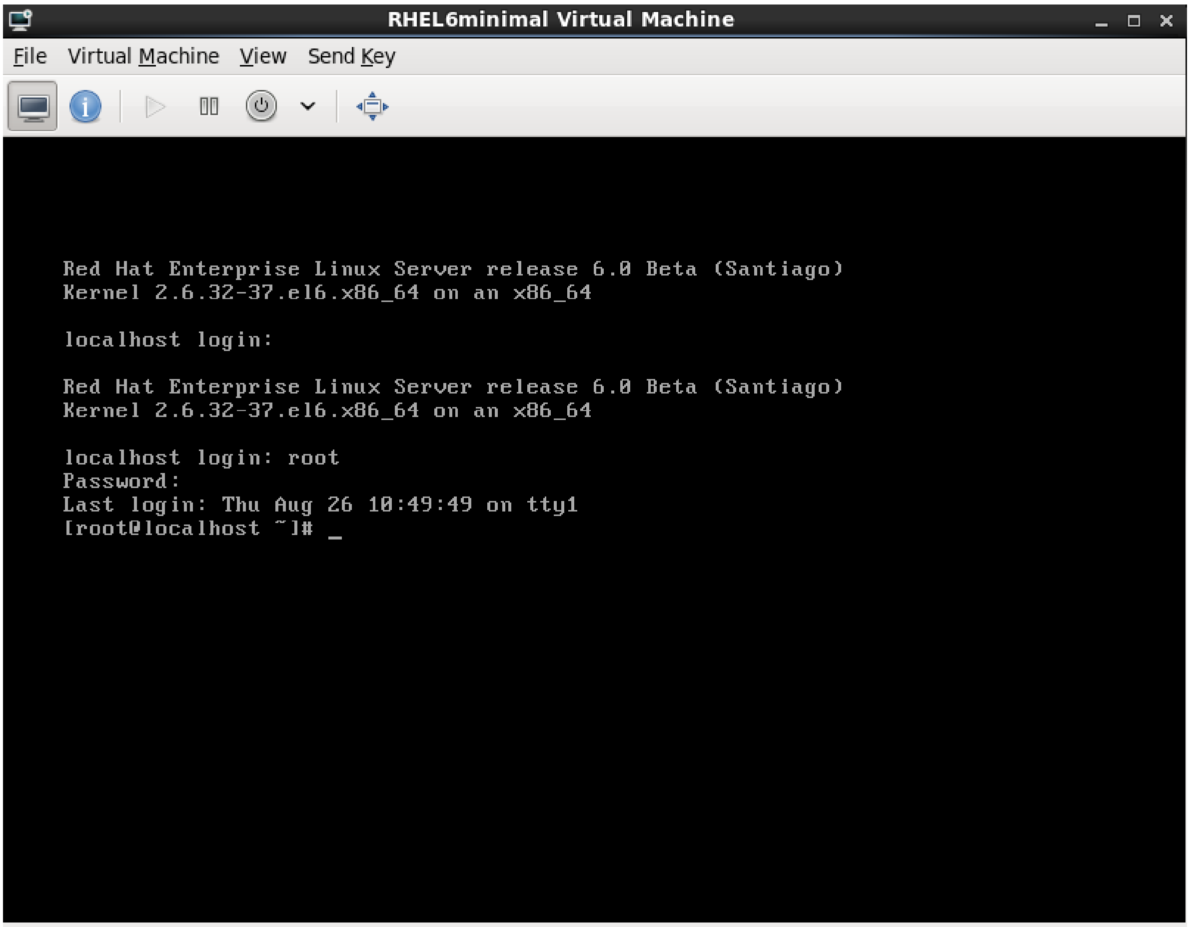


Figure 18.9. Virtual Machine window

4. **Migrate the virtualized guest**
   From the main virt-manager screen, right-click on the virtual machine and select **Migrate...**. The **Migrate the virtual machine** window appears.

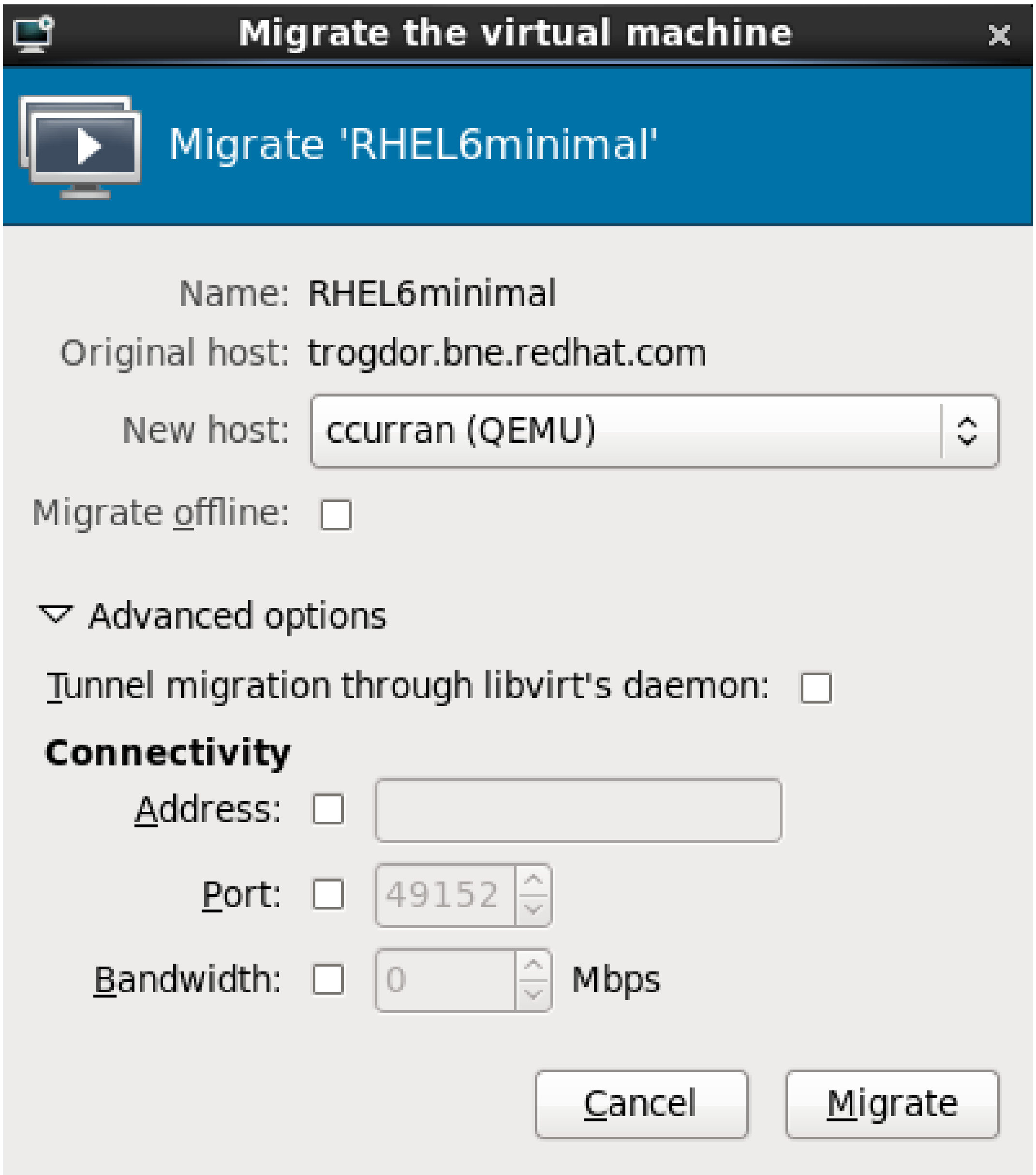


Figure 18.10. Migrate the virtual machine

Select the destination host from the list.

Select **Migrate offline** to disable live migration and do an offline migration.

Select advanced options if required. For a standard migration, no of these settings should be modified.

Press **Migrate** to confirm and migrate the virtualized guest.

5. A status bar tracks the progress of the migration. Once the migration is complete the virtualized guest will appear in the list of virtualized guests on the destination.

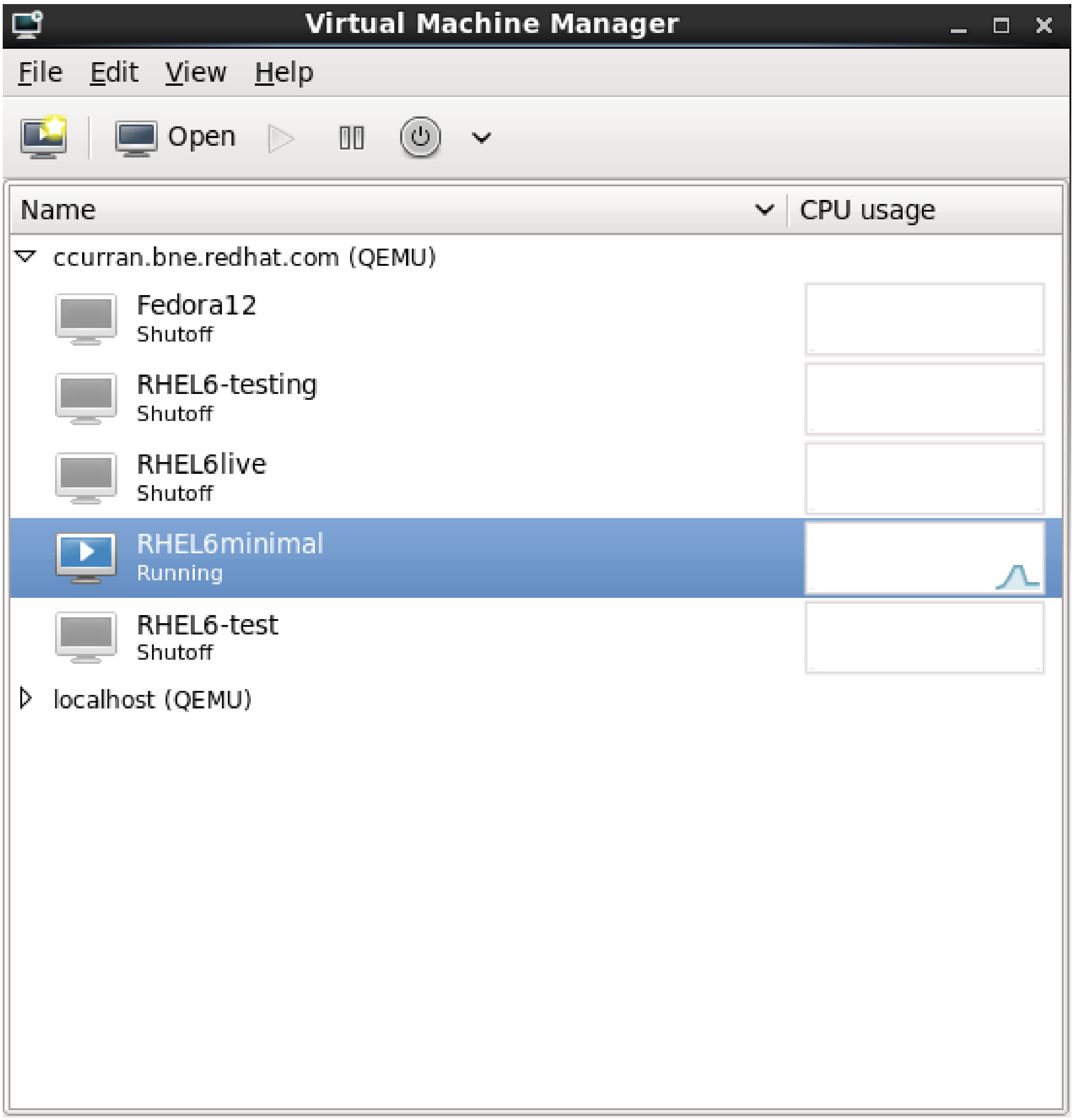


Figure 18.11. Completed migration

Remote management of virtualized guests

This section explains how to remotely manage your virtualized guests using **`ssh`** or TLS and SSL.

19.1. Remote management with SSH

The *ssh* package provides an encrypted network protocol which can securely send management functions to remote virtualization servers. The method described uses the **`libvirt`** management connection securely tunneled over an **SSH** connection to manage the remote machines. All the authentication is done using **SSH** public key cryptography and passwords or passphrases gathered by your local **SSH** agent. In addition the **VNC** console for each guest virtual machine is tunneled over **SSH**.

SSH is usually configured by default so you probably already have SSH keys setup and no extra firewall rules needed to access the management service or **VNC** console.

Be aware of the issues with using **SSH** for remotely managing your virtual machines, including:

- you require root log in access to the remote machine for managing virtual machines,
- the initial connection setup process may be slow,
- there is no standard or trivial way to revoke a user's key on all hosts or guests, and
- ssh does not scale well with larger numbers of remote machines.

Configuring password less or password managed SSH access for `virt-manager`

The following instructions assume you are starting from scratch and do not already have **SSH** keys set up. If you have SSH keys set up and copied to the other systems you can skip this procedure.

The user is important for remote management

SSH keys are user dependent. Only the user who owns the key may access that key.

`virt-manager` must run as the user who owns the keys to connect to the remote host. That means, if the remote systems are managed by a non-root user **`virt-manager`** must be run in unprivileged mode. If the remote systems are managed by the local root user then the SSH keys must be owned and created by root.

You cannot manage the local host as an unprivileged user with **`virt-manager`**.

1. **Optional: Changing user**
   Change user, if required. This example uses the local root user for remotely managing the other hosts and the local host.

   ```
   $ su -
   ```

2. **Generating the SSH key pair**
   Generate a public key pair on the machine **`virt-manager`** is used. This example uses the default key location, in the **`~/.ssh/`** directory.

```
$ ssh-keygen -t rsa
```

3. **Copying the keys to the remote hosts**
   Remote login without a password, or with a passphrase, requires an SSH key to be distributed to the systems being managed. Use the **`ssh-copy-id`** command to copy the key to root user at the system address provided (in the example, *`root@example.com`*).

   ```
   $ ssh-copy-id -i ~/.ssh/id_rsa.pub root@example.com
   root@example.com's password:
   ```

   Now try logging into the machine, with the **`ssh root@example.com`** command and check in the **`.ssh/authorized_keys`** file to make sure unexpected keys have not been added.

   Repeat for other systems, as required.

4. **Optional: Add the passphrase to the ssh-agent**
   Add the passphrase for the SSH key to the **`ssh-agent`**, if required. On the local host, use the following command to add the passphrase (if there was one) to enable password-less login.

   ```
   # ssh-add ~/.ssh/id_rsa.pub
   ```

The SSH key was added to the remote system.

The `libvirt` daemon (`libvirtd`)

The `libvirt` daemon provide an interface for managing virtual machines. You must have the `libvirtd` daemon installed and running on every remote host that needs managing.

```
$ ssh root@somehost
# chkconfig libvirtd on
# service libvirtd start
```

After `libvirtd` and **SSH** are configured you should be able to remotely access and manage your virtual machines. You should also be able to access your guests with **`VNC`** at this point.

Accessing remote hosts with virt-manager

Remote hosts can be managed with the virt-manager GUI tool. SSH keys must belong to the user executing virt-manager for password-less login to work.

1. Start virt-manager.

2. Open the **File**->**Add Connection** menu.

3. Input values for the hypervisor type, the connection, Connection->Remote tunnel over SSH, and enter the desired hostname, then click connection.

19.2. Remote management over TLS and SSL

You can manage virtual machines using TLS and SSL. TLS and SSL provides greater scalability but is more complicated than ssh (refer to *Section 19.1, "Remote management with SSH"*). TLS and SSL is the same technology used by web browsers for secure connections. The **`libvirt`** management connection opens a TCP port for incoming connections, which is securely encrypted and authenticated based on x509 certificates.

TLS/SSL access for virt-manager

The libvirt Wiki contains complete details on how to configure TLS/SSL access: *http://wiki.libvirt.org/page/TLSSetup*

To enable SSL and TLS for VNC, refer to the libvirt Wiki: *http://wiki.libvirt.org/page/VNCTLSSetup*. It is necessary to place the Certificate Authority Certificate, Client Certificate, and Client Certificate Private Key, in the following locations:

- The Certificate Authority Certificate should be placed in **`/etc/pki/CA/cacert.pem`**.
- The Client Certificate, signed by the CA, should be placed in either of:
  - **`/etc/pki/libvirt-vnc/clientcert.pem`** for system wide use, or
  - **`$HOME/.pki/libvirt-vnc/clientcert.pem`** for an individual user.
- The Private Key for the Client Certificate should be placed in either of:
  - **`/etc/pki/libvirt-vnc/private/clientkey.pem`** for system wide use, or
  - **`$HOME/.pki/libvirt-vnc/private/clientkey.pem`** for an individual user.

19.3. Transport modes

For remote management, **`libvirt`** supports the following transport modes:

Transport Layer Security (TLS)

Transport Layer Security TLS 1.0 (SSL 3.1) authenticated and encrypted TCP/IP socket, usually listening on a public port number. To use this you will need to generate client and server certificates. The standard port is 16514.

UNIX sockets

Unix domain sockets are only accessible on the local machine. Sockets are not encrypted, and use UNIX permissions or SELinux for authentication. The standard socket names are **`/var/run/libvirt/libvirt-sock`** and **`/var/run/libvirt/libvirt-sock-ro`** (for read-only connections).

SSH

Transported over a Secure Shell protocol (SSH) connection. Requires Netcat (the *nc* package) installed. The libvirt daemon (**`libvirtd`**) must be running on the remote machine. Port 22 must be open for SSH access. You should use some sort of ssh key management (for example, the **`ssh-agent`** utility) or you will be prompted for a password.

ext

The *`ext`* parameter is used for any external program which can make a connection to the remote machine by means outside the scope of libvirt. This parameter is unsupported.

tcp

Unencrypted TCP/IP socket. Not recommended for production use, this is normally disabled, but an administrator can enable it for testing or use over a trusted network. The default port is 16509.

The default transport, if no other is specified, is tls.

Remote URIs

A Uniform Resource Identifier (URI) is used by **virsh** and **libvirt** to connect to a remote host. URIs can also be used with the **--connect** parameter for the **virsh** command to execute single commands or migrations on remote hosts.

libvirt URIs take the general form (content in square brackets, "[]", represents optional functions):

```
driver[+transport]://[username@][hostname][:port]/[path][?extraparameters]
```

The transport method or the hostname must be provided to target an external location.

Examples of remote management parameters

- Connect to a remote KVM host named `server7`, using SSH transport and the SSH username `ccurran`.

  ```
  qemu+ssh://ccurran@server7/
  ```

- Connect to a remote KVM hypervisor on the host named `server7` using TLS.

  ```
  qemu://server7/
  ```

- Connect to a remote KVM hypervisor on host `server7` using TLS. The *`no_verify=1`* instructs libvirt not to verify the server's certificate.

  ```
  qemu://server7/?no_verify=1
  ```

Testing examples

- Connect to the local KVM hypervisor with a non-standard UNIX socket. The full path to the Unix socket is supplied explicitly in this case.

  ```
  qemu+unix:///system?socket=/opt/libvirt/run/libvirt/libvirt-sock
  ```

- Connect to the libvirt daemon with an unencrypted TCP/IP connection to the server with the IP address 10.1.1.10 on port 5000. This uses the test driver with default settings.

  ```
  test+tcp://10.1.1.10:5000/default
  ```

Extra URI parameters

Extra parameters can be appended to remote URIs. The table below *Table 19.1, “Extra URI parameters”* covers the recognized parameters. All other parameters are ignored. Note that parameter values must be URI-escaped (that is, a question mark (?) is appended before the parameter and special characters are converted into the URI format).

Table 19.1. Extra URI parameters

Name	Transport mode	Description	Example usage
name	all modes	The name passed to the remote virConnectOpen function. The name is normally formed by removing transport,	name=qemu:///system

Name	Transport mode	Description	Example usage
		hostname, port number, username and extra parameters from the remote URI, but in certain very complex cases it may be better to supply the name explicitly.	
command	ssh and ext	The external command. For ext transport this is required. For ssh the default is ssh. The PATH is searched for the command.	command=/opt/openssh/bin/ssh
socket	unix and ssh	The path to the UNIX domain socket, which overrides the default. For ssh transport, this is passed to the remote netcat command (see netcat).	socket=/opt/libvirt/run/libvirt/libvirt-sock
netcat	ssh	The **`netcat`** command can be used to connect to remote systems. The default netcat parameter uses the **nc** command. For SSH transport, libvirt constructs an SSH command using the form below: *`command`* -p *`port`* [-l *`username`*] *`hostname`* *`netcat`* -U socket The *`port`*, *`username`* and *`hostname`* parameters can be specified as part of the remote URI. The *`command`*, *`netcat`* and *`socket`* come from other extra parameters.	netcat=/opt/netcat/bin/nc
no_verify	tls	If set to a non-zero value, this disables client checks of the server's certificate. Note that to disable	no_verify=1

Name	Transport mode	Description	Example usage
		server checks of the client's certificate or IP address you must change the libvirtd configuration.	
no_tty	ssh	If set to a non-zero value, this stops ssh from asking for a password if it cannot log in to the remote machine automatically (for using ssh-agent or similar). Use this when you do not have access to a terminal - for example in graphical programs which use libvirt.	no_tty=1

Overcommitting with KVM

The KVM hypervisor supports overcommitting CPUs and overcommitting memory. Overcommitting is allocating more virtualized CPUs or memory than there are physical resources on the system. With CPU overcommit, under-utilized virtualized servers or desktops can run on fewer servers which saves power and money.

Overcommitting memory

Most operating systems and applications do not use 100% of the available RAM all the time. This behavior can be exploited with KVM. KVM can allocate more memory for virtualized guests than the host has physically available.

With KVM, virtual machines are Linux processes. Guests on the KVM hypervisor do not have dedicated blocks of physical RAM assigned to them, instead guests function as Linux processes. The Linux kernel allocates each process memory when the process requests more memory. KVM guests are allocated memory when requested by the guest operating system. The guest only requires slightly more physical memory than the virtualized operating system reports as used. The Linux kernel swaps infrequently used memory out of physical memory and into virtual memory. Swapping decreases the amount of memory required by virtualized guests.

When physical memory is completely used or a process is inactive for some time, Linux moves the process's memory to swap. Swap is usually a partition on a hard disk drive or solid state drive which Linux uses to extend virtual memory. Swap is significantly slower than RAM due to the throughput and response times of hard drives and solid state drives.

As KVM virtual machines are Linux processes, underused or idle memory of virtualized guests is moved by default to swap. The total memory used by guests can be overcommitted, which is to use more than the physically available host memory. Overcommitting requires sufficient swap space for all guests and all host processes.

Without sufficient swap space for all processes in virtual memory the **`pdflush`** process, the cleanup process, starts. The **`pdflush`** process kills processes to free memory so the system does not crash. **`pdflush`** may destroy virtualized guests or other system processes which may cause file system errors and may leave virtualized guests unbootable.This can cause issues if virtualized guests use their total RAM.

> **Warning**
>
> If sufficient swap is not available guest operating systems will be forcibly shut down. This may leave guests inoperable. Avoid this by never overcommitting more memory than there is swap available.

> **Overcommitting with KSM**
>
> If KSM is used ensure the swap size is sufficient for the overcommitted RAM. KSM reduces the RAM usage of identical or similar guests. Overcommitting guests with KSM without sufficient swap may be possible but is not recommended. For more information on KSM and overcommitting, refer to *Chapter 21, KSM*.

Configuring swap for overcommitting memory

The swap partition is used for swapping underused memory to the hard drive to speed up memory performance. The default size of the swap partition is calculated from the physical RAM of the host.

Red Hat *Knowledgebase*[1] has an article on safely and efficiently determining the size of the swap partition.

The swap partition must be large enough to provide virtual memory for all guests and the host system.

Important

The example below is provided as a guide for configuring swap only. The settings listed may not be appropriate for your environment.

Example 20.1. Memory overcommit example

ExampleServer1 has 32GB of RAM. The system is being configured to run 56 guests with 1GB of virtualized memory. The host system rarely uses more than 4GB of memory for system processes, drivers and storage caching.

32GB minus 4GB for the host leaves 28GB of physical RAM for virtualized guests. Each guest uses 1GB of RAM, a total of 56GB of virtual RAM is required for the guests.

The Red Hat Knowledgebase recommends 8GB of swap for a system with 32GB of RAM. To safely overcommit memory there must be sufficient virtual memory for all guests and the host. The host has 28GB of RAM for guests (which need 56GB of RAM). Therefore, the system needs at least 28GB of swap for the guests.

ExampleServer1 requires at least 36GB (8GB for the host and 28GB for the guests) of swap to safely overcommit for all 56 guests.

It is possible to overcommit memory over ten times the amount of physical RAM in the system. This only works with certain types of guest, for example, desktop virtualization with minimal intensive usage or running several identical guests with KSM. Configuring swap and memory overcommit is not a formula, each environment and setup is different. Your environment must be tested and customized to ensure stability and performance.

For more information on KSM and overcommitting, refer to *Chapter 21, KSM*.

Overcommitting virtualized CPUs

The KVM hypervisor supports overcommitting virtualized CPUs. Virtualized CPUs can be overcommitted as far as load limits of virtualized guests allow. Use caution when overcommitting VCPUs as loads near 100% may cause dropped requests or unusable response times.

Virtualized CPUs are overcommitted best when each virtualized guest only has a single VCPU. The Linux scheduler is very efficient with this type of load. KVM should safely support guests with loads under 100% at a ratio of five VCPUs. Overcommitting single VCPU virtualized guests is not an issue.

You cannot overcommit symmetric multiprocessing guests on more than the physical number of processing cores. For example a guest with four VCPUs should not be run on a host with a dual

[1] http://kbase.redhat.com/faq/docs/DOC-15252

core processor. Overcommitting symmetric multiprocessing guests in over the physical number of processing cores will cause significant performance degradation.

Assigning guests VCPUs up to the number of physical cores is appropriate and works as expected. For example, running virtualized guests with four VCPUs on a quad core host. Guests with less than 100% loads should function effectively in this setup.

Always test first

Do not overcommit memory or CPUs in a production environment without extensive testing. Applications which use 100% of memory or processing resources may become unstable in overcommitted environments. Test before deploying.

KSM

The concept of shared memory is common in modern operating systems. For example, when a program is first started it shares all of its memory with the parent program. When either the child or parent program tries to modify this memory, the kernel allocates a new memory region, copies the original contents and allows the program to modify this new region. This is known as copy on write.

KSM is a new Linux feature which uses this concept in reverse. KSM enables the kernel to examine two or more already running programs and compare their memory. If any memory regions or pages are identical, KSM reduces multiple references to multiple identical memory pages to a single reference to a single page. This page is then marked copy on write. If the contents of the page is modified, a new page is created.

This is useful for virtualization with KVM. When a virtualized guest is started, it only inherits the memory from the parent `qemu-kvm` process. Once the guest is running the contents of the guest operating system image can be shared when guests are running the same operating system or applications. KSM only identifies and merges identical pages which does not interfere with the guest or impact the security of the host or the guests. KSM allows KVM to request that these identical guest memory regions be shared.

KSM provides enhanced memory speed and utilization. With KSM, common process data is stored in cache or in main memory. This reduces cache misses for the KVM guests which can improve performance for some applications and operating systems. Secondly, sharing memory reduces the overall memory usage of guests which allows for higher densities and greater utilization of resources.

Red Hat Enterprise Linux uses two separate methods for controlling KSM:

- The `ksm` service starts and stops the KSM kernel thread.
- The `ksmtuned` service controls and tunes the `ksm`, dynamically managing same-page merging. The `ksmtuned` service starts `ksm` and stops the `ksm` service if memory sharing is not necessary. The `ksmtuned` service must be told with the *`retune`* parameter to run when new virtualized guests are created or destroyed.

Both of these services are controlled with the standard service management tools.

The KSM service

The `ksm` service is a standard Linux daemon that uses the KSM kernel features.

KSM is included in the *qemu-common* package, which is a dependency of KVM. KSM is enabled by default in Red Hat Enterprise Linux. When the `ksm` service is not started, KSM shares only 2000 pages. This default is low and provides limited memory saving benefits.

When the `ksm` service is started, KSM will share up to half of the host system's main memory. Start the `ksm` service to enable KSM to share more memory.

```
# service ksm start
Starting ksm:                                              [  OK  ]
```

The `ksm` service can be added to the default startup sequence. Make the `ksm` service persistent with the chkconfig command.

```
# chkconfig ksm on
```

The KSM tuning service

The `ksmtuned` service does not have any options. The `ksmtuned` service loops and adjusts `ksm`. The `ksmtuned` service is notified by libvirt when a virtualized guest is created or destroyed.

```
# service ksmtuned start
Starting ksmtuned:                                           [  OK  ]
```

The `ksmtuned` service can be tuned with the *`retune`* parameter. The *`retune`* parameter instructs `ksmtuned` to run tuning functions manually.

The **`/etc/ksmtuned.conf`** file is the configuration file for the `ksmtuned` service. The file output below is the default **`ksmtuned.conf`** file.

```
# Configuration file for ksmtuned.

# How long ksmtuned should sleep between tuning adjustments
# KSM_MONITOR_INTERVAL=60

# Millisecond sleep between ksm scans for 16Gb server.
# Smaller servers sleep more, bigger sleep less.
# KSM_SLEEP_MSEC=10

# KSM_NPAGES_BOOST=300
# KSM_NPAGES_DECAY=-50
# KSM_NPAGES_MIN=64
# KSM_NPAGES_MAX=1250

# KSM_THRES_COEF=20
# KSM_THRES_CONST=2048

# uncomment the following to enable ksmtuned debug information
# LOGFILE=/var/log/ksmtuned
# DEBUG=1
```

KSM variables and monitoring

KSM stores monitoring data in the **`/sys/kernel/mm/ksm/`** directory. Files in this directory are updated by the kernel and are an accurate record of KSM usage and statistics.

The variables in the list below are also configurable variables in the **`/etc/ksmtuned.conf`** file as noted below.

The **`/sys/kernel/mm/ksm/`** files

full_scans
    Full scans run.

pages_shared
    Total pages shared.

pages_sharing
    Pages presently shared.

pages_to_scan
    Pages not scanned.

pages_unshared
    Pages no longer shared.

pages_volatile
: Number of volatile pages.

run
: Whether the KSM process is running.

sleep_millisecs
: Sleep milliseconds.

KSM tuning activity is stored in the **/var/log/ksmtuned** log file if the *DEBUG=1* line is added to the **/etc/ksmtuned.conf** file. The log file location can be changed with the *LOGFILE* parameter. Changing the log file location is not advised and may require special configuration of SELinux settings.

The **/etc/sysconfig/ksm** file can manually set a number or all pages used by KSM as not swappable.

1. Open the **/etc/sysconfig/ksm** file with a text editor.

```
# The maximum number of unswappable kernel pages
# which may be allocated by ksm (0 for unlimited)
# If unset, defaults to half of total memory
# KSM_MAX_KERNEL_PAGES=
```

2. Uncomment the **KSM_MAX_KERNEL_PAGES** line to manually configure the number of unswappable pages for KSM. Setting this variable to *0* configures KSM to keep all identical pages in main memory which can improve performance if the system has sufficient main memory.

```
# The maximum number of unswappable kernel pages
# which may be allocated by ksm (0 for unlimited)
# If unset, defaults to half of total memory
KSM_MAX_KERNEL_PAGES=0
```

Deactivating KSM

KSM has a performance overhead which may be too large for certain environments or host systems.

KSM can be deactivated by stopping the `ksm` service and the `ksmtuned` service. Stopping the services deactivates KSM but does not persist after restarting.

```
# service ksm stop
Stopping ksm:                                           [  OK  ]
# service ksmtuned stop
Stopping ksmtuned:                                      [  OK  ]
```

Persistently deactivate KSM with the **chkconfig** command. To turn off the services, run the following commands:

```
# chkconfig ksm off
# chkconfig ksmtuned off
```

Hugepage support

Introduction

x86 CPUs usually address memory in 4kB pages, but they are capable of using larger pages known as **huge pages**. KVM guests can be deployed with huge page memory support in order to reduce memory consumption and improve performance by reducing CPU cache usage.

By using huge pages for a KVM guest, less memory is used for page tables and TLB (Translation Lookaside Buffer) errors are reduced, thereby significantly increasing performance, especially for memory-intensive situations.

Transparent Hugepage Support is a kernel feature that reduces TLB entries needed for an application. By also allowing all free memory to be used as cache, performance is increased.

Using Transparent Hugepage Support

To use Transparent Hugepage Support, no special configuration in the **`qemu.conf`** file is required. Hugepages are used by default if **`/sys/kernel/mm/redhat_transparent_hugepage/enabled`** is set to **always**.

Transparent Hugepage Support does not prevent the use of hugetlbfs. However, when hugetlbfs is not used, KVM will use transparent hugepages instead of the regular 4kB page size.

Migrating to KVM from other hypervisors using virt-v2v

The **`virt-v2v`** command converts guests from a foreign hypervisor to run on KVM, managed by libvirt. The following guest operating systems are supported by **`virt-v2v`**:

- Red Hat Enterprise Linux 4
- Red Hat Enterprise Linux 5
- Red Hat Enterprise Linux 6
- Windows XP
- Windows Vista
- Windows 7
- Windows Server 2003
- Windows Server 2008

The **`virt-v2v`** command can currently convert virtualized guests running the listed operating systems running on libvirt-managed Xen, KVM, and VMware ESX. The **`virt-v2v`** command enables para-virtualized (**`virtio`**) drivers in the converted guest if possible.

`virt-v2v` is available on Red Hat Network (RHN) in the **Red Hat Enterprise Linux Server (v.6 for 64-bit x86_64)** or **Red Hat Enterprise Linux Workstation (v.6 for x86_64)** channel.

The **`virt-v2v`** tool requires root access to the host system.

Installing virt-v2v

To install **`virt-v2v`** from RHN, ensure the system is subscribed to the appropriate channel, then run:

```
yum install virt-v2v
```

23.1. Preparing to convert a virtualized guest

Before a virtualized guest can be converted, ensure that the following steps are completed.

1. Create a local storage domain for transferred storage

   `virt-v2v` copies the guest storage to a locally defined libvirt storage pool during import. This pool can be defined using any libvirt tool, and can be of any type. The simplest way to create a new pool is with **`virt-manager`**. Select your host, right click and select details.

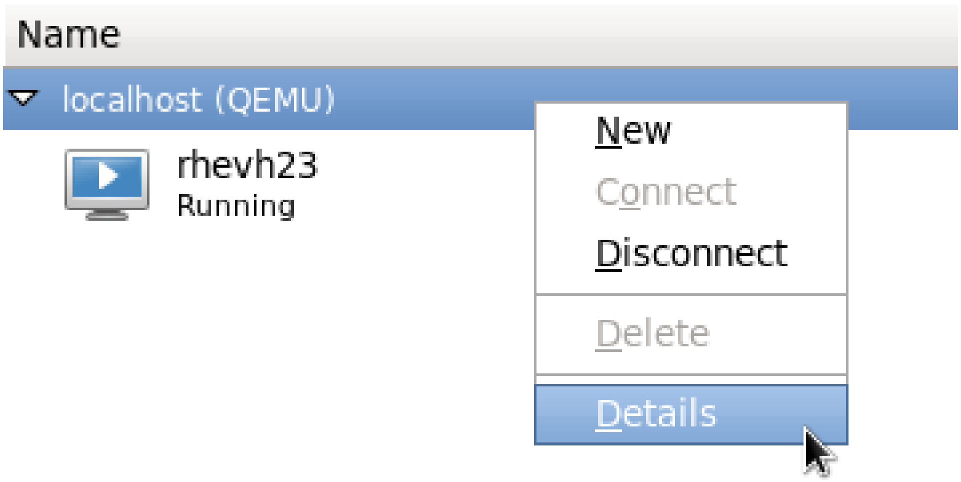


Figure 23.1. Select host details

Select the **Storage** tab.

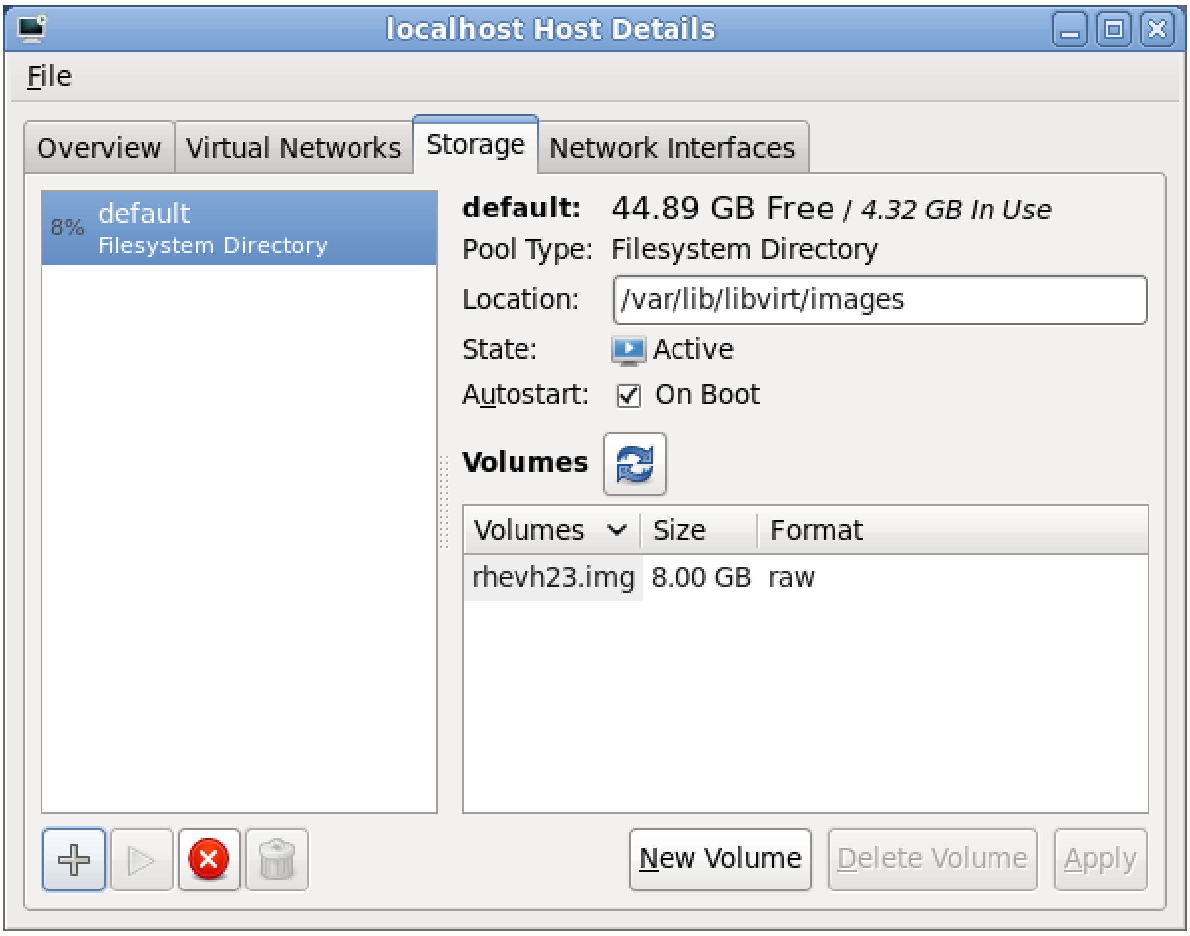


Figure 23.2. The storage tab

Click the plus sign (**+**) button to add a new storage pool.

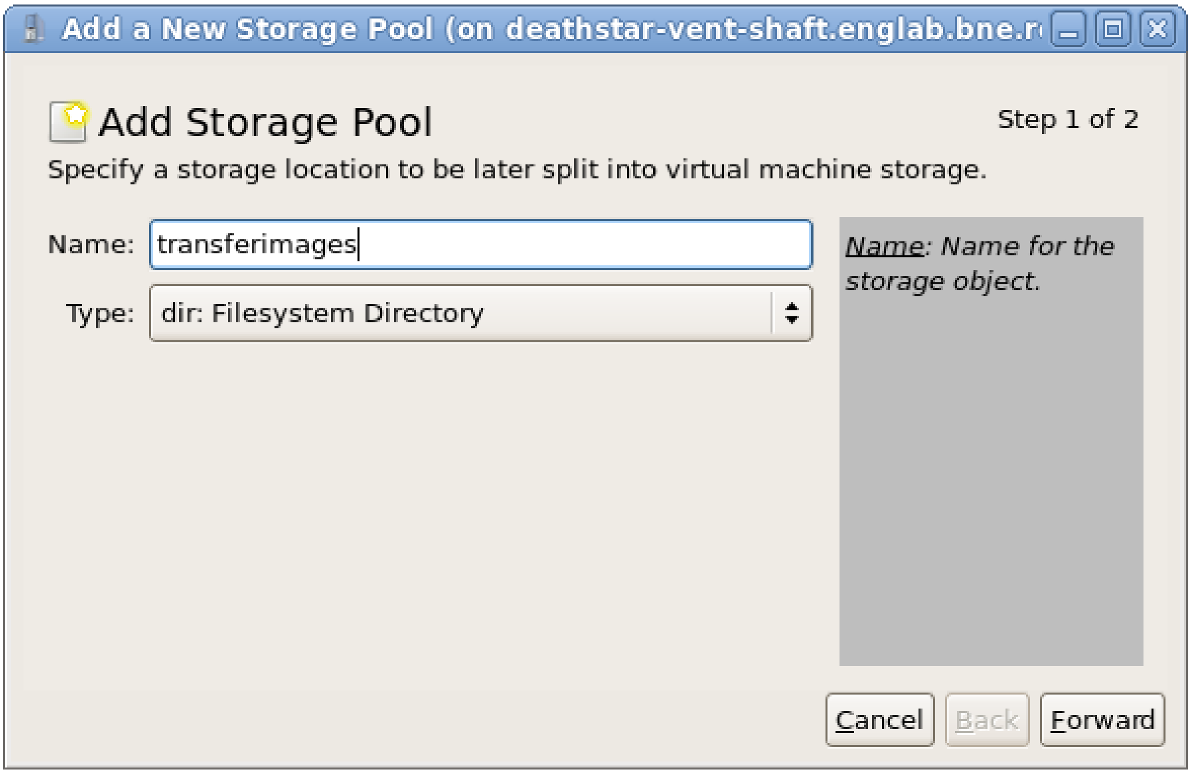


Figure 23.3. Adding a storage pool

2. Create local network interfaces.

   The local machine must have an appropriate network to which the converted virtualized guest can connect. This is likely to be a bridge interface. A bridge interface can be created using standard tools on the host. Since version 0.8.3, **`virt-manager`** can also create and manage bridges.

3. Specify network mappings in **`virt-v2v.conf`**. This step is *optional*, and is not required for most use cases.

   If your virtualized guest has multiple network interfaces, **`/etc/virt-v2v.conf`** must be edited to specify the network mapping for all interfaces. You can specify an alternative **`virt-v2v.conf`** file with the *`-f`* parameter.

   If your virtualized guest only has a single network interface, it is simpler to use the *`--network`* or *`--bridge`* parameters, rather than modifying **`virt-v2v.conf`**.

Preparing to convert a virtualized guest running Linux

Before a virtualized guest running Linux can be converted, ensure that the following steps are completed.

1. Obtain the software

   As part of the conversion process, **`virt-v2v`** may install a new kernel and drivers on the virtualized guest. If the virtual machine being converted is registered to Red Hat Network (RHN), the required packages will be automatically downloaded. For environments where RHN is not available, the **`virt-v2v.conf`** file references a list of RPMs used for this purpose. The RPMs relevant to your virtualized guest must be downloaded manually from RHN and made available in the directory specified by the path-root configuration element, which by default is **`/var/lib/`**

`virt-v2v/software/`. **`virt-v2v`** will display an error similar to *Example 23.1, “Missing Package error”* if software it depends upon for a particular conversion is not available.

Example 23.1. Missing Package error

```
virt-v2v: Installation failed because the following files referenced in the
 configuration file are required, but missing:
rhel/5/kernel-2.6.18-128.el5.x86_64.rpm
rhel/5/ecryptfs-utils-56-8.el5.x86_64.rpm
rhel/5/ecryptfs-utils-56-8.el5.i386.rpm
```

To obtain the relevant RPMs for your environment, follow these steps:

1. Log in to Red Hat Network: *https://rhn.redhat.com/*
2. In the Customer Portal section of RHN (*https://rhn.redhat.com/rhn/software/channels/All.do*), select the **Software Channels** tab.
3. Select your product, version and architecture to enter the correct channel.
4. Select the **Packages** tab.
5. Use the **Filter by Package** function to locate the missing package.
6. Select the package exactly matching the one shown in the error message. For the example shown in *Example 23.1, “Missing Package error”*, the first package is **kernel-2.6.18-128.el5.x86_64**
7. Select **Download Packages** at the bottom of the package details page.
8. Save the downloaded package to the appropriate directory in **`/var/lib/virt-v2v/software`**. For example, the Red Hat Enterprise Linux 5 directory is **/var/lib/virt-v2v/software/rhel/5**.

Preparing to convert a virtualized guest running Windows

Before a virtualized guest running Windows can be converted, ensure that the following steps are completed.

Important

Virtualized guests running Windows can only be converted for output to Red Hat Enterprise Virtualization. The conversion procedure depends on post-processing by the Red Hat Enterprise Virtualization Manager for completion. See *Section 23.4.2, “Configuration changes for Windows virtualized guests”* for details of the process. Virtualized guests running Windows cannot be converted for output to libvirt.

1. Obtain the Guest Tools ISO

   As part of the conversion process for virtualized guests running Windows, the Red Hat Enterprise Virtualization Manager will install drivers using the Guest Tools ISO. See *Section 23.4.2, “Configuration changes for Windows virtualized guests”* for details of the process. The Guest Tools ISO is obtained as follows:

   1. From the Red Hat Enterprise Virtualization Manager, Login to Red Hat Network
   2. Click on **Download Software**
   3. Select the **Red Hat Enterprise Virtualization (x86-64)** channel
   4. Select the **Red Hat Enterprise Virt Manager for Desktops (v.2 x86)** or **Red Hat Enterprise Virt Manager for Desktops (v.2 x86)** channel, as appropriate for your subscription.
   5. Download **Guest Tools ISO for 2.2** and save it locally

2. Upload the Guest Tools ISO to the Red Hat Enterprise Virtualization Manager

   Upload the Guest Tools ISO using the ISO Uploader. See the *Red Hat Enterprise Virtualization for Servers Administration Guide* for instructions.

3. Ensure that the *libguestfs-winsupport* package is installed on the host running **`virt-v2v`**. This package provides support for NTFS, which is used by many Windows systems. If you attempt to convert a virtualized guest using NTFS without the *libguestfs-winsupport* package installed, the conversion will fail.

4. Ensure that the *virtio-win* package is installed on the host running **`virt-v2v`**. This package provides para-virtualized block and network drivers for Windows guests. If you attempt to convert a virtualized guest running Windows without the *virtio-win* package installed, the conversion will fail giving an error message concerning missing files.

Preparing to convert a local Xen virtualized guest

The following is required when converting virtualized guests on a host which used to run Xen, but has been updated to run KVM. It is not required when converting a Xen guest imported directly from a running libvirt/Xen instance.

1. Obtain the XML for the virtualized guest

   `virt-v2v` uses a libvirt domain description to determine the current configuration of the virtualized guest, including the location of its storage. Before starting the conversion, obtain this from the host running the virtualized guest with the following command:

   ```
   virsh dumpxml vm-name > vm-name.xml
   ```

   This will require booting into a Xen kernel to obtain the XML, as libvirt needs to connect to a running Xen hypervisor to obtain its metadata. The conversion process is optimized for KVM, so obtaining domain data while running a Xen kernel, then performing the conversion using a KVM kernel will be more efficient than running the conversion on a Xen kernel.

23.2. Converting virtualized guests

Once you have prepared to convert the virtualized guests, use **`virt-v2v`** to perform the actual conversions. This section provides the steps to convert the virtualized guests, and the reference table for **`virt-v2v`**. Note that conversions are resource intensive processes, involving copying the whole disk image for a virtualized guest. In typical environments, converting a single virtualized guest takes approximately 5-10 minutes.

23.2.1. virt-v2v

virt-v2v converts guests from a foreign hypervisor to run on KVM, managed by libvirt.

```
virt-v2v -i libvirtxml -op pool --bridge brname vm-name.xml
virt-v2v -op pool --network netname vm-name
virt-v2v -ic esx://esx.example.com/?no_verify=1 -op pool --bridge brname vm-name
```

Parameters

`-i input`	Specifies the input method to obtain the guest for conversion. The default is libvirt. Supported options are: • **`libvirt`** Guest argument is the name of a libvirt domain. • **`libvirtxml`** Guest argument is the path to an XML file containing a libvirt domain.
`-ic URI`	Specifies the connection to use when using the libvirt input method. If omitted, this defaults to qemu:///system. **`virt-v2v`** can currently automatically obtain guest storage from local libvirt connections, ESX connections, and connections over SSH. Other types of connection are not supported.
`-o method`	Specifies the output method. If no output method is specified, the default is libvirt. Supported output methods are: • **`libvirt`**, create a libvirt guest. See the -oc and -op options. -op must be specified for the libvirt output method. • **`rhev`**, create a guest on a Red Hat Enterprise Virtualization Export storage domain, which can later be imported using the manager. The -osd or Export storage domain must be specified for the rhev output method.
`-oc URI`	Specifies the libvirt connection to use to create the converted guest. If omitted, this defaults to qemu:///system. Note that virt-v2v must be able to write directly to storage described by this libvirt connection. This makes writing to a remote connection impractical at present.
`-op pool`	Specifies the pool which will be used to create new storage for the converted guest.
`-osd domain`	Specifies the path to an existing Red Hat Enterprise Virtualization Export storage domain. The domain must be in the format <host > <path>; for example, **`storage.example.com:/rhev/export`**. The nfs export must be mountable and writable by the machine running **`virt-v2v`**.
`-f file | --config file`	Load the virt-v2v configuration from file. Defaults to /etc/virt-v2v.conf if it exists.
`-n network | --network network`	Map all guest bridges or networks which don't have a mapping in the configuration file to the specified network. This option cannot be used in conjunction with --bridge.
`-b bridge | --bridge bridge`	Map all guest bridges or networks which don't have a mapping in the configuration file to the specified bridge. This option cannot be used in conjunction with --network.
`--help`	Display brief help.

--version	Display version number and exit.

23.2.2. Converting a local Xen virtualized guest

Ensure that the virtualized guest's XML is available locally, and that the storage referred to in the XML is available locally at the same paths.

To convert the virtualized guest from an XML file, run:

```
virt-v2v -i libvirtxml -op pool --bridge brname vm-name.xml
```

Where **pool** is the local storage pool to hold the image, **brname** is the name of a local network bridge to connect the converted guest's network to, and **vm-name.xml** is the path to the virtualized guest's exported XML. You may also use the *--network* parameter to connect to a locally managed network, or specify multiple mappings in **/etc/virt-v2v.conf**.

If your guest uses a Xen para-virtualized kernel (it would be called something like kernel-xen or kernel-xenU), **virt-v2v** will attempt to install a new kernel during the conversion process. You can avoid this requirement by installing a regular kernel, which won't reference a hypervisor in its name, alongside the Xen kernel prior to conversion. You should not make this newly installed kernel your default kernel, because Xen will not boot it. **virt-v2v** will make it the default during conversion.

23.2.3. Converting a remote Xen virtualized guest

Xen virtualized guests can be converted remotely via SSH. Ensure that the host running the virtualized guest is accessible via SSH.

To convert the virtualized guest, run:

```
virt-v2v -ic xen+ssh://root@vmhost.example.com -op pool --bridge brname vm-name
```

Where **vmhost.example.com** is the host running the virtualized guest, **pool** is the local storage pool to hold the image, **brname** is the name of a local network bridge to connect the converted guest's network to, and **vm-name** is the domain of the Xen virtualized guest. You may also use the *--network* parameter to connect to a locally managed network, or specify multiple mappings in **/etc/virt-v2v.conf**.

If your guest uses a Xen para-virtualized kernel (it would be called something like kernel-xen or kernel-xenU), **virt-v2v** will attempt to install a new kernel during the conversion process. You can avoid this requirement by installing a regular kernel, which won't reference a hypervisor in its name, alongside the Xen kernel prior to conversion. You should not make this newly installed kernel your default kernel, because Xen will not boot it. **virt-v2v** will make it the default during conversion.

23.2.4. Converting a VMware ESX virtualized guest

Ensure that the virtualized guest is stopped prior to running the v2v process.

To convert the virtualized guest, run:

```
virt-v2v -ic esx://esx.example.com/ -op pool --bridge brname vm-name
```

Where **esx.example.com** is the VMware ESX server, **pool** is the local storage pool to hold the image, **brname** is the name of a local network bridge to connect the converted guest's network to, and **vm-name** is the name of the virtualized guest. You may also use the *--network* parameter to connect to a locally managed network, or specify multiple mappings in **/etc/virt-v2v.conf**.

Authenticating to the ESX server

Connecting to the ESX server will require authentication. **virt-v2v** supports password authentication when connecting to ESX. It reads passwords from $HOME/.netrc. The format of this file is described in the netrc(5) man page. An example entry is:

```
machine esx.example.com login root password s3cr3t
```

.netrc permissions

The **.netrc** file must have a permission mask of 0600 to be read correctly by **virt-v2v**

Connecting to an ESX server with an invalid certificate

In non-production environments, the ESX server may have a non-valid certificate, for example a self-signed certificate. In this case, certificate checking can be explicitly disabled by adding '?no_verify=1' to the connection URI as shown below:

```
... -ic esx://esx.example.com/?no_verify=1 ...
```

23.2.5. Converting a virtualized guest running Windows

Important

Virtualized guests running Windows can only be converted for output to Red Hat Enterprise Virtualization. The conversion procedure depends on post-processing by the Red Hat Enterprise Virtualization Manager for completion. See *Section 23.4.2, “Configuration changes for Windows virtualized guests”* for details of the process. Virtualized guests running Windows cannot be converted for output to libvirt.

This example demonstrates converting a local (libvirt-managed) Xen virtualized guest running Windows for output to Red Hat Enterprise Virtualization. Ensure that the virtualized guest's XML is available locally, and that the storage referred to in the XML is available locally at the same paths.

To convert the virtualized guest from an XML file, run:

```
virt-v2v -i libvirtxml -o rhev -osd storage.example.com:/exportdomain --network rhevm vm-
name.xml
```

Where **vm-name.xml** is the path to the virtualized guest's exported xml, and **storage.example.com:/exportdomain** is the export storage domain. You may also use the *--network* parameter to connect to a locally managed network, or specify multiple mappings in **/etc/virt-v2v.conf**.

If your guest uses a Xen para-virtualized kernel (it would be called something like kernel-xen or kernel-xenU), **virt-v2v** will attempt to install a new kernel during the conversion process. You can avoid this requirement by installing a regular kernel, which won't reference a hypervisor in its name, alongside the Xen kernel prior to conversion. You should not make this newly installed kernel your default kernel, because Xen will not boot it. **`virt-v2v`** will make it the default during conversion.

23.3. Running converted virtualized guests

On successful completion, **`virt-v2v`** will create a new libvirt domain for the converted virtualized guest with the same name as the original virtualized guest. It can be started as usual using libvirt tools, for example **`virt-manager`**.

Guest network configuration

virt-v2v cannot currently reconfigure a guest's network configuration. If the converted guest is not connected to the same subnet as the source, its network configuration may have to be updated.

23.4. Configuration changes

As well as configuring libvirt appropriately, **`virt-v2v`** will make certain changes to a guest to enable it to run on a KVM hypervisor either with or without virtio drivers. These changes are specific to the guest operating system. The details specified here pertain to supported Red Hat based Linux distributions and Windows.

23.4.1. Configuration changes for Linux virtualized guests

Table 23.1. virt-v2v changes to Linux virtualized guests

Change	Description
Kernel	Un-bootable, that is, xen para-virtualized, kernels will be uninstalled. No new kernel will be installed if there is a remaining kernel which supports virtio. If no remaining kernel supports virtio and the configuration file specifies a new kernel it will be installed and configured as the default.
X reconfiguration	If the guest has X configured, its display driver will be updated. See GUEST DRIVERS for which driver will be used.
Rename block devices	If changes have caused block devices to change name, these changes will be reflected in /etc/fstab
Configure device drivers	Whether virtio or non-virtio drivers are configured, virt-v2v will ensure that the correct network and block drivers are specified in the modprobe configuration.
initrd	virt-v2v will ensure that the initrd for the default kernel supports booting the root device, whether it is using virtio or not.
SELinux	virt-v2v will initiate a relabel of the guest on the next boot. This ensures that any changes it has made are correctly labeled according to the guest's local policy.

`virt-v2v` will configure the following drivers in a Linux guest:

Table 23.2. Configured drivers in a Linux Guest

Para-virtualized driver type	Driver module
Display	cirrus
Storage	virtio_blk
Network	virtio_net
In addition, initrd will preload the virtio_pci driver	
Other drivers	
Display	cirrus
Block	Virtualized IDE
Network	Virtualized e1000

23.4.2. Configuration changes for Windows virtualized guests

Warning

Before converting Windows virtualized guests, ensure that the *libguestfs-winsupport* and *virtio-win* packages are installed on the host running **`virt-v2v`**. These packages provide support for NTFS and Windows para-virtualized block and network drivers. If you attempt to convert a virtualized guest using NTFS without the *libguestfs-winsupport* package installed, the conversion will fail. If you attempt to convert a virtualized guest running Windows without the *virtio-win* package installed, the conversion will fail giving an error message concerning missing files.

`virt-v2v` can convert virtualized guests running Windows XP, Windows Vista, Windows 7, Windows Server 2003 and Windows Server 2008. The conversion process for virtualized guests running Windows is slightly to different to the process for virtualized guests running Linux. Windows virtualized guest images are converted as follows:

1. virt-v2v installs virtio block drivers.

2. virt-v2v installs the CDUpgrader utility.

3. virt-v2v copies the virtio block and network drivers to **`%SystemRoot%\Drivers\VirtIO`**. The *virtio-win* package does not include drivers for Windows 7 and Windows XP. When using these operating systems, **rtl8139** network drivers are used. Support for **rtl8139** must be already available in the guest.

4. virt-v2v adds **`%SystemRoot%\Drivers\VirtIO`** to DevicePath, meaning this directory is automatically searched for drivers when a new device is connected.

5. virt-v2v makes registry changes to include the virtio block drivers in the CriticalDeviceDatabase section of the registry, and ensures the CDUpgrader service is started at the next boot.

At this point, **`virt-v2v`** has completed the conversion. The converted virtualized guest is now bootable, but does not yet have all the drivers installed necessary to function correctly. The conversion must be finished by the Red Hat Enterprise Virtualization Manager. The Manager performs the following steps:

1. The virtualized guest is imported and run on the Manager. See the *Red Hat Enterprise Virtualization for Servers Administration Guide* for details.

Important

The first boot stage can take several minutes to run, and must not be interrupted. It will run automatically without any administrator intervention other than starting the virtualized guest. To ensure the process is not interrupted, no user should login to the virtualized guest until it has quiesced. You can check for this in the Manager GUI.

2. The Guest Tools ISO is detected and, if found, installs all the virtio drivers from it, including a re-install of the virtio block drivers.

Note

As the Windows conversion can copy drivers from *virtio-win* directly to the guest, the Guest Tools ISO is not required. It is however recommended as the included tools will be kept up to date, and additional tools that are not included in *virtio-win* can be installed.

Miscellaneous administration tasks

This chapter contain useful hints and tips to improve virtualization performance, scale and stability.

24.1. Automatically starting guests

This section covers how to make virtualized guests start automatically during the host system's boot phase.

This example uses **virsh** to set a guest, *TestServer*, to automatically start when the host boots.

```
# virsh autostart TestServer
Domain TestServer marked as autostarted
```

The guest now automatically starts with the host.

To stop a guest automatically booting use the *--disable* parameter

```
# virsh autostart --disable TestServer
Domain TestServer unmarked as autostarted
```

The guest no longer automatically starts with the host.

24.2. Using qemu-img

The **qemu-img** command line tool is used for formatting various file systems used by KVM. **qemu-img** should be used for formatting virtualized guest images, additional storage devices and network storage. **qemu-img** options and usages are listed below.

Create

Create the new disk image *filename* of size *size* and format *format*.

```
# qemu-img create [-f format] [-o options] filename [size]
```

If base_image is specified, then the image will record only the differences from base_image. No size needs to be specified in this case. base_image will never be modified unless you use the **commit** command.

Commit

Commit any changes recorded in the file name *filename* with format *format* into its base image with the **qemu-img commit** command:

```
 # qemu-img commit [-f format] filename
```

Convert

The *convert* option is used for converting a recognized format to another image format.

Command format:

```
# qemu-img convert [-c] [-e] [-f format] filename [-O output_format] output_filename
```

Convert the disk image *filename* to disk image *output_filename* using format *output_format*. The disk image can be optionally encrypted with the *-e* option or compressed with the *-c* option.

Only the **qcow2** format supports encryption or compression. The compression is read-only. It means that if a compressed sector is rewritten, then it is rewritten as uncompressed data.

The encryption uses the AES format with very secure 128-bit keys. Use a long password (over 16 characters) to get maximum protection.

Image conversion is also useful to get a smaller image when using a format which can grow, such as **qcow** or **cow**. The empty sectors are detected and suppressed from the destination image.

Info

The **info** parameter displays information about a disk image *filename*. The format for the **info** option is as follows:

```
# qemu-img info [-f format] filename
```

This command is often used to discover the size reserved on disk which can be different from the displayed size. If snapshots are stored in the disk image, they are displayed also.

Resize

Change the disk image *filename* as if it had been created with size *size*.

```
# qemu-img resize filename [+ | -] size
```

> **Warning**
>
> Before using this command to shrink a disk image, you **must** use file system and partitioning tools inside the VM itself to reduce allocated file systems and partition sizes accordingly. Failure to do so will result in data loss.
>
> After using this command to grow a disk image, you must use file system and partitioning tools inside the VM to actually begin using the new space on the device.

Snapshot

List (*-l*), apply (*-a*), create (*-c*), or delete (*-d*) snapshot *snapshot* in image *filename*.

```
# qemu-img snapshot [-l | -a snapshot | -c snapshot | -d snapshot ] filename
```

Supported formats

The format of an image is usually guessed automatically. The following formats are supported:

raw
: Raw disk image format (default). This can be the fastest file-based format. If your file system supports holes (for example in ext2 or ext3 on Linux or NTFS on Windows), then only the written sectors will reserve space. Use **qemu-img info** to know the real size used by the image or **ls -ls** on Unix/Linux.

qcow2
QEMU image format, the most versatile format. Use it to have smaller images (useful if your file system does not support holes, for example on Windows), optional AES encryption, zlib based compression and support of multiple VM snapshots.

qcow
Old QEMU image format. Only included for compatibility with older versions.

cow
User Mode Linux Copy On Write image format. The **cow** format is included only for compatibility with previous versions. It does not work with Windows.

vmdk
VMware 3 and 4 compatible image format.

cloop
Linux Compressed Loop image, useful only to reuse directly compressed CD-ROM images present for example in the Knoppix CD-ROMs.

24.3. Verifying virtualization extensions

Use this section to determine whether your system has the hardware virtualization extensions. Virtualization extensions (Intel VT or AMD-V) are required for full virtualization.

1. Run the following command to verify the CPU virtualization extensions are available:

```
$ grep -E 'svm|vmx' /proc/cpuinfo
```

2. Analyze the output.

   - The following output contains a **vmx** entry indicating an Intel processor with the Intel VT extensions:

```
flags   : fpu tsc msr pae mce cx8 apic mtrr mca cmov pat pse36 clflush
 dts acpi mmx fxsr sse sse2 ss ht  tm syscall lm constant_tsc pni monitor ds_cpl
 vmx est tm2 cx16 xtpr lahf_lm
```

   - The following output contains an **svm** entry indicating an AMD processor with the AMD-V extensions:

```
flags   :  fpu tsc msr pae mce cx8 apic mtrr mca cmov pat pse36 clflush
 mmx fxsr sse sse2 ht syscall nx mmxext fxsr_opt lm 3dnowext 3dnow pni cx16
 lahf_lm cmp_legacy svm cr8legacy ts fid vid ttp tm stc
```

   If any output is received, the processor has the hardware virtualization extensions. However in some circumstances manufacturers disable the virtualization extensions in BIOS.

   The "**flags:**" output content may appear multiple times, once for each hyperthread, core or CPU on the system.

   The virtualization extensions may be disabled in the BIOS. If the extensions do not appear or full virtualization does not work refer to *Procedure 36.1, "Enabling virtualization extensions in BIOS"*.

3. **Ensure KVM subsystem is loaded**
   As an additional check, verify that the **kvm** modules are loaded in the kernel:

```
# lsmod | grep kvm
```

If the output includes **`kvm_intel`** or **`kvm_amd`** then the **`kvm`** hardware virtualization modules are loaded and your system meets requirements.

Additional output

If the *libvirt* package is installed, the **`virsh`** command can output a full list of virtualization system capabilities. Run **`virsh capabilities`** as root to receive the complete list.

24.4. Setting KVM processor affinities

This section covers setting processor and processing core affinities with **libvirt** and KVM guests.

By default, libvirt provisions guests using the hypervisor's default policy. For most hypervisors, the policy is to run guests on any available processing core or CPU. There are times when an explicit policy may be better, particularly for systems with a NUMA (Non-Uniform Memory Access) architecture. A guest on a NUMA system should be pinned to a processing core so that its memory allocations are always local to the node it is running on. This avoids cross-node memory transports which have less bandwidth and can significantly degrade performance.

On non-NUMA systems some form of explicit placement across the hosts’ sockets, cores and hyperthreads may be more efficient.

Identifying CPU and NUMA topology

The first step in deciding which policy to apply is to determine the host’s memory and CPU topology. The **`virsh nodeinfo`** command provides information about how many sockets, cores and hyperthreads are attached to a host.

```
# virsh nodeinfo
CPU model:           x86_64
CPU(s):              8
CPU frequency:       1000 MHz
CPU socket(s):       2
Core(s) per socket:  4
Thread(s) per core:  1
NUMA cell(s):        1
Memory size:         8179176 kB
```

This system has eight CPUs in two sockets, and each processor has four cores.

The output shows that that the system has a NUMA architecture, which can be more complex than other architectures. Use the **`virsh capabilities`** to get additional output data on the CPU configuration.

```
# virsh capabilities
<capabilities>
  <host>
    <cpu>
      <arch>x86_64</arch>
    </cpu>
    <migration_features>
      <live/>
      <uri_transports>
        <uri_transport>tcp</uri_transport>
```

```
      </uri_transports>
    </migration_features>
    <topology>
      <cells num='2'>
        <cell id='0'>
          <cpus num='4'>
            <cpu id='0'/>
            <cpu id='1'/>
            <cpu id='2'/>
            <cpu id='3'/>
          </cpus>
        </cell>
        <cell id='1'>
          <cpus num='4'>
            <cpu id='4'/>
            <cpu id='5'/>
            <cpu id='6'/>
            <cpu id='7'/>
          </cpus>
        </cell>
      </cells>
    </topology>
    <secmodel>
      <model>selinux</model>
      <doi>0</doi>
    </secmodel>
  </host>

 [ Additional XML removed ]

</capabilities>
```

This output shows two NUMA nodes (also know as NUMA cells), each containing four logical CPUs (four processing cores). This system has two sockets, therefore it can be inferred that each socket is a separate NUMA node. For a guest with four virtual CPUs, it is optimal to lock the guest to physical CPUs 0 to 3, or 4 to 7, to avoid accessing non-local memory, which is significantly slower than accessing local memory.

If a guest requires eight virtual CPUs, you could run two sets of four virtual CPU guests and split the work between them, since each NUMA node only has four physical CPUs. Running across multiple NUMA nodes significantly degrades performance for physical and virtualized tasks.

Decide which NUMA node can run the guest

Locking a guest to a particular NUMA node offers no benefit if that node does not have sufficient free memory for that guest. libvirt stores information on the free memory available on each node. Use the **`virsh freecell`** command to display the free memory on all NUMA nodes.

```
# virsh freecell
0: 2203620 kB
1: 3354784 kB
```

If a guest requires 3 GB of RAM allocated, then the guest should be run on NUMA node (cell) 1. Node 0 only has 2.2GB free which may not be sufficient for certain guests.

Lock a guest to a NUMA node or physical CPU set

Once you have determined which node to run the guest on, refer to the capabilities data (the output of the **`virsh capabilities`** command) about NUMA topology.

1. Extract from the **`virsh capabilities`** output.

```
<topology>
  <cells num='2'>
    <cell id='0'>
    <cpus num='4'>
      <cpu id='0'/>
      <cpu id='1'/>
      <cpu id='2'/>
      <cpu id='3'/>
    </cpus>
  </cell>
  <cell id='1'>
    <cpus num='4'>
      <cpu id='4'/>
      <cpu id='5'/>
      <cpu id='6'/>
      <cpu id='7'/>
    </cpus>
  </cell>
  </cells>
</topology>
```

2. Observe that the node 1, **`<cell id='1'>`**, uses physical CPUs 4 to 7.

3. The guest can be locked to a set of CPUs by appending the **`cpuset`** attribute to the configuration file.

   a. While the guest is offline, open the configuration file with **`virsh edit`**.

   b. Locate the guest's virtual CPU count, defined in the **`vcpus`** element.

   ```
   <vcpus>4</vcpus>
   ```

   The guest in this example has four CPUs.

   c. Add a **`cpuset`** attribute with the CPU numbers for the relevant NUMA cell.

   ```
   <vcpus cpuset='4-7'>4</vcpus>
   ```

4. Save the configuration file and restart the guest.

The guest has been locked to CPUs 4 to 7.

Automatically locking guests to CPUs with virt-install

The **`virt-install`** provisioning tool provides a simple way to automatically apply a 'best fit' NUMA policy when guests are created.

The *`cpuset`* option for **`virt-install`** can use a CPU set of processors or the parameter *`auto`*. The *`auto`* parameter automatically determines the optimal CPU locking using the available NUMA data.

For a NUMA system, use the `--`*`cpuset=auto`* with the **`virt-install`** command when creating new guests.

Tuning CPU affinity on running guests

There may be times where modifying CPU affinities on running guests is preferable to rebooting the guest. The **`virsh vcpuinfo`** and **`virsh vcpupin`** commands can perform CPU affinity changes on running guests.

The **virsh vcpuinfo** command gives up to date information about where each virtual CPU is running.

In this example, *guest1* is a guest with four virtual CPUs is running on a KVM host.

```
# virsh vcpuinfo guest1
VCPU:           0
CPU:            3
State:          running
CPU time:       0.5s
CPU Affinity:   yyyyyyyy
VCPU:           1
CPU:            1
State:          running
CPU Affinity:   yyyyyyyy
VCPU:           2
CPU:            1
State:          running
CPU Affinity:   yyyyyyyy
VCPU:           3
CPU:            2
State:          running
CPU Affinity:   yyyyyyyy
```

The **virsh vcpuinfo** output (the **yyyyyyyy** value of **CPU Affinity**) shows that the guest can presently run on any CPU.

To lock the virtual CPUs to the second NUMA node (CPUs four to seven), run the following commands.

```
# virsh vcpupin guest1 0 4
# virsh vcpupin guest1 1 5
# virsh vcpupin guest1 2 6
# virsh vcpupin guest1 3 7
```

The **virsh vcpuinfo** command confirms the change in affinity.

```
# virsh vcpuinfo guest1
VCPU:           0
CPU:            4
State:          running
CPU time:       32.2s
CPU Affinity:   ----y---
VCPU:           1
CPU:            5
State:          running
CPU time:       16.9s
CPU Affinity:   -----y--
VCPU:           2
CPU:            6
State:          running
CPU time:       11.9s
CPU Affinity:   ------y-
VCPU:           3
CPU:            7
State:          running
CPU time:       14.6s
CPU Affinity:   -------y
```

Information from the KVM processes can also confirm that the guest is now running on the second NUMA node.

```
# grep pid /var/run/libvirt/qemu/guest1.xml
<domstatus state='running' pid='4907'>
# grep Cpus_allowed_list /proc/4907/task/*/status
/proc/4907/task/4916/status:Cpus_allowed_list: 4
/proc/4907/task/4917/status:Cpus_allowed_list: 5
/proc/4907/task/4918/status:Cpus_allowed_list: 6
/proc/4907/task/4919/status:Cpus_allowed_list: 7
```

24.5. Generating a new unique MAC address

In some case you will need to generate a new and unique MAC address for a guest. There is no command line tool available to generate a new MAC address at the time of writing. The script provided below can generate a new MAC address for your guests. Save the script to your guest as **`macgen.py`**. Now from that directory you can run the script using **`./macgen.py`** and it will generate a new MAC address. A sample output would look like the following:

```
$ ./macgen.py
00:16:3e:20:b0:11
```

```
#!/usr/bin/python
# macgen.py script to generate a MAC address for virtualized guests
#
import random
#
def randomMAC():
 mac = [ 0x00, 0x16, 0x3e,
  random.randint(0x00, 0x7f),
  random.randint(0x00, 0xff),
  random.randint(0x00, 0xff) ]
 return ':'.join(map(lambda x: "%02x" % x, mac))
#
print randomMAC()
```

Another method to generate a new MAC for your guest

You can also use the built-in modules of **`python-virtinst`** to generate a new MAC address and **`UUID`** for use in a guest configuration file:

```
# echo  'import virtinst.util ; print\
 virtinst.util.uuidToString(virtinst.util.randomUUID())' | python
# echo  'import virtinst.util ; print virtinst.util.randomMAC()' | python
```

The script above can also be implemented as a script file as seen below.

```
#!/usr/bin/env python
#  -*- mode: python; -*-
print ""
print "New UUID:"
import virtinst.util ; print virtinst.util.uuidToString(virtinst.util.randomUUID())
print "New MAC:"
import virtinst.util ; print virtinst.util.randomMAC()
print ""
```

24.6. Improving guest response time

Virtualized guests can sometimes be slow to respond with certain workloads and usage patterns. Examples of situations which may cause slow or unresponsive guests:

- Severely overcommitted memory.
- Overcommitted memory with high processor usage
- Other (not **qemu-kvm** processes) busy or stalled processes on the host.

These types of workload may cause guests to appear slow or unresponsive. Usually, the guest's memory is eventually fully loaded into the host's main memory from swap. Once the guest is loaded in main memory, the guest will perform normally. Note, the process of loading a guest from swap to main memory may take several seconds per gigabyte of RAM assigned to the guest, depending on the type of storage used for swap and the performance of the components.

KVM virtualized guests function as Linux processes. Linux processes are not permanently kept in main memory (physical RAM). The kernel scheduler swaps process memory into virtual memory (swap). Swap, with conventional hard disk drives, is thousands of times slower than main memory in modern computers. If a guest is inactive for long periods of time, the guest may be placed into swap by the kernel.

KVM virtualized guests processes may be moved to swap regardless of whether memory is overcommitted or overall memory usage.

Using unsafe overcommit levels or overcommitting with swap turned off guest processes or other critical processes may be killed by the **pdflush** kernel function. **pdflush** automatically kills processes to keep the system from crashing and to free up memory. Always ensure the host has sufficient swap space when overcommitting memory.

For more information on overcommitting with KVM, refer to *Chapter 20, Overcommitting with KVM*.

Warning: turning off swap

Virtual memory allows a Linux system to use more memory than there is physical RAM on the system. Underused processes are swapped out which allows active processes to use memory, improving memory utilization. Disabling swap reduces memory utilization as all processes are stored in physical RAM.

If swap is turned off, do not overcommit guests. Overcommitting guests without any swap can cause guests or the host system to crash.

Turning off swap

Swap usage can be completely turned off to prevent guests from being unresponsive while they are moved back to main memory. Swap may also not be desired for guests as it can be resource-intensive on some systems.

The **swapoff** command can disable all swap partitions and swap files on a system.

```
# swapoff -a
```

To make this change permanent, remove *swap* lines from the **/etc/fstab** file and restart the host system.

Using SSDs for swap

Using Solid State Drives (SSDs) for swap storage may improve the performance of virtualized guests.

Using RAID arrays, faster disks or separate drives dedicated to swap may also improve performance.

24.7. Very Secure `ftpd`

`vsftpd` can provide access to installation trees for para-virtualized guests (for example, the Red Hat Enterprise Linux repositories) or other data. If you have not installed `vsftpd` during the server installation you can grab the RPM package from your **`Server`** directory of your installation media and install it using the **`rpm -ivh vsftpd*.rpm`** (note that the RPM package must be in your current directory).

1. To configure `vsftpd`, edit **`/etc/passwd`** using **`vipw`** and change the ftp user's home directory to the directory where you are going to keep the installation trees for your guests. An example entry for the FTP user would look like the following:

```
ftp:x:14:50:FTP User:/installtree/:/sbin/nologin
```

2. Verify that `vsftpd` is not enabled using the **`chkconfig --list vsftpd`**:

```
$ chkconfig --list vsftpd
vsftpd          0:off   1:off   2:off   3:off   4:off   5:off   6:off
```

3. Run the **`chkconfig --levels 345 vsftpd on`** to start vsftpd automatically for run levels 3, 4 and 5.

4. Use the **`chkconfig --list vsftpd`** command to verify the **`vsftpd`** daemon is enabled to start during system boot:

```
$ chkconfig --list vsftpd
vsftpd          0:off   1:off   2:off   3:on    4:on    5:on    6:off
```

5. use the **`service vsftpd start vsftpd`** to start the vsftpd service:

```
$service vsftpd start vsftpd
Starting vsftpd for vsftpd:                             [  OK  ]
```

24.8. Disable SMART disk monitoring for guests

SMART disk monitoring can be safely disabled as virtual disks and the physical storage devices are managed by the host.

```
# service smartd stop
# chkconfig --del smartd
```

24.9. Configuring a VNC Server

To configure a VNC server use the **Remote Desktop** application in **System** > **Preferences**. Alternatively, you can run the **`vino-preferences`** command.

The following steps set up a dedicated VNC server session:

1. Edit the **`~/.vnc/xstartup`** file to start a GNOME session whenever **vncserver** is started. The first time you run the **vncserver** script it will ask you for a password you want to use for your VNC session.

2. A sample **xstartup** file:

```
#!/bin/sh
# Uncomment the following two lines for normal desktop:
# unset SESSION_MANAGER
# exec /etc/X11/xinit/xinitrc
[ -x /etc/vnc/xstartup ] && exec /etc/vnc/xstartup
[ -r $HOME/.Xresources ] && xrdb $HOME/.Xresources
#xsetroot -solid grey
#vncconfig -iconic &
#xterm -geometry 80x24+10+10 -ls -title "$VNCDESKTOP Desktop" &
#twm &
if test -z "$DBUS_SESSION_BUS_ADDRESS" ; then
 eval `dbus-launch --sh-syntax –exit-with-session`
 echo "D-BUS per-session daemon address is: \
 $DBUS_SESSION_BUS_ADDRESS"
fi
exec  gnome-session
```

24.10. Gracefully shutting down guests

Installing virtualized Red Hat Enterprise Linux 6 guests with the **Minimal installation** installation option will not install the *acpid* package.

Without the *acpid* package, the Red Hat Enterprise Linux 6 guest does not shut down when the **virsh shutdown** command is executed. The **virsh shutdown** command is designed to gracefully shut down virtualized guests.

Using **virsh shutdown** is easier and safer for system administration. Without graceful shut down with the **virsh shutdown** command a system administrator must log into a virtualized guest manually or send the **Ctrl**-**Alt**-**Del** key combination to each guest.

Other virtualized operating systems

Other virtualized operating systems may be affected by this issue. The **virsh shutdown** command requires that the guest operating system is configured to handle ACPI shut down requests. Many operating systems require additional configuration on the guest operating system to accept ACPI shut down requests.

Procedure 24.1. Workaround for Red Hat Enterprise Linux 6

1. **Install the acpid package**

   The **acpid** service listen and processes ACPI requests.

   Log into the guest and install the *acpid* package on the guest:

   ```
   # yum install acpid
   ```

2. **Enable the acpid service**

   Set the acpid service to start during the guest boot sequence and start the service:

   ```
   # chkconfig acpid on
   # service acpid start
   ```

The guest is now configured to shut down when the **virsh shutdown** command is used.

24.11. Virtual machine timer management with libvirt

Accurate time keeping on virtualized guests is a key challenge for virtualization platforms. Different hypervisors attempt to handle the problem of time keeping in a variety of ways. Libvirt provides hypervisor independent configuration settings for time management, using the <clock> and <timer> elements in the domain XML. Note that not all options are supported for all hypervisors. The domain XML can be edited using the **virsh edit** command. See *Editing a guest's configuration file* for details.

<clock>

The clock element is used to determine how the guest clock is synchronized with the host clock. The clock element has the following attributes:

- **offset**

  Determines how the guest clock is offset from the host clock. The offset attribute has the following possible values:

  Table 24.1. Offset attribute values

Value	Description
utc	The guest clock will be synchronized to UTC when booted.
localtime	The guest clock will be synchronized to the host's configured timezone when booted, if any.
timezone	The guest clock will be synchronized to a given timezone, specified by the *timezone* attribute.
variable	The guest clock will be synchronized to an arbitrary offset from UTC. The delta relative to UTC is specified in seconds, using the *adjustment* attribute. The guest is free to adjust the Real Time Clock (RTC) over time and expect that it will be honored following the next reboot. This is in contrast to *utc* mode, where any RTC adjustments are lost at each reboot.

- **timezone**

  The timezone to which the guest clock is to be synchronized.

- **adjustment**

  The delta for guest clock synchronization. In seconds, relative to UTC.

Example 24.1. Always synchronize to UTC

```
<clock offset="utc" />
```

Example 24.2. Always synchronize to the host timezone

```
<clock offset="localtime" />
```

Example 24.3. Synchronize to an arbitrary timezone

```
<clock offset="timezone" timezone="Europe/Paris" />
```

Example 24.4. Synchronize to UTC + arbitrary offset

```
<clock offset="variable" adjustment="123456" />
```

<timer>

A clock element can have zero or more timer elements as children. The timer element specifies a time source used for guest clock synchronization. The timer element has the following attributes. Only the *name* is required, all other attributes are optional.

- **name**

  The name of the time source to use.

  Table 24.2. name attribute values

Value	Description
platform	The master virtual time source which may be used to drive the policy of other time sources.
pit	Programmable Interval Timer - a timer with periodic interrupts.
rtc	Real Time Clock - a continuously running timer with periodic interrupts.
hpet	High Precision Event Timer - multiple timers with periodic interrupts.
tsc	Time Stamp Counter - counts the number of ticks since reset, no interrupts.

- **wallclock**

  Specifies whether the wallclock should track host or guest time. Only valid for a name value of `platform` or `rtc`.

  Table 24.3. wallclock attribute values

Value	Description
host	RTC wallclock always tracks host time.
guest	RTC wallclock always tracks guest time.

- **tickpolicy**

  The policy used to pass ticks on to the guest.

  Table 24.4. tickpolicy attribute values

Value	Description
none	Continue to deliver at normal rate (i.e. ticks are delayed).
catchup	Deliver at a higher rate to catch up.
merge	Ticks merged into one single tick.

Value	Description
discard	All missed ticks are discarded.

- **frequency**
  Used to set a fixed frequency, measured in Hz. This attribute is only relevant for a name value of *tsc*. All other timers operate at a fixed frequency (*pit*, *rtc*), or at a frequency fully controlled by the guest (*hpet*).

- **mode**
  Determines how the time source is exposed to the guest. This attribute is only relevant for a name value of *tsc*. All other timers are always emulated.

  Table 24.5. mode attribute values

Value	Description
auto	Native if safe, otherwise emulated.
native	Always native.
emulate	Always emulate.
paravirt	Native + para-virtualized.

- **present**
  Used to override the default set of timers visible to the guest. For example, to enable or disable the HPET.

  Table 24.6. present attribute values

Value	Description
yes	Force this timer to the visible to the guest.
no	Force this timer to not be visible to the guest.

Example 24.5. Clock synchronizing to local time with RTC and PIT timers, and the HPET timer disabled

```
<clock mode="localtime">
 <timer name="rtc" tickpolicy="catchup" wallclock="guest" />
 <timer name="pit" tickpolicy="none" />
 <timer name="hpet" present="no" />
</clock>
```

Part V. Virtualization storage topics

Introduction to storage administration for virtualization

These chapters contain information on how storage is used in a virtualized environment. Included are details on storage pools and volumes, configuration procedures and other storage topics.

Storage concepts

This chapter introduces the concepts used for describing and managing storage devices.

Local storage

Local storage is directly attached to the host server. Local storage includes local directories, directly attached disks, and LVM volume groups on local storage devices.

Networked storage

Networked storage covers storage devices shared over a network using standard protocols. Networked storage includes shared storage devices using Fibre Channel, iSCSI, NFS, GFS2, and SCSI RDMA protocols. Networked storage is a requirement for migrating guest virtualized guests between hosts.

25.1. Storage pools

A *storage pool* is a file, directory, or storage device managed by libvirt for the purpose of providing storage to virtualized guests. Storage pools are divided into storage *volumes* that store virtualized guest images or are attached to virtualized guests as additional storage.

libvirt uses a directory-based storage pool, the **`/var/lib/libvirt/images/`** directory, as the default storage pool. The default storage pool can be changed to another storage pool.

- **Local storage pools** - Local storage pools are directly attached to the host server. Local storage pools include local directories, directly attached disks, physical partitions, and LVM volume groups on local devices. Local storage pools are useful for development, testing and small deployments that do not require migration or large numbers of virtualized guests. Local storage pools are not suitable for many production environments as local storage pools do not support live migration.

- **Networked (shared) storage pools** - Networked storage pools cover storage devices shared over a network using standard protocols. Networked storage is required for migrating guest virtualized guests between hosts. Networked storage pools are managed by libvirt. Storage pools are divided into storage volumes. Storage volumes are an abstraction of physical partitions, LVM logical volumes, file-based disk images and other storage types handled by libvirt. Networked storage pools cover storage devices shared over a network using standard protocols. Supported protocols for networked storage pools:

  - Fibre Channel-based LUNs
  - iSCSI
  - NFS
  - GFS2
  - SCSI RDMA protocols (SCSI RCP), the block export protocol used in Infiniband and 10GbE iWARP adapters.

Networked storage is a requirement for migrating guest virtualized guests between hosts. Networked storage pools are managed by libvirt.

Storage volumes

Storage pools are divided into storage volumes. Storage volumes are an abstraction of physical partitions, LVM logical volumes, file-based disk images and other storage types handled by libvirt. Storage volumes are presented to virtualized guests as local storage devices regardless of the underlying hardware.

25.2. Volumes

Storage pools are divided into storage volumes. Storage volumes are an abstraction of physical partitions, LVM logical volumes, file-based disk images and other storage types handled by libvirt. Storage volumes are presented to virtualized guests as local storage devices regardless of the underlying hardware.

Referencing volumes

To reference a specific volume, three approaches are possible:

The name of the volume and the storage pool

A volume may be referred to by name, along with an identifier for the storage pool it belongs in. On the virsh command line, this takes the form `--pool` *`storage_pool`* *`volume_name`*.

For example, 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

virsh #
```

The full path to the storage on the host system

A volume may also be referred to by its full path on the file system. When using this approach, a pool identifier does not need to be included.

For example, a volume named *`secondimage.img`*, visible to the host system as *`/images/secondimage.img`*. The image can be referred to as *`/images/secondimage.img`*.

```
# virsh vol-info /images/secondimage.img
Name:           secondimage.img
Type:           file
Capacity:       20.00 GB
Allocation:     136.00 KB
```

The unique volume key

When a volume is first created in the virtualization system, a unique identifier is generated and assigned to it. The unique identifier is termed the *volume key*. The format of this volume key varies upon the storage used.

When used with block based storage such as LVM, the volume key may follow this format:

```
c3pKz4-qPVc-Xf7M-7WNM-WJc8-qSiz-mtvpGn
```

When used with file based storage, the volume key may instead be a copy of the full path to the volume storage.

```
/images/secondimage.img
```

For example, a volume with the volume key of *Wlvnf7-a4a3-Tlje-lJDa-9eak-PZBv-LoZuUr*:

```
# virsh vol-info Wlvnf7-a4a3-Tlje-lJDa-9eak-PZBv-LoZuUr
Name:           firstimage
Type:           block
Capacity:       20.00 GB
Allocation:     20.00 GB
```

virsh provides commands for converting between a volume name, volume path, or volume key:

vol-name
: Returns the volume name when provided with a volume path or volume key.

```
# virsh vol-name /dev/guest_images/firstimage firstimage
# virsh vol-name Wlvnf7-a4a3-Tlje-lJDa-9eak-PZBv-LoZuUr
```

vol-path
: Returns the volume path when provided with a volume key, or a storage pool identifier and volume name.

```
# virsh vol-path Wlvnf7-a4a3-Tlje-lJDa-9eak-PZBv-LoZuUr
/dev/guest_images/firstimage
# virsh vol-path --pool guest_images firstimage
/dev/guest_images/firstimage
```

The vol-key command
: Returns the volume key when provided with a volume path, or a storage pool identifier and volume name.

```
# virsh vol-key /dev/guest_images/firstimage
Wlvnf7-a4a3-Tlje-lJDa-9eak-PZBv-LoZuUr
# virsh vol-key --pool guest_images firstimage Wlvnf7-a4a3-Tlje-lJDa-9eak-PZBv-LoZuUr
```

Storage pools

26.1. Creating storage pools

26.1.1. Dedicated storage device-based storage pools

This section covers dedicating storage devices to virtualized guests.

> **Problems with dedicated disks**
>
> Guests 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 the guest, the guest will likely partition it or create its own LVM groups on it. This can cause the host to detect these partitions or LVM groups and cause errors.

26.1.1.1. Creating a dedicated disk storage pool using virsh

This procedure creates a new storage pool using a dedicated disk device with the **`virsh`** command.

> **Warning**
>
> Dedicating a disk to a storage pool will reformat and erase all data presently stored on the disk device. Back up the storage device before commencing the following procedure.

1. **Create a GPT disk label on the disk**
   The disk must be relabeled with a *GUID Partition Table* (GPT) disk label. GPT disk labels allow for creating a large numbers of partitions, up to 128 partitions, on each device. GPT partition tables can store partition data for far more partitions than the **`msdos`** partition table.

   ```
   # parted /dev/sdb
   GNU Parted 2.1
   Using /dev/sdb
   Welcome to GNU Parted! Type 'help' to view a list of commands.
   (parted) mklabel
   New disk label type? gpt
   (parted) quit
   Information: You may need to update /etc/fstab.

   #
   ```

2. **Create the storage pool configuration file**
   Create a temporary XML text file containing the storage pool information required for the new device.

   The file must be in the format shown below, and contain the following fields:

   <name>guest_images_disk</name>
      The *name* parameter determines the name of the storage pool. This example uses the name *`guest_images_disk`* in the example below.

<device path='*/dev/sdb*'/>
: The `device` parameter with the `path` attribute specifies the device path of the storage device. This example uses the device */dev/sdb* .

<target> <path>*/dev*</path>
: The file system `target` parameter with the `path` sub-parameter determines the location on the host file system to attach volumes created with this this storage pool.

  For example, sdb1, sdb2, sdb3. Using */dev/*, as in the example below, means volumes created from this storage pool can be accessed as */dev*/sdb1, */dev*/sdb2, */dev*/sdb3.

<format type='*gpt*'/>
: The `format` parameter specifies the partition table type. his example uses the *gpt* in the example below, to match the GPT disk label type created in the previous step.

Create the XML file for the storage pool device with a text editor.

Example 26.1. Dedicated storage device storage pool

```
<pool type='disk'>
  <name>guest_images_disk</name>
  <source>
    <device path='/dev/sdb'/>
    <format type='gpt'/>
  </source>
  <target>
    <path>/dev</path>
  </target>
  </pool>
```

3. **Attach the device**

   Add the storage pool definition using the **virsh pool-define** command with the XML configuration file created in the previous step.

```
# virsh pool-define ~/guest_images_disk.xml
Pool guest_images_disk defined from /root/guest_images_disk.xml
# virsh pool-list --all
Name                 State      Autostart
-----------------------------------------
default              active     yes
guest_images_disk    inactive   no
```

4. **Start the storage pool**

   Start the storage pool with the **virsh pool-start** command. Verify the pool is started with the **virsh pool-list --all** command.

```
# virsh pool-start guest_images_disk
Pool guest_images_disk started
# virsh pool-list --all
Name                 State      Autostart
-----------------------------------------
default              active     yes
guest_images_disk    active     no
```

5. **Turn on autostart**
   Turn on *autostart* for the storage pool. Autostart configures the `libvirtd` service to start the storage pool when the service starts.

```
# virsh pool-autostart guest_images_disk
Pool guest_images_disk marked as autostarted
# virsh pool-list --all
Name                 State      Autostart
-----------------------------------------
default              active     yes
guest_images_disk    active     yes
```

6. **Verify the storage pool configuration**
   Verify the storage pool was created correctly, the sizes reported correctly, and the state reports as **`running`**.

```
# virsh pool-info guest_images_disk
Name:           guest_images_disk
UUID:           551a67c8-5f2a-012c-3844-df29b167431c
State:          running
Capacity:       465.76 GB
Allocation:     0.00
Available:      465.76 GB
# ls -la /dev/sdb
brw-rw----. 1 root disk 8, 16 May 30 14:08 /dev/sdb
# virsh vol-list guest_images_disk
Name                 Path
-----------------------------------------
```

7. **Optional: Remove the temporary configuration file**
   Remove the temporary storage pool XML configuration file if it is not needed.

```
# rm ~/guest_images_disk.xml
```

A dedicated storage device storage pool is now available.

26.1.2. Partition-based storage pools

This section covers using a pre-formatted block device, a partition, as a storage pool.

For the following examples, a host has a 500GB hard drive (`/dev/sdc`) partitioned into one 500GB, ext4 formatted partition (`/dev/sdc1`). We set up a storage pool for it using the procedure below.

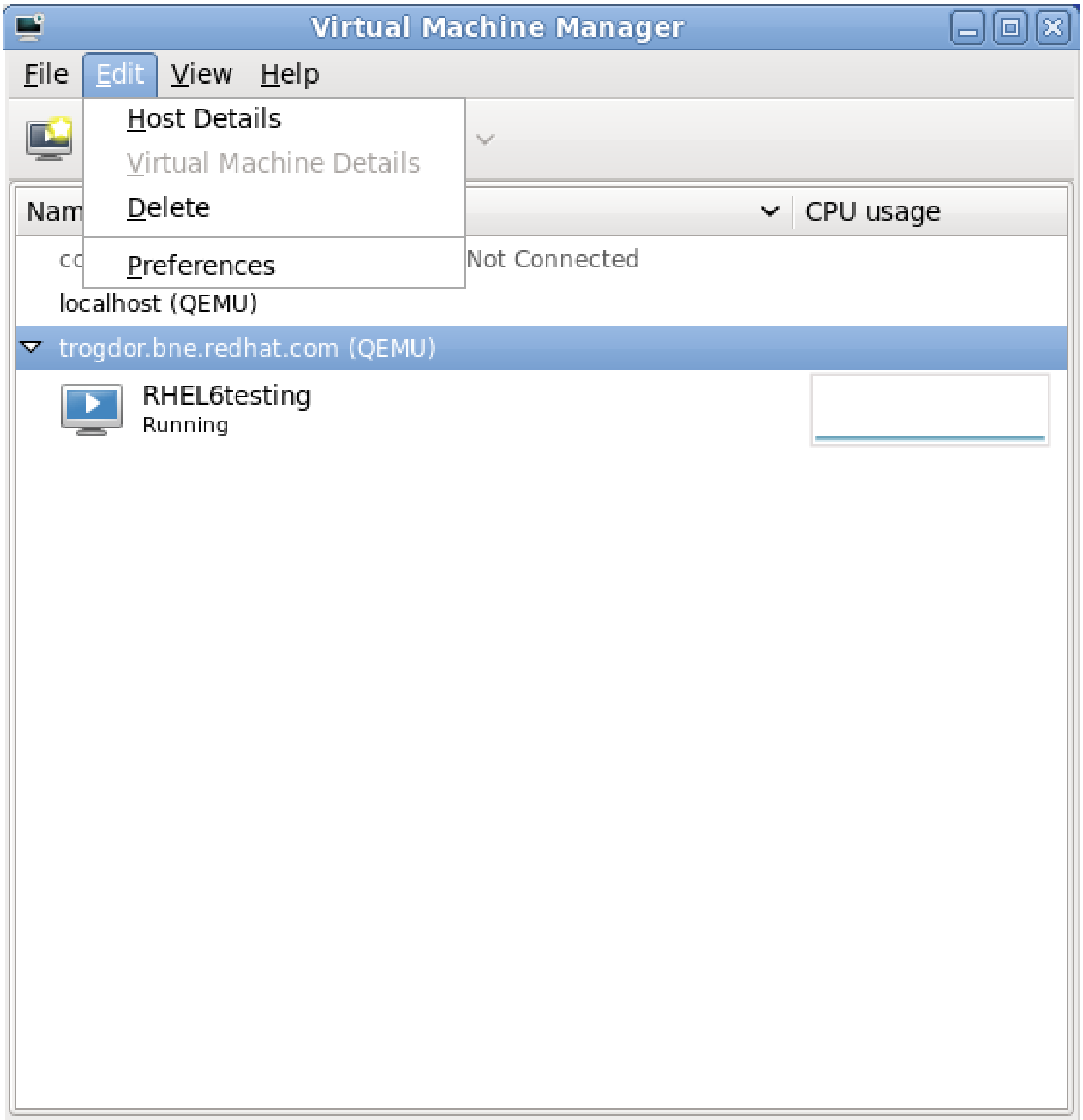
26.1.2.1. Creating a partition-based storage pool using virt-manager

This procedure creates a new storage pool using a partition of a storage device.

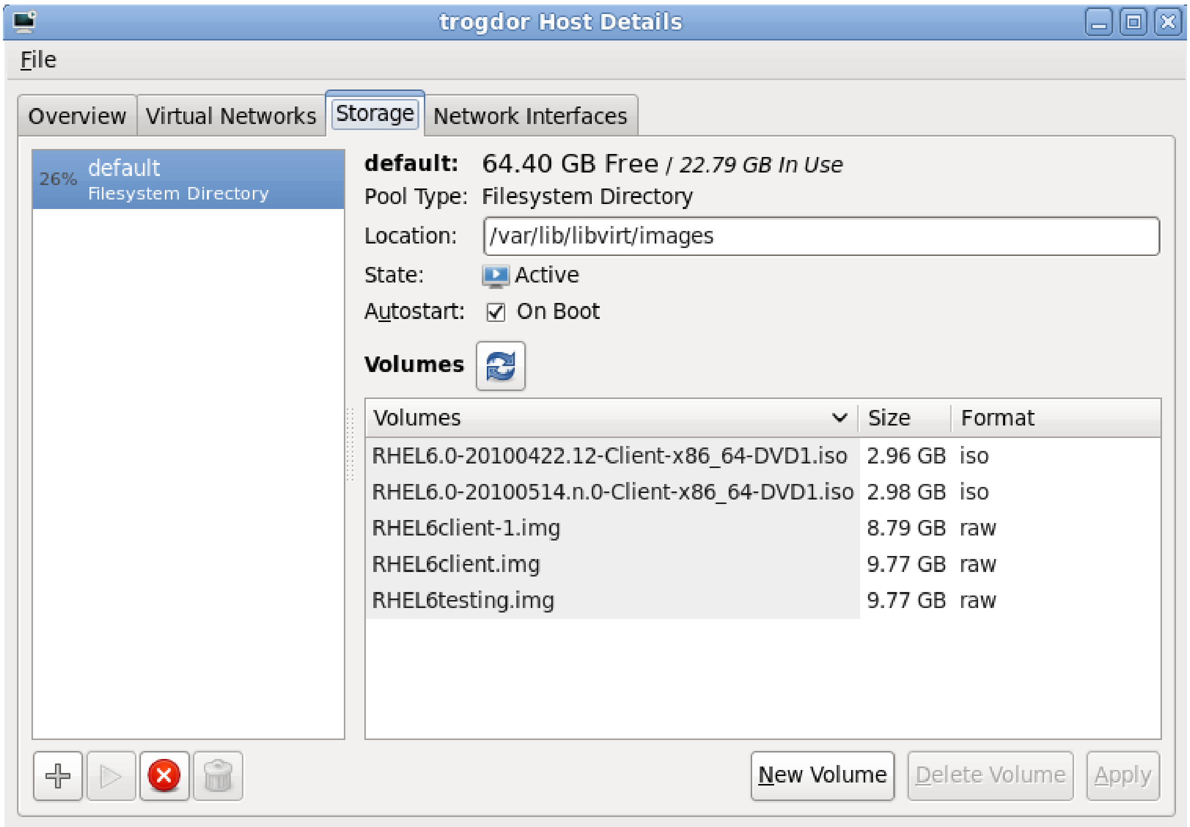
Procedure 26.1. Creating a partition-based storage pool with virt-manager

1. **Open the storage pool settings**
   a. In the **`virt-manager`** graphical interface, select the host from the main window.

      Open the **Edit** menu and select **Host Details**



b. Click on the **Storage** tab of the **Host Details** window.

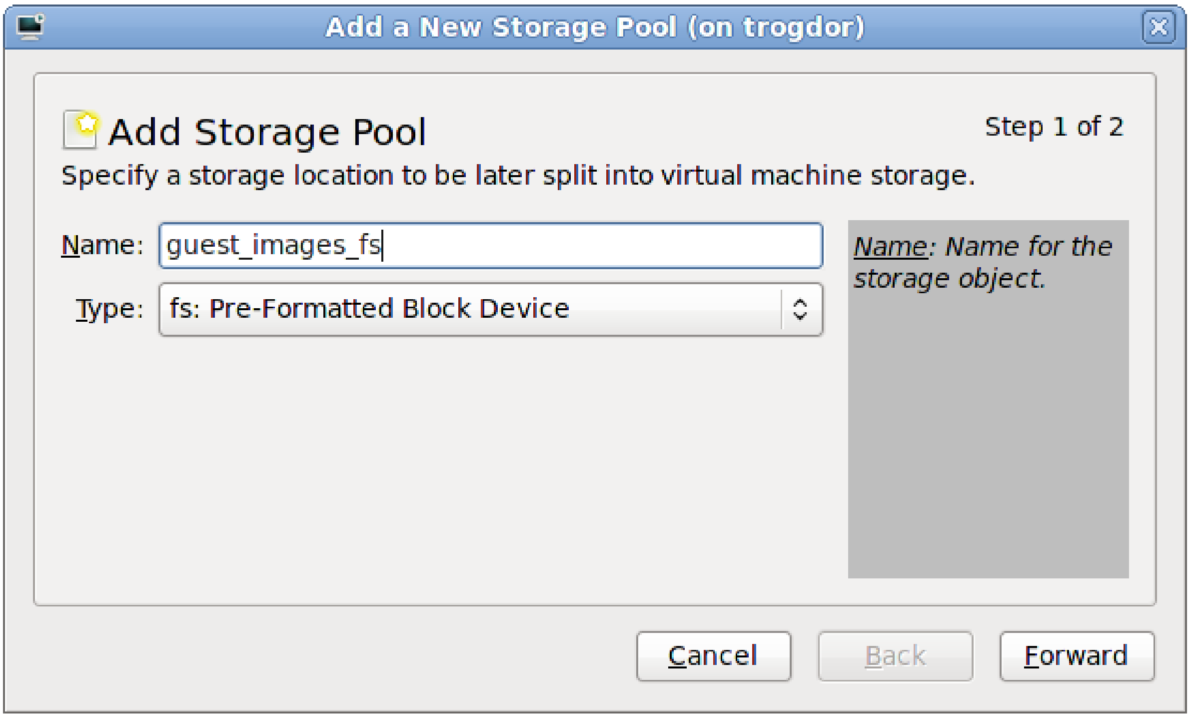


2. **Create the new storage pool**

   a. **Add a new pool (part 1)**

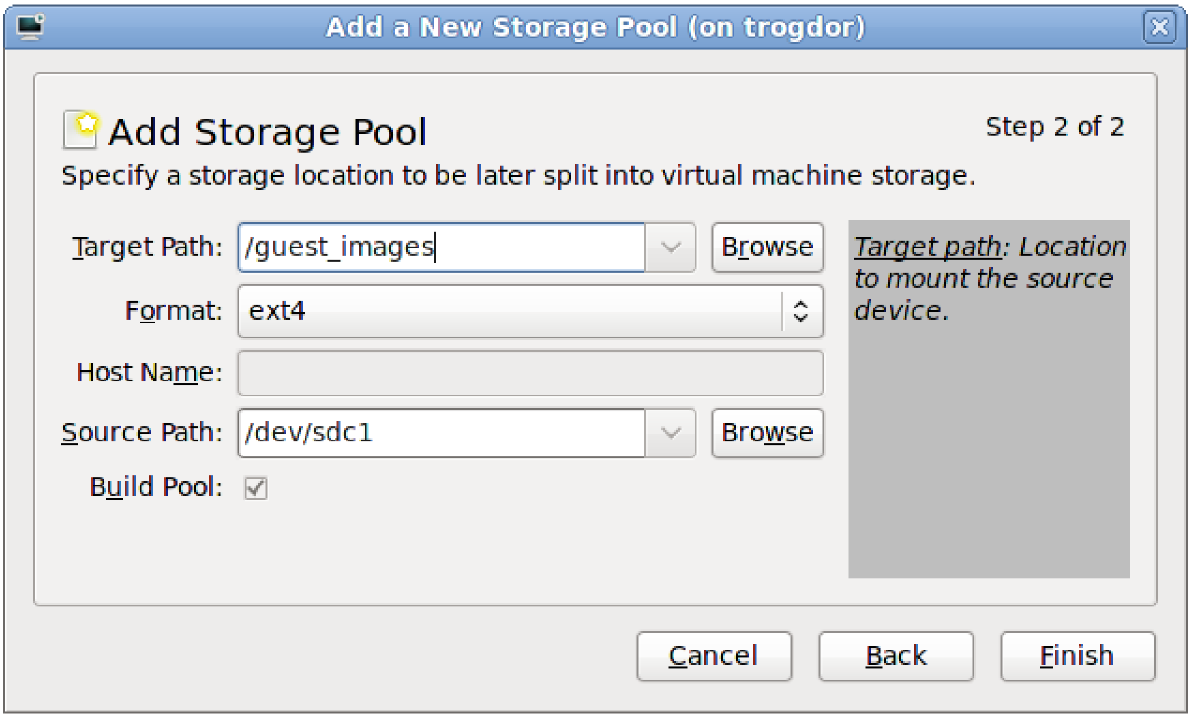
   Press the **+** button (the add pool button). The **Add a New Storage Pool** wizard appears.

   Choose a **Name** for the storage pool. This example uses the name *`guest_images_fs`*. Change the **Type** to **`fs: Pre-Formatted Block Device`**.



Press the **Forward** button to continue.

b. **Add a new pool (part 2)**
Change the **Target Path**, **Format**, and **Source Path** fields.



Target Path
: Enter the location to mount the source device for the storage pool in the **Target Path** field. If the location does does not already exist, **`virt-manager`** will create the directory.

Format
: Select a format from the **Format** list. The device is formatted with the selected format.

  This example uses the *`ext4`* file system, the default Red Hat Enterprise Linux file system.

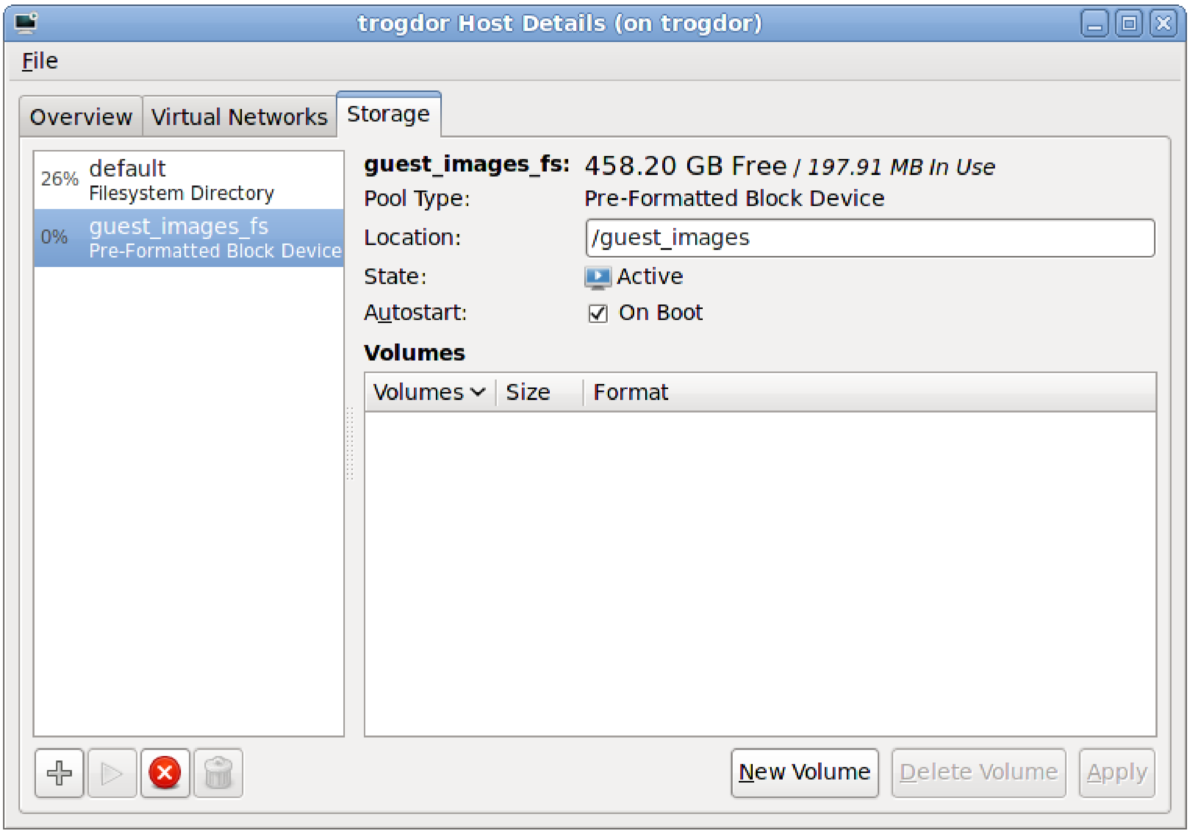
Source Path
: Enter the device in the **`Source Path`** field.

  This example uses the *`/dev/sdc1`* device.

Verify the details and press the **Finish** button to create the storage pool.

3. **Verify the new storage pool**
The new storage pool appears in the storage list on the left after a few seconds. Verify the size is reported as expected, *`458.20 GB Free`* in this example. Verify the **State** field reports the new storage pool as *`Active`*.

Select the storage pool. In the **Autostart** field, click the **On Boot** checkbox. This will make sure the storage device starts whenever the `libvirtd` service starts.



The storage pool is now created, close the **Host Details** window.

26.1.2.2. Creating a partition-based storage pool using virsh

This section covers creating a partition-based storage pool with the **`virsh`** command.

Security warning

Do not use this procedure to assign an entire disk as a storage pool (for example, **`/dev/sdb`**). Guests should not be given write access to whole disks or block devices. Only use this method to assign partitions (for example, **`/dev/sdb1`**) to storage pools.

Procedure 26.2. Creating pre-formatted block device storage pools using virsh

1. **Create the storage pool definition**

   Use the virsh **`pool-define-as`** command to create a new storage pool definition. There are three options that must be provided to define a pre-formatted disk as a storage pool:

   Partition name
   : The *`name`* parameter determines the name of the storage pool. This example uses the name *`guest_images_fs`* in the example below.

   device
   : The *`device`* parameter with the *`path`* attribute specifies the device path of the storage device. This example uses the partition *`/dev/sdc1`* .

   mountpoint
   : The *`mountpoint`* on the local file system where the formatted device will be mounted. If the mount point directory does not exist, the **`virsh`** command can create the directory.

The directory */guest_images* is used in this example.

```
# virsh pool-define-as guest_images_fs fs - - /dev/sdc1 - "/guest_images"
Pool guest_images_fs defined
```

The new pool and mount points are now created.

2. **Verify the new pool**
   List the present storage pools.

```
# virsh pool-list --all
Name                 State      Autostart
-----------------------------------------
default              active     yes
guest_images_fs      inactive   no
```

3. **Ceate the mount point**
   Use the **virsh pool-build** command to create a mount point for a pre-formatted file system storage pool.

```
# 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 ..
# 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 file system onto the mount point and make the pool available for use.

```
# virsh pool-start guest_images_fs
Pool guest_images_fs started
# virsh pool-list --all
Name                 State      Autostart
-----------------------------------------
default              active     yes
guest_images_fs      active     no
```

5. **Turn on autostart**
   By default, a storage pool is defined with **virsh** is not set to automatically start each time the `libvirtd` starts. Turn on automatic start with the **virsh pool-autostart** command. The storage pool is now automatically started each time `libvirtd` starts.

```
# virsh pool-autostart guest_images_fs
Pool guest_images_fs marked as autostarted

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

```
guest_images_fs      active     yes
```

6. **Verify the storage pool**
   Verify the storage pool was created correctly, the sizes reported are as expected, and the state is reported as **`running`**. Verify there is a "lost+found" directory in the mount point on the file system, indicating the device is mounted.

```
# virsh pool-info guest_images_fs
Name:           guest_images_fs
UUID:           c7466869-e82a-a66c-2187-dc9d6f0877d0
State:          running
Capacity:       458.39 GB
Allocation:     197.91 MB
Available:      458.20 GB
# 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
```

26.1.3. Directory-based storage pools

This section covers storing virtualized guests in a directory on the host.

Directory-based storage pools can be created with **`virt-manager`** or the **`virsh`** command line tools.

26.1.3.1. Creating a directory-based storage pool with virt-manager

1. **Create the local directory**
   a. **Optional: Create a new directory for the storage pool**
      Create the directory on the host for the storage pool. An existing directory can be used if permissions and SELinux are configured correctly. This example uses a directory named *`/guest_images`*.

```
# mkdir /guest_images
```

   b. **Set directory ownership**
      Change the user and group ownership of the directory. The directory must be owned by the root user.

```
# chown root:root /guest_images
```

   c. **Set directory permissions**
      Change the file permissions of the directory.

```
# chmod 700 /guest_images
```

   d. **Verify the changes**
      Verify the permissions were modified. The output shows a correctly configured empty directory.

```
# ls -la /guest_images
```

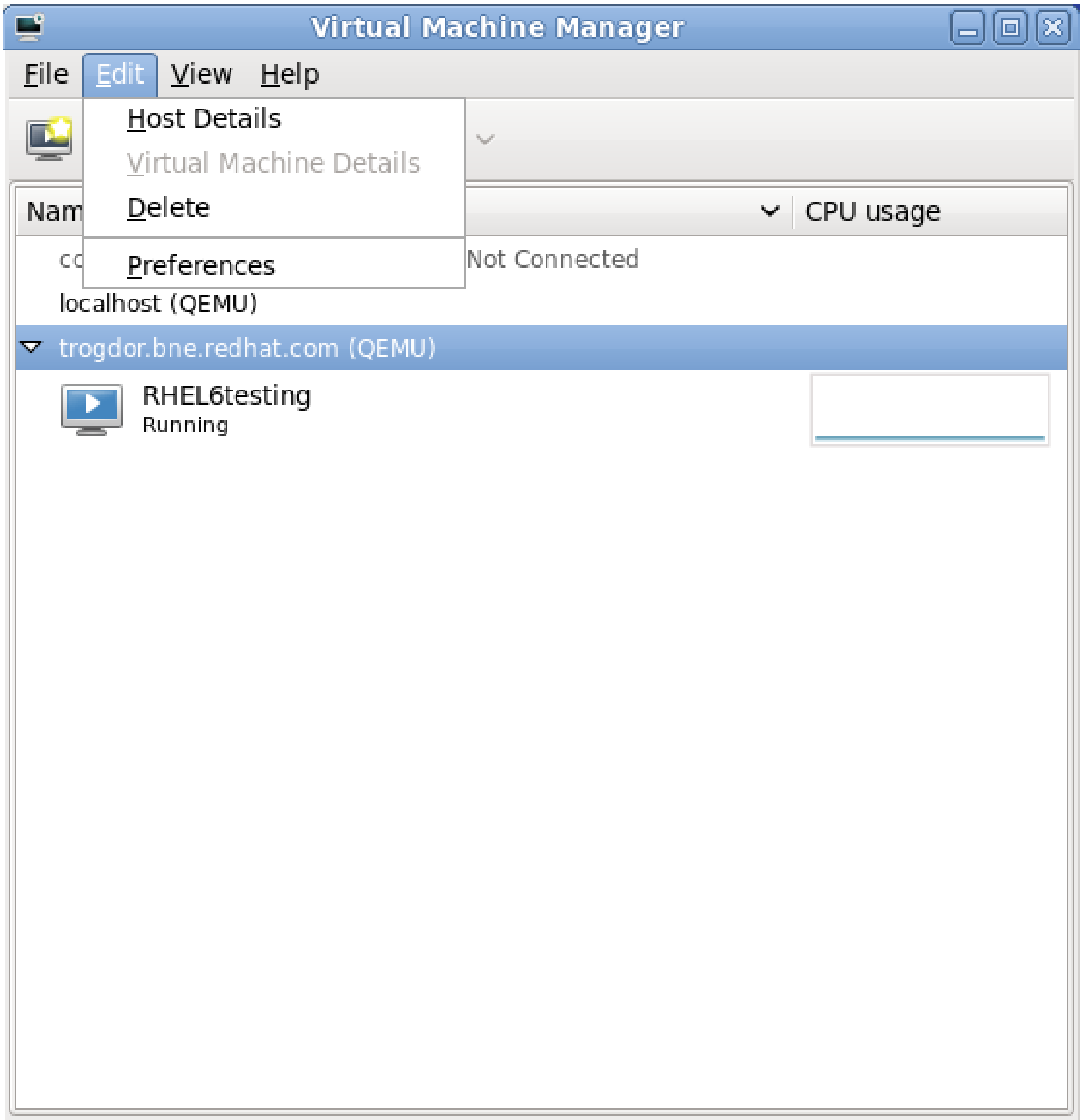
```
total 8
drwx------.  2 root root 4096 May 28 13:57 .
dr-xr-xr-x. 26 root root 4096 May 28 13:57 ..
```

2. **Configure SELinux file contexts**
   Configure the correct SELinux context for the new directory.

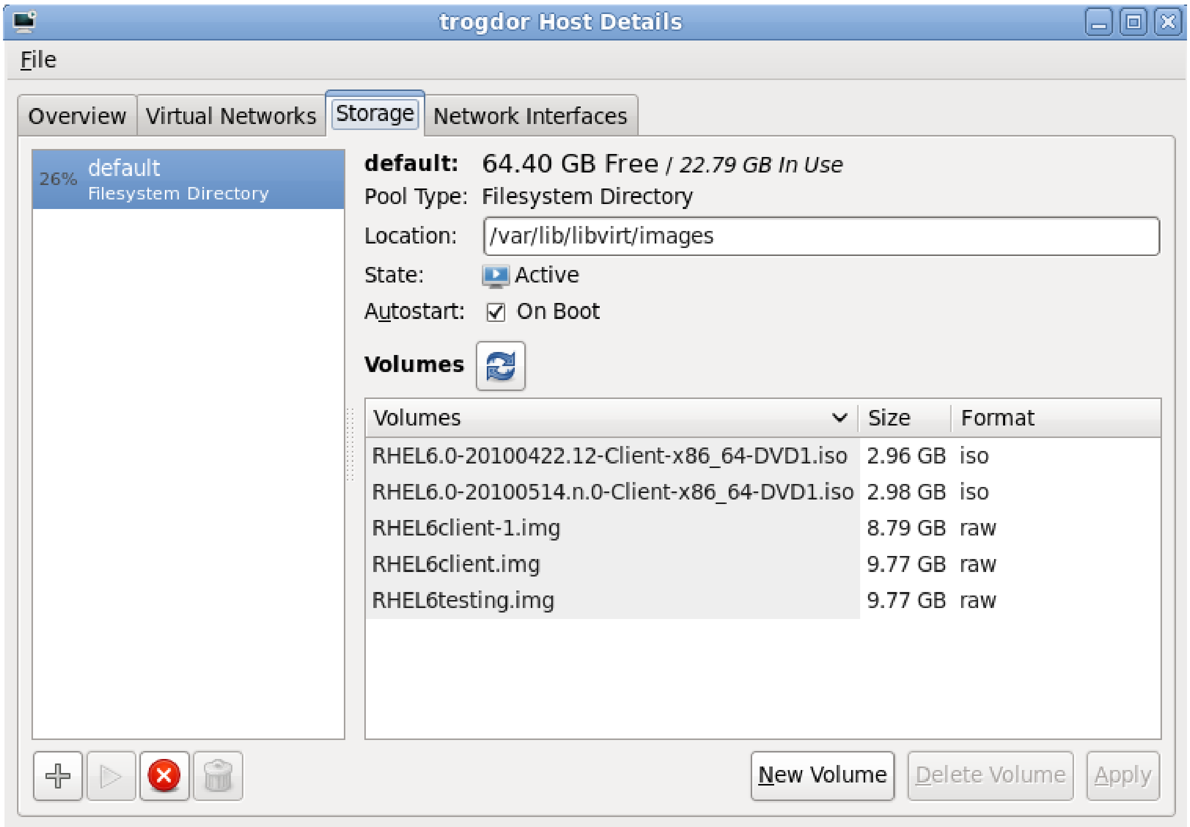
```
# semanage fcontext -a -t virt_image_t /guest_images
```

3. **Open the storage pool settings**
   a. In the **`virt-manager`** graphical interface, select the host from the main window.

      Open the **Edit** menu and select **Host Details**



   b. Click on the **Storage** tab of the **Host Details** window.

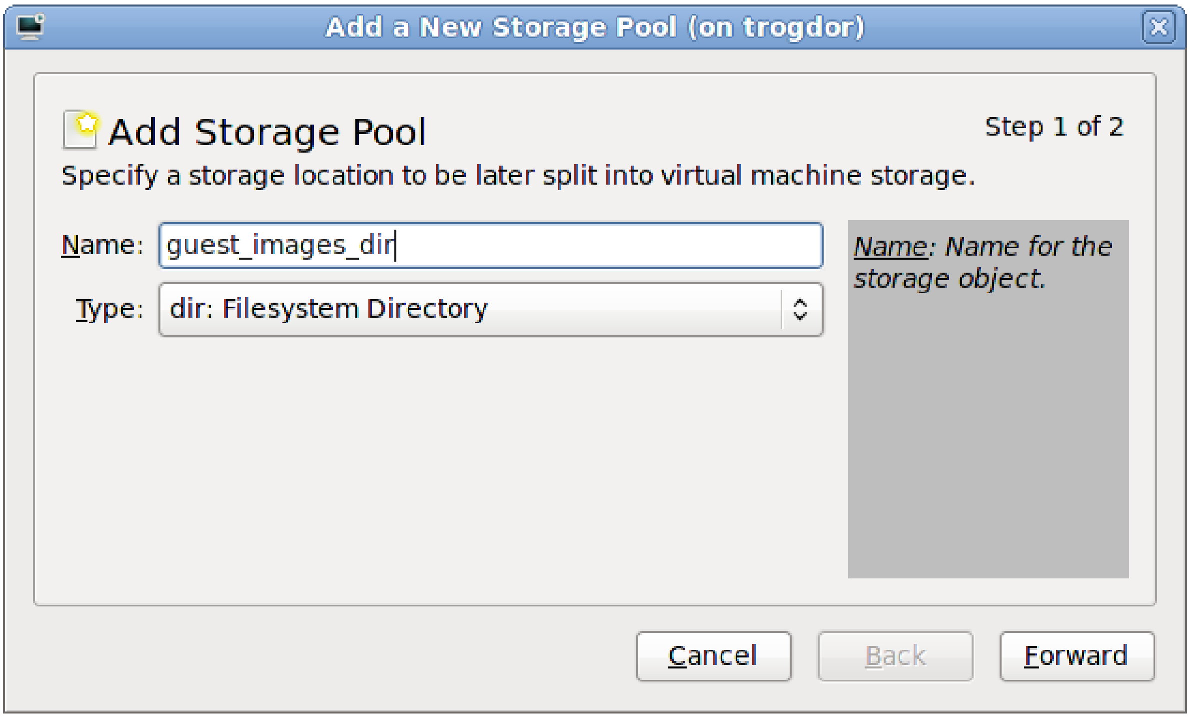


4. **Create the new storage pool**

   a. **Add a new pool (part 1)**

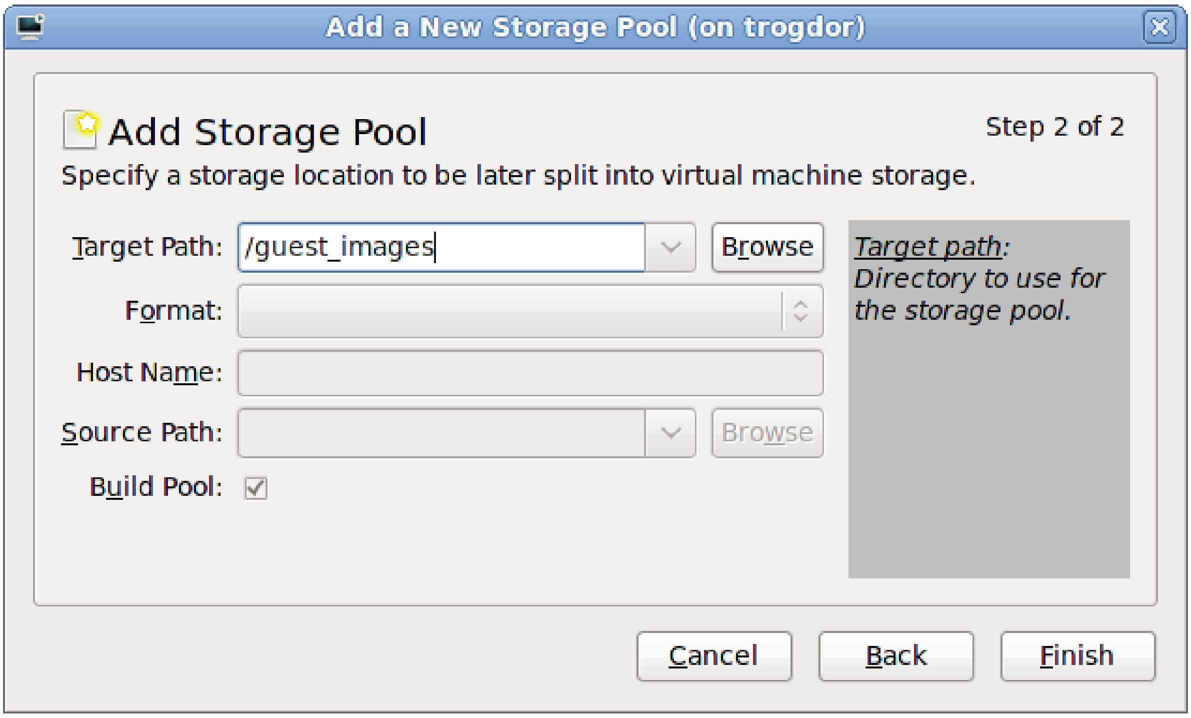
   Press the **+** button (the add pool button). The **Add a New Storage Pool** wizard appears.

   Choose a **Name** for the storage pool. This example uses the name *`guest_images_dir`*. Change the **Type** to **`dir: Filesystem Directory`**.



Press the **Forward** button to continue.

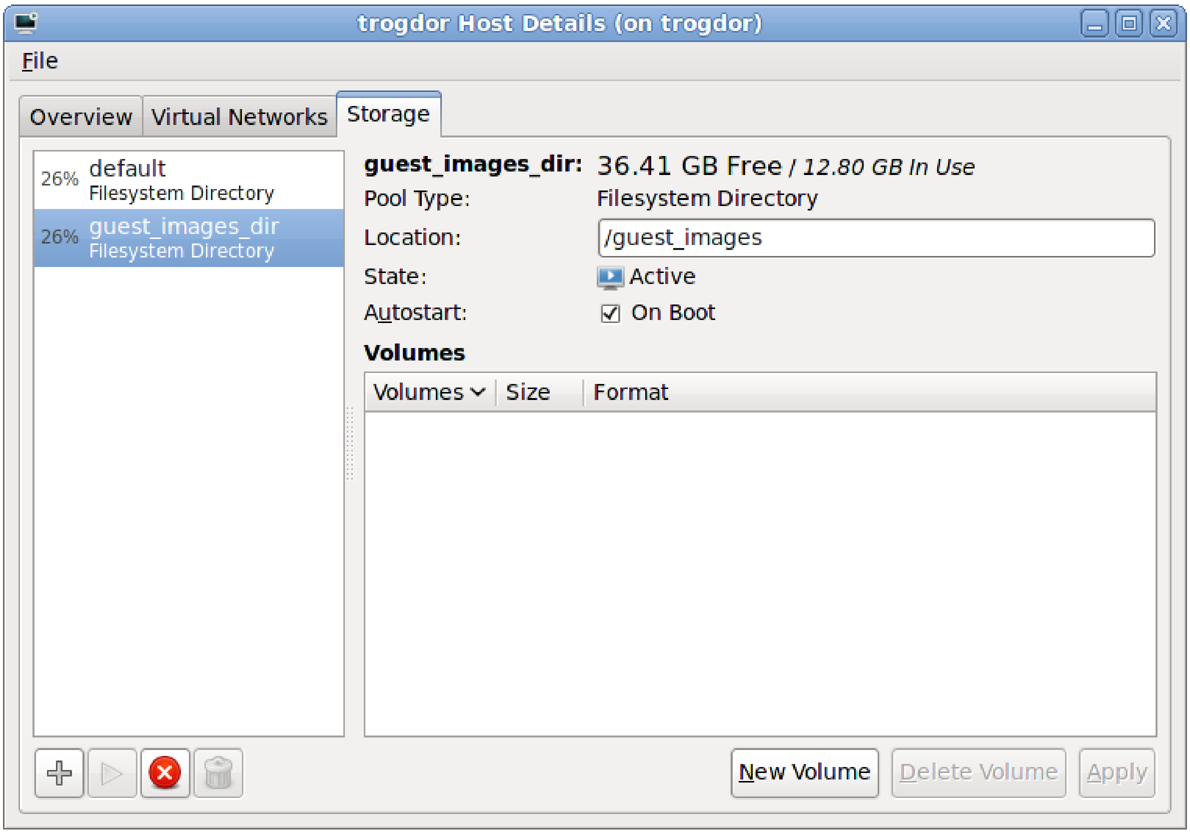
b. **Add a new pool (part 2)**
Change the **Target Path** field. This example uses `/guest_images`.



Verify the details and press the **Finish** button to create the storage pool.

5. **Verify the new storage pool**
The new storage pool appears in the storage list on the left after a few seconds. Verify the size is reported as expected, *36.41 GB Free* in this example. Verify the **State** field reports the new storage pool as *Active*.

Select the storage pool. In the **Autostart** field, click the **On Boot** checkbox. This will make sure the storage pool starts whenever the `libvirtd` service sarts.



The storage pool is now created, close the **Host Details** window.

26.1.3.2. Creating a directory-based storage pool with virsh

1. **Create the storage pool definition**
   Use the **`virsh pool-define-as`** command to define a new storage pool. There are two options required for creating directory-based storage pools:

   - The **name** of the storage pool.

     This example uses the name *`guest_images_dir`*. All further **`virsh`** commands used in this example use this name.

   - The **`path`** to a file system directory for storing virtualized guest image files . If this directory does not exist, **`virsh`** will create it.

     This example uses the */`guest_images`* directory.

   ```
    # virsh pool-define-as guest_images_dir dir - - - - "/guest_images"
   Pool guest_images_dir defined
   ```

2. **Verify the storage pool is listed**
   Verify the storage pool object is created correctly and the state reports it as **`inactive`**.

   ```
   # virsh pool-list --all
   Name                 State      Autostart
   -----------------------------------------
   default              active     yes
   guest_images_dir     inactive   no
   ```

3. **Create the local directory**

   Use the **`virsh pool-build`** command to build the directory-based storage pool. **`virsh pool-build`** sets the required permissions and SELinux settings for the directory and creates the directory if it does not exist.

```
# virsh pool-build guest_images_dir
Pool guest_images_dir built
# ls -la /guest_images
total 8
drwx------.  2 root root 4096 May 30 02:44 .
dr-xr-xr-x. 26 root root 4096 May 30 02:44 ..
# virsh pool-list --all
Name                 State      Autostart
-----------------------------------------
default              active     yes
guest_images_dir     inactive   no
```

4. **Start the storage pool**

   Use the virsh command **`pool-start`** for this. **`pool-start`** enables a directory storage pool, allowing it to be used for volumes and guests.

```
# virsh pool-start guest_images_dir
Pool guest_images_dir started
# virsh pool-list --all
Name                 State      Autostart
-----------------------------------------
default              active     yes
guest_images_dir    active     no
```

5. **Turn on autostart**

   Turn on *`autostart`* for the storage pool. Autostart configures the `libvirtd` service to start the storage pool when the service starts.

```
# virsh pool-autostart guest_images_dir
Pool guest_images_dir marked as autostarted
# virsh pool-list --all
Name                 State      Autostart
-----------------------------------------
default              active     yes
guest_images_dir     active     yes
```

6. **Verify the storage pool configuration**

   Verify the storage pool was created correctly, the sizes reported correctly, and the state reports as **`running`**.

```
# virsh pool-info guest_images_dir
Name:           guest_images_dir
UUID:           779081bf-7a82-107b-2874-a19a9c51d24c
State:          running
Capacity:       49.22 GB
Allocation:     12.80 GB
Available:      36.41 GB

# ls -la /guest_images
total 8
drwx------.  2 root root 4096 May 30 02:44 .
dr-xr-xr-x. 26 root root 4096 May 30 02:44 ..
#
```

A directory-based storage pool is now available.

26.1.4. LVM-based storage pools

This chapter covers using LVM volume groups as storage pools.

LVM-based storage groups provide the full flexibility of LVM.

LVM

Please refer to Chapter 3 of the Red Hat Enterprise Linux Storage Administration Guide for more details on LVM: *http://docs.redhat.com/docs/en-US/Red_Hat_Enterprise_Linux/6/html/Storage_Administration_Guide/ch-lvm.html*

Warning

LVM-based storage pools require a full disk partition. This partition will be formatted and all data presently stored on the disk device will be erased. Back up the storage device before commencing the following procedure.

26.1.4.1. Creating an LVM-based storage pool with virt-manager

LVM-based storage pools can use existing LVM volume groups or create new LVM volume groups on a blank partition.

1. **Optional: Create new partition for LVM volumes**
   These steps describe how to create a new partition and LVM volume group on a new hard disk drive.

   Warning

   This procedure will remove all data from the selected storage device.

   a. **Create a new partition**
      Use the **`fdisk`** command to create a new disk partition from the command line. The following example creates a new partition that uses the entire disk on the storage device **`/dev/sdb`**.

      ```
      # fdisk /dev/sdb
      Command (m for help):
      ```

      Press *n* for a new partition.

   b. Press *p* for a primary partition.

      ```
      Command action
         e   extended
         p   primary partition (1-4)
      ```

   c. Choose an available partition number. In this example the first partition is chosen by entering *`1`*.

```
Partition number (1-4): 1
```

d. Enter the default first cylinder by pressing *Enter*.

```
First cylinder (1-400, default 1):
```

e. Select the size of the partition. In this example the entire disk is allocated by pressing *Enter*.

```
Last cylinder or +size or +sizeM or +sizeK (2-400, default 400):
```

f. Set the type of partition by pressing *t*.

```
Command (m for help): t
```

g. Choose the partition you created in the previous steps. In this example, the partition number is *1*.

```
Partition number (1-4): 1
```

h. Enter *8e* for a Linux LVM partition.

```
Hex code (type L to list codes): 8e
```

i. write changes to disk and quit.

```
Command (m for help): w
Command (m for help): q
```

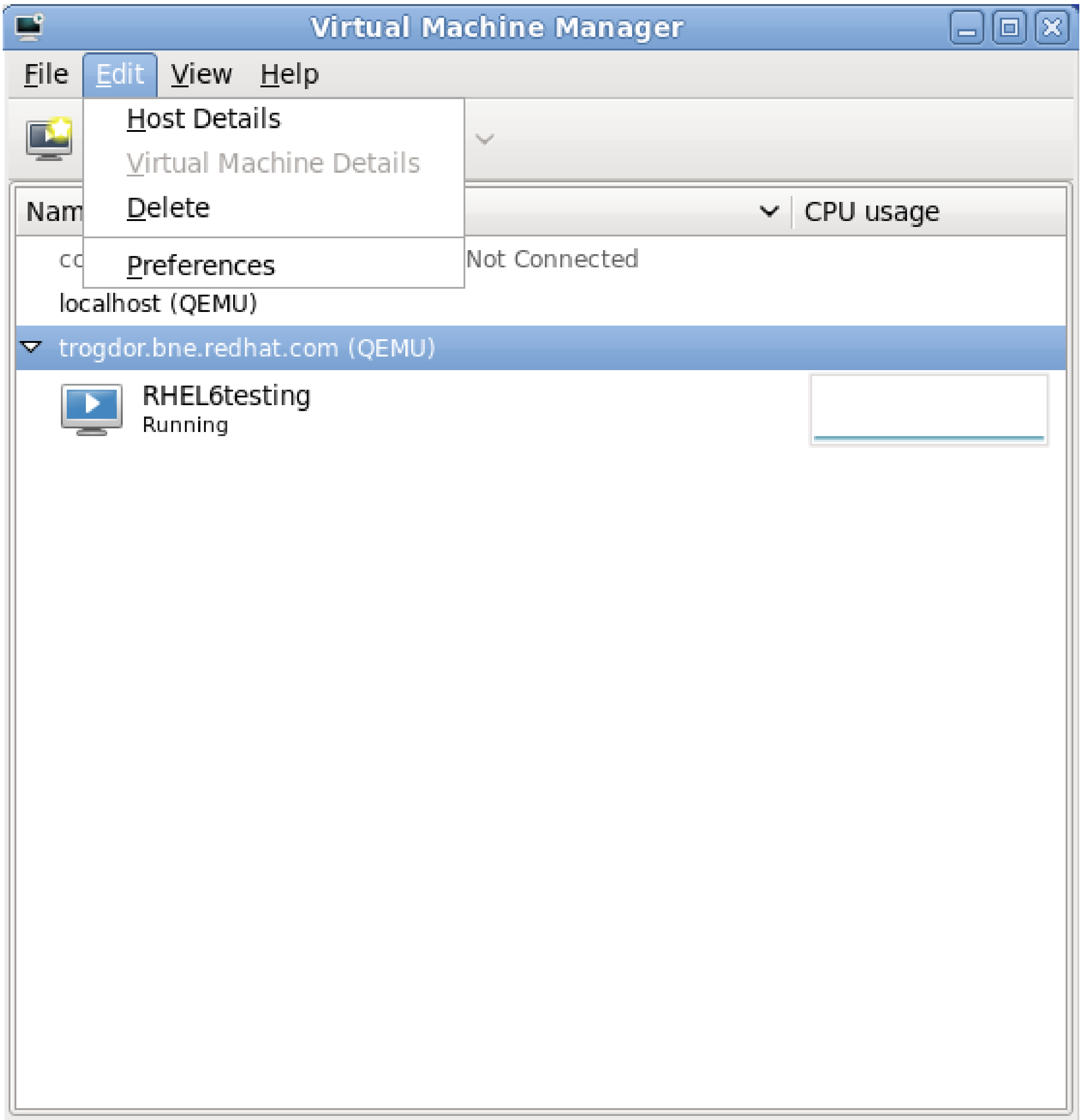
j. **Create a new LVM volume group**
Create a new LVM volume group with the vgcreate command. This example creates a volume group named *guest_images_lvm*.

```
# vgcreate guest_images_lvm /dev/sdb1
  Physical volmue "/dev/vdb1" successfully created
  Volume group "guest_images_lvm" successfully created
```

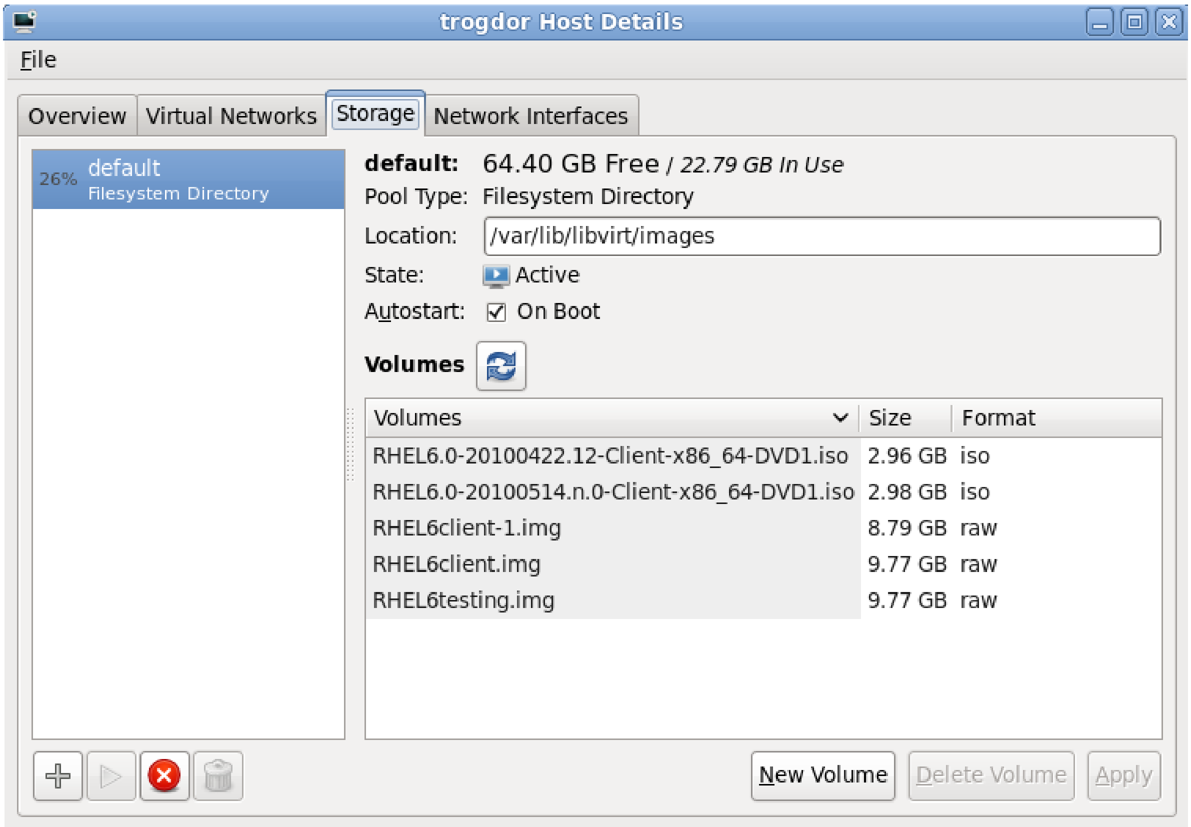
The new LVM volume group, *guest_images_lvm*, can now be used for an LVM-based storage pool.

2. **Open the storage pool settings**
   a. In the **virt-manager** graphical interface, select the host from the main window.

   Open the **Edit** menu and select **Host Details**



b. Click on the **Storage** tab of the **Host Details** window.

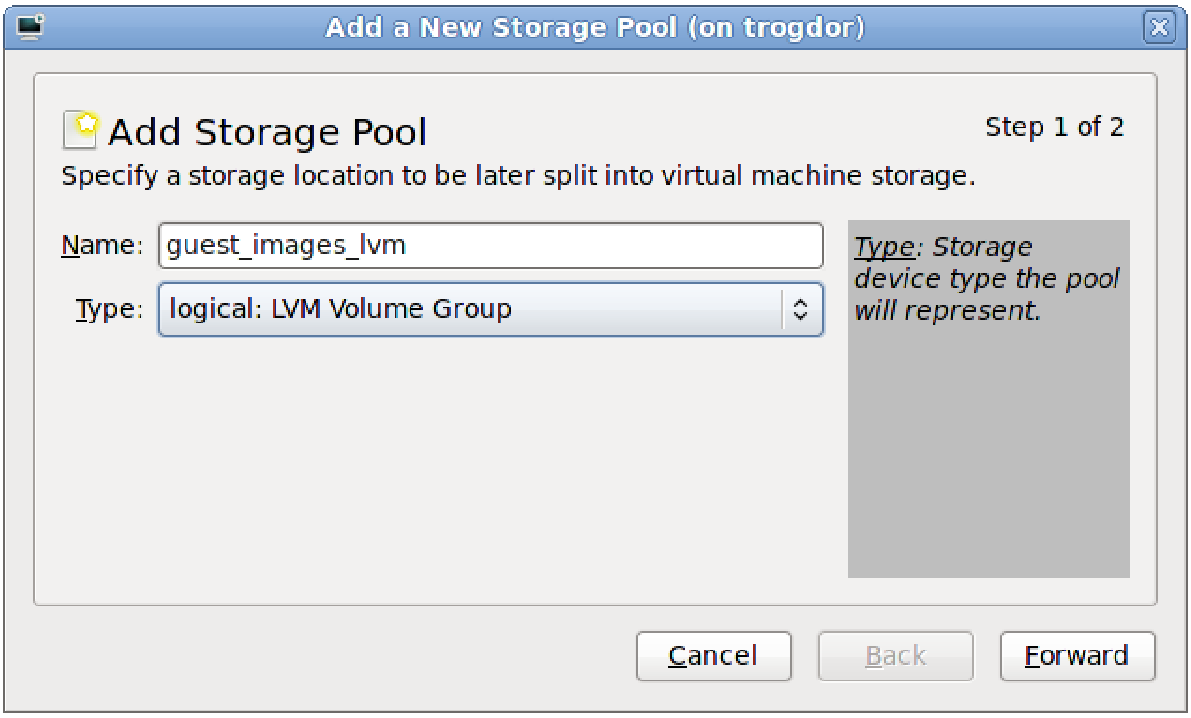


3. **Create the new storage pool**

   a. **Start the Wizard**

      Press the **+** button (the add pool button). The **Add a New Storage Pool** wizard appears.

      Choose a **Name** for the storage pool. We use *`guest_images_lvm`* for this example. Then change the **Type** to **`logical: LVM Volume Group`**, and



Press the **Forward** button to continue.

b. **Add a new pool (part 2)**
Change the **Target Path** field. This example uses */guest_images*.

Now fill in the **Target Path** and **Source Path** fields, then tick the **Build Pool** check box.

- Use the **Target Path** field to *either* select an existing LVM volume group or as the name for a new volume group. The default format is **/dev/***storage_pool_name*.

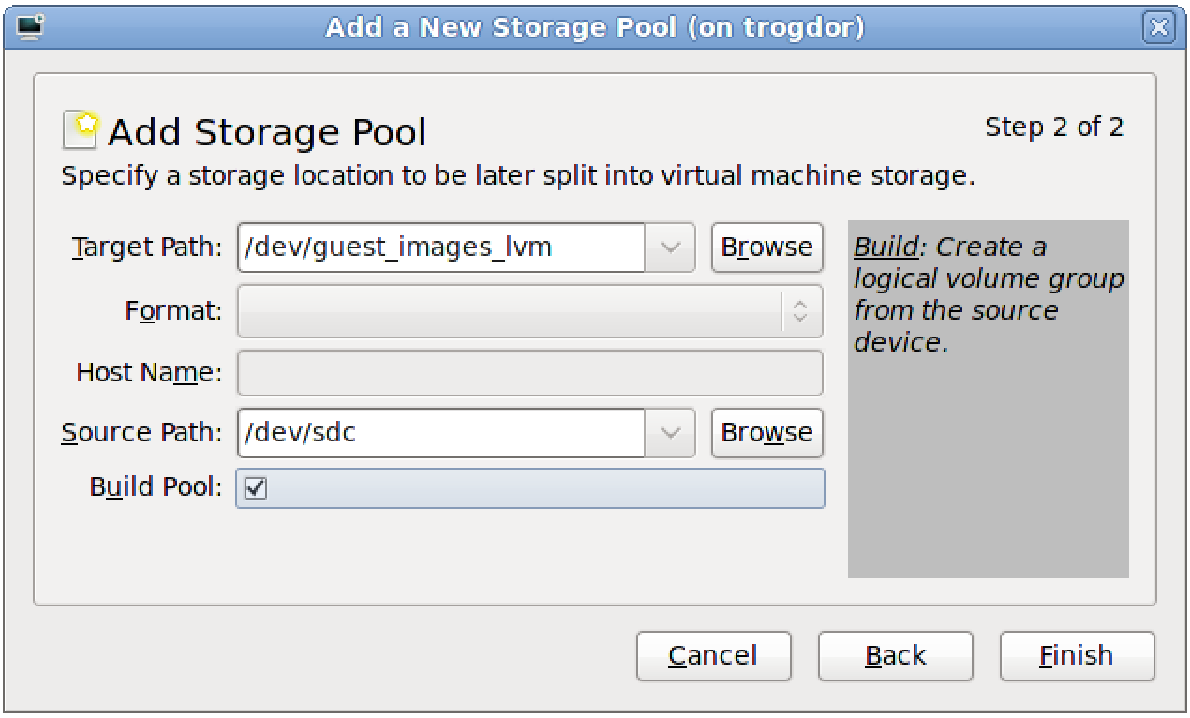
  This example uses a new volume group named */dev/guest_images_lvm*.

- The **Source Path** field is optional if an existing LVM volume group is used in the **Target Path**.

  For new LVM volume groups, input the location of a storage device in the **Source Path** field. This example uses a blank partition */dev/sdc*.

- The **Build Pool** checkbox instructs **virt-manager** to create a new LVM volume group. If you are using an existing volume group you should not select the **Build Pool** checkbox.

  This example is using a blank partition to create a new volume group so the **Build Pool** checkbox must be selected.



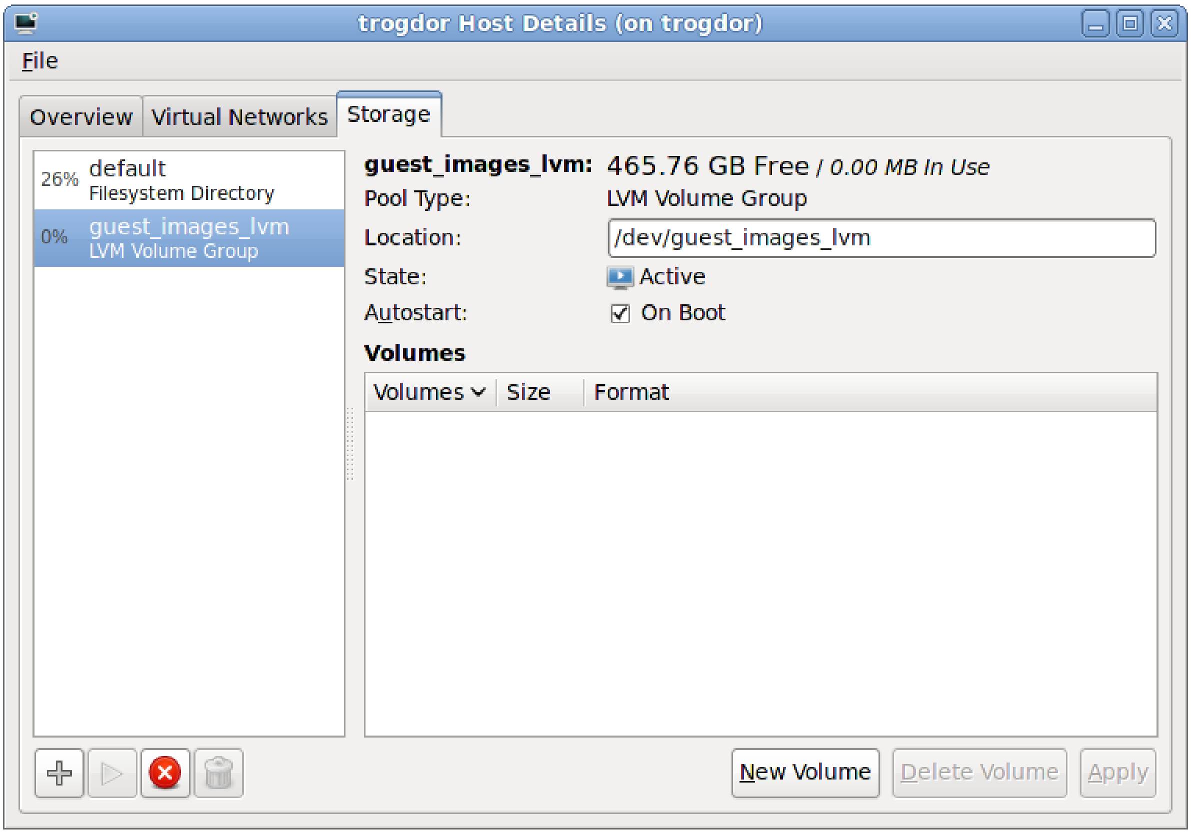
Verify the details and press the **Finish** button format the LVM volume group and create the storage pool.

c. **Confirm the device to be formatted**
A warning message appears.

Press the **Yes** button to proceed to erase all data on the storage device and create the storage pool.

4. **Verify the new storage pool**
   The new storage pool will appear in the list on the left after a few seconds. Verify the details are what you expect, *`465.76 GB Free`* in our example. Also verify the **State** field reports the new storage pool as *`Active`*.

   It is generally a good idea to have the **Autostart** check box enabled, to ensure the storage pool starts automatically with libvirtd.



Close the Host Details dialog, as the task is now complete.

26.1.4.2. Creating an LVM-based storage pool with virsh

- ```
  # virsh pool-define-as guest_images_lvm logical - - /dev/sdc libvirt_lvm /
  dev/libvirt_lvm
  ```
  ```

```
Pool guest_images_lvm defined
# virsh pool-build guest_images_lvm
Pool guest_images_lvm built
# virsh pool-start guest_images_lvm
Pool guest_images_lvm started
# vgs
VG          #PV #LV #SN Attr   VSize   VFree
libvirt_lvm   1   0   0 wz--n- 465.76g 465.76g
# virsh pool-autostart guest_images_lvm
Pool guest_images_lvm marked as autostarted

# virsh pool-list --all
Name                 State      Autostart
-----------------------------------------
default              active     yes
guest_images_lvm     active     yes

# virsh vol-create-as guest_images_lvm volume1 8G
Vol volume1 created

# virsh vol-create-as guest_images_lvm volume2 8G
Vol volume2 created

# virsh vol-create-as guest_images_lvm volume3 8G
Vol volume3 created

# virsh vol-list guest_images_lvm
Name                 Path
-----------------------------------------
volume1              /dev/libvirt_lvm/volume1
volume2              /dev/libvirt_lvm/volume2
volume3              /dev/libvirt_lvm/volume3

# lvscan
ACTIVE            '/dev/libvirt_lvm/volume1' [8.00 GiB] inherit
ACTIVE            '/dev/libvirt_lvm/volume2' [8.00 GiB] inherit
ACTIVE            '/dev/libvirt_lvm/volume3' [8.00 GiB] inherit
# lvs
LV       VG          Attr   LSize   Origin Snap%  Move Log Copy%  Convert
volume1 libvirt_lvm -wi-a-   8.00g
volume2 libvirt_lvm -wi-a-   8.00g
volume3 libvirt_lvm -wi-a-   8.00g
# vgs
VG          #PV #LV #SN Attr   VSize   VFree
libvirt_lvm   1   3   0 wz--n- 465.76g 441.76g
vg_host2      1   3   0 wz--n- 465.27g      0
#
```

26.1.5. iSCSI-based storage pools

This section covers using iSCSI-based devices to store virtualized guests.

iSCSI (Internet Small Computer System Interface) is a network protocol for sharing storage devices. iSCSI connects initiators (storage clients) to targets (storage servers) using SCSI instructions over the IP layer. For more information and background on the iSCSI protocol refer to *wikipedia's iSCSI article*[1].

26.1.5.1. Configuring a software iSCSI target

The *scsi-target-utils* package provides a tool for creating software-backed iSCSI targets.

[1] http://en.wikipedia.org/wiki/ISCSI

Procedure 26.3. Creating an iSCSI target

1. **Install the required packages**

   Install the *scsi-target-utils* package and all dependencies

   ```
   # yum install scsi-target-utils
   ```

2. **Start the tgtd service**

   The **tgtd** service hosts SCSI targets and uses the iSCSI protocol to host targets. Start the **tgtd** service and make the service persistent after restarting with the **chkconfig** command.

   ```
   # service tgtd start
   # chkconfig tgtd on
   ```

3. **Optional: Create LVM volumes**

   LVM volumes are useful for iSCSI backing images. LVM snapshots and resizing can be beneficial for virtualized guests. This example creates an LVM image named *virtimage1* on a new volume group named *virtstore* on a RAID5 array for hosting virtualized guests with iSCSI.

   a. **Create the RAID array**

      Creating software RAID5 arrays is covered by the *Red Hat Enterprise Linux Deployment Guide*.

   b. **Create the LVM volume group**

      Create a volume group named *virtstore* with the **vgcreate** command.

      ```
      # vgcreate virtstore /dev/md1
      ```

   c. **Create a LVM logical volume**

      Create a logical volume group named *virtimage1* on the *virtstore* volume group with a size of 20GB using the **lvcreate** command.

      ```
      # lvcreate --size 20G -n virtimage1
             virtstore
      ```

      The new logical volume, *virtimage1*, is ready to use for iSCSI.

4. **Optional: Create file-based images**

   File-based storage is sufficient for testing but is not recommended for production environments or any significant I/O activity. This optional procedure creates a file based imaged named *virtimage2.img* for an iSCSI target.

   a. **Create a new directory for the image**

      Create a new directory to store the image. The directory must have the correct SELinux contexts.

      ```
      # mkdir -p /var/lib/tgtd/virtualization
      ```

   b. **Create the image file**

      Create an image named *virtimage2.img* with a size of 10GB.

      ```
      # dd if=/dev/zero of=/var/lib/tgtd/virtualization/virtimage2.img bs=1M seek=10000
       count=0
      ```

c. **Configure SELinux file contexts**
Configure the correct SELinux context for the new image and directory.

```
# restorecon -R /var/lib/tgtd
```

The new file-based image, *virtimage2.img*, is ready to use for iSCSI.

5. **Create targets**
Targets can be created by adding a XML entry to the **/etc/tgt/targets.conf** file. The **target** attribute requires an iSCSI Qualified Name (IQN). The IQN is in the format:

```
iqn.yyyy-mm.reversed domain name:optional identifier text
```

Where:

- *yyyy-mm* represents the year and month the device was started (for example: *2010-05*);
- *reversed domain name* is the hosts domain name in reverse (for example *server1.example.com* in an IQN would be *com.example.server1*); and
- *optional identifier text* is any text string, without spaces, that assists the administrator in identifying devices or hardware.

This example creates iSCSI targets for the two types of images created in the optional steps on *server1.example.com* with an optional identifier *trial*. Add the following to the **/etc/tgt/targets.conf** file.

```
<target iqn.2010-05.com.example.server1:trial>
backing-store /dev/virtstore/virtimage1  #LUN 1
backing-store /var/lib/tgtd/virtualization/virtimage2.img  #LUN 2
write-cache off
</target>
```

Ensure that the **/etc/tgt/targets.conf** file contains the **default-driver iscsi** line to set the driver type as iSCSI. The driver uses iSCSI by default.

Important

This example creates a globally accessible target without access control. Refer to the scsi-target-utils for information on implementing secure access.

6. **Restart the tgtd service**
Restart the `tgtd` service to reload the configuration changes.

```
# service tgtd restart
```

7. **iptables configuration**
Open port 3260 for iSCSI access with **iptables**.

```
# iptables -I INPUT -p tcp -m tcp --dport 3260 -j ACCEPT
# service iptables save
```

```
# service iptables restart
```

8. **Verify the new targets**
   View the new targets to ensure the setup was success with the **`tgt-admin --show`** command.

```
# tgt-admin --show
Target 1: iqn.2010-05.com.example.server1:trial
System information:
Driver: iscsi
State: ready
I_T nexus information:
LUN information:
LUN: 0
    Type: controller
    SCSI ID: IET     00010000
    SCSI SN: beaf10
    Size: 0 MB
    Online: Yes
    Removable media: No
    Backing store type: rdwr
    Backing store path: None
LUN: 1
    Type: disk
    SCSI ID: IET     00010001
    SCSI SN: beaf11
    Size: 20000 MB
    Online: Yes
    Removable media: No
    Backing store type: rdwr
    Backing store path: /dev/virtstore/virtimage1
LUN: 2
    Type: disk
    SCSI ID: IET     00010002
    SCSI SN: beaf12
    Size: 10000 MB
    Online: Yes
    Removable media: No
    Backing store type: rdwr
    Backing store path: /var/lib/tgtd/virtualization/virtimage2.img
Account information:
ACL information:
ALL
```

Security warning

The ACL list is set to all. This allows all systems on the local network to access this device. It is recommended to set host access ACLs for production environments.

9. **Optional: Test discovery**
   Test whether the new iSCSI device is discoverable.

```
# iscsiadm --mode discovery --type sendtargets --portal server1.example.com
127.0.0.1:3260,1 iqn.2010-05.com.example.server1:trial1
```

10. **Optional: Test attaching the device**
    Attach the new device (*`iqn.2010-05.com.example.server1:trial1`*) to determine whether the device can be attached.

```
# iscsiadm -d2 -m node --login
scsiadm: Max file limits 1024 1024

Logging in to [iface: default, target: iqn.2010-05.com.example.server1:trial1, portal:
 10.0.0.1,3260]
Login to [iface: default, target: iqn.2010-05.com.example.server1:trial1, portal:
 10.0.0.1,3260] successful.
```

Detach the device.

```
# iscsiadm -d2 -m node --logout
scsiadm: Max file limits 1024 1024

Logging out of session [sid: 2, target: iqn.2010-05.com.example.server1:trial1, portal:
 10.0.0.1,3260
Logout of [sid: 2, target: iqn.2010-05.com.example.server1:trial1, portal:
 10.0.0.1,3260] successful.
```

An iSCSI device is now ready to use for virtualization.

26.1.5.2. Adding an iSCSI target to virt-manager

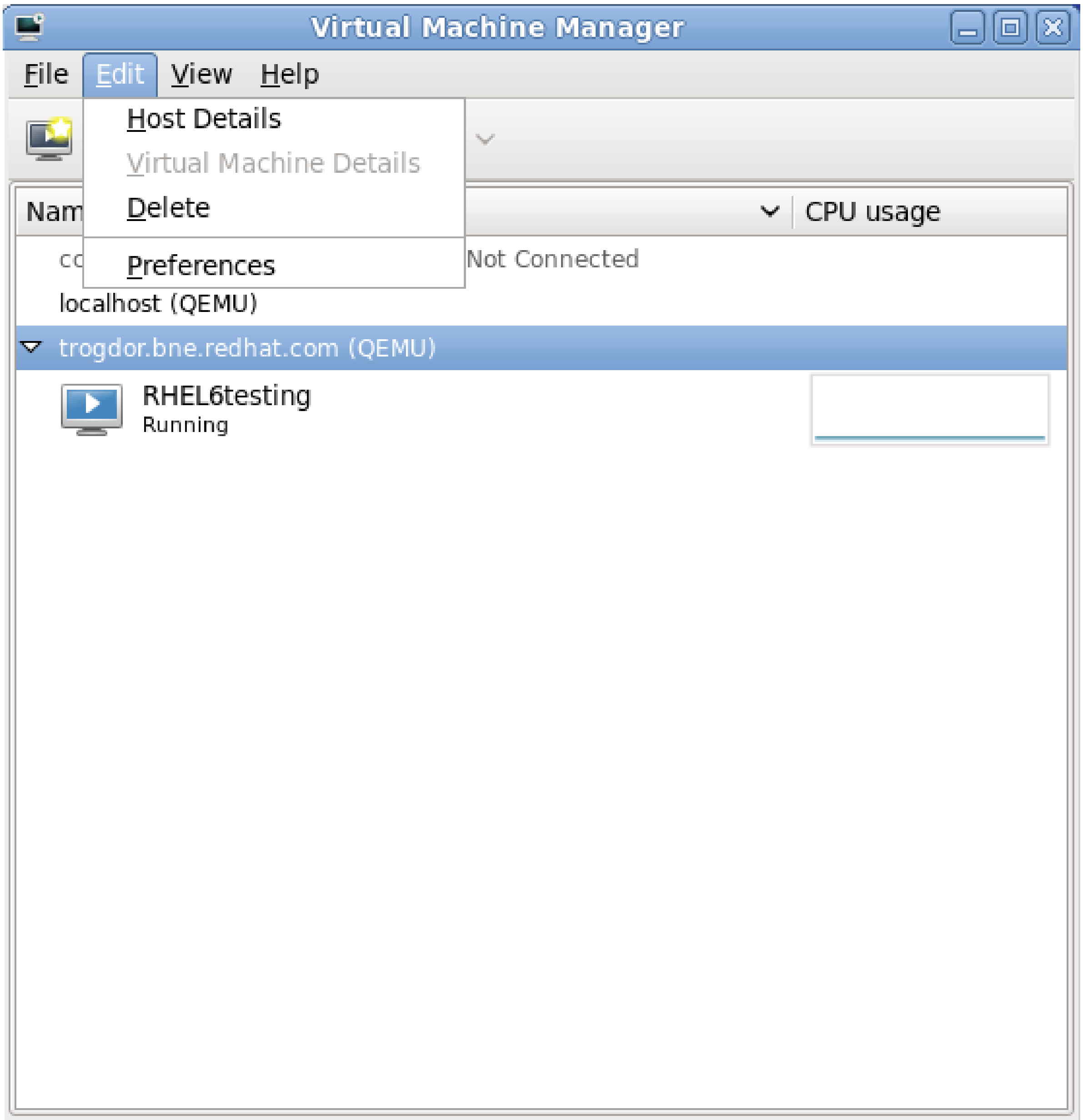
This procedure covers creating a storage pool with an iSCSI target in **`virt-manager`**.

Procedure 26.4. Adding an iSCSI device to virt-manager

1. **Open the host storage tab**
   Open the **Storage** tab in the **Host Details** window.

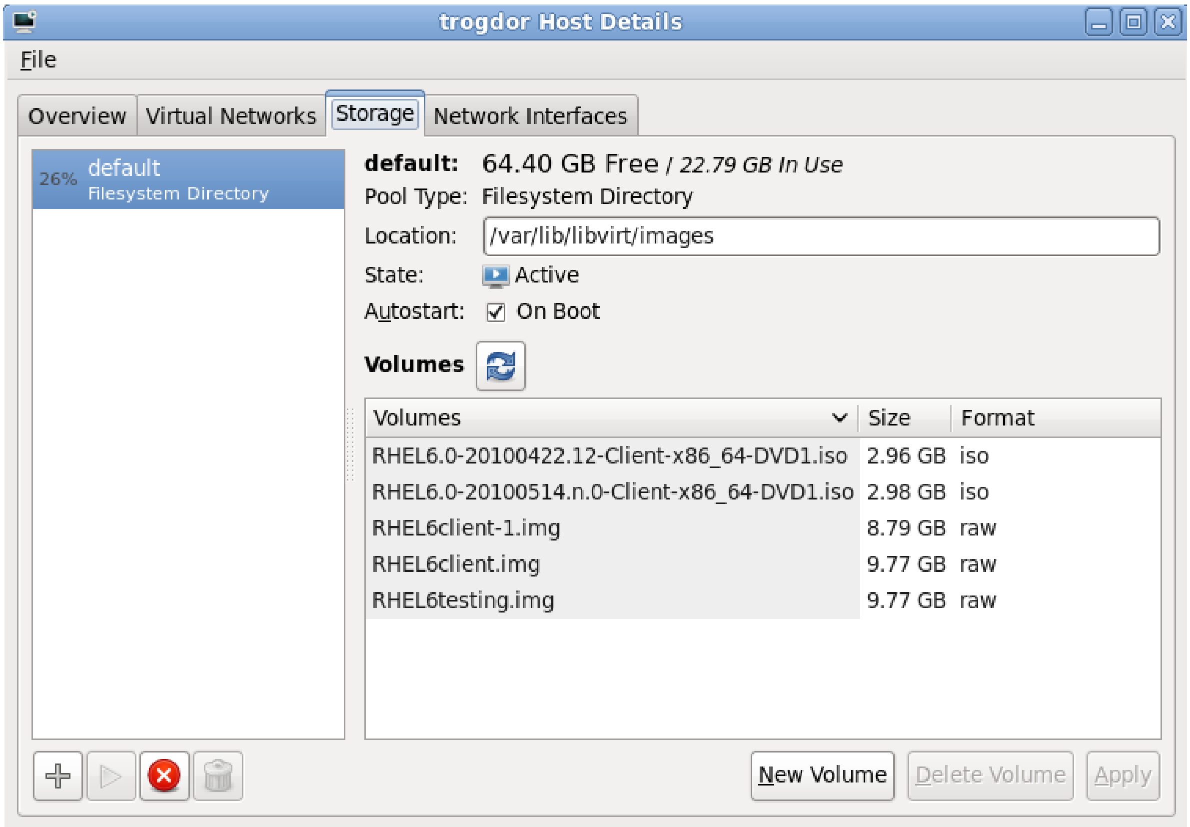
   a. Open **`virt-manager`**.

   b. Select a host from the main **`virt-manager`** window.

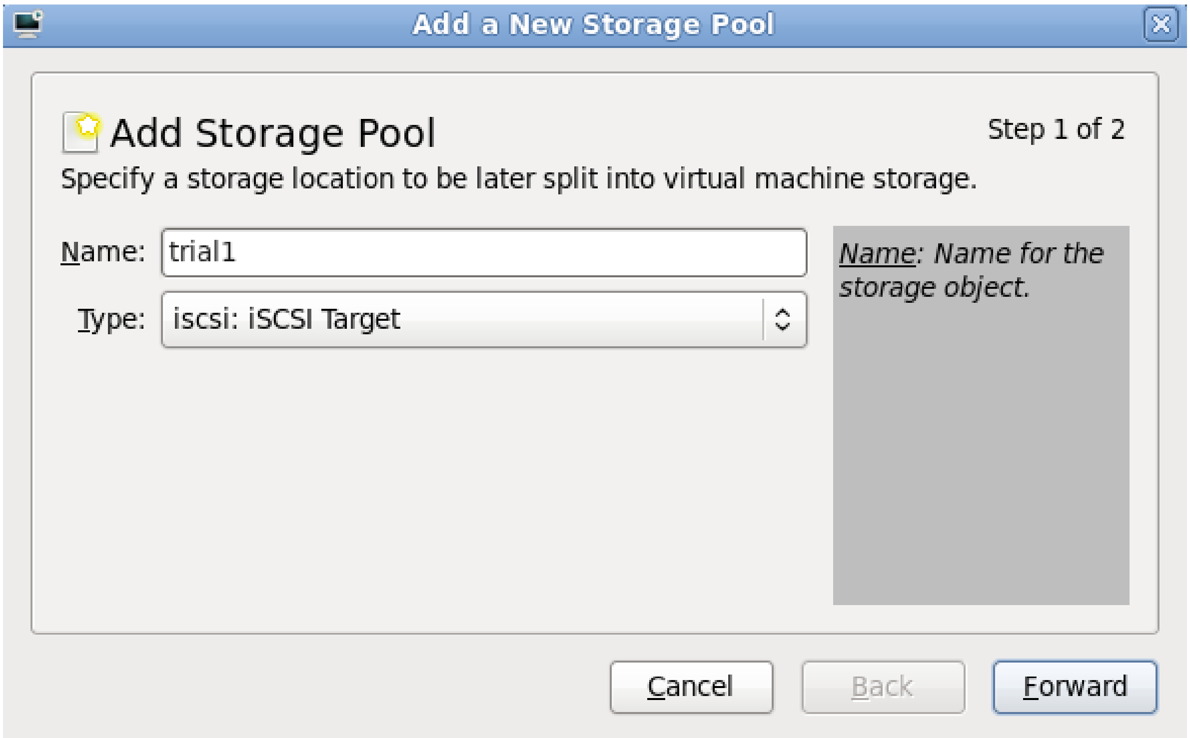


c. Open the Edit menu and select Host Details.

d. Click on the Storage tab of the Host Details window.



2. **Add a new pool (part 1)**
   Press the **+** button (the add pool button). The **Add a New Storage Pool** wizard appears.

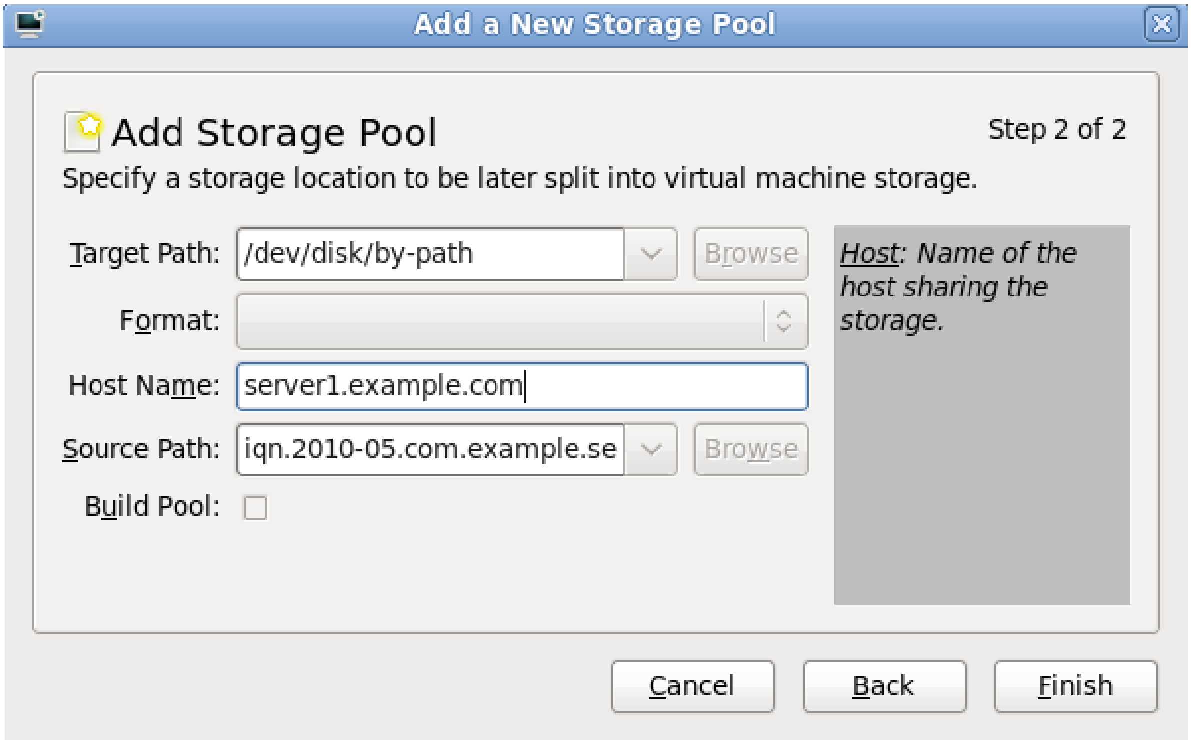


   Choose a name for the storage pool, change the Type to iscsi, and press **Forward** to continue.

3. **Add a new pool (part 2)**
   Enter the target path for the device, the host name of the target and the source path (the IQN). The **Format** option is not available as formatting is handled by the guests. It is not advised to edit the **Target Path**. The default target path value, **`/dev/disk/by-path/`**, adds the drive path to that directory. The target path should be the same on all hosts for migration.

   Enter the hostname or IP address of the iSCSI target. This example uses **`server1.example.com`**.

   Enter the source path, the IQN for the iSCSI target. This example uses **`iqn.2010-05.com.example.server1:trial1`**.



   Press **Finish** to create the new storage pool.

26.1.5.3. Creating an iSCSI-based storage pool with virsh

1. **Create the storage pool definition**
   The example below is an XML definition file for a iSCSI-based storage pool.

   <name>trial1</name>
   : The **name** element sets the name for the storage pool. The name is required and must be unique.

   <uuid>afcc5367-6770-e151-bcb3-847bc36c5e28</uuid>
   : The optional **`uuid`** element provides a unique global identifier for the storage pool. The **`uuid`** element can contain any valid UUID or an existing UUID for the storage device. If a UUID is not provided, **`virsh`** will generate a UUID for the storage pool.

   <host name='server1.example.com'/>
   : The **`host`** element with the *name* attribute specifies the hostname of the iSCSI server. The **`host`** element attribute can contain a *`port`* attribute for a non-standard iSCSI protocol port number.

<device path='*iqn.2010-05.com.example.server1:trial1*'/>
The **device** element *path* attribute must contain the IQN for the iSCSI server.

With a text editor, create an XML file for the iSCSI storage pool. This example uses a XML definition named **trial1.xml**.

```
<pool type='iscsi'>
  <name>trial1</name>
  <uuid>afcc5367-6770-e151-bcb3-847bc36c5e28</uuid>
  <source>
    <host name='server1.example.com'/>
    <device path='iqn.2010-05.com.example.server1:trial1'/>
  </source>
  <target>
    <path>/dev/disk/by-path</path>
   </target>
</pool>
```

Use the **pool-define** command to define the storage pool but not start it.

```
# virsh pool-define trial1.xml
Pool trial1 defined
```

2. **Alternative step: Use pool-define-as to define the pool from the command line**
Storage pool definitions can be created with the **virsh** command line tool. Creating storage pools with **virsh** is useful for systems administrators using scripts to create multiple storage pools.

The **virsh pool-define-as** command has several parameters which are accepted in the following format:

```
virsh pool-define-as name type source-host source-path source-dev source-name target
```

The type, *iscsi*, defines this pool as an iSCSI based storage pool. The *name* parameter must be unique and sets the name for the storage pool. The *source-host* and *source-path* parameters are the hostname and iSCSI IQN respectively. The *source-dev* and *source-name* parameters are not required for iSCSI-based pools, use a **-** character to leave the field blank. The *target* parameter defines the location for mounting the iSCSI device on the host.

The example below creates the same iSCSI-based storage pool as the previous step.

```
# virsh pool-define-as trial1 iscsi server1.example.com
 iqn.2010-05.com.example.server1:trial1 - - /dev/disk/by-path
Pool trial1 defined
```

3. **Verify the storage pool is listed**
Verify the storage pool object is created correctly and the state reports as **inactive**.

```
# virsh pool-list --all
Name                 State      Autostart
-----------------------------------------
default              active     yes
trial1               inactive   no
```

4. **Start the storage pool**
   Use the virsh command **`pool-start`** for this. **`pool-start`** enables a directory storage pool, allowing it to be used for volumes and guests.

```
# virsh pool-start guest_images_disk
Pool guest_images_disk started
# virsh pool-list --all
Name                 State      Autostart
-----------------------------------------
default              active     yes
trial1               active     no
```

5. **Turn on autostart**
   Turn on *`autostart`* for the storage pool. Autostart configures the `libvirtd` service to start the storage pool when the service starts.

```
# virsh pool-autostart trial1
Pool trial1 marked as autostarted
```

   Verify that the *`trial1`* pool has autostart set:

```
# virsh pool-list --all
Name                 State      Autostart
-----------------------------------------
default              active     yes
trial1               active     yes
```

6. **Verify the storage pool configuration**
   Verify the storage pool was created correctly, the sizes reported correctly, and the state reports as **`running`**.

```
# virsh pool-info trial1
Name:            trial1
UUID:            afcc5367-6770-e151-bcb3-847bc36c5e28
State:           running
Persistent:      unknown
Autostart:       yes
Capacity:        100.31 GB
Allocation:      0.00
Available:       100.31 GB
```

An iSCSI-based storage pool is now available.

26.1.6. NFS-based storage pools

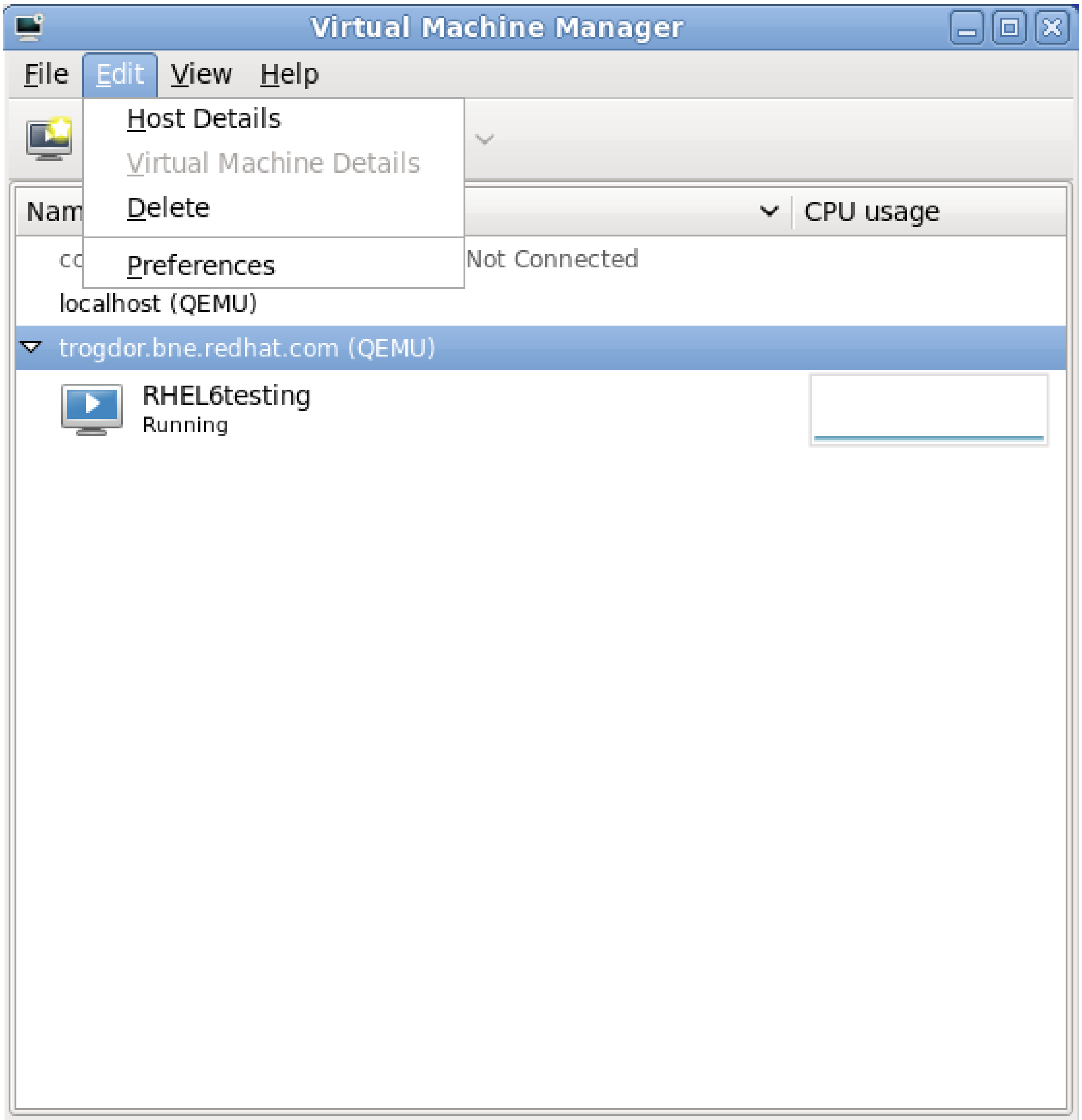
This procedure covers creating a storage pool with a NFS mount point in **`virt-manager`**.

26.1.6.1. Creating a NFS-based storage pool with virt-manager

1. **Open the host storage tab**
   Open the **Storage** tab in the **Host Details** window.

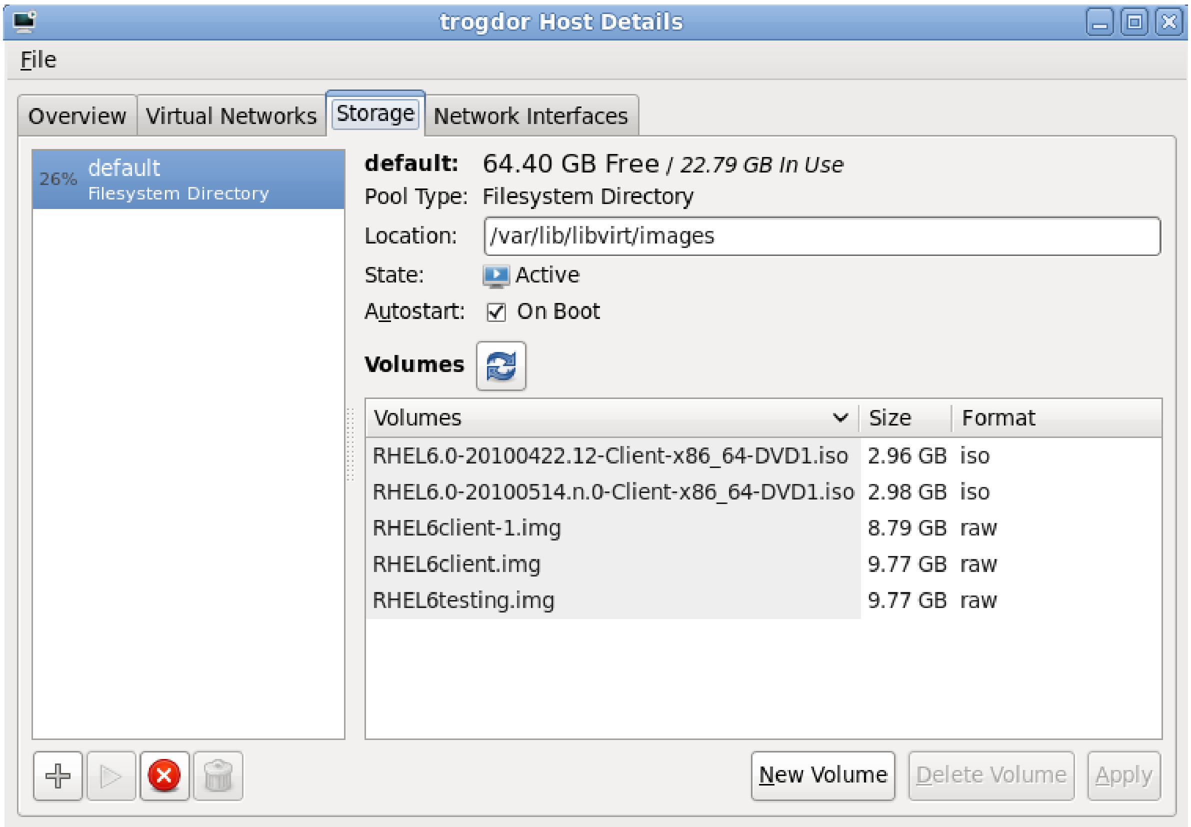
   a. Open **`virt-manager`**.

   b. Select a host from the main **`virt-manager`** window.

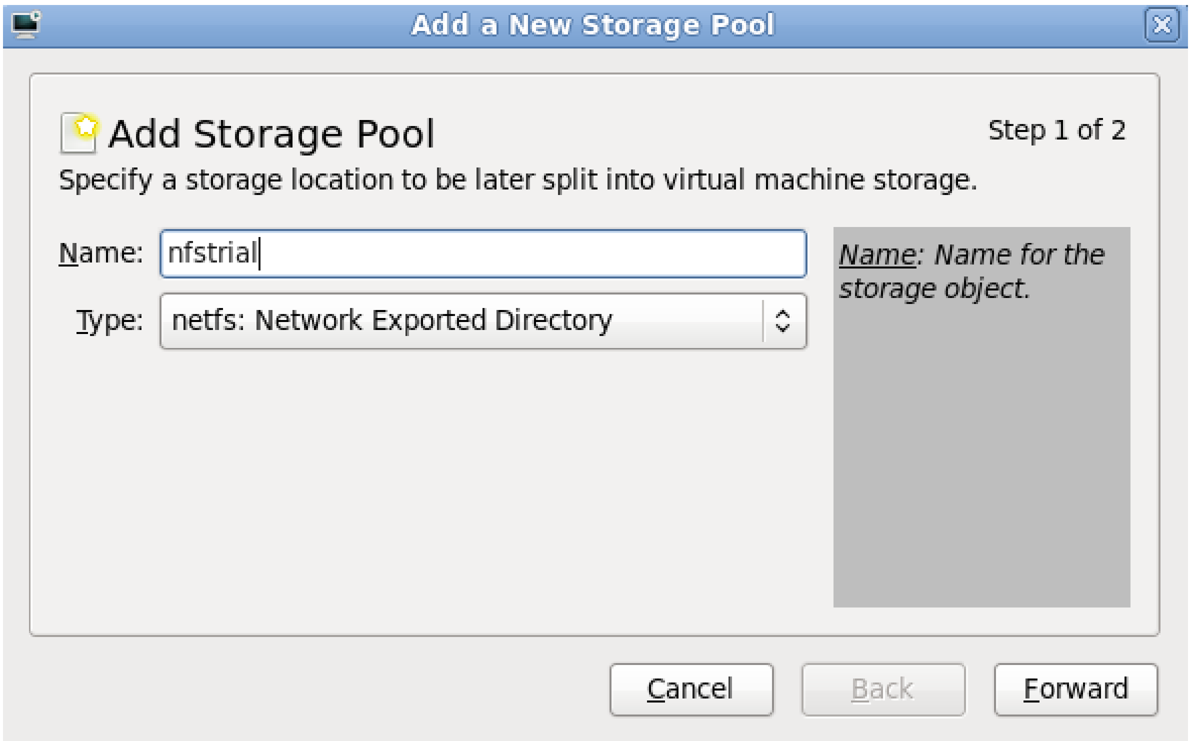


c. Open the Edit menu and select Host Details.

d. Click on the Storage tab of the Host Details window.



2. **Create a new pool (part 1)**
   Press the **+** button (the add pool button). The **Add a New Storage Pool** wizard appears.

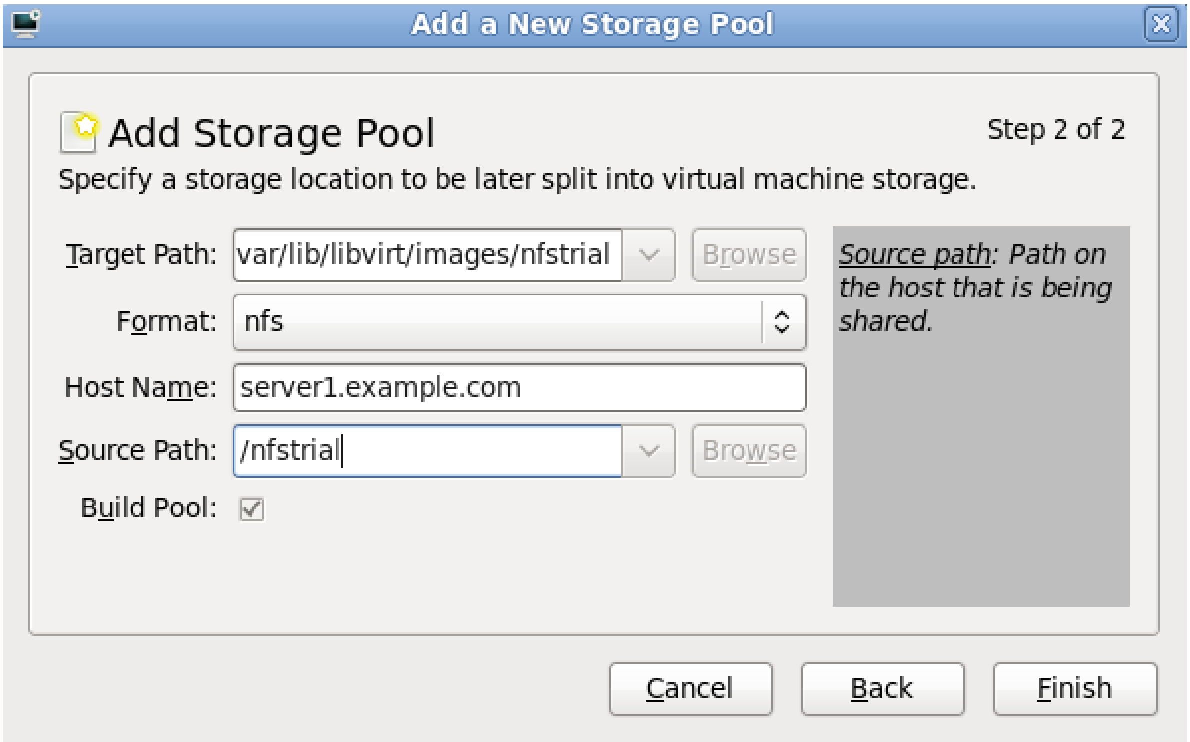


   Choose a name for the storage pool and press **Forward** to continue.

3. **Create a new pool (part 2)**
   Enter the target path for the device, the hostname and the NFS share path. Set the **Format** option to **NFS** or **auto** (to detect the type). The target path must be identical on all hosts for migration.

   Enter the hostname or IP address of the NFS server. This example uses **`server1.example.com`**.

   Enter the NFS path. This example uses **`/nfstrial`**.



   Press **Finish** to create the new storage pool.

Volumes

27.1. Creating volumes

This section shows how to create disk volumes inside a block based storage pool.

```
# virsh vol-create-as guest_images_disk volume1 8G
Vol volume1 created

# virsh vol-create-as guest_images_disk volume2 8G
Vol volume2 created

# virsh vol-create-as guest_images_disk volume3 8G
Vol volume3 created

# virsh vol-list guest_images_disk
Name                 Path
-----------------------------------------
volume1              /dev/sdb1
volume2              /dev/sdb2
volume3              /dev/sdb3

# parted -s /dev/sdb print
Model: ATA ST3500418AS (scsi)
Disk /dev/sdb: 500GB
Sector size (logical/physical): 512B/512B
Partition Table: gpt

Number  Start   End     Size    File system  Name     Flags
2      17.4kB  8590MB  8590MB               primary
3      8590MB  17.2GB  8590MB               primary
1      21.5GB  30.1GB  8590MB               primary

#
```

27.2. Cloning volumes

The new volume will be allocated from storage in the same storage pool as the volume being cloned.

```
# virsh vol-clone --pool guest_images_disk volume3 clone1
Vol clone1 cloned from volume3

# virsh vol-list guest_images_disk
Name                 Path
-----------------------------------------
clone1               /dev/sdb1
volume2              /dev/sdb2
volume3              /dev/sdb3

# parted -s /dev/sdb print
Model: ATA ST3500418AS (scsi)
Disk /dev/sdb: 500GB
Sector size (logical/physical): 512B/512B
Partition Table: gpt

Number  Start   End     Size    File system  Name     Flags
2      8590MB  17.2GB  8590MB               primary
3      17.2GB  25.8GB  8590MB               primary
1      25.8GB  34.4GB  8590MB               primary

#
```

27.3. Adding storage devices to guests

This section covers adding storage devices to a virtualized guest. Additional storage can only be added after guests are created.

27.3.1. Adding file based storage to a guest

File-based storage or file-based containers are files on the hosts file system which act as virtualized hard drives for virtualized guests. To add a file-based container perform the following steps:

1. Create an empty container file or using an existing file container (such as an ISO file).

   a. Create a sparse file using the **dd** command. Sparse files are not recommended due to data integrity and performance issues. Sparse files are created much faster and can used for testing but should not be used in production environments.

   ```
   # dd if=/dev/zero of=/var/lib/libvirt/images/FileName.img bs=1M seek=4096 count=0
   ```

   b. Non-sparse, pre-allocated files are recommended for file-based storage images. Create a non-sparse file, execute:

   ```
   # dd if=/dev/zero of=/var/lib/libvirt/images/FileName.img bs=1M count=4096
   ```

   Both commands create a 4GB file which can be used as additional storage for a virtualized guest.

2. Dump the configuration for the guest. In this example the guest is called *`Guest1`* and the file is saved in the users home directory.

   ```
   # virsh dumpxml Guest1 > ~/Guest1.xml
   ```

3. Open the configuration file (*`Guest1.xml`* in this example) in a text editor. Find the **`<disk>`** elements, these elements describe storage devices. The following is an example disk element:

   ```
   <disk type='file' device='disk'>
        <driver name='virtio' cache='none'/>
       <source file='/var/lib/libvirt/images/Guest1.img'/>
       <target dev='sda' />
   </disk>
   ```

4. Add the additional storage by duplicating or writing a new **`<disk>`** element. Ensure you specify a device name for the virtual block device attributes. These attributes must be unique for each guest configuration file. The following example is a configuration file section which contains an additional file-based storage container named **`FileName.img`**.

   ```
   <disk type='file' device='disk'>
       <driver name='virtio' cache='none'/>
       <source file='/var/lib/libvirt/images/Guest1.img'/>
       <target dev='sda' />
   </disk>
   <disk type='block' device='disk'>
        <driver name='qemu' type='raw' cache='none'/>
       <source dev='/var/lib/libvirt/images/FileName.img'/>
       <target dev='vdb' bus='virtio'/>
   </disk>
   ```

5. Start the guest from the updated configuration file.

```
# virsh start Guest1.xml
```

6. The following steps are Linux guest specific. Other operating systems handle new storage devices in different ways. For other systems, refer to that operating system's documentation

   The guest now uses the file **`FileName.img`** as the device called **`/dev/sdb`**. This device requires formatting from the guest. On the guest, partition the device into one primary partition for the entire device then format the device.

   a. Press *n* for a new partition.

   ```
   # fdisk /dev/sdb
   Command (m for help):
   ```

   b. Press *p* for a primary partition.

   ```
   Command action
   e   extended
   p   primary partition (1-4)
   ```

   c. Choose an available partition number. In this example the first partition is chosen by entering *`1`*.

   ```
   Partition number (1-4): 1
   ```

   d. Enter the default first cylinder by pressing *`Enter`*.

   ```
   First cylinder (1-400, default 1):
   ```

   e. Select the size of the partition. In this example the entire disk is allocated by pressing *`Enter`*.

   ```
   Last cylinder or +size or +sizeM or +sizeK (2-400, default 400):
   ```

   f. Set the type of partition by pressing *`t`*.

   ```
   Command (m for help): t
   ```

   g. Choose the partition you created in the previous steps. In this example, the partition number is *`1`*.

   ```
   Partition number (1-4): 1
   ```

   h. Enter *83* for a linux partition.

   ```
   Hex code (type L to list codes): 83
   ```

   i. write changes to disk and quit.

   ```
   Command (m for help): w
   ```

```
Command (m for help): q
```

j. Format the new partition with the `ext3` file system.

```
# mke2fs -j /dev/sdb1
```

7. Mount the disk on the guest.

```
# mount /dev/sdb1 /myfiles
```

The guest now has an additional virtualized file-based storage device.

27.3.2. Adding hard drives and other block devices to a guest

System administrators use additional hard drives to provide increased storage space for a guest, or to separate system data from user data.

Procedure 27.1. Adding physical block devices to virtualized guests

This procedure describes how to add a hard drive on the host to a virtualized guest. It applies to all physical block devices, including CD-ROM, DVD and floppy devices.

1. Physically attach the hard disk device to the host. Configure the host if the drive is not accessible by default.

2. Configure the device with **`multipath`** and persistence on the host if required.

3. Use the **`virsh attach`** command as below, replacing:

   ```
   # virsh attach-disk myguest /dev/sdb1 sdc --driver tap --mode readonly
   ```

   - *`myguest`* with the name of the guest.
   - *`/dev/sdb1`* with the device on the host to add.
   - *`sdc`* with the location on the guest where the device should be added. It must be an unused device name.

     Use the *`sd*`* notation for Windows guests as well, the guest will recognize the device correctly.

   - Only include the `--`*`mode readonly`* parameter if the device should be read only to the guest.

   Additionally, there are optional arguments that may be added:

   - Append the `--`*`type hdd`* parameter to the command for CD-ROM or DVD devices.
   - Append the `--`*`type floppy`* parameter to the command for floppy devices.

4. The guest now has a new hard disk device called **`/dev/sdb`** on Linux or **`D: drive`**, or similar, on Windows. This device may require formatting.

Block device security - disk labels

The host should not use disk labels to identify file systems in the **`fstab`** file, the **`initrd`** file or on the kernel command line. Doing so presents a security risk if less privileged users, such as virtualized guests, have write access to whole partitions or LVM volumes.

A virtualized guest could write a disk label belonging to the host, to its own block device storage. Upon reboot of the host, the host could then mistakenly use the virtualized guests disk as a system disk, compromising the host system.

Block device security - whole disk access

Guests should not be given write access to whole disks or block devices (for example, **`/dev/sdb`**). Virtualized guests with access to block devices may be able to access other block devices on the system or modify volume labels which can be used to compromise the host system. Use partitions (for example, **`/dev/sdb1`**) or LVM volumes to prevent this issue.

27.4. Deleting and removing volumes

This section shows how to delete a disk volume from a block based storage pool.

```
# virsh vol-delete --pool guest_images_disk volume1
Vol volume1 deleted

# virsh vol-list guest_images_disk
Name                 Path
-----------------------------------------
volume2              /dev/sdb2
volume3              /dev/sdb3

# parted -s /dev/sdb print
Model: ATA ST3500418AS (scsi)
Disk /dev/sdb: 500GB
Sector size (logical/physical): 512B/512B
Partition Table: gpt

Number  Start   End     Size    File system  Name     Flags
2       8590MB  17.2GB  8590MB               primary
3       17.2GB  25.8GB  8590MB               primary

#
```

Miscellaneous storage topics

28.1. Creating a virtualized floppy disk controller

Floppy disk controllers are required for a number of older operating systems, especially for installing drivers. Presently, physical floppy disk devices cannot be accessed from virtualized guests. However, creating and accessing floppy disk images from virtualized floppy drives should work. This section covers creating a virtualized floppy device.

An image file of a floppy disk is required. Create floppy disk image files with the **dd** command. Replace **/dev/fd0** with the name of a floppy device and name the disk appropriately.

```
# dd if=/dev/fd0 of=~/legacydrivers.img
```

This example uses a guest created with **virt-manager** running a fully virtualized Fedora installation with an image located in **/var/lib/libvirt/images/Fedora.img**.

1. Create the XML configuration file for your guest image using the **virsh** command on a running guest.

   ```
   # virsh dumpxml Fedora > Fedora.xml
   ```

   This saves the configuration settings as an XML file which can be edited to customize the operations and devices used by the guest. For more information on using the virsh XML configuration files, refer to *Chapter 35, Creating custom libvirt scripts*.

2. Create a floppy disk image for the guest.

   ```
   # dd if=/dev/zero of=/var/lib/libvirt/images/Fedora-floppy.img bs=512 count=2880
   ```

3. Add the content below, changing where appropriate, to your guest's configuration XML file. This example is an emulated floppy device using a file-based image.

   ```
   <disk type='file' device='floppy'>
    <source file='/var/lib/libvirt/images/Fedora-floppy.img'/>
    <target dev='fda'/>
   </disk>
   ```

4. Force the guest to stop. To shut down the guest gracefully, use the **virsh shutdown** command instead.

   ```
   # virsh destroy Fedora
   ```

5. Restart the guest using the XML configuration file.

   ```
   # virsh create Fedora.xml
   ```

The floppy device is now available in the guest and stored as an image file on the host.

28.2. Configuring persistent storage in Red Hat Enterprise Linux 6

This section is for systems with external or networked storage; for example, Fibre Channel, iSCSI, or SRP based storage devices. It is recommended that those systems have persistent device names configured for your hosts. This assists live migration as well as providing consistent device names and storage for multiple virtualized systems.

Universally Unique Identifiers (UUIDs) are a standardized method for identifying computers and devices in distributed computing environments. This section uses UUIDs to identify iSCSI, SRP, or Fibre Channel LUNs. UUIDs persist after restarts, disconnection and device swaps. The UUID is similar to a label on the device.

Systems which are not running **multipath** must use *Single path configuration*. Systems running **multipath** can use *Multiple path configuration*.

Single path configuration

This procedure implements LUN device persistence using **udev**. Only use this procedure for hosts which are not using **multipath**.

1. Edit the **/etc/scsi_id.config** file.

   - Add the following line:

     ```
     options=--whitelisted --replace-whitespace
     ```

     This sets the default options for scsi_id, ensuring returned UUIDs contains no spaces. The IET iSCSI target otherwise returns spaces in UUIDs, which can cause problems.

2. To display the UUID for a given device run the **scsi_id --whitelisted --replace-whitespace --device=/dev/sd*** command. For example:

   ```
   # scsi_id --whitelisted --replace-whitespace --device=/dev/sdc
   1IET_00010001
   ```

   The output may vary from the example above. The output in this example displays the UUID of the device `/dev/sdc`.

3. Verify the UUID output from the **scsi_id --whitelisted --replace-whitespace --device=/dev/sd*** command is correct and as expected.

4. Create a rule to name the device. Create a file named **20-names.rules** in the **/etc/udev/rules.d** directory. Add new rules to this file. All rules are added to the same file using the same format. Rules follow this format:

   ```
   KERNEL=="sd*", SUBSYSTEM=="block", PROGRAM="/sbin/scsi_id --whitelisted --replace-
   whitespace /dev/$name", RESULT=="UUID", NAME="devicename"
   ```

   Replace *UUID* and *devicename* with the UUID retrieved above, and a name for the device. This is an example for the rule above for three example iSCSI luns:

   ```
   KERNEL=="sd*", SUBSYSTEM=="block", PROGRAM="/sbin/scsi_id --whitelisted --replace-
   whitespace /dev/$name", RESULT=="1IET_00010001", NAME="rack4row16lun1"
   KERNEL=="sd*", SUBSYSTEM=="block", PROGRAM="/sbin/scsi_id --whitelisted --replace-
   whitespace /dev/$name", RESULT=="1IET_00010002", NAME="rack4row16lun2"
   ```

```
KERNEL=="sd*", SUBSYSTEM=="block", PROGRAM="/sbin/scsi_id --whitelisted --replace-
whitespace /dev/$name", RESULT=="1IET_00010003", NAME="rack4row16lun3"
```

The **udev** daemon now searches all devices named **/dev/sd*** for a matching UUID in the rules. When a matching device is connected to the system the device is assigned the name from the rule. For example:

```
# ls -la /dev/rack4row16*
brw-rw---- 1 root disk 8, 18 May 25 23:35 /dev/rack4row16lun1
brw-rw---- 1 root disk 8, 34 May 25 23:35 /dev/rack4row16lun2
brw-rw---- 1 root disk 8, 50 May 25 23:35 /dev/rack4row16lun3
```

5. Copy the changes in **/etc/scsi_id.config** and **/etc/udev/rules.d/20-names.rules** to all relevant hosts.

Networked storage devices with configured rules now have persistent names on all hosts where the files were updated This means you can migrate guests between hosts using the shared storage and the guests can access the storage devices in their configuration files.

Multiple path configuration

The **multipath** package is used for systems with more than one physical path from the computer to storage devices. **multipath** provides fault tolerance, fail-over and enhanced performance for network storage devices attached to Red Hat Enterprise Linux 6 systems.

Implementing LUN persistence in a **multipath** environment requires defined alias names for your multipath devices. Each storage device has a UUID, also known as a *World Wide Identifier* or *WWID*, which acts as a key for the aliased names.

This procedure implements LUN device persistence using the **multipath** daemon.

1. Determine the World Wide Identifier of each device using the **scsi_id --whitelisted --replace-whitespace --device=/dev/sd*** command:

```
# scsi_id --whitelisted --replace-whitespace --device=/dev/sde
1IET_00010004
# scsi_id --whitelisted --replace-whitespace --device=/dev/sdf
1IET_00010005
# scsi_id --whitelisted --replace-whitespace --device=/dev/sdg
1IET_00010006
# scsi_id --whitelisted --replace-whitespace --device=/dev/sdh
1IET_00010007
```

2. Create the multipath configuration file, **/etc/multipath.conf**. In it create a **defaults** section, and disable the **user_friendly_names** option unless you have a specific need for it. It is also a good idea to configure the default arguments for the **getuid_callout** option. This is generally a useful start:

```
defaults {
 user_friendly_names no
 getuid_callout      "/sbin/scsi_id --whitelisted --replace-whitespace --device=/dev/%n"
}
```

3. Below the **defaults** section add a **multipaths** section (note the plural spelling). In this section add each of the WWIDs identified from the **scsi_id** command above. For example:

```
multipaths {
```

```
 multipath {
  wwid   1IET_00010004
  alias   oramp1
 }

 multipath {
  wwid   1IET_00010005
  alias   oramp2
 }

 multipath {
  wwid   1IET_00010006
  alias   oramp3
 }

 multipath {
  wwid   1IET_00010007
  alias   oramp4
 }
}
```

Multipath devices are created in the **/dev/mapper** directory. The above example will create 4 LUNs named **/dev/mapper/oramp1**, **/dev/mapper/oramp2**, **/dev/mapper/oramp3** and **/dev/mapper/oramp4**.

4. Enable the **multipathd** daemon to start at system boot.

```
# chkconfig multipathd on
# chkconfig --list multipathd
multipathd      0:off 1:off 2:on 3:on 4:on 5:on 6:off
```

5. The mapping of these device WWIDs to their alias names will now persist across reboots. For example:

```
# ls -la /dev/mapper/oramp*
brw-rw---- 1 root disk 253, 6 May 26 00:17 /dev/mapper/oramp1
brw-rw---- 1 root disk 253, 7 May 26 00:17 /dev/mapper/oramp2
brw-rw---- 1 root disk 253, 8 May 26 00:17 /dev/mapper/oramp3
brw-rw---- 1 root disk 253, 9 May 26 00:17 /dev/mapper/oramp4
# multipath -ll
oramp1 (1IET_00010004) dm-6 IET,VIRTUAL-DISK
size=20.0G features='0' hwhandler='0' wp=rw
|-+- policy='round-robin 0' prio=1 status=active
| `- 8:0:0:4  sde  8:64   active ready running
`-+- policy='round-robin 0' prio=1 status=enabled
  `- 9:0:0:4  sdbl 67:240 active ready running
oramp3 (1IET_00010006) dm-8 IET,VIRTUAL-DISK
size=20.0G features='0' hwhandler='0' wp=rw
|-+- policy='round-robin 0' prio=1 status=active
| `- 8:0:0:6  sdg  8:96   active ready running
`-+- policy='round-robin 0' prio=1 status=enabled
  `- 9:0:0:6  sdbn 68:16  active ready running
oramp2 (1IET_00010005) dm-7 IET,VIRTUAL-DISK
size=20.0G features='0' hwhandler='0' wp=rw
|-+- policy='round-robin 0' prio=1 status=active
| `- 8:0:0:5  sdf  8:80   active ready running
`-+- policy='round-robin 0' prio=1 status=enabled
  `- 9:0:0:5  sdbm 68:0   active ready running
oramp4 (1IET_00010007) dm-9 IET,VIRTUAL-DISK
size=20.0G features='0' hwhandler='0' wp=rw
|-+- policy='round-robin 0' prio=1 status=active
| `- 8:0:0:7  sdh  8:112  active ready running
`-+- policy='round-robin 0' prio=1 status=enabled
```

```
  `- 9:0:0:7  sdbo 68:32  active ready running
```

28.3. Accessing data from a guest disk image

There are various methods for accessing the data from guest image files. One common method is to use the **kpartx** tool, covered by this section, to mount the guest file system as a loop device which can then be accessed.

The **kpartx** command creates device maps from partition tables. Each guest storage image has a partition table embedded in the file.

The *libguestfs* and *guestfish* packages allow advanced modification and access to guest file systems. The *libguestfs* and *guestfish* packages are not covered in this section at this time.

Note

kpartx works only for disk images in raw format.

Warning

Guests must be offline before their files can be read. Editing or reading files of an active guest is not possible and may cause data loss or damage.

Procedure 28.1. Accessing guest image data

1. Install the *kpartx* package.

```
# yum install kpartx
```

2. Use kpartx to list partition device mappings attached to a file-based storage image. This example uses a image file named *guest1.img*.

```
# kpartx -l /var/lib/libvirt/images/guest1.img
loop0p1 : 0 409600 /dev/loop0 63
loop0p2 : 0 10064717 /dev/loop0 409663
```

guest1 is a Linux guest. The first partition is the boot partition and the second partition is an EXT3 containing the root partition.

3. Add the partition mappings to the recognized devices in **/dev/mapper/**.

```
# kpartx -a /var/lib/libvirt/images/guest1.img
```

- Test that the partition mapping worked. There should be new devices in the /dev/mapper/ directory

```
# ls /dev/mapper/
loop0p1
loop0p2
```

The mappings for the image are named in the format **loopXpY**.

4. Mount the loop device which to a directory. If required, create the directory. This example uses **/mnt/guest1** for mounting the partition.

```
# mkdir /mnt/guest1
# mount /dev/mapper/loop0p1 /mnt/guest1 -o loop,ro
```

5. The files are now available for reading in the **/mnt/guest1** directory. Read or copy the files.

6. Unmount the device so the guest image can be reused by the guest. If the device is mounted the guest cannot access the image and therefore cannot start.

```
# umount /mnt/guest1
```

7. Disconnect the image file from the partition mappings.

```
# kpartx -d /var/lib/libvirt/images/guest1.img
```

The guest can now be restarted.

Accessing data from guest LVM volumes

Many Linux guests use Logical Volume Management (LVM) volumes. Additional steps are required to read data on LVM volumes on virtual storage images.

1. Add the partition mappings for the *guest1.img* to the recognized devices in the **/dev/mapper/** directory.

```
# kpartx -a /var/lib/libvirt/images/guest1.img
```

2. In this example the LVM volumes are on a second partition. The volumes require a rescan with the **vgscan** command to find the new volume groups.

```
# vgscan
Reading all physical volumes . This may take a while...
Found volume group "VolGroup00" using metadata type lvm2
```

3. Activate the volume group on the partition (called **VolGroup00** by default) with the **vgchange -ay** command.

```
# vgchange -ay VolGroup00
2 logical volumes in volume group VolGroup00 now active.
```

4. Use the **lvs** command to display information about the new volumes. The volume names (the **LV** column) are required to mount the volumes.

```
# lvs
LV VG Attr Lsize Origin Snap% Move Log Copy%
LogVol00 VolGroup00 -wi-a- 5.06G
LogVol01 VolGroup00 -wi-a- 800.00M
```

5. Mount **/dev/VolGroup00/LogVol00** in the **/mnt/guestboot/** directory.

```
# mount /dev/VolGroup00/LogVol00 /mnt/guestboot
```

6. The files are now available for reading in the **`/mnt/guestboot`** directory. Read or copy the files.

7. Unmount the device so the guest image can be reused by the guest. If the device is mounted the guest cannot access the image and therefore cannot start.

```
# umount /mnt/guestboot
```

8. Disconnect the volume group *`VolGroup00`*

```
# vgchange -an VolGroup00
```

9. Disconnect the image file from the partition mappings.

```
# kpartx -d /var/lib/libvirt/images/guest1.img
```

The guest can now be restarted.

N_Port ID Virtualization (NPIV)

N_Port ID Virtualization (NPIV) is a function available with some Fibre Channel devices. NPIV shares a single physical N_Port as multiple N_Port IDs. NPIV provides similar functionality for Host Bus Adaptors (HBAs) that SR-IOV provides for network interfaces. With NPIV, virtualized guests can be provided with a virtual Fibre Channel initiator to Storage Area Networks (SANs).

N_Ports are addressed with a 24 bit N_Port ID, which is assigned by the Fibre Channel switch.

Why use NPIV

- Without NPIV virtualized guests must share an HBA's WWN on the SAN. With NPIV, it is possible to use LUN masking and zoning for virtualized guest.
- With NPIV migration with zones and LUN masking is possible.
- Physical HBAs are expensive and use an expansion slot. With NPIV, more guests can access SAN resources and guest density can be increased.

Each N_Port has a unique identity (port WWN and node WWN) on the SAN and can be used for zoning and LUN masking. Soft zoning, which you can use to group ports together by port WWN, is the preferred method of zoning.

29.1. Enabling NPIV on the switch

Enabling the NPIV on a Fibre Channel port on a switch

```
admin> portcfgshow 0
......
NPIV capability                   ON
......
Usage
portCfgNPIVPort <PortNumber> <Mode>
Mode      Meaning
0             Disable the NPIV capability on the port
1             Enable the NPIV capability on the port
```

Example:

```
admin> portCfgNPIVPort 0 1
```

29.1.1. Identifying HBAs in a Host System

To determine the types of HBAs in the system, enter the following command:

```
# ls /proc/scsi
QLogic HBAs are listed as qla2xxx. Emulex HBAs are listed as lpfc.
```

QLogic Example

```
# ls /proc/scsi/qla2xxx
```

Emulex Example

```

# ls /proc/scsi/lpfc
```

29.1.2. Verify NPIV is used on the HBA

Output the data from the kernel on the port nodes of the HBA.

Example 29.1. QLogic controller example

```
# cat /proc/scsi/qla2xxx/7
FC Port Information for Virtual Ports:
Virtual Port index = 1
Virtual Port 1:VP State = <ACTIVE>, Vp Flags = 0x0
scsiqla2port3=500601609020fd54:500601601020fd54:a00000:1000: 1;
scsiqla2port4=500601609020fd54:500601681020fd54:a10000:1000: 1;
Virtual Port 1 SCSI LUN Information:
( 0:10): Total reqs 10, Pending reqs 0, flags 0x0, 2:0:1000,
```

Example 29.2. Emulex controller example

```
# cat /proc/scsi/lpfc/3
SLI Rev: 3
NPIV Supported: VPIs max 127 VPIs used 1
RPIs max 512 RPIs used 13
Vports list on this physical port:
Vport DID 0x2f0901, vpi 1, state 0x20
Portname: 48:19:00:0c:29:00:00:0d Nodename: 48:19:00:0c:29:00:00:0b
```

29.1.2.1. Create and destroy a virtual HBA with NPIV

Issue an NPIV create call. Confirm that the host has started a new virtual HBA and that any storage zones are usable.

To create virtual HBAs using **libvirt**, you require a NPIV capable HBA and switch.

Confirm that you have those by manually creating a new HBA by printing the contents of the **/sys/*class*/*fc_host*/hostN** directory where *class* is the type of adaptor and *fc_host* is the host number.

Note that the WWN used below are for demonstrative purposes only. Use WWN customized for your SAN environment.

Add a new virtual HBA with the following command where '*1111222233334444:5555666677778888*' is **WWPN:WWNN** and *host5* is the physical HBA which the virtual HBA is a client of.

```
# echo '1111222233334444:5555666677778888' > /sys/class/fc_host/host5/vport_create
```

If the creation is successful, a new HBA in the system with the next available host number.

Note

The virtual HBAs can be destroyed with the following command:

```
# echo '1111222233334444:5555666677778888' > /sys/class/fc_host/host5/vport_delete
```

Adding the virtual HBA with virsh

This procedure covers creating virtual HBA devices on a host with **virsh**. This procedure requires a compatible HBA device.

1. **List available HBAs**

   Find the node device name of the HBA with the virtual adapters. List of all the HBAs on the host with the following command:

```
# virsh nodedev-list -TODO-cap=scsi_host
pci_10df_fe00_0_scsi_host
pci_10df_fe00_0_scsi_host_0
pci_10df_fe00_scsi_host
pci_10df_fe00_scsi_host_0
pci_10df_fe00_scsi_host_0_scsi_host
pci_10df_fe00_scsi_host_0_scsi_host_0
```

2. **Gather parent HBA device data**

   Output the XML definition for each required HBA. This example uses the HBA, **pci_10df_fe00_scsi_host**.

```
# virsh nodedev-dumpxml pci_10df_fe00_scsi_host
<device>
  <name>pci_10df_fe00_scsi_host</name>
  <parent>pci_10df_fe00</parent>
  <capability type='scsi_host'>
    <host>5</host>
    <capability type='fc_host'>
      <wwnn>20000000c9848140</wwnn>
      <wwpn>10000000c9848140</wwpn>
    </capability>
    <capability type='vport_ops' />
  </capability>
</device>
```

   HBAs capable of creating virtual HBAs have a capability **type='vport_ops'** in the XML definition.

3. **Create the XML definition for the virtual HBA**

   With information gathered in the previous step, create an XML definition for the virtual HBA. This example uses a file named **newHBA.xml**.

```
<device>
  <parent>pci_10df_fe00_0_scsi_host</parent>
  <capability type='scsi_host'>
    <capability type='fc_host'>
      <wwpn>1111222233334444</wwpn>
      <wwnn>5555666677778888</wwnn>
    </capability>
  </capability>
</device>
```

   The **<parent>** element is the name of the parent HBA listed by the **virsh nodedev-list** command. The **<wwpn>** and **<wwnn>** elements are the WWNN and WWPN for the virtual HBA.

WWNN and WWPN validation

Libvirt does not validate the WWPN or WWNN values, invalid WWNs are rejected by the kernel and libvirt reports the failure. The error reported by the kernel is similar to the following:

```
# virsh nodedev-create badwwn.xml
error: Failed to create node device from badwwn.xml
error: Write of '1111222233334444:5555666677778888' to '/sys/class/fc_host/host6/
vport_create' during vport create/delete failed: No such file or directory
```

4. **Create the virtual HBA**
   Create the virtual HBA with the **`virsh nodedev-create`** command using the file from the previous step.

   ```
   # virsh nodedev-create newHBA.xml
   Node device pci_10df_fe00_0_scsi_host_0_scsi_host created from newHBA.xml
   ```

   The new virtual HBA should be detected and available to the host. The create command output gives you the node device name of the newly created device.

Destroying a virtual HBA with virsh

To destroy the device, use **`virsh nodedev-destroy`**:

```
# virsh nodedev-destroy pci_10df_fe00_0_scsi_host_0_scsi_host
Destroyed node device 'pci_10df_fe00_0_scsi_host_0_scsi_host'
```

Part VI. Host virtualization tools

Virtualization commands, system tools, applications and additional systems reference

These chapters provide detailed descriptions of virtualization commands, system tools, and applications included in Red Hat Enterprise Linux 6. These chapters are designed for users requiring information on advanced functionality and other features.

Managing guests with virsh

virsh is a command line interface tool for managing guests and the hypervisor.

The **virsh** command-line tool is built on the **libvirt** management API and operates as an alternative to the **qemu-kvm** command and the graphical **virt-manager** application. The **virsh** command can be used in read-only mode by unprivileged users or, with root access, full administration functionality. The **virsh** command is ideal for scripting virtualization administration.

virsh command quick reference

The following tables provide a quick reference for all virsh command line options.

Table 30.1. Guest management commands

Command	Description
help	Prints basic help information.
list	Lists all guests.
dumpxml	Outputs the XML configuration file for the guest.
create	Creates a guest from an XML configuration file and starts the new guest.
start	Starts an inactive guest.
destroy	Forces a guest to stop.
define	Creates a guest from an XML configuration file without starting the new guest.
domid	Displays the guest's ID.
domuuid	Displays the guest's UUID.
dominfo	Displays guest information.
domname	Displays the guest's name.
domstate	Displays the state of a guest.
quit	Quits the interactive terminal.
reboot	Reboots a guest.
restore	Restores a previously saved guest stored in a file.
resume	Resumes a paused guest.
save	Save the present state of a guest to a file.
shutdown	Gracefully shuts down a guest.
suspend	Pauses a guest.
undefine	Deletes all files associated with a guest.
migrate	Migrates a guest to another host.

The following **virsh** command options manage guest and hypervisor resources:

Table 30.2. Resource management options

Command	Description
setmem	Sets the allocated memory for a guest. Refer to the **virsh** manpage for more details.

Command	Description
setmaxmem	Sets maximum memory limit for the hypervisor. Refer to the **virsh** manpage for more details.
setvcpus	Changes number of virtual CPUs assigned to a guest. Refer to the **virsh** manpage for more details.
vcpuinfo	Displays virtual CPU information about a guest.
vcpupin	Controls the virtual CPU affinity of a guest.
domblkstat	Displays block device statistics for a running guest.
domifstat	Displays network interface statistics for a running guest.
attach-device	Attach a device to a guest, using a device definition in an XML file.
attach-disk	Attaches a new disk device to a guest.
attach-interface	Attaches a new network interface to a guest.
update-device	Detach a disk image from a guest's CD-ROM drive. See *Attaching and updating a device with virsh* for more details.
detach-device	Detach a device from a guest, takes the same kind of XML descriptions as command **attach-device**.
detach-disk	Detach a disk device from a guest.
detach-interface	Detach a network interface from a guest.

The **virsh** commands for managing and creating storage pools and volumes.

For more information on using storage pools with virsh, refer to *http://libvirt.org/formatstorage.html*

Table 30.3. Storage Pool options

Command	Description
find-storage-pool-sources	Returns the XML definition for all storage pools of a given type that could be found.
find-storage-pool-sources port	Returns data on all storage pools of a given type that could be found as XML. If the host and port are provided, this command can be run remotely.
pool-autostart	Sets the storage pool to start at boot time.
pool-build	The **pool-build** command builds a defined pool. This command can format disks and create partitions.
pool-create	**pool-create** creates and starts a storage pool from the provided XML storage pool definition file.
pool-create-as name	Creates and starts a storage pool from the provided parameters. If the *--print-xml* parameter is specified, the command prints the XML definition for the storage pool without creating the storage pool.

Command	Description
pool-define	Creates a storage bool from an XML definition file but does not start the new storage pool.
pool-define-as name	Creates but does not start, a storage pool from the provided parameters. If the *--print-xml* parameter is specified, the command prints the XML definition for the storage pool without creating the storage pool.
pool-destroy	Permanently destroys a storage pool in **libvirt**. The raw data contained in the storage pool is not changed and can be recovered with the **pool-create** command.
pool-delete	Destroys the storage resources used by a storage pool. This operation cannot be recovered. The storage pool still exists after this command but all data is deleted.
pool-dumpxml	Prints the XML definition for a storage pool.
pool-edit	Opens the XML definition file for a storage pool in the users default text editor.
pool-info	Returns information about a storage pool.
pool-list	Lists storage pools known to libvirt. By default, **pool-list** lists pools in use by active guests. The *--inactive* parameter lists inactive pools and the *--all* parameter lists all pools.
pool-undefine	Deletes the definition for an inactive storage pool.
pool-uuid	Returns the UUID of the named pool.
pool-name	Prints a storage pool's name when provided the UUID of a storage pool.
pool-refresh	Refreshes the list of volumes contained in a storage pool.
pool-start	Starts a storage pool that is defined but inactive.

Table 30.4. Volume options

Command	Description
vol-create	Create a volume from an XML file.
vol-create-from	Create a volume using another volume as input.
vol-create-as	Create a volume from a set of arguments.
vol-clone	Clone a volume.
vol-delete	Delete a volume.
vol-wipe	Wipe a volume.
vol-dumpxml	Show volume information in XML.
vol-info	Show storage volume information.
vol-list	List volumes.

Command	Description
`vol-pool`	Returns the storage pool for a given volume key or path.
`vol-path`	Returns the volume path for a given volume name or key.
`vol-name`	Returns the volume name for a given volume key or path.
`vol-key`	Returns the volume key for a given volume name or path.

Table 30.5. Secret options

Command	Description
`secret-define`	Define or modify a secret from an XML file.
`secret-dumpxml`	Show secret attributes in XML.
`secret-set-value`	Set a secret value.
`secret-get-value`	Output a secret value.
`secret-undefine`	Undefine a secret.
`secret-list`	List secrets.

Table 30.6. Network filter options

Command	Description
`nwfilter-define`	Define or update a network filter from an XML file.
`nwfilter-undefine`	Undefine a network filter.
`nwfilter-dumpxml`	Show network filter information in XML.
`nwfilter-list`	List network filters.
`nwfilter-edit`	Edit XML configuration for a network filter.

This table contains **`virsh`** command options for snapshots:

Table 30.7. Snapshot options

Command	Description
`snapshot-create`	Create a snapshot.
`snapshot-current`	Get the current snapshot.
`snapshot-delete`	Delete a domain snapshot.
`snapshot-dumpxml`	Dump XML for a domain snapshot.
`snapshot-list`	List snapshots for a domain.
`snapshot-revert`	Revert a domain to a snapshot.

This table contains miscellaneous **`virsh`** commands:

Table 30.8. Miscellaneous options

Command	Description
`version`	Displays the version of **`virsh`**.
`nodeinfo`	Outputs information about the hypervisor.

Attaching and updating a device with virsh

Attaching a disk image to a guest's CD-ROM drive with **virsh**:

1. Attach a disk image to a guest's CD-ROM drive:

   ```
   # virsh attach-disk <GuestName> sample.iso hdc --type cdrom --mode readonly
   Disk attached successfully
   ```

2. Create an XML file to update a specific device. To detach, remove a line for the source device:

   ```
   <disk type='block' device='cdrom'>
     <driver name='qemu' type='raw'/>
     <target dev='hdc' bus='ide'/>
     <readonly/>
     <alias name='ide0-1-0'/>
     <address type='drive' controller='0' bus='1' unit='0'/>
   </disk>
   ```

3. Detach a disk image by updating the device:

   ```
   virsh update-device <GuestName> guest-device.xml
   Device updated successfully
   ```

Connecting to the hypervisor

Connect to a hypervisor session with **virsh**:

```
# virsh connect {name}
```

Where *{name}* is the machine name (hostname) or URL of the hypervisor. To initiate a read-only connection, append the above command with **--readonly**.

Creating a virtual machine XML dump (configuration file)

Output a guest's XML configuration file with **virsh**:

```
# virsh dumpxml {guest-id, guestname or uuid}
```

This command outputs the guest's XML configuration file to standard out (**stdout**). You can save the data by piping the output to a file. An example of piping the output to a file called *guest.xml*:

```
# virsh dumpxml GuestID > guest.xml
```

This file **guest.xml** can recreate the guest (refer to *Editing a guest's configuration file*. You can edit this XML configuration file to configure additional devices or to deploy additional guests. Refer to *Section 35.1, "Using XML configuration files with virsh"* for more information on modifying files created with **virsh dumpxml**.

An example of **virsh dumpxml** output:

```
# virsh dumpxml r5b2-mySQL01
<domain type='kvm' id='13'>
```

```
    <name>r5b2-mySQL01</name>
    <uuid>4a4c59a7ee3fc78196e4288f2862f011</uuid>
    <bootloader>/usr/bin/pygrub</bootloader>
    <os>
        <type>linux</type>
        <kernel>/var/lib/libvirt/vmlinuz.2dgnU_</kernel>
 <initrd>/var/lib/libvirt/initrd.UQafMw</initrd>
        <cmdline>ro root=/dev/VolGroup00/LogVol00 rhgb quiet</cmdline>
    </os>
    <memory>512000</memory>
    <vcpu>1</vcpu>
    <on_poweroff>destroy</on_poweroff>
    <on_reboot>restart</on_reboot>
    <on_crash>restart</on_crash>
    <devices>
        <interface type='bridge'>
            <source bridge='br0'/>
            <mac address='00:16:3e:49:1d:11'/>
            <script path='bridge'/>
        </interface>
        <graphics type='vnc' port='5900'/>
        <console tty='/dev/pts/4'/>
    </devices>
</domain>
```

Creating a guest from a configuration file

Guests can be created from XML configuration files. You can copy existing XML from previously created guests or use the **dumpxml** option (refer to *Creating a virtual machine XML dump (configuration file)*). To create a guest with **virsh** from an XML file:

```
# virsh create configuration_file.xml
```

Editing a guest's configuration file

Instead of using the **dumpxml** option (refer to *Creating a virtual machine XML dump (configuration file)*) guests can be edited either while they run or while they are offline. The **virsh edit** command provides this functionality. For example, to edit the guest named *softwaretesting*:

```
# virsh edit softwaretesting
```

This opens a text editor. The default text editor is the **$EDITOR** shell parameter (set to **vi** by default).

Suspending a guest

Suspend a guest with **virsh**:

```
# virsh suspend {domain-id, domain-name or domain-uuid}
```

When a guest is in a suspended state, it consumes system RAM but not processor resources. Disk and network I/O does not occur while the guest is suspended. This operation is immediate and the guest can be restarted with the **resume** (*Resuming a guest*) option.

Resuming a guest

Restore a suspended guest with **virsh** using the **resume** option:

```
# virsh resume {domain-id, domain-name or domain-uuid}
```

This operation is immediate and the guest parameters are preserved for **suspend** and **resume** operations.

Save a guest

Save the current state of a guest to a file using the **virsh** command:

```
# virsh save {domain-name, domain-id or domain-uuid} filename
```

This stops the guest you specify and saves the data to a file, which may take some time given the amount of memory in use by your guest. You can restore the state of the guest with the **restore** (*Restore a guest*) option. Save is similar to pause, instead of just pausing a guest the present state of the guest is saved.

Restore a guest

Restore a guest previously saved with the **virsh save** command (*Save a guest*) using **virsh**:

```
# virsh restore filename
```

This restarts the saved guest, which may take some time. The guest's name and UUID are preserved but are allocated for a new id.

Shut down a guest

Shut down a guest using the **virsh** command:

```
# virsh shutdown {domain-id, domain-name or domain-uuid}
```

You can control the behavior of the rebooting guest by modifying the **on_shutdown** parameter in the guest's configuration file.

Rebooting a guest

Reboot a guest using **virsh** command:

```
#virsh reboot {domain-id, domain-name or domain-uuid}
```

You can control the behavior of the rebooting guest by modifying the **on_reboot** element in the guest's configuration file.

Forcing a guest to stop

Force a guest to stop with the **virsh** command:

```
# virsh destroy {domain-id, domain-name or domain-uuid}
```

This command does an immediate ungraceful shutdown and stops the specified guest. Using **virsh destroy** can corrupt guest file systems . Use the **destroy** option only when the guest is unresponsive.

Getting the domain ID of a guest

To get the domain ID of a guest:

```
# virsh domid {domain-name or domain-uuid}
```

Getting the domain name of a guest

To get the domain name of a guest:

```
# virsh domname {domain-id or domain-uuid}
```

Getting the UUID of a guest

To get the Universally Unique Identifier (UUID) for a guest:

```
# virsh domuuid {domain-id or domain-name}
```

An example of **virsh domuuid** output:

```
# virsh domuuid r5b2-mySQL01
4a4c59a7-ee3f-c781-96e4-288f2862f011
```

Displaying guest Information

Using **virsh** with the guest's domain ID, domain name or UUID you can display information on the specified guest:

```
# virsh dominfo {domain-id, domain-name or domain-uuid}
```

This is an example of **virsh dominfo** output:

```
# virsh dominfo r5b2-mySQL01
id:                13
name:              r5b2-mysql01
uuid:              4a4c59a7-ee3f-c781-96e4-288f2862f011
os type:          linux
state:             blocked
cpu(s):            1
cpu time:         11.0s
max memory:        512000 kb
used memory:       512000 kb
```

Displaying host information

To display information about the host:

```
# virsh nodeinfo
```

An example of **virsh nodeinfo** output:

```
# virsh nodeinfo
CPU model                    x86_64
CPU (s)                      8
CPU frequency                2895 Mhz
CPU socket(s)                2
Core(s) per socket           2
Threads per core:            2
Numa cell(s)                 1
```

```
Memory size:                   1046528 kb
```

This displays the node information and the machines that support the virtualization process.

Editing a storage pool definition

The **virsh pool-edit** command takes the name or UUID for a storage pool and opens the XML definition file for a storage pool in the users default text editor.

The **virsh pool-edit** command is equivalent to running the following commands:

```
# virsh pool-dumpxml pool > pool.xml
# vim pool.xml
# virsh pool-define pool.xml
```

> **Note**
>
> The default editor is defined by the **$VISUAL** or **$EDITOR** environment variables, and default is **vi**.

Displaying the guests

To display the guest list and their current states with **virsh**:

```
# virsh list
```

Other options available include:

the **--inactive** option to list inactive guests (that is, guests that have been defined but are not currently active), and

the **--all** option lists all guests. For example:

```
# virsh list --all
 Id Name                 State
----------------------------------
  0 Domain-0             running
  1 Domain202            paused
  2 Domain010            inactive
  3 Domain9600           crashed
```

The output from **virsh list** is categorized as one of the six states (listed below).

- The **running** state refers to guests which are currently active on a CPU.
- Guests listed as **blocked** are blocked, and are not running or runnable. This is caused by a guest waiting on I/O (a traditional wait state) or guests in a sleep mode.
- The **paused** state lists domains that are paused. This occurs if an administrator uses the **pause** button in **virt-manager**, **xm pause** or **virsh suspend**. When a guest is paused it consumes memory and other resources but it is ineligible for scheduling and CPU resources from the hypervisor.
- The **shutdown** state is for guests in the process of shutting down. The guest is sent a shutdown signal and should be in the process of stopping its operations gracefully. This may not work with all guest operating systems; some operating systems do not respond to these signals.

- Domains in the **dying** state are in is in process of dying, which is a state where the domain has not completely shut-down or crashed.
- **crashed** guests have failed while running and are no longer running. This state can only occur if the guest has been configured not to restart on crash.

Displaying virtual CPU information

To display virtual CPU information from a guest with **virsh**:

```
# virsh vcpuinfo {domain-id, domain-name or domain-uuid}
```

An example of **virsh vcpuinfo** output:

```
# virsh vcpuinfo r5b2-mySQL01
VCPU:           0
CPU:            0
State:          blocked
CPU time:       0.0s
CPU Affinity:   yy
```

Configuring virtual CPU affinity

To configure the affinity of virtual CPUs with physical CPUs:

```
# virsh vcpupin domain-id vcpu cpulist
```

The **domain-id** parameter is the guest's ID number or name.

The **vcpu** parameter denotes the number of virtualized CPUs allocated to the guest.The **vcpu** parameter must be provided.

The **cpulist** parameter is a list of physical CPU identifier numbers separated by commas. The **cpulist** parameter determines which physical CPUs the VCPUs can run on.

Configuring virtual CPU count

To modify the number of CPUs assigned to a guest with **virsh**:

```
# virsh setvcpus {domain-name, domain-id or domain-uuid} count
```

The new *count* value cannot exceed the count above the amount specified when the guest was created.

Configuring memory allocation

To modify a guest's memory allocation with **virsh** :

```
# virsh setmem {domain-id or domain-name} count
```

You must specify the *count* in kilobytes. The new count value cannot exceed the amount you specified when you created the guest. Values lower than 64 MB are unlikely to work with most guest operating systems. A higher maximum memory value does not affect an active guests. If the new value is lower the available memory will shrink and the guest may crash.

Displaying guest block device information

Use **virsh domblkstat** to display block device statistics for a running guest.

```
# virsh domblkstat GuestName block-device
```

Displaying guest network device information

Use **virsh domifstat** to display network interface statistics for a running guest.

```
# virsh domifstat GuestName interface-device
```

Migrating guests with virsh

A guest can be migrated to another host with **virsh**. Migrate domain to another host. Add --live for live migration. The **migrate** command accepts parameters in the following format:

```
# virsh migrate --live GuestName DestinationURL
```

The *--live* parameter is optional. Add the *--live* parameter for live migrations.

The *GuestName* parameter represents the name of the guest which you want to migrate.

The *DestinationURL* parameter is the URL or hostname of the destination system. The destination system requires:

- Red Hat Enterprise Linux 5.4 (ASYNC update 4) or newer,
- the same hypervisor version, and
- the **libvirt** service must be started.

Once the command is entered you will be prompted for the root password of the destination system.

Managing virtual networks

This section covers managing virtual networks with the **virsh** command. To list virtual networks:

```
# virsh net-list
```

This command generates output similar to:

```
# virsh net-list
Name                 State      Autostart
-----------------------------------------
default              active     yes
vnet1              active     yes
vnet2              active     yes
```

To view network information for a specific virtual network:

```
# virsh net-dumpxml NetworkName
```

This displays information about a specified virtual network in XML format:

```
# virsh net-dumpxml vnet1
```

```
<network>
  <name>vnet1</name>
  <uuid>98361b46-1581-acb7-1643-85a412626e70</uuid>
  <forward dev='eth0'/>
  <bridge name='vnet0' stp='on' forwardDelay='0' />
  <ip address='192.168.100.1' netmask='255.255.255.0'>
    <dhcp>
      <range start='192.168.100.128' end='192.168.100.254' />
    </dhcp>
  </ip>
</network>
```

Other **virsh** commands used in managing virtual networks are:

- **virsh net-autostart *network-name*** — Autostart a network specified as *network-name*.
- **virsh net-create *XMLfile*** — generates and starts a new network using an existing XML file.
- **virsh net-define *XMLfile*** — generates a new network device from an existing XML file without starting it.
- **virsh net-destroy *network-name*** — destroy a network specified as *network-name*.
- **virsh net-name *networkUUID*** — convert a specified *networkUUID* to a network name.
- **virsh net-uuid *network-name*** — convert a specified *network-name* to a network UUID.
- **virsh net-start *nameOfInactiveNetwork*** — starts an inactive network.
- **virsh net-undefine *nameOfInactiveNetwork*** — removes the definition of an inactive network.

Managing guests with the Virtual Machine Manager (virt-manager)

This section describes the Virtual Machine Manager (**`virt-manager`**) windows, dialog boxes, and various GUI controls.

`virt-manager` provides a graphical view of hypervisors and guest on your system and on remote machines. You can use **`virt-manager`** to define virtualized guests. **`virt-manager`** can perform virtualization management tasks, including:

- assigning memory,
- assigning virtual CPUs,
- monitoring operational performance,
- saving and restoring, pausing and resuming, and shutting down and starting virtualized guests,
- links to the textual and graphical consoles, and
- live and offline migrations.

31.1. Starting virt-manager

To start **`virt-manager`** session open the **Applications** menu, then the **System Tools** menu and select **Virtual Machine Manager** (**`virt-manager`**).

The **`virt-manager`** main window appears.

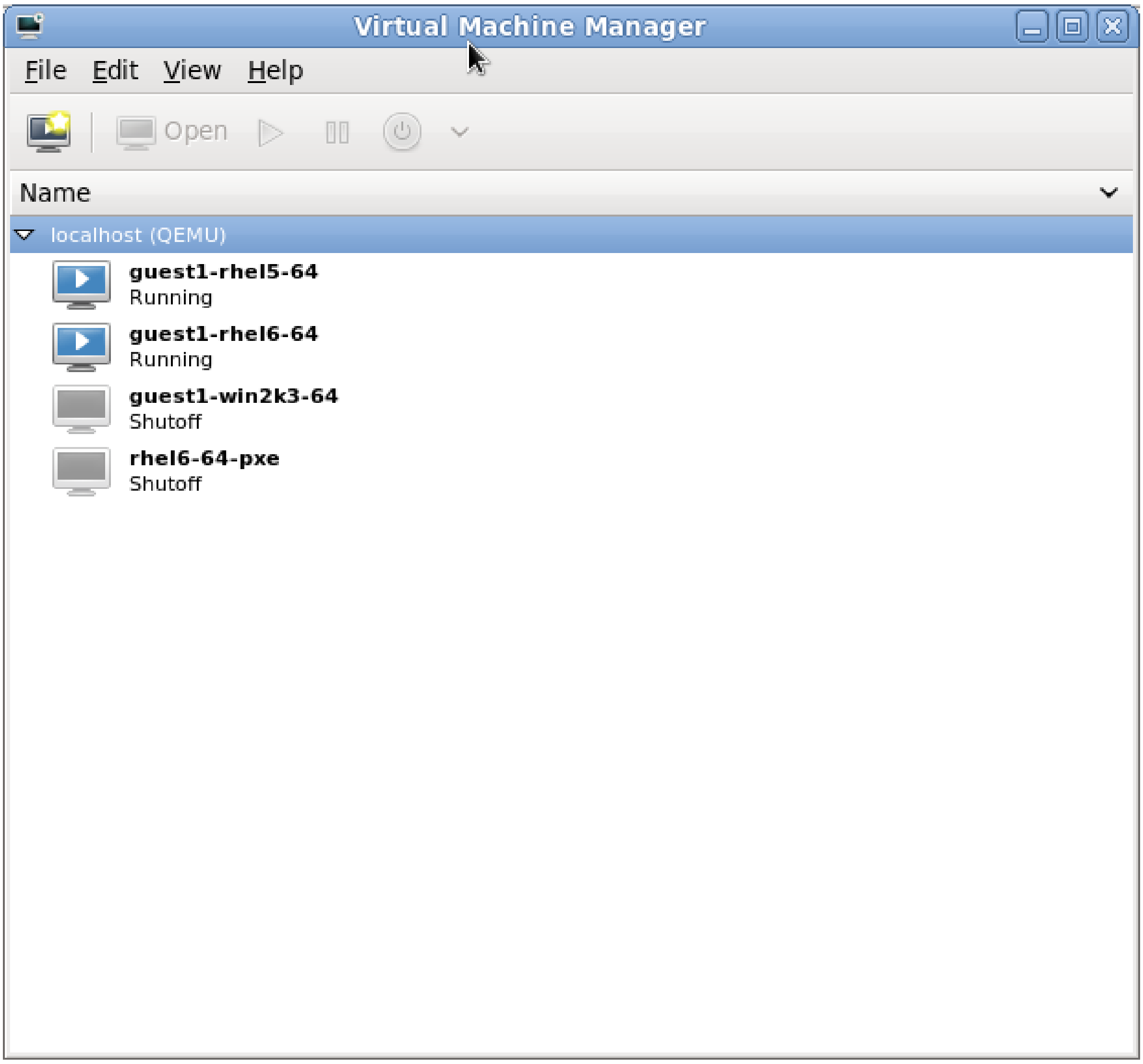


Figure 31.1. Starting **`virt-manager`**

Alternatively, **`virt-manager`** can be started remotely using ssh as demonstrated in the following command:

```
ssh -X host's address
[remotehost]# virt-manager
```

Using **ssh** to manage virtual machines and hosts is discussed further in *Section 19.1, “Remote management with SSH”*.

31.2. The Virtual Machine Manager main window

This main window displays all the running guests and resources used by guests. Select a virtualized guest by double clicking the guest's name.

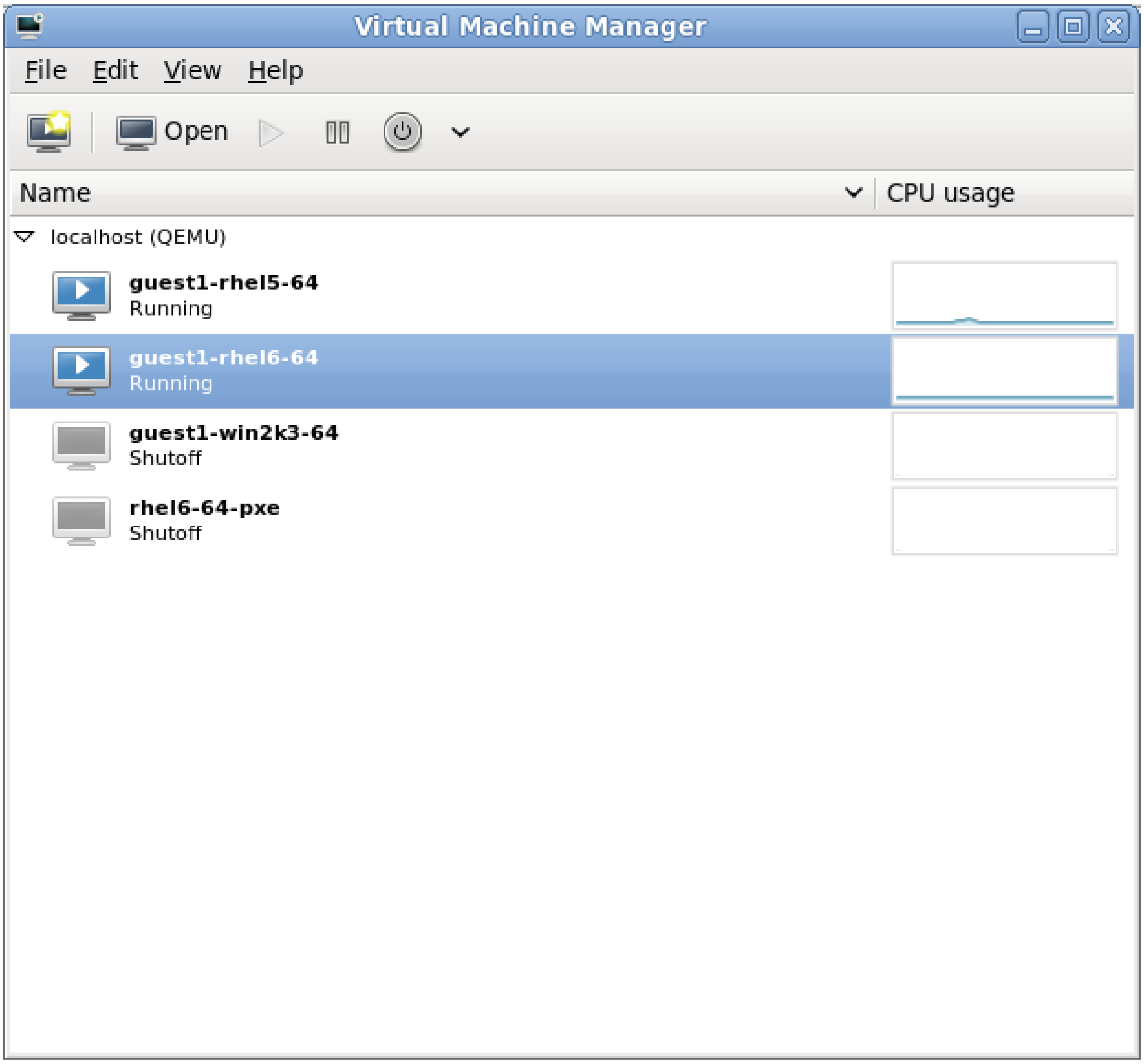


Figure 31.2. Virtual Machine Manager main window

31.3. The virtual hardware details window

The virtual hardware details window displays information about the virtual hardware configured for the virtualized guest. Virtual hardware resources can be added, removed and modified in this window. To access the virtual hardware details window, click on the icon in the toolbar.

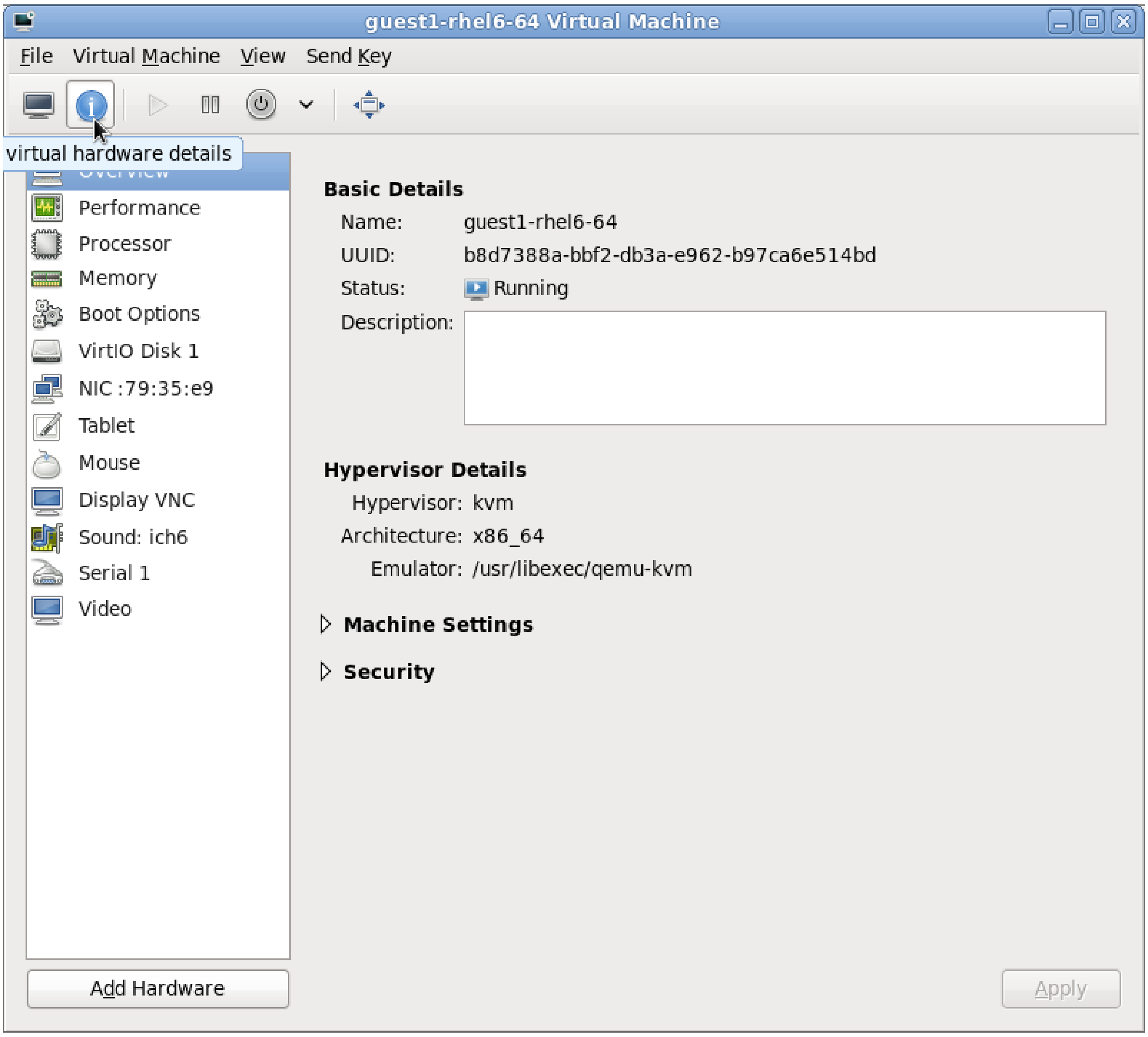


Figure 31.3. The virtual hardware details icon

Clicking the icon displays the virtual hardware details window.

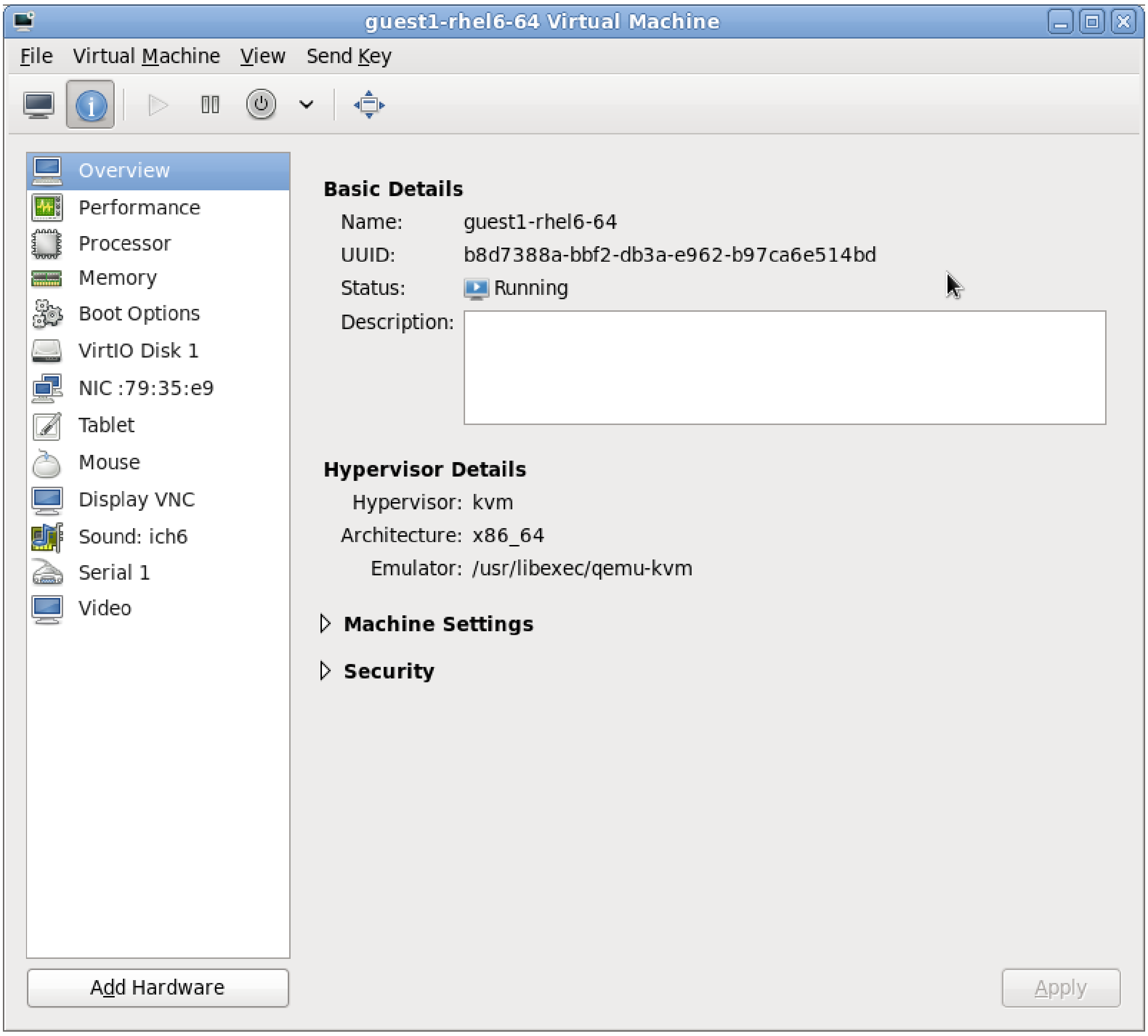


Figure 31.4. The virtual hardware details window

31.4. Virtual Machine graphical console

This window displays a virtualized guest's graphical console. Virtualized guests use different techniques to export their local virtual framebuffers, but both technologies use **VNC** to make them available to the Virtual Machine Manager's console window. If your virtual machine is set to require authentication, the Virtual Machine graphical console prompts you for a password before the display appears.

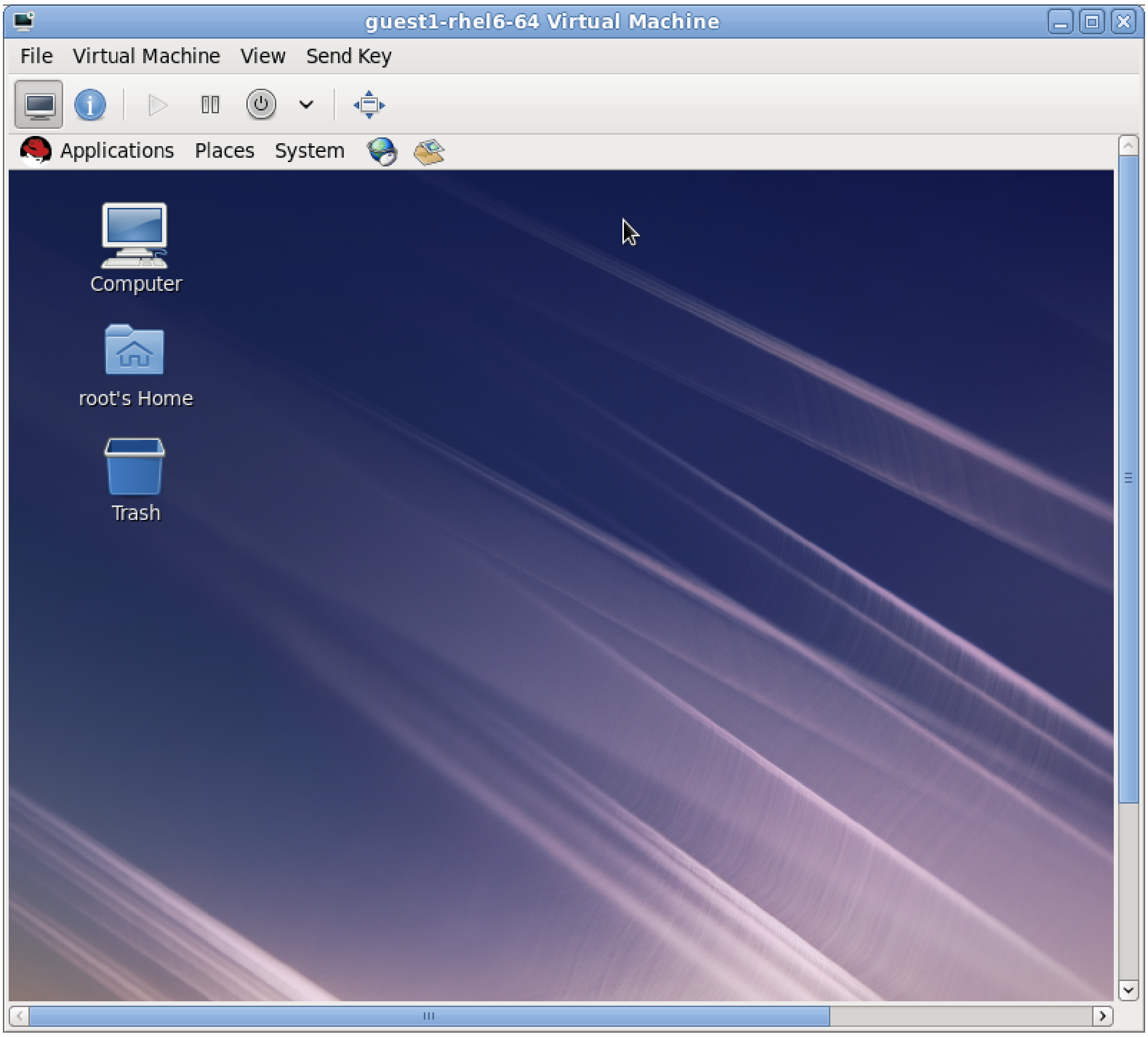


Figure 31.5. Graphical console window

A note on security and VNC

VNC is considered insecure by many security experts, however, several changes have been made to enable the secure usage of VNC for virtualization on Red Hat enterprise Linux. The guest machines only listen to the local host's loopback address (`127.0.0.1`). This ensures only those with shell privileges on the host can access virt-manager and the virtual machine through VNC.

Remote administration can be performed following the instructions in *Chapter 19, Remote management of virtualized guests*. TLS can provide enterprise level security for managing guest and host systems.

Your local desktop can intercept key combinations (for example, Ctrl+Alt+F11) to prevent them from being sent to the guest machine. You can use **`virt-manager`**sticky key' capability to send these sequences. You must press any modifier key (Ctrl or Alt) 3 times and the key you specify gets treated as active until the next non-modifier key is pressed. Then you can send Ctrl-Alt-F11 to the guest by entering the key sequence 'Ctrl Ctrl Ctrl Alt+F1'.

SPICE is an alternative to VNC available for Red Hat Enterprise Linux.

31.5. Adding a remote connection

This procedure covers how to set up a connection to a remote system using **`virt-manager`**.

1. To create a new connection open the **File** menu and select the **Add Connection...** menu item.

2. The **Add Connection** wizard appears. Select the hypervisor. For Red Hat Enterprise Linux 6 systems select **QEMU/KVM**. Select Local for the local system or one of the remote connection options and click **Connect**. This example uses Remote tunnel over SSH which works on default installations. For more information on configuring remote connections refer to *Chapter 19, Remote management of virtualized guests*

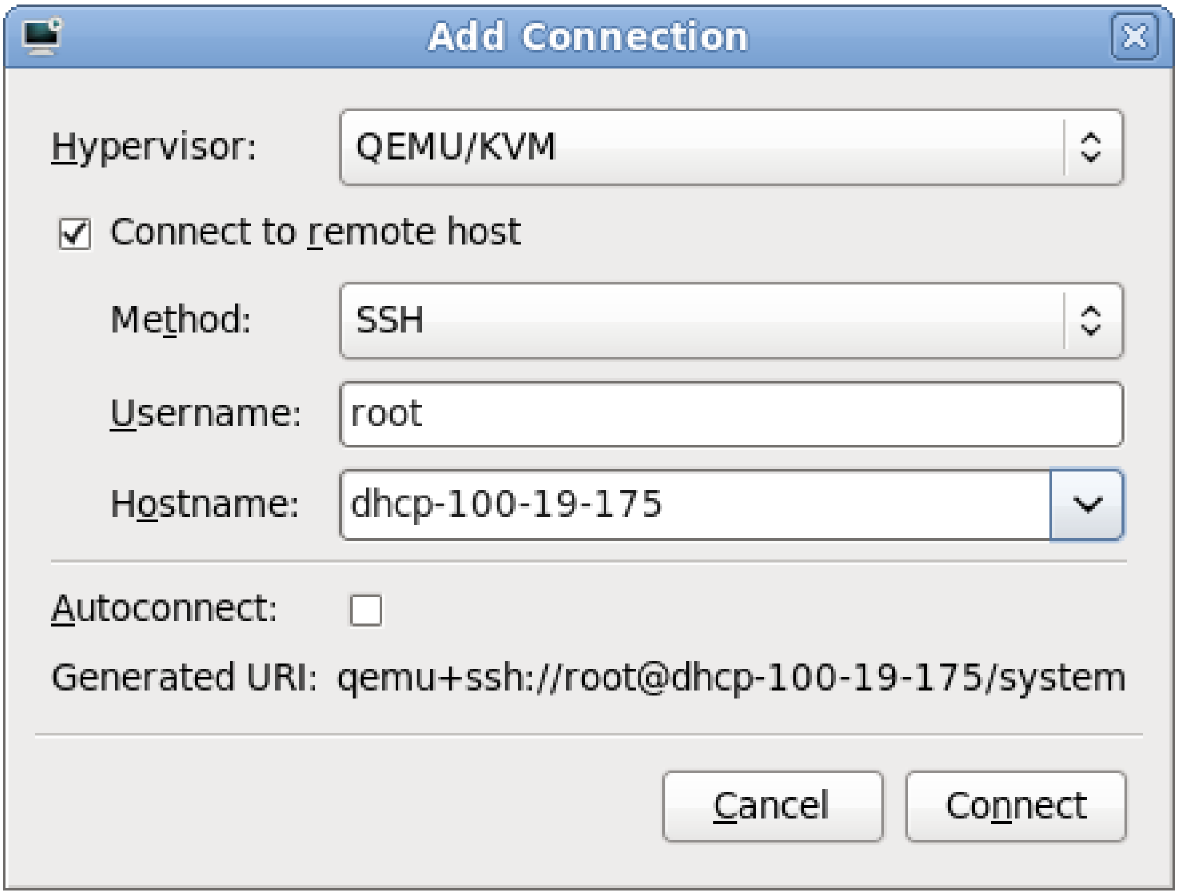


Figure 31.6. Add Connection

3. Enter the root password for the selected host when prompted.

A remote host is now connected and appears in the main **`virt-manager`** window.

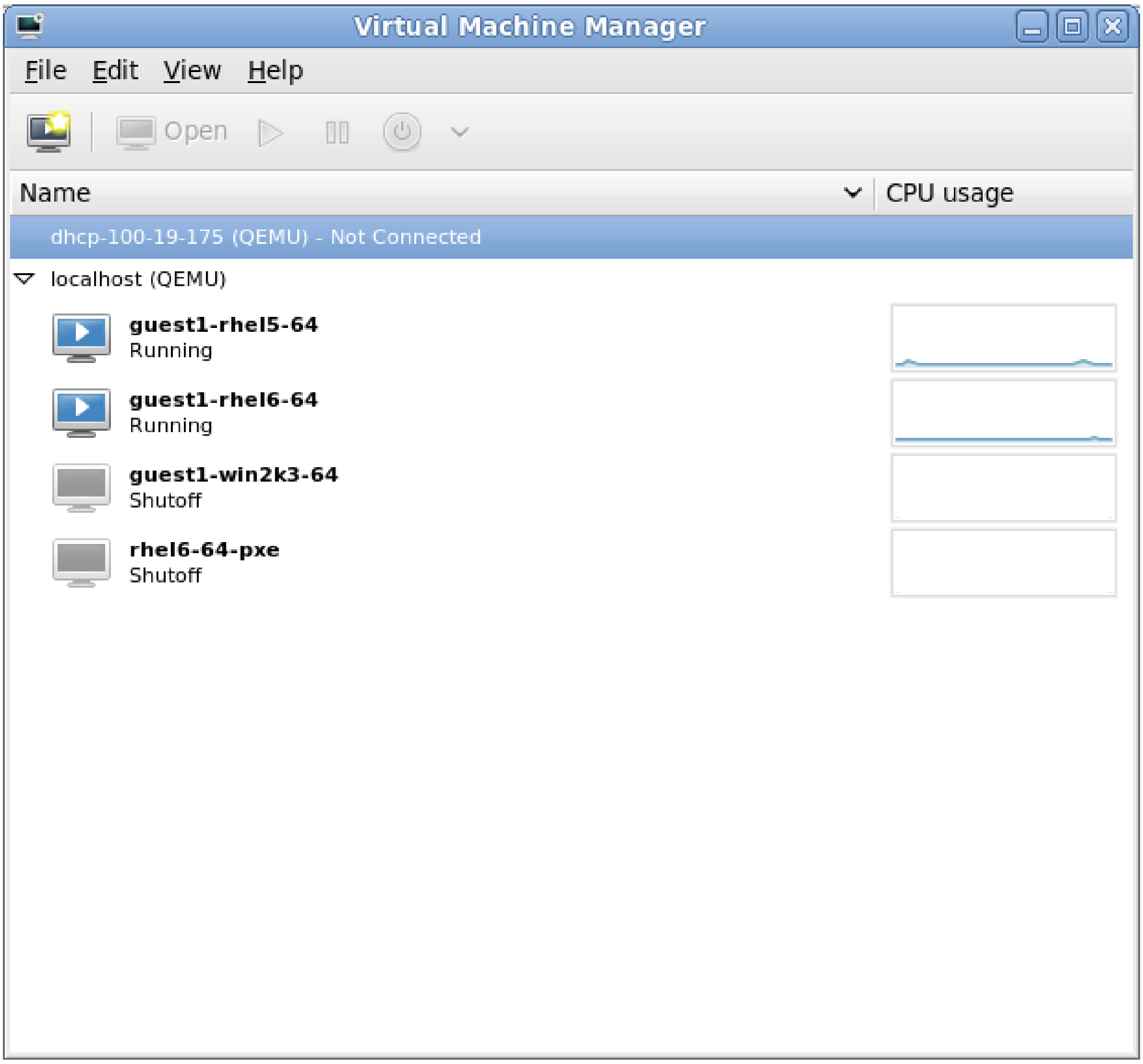


Figure 31.7. Remote host in the main virt-manager window

31.6. Displaying guest details

You can use the Virtual Machine Monitor to view activity information for any virtual machines on your system.

To view a virtual system's details:

1. In the Virtual Machine Manager main window, highlight the virtual machine that you want to view.

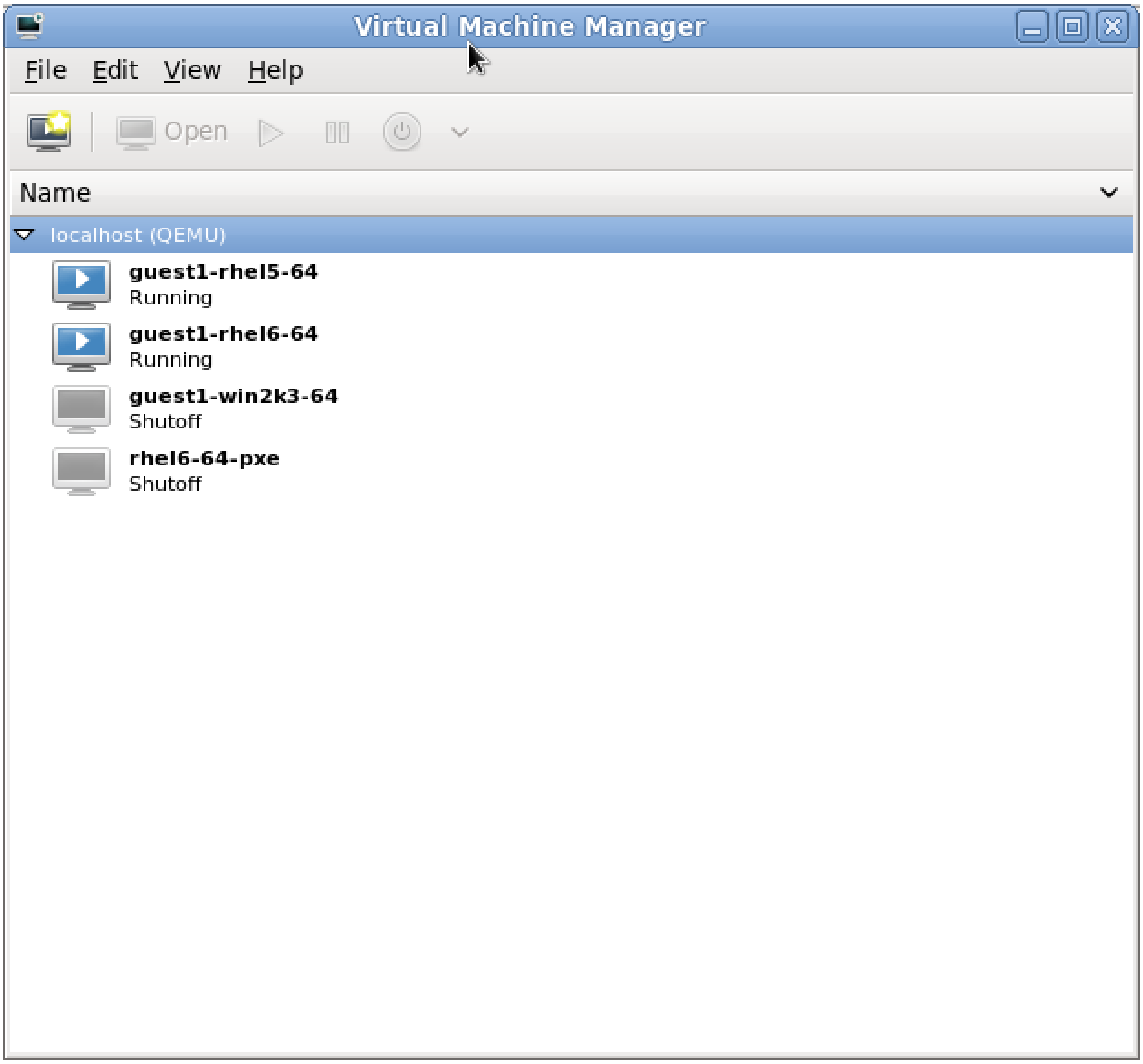


Figure 31.8. Selecting a virtual machine to display

2. From the Virtual Machine Manager **Edit** menu, select **Virtual Machine Details**.

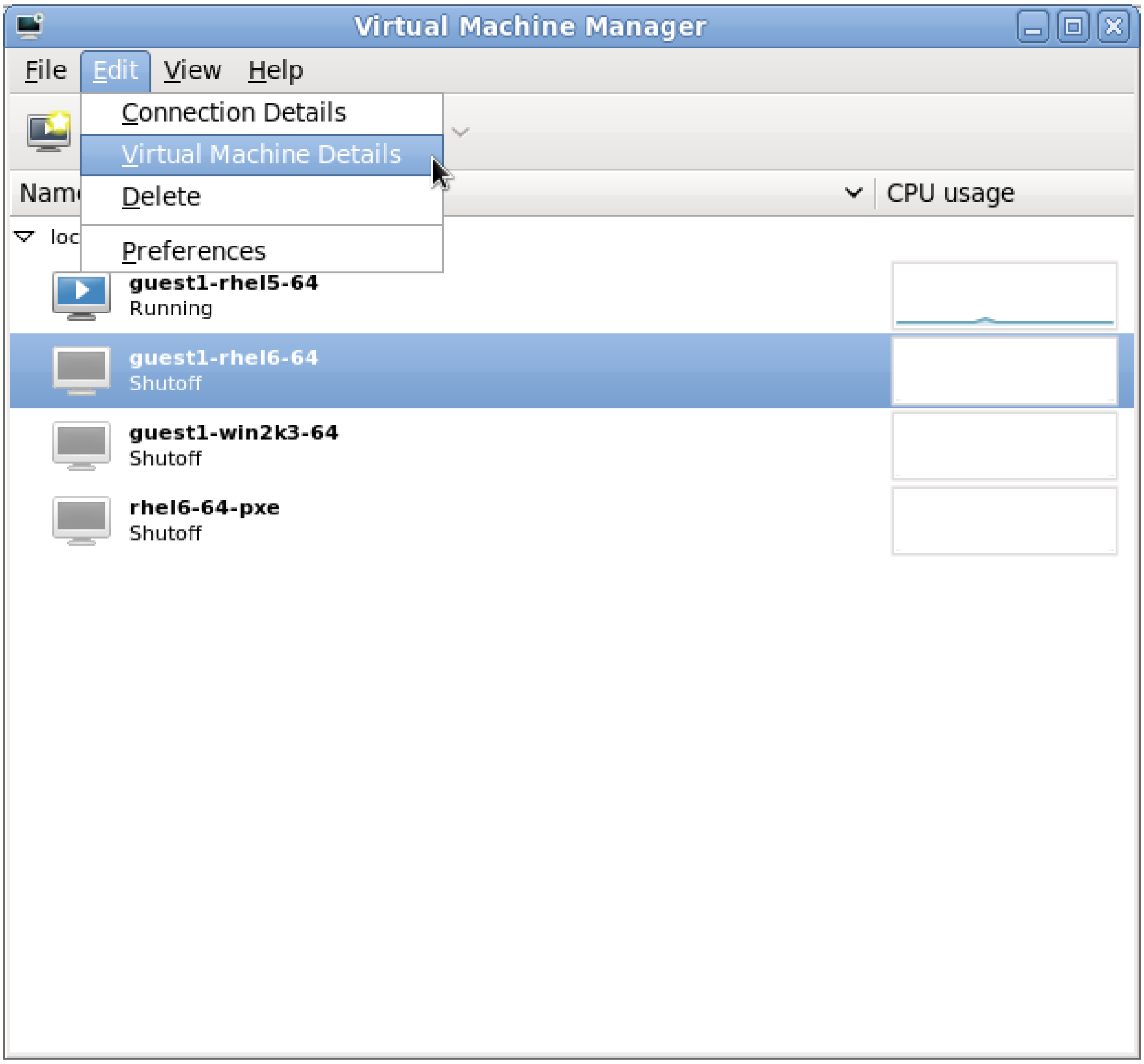


Figure 31.9. Displaying the virtual machine details

On the **Virtual Machine** window, select **Overview** from the navigation pane on the left hand side.

The **Overview** view shows a summary of configuration details for the virtualized guest.

3. Select **Performance** from the navigation pane on the left hand side.

The **Performance** view shows a summary of guest performance, including CPU and Memory usage.

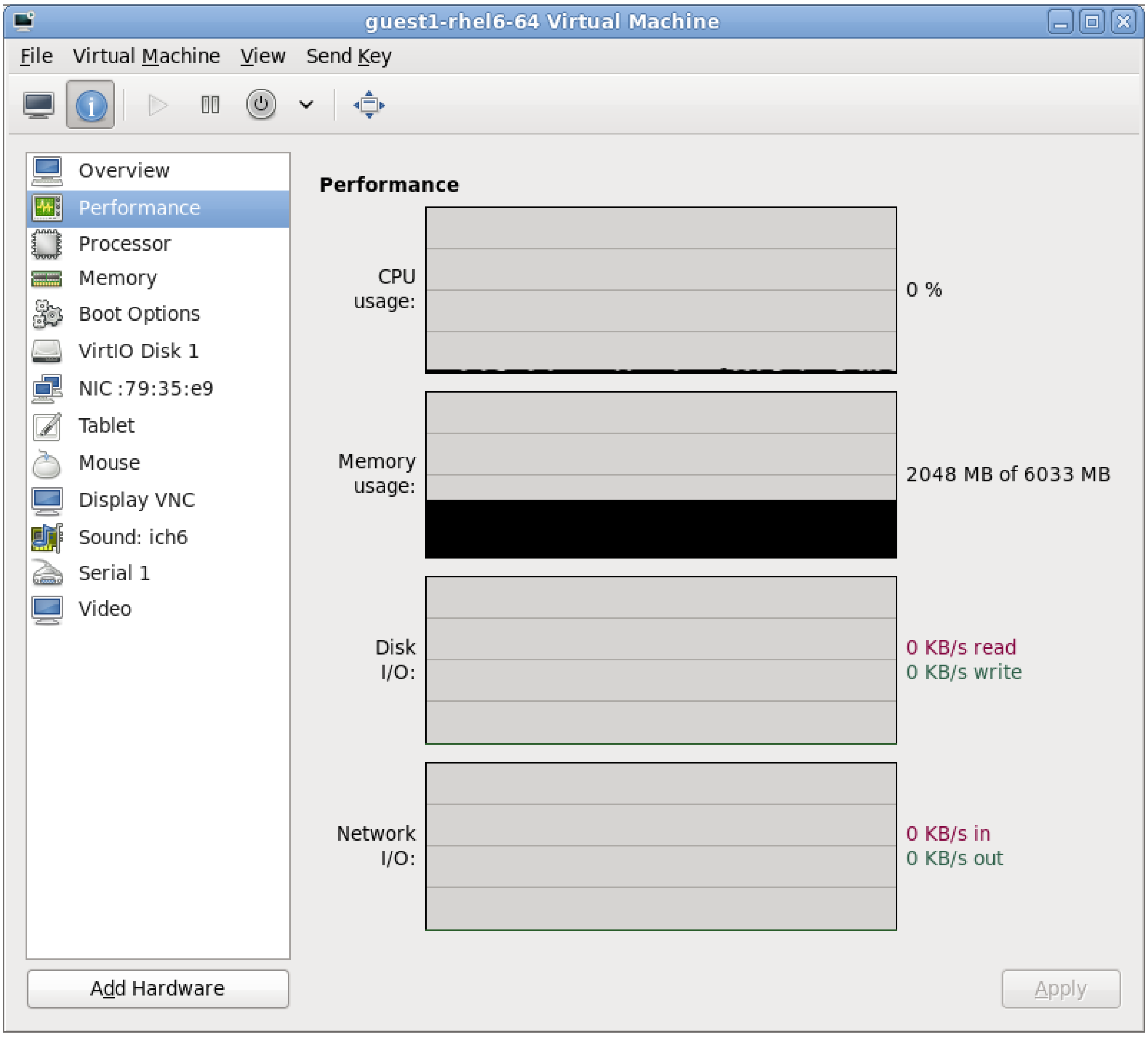


Figure 31.10. Displaying guest performance details

4. Select **Processor** from the navigation pane on the left hand side. The **Processor** view allows you to view or change the current processor allocation.

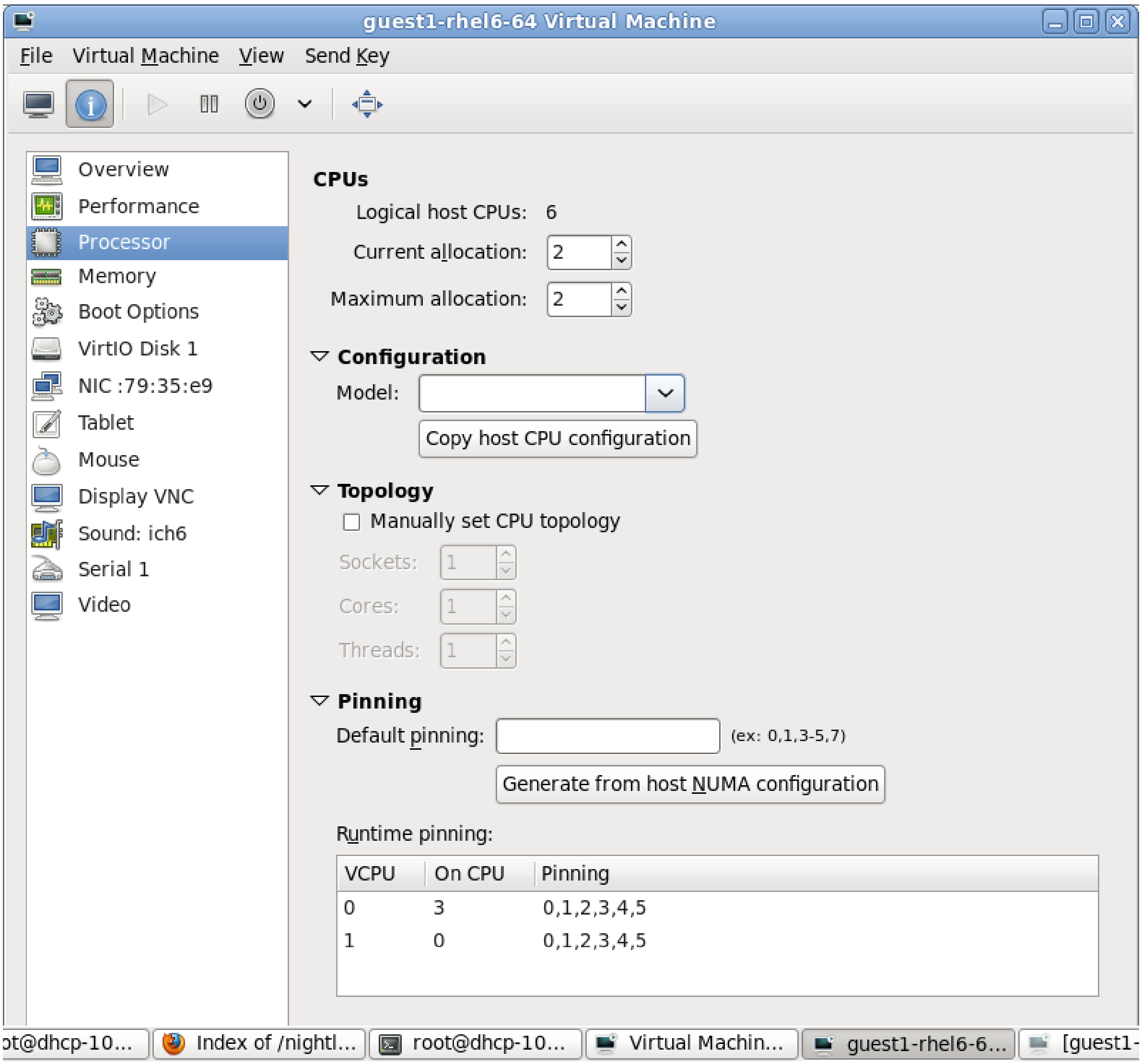


Figure 31.11. Processor allocation panel

5. Select **Memory** from the navigation pane on the left hand side. The **Memory** view allows you to view or change the current memory allocation.

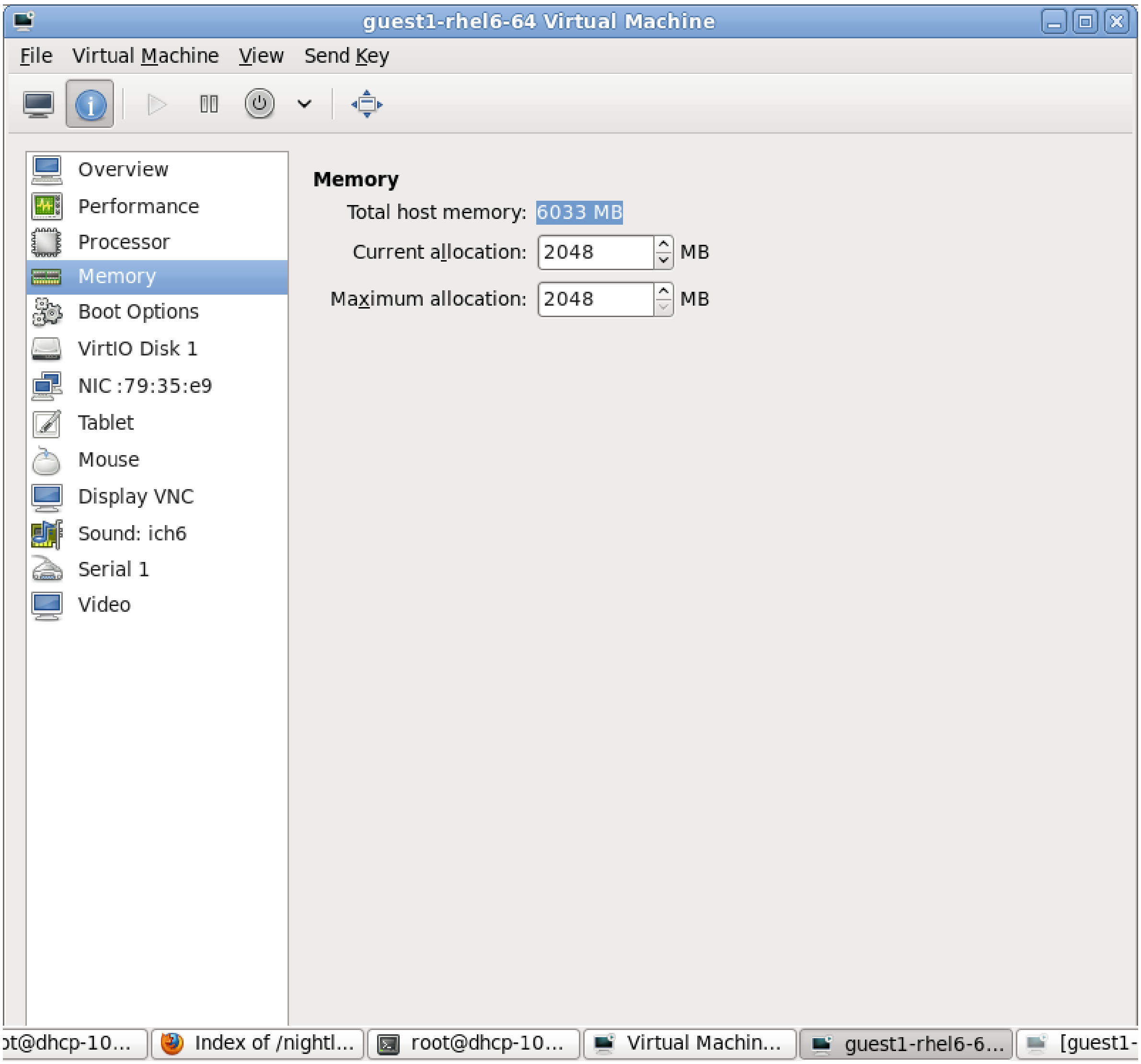


Figure 31.12. Displaying memory allocation

6. Each virtual disk attached to the virtual machine is displayed in the navigation pane. Click on a virtual disk to modify or remove it.

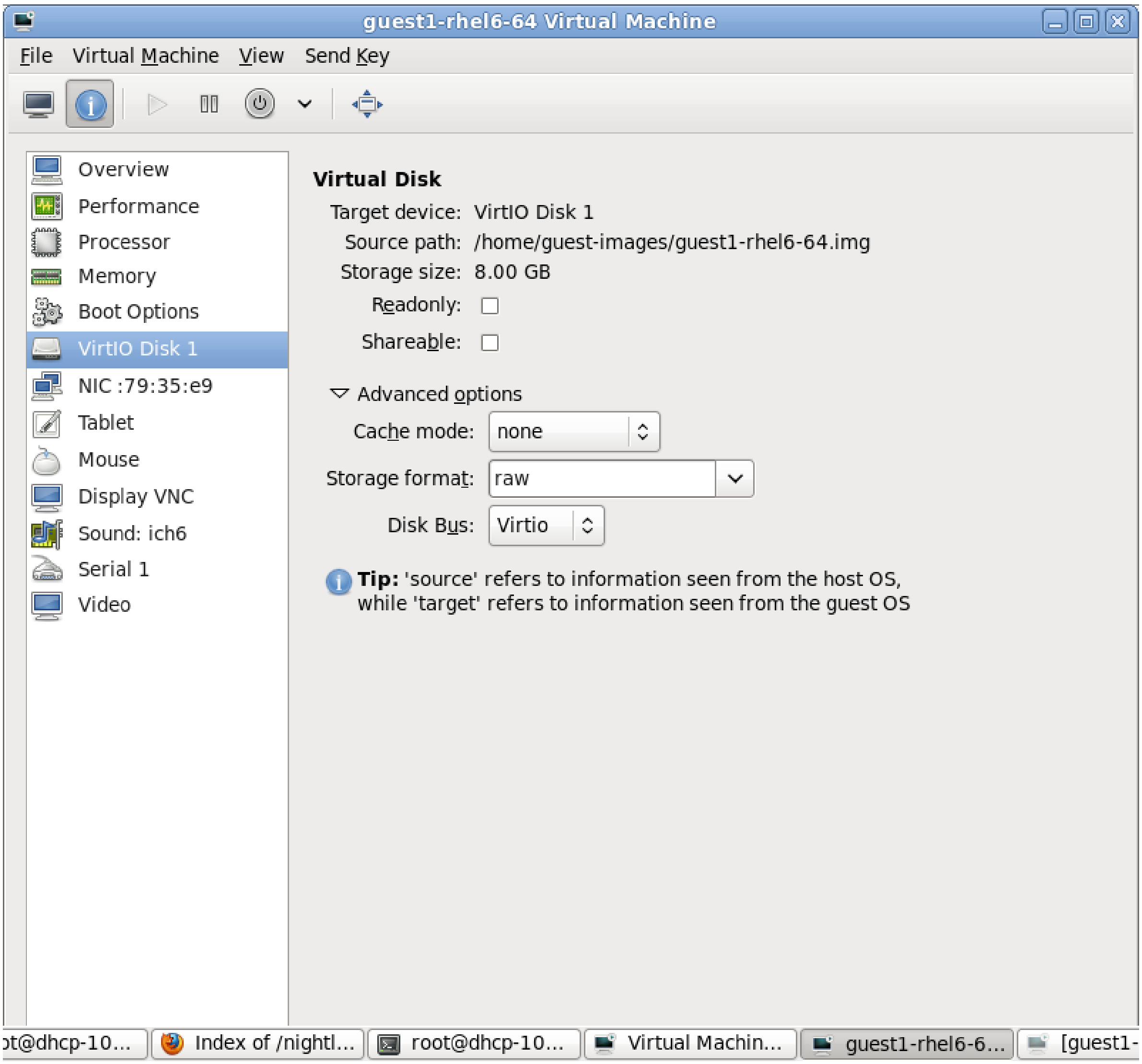


Figure 31.13. Displaying disk configuration

7. Each virtual network interface attached to the virtual machine is displayed in the nagivation pane. Click on a virtual network interface to modify or remove it.

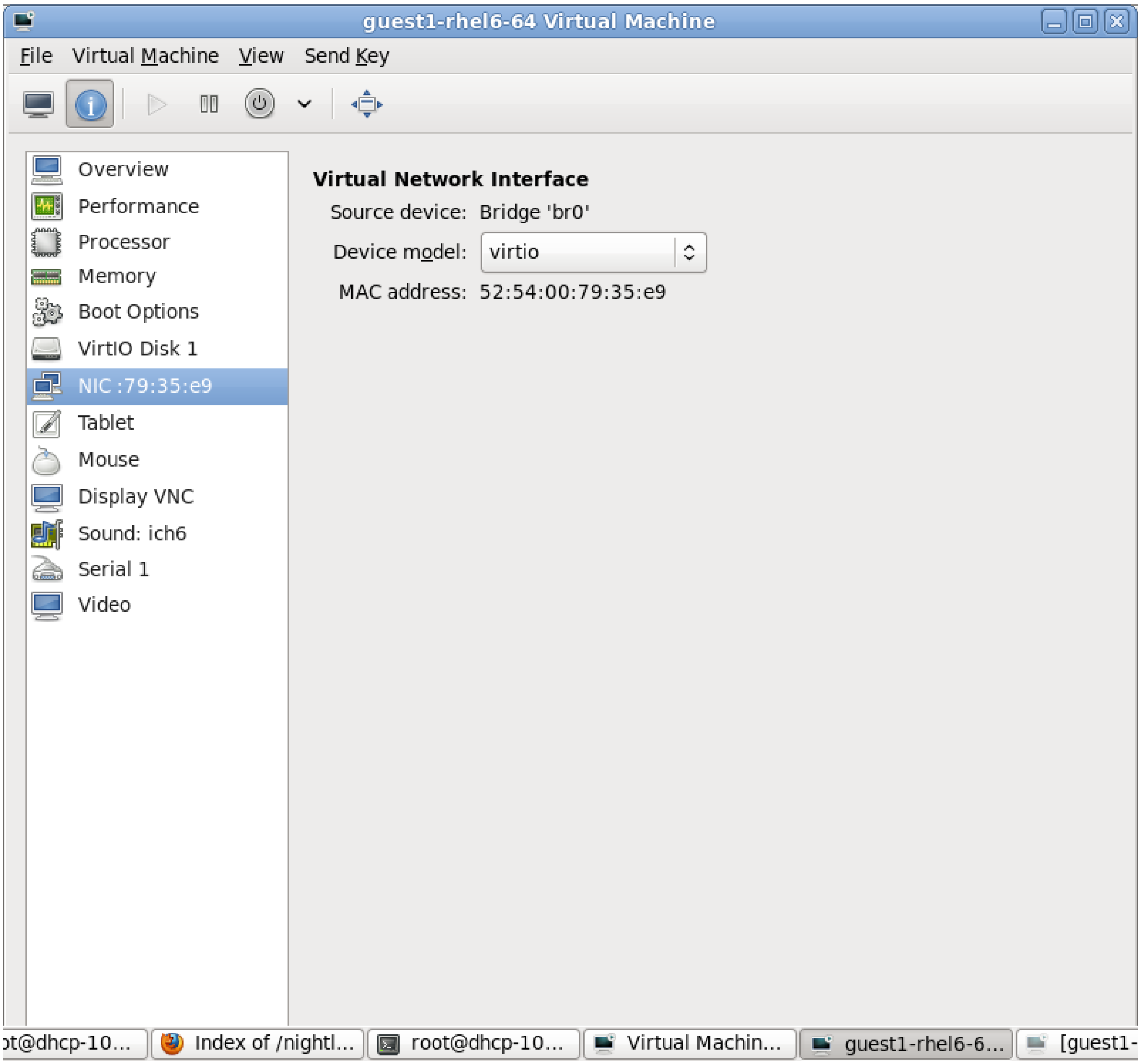


Figure 31.14. Displaying network configuration

31.7. Performance monitoring

Performance monitoring preferences can be modified with **`virt-manager`**'s preferences window.

To configure Performance monitoring:

1. From the **Edit** menu, select **Preferences**.

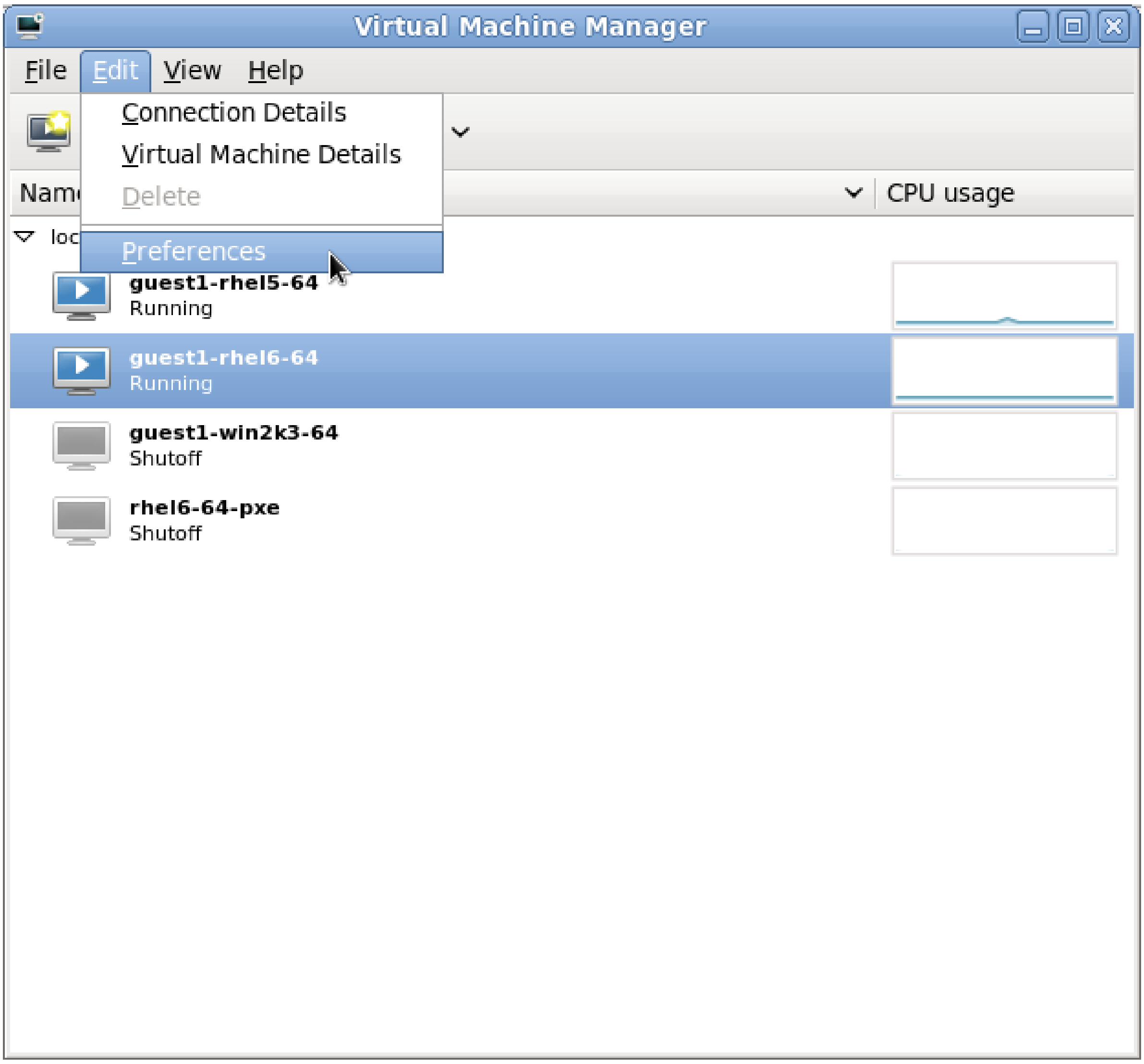


Figure 31.15. Modifying guest preferences

The **Preferences** window appears.

2. From the **Stats** tab specify the time in seconds or stats polling options.

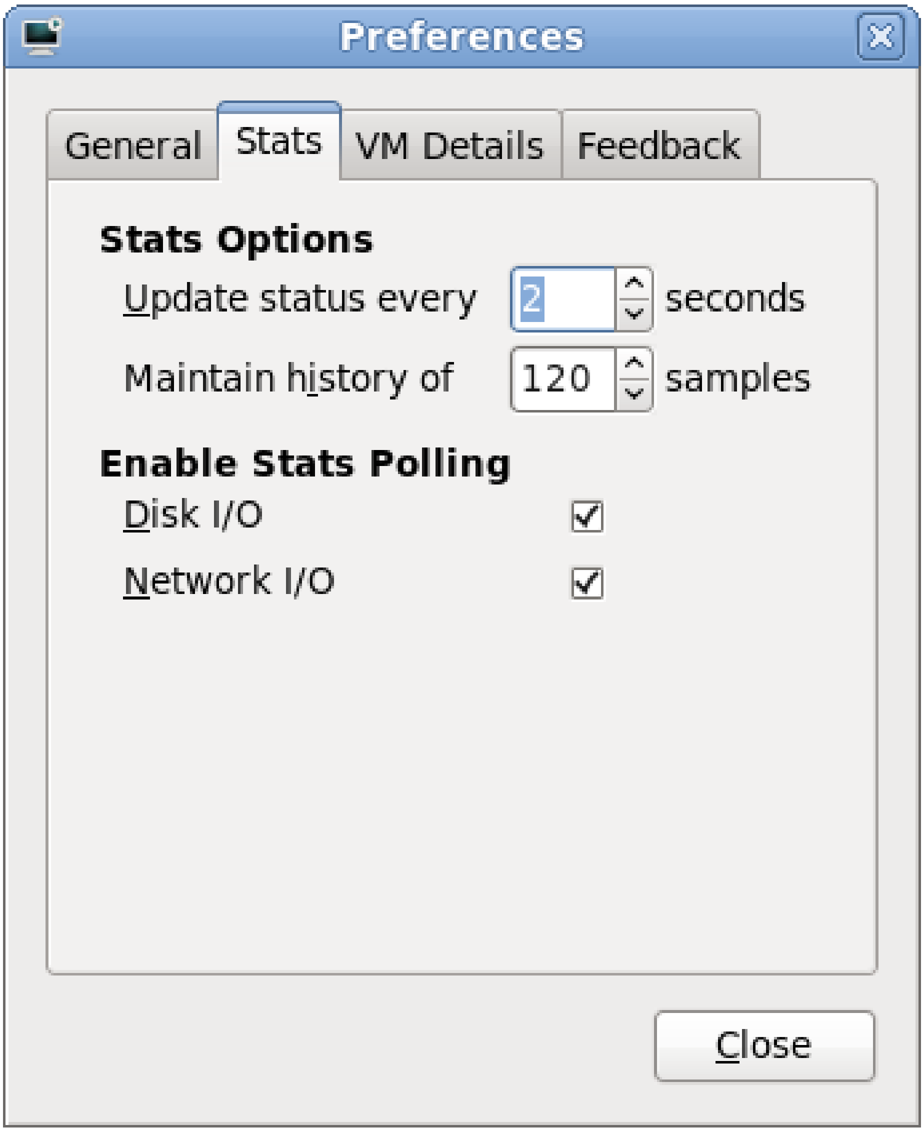


Figure 31.16. Configuring performance monitoring

31.8. Displaying CPU usage

To view the CPU usage for all virtual machines on your system:

1. From the **View** menu, select **Graph**, then the **CPU Usage** check box.

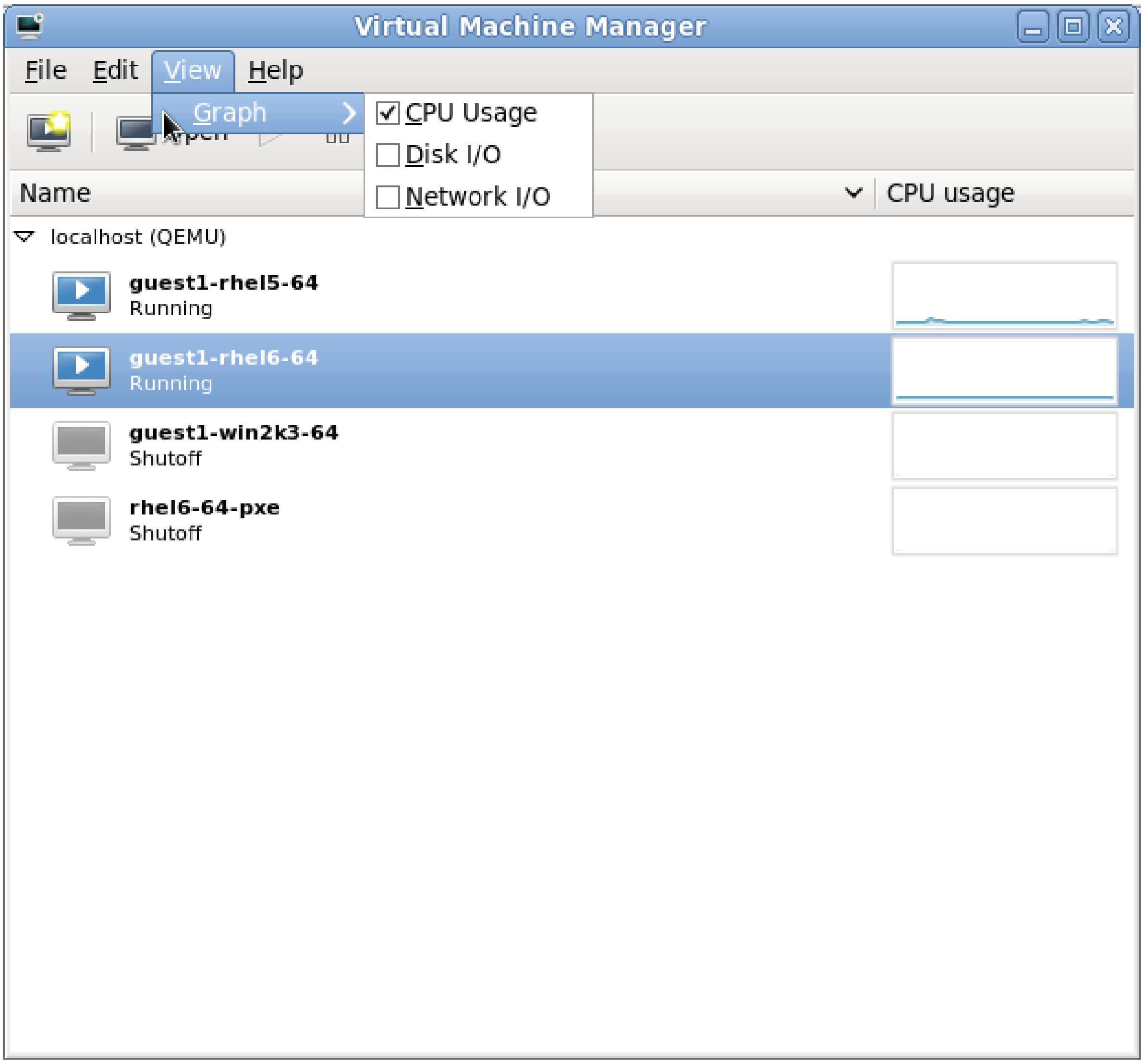


Figure 31.17. Selecting CPU usage

2. The Virtual Machine Manager shows a graph of CPU usage for all virtual machines on your system.

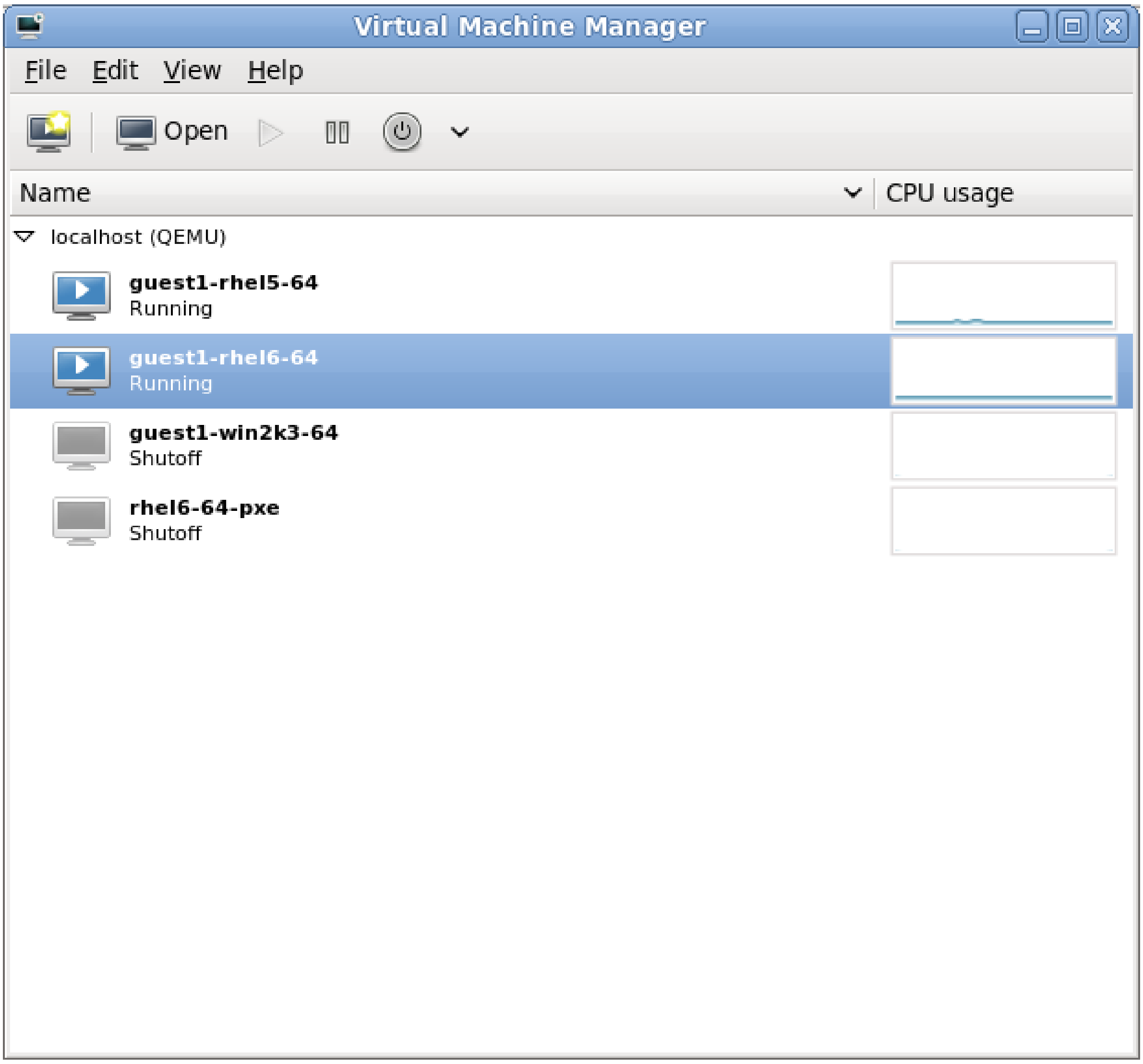


Figure 31.18. Displaying CPU usage

31.9. Displaying Disk I/O

To view the disk I/O for all virtual machines on your system:

1. From the **View** menu, select **Graph**, then the **Disk I/O** check box.

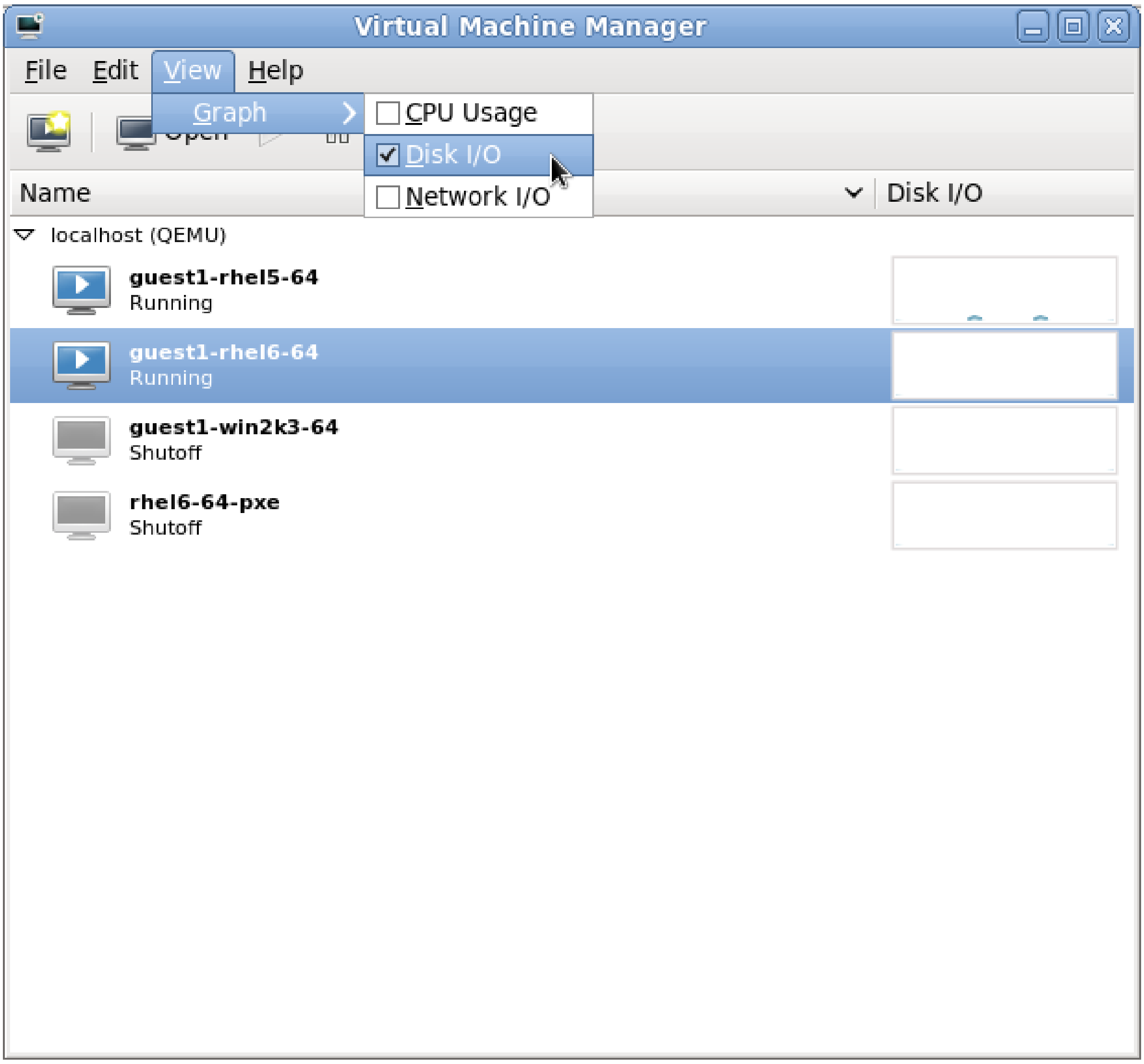


Figure 31.19. Selecting Disk I/O

2. The Virtual Machine Manager shows a graph of Disk I/O for all virtual machines on your system.

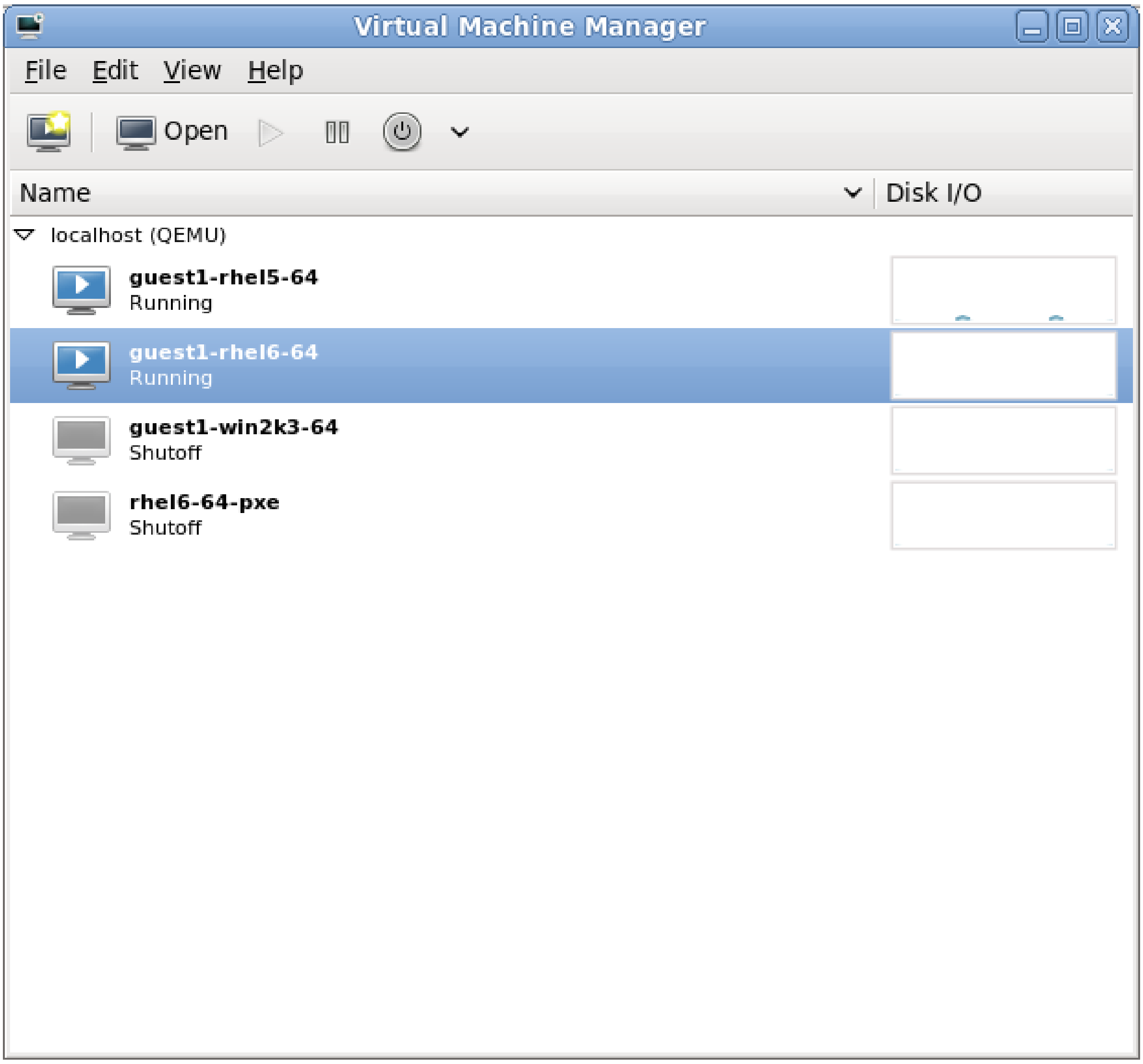


Figure 31.20. Displaying Disk I/O

31.10. Displaying Network I/O

To view the network I/O for all virtual machines on your system:

1. From the **View** menu, select **Graph**, then the **Network I/O** check box.

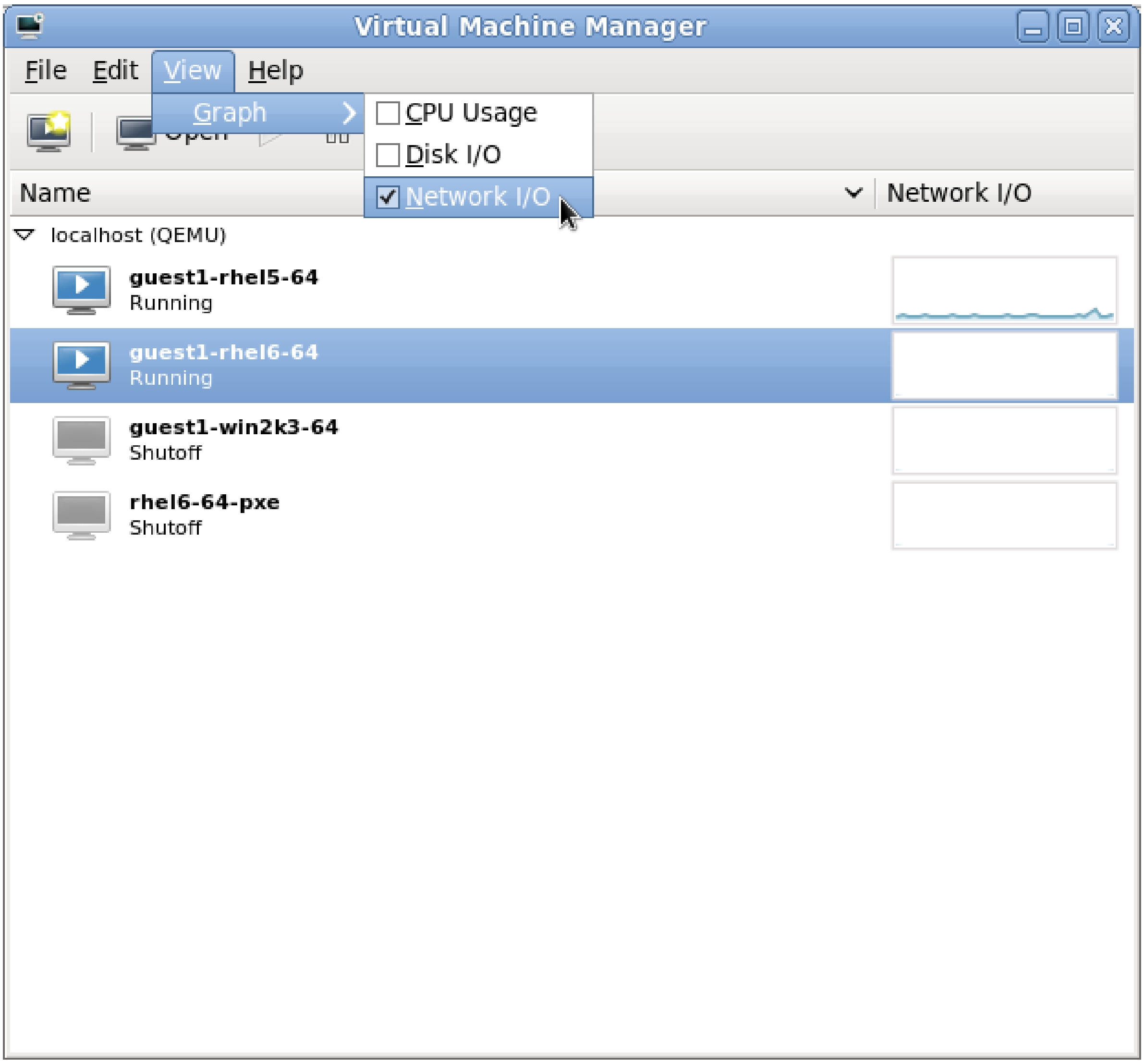


Figure 31.21. Selecting Network I/O

2. The Virtual Machine Manager shows a graph of Network I/O for all virtual machines on your system.

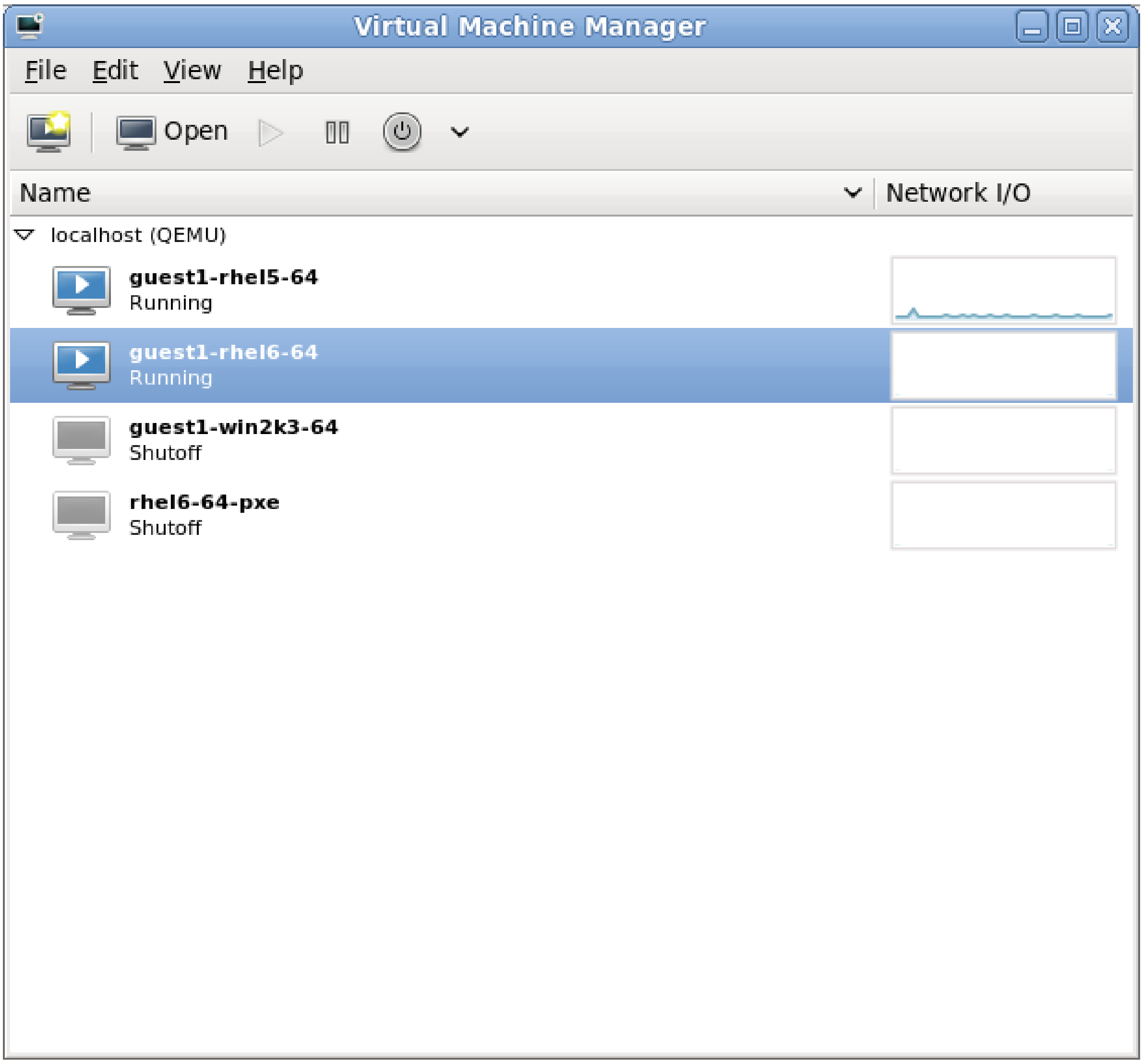


Figure 31.22. Displaying Network I/O

Guest disk access with offline tools

32.1. Introduction

Red Hat Enterprise Linux 6 comes with tools to access, edit and create guest disks or other disk images. There are several uses for these tools, including:

- Viewing or downloading files located on a guest disk.
- Editing or uploading files onto a guest disk.
- Reading or writing guest configuration.
- Reading or writing the Windows Registry in Windows guests.
- Preparing new disk images containing files, directories, file systems, partitions, logical volumes and other options.
- Rescuing and repairing guests that fail to boot or those that need boot configuration changes.
- Monitoring disk usage of guests.
- Auditing compliance of guests, for example to organizational security standards.
- Deploying guests by cloning and modifying templates.
- Reading CD and DVD ISO and floppy disk images.

Warning

You must **never** use these tools to write to a guest or disk image which is attached to a running virtual machine, not even to open such a disk image in write mode. Doing so will result in disk corruption of the guest. The tools try to prevent you from doing this, however do not catch all cases. If there is any suspicion that a guest might be running, it is strongly recommended that the tools not be used, or at least **always** use the tools in read-only mode.

32.2. Terminology

This section explains the terms used throughout this chapter.

- **libguestfs (GUEST FileSystem LIBrary) -** the underlying C library that provides the basic functionality for opening disk images, reading and writing files and so on. You can write C programs directly to this API, but it is quite low level.
- **guestfish (GUEST Filesystem Interactive SHell)** is an interactive shell that you can use from the command line or from shell scripts. It exposes all of the functionality of the libguestfs API.
- Various virt tools are built on top of libguestfs, and these provide a way to perform specific single tasks from the command line. Tools include **virt-df**, **virt-rescue**, **virt-resize** and **virt-edit**.
- **hivex** and **Augeas** are libraries for editing the Windows Registry and Linux configuration files respectively. Although these are separate from libguestfs, much of the value of libguestfs comes from the combination of these tools.

- **guestmount** is an interface between libguestfs and FUSE. It is primarily used to mount file systems from disk images on your host. This functionality is not necessary, but can be useful.

32.3. Installation

To install libguestfs, guestfish, the libguestfs tools, guestmount and support for Windows guests, run the following command:

```
# yum install libguestfs guestfish libguestfs-tools libguestfs-mount libguestfs-winsupport
```

To install every libguestfs-related package including the language bindings, run the following command:

```
# yum install '*guestf*'
```

32.4. The guestfish shell

guestfish is an interactive shell that you can use from the command line or from shell scripts to access guest file systems. All of the functionality of the libguestfs API is available from the shell.

To begin viewing or editing a virtual machine disk image, run the following command, substituting the path to your desired disk image:

```
guestfish --ro -a /path/to/disk/image
```

--ro means that the disk image is opened read-only. This mode is always safe but does not allow write access. Only omit this option when you are **certain** that the guest is not running, or the disk image is not attached to a live guest. It is not possible to use libguestfs to edit a live guest, and attempting to will assuredly result in irreversible disk corruption.

/path/to/disk/image is the path to the disk. This can be a file, a host logical volume (such as /dev/VG/LV), a host device (/dev/cdrom) or a SAN LUN (/dev/sdf3).

Note

libguestfs and guestfish do not require root privileges. You only need to run them as root if the disk image being accessed needs root to read and/or write.

When you start guestfish interactively, it will display this prompt:

```
 guestfish --ro -a /path/to/disk/image

Welcome to guestfish, the libguestfs filesystem interactive shell for editing virtual machine
 filesystems.

 Type: 'help' for help on commands
       'man' to read the manual
       'quit' to quit the shell
```

```
><fs>
```

At the prompt, type **run** to initiate the library and attach the disk image. This can take up to 30 seconds the first time it is done. Subsequent starts will complete much faster.

Note

libguestfs will use hardware virtualization acceleration such as KVM (if available) to speed up this process.

Once the **run** command has been entered, other commands can be used, as the following section demonstrates.

32.4.1. Viewing file systems with guestfish

32.4.1.1. Manual listing and viewing

The **`list-filesystems`** command will list file systems found by libguestfs. This output shows a Red Hat Enterprise Linux 4 disk image:

```
><fs> run
><fs> list-filesystems
/dev/vda1: ext3
/dev/VolGroup00/LogVol00: ext3
/dev/VolGroup00/LogVol01: swap
```

This output shows a Windows disk image:

```
><fs> run
><fs> list-filesystems
/dev/vda1: ntfs
/dev/vda2: ntfs
```

Other useful commands are **`list-devices`**, **`list-partitions`**, **`lvs`**, **`pvs`**, **`vfs-type`** and **`file`**. You can get more information and help on any command by typing **`help`** *command*, as shown in the following output:

```
><fs> help vfs-type
 NAME
    vfs-type - get the Linux VFS type corresponding to a mounted device

 SYNOPSIS
     vfs-type device

 DESCRIPTION
    This command gets the filesystem type corresponding to the filesystem on
    "device".

    For most filesystems, the result is the name of the Linux VFS module
    which would be used to mount this filesystem if you mounted it without
    specifying the filesystem type. For example a string such as "ext3" or
```

```
    "ntfs".
```

To view the actual contents of a file system, it must first be mounted. This example uses one of the Windows partitions shown in the previous output (**/dev/vda2**), which in this case is known to correspond to the **C:** drive:

```
><fs> mount-ro /dev/vda2 /
><fs> ll /
total 1834753
 drwxrwxrwx  1 root root       4096 Nov  1 11:40 .
 drwxr-xr-x 21 root root       4096 Nov 16 21:45 ..
 lrwxrwxrwx  2 root root         60 Jul 14  2009 Documents and Settings
 drwxrwxrwx  1 root root       4096 Nov 15 18:00 Program Files
 drwxrwxrwx  1 root root       4096 Sep 19 10:34 Users
 drwxrwxrwx  1 root root      16384 Sep 19 10:34 Windows
```

You can use guestfish commands such as **ls**, **ll**, **cat**, **more**, **download** and **tar-out** to view and download files and directories.

Note

There is no concept of a current working directory in this shell. Unlike ordinary shells, you can not for example use the **cd** command to change directories. All paths must be fully qualified starting at the top with a forward slash (**/**) character. Use the *Tab* key to complete paths.

To exit from the guestfish shell, type **exit** or enter **Ctrl+d**.

32.4.1.2. Via guestfish inspection

Instead of listing and mounting file systems by hand, it is possible to let guestfish itself inspect the image and mount the file systems as they would be in the guest. To do this, add the **-i** option on the command line:

```
guestfish --ro -a /path/to/disk/image -i

Welcome to guestfish, the libguestfs filesystem interactive shell for
 editing virtual machine filesystems.

 Type: 'help' for help on commands
       'man' to read the manual
       'quit' to quit the shell

 Operating system: Red Hat Enterprise Linux AS release 4 (Nahant Update 8)
 /dev/VolGroup00/LogVol00 mounted on /
 /dev/vda1 mounted on /boot

 ><fs> ll /
 total 210
 drwxr-xr-x. 24 root root  4096 Oct 28 09:09 .
 drwxr-xr-x  21 root root  4096 Nov 17 15:10 ..
 drwxr-xr-x.  2 root root  4096 Oct 27 22:37 bin
 drwxr-xr-x.  4 root root  1024 Oct 27 21:52 boot
 drwxr-xr-x.  4 root root  4096 Oct 27 21:21 dev
 drwxr-xr-x. 86 root root 12288 Oct 28 09:09 etc
 [etc]
```

Because guestfish needs to start up the libguestfs back end in order to perform the inspection and mounting, the **run** command is not necessary when using the **-i** option. The **-i** option works for many common Linux and Windows guests.

32.4.1.3. Accessing a guest by name

A guest can be accessed from the command line when you specify its name as known to libvirt (in other words, as it appears in **virsh list --all**). Use the **-d** option to access a guest by its name, with or without the **-i** option:

```
guestfish --ro -d GuestName -i
```

32.4.2. Modifying files with guestfish

To modify files, create directories or make other changes to a guest, first heed the warning at the beginning of this section: *your guest must be shut down*. Editing or changing a running disk with guestfish **will** result in disk corruption. This section gives an example of editing the **/boot/grub/grub.conf** file. When you are sure the guest is shut down you can omit the **--ro** flag in order to get write access via a command such as:

```
guestfish -d RHEL3 -i

Welcome to guestfish, the libguestfs filesystem interactive shell for
 editing virtual machine filesystems.

 Type: 'help' for help on commands
       'man' to read the manual
       'quit' to quit the shell

 Operating system: Red Hat Enterprise Linux AS release 3 (Taroon Update 9)
 /dev/vda2 mounted on /
 /dev/vda1 mounted on /boot

><fs> edit /boot/grub/grub.conf
```

Commands to edit files include **edit**, **vi** and **emacs**. Many commands also exist for creating files and directories, such as **write**, **mkdir**, **upload** and **tar-in**.

32.4.3. Other actions with guestfish

You can also format file systems, create partitions, create and resize LVM logical volumes and much more, with commands such as **mkfs**, **part-add**, **lvresize**, **lvcreate**, **vgcreate** and **pvcreate**.

32.4.4. Shell scripting with guestfish

Once you are familiar with using guestfish interactively, according to your needs, writing shell scripts with it may be useful. The following is a simple shell script to add a new MOTD (message of the day) to a guest:

```
#!/bin/bash -
 set -e
 guestname="$1"

 guestfish -d "$guestname" -i <<'EOF'
```

```
   write /etc/motd "Welcome to Acme Incorporated."
   chmod 0644 /etc/motd
 EOF
```

32.4.5. Augeas and libguestfs scripting

Combining libguestfs with Augeas can help when writing scripts to manipulate Linux guest configuration. For example, the following script uses Augeas to parse the keyboard configuration of a guest, and to print out the layout. Note that this example only works with guests running Red Hat Enterprise Linux:

```
#!/bin/bash -
 set -e
 guestname="$1"

 guestfish -d "$1" -i --ro <<'EOF'
   aug-init / 0
   aug-get /files/etc/sysconfig/keyboard/LAYOUT
 EOF
```

Augeas can also be used to modify configuration files. You can modify the above script to **change** the keyboard layout:

```
#!/bin/bash -
 set -e
 guestname="$1"

 guestfish -d "$1" -i <<'EOF'
   aug-init / 0
   aug-set /files/etc/sysconfig/keyboard/LAYOUT '"gb"'
   aug-save
 EOF
```

Note the three changes between the two scripts:

1. The **`--ro`** option has been removed in the second example, giving the ability to write to the guest.
2. The **`aug-get`** command has been changed to **`aug-set`** to modify the value instead of fetching it. The new value will be **`"gb"`** (including the quotes).
3. The **`aug-save`** command is used here so Augeas will write the changes out to disk.

Note

More information about Augeas can be found on the website *http://augeas.net*.

guestfish can do much more than we can cover in this introductory document. For example, creating disk images from scratch:

```
guestfish -N fs
```

Or copying out whole directories from a disk image:

```
><fs> copy-out /home /tmp/home
```

For more information see the man page guestfish(1).

32.5. Other commands

This section describes tools that are simpler equivalents to using guestfish to view and edit guest disk images.

- **`virt-cat`** is similar to the guestfish **`download`** command. It downloads and displays a single file to the guest. For example:

  ```
  $ virt-cat RHEL3 /etc/ntp.conf | grep ^server
   server     127.127.1.0       # local clock
  ```

- **`virt-edit`** is similar to the guestfish **`edit`** command. It can be used to interactively edit a single file within a guest. For example, you may need to edit the **`grub.conf`** file in a Linux-based guest that will not boot:

  ```
  $ virt-edit LinuxGuest /boot/grub/grub.conf
  ```

  `virt-edit` has another mode where it can be used to make simple non-interactive changes to a single file. For this, the **-e** option is used. This command, for example, changes the root password in a Linux guest to having no password:

  ```
  $ virt-edit LinuxGuest /etc/passwd -e 's/^root:.*?:/root::/'
  ```

- **`virt-ls`** is similar to the guestfish **`ls`**, **`ll`** and **`find`** commands. It is used to list a directory or directories (recursively). For example, the following command would recursively list files and directories under /home in a Linux guest:

  ```
  $ virt-ls -R LinuxGuest /home/ | less
  ```

32.6. virt-rescue: The rescue shell

32.6.1. Introduction

This section describes **`virt-rescue`**, which can be considered analogous to a rescue CD for virtual machines. It boots a guest into a rescue shell so that maintenance can be performed to correct errors and the guest can be repaired.

There is some overlap between virt-rescue and guestfish. It is important to distinguish their differing uses. virt-rescue is for making interactive, ad-hoc changes using ordinary Linux file system tools. It is particularly suited to rescuing a guest that has gone wrong. virt-rescue cannot be scripted.

In contrast, guestfish is particularly useful for making scripted, structured changes through a formal set of commands (the libguestfs API), although it can also be used interactively.

32.6.2. Running virt-rescue

Before you use **`virt-rescue`** on a guest, make sure the guest is not running, otherwise disk corruption will occur. When you are sure the guest is not live, enter:

```
virt-rescue GuestName
```

(where GuestName is the guest name as known to libvirt), or:

```
virt-rescue /path/to/disk/image
```

(where the path can be any file, any logical volume, LUN, or so on) containing a guest disk.

You will first see output scroll past, as virt-rescue boots the rescue VM. In the end you will see:

```
Welcome to virt-rescue, the libguestfs rescue shell.

 Note: The contents of / are the rescue appliance.
 You have to mount the guest's partitions under /sysroot
 before you can examine them.

 bash: cannot set terminal process group (-1): Inappropriate ioctl for device
 bash: no job control in this shell
 ><rescue>
```

The shell prompt here is an ordinary bash shell, and a reduced set of ordinary Red Hat Enterprise Linux commands is available. For example, you can enter:

```
><rescue> fdisk -l /dev/vda
```

The previous command will list disk partitions. To mount a file system, it is suggested that you mount it under **`/sysroot`**, which is an empty directory in the rescue machine for the user to mount anything you like. Note that the files under **`/`** are files from the rescue VM itself:

```
><rescue> mount /dev/vda1 /sysroot/
EXT4-fs (vda1): mounted filesystem with ordered data mode. Opts: (null)
><rescue> ls -l /sysroot/grub/
 total 324
 -rw-r--r--. 1 root root     63 Sep 16 18:14 device.map
 -rw-r--r--. 1 root root  13200 Sep 16 18:14 e2fs_stage1_5
 -rw-r--r--. 1 root root  12512 Sep 16 18:14 fat_stage1_5
 -rw-r--r--. 1 root root  11744 Sep 16 18:14 ffs_stage1_5
 -rw-------. 1 root root   1503 Oct 15 11:19 grub.conf
 [...]
```

When you are finished rescuing the guest, exit the shell by entering **`exit`** or **`Ctrl+d`**.

`virt-rescue` has many command line options. The options most often used are:

- **--ro**: Operate in read-only mode on the guest. No changes will be saved. You can use this to experiment with the guest. As soon as you exit from the shell, all of your changes are discarded.
- **--network**: Enable network access from the rescue shell. Use this if you need to, for example, download RPM or other files into the guest.

32.7. virt-df: Monitoring disk usage

32.7.1. Introduction

This section describes **virt-df**, which displays file system usage from a disk image or a guest. It is similar to the Linux **df** command, but for virtual machines.

32.7.2. Running virt-df

To display file system usage for all file systems found in a disk image, enter the following:

```
# virt-df /dev/vg_guests/RHEL4
 Filesystem                   1K-blocks       Used  Available  Use%
 RHEL4:/dev/sda1                 101086      10233      85634   11%
 RHEL4:/dev/VolGroup00/LogVol00 7127864    2272744    4493036   32%
```

(Where **/dev/vg_guests/RHEL4** is a Red Hat Enterprise Linux 4 guest disk image. The path in this case is the host logical volume where this disk image is located.)

You can also use **virt-df** on its own to list information about all of your guests (ie. those known to libvirt). The **virt-df** command recognizes some of the same options as the standard **df** such as **-h** (human-readable) and **-i** (show inodes instead of blocks).

virt-df also works on Windows guests:

```
# virt-df -h
 Filesystem                       Size       Used  Available  Use%
 F14x64:/dev/sda1               484.2M      66.3M     392.9M   14%
 F14x64:/dev/vg_f14x64/lv_root    7.4G       3.0G       4.4G   41%
 RHEL6brewx64:/dev/sda1         484.2M      52.6M     406.6M   11%
 RHEL6brewx64:/dev/vg_rhel6brewx64/lv_root
                                 13.3G       3.4G       9.2G   26%
 Win7x32:/dev/sda1              100.0M      24.1M      75.9M   25%
 Win7x32:/dev/sda2       19.9G      7.4G      12.5G   38%
```

> **Note**
>
> You can use **virt-df** safely on live guests, since it only needs read-only access. However, you should not expect the numbers to be precisely the same as those from a **df** command running inside the guest. This is because what is on disk will be slightly out of synch with the state of the live guest. Nevertheless it should be a good enough approximation for analysis and monitoring purposes.

virt-df is designed to allow you to integrate the statistics into monitoring tools, databases and so on. This allows system administrators to generate reports on trends in disk usage, and alerts if a guest is about to run out of disk space. To do this you should use the **--csv** option to generate machine-readable Comma-Separated-Values (CSV) output. CSV output is readable by most databases, spreadsheet software and a variety of other tools and programming languages. The raw CSV looks like the following:

```
# virt-df --csv WindowsGuest
 Virtual Machine,Filesystem,1K-blocks,Used,Available,Use%
```

```
Win7x32,/dev/sda1,102396,24712,77684,24.1%
Win7x32,/dev/sda2,20866940,7786652,13080288,37.3%
```

For resources and ideas on how to process this output to produce trends and alerts, refer to the following URL: *http://virt-tools.org/learning/advanced-virt-df/*.

32.8. virt-resize: resizing guests offline

32.8.1. Introduction

This section describes **virt-resize**, a tool for expanding or shrinking guests. It only works for guests which are offline (shut down). It works by copying the guest image and leaving the original disk image untouched. This is ideal because you can use the original image as a backup, however there is a trade-off as you need twice the amount of disk space.

32.8.2. Expanding a disk image

This section demonstrates a simple case of expanding a disk image:

1. Locate the disk image to be resized. You can use the command **virsh dumpxml GuestName** for a libvirt guest.

2. Decide on how you wish to expand the guest. Run **virt-df -h** and **virt-list-partitions -lh** on the guest disk, as shown in the following output:

```
# virt-df -h /dev/vg_guests/RHEL4
Filesystem                      Size       Used  Available  Use%
RHEL4:/dev/sda1                98.7M      10.0M      83.6M   11%
RHEL4:/dev/VolGroup00/LogVol00  6.8G       2.2G       4.3G   32%

# virt-list-partitions -lh /dev/vg_guests/RHEL4
/dev/sda1 ext3 101.9M
/dev/sda2 pv 7.9G
```

This example will demonstrate how to:

- Increase the size of the first (boot) partition, from approximately 100MB to 500MB.
- Increase the total disk size from 8GB to 16GB.
- Expand the second partition to fill the remaining space.
- Expand **/dev/VolGroup00/LogVol00** to fill the new space in the second partition.

1. Make sure the guest is shut down.

2. Rename the original disk as the backup. How you do this depends on the host storage environment for the original disk. If it is stored as a file, use the **mv** command. For logical volumes (as demonstrated in this example), use **lvrename**:

```
# lvrename /dev/vg_guests/RHEL4 /dev/vg_guests/RHEL4.backup
```

3. Create the new disk. The requirements in this example are to expand the total disk size up to 16GB. Since logical volumes are used here, the following command is used:

```
# lvcreate -L 16G -n RHEL4 /dev/vg_guests
Logical volume "RHEL4" created
```

4. The requirements from step 2 are expressed by this command:

```
# virt-resize \
       /dev/vg_guests/RHEL4.backup /dev/vg_guests/RHEL4 \
       --resize /dev/sda1=500M \
       --expand /dev/sda2 \
       --LV-expand /dev/VolGroup00/LogVol00
```

   The first two arguments are the input disk and output disk. **`--resize /dev/sda1=500M`** resizes the first partition up to 500MB. **`--expand /dev/sda2`** expands the second partition to fill all remaining space. **`--LV-expand /dev/VolGroup00/LogVol00`** expands the guest logical volume to fill the extra space in the second partition.

   `virt-resize` describes what it is doing in the output:

```
Summary of changes:
   /dev/sda1: partition will be resized from 101.9M to 500.0M
   /dev/sda1: content will be expanded using the 'resize2fs' method
   /dev/sda2: partition will be resized from 7.9G to 15.5G
   /dev/sda2: content will be expanded using the 'pvresize' method
   /dev/VolGroup00/LogVol00: LV will be expanded to maximum size
   /dev/VolGroup00/LogVol00: content will be expanded using the 'resize2fs' method
   Copying /dev/sda1 ...
   [#####################################################]
   Copying /dev/sda2 ...
   [#####################################################]
   Expanding /dev/sda1 using the 'resize2fs' method
   Expanding /dev/sda2 using the 'pvresize' method
   Expanding /dev/VolGroup00/LogVol00 using the 'resize2fs' method
```

5. Try to boot the virtual machine. If it works (and after testing it thoroughly) you can delete the backup disk. If it fails, shut down the virtual machine, delete the new disk, and rename the backup disk back to its original name.

6. Use **`virt-df`** and/or **`virt-list-partitions`** to show the new size:

```
# virt-df -h /dev/vg_pin/RHEL4
   Filesystem                      Size       Used  Available  Use%
   RHEL4:/dev/sda1               484.4M      10.8M     448.6M    3%
   RHEL4:/dev/VolGroup00/LogVol00 14.3G       2.2G      11.4G   16%
```

Resizing guests is not an exact science. If **`virt-resize`** fails, there are a number of tips that you can review and attempt in the virt-resize(1) man page. For some older Red Hat Enterprise Linux guests, you may need to pay particular attention to the tip regarding GRUB.

32.9. virt-inspector: inspecting guests

32.9.1. Introduction

`virt-inspector` is a tool for inspecting a disk image to find out what operating system it contains.

> **Note**
>
> Red Hat Enterprise Linux 6.1 ships with two variations of this progam: **`virt-inspector`** is the original program as found in Red Hat Enteprise Linux 6.0 and is now deprecated upstream. **`virt-inspector2`** is the same as the new upsteam **`virt-inspector`** program.

32.9.2. Installation

To install virt-inspector and the documentation, enter the following command:

```
# yum install libguestfs-tools libguestfs-devel
```

To process Windows guests you must also install *libguestfs-winsupport*. The documentation, including example XML output and a Relax-NG schema for the output, will be installed in **`/usr/share/doc/libguestfs-devel-*/`** where "*" is replaced by the version number of libguestfs.

32.9.3. Running virt-inspector

You can run **`virt-inspector`** against any disk image or libvirt guest as shown in the following example:

```
virt-inspector --xml disk.img > report.xml
```

Or as shown here:

```
virt-inspector --xml GuestName > report.xml
```

The result will be an XML report (**`report.xml`**). The main components of the XML file are a top-level <operatingsytems> element containing usually a single <operatingsystem> element, similar to the following:

```
<operatingsystems>
  <operatingsystem>

    <!-- the type of operating system and Linux distribution -->
    <name>linux</name>
    <distro>fedora</distro>

    <!-- the name, version and architecture -->
    <product_name>Fedora release 12 (Constantine)</product_name>
    <major_version>12</major_version>
    <arch>x86_64</arch>
```

```
    <!-- how the filesystems would be mounted when live -->
    <mountpoints>
      <mountpoint dev="/dev/vg_f12x64/lv_root">/</mountpoint>
      <mountpoint dev="/dev/sda1">/boot</mountpoint>
    </mountpoints>

    <!-- the filesystems -->
    <filesystems>
      <filesystem dev="/dev/sda1">
        <type>ext4</type>
      </filesystem>
      <filesystem dev="/dev/vg_f12x64/lv_root">
        <type>ext4</type>
      </filesystem>
      <filesystem dev="/dev/vg_f12x64/lv_swap">
        <type>swap</type>
      </filesystem>
    </filesystems>

    <!-- packages installed -->
    <applications>
      <application>
        <name>firefox</name>
        <version>3.5.5</version>
        <release>1.fc12</release>
      </application>
    </applications>

  </operatingsystem>
</operatingsystems>
```

Processing these reports is best done using W3C standard XPath queries. Red Hat Enterprise Linux 6.1 comes with a command line program (**`xpath`**) which can be used for simple instances; however, for long-term and advanced usage, you should consider using an XPath library along with your favorite programming language.

As an example, you can list out all file system devices using the following XPath query:

```
virt-inspector --xml GuestName | xpath //filesystem/@dev
 Found 3 nodes:
 -- NODE --
 dev="/dev/sda1"
 -- NODE --
 dev="/dev/vg_f12x64/lv_root"
 -- NODE --
 dev="/dev/vg_f12x64/lv_swap"
```

Or list the names of all applications installed by entering:

```
virt-inspector --xml GuestName | xpath //application/name
[...long list...]
```

The version of virt-inspector in Red Hat Enterprise Linux 6.1 has a number of shortcomings. It has limited support for Windows guests and the XML output is over-complicated for Linux guests. These limitations will addressed in future releases.

32.10. virt-win-reg: Reading and editing the Windows Registry

32.10.1. Introduction

virt-win-reg is a tool that manipulates the Registry in Windows guests. It can be used to read out registry keys. You can also use it to make changes to the Registry, but you must **never** try to do this for live/running guests, as it will result in disk corruption.

32.10.2. Installation

To use **virt-win-reg** you must run the following:

```
# yum install libguestfs-tools libguestfs-winsupport
```

32.10.3. Using virt-win-reg

To read out Registry keys, specify the name of the guest (or its disk image) and the name of the Registry key. You must use single quotes to surround the name of the desired key:

```
# virt-win-reg WindowsGuest \
    'HKEY_LOCAL_MACHINE\Software\Microsoft\Windows\CurrentVersion\Uninstall' \
    | less
```

The output is in the standard text-based format used by **.REG** files on Windows.

Note

Hex-quoting is used for strings because the format does not properly define a portable encoding method for strings. This is the only way to ensure fidelity when transporting **.REG** files from one machine to another.

You can make hex-quoted strings printable by piping the output of **virt-win-reg** through this simple Perl script:

```
perl -MEncode -pe's?hex\((\d+)\):(\S+)?$t=$1;$_=$2;s,\,,,g;"str($t):
\"".decode(utf16le=>pack("H*",$_))."\""?eg'
```

To merge changes into the Windows Registry of an offline guest, you must first prepare a **.REG** file. There is a great deal of documentation about doing this available from MSDN, and there is a good summary in the following Wikipedia page: *https://secure.wikimedia.org/wikipedia/en/wiki/Windows_Registry#.REG_files*. When you have prepared a **.REG** file, enter the following:

```
# virt-win-reg --merge WindowsGuest input.reg
```

This will update the registry in the guest.

32.11. Using the API from Programming Languages

The libguestfs API can be used directly from the following languages in Red Hat Enterprise Linux 6.1: C, C++, Perl, Python, Java, Ruby and OCaml.

- To install C and C++ bindings, enter the following command:

  ```
  # yum install libguestfs-devel
  ```

- To install Perl bindings:

  ```
  # yum install 'perl(Sys::Guestfs)'
  ```

- To install Python bindings:

  ```
  # yum install python-libguestfs
  ```

- To install Java bindings:

  ```
  # yum install libguestfs-java libguestfs-java-devel libguestfs-javadoc
  ```

- To install Ruby bindings:

  ```
  # yum install ruby-libguestfs
  ```

- To install OCaml bindings:

  ```
  # yum install ocaml-libguestfs ocaml-libguestfs-devel
  ```

The binding for each language is essentially the same, but with minor syntactic changes. A C statement:

```
guestfs_launch (g);
```

Would appear like the following in Perl:

```
$g->launch ()
```

Or like the following in OCaml:

```
g#launch ()
```

Only the API from C is detailed in this section.

In the C and C++ bindings, you must manually check for errors. In the other bindings, errors are converted into exceptions; the additional error checks shown in the examples below are not necessary for other languages, but conversely you may wish to add code to catch exceptions. Refer to the following list for some points of interest regarding the architecture of the libguestfs API:

- The libguestfs API is synchronous. Each call blocks until it has completed. If you want to make calls asynchronously, you have to create a thread.
- The libguestfs API is not thread safe: each handle should be used only from a single thread, or if you want to share a handle between threads you should implement your own mutex to ensure that two threads cannot execute commands on one handle at the same time.
- You should not open multiple handles on the same disk image. It is permissible if all the handles are read-only, but still not recommended.
- You should not add a disk image for writing if anything else could be using that disk image (eg. a live VM). Doing this will cause disk corruption.
- Opening a read-only handle on a disk image which is currently in use (eg. by a live VM) is possible; however, the results may be unpredictable or inconsistent particularly if the disk image is being heavily written to at the time you are reading it.

32.11.1. Interaction with the API via a C program

Your C program should start by including the <guestfs.h> header file, and creating a handle:

```
#include <stdio.h>
#include <stdlib.h>
#include <guestfs.h>

int
main (int argc, char *argv[])
{
  guestfs_h *g;

  g = guestfs_create ();
  if (g == NULL) {
    perror ("failed to create libguestfs handle");
    exit (EXIT_FAILURE);
   }

   /* ... */

   guestfs_close (g);

   exit (EXIT_SUCCESS);
 }
```

Save this program to a file (**`test.c`**). Compile this program and run it with the following two commands:

```
gcc -Wall test.c -o test -lguestfs
./test
```

At this stage it should print no output. The rest of this section demonstrates an example showing how to extend this program to create a new disk image, partition it, format it with an ext4 file system, and create some files in the file system. The disk image will be called **`disk.img`** and be created in the current directory.

The outline of the program is:

- Create the handle.
- Add disk(s) to the handle.
- Launch the libguestfs back end.
- Create the partition, file system and files.
- Close the handle and exit.

Here is the modified program:

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <fcntl.h>
#include <unistd.h>
#include <guestfs.h>

 int
 main (int argc, char *argv[])
 {
   guestfs_h *g;
   size_t i;

   g = guestfs_create ();
   if (g == NULL) {
     perror ("failed to create libguestfs handle");
     exit (EXIT_FAILURE);
  }

   /* Create a raw-format sparse disk image, 512 MB in size. */
   int fd = open ("disk.img", O_CREAT|O_WRONLY|O_TRUNC|O_NOCTTY, 0666);
   if (fd == -1) {
     perror ("disk.img");
     exit (EXIT_FAILURE);
   }
   if (ftruncate (fd, 512 * 1024 * 1024) == -1) {
     perror ("disk.img: truncate");
     exit (EXIT_FAILURE);
   }
   if (close (fd) == -1) {
     perror ("disk.img: close");
     exit (EXIT_FAILURE);
   }

   /* Set the trace flag so that we can see each libguestfs call. */
   guestfs_set_trace (g, 1);

   /* Set the autosync flag so that the disk will be synchronized
    * automatically when the libguestfs handle is closed.
    */
   guestfs_set_autosync (g, 1);

   /* Add the disk image to libguestfs. */
   if (guestfs_add_drive_opts (g, "disk.img",
         GUESTFS_ADD_DRIVE_OPTS_FORMAT, "raw", /* raw format */
         GUESTFS_ADD_DRIVE_OPTS_READONLY, 0,   /* for write */
         -1 /* this marks end of optional arguments */ )
       == -1)
     exit (EXIT_FAILURE);
```

```
  /* Run the libguestfs back-end. */
  if (guestfs_launch (g) == -1)
    exit (EXIT_FAILURE);

  /* Get the list of devices.  Because we only added one drive
   * above, we expect that this list should contain a single
   * element.
   */
  char **devices = guestfs_list_devices (g);
  if (devices == NULL)
    exit (EXIT_FAILURE);
  if (devices[0] == NULL || devices[1] != NULL) {
    fprintf (stderr,
             "error: expected a single device from list-devices\n");
    exit (EXIT_FAILURE);
  }

  /* Partition the disk as one single MBR partition. */
  if (guestfs_part_disk (g, devices[0], "mbr") == -1)
    exit (EXIT_FAILURE);

  /* Get the list of partitions.  We expect a single element, which
   * is the partition we have just created.
   */
  char **partitions = guestfs_list_partitions (g);
  if (partitions == NULL)
    exit (EXIT_FAILURE);
  if (partitions[0] == NULL || partitions[1] != NULL) {
    fprintf (stderr,
             "error: expected a single partition from list-partitions\n");
    exit (EXIT_FAILURE);
  }

  /* Create an ext4 filesystem on the partition. */
  if (guestfs_mkfs (g, "ext4", partitions[0]) == -1)
    exit (EXIT_FAILURE);

  /* Now mount the filesystem so that we can add files. */
  if (guestfs_mount_options (g, "", partitions[0], "/") == -1)
    exit (EXIT_FAILURE);

  /* Create some files and directories. */
  if (guestfs_touch (g, "/empty") == -1)
    exit (EXIT_FAILURE);

  const char *message = "Hello, world\n";
  if (guestfs_write (g, "/hello", message, strlen (message)) == -1)
    exit (EXIT_FAILURE);

  if (guestfs_mkdir (g, "/foo") == -1)
    exit (EXIT_FAILURE);

  /* This uploads the local file /etc/resolv.conf into the disk image. */
  if (guestfs_upload (g, "/etc/resolv.conf", "/foo/resolv.conf") == -1)
    exit (EXIT_FAILURE);

  /* Because 'autosync' was set (above) we can just close the handle
   * and the disk contents will be synchronized.  You can also do
   * this manually by calling guestfs_umount_all and guestfs_sync.
   */
  guestfs_close (g);

  /* Free up the lists. */
  for (i = 0; devices[i] != NULL; ++i)
    free (devices[i]);
  free (devices);
  for (i = 0; partitions[i] != NULL; ++i)
```

```
    free (partitions[i]);
  free (partitions);

  exit (EXIT_SUCCESS);
}
```

Compile and run this program with the following two commands:

```
gcc -Wall test.c -o test -lguestfs
./test
```

If the program runs to completion successfully then you should be left with a disk image called **`disk.img`**, which you can examine with guestfish:

```
guestfish --ro -a disk.img -m /dev/sda1
><fs> ll /
><fs> cat /foo/resolv.conf
```

By default (for C and C++ bindings only), libguestfs prints errors to stderr. You can change this behavior by setting an error handler. The guestfs(3) man page discusses this in detail.

32.12. Troubleshooting

A test tool is available to check that libguestfs is working. Run the following command after installing libguestfs (root access not required) to test for normal operation:

```
$ libguestfs-test-tool
```

This tool prints a large amount of text to test the operation of libguestfs. If the test is successful, the following text will appear near the end of the output:

```
===== TEST FINISHED OK =====
```

32.13. Where to find further documentation

The primary source for documentation for libguestfs and the tools are the Unix man pages. The API is documented in guestfs(3). guestfish is documented in guestfish(1). The virt tools are documented in their own man pages (eg. virt-df(1)).

Virtual Networking

This chapter introduces the concepts needed to create, start, stop, remove and modify virtual networks with libvirt.

33.1. Virtual network switches

Libvirt virtual networking uses the concept of a *virtual network switch*. A virtual network switch is a software construct that operates on a host server, to which virtual machines (guests) connect. The network traffic for a guest is directed through this switch:

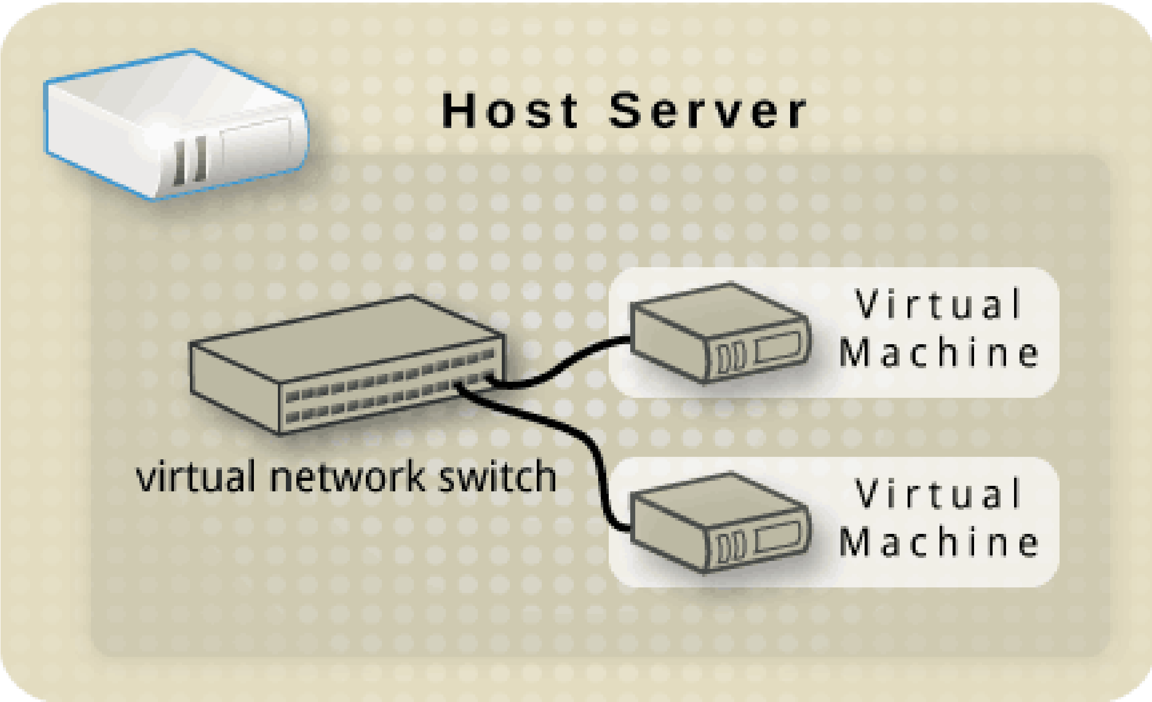


Figure 33.1. Virtual network switch with two guests

Linux host servers represent a virtual network switch as a network interface. When the `libvirt` daemon is first installed and started, the default network interface representing the virtual network switch is **`virbr0`**.

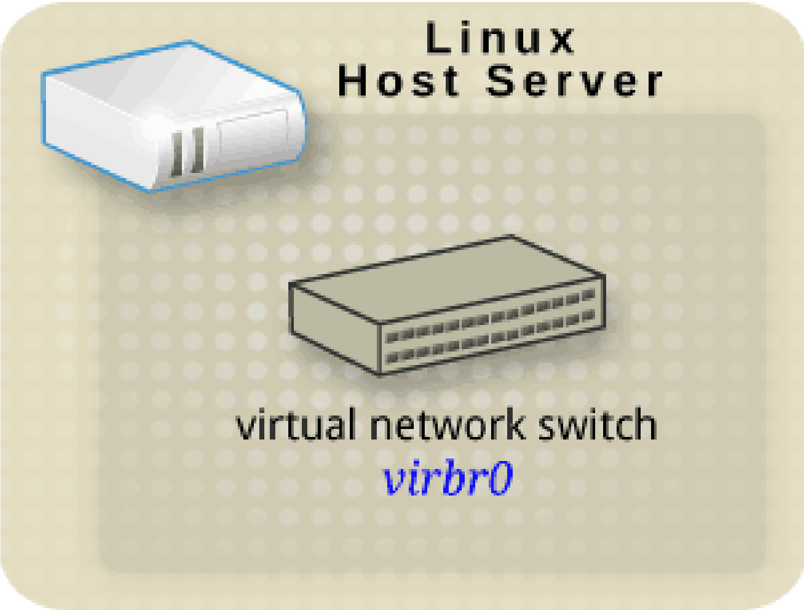


Figure 33.2. Linux host with an interface to a virtual network switch

This **virbr0** interface can be viewed with the **ifconfig** and **ip** commands like any other interface:

```
$ ifconfig virbr0
 virbr0    Link encap:Ethernet  HWaddr 1B:C4:94:CF:FD:17
           inet addr:192.168.122.1  Bcast:192.168.122.255  Mask:255.255.255.0
           UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
           RX packets:0 errors:0 dropped:0 overruns:0 frame:0
           TX packets:11 errors:0 dropped:0 overruns:0 carrier:0
           collisions:0 txqueuelen:0
           RX bytes:0 (0.0 b)  TX bytes:3097 (3.0 KiB)
```

```
 $ 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
```

33.1.1. Network Address Translation

By default, virtual network switches operate in NAT mode. They use IP masquerading rather than SNAT (Source-NAT) or DNAT (Destination-NAT). IP masquerading enables connected guest to use the host IP address for communication to any external network. By default, computers that are placed externally to the host can not communicate to the guests inside when the virtual network switch is operating in NAT mode, as shown in the following diagram:

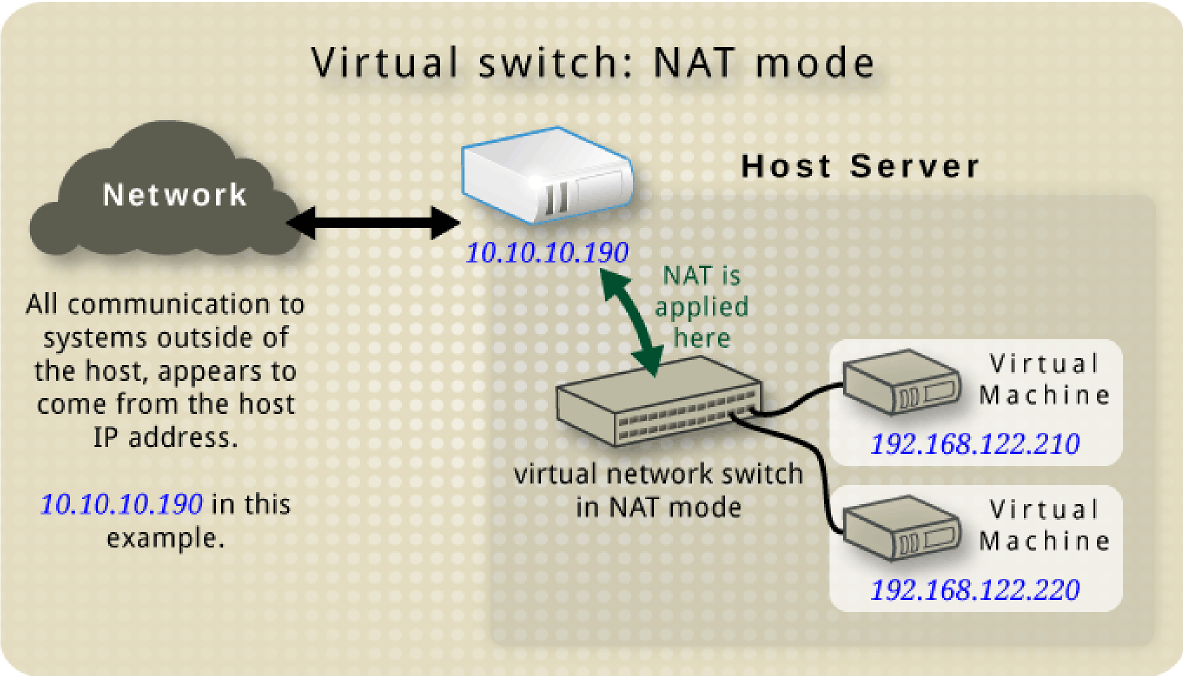


Figure 33.3. Virtual network switch using NAT with two guests

> **Warning**
>
> Virtual network switches use NAT configured by iptables rules. Editing these rules while the switch is running is not recommended, as incorrect rules may result in the switch being unable to communicate.

33.2. DNS and DHCP

IP information can be assigned to guests via DHCP. A pool of addresses can be assigned to a virtual network switch for this purpose. Libvirt uses the **dnsmasq** program for this. An instance of dnsmasq is automatically configured and started by libvirt for each virtual network switch that needs it.

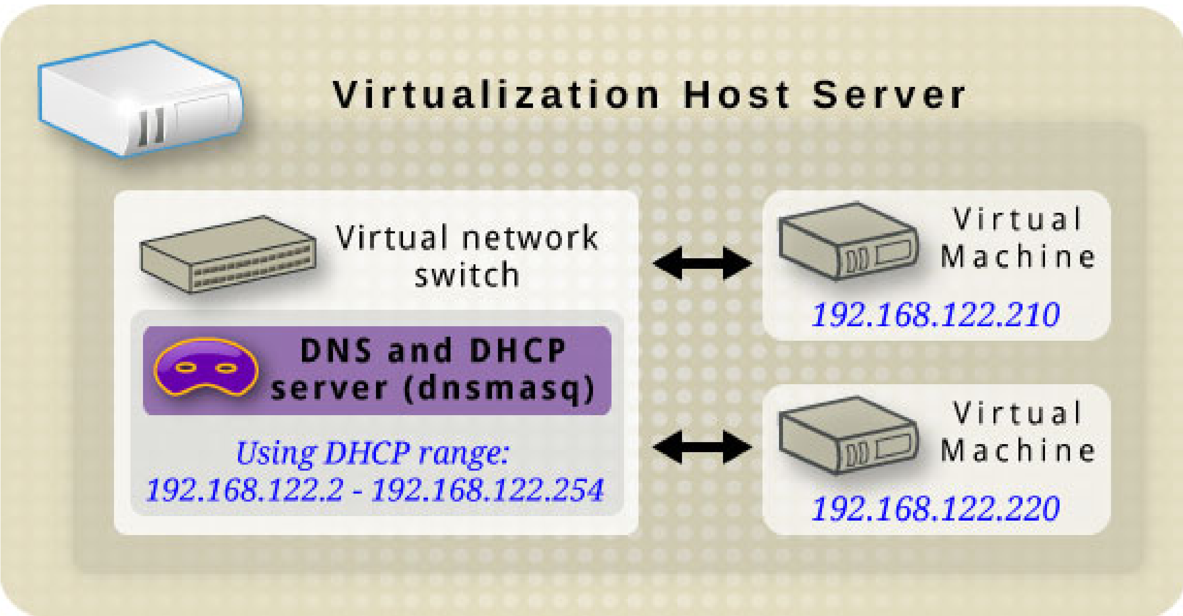


Figure 33.4. Virtual network switch running dnsmasq

33.3. Other virtual network switch routing types

Virtual network switches can operate in two other modes besides NAT, *Routed mode* and *Isolated mode*:

Routed mode

When using *routed mode*, the virtual switch connects to the physical LAN connected to the host, 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, all of the virtual machines are in their own subnet, routed through a virtual switch. This situation is not always ideal as no other hosts on the physical network are aware of the virtual machines without manual physical router configuration, and can not access the virtual machines. Routed mode operates at Layer 3 of the ISO networking model.

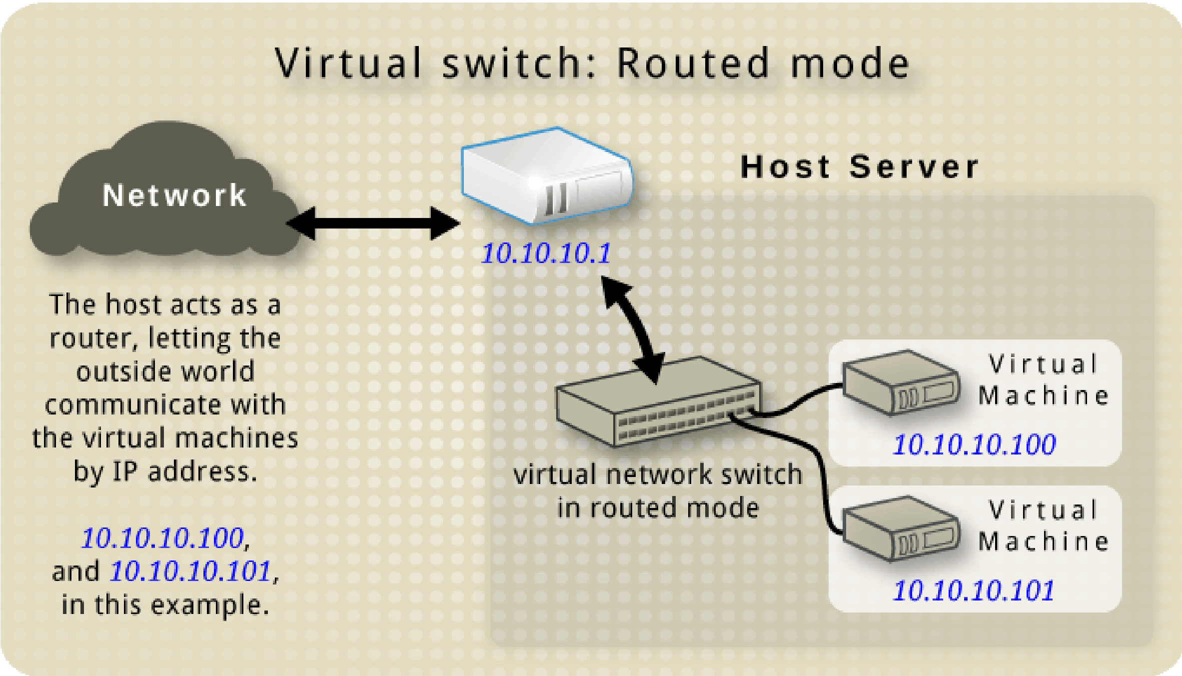


Figure 33.5. Virtual network switch in routed mode

Isolated mode

When using *Isolated mode*, guests guests connected to the virtual switch can communicate with each other, and with the host, but their traffic will not pass outside of the host, nor can they receive traffic from outside the host. Using dnsmasq in this mode is required for basic functionality such as DHCP. However, even if this network is isolated from any physical network, DNS names are still resolved. Therefore a situation can arise when DNS names resolve but ICMP echo request (ping) commands fail.

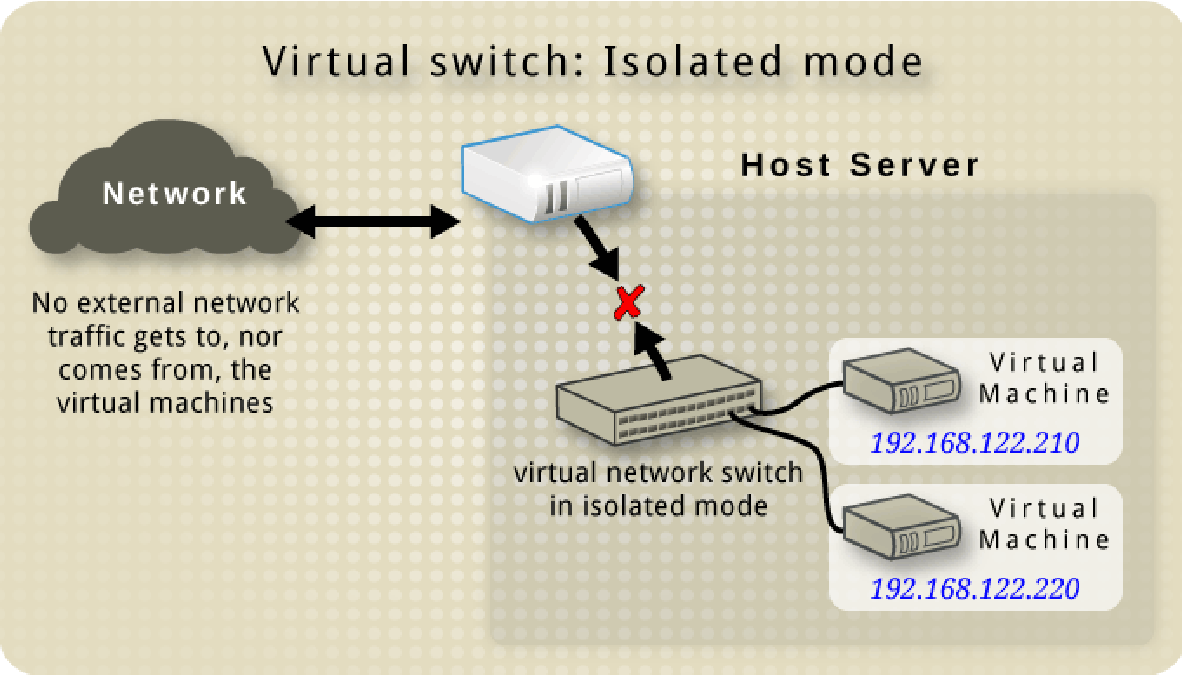


Figure 33.6. Virtual network switch in isolated mode

33.4. The default configuration

When the `libvirtd` daemon is first installed, it contains an initial virtual network switch configuration in NAT mode. This configuration is used so that installed guests can communicate to the external network, through the host. The following image demonstrates this default configuration for `libvirtd`:

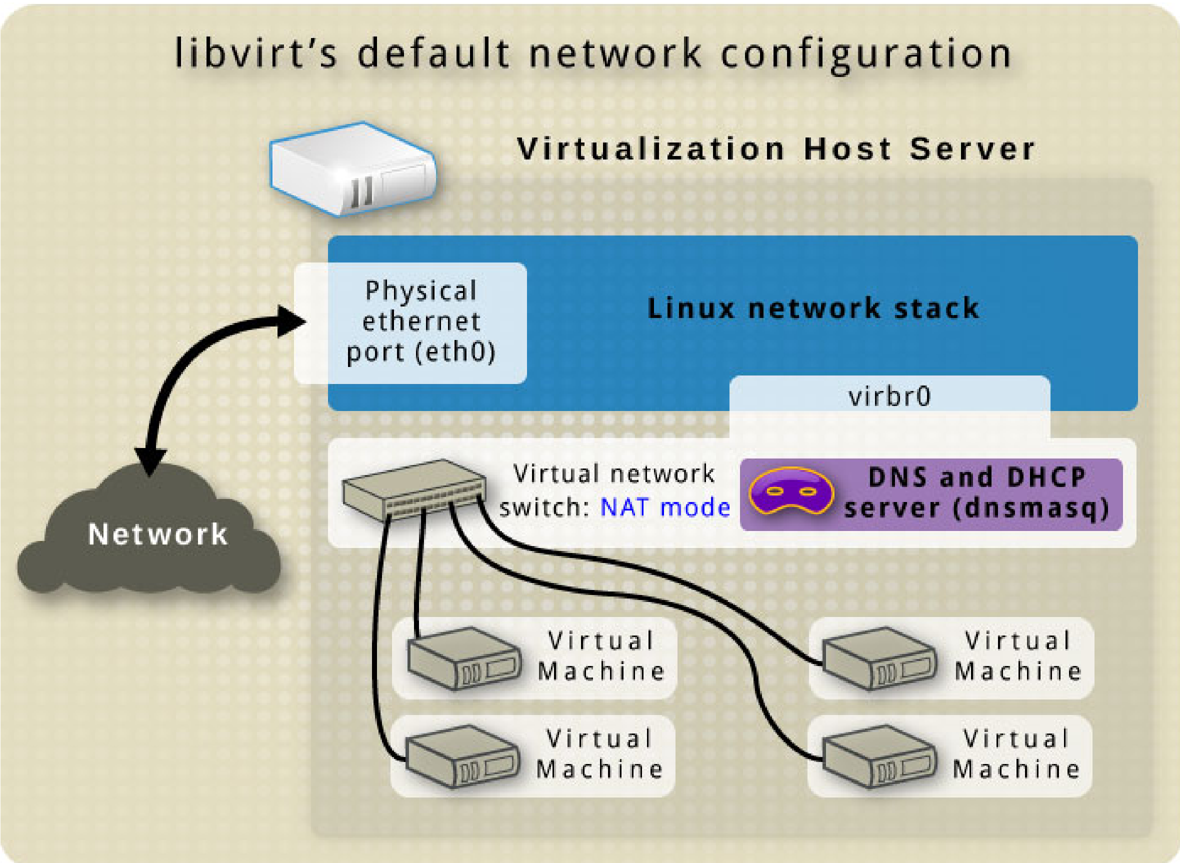


Figure 33.7. Default libvirt network configuration

Restricting virtual network traffic by interface

A virtual network can be restricted to a specific physical interface. This may be useful on a physical system that has several interfaces (for example, **eth0**, **eth1** and **eth2**). This is only useful in routed and NAT modes, and can be defined in the **dev=<interface>** option, or in **virt-manager** when creating a new virtual network.

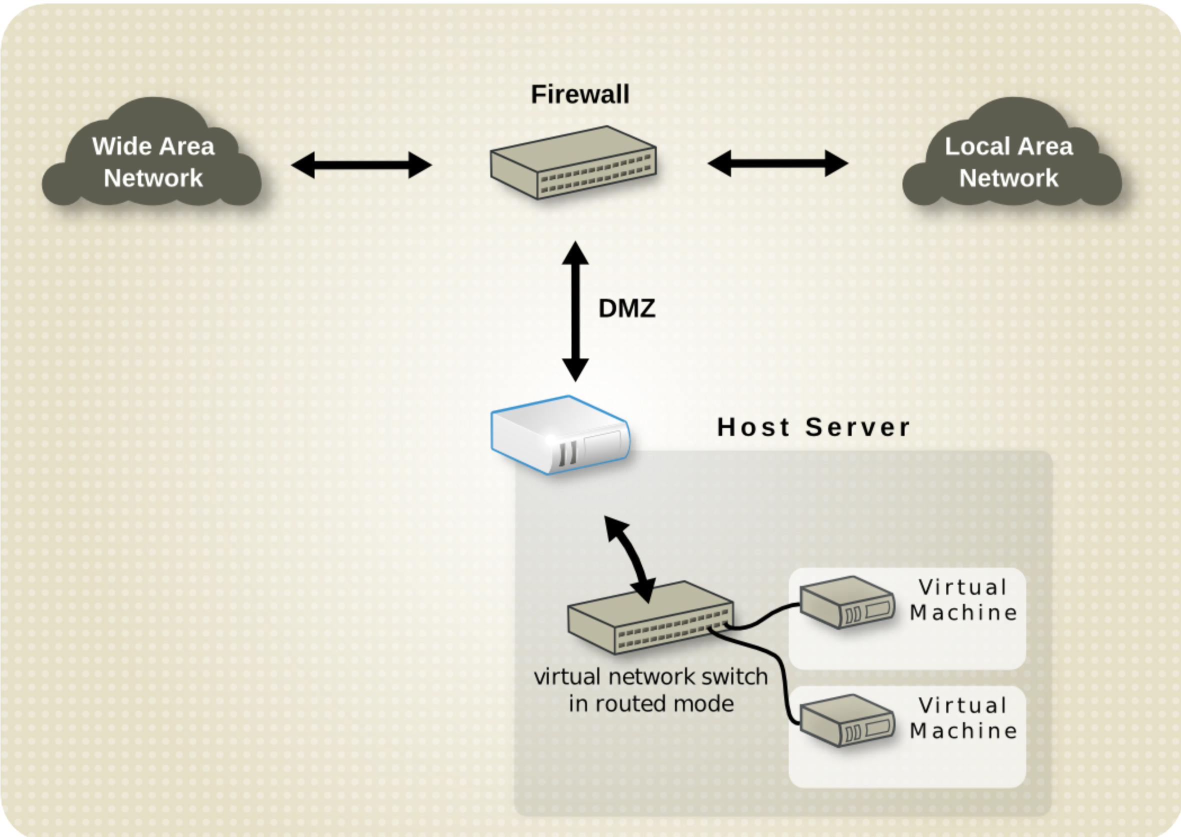
33.5. Examples of common scenarios

This section demonstrates different virtual networking modes and provides some example scenarios.

33.5.1. Routed mode

DMZ

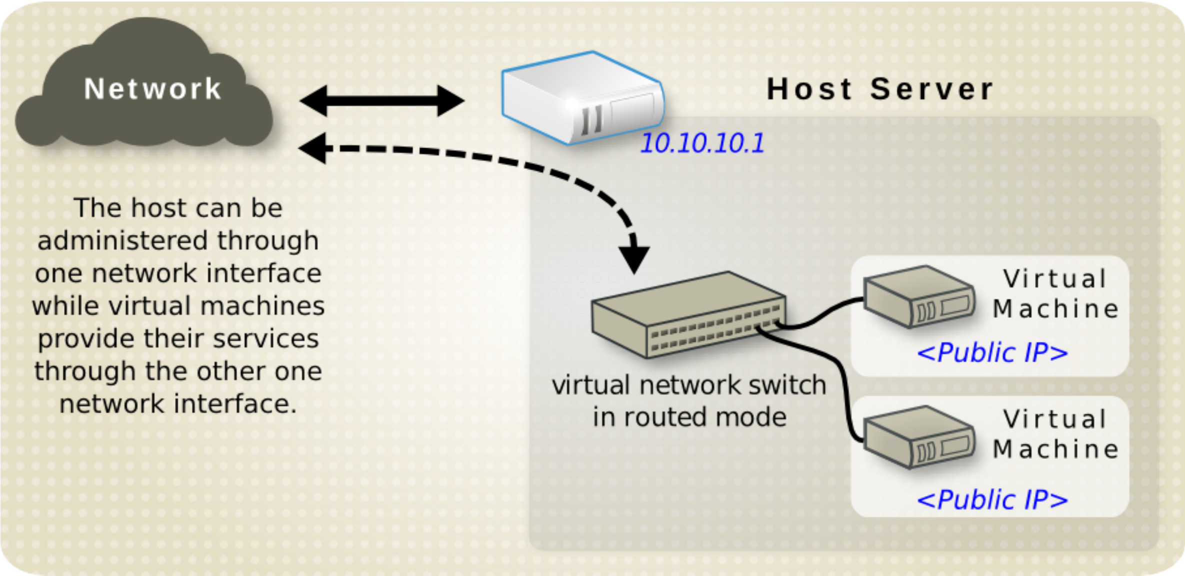
Consider a network where one or more nodes are placed in a controlled subnetwork for security reasons. The deployment of a special subnetwork such as this is a common practice, and the subnetwork is known as a DMZ. Refer to the following diagram for more details on this layout:



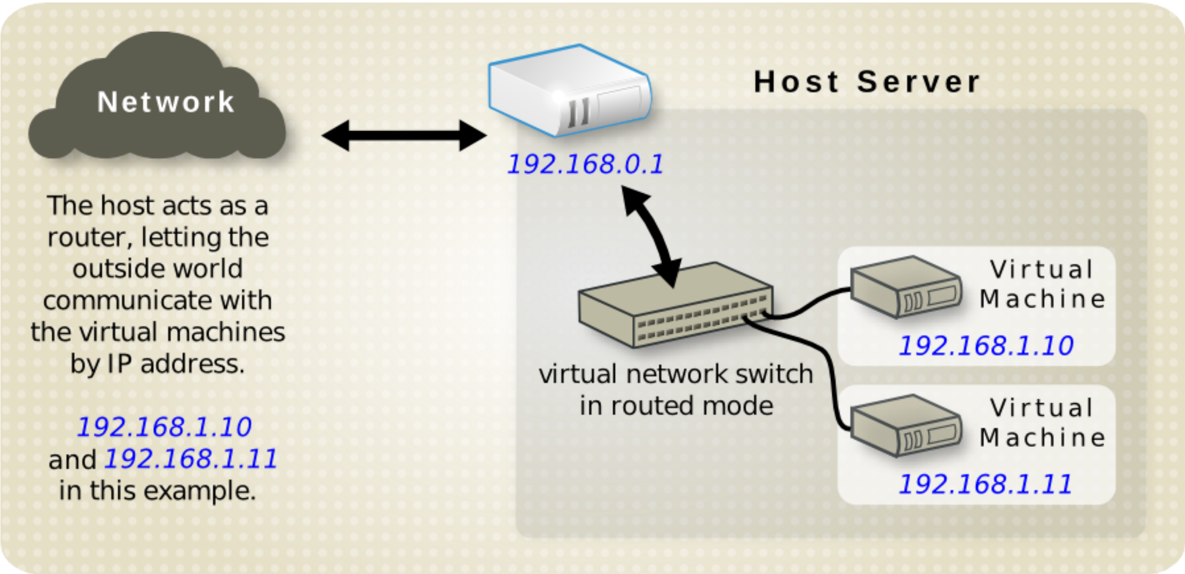
Hosts in a DMZ typically provide services to WAN (external) hosts as well as LAN (internal) hosts. As this requires them to be accessible from multiple locations, and considering that these locations are controlled and operated in different ways based on their security and trust level, routed mode is the best configuration for this environment.

Virtual Server hosting

Consider a virtual server hosting company that has several hosts, each with two physical network connections. One interface is used for management and accounting, the other is for the virtual machines to connect through. Each guest has its own public IP address, but the hosts use private IP address as management of the guests can only be performed by internal administrators. Refer to the following diagram to understand this scenario:



When the host has a public IP address and the virtual machines have static public IPs, bridged networking can not be used, as the provider only accepts packets from the MAC adress of the public host. The following diagram demonstrates this:



33.5.2. NAT mode

NAT (Network Address Translation) mode is the default mode. It can be used for testing when there is no need for direct network visibility.

33.5.3. Isolated mode

Isolated mode allows virtual machines to communicate with each other only. They are unable to interact with the physical network.

33.6. Managing a virtual network

To configure a virtual network on your system:

1. From the **Edit** menu, select **Connection Details**.

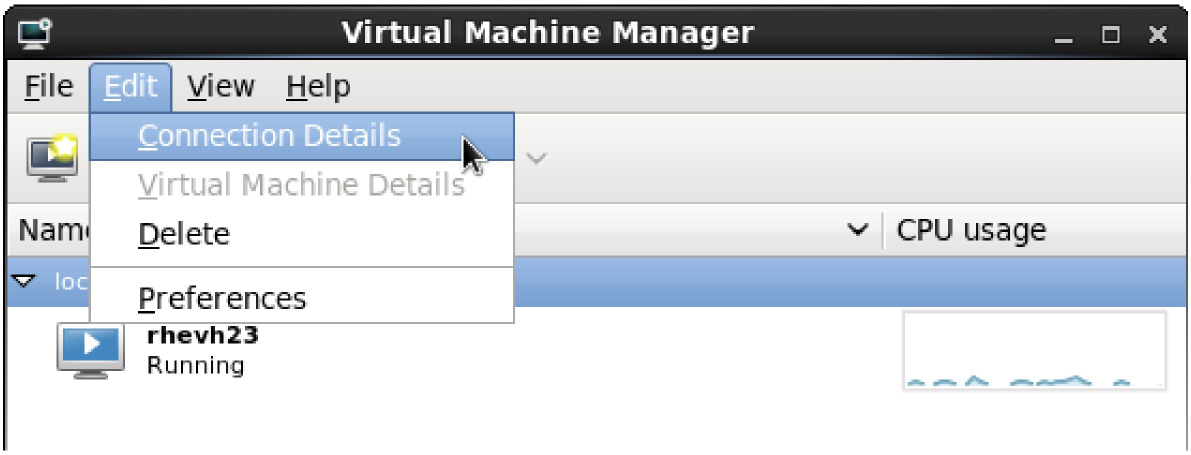


Figure 33.8. Selecting a host's details

2. This will open the **Host Details** menu. Click the **Virtual Networks** tab.

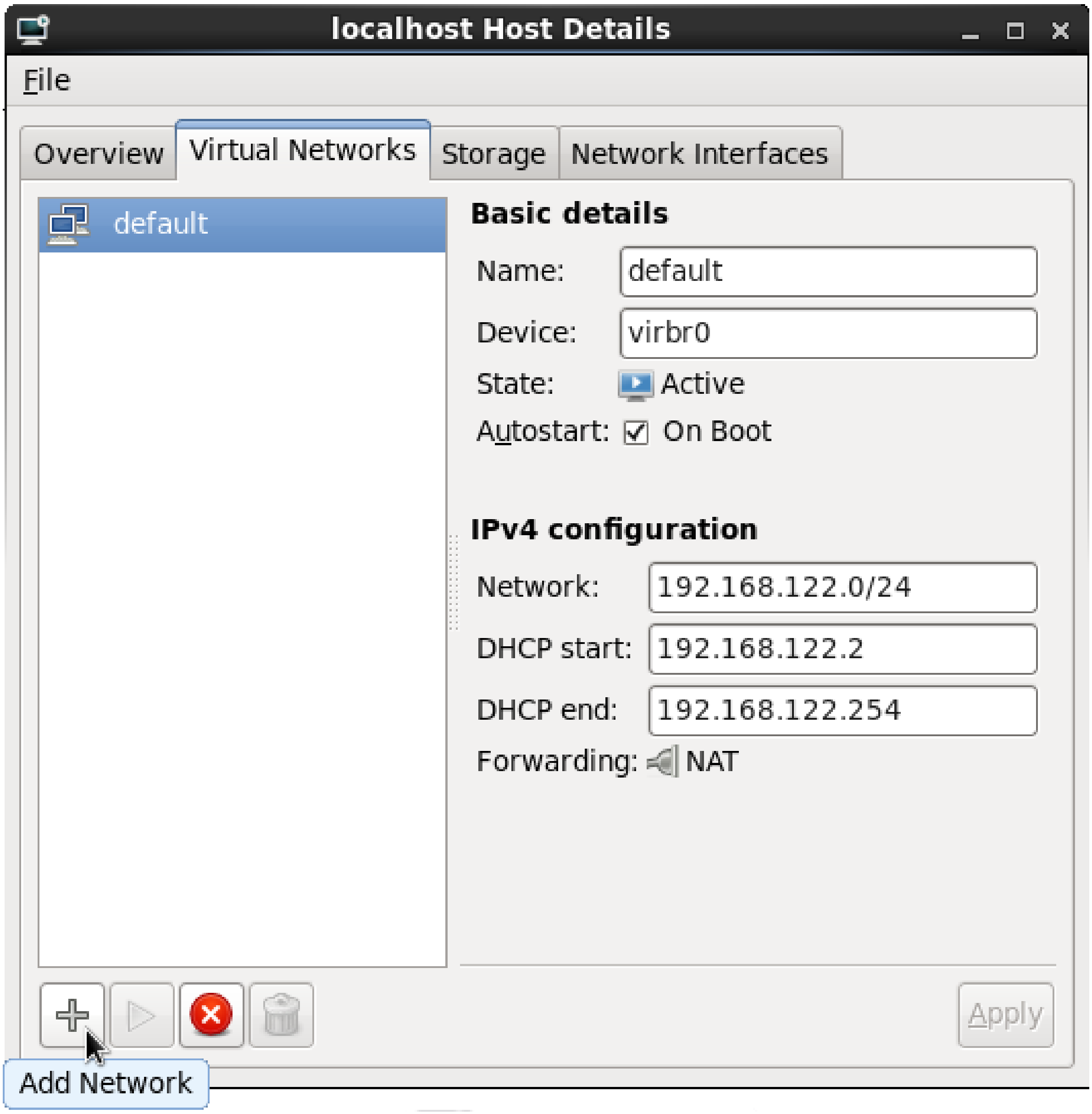


Figure 33.9. Virtual network configuration

3. All available virtual networks are listed on the left-hand box of the menu. You can edit the configuration of a virtual network by selecting it from this box and editing as you see fit.

33.7. Creating a virtual network

To create a virtual network on your system:

1. Open the **Host Details** menu (refer to *Section 33.6, “Managing a virtual network”*) and click the **Add Network** button, identified by a plus sign (+) icon.

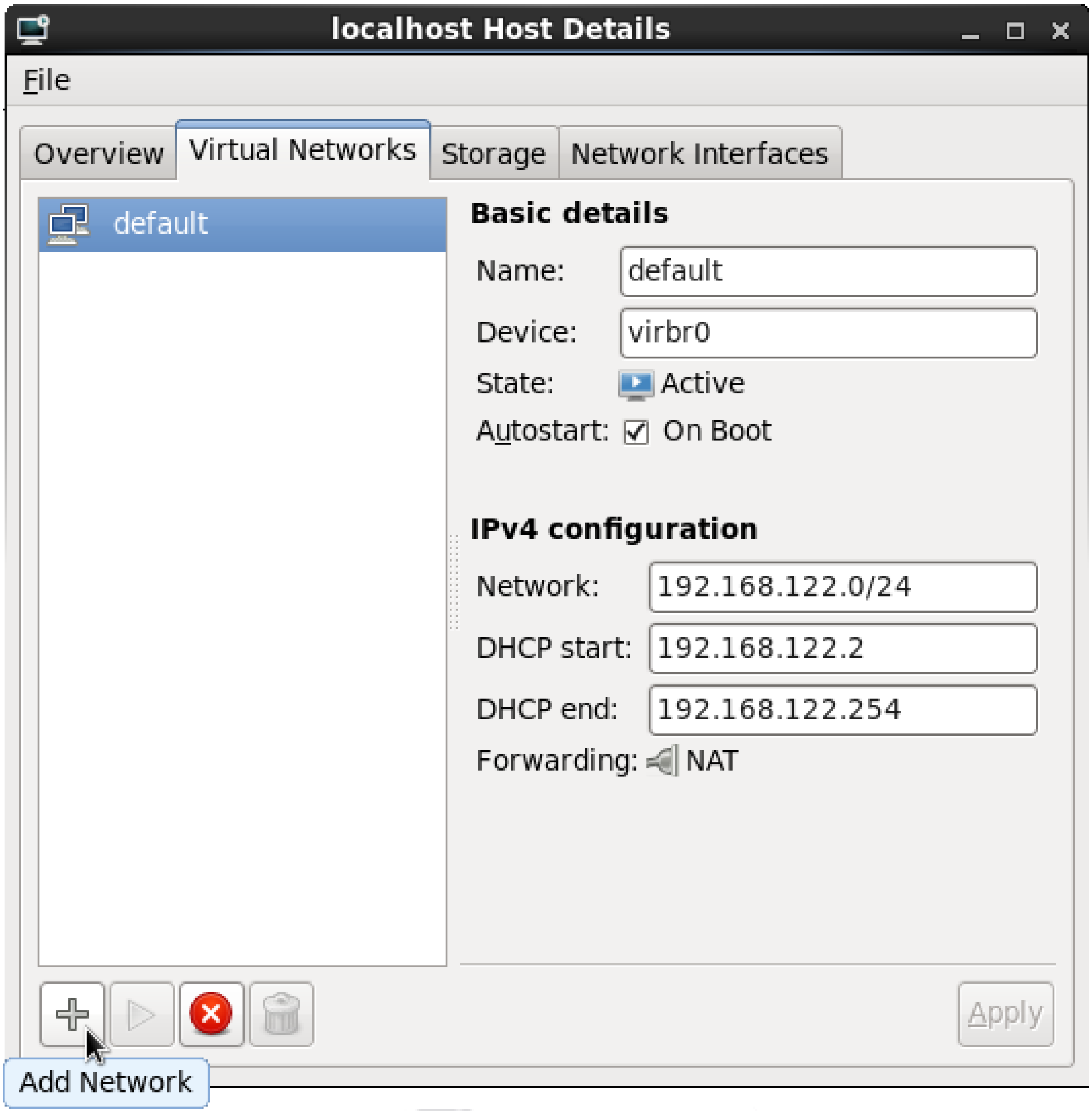


Figure 33.10. Virtual network configuration

This will open the **Create a new virtual network** window. Click **Forward** to continue.

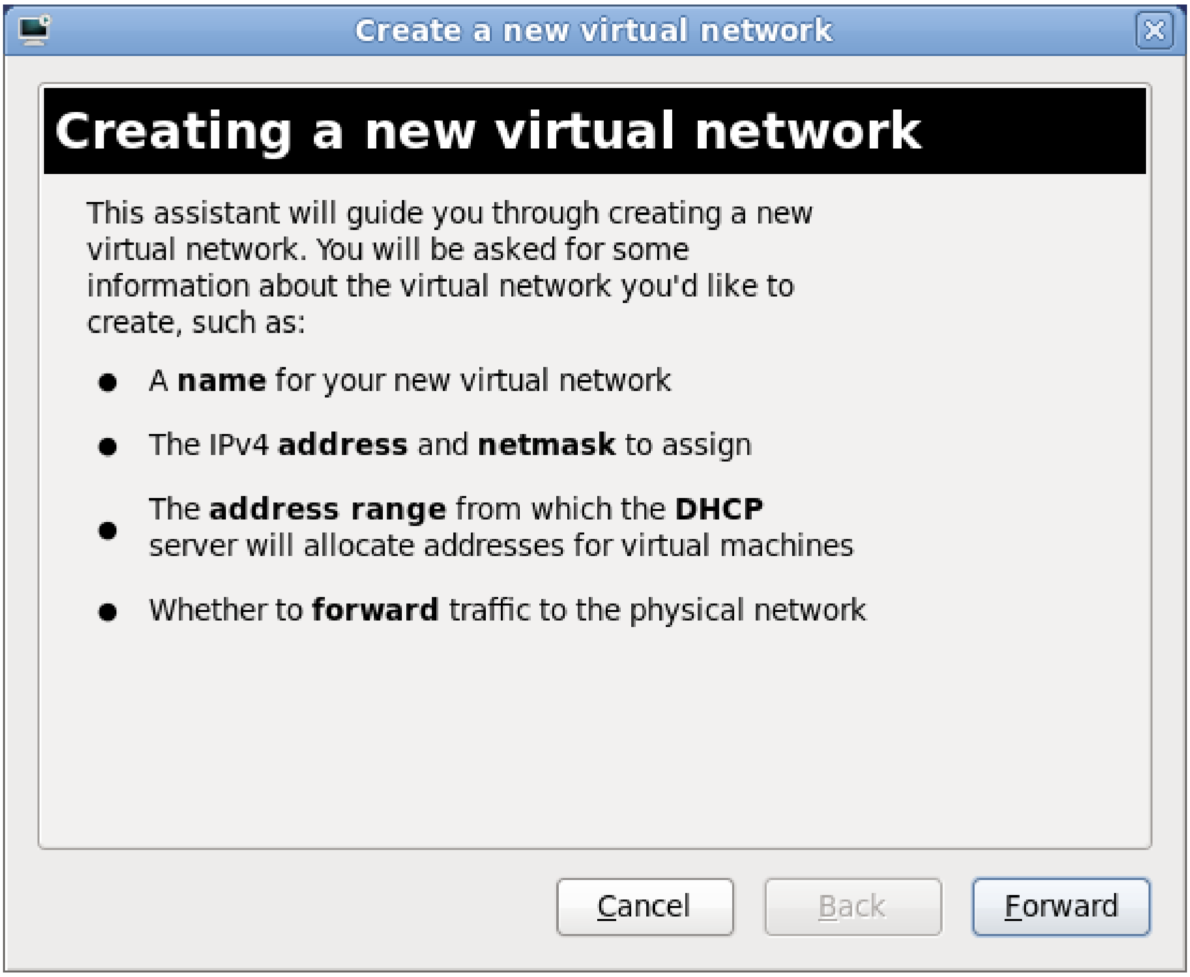


Figure 33.11. Creating a new virtual network

2. Enter an appropriate name for your virtual network and click **Forward**.

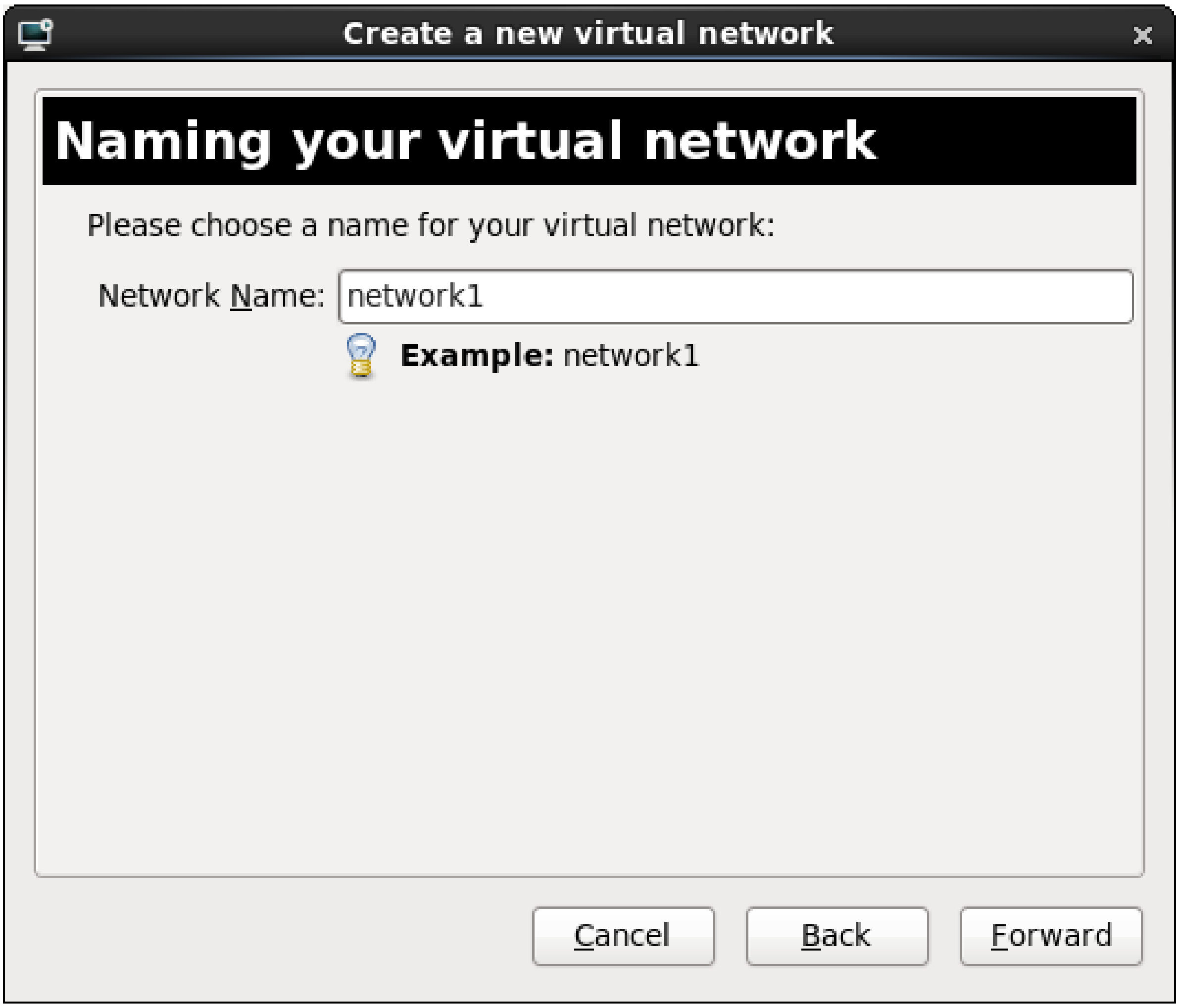


Figure 33.12. Naming your virtual network

3. Enter an IPv4 address space for your virtual network and click **Forward**.

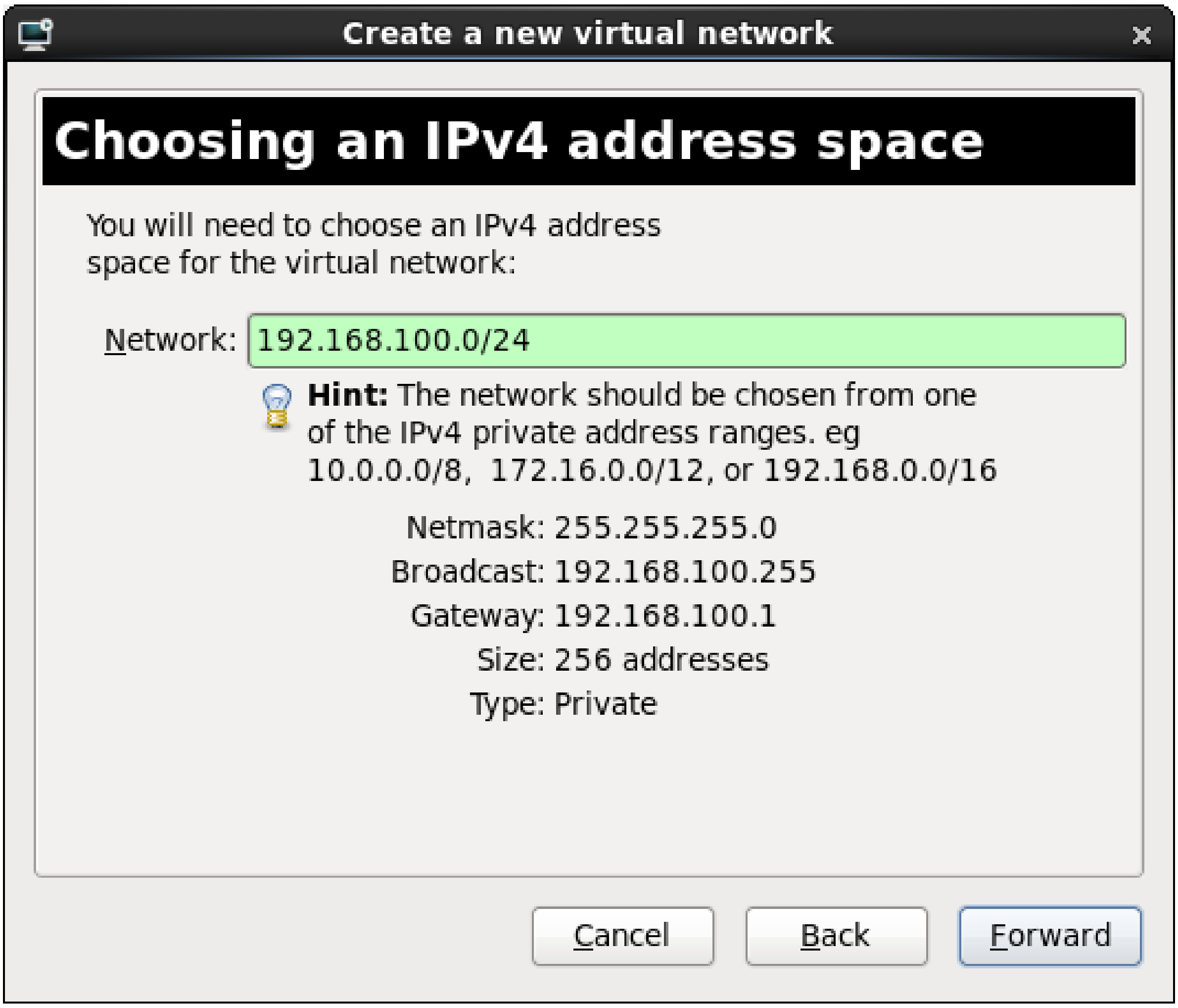


Figure 33.13. Choosing an IPv4 address space

4. Define the DHCP range for your virtual network by specifying a **Start** and **End** range of IP addresses. Click **Forward** to continue.

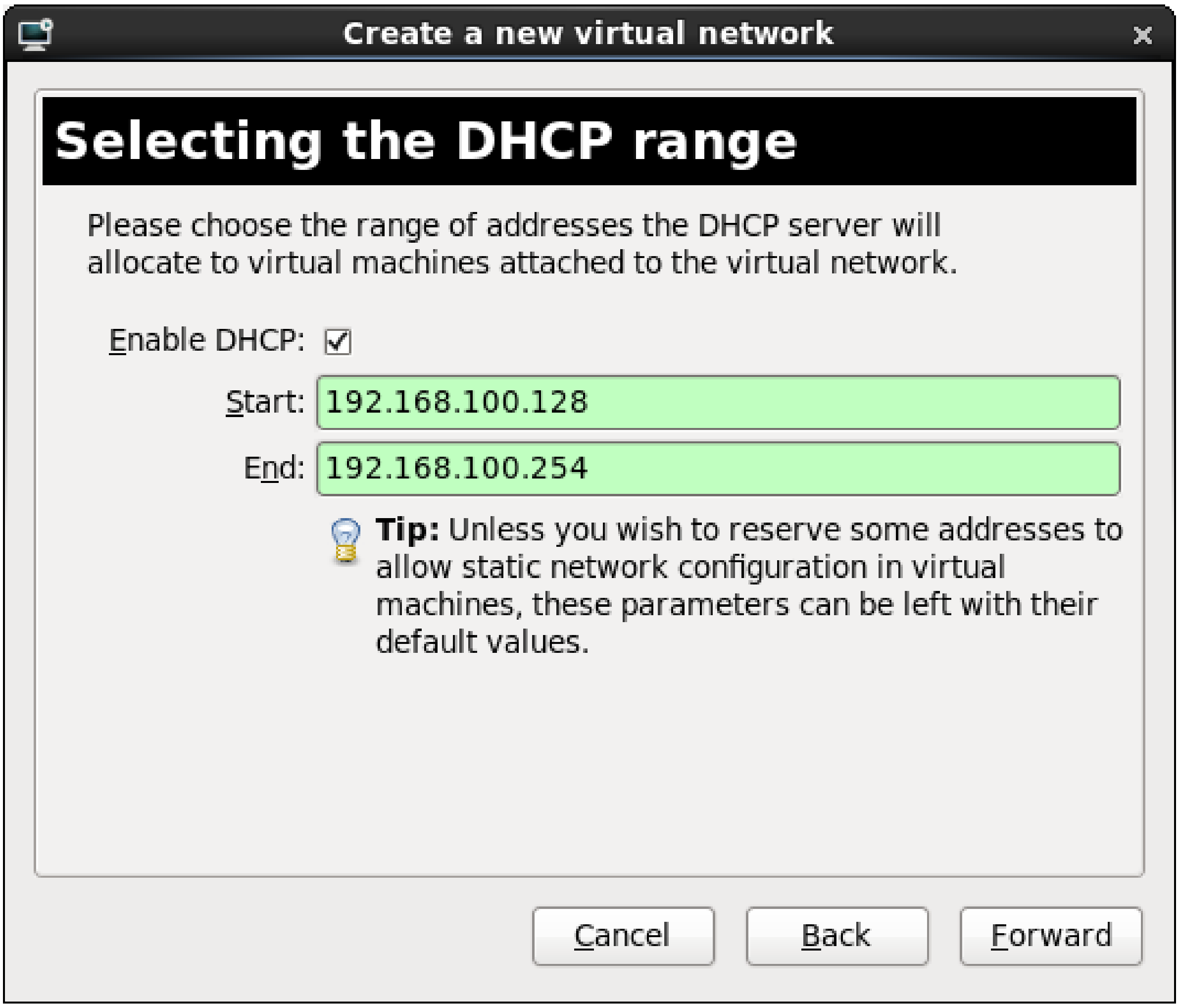


Figure 33.14. Selecting the DHCP range

5. Select how the virtual network should connect to the physical network.

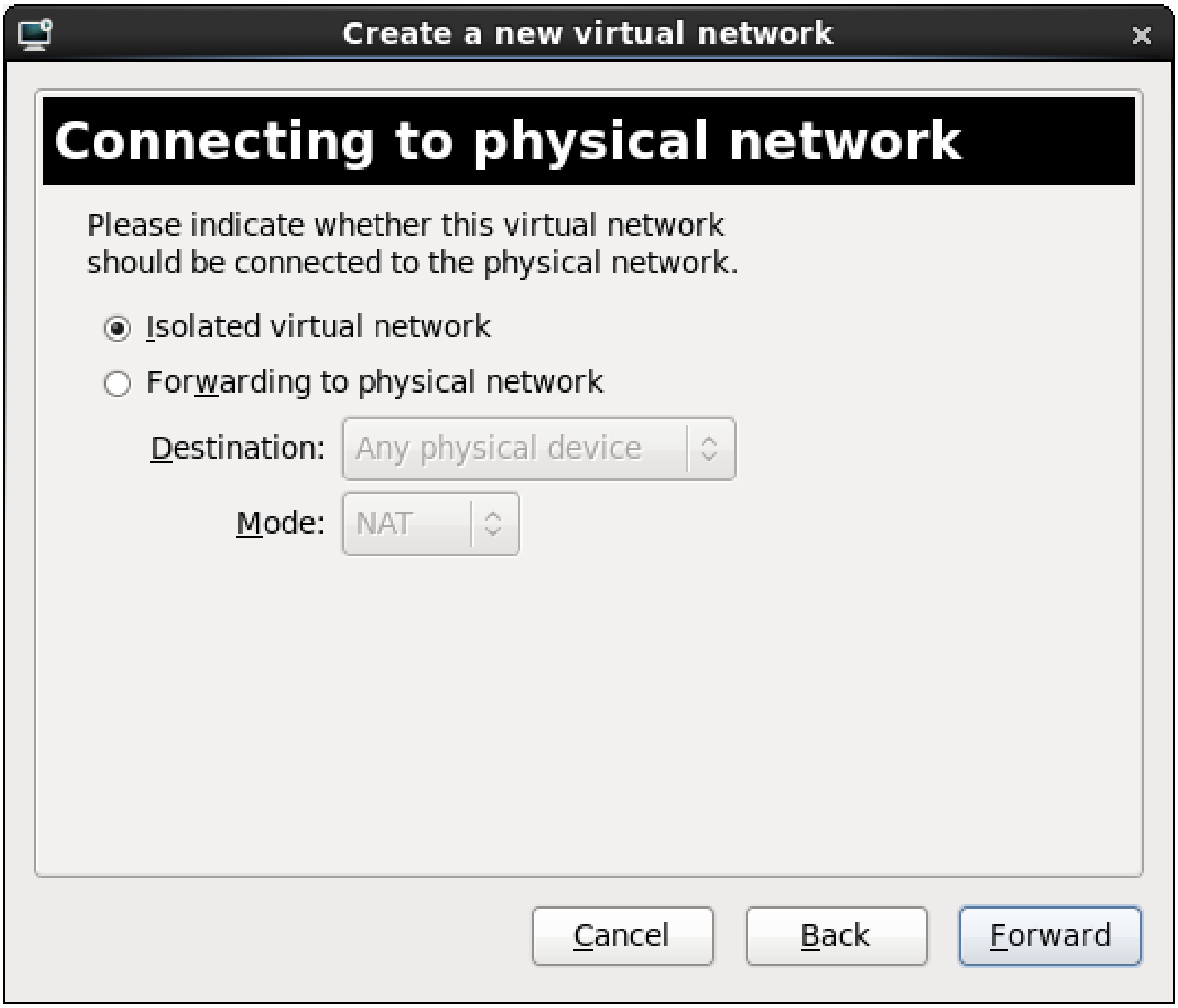


Figure 33.15. Connecting to physical network

If you select **Forwarding to physical network**, choose whether the **Destination** should be **Any physical device** or a specific physical device. Also select whether the **Mode** should be **NAT** or **Routed**.

Click **Forward** to continue.

6. You are now ready to create the network. Check the configuration of your network and click **Finish**.

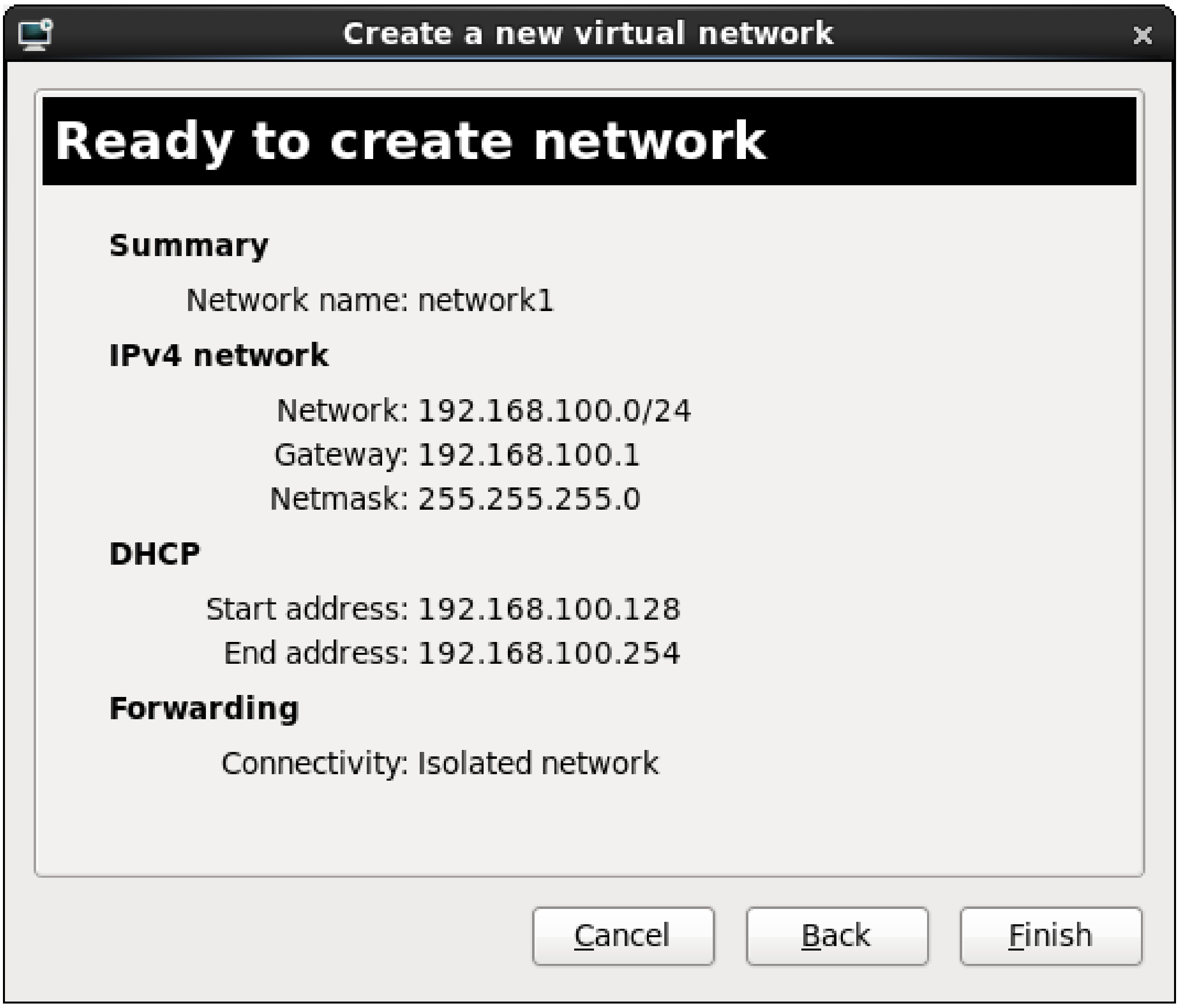


Figure 33.16. Ready to create network

7. The new virtual network is now available in the **Virtual Network** tab of the **Host Details** window.

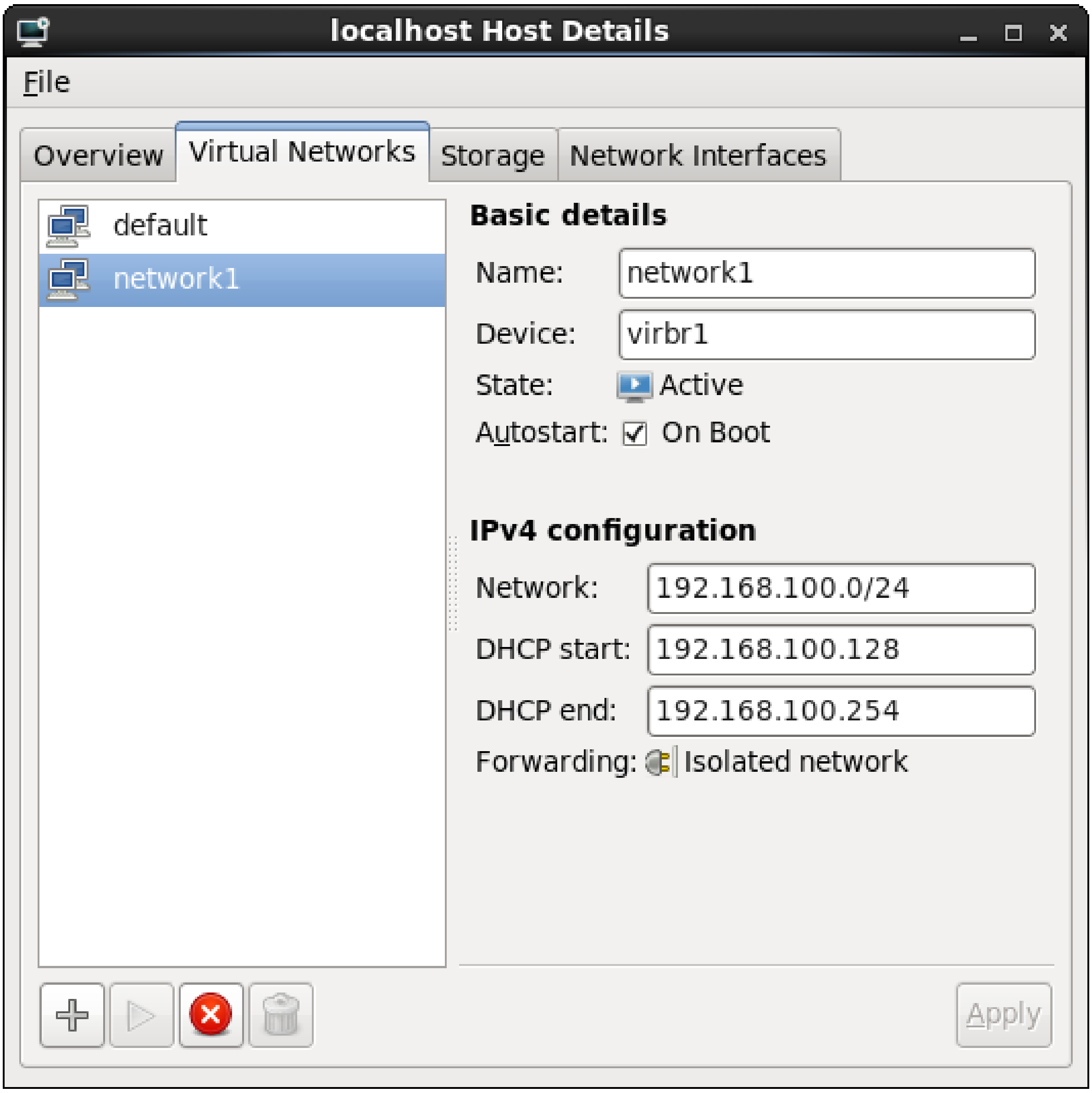


Figure 33.17. New virtual network is now available

libvirt configuration reference

This chapter provides is a references for various parameters of libvirt XML configuration files

Table 34.1. libvirt configuration files

Item	Description
pae	Specifies the physical address extension configuration data.
apic	Specifies the advanced programmable interrupt controller configuration data.
memory	Specifies the memory size in megabytes.
vcpus	Specifies the numbers of virtual CPUs.
console	Specifies the port numbers to export the domain consoles to.
nic	Specifies the number of virtual network interfaces.
vif	Lists the randomly-assigned MAC addresses and bridges assigned to use for the domain's network addresses.
disk	Lists the block devices to export to the domain and exports physical devices to domain with read only access.
dhcp	Enables networking using DHCP.
netmask	Specifies the configured IP netmasks.
gateway	Specifies the configured IP gateways.
acpi	Specifies the advanced configuration power interface configuration data.

Creating custom libvirt scripts

This section provides some information which may be useful to programmers and system administrators intending to write custom scripts to make their lives easier by using **`libvirt`**.

Chapter 24, Miscellaneous administration tasks is recommended reading for programmers thinking of writing new applications which use **`libvirt`**.

35.1. Using XML configuration files with virsh

`virsh` can handle XML configuration files. You may want to use this to your advantage for scripting large deployments with special options. You can add devices defined in an XML file to a running virtualized guest. For example, to add a ISO file as **hdc** to a running guest create an XML file:

```
# cat satelliteiso.xml
<disk type="file" device="disk">
 <driver name="file"/>
 <source file="/var/lib/libvirt/images/rhn-satellite-5.0.1-11-redhat-linux-as-i386-4-
embedded-oracle.iso"/>
 <target dev="hdc"/>
 <readonly/>
</disk>
```

Run **`virsh attach-device`** to attach the ISO as **hdc** to a guest called "satellite" :

```
# virsh attach-device satellite satelliteiso.xml
```

Part VII. Troubleshooting

Introduction to troubleshooting and problem solving

The following chapters provide information to assist you in troubleshooting issues you may encounter using virtualization.

Important note on virtualization issues

Your particular problem may not appear in this book due to ongoing development which creates and fixes bugs. For the most up to date list of known bugs, issues and bug fixes read the Red Hat Enterprise Linux 6 *Release Notes* for your version and hardware architecture. The *Release Notes* can be found in the documentation section of the Red Hat website, *www.redhat.com/docs/manuals/enterprise/*[1].

If all else fails...

Contact Red Hat Global Support Services (*https://www.redhat.com/apps/support/*). Our staff can assist you in resolving your issues.

[1] http://www.redhat.com/docs/manuals/enterprise/

Troubleshooting

This chapter covers common problems and solutions for Red Hat Enterprise Linux 6 virtualization issues.

Read this chapter to develop an understanding of some of the common problems associated with virtualization technologies. Troubleshooting takes practice and experience which are difficult to learn from a book. It is recommended that you experiment and test virtualization on Red Hat Enterprise Linux 6 to develop your troubleshooting skills.

If you cannot find the answer in this document there may be an answer online from the virtualization community. Refer to *Section A.1, "Online resources"* for a list of Linux virtualization websites.

36.1. Debugging and troubleshooting tools

This section summarizes the System Administrator applications, the networking utilities, and debugging tools. You can employ these standard System administration tools and logs to assist with troubleshooting:

- **kvm_stat**
- **trace-cmd**
- **vmstat**
- **iostat**
- **lsof**
- **systemtap**
- **crash**
- **sysrq**
- **sysrq t**
- **sysrq w**

These networking tools can assist with troubleshooting virtualization networking problems:

- **ifconfig**
- **tcpdump**

  The **tcpdump** command 'sniffs' network packets. **tcpdump** is useful for finding network abnormalities and problems with network authentication. There is a graphical version of **tcpdump** named **wireshark**.

- **brctl**

  brctl is a networking tool that inspects and configures the Ethernet bridge configuration in the Virtualization linux kernel. You must have root access before performing these example commands:

```
# brctl show
bridge-name    bridge-id          STP  enabled  interfaces
-----------------------------------------------------------------------------
virtbr0             8000.feffffff       yes        eth0
```

```
# brctl showmacs virtbr0
port-no           mac-addr                  local?       aging timer
1                 fe:ff:ff:ff:ff:           yes            0.00
2                 fe:ff:ff:fe:ff:           yes            0.00
# brctl showstp virtbr0
virtbr0
bridge-id              8000.fefffffffff
designated-root        8000.fefffffffff
root-port              0                    path-cost             0
max-age                20.00                bridge-max-age        20.00
hello-time             2.00                 bridge-hello-time     2.00
forward-delay          0.00                 bridge-forward-delay  0.00
aging-time            300.01
hello-timer            1.43                 tcn-timer             0.00
topology-change-timer  0.00                 gc-timer              0.02
```

Listed below are some other useful commands for troubleshooting virtualization.

- **strace** is a command which traces system calls and events received and used by another process.
- **vncviewer**: connect to a VNC server running on your server or a virtual machine. Install **vncviwer** using the **`yum install vnc`** command.
- **vncserver**: start a remote desktop on your server. Gives you the ability to run graphical user interfaces such as virt-manager via a remote session. Install **vncserver** using the **`yum install vnc-server`** command.

36.2. kvm_stat

The **`kvm_stat`** command is a python script which retrieves runtime statistics from the `kvm` kernel module. The **`kvm_stat`** command can be used to diagnose guest behavior visible to `kvm`. In particular, performance related issues with guests. Currently, the reported statistics are for the entire system; the behavior of all running guests is reported.

The **`kvm_stat`** command requires that the `kvm` kernel module is loaded and **`debugfs`** is mounted. If either of these features are not enabled, the command will output the required steps to enable **`debugfs`** or the `kvm` module. For example:

```
# kvm_stat
Please mount debugfs ('mount -t debugfs debugfs /sys/kernel/debug')
and ensure the kvm modules are loaded
```

Mount **`debugfs`** if required:

```
# mount -t debugfs debugfs /sys/kernel/debug
```

kvm_stat output

The **`kvm_stat`** command outputs statistics for all virtualized guests and the host. The output is updated until the command is terminated (using **`Ctrl`**+**`c`** or the **`q`** key).

```
# kvm_stat

kvm statistics

efer_reload                 94       0
exits                  4003074   31272
fpu_reload             1313881   10796
```

```
halt_exits                 14050      259
halt_wakeup                 4496      203
host_state_reload 1638354    24893
hypercalls                     0        0
insn_emulation           1093850     1909
insn_emulation_fail            0        0
invlpg                     75569        0
io_exits                 1596984    24509
irq_exits                  21013      363
irq_injections             48039     1222
irq_window                 24656      870
largepages                     0        0
mmio_exits                 11873        0
mmu_cache_miss             42565        8
mmu_flooded                14752        0
mmu_pde_zapped             58730        0
mmu_pte_updated                6        0
mmu_pte_write             138795        0
mmu_recycled                   0        0
mmu_shadow_zapped          40358        0
mmu_unsync                   793        0
nmi_injections                 0        0
nmi_window                     0        0
pf_fixed                  697731     3150
pf_guest                  279349        0
remote_tlb_flush               5        0
request_irq                    0        0
signal_exits                   1        0
tlb_flush                 200190        0
```

Explanation of variables:

efer_reload
: The number of Extended Feature Enable Register (EFER) reloads.

exits
: The count of all **VMEXIT** calls.

fpu_reload
: The number of times a **VMENTRY** reloaded the FPU state. The **fpu_reload** is incremented when a guest is using the Floating Point Unit (FPU).

halt_exits
: Number of guest exits due to **halt** calls. This type of exit is usually seen when a guest is idle.

halt_wakeup
: Number of wakeups from a **halt**.

host_state_reload
: Count of full reloads of the host state (currently tallies MSR setup and guest MSR reads).

hypercalls
: Number of guest hypervisor service calls.

insn_emulation
: Number of guest instructions emulated by the host.

insn_emulation_fail
: Number of failed **insn_emulation** attempts.

io_exits
: Number of guest exits from I/O port accesses.

irq_exits
: Number of guest exits due to external interrupts.

irq_injections
: Number of interrupts sent to guests.

irq_window
: Number of guest exits from an outstanding interrupt window.

largepages
: Number of large pages currently in use.

mmio_exits
: Number of guest exits due to memory mapped I/O (MMIO) accesses.

mmu_cache_miss
: Number of KVM MMU shadow pages created.

mmu_flooded
: Detection count of excessive write operations to an MMU page. This counts detected write operations not of individual write operations.

mmu_pde_zapped
: Number of page directory entry (PDE) destruction operations.

mmu_pte_updated
: Number of page table entry (PTE) destruction operations.

mmu_pte_write
: Number of guest page table entry (PTE) write operations.

mmu_recycled
: Number of shadow pages that can be reclaimed.

mmu_shadow_zapped
: Number of invalidated shadow pages.

mmu_unsync
: Number of non-synchronized pages which are not yet unlinked.

nmi_injections
: Number of Non-maskable Interrupt (NMI) injections to the guest.

nmi_window
: Number of guest exits from (outstanding) Non-maskable Interrupt (NMI) windows.

pf_fixed
: Number of fixed (non-paging) page table entry (PTE) maps.

pf_guest
: Number of page faults injected into guests.

remote_tlb_flush
: Number of remote (sibling CPU) Translation Lookaside Buffer (TLB) flush requests.

request_irq
: Number of guest interrupt window request exits.

signal_exits
: Number of guest exits due to pending signals from the host.

tlb_flush
: Number of **`tlb_flush`** operations performed by the hypervisor.

> **Note**
>
> The output information from the **`kvm_stat`** command is exported by the KVM hypervisor as pseudo files located in the **`/sys/kernel/debug/kvm/`** directory.

36.3. Log files

KVM uses various log files. All the log files are standard ASCII files, and accessible with a text editor.

- The default directory for all file-based images is the **`/var/lib/libvirt/images`** directory.
- **`qemu-kvm.[PID].log`** is the log file created by the **`qemu-kvm`** process for each fully virtualized guest. When using this log file, you must retrieve the given **`qemu-kvm`** process PID, by using the **`ps`** command to examine process arguments to isolate the **`qemu-kvm`** process on the virtual machine. Note that you must replace the [PID] symbol with the actual PID **`qemu-kvm`** process.

If you encounter any errors with the Virtual Machine Manager, you can review the generated data in the **`virt-manager.log`** file that resides in the **`/.virt-manager`** directory. Note that every time you start the Virtual Machine Manager, it overwrites the existing log file contents. Make sure to backup the **`virt-manager.log`** file, before you restart the Virtual Machine manager after a system error.

36.4. Troubleshooting with serial consoles

Linux kernels can output information to serial ports. This is useful for debugging kernel panics and hardware issues with video devices or headless servers. The subsections in this section cover setting up serial console output for machines running Red Hat Enterprise Linux 6 virtualization kernels and their virtualized guests.

This section covers how to enable serial console output for fully virtualized guests.

Fully virtualized guest serial console output can be viewed with the **`virsh console`** command.

Be aware fully virtualized guest serial consoles have some limitations. Present limitations include:

- output data may be dropped or scrambled.

The serial port is called `ttyS0` on Linux or `COM1` on Windows.

You must configure the virtualized operating system to output information to the virtual serial port.

To output kernel information from a fully virtualized Linux guest into the domain modify the **`/boot/grub/grub.conf`** file by inserting the line *`console=tty0 console=ttyS0,115200`*.

```
title Red Hat Enterprise Linux Server (2.6.32-36.x86-64)
 root (hd0,0)
 kernel /vmlinuz-2.6.32-36.x86-64 ro root=/dev/volgroup00/logvol00
 console=tty0 console=ttyS0,115200
```

```
initrd /initrd-2.6.32-36.x86-64.img
```

Reboot the guest.

On the host, access the serial console with the following command:

```
# virsh console
```

You can also use **virt-manager** to display the virtual text console. In the guest console window, select **Serial Console** from the **View** menu.

36.5. Virtualization log files

- /var/log/libvirt/qemu/*GuestName*.log

If you encounter any errors with the Virtual Machine Manager, you can review the generated data in the **virt-manager.log** file that resides in the **/.virt-manager** directory. Note that every time you start the Virtual Machine Manager, it overwrites the existing log file contents. Make sure to backup the **virt-manager.log** file, before you restart the Virtual Machine manager after a system error.

36.6. Loop device errors

If file-based guest images are used you may have to increase the number of configured loop devices. The default configuration allows up to eight active loop devices. If more than eight file-based guests or loop devices are needed the number of loop devices configured can be adjusted in **/etc/modprobe.conf**. Edit **/etc/modprobe.conf** and add the following line to it:

```
options loop max_loop=64
```

This example uses 64 but you can specify another number to set the maximum loop value. You may also have to implement loop device backed guests on your system. To use a loop device backed guests for a full virtualized system, use the **phy: device** or **file: file** commands.

36.7. Enabling Intel VT and AMD-V virtualization hardware extensions in BIOS

This section describes how to identify hardware virtualization extensions and enable them in your BIOS if they are disabled.

The Intel VT extensions can be disabled in the BIOS. Certain laptop vendors have disabled the Intel VT extensions by default in their CPUs.

The virtualization extensions cannot be disabled in the BIOS for AMD-V.

The virtualization extensions are sometimes disabled in BIOS, usually by laptop manufacturers. Refer to the following section for instructions on enabling disabled virtualization extensions.

Verify the virtualization extensions are enabled in BIOS. The BIOS settings for Intel® VT or AMD-V are usually in the **Chipset** or **Processor** menus. The menu names may vary from this guide, the virtualization extension settings may be found in **Security Settings** or other non standard menu names.

Procedure 36.1. Enabling virtualization extensions in BIOS

1. Reboot the computer and open the system's BIOS menu. This can usually be done by pressing the **delete** key, the **F1** key or **Alt** and **F4** keys depending on the system.

2. **Enabling the virtualization extensions in BIOS**

> **Note: BIOS steps**
>
> Many of the steps below may vary depending on your motherboard, processor type, chipset and OEM. Refer to your system's accompanying documentation for the correct information on configuring your system.

   a. Open the **Processor** submenu The processor settings menu may be hidden in the **Chipset**, **Advanced CPU Configuration** or **Northbridge**.

   b. Enable **Intel Virtualization Technology** (also known as Intel VT). **AMD-V** extensions cannot be disabled in the BIOS and should already be enabled. The virtualization extensions may be labeled **Virtualization Extensions**, **Vanderpool** or various other names depending on the OEM and system BIOS.

   c. Enable Intel VTd or AMD IOMMU, if the options are available. Intel VTd and AMD IOMMU are used for PCI device assignment.

   d. Select **Save & Exit**.

3. Reboot the machine.

4. When the machine has booted, run **`cat /proc/cpuinfo | grep "vmx svm"`**. If the command outputs, the virtualization extensions are now enabled. If there is no output your system may not have the virtualization extensions or the correct BIOS setting enabled.

36.8. KVM networking performance

By default, KVM virtual machines are assigned a virtual Realtek 8139 (rtl8139) NIC (network interface controller) if they are Windows guests or the guest type is not specified. Red Hat Enterprise Linux guests are assigned a virtio NIC by default.

The rtl8139 virtualized NIC works fine in most environments. However, this device can suffer from performance degradation problems on some networks, for example, a 10 Gigabit Ethernet network.

To improve performance switch to the para-virtualized network driver.

> **Note**
>
> Note that the virtualized Intel PRO/1000 (`e1000`) driver is also supported as an emulated driver choice. To use the **`e1000`** driver, replace **`virtio`** in the procedure below with **`e1000`**. For the best performance it is recommended to use the **`virtio`** driver.

Procedure 36.2. Switching to the virtio driver

1. Shutdown the guest operating system.

2. Edit the guest's configuration file with the **`virsh`** command (where *`GUEST`* is the guest's name):

```
# virsh edit GUEST
```

   The **`virsh edit`** command uses the **`$EDITOR`** shell variable to determine which editor to use.

3. Find the network interface section of the configuration. This section resembles the snippet below:

```
<interface type='network'>
  [output truncated]
  <model type='rtl8139' />
</interface>
```

4. Change the type attribute of the model element from *'rtl8139'* to *'virtio'*. This will change the driver from the rtl8139 driver to the e1000 driver.

```
<interface type='network'>
  [output truncated]
  <model type='virtio' />
</interface>
```

5. Save the changes and exit the text editor

6. Restart the guest operating system.

Creating new guests using other network drivers

Alternatively, new virtualized guests can be created with a different network driver. This may be required if you are having difficulty installing guests over a network connection. This method requires you to have at least one virtualized guest already created (possibly installed from CD or DVD) to use as a template.

1. Create an XML template from an existing virtualized guest (in this example, named *Guest1*):

```
# virsh dumpxml Guest1 > /tmp/guest-template.xml
```

2. Copy and edit the XML file and update the unique fields: virtual machine name, UUID, disk image, MAC address, and any other unique parameters. Note that you can delete the UUID and MAC address lines and virsh will generate a UUID and MAC address.

```
# cp /tmp/guest-template.xml /tmp/new-guest.xml
# vi /tmp/new-guest.xml
```

   Add the model line in the network interface section:

```
 <interface type='network'>
  [output truncated]
  <model type='virtio' />
</interface>
```

3. Create the new virtual machine:

```
# virsh define /tmp/new-guest.xml
# virsh start new-guest
```

Appendix A. Additional resources

To learn more about virtualization and Red Hat Enterprise Linux, refer to the following resources.

A.1. Online resources

- *http://www.libvirt.org/* is the official website for the **`libvirt`** virtualization API.
- *http://virt-manager.et.redhat.com/* is the project website for the **Virtual Machine Manager** (virt-manager), the graphical application for managing virtual machines.
- Open Virtualization Center

  http://www.openvirtualization.com[1]
- Red Hat Documentation

  http://www.redhat.com/docs/
- Virtualization technologies overview

  http://virt.kernelnewbies.org[2]
- Red Hat Emerging Technologies group

  http://et.redhat.com[3]

A.2. Installed documentation

- **`man virsh`** and **`/usr/share/doc/libvirt-<version-number>`** — Contains sub commands and options for the **`virsh`** virtual machine management utility as well as comprehensive information about the **`libvirt`** virtualization library API.
- **`/usr/share/doc/gnome-applet-vm-<version-number>`** — Documentation for the GNOME graphical panel applet that monitors and manages locally-running virtual machines.
- **`/usr/share/doc/libvirt-python-<version-number>`** — Provides details on the Python bindings for the **`libvirt`** library. The **`libvirt-python`** package allows python developers to create programs that interface with the **`libvirt`** virtualization management library.
- **`/usr/share/doc/python-virtinst-<version-number>`** — Provides documentation on the **`virt-install`** command that helps in starting installations of Fedora and Red Hat Enterprise Linux related distributions inside of virtual machines.
- **`/usr/share/doc/virt-manager-<version-number>`** — Provides documentation on the Virtual Machine Manager, which provides a graphical tool for administering virtual machines.

Appendix B. Revision History

Revision 3.2-064 **Wed May 18 2011** **Scott Radvan** *sradvan@redhat.com*

Review for 6.1 release.

Revision 3.2-061 **Tue May 10 2011** **Scott Radvan** *sradvan@redhat.com*

SR-IOV updates

Revision 3.2-057 **Thu Apr 21 2011** **Scott Radvan** *sradvan@redhat.com*

Drop KVM Live Migration chapter

Revision 3.2-056 **Fri Apr 15 2011** **Scott Radvan** *sradvan@redhat.com*

Updated screenshots for 6.3, 6.4 and 11.

Revision 3.2-055-draft **Wed Apr 13 2011** **Scott Radvan** *sradvan@redhat.com*

virt-v2v RHN steps: 23.1

Revision 3.2-052-draft **Wed Apr 13 2011** **Scott Radvan** *sradvan@redhat.com*

Update steps of Windows guest conversion: 23.4.2

Revision 3.2-051-draft **Tue Apr 12 2011** **Scott Radvan** *sradvan@redhat.com*

Refer to virsh manpage in Table 30.2. List supported guest O/S for virt-v2v in Chapter 23.

Revision 3.2-048-draft **Mon Apr 04 2011** **Scott Radvan** *sradvan@redhat.com*

Show SELinux Booleans for qemu launched by libvirt.

Revision 3.2-047-draft **Mon Apr 04 2011** **Scott Radvan** *sradvan@redhat.com*

Fix adding of file-based storage to work with virtio bus.

Revision 3.2-045-draft **Tue Mar 29 2011** **Scott Radvan** *sradvan@redhat.com*

Add volume, secret, and nwfilter command options to virsh chapter.

Revision 3.2-044-draft **Thu Mar 24 2011** **Scott Radvan** *sradvan@redhat.com*

Fix for libguestfs typo.

Revision 3.2-043-draft **Wed Mar 23 2011** **Scott Radvan** *sradvan@redhat.com*

Rename `virtualization reference guide' Part, to `host virtualization tools'.

Revision 3.2-040-draft **Mon Mar 7 2011** **Scott Radvan** *sradvan@redhat.com*

Added a description and steps for attaching and updating a disk image with virsh.

Revision 3.2-039-draft **Fri Mar 4 2011** **Scott Radvan** *sradvan@redhat.com*

use "size=8" on the disk path line for guest creation.

Revision 3.2-038-draft **Thu Mar 3 2011** **Scott Radvan** *sradvan@redhat.com*

Minor virt-install command errors fixed (6.2).

Revision 3.2-037-draft **Wed Mar 2 2011** **Scott Radvan** *sradvan@redhat.com*

Fix `virsh restart' command in 27.3.1

Revision 3.2-034-draft **Wed Feb 23 2011** **Scott Radvan** *sradvan@redhat.com*

PCI management from guest now uses `virt_use_sysfs'.

Revision 3.2-033-draft **Thu Feb 17 2011** **Scott Radvan** *sradvan@redhat.com*

Add Transparent Hugepage Support to Chapter 22, describe turning off swap in 24.6.

Revision 3.2-032-draft **Thu Feb 17 2011** **Scott Radvan** *sradvan@redhat.com*

Fix storage size for virtual disk in 8.2

Revision 3.2-028-draft **Wed Feb 16 2011** **Scott Radvan** *sradvan@redhat.com*

Remove `xen_emul_unplug' from screenshots.

Revision 3.2-027-draft	**Wed Feb 16 2011**	**Scott Radvan** *sradvan@redhat.com*

Chapter 6 screenshots.

Revision 3.2-021-draft	**Mon Feb 07 2011**	**Scott Radvan** *sradvan@redhat.com*

Add table showing virsh command options, other minor fixes.

Revision 3.2-020-draft	**Fri Feb 04 2011**	**Scott Radvan** *sradvan@redhat.com*

Remove unsupported guest CPU models.

Revision 3.2-019-draft	**Fri Feb 04 2011**	**Scott Radvan** *sradvan@redhat.com*

Add table of supported CPUs that can be presented to guests.

Revision 3.2-017-draft	**Thu Feb 03 2011**	**Scott Radvan** *sradvan@redhat.com*

Fix description for the 'define' guest management command (#657337)

Revision 3.2-017-draft	**Thu Feb 03 2011**	**Scott Radvan** *sradvan@redhat.com*

Add --os-type and --os-variant descriptions to virt-install with Windows guests.

Revision 3.2-016-draft	**Wed Feb 02 2011**	**Scott Radvan** *sradvan@redhat.com*

Should be virtio-win.vfd; specify IP forwarding not required for physical bridges, dd calculation fix.

Revision 3.2-015-draft	**Tue Feb 01 2011**	**Scott Radvan** *sradvan@redhat.com*

Several wording and flow issues.

Revision 3.2-014-draft	**Mon Jan 31 2011**	**Scott Radvan** *sradvan@redhat.com*

Minor fixes in storage chapter; remove text describing storage pool volume allocation.

Revision 3.2-013-draft	**Tue Jan 25 2011**	**Scott Radvan** *sradvan@redhat.com*

Remove Fedora from list of supported KVM guests.

Revision 3.2-012-draft **Tue Jan 25 2011** **Scott Radvan** *sradvan@redhat.com*

Add device assignment restrictions and fix minor wording issues.

Revision 3.2-011-draft **Fri Jan 21 2011** **Scott Radvan** *sradvan@redhat.com*

Add PCI-e passthrough limitations in Introduction and link to related chapter. Start `Virtual networking' chapter.

Revision 3.2-007 **Wed Jan 19 2011** **Scott Radvan** *sradvan@redhat.com*

Replace `passthrough' with `device assignment', but reference old term as meaning the same thing.

Revision 3.2-006 **Tue Jan 18 2011** **Scott Radvan** *sradvan@redhat.com*

Fix command used when running grep on /proc/cpuinfo for CPU extensions.

Revision 3.2-005 **Tue Jan 18 2011** **Scott Radvan** *sradvan@redhat.com*

Resolve small typographical errors and add balloon driver details.

Revision 3.2-004 **Tue Jan 18 2011** **Scott Radvan** *sradvan@redhat.com*

Add more corrections for Introduction and Part I; include draft watermark.

Revision 3.2-003 **Mon Jan 17 2011** **Scott Radvan** *sradvan@redhat.com*

Corrections for Introduction and Part I.

Revision 6.0-35 **Mon Oct 04 2010** **Scott Radvan** *sradvan@redhat.com*

Review for 6.0 release.

Revision 6.0-25 **Thu Sep 09 2010** **Christopher Curran** *ccurran@redhat.com*

Resolves *BZ#621740*[1].

Revision 6.0-24 **Fri Sep 03 2010** **Christopher Curran** *ccurran@redhat.com*

Updated para-virtualized driver usage procedures. *BZ#621740*[2].

Revision 6.0-23 **Tue May 25 2010** **Christopher Curran** *ccurran@redhat.com*

New storage content *BZ#536816*[3].

Revision 6.0-22 **Fri May 14 2010** **Christopher Curran** *ccurran@redhat.com*

Fixes *BZ#587911*[4], which expands supported storage devices.
Updated Introduction chapter
Updated Troubleshooting chapter
Updated KSM chapter
Updated overcommitting guidance.

Revision 6.0-11 **Tue Apr 20 2010** **Christopher Curran** *ccurran@redhat.com*

Beta version update. Various fixes included.

Revision 6.0-10 **Thu Apr 15 2010** **Christopher Curran** *ccurran@redhat.com*

Forward-ported the following fixes from the Red Hat Enterprise Linux 5.5 release:
Fixes *BZ#573558*[5], and expands SR-IOV content.
Fixes *BZ#559052*[6], expands the KVM para-virtualized drivers chapter.
Fixes *BZ#578342*[7].
Fixes *BZ#573553*[8].
Fixes *BZ#573556*[9].
Fixes *BZ#573549*[10].
Fixes *BZ#534020*[11].
Fixes *BZ#573555*[12].

Revision 6.0-5 **Mon Mar 01 2010** **Christopher Curran** *ccurran@redhat.com*

Beta version released.

Appendix C. Colophon

This manual was written in the DocBook XML v4.3 format.

This book is based on the original work of Jan Mark Holzer, Justin Clift and Chris Curran.

This book is edited and maintained by Scott Radvan.

Other writing credits go to:

- Daniel Berrange contributed various sections on libvirt.
- Don Dutile contributed technical editing for the para-virtualized drivers section.
- Barry Donahue contributed technical editing for the para-virtualized drivers section.
- Rick Ring contributed technical editing for the Virtual Machine Manager Section.
- Michael Kearey contributed technical editing for the sections on using XML configuration files with virsh and virtualized floppy drives.
- Marco Grigull contributed technical editing for the software compatibility and performance section.
- Eugene Teo contributed technical editing for the Managing Guests with virsh section.

Publican, the publishing tool which produced this book, was written by Jeffrey Fearn.

Translators

Due to technical limitations, the translators credited in this section are those who worked on previous versions of the *Red Hat Enterprise Linux Virtualization Guide* and the *Fedora Virtualization Guide*.

To find out who translated the current version of the guide, visit *https://fedoraproject.org/wiki/Fedora_13_Documentation_Translations_-_Contributors*. These translators will receive credit in subsequent versions of this guide.

- Simplified Chinese
  - Leah Wei Liu
- Traditional Chinese
  - Chester Cheng
  - Terry Chuang
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