Server Configuration Guide

ESX Server 3.0.1 and VirtualCenter 2.0.1

Server Configuration Guide
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Preface

This preface describes the contents of the *Server Configuration Guide* and provides pointers to VMware® technical and educational resources.

This preface contains the following topics:

About This Book

This manual, the *Server Configuration Guide*, provides information on how to configure networking for ESX Server, including how to create virtual switches and ports and how to set up networking for virtual machines, VMotion, IP storage, and the service console. It also covers configuring file system and various types of storage such as iSCSI, Fibre Channel, and so forth. To help you protect your ESX Server installation, the guide provides a discussion of security features built into ESX Server and the measures you can take to safeguard it from attack. In addition, it includes a list of ESX Server technical support commands along with their VI Client equivalents and a description of the `vmkfstools` utility.

Revision History

This manual is revised with each release of the product or when necessary. A revised version can contain minor or major changes. Table P-1 provides you with the revision history of this manual.

Table P-1. Revision History

Revision	Description
20060615	ESX Server 3.0 and VirtualCenter 2.0 version of the VMware Infrastructure 3 *Server Configuration Guide*. This is the first edition of this manual.
20060925	ESX Server 3.0.1 and VirtualCenter 2.0.1 version of the VMware Infrastructure 3 *Server Configuration Guide*. This edition includes minor changes to storage and networking configuration information.

Intended Audience

This manual is intended for anyone who needs to install, upgrade, or use ESX Server 3. The information in this manual is written for experienced Windows or Linux system administrators who are familiar with virtual machine technology and datacenter operations.

Document Feedback

If you have comments about this documentation, submit your feedback to:

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VMware Infrastructure Documentation

The VMware Infrastructure documentation consists of the combined VirtualCenter and ESX Server documentation set.

You can access the most current versions of this manual and other books by going to:

http://www.vmware.com/support/pubs

Conventions

Table P-2 illustrates the typographic conventions used in this manual.

Table P-2. Conventions Used in This Manual

Style	Elements
Blue (online only)	Cross-references and email addresses
Blue boldface (online only)	Links
Black boldface	User interface elements such as button names and menu items
`Monospace`	Commands, filenames, directories, and paths
`Monospace bold`	User input
Italic	Document titles, glossary terms, and occasional emphasis
< Name >	Variable and parameter names

Abbreviations Used in Graphics

The graphics in this manual use the abbreviations listed in Table P-3.

Table P-3. Abbreviations

Abbreviation	Description
VC	VirtualCenter
VI	Virtual Infrastructure Client
server	VirtualCenter Server
database	VirtualCenter database
host*n*	VirtualCenter managed hosts
VM#	Virtual machines on a managed host
user#	User with access permissions
dsk#	Storage disk for the managed host
datastore	Storage for the managed host
SAN	Storage area network type datastore shared between managed hosts
tmplt	Template

Technical Support and Education Resources

The following sections describe the technical support resources available to you.

Self-Service Support

Use the VMware Technology Network (VMTN) for self-help tools and technical information:

- Product information – **http://www.vmware.com/products/**
- Technology information – **http://www.vmware.com/vcommunity/technology**
- Documentation – **http://www.vmware.com/support/pubs**
- VMTN Knowledge Base – **http://www.vmware.com/support/kb**
- Discussion forums – **http://www.vmware.com/community**
- User groups – **http://www.vmware.com/vcommunity/usergroups.html**

For more information about the VMware Technology Network, go to **http://www.vmtn.net**.

Online and Telephone Support

Use online support to submit technical support requests, view your product and contract information, and register your products. Go to **http://www.vmware.com/support**.

Customers with appropriate support contracts should use telephone support for the fastest response on priority 1 issues. Go to **http://www.vmware.com/support/phone_support.html**.

Support Offerings

Find out how VMware support offerings can help meet your business needs. Go to **http://www.vmware.com/support/services**.

VMware Education Services

VMware courses offer extensive hands-on labs, case study examples, and course materials designed to be used as on-the-job reference tools. For more information about VMware Education Services, go to **http://mylearn1.vmware.com/mgrreg/index.cfm**.

Introduction 1

The *Server Configuration Guide* describes the tasks you need to complete to configure ESX Server host networking, storage, and security. In addition, it provides overviews, recommendations, and conceptual discussions to help you understand these tasks and how to deploy an ESX Server host to meet your needs. Before using the information in the *Server Configuration Guide*, read the *Introduction to Virtual Infrastructure* for an overview of system architecture and the physical and virtual devices that make up a Virtual Infrastructure system.

This introduction summarizes the contents of this guide so that you can find the information you need. This guide covers these subjects:

- ESX Server network configurations
- ESX Server storage configurations
- ESX Server security features
- ESX command reference
- The `vmkfstools` command

Networking

The ESX Server networking chapters provide you with a conceptual understanding of physical and virtual network concepts, a description of the basic tasks you need to complete to configure your ESX Server host's network connections, and a discussion of advanced networking topics and tasks. The networking section contains the following chapters:

- **"Networking"** – Introduces you to network concepts and guides you through the most common tasks you need to complete when setting up the network for the ESX Server host.
- **"Advanced Networking"** – Covers advanced networking tasks such as setting up MAC addresses, editing virtual switches and ports, and DNS routing. In addition, it provides tips on making your network configuration more efficient.
- **"Networking Scenarios and Troubleshooting"** – Describes common networking configuration and troubleshooting scenarios.

Storage

The ESX Server storage chapters provide you with a basic understanding of storage, a description of the basic tasks you perform to configure and manage your ESX Server host's storage, and a discussion of how to set up raw device mapping. The storage section contains the following chapters:

- **"Introduction to Storage"** – Introduces you to the types of storage you can configure for the ESX Server host.
- **"Configuring Storage"** – Explains how to configure local SCSI storage, Fibre Channel storage, and iSCSI storage. It also addresses VMFS storage and network-attached storage.
- **"Managing Storage"** – Explains how to manage existing datastores and the file systems that comprise datastores.
- **"Raw Device Mapping"** – Discusses raw device mapping, how to configure this type of storage, and how to manage raw device mappings by setting up multipathing, failover, and so forth.

Security

The ESX Server security chapters discuss safeguards VMware has built into ESX Server and measures you can take to protect your ESX Server host from security threats. These measures include using firewalls, leveraging the security features of virtual switches, and setting up user authentication and permissions. The security section contains the following chapters:

- **"Security for ESX Server Systems"** – Introduces you to the ESX Server features that help you ensure a secure environment for your data and gives you an overview of system design as it relates to security.
- **"Securing an ESX Server Configuration"** – Explains how to configure firewall ports for ESX Server hosts and VMware VirtualCenter, how to use virtual switches

and VLANs to ensure network isolation for virtual machines, and how to secure iSCSI storage.

- **"Authentication and User Management"** – Discusses how to set up users, groups, permissions, and roles to control access to ESX Server hosts and VirtualCenter. It also discusses encryption and delegate users.
- **"Service Console Security"** – Discusses the security features built into the service console and shows you how to configure these features.
- **"Security Deployments and Recommendations"** – Provides some sample deployments to give you an idea of the issues you need to consider when setting up your own ESX Server deployment. This chapter also tells you about actions you can take to further secure virtual machines.

Appendixes

The *Server Configuration Guide* includes appendixes that provide specialized information you may find useful when configuring an ESX Server host.

- **"ESX Technical Support Commands"** – Covers the ESX Server configuration commands that can be issued through a command line shell such as SSH. While these commands are available for your use, you should not consider them to be an API upon which you can build scripts. These commands are subject to change and VMware does not support applications and scripts that rely on ESX Server configuration commands. This appendix provides you with VMware Virtual Infrastructure Client equivalents for these commands.
- **"Using vmkfstools"** – Covers the `vmkfstools` utility, which you can use to perform management and migration tasks for iSCSI disks.

Networking

Networking 2

This chapter guides you through the basic concepts of networking in the ESX Server environment and how to set up and configure a network in a virtual infrastructure environment.

Use the Virtual Infrastructure (VI) Client to add networking based on three categories that reflect the three types of network services:

- Virtual machines
- VMkernel
- Service console

This chapter covers the following topics:

Networking Concepts

A few concepts are essential to a thorough understanding of virtual networking. If you are new to ESX Server 3.0, VMware highly recommends you read this section.

Concepts Overview

A *physical network* is a network of physical machines that are connected so that they can send data to and receive data from each other. VMware ESX Server runs on a physical machine.

A *virtual network* is a network of virtual machines running on a single physical machine that are connected logically to each other so that they can send data to and receive data from each other. Virtual machines can be connected to the virtual networks that you create in the procedure to add a network. Each virtual network is serviced by a single virtual switch. A virtual network can be connected to a physical network by associating one or more physical Ethernet adapters, also referred to as uplink adapters, with the virtual network's virtual switch. If no uplink adapters are associated with the virtual switch, all traffic on the virtual network is confined within the physical host machine. If one or more uplink adapters are associated with the virtual switch, virtual machines connected to that virtual network are also able to access the physical networks connected to the uplink adapters.

A *physical Ethernet switch* manages network traffic between machines on the physical network. A switch has multiple ports, each of which can be connected to a single other machine or another switch on the network. Each port can be configured to behave in certain ways depending on the needs of the machine connected to it. The switch learns which hosts are connected to which of its ports and uses that information to forward traffic to the correct physical machines. Switches are the core of a physical network. Multiple switches can be connected together to form larger networks.

A virtual switch, *vSwitch*, works much like a physical Ethernet switch. It detects which virtual machines are logically connected to each of its virtual ports and uses that information to forward traffic to the correct virtual machines. A vSwitch can be connected to physical switches using physical Ethernet adapters, also referred to as uplink adapters, to join virtual networks with physical networks. This type of connection is similar to connecting physical switches together to create a larger network. Even though a vSwitch works much like a physical switch, it does not have some of the advanced functionality of a physical switch. For more information on vSwitches, see "Virtual Switches" on page 23.

A *port group* specifies port configuration options such as bandwidth limitations and VLAN tagging policies for each member port. Network services connect to vSwitches through port groups. Port groups define how a connection is made through the vSwitch to the network. In typical use, one or more port groups is associated with a single vSwitch. For more information on port groups, see "Port Groups" on page 26.

NIC teaming occurs when multiple uplink adapters are associated with a single vSwitch to form a team. A team can either share the load of traffic between physical and virtual networks among some or all of its members or provide passive failover in the event of a hardware failure or a network outage.

VLANs enable a single physical LAN segment to be further segmented so that groups of ports are isolated from one another as if they were on physically different segments. 802.1Q is the standard.

The *VMkernel TCP/IP networking stack* supports iSCSI, NFS, and VMotion. Virtual machines run their own systems' TCP/IP stacks, and connect to the VMkernel at the Ethernet level through virtual switches. Two new features in ESX Server 3, iSCSI and NFS, are referred as *IP storage* in this chapter. IP storage refers to any form of storage that uses TCP/IP network communication as its foundation. iSCSI can be used as a virtual machine datastore, and NFS can be used as a virtual machine datastore and for direct mounting of `.ISO` files, which are presented as CD-ROMs to virtual machines.

NOTE The networking chapters cover how to set up networking for iSCSI and NFS. To configure the storage portion of iSCSI and NFS, see the storage chapters.

Migration with VMotion enables a powered on virtual machine to be transferred from one ESX Server host to another without shutting down the virtual machine. The optional VMotion feature requires its own license key.

Virtual Switches

Virtual Infrastructure (VI) Client lets you create abstracted network devices called virtual switches (vSwitches). A vSwitch can route traffic internally between virtual machines and link to external networks.

NOTE You can create a maximum of 248 vSwitches on a single host. (SEE UPDATE)

Use virtual switches to combine the bandwidth of multiple network adapters and balance communications traffic among them. They can also be configured to handle physical NIC failover.

A vSwitch models a physical Ethernet switch. The default number of logical ports for a vSwitch is 56. However, a vSwitch can be created with up to 1016 ports in ESX Server 3.0. You can connect one network adapter of a virtual machine to each port. Each uplink adapter associated with a vSwitch uses one port. Each logical port on the vSwitch is a member of a single port group. Each vSwitch can also have one or more port groups assigned to it. See "Port Groups" on page 26.

Before you can configure virtual machines to access a network, you must create at least one vSwitch. When two or more virtual machines are connected to the same vSwitch, network traffic between them is routed locally. If an uplink adapter is attached to the vSwitch, each virtual machine can access the external network that the adapter is connected to as shown in Figure 2-1.

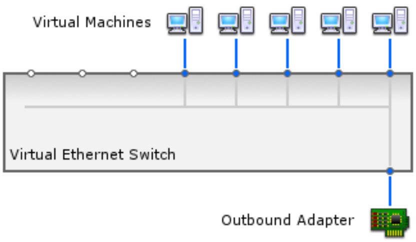


Figure 2-1. Virtual Switch Connections

In the VI Client, the details for the selected vSwitch are presented as an interactive diagram as shown in Figure 2-2. The most important information for each vSwitch is always visible.

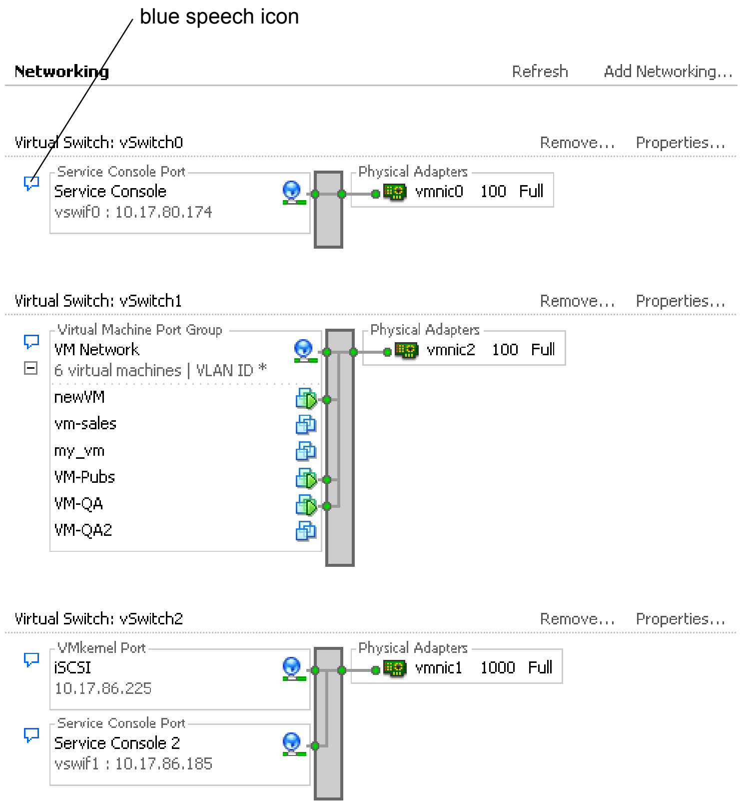


Figure 2-2. Virtual Switch Interactive Diagram

Click the blue speech icon to selectively reveal secondary and tertiary information.

A pop-up window displays detailed properties as shown in Figure 2-3.

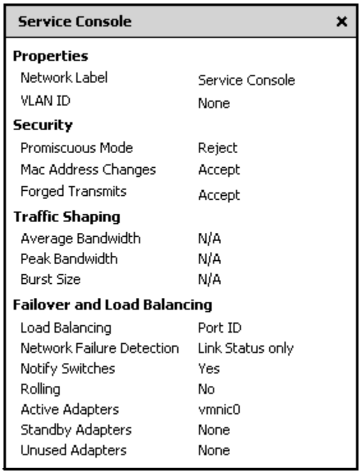


Figure 2-3. Virtual Switch Detailed Properties

Port Groups

Port groups aggregate multiple ports under a common configuration and provide a stable anchor point for virtual machines connecting to labeled networks. Each port group is identified by a network label, which is unique to the current host. A VLAN ID, which restricts port group traffic to a logical Ethernet segment within the physical network, is optional.

NOTE You can create a maximum of 512 port groups on a single host.

Labeled networks are properly configured only when all port groups using the same network label are able to see the same broadcast traffic. Because a VLAN can restrict visibility on a physical network, it might be necessary to synchronize the network label and VLAN ID controls when one of them is changed. More than one port group can use the same VLAN ID.

NOTE In order for a port group to reach port groups located on other VLANs, you must set the VLAN ID to 4095.

Network Services

You need to enable two types of network services in ESX Server:

- Connecting virtual machines to the physical network
- Connecting VMkernel services (such as NFS, iSCSI, or VMotion) to the physical network

The service console, which runs the management services, is set up by default during the installation of ESX Server.

Viewing Networking Information in the VI Client

The VI Client displays both general networking information and information specific to network adapters.

To view general networking information in the VI Client

1. Log on to the VMware VI Client and select the server from the inventory panel.

   The hardware configuration page for this server appears.

2. Click the **Configuration** tab, and click **Networking**.

The networking panel displays the following information as shown in Figure 2-4:

- Virtual switches
- Adapter information for each adapter
  - Link status
  - Apparent speed and duplex
- Service console and VMkernel TCP/IP services
  - IP address
- Service console
  - Virtual device name
- Virtual machines
  - Power status
  - Connection status
- Port group
  - Network label – common to all three port configuration types

- Number of configured virtual machines
- VLAN ID, if any – common to all three port configuration types

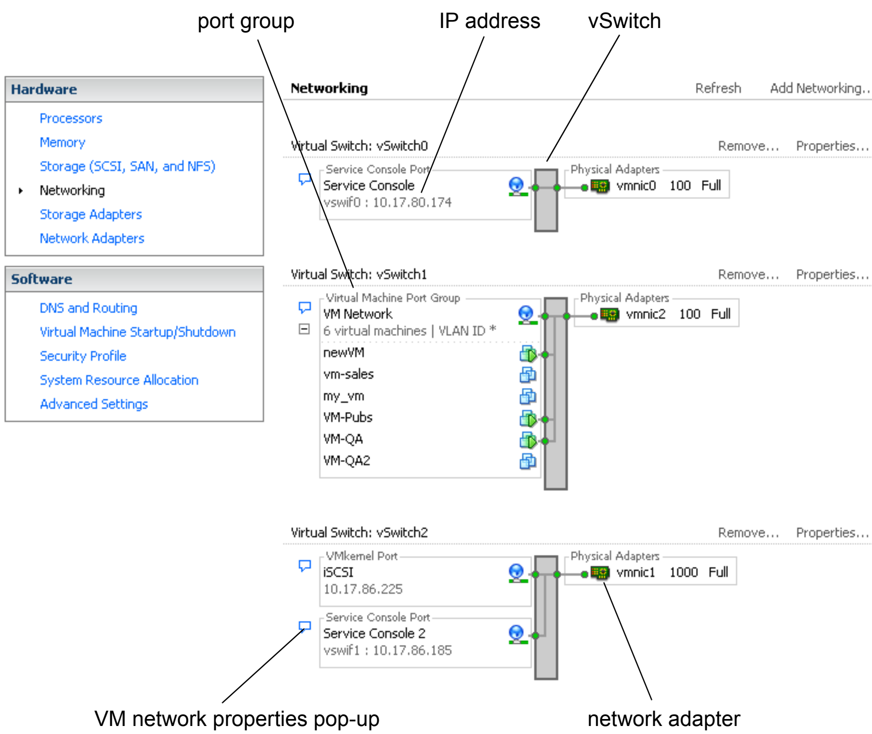


Figure 2-4. General Networking Information

To view network adapter information in the VI Client

1 Log into the VMware VI Client and select the server from the inventory panel.

The hardware configuration page for this server appears.

2 Click the **Configuration** tab, and click **Network Adapters**.

The network adapters panel displays the following information:

- **Device** – Name of the network adapter
- **Speed** – Actual speed and duplex of the network adapter
- **Configured** – Configured speed and duplex of the network adapter

- **vSwitch** – vSwitch that the network adapter is associated with
- **Networks** – IP addresses that the network adapter has access to

Networking Tasks

This chapter outlines how to perform the following networking tasks

- "To create or add a virtual network for a virtual machine" on page 30
  - Setting the connection type for a virtual machine.
  - Adding the virtual network to a new or an existing virtual switch.
  - Configuring the network label and VLAN ID connection settings.
- "To set up the VMkernel" on page 34
  - Setting the connection type for the VMkernel.
  - Adding the virtual network to a new or an existing virtual switch.
  - Configuring the network label, VLAN ID, TCP/IP, and gateway connection settings.
- "To configure service console networking" on page 37
  - Setting the connection type for the service console.
  - Adding the virtual network to a new or an existing virtual switch.
  - Configuring the network label, VLAN ID, DHCP/Static IP, and gateway connection settings.
- "To set the default gateway" on page 41
- "To display service console information" on page 43

Virtual Network Configuration for Virtual Machines

The VI Client **Add Network Wizard** steps you through the tasks to create a virtual network for a virtual machine. These tasks include:

- Setting the connection type for a virtual machine
- Adding the virtual network to a new or an existing vSwitch
- Configuring the connection settings for the network label and the VLAN ID

When setting up virtual machine networks, consider whether you want to migrate the virtual machines in the network between ESX Server hosts. If so, be sure that both hosts are in the same broadcast domain—that is, the same Layer 2 subnet.

ESX Server doesn't support virtual machine migration between hosts in different broadcast domains because the migrated virtual machine might require systems and resources that it would no longer have access to by virtue of being moved to a separate network. Even if your network configuration is set up as a high availability environment or includes intelligent switches capable of resolving the virtual machine's needs across different networks, you may experience lag times as the ARP table updates and resumes network traffic for the virtual machines.

To create or add a virtual network for a virtual machine

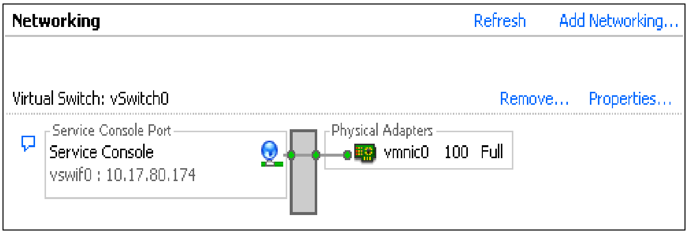
1 Log on to the VMware VI Client and select the server from the inventory panel.

The hardware configuration page for this server appears.

2 Click the **Configuration** tab, and click **Networking**.

3 On the right side of the screen, click **Add Networking**.

Virtual switches are presented in an overview plus details layout.



4 Click **Add Networking** from the **Configuration** tab.

The **Add Network Wizard** appears.

NOTE The **Add Network Wizard** is reused for new ports and port groups.

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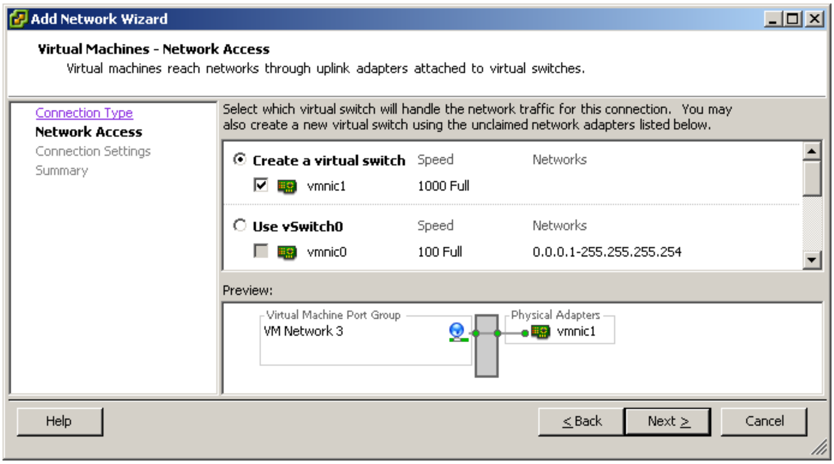
5 Accept the default connection type, **Virtual Machines**.

Virtual Machines lets you add a labeled network to handle virtual machine network traffic.

6 Click **Next**.

The **Network Access** screen appears.



Virtual machines reach physical networks through uplink adapters. A vSwitch is able to transfer data only to external networks when one or more network adapters are attached to it. When two or more adapters are attached to a single vSwitch, they are transparently teamed.

7 Select **Create a virtual switch**.

You can create a new vSwitch with or without Ethernet adapters.

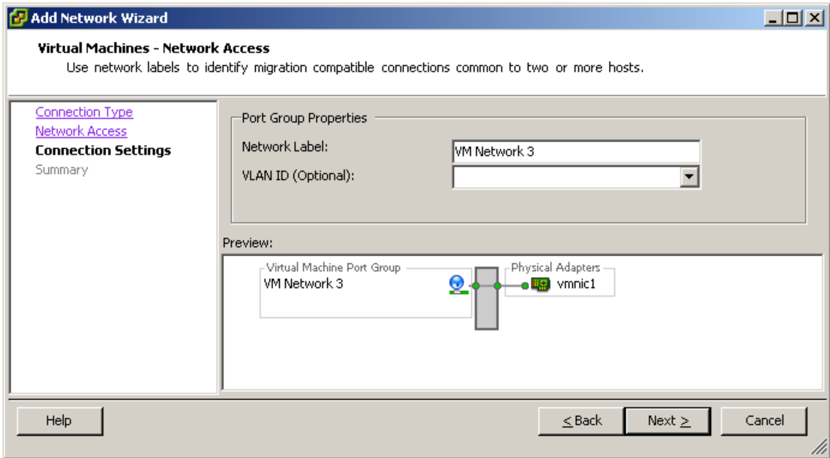
If you create a vSwitch without physical network adapters, then all traffic on that vSwitch will be confined to that vSwitch. No other hosts on the physical network or virtual machines on other vSwitches will be able to send or receive traffic over this vSwitch. You might do this if you want a group of virtual machines to be able to communicate with each other, but not with other hosts or with virtual machines outside the group.

Changes appear in the **Preview** pane.

8 Click **Next**.

The **Connection Settings** screen appears.

9 Under **Port Group Properties**, enter a network label that identifies the port group that you are creating.



Use network labels to identify migration-compatible connections common to two or more hosts.

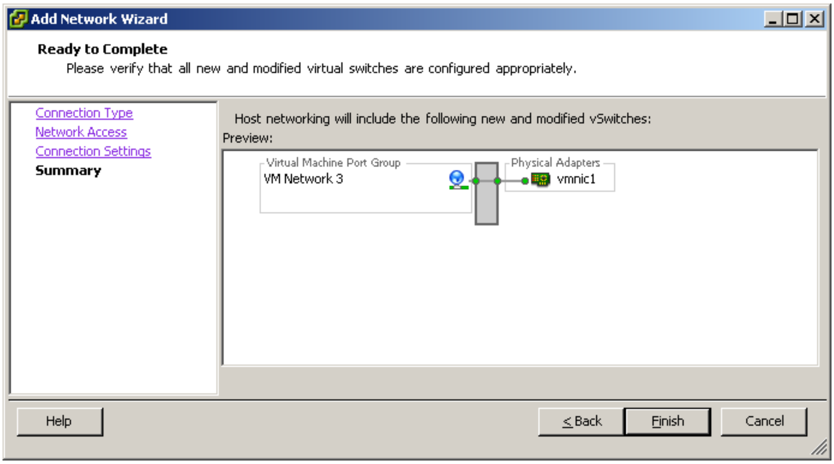
10 If you are using a VLAN, in the **VLAN ID** field, enter a number between 1 and 4094.

If you are unsure what to enter, leave this blank or ask your network administrator.

If you enter 0 or leave the field blank, the port group can see only untagged (non-VLAN) traffic. If you enter 4095, the port group can see traffic on any VLAN while leaving the VLAN tags intact.

11 Click **Next**.

The **Ready to Complete** screen appears.



12 After you have determined that the vSwitch is configured correctly, click **Finish**.

NOTE To enable failover (NIC teaming), bind two or more adapters to the same switch. If one uplink adapter is not operational, network traffic is routed to another adapter attached to the switch. NIC teaming requires both Ethernet devices to be on the same Ethernet broadcast domain.

VMkernel Configuration

Moving a virtual machine from one host to another is called migration. Migrating a powered-on virtual machine is called VMotion. Migration with VMotion, designed to be used between highly compatible systems, lets you migrate virtual machines with no downtime. Your VMkernel networking stack must be set up properly to accommodate VMotion.

IP Storage refers to any form of storage that uses TCP/IP network communication as its foundation, which includes iSCSI and NAS for ESX Server. Because both of these storage types are network-based, both types can use the same port group.

The network services provided by the VMkernel (iSCSI, NFS, and VMotion) use a TCP/IP stack in the VMkernel. This TCP/IP stack is completely separate from the TCP/IP stack used in the service console. Each of these TCP/IP stacks accesses various networks by attaching to one or more port groups on one or more vSwitches.

TCP/IP Stack at the Virtual Machine Monitor Level

The VMware VMkernel TCP/IP networking stack has been extended to handle iSCSI, NFS, and VMotion in the following ways:

- iSCSI as a virtual machine datastore.
- iSCSI for the direct mounting of .ISO files, which are presented as CD-ROMs to virtual machines.
- NFS as a virtual machine datastore.
- NFS for the direct mounting of `.ISO` files, which are presented as CD-ROMs to virtual machines.
- Migration with VMotion.

NOTE ESX supports only NFS version 3 over TCP/IP.

Implications and Guidelines

Refer to the following guidelines when configuring VMkernel networking:

- The IP address that you assign to the service console during installation must be different from the IP address that you assign to VMkernel's TCP/IP stack from the Configuration > Networking tab of the Virtual Infrastructure Client.
- Before configuring software iSCSI for the ESX Server host, open a firewall port by enabling the iSCSI software client service. For more information, see "Opening Firewall Ports for Supported Services and Management Agents" on page 192.
- Unlike other VMkernel services, iSCSI has a service console component, so networks that are used to reach iSCSI targets must be accessible to both service console and VMkernel TCP/IP stacks.

To set up the VMkernel

1. Log on to the VMware VI Client and select the server from the inventory panel.

   The hardware configuration page for this server appears.

2. Click the **Configuration** tab, and click **Networking**.
3. Click the **Add Networking** link.

   The **Add Network Wizard** appears.

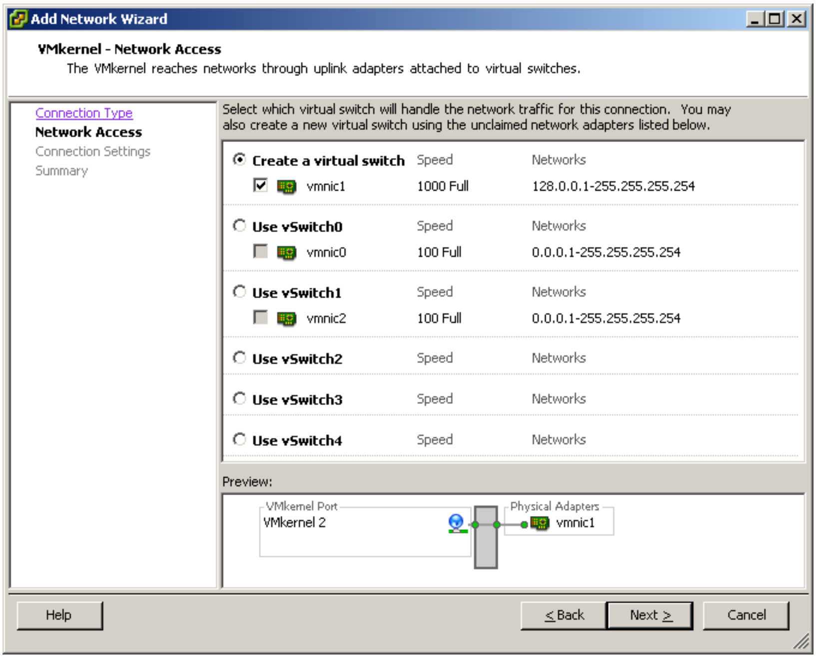
4. Select **VMkernel** and click **Next**.

Selecting **VMotion and IP Storage** lets you connect the VMkernel, which runs services for VMotion and IP storage (NFS or iSCSI), to the physical network.

The **Network Access** page appears.

5 Select the vSwitch you would like to use, or select the **Create a virtual switch** radio button to create a new vSwitch.

6 Select the check boxes for the network adapters your vSwitch will use.



Your choices appear in the **Preview** pane.

Select adapters for each vSwitch so that virtual machines or other services that connect through the adapter can reach the correct Ethernet segment. If no adapters appear under **Create a new virtual switch**, all the network adapters in the system are being used by existing vSwitches. You can either create a new vSwitch without a network adapter or select a network adapter used by an existing vSwitch.

For information on moving network adapters between vSwitches, see "To add uplink adapters" on page 50.

7 Click **Next**.

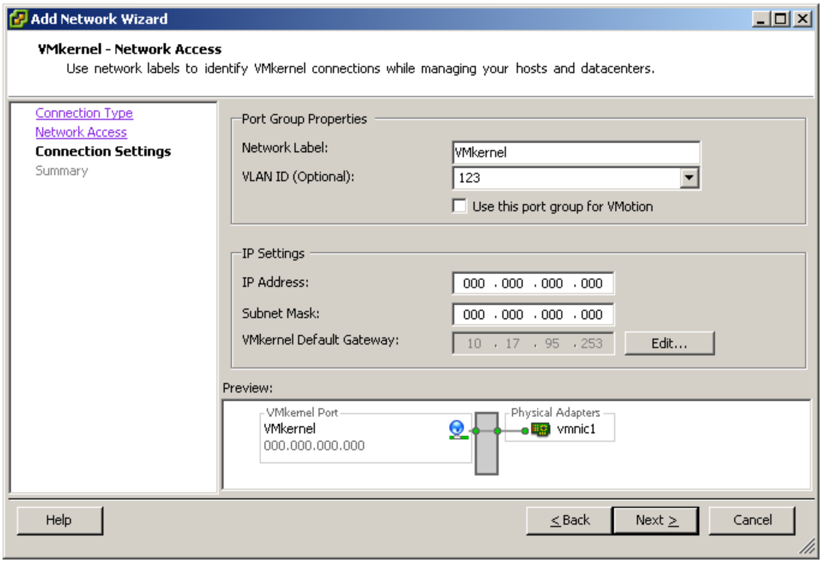
The **Connection Settings** page appears.

8 Under **Port Group Properties**, select or enter a network label and a VLAN ID.

- **Network Label** — A name that identifies the port group that you are creating. This is the label that you specify when configuring a virtual adapter to be attached to this port group, when configuring VMkernel services, such as VMotion and IP storage.
- **VLAN ID** — Identifies the VLAN that the port group's network traffic will use.

9 Select the **Use this port group for VMotion** check box to enable this port group to advertise itself to another ESX Server as the network connection where VMotion traffic should be sent.

You can enable this property for only one VMotion and IP storage port group for each ESX Server host. If this property is not enabled for any port group, migration with VMotion to this host is not possible.



10 Under **IP Settings**, click **Edit** to set the **VMkernel Default Gateway** for VMkernel services, such as VMotion, NAS, and iSCSI.

NOTE Make sure that you set a default gateway for the port that you created. VirtualCenter 2 behaves differently here from VirtualCenter 1.x. You must use a valid IP address to configure the VMkernel IP stack, not a dummy address.

The **DNS and Routing Configuration** dialog box appears. Under the **DNS Configuration** tab, the name of the host is entered into the name field by default. The DNS server addresses that were specified during installation are also preselected as is the domain.

Under the **Routing** tab, the service console and the VMkernel each need their own gateway information. A gateway is for needed if connectivity to machines not on the same IP subnet as the service console or VMkernel.

Static IP settings is the default.

11 Click **OK** to save your changes and close the **DNS Configuration and Routing** dialog box.

12 Click **Next**.

13 Use the **Back** button to make any changes.

14 Review your changes on the **Ready to Complete** page and click **Finish**.

Service Console Configuration

Both the service console and the VMkernel use virtual Ethernet adapters to connect to a vSwitch and to reach networks serviced by the vSwitch.

Basic Service Console Configuration Tasks

There are two common service console configuration changes: changing NICs and changing the settings for an existing NIC that is in use.

When only one service console connection is present, changing the service console configuration is not allowed. If you want a new connection, you must change the network settings to use an additional NIC. After verifying that the new connection is functioning properly, remove the old connection. You are switching over to the new NIC.

To configure service console networking

1 Log into the VMware VI Client and select the server from the inventory panel.

The hardware configuration page for this server appears.

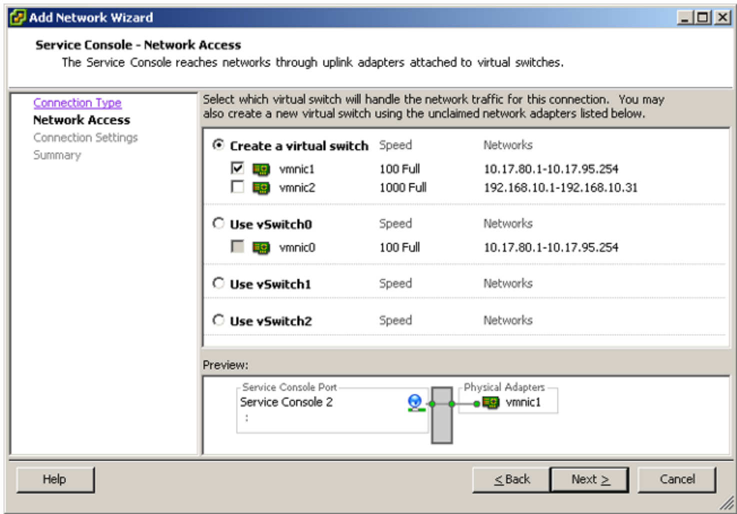
2 Click the **Configuration** tab, and click **Networking**.

3 Click the **Add Networking** link.

The **Add Network Wizard** appears.

4 Select **Service Console** on the **Connection Types** screen, and click **Next**.

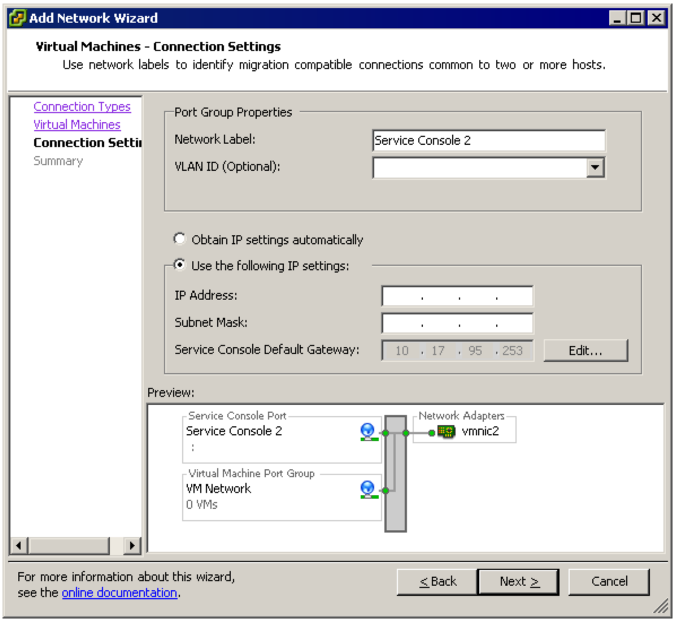
The **Service Console Network Access** page appears.



5 Select the vSwitch you want to use for network access, or select **Create a new vSwitch** and click **Next**.

If no adapters appear under **Create a new virtual switch**, all the network adapters in the system are being used by existing vSwitches. For information on moving network adapters between vSwitches, see "To add uplink adapters" on page 50.

6 Under **Port Group Properties**, select or enter the **Network Label** and **VLAN ID**.



Newer ports and port groups appear at the top of the vSwitch diagram.

7 Enter the **IP Address** and **Subnet Mask,** or select the DHCP option **Obtain IP setting automatically** for the IP address and subnet mask.

8 Click the **Edit** button to set the **Service Console Default Gateway**.

See "To set the default gateway" on page 41.

9 Click **Next**.

The **Ready to Complete** page appears.

10 Check the information and click **Finish**.

To configure service console ports

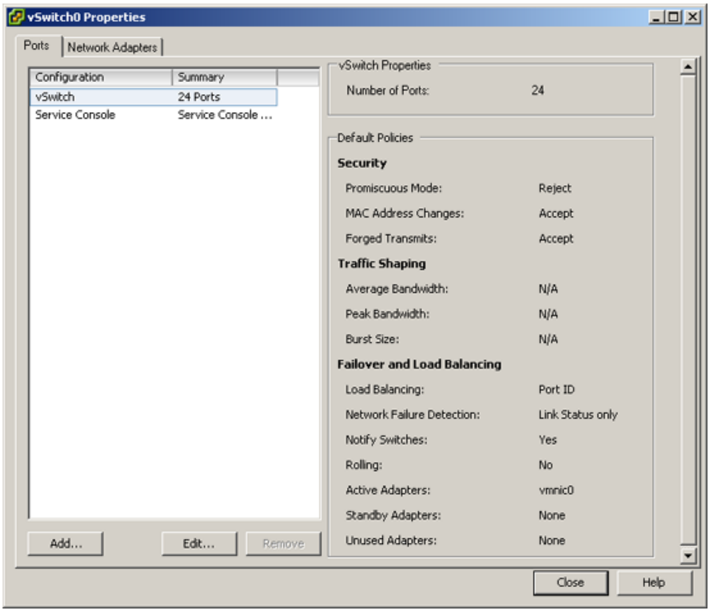
1 Log into the VMware VI Client and select the server from the inventory panel.

The hardware configuration page for this server appears.

2 Click the **Configuration** tab, and click **Networking**.

3 On the right side of the screen, find the vSwitch that you want to edit and click **Properties** for that vSwitch.

The **vSwitch Properties** dialog box appears.



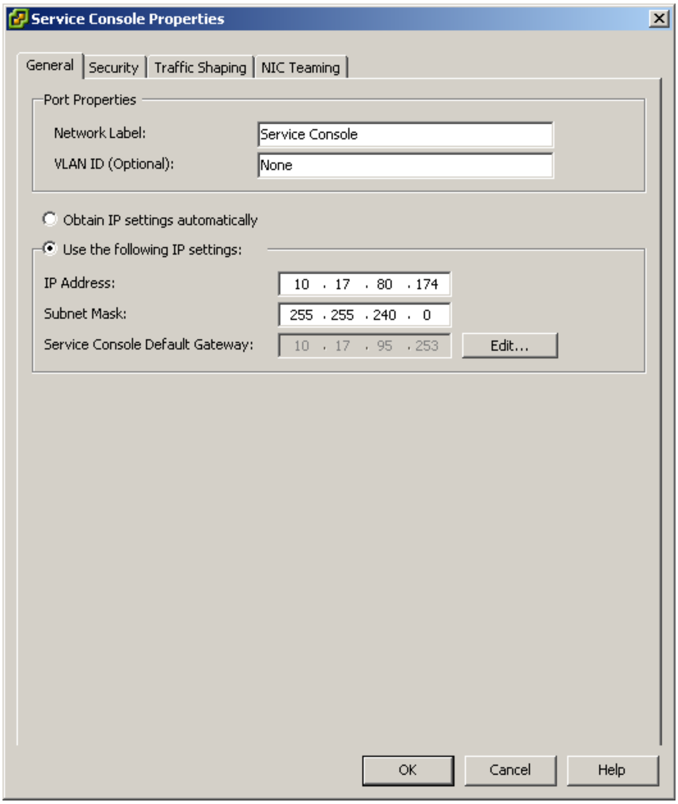
4 In the **vSwitch Properties** dialog box, click the **Ports** tab.

5 Select **Service Console**, and click **Edit**.

A warning dialog box appears to explain that modifying your service console connection may disconnect all management agents.

6 To continue with the service console configuration, click **Continue modifying this connection**.

The **Service Console Properties** dialog box appears.



7 Edit port properties, IP settings, and effective policies as necessary.

8 Click OK.

Only one default gateway can be configured per TCP/IP stack.

To set the default gateway

1 Log into the VMware VI Client and select the server from the inventory panel.

The hardware configuration page for this server appears.

2 Click the **Configuration** tab, and click **DNS and Routing**.

The **DNS and Routing** panel appears.

3 Click the **Properties** link.

The **DNS Configuration** dialog box appears.

Under the **DNS Configuration** tab, the name of the host is entered into the name field by default. The DNS server addresses and the domain previously selected during installation are also preselected.

Under the **Routing** tab, the service console and the VMkernel are often not connected to the same network, and each needs its own gateway information. A gateway is needed for connectivity to machines not on the same IP subnet as the service console or VMkernel.

NOTE All NAS and iSCSI servers need to be either reachable by the default gateway or on the same broadcast domain as the associated vSwitches.

For the service console, the gateway device is needed only when two or more network adapters are using the same subnet. The gateway device determines which network adapter will be used for the default route.

4 Click the **Routing** tab.

5 Set the VMkernel default gateway.

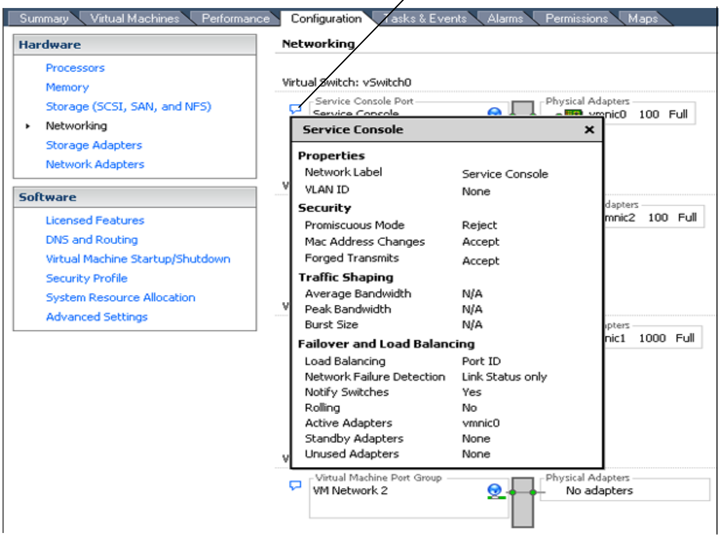
CAUTION There is a risk of misconfiguration, which can cause the UI to lose connectivity to the host, in which case the host will have to be reconfigured from command line at the service console.

6 Click **OK** to save your changes and close the **DNS Configuration** dialog box.

To display service console information

1 Click the blue speech icon to display service console information.

blue speech icon



2 Click the **X** to close the information pop-up window.

Using DHCP for the Service Console

In most cases, you should use static IP addresses for the service console. You can also set up the service console to use dynamic addressing, DHCP, if your DNS server is capable of mapping the service console's host name to the dynamically-generated IP address.

If your DNS server cannot map the host's name to its DHCP-generated IP address, you must determine the service console's numeric IP address and use that numeric address when accessing the host.

The numeric IP address might change as DHCP leases run out or when the system is rebooted. For this reason, we do not recommend using DHCP for the service console unless your DNS server can handle the host name translation.

Advanced Networking 3

This chapter guides you through advanced networking topics in an ESX Server environment and how to set up and change advanced networking configuration options.

This chapter covers the following topics:

Advanced Networking Tasks

This chapter outlines how to perform the following advanced networking tasks:

- "To edit the number of ports for a vSwitch" on page 46
- "To configure the uplink network adapter by changing its speed" on page 49
- "To add uplink adapters" on page 50
- "To edit the Layer 2 Security policy" on page 53
- "To edit the Traffic Shaping policy" on page 55
- "To edit the failover and load balancing policy" on page 57
- "To edit port group properties" on page 60
- "To override labeled network policies" on page 60
- "To change the DNS and Routing configuration" on page 62
- "To set up a MAC address" on page 66

Virtual Switch Configuration

This section contains the following information:

- "Virtual Switch Properties" on page 46
- "Virtual Switch Policies" on page 53

Virtual Switch Properties

Virtual switch settings control vSwitch-wide defaults for ports, which can be overridden by port group settings for each vSwitch.

Editing Virtual Switch Properties

Editing vSwitch properties consists of:

- Configuring ports
- Configuring the uplink network adapters

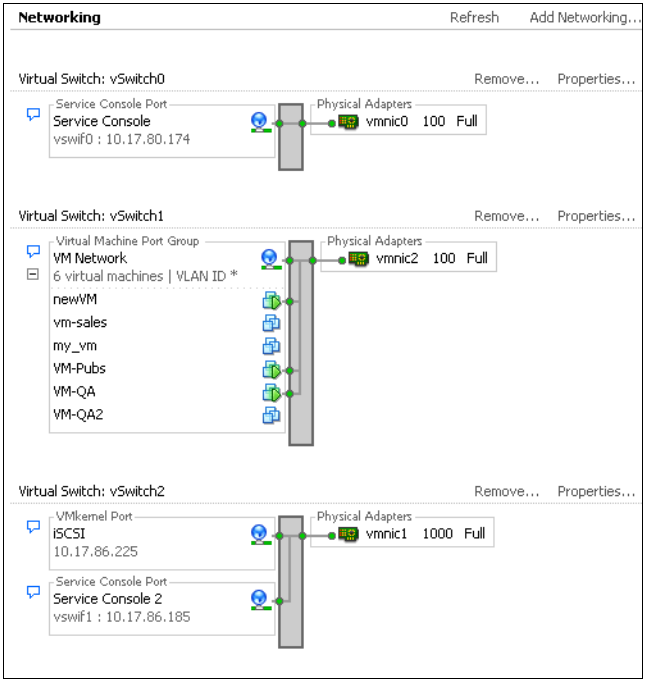
To edit the number of ports for a vSwitch

1. Log into the VMware VI Client, and select the server from the inventory panel.

   The hardware configuration page for this server appears.

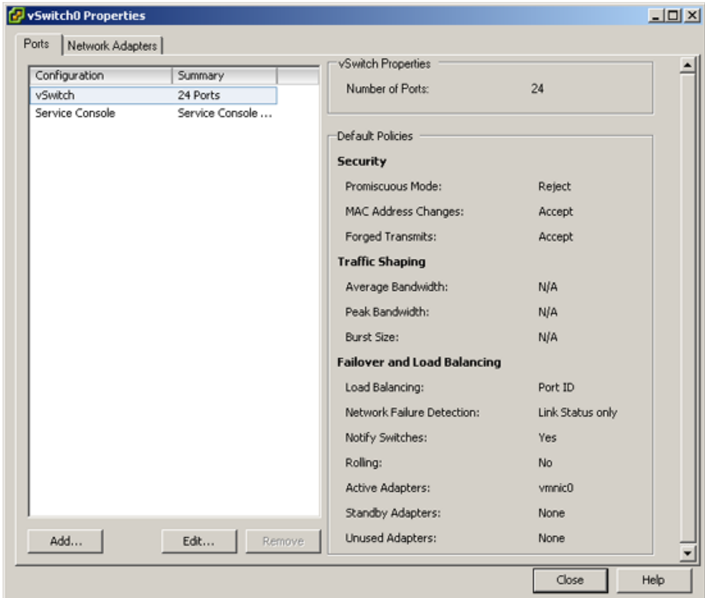
2. Click the **Configuration** tab, and click **Networking**.

3 On the right side of the window, find the vSwitch that you want to edit.



4 Click **Properties** for that vSwitch.

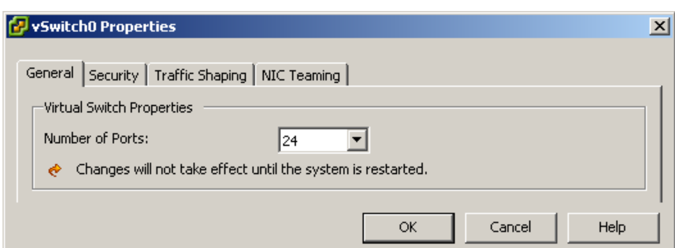
The **vSwitch Properties** dialog box appears.



5 Click the **Ports** tab.

6 Select the vSwitch item in the **Configuration** list, and click **Edit**.

The **vSwitch Properties** dialog box appears.



7 Click the **General** tab to set the number of ports.

8 Choose or enter the number of ports you want to use.

Modifications will not take effect until you reboot ESX Server.

9 Click **OK**.

To configure the uplink network adapter by changing its speed

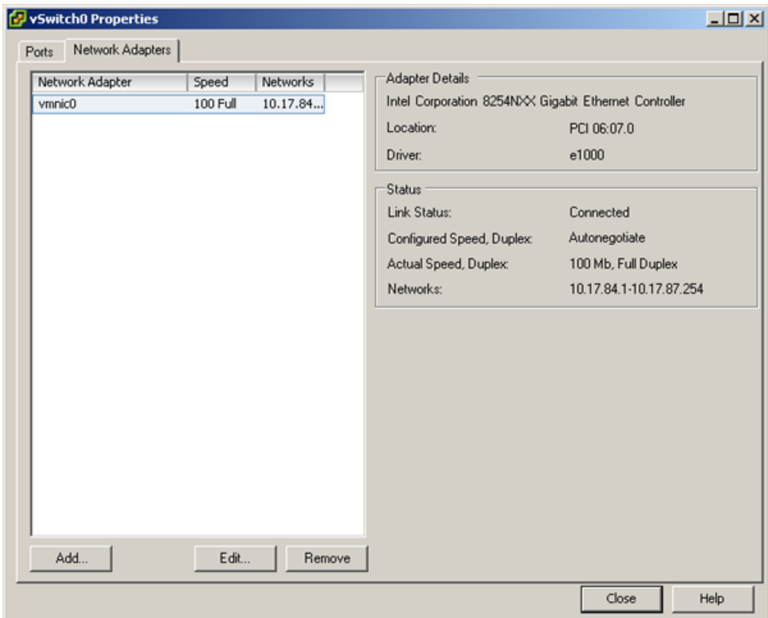
1 Log into the VMware VI Client and select the server from the inventory panel.

The hardware configuration page for this server appears.

2 Click the **Configuration** tab, and click **Networking**.

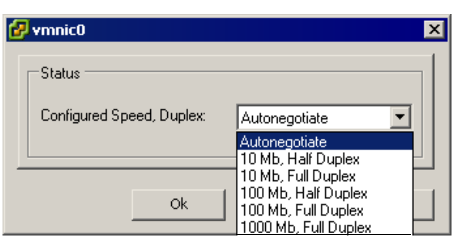
3 Select a vSwitch and click **Properties**.

4 In the **vSwitch Properties** dialog box, click the **Network Adapters** tab.



5 To change the configured speed, duplex value of a network adapter, select the network adapter and click **Edit**.

The **Status** dialog box appears. The default is **Autonegotiate**, which is usually the correct choice.



6 To select the connection speed manually, select the speed/duplex from the drop-down menu.

Choose the connection speed manually if the NIC and a physical switch might fail to negotiate the proper connection speed. Symptoms of mismatched speed and duplex include low bandwidth or no link connectivity at all.

The adapter and the physical switch port it is connected to must be set to the same value, that is, auto/auto or ND/ND where ND is some speed and duplex, but not auto/ND.

7 Click **OK**.

To add uplink adapters

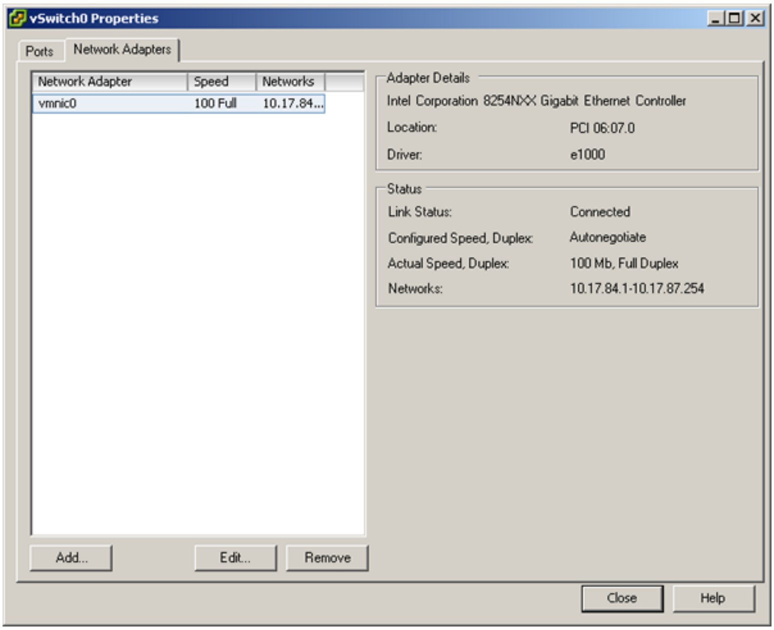
1 Log into the VMware VI Client, and select the server from the inventory panel.

The hardware configuration page for this server appears.

2 Click the **Configuration** tab, and click **Networking**.

3 Select a vSwitch and click **Properties**.

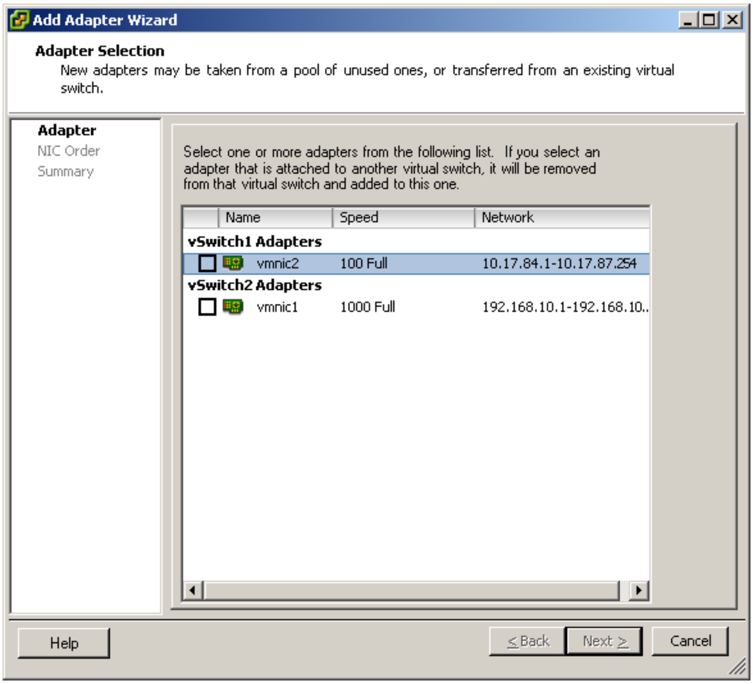
4 In the **Properties** dialog box for the vSwitch, click the **Network Adapters** tab.



5 Click **Add** to launch the Add Adapter Wizard.

You can associate multiple adapters to a single vSwitch to provide NIC teaming. Such a team can share traffic and provide failover.

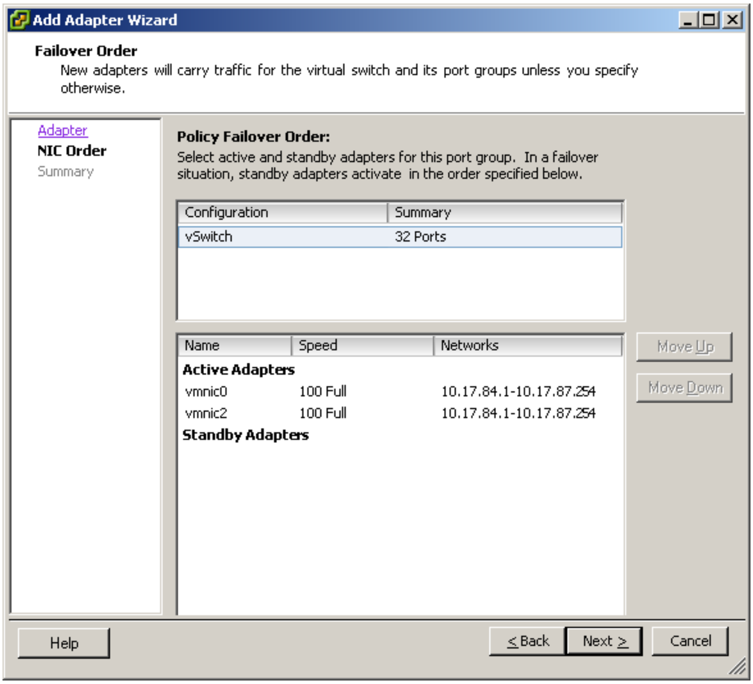
CAUTION Misconfiguration can result in the loss of the VI Client ability to connect to the host.



6 Select one or more adapters from the list, and click **Next**.

7 To order the NICs, select a NIC and click the buttons to move it up or down into the category (Active or Standby) that you want.

- **Active Adapters** — Adapters currently used by the vSwitch.
- **Standby Adapters** — Adapters that become active in the event that one or more of the active adapters should fail.



8 Click **Next**.

The **Adapter Summary** page appears.

9 Review the information on this page, use the **Back** button to change any entries, and click **Finish** to leave the Add Adapter Wizard.

The list of network adapters re-appears, showing those adapters now claimed by the vSwitch.

10 Click **Close** to exit the **vSwitch Properties** dialog box.

The **Networking** section in the **Configuration** tab shows the network adapters in their designated order and categories.

Virtual Switch Policies

You can apply a set of vSwitch-wide policies by selecting the vSwitch at the top of the **Ports** tab and clicking **Edit**.

To override any of these settings for a port group, select that port group and click **Edit**. Any changes to the vSwitch-wide configuration are applied to any of the port groups on that vSwitch except for those configuration options that have been overridden by the port group.

The vSwitch policies consist of:

- Layer 2 Security policy
- Traffic Shaping policy
- Load Balancing and Failover policy

Layer 2 Security Policy

Layer 2 is the data link layer. The three elements of the Layer 2 Security policy are promiscuous mode, MAC address changes, and forged transmits.

In non-promiscuous mode, a guest adapter listens to traffic only on its own MAC address. In promiscuous mode, it can listen to all the packets. By default, guest adapters are set to non-promiscuous mode.

For further information on security, see "Securing Virtual Switch Ports" on page 201.

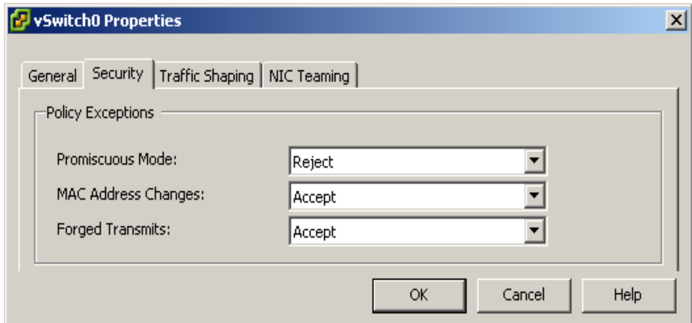
To edit the Layer 2 Security policy

1. Log into the VMware VI Client and select the server from the inventory panel.

   The hardware configuration page for this server appears.

2. Click the **Configuration** tab, and click **Networking**.
3. Click **Properties** for the vSwitch whose Layer 2 Security policy you want to edit.
4. In the **Properties** dialog box for the vSwitch, click the **Ports** tab.
5. Select the vSwitch item and click **Edit**.

6 In the Properties dialog box for the vSwitch, click the **Security** tab.



By default, **Promiscuous Mode** is set to **Reject**, and **MAC Address Changes** and **Forced Transmits** are set to **Accept**.

The policy here applies to all virtual adapters on the vSwitch except where the port group for the virtual adapter specifies a policy exception.

7 In the **Policy Exceptions** pane, select whether to reject or accept the Layer2 Security policy exceptions:

- **Promiscuous Mode**
  - **Reject** — Placing a guest adapter in promiscuous mode has no effect on which frames are received by the adapter.
  - **Accept** — Placing a guest adapter in promiscuous mode causes it to detect all frames passed on the vSwitch that are allowed under the VLAN policy for the port group that the adapter is connected to.
- **MAC Address Changes**
  - **Reject** — If you set the **MAC Address Changes** to **Reject** and the guest operating system changes the MAC address of the adapter to anything other than what is in the `.vmx configuration` file, all inbound frames will be dropped.

    If the Guest OS changes the MAC address back to match the MAC address in the `.vmx configuration` file, inbound frames will be passed again.
  - **Accept** — Changing the MAC address from the Guest OS has the intended effect: frames to the new MAC address are received.

- **Forged Transmits**
  - **Reject** — Any outbound frame with a source MAC address that is different from the one currently set on the adapter will be dropped.
  - **Accept** — No filtering is performed and all outbound frames are passed.

8 Click **OK**.

Traffic Shaping Policy

ESX Server shapes traffic by establishing parameters for three outbound traffic characteristics: average bandwidth, burst size, and peak bandwidth. You can set values for these characteristics through the VI Client, establishing a traffic shaping policy for each uplink adapter.

- **Average Bandwidth** establishes the number of bits per second to allow across the vSwitch averaged over time—the allowed average load.
- **Burst Size** establishes the maximum number of bytes to allow in a burst. If a burst exceeds the burst size parameter, excess packets are queued for later transmission. If the queue is full, the packets are dropped. When you specify values for these two characteristics, you indicate what you expect the vSwitch to handle during normal operation.
- **Peak Bandwidth** is the maximum bandwidth the vSwitch can absorb without dropping packets. If traffic exceeds the peak bandwidth you establish, excess packets are queued for later transmission after traffic on the connection has returned to the average and there are enough spare cycles to handle the queued packets. If the queue is full, the packets are dropped. Even if you have spare bandwidth because the connection has been idle, the peak bandwidth parameter limits transmission to no more than peak until traffic returns to the allowed average load.

To edit the Traffic Shaping policy

1 Log into the VMware VI Client and select the server from the inventory panel.

The hardware configuration page for this server appears.

2 Click the **Configuration** tab, and click **Networking**.

3 Select a vSwitch and click **Properties**.

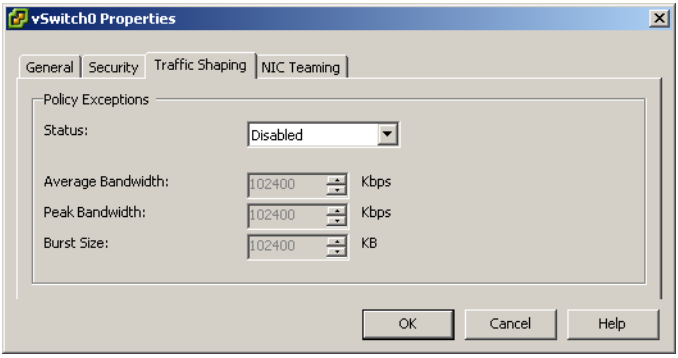
4 In the **vSwitch Properties** dialog box, click the **Ports** tab.

5 Select the vSwitch and click **Edit**.

The **Properties** dialog box for the selected vSwitch appears.

6 Click the **Traffic Shaping** tab.

The **Policy Exceptions** pane appears. When traffic shaping is disabled, the tunable features are dimmed. You can selectively override all traffic-shaping features at the port group level if traffic shaping is enabled.



These are the policies to which the per port group exceptions are applied.

The policy here is applied to each virtual adapter attached to the port group, not to the vSwitch as a whole.

- **Status** — If you enable the policy exception in the **Status** field, you are setting limits on the amount of networking bandwidth allocation each virtual adapter associated with this particular port group. If you disable the policy, services will have a free, clear connection to the physical network by default.

The remaining fields define network traffic parameters:

- **Average Bandwidth** — A value measured over a particular period of time.
- **Peak Bandwidth** — A value that is the maximum bandwidth allowed and that can never be smaller than average bandwidth. This parameter limits the maximum bandwidth during a burst.
- **Burst Size** — A value specifying how large a burst can be in kilobytes (K). This parameter controls the amount of data that can be sent in one burst while exceeding the average rate.

Load Balancing and Failover Policy

Load Balancing and Failover policies allow you to determine how network traffic is distributed between adapters and how to re-route traffic in the event of an adapter failure by configuring the following parameters:

- Load Balancing policy

  The Load Balancing policy determines how outgoing traffic is distributed among the network adapters assigned to a vSwitch.

NOTE Incoming traffic is controlled by the Load Balancing policy on the physical switch.

- Failover Detection: Link Status/Beacon Probing
- Network Adapter Order (Active/Standby)

To edit the failover and load balancing policy

1. Log into the VMware VI Client and select the server from the inventory panel.

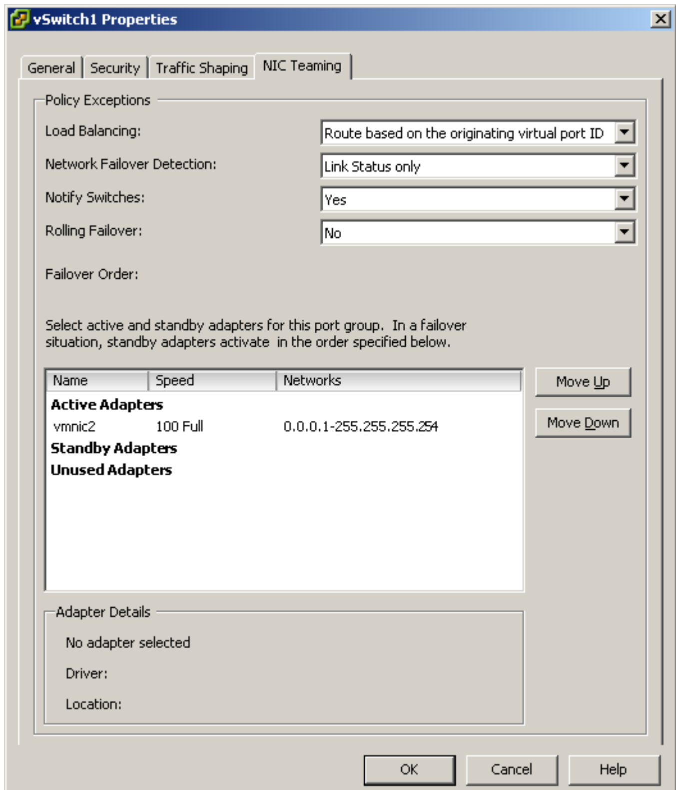
   The hardware configuration page for this server appears.

2. Click the **Configuration** tab, and click **Networking**.
3. Select a vSwitch and click **Edit**.
4. In the **vSwitch Properties** dialog box, click the **Ports** tab.
5. To edit the **Failover and Load Balancing** values for the vSwitch, select the vSwitch item and click **Properties**.

   The **Properties** dialog box for the vSwitch appears.

6 Click the **NIC Teaming** tab.

The **Policy Exceptions** area appears. You can override the failover order at the port group level. By default, new adapters are active for all policies. New adapters carry traffic for the vSwitch and its port group unless you specify otherwise.



7 In the **Policy Exceptions** pane:

- **Load Balancing** — Specify how to choose an uplink.
  - **Route based on the originating port ID** — Choose an uplink based on the virtual port where the traffic entered the virtual switch.
  - **Route based on ip hash** — Choose an uplink based on a hash of the source and destination IP addresses of each packet. For non-IP packets, whatever is at those offsets is used to compute the hash.

- **Route based on source MAC hash** — Choose an uplink based on a hash of the source Ethernet.
- **Use explicit failover order** — Always use the highest order uplink from the list of Active adapters which passes failover detection criteria.

- **Network Failover Detection** — Specify the method to use for failover detection.

  - **Link Status only** – Relies solely on the link status provided by the network adapter. This detects failures, such as cable pulls and physical switch power failures, but not configuration errors, such as a physical switch port being blocked by spanning tree or misconfigured to the wrong VLAN or cable pulls on the other side of a physical switch.
  - **Beacon Probing** – Sends out and listens for beacon probes on all NICs in the team and uses this information, in addition to link status, to determine link failure. This detects many of the failures mentioned above that are not detected by link status alone.

- **Notify Switches** — Select **Yes** or **No** to notify switches in the case of failover.

  If you select **Yes**, whenever a virtual NIC is connected to the vSwitch or whenever that virtual NIC's traffic would be routed over a different physical NIC in the team due to a failover event, a notification is sent out over the network to update the lookup tables on physical switches. In almost all cases, this is desirable for the lowest latency of failover occurrences and migrations with VMotion.

NOTE Do not use this option when the virtual machines using the port group are using Microsoft Network Load Balancing in unicast mode. No such issue exists with NLB running in multicast mode.

- **Rolling Failover**— Select **Yes** or **No** to disable or enable rolling.

  This option determines how a physical adapter is returned to active duty after recovering from a failure. If rolling is set to **No**, the adapter is returned to active duty immediately upon recovery, displacing the standby adapter that took over its slot, if any. If rolling is set to **Yes**, a failed adapter is left inactive even after recovery until another currently active adapter fails, requiring its replacement.

- **Failover Order** — Specify how to distribute the work load for adapters. If you want to use some adapters but reserve others for emergencies in case the ones in use fail, you can set this condition using the drop-down menu to place them into the two groups:

- **Active Adapters** — Continue to use it when the network adapter connectivity is up and active.
- **Standby Adapters** — Use this adapter if one of the active adapter's connectivity is down.
- **Unused Adapters** — Not to be used.

Port Group Configuration

You can change the following port group configurations:

- Port group properties
- Labelled network policies

To edit port group properties

1. Log into the VMware VI Client, and select the server from the inventory panel.

   The hardware configuration page for this server appears.

2. Click the **Configuration** tab, and click **Networking**.
3. On the right side of the window, click **Properties** for a network.

   The **vSwitch Properties** dialog box appears.

4. Click the **Ports** tab.
5. Select the port group and click **Edit**.
6. In the **Properties** dialog box for the port group, click the **General** tab to change:
   - **Network Label** — Identifies the port group that you are creating. Specify this label when configuring a virtual adapter to be attached to this port group, either when configuring virtual machines or VMkernel services, such as VMotion and IP storage.
   - **VLAN ID** — Identifies the VLAN that the port group's network traffic will use.
7. Click **OK** to exit the **vSwitch Properties** dialog box.

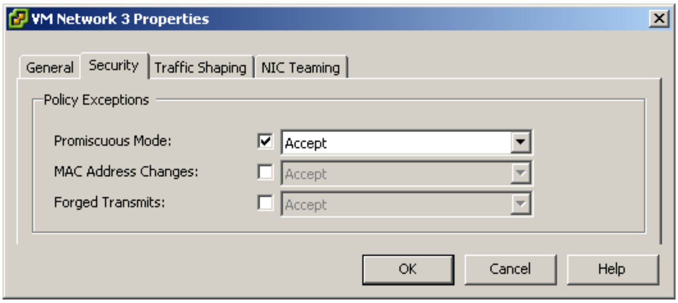
To override labeled network policies

1. To override any of these settings for a particular labeled network, select the network.
2. Click **Edit**.

3 Click the **Security** tab.

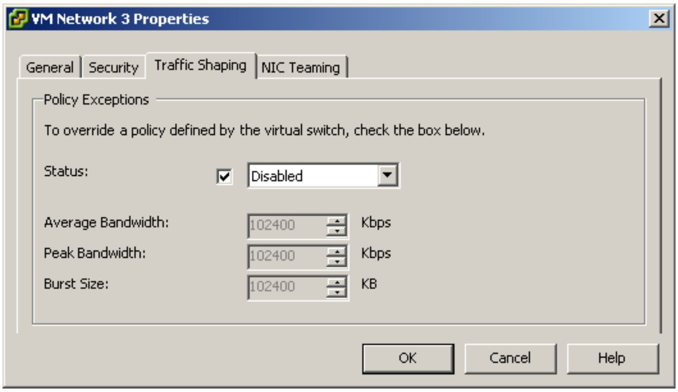
4 Select the check box for the labeled network policy that you want to override.

For information on these settings, see "Layer 2 Security Policy" on page 53.



5 Click **the Traffic Shaping tab**.

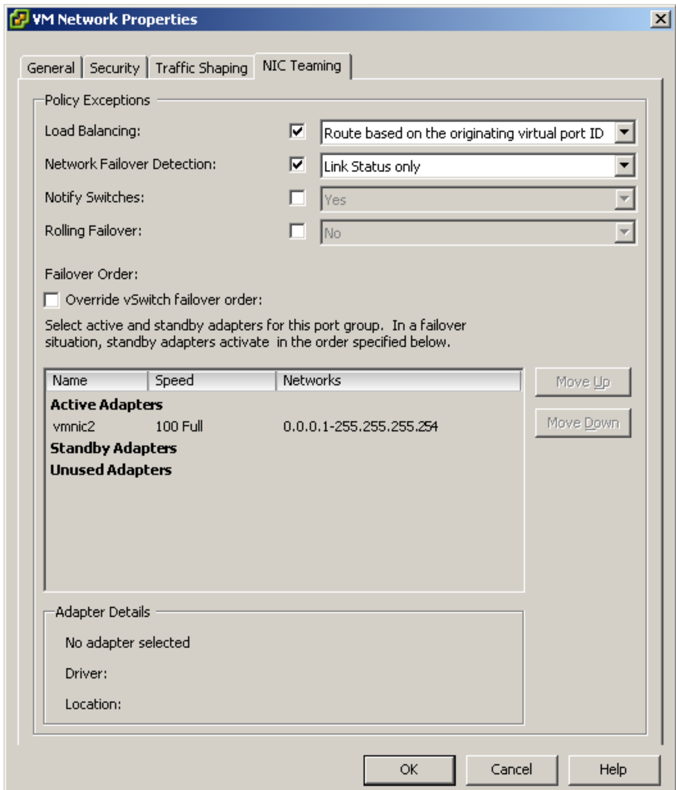
6 Select the check box to override the enabled or disabled **Status**. For information on the **Status** settings, see "Traffic Shaping Policy" on page 55.



7 Click the **NIC Teaming** tab.

8 Select the associated check box to override the load balancing or failover order policies.

For information on these settings, see "Load Balancing and Failover Policy" on page 56.



9 Click **OK** to exit the labeled **VM Network Properties** dialog box.

DNS and Routing

Configure DNS and routing through the VI Client.

To change the DNS and Routing configuration

1 Log into the VMware VI Client and select the server from the inventory panel.

The hardware configuration page for this server appears.

2 Click the **Configuration** tab, and click **DNS and Routing**.

3 On the right of the window, click **Properties**.

4 In the **DNS Configuration** tab, enter values for the **Name** and **Domain** fields.

5 Choose to either obtain the DNS server address automatically or use a DNS server address.

NOTE DHCP is supported only if the DHCP server is accessible to the service console. In other words, the service console must have a virtual interface (vswif) configured and attached to the network where the DHCP server resides.

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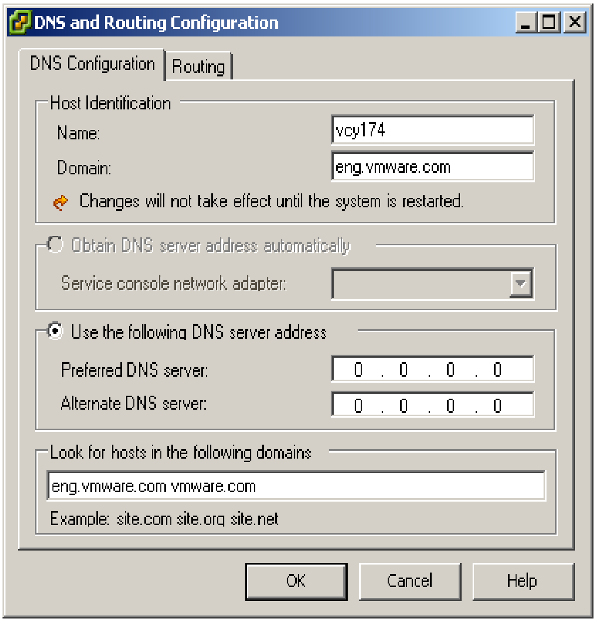
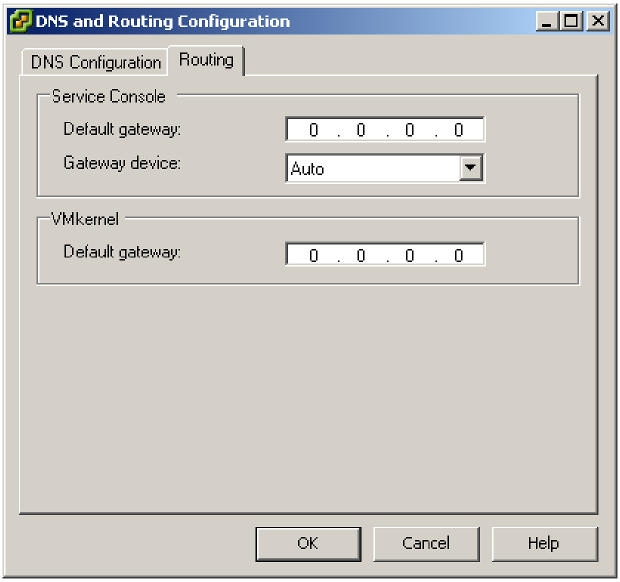
6 Specify the domains in which to look for hosts.



7 In the **Routing** tab, change default gateway information as needed.

You need to select a gateway device only if you have configured the service console to connect to more than one subnet.



8 Click **OK** to close the **DNS Configuration** dialog box.

Setting Up MAC Addresses

MAC addresses are generated for virtual network adapters used by the service console, the VMkernal and virtual machines. In most cases, these MAC addresses are appropriate. However, you might need to set a MAC address for a virtual network adapter as in the following cases:

- Virtual network adapters on different physical servers share the same subnet and are assigned the same MAC address, causing a conflict.
- You want to ensure that a virtual network adapter always has the same MAC address.

The following sections describe how MAC addresses are generated and how you can set the MAC address for a virtual network adapter.

MAC Addresses Generation

Each virtual network adapter in a virtual machine is assigned its own unique MAC address. A MAC address is a six-byte number. Each network adapter manufacturer is assigned a unique three-byte prefix called an OUI (Organizationally Unique Identifier) that it can use to generate unique MAC addresses.

VMware has three OUIs:

- One for generated MAC addresses.
- One for manually set MAC addresses.
- One which was previously used for legacy virtual machines, but is no longer used with ESX Server 3.0.

The first three bytes of the MAC address that is generated for each virtual network adapter have this value. This MAC address generation algorithm produces the other three bytes. The algorithm guarantees unique MAC addresses within a machine and attempts to provide unique MAC addresses across machines.

The network adapters for each virtual machine on the same subnet should have unique MAC addresses. Otherwise, they can behave unpredictably. The algorithm puts a limit on the number of running and suspended virtual machines at any one time on any given server. It also does not handle all cases when virtual machines on distinct physical machines share a subnet.

The VMware UUID (Universally Unique Identifier) generates MAC addresses that are checked for any conflicts. The generated MAC addresses are created using three parts: the VMware OUI, the SMBIOS UUID for the physical ESX Server machine, and a hash based on the name of the entity that the MAC address is being generated for.

After the MAC address has been generated, it does not change unless the virtual machine is moved to a different location, for example, to a different path on the same server. The MAC address in the configuration file of the virtual machine is saved. All MAC addresses that have been assigned to network adapters of running and suspended virtual machines on a given physical machine are tracked.

The MAC address of a powered-off virtual machine is not checked against those of running or suspended virtual machines. It is possible but unlikely that when a virtual machine is powered on again, it can acquire a different MAC address. This acquisition is due to a conflict with a virtual machine that was powered on when this virtual machine was powered off.

Setting MAC Addresses

To circumvent the limit of 256 virtual network adapters per physical machine and possible MAC address conflicts between virtual machines, system administrators can manually assign MAC addresses. VMware uses this OUI for manually-generated addresses: 00:50:56.

The MAC address range is

`00:50:56:00:00:00–00:50:56:3F:FF:FF`

You can set the addresses by adding the following line to a virtual machine's configuration file:

```
ethernet <number>.address = 00:50:56:XX:YY:ZZ
```

where `<number>` refers to the number of the Ethernet adapter, `XX` is a valid hexadecimal number between 00 and 3F, and `YY` and `ZZ` are valid hexadecimal numbers between 00 and FF. The value for `XX` must not be greater than 3F to avoid conflict with MAC addresses that are generated by the VMware Workstation and VMware GSX Server products. The maximum value for a manually generated MAC address is

```
ethernet<number>.address = 00:50:56:3F:FF:FF
```

You must also set the option in a virtual machine's configuration file:

```
ethernet<number>.addressType="static"
```

Because VMware ESX Server virtual machines do not support arbitrary MAC addresses, the above format must be used. As long as you choose a unique value for `XX:YY:ZZ` among your hard-coded addresses, conflicts between the automatically assigned MAC addresses and the manually assigned ones should never occur.

Using MAC Addresses

The easiest way to familiarize yourself with MAC addresses is to set up a MAC address.

To set up a MAC address

1 Set the MAC address statically.

2 Remove the virtual machine configuration file options:

   `ethernet<number>.address, ethernet<number>.addressType`

   and

   `ethernet<number>.generatedAddressOffset`

3 Verify that the virtual machine receives a generated MAC address.

VMware guarantees, however, that the MAC address will never conflict with any physical host by using the VMware OUIs (00:0C:29 and 00:50:56), which are unique to virtual machines.

Networking Tips and Best Practices

This section provides information about:

- Networking best practices
- Network hints

Networking Best Practices

Consider these best practices for configuring your network:

- Separate network services from one another to achieve greater security or better performance.

  If you want a particular set of virtual machines to function at the highest performance levels, put them on a separate physical NIC. This separation allows for a portion of the total networking workload to be more evenly shared across multiple CPUs. The isolated virtual machines are then more able to serve traffic from a Web client, for instance.

- The recommendations below can be satisfied either by using VLANs to segment a single physical network or by using separate physical networks (the latter is preferable).

  - Keeping the service console on its own network is an important part of securing the ESX system. Consider the service console network connectivity in the same light as any remote access device in a server because compromise of the service console gives an attacker full control of all virtual machines running on the system.

  - Keeping the VMotion connection on a separate network devoted to this purpose is important because when migration with VMotion occurs, the contents of the guest operating system's memory are transmitted over the network.

Mounting NFS Volumes

In ESX Server 3.0, the model of how ESX accesses NFS storage of ISO images that are used as virtual CD-ROMs for virtual machines is different from the model used in ESX Server 2.x.

ESX Server 3.0 has support for VMkernel-based NFS mounts. The new model is to mount your NFS volume with the ISO images through the VMkernel NFS functionality. All NFS volumes mounted in this way appear as datastores in the VI Client. The virtual machine configuration editor allows you to browse the service console file system for ISO images to be used as virtual CD-ROM devices.

Networking Tips

Consider the following network hints:

- The easiest way to physically separate network services and to dedicate a particular set of NICs to a specific network service is to create a vSwitch for each service. If this is not possible, they can be separated from each other on a single vSwitch by attaching them to port groups with different VLAN IDs. In either case, confirm with your network administrator that the networks or VLANs you choose are isolated in the rest of your environment, that is, no routers connect them.
- You can add and remove NICs from the vSwitch without affecting the virtual machines or the network service that is running behind that vSwitch. If you removed all the running hardware, the virtual machines would still be able to communicate amongst themselves, as if they were going out to the network and back. Moreover, if you left one NIC intact, all of the virtual machines would still be able to connect with the physical network.
- Use port groups with different sets of active adapters in their teaming policy to separate virtual machines into groups. These can use separate adapters as long as all adapters are up but still fall back to sharing in the event of a network or hardware failure.
- Deploy firewalls in virtual machines that route between virtual networks with uplinks to physical networks and pure virtual networks with no uplinks to protect your most sensitive virtual machines.

Networking Scenarios and Troubleshooting

4

This chapter describes common networking configuration and troubleshooting scenarios.

This chapter covers the following topics:

Networking Configuration for Software iSCSI Storage

The storage you configure for an ESX Server host might include one or more storage area networks (SANs) that use iSCSI, which is a means of accessing SCSI devices and exchanging data records using TCP/IP protocol over a network port rather than through a direct connection to a SCSI device. In iSCSI transactions, blocks of raw SCSI data are encapsulated in iSCSI records and transmitted to the requesting device or user.

Before you can configure iSCSI storage, you must create a VMkernel port to handle iSCSI networking and a service console connection to the iSCSI network.

To create a VMkernel port for software iSCSI

1 Log into the VMware VI Client, and select the server from the inventory panel.

The hardware configuration page for this server appears.

2 Click the **Configuration** tab, and click **Networking**.

3 Click the **Add Networking** link.

The **Add Network Wizard** appears.

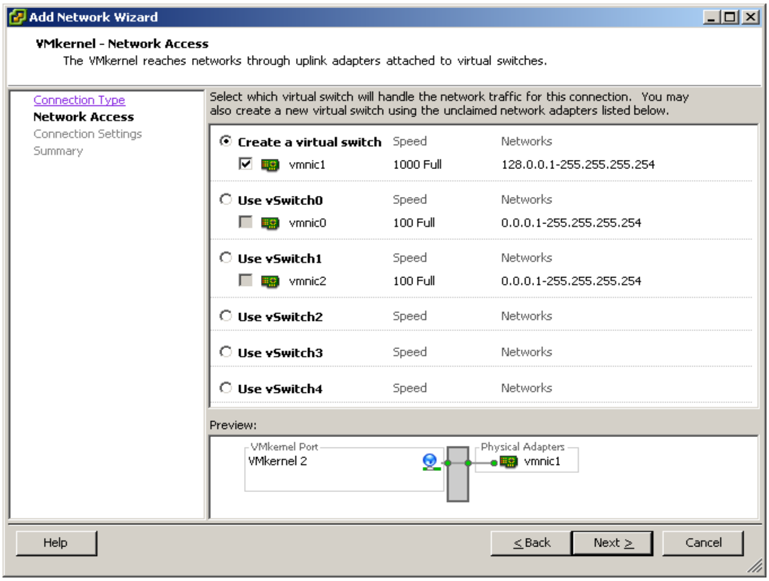
4 Select **VMkernel** and click **Next**.

This lets you connect the VMkernel, which runs services for iSCSI storage, to the physical network.

The **Network Access** page appears.

5 Select the vSwitch you want to use or the **Create a virtual switch** radio button.

6 Select the check boxes for the network adapters your vSwitch will use.



Your choices appear in the **Preview** pane.

Select adapters for each vSwitch so that virtual machines or other services that connect through the adapter can reach the correct Ethernet segment. If no adapters appear under **Create a new virtual switch**, this means that all the network adapters in the system are being used by existing vSwitches.

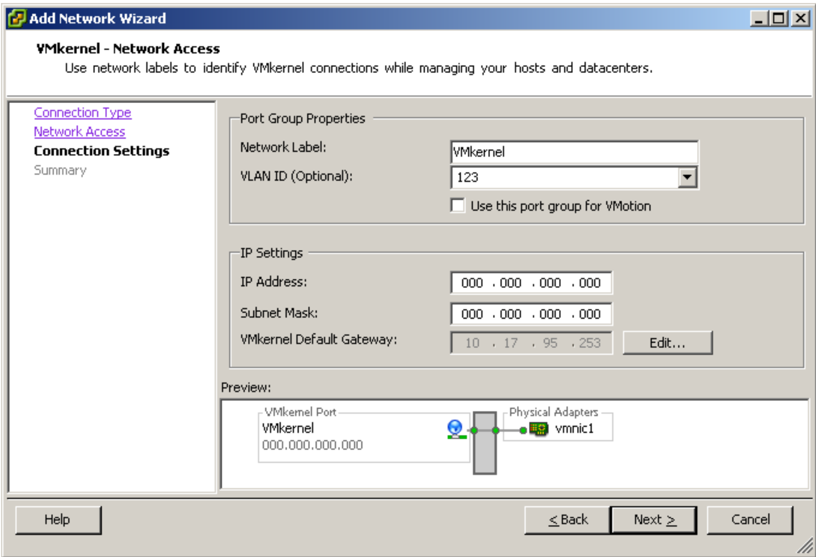
For information on moving network adapters between vSwitches, see "To add uplink adapters" on page 50.

7 Click **Next**.

The **Connection Settings** page appears.

8 Under **Port Group Properties**, select or enter a network label and a VLAN ID.

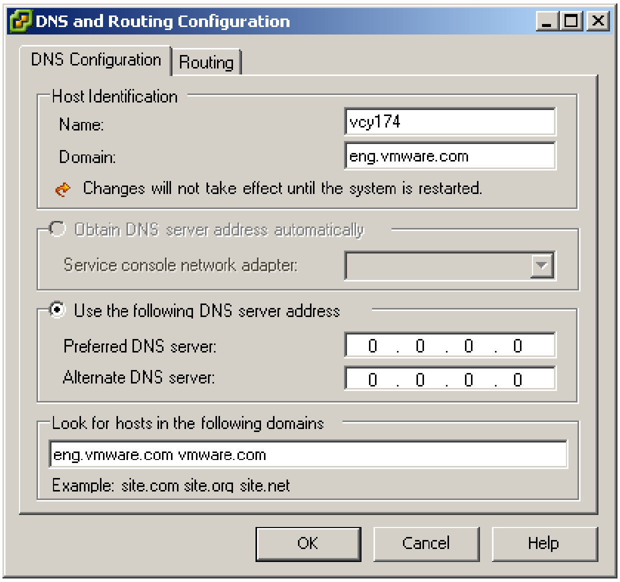
- **Network Label** — A name that identifies the port group that you are creating. This is the label that you specify when configuring a virtual adapter to be attached to this port group, when configuring iSCSI storage.
- **VLAN ID** — Identifies the VLAN that the port group's network traffic will use.



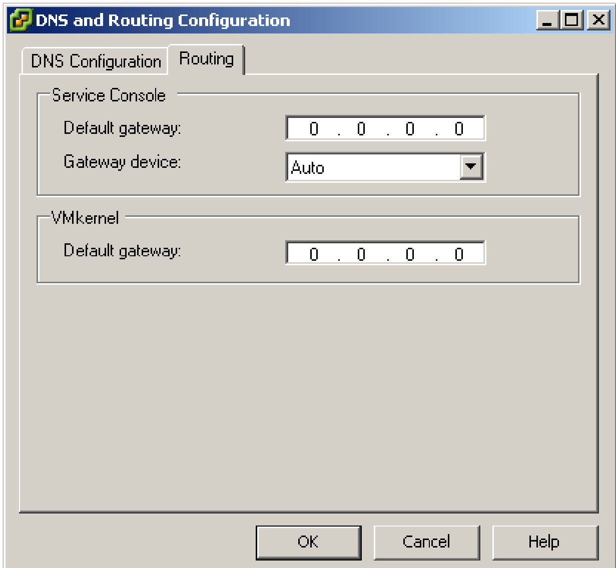
9 Under **IP Settings**, click **Edit** to set the **VMkernel Default Gateway** for iSCSI.

The **DNS and Routing Configuration** dialog box appears. Under the **DNS Configuration** tab, the name of the host is entered into the name field by default.

The DNS server addresses that were specified during installation are also preselected as is the domain.



Under the **Routing** tab, the service console and the VMkernel each need their own gateway information. A gateway is needed for connectivity to machines not on the same IP subnet as the service console or VMkernel.



NOTE Make sure that you set a default gateway for the port that you created. You must use a valid static IP address to configure the VMkernel stack.

10 Click **OK** to save your changes, and close the **DNS and Routing Configuration** dialog box.

11 Click **Next**.

12 Use the **Back** button to make any changes.

13 Review your changes on the **Ready to Complete** page and click **Finish**.

After you create a VMkernel port for iSCSI, you must create a service console connection on the same vSwitch as the VMkernel port.

To configure a service console connection for software iSCSI storage

1 Log into the VMware VI Client and select the server from the inventory panel.

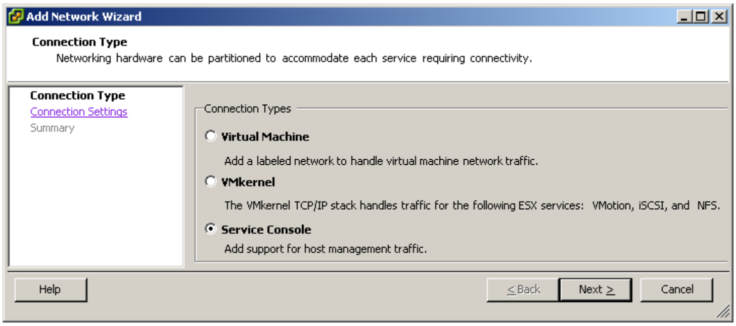
The hardware configuration page for this server appears.

2 Click the **Configuration** tab, and click **Networking**.

3 On the right side of the screen, click **Properties** for vSwitch associated with the VMkernel port you just created.

4 On the **Ports** tab, click **Add**.

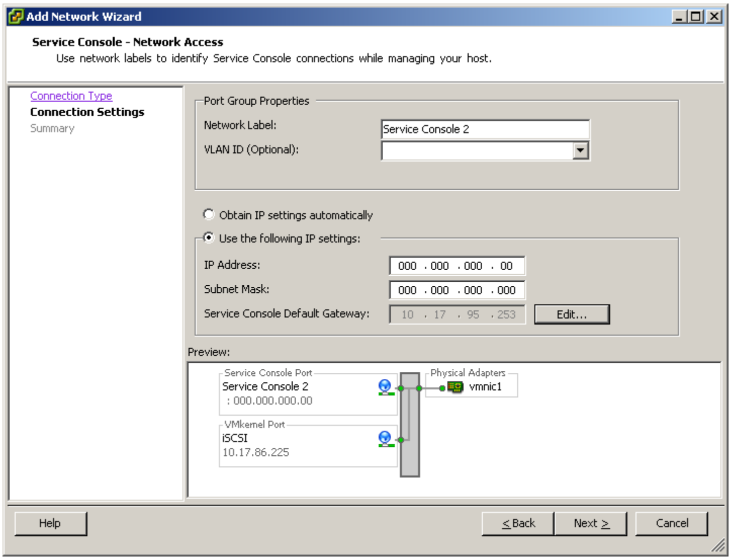
The **Add Network Wizard** appears.



5 As a connection type, select **Service Console** and click **Next**.

The **Connection Settings** screen appears.

6 Under **Port Group Properties**, enter a network label that identifies the port group that you are creating.



Newer ports and port groups appear at the top of the vSwitch diagram.

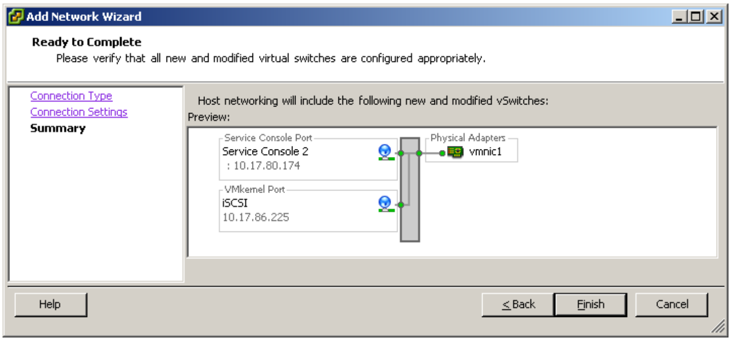
7 Enter the **IP Address** and **Subnet Mask,** or select the DHCP option **Obtain IP setting automatically** for the IP address and subnet mask.

8 Click the **Edit** button to set the **Service Console Default Gateway**.

See "To set the default gateway" on page 41.

9 Click **Next**.

The **Ready to Complete** screen appears.



10 After you have determined that the vSwitch is configured correctly, click **Finish**.

After you create a VMkernel port and service console connection, you are able to enable and configure software iSCSI storage. For information on configuring iSCSI adapters and storage, see "iSCSI Storage" on page 110.

Configuring Networking on Blade Servers

Because blade servers may have a limited number of network adapters, it will likely be necessary to use VLANs to separate traffic for the service console, VMotion, IP storage, and various groups of VMs. VMware best practices recommend that the service console and VMotion have their own networks for security reasons. If you dedicate physical adapters to separate vSwitches for this purpose, you will likely have to give up redundant (teamed) connections or give up isolating the various networking clients, or both. VLANs allow you to achieve network ostentation without having to use multiple physical adapters.

For the network blade of a blade server to support an ESX Server port group with VLAN tagged traffic, you must configure the blade to support 802.1Q and configure the port as a tagged port.

The method for configuring a port as a tagged port differs from server to server. The following list describes how to configure a tagged port on three of the most commonly used blade servers:

- **HP Blade** — Set the port's **VLAN Tagging** to **enabled**.
- **Dell PowerEdge** — Set the port to **Tagged**.
- **IBM eServer Blade Center** — Select **Tag** in the port's configuration.

To configure a virtual machine port group with VLAN on a blade server

1. Log into the VMware VI Client and select the server from the inventory panel.

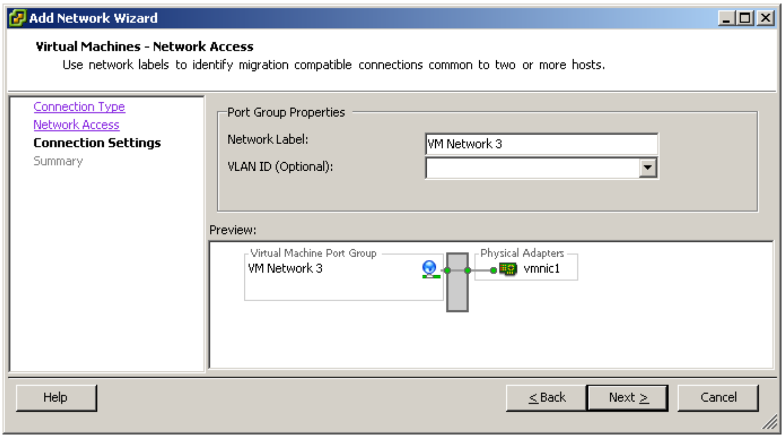
   The hardware configuration page for this server appears.

2. Click the **Configuration** tab, and click **Networking**.
3. On the right side of the screen, click **Properties** for vSwitch associated with the service console.
4. On the **Ports** tab, click **Add**.

   The **Add Network Wizard** appears.

5. As a connection type, select **Virtual Machines**, which is the default.
6. Click **Next**.

   The **Connection Settings** page appears.



7 Under **Port Group Properties**, enter a network label that identifies the port group that you are creating.

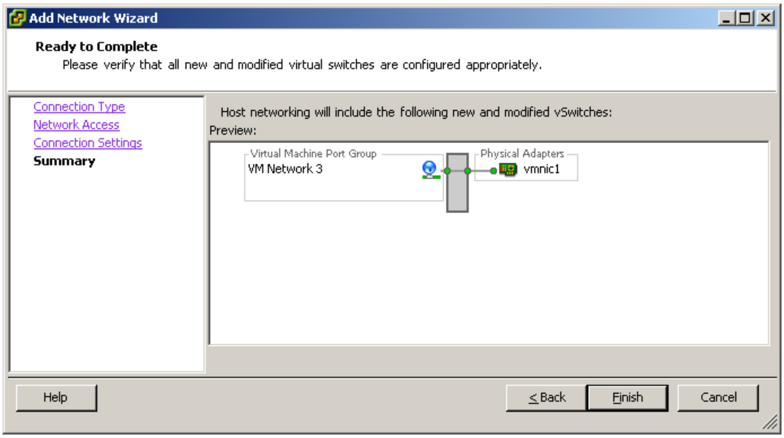
Use network labels to identify migration-compatible connections common to two or more hosts.

8 In the **VLAN ID** field, enter a number between 1 and 4094.

If you are unsure what to enter, leave this blank or ask your network administrator.

9 Click **Next**.

The **Ready to Complete** page appears.



10 After you have determined that the vSwitch is configured correctly, click **Finish**.

To configure a VMkernel port with VLAN on a blade server

1 Log into the VMware VI Client and select the server from the inventory panel.

The hardware configuration page for this server appears.

2 Click the **Configuration** tab, and click **Networking**.

3 On the right side of the screen, click **Properties** for vSwitch associated with the service console.

4 On the **Ports** tab, click **Add**.

The **Add Network Wizard** appears.

5 Select **VMkernel** and click **Next**.

This lets you connect the VMkernel, which runs services for VMotion and IP storage (NFS or iSCSI), to the physical network.

The **Connection Settings** page appears.

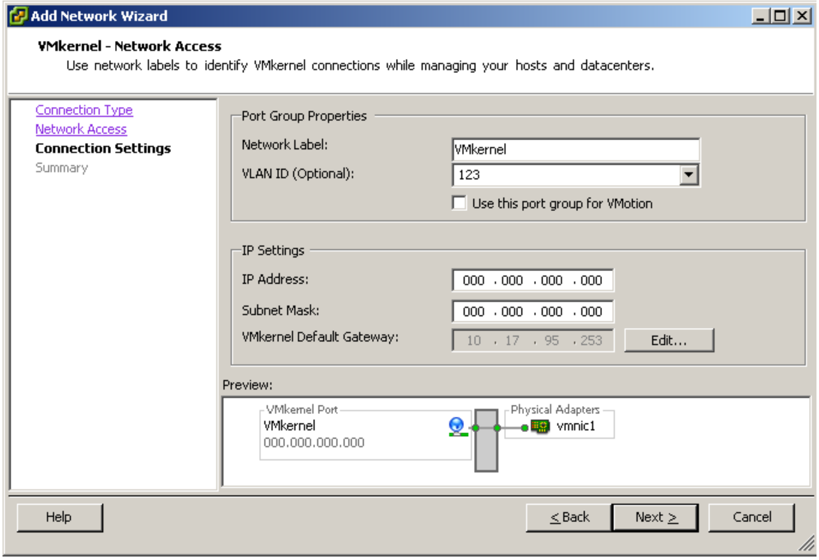
6 Under **Port Group Properties**, select or enter a network label and a VLAN ID.

- **Network Label** — A name that identifies the port group that you are creating. This is the label that you specify when configuring a virtual adapter to be attached to this port group, when configuring VMkernel services, such as VMotion and IP storage.

- **VLAN ID** — Identifies the VLAN that the port group's network traffic will use.

7 Select the **Use this port group for VMotion** check box to enable this port group to advertise itself to another ESX Server as the network connection where VMotion traffic should be sent.

You can enable this property for only one VMotion and IP storage port group for each ESX Server host. If this property is not enabled for any port group, migration with VMotion to this host is not possible.



8 Under **IP Settings**, click **Edit** to set the **VMkernel Default Gateway** for VMkernel services, such as VMotion, NAS, and iSCSI

NOTE Make sure that you set a default gateway for the port that you created. VirtualCenter 2 behaves differently here from VirtualCenter 1.x. You must use a valid IP address to configure the VMkernel IP stack, not a dummy address.

The **DNS and Routing Configuration** dialog box appears. Under the **DNS Configuration** tab, the name of the host is entered into the name field by default. The DNS server addresses that were specified during installation are also preselected as is the domain.

Under the **Routing** tab, the service console and the VMkernel each need their own gateway information. A gateway is needed if connectivity to machines not on the same IP subnet as the service console or VMkernel.

Static IP settings is the default.

9 Click **OK** to save your changes, and close the **DNS Configuration and Routing** dialog box.

10 Click **Next**.

11 Use the **Back** button to make any changes.

12 Review your changes on the **Ready to Complete** page and click **Finish**.

Troubleshooting

The following section guides you through troubleshooting common networking issues.

This section covers the following topics:

- "Troubleshooting Service Console Networking" on page 80
- "Troubleshooting Network Adapter Configuration" on page 82
- "Troubleshooting Physical Switch Configuration" on page 82
- "Troubleshooting Port Group Configuration" on page 82

Troubleshooting Service Console Networking

If certain parts of the service console's networking are misconfigured, you will lose your ability to access your ESX Server host with the VI Client. In the event that this happens, you can reconfigure networking by connecting directly to service console and using the following service console commands:

- `esxcfg-vswif -l`

  Provides a list of the service console's current network interfaces.

  Check that `vswif0` is present and that the current IP address and Netmask are correct.

- `esxcfg-vswitch -l`

  Provides a list of current virtual switch configurations.

  Check that the uplink adapter configured for the service console is connected to the appropriate physical network.

- `exscfg-nics -l`

  Provides a list of current network adapters.

  Check that the uplink adapter configured for the service console is up and that the speed and duplex are both correct.

- `esxcfg-nics -s <speed> <nic>`

  Changes the speed of a network adapter.

- esxcfg-nics -d <duplex> <nic>

  Changes the duplex of a network adapter.

- `esxcfg-vswif -i <new ip address> vswifX`

  Changes the service console's IP address.

- `esxcfg-vswif -n <new netmask> vswifX`

  Changes the service console's netmask.

- `esxcfg-vswitch -U <old vmnic> <service console vswitch>`

  Removes the uplink for the service console

- `esxcfg-vswitch -L <new vmnic> <service console vswitch>`

  Changes the uplink for the service console.

If you encounter long waits when using `esxcfg-*` commands, it is possible that DNS is misconfigured. The `esxcfg-*` commands require that DNS be configured so that localhost name resolution works properly. This requires that the `/etc/hosts` file contain an entry for the configured IP address and the 127.0.0.1 localhost address.

Troubleshooting Network Adapter Configuration

Adding a new network adapter, in certain cases, can cause loss of service console connectivity and manageability using the VI Client due to network adapters getting renamed.

If this happens, you must rename the affected network adapters using the service console.

To rename network adapters using the service console

1. Log in directly to your ESX Server's console.
2. Use the command `esxcfg-nics -l` to see which names have been assigned to your network adapters.
3. Use the command `esxcfg-vswitch -l` to see which vSwitches, if any, are now associated with device names no longer shown by esxcfg-nics.
4. Use the command `esxcfg-vswitch -U <old vmnic name> <vswitch>` to remove any network adapters that have been renamed.
5. Use the command `esxcfg-vswitch -L <new vmnic name> <vswitch>` to re-add the network adapters, giving them the correct names.

Troubleshooting Physical Switch Configuration

In some cases, you might lose vSwitch connectivity when a failover or failback event occurs. This causes the MAC addresses used by virtual machines associated with that vSwitch to appear on a different switch port than they previously did.

To avoid this problem, put your physical switch in **portfast** or **portfast trunk** mode.

Troubleshooting Port Group Configuration

Changing the name of a port group when virtual machines are already connected to that port group causes the virtual machines configured to connect to that port group to have invalid network configuration.

The connection from virtual network adapters to port groups is made by name, and the name is what is stored in the virtual machine configuration. Changing the name of a port group does not cause a mass reconfiguration of all the virtual machines connected to that port group. Virtual machines that are already powered on will continue to function until they are powered off because their connections to the network have already been established.

The best principle is to avoid renaming networks after they are in use. After you rename a port group, you must re-configure each associated virtual machine using the service console to reflect the new port group name.

Storage

5 Introduction to Storage

This chapter contains overview information about the available storage options for ESX Server.

For information about configuring SANs, see the *SAN Configuration Guide*.

This chapter covers the following topics:

Storage Concepts

A few concepts are essential for a thorough understanding of storage.

- **Datastore** – Formatted logical container analogous to a file system on a logical *volume*. The datastore holds virtual machine files and can exist on different types of physical storage including SCSI, iSCSI, Fibre Channel SAN, or NFS. Datastores can be of the two types: VMFS-based or NFS-based.
- **Disk partition** – Reserved part of hard disk that is set aside for specific purposes. In the context of ESX Server storage, disk partitions on various physical storage devices can be reserved and formatted as datastores.
- **Extent** – In the ESX Server context, an extent is a hard disk partition on a physical storage device that can be dynamically added to an existing VMFS-based datastore. The datastore can stretch over multiple extents, yet appear as a single volume analogous to a *spanned volume*.
- **Failover path** – Redundant physical path that the ESX Server system can use when communicating with its networked storage. The ESX Server system uses the failover path if any component responsible for transferring storage data fails. See *Multipathing*.
- **Fibre Channel (FC)** – High-speed data transmitting technology that ESX Server systems use to transport SCSI traffic from virtual machines to storage devices on a SAN. The Fibre Channel Protocol (FCP) packages SCSI commands into Fibre Channel frames.
- **iSCSI (Internet SCSI)** – Packages SCSI storage traffic into TCP so it can travel through IP networks instead of the specialized FC network. With iSCSI connection, your ESX Server system (initiator) communicates with a remote storage device (target) as it would do with a local hard disk.
- **LUN (logical unit number)** – Address uniquely identifying each SCSI disk that an ESX Server system uses for storage. The terms *hard disk* and *LUN* are often used interchangeably.
- **Multipathing** – Technique that lets you use more than one physical path, or an element on this path, responsible for transferring data between the ESX Server system and its remote storage. This redundant use of physical paths or elements, such as adapters, helps ensure uninterrupted traffic between the ESX Server system and storage devices.
- **NAS (network-attached storage)** – Specialized storage device that connects to a network and can provide file access services to ESX Server systems. ESX Server systems use the NFS protocol to communicate with NAS servers.

- **NFS (network file system)** – File sharing protocol ESX Server supports to communicate with a NAS device.
- **Raw device (raw disk)** – SCSI device used directly by a virtual machine. The device might be accessed through an RDM.
- **Raw device mapping (RDM)** – Special mapping file in a VMFS volume that acts as a proxy for a raw device and maps SAN LUNs directly to a virtual machine. RDM can be also called metadata file.
- **Raw LUN** – Logical disk located in a SAN.
- **Spanned volume** – Dynamic volume that uses disk space on more than one physical disk, yet appears as a single logical volume.
- **Storage device** – Physical disk or storage array that can either be internal or located outside of your system and connected to the system either directly or through an adapter.
- **VMFS (VMware File System)** – High-performance cluster file system that provides storage virtualization optimized for virtual machines.
- **Volume** – Logical storage unit, which can use disk space on one physical device, or its part, or span several physical devices.

Storage Overview

In the most common configuration, a virtual machine uses a virtual hard disk to store its operating system, program files, and other data associated with its activities. A virtual disk is a large physical file that can be copied, moved, archived, and backed up as easy as any other file.

Virtual disk files reside on specially formatted volumes called datastores. A datastore can be deployed on the host machine's internal direct-attached storage devices or on networked storage devices. A networked storage device represents an external shared storage device or array that is located outside of your system and is typically accessed over a network through an adapter.

Storing virtual disks and other essential pieces of your virtual machine on a single datastore shared between physical hosts lets you:

- Use such features as VMware DRS (Distributed Resource Scheduling) and VMware HA (High Availability Options).
- Use VMotion to move running virtual machines from one ESX Server to another without service interruption.
- Use Consolidated Backup to perform backups more efficiently.

- Have better protection from planned or unplanned server outages.
- Have more control over load balancing.

ESX Server lets you access a variety of physical storage devices, both internal and external, configure and format them, and use them for your storage needs.

Most of the time, you will be using VI Client to work with your storage. To learn how to access and configure your storage devices, as well as how to deploy and manage datastores, see the following chapters:

- "Configuring Storage" on page 103
- "Managing Storage" on page 137

The rest of the Storage Overview section covers these topics:

- "Datastores and File Systems" on page 90
- "File System Formats" on page 91
- "Types of Storage" on page 91
- "Supported Storage Adapters" on page 92
- "How Virtual Machines Access Storage" on page 92

Datastores and File Systems

ESX Server virtual machines store their virtual disk files on specially formatted logical containers, or datastores, that can exist on different types of physical storage devices. A datastore can use disk space on one physical device or several physical devices.

Your datastore management process starts with storage space that your storage administrator preallocates for your ESX Server system on different storage devices. The storage space is presented to your ESX Server system as LUNs (logical unit numbers) or, in case of a network attached storage, as NFS volumes.

Using the VI Client, you can create datastores by accessing and formatting available LUNs or by mounting the NFS volumes.

After you create the datastores, you can use them to store virtual machine files. When needed, you can modify the datastores. For example, you can add extents to your datastore, rename, or remove it.

For information on managing datastores, see "Managing Datastores and File Systems" on page 138.

File System Formats

Datastores that you use can have the following file system formats:

- **VMFS** – ESX Server deploys this type of file system on local SCSI disks, iSCSI LUNs, or Fibre Channel LUNs, creating one directory for each virtual machine. VMFS is a clustered file system that can be accessed simultaneously by multiple ESX Server systems.

NOTE ESX Server 3.0 supports VMFS version 3 (VMFS-3). VMFS-3 is not backward compatible with versions of ESX Server earlier than ESX Server 3.0. If you are using VMFS-2, you need to upgrade it to VMFS-3. For information on upgrading your VMFS-2, see "Upgrading Datastores" on page 139.

  For more information on VMFS, see "VMware File System" on page 97.

  As an alternative to using the VMFS-based datastore, your virtual machine can have direct access to raw devices using a mapping file (RDM) as a proxy. For more information on RDMs, see "Raw Device Mapping" on page 151.

- **NFS** – ESX Server can use a designated NFS volume located on an NFS server. ESX Server mounts the NFS volume creating one directory for each virtual machine. From the viewpoint of the user on a client computer, the mounted files are indistinguishable from local files.

Types of Storage

Datastores can reside on a variety of storage devices. You can deploy a datastore on your system's direct-attached storage device or on a networked storage device.

ESX Server supports the following types of storage devices:

- **Local** – Stores files locally on an internal or external SCSI device.
- **Fibre Channel** – Stores files remotely on a Storage Area Network (SAN). Requires Fibre Channel adapters.
- **iSCSI (hardware initiated)** – Stores files on remote iSCSI storage devices. Files are accessed over TCP/IP network using hardware-based iSCSI HBAs (host bus adapters).
- **iSCSI (software initiated)** – Stores files on remote iSCSI storage devices. Files are accessed over TCP/IP network using software-based iSCSI code in the VMkernel. Requires a standard network adapter for network connectivity.

- **Network file system (NFS)** – Stores files on remote file servers. Files are accessed over TCP/IP network using the NFS protocol. Requires a standard network adapter for network connectivity.

NOTE You can't store virtual machines on IDE or SATA drives. An ESX Server host must have SCSI storage, NAS, or a SAN on which to store virtual machines.

You use the VI Client to access storage devices mapped to your ESX Server system and deploy datastores on them. For more information, refer to "Configuring Storage" on page 103.

Supported Storage Adapters

To access different types of storage, your ESX Server system needs different adapters that provide connectivity to the storage device or network. ESX Server supports PCI-based SCSI and iSCSI, RAID, Fibre Channel, and Ethernet adapters and accesses them directly through device drivers in the VMkernel.

How Virtual Machines Access Storage

When a virtual machine communicates with its virtual disk stored on a datastore, it issues SCSI commands. Because datastores can exist on various types of physical storage, these commands are encapsulated into other forms depending on the protocol the ESX Server system uses to connect to a storage device. ESX Server supports Fibre Channel (FC), Internet SCSI (iSCSI), and NFS protocols.

The diagram in Figure 5-1 depicts five virtual machines using different types of storage to illustrate the differences between each type.

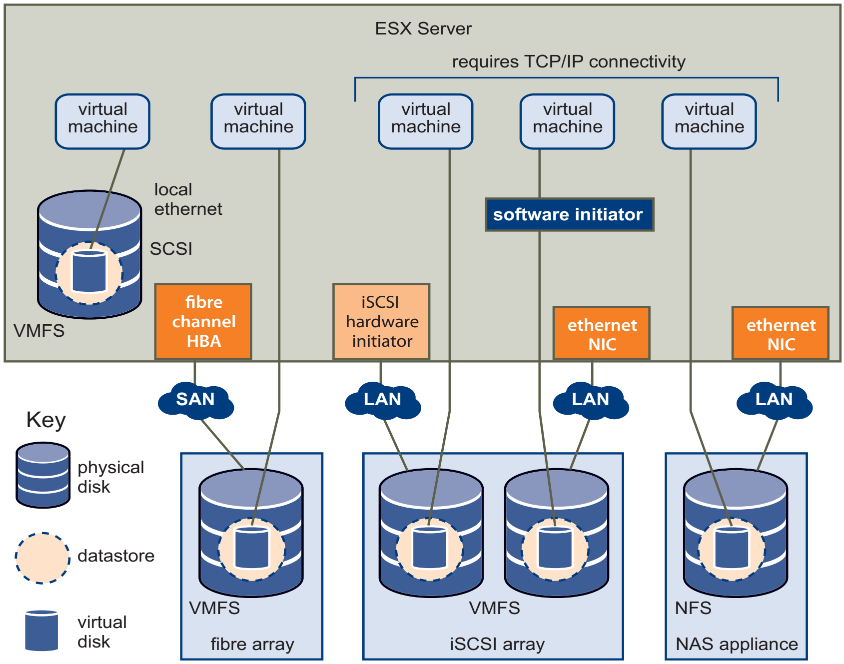


Figure 5-1. Types of storage

NOTE This diagram is for conceptual purposes only. It is not a recommended configuration.

You can configure a virtual machine to access the virtual disks on the physical storage devices. To configure a virtual machine, refer to the *Virtual Machine Management Guide*.

Viewing Storage Information in the Virtual Infrastructure Client

The VI Client displays detailed information on available datastores, storage devices the datastores use, and configured adapters. See these sections for more information:

- "Displaying Datastores" on page 94
- "Viewing Storage Adapters" on page 95
- "Understanding Storage Device Naming in the Display" on page 96

Displaying Datastores

Datastores are added to the VI Client in one of two ways:

- Discovered when a host is added to the inventory – When you add a host to the inventory, the VI Client displays any datastores recognized by the host.
- Created on an available storage device – You can use the **Add Storage** option to create and configure a new datastore. For more information, see "Configuring Storage" on page 103.

You can view a list of available datastores and analyze their properties.

To display datastores, on the host Configuration tab, click the **Storage (SCSI, SAN, and NFS)** link.

For each datastore, the Storage section shows summary information, including:

- Target storage device where the datastore is located. See "Understanding Storage Device Naming in the Display" on page 96.
- Type of file system the datastore uses. See "File System Formats" on page 91.
- Total capacity, including the used and available space.

To view additional details about the specific datastore, select the datastore from the list. The Details section shows the following information:

- Location of the datastore.
- Individual extents the datastore spans and their capacity.
- Paths used to access the storage device.

In Figure 5-2, the datastore “symm-07” is selected from the list of available datastores. The **Details** view provides information about the selected datastore.

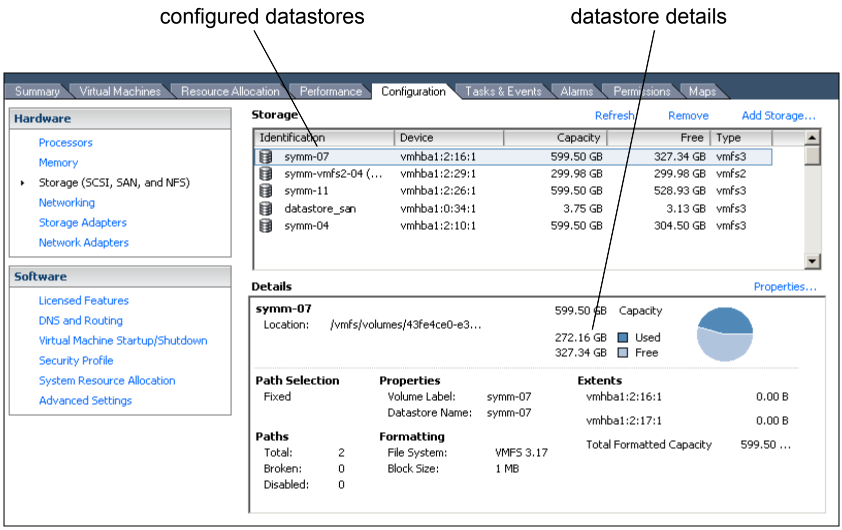


Figure 5-2. Datastore information

You can edit or remove any of the existing datastores. When you edit a datastore, you can change its label, add extents, or modify paths for storage devices. You can also upgrade the datastore. For more information, see “Managing Storage” on page 137.

Viewing Storage Adapters

The VI Client displays any storage adapters available to your system.

To display storage adapters, on the host **Configuration** tab, click the **Storage Adapters** link.

You can view the following information about the storage adapters:

- Existing storage adapters.
- Type of storage adapter, such as Fibre Channel SCSI or iSCSI.
- Details for each adapter, such as the storage device it connects to and target ID.

To view configuration properties for a specific adapter, select the adapter from the **Storage Adapters** list.

In Figure 5-3, the Fibre Channel storage adapter “vmhba0” is selected. The **Details** view provides information about the number of LUNs the adapter connects to and the paths is uses.

If you want to change the path's configuration, you can select this path from the list, right-click the path, and click **Manage Paths** to bring up the **Manage Paths** wizard. For information on managing paths, see "Managing Paths for Fibre Channel and iSCSI" on page 143.

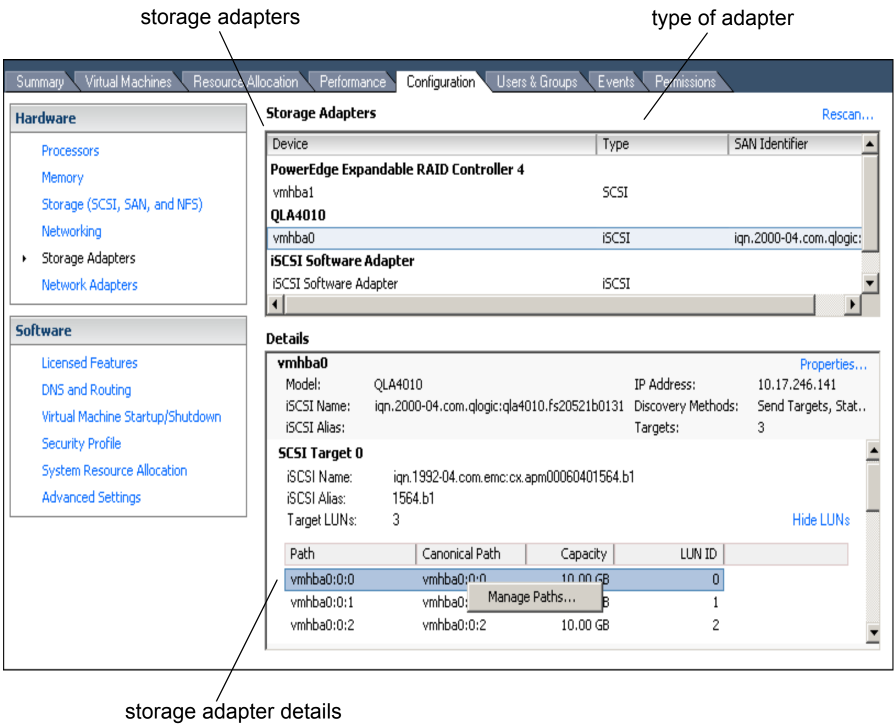


Figure 5-3. Storage adapter information

Understanding Storage Device Naming in the Display

In the VI Client, the name of a storage device is displayed as a sequence of three or four numbers, separated by colons, such as `vmhba1:1:3:1`. The name has the following meaning:

```
<HBA>:<SCSI target>:<SCSI LUN>:<disk partition>
```

The abbreviation `vmhba` refers to different physical HBAs on the ESX Server system. It can also refer to the virtual iSCSI initiator that ESX Server implements using the VMkernel network stack. The forth number indicates a partition on a disk or LUN. When a datastore occupies the entire disk or LUN, the forth number isn't present.

The `vmhba1:1:3:1` example refers to the first partition on SCSI LUN3, SCSI target 1, which is accessed through HBA 1.

While the third and the forth numbers never change, the first two numbers can change. For example, after rebooting the ESX Server system, `vmhba1:1:3:1` can change to `vmhba3:2:3:1`, however, the name still refers to the same physical device. The first and the second numbers can change for the following reasons:

- The first number, the HBA, changes when an outage on the Fibre Channel or iSCSI network occurs. In this case, the ESX Server system has to use a different HBA to access the storage device.
- The second number, the SCSI target, changes in case of any modifications in the mappings of the Fibre Channel or iSCSI targets visible to the ESX Server host.

VMware File System

A file system is a method for storing, organizing, accessing, navigating, and retrieving computer files and the data they contain. File systems come in different formats, including FAT, NTFS, HPFS, UFS, and EXT3. VMware offers a special high-performance file system, VMware file system (VMFS), optimized for storing ESX Server virtual machines.

This section provides information on VMFS and includes these topics:

- "VMFS Versions" on page 97
- "Creating and Growing VMFS" on page 98
- "VMFS Sharing Capabilities" on page 99

VMFS Versions

ESX Server offers the following versions of this file system:

- **VMFS2** – This file system is created with ESX Server version 2.x.
- **VMFS3** – This file system is created with ESX Server version 3. VMFS3 enhancements include multi-directory support. A virtual machine must reside on a VMFS3 file system before an ESX Server version 3 host can power it on.

Table 5-1. Host Access to VMFS File Systems

Host	VMFS2 Datastore	VMFS3 Datastore
ESX Server version2 host	Read/Write (Runs VMs)	No access
ESX Server version3 host	Read Only (Copies VMs)	Read/Write (Runs VMs)

Creating and Growing VMFS

VMFS can be deployed on a variety of SCSI-based storage devices, including Fibre Channel and iSCSI SAN equipment. A virtual disk stored on VMFS always appears to the virtual machine as a mounted SCSI device. The virtual disk hides a physical storage layer from the virtual machine's operating system. This allows you to run even operating systems not certified for SAN inside the virtual machine.

For the operating system inside the virtual machine, VMFS preserves the internal file system semantics, which ensures correct application behavior and data integrity for applications running in virtual machines.

You can set up VMFS-based datastores in advance on any storage device that your ESX Server discovers. Select a large LUN if you plan to create multiple virtual machines on it. You can then add virtual machines dynamically without having to request additional disk space.

However, if more space is needed, you can increase the VMFS volume at any time—up to 64 TB.

For special considerations when creating a VMFS, see "Considerations when Creating VMFS" on page 98.

Considerations when Creating VMFS

You need to plan how to set up storage for your ESX Server systems before you format storage devices with VMFS. You should always have only one VMFS volume per LUN. You can, however, decide to use one large VMFS volume or multiple smaller VMFS volumes. ESX Server lets you have up to 256 VMFS volumes per system with the minimum volume size 1.2 GB.

You might want fewer, larger VMFS volumes for the following reasons:

- More flexibility to create virtual machines without going back to the storage administrator for more space.
- More flexibility for resizing virtual disks, doing snapshots, and so on.
- Fewer VMFS-based datastores to manage.

You might want more, smaller VMFS volumes for the following reasons:

- Less contention on each VMFS due to locking and SCSI reservation issues.
- Less wasted storage space.
- Different applications might need different RAID characteristics.
- More flexibility, as the multipathing policy and disk shares are set per LUN.

- Use of Microsoft Cluster Service requires that each cluster disk resource is in its own LUN.

You might decide to configure some of your servers to use fewer, larger VMFS volumes and other servers to use more, smaller VMFS volumes.

VMFS Sharing Capabilities

You can store multiple virtual machines on a single VMFS volume and let multiple ESX Servers to access this volume.

See these sections for more information:

- "Storing Multiple Virtual Machines on a VMFS Volume" on page 99
- "Sharing a VMFS Volume Across ESX Servers" on page 100

Storing Multiple Virtual Machines on a VMFS Volume

You can store multiple virtual machines on the same VMFS volume. Each virtual machine, encapsulated in a small set of files, occupies a separate single directory. VMFS supports the following file and block sizes enabling you to run even the most data intensive applications, including databases, ERP, and CRM in virtual machines:

- Maximum virtual disk size: 2 TB
- Maximum file size: 2 TB
- Block size: 1 MB to 8 MB

When planning to store multiple virtual machines on the same VMFS volume, keep in mind that the more virtual machines are sharing the same volume, the greater is the potential for performance degradation due to I/O contention.

Sharing a VMFS Volume Across ESX Servers

As a cluster file system, VMFS lets multiple ESX Servers access the same storage concurrently. You can connect up to 32 ESX Servers to a single VMFS volume.

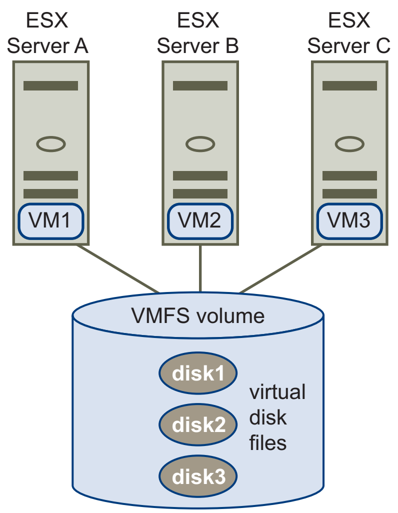


Figure 5-4. Sharing a VMFS Volume Across ESX Servers

To ensure that the same virtual machine is not accessed by multiple servers at the same time, VMFS provides on-disk locking.

Sharing the same VMFS volume across multiple ESX Servers gives you the following advantages:

- You can distribute virtual machines across different physical servers. That means you run a mix of virtual machines on each given server so that not all experience high demand in the same area at the same time.
- If a server fails, you can restart virtual machines on another physical server. In case of a failure, the on-disk lock for each virtual machine is released.
- You can perform live migration of running virtual machines from one physical server to another using VMotion.
- You can use Consolidated Backup, which lets a proxy server backup a snapshot of a virtual machine while the virtual machine is powered-on and is reading and writing to its storage.

Configuring and Managing Storage

The Configuring Storage and Managing Storage chapters of this guide cover most of the concepts and outline tasks you need to perform when working with storage.

For detailed information on configuring SANs, refer to the *SAN Configuration Guide*.

The storage tasks you can perform in ESX Server are listed in the following sections.

Local SCSI Configuration Tasks

"To create a datastore on a local SCSI disk" on page 104

Fibre Channel Tasks

"To create a datastore on a Fibre Channel device" on page 108

Hardware-Initiated iSCSI Tasks

- "To view the iSCSI hardware initiator properties" on page 114
- "To set up the iSCSI name and IP address for the hardware initiator" on page 116
- "To set up target discovery addresses for the hardware initiator" on page 117
- "To set up CHAP parameters for the hardware initiator" on page 119
- "To create a datastore on a hardware-initiated iSCSI device" on page 120

Software-Initiated iSCSI Tasks

- "To view the iSCSI software initiator properties" on page 122
- "To enable the iSCSI software initiator" on page 125
- "To set up target discovery addresses for the software initiator" on page 126
- "To set up CHAP parameters for the software initiator" on page 128
- "To create a datastore on a software-initiated iSCSI device" on page 129

NFS Tasks

"To mount an NFS volume" on page 135

General Storage Tasks

- "To upgrade the VMFS-2 to VMFS-3" on page 140
- "To edit the name of the datastore" on page 140
- "To add one or more extents to the datastore" on page 141
- "To remove a datastore" on page 139

Path Managing Tasks

- "To set the multipathing policy" on page 147
- "To disable a path" on page 148
- "To set the preferred path" on page 149

Configuring Storage 6

This chapter contains information about configuring local SCSI disks, Fibre Channel Storage Area Network (SAN) storage, iSCSI storage, and NFS volumes.

NOTE For additional information about configuring SANs, see the *SAN Configuration Guide*.

This chapter covers the following topics:

Local SCSI Disk Storage

The simplest type of storage uses a SCSI device such as your system's hard disk or any external SCSI storage device.

The diagram in Figure 6-1 depicts a virtual machine using local SCSI storage.

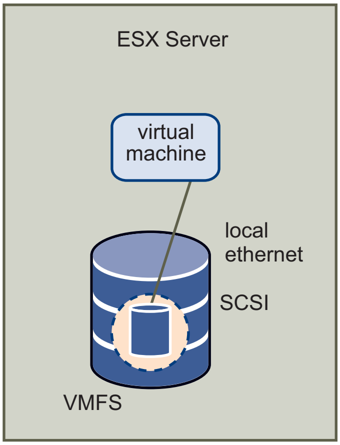


Figure 6-1. Local SCSI Storage

In this example of local storage configuration, the ESX Server SCSI card uses a cable to plug into a disk. On that disk, you can create a datastore, which you use to store virtual machine disk files. The datastore you create has the VMFS format.

For more information on configuring local storage on internal or external SCSI devices, see "Adding Local SCSI Storage" on page 104.

Adding Local SCSI Storage

As soon as you load SCSI storage adapter drivers, ESX Server detects available SCSI storage devices. Before creating a new datastore on a SCSI device, you might need to perform a rescan. For more information, see "Performing a Rescan" on page 131.

When you create a datastore on a SCSI storage device, the **Add Storage** wizard guides you through the configuration steps.

To create a datastore on a local SCSI disk

1 Log into the VMware VI Client and select the server from the inventory panel.

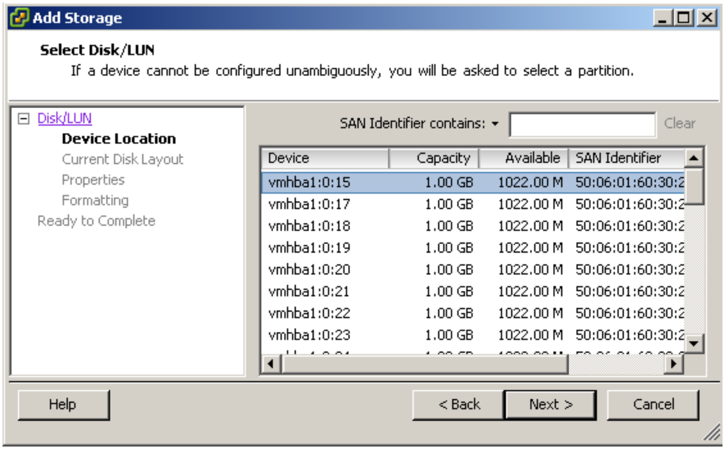
2 Click the **Configuration** tab, and click **Storage (SCSI, SAN, and NFS)** under hardware.

3 Click the **Add Storage** link.

The **Select Storage Type** page appears.

4 Select the **Disk/LUN** storage type, and click **Next**.

The **Select Disk/LUN** page appears.



5 Select the SCSI device you want to use for your datastore, and click **Next**.

The **Current Disk Layout** page appears.

6 Look over the current disk layout, and click **Next**.

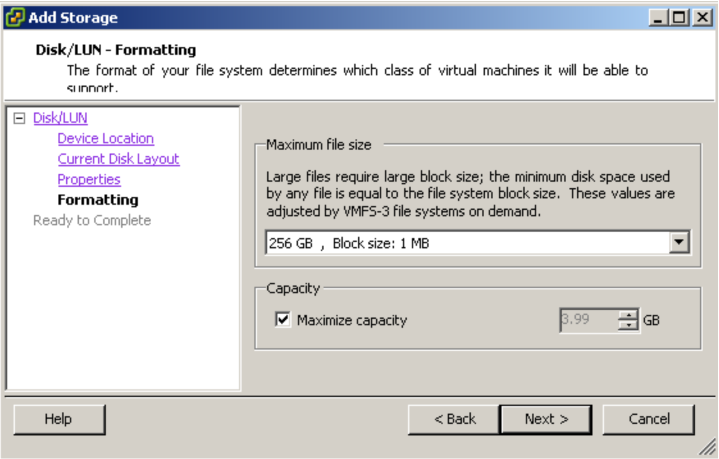
The the **Disk/LUN–Properties** page appears.

7 Enter a datastore name.

The label name must be unique within the current Virtual Infrastructure instance.

8 Click **Next**.

The **Disk/LUN–Formatting** page appears.



9 If needed, adjust the file system and capacity values.

By default, the entire free space available on the storage device is offered to you.

10 Click **Next**.

The **Ready to Complete** page appears.

11 Review the datastore configuration information, and click **Finish**.

This process creates a datastore on the local SCSI disk on your ESX Server host.

Fibre Channel Storage

ESX Server supports Fibre Channel adapters, which allow an ESX Server system to be connected to a SAN and see the disk arrays on the SAN.

The diagram in Figure 6-2 depicts virtual machines using Fibre Channel storage.

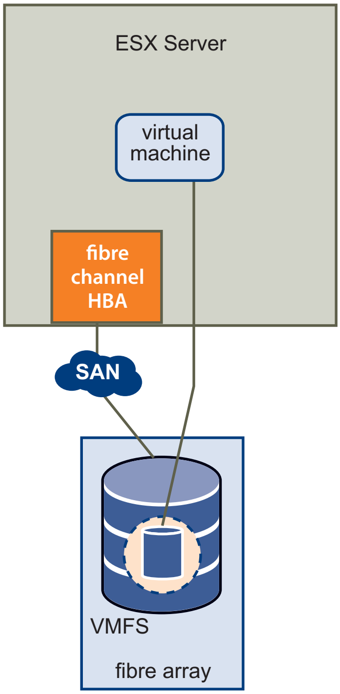


Figure 6-2. Fibre Channel Storage

In this configuration, an ESX Server system connects to SAN fabric, which consists of Fibre Channel switches and storage arrays, using a Fibre Channel adapter. LUNs from storage array become available to your ESX Server system. You can access the LUNs and create a datastore that you use for your ESX Server storage needs. The datastore uses the VMFS format.

For information on configuring Fibre Channel storage, see "Adding Fibre Channel Storage" on page 108.

For additional information:

- About configuring SANs, see the *SAN Configuration Guide*.
- About supported SAN storage devices for ESX Server, see the *SAN Compatibility Guide*.
- About multipathing for Fibre Channel HBAs and how to manage paths, see "Managing Paths for Fibre Channel and iSCSI" on page 143.

Adding Fibre Channel Storage

Before creating a new datastore on a Fibre Channel device, rescan a Fibre Channel adapter to discover any newly added LUNs. For more information, see "Performing a Rescan" on page 131.

When you create a datastore on a Fibre Channel storage device, the **Add Storage** wizard guides you through the configuration.

To create a datastore on a Fibre Channel device

1 Log into the VMware VI Client, and select a server from the inventory panel.

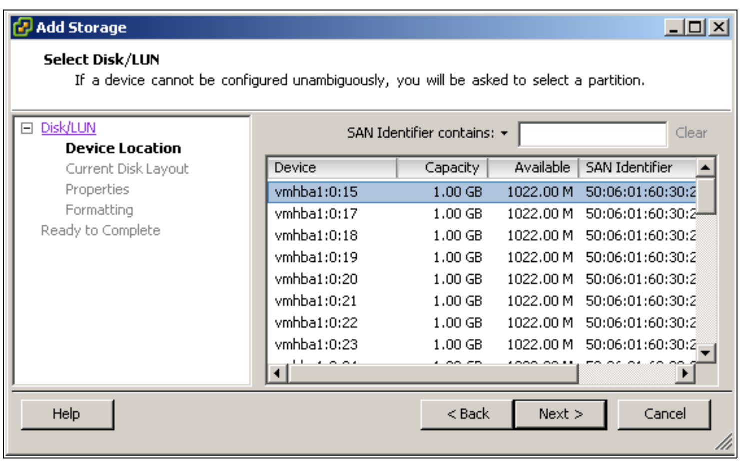
2 Click the **Configuration** tab, and click **Storage (SCSI, SAN, and NFS)** under hardware.

3 Click the **Add Storage** link.

The **Select Storage Type** page appears.

4 Select the **Disk/LUN** storage type, and click **Next**.

The **Select Disk/LUN** page appears.



5 Select the Fibre Channel device you want to use for your datastore, and click **Next**.

The **Current Disk Layout** page appears.

6 Look over the current disk layout, and click **Next**.

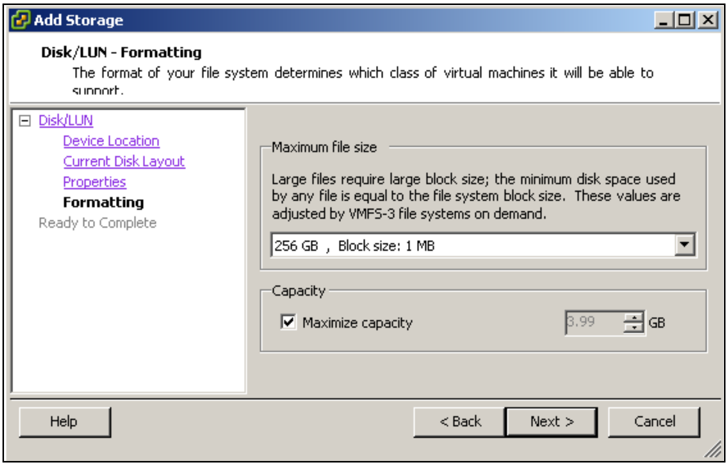
The **Disk/LUN–Properties** page appears.

7 Enter a datastore name.

The datastore name appears in the VI Client and must be unique within the current Virtual Infrastructure instance.

8 Click **Next**.

The **Disk/LUN–Formatting** page appears.



9 If needed, adjust the file system values and capacity you use for the datastore.

By default, the entire free space available on the storage device is offered to you.

10 Click **Next**.

The **Ready to Complete** page appears.

11 Review the datastore information, and click **Finish**.

This process creates the datastore on a Fibre Channel disk for the ESX Server host.

12 Perform a rescan.

See "Performing a Rescan" on page 131.

For advanced configuration, such as using multipathing, masking, and zoning, refer to the *SAN Configuration Guide*.

iSCSI Storage

This section discusses configuring iSCSI storage and provides the following information:

- "About iSCSI Storage" on page 110
- "Configuring Hardware-Initiated iSCSI Storage" on page 113
- "Configuring Software-Initiated iSCSI Storage" on page 121

For information on multipathing, see "Managing Paths for Fibre Channel and iSCSI" on page 143.

About iSCSI Storage

ESX Server 3.0 supports iSCSI technology that allows your ESX Server system to use IP network while accessing remote storage. With iSCSI, SCSI storage commands that your virtual machine issues to its virtual disk are converted into TCP/IP protocol packets and transmitted to a remote device, or target, that stores the virtual disk. From the point of view of the virtual machine, the device appears as locally attached SCSI drive.

This section provides information on iSCSI concepts and covers the following topics:

- "iSCSI Initiators" on page 110
- "Naming Requirements" on page 112
- "Discovery Methods" on page 112
- "iSCSI Security" on page 112

iSCSI Initiators

To access remote targets, your ESX Server host uses iSCSI initiators. Initiators transport SCSI requests and responses between the ESX Server system and the target storage device on the IP network.

ESX Server supports hardware-based and software-based iSCSI initiators:

- **Hardware iSCSI initiator –** A third-party host bus adapter (HBA) with the iSCSI over TCP/IP capability. This specialized iSCSI adapter is responsible for all iSCSI processing and management. Currently, ESX Server supports only QLogic QLA4010 iSCSI HBA.
- **Software iSCSI initiator** – A code built into VMkernel that lets your ESX Server system to connect to the iSCSI storage device through standard network adapters. The software initiator handles the iSCSI processing while communicating with the

network adapter through the network stack. With the software initiator, you can use the iSCSI technology without purchasing specialized hardware.

NOTE Guest operating systems in virtual machines cannot see iSCSI storage directly. To the guest operating systems, iSCSI storage attached to the ESX Server system appears to be available through a SCSI HBA.

The diagram in Figure 6-3 depicts two virtual machines that use different types of iSCSI initiators.

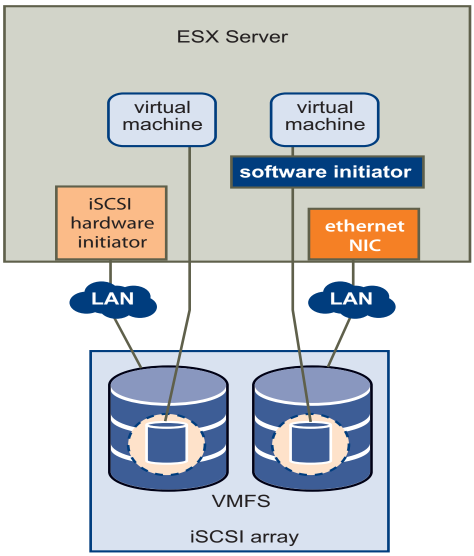


Figure 6-3. iSCSI Storage

In the first example of iSCSI storage configuration, the ESX Server system uses the hardware iSCSI adapter. This specialized iSCSI adapter sends iSCSI packets to a disk over a LAN.

In the second example, the ESX Server system is configured with the software iSCSI initiator. Using the software initiator, the ESX Server system connects to a LAN through an existing NIC card.

NOTE This release doesn't support using both the hardware and software iSCSI initiators on the same ESX Server system. Use the software initiator only when iSCSI traffic goes over standard network adapters, not when the specialized iSCSI adapters are used.

Naming Requirements

Because storage area networks can become large and complex, all iSCSI initiators and targets that use the network have unique and permanent iSCSI names and are assigned addresses for access. The iSCSI name provides a correct identification of a particular iSCSI device, an initiator or a target, regardless of its physical location.

When configuring your iSCSI initiators, make sure they have properly formatted names. The initiators can use one of the following formats:

- **IQN (iSCSI qualified name)** – Can be up to 255 characters long and has the following format:

  ```
  iqn.<year-mo>.<reversed_domain_name>:<unique_name>,
  ```

  where `<year-mo>` represents the year and month your domain name was registered, `<reversed_domain_name>` is the official domain name, reversed, and `<unique_name>` is any name you want to use, for example, the name of your server.

  An example might be `iqn.1998-01.com.mycompany:myserver`.

- **EUI (extended unique identifier)** – Represents the `eui.` prefix followed by the 16-character name. The name includes 24 bits for company name assigned by the IEEE and 40 bits for a unique ID such as a serial number.

Discovery Methods

To determine which storage resource on the network is available for access, the iSCSI initiators ESX Server system uses these discovery methods:

- **Dynamic Discovery** – The initiator discovers iSCSI targets by sending a *SendTargets* request to a specified target address. To use this method, enter the address of the target device so that the initiator can establish a discovery session with this target. The target device responds by forwarding a list of additional targets that the initiator is allowed to access.

- **Static Discovery** – After the target device used in the SendTargets session sends you the list of available targets, they appear on the Static Discovery list. To this list, you can manually add any additional targets, or remove targets you don't need.

  The static discovery method is available only with the hardware-initiated storage.

iSCSI Security

Because iSCSI technology uses the IP networks to connect to remote targets, it is necessary to ensure security of the connection. The IP protocol itself doesn't protect the data it transports, and it doesn't have the capability to verify the legitimacy of initiators that access targets on the network. You need to take specific measures to guarantee security across IP networks.

ESX Server supports the Challenge Handshake Authentication Protocol (CHAP) that your iSCSI initiators can use for authentication purposes. After your initiator establishes the initial connection with the target, CHAP verifies the identity of the initiator and checks a CHAP secret that your initiator and the target share. This can be repeated periodically during the iSCSI session.

When configuring iSCSI initiators for your ESX Server system, make sure that CHAP is enabled. For more information, see "Securing iSCSI Storage" on page 203.

Configuring Hardware-Initiated iSCSI Storage

With hardware-based iSCSI storage, you use a specialized third-party adapter capable of accessing iSCSI storage over TCP/IP. This iSCSI adapter handles all iSCSI processing and management for your ESX Server system.

Install and configure the iSCSI hardware adapter before setting up the datastore that resides on an iSCSI storage device.

Use the following instructions when preparing and setting up datastores that you access through the iSCSI hardware connection:

- "Installing iSCSI Hardware Initiator" on page 113
- "Viewing iSCSI Hardware Initiator" on page 113
- "Configuring iSCSI Hardware Initiator" on page 115
- "Adding Hardware-Initiated iSCSI Storage" on page 120

Installing iSCSI Hardware Initiator

ESX Server 3.0 requires that your host system uses the QLogic QLA4010 iSCSI HBA to initiate iSCSI transactions.

For more information, see the *I/O Compatibility Guide* on the VMware Web site at **www.vmware.com**.

For information on obtaining and installing the adapter, see the QLogic web site at **www.qlogic.com**.

Viewing iSCSI Hardware Initiator

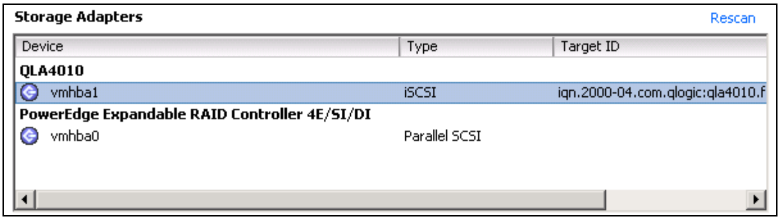
Before you begin configuring the iSCSI hardware initiator, make sure that the iSCSI HBA is successfully installed and appears on the list of adapters available for configuration. If the initiator is installed, you can view its properties.

To view the iSCSI hardware initiator properties

1 Log into the VMware VI Client, and select a server from the inventory panel.

2 Click the **Configuration** tab, and click **Storage Adapters** under hardware.

The list of available storage adapters appears. The iSCSI HBA appears in the list of storage adapters.

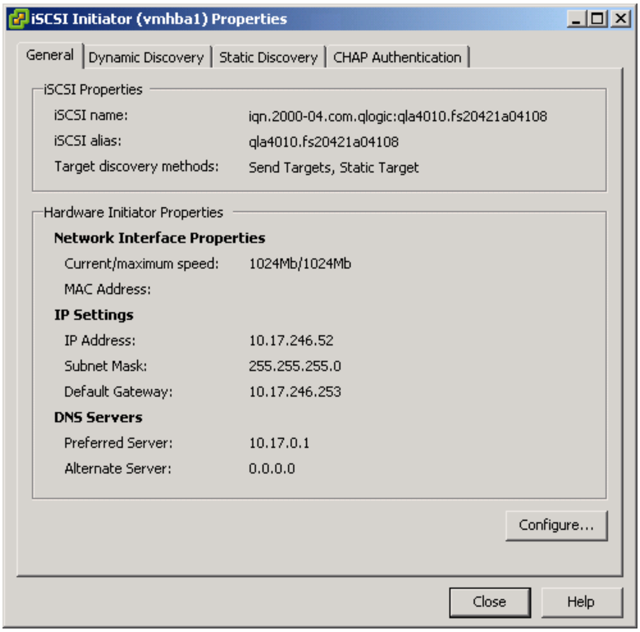


3 Under HBA, choose the initiator you want to configure.

The details for the initiator display, including the model, IP address, iSCSI name, discovery methods, iSCSI alias, and any discovered targets.

4 Click **Properties**.

The **iSCSI Initiator Properties** dialog box opens. The **General** tab displays additional characteristics of the initiator.



You can now configure your hardware initiator or change its default characteristics.

Configuring iSCSI Hardware Initiator

While configuring the iSCSI hardware initiator, you need to set up your initiator's iSCSI name, IP address, target addresses, and CHAP parameters. See the following sections for more information:

- "Setting up Naming Parameters for Hardware Initiators" on page 115
- "Setting up Discovery Addresses for Hardware Initiators" on page 117
- "Setting up CHAP Parameters for Hardware Initiators" on page 118

After you configure your iSCSI hardware initiator, perform a rescan, so that all LUNs that the initiator has access to appear on the list of storage devices available to your ESX Server host. For more information, see "Performing a Rescan" on page 131.

Setting up Naming Parameters for Hardware Initiators

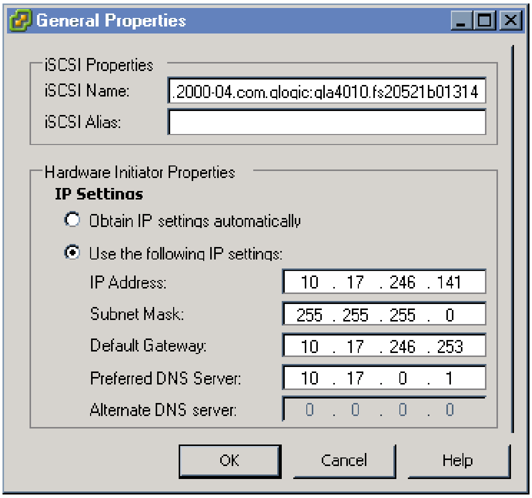
When configuring your iSCSI hardware initiators, make sure their names and IP addresses are formatted properly.

For more information, see "Naming Requirements" on page 112.

To set up the iSCSI name and IP address for the hardware initiator

1. Open the **iSCSI Initiator Properties** dialog box by performing the steps listed in "To view the iSCSI hardware initiator properties" on page 114.
2. Click **Configure**.

   The **General Properties** dialog box opens.

3. To change the default iSCSI name for your initiator, enter the new name.

   Make sure the name you enter is properly formatted; otherwise, some storage devices may not recognize the iSCSI hardware initiator.
4. Enter the iSCSI alias.

   The alias is a friendly name that you use to identify the iSCSI hardware initiator.
5. Under **Hardware Initiator Properties**, choose one of these options:
   - **Obtain IP settings automatically**
   - **Use the following IP settings**
6. If you selected **Use the following IP settings**, enter values for the following:
   - **IP Address**
   - **Subnet Mask**
   - **Default Gateway**

- **Preferred DNS Server**
- **Alternate DNS server** (optional)

7 Click **OK** to save your changes.

Setting up Discovery Addresses for Hardware Initiators

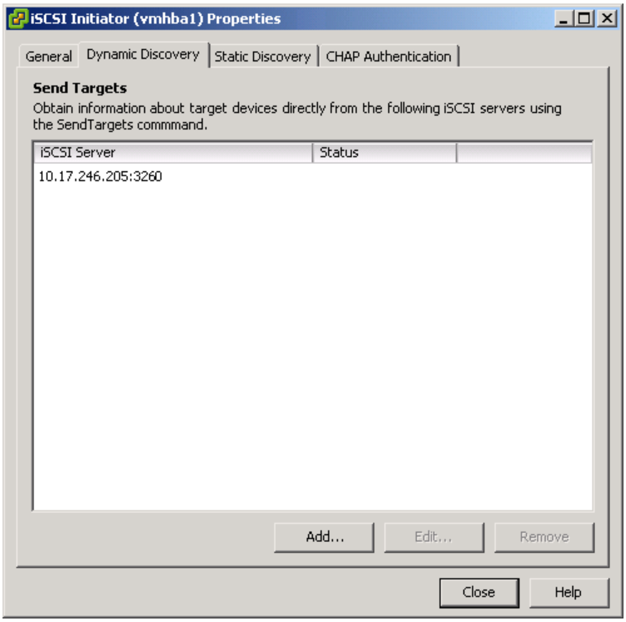
You need to set up target discovery addresses so that the hardware initiator can determine which storage resource on the network is available for access.

For more information, see "Discovery Methods" on page 112.

To set up target discovery addresses for the hardware initiator

1 Open the **iSCSI Initiator Properties** dialog box by performing the steps listed in "To view the iSCSI hardware initiator properties" on page 114.

2 In the **iSCSI Initiator Properties** dialog box, click the **Dynamic Discovery** tab.



3 To add a new iSCSI target your ESX Server host can use for a SendTargets session, click **Add**.

The **Add SendTargets Server** dialog box appears.

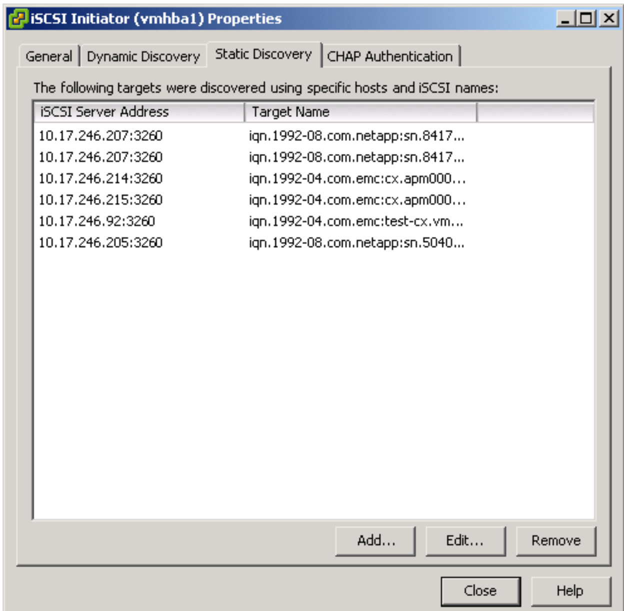
4 Enter the target's information and click **OK**.

After your ESX Server host establishes the SendTargets session with this target device, any newly discovered targets will appear in the **Static Discovery** list.

5 To change or delete a specific target, select the target and click **Edit** or **Remove**.

6 Click the **Static Discovery** tab.

The tab displays all dynamically discovered targets.



7 To add a target accessible to your ESX Server host, click **Add** and enter the target's information.

8 To change or delete a specific dynamically discovered target, select the target and click **Edit** or **Remove**.

NOTE If you remove a dynamically discovered static target, the target can be returned to the list the next time a rescan happens, the HBA is reset, or the system is rebooted.

Setting up CHAP Parameters for Hardware Initiators

When configuring your iSCSI hardware initiator, make sure that CHAP parameters are enabled for the initiator. If they are not enabled, you need to set them up.

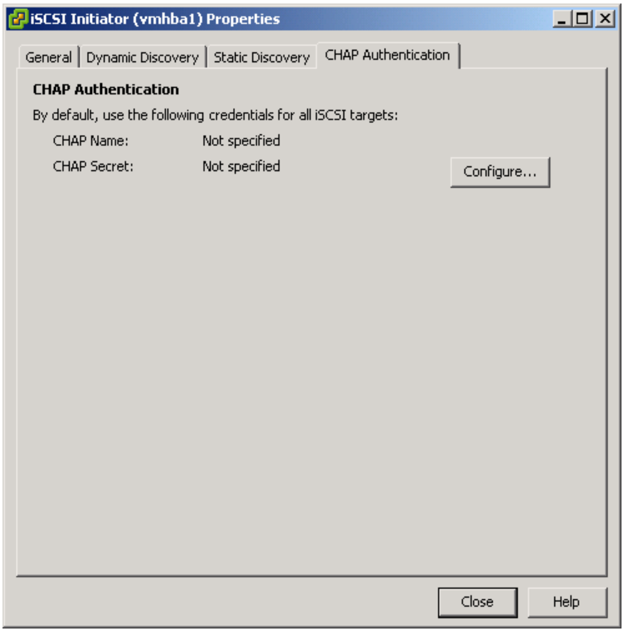
For more information, see "iSCSI Security" on page 112.

To set up CHAP parameters for the hardware initiator

1 Open the **iSCSI Initiator Properties** dialog box by performing the steps listed in "To view the iSCSI hardware initiator properties" on page 114.

2 Click the **CHAP Authentication** tab.

The tab displays the default CHAP parameters.



3 To make any changes to the existing CHAP parameters, click **Configure**.

The **CHAP Authentication** dialog box opens.

4 To keep CHAP enabled, make sure **Use the following CHAP credentials** is selected.

5 To use a new CHAP name, deselect the **Use initiator name** check box and enter the name of your choice.

6 If needed, specify the CHAP secret.

All new targets will use the CHAP secret to authenticate the initiator.

7 Click **OK** to save changes.

NOTE If you disable CHAP, all sessions that require CHAP authentication will end immediately.

Adding Hardware-Initiated iSCSI Storage

When you create a datastore on a hardware-initiated iSCSI storage device, the **Add Storage** wizard guides you through the configuration.

To create a datastore on a hardware-initiated iSCSI device

1 Log into the VMware VI Client, and select a server from the inventory panel.

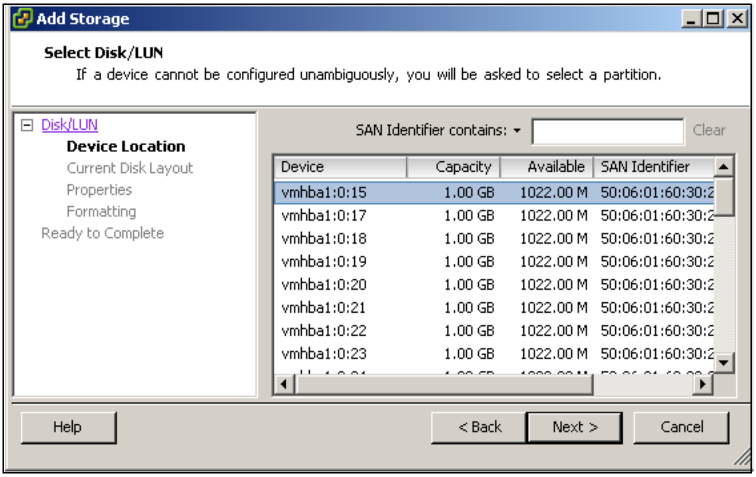
2 Click the **Configuration** tab, and click **Storage (SCSI, SAN, and NFS)** under hardware.

3 Click the **Add Storage** link.

The **Select Storage Type** page appears.

4 Select the **Disk/LUN** storage type, and click **Next**.

The **Select Disk/LUN** page appears.



5 Select the iSCSI device you want to use for your datastore, and click **Next**.

The **Current Disk Layout** page appears.

6 Look over the current disk layout, and click **Next**.

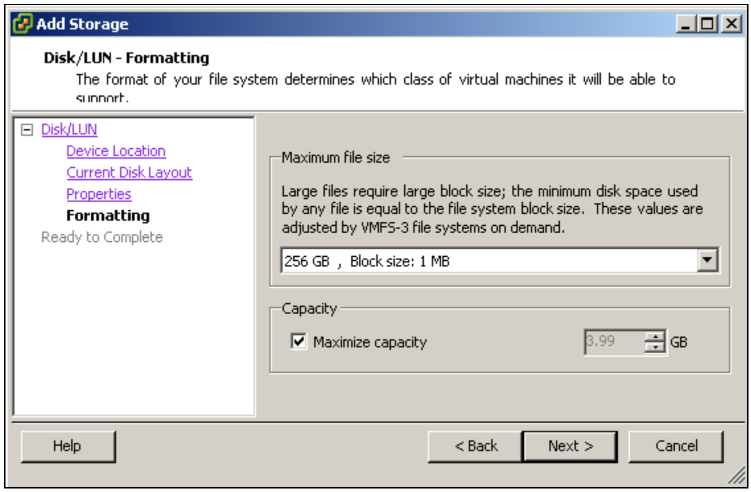
The **Disk/LUN–Properties** page appears.

7 Enter a datastore name.

The datastore name appears in the VI Client, and the label must be unique within the current Virtual Infrastructure instance.

8 Click **Next**.

The **Disk/LUN–Formatting** page appears.



9 If needed, adjust the file system values and capacity you use for the datastore. By default, the entire free space available on the storage device is offered to you.

10 Click **Next**.

The **Summary** page appears.

11 Review the datastore information, and click **Finish**.

This creates the datastore on the hardware-initiated iSCSI device.

12 Perform a rescan.

See "Performing a Rescan" on page 131.

Configuring Software-Initiated iSCSI Storage

With the software-based iSCSI implementation, you can use a standard network adapter to connect your ESX Server system to a remote iSCSI target on the IP network. The ESX Server software iSCSI initiator built into VMkernel facilitates this connection communicating with the network adapter through the network stack.

Before configuring software-based iSCSI storage, enable network connectivity and configure the iSCSI software initiator.

Use the following procedure when preparing and setting up datastores that use iSCSI software-initiated connection to access the iSCSI storage:

1 Configure the VMkernel TCP/IP networking stack.

   See "VMkernel Configuration" on page 33 and "Networking Configuration for Software iSCSI Storage" on page 70.

2 Open a firewall port by enabling the iSCSI software client service.

   See "Opening Firewall Ports for Supported Services and Management Agents" on page 192.

3 Configure the iSCSI software initiator.

   See "Configuring iSCSI Software Initiator" on page 124.

4 Rescan for new iSCSI LUNs.

   See "Performing a Rescan" on page 131.

5 Set up the datastore.

   See "Adding Software-Initiated iSCSI Storage" on page 129.

Viewing Software iSCSI Initiator

The software iSCSI adapter that your ESX Server system uses to access a software-initiated iSCSI storage device appears on the list of available adapters. You can use the VI Client to review its properties.

To view the iSCSI software initiator properties

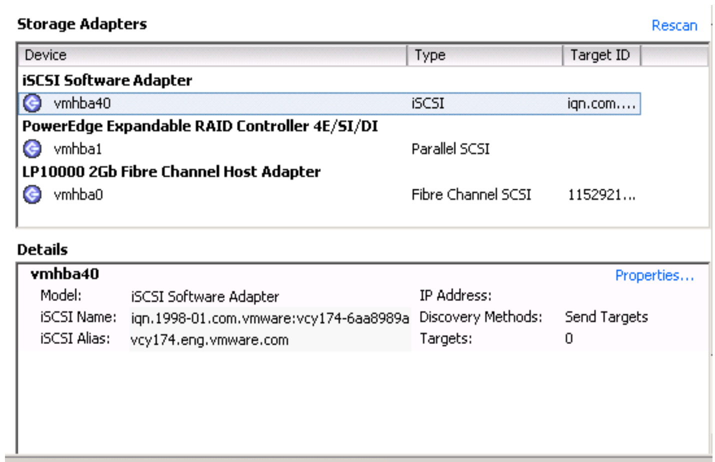
1 Log into the VMware VI Client, and select a server from the inventory panel.

2 Click the **Configuration** tab, and click **Storage Adapters** under hardware.

   The list of available storage adapters appears.

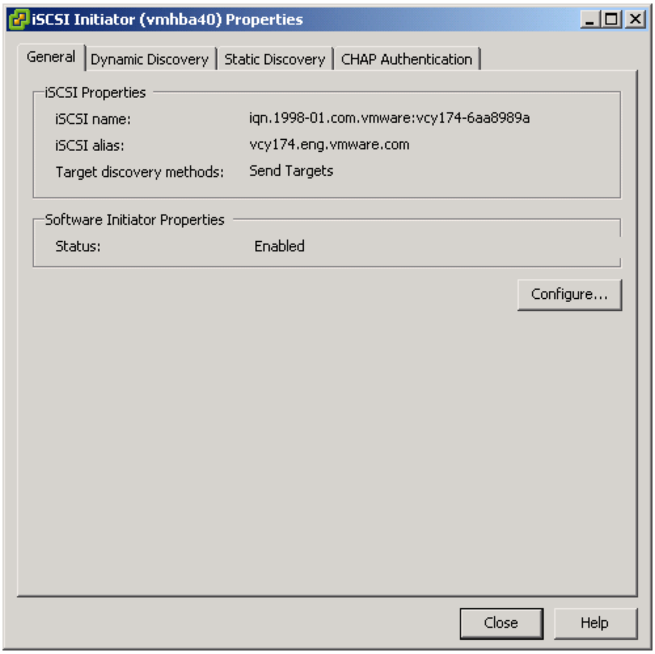
3 Under **iSCSI Software Adapter**, choose the available software initiator.

The details for the initiator display, including the model, IP address, iSCSI name, discovery methods, iSCSI alias, and any discovered targets.



4 Click **Properties**.

The **iSCSI Initiator Properties** dialog box opens. The **General** tab displays additional characteristics of the software initiator.



You can now configure your software initiator or change its default characteristics.

Configuring iSCSI Software Initiator

While configuring the iSCSI software initiator, you enable your initiator and set up the initiator's target addresses and CHAP parameters. See the following sections for more information:

- "Enabling iSCSI Software Initiators" on page 125
- "Setting up Discovery Addresses for Software Initiators" on page 126
- "Setting up CHAP Parameters for Software Initiators" on page 127

After you configure your iSCSI software initiator, perform a rescan, so that all LUNs that the initiator has access to appear on the list of storage devices available to your ESX Server. For more information, see "Performing a Rescan" on page 131.

Enabling iSCSI Software Initiators

You need to enable your iSCSI software initiator, so that ESX Server can use it.

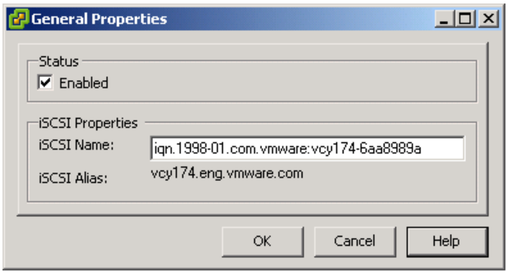
To enable the iSCSI software initiator

1. Open the **iSCSI Initiator Properties** dialog box by performing the steps listed in "To view the iSCSI software initiator properties" on page 122.

2. Click **Configure**.

   The **General Properties** dialog box opens, displaying the initiator's status, default name, and alias.

3. To enable the initiator, select the **Enabled** check box.



4. To change the default iSCSI name for your initiator, enter the new name.

   Make sure the name you enter is properly formatted; otherwise, some storage devices might not recognize the iSCSI hardware initiator. For more information, see "Naming Requirements" on page 112.

5. Enter the iSCSI alias or change the existing one.

   The alias is a friendly name that you use to identify the iSCSI hardware initiator.

6. Click **OK** to save your changes.

Setting up Discovery Addresses for Software Initiators

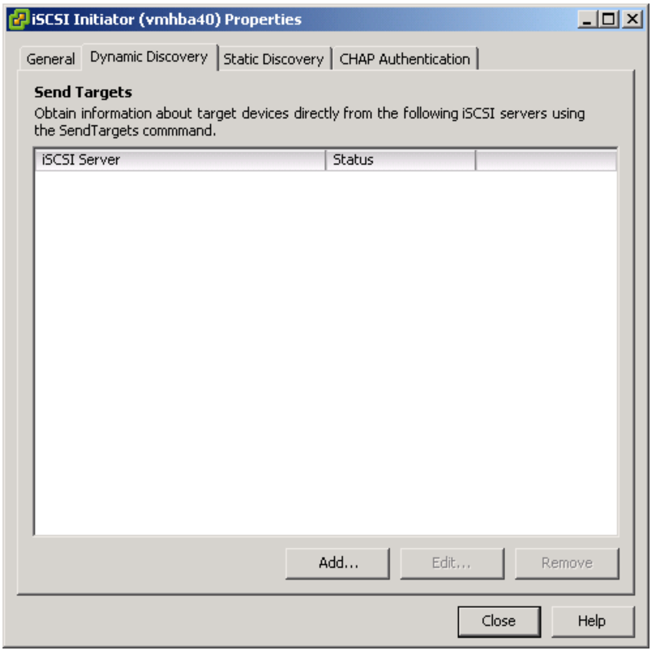
You need to set up target discovery addresses so that the software initiator can determine which storage resource on the network is available for access.

For more information, see "Discovery Methods" **on page 112**.

To set up target discovery addresses for the software initiator

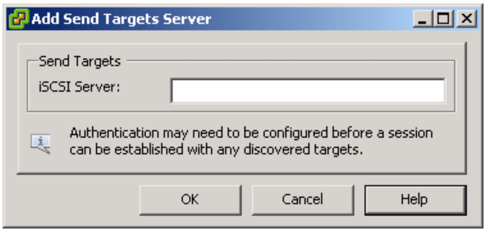
1 Open the **iSCSI Initiator Properties** dialog box by performing the steps listed in "To view the iSCSI software initiator properties" on page 122.

2 Click the **Dynamic Discovery** tab.



3 To add a new iSCSI target your ESX Server host can use for a SendTargets session, click **Add**.

The **Add Send Targets Server** dialog box appears.



4 Enter the Send Targets server IP address, and click **OK**.

5 To change or delete a Send Targets server, select the server and click **Edit** or **Remove**.

Setting up CHAP Parameters for Software Initiators

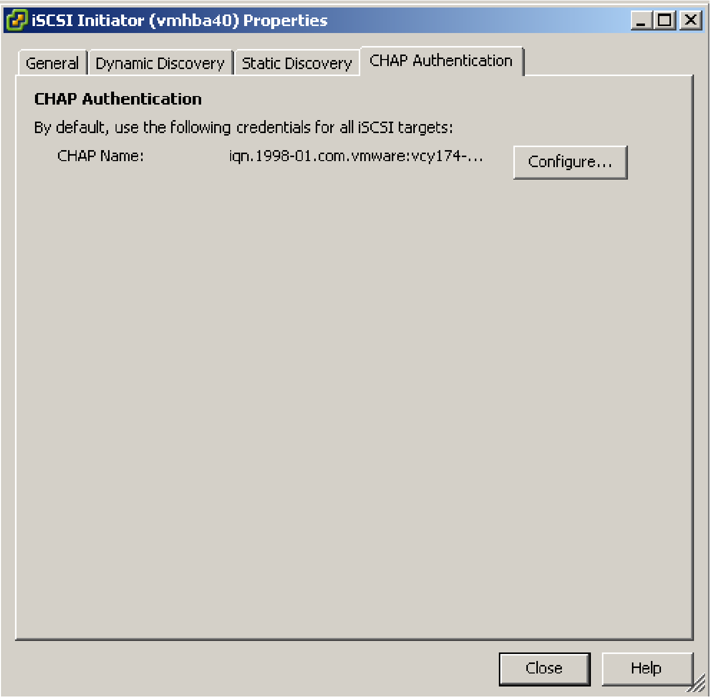
When configuring your iSCSI software initiator, make sure that CHAP parameters are enabled for the initiator. If they are not enabled, you need to set them up.

For more information, see "iSCSI Security" on page 112.

To set up CHAP parameters for the software initiator

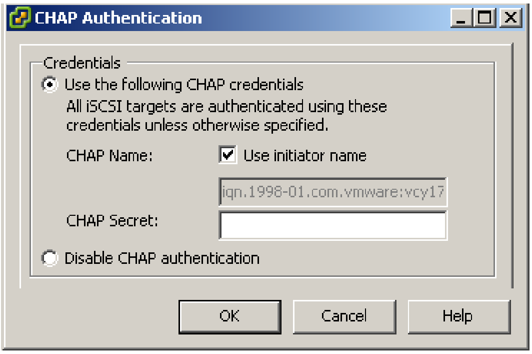
1. Open the iSCSI Initiator Properties dialog box by performing the steps listed in "To view the iSCSI software initiator properties" on page 122.
2. Click the **CHAP Authentication** tab.

   The tab displays the default CHAP parameters.



3 To make any changes to the existing CHAP parameters, click **Configure**.

The **CHAP Authentication dialog** box opens.



4 To keep CHAP enabled, make sure **Use the following CHAP credentials** is selected.

5 To use a new CHAP name, deselect the **Use initiator name** check box, and enter the name of your choice.

6 If needed, specify the CHAP secret.

All new targets will use the CHAP secret to authenticate the initiator. Any established sessions are not affected.

7 Click **OK** to save changes.

NOTE If you disable CHAP, all sessions that require CHAP authentication will end immediately.

Adding Software-Initiated iSCSI Storage

When you create a datastore on a software-initiated iSCSI storage device, the **Add Storage** wizard guides you through the configuration.

To create a datastore on a software-initiated iSCSI device

1 Log into the VMware VI Client, and select a server from the inventory panel.

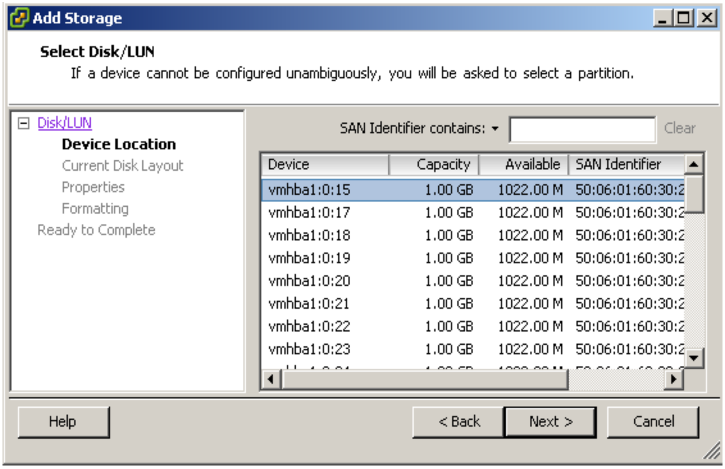
2 Click the **Configuration** tab, and click **Storage (SCSI, SAN, and NFS)** under hardware.

3 Click the **Add Storage** link.

The **Select Storage Type** page appears.

4 Select the **Disk/LUN** storage type, and click **Next**.

The **Select Disk/LUN** page appears.



5 Select the iSCSI device that you want to use for your datastore, and click **Next**.

The **Current Disk Layout** page appears.

6 Look over the current disk layout, and click **Next**.

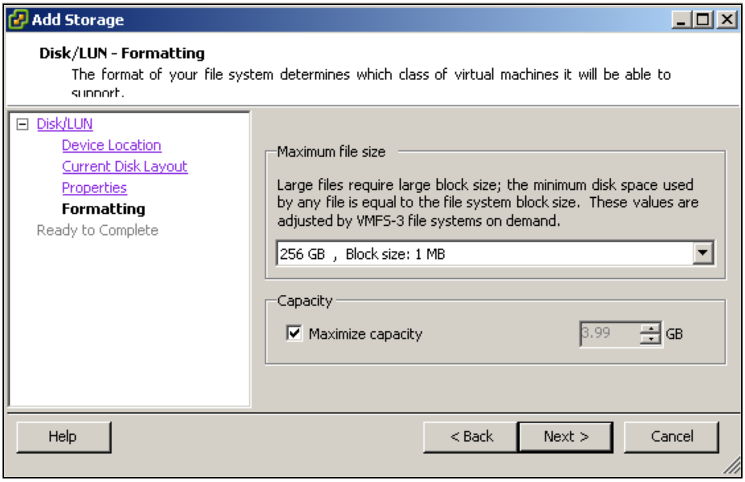
The **Disk/LUN–Properties** page appears.

7 Enter a datastore name.

The datastore name appears in the VI Client, and the label must be unique within the current Virtual Infrastructure instance.

8 Click **Next**.

The **Disk/LUN–Formatting** page appears.



9 If needed, adjust the file system values and capacity you use for the datastore.

By default, the entire free space available on the storage device is offered to you.

10 Click **Next**.

The **Ready to Complete** page appears.

11 Review the datastore configuration information, and click **Finish**.

This creates the datastore on the software-initiated iSCSI storage device.

12 Perform a rescan.

See "Performing a Rescan" on page 131.

Performing a Rescan

If a new LUN becomes accessible through the adapter, then ESX Server registers this new virtual device for use by virtual machines. If an existing LUN is no longer used and appears to be gone, then it is removed from use by virtual machines.

Consider performing a rescan when:

- Any changes are made to storage disks or LUNs available to your ESX Server system
- Any changes are made to storage adapters

- New datastores are created
- Existing datastores are edited or removed

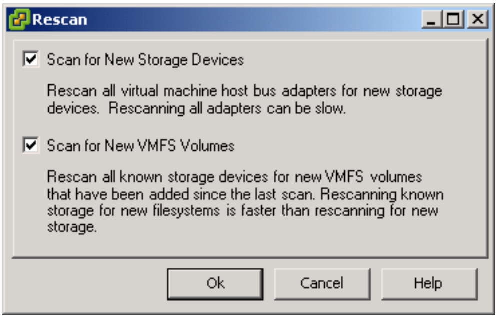
To perform a rescan

1 In the VI Client, select a host, and click the **Configuration** tab.

2 Choose **Storage Adapters** in the Hardware panel, and click **Rescan** above the **Storage Adapters** panel.

NOTE You can also select an individual adapter and click **Rescan** to rescan just that adapter.

The **Rescan** dialog box opens.



3 To discover new disks or LUNs, select **Scan for New Storage Devices**.

If new LUNs are discovered, they appear in the disk/LUN list.

4 To discover new datastores, select **Scan for New VMFS Volumes**.

If new datastores or VMFS volumes are discovered, they appear in the datastore list.

Network Attached Storage

This section contains information about network attached storage (NAS) and provides the following information:

- "Shared Storage Capabilities" on page 133
- "How Virtual Machines Use NFS" on page 133
- "NFS Volumes and Virtual Machine Delegate Users" on page 134

■ "Configuring ESX Server to Access NFS Volumes" on page 135

■ "Creating an NFS-Based Datastore" on page 135

ESX Server supports using network attached storage (NAS) through the NFS protocol. For some users, NFS might be a more cost-effective alternative to SAN storage.

Shared Storage Capabilities

ESX Server supports the following shared storage capabilities on NFS volumes:

- Use VMotion. Move running virtual machines from one ESX Server to another without service interruption.
- Create virtual machines on NFS mounted volumes.
- Boot virtual machines stored on NFS mounted volumes.
- Create virtual machine snapshots on NFS mounted volumes. The snapshot feature lets you preserve the state of the virtual machine so you can return to the same state repeatedly.

How Virtual Machines Use NFS

The NFS protocol that ESX Server supports enables communication between an NFS client and NFS server. The client issues requests for information from the server which replies with the result.

The NFS client built into ESX Server lets you access the NFS server and use NFS volumes to store virtual machine disks. ESX Server supports NFS Version 3 over TCP only.

You use the VI Client to configure NFS volumes as datastores. Configured NFS datastores appear in the VI Client and you can use them to store virtual disk files in the same way you use VMFS-based datastores.

The virtual disks that you create on NFS-based datastores use a disk format dictated by the NFS server, typically a thin disk format that requires on-demand space allocation. If the virtual machine runs out of space while writing to this disk, the VI Client notifies you that more space is needed. You have the following options:

- Free up additional space on the volume, so that the virtual machine continues writing to the disk.
- Terminate the virtual machine session. Terminating the session, shuts down the virtual machine.

The diagram in Figure 6-4 depicts a virtual machine using the NFS volume to store its files.

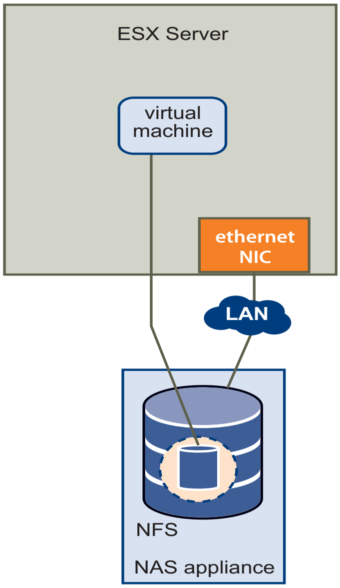


Figure 6-4. NFS Storage

In this configuration, ESX Server connects to the NFS server, which stores the virtual disk files.

WARNING When ESX Server accesses a virtual machine disk file on an NFS-based datastore, a special `.lck-XXX` lock file is generated in the same directory where the disk file resides to prevent other ESX Server hosts from accessing this virtual disk file. Don't remove the `.lck-XXX` lock file, otherwise the running virtual machine will not be able to access its virtual disk file.

NFS Volumes and Virtual Machine Delegate Users

If you are planning to create, configure, or administer virtual machines on an NFS-based datastore, you need to assign NFS access privileges to a special user, known as the delegate user.

By default, the delegate user for the ESX Server host is `root`. However, having `root` as the delegate user may not work for all NFS volumes. In some cases, to protect NFS volumes from unauthorized access, NFS administrators may export the volumes with the `root squash` option turned on. When `root squash` is on, the NFS server treats access by root as access by any unprivileged user and might refuse the ESX Server host access to virtual machine files stored on the NFS volume.

You can change the delegate user to a different identity through experimental ESX Server functionality. This identity must match the owner of the directory on the NFS server, otherwise the ESX Server host will be unable to perform file level operations.

For more information on setting up a different identity for the delegate user, see "Virtual Machine Delegates for NFS Storage" on page 232.

WARNING Changing the delegate user for an ESX Server host is experimental and, currently, VMware provides limited support for this feature. Use of this feature may result in unexpected behavior.

Configuring ESX Server to Access NFS Volumes

NFS requires network connectivity to access data stored on remote servers. Before configuring NFS, you must first configure networking for VMotion and IP storage.

For information on configuring a network, see "VMkernel Configuration" on page 33.

Creating an NFS-Based Datastore

When you create a datastore on an NFS volume, the **Add Storage** wizard guides you through the configuration steps.

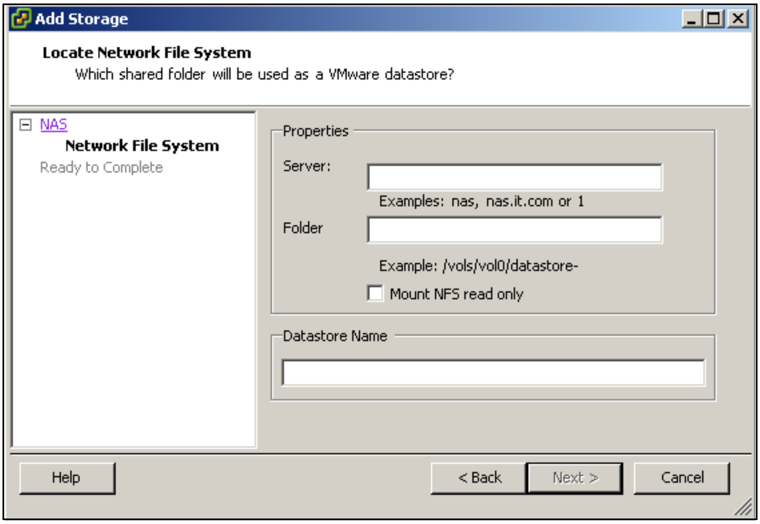
To mount an NFS volume

1. Log into the VMware VI Client, and select a server from the inventory panel.
2. Click the **Configuration** tab, and click **Storage (SCSI, SAN, and NFS)** under hardware.
3. Click the **Add Storage** link.

   The **Select Storage Type** page appears.

4 Select **Network File System** as the storage type, and click **Next**.

The **Locate Network File System** page appears.



5 Enter the server name, the mount point folder, and the datastore name.

6 Click **Next**.

The **Network File System Summary** page appears.

7 Review the configuration options and click **Finish**.

Managing Storage 7

This chapter contains information about managing existing datastores and file systems that comprise datastores. The chapter covers the following sections:

Managing Datastores and File Systems

An ESX Server system uses datastores to store all files associated with its virtual machines. The datastore is a logical storage unit, which can use disk space on one physical device, one disk partition, or span several physical devices. The datastore can exist on different types of physical devices including SCSI, iSCSI, Fibre Channel SAN, or NFS.

NOTE As an alternative to using the datastore, your virtual machine can have direct access to raw devices using a mapping file (RDM) as a proxy. For more information on RDMs, see "Raw Device Mapping" on page 151.

For more information on datastores, see "Datastores and File Systems" on page 90.

Datastores are added to the VI Client in one of two ways:

- Discovered when a host is added to the inventory – When you add a host to the inventory, the VI Client displays any datastores that the host can recognize.
- Created on an available storage device – You can use the **Add Storage** command to create and configure a new datastore.

After you create the datastores, you can use them to store virtual machine files. When needed, you can modify the datastores. For example, you can add extents to your datastore, rename, or remove it.

See these sections for more information:

- "Adding New Datastores" on page 138
- "Removing Existing Datastores" on page 139

Adding New Datastores

You can create a datastore on a Fibre Channel, iSCSI, or local SCSI disk. You can also mount an NFS volume over a network connection and use it as a VMware datastore. To create a datastore, choose the type of datastore you want to create using the following options:

- "Adding Local SCSI Storage" on page 104
- "Adding Fibre Channel Storage" on page 108
- "Adding Hardware-Initiated iSCSI Storage" on page 120
- "Adding Software-Initiated iSCSI Storage" on page 129
- "Creating an NFS-Based Datastore" on page 135

Removing Existing Datastores

You can remove a datastore that you don't use.

CAUTION Removing a datastore from the ESX Server system breaks the connection between the system and the storage device that holds the datastore and stops all functions of that storage device.

You cannot remove a datastore if it holds virtual disks of a currently running virtual machine.

To remove a datastore

1 Log into the VMware VI Client, and select a server from the inventory panel.

2 Click the **Configuration** tab, and click **Storage (SCSI, SAN, and NFS)**.

3 Select the datastore you want to remove, and click **Remove**.

4 Confirm that you want to remove the datastore.

Editing Existing VMFS-based Datastores

Datastores that use the VMFS format are deployed on SCSI-based storage devices.

After you create a VMFS-based datastore, you can modify it. See the following sections for more information:

- "Upgrading Datastores" on page 139
- "Changing the Names of Datastores" on page 140
- "Adding Extents to Datastores" on page 141

Upgrading Datastores

ESX Server 3 includes a new file system, VMFS version 3 (VMFS-3). If your datastore was formatted with VMFS-2, you can only read files stored on VMFS-2, but you are not able to use them. To use the files, upgrade VMFS-2 to VMFS-3.

When upgrading VMFS-2 to VMFS-3, the ESX Server file-locking mechanism ensures that no remote ESX Server or local process is accessing the VMFS volume being converted. ESX Server preserves all files on the datastore.

As a precaution, before using the upgrade option, consider the following:

- Commit or discard any changes to virtual disks in the VMFS-2 volume you want to upgrade.
- Back up the VMFS-2 volume you want to upgrade.

- Be sure no powered-on virtual machines are using this VMFS-2 volume.
- Be sure no other ESX Server is accessing this VMFS-2 volume.
- Be sure this VMFS-2 volume is not mounted on any other ESX Server.

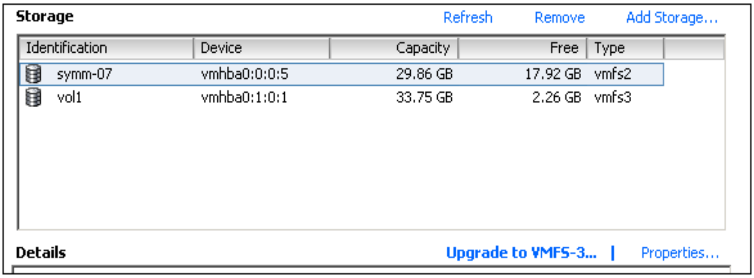
CAUTION
- The VMFS-2 to VMFS-3 conversion is a one-way process. After converting the VMFS-based datastore to VMFS-3, you cannot revert it back to VMFS-2.
- To be able to upgrade the VMFS-2 file system, its file block size shouldn't exceed 8 MB.

To upgrade the VMFS-2 to VMFS-3

1 Log into the VMware VI Client, and select a server from the inventory panel.

2 Click the **Configuration** tab, and click **Storage (SCSI, SAN, and NFS)**.

3 Click the datastore that uses the VMFS-2 format.



4 Click **Upgrade to VMFS-3**.

Changing the Names of Datastores

You can change the name of an existing VMFS-based datastore.

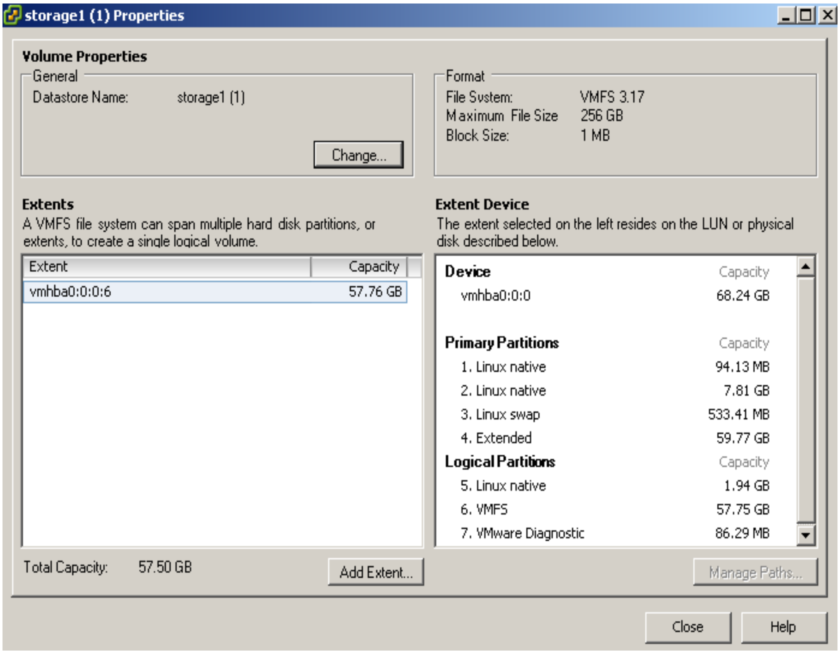
To edit the name of the datastore

1 Log into the VMware VI Client, and select a server from the inventory panel.

2 Click the **Configuration** tab, and click **Storage (SCSI, SAN, and NFS)**.

3 Select the datastore whose name you want to edit, and click the **Properties** link.

The **Volume Properties** dialog box appears.



4 Under **General**, click **Change**.

The **Properties** dialog box opens.

5 Enter the new datastore name, and click **OK**.

Adding Extents to Datastores

You can expand a datastore that uses the VMFS format by attaching a hard disk partition as an extent. The datastore can span over 32 physical storage extents.

You can dynamically add the new extents to the datastore when you need to create new virtual machines on this datastore, or when the virtual machines running on this datastore require more space.

To add one or more extents to the datastore

1 Log in to the VI Client, and select a server from the inventory panel.

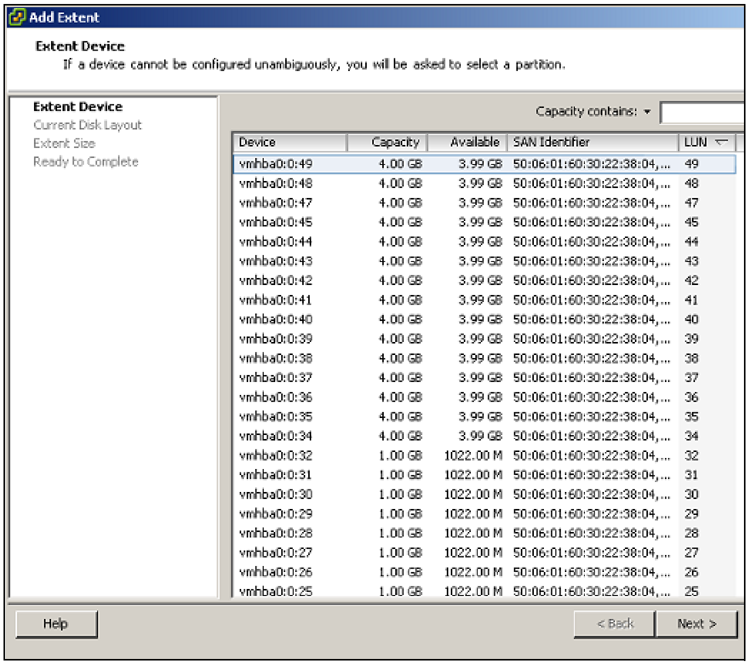
2 Click the **Configuration** tab, and click **Storage (SCSI, SAN, and NFS)**.

3 Select the datastore you want to expand, and click the **Properties** link.

The **Volume Properties** dialog box appears.

4 Under **Extents**, click **Add Extent**.

The **Add Extent** wizard opens.



5 Select the disk you want to add as the new extent, and click **Next**.

The **Current Disk Layout** page appears.

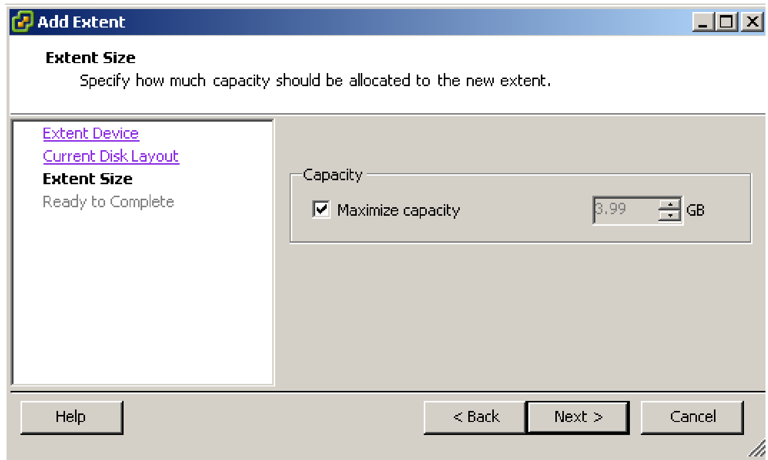
6 Review the current layout of the disk you are using for the extent to make sure the disk doesn't contain any important information.

NOTE If a disk or partition you add was formatted previously, it will be reformatted and loose the file systems and any data it contained.

---

7 Click **Next**.

The **Extent Size** page appears.



8 Set the capacity for the extent.

By default, the entire free space available on the storage device is offered to you.

9 Click **Next**.

The **Ready to Complete** page appears.

10 Review the proposed extent layout and the new configuration of your datastore, and click **Finish**.

Managing Paths for Fibre Channel and iSCSI

ESX Server supports multipathing to maintain a constant connection between the server machine and the storage device in case of the failure of an HBA, switch, storage processor (SP), or cable. Multipathing support does not require specific failover drivers.

To support path switching, the server typically has two or more HBAs available, from which the storage array can be reached using one or more switches. Alternatively, the setup could include one HBA and two storage processors so that the HBA can use a different path to reach the disk array.

By default, ESX Server systems use only one path from the host to a given LUN at any given time. If the path being used by the ESX Server system fails, the server selects another of the available paths. The process of detecting a failed path and switching to another is called path failover. A path fails if any of the components—HBA, cable, switch port, or storage processor—along the path fails.

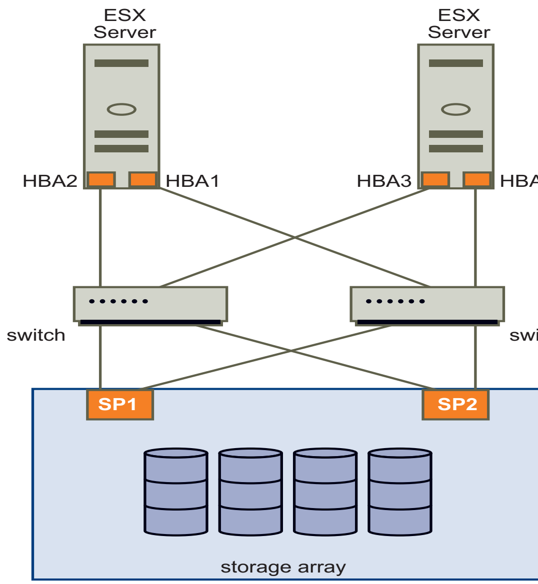


Figure 7-1. Multipathing

In Figure 7-1, multiple paths connect each server with the storage device. For example, if HBA1 or the link between HBA1 and the switch fails, HBA2 takes over and provides the connection between the server and the switch. The process of one HBA taking over for another is called HBA failover.

Similarly, if SP1 or the link between SP1 and the switch breaks, SP2 takes over and provides the connection between the switch and the storage device. This process is called SP failover. VMware ESX Server supports both HBA and SP failover with its multipathing capability.

For more information on multipathing, refer to the *SAN Configuration Guide*.

For information on managing paths, see the following sections:

- "Viewing the Current Multipathing State" on page 145
- "Active Paths" on page 146
- "Setting Multipathing Policies for LUNs" on page 147
- "Disabling and Enabling Paths" on page 148
- "Setting the Preferred Path (Fixed Path Policy Only)" on page 149

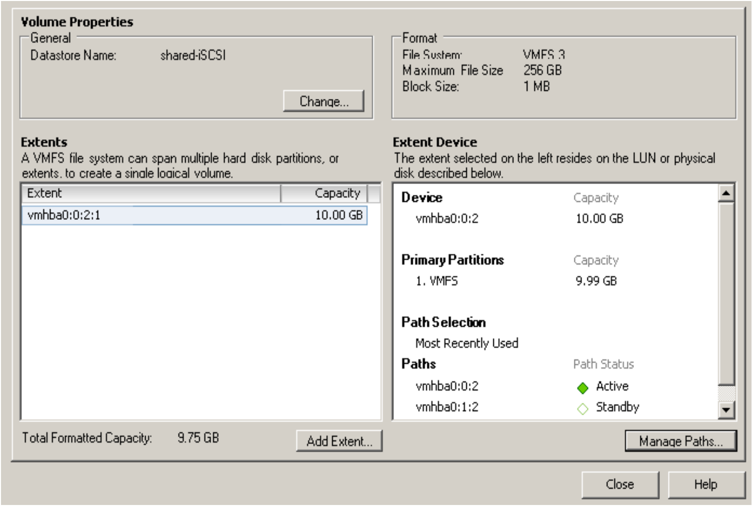
Viewing the Current Multipathing State

Use the VI Client to view the current multipathing state.

To view the current multipathing state

1. Log into the VMware VI Client, and select a server from the inventory panel.
2. Click the **Configuration** tab, and click **Storage (SCSI, SAN, and NFS)** under hardware.
3. From the list of configured datastores, select the datastore whose paths you want to view or configure, and click **Properties**.

   The **Volume Properties** dialog box for this datastore opens.

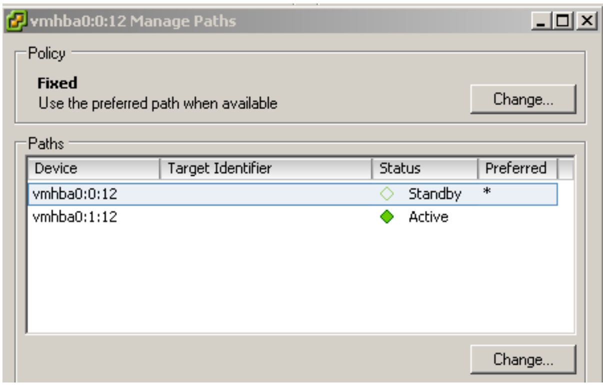


The **Extent Device** panel includes information on the status of each path to the storage device. The following path information appears:

- **Active** – The path is working and is the current path being used for transferring data.
- **Disabled** – The path has been disabled and no data can be transferred.
- **Standby** – The path is working but is not currently being used for transferring data.
- **Dead** – The software cannot connect to the disk through this path.

4 Click **Manage Paths** to open the **Manage Paths** wizard.

If you are using path policy **Fixed**, you can see which path is the preferred path. The preferred path is marked with an asterisk (*) in the fourth column.



You can use the **Manage Paths** wizard to enable or disable your paths, set multipathing policy, and specify the preferred path.

Follow these procedures:

- "To set the multipathing policy" on page 147
- "To disable a path" on page 148
- "To enable a path" on page 149
- "To set the preferred path" on page 149

Active Paths

ESX Server does not typically perform I/O load balancing across paths for a given storage device. At any one time, only a single path is used to issue I/O to storage device. This path is known as the active path.

- If the path policy of a storage device is set to **Fixed**, ESX Server selects the path marked as **Preferred** as the active path.

  If the preferred path is disabled or unavailable, the ESX Server system uses an alternate working path as the active path.

- If the path policy of a storage device is set to **Most Recently Used**, the ESX Server host selects an active path to the storage device that prevents path thrashing. The preferred path designation is not considered.

Setting Multipathing Policies for LUNs

The following multipathing policies are currently supported:

- **Fixed** — The ESX Server host always uses the preferred path to the disk when that path is available. If it cannot access the disk through the preferred path, then it tries the alternate paths. **Fixed** is the default policy for active/active storage devices.
- **Most Recently Used** — The ESX Server host uses the most recent path to the disk until this path becomes unavailable. That is, the ESX Server host does not automatically revert back to the preferred path. **Most Recently Used** is the default policy for active/passive storage devices and is required for those devices.

The ESX Server host automatically sets the multipathing policy according to the make and model of the array it detects. If the detected array is not supported, it is treated as active/active. For a list of supported arrays, see the *SAN Compatibility Guide*.

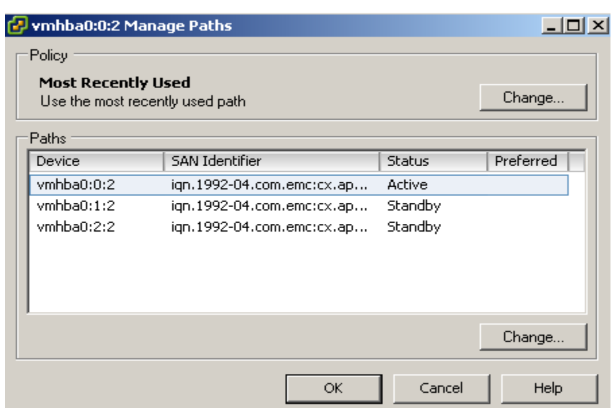
NOTE Manually changing **Most Recently Used** to **Fixed** is not recommended. The system sets this policy for those arrays that require it.

To set the multipathing policy

1 Open the **Manage Paths** wizard by performing the steps listed in "To view the current multipathing state" on page 145.

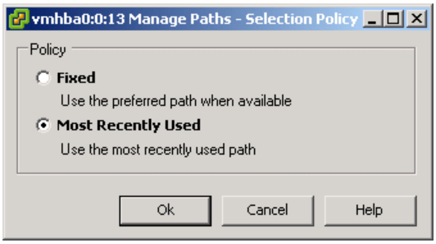
If you are managing paths for RDMs, see "To manage paths" on page 163.

The **Manage Paths** wizard shows the list of different paths to the disk, with the multipathing policy for the disk and the connection status for each path. It also shows the preferred path to the disk.



2 Under **Policy**, click **Change**.

The **Selection Policy** page opens.



3 Select one of the following options:

- **Fixed**
- **Most Recently Used**

4 Click **OK**, and click **Close** to save your settings and return to the **Configuration** page.

NOTE For active/passive storage devices, **Most Recently Used** is highly recommended.

Disabling and Enabling Paths

If you need to temporarily disable paths for maintenance or any other reasons, you can do so using the VI Client.

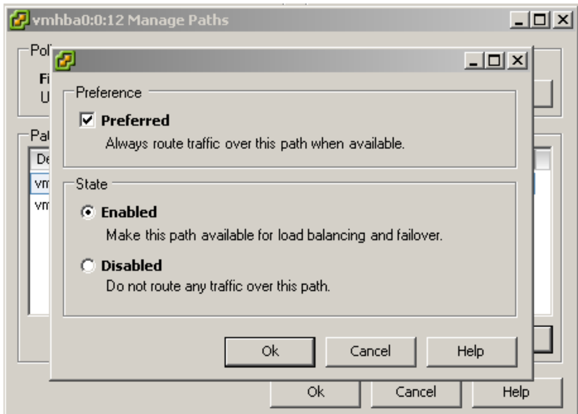
To disable a path

1 Open the **Manage Paths** wizard by performing the steps listed in "To view the current multipathing state" on page 145.

If you are managing paths for RDMs, see "To manage paths" on page 163.

The **Manage Paths** wizard appears.

2 Under **Paths**, select the path you want to disable, and click **Change**.



3 Select the **Disable** radio button to disable the path.

4 Click **OK** twice to save your changes and exit the dialog boxes.

To enable a path

If you have disabled a path (for example, for maintenance) you can enable it by following the steps in "To disable a path" on page 148, but clicking the **Enable** radio button.

Setting the Preferred Path (Fixed Path Policy Only)

If you set path policy to **Fixed**, the server always uses the preferred path when available.

To set the preferred path

1 Open the **Manage Paths** wizard by performing the steps listed in "To view the current multipathing state" on page 145.

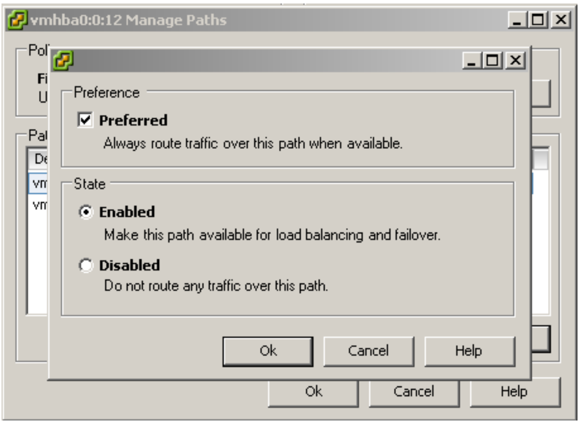
If you are managing paths for RDMs, see "To manage paths" on page 163.

The **Manage Paths** wizard appears.

2 Under Paths, select the path you want to make the preferred path and click **Change**.

3 In the **Preference** pane, click **Preferred**.

If **Preferred** is not an option, make sure that the **Path Policy** is **Fixed**.



4 Click **OK** twice to save your settings and exit the dialog boxes.

The `vmkfstools` Commands

The `vmkfstools` commands provide additional functions that are useful when you need to create files of a particular size and when you need to import files from and export files to the service console's file system. In addition, `vmkfstools` is designed to work with large files, overcoming the 2GB limit of some standard file utilities.

For a list of supported `vmkfstools` commands, see "Using vmkfstools" on page 281.

8 Raw Device Mapping

Raw Device Mapping (RDM) provides a mechanism for a virtual machine to have direct access to a LUN on the physical storage subsystem (Fibre Channel or iSCSI only). This chapter contains information about RDM.

NOTE For information about configuring SANs, see the *SAN Configuration Guide*.

This chapter covers the following topics:

About Raw Device Mapping

RDM is a mapping file in a VMFS volume that acts as a proxy for a raw physical device. The RDM contains metadata used to manage and redirect disk accesses to the physical device. The file gives you advantages of direct access to physical device while keeping some advantages of a virtual disk in the VMFS file system. As a result, it merges VMFS manageability with a raw device access.

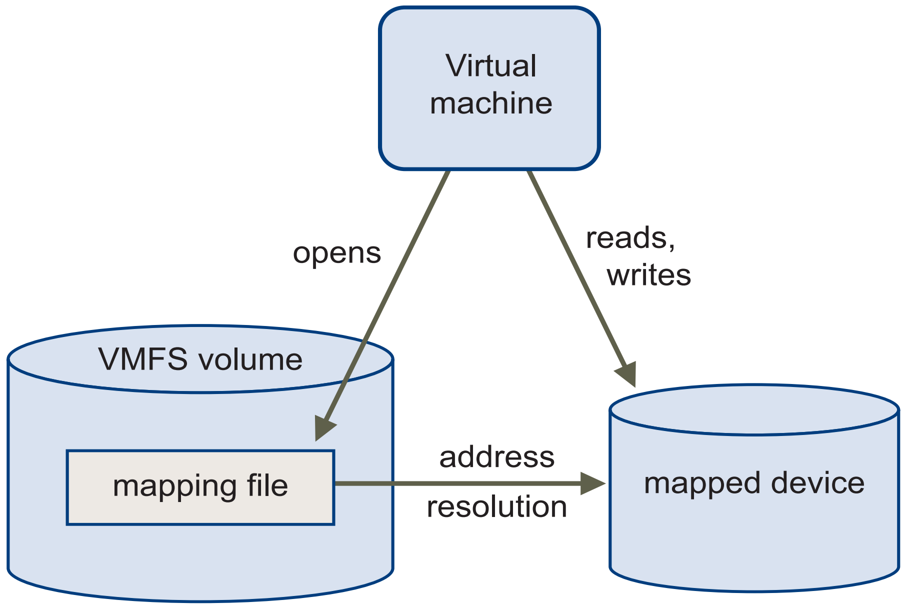


Figure 8-1. Raw Device Mapping

While VMFS is recommended for most virtual disk storage, on certain occasions, you might need to use raw LUNs.

For example, it is necessary to use raw LUNs along with RDMs in the following situations:

- When SAN snapshot or other layered applications are run in the virtual machine. The RDM better enables scalable backup offloading systems using features inherent to the SAN.
- In any MSCS clustering scenario that spans physical hosts — virtual-to-virtual clusters as well as physical-to-virtual clusters. In this case, cluster data and quorum disks should be configured as RDMs rather than as files on a shared VMFS.

Think of an RDM as a symbolic link from a VMFS volume to a raw LUN (see Figure 8-1). The mapping makes LUNs appear as files in a VMFS volume. The RDM, not the raw LUN, is referenced in the virtual machine configuration. The RDM contains a reference to the raw LUN.

Using RDMs, you can:

- Use VMotion to migrate virtual machines using raw LUNs.
- Add raw LUNs to virtual machines using the Virtual Infrastructure Client.
- Use file system features such as distributed file locking, permissions, and naming.

Two compatibility modes are available for RDMs:

- Virtual compatibility mode allows an RDM to act exactly like a virtual disk file, including the use of snapshots.
- Physical compatibility mode allows direct access of the SCSI device, for those applications that need lower level control.

Terminology

RDMs can be described in terms such as "Mapping a raw device into a datastore," "mapping a system LUN", or "mapping a disk file to a physical disk volume." All these terms refer to RDMs.

Benefits of Raw Device Mapping

An RDM provides a number of benefits, but it shouldn't be used in every situation. In general, virtual disk files are preferable to RDMs for manageability. However, when you need raw devices, you must use the RDM. The following list highlights the benefits of the RDM.

- **User-Friendly Persistent Names** – RDM provides a user-friendly name for a mapped device. When you use an RDM, you don't need to refer to the device by its device name. You refer to it by the name of the mapping file, for example:

  `/vmfs/volumes/myVolume/myVMDirectory/myRawDisk.vmdk`

- **Dynamic Name Resolution** – RDM stores unique identification information for each mapped device. The VMFS file system associates each RDM with its current SCSI device, regardless of changes in the physical configuration of the server due to adapter hardware changes, path changes, device relocation, and so forth.
- **Distributed File Locking** – RDM makes it possible to use VMFS distributed locking for raw SCSI devices. Distributed locking on an RDM makes it safe to use a shared raw LUN without losing data when two virtual machines on different servers try to access the same LUN.

- **File Permissions** – RDM makes file permissions possible. The permissions of the mapping file are enforced at file open time to protect the mapped volume.
- **File System Operations** – RDM makes it possible to use file system utilities to work with a mapped volume, using the mapping file as a proxy. Most operations that are valid for an ordinary file can be applied to the mapping file and are redirected to operate on the mapped device.
- **Snapshots** – RDM makes it possible to use virtual machine snapshots on a mapped volume.

NOTE Snapshots are not available when the RDM is used in physical compatibility mode.

- **VMotion** – RDM lets you migrate a virtual machine with VMotion. The mapping file acts as a proxy to allow VirtualCenter to migrate the virtual machine using the same mechanism that exists for migrating virtual disk files. See Figure 8-2.

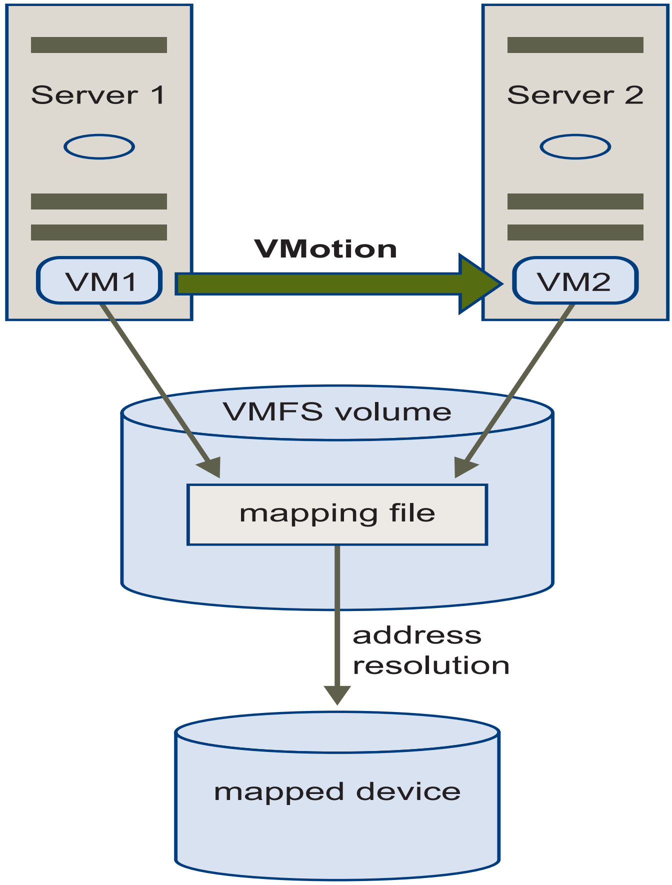


Figure 8-2. VMotion of a Virtual Machine Using a Raw Device Mapping

- **SAN Management Agents** – RDM makes it possible to run some SAN management agents inside a virtual machine. Similarly, any software that needs to access a device using hardware-specific SCSI commands can be run inside a virtual machine. This kind of software is called SCSI target-based software.

NOTE When you use SAN management agents, you need to select physical compatibility mode for the RDM.

VMware works with vendors of storage management software to ensure that their software functions correctly in environments that include ESX Server. Some applications of this kind are:

- SAN management software

- Storage resource management (SRM) software
- Snapshot software
- Replication software

Such software uses physical compatibility mode for RDMs, so that the software can access SCSI devices directly.

Various management products are best run centrally (not on the ESX Server machine), while others run well in the service console or in the virtual machines. VMware does not certify these applications or provide a compatibility matrix. To find out whether a SAN management application is supported in an ESX Server environment, contact the SAN management software provider.

Limitations of Raw Device Mapping

When planning to use an RDM, consider the following:

- **Not Available for Block Devices or Certain RAID Devices** – RDM (in the current implementation) uses a SCSI serial number to identify the mapped device. Because block devices and some direct-attach RAID devices do not export serial numbers, they can't be used with RDMs.
- **Available with VMFS-2 and VMFS-3 Volumes Only** – RDM requires the VMFS-2 or VMFS-3 format. In ESX Server 3.0, the VMFS-2 file system is read-only. You need to upgrade it to VMFS-3 to be able to use files it stores.
- **No Snapshots in Physical Compatibility Mode** – If you are using an RDM in physical compatibility mode, you can't use a snapshot with the disk. Physical compatibility mode allows the virtual machine to manage its own snapshot or mirroring operations.

  Snapshots are available, however, in virtual mode. For more information on compatibility modes, see "Virtual Compatibility Mode Versus Physical Compatibility Mode" on page 157.
- **No Partition Mapping** – RDM requires the mapped device to be a whole LUN. Mapping to a partition is not supported.

Raw Device Mapping Characteristics

An RDM is a special mapping file in a VMFS volume that manages metadata for its mapped device. The mapping file is presented to the management software as an ordinary disk file, available for the usual file system operations. To the virtual machine, the storage virtualization layer presents the mapped device as a virtual SCSI device.

Key contents of the metadata in the mapping file include the location of the mapped device (name resolution) and the locking state of the mapped device.

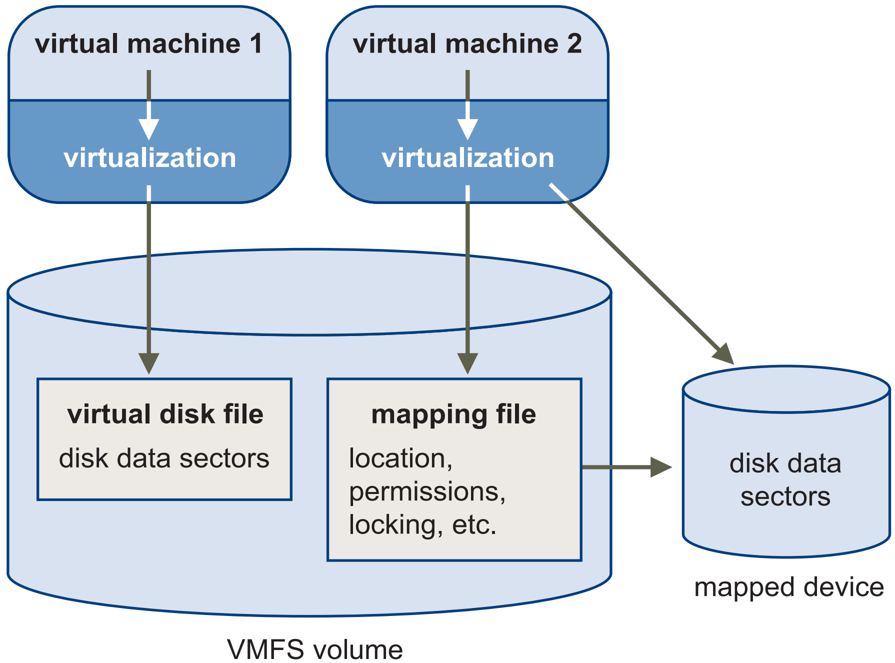


Figure 8-3. Mapping File Metadata

Virtual Compatibility Mode Versus Physical Compatibility Mode

Virtual mode for an RDM specifies full virtualization of the mapped device. It appears to the guest operating system exactly the same as a virtual disk file in a VMFS volume. The real hardware characteristics are hidden. Virtual mode allows customers using raw disks to realize the benefits of VMFS such as advanced file locking for data protection and snapshots for streamlining development processes. Virtual mode is also more portable across storage hardware than physical mode, presenting the same behavior as a virtual disk file.

Physical mode for the RDM specifies minimal SCSI virtualization of the mapped device, allowing the greatest flexibility for SAN management software. In physical mode, the VMkernel passes all SCSI commands to the device, with one exception: the REPORT LUNs command is virtualized, so that the VMkernel can isolate the LUN for the owning virtual machine. Otherwise, all physical characteristics of the underlying hardware are exposed. Physical mode is useful to run SAN management agents or other SCSI target based software in the virtual machine. Physical mode also allows virtual to physical clustering for cost-effective high availability.

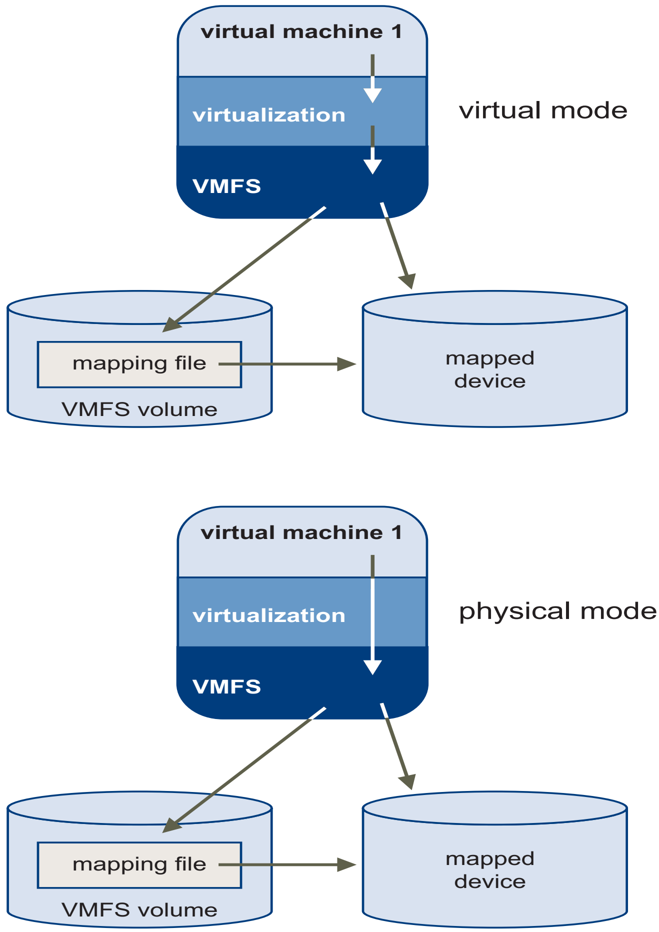


Figure 8-4. Virtual And Physical Compatibility Modes

Dynamic Name Resolution

RDM lets you give a permanent name to a device by referring to the name of the mapping file in the `/vmfs` subtree.

The example in Figure 8-5 shows three LUNs. LUN 1 is accessed by its device name, which is relative to the first visible LUN. LUN 2 is a mapped device, managed by an RDM on LUN 3. The RDM is accessed by its path name in the `/vmfs` subtree, which is fixed.

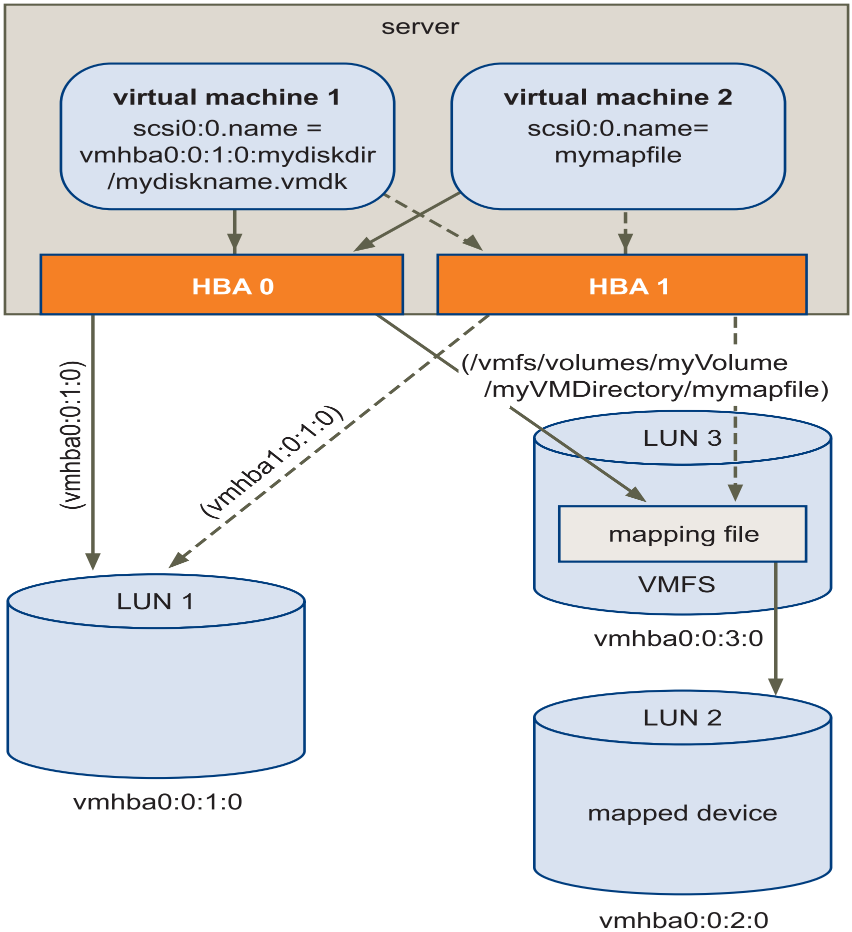


Figure 8-5. Example of Name Resolution

All mapped LUNs are uniquely identified by VMFS, and the identification is stored in its internal data structures. Any change in the SCSI path, such as a Fibre Channel switch failure or the addition of a new host bus adapter, has the potential to change the vmhba device name, because the name includes the path designation (initiator, target, LUN). Dynamic name resolution compensates for these changes by adjusting the data structures to re-target LUNs to their new device names.

Raw Device Mapping with Virtual Machine Clusters

You need to use an RDM with virtual machine clusters that need to access the same raw LUN for failover scenarios. The setup is similar to that of a virtual machine cluster that accesses the same virtual disk file, but an RDM replaces the virtual disk file.

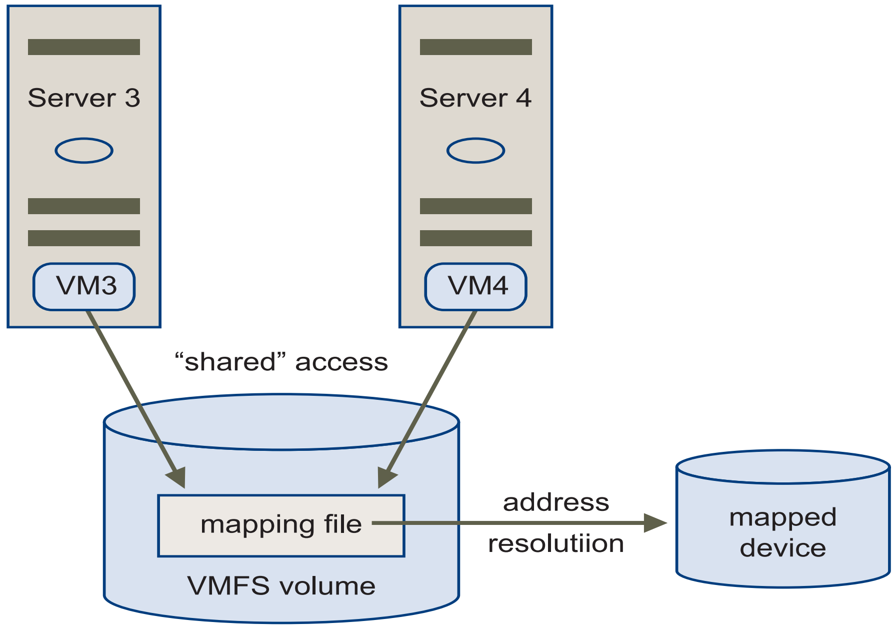


Figure 8-6. Access from Clustered Virtual Machines

For more information on configuring clustering, refer to *Setup for Microsoft Cluster Service* and *Resource Management Guide*.

Comparing Raw Device Mapping to Other Means of SCSI Device Access

To help you choose between several available access modes for SCSI devices, Table 8-1 provides a quick comparison of features available with the different modes.

Table 8-1. Features available with virtual disks and raw device mappings

ESX Server Features	Virtual Disk File	Virtual Mode RDM	Physical Mode RDM
SCSI Commands Passed Through	No	No	Yes[1]
VirtualCenter Support	Yes	Yes	Yes

Table 8-1. Features available with virtual disks and raw device mappings

ESX Server Features	Virtual Disk File	Virtual Mode RDM	Physical Mode RDM
Snapshots	Yes	Yes	No
Distributed Locking	Yes	Yes	Yes
Clustering	CIB[2] only	CIB, CAB[3, 4]	N+1[5] only
SCSI Target-Based Software	NO	NO	YES

1 REPORT LUNS is not passed through

2 CIB = Cluster-In-a-Box

3 CAB = Cluster-Across-Boxes

4 VMware recommends that you use virtual disk files for CIB. If your CIB clusters will be reconfigured as CAB clusters, use virtual mode RDMs for CIB. For more information on clustering, see *Setup for Microsoft Cluster Service* and *Resource Management Guide*.

5 N+1 = Physical to Virtual Clustering

Managing Mapped LUNs

The tools available to manage mapped LUNs and their RDMs, or mapping files, include the VMware Virtual Infrastructure Client, the `vmkfstools` utility, and ordinary file system utilities used in the service console.

See the following topics for more information:

- "VMware Virtual Infrastructure Client" on page 161
- "The vmkfstools Utility" on page 164
- "File System Operations" on page 164

VMware Virtual Infrastructure Client

Using the VI Client, you can map a SAN LUN to a datastore and manage paths to your mapped LUN.

See the following sections for more information:

- "Mapping a SAN LUN" on page 161
- "Managing Paths for a Mapped Raw LUN" on page 163

Mapping a SAN LUN

When you map a LUN to a VMFS volume, VirtualCenter creates a mapping file (RDM) that points to the raw LUN. The mapping file has a `.vmdk` extension, but the file contains only disk information describing the mapping to the LUN on the ESX Server system. The actual data is stored on the LUN.

To map a SAN LUN

1 Log on as administrator or as the owner of the virtual machine to which the mapped disk will belong.

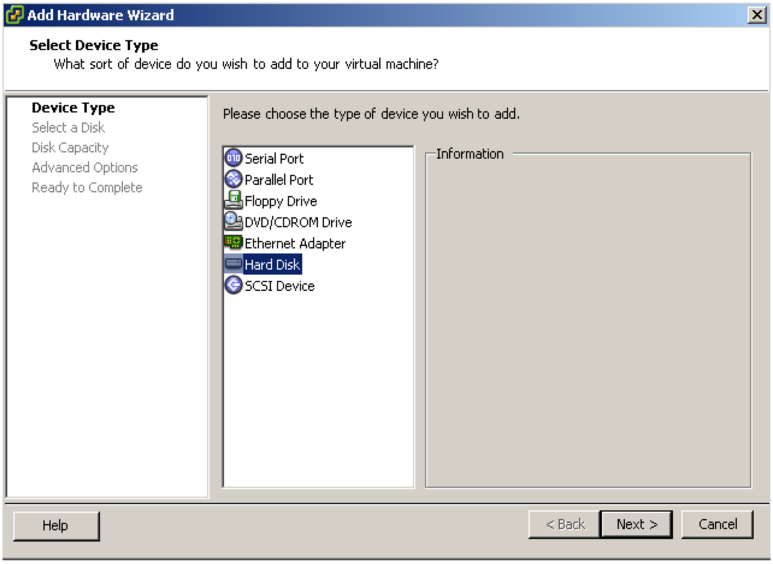
2 Select the virtual machine from the inventory panel.

3 On the **Summary** tab, click the **Edit Settings** link.

The Virtual Machine Properties dialog box opens.

4 Click **Add**.

The Add Hardware Wizard opens.



5 Choose **Hard Disk** as the type of device you want to add, and click **Next**.

6 In the Select a Disk window, select **Mapped SAN LUN**.

7 Choose a raw LUN from the list of available LUNs.

8 Select a datastore onto which to map the raw LUN.

9 Choose **Physical** or **Virtual** for the compatibility mode.

Depending on your choice, subsequent screens offer different options.

10 On the Specify Advanced Options page, you can change the virtual device node and click **Next**.

The Ready to Complete New Virtual Machine page appears.

11 Review the options for your new virtual machine, and click **Finish**.

You have finished creating a virtual machine with a virtual disk that is mapped to a LUN.

Managing Paths for a Mapped Raw LUN

You use the Manage Paths wizard to manage paths for your mapping files and mapped raw LUNs.

To manage paths

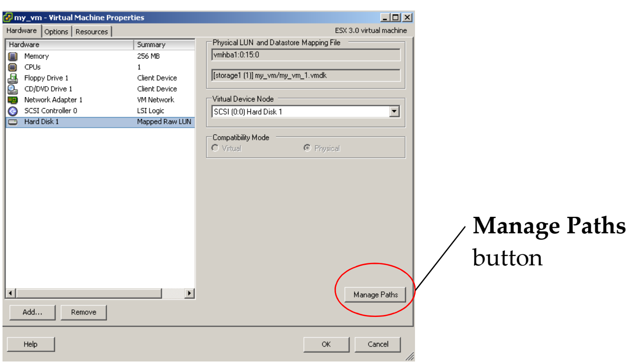
1 Log on as administrator or as the owner of the virtual machine to which the mapped disk belongs.

2 Select the virtual machine from the inventory panel.

3 On the **Summary** tab, click the **Edit Settings** link.

The Virtual Machine Properties dialog box opens.

4 On the **Hardware** tab, select **Hard Disk**, then click **Manage Paths**.



The Manage Paths wizard opens.

5 Use the Manage Paths wizard to enable or disable your paths, set multipathing policy, and specify the preferred path.

Follow these procedures:

- "To set the multipathing policy" on page 147

- "To disable a path" on page 148
- "To enable a path" on page 149
- "To set the preferred path" on page 149

The `vmkfstools` Utility

The `vmkfstools` command line utility can be used in the service console to do many of the same operations available through the VI Client. Typical operations applicable to RDMs are the commands to create a mapping file, to query mapping information such as the name and identification of the mapped device, and to import or export a virtual disk.

For more information, see "Using vmkfstools" on page 281.

File System Operations

Most common file system operations done in the service console can be applied to RDMs.

`ls -l`

The `ls` command with the `-l` option shows the file name and permissions of the mapping file, while showing the length of the mapped device.

`du`

Similarly, the `du` command shows the space used by the mapped device, rather than the mapping file.

`mv`

The `mv` command renames the mapping file, but doesn't affect the mapped device.

`cp`

You can use the `cp` command to copy the contents of a mapped device, but it does not work in reverse. You can't use it to copy a virtual disk file to a mapped device. Instead, you can use the `vmkfstools` command.

`dd`

You can use the `dd` command to copy data into or out of a mapped device. However, VMware recommends that you use `vmkfstools` import and export commands to do this in an efficient manner.

Security

Security for ESX Server Systems 9

ESX Server has been developed with a focus on strong security. This section provides you with an overview of how VMware ensures security in the ESX Server environment, addressing system architecture from a security standpoint and giving you a list of additional security resources.

This chapter contains the following sections:

ESX Server Architecture and Security Features

From a security perspective, VMware ESX Server consists of four major components the virtualization layer, the virtual machines, the service console, and the virtual networking layer. Figure 9-1 provides an overview of these components.

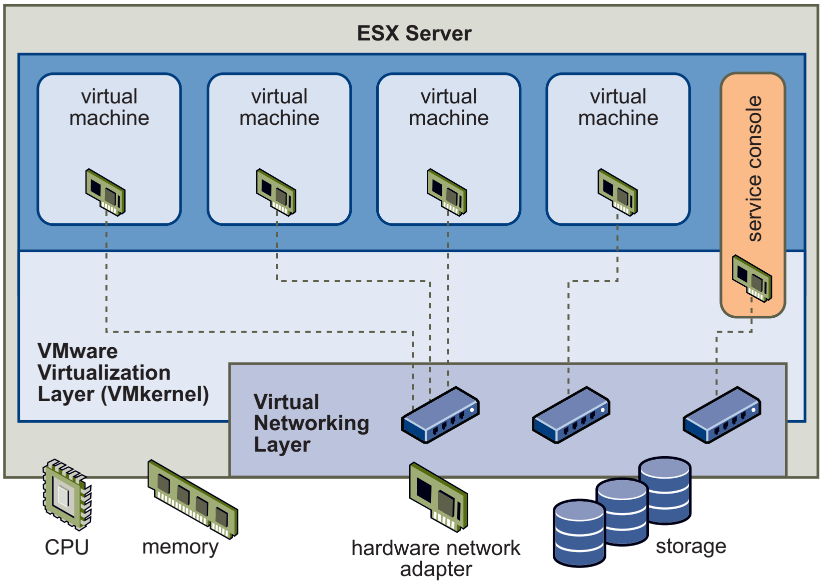


Figure 9-1. ESX Server Architecture

Each of these components and this overall architecture have been designed to ensure security of the ESX Server system as a whole.

Security and the Virtualization Layer

The virtualization layer, or VMkernel, is a kernel designed by VMware from the ground up to run virtual machines. It controls the hardware utilized by ESX Server hosts and schedules the allocation of hardware resources among the virtual machines. Because the VMkernel is fully dedicated to supporting virtual machines and is not used for other purposes, the interface to the VMkernel is strictly limited to the API required to manage virtual machines.

Security and Virtual Machines

Virtual machines are the containers in which applications and guest operating systems run. By design, all VMware virtual machines are isolated from one another. Virtual machine isolation is imperceptible to the guest operating system. Even a user with system administrator privileges on a virtual machine's guest operating system cannot breach this layer of isolation to access another virtual machine without privileges explicitly granted by the ESX Server system administrator.

This isolation enables multiple virtual machines to run securely while sharing hardware and ensures both their ability to access hardware and their uninterrupted performance. For example, if a guest operating system running in a virtual machine crashes, other virtual machines on the same ESX Server host continue to run. The guest operating system crash has no effect on:

- The ability of users to access the other virtual machines
- The ability of the operational virtual machines to access the resources they need
- The performance of the other virtual machines

Each virtual machine is isolated from other virtual machines running on the same hardware. While virtual machines share physical resources such as CPU, memory, and I/O devices, a guest operating system in an individual virtual machine cannot detect any device other than the virtual devices made available to it, as shown in Figure 9-2.

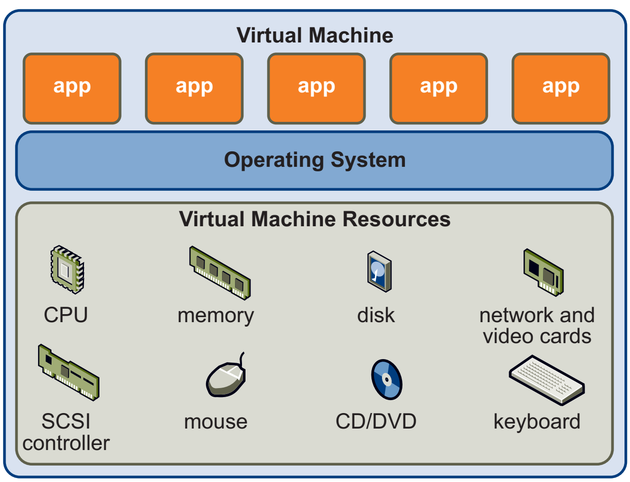


Figure 9-2. Virtual Machine Isolation

Because the VMkernel mediates the physical resources and all physical hardware access takes place through the VMkernel, virtual machines cannot circumvent this level of isolation.

Just as a physical machine can communicate with other machines in a network only through a network card, a virtual machine can communicate with other virtual machines running in the same ESX Server host only through a virtual switch. Further, a virtual machine communicates with the physical network, including virtual machines on other ESX Server hosts, only through a physical network adapter, as shown in Figure 9-3.

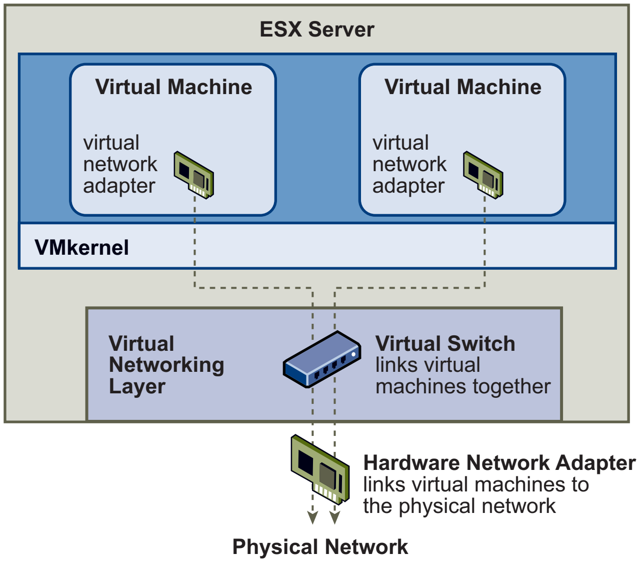


Figure 9-3. Virtual Networking Through Virtual Switches

In considering virtual machine isolation in a network context, you can apply these rules:

- If a virtual machine does not share a virtual switch with any other virtual machine, it is completely isolated from virtual networks within the host.
- If no physical network adapter is configured for a virtual machine, the virtual machine is completely isolated from any physical networks.
- If you use the same safeguards (firewalls, antivirus software, and so forth) to protect a virtual machine from the network as you would for a physical machine, the virtual machine is as secure as the physical machine would be.

You can further protect virtual machines by setting up resource reservations and limits on the ESX Server host. For example, through the fine-grained resource controls available in ESX Server, you can configure a virtual machine so that it always gets at least ten percent of the ESX Server host's CPU resources, but never more than twenty percent.

Resource reservations and limits protect virtual machines from performance degradation if another virtual machine tries to consume too many resources on shared hardware. For example, if one of the virtual machines on an ESX Server host is incapacitated by a denial-of-service (DOS) or distributed denial-of-service (DDOS) attack, a resource limit on that machine prevents the attack from taking up so many hardware resources that the other virtual machines are also affected. Similarly, a resource reservation on each of the virtual machines ensures that, in the event of high resource demands by the virtual machine targeted by the DOS attack, all the other virtual machines still have enough resources to operate.

By default, ESX server imposes a form of resource reservation by applying a distribution algorithm that divides the available host resources equally among the virtual machines while keeping a certain percentage of resources for use by other system components such as the service console. This default behavior provides a degree of natural protection from DOS and DDOS attacks. You set specific resource reservations and limits on an individual basis if you want to customize the default behavior so that the distribution isn't equal across the virtual machine configuration. For a discussion of how to manage resource allocation for virtual machines, see the *Resource Management Guide*.

Security and the Service Console

The ESX Server 3.0 service console is a limited distribution of Linux based on Red Hat Enterprise Linux 3, Update 6 (RHEL 3 U6). The service console provides an execution environment to monitor and administer the entire ESX Server host.

If the service console is compromised in certain ways, the virtual machines it interacts with might also be compromised. To minimize the risk of an attack through the service console, VMware protects the service console with a firewall. For information about this firewall, see "Service Console Firewall Configuration" on page 239.

In addition to implementing the service console firewall, here are some of the other ways VMware mitigates risks to the service console:

- ESX Server runs only services essential to managing its functions, and the distribution is limited to the features required to run ESX Server.
- By default, ESX Server is installed with a high security setting, which means that all outbound ports are closed and the only inbound ports that are open are those required for interactions with clients such as the VMware Virtual Infrastructure Client. VMware recommends that you keep this security setting unless the service console is connected to a trusted network.
- By default, all ports not specifically required for management access to the service console are closed. You must specifically open ports if you need additional services.

- All communications from clients are encrypted through SSL by default. The SSL connection uses 256-bit AES block encryption and 1024-bit RSA key encryption.
- The Tomcat Web service, used internally by ESX Server to support access to the service console by Web clients like VMware Virtual Infrastructure Web Access, has been modified to run only those functions required for administration and monitoring by a Web client. As a result, ESX Server is not vulnerable to the Tomcat security issues reported in broader usage.
- VMware monitors all security alerts that could affect service console security and, if needed, issues a security patch, as it would for any other security vulnerability that could affect ESX Server hosts. VMware provides security patches for RHEL 3 U6 and later as they become available
- Insecure services such as FTP and Telnet are not installed and the ports for these services are closed by default. Because more secure services such as SSH and SFTP are easily available, always avoid using these insecure services in favor of their safer alternatives. If you must use insecure services and have implemented sufficient protection for the service console, you must explicitly open ports to support them.
- The number of applications that use a `setuid` or `setgid` flag has been minimized, and you can disable any `setuid` or `setgid` application that is optional to ESX Server operation. For information on required and options `setuid` and `setgid` applications, see "setuid and setgid Applications" on page 252.

For details on these security measures and other service console security recommendations, see "Service Console Security" on page 237.

While you can install and run certain types of programs designed for RHEL 3 U6 in the service console, this usage can have serious security consequences and is not supported unless VMware explicitly states that it is. If a security vulnerability is discovered in a supported configuration, VMware proactively notifies all customers with valid Support and Subscription contracts and provides all necessary patches.

NOTE Some security advisories issued by Red Hat don't apply to the ESX Server environment. If this is the case, VMware does not provide notification or patches.

To learn more about VMware's policies on security patches for supported programs as well as its policies on unsupported software, see "Security Resources and Information" on page 179.

Security and the Virtual Networking Layer

The virtual networking layer consists of the virtual network devices through which virtual machines and the service console interface with the rest of the network. ESX Server relies on the connectivity layer to support communications between virtual machines and their users. In addition, ESX Server hosts use the connectivity layer to communicate with iSCSI SANs, NAS storage, and so forth. The connectivity layer includes virtual network adapters and the virtual switches.

The methods you use to secure a virtual machine network depend on which guest operating system is installed, whether the virtual machines operate in a trusted environment, and a variety of other factors. Virtual switches provide a substantial degree of protection when used with other common security practices such as installing firewalls. ESX Server also supports IEEE 802.1q VLANs, which you can use to further protect the virtual machine network, service console, or storage configuration. VLANs let you segment a physical network so that two machines on the same physical network cannot send packets to or receive packets from each other unless they are on the same VLAN.

You can get a sense of how to use virtual switches to implement security tools like DMZs and configure virtual machines on different networks within the same ESX Server host by reviewing the following examples.

NOTE For a specific discussion of how virtual switches and VLANs help safeguard the virtual machine network and a discussion of other security recommendations for virtual machine networks, see "Securing Virtual Machines with VLANs" on page 194.

Example: Creating a Network DMZ Within a Single ESX Server Host

One example of how to leverage ESX Server isolation and virtual networking features to configure a secure environment is the creation of a network demilitarized zone (DMZ) on a single ESX Server host, as shown in Figure 9-4.

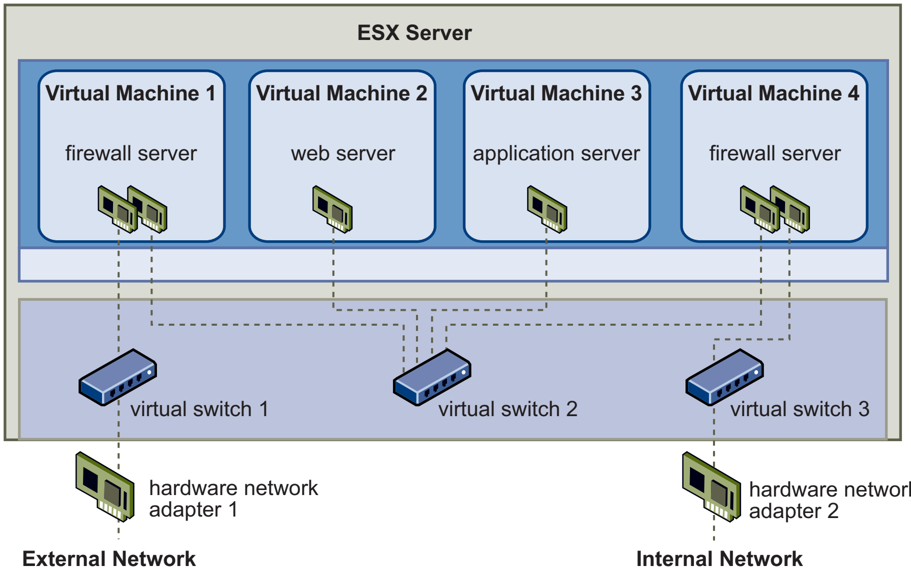


Figure 9-4. DMZ Configured Within a Single ESX Server Host

This configuration includes four virtual machines configured to create a virtual DMZ on *Virtual Switch 2*. *Virtual Machine 1* and *Virtual Machine 4* run firewalls and are connected to virtual adapters through virtual switches. Both of these virtual machines are multihomed. Of the remaining two virtual machines, *Virtual Machine 2* runs a Web server and *Virtual Machine 3* runs as an application server. Both these virtual machines are single homed.

The Web server and application server occupy the DMZ between the two firewalls. The conduit between these elements is *Virtual Switch 2*, which connects the firewalls with the servers. This switch has no direct connection with any elements outside the DMZ and is isolated from external traffic by the two firewalls.

From an operational viewpoint, external traffic from the Internet enters *Virtual Machine 1* through *Hardware Network Adapter 1* (routed by *Virtual Switch 1*) and is verified by the firewall installed on this machine. If the firewall authorizes the traffic, it is routed to the virtual switch in the DMZ, *Virtual Switch 2*. Because the Web server and application server are also connected to this switch, they can serve external requests.

Virtual Switch 2 is also connected to *Virtual Machine 4*. This virtual machine provides a firewall between the DMZ and the internal corporate network. This firewall filters packets from the Web server and application server. If a packet is verified, it is routed to *Hardware Network Adapter 2* through *Virtual Switch 3*. *Hardware Network Adapter 2* is connected to the internal corporate network.

When creating a DMZ within a single ESX Server, you can use fairly lightweight firewalls. While a virtual machine in this configuration cannot exert direct control over another virtual machine or access its memory, all the virtual machines are still connected through a virtual network, and this network could be leveraged for virus propagation or targeted for other types of attacks. You can consider the virtual machines in the DMZ neither more nor less secure than separate physical machines connected to the same network.

Example: Creating Multiple Networks Within a Single ESX Server Host

The ESX Server system is designed so that you can connect some groups of virtual machines to the internal network, others to the external network, and still others to both—all within the same ESX Server host. This capability is an outgrowth of basic virtual machine isolation coupled with a well planned use of virtual networking features, as shown in Figure 9-5.

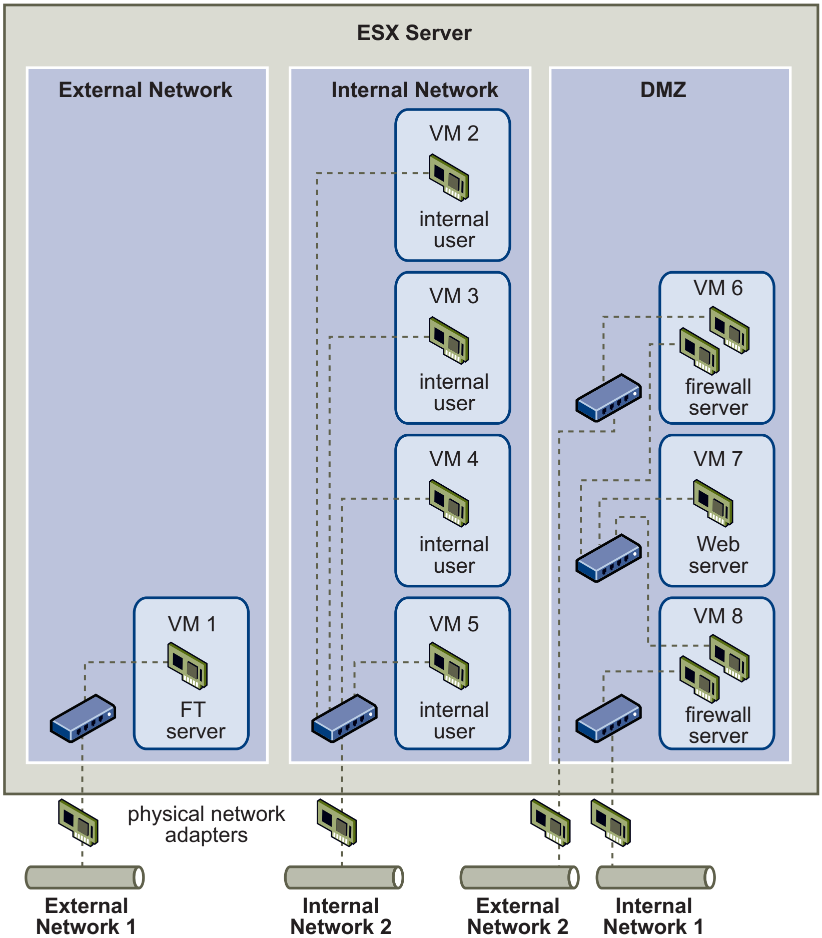


Figure 9-5. External Networks, Internal Networks, and a DMZ Configured Within a Single ESX Server Host

Here, the system administrator configured an ESX Server host into three distinct virtual machine zones, each serving a unique function:

- **FTP server** – *Virtual Machine 1* is configured with FTP software and acts as a holding area for data sent to and from outside resources such as forms and collateral localized by a vendor.

  This virtual machine is associated with an external network only. It has its own virtual switch and physical network adapter that connect it to *External Network 1*. This network is dedicated to servers that the company uses to receive data from outside sources. For example, the company uses *External Network 1* to receive FTP traffic from vendors and allow vendors access to data stored on externally available servers though FTP. In addition to servicing *Virtual Machine 1*, *External Network 1* services FTP servers configured on different ESX Server hosts throughout the site.

Because *Virtual Machine 1* doesn't share a virtual switch or physical network adapter with any virtual machines in the host, the other resident virtual machines cannot transmit packets to or receive packets from *Virtual Machine 1*'s network. This prevents sniffing attacks, which require sending network traffic to the victim. More importantly, an attacker cannot leverage the natural vulnerability of FTP to access any of the host's other virtual machines.

- **Internal virtual machines** – *Virtual Machines 2 – 5* are reserved for internal use. These virtual machines process and store company-private data such as medical records, legal settlements, and fraud investigations. As a result, the system administrators must ensure the highest level of protection for these virtual machines.

  These virtual machines connect to *Internal Network 2* through their own virtual switch and network adapter. *Internal Network 2* is reserved for internal use by personnel such as claims processors, in-house lawyers, or adjustors.

  Virtual Machines 2 – 5 can communicate with one another through the virtual switch and with internal virtual machines elsewhere on *Internal Network 2* through the physical network adapter. They cannot communicate with externally-facing machines. As with the FTP server, these virtual machines cannot send packets to or receive packets from the other virtual machines' networks. Similarly, the host's other virtual machines cannot send packets to or receive packets from *Virtual Machines 2 – 5*.

- **DMZ** – *Virtual Machines 6 – 8* are configured as a DMZ that the marketing group uses to publish the company's external Web site.

  This group of virtual machines is associated with *External Network 2* and *Internal Network 1*. The company uses *External Network 2* to support the Web servers used by the marketing and financial department to host the corporate Web site and other Web facilities that it hosts to outside users. *Internal Network 1* is the conduit that the marketing department uses to publish web pages to the corporate Web site, post downloads, and maintain services like user forums.

  Because these networks are separate from *External Network 1* and *Internal Network 2* and the virtual machines have no shared points of contact (switches or adapters), there is no risk of attack to or from the FTP Server or the internal virtual machine group.

For an example of configuring a DMZ with virtual machines, see "Example: Creating a Network DMZ Within a Single ESX Server Host" on page 173.

By capitalizing on virtual machine isolation, correctly configuring virtual switches, and maintaining network separation, the system administrator can house all three virtual machine zones in the same ESX Server host and be confident that there will be no data or resource breaches.

The company enforces isolation among the virtual machine groups by using multiple internal and external networks and making sure that the virtual switches and physical network adapters for each group are completely separate from those of other groups.

Because none of the virtual switches straddle virtual machine zones, the system administrator succeeds in eliminating the risk of packet leakage from one zone to another. A virtual switch, by design, cannot leak packets directly to another virtual switch. The only way for packets to travel from one virtual switch to another is if:

- The virtual switches are connected to the same physical LAN.
- The virtual switches connect to a common virtual machine, which could then be used to transmit packets.

Neither of these conditions occur in sample configuration. If the system administrator wants to verify that no common virtual switch paths exist, he or she can check for possible shared points of contact by reviewing the network switch layout in the VI Client or VI Web Access. For information on the virtual switch layout, see "Virtual Switches" on page 23.

To safeguard the virtual machines' resources, the system administrator lowers the risk of DOS and DDOS attacks by configuring a resource reservation and limit for each virtual machine. The system administrator further protects the ESX Server host and virtual machines by installing software firewalls at the front and back ends of the DMZ, ensuring that the ESX Server host is behind a physical firewall, and configuring the service console and networked storage resources so that each has its own virtual switch.

Security Resources and Information

You can find additional information on security topics through the following resources.

Table 9-1. VMware Security Resources on the Web

Topic	Resource
VMware security policy, up-to-date security alerts, security downloads, and focus discussions of security topics	**http://www.vmware.com/vmtn/technology/security**
Corporate security response policy	**http://www.vmware.com/support/policies/security_response.html** VMware is committed to helping you maintain a secure environment. To reassure you that any security issues will be corrected in a timely fashion, the VMware Security Response Policy states our commitment to resolve possible vulnerabilities in our products.
Certification of VMware products	**http://www.vmware.com/security/** Search for the term "VMware" on this site to find the certification status of specific VMware products.
Third-party software support policy	**http://www.vmware.com/support/policies** VMware supports a variety of storage systems, software agents such as backup agents, system management agents, and so forth. You can find lists of agents, tools, and other software supported by ESX Server by searching **http://www.vmware.com/vmtn/resources** for ESX Server compatibility guides. The industry offers more products and configurations than VMware can test. If VMware does not list a product or configuration in a compatibility guide, Technical Support will attempt to help you with any problems, but cannot guarantee that the product or configuration can be used. Always evaluate any security risks for unsupported products or configurations carefully.

Securing an ESX Server Configuration 10

This chapter describes measures you can take to promote a secure environment for your ESX Server hosts, virtual machines, and iSCSI SANs. The discussion focuses on network configuration planning from a security perspective and the steps you can take to protect the components in your configuration from attack.

This chapter covers the following topics:

Securing the Network with Firewalls

Security administrators use firewalls to safeguard the network or selected components within the network from intrusion. Firewalls control access to devices within their perimeter by closing all communication pathways except for those that the administrator explicitly or implicitly designates as authorized, thus preventing unauthorized use of the devices. The pathways, or ports, that administrators open in the firewall allow traffic between devices on different sides of the firewall.

In a virtual machine environment, you can plan your layout for firewalls between:

- Physical machines such as VirtualCenter Management Server hosts and ESX Server hosts.
- One virtual machine and another—for example, between a virtual machine acting as an external Web server and a virtual machine connected to your company's internal network.

- A physical machine and a virtual machine as when you place a firewall between a physical network adapter card and a virtual machine.

How you utilize firewalls in an ESX Server configuration is based on how you plan to use the network and how secure any given component needs to be. For example, if you create a virtual network where each virtual machine is dedicated to running a different benchmark test suite for the same department, the risk of unwanted access from one virtual machine to the next is minimal. Hence, you have little need to set up the configuration so that firewalls are present between the virtual machines. However, to prevent interruption of a test run from an outside host, you might set up the configuration so that a firewall is present at the entry point of the virtual network to protect the entire set of virtual machines.

This section shows firewall placement for configurations with and without VirtualCenter. It also provides information on the firewall ports required for ESX Server systems. The section covers the following topics:

- "Firewalls for Configurations with a VirtualCenter Server" on page 182
- "Firewalls for Configurations Without a VirtualCenter Server" on page 185
- "TCP and UDP Ports for Management Access" on page 187
- "Connecting to VirtualCenter Server Through a Firewall" on page 189
- "Connecting to the Virtual Machine Console Through a Firewall" on page 189
- "Connecting ESX Server Hosts Through Firewalls" on page 191
- "Opening Firewall Ports for Supported Services and Management Agents" on page 192

For information on the service console firewall, see "Service Console Firewall Configuration" on page 239. To configure the firewall and port settings during installation, see the *Installation and Upgrade Guide*.

Firewalls for Configurations with a VirtualCenter Server

If you use a VirtualCenter Server, you can install firewalls at any of the locations shown in Figure 10-1.

NOTE Depending on your configuration, you might not need all the firewalls in the illustration, or you might need firewalls in locations not shown.

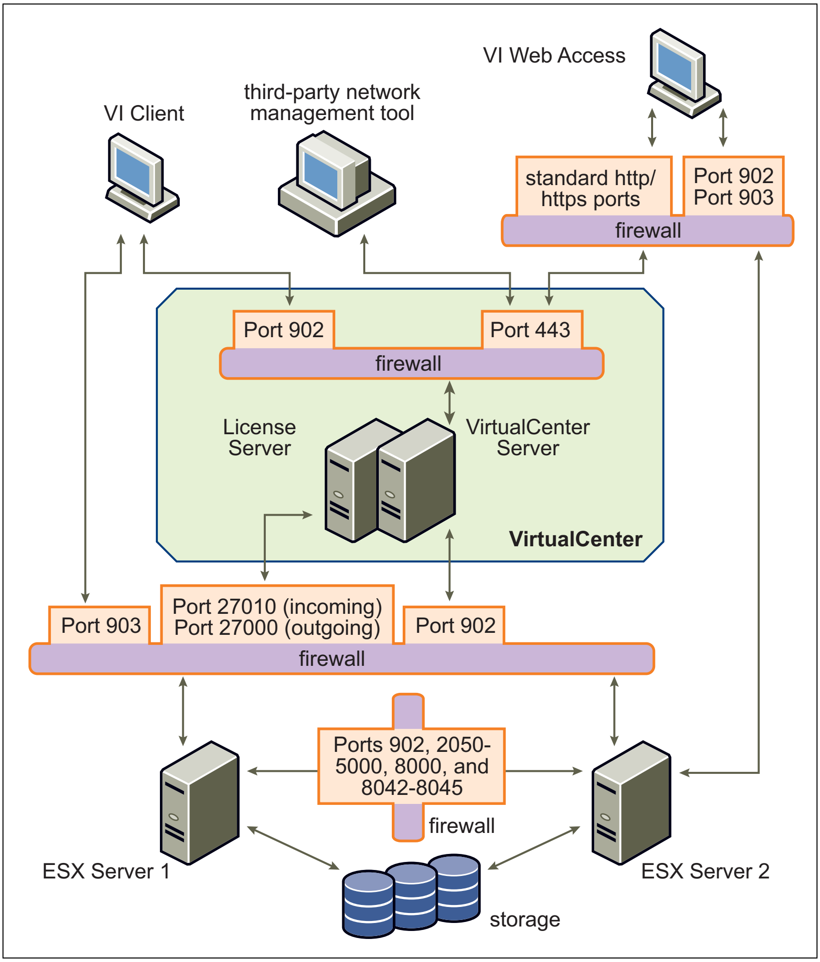


Figure 10-1. Firewall Configuration for ESX Server Networks Managed by a VirtualCenter Server (SEE UPDATE)

Networks configured with a VirtualCenter Server can receive communications through several types of clients: the VI Client, VI Web Access, or third-party network management clients that use the SDK to interface with the host. During normal operation, VirtualCenter listens for data from its managed hosts and clients on designated ports. VirtualCenter also assumes that its managed hosts listen for data from VirtualCenter on designated ports. If a firewall is present between any of these elements, you must ensure that there are open ports in the firewall to support data transfer.

If you access ESX Server hosts through a VirtualCenter Server, you typically protect the VirtualCenter Server using a firewall. This firewall provides basic protection for your network. Whether this firewall lies between the clients and the VirtualCenter Server or both the VirtualCenter Server and the clients are behind the firewall depends on your deployment. The main thing is to ensure that a firewall is present at what you consider to be an entry point for the system as a whole.

You might also include firewalls at a variety of other access points in the network, depending on how you plan to use the network and how secure the various devices need to be. Select the locations for your firewalls based on the security risks that you've identified for your network configuration. The following is a list of firewall locations common to ESX Server implementations. Many of the firewall locations in the list and illustration are optional.

- Between your Web browser and VI Web Access HTTP and HTTPS proxy server.
- Between the VI Client, VI Web Access, or a third-party network management client and the VirtualCenter Server.
- If your users access virtual machines through the VI Client, between the VI Client and the ESX Server host. This connection is in addition to the connection between the VI Client and the VirtualCenter Server, and it requires a different port.
- If your users access virtual machines through a Web browser, between the Web browser and the ESX Server host. This connection is in addition to the connection between the VI Web Access Client and VirtualCenter Server, and it requires different ports.
- Between the license server and either the VirtualCenter Server or the ESX Server host. Typically, in configurations that include a VirtualCenter Server, the license server runs on the same physical machine as does the VirtualCenter Server. In this case, the license server connects to the ESX Server network through a firewall, running in parallel with the VirtualCenter Server but using different ports.

  In some configurations, you might use an external license server—for example, if your company wants to control all licenses through a single, dedicated appliance. Here, you would connect the license server to the VirtualCenter Server through a firewall between these two servers.

  Regardless of how you set up the license server connection, the ports you use for license traffic are the same. For information on licensing, see the *Installation and Upgrade Guide*.
- Between the VirtualCenter Server and the ESX Server hosts.
- Between the ESX Server hosts in your network. Although traffic between ESX Server hosts is usually considered trusted, you can add firewalls between your ESX

Server hosts if you are concerned about security breaches from machine to machine.

If you add firewalls between ESX Server hosts and plan to migrate virtual machines between the servers, perform cloning, or use VMotion, you must also open ports in any firewall that divides the source host from the target hosts so that the source and targets can communicate.

- Between the ESX Server hosts and peripheral devices such as NFS storage. These ports are not specific to VMware, and you configure them according to the specifications for your network.

For information on the ports to open for these communications paths, see "TCP and UDP Ports for Management Access" on page 187.

Firewalls for Configurations Without a VirtualCenter Server

If you connect clients directly to your ESX Server network instead of using a VirtualCenter Server, your firewall configuration is somewhat simpler. You might install firewalls at any of the locations shown in Figure 10-2.

NOTE Depending on your configuration, you might not need all the firewalls in the illustration, or you might need firewalls in locations not shown.

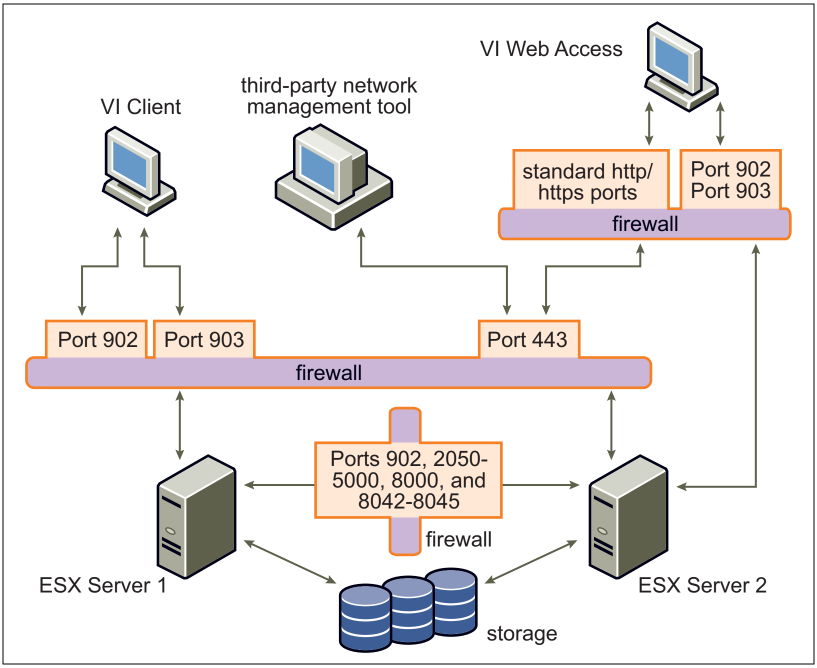


Figure 10-2. Firewall Configuration for ESX Server Networks Managed Directly by a Client

Networks configured without a VirtualCenter Server receive communications through the same types of clients as they do if a VirtualCenter Server were present: VI Client, VI Web Access Clients, or third-party network management clients. For the most part, the firewall needs are the same, but there are several key differences:

- Just as you would for configurations that include a VirtualCenter Server, you should be sure a firewall is present to protect your ESX Server layer or, depending on your configuration, your clients and ESX Server layer. This firewall provides basic protection for your network. The firewall ports you use are the same as those you use if a VirtualCenter Server is in place.
- Licensing in this type of configuration is part of the ESX Server package that you install on each of the ESX Server hosts. Because licensing is resident to the server, you do not need to install a separate license server. This eliminates the need for a firewall between the license server and the ESX Server network.

NOTE In some situations, you might want to centralize your licenses. You can choose to maintain a separate license server or house the license server on one of the ESX Server hosts in your network. With either of these approaches, you connect the license server to the ESX Server network through a firewall using the ports normally reserved for virtual machine licensing, much as you do if a VirtualCenter Server is present. Configurations that use a license server other than the one automatically installed on the ESX Server host require additional setup. For information on licensing, see the *Installation and Upgrade Guide*.

TCP and UDP Ports for Management Access

This section lists predetermined TCP and UDP ports used for management access to your VirtualCenter Server, ESX Server hosts, and other network components. If you need to manage network components from outside a firewall, you might need to reconfigure the firewall to allow access on the appropriate ports.

NOTE The ports listed in the table are connected through the service console interface unless otherwise indicated.

Table 10-1. TCP and UDP Ports

Port	Purpose	Traffic Type
80	HTTP access. The default non-secure TCP Web port typically used in conjunction with port 443 as a front end for access to ESX Server networks from the Web. Port 80 redirects traffic to an HTTPS landing page (port 443) from which you launch your virtual machine console. Use port 80 for connection to VI Web Access from the Web.	Incoming TCP
443	HTTPS access. (SEE UPDATE) The default SSL Web port. Use Port 443 for the following: ■ Connection to VI Web Access from the Web. ■ VI Web Access and third-party network management client connections to the VirtualCenter Server. ■ Direct VI Web Access and third-party network management clients access to ESX Server hosts.	Incoming TCP

Table 10-1. TCP and UDP Ports (Continued)

Port	Purpose	Traffic Type
902	Authentication traffic for the ESX Server host and virtual machine configuration. (SEE UPDATE) Use Port 902 for the following: ■ VI Client access to the VirtualCenter Server. ■ VirtualCenter Server access to ESX Server hosts. ■ Direct VI Client access to ESX Server hosts. ■ ESX Server host access to other ESX Server hosts for migration and provisioning.	Incoming TCP, outgoing UDP
903	Remote console traffic generated by user access to virtual machines on a specific ESX Server host. Use Port 903 for the following: ■ VI Client access to virtual machine consoles. ■ VI Web Access Client access to virtual machine consoles.	Incoming TCP
2049	Transactions from your NFS storage devices. This port is used on the VMkernel interface rather than the service console interface.	Incoming and outgoing TCP
2050–5000	Traffic between ESX Server hosts for VMware High Availability (HA) and EMC Autostart Manager.	Outgoing TCP, incoming and outgoing UDP
3260	Transactions from your iSCSI storage devices. This port is used on the VMkernel interface and the service console interface.	Outgoing TCP
8000	Incoming requests from VMotion. This port is used on the VMkernel interface rather than the service console interface.	Incoming and outgoing TCP
8042–8045	Traffic between ESX Server hosts for HA and EMC Autostart Manager.	Outgoing TCP, incoming and outgoing UDP
27000	License transactions from ESX Server to the license server.	Outgoing TCP
27010	License transactions from the license server. (SEE UPDATE)	Incoming TCP

NOTE ESX Server and VirtualCenter use ports 8085, 8087, and 9080 internally. For ESX Server, ports 8085, 8087, and 9080 are protected because they don't accept remote connections.

In addition to the TCP and UDP ports just discussed, you can configure other ports depending on your needs:

- You can use VirtualCenter to open ports for installed management agents and supported services such as SSH, NFS, and so forth. For information on configuring additional ports for these services, see "Opening Firewall Ports for Supported Services and Management Agents" on page 192.

- You can open ports in the service console firewall for other services and agents required for your network by running command line scripts. For more information, see "Service Console Firewall Configuration" on page 239.

Connecting to VirtualCenter Server Through a Firewall

As shown in Table 10-1, the ports that VirtualCenter Server uses to listen for data transfer from its clients are 902 (VI Client) and 443 (other clients). If you have a firewall between your VirtualCenter Server and its clients, you must configure a connection through which the VirtualCenter Server can receive data from the clients.

To enable the VirtualCenter Server to receive data from a VI Client, open port 902 in the firewall to allow data transfer from the VI Client to the VirtualCenter Server. For connections between the VirtualCenter Server and VI Web Access Clients or third-party clients working through the SDK, open port 443. Contact the firewall system administrator for additional information on configuring ports in a firewall.

If you are using the VI Client and don't want to use port 902 as the port for the VI Client-to-VirtualCenter Server communication, you can switch to another port by changing the VirtualCenter settings in the VI Client. To learn how to change these settings, see the *Virtual Infrastructure User's Guide*.

Connecting to the Virtual Machine Console Through a Firewall

Whether you connect your client to ESX Server hosts through a VirtualCenter Server or use a direct connection to the ESX Server host, certain ports are required for user and administrator communication with virtual machine consoles. These ports support different client functions, interface with different layers within ESX Server, and use different authentication protocols. They are:

- (SEE UPDATE) **Port 902** – The VirtualCenter Server uses this port to send data to the VirtualCenter managed hosts. Also, the VI Client, when connected directly to an ESX Server host, uses this port to support any management functions related to the server and its virtual machines. Port 902 is the port that the VirtualCenter Server and the VI Client assume is available when sending data to the ESX Server host. VMware doesn't support configuring a different port for these connections.

Port 902 connects the VirtualCenter Server or client to the ESX Server host through the VMware Authorization Daemon (`vmware-authd`) running in the service console. The authorization daemon multiplexes port 902 data to the VMware Host Agent (`vmware-hostd`) for processing.

- (SEE UPDATE) **Port 443** – The VI Web Access Client and SDK use this port to send data to the VirtualCenter managed hosts. Also, the VI Web Access Client and SDK, when connected directly to an ESX Server host, use this port to support any management functions related to the server and its virtual machines. Port 443 is the port that the VI Web Access Client and the SDK assume is available when sending data to the ESX Server host. VMware doesn't support configuring a different port for these connections.

  Port 443 connects the VI Web Access Client or third-party network management client to the ESX Server host through the Tomcat Web service or the SDK, respectively. These processes multiplex port 443 data to `vmware-hostd` for processing.

- **Port 903** – The VI Client and VI Web Access use this port to provide a connection for guest operating system mouse/keyboard/screen (MKS) activities on virtual machines. It is through this port that users interact with the virtual machine guest operating systems and applications. Port 903 is the port that the VI Client and VI Web Access assume is available when interacting with virtual machines. VMware doesn't support configuring a different port for this function.

  Port 903 connects the VI Client to a specified virtual machines configured on the ESX Server host.

Figure 10-3 shows the relationships between VI Client functions, ports, and ESX Server processes. The VI Web Access Client uses the same basic mapping for its interactions with the ESX Server host.

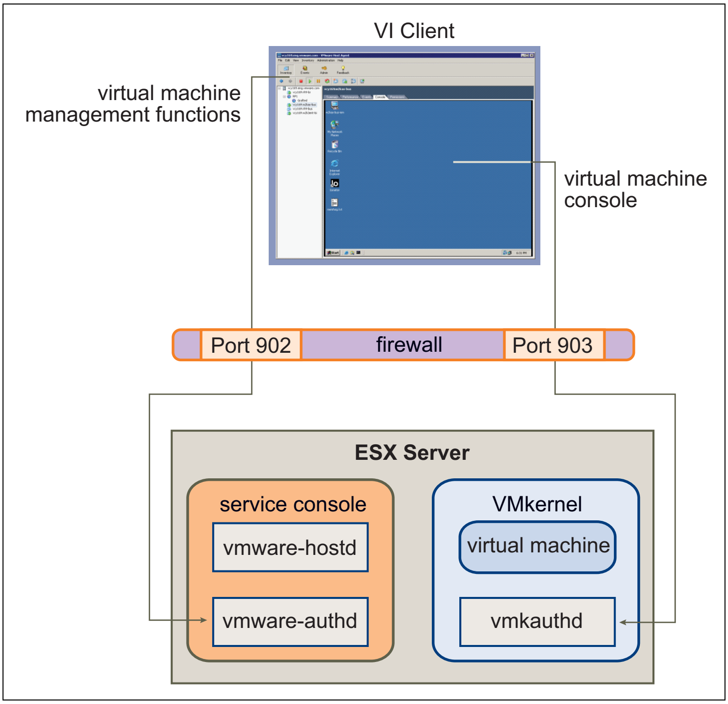


Figure 10-3. Port Usage for VI Client Communications with ESX Server

If you have a firewall between your VirtualCenter Server and VirtualCenter managed host, open Ports 902 and 903 in the firewall to allow data transfer to:

- ESX Server hosts from the VirtualCenter Server.
- ESX Server hosts directly from the VI Client and VI Web Access.

Refer to the firewall system administrator for additional information on configuring the ports.

Connecting ESX Server Hosts Through Firewalls

If you have a firewall between two ESX Server hosts and you want to allow transactions between the hosts or use VirtualCenter to perform any source/target activities, such as VMware High Availability (HA) traffic, migration, cloning, or VMotion, you must configure a connection through which the managed hosts can receive data. To do so, you open ports in the following ranges:

- 902 (server-to-server migration and provisioning traffic)
- 2050–5000 (for HA traffic)

- 8000 (for VMotion)
- 8042–8045 (for HA traffic)

Refer to the firewall system administrator for additional information on configuring the ports. For more detailed information on the directionality and protocol for these ports, see "TCP and UDP Ports for Management Access" on page 187.

Opening Firewall Ports for Supported Services and Management Agents

Use VI Client to configure the service console firewall to accept commonly supported services and installed management agents. When you configure the ESX Server host security profile in VirtualCenter, you add or remove these services or agents, automatically opening or closing predetermined ports in the firewall to allow communication with the service or agent. The following is a list of the services and agents you can add or remove:

- NIS client
- NFS client (insecure service)
- SMB client (insecure service)
- FTP client (insecure service)
- SSH client
- Telnet client (insecure service)
- NTP client
- iSCSI software client
- SSH server
- Telnet server (insecure service)
- FTP server (insecure service)
- NFS server (insecure service)
- CIM HTTP server (insecure service)
- CIM HTTPS server
- SNMP server
- Other supported management agents you install

NOTE This list can change so you might find that the VI Client provides services and agents not mentioned in the list. Also, not all services on the list are installed by default. You may need to perform additional activities to configure and enable these services.

If you are installing a device, service, or agent not on this list, you need to open ports in the service console firewall from a command line. For more information, see "Service Console Firewall Configuration" on page 239.

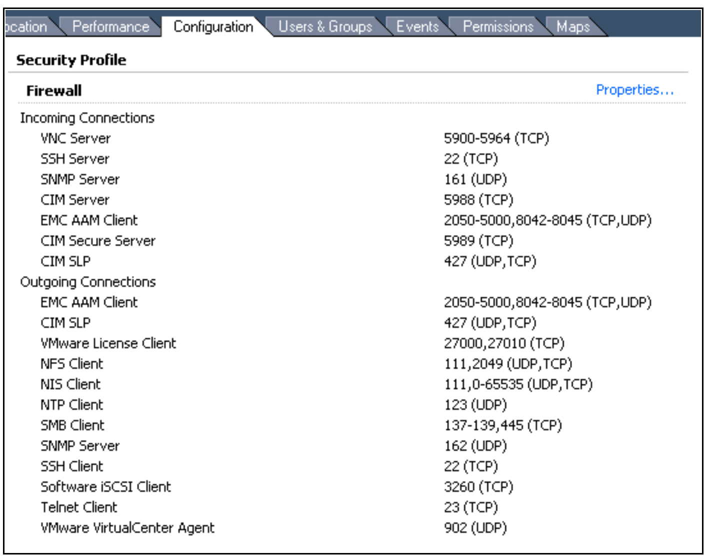
To allow access to ESX Server for a service or management agent

1 Log on to the VI Client and select the server from the inventory panel.

The hardware configuration page for this server appears.

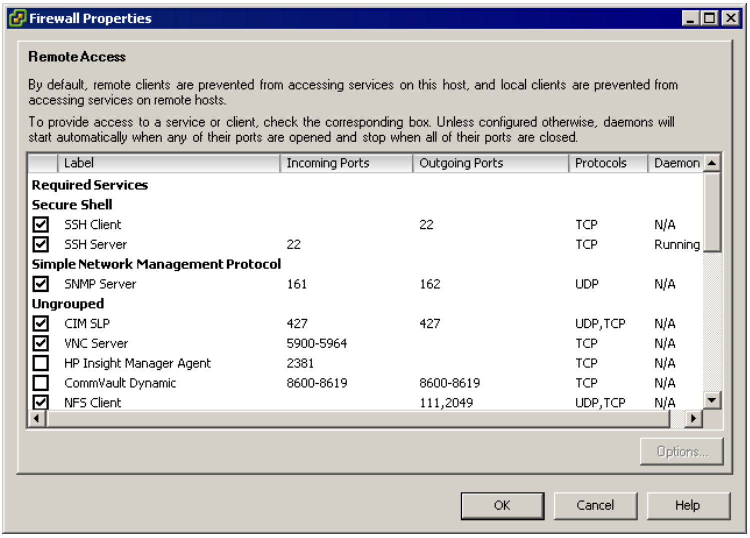
2 Click the **Configuration** tab and click **Security Profile**.

The VI Client displays a list of currently active incoming and outgoing connections with the corresponding firewall ports.



3 Click **Firewall** > **Properties** to open the **Firewall Properties** dialog box.

This dialog box lists all the services and management agents you can configure for the host.



4 Select the check boxes for the services and agents you want to enable.

The **Incoming Ports** and **Outgoing Ports** columns indicate the port or ports that the VI Client opens for the service, the **Protocol** column indicates the protocol the service uses, and the **Daemon** column indicates the status of daemons associated with the service.

5 Click **OK**.

Securing Virtual Machines with VLANs

The network can be one of the most vulnerable parts of any system. Just as the physical network requires protection, so does your virtual machine network. If your virtual machine network is connected to a physical network, it can be subject to breaches to the same degree that a network made up of physical machines would be. Even if the virtual machine network is isolated from any physical network, virtual machines within the network can be subject to attacks from other virtual machines in the network. The requirements for securing virtual machines are often the same as those for physical machines.

Virtual machines are isolated from each other. One virtual machine can't read or write another virtual machine's memory, access its data, use its applications, and so forth. However, within the network, any virtual machine or group of virtual machines can still be the target of unauthorized access from other virtual machines and might require further protection by external means. You can add this level of security by:

- Adding firewall protection to your virtual network by installing and configuring software firewalls on some or all of its virtual machines.

NOTE For efficiency, you can set up private virtual machine Ethernet networks, or *virtual networks*. With virtual networks, you install a software firewall on a virtual machine at the head of the virtual network. This serves as a protective buffer between the physical network adapter and the remaining virtual machines in the virtual network.

Installing a software firewall on virtual machines at the head of virtual networks is a good security practice. However, because software firewalls can slow performance, balance your security needs against performance before deciding to install software firewalls on virtual machines elsewhere in the virtual network. For more information on virtual networks, see "Networking Concepts" on page 22.

- Keeping different virtual machine zones within a host on different network segments. If you isolate virtual machine zones on their own network segments, you minimize the risks of data leakage from one virtual machine zone to the next. Segmentation prevents various threats, including Address Resolution Protocol (ARP) spoofing in which an attacker manipulates the ARP table to remap MAC and IP addresses, thereby gaining access to network traffic to and from a host. Attackers use ARP spoofing to generate denials of service, hijack the target system, and otherwise disrupt the virtual network.

  Planning segmentation carefully lowers the chances of packet transmissions between virtual machine zones, thus preventing sniffing attacks, which require sending network traffic to the victim. Also, an attacker cannot leverage an insecure service in one virtual machine zone to access other virtual machine zones in the host. against various security threats. You can implement segmentation using either of two approaches, each of which has different benefits.

  - Use separate physical network adapters for virtual machine zones to ensure that the zones are isolated. Maintaining separate physical network adapters for virtual machine zones is probably the most secure method and is less prone to misconfiguration after the initial segment creation.

  - Set up Virtual Local Area Networks (VLANs) to help safeguard your network. Because VLANs provide the almost all of the security benefits inherent in implementing physically separate networks without the hardware overhead, they offer a viable solution that can save you the cost of deploying and maintaining additional devices, cabling, and so forth.

VLANs are an IEEE standard networking scheme with specific tagging methods that allow routing of packets to only those ports that are part of the VLAN. When properly configured, VLANs provide a dependable means for you to protect a set of virtual machines from accidental or malicious intrusions.

VLANs let you segment a physical network so that two machines in the network are unable to transmit packets back and forth unless they are part of the same VLAN. For example, accounting records and transactions are among a company's most sensitive internal information. In a company whose sales, shipping, and accounting employees all use virtual machines in the same physical network, you might protect the virtual machines for the accounting department by setting up VLANs as shown in Figure 10-4.

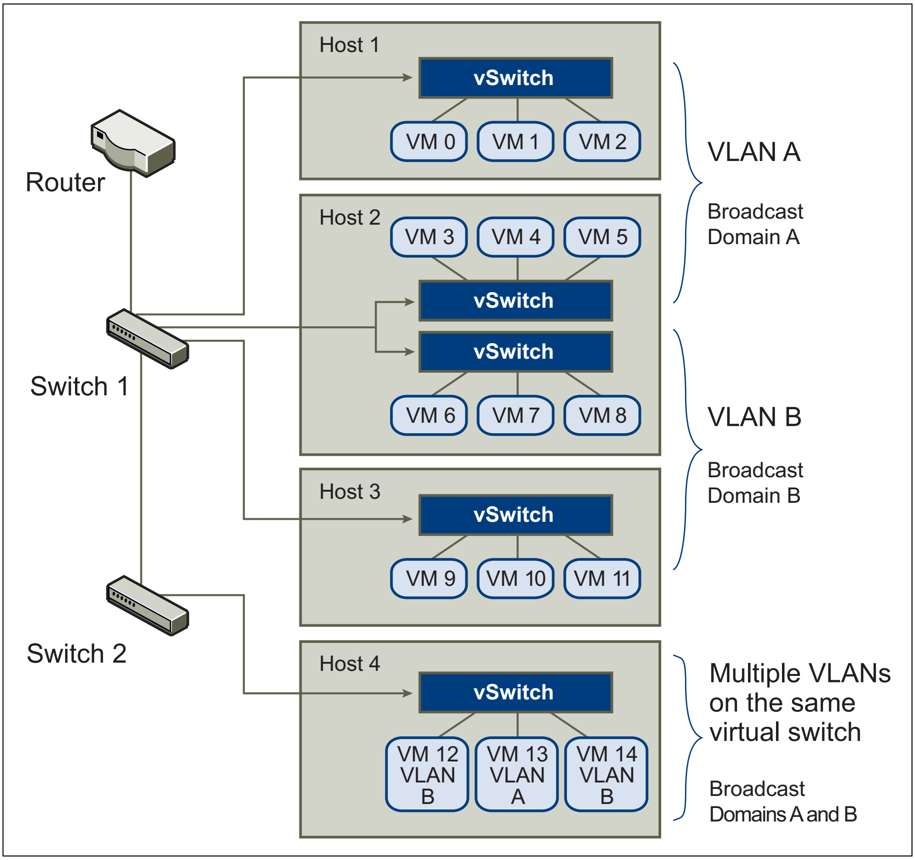


Figure 10-4. Sample VLAN Layout

In this configuration, all employees in the accounting department use virtual machines in *VLAN A* and the employees in sales use virtual machines in *VLAN B*.

The router forwards packets containing accounting data to the switches. These packets are tagged for distribution to *VLAN A* only. Therefore, the data is confined to *Broadcast Domain A*, and cannot be routed to *Broadcast Domain B* unless the router is configured to do so.

This VLAN configuration prevents the sales force from intercepting packets destined for the accounting department. It also prevents the accounting department from receiving packets intended for the sales group. Note that the virtual machines serviced by a single virtual switch can be in different VLANs.

The following section provides suggestions for securing your network through virtual switches and VLANs. The section covers the following topics:

- "Security Considerations for VLANs" on page 197
- "Virtual Switch Protection and VLANs" on page 199
- "Securing Virtual Switch Ports" on page 201

Security Considerations for VLANs

ESX Server features a complete IEEE 802.1q-compliant VLAN implementation. The way you set up VLANs to secure parts of a network depends on factors such as the guest operating system you install, the way your network equipment is configured, and so forth. While VMware cannot make specific recommendations on how to set up VLANs, here are some factors to consider when using a VLAN deployment as part of your security enforcement policy:

- **Treat VLANs as part of a broader security implementation** – VLANs are an effective means of controlling where and how widely data is transmitted within the network. If an attacker gains access to the network, the attack is likely to be limited to the VLAN that served as the entry point, lessening the risk to the network as a whole.

  VLANs provide protection only in that they control how data is routed and contained after it passes through the switches and enters the network. You can use VLANs to help secure Layer 2 of your network model—the data link layer. However, configuring VLANs doesn't protect the physical layer of your network model or any of the other layers. Even if you create VLANs, you should provide additional protection by securing your hardware (routers, hubs, and so forth) and encrypting data transmissions.

  VLANs are not a substitute for firewalls in your virtual machine configurations. Most network configurations that include VLANs also include software firewalls. If you include VLANs in your virtual network, be sure that any firewalls you install are VLAN-aware.

- **Be sure your VLANs are properly configured** – Equipment misconfiguration and network hardware, firmware, or software defects can make a VLAN susceptible to VLAN hopping attacks. VLAN hopping occurs when an attacker with authorized access to one VLAN creates packets that trick physical switches into transmitting the packets to another VLAN that the attacker is not authorized to access. Vulnerability to this type of attack usually results from a switch being misconfigured for native VLAN operation, in which the switch can receive and transmit untagged packets.

  To help prevent VLAN hopping, keep your equipment up to date by installing hardware and firmware updates as they become available. Also, be sure to follow your vendor's best practice guidelines when configuring your equipment.

  Be aware that VMware virtual switches don't support the concept of a native VLAN. All data passed on these switches is appropriately tagged. However, because there might be other switches in the network that are configured for native VLAN operation, VLANs configured with virtual switches can still be vulnerable to VLAN hopping.

  If you plan to use VLANs to enforce network security, VMware recommends that you disable the native VLAN feature for all switches unless you have a compelling need to operate some of your VLANs in native mode. If you need to use native VLAN, pay attention to your switch vendor's configuration guidelines for this feature.

- **Create a separate VLAN or virtual switch for communication between management tools and the service console** – Whether you use a management client or the command line, all configuration tasks for ESX Server are performed through the service console, including configuring storage, controlling aspects of virtual machine behavior, and setting up virtual switches or virtual networks. Because the service console is the point of control for ESX Server, safeguarding it from misuse is crucial.

  While VMware ESX Server management clients use authentication and encryption to prevent unauthorized access to the service console, other services might not offer the same protection. If attackers gain access to the service console, they are free to reconfigure many attributes of the ESX Server host. For example, they could change the entire virtual switch configuration, change authorization methods, and so forth.

  Network connectivity for the service console is established through virtual switches. To provide better protection for this critical ESX Server component, VMware recommends that you isolate the service console using one of these methods:

- Create a separate VLAN for management tool communication with the service console.
- Configure network access for management tool connections with the service console through a single virtual switch and one or more uplink ports.

Both methods prevent anyone without access to the service console VLAN or virtual switch from seeing traffic to and from the service console. They also prevent attackers from sending any packets to the service console. As an alternative, you can choose to configure the service console on a separate physical network segment instead. Physical segmentation provides a degree of additional security in that it is less prone to later misconfiguration

In addition to setting up a separate VLANs or virtual switch for management tool communication with the service console, you should set up separate a VLAN or virtual switch for VMotion and for network attached storage.

NOTE If your configuration includes an iSCSI SAN configured directly through the host rather than through a hardware adapter, you should create a separate virtual switch that provides shared network connectivity for a the service console and for iSCSI. This second network connection for the service console is in addition to the primary service console network connection that you use for management tool communications. The second service console network connection supports iSCSI activities only, and you should not use it for any management activities or management tool communications.

Virtual Switch Protection and VLANs

VMware virtual switches provide safeguards against certain threats to VLAN security. Because of the way that virtual switches are designed, they protect VLANs against a variety of attacks, many of which involve VLAN hopping. Having this protection does not guarantee that your virtual machine configuration is invulnerable to other types of attacks. For example, virtual switches do not protect the physical network against these attacks, just the virtual network.

The following list gives you an idea of some attacks virtual switches and VLANs can protect against.

- **MAC flooding** – These attacks flood a switch with packets containing MAC addresses tagged as having come from different sources. Many switches use a Content-Addressable Memory (CAM) table to learn and store the source address for each packet. When the table is full, the switch may enter a fully open state in which every incoming packet is broadcast on all ports, letting the attacker see all the switch's traffic. This state might result in packet leakage across VLANs.

While VMware virtual switches store a MAC address table, they don't get the MAC addresses from observable traffic and are not vulnerable to this type of attack.

- **802.1q and ISL tagging attacks** – These attacks force a switch to redirect frames from one VLAN to another by tricking the switch into acting as a trunk and broadcasting the traffic to other VLANs.

  VMware virtual switches don't perform the dynamic trunking required for this type of attack and, therefore, are not vulnerable.

- **Double-encapsulation attacks** – These attacks occur when an attacker creates a double-encapsulated packet in which the VLAN identifier in the inner tag is different from the VLAN identifier in the outer tag. For backward compatibility, native VLANs strip the outer tag from transmitted packets unless configured to do otherwise. When a native VLAN switch strips the outer tag, only the inner tag is left, and that inner tag routes the packet to a different VLAN than the one identified in the now-missing outer tag.

  VMware virtual switches drop any double-encapsulated frames that a virtual machine attempts to send on a port configured for a specific VLAN. Therefore, they are not vulnerable to this type of attack.

- **Multicast brute-force attacks** – These attacks involve sending large numbers of multicast frames to a known VLAN almost simultaneously in hopes of overloading the switch so that it mistakenly allows some of the frames to broadcast to other VLANs.

  VMware virtual switches do not allow frames to leave their correct broadcast domain (VLAN) and are not vulnerable to this type of attack.

- **Spanning-tree attacks** – These attacks target Spanning-Tree Protocol (STP), which is used to control bridging between parts of the LAN. The attacker sends Bridge Protocol Data Unit (BPDU) packets that attempt to change the network topology, establishing himself or herself as the root bridge. As the root bridge, the attacker can sniff the contents of transmitted frames.

  VMware virtual switches don't support STP and are not vulnerable to this type of attack.

- **Random frame attacks** – These attacks involve sending large numbers of packets in which the source and destination addresses stay the same, but in which fields are randomly changed in length, type, or content. The goal of this attack is to force packets to be mistakenly rerouted to a different VLAN.

  VMware virtual switches are not vulnerable to this type of attack.

Because new security threats develop over time, do not consider this an exhaustive list of attacks. Regularly check VMware security resources on the Web (**http://www.vmware.com/vmtn/technology/security**) to learn about security, recent security alerts, and VMware security tactics.

Securing Virtual Switch Ports

As with physical network adapters, a virtual network adapter can send frames that appear to be from a different machine or impersonate another machine so that it is able to receive network frames intended for that machine. Also, like physical network adapters, a virtual network adapter can be configured such that it receives frames targeted for other machines.

When you create a virtual switch for your network, you add port groups to impose a policy configuration for the virtual machines, storage systems, and so forth attached to the switch. You create virtual switches through the VI Client.

As part of adding a port or port group to a virtual switch, the VI Client configures a security profile for the port. You can use this security profile to ensure that ESX Server prevents the guest operating systems for its virtual machines from impersonating other machines on the network. This security feature is implemented so that the guest operating system responsible for the impersonation does not detect that the impersonation has been prevented.

The security profile determines how strongly you enforce protection against impersonation and interception attacks on virtual machines. To correctly use the settings in the security profile, you need to understand the basics of how virtual network adapters control transmissions and how attacks are staged at this level.

Each virtual network adapter has its own MAC address assigned when the adapter is created. This address is called the initial MAC address. Although the initial MAC address can be reconfigured from outside the guest operating system, it cannot be changed by the guest operating system. In addition, each adapter has an effective MAC address that filters out incoming network traffic with a destination MAC address different from the effective MAC address. The guest operating system is responsible for setting the effective MAC address and typically matches the effective MAC address to the initial MAC address.

When sending packets, an operating system typically places its own network adapter's effective MAC address in the source MAC address field of the Ethernet frame. It also places the MAC address for the receiving network adapter in the destination MAC address field. The receiving adapter accepts packets only when the destination MAC address in the packet matches its own effective MAC address.

Upon creation, a network adapter's effective MAC address and initial MAC address are the same. The virtual machine's operating system can alter the effective MAC address to another value at any time. If an operating system changes the effective MAC address, its network adapter then receives network traffic destined for the new MAC address. The operating system can send frames with an impersonated source MAC address at any time. Thus, an operating system can stage malicious attacks on the devices in a network by impersonating a network adapter authorized by the receiving network.

You can use virtual switch security profiles on ESX Server hosts protect against this type of attack by setting three options:

- **MAC address changes** – By default, this option is set to **Accept**, meaning that the ESX Server host accepts requests to change the effective MAC address to other than the initial MAC address. The **MAC Address Changes** option setting affects traffic received by a virtual machine.

  To protect against MAC impersonation, you can set this option to **Reject**. If you do, the ESX Server host does not honor requests to change the effective MAC address to anything other than the initial MAC address. Instead, the port that the virtual adapter used to send the request is disabled. As a result, the virtual adapter does not receive any more frames until it changes the effective MAC address to match the initial MAC address. The guest operating system does not detect that the MAC address change has not been honored.

NOTE In some situations, you might have a legitimate need for more than one adapter to have the same MAC address on a network—for example, if you are using Microsoft Network Load Balancing in unicast mode. Note that when Microsoft Network Load Balancing is used in the standard multicast mode, adapters do not share MAC addresses.

- **Forged transmissions** – By default, this option is set to **Accept**, meaning the ESX Server host does not compare source and effective MAC addresses. The **Forged Trasmits** option setting affects traffic transmitted from a virtual machine.

  To protect against MAC impersonation, you can set this option to **Reject**. If you do, the ESX Server host compares the source MAC address being transmitted by the operating system with the effective MAC address for its adapter to see if they match. If the addresses don't match, ESX Server drops the packet.

  The guest operating system does not detect that its virtual network adapter cannot send packets using the impersonated MAC address. The ESX Server host intercepts any packets with impersonated addresses before they are delivered, and the guest operating system might assume that the packets have been dropped.

- **Promiscuous mode operation** – By default, this option is set to **Reject**, meaning that the virtual network adapter cannot operate in promiscuous mode. Promiscuous mode eliminates any reception filtering that the virtual network adapter would perform so that very frame that the guest operating system receives all traffic observed on the wire.

  While promiscuous mode can be useful for tracking network activity, it is an insecure mode of operation because any adapter in promiscuous mode had access to the packets regardless of whether some of the packets should be received only by a particular network adapter. This means that an administrator or root user within a virtual machine can potentially view traffic destined for other guest or host operating systems.

NOTE In some situations, you might have a legitimate need to configure a virtual switch to operate in promiscuous mode—for example, if you are running network intrusion detection software or a packet sniffer.

If you need to change any of these default settings for a port, you must modify the security profile by editing virtual switch settings in the VI Client. For information on editing these settings, see "Virtual Switch Policies" on page 53.

Securing iSCSI Storage

The storage you configure for an ESX Server host might include one or more storage area networks (SANs) that use iSCSI. iSCSI is a means of accessing SCSI devices and exchanging data records using TCP/IP protocol over a network port rather than through a direct connection to a SCSI device. In iSCSI transactions, blocks of raw SCSI data are encapsulated in iSCSI records and transmitted to the requesting device or user.

iSCSI SANs let you make efficient use of existing Ethernet infrastructures to provide ESX Server hosts access to storage resources that they can dynamically share. As such, iSCSI SANs provide an economical storage solution for environments that rely on a common storage pool to serve numerous users. As with any networked system, your iSCSI SANs can be subject to security breaches. When you configure iSCSI on an ESX Server host, you can take several measures to minimize security risks.

NOTE The requirements and procedures for securing an iSCSI SAN are similar for the hardware iSCSI adapters you can use with ESX Server hosts and for iSCSI configured directly through the ESX Server host. For information on configuring iSCSI adapters and storage, see "iSCSI Storage" on page 110.

The following section tells you how to configure authentication for iSCSI SANs and provides suggestions for securing iSCSI SANs. The section covers the following topics:

- "Securing iSCSI Devices Through Authentication" on page 204
- "Protecting an iSCSI SAN" on page 208

Securing iSCSI Devices Through Authentication

One means of securing iSCSI devices from unwanted intrusion is to require that the ESX Server host, or *initiator*, be authenticated by the iSCSI device, or *target*, whenever the host attempts to access data on the target LUN. The goal of authentication is to prove that the initiator has the right to access a target, a right granted when you configure authentication.

You have two choices when setting up authentication for iSCSI SANs on the ESX Server host:

- **Challenge Handshake Authentication Protocol (CHAP)** – You can configure the iSCSI SAN to use CHAP authentication. In CHAP authentication, when the initiator contacts an iSCSI target, the target sends a predefined ID value and a random value, or *key*, to the initiator. The initiator then creates a one-way hash value that it sends to the target. The hash contains three elements: a predefined ID value, the random value sent by the target, and a private value, or *CHAP secret*, shared by the initiator and target. When the target receives the hash from the initiator, it creates its own hash value using the same elements and compares it to the initiator's hash. If the results match, the target authenticates the initiator.

  ESX Server supports one-way CHAP authentication for iSCSI. It does not support bi-directional CHAP. In one-way CHAP authentication, the target authenticates the initiator, but the initiator does not authenticate the target. The initiator has only one set of credentials, and these credentials are used by all the iSCSI targets.

  ESX Server supports CHAP authentication at the HBA level only. It does not support per-target CHAP authentication, which enables you to configure different credentials for each target to achieve greater target refinement.

- **Disabled** – You can configure the iSCSI SAN to use no authentication. Be aware that communications between the initiator and target are still authenticated in a rudimentary way because the iSCSI target devices are typically set up to communicate with specific initiators only.

  Choosing not to enforce more stringent authentication can make sense if your iSCSI storage is housed in one location and you create a dedicated network or VLAN to service all your iSCSI devices. The premise here is that the iSCSI configuration is secure because it is isolated from any unwanted access, much as a Fibre Channel SAN would be.

As a basic rule, disable authentication only if you are willing to risk an attack to the iSCSI SAN or cope with problems that result from human error.

ESX Server does not support Kerberos, Secure Remote Protocol (SRP), or public key authentication methods for iSCSI. Additionally, it does not support IPsec authentication and encryption.

You use the VI Client to determine whether authentication is currently being performed and to configure the authentication method.

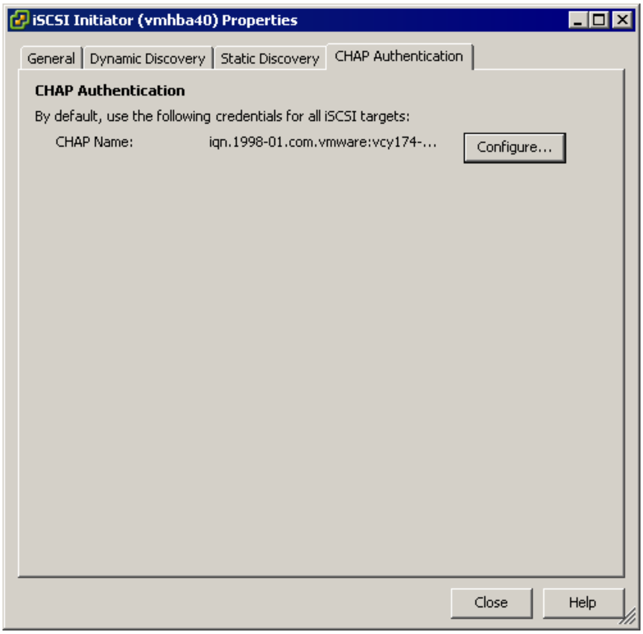
To check the authentication method

1. Log on to the VI Client and select the server from the inventory panel.

   The hardware configuration page for this server appears.

2. Click the **Configuration** tab and click **Storage Adapter**.
3. Select the iSCSI adapter you want to check and click **Properties** to open the **iSCSI Initiator Properties** dialog box.
4. Click **CHAP Authentication**.

If **CHAP Name** shows a name—often the iSCSI initiator name, the iSCSI SAN is using CHAP authentication, as shown below.



NOTE If **CHAP Name** shows **Not Specified**, the iSCSI SAN is not using CHAP authentication.

5 Click **Close**.

To configure iSCSI for CHAP authentication

1 Log on to the VI Client and select the server from the inventory panel.

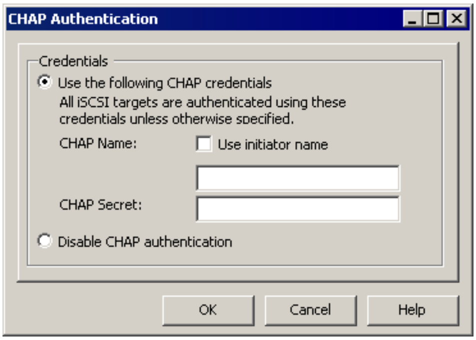
The hardware configuration page for this server appears.

2 Click the **Configuration** tab and click **Storage Adapter**.

3 Select the iSCSI adapter and click **Properties** to open the **iSCSI Initiator Properties** dialog box.

4 Click **CHAP Authentication** > **Configure** to open the **CHAP Authentication** dialog box.

5 Click **Use the following CHAP credentials**.



6 Perform one of the following actions:

- To set the CHAP name to the iSCSI adapter name, select **Use initiator name**.
- To set the CHAP name to anything other than the iSCSI adapter name, deselect **Use initiator name** and enter a name of up to 255 alphanumeric characters in the **CHAP Name** field.

7 Enter a CHAP secret to be used as part of authentication.

The secret you enter is a text string.

NOTE The VI Client doesn't impose a minimum or maximum length for the CHAP secret you enter. However, some iSCSI storage devices require that the secret exceed a minimum number of characters or have limitations on the character types you can use. Check the manufacturer's documentation to determine the requirements.

---

8 Click **OK**.

To disable iSCSI authentication

1 Log on to the VI Client and select the server from the inventory panel.

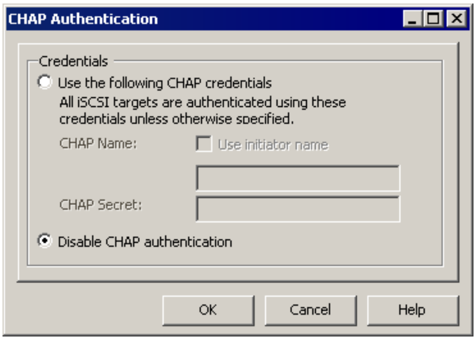
The hardware configuration page for this server appears.

2 Click the **Configuration** tab and click **Storage Adapter**.

3 Select the iSCSI adapter and click **Properties** to open the **iSCSI Initiator Properties** dialog box.

4 Click **CHAP Authentication** > **Configure** to open the **CHAP Authentication** dialog box.

5 Select **Disable CHAP authentication**.



6 Click **OK**.

Protecting an iSCSI SAN

When planning your iSCSI configuration, you should take measures to improve the overall security of the iSCSI SAN. Your iSCSI configuration is only as secure as your IP network, so by enforcing good security standards when setting up your network, you help safeguard your iSCSI storage.

Here are some specific suggestions:

- **Protecting transmitted data** – A primary security risk in iSCSI SANs is that an attacker might sniff transmitted storage data.

  VMware recommends that you take additional measures to prevent attackers from easily seeing iSCSI data. Neither the hardware iSCSI adapter nor the ESX Server host iSCSI initiator encrypts the data they transmit to and from the targets, making the data more vulnerable to sniffing attacks.

  Allowing your virtual machines to share virtual switches and VLANs with your iSCSI configuration potentially exposes iSCSI traffic to misuse by a virtual machine attacker. To help ensure that intruders can't listen to iSCSI transmissions, make sure that none of your virtual machines can see the iSCSI storage network.

  If you use a hardware iSCSI adapter, you can accomplish this by making sure that the iSCSI adapter and ESX physical network adapter are not inadvertently connected outside the host by virtue of sharing a switch or some other means. If you configure iSCSI directly through the ESX Server host, you can accomplish this by configuring iSCSI storage through a different virtual switch than the one used by your virtual machines, as shown in Figure 10-5.

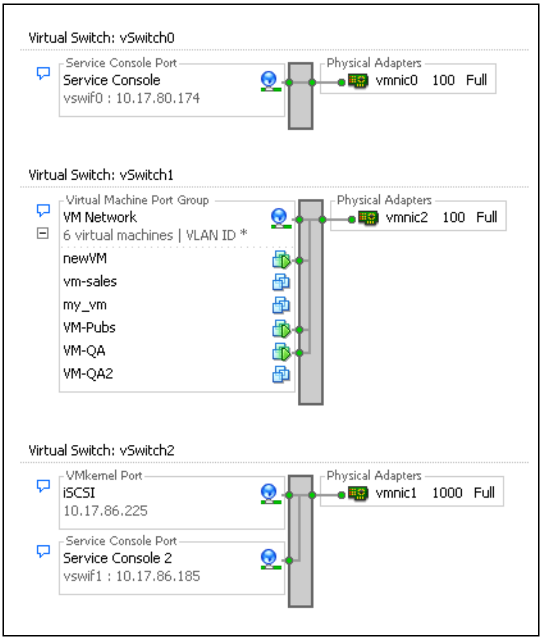


Figure 10-5. iSCSI Storage on a Separate Virtual Switch

Note that if you configure iSCSI directly through the host rather than through a hardware adapter, you must create two network connections for the service console within the virtual network setup. You configure the first service console network connection on its own virtual switch and use it exclusively for management tool connectivity (*Virtual Switch 0* in the figure). You configure the second service console network connection so that it shares the virtual switch you use for iSCSI connectivity (*Virtual Switch 2* in the figure). The second service console network connection supports iSCSI activities only, and you should not use it for any management activities or management tool communications. If you want to enforce a degree of separation between the iSCSI and service console on the shared virtual switch, you can configure them on different VLANs.

NOTE Do not configure the default gateway for the service console on the virtual switch you use for iSCSI connectivity. Configure it on the virtual switch you use for management tool connectivity instead.

In addition to protecting the iSCSI SAN by giving it a dedicated virtual switch, consider configuring your iSCSI SAN on its own VLAN. Placing your iSCSI configuration on a separate VLAN ensures that no devices other than the iSCSI adapter have visibility into transmissions within the iSCSI SAN.

- **Securing iSCSI ports** – When you run iSCSI devices, the ESX Server host doesn't open any ports that listen for network connections. This measure reduces the chances that an intruder can break into the ESX Server host through spare ports and gain control over the host. Therefore, running iSCSI doesn't present any additional security risks at the ESX Server host end of the connection.

  Be aware that any iSCSI target device that you run must have one or more open TCP ports used to listen for iSCSI connections. If any security vulnerabilities exist in the iSCSI device software, your data can be at risk through no fault of ESX Server. To lower this risk, install all security patches provided by your storage equipment manufacturer and limit the devices connected to the iSCSI network.

Authentication and User Management

11

This chapter explains how ESX Server handles user authentication and shows you how to set up user and group permissions. In addition, it discusses encryption for connections to the VI Client, SDK, and VI Web Access as well as configuring a delegate user name for transactions with NFS storage.

This chapter covers the following topics:

Securing ESX Server Through Authentication and Permissions

ESX Server uses the Pluggable Authentication Modules (PAM) structure for authentication when users access the ESX Server host using VirtualCenter, VI Web Access, or the service console. The PAM configuration for VMware services is located in `/etc/pam.d/vmware-authd`, which stores paths to authentication modules.

The default installation of ESX Server uses `/etc/passwd` authentication, just as Linux does, but you can configure ESX Server to use another distributed authentication mechanism. If you plan to use a third-party authentication tool instead of the ESX Server default implementation, refer to the vendor documentation for instructions. As part of setting up third-party authentication, you might need to update the `/etc/pam.d/vmware-authd` file with new module information.

Every time a VI Client or VirtualCenter user connects to an ESX Server host, the `sinnet` process starts an instance of the VMware Authentication Daemon (`vmware-authd`), which is used as a proxy to pass the information to and from the VMware Host Agent (`vmware-host`) process. The `vmware-authd` process receives an incoming connection attempt and hands it off to the `vmware-host` process, which receives the user name and password from the client and forwards them to the PAM module to perform the authentication.

Figure 11-1 gives you a basic idea of how ESX Server authenticates transactions from the VI Client.

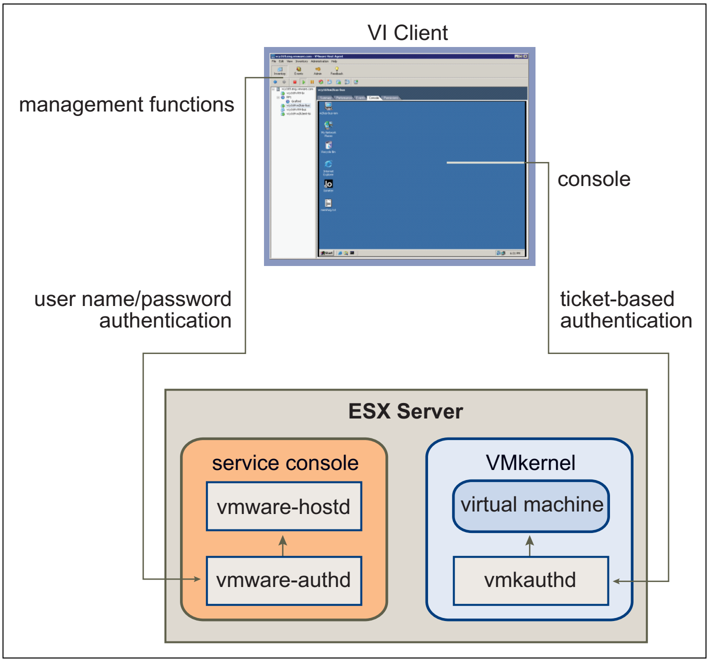


Figure 11-1. Authentication for VI Client Communications with ESX Server

The `vmware-authd` process exits as soon as a connection to a VMware process like `vmware-hostd` is established. Each virtual machine authentication process shuts down after the last user disconnects.

ESX Server transactions with VI Web Access and third-party network management clients interact directly with the `vmware-hostd` process during authentication. These management tools bypass the `vmware-authd` process.

To make sure that authentication works efficiently for your site, you might need to perform basic tasks such as setting up users, groups, permissions, and roles, configuring user attributes, adding your own certificates, determining whether you want to use SSL, and so forth. You can learn more about these issues and tasks in this section, which covers the following topics:

- "About Users, Groups, Permissions, and Roles" on page 213
- "Working with Users and Groups on ESX Server Hosts" on page 219
- "Encryption and Security Certificates for ESX Server" on page 227
- "Virtual Machine Delegates for NFS Storage" on page 232

About Users, Groups, Permissions, and Roles

Access to an ESX Server host and its resources is granted when a known user with appropriate permissions logs on to the host with a password that matches the one stored for that user. VirtualCenter uses a similar approach when determining whether to grant access to a user. VirtualCenter and ESX Server hosts determine the level of access for the user based on the permissions assigned to the user. For example, one user might have permissions that allow him or her to create virtual machines on the host and another user might have permissions that allow him or her to power on virtual machines but not create them.

The combination of user name, password, and permissions is the mechanism by which VirtualCenter and ESX Server hosts authenticate a user for access and authorize the user to perform activities. To support this mechanism, the VirtualCenter and ESX Server host maintain lists of authorized users, their passwords, and the permissions assigned to each user. VirtualCenter and ESX Server hosts deny access under the following circumstances:

- A user not in the user list attempts to log on.
- A user enters the wrong password.
- A user is in the list but has not been assigned permissions.
- A user who successfully logged on attempts operations that he or she does not have permission to perform.

As part of managing ESX Server hosts and VirtualCenter, you need to develop user and permission models, which are basic plans for how you want to handle particular types of users and how you want to design your permissions. In developing your user and permission models, be aware that:

- ESX Server and VirtualCenter use sets of privileges, or *roles*, to control which operations individual users or groups can perform. ESX Server and VirtualCenter provide you with a set of pre-established roles, but you can also create new ones.
- You can manage users more easily by assigning them to groups. If you create groups, you can apply a role to the group, and this role is inherited by all the users in the group.

Understanding Users

A user is an individual authorized to log on to either an ESX Server host or to VirtualCenter. ESX Server users fall into two categories: those who can access the ESX Server host through VirtualCenter and those who can access the ESX Server host by directly logging on to the host from the VI Client, VI Web Access, a third-party client, or a command shell. These two categories draw users from different sources.

- **VirtualCenter users** – Authorized users for VirtualCenter are those included in the Windows domain list referenced by VirtualCenter or are local Windows users on the VirtualCenter host.

  You cannot use VirtualCenter to manually create, remove, or otherwise change users. To manipulate the user list or change user passwords, you must do so through the tools you use to manage your Windows domain.

  Any changes you make to the Windows domain are reflected in VirtualCenter. However, because you cannot directly manage users in VirtualCenter, the user interface doesn't provide a user list for you to review. The only time you work with user and group lists is when you select users and groups during role assignment. You will notice these changes only when you select users in order to configure permissions.

- **Direct access users** – Users authorized to work directly on an ESX Server host are those added to the internal user list by default when ESX Server is installed or by a system administrator after installation.

  If you log on to the host as an administrator, you can perform a variety of management activities for these users, such as changing passwords, group memberships, permissions, and so forth. You can also add and remove users.

The user list maintained by VirtualCenter is completely separate from the user list maintained by the ESX Server host. Even if the lists maintained by a host and VirtualCenter appear to have common users (for instance, a user called *devuser*), these users should be treated as separate users who happen to have the same name. The attributes of *devuser* in VirtualCenter, including permissions, passwords, and so forth are separate from the attributes of *devuser* on the ESX Server host. If you log on to VirtualCenter as *devuser*, you might have permission to view and delete files from a datastore, whereas if you log on to an ESX Server host as *devuser*, you might not.

Because of the confusion that duplicate naming can cause, VMware recommends that you check the VirtualCenter user list before you create ESX Server host users so that you can avoid creating host users that have the same name as VirtualCenter users. To check for VirtualCenter users, review the Windows domain list.

Understanding Groups

You can more efficiently manage some user attributes by creating groups. A group is a set of users that you want to manage through a common set of rules and permissions. When you assign permissions to a group, they are inherited by all users in the group, and you do not have to work with the user profiles one by one. Therefore, using groups can significantly reduce the time it takes to set up your permissions model and improve future scalability.

As an administrator, you need to decide how to structure groups to achieve your security and usage goals. For example, three part-time sales team members work different days, and you want them to share a single virtual machine but not use the virtual machines belonging to sales managers. In this case, you might create a group called *SalesShare* that includes the three sales people: *Mary*, *John*, and *Tom*. You might then give the *SalesShare* group permission to interact with only one object, *Virtual Machine A*. *Mary*, *John*, and *Tom* inherit these permissions and are able to power up *Virtual Machine A*, start console sessions on *Virtual Machine A*, and so forth. They cannot perform these actions on the sales managers' virtual machines: *Virtual Machines B*, *C*, and *D*.

The group lists in VirtualCenter and an ESX Server host are drawn from the same sources as their respective user lists. If you are working through VirtualCenter, the group list is called from the Windows domain. If you are logged on to an ESX Server host directly, the group list is called from a table maintained by the host. All the recommendations for how you treat group lists are the same as those for user lists.

Understanding Permissions

For ESX Server and VirtualCenter, permissions are defined as access roles that consist of a user and the user's assigned role for an object such as a virtual machine or ESX Server host. Permissions grant users the right to perform specific activities and manage specific objects on an ESX Server host or, if users are working from VirtualCenter, all VirtualCenter-managed objects. For example, to configure memory for an ESX Server host, you must have a permission that grants host configuration privileges.

Most VirtualCenter and ESX Server users have limited ability to manipulate the objects associated with the host. However, ESX Server provides full access rights and permissions on all virtual objects, such as datastores, hosts, virtual machines, and resource pools, to two users—root and, if the host is under VirtualCenter management, vpxuser. Root and vpxuser have the following permissions:

- **root** – The root user can perform a complete range of control activities on the specific ESX Server host that he or she is logged on to, including manipulating permissions, creating groups and users, working with events, and so forth. A root user logged on to one ESX Server host cannot control the activities of any other host in the broader ESX Server deployment.

For security reasons, you might not want to use the root user in the Administrator role. In this case, you can change permissions after installation so that the root user no longer has administrative privileges or you can delete the root user's access permissions altogether through the VI Client as described in the "Managing Users, Groups, Permissions, and Roles" chapter of *Basic System Administration*. If you do so, you must first create another permission at the root level that has a different user assigned to the Administrator role.

Assigning the Administrator role to a different user helps you maintain security through traceability. The VI Client logs all actions initiated by the Administrator role user as events, providing you with an audit trail. You can use this feature to improve accountability among the various users who act as administrators for the host. If all the administrators log on to the host as the root user, you cannot tell which administrator performed an action. If, instead, you create multiple permissions at the root level—each associated with a different user or user group—you can track the actions of each administrator or administrative group.

After you create an alternative Administrator user, you can safely delete the root user's permissions or change its role to limit its privileges. If you delete or change the root user's permissions, you must use the new user you created as the host authentication point when you bring the host under VirtualCenter management. For more information on roles, see "Understanding Roles" on page 217.

NOTE Configuration commands that you run through the command line interface (`esxcfg` commands) do not perform an access check.

- **vpxuser** – This user is VirtualCenter acting as an entity with Administrator rights on the ESX Server host, allowing it to manage activities for that host. vpxuser is created at the time that an ESX Server host is attached to VirtualCenter. It is not present on the ESX Server host unless the host is being managed through VirtualCenter.

  When an ESX Server host is managed through VirtualCenter, VirtualCenter has privileges on the host. For example, VirtualCenter can move virtual machines to and from hosts and perform configuration changes needed to support virtual machines.

  The VirtualCenter administrator, through vpxuser, can perform most of the same tasks on the host as the root user and also schedule tasks, work with templates, and so forth. However, there are certain activities you cannot perform as a VirtualCenter administrator. These activities, which include directly creating, deleting, or editing users and groups for ESX Server hosts, can be performed only by a user with Administer permissions directly on each ESX Server host.

CAUTION Do not change vpxuser in any way and do not change its permissions. If you do so, you might experience problems in working with the ESX Server host through VirtualCenter.

If you are acting in the Administrator role on and ESX Server host, you can grant permissions on the host to individual users or groups that have been added to the ESX Server user list and group list by default when ESX Server was installed or because they were manually added to the host after installation. If you are acting in the Administrator role in VirtualCenter, you can grant permissions to any user or group included in the Windows domain list referenced by VirtualCenter.

NOTE VirtualCenter registers any selected Windows domain user or group through the process of assigning permissions. By default, all users who are members of the local Windows Administrators group on the VirtualCenter Server are granted the same access rights as any user assigned to the Administrator role. Users who are members of the Administrators group can log on as individuals and have full access.

The method you use to configure permissions directly on an ESX Server host is identical to the method you use to configure permissions in VirtualCenter. Also, the list of privileges is the same for both ESX Server and VirtualCenter. For information on configuring permissions and to read about the privileges you can assign, see the *Introduction to Virtual Infrastructure*.

Understanding Roles

VirtualCenter and ESX Server grant access to objects only to users who have been assigned permissions for the object. When you assign a user or group permissions for the object, you do so by pairing the user or group with a role. A role is a pre-defined set of privileges.

ESX Server hosts provide three default roles, and you cannot change the privileges associated with these roles. Each subsequent default role includes the privileges of the previous role. For example, the Administrator role inherits the privileges of the Read Only role. Roles you create yourself do not inherit privileges from any of the default roles. The default roles are:

- **No Access** – Users assigned this role for an object cannot view or change the object in any way. For example, a user who has a No Access role for a particular virtual machine cannot see the virtual machine in the VI Client inventory when he or she logs on to the ESX Server host. With a No Access role for a particular object, a user can select the VI Client tabs associated with the no-access object, but the tab displays no content. For example, if the user doesn't have access to any virtual machines, he or she can select the Virtual Machines tab but won't see a virtual machine listing on the tab or any status information—the table is blank.

The No Access role is the default assigned to any user or group you create on an ESX Server host. You can elevate or lower a newly created user's or group's role on an object-by-object basis.

NOTE The root user and vpxuser are the only users not assigned the No Access role by default. Instead, they are assigned the Administrator role. Do not change the role for these users.

You can delete the root user's permissions altogether or change its role to No Access as long as you first create a replacement permission at the root level with the Administrator role and associate this role with a different user. If you delete or change the root user's permissions, you must use the new user you created as the host authentication point when you bring the host under VirtualCenter management.

- **Read Only** – Users assigned this role for an object are allowed to view the state of the object and details about the object.

  With this role, a user can view virtual machine, host, and resource pool attributes. The user cannot view the remote console for a host. All actions through the menus and toolbars are disallowed.

- **Administrator** – Users assigned this role for an object are allowed to view and perform all actions on the object. This role also includes all permissions inherent in the Read Only role.

You can create custom roles by using the role-editing facilities in the VI Client to create privilege sets that match your user needs. If you use the VI Client connected to VirtualCenter to manage your ESX Server hosts, you have additional roles to choose from in VirtualCenter. Also, the roles you create directly on an ESX Server host are not accessible within VirtualCenter. You can work with these roles only if you log on to the host directly from the VI Client.

If you manage ESX Server hosts through VirtualCenter, be aware that maintaining custom roles in both the host and VirtualCenter can result in confusion and misuse. In this type of configuration, VMware recommends that you maintain custom roles only in VirtualCenter. For information on creating, altering, and deleting roles as well as a discussion of additional roles available in VirtualCenter, see *Basic System Administration*.

Working with Users and Groups on ESX Server Hosts

If you are directly connected to an ESX Server host through the VI Client, you can create, edit, and delete users and groups. These users and groups are visible in the VI Client whenever you log on to the ESX Server host but are not available if you log on to VirtualCenter.

The following section explains how to work with users and groups in the VI Client directly connected to an ESX Server host. The section covers basic tasks you can perform for users and groups, such as viewing and sorting information and exporting reports. It also shows you how to create, delete, and edit users and groups.

NOTE You can also create roles and set permissions through a direct connection to the ESX Server host. Because these tasks are more widely performed in VirtualCenter, see the *Introduction to Virtual Infrastructure* for information on working with permissions and roles.

Viewing and Exporting Users and Group Information

You work with users and groups through the **Users & Groups** tab in the VI Client. This tab displays a **Users** table or **Groups** table depending on whether you click the **Users** button or **Groups** button.

Figure 11-2 shows the **Users** table. The **Groups** table is similar.

UID	User	Name
0	root	root
1	bin	bin
2	daemon	daemon
3	adm	adm
4	lp	lp
5	sync	sync
6	shutdown	shutdown
7	halt	halt
8	mail	mail
9	news	news
10	uucp	uucp
11	operator	operator
12	games	games
13	gopher	gopher
14	ftp	FTP User
28	nscd	NSCD Daemon

Figure 11-2. Users Table

You can sort the lists according to column, show and hide columns, and export the list in formats you can use when preparing reports or publishing user or group lists on the Web.

To view and sort ESX Server users or groups

1 Log on to the VI Client through the ESX Server host.

2 Select the server from the inventory panel.

The hardware configuration page for this server appears.

3 Click the **Users & Groups** tab and click **Users** or **Groups**.

4 Perform any of these actions as appropriate:

- To sort the table by any of the columns, click the column heading.
- To show or hide columns, right-click any of the column headings and deselect or select the name of the column you want to hide.

To export data in the ESX Server Users or Groups table

1 Log on to the VI Client through the ESX Server host.

2 Select the server from the inventory panel.

The hardware configuration page for this server appears.

3 Click the **Users & Groups** tab and click **Users** or **Groups**.

4 Determine how you want the table sorted, and hide or show columns according to the information you want to see in the exported file.

5 Right-click anywhere in the user table and click **Export** to open the **Save As** dialog box.

6 Select a path and enter a filename.

7 Select the file type.

You can export the user or group table in any of the following formats:

- HTML (plain HTML or HTML formatted for use with a CSS style sheet)
- XML
- Microsoft Excel
- CSV (Comma Separated Values)

8 Click **OK**.

Working with the Users Table

You can add users to the **Users** table for an ESX Server host, remove users, and change various user attributes such as password and group memberships. When you perform these activities, you are altering the internal user list maintained by the ESX Server host.

To add a user to the ESX Server Users table

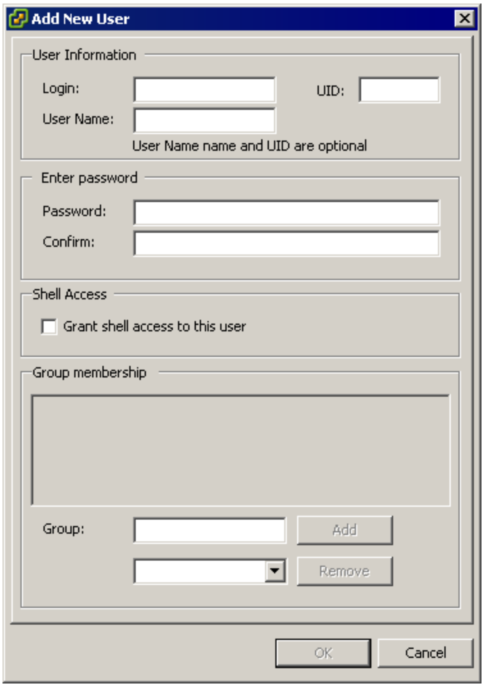
1 Log on to the VI Client through the ESX Server host.

2 Select the server from the inventory panel.

The hardware configuration page for this server appears.

3 Click the **Users & Groups** tab and click **Users**.

4 Right-click anywhere in the **Users** table and click **Add** to open the **Add New User** dialog box.



5 Enter a login, a user name, a numeric user ID (UID), and a password.

Specifying the user name and UID are optional. If you don't specify the UID, the VI Client assigns the next available UID.

The password should meet the length and complexity requirements outlined in "Password Restrictions" on page 243. However, the ESX Server host checks for password compliance only if you have switched to the `pam_passwdqc.so` plugin for authentication. The password settings in the default authentication plugin, `pam_cracklib.so`, are not enforced.

6. If you want the user to be able to access the ESX Server host through a command shell, select **Grant shell access to this user**.

   In general, you should not grant shell access to ESX Server host users unless you determine that they have a justifiable need to access the host through a shell rather than through the VI Client. Users that access the host only through the VI Client do not need shell access.

7. For each existing group you want the user to be part of, enter the group name and click **Add**.

   If you type a nonexistent group name, the VI Client warns you and does not add the group to the **Group membership** list.

8. Click **OK**.

The login and user name you entered now appear in the **Users** table. The VI Client assigns the next available user ID to the user.

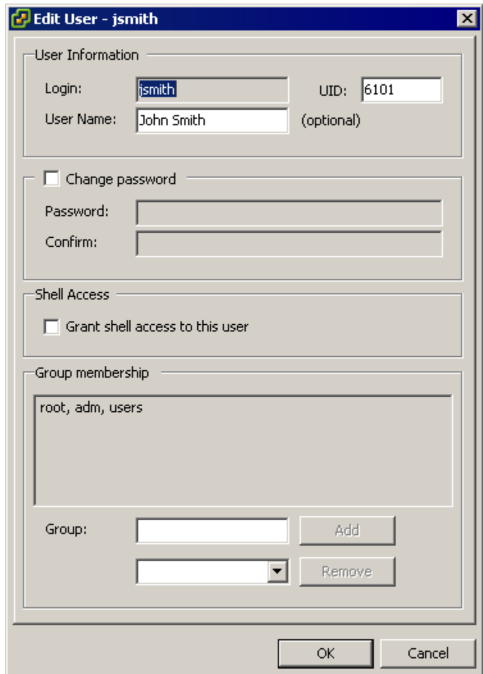
To modify the settings for a user

1. Log on to the VI Client through the ESX Server host.
2. Select the server from the inventory panel.

   The hardware configuration page for this server appears.

3. Click the **Users & Groups** tab and click **Users**.

4 Right-click anywhere in the **Users** table and click **Edit** to open the **Edit User** dialog box.



5 To change the user ID, enter a numeric user UID in the **UID** field.

The VI Client assigns the UID when you first create the user. In most cases, this assignment doesn't need to be changed.

6 Enter a new user name.

7 To change the user's password, select **Change Password** and enter the new password.

The password should meet the length and complexity requirements outlined in "Password Restrictions" on page 243. However, the ESX Server host checks for password compliance only if you have switched to the `pam_passwdqc.so` plugin for authentication. The password settings in the default authentication plugin, `pam_cracklib.so`, are not enforced.

8 To change the user's ability to access the ESX Server host through a command shell, select or deselect **Grant shell access to this user**.

9 To add the user to another group, enter the group name and click **Add**.

If you type a nonexistent group name, the VI Client warns you and does not add the group to the **Group membership** list.

10. To remove the user from a group, select the group name from the list and click **Remove**.
11. Click **OK**.

To remove a user from the ESX Server Users table

1. Log on to the VI Client through the ESX Server host.
2. Select the server from the inventory panel.

   The hardware configuration page for this server appears.
3. Click the **Users & Groups** tab and click **Users**.
4. Right-click the user you want to remove and click **Remove**.

CAUTION Do **not** remove the root user.

Working with the Groups Table

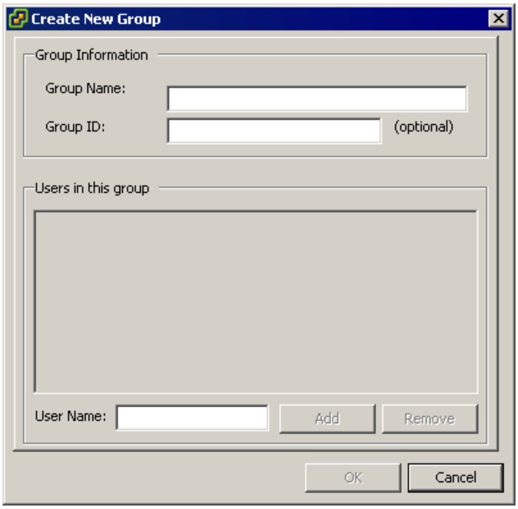
You can add groups to the **Groups** table for an ESX Server host, remove groups, and add or remove group members. When you perform these activities, you are altering the internal group list maintained by the ESX Server host.

To add a group to the ESX Server Groups table

1. Log on to the VI Client through the ESX Server host.
2. Select the server from the inventory panel.

   The hardware configuration page for this server appears.
3. Click the **Users & Groups** tab and click **Groups**.

4 Right-click anywhere in the **Groups** table and click **Add** to open the **Create New Group** dialog box.



5 Enter a group name and numeric group ID (GID).

Specifying the GID is optional. If don't specify a GID, the VI Client assigns the next available group ID.

6 For each user that you want as a group member, enter the user name and click **Add**.

If you type a nonexistent user name, the VI Client warns you and does not add the user to the **Users in this group** list.

7 Click **OK**.

The group ID and group name you entered now appear in the **Groups** table.

To add or remove users from a group

1 Log on to the VI Client through the ESX Server host.

2 Select the server from the inventory panel.

The hardware configuration page for this server appears.

3 Click the **Users & Groups** tab and click **Groups**.

4 Right-click anywhere in the **Groups** table and click **Properties** to open the **Edit Group** dialog box.

5 To add a user to the group, enter the user name and click **Add**.

If you type an nonexistent group name, the VI Client warns you and does not add the user to the **Users in this group** list.

6 To remove a user from the group, select the user name from the list and click **Remove**.

7 Click **OK**.

To remove a group from the ESX Server Groups table

1 Log on to the VI Client through the ESX Server host.

2 Select the server from the inventory panel.

The hardware configuration page for this server appears.

3 Click the **Users & Groups** tab and click **Groups**.

4 Right-click the group you want to remove and click **Remove**.

CAUTION Do **not** remove the root group.

Encryption and Security Certificates for ESX Server

All network traffic including user names passwords sent to an ESX Server host over a network connection from VirtualCenter or VI Web Access pass through port 902 or 443 respectively, and are encrypted in ESX Server by default as long as the following conditions are true:

- SSL is enabled.
- You have not changed the Web proxy service to allow unencrypted traffic for the port.
- Your service console firewall is configured for medium or high security. For information on configuring the service console firewall, see "Service Console Firewall Configuration" on page 239.

CAUTION If you disable your firewall by configuring it for low security, users can access the ESX Server host through port 8080, an insecure port. Anyone who connects to the ESX Server host through port 8080 using an authorized user name and password has access to the services on the host.

Security certificates used for encryption are created by ESX Server and stored on the host. The certificates used to secure your VirtualCenter and VI Web Access sessions are not signed by a trusted certificate authority and, therefore, do not provide the authentication security you might need in a production environment. For example, self-signed certificates are vulnerable to man-in-the-middle attacks. If you intend to use encrypted remote connections externally, consider purchasing a certificate from a trusted certificate authority or use your own security certificate for your SSL connections.

The default location for your certificate is `/etc/vmware/ssl/` on the ESX Server host. The certificate consists of two files: the certificate itself (`rui.crt`) and the private key file (`rui.key`).

Adding Certificates and Modifying ESX Server Web Proxy Settings

In adding certificates for ESX Server and thinking about encryption and user security, be aware of the following:

- ESX Server doesn't handle pass phrases, also known as encrypted keys. If you set up a pass phrase, ESX Server processes will be unable to start correctly, so avoid setting up certificates using pass phrases.

- You can configure the Web proxy so that it searches for certificates in a location other than the default location. This capability proves useful for companies that prefer to centralize their certificates on a single machine so the certificates can be used by multiple hosts.

CAUTION If you store certificates in a location other the ESX Server host, you will be unable to use the certificates if the host loses network connectivity with the machine storing the certificates.

- To support encryption for user names, passwords, and packets, SSL is enabled by default for VI Web Access and Web SDK connections. If you want to configure the these connections so that they don't encrypt transmissions, disable SSL for your VI Web Access connection or Web SDK connection by switching the connection from HTTP to HTTPS as described in "To change security settings for a Web proxy service" on page 229. Consider disabling SSL only if you have created a fully trusted environment for these clients, meaning that firewalls are in place and transmissions to and from the host are fully isolated. Disabling SSL can improve performance for VI Web Access because you avoid the overhead required to perform encryption.
- To protect against misuse of ESX Server services such as the internal Web server that hosts VI Web Access, most internal ESX Server services are accessible only through port 443, the port used for HTTPS transmission. Port 443 acts as a reverse proxy for ESX Server. You can see a list of services on ESX Server through an HTTP welcome page, but you can't directly access these services without proper authorization. You can change this configuration so that individual services are directly accessible through HTTP connections. VMware recommends that you not make this change unless you are using ESX Server in a fully trusted environment.
- When you upgrade VirtualCenter and VI Web Access, the certificate remains in place. If you remove VirtualCenter and VI Web Access, the certificate directory is not removed from the service console.

To configure the Web proxy to search for certificates in nondefault locations

1. Log on to the service console as the root user.
2. Change directories to `/etc/vmware/hostd/`.
3. Use nano or another text editor to open the proxy`.xml` file and find the following XML segment:

```
<ssl>
   <!-- The server private key file -->
   <privateKey>/etc/vmware/ssl/rui.key</privateKey>
   <!-- The server side certificate file -->
```

```
   <certificate>/etc/vmware/ssl/rui.crt</certificate>
</ssl>
```

4 Replace /etc/vmware/ssl/rui.key with the absolute path to the private key file that you received from your trusted certificate authority.

This path can be on the ESX Server host or on a centralized machine on which you store certificates and keys for your company.

NOTE Leave the <privateKey> and </privateKey> XML tags in place.

5 Replace /etc/vmware/ssl/rui.crt with the absolute path to the certificate file that you received from your trusted certificate authority.

CAUTION Do not delete the original rui.key and rui.crt files. These files are used by the ESX Server host.

6 Save your changes and close the file.

7 Enter the following command to restart the vmware-hostd process:

```
service mgmt-vmware restart
```

To change security settings for a Web proxy service

1 Log on to the service console as the root user.

2 Change directories to /etc/vmware/hostd/.

3 Use nano or another text editor to open the proxy.xml file and find the following XML segment:

```
<proxysvc>
   <path>/usr/lib/vmware/hostd/libproxysvc.so</path>
   <http>
      <port>80</port>
      <proxyDatabase>
         <server id="0">
            <namespace> / </namespace>
            <host> localhost </host>
            <port> 9080 </port>
         </server>
         <redirect id="0"> /ui </redirect>
         <redirect id="1"> /mob </redirect>
         <redirect id="2"> /sdk </redirect>
      </proxyDatabase>
   </http>
   <https>
      <port>443</port>
```

```
      <proxyDatabase>
         <server id="0">
            <namespace> / </namespace>
            <host> localhost </host>
            <port> 9080 </port>
         </server>
         <server id="1">
            <namespace> /sdk </namespace>
            <host> localhost </host>
            <port> 8085 </port>
         </server>
         <server id="2">
            <namespace> /ui </namespace>
            <host> localhost </host>
            <port> 8080 </port>
         </server>
         <server id="3">
            <namespace>/mob</namespace>
            <host>localhost</host>
            <port>8087</port>
         </server>
      </proxyDatabase>
   /https>
</proxysvc>
```

4 For every HTTPS service that you want to access using HTTP, move the following segment up to the HTTP area:

```
<server id="id_number">
   <namespace> service_domain </namespace>
   <host> localhost </host>
   <port> port_number </port>
</server>
```

Where:

- `id_number` is an ID number for the server ID XML tag. ID numbers must be unique within the HTTP area.
- `service_domain` is the name of the service you are moving, for example `/sdk` or `/mob`.
- `port_number` is the port number assigned to the service. You can assign a different port number to the service.

5 In the HTTP section, remove the redirect statement for the service you are moving.

6 Save your changes and close the file.

7 Enter the following command to restart the `vmware-hostd` process:

```
service mgmt-vmware restart
```

To move an HTTP service to the HTTPS section, use the same procedure but add a redirect statement to the HTTP section after you move the service. Place the new redirect statement after the other redirect statements and use a unique number as the ID number for the redirect tag.

Example: Setting up VI Web Access to communicate through an insecure port

VI Web Access normally communicates with an ESX Server host through a secure port (HTTPS, 443). If you are in a fully trusted environment, you might decide that you can use an insecure port (for example, HTTP, 80). To do so, change the proxy services area of the `/etc/vmware/hostd/proxy.xml` file as described in the procedure. The result is as follows, with changed and moved areas shown in bold. Note that the server segment for `/ui` (the VI Web Access service) is moved to the HTTP section and the redirect statement for `/ui` has been removed.

```
<proxysvc>
   <path>/usr/lib/vmware/hostd/libproxysvc.so</path>
   <http>
      <port>80</port>
      <proxyDatabase>
         <server id="0">
            <namespace> / </namespace>
            <host> localhost </host>
            <port> 9080 </port>
         </server>
         <server id="1">
            <namespace> /ui </namespace>
            <host> localhost </host>
            <port> 8080 </port>
         </server>
         <redirect id="0"> /mob </redirect>
         <redirect id="1"> /sdk </redirect>
      </proxyDatabase>
   </http>
   <https>
      <port>443</port>
      <proxyDatabase>
         <server id="0">
            <namespace> / </namespace>
            <host> localhost </host>
            <port> 9080 </port>
         </server>
         <server id="1">
            <namespace> /sdk </namespace>
            <host> localhost </host>
            <port> 8085 </port>
         </server>
         <server id="2">
            <namespace>/mob</namespace>
```

```
                <host>localhost</host>
                <port>8087</port>
            </server>
        </proxyDatabase>
    </https>
</proxysvc>
```

Regenerating Certificates

The ESX Server host generates certificates when you first start the host after installation. Thereafter, whenever you restart the vmware-hostd process, the vmware-mgmt script searches for existing certificate files (rui.crt and rui.key) and, if it can't find them, generates new certificate files.

Under certain circumstances, you might need to force ESX Server host to generate new certificates. You typically need to generate new certificates only if:

- You change the host name.
- You accidentally delete the certificates.

To generate new Certificates for the ESX Server host

1 Change directories to /etc/vmware/ssl.

2 Create backups of any existing certificates by executing the following commands:

```
mv rui.crt orig.rui.crt
               mv rui.key orig.rui.key
```

NOTE If you are regenerating certificates because you accidentally deleted your certificates, you do not need to complete the backup step.

3 Enter the following command to restart the vmware-hostd process:

```
service mgmt-vmware restart
```

4 Confirm that the ESX Server host generated new certificates by executing the following command comparing the time stamps of the new certificate files with orig.rui.crt and orig.rui.key:

```
ls -la
```

Virtual Machine Delegates for NFS Storage

To perform most activities on virtual machines, an ESX Server needs access to virtual machine files. For instance, to power on and off virtual machines the ESX Server must be able to create, manipulate, and delete files on the volume that is storing the virtual disk files.

If you are creating, configuring, or administering virtual machines on an NFS datastore you do so through a special user, known as the delegate user. The delegate user's identity is used by the ESX Server for all I/O requests issued to the underlying file system.

By default, the delegate user for the ESX Server host is `root`. However, having `root` as the delegate user may not work for all NFS datastores. NFS administrators may export volumes with root squashing enabled. The `root squash` feature maps root to a user with no significant privileges on the NFS server, limiting the root user's abilities. This feature is commonly used to prevent unauthorized access to files on an NFS volume. If the NFS volume was exported with `root squash` enabled, the NFS server might refuse access to the ESX Server host. To ensure that you can create and manage virtual machines from your host, the NFS administrator must turn off the `root squash` feature or add the ESX Server host’s physical network adapter to the list of trusted servers.

If the NFS administrator is unwilling to take either of these actions, you can change the delegate user to a different identity through experimental ESX Server functionality. This identity must match the owner of the directory on the NFS server otherwise the ESX Server host will be unable to perform file level operations. To set up a different identity for the delegate user, acquire the following information:

- User name of the directory owner
- User ID (UID) of the directory owner
- Group ID (GID) of the directory owner

Then, use this information to change the delegate user setting for the ESX Server host so that it matches the owner of the directory, enabling NFS datastore to recognize the ESX Server host correctly. The delegate user is configured globally, and the same identity is used to access to every volume.

Setting up the delegate user on an ESX Server host requires that you complete these activities:

- From the Users & Groups tab for a VI Client running directly on the ESX Server host, either:
  - Edit the user named `vimuser` to add the correct UID and GID. `vimuser` is an ESX Server host user provided to you as a convenience for setting up delegate users. By default, `vimuser` has a UID of 12 and a GID of 20.
  - Add a completely new user to the ESX Server host with the delegate user name, UID, and GID.

  You must perform one of these steps regardless of whether you manage the host through a direct connection or through the VirtualCenter Server. Also, you need to make sure that the delegate user (`vimuser` or a delegate user you create) is identical across all ESX Server hosts that use the NFS datastore. For information on adding users, see "Working with the Users Table" on page 221.

- Configure a virtual machine delegate as part of the security profile for the host, as described in the procedure that follows.

  You configure the security profile through VirtualCenter or through a VI Client running directly on the ESX Server host. Performing this task through VirtualCenter is more efficient because you can work through each host one-by-one in the same session. In this case, the users that can access NFS volumes are those that are in the Windows domain.

WARNING Changing the delegate user for an ESX Server host is experimental and, currently, VMware does not support this implementation. Use of this functional may result in unexpected behavior.

To change the virtual machine delegate

1 Log on to the VI Client through the ESX Server host.

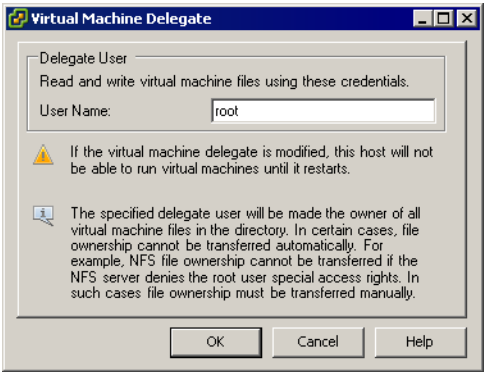
2 Select the server from the inventory panel.

The hardware configuration page for this server appears with the Summary tab displayed.

3 Click **Enter Maintenance Mode**.

4 Click the Configuration tab and click **Security Profile**.

5 Click **Virtual Machine Delegate** > **Edit** to open the **Virtual Machine Delegate** dialog box.



6 Enter the user name for the delegate user.

7 Click **OK**.

8 Reboot the ESX Server host.

After you reboot the host, the delegate user setting is visible in both VirtualCenter and the VI Client running directly on the ESX Server host.

Service Console Security 12

This chapter makes basic security recommendations for using the service console and explains some of the service console's built-in security features. The service console is a management interface to ESX Server and, as such, its security is critical. To protect the service console against unauthorized intrusion and misuse, VMware imposes constraints on several service console parameters, settings, and activities.

These constraints are designed to raise the security level for ESX Server. You can loosen them to meet your particular configuration needs, but if you do so, make sure you are working in a trusted environment and have taken enough other security measures to protect the network as a whole and the devices connected to the ESX Server host.

This chapter covers the following topics:

General Security Recommendations

Consider the following recommendations when evaluating service console security and administering the service console:

- **Install antivirus software.**

  Even though you can run an ESX Server host without connecting the service console to any network, most implementations allow network access to the service console. Because the service console is a full operating system, you should protect it from viruses, just as you would a standard operating system or virtual machine at your site. If you're already using Linux antivirus software in your organization, you can install the same antivirus software on the service console. You can also install third-party intrusion and root kit detection software such as Tripwire.

NOTE Antivirus software can affect performance. If you are confident that the ESX Server host is operating in a fully trusted environment, you can balance the need for this security measure against performance costs.

- **Limit user access.**

  To improve security, restrict user access to the service console and enforce access security policies like setting up password restrictions—for example, character length, password aging limits, and use of a `grub` password for booting the host.

  The service console has privileged access to certain parts of ESX Server. Therefore, only trusted users should be provided logon access. By default, root access is limited by not allowing secure shell (SSH) logon as root, and you should strongly consider keeping this default. ESX Server system administrators should be required to log on as regular users and then use `sudo` to perform specific tasks that require root privileges.

  Also, try to run as few processes on the service console as possible. Ideally, you should strive to run only the processes, services, and agents that you absolutely need such as virus checkers, virtual machine backups, and so forth.

- **Use VI Client to administer your ESX Server hosts.**

  Whenever possible, use VI Client, VI Web Access, or a third-party network management tool to administer your ESX Server hosts instead of working though the command line interface as root. Using VI Client lets you limit the accounts with access to the service console, safely delegate responsibilities, and set up roles that prevent administrators and users from using capabilities they don’t need.

- **Use only VMware sources to upgrade ESX Server components you run on the service console.**

  The service console runs a variety of third-party packages such as the Tomcat Web service to support management interfaces or tasks that you need to perform. VMware does not support upgrading these packages from anything other than a VMware source. If you use a download or patch from another source, you might compromise service console security or functions. Regularly check third-party vendor sites and the VMware knowledge base for security alerts.

Logging On to the Service Console

Although you perform most ESX Server configuration activities through the VI Client, you use the service console command-line interface when configuring certain security features. Using the command line interface requires that you log on to the host. If you have direct access to the ESX Server host, you can log on to the physical console on that machine. To do so, press Alt-F2 to open the login screen. For remote connections, use SSH or another remote console connection to start a session on the host.

Whether you access the service console locally or through a remote connection such as SSH, you must log on using a user name and password recognized by the ESX Server host. For information on user names and passwords for ESX Server hosts, see "Working with Users and Groups on ESX Server Hosts" on page 219.

If you are logging onto the host to perform activities that require root privileges, you should log on to the service console as a recognized user and acquire root privileges through the `su` command or, preferably, the `sudo` command. The `sudo` command enhances security because it grants root privileges only for select activities in contrast to the `su` command, which grants root privileges for all activities. Using `sudo` also provides superior accountability because all `sudo` activities are logged, whereas if you use `su`, ESX Server only logs the fact that the user switched to root by way of `su`.

In addition to ESX-specific commands, you can use the service console command-line interface to execute many Linux and Unix commands. For detailed usage notes on service console commands, use the `man <command_name>` command to check for man pages.

Service Console Firewall Configuration

ESX Server includes a firewall between the service console and the network. To ensure the integrity of the service console, VMware has reduced the number of firewall ports that are open by default. At installation time, the service console firewall is configured to block all incoming and outgoing traffic except for that on ports 902, 80, 443, and 22, which are used for basic communication with ESX Server. This setting enforces a high level of security for your ESX Server host.

NOTE The firewall also allows Internet Control Message Protocol (ICMP) pings and communication with DHCP and DNS (UDP only) clients.

In trusted environments, you might decide that a lower security level is acceptable. If so, you can set the firewall for either medium or low security:

- **Medium security** – All incoming traffic is blocked except on the default ports (902, 433, 80, and 22) and any ports you specifically open. Outgoing traffic is not blocked.
- **Low security** – There are no blocks on either incoming or outgoing traffic. This setting is equivalent to removing the firewall.

Because the ports open by default are strictly limited, you might need to open additional ports after installation. For a list of commonly used ports you might need to open, see "TCP and UDP Ports for Management Access" on page 187.

Be aware that as you add the supported services and management agents required to operate ESX Server effectively, you open other ports in the service console firewall. You add services and management agents through VirtualCenter as described in "Opening Firewall Ports for Supported Services and Management Agents" on page 192.

In addition to the ports you open for these services and agents, you might need to open other ports when you configure certain devices, services, or agents such as storage devices, backup agents, and management agents. For example, if you are using Veritas NetBackup™ 4.5 as a backup agent, you need to open ports 13720, 13724, 13782, and 13783, which NetBackup uses for client-media transactions, database backups, user backups or restores, and so forth. Refer to vendor specifications for the device, service, or agent to determine which ports to open.

The following discussion tells you how to change the service console security level and open ports for additional devices, services, and agents.

NOTE Each time you lower your security setting or open additional ports, you increase the risk of intrusion in your network. You should balance your access needs against how tightly you want to control the security of the network.

Changing the Service Console Security Level

Altering the security level for the service console is a two-part process: determining the service console firewall security level and resetting the service console firewall setting. To prevent unnecessary steps, always check the firewall setting before changing it.

To determine the service console firewall security level

1 Log on to the service console and acquire root privileges.

2 Execute these two commands to determine whether incoming and outgoing traffic is blocked or allowed:

```
esxcfg-firewall -q incoming
esxcfg-firewall -q outgoing
```

3 Interpret the results as follows:

Command Line Response	Security Level
`Incoming ports blocked by default.` `Outgoing ports blocked by default.`	High
`Incoming ports blocked by default.` `Outgoing ports not blocked by default.`	Medium
`Incoming ports not blocked by default.` `Outgoing ports not blocked by default.`	Low

To set the service console firewall security level

1 Log on to the service console and acquire root privileges.

2 Execute one of the following commands as applicable.

- To set the service console firewall to medium security:

  ```
  esxcfg-firewall --allowOutgoing --blockIncoming
  ```

- To set the virtual firewall to low security:

  ```
  esxcfg-firewall --allowIncoming --allowOutgoing
  ```

CAUTION Using the above command disables all firewall protection.

- To return the service console firewall to high security:

  ```
  esxcfg-firewall --blockIncoming --blockOutgoing
  ```

3 Execute the following command to restart the `vmware-hostd` process:

```
service mgmt-vmware restart
```

Changing the service console firewall security level does not affect existing connections. For example, if the firewall is set to low security and a backup is running on a port you didn't explicitly open, raising the firewall setting to high does not terminate the backup. Rather, because the firewall is configured to pass packets for previously established connections, the backup completes, releases the connection, and no further connections are accepted for the port.

Opening and Closing Ports in the Service Console Firewall

You can open service console firewall ports when you install third-party devices, services, and agents. Before you open ports to support the item you are installing, refer to vendor specifications to determine the necessary ports.

If you close a port, active sessions of the service associated with the port are not automatically disconnected when you close the port. For example, if a backup is executing and you close the port for the backup agent, the backup continues until it completes and the agent releases the connection.

Perform the following procedures only if you are opening or closing ports for services or agents not specifically configurable through the VI CLient. For information on configuring additional ports in VirtualCenter, see "Opening Firewall Ports for Supported Services and Management Agents" on page 192.

WARNING VMware supports opening and closing firewall ports only through the VI Client or the `esxcfg-firewall` command, as described below. Using any other methods or scripts to open and close firewall ports can lead to unexpected behavior.

To open a specific port in the service console firewall

1 Log on to the service console and acquire root privileges.

2 Execute this command:

```
esxcfg-firewall --openPort <port_number>,tcp|udp,in|out,<port_name>
```

Where:

- `port_number` is the vendor-specified port number.
- `tcp|udp` is the protocol. Select `tcp` for TCP traffic or `udp` for UDP traffic.
- `in|out` is the traffic direction. Select `in` to open the port for inbound traffic or `out` to open it for outbound traffic.
- `port_name` is a descriptive name. The name does not need to be unique, but it should be meaningful to help identify the service or agent using the port.

For example:

```
esxcfg-firewall --openPort 6380,tcp,in,Navisphere
```

3 Execute the following command to restart the `vmware-hostd` process:

```
service mgmt-vmware restart
```

To close a specific port in the service console firewall

1 Log on to the service console and acquire root privileges.

2 Execute this command:

```
esxcfg-firewall -closePort <port_number>,tcp|udp,in|out,<port_name>
```

The `port_name` argument is optional for `-closePort`.

For example:

```
esxcfg-firewall --closePort 6380,tcp,in
```

3 Execute the following command to restart the `vmware-hostd` process:

```
service mgmt-vmware restart
```

You can use the `-closepPort` option to close only those ports that you opened with the `-openPort` option. If you used a different method to open the port, you need to use an equivalent method to close it. For example, you can close the SSH port (22) only by disabling the SSH Server incoming connection and SSH Client outgoing connection in the VI Client. For information on opening and closing ports through the VI Client, see "Opening Firewall Ports for Supported Services and Management Agents" on page 192.

Password Restrictions

The ease with which an attacker can log on to an ESX Server host depends on his or her ability to find a legitimate user name/password combination. A malicious user can obtain a password in a number of ways. For example, an attacker can sniff insecure network traffic, such as Telnet or FTP transmissions, for successful logon attempts.

Another common method is to crack the password by running a password generator. Passwords generators are useful for mounting various kinds of password attacks, including brute force attacks, in which the generator tries every character combination up to a certain password length, and dictionary attacks, in which the generator tries real words and simple mutations of real words.

Implementing restrictions that govern the length, character sets, and duration of passwords can make attacks initiated by a password generator far more difficult. The longer and more complex the password, the harder it is for an attacker to discover. The more often users have to change passwords, the more difficult it is to find a password that works repeatably.

NOTE Always consider the human factor when deciding how to implement password restrictions. If you make passwords too hard to remember or enforce frequent password changes, your users might be inclined to write down their passwords, thus eliminating any benefit.

To help protect your password database from misuse, password shadowing is enabled for ESX Server so that password hashes are hidden from access. Also, ESX Server uses MD5 password hashes, which provide stronger password security and let you set minimum length requirements to more than 8 characters.

ESX Server provides password controls on two levels to help you enforce password policies for your users and limit the risk of password cracking:

- **Password aging** – These controls govern how long a user password can be active before the user is required to change it. They help ensure that passwords change often enough so that if an attacker obtains a password through sniffing or social engineering, he or she cannot keep accessing ESX Server indefinitely.
- **Password complexity** – These controls ensure that the users select passwords that are hard for password generators to determine.

Password Aging

To ensure that passwords don't stay active for long periods, ESX Server imposes the following password aging restrictions for user logons by default:

- **Maximum days** – (SEE UPDATE) The number of days that a user can keep a password before it needs to be changed. The default setting for ESX Server is 90 days. By default, the `root` account and other service accounts are exempt from the 90 day expiration.
- **Minimum days** – The minimum number of days between password changes. The default setting is 0, meaning that the users can change their passwords any time.
- **Warning time** – The number of days in advance of password expiration that ESX Server observes when issuing a password change reminder. The default setting is 7 days. Warnings are only displayed when logging directly onto the service console or when using SSH.

You can tighten or loosen any of these settings by executing `esxcfg-auth` command options. If you need to override the default password aging settings for an individual user, use the `chage` command.

To change default password aging restrictions for ESX Server

1. Log on to the service console and acquire root privileges.
2. Execute one or more of the following commands as applicable.
   - To change maximum number of days a user can keep a password:

     ```
     esxcfg-auth --passmaxdays=<number_of_days>
     ```

     Where `<number_of_days>` is the maximum number of days before password expiration.
   - To change minimum number of days between password changes:

     ```
     esxcfg-auth --passmindays=<number_of_days>
     ```

     Where `<number_of_days>` is the minimum number of days between password changes.
   - To change warning time before a password change:

     ```
     esxcfg-auth --passwarnage=<number_of_days>
     ```

     Where `<number_of_days>` is the number of days of advanced warning a user receives before a password change is due.

To override default password aging restrictions for individual users or groups

1. Log on to the service console and acquire root privileges.
2. Execute one or more of the following commands as applicable.
   - To specify a new maximum days value:

     ```
     chage -M <number_of_days> <username>
     ```
   - To specify a new minimum days value:

     ```
     chage -m <number_of_days> <username>
     ```
   - To specify a new warning time value:

     ```
     chage -W <number_of_days> <username>
     ```

     You can use the `man chage` command to learn about other `chage` options.

Password Complexity

By default, ESX Server uses the `pam_cracklib.so` plugin to set the rules that users must observe when creating passwords and to check password strength during the creation process.

The pam_cracklib.so plugin lets you determine the basic standards that all passwords must meet. By default, ESX Server imposes no restrictions on the root password. However, when non-root users attempt to change their passwords, the passwords they choose must meet the basic standards set by pam_cracklib.so. In addition, non-root users can make only a certain number of password change attempts before pam_cracklib.so begins issuing messages and eventually closes the password change screen. The ESX Server defaults for pam_cracklib.so password standards and retry restrictions are as follows:

- **Minimum length** – The pam_cracklib.so minimum length parameter for ESX Server systems is set to 9. This means that the user must enter at least 8 characters if he or she uses only one character class (lowercase, uppercase, digit, or other).

  The password length algorithm allows shorter passwords if the user enters a mix of character classes. To calculate the actual character length a user needs to enter to form a valid password for a given minimum length setting, apply the password length algorithm as follows:

  M – CC = E

  Where:

  - M is the minimum length parameter.
  - CC is the number of character classes the user includes in the password.
  - E is the number of characters the user must enter.

  Table 12-1 shows how the algorithm works assuming the user enters at least one lowercase character as part of the password.

Table 12-1. Password Complexity Algorithm Results

# of Characters for a Valid Password	Character Types in the Password Attempt			
	Lowercase Characters	Uppercase Characters	Digits	Other Characters
8	yes			
7	yes	yes		
	yes		yes	
	yes			yes
6	yes	yes	yes	
	yes	yes		yes
	yes		yes	yes
5 [a]	yes	yes	yes	yes

[a] The `pam_cracklib.so` plugin does not allow passwords of fewer than six characters. Thus, while the mathematically accurate character requirement for a four character-class password is five characters, the effective requirement is six.

- **Retries** – The `pam_cracklib.so` retries parameter for ESX Server systems is set to 3, meaning that if the user doesn't enter a strong enough password in three attempts, `pam_cracklib.so` closes the password change dialog box. The user must open a new password change session to try again.

The `pam_cracklib.so` plugin checks all password change attempts to ensure that passwords meet the following strength criteria:

- The new password must not be a palindrome—a password where the characters mirror each other around a central letter, as in radar or civic.
- The new password must not be the reverse of the old password.
- The new password must not be a rotation—a version of the old password in which one or more characters have been rotated to the front or back of the password string.
- The new password must differ from the old password by more than a change of case.
- The new password must differ from the old password by more than a few characters.
- The new password must not have been used in the past. The `pam_cracklib.so` plugin applies this criterion only If you have configured a password reuse rule.

  By default ESX Server does not enforce any password reuse rules, so ordinarily the `pam_cracklib.so` plugin never rejects a password change attempt on these grounds. However, you can configure a reuse rule to ensure that your users don't alternate between a few passwords.

If you configure a reuse rule, old passwords are stored in a file that the `pam_cracklib.so` plugin references during each password change attempt. The number of old passwords that ESX Server retains is determined by the reuse rule. When a user has created enough passwords to reach the value specified in the reuse rule, old passwords are removed from the file in age order. To learn how to configure a reuse rule, see "To configure a password reuse rule" on page 248.

- The new password must be long enough and complex enough. You configure these requirements by changing the `pam_cracklib.so` complexity parameters with the `esxcfg-auth` command, which lets you set the number of retries, the minimum password length, and a variety of character credits. Character credits let the user enter shorter passwords if they include more character types in the password. To learn how to configure password length and complexity, see "To change default password complexity for the pam_cracklib.so plugin" on page 249.

For more information on the `pam_cracklib.so` plugin, see your Linux documentation.

NOTE The `pam_cracklib.so` plugin used in Linux provides more parameters than the ones supported for ESX Server. You cannot specify these additional parameters in `esxcfg-auth`.

To configure a password reuse rule

1. Log on to the service console and acquire root privileges.
2. Change directories by entering `cd /etc/pam.d/` at the command prompt.
3. Use nano or another text editor to open the `system-auth` file.
4. Locate the line that starts with:

   ```
   password    sufficient    /lib/security/$ISA/pam_unix.so
   ```

5. Add the following parameters to the end of the line:

   ```
   remember=X
   ```

   Where X is the number of old passwords you want ESX Server to store for each user. Use a space as the delimiter between `remember=X` and the preceding parameter.

6. Save your changes and close the file.
7. Change directories to `/etc/security/`, and issue the following command to make a zero length file with `opasswd` as the filename:

```
touch opasswd
```

8 Issue the following commands:

```
chmod 0600 opasswd
               chown root:root /etc/security/opasswd
```

To change default password complexity for the pam_cracklib.so plugin

1 Log on to the service console and acquire root privileges.

2 Enter the following command:

```
esxcfg-auth --usecrack=<retries> <minimum_length> <lc_credit> <uc_credit>
               <d_credit> <oc_credit>
```

Where:

- `retries` is the number of retries the user is allowed before ESX Server locks him or her out of password change mode.
- `minimum_length` is the minimum number of characters a user must enter to make the password acceptable. This number is the total length before any length credits are applied.

  One length credit is always applied so, in effect, the password length is one character less than the `minimum_length` parameter you specify. Because the `pam_cracklib.so` plugin does not accept passwords of less than 6 characters, calculate the `minimum_length` parameter so that users can't drop the password length below 6 as a result of subtracting the length credits.
- `lc_credit` is the number by which the `minimum_length` parameter is reduced if the user includes at least one lower case character in the password.
- `uc_credit` is the number by which the `minimum_length` parameter is reduced if the user includes at least one upper case character.
- `d_credit` is the number by which the `minimum_length` parameter is reduced if the user includes at least one digit.
- `oc_credit` is the number by which the `minimum_length` parameter is reduced if the user includes at least one special character, such as an underscore or dash.

Enter character credit parameters as a positive number or as 0 if you do not want the plugin to give the user credit for including this character class. Character credits are additive. The more different types of characters the user enters, the fewer characters are required to form a valid password. For example, you issue the following command:

```
esxcfg-auth --usecrack=3 11 1 1 1 2
```

With this setting in effect, a user creating a password that contains lowercase characters and one underscore would need eight characters to create a valid password. If the user decided to include all types of characters (lowercase alphabetical, uppercase alphabetical, numeric, and special), he or she would need only six characters.

Changing the Password Plugin

The `pam_cracklib.so` plugin provides sufficient password strength enforcement for most environments. However, if the `pam_cracklib.so` plugin is not stringent enough for your needs, you can use the `pam_passwdqc.so` plugin instead. You change the plugin through the `esxcfg-auth` command.

The `pam_passwdqc.so` plugin tests for the same password characteristics as the `pam_cracklib.so` plugin. However, it provides a greater number of options for fine-tuning password strength and performs password strength tests for all users, including the root user. The `pam_passwdqc.so` plugin is also somewhat more difficult to use than the `pam_cracklib.so` plugin. For more information on this plugin, see your Linux documentation.

NOTE The `pam_passwdqc.so` plugin used in Linux provides more parameters than the ones supported for ESX Server. You cannot specify these additional parameters in `esxcfg-auth`.

To switch to the pam_passwdqc.so plugin

1 Log on to the service console and acquire root privileges.

2 Enter the following command:

```
esxcfg-auth --usepamqc=<N0> <N1> <N2> <N3> <N4> <match>
```

Where:

- `N0` is the number of characters required for a password that uses characters from only one character class.
- `N1` is the number of characters required for a password that uses characters from two character classes.
- `N2` is used for passphrases. ESX Server requires three words for a passphrase.
- `N3` is the number of characters required for a password that uses characters from three character classes.
- `N4` is the number of characters required for a password that uses characters from all four character classes.

- `match` is the number of characters allowed in a string that is reused from the old password. If the `pam_passwdqc.so` plugin finds a reused string of this length or longer, it disqualifies the string from the strength test and uses only the remaining characters.

Setting any of these options to -1 directs the `pam_passwdqc.so` plugin to ignore the requirement. Setting any of these options to `disabled` directs the `pam_passwdqc.so` plugin to disqualify passwords with the associated characteristic. The values used must be in descending order except for `-1` and `disabled`.

For example, you issue the following command:

```
esxcfg-auth --usepamqc=disabled 18 -1 12 8
```

With this setting in effect, a user creating a password would never be able to set passwords that contain only one character class. He or she would need to use at least 18 characters for a password with two-character class, 12 characters for a three-character class password, and eight characters for four-character class passwords. Attempts to create passphrases would be ignored.

Cipher Strength

Transmitting data over insecure connections presents a security risk because malicious users might be able to scan data as it travels through the network. As a safeguard, network components commonly encrypt the data so that it can't be easily read. To encrypt data, the sending component, such as a gateway or redirector, applies algorithms, or *ciphers*, to alter the data before transmitting it. The receiving component uses a key to decrypt the data, returning it to its original form.

Several different ciphers are currently in use, and the level of security provided by each is different. One measure of a cipher's ability to protect data is its *cipher strength*—the number of bits in the encryption key. The larger the number, the more secure the cipher.

To ensure the protection of the data transmitted to and from external network connections, ESX Server uses one of the strongest block ciphers available—256-bit AES block encryption. ESX Server also uses 1024-bit RSA for key exchange. These encryption algorithms are the default for the following connections:

- VI Client connections to the VirtualCenter Server and to the ESX Server host through the service console.
- VI Web Access connections to the ESX Server host through the service console.

NOTE Because VI Web Access cipher usage is determined by the Web browser you are using, this management tool might use other ciphers.

- SDK connections to the VirtualCenter Server and to the ESX Server.
- Service console connections to virtual machines through the VMkernel.
- SSH connections to the ESX Server host through the service console. For more information, see "SSH Security" on page 254.

setuid and setgid Applications

`setuid` is a flag that allows an application to temporarily change the permissions of the user running the application by setting the effective user ID to the program owner's user ID. `setgid` is a flag that allows an application to temporarily change the permissions of the group running the application by setting the effective group ID to the program owner's group ID.

During ESX Server installation, several applications that include the `setuid` and `setgid` flags are installed by default. These applications are initiated by or through the service console. Some of them provide facilities required for correct operation of the ESX Server host. Others are optional, but they can make maintaining and troubleshooting the ESX Server host and the network easier.

Default setuid Applications

Table 12-2 lists the default `setuid` applications and indicates whether the application is required or optional.

Table 12-2. Default `setuid` Applications

Application	Purpose and Path	Required or Optional
`crontab`	Lets individual users add cron jobs. **Path:** `/usr/bin/crontab`	Optional
`pam_timestamp_check`	Supports password authentication. **Path:** `/sbin/pam_timestamp_check`	Required
`passwd`	Supports password authentication. **Path:** `/usr/bin/passwd`	Required
`ping`	Sends and listens for control packets on the network interface. Useful for debugging networks. **Path:** `/bin/ping`	Optional
`pwdb_chkpwd`	Supports password authentication. **Path:** `/sbin/pwdb_chkpwd`	Required

Table 12-2. Default `setuid` Applications (Continued)

Application	Purpose and Path	Required or Optional
`ssh-keysign`	Performs host-based authentication for SSH secure shells. **Path:** `/usr/libexec/openssh/ssh-keysign`	Required if you use host-based authentication. Otherwise optional.
`su`	Lets a general user become the root user by changing users. **Path:** `/bin/su`	Required
`sudo`	Lets a general user act as the root user only for specific operations. **Path:** `/usr/bin/sudo`	Optional
`unix_chkpwd`	Supports password authentication. **Path:** `/sbin/unix_chkpwd`	Required

`vmkload_app`	Performs tasks required to run virtual machines. This application is installed in two locations: one for standard use and one for debugging.
	Path for standard use:
	`/usr/lib/vmware/bin/vmkload_app`
	Path for debugging:
	`/usr/lib/vmware/bin-debug/vmkload_app`
		Required in both paths

`vmkping`	Sends and listens for control packets on the network interface. Useful for debugging networks. **Path:** `/usr/lib/vmware/bin/vmkping`	Optional
`vmware-authd`	Authenticates users for use of services specific to VMware. Path: `/usr/sbin/vmware-authd`	Required

`vmware-vmx`	Performs tasks required to run virtual machines. This application is installed in two locations: one for standard use and one for debugging.
	Path for standard use:
	`/usr/lib/vmware/bin/vmware-vmx`
	Path for debugging:
	`/usr/lib/vmware/bin-debug/vmware-vmk`
		Required in both paths

Disabling any of the required applications will result in problems with ESX Server authentication and virtual machine operation, but you can disable any optional application.

To disable an optional setuid application

1 Log on to the service console and acquire root privileges.

2 Execute this command:

```
chmod a-s <path_to_executable>
```

Default setgid Applications

Two applications that include the `setgid` flag are installed by default. Table 12-3 lists the default `setgid` applications and indicates whether the application is required or optional.

Table 12-3. Default `setgid` Applications

Application	Purpose and Path	Required or Optional
`wall`	Alerts all terminals that an action is about to occur. This application is called by `shutdown` and other commands. **Path:** `/usr/bin/wall`	Optional
`lockfile`	Performs locking for the Dell OM management agent. **Path:** `/usr/bin/lockfile`	Required for Dell OM but optional otherwise

Disabling a required application will result in problems with ESX Server authentication and virtual machine operation, but you can disable any optional application.

To disable an optional setgid application

1 Log on to the service console and acquire root privileges.

2 Execute this command:

```
chmod a-g <path_to_executable>
```

SSH Security

SSH is a commonly used UNIX and Linux command shell that lets you remotely log on to the service console and perform certain management and configuration tasks for ESX Server. SSH is used for secure logons and data transfers because it offers stronger protection than other command shells. In this ESX Server release, the SSH configuration has been enhanced to provide a higher security level than in the past. Key features of this enhancement include:

- **Version 1 SSH protocol disabled** – VMware no longer supports Version 1 SSH protocol and uses Version 2 protocol exclusively. Version 2 eliminates certain security issues present in Version 1 and provides you with a safer communications interface to the service console.

- **Improved cipher strength** – SSH now supports only 256-bit and 128-bit AES ciphers for your connections.
- **Limits on remote logons as root** – You can no longer remotely log on as root. Instead, you log on as an identifiable user and either use the `sudo` command to execute specific operations that require root privileges or enter the `su` command to become the root user.

NOTE The `sudo` command provides security benefits in that it limits root activities and helps you check for possible misuse of root privileges by generating an audit trail of any root activities that the user performs.

These settings are designed to provide solid protection for the data you transmit to the service console through SSH. If this configuration is too rigid for your needs, you can lower security parameters.

To change the default SSH configuration

1. Log on to the service console and acquire root privileges.
2. Change directories by entering `cd /etc/ssh` at the command prompt.
3. Use nano or another text editor to perform any or all of following actions, as appropriate.
   - To allow remote root logon, change the setting to `yes` in the following line in the `sshd_config` file:

     ```
     PermitRootLogin no
     ```

   - To revert to the default SSH protocol (Version 1 and 2), comment out the following line in the `sshd_config` file:

     ```
     Protocol 2
     ```

   - To revert to the 3DES cipher and other ciphers, comment out the following line in the `sshd_config` file:

     ```
     Ciphers aes256-cbc,aes128-cbc
     ```

   - To disable Secure FTP (SFTP) on SSH, comment out the following line in the `sshd_config` file:

     ```
     Subsystem ftp /usr/libexec/openssh/sftp-server
     ```

4. Save your changes and close the file.

5 Execute the following command to restart the SSHD service:

```
service sshd restart
```

Security Patches and Security Vulnerability Scanning Software

If a fix for a particular LINUX-supported software package provided by VMware as a service console component—for example, a service, facility, or protocol—becomes available, VMware provides an RPM Package Manager (RPM) package that you use to update the software package on ESX Server. Although these fixes might be available from other sources, always use RPMs generated by VMware instead of using third-party RPMs.

When providing patches for a software package, the VMware policy is to backport the fix to a version of the software known to be stable. This approach reduces the chance of introducing new problems and instability in the software. Because the patch is added to an existing version of the software, the version number of the software stays the same, but a patch number is added as a suffix.

Certain security scanners such as Nessus check the version number but not the patch suffix as they search for security holes. As a result, these scanners can falsely report that software is down-level and doesn't include the most recent security patches even though it does. This problem is common to the industry and not specific to VMware.

NOTE Some security scanners are able to handle this situation correctly, but they typically lag by a version or more. For example, the version of Nessus released after a Red Hat patch often doesn't report these false positives.

Here is an example of how this problem occurs:

1 You initially install ESX Server with OpenSSL version 0.9.7a (where 0.9.7a is the original version with no patches).

2 OpenSSL releases a patch that fixes a security hole in version 0.9.7. This version is called 0.9.7x.

3 VMware backports the OpenSSL 0.9.7x fix to the original version, updates the patch number, and creates an RPM. The OpenSSL version in the RPM is 0.9.7a-1, indicating that the original version (0.9.7a) now contains patch 1.

4 You install the RPM.

5 The security scanner fails to note the -1 suffix and erroneously reports that security for OpenSSL isn't up-to-date.

If your scanner reports that security for a package is down-level, perform the following checks:

- Look at the patch suffix to determine whether you need to get an update.
- Read the VMware RPM documentation for information on the patch contents.
- Use the following command to look for Common Vulnerabilities and Exposures (CVE) number from the security alert in the RPM change log:

  ```
  rpm-q --changelog openssl | grep <CVE_number>
  ```

  If the CVE number is there, the package covers that vulnerability.

Security Deployments and Recommendations 13

The chapter focuses on giving you a better idea of how to secure your ESX Server in particular environments by presenting a series of ESX Server deployment scenarios that you can consider as you plan some of the security features of your own deployment. It also makes some basic security recommendations you can consider when creating and configuring virtual machines.

This chapter covers the following topics:

Security Approaches for Common ESX Server Deployments

The complexity of ESX Server deployments can vary significantly depending on the size of your company, the way that data and resources need to be shared with the outside world, whether there are multiple datacenters or just one, and so forth.

Inherent in the following deployments are policies for user access, resource sharing, and security level. By comparing the deployments, you can get a sense of the issues you face in planning security for your own ESX Server deployment.

Single Customer Deployment

In this deployment, the ESX Server hosts are owned and maintained within a single corporation and single datacenter. No ESX Server resources are shared with outside users. One site administrator maintains the ESX Server hosts, and these hosts run a number of virtual machines.

The deployment does not allow customer administrators, and the site administrator is solely responsible for maintaining the various virtual machines. The corporation staffs a set of system administrators who do not have accounts on the ESX Server host and cannot access any of the ESX Server tools such as VirtualCenter or command line shells for the host. These system administrators have access to virtual machines through the virtual machine console so that they can load software and perform other maintenance tasks inside the virtual machines.

Table 13-1 shows how you might handle sharing for the components you use and configure for the ESX Server host.

Table 13-1. Sharing for Components in a Single Customer Deployment

Function	Configuration	Comments
Service console shares the same physical network as the virtual machines?	No	Isolate the service console by configuring it on its own physical network.
Service console shares the same VLAN as the virtual machines?	No	Isolate the service console by configuring it on its own VLAN. No virtual machine or other system facility such as VMotion should use this VLAN.
Virtual machines share the same physical network?	Yes	Configure your virtual machines on the same physical network.
Network adapter sharing?	Partial	Isolate the service console by configuring it on its own virtual switch and virtual network adapter. No virtual machine or other system facility should use this switch or adapter. However, you can configure your virtual machines on the same virtual switch and network adapter.
VMFS sharing?	Yes	All `.vmdk` files should reside in the same VMFS partition.
Security level	High	Open ports for needed services like FTP on an individual basis. See "Service Console Firewall Configuration" on page 239 for information on security levels.
Virtual machine memory overcommitment?	Yes	Configure the total memory for the virtual machines as greater than the total physical memory.

Table 13-2 shows how you might set up user accounts for the ESX Server host.

Table 13-2. User Account Setup in a Single Customer Deployment

User Category	Total Number of Accounts
Site administrators	1
Customer administrators	0
System administrators	0
Business users	0

Table 13-3 shows the level of access for each user.

Table 13-3. User Access in a Single Customer Deployment

Access Level	Site Administrator	System Administrator
Root access?	Yes	No
Service console access through SSH?	Yes	No
VirtualCenter and VI Web Access?	Yes	No
Virtual machine creation and modification?	Yes	No
Virtual machine access through the console?	Yes	Yes

Multiple Customer Restricted Deployment

In this deployment, the ESX Server hosts are in the same datacenter and are used to serve applications for multiple customers. The site administrator maintains the ESX Server hosts, and these hosts run a number of virtual machines dedicated to the customers. Virtual machines that belong to the various customers can be on the same ESX Server host, but the site administrator restricts resource sharing to prevent rogue interaction.

While there is only one site administrator, several customer administrators maintain the virtual machines assigned to their customers. This deployment also includes customer system administrators who do not have ESX Server accounts but have access to the virtual machines through the virtual machine console so that they can load software and perform other maintenance tasks inside the virtual machines.

Table 13-4 shows how you might handle sharing for the components you use and configure for the ESX Server host.

Table 13-4. Sharing for Components in a Multiple Customer Restricted Deployment

Function	Configuration	Comments
Service console shares the same physical network as the virtual machines?	No	Isolate the service console by configuring it on its own physical network.
Service console shares the same VLAN as the virtual machines?	No	Isolate the service console by configuring it on its own VLAN. No virtual machine or other system facility such as VMotion should use this VLAN.
Virtual machines share the same physical network?	Partial	Put the virtual machines for each customer on a different physical network. All physical networks are independent of each other.
Network adapter sharing?	Partial	Isolate the service console by configuring it on its own virtual switch and virtual network adapter. No virtual machine or other system facility should use this switch or adapter. You configure virtual machines for one customer so that they all share the same virtual switch and network adapter. However, they do not share the switch and adapter with any other customers.
VMFS sharing?	No	Each customer has their own VMFS partition and their virtual machine `.vmdk` files reside exclusively on that partition. The partition can span multiple LUNs.
Security level	High	Open ports for services like FTP as needed.
Virtual machine memory overcommitment?	Yes	Configure the total memory for the virtual machines as greater than the total physical memory.

Table 13-5 shows how you might set up user accounts for the ESX Server host.

Table 13-5. User Account Setup in a Multiple Customer Restricted Deployment

User Category	Total Number of Accounts
Site administrators	1
Customer administrators	10
System administrators	0
Business users	0

Table 13-6 shows the level of access for each user.

Table 13-6. User Access in a Multiple Customer Restricted Deployment

Access Level	Site Administrator	Customer Administrator	System Administrator
Root access?	Yes	No	No
Service console access through SSH?	Yes	Yes	No
VirtualCenter and VI Web Access?	Yes	Yes	No
Virtual machine creation and modification?	Yes	Yes	No
Virtual machine access through the console?	Yes	Yes	Yes

Multiple Customer Open Deployment

In this deployment, the ESX Server hosts are in the same datacenter and are used to serve applications for multiple customers. The site administrator maintains the ESX Server hosts, and these hosts run a number of virtual machines dedicated to the customers. Virtual machines that belong to the various customers can be on the same ESX Server host, but there are fewer restrictions on resource sharing.

While there is only one site administrator, several customer administrators maintain the virtual machines assigned to their customers. The deployment also includes customer system administrators who do not have ESX Server accounts but have access to the virtual machines through the virtual machine console so that they can load software and perform other maintenance tasks inside the virtual machines. Lastly, a group of business users who do not have accounts can use virtual machines to run their applications.

Table 13-7 shows how you might handle sharing for the components you use and configure for the ESX Server host.

Table 13-7. Sharing for Components in a Multiple Customer Open Deployment

Function	Configuration	Comments
Service console shares the same physical network as the virtual machines?	No	Isolate the service console by configuring it on its own physical network.
Service console shares the same VLAN as the virtual machines?	No	Isolate the service console by configuring it on its own VLAN. No virtual machine or other system facility such as VMotion should use this VLAN.
Virtual machines share the same physical network?	Yes	Configure your virtual machines on the same physical network.

Table 13-7. Sharing for Components in a Multiple Customer Open Deployment (Continued)

Function	Configuration	Comments
Network adapter sharing?	Partial	Isolate the service console by configuring it on its own virtual switch and virtual network adapter. No virtual machine or other system facility should use this switch or adapter. You configure all virtual machines on the same virtual switch and network adapter.
VMFS sharing?	Yes	Virtual machines can share VMFS partitions and their virtual machine `.vmdk` files can reside on shared partitions. Virtual machines do not share `.vmdk` files.
Security level	High	Open ports for services like FTP as needed.
Virtual machine memory overcommitment?	Yes	Configure the total memory for the virtual machines as greater than the total physical memory.

Table 13-8 shows how you might set up user accounts for the ESX Server host.

Table 13-8. User Account Setup in a Multiple Customer Open Deployment

User Category	Total Number of Accounts
Site administrators	1
Customer administrators	10
System administrators	0
Business users	0

Table 13-9 shows the level of access for each user.

Table 13-9. User Access in a Multiple Customer Open Deployment

Access Level	Site Administrator	Customer Administrator	System Administrator	Business User
Root access?	Yes	No	No	No
Service console access through SSH?	Yes	Yes	No	No
VirtualCenter and VI Web Access?	Yes	Yes	No	No
Virtual machine creation and modification?	Yes	Yes	No	No
Virtual machine access through the console?	Yes	Yes	Yes	Yes

Virtual Machine Recommendations

Consider the following safety precautions when evaluating virtual machine security and administering virtual machines.

Installing Antivirus Software

Because each virtual machine hosts a standard operating system, you should consider protecting it from viruses by installing antivirus software. Depending on how you are using the virtual machine, you might also want to install a software firewall.

NOTE Software firewalls and antivirus software can be virtualization-intensive. If you are confident that your virtual machines are in a fully trusted environment, you can balance the need for these two security measures against virtual machine performance.

Disabling Copy and Paste Operations Between the Guest Operating System and Remote Console

When VMware Tools runs on a virtual machine, you can copy and paste between the guest operating system and remote console. As soon as the console window gains focus, non-privileged users and processes running in the virtual machine can access the clipboard for the virtual machine console. If a user copies sensitive information to the clipboard before using the console, the user—perhaps unknowingly—exposes sensitive data to the virtual machine.

To prevent this problem, consider disabling copy and paste operations for the guest operating system.

To disable copy and paste operations between the guest operating system and remote console

1. Log on to the VI Client and select the virtual machine from the inventory panel.

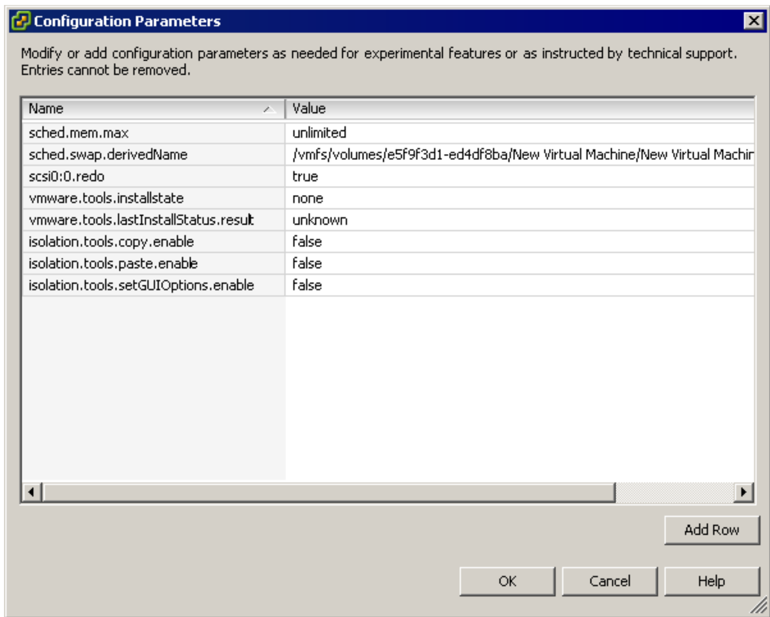
   The configuration page for this virtual machine appears with the **Summary** tab displayed.

2. Click **Edit Settings**.
3. Click **Options** > **Advanced** > **Configuration Parameters** to open the **Configuration Parameters** dialog box.
4. Click the **Add** button.

5 Type the following values in the **Name** field **Value** column.

Name Field	Value Field
`isolation.tools.copy.enable`	`false`
`isolation.tools.paste.enable`	`false`
`isolation.tools.setGUIOptions.enable`	`false`

The result appears as follows.



NOTE These options override any settings made in the guest operating system's VMware Tools control panel.

6 Click **OK** to close the **Configuration Parameters** dialog box and then click **OK** again to close the **Virtual Machine Properties** dialog box.

Removing Unnecessary Hardware Devices

Nonprivileged users and processes within virtual machines can connect or disconnect hardware devices, such as network adapters and CD-ROM drives. Attackers can use this capability to breach virtual machine security in several ways. For example, by default, an attacker with access to a virtual machine can:

- Connect a disconnected CD-ROM drive and access sensitive information on the media left in the drive.
- Disconnect a network adapter to isolate the virtual machine from its network, resulting in a denial of service.

As a general security precaution, use commands on the VI Client Configuration tab to remove any unneeded or unused hardware devices. While this measure tightens virtual machine security, it isn't a good solution in situations where you might need to bring a currently unused device back into service at a later time.

If you don't want to permanently remove a device, you can prevent a virtual machine user or process from connecting or disconnecting the device from within the guest operating system.

To prevent a virtual machine user or process from disconnecting devices

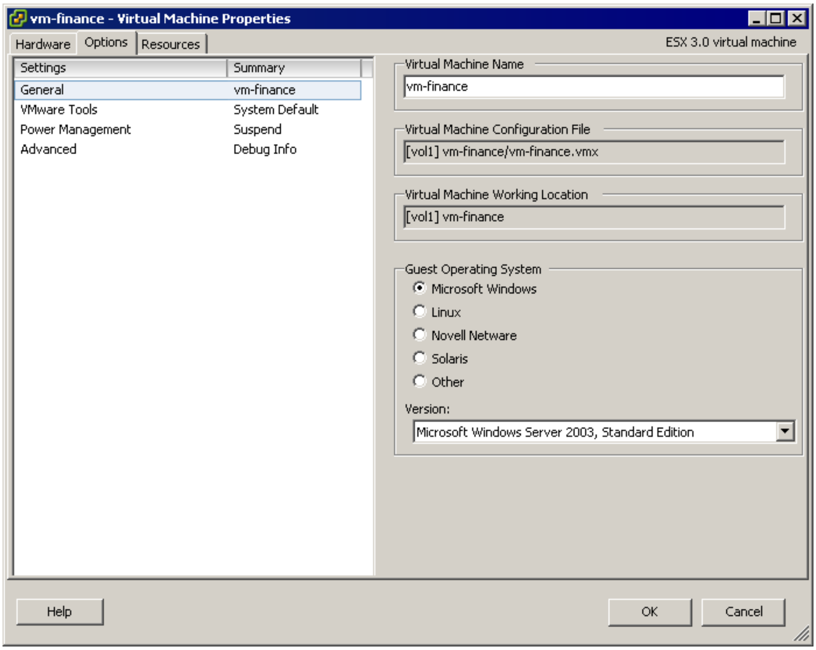
1. Log on to the VI Client and select the virtual machine from the inventory panel.

   The configuration page for this virtual machine appears with the **Summary** tab displayed.

2. Click **Edit Settings**.

   The **Virtual Machine Properties** dialog box appears.

3 Click **Options** > **General** and make a record of the path displayed in the **Virtual Machine Configuration File** field.



4 Log on to the service console and acquire root privileges.

5 Change directories to access the virtual machine configuration file whose path you recorded in Step 3.

Virtual machine configuration files are located in the `/vmfs/volumes/<datastore>` directory, where `<datastore>` is the name of the storage device on which the virtual machine files reside. For example, if the virtual machine configuration file you obtained from the **Virtual Machine Properties** dialog box is `[vol1]vm-finance/vm-finance.vmx`, you change directories as follows:

```
cd /vmfs/volumes/vol1/vm-finance/
```

6 Use nano or another text editor to add the following line to the `.vmx` file.

```
<device_name>.allowGuestConnectionControl = “false”
```

Where `<device_name>` is the name of the device you want to protect, for example, ethernet1.

NOTE By default, Ethernet 0 is configured to disallow device disconnection. The only reason you might need to change this is if a prior administrator set the <device_name>.allowGuestConnectionControl to true.

7 Save your changes and close the file.

8 Return to the VI Client and power off and power on the virtual machine. To do so, right-click the virtual machine in the inventory panel and click **Power Off** followed by **Power On**.

Preventing the Guest Operating System Processes from Flooding the ESX Server Host

The guest operating system processes send informational messages to the ESX Server host through VMware Tools. These messages, known as `setinfo` messages, typically contain name-value pairs that define virtual machine characteristics or identifiers that the host stores—for example, `ipaddress=10.17.87.224`.

A `setinfo` message has no predefined format, and it can be any length. Therefore, the amount of data passed to the host this way is unlimited. An unrestricted data flow provides an opportunity for an attacker to stage a DOS attack by writing software that mimics VMware Tools and flooding the host with packets, thus consuming resources needed by the virtual machines.

To prevent this problem, consider limiting the ability of VMware Tools to arbitrarily send `setinfo` messages to the ESX Server host.

NOTE VMware Tools also sends other types of messages, but these have predefined formats and, therefore, are not good vehicles for DOS attacks.

To prevent the guest operating system processes from sending arbitrary messages to the host

1 Log on to the VI Client and select the virtual machine from the inventory panel.

The configuration page for this virtual machine appears with the **Summary** tab displayed.

2 Click **Edit Settings**.

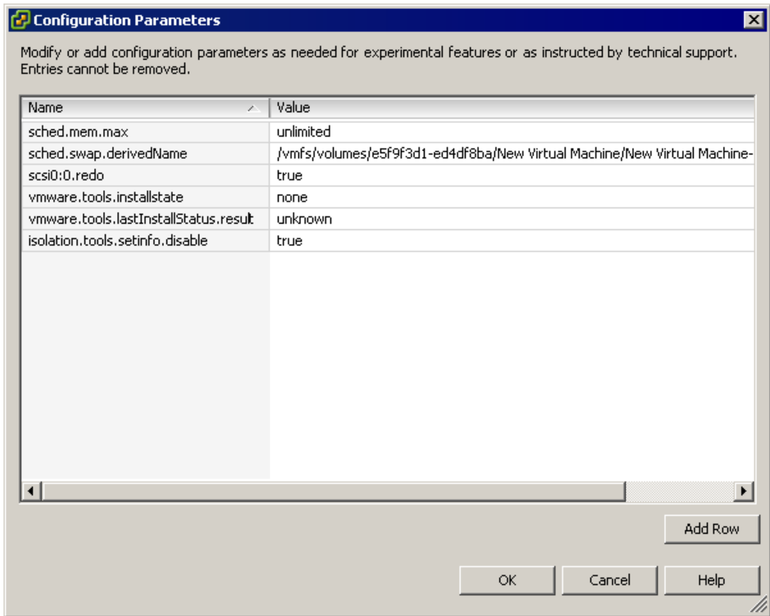
3 Click **Options** > **Advanced** > **Configuration Parameters** to open the **Configuration Parameters** dialog box.

4 Click the **Add** button and type the following:

- **Name field** – `isolation.tools.setinfo.disable`

- **Value field** – `true`

The result appears as follows.



5 Click **OK** to close the **Configuration Parameters** dialog box and then click **OK** again to close the **Virtual Machine Properties** dialog box.

Disabling Logging for the Guest Operating System

Virtual machines can write troubleshooting information into a virtual machine log file stored on the VMFS volume. Virtual machine users and processes can abuse logging either on purpose or inadvertently so that large amounts of data flood the log file. Over time, the log file can consume enough of the service console's file system space to cause a denial of service.

To prevent this problem, consider disabling logging for virtual machine guest operating systems. In making this decision, be aware that you might not be able to gather adequate logs to allow troubleshooting. Further, VMware does not offer technical support for virtual machine problems if logging has been disabled.

To disable logging for the guest operating system

1. Log on to the VI Client and select the virtual machine from the inventory panel.

   The configuration page for this virtual machine appears with the **Summary** tab displayed.

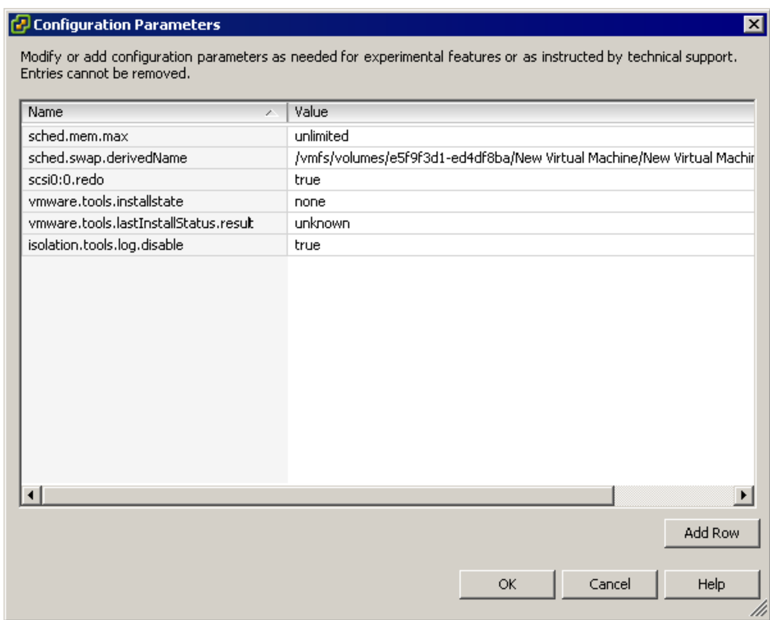
2. Click **Edit Settings**.

3. Click **Options** > **Advanced** > **Configuration Parameters** to open the **Configuration Parameters** dialog box.

4. Click the **Add** button and type the following:

   - **Name field** – `isolation.tools.log.disable`
   - **Value field** – `true`

   The result appears as follows.



5. Click **OK** to close the **Configuration Parameters** dialog box and then click **OK** again to close the **Virtual Machine Properties** dialog box.

Appendixes

ESX Technical Support Commands

A

This appendix lists the service console commands used to configure ESX Server. Most of these commands are reserved for Technical Support use and are included for your reference only. In a few cases, however, these commands provide the only means of performing a configuration task for the ESX Server host. Also, if you lose your connection to the host, executing certain of these commands through the command-line interface may be your only recourse—for example, if networking becomes nonfunctional and VI Client access is therefore unavailable.

NOTE If you use the commands in this appendix, you must execute the `service mgmt-vmware restart` command to restart the `vmware-hostd` process and alert the VI Client and other management tools that the configuration has changed. In general, avoid executing the commands in this appendix if the host is currently under the VI Client or VirtualCenter Server management.

The VI Client graphical user interface provides the preferred means of performing the configuration tasks described in this appendix. You can use this appendix to learn which VI Client commands to use in place of the service console commands. This appendix provides a summary of the actions you take in VI Client but doesn't give complete instructions. For details on using commands and performing configuration tasks through VI Client, see the online help.

You can find additional information on a number of ESX commands by logging on to the service console and using the `man <esxcfg_command_name>` command to display man pages.

Table A-1 lists the Technical Support commands provided for ESX Server, summarizes the purpose of each command, and provides a VI Client alternative. You can perform most of the VI Client actions listed in the table only after you have selected an ESX

Server host from the inventory panel and clicked the **Configuration** tab. These actions are preliminary to any procedure discussed below unless otherwise stated.

Table A-1. ESX Server Technical Support Commands

Service Console Command	Command Purpose and VI Client Procedure
`esxcfg-advcfg`	Configures advanced options for ESX Server. To configure advanced options in VI Client, click **Advanced Settings**. When the **Advanced Settings** dialog box opens, use the list on the left to select the device type or activity you want to work with and then enter the appropriate settings.
`esxcfg-auth`	Configures authentication. You can use this command to switch between the `pam_cracklib.so` and `pam_passwdqc.so` plugins for password change rule enforcement. You also use this command to reset options for these two plugins. For more information, see "Password Complexity" on page 245. There is no means of configuring these functions in VI Client.
`esxcfg-boot`	Configures bootstrap settings. This command is used for the bootstrap process and is intended for VMware Technical Support use only. You should not issue this command unless instructed to do so by a VMware Technical Support representative. There is no means of configuring these functions in VI Client.
`esxcfg-dumppart`	Configures a diagnostic partition or searches for existing diagnostic partitions. When you install ESX Server, a diagnostic partition is created to store debugging information in the event of a system fault. You don't need to create this partition manually unless you determine that there is no diagnostic partition for the host. You can perform the following management activities for diagnostic partitions in VI Client: ■ **Determine whether there is a diagnostic partition** — Click **Storage** > **Add** and check the first page of the **Add Storage** Wizard to see whether it includes the **Diagnostic** option. If **Diagnostic** is not one of the options, ESX Server already has a diagnostic partition. ■ **Configure a diagnostic partition** — Click **Storage** > **Add** > **Diagnostic** and step through the wizard.
`esxcfg-firewall`	Configures the service console firewall ports. To configure firewall ports for supported services and agents in VI Client, you select the Internet services that will be allowed to access the ESX Server host. Click **Security Profile** > **Firewall** > **Properties** and use the **Firewall Properties** dialog box to add services. For details on adding supported services and configuring firewalls, see "Opening Firewall Ports for Supported Services and Management Agents" on page 192. You cannot configure unsupported services through the VI Client. For these services, use the `esxcfg-firewall` command as described in "Service Console Firewall Configuration" on page 239.

Table A-1. ESX Server Technical Support Commands (Continued)

Service Console Command	Command Purpose and VI Client Procedure
`esxcfg-info`	Prints information about the state of the service console, VMkernel, various subsystems in the virtual network, and storage resource hardware. VI Client doesn't provide a method for printing this information, but you can obtain much of it through different tabs and functions in the user interface. For example, you can check the status of your virtual machines by reviewing the information on the **Virtual Machines** tab.
`esxcfg-init`	Performs internal initialization routines. This command is used for the bootstrap process you should not use it under any circumstances. Using this command can cause problems for your ESX Server host. There is no VI Client equivalent for this command.
`esxcfg-linuxnet`	Converts `vswif` to `eth` when booting ESX Server into service-console-only mode rather than into ESX mode. This command is used for the bootstrap process and is intended for VMware Technical Support use only. You should not issue this command unless instructed to do so by a VMware Technical Support representative. There is no VI Client equivalent for this command.
`esxcfg-module`	Sets driver parameters and modifies which drivers are loaded during startup. This command is used for the bootstrap process and is intended for VMware Technical Support use only. You should not issue this command unless instructed to do so by a VMware Technical Support representative. There is no VI Client equivalent for this command.
`esxcfg-mpath`	Configures multipath settings for your Fibre Channel or iSCSI disks. To configure multipath settings for your storage in VI Client, click **Storage**. Select a datastore or mapped LUN and click **Properties**. When the **Properties** dialog box opens, select the desired extent if necessary. Then, click **Extent Device** > **Manage Paths** and use the **Manage Path** dialog box to configure the paths.
`esxcfg-nas`	Manages NAS mounts. You use this command to add, delete, list, and change the attributes of NAS devices. To view NAS devices in VI Client, click **Storage** and scroll through the storage list. You can also perform the following activities from the **Storage** view: ■ **Display the attributes of a NAS device** – Click the device and review the information under **Details**. ■ **Add a NAS device** – Click **Add Storage**. ■ **Delete a NAS device** – Click **Remove**. ■ **Change the attributes of a NAS device** – Click the device and click **Details** > **Properties**. For complete instructions on how to create and configure NAS datastores, see "Configuring ESX Server to Access NFS Volumes" on page 135.

Table A-1. ESX Server Technical Support Commands (Continued)

Service Console Command	Command Purpose and VI Client Procedure
`esxcfg-nics`	Prints a list of physical network adapters along with information on the driver, PCI device, and link state of each NIC. You can also use this command to control a physical network adapter's speed and duplexing. To view information on the physical network adapters for the host in VI Client, click **Network Adapters**. To change the speed and duplexing for a physical network adapter in the VI Client, click **Networking** > **Properties** for any of the virtual switches associated with the physical network adapter. In the **Properties** dialog box, click **Network Adapters** > **Edit** and select the speed and duplex combination. For complete instructions on how to change the speed and duplexing, see "To configure the uplink network adapter by changing its speed" on page 49.
`esxcfg-resgrp`	Restores resource group settings and lets you perform basic resource group management. Select a resource pool from the inventory panel and click **Edit Settings** on the **Summary** tab to change the resource group settings.
`esxcfg-route`	Sets or retrieves the default VMkernel gateway route. To view the default VMkernel gateway route in VI Client, click **DNS and Routing**. To change the default routing, click **Properties** and update the information in both tabs of the **DNS and Routing Configuration** dialog box.
`esxcfg-swiscsi`	Configures your software iSCSI software adapter. To configure your software iSCSI system in VI Client, click **Storage Adapters**, select the iSCSI adapter you want to configure, and click **Properties**. Use the **iSCSI Initiator Properties** dialog box to configure the adapter. For complete instructions on how to create and configure iSCSI datastores, see "iSCSI Storage" on page 110.
`esxcfg-upgrade`	Upgrades ESX Server from ESX Server 2.*x* to ESX Server 3.*x*. This command is not for general use. You complete the following three tasks when upgrading from 2.*x* to 3.*x*. Some of these can be performed in VI Client: ■ **Upgrade the host** — You upgrade the binaries, converting from ESX Server 2.*x* to ESX Server 3.*x*. You cannot perform this step from VI Client. For information on performing this upgrade, see the *Installation and Upgrade Guide*. ■ **Upgrade the file system** — To upgrade VMFS-2 to VMFS-3, suspend or power off your virtual machines and then click **Inventory** > **Host** > **Enter Maintenance Mode**. Click **Storage**, select a storage device, and click **Upgrade to VMFS-3**. You must perform this step for each storage device you want to upgrade. ■ **Upgrade the virtual machines** — To upgrade a virtual machine from VMS-2 to VMS-3, right-click the virtual machine in the inventory panel and choose **Upgrade Virtual Machine**.

Table A-1. ESX Server Technical Support Commands (Continued)

Service Console Command	Command Purpose and VI Client Procedure
`esxcfg-vmhbadevs`	Prints a map of VMkernel storage devices to service console devices. There is no VI Client equivalent for this command.
`esxcfg-vmknic`	Creates and updates VMkernel TCP/IP settings for VMotion, NAS, and iSCSI. To set up VMotion, NFS, or iSCSI network connections in VI Client, click **Networking > Add Networking**. Select **VMkernel** and step through the **Add Network Wizard**. Define the IP address subnet mask and VMkernel default gateway in the **Connection Settings** step. To review your settings, click the blue icon to the left of the VMotion, iSCSI, or NFS port. To edit any of these settings, click **Properties** for the switch. Select the port from the list on the switch **Properties** dialog box and click **Edit** to open the port **Properties** dialog box and change the settings for the port. For complete instructions on how to create and update VMotion, NFS, or iSCSI network connections, see "VMkernel Configuration" on page 33.
`esxcfg-vswif`	Creates and updates service console network settings. This command is used if you cannot manage the ESX Server host through the VI Client because of network configuration issues. For more information, see "Troubleshooting Service Console Networking" on page 80. To set up connections for the service console in VI Client, click **Networking > Add Networking**. Select **Service Console** and step through the **Add Network Wizard**. Define the IP address subnet mask and the service console default gateway in the **Connection Settings** step. To review your settings, click the blue icon to the left of the service console port. To edit any of these settings, click **Properties** for the switch. Select the service console port from the list on the switch **Properties** dialog box. Click **Edit** to open the port **Properties** dialog box and change the settings for the port. For complete instructions on how to create and update the service console connection, see "Service Console Configuration" on page 37.
`esxcfg-vswitch`	Creates and updates virtual machine network settings. To set up connections for a virtual machine in VI Client, click **Networking > Add Networking**. Select **Virtual Machine** and step through the **Add Network Wizard**. To review your settings, click the speech bubble icon to the left of the virtual machine port group. To edit any of these settings, click **Properties** for the switch. Select the virtual machine port from the list on the switch **Properties** dialog box, then click **Edit** to open the port **Properties** dialog box and change the settings for the port. For complete instructions on how to create and update virtual machines, see "Virtual Network Configuration for Virtual Machines" on page 29.

Other Commands

To support certain internal operations, ESX Server installations include a subset of standard Linux configuration commands, for example, network and storage configuration commands. Using these commands to perform configuration tasks can result in serious configuration conflicts and render some ESX Server functions unusable. Always work through the VI Client when configuring ESX Server unless otherwise instructed in VMware Infrastructure documentation or by VMware Technical Support.

Using vmkfstools

B

You use the vmkfstools program to create and manipulate virtual disks, file systems, logical volumes, and physical storage devices on the VMware ESX Server. Using vmkfstools, you can create and manage VMware File System (VMFS) on a physical partition of a disk. You can also use this program to manipulate files, such as virtual disks, stored on VMFS-2, VMFS-3, and NFS.

Most vmkfstools operations can also be performed through the VI Client. For information on using the VI Client to work with storage, see "Configuring Storage" on page 103.

This appendix covers the following sections:

vmkfstools Command Syntax

Generally, you don't need to log in as the root user to run the `vmkfstools` commands. However, some commands, such as the file system commands, might require the root login.

Use the following arguments with the `vmkfstools` command:

- `<options>` are one or more command line options and associated arguments you use to specify the activity that you want `vmkfstools` to perform — for example, choosing the disk format when creating a new virtual disk.

  After entering the option, specify a file or VMFS file system, on which you perform the operation, by entering a relative or absolute file path name in the `/vmfs` hierarchy.

- `<partition>` specifies disk partitions. This argument uses a `vmhbaA:T:L:P` format, where `A`, `T`, `L`, and `P` are integers representing adapter, target, LUN, and partition number respectively. The partition digit must be greater than zero and should correspond to a valid VMFS partition of type `fb`.

  For example, `vmhba0:2:3:1` refers to the first partition on LUN 3, target 2, HBA 0.

- `<device>` specifies devices or logical volumes. This argument uses a path name in the ESX Server device file system. The path name begins with `/vmfs/devices`, which is the mount point of the device file system.

  Use the following formats when specifying different types of devices:

  - `/vmfs/devices/disks` for local or SAN-based disks.
  - `/vmfs/devices/lvm` for ESX Server logical volumes.
  - `/vmfs/devices/generic` for generic SCSI devices, such as tape drives.

- `<path>` specifies a VMFS file system or file. This argument is an absolute or relative path that names a directory symbolic link, raw device mapping, or a file under `/vmfs`.

  - To specify a VMFS file system, use this format:

    ```
    /vmfs/volumes/<file_system_UUID> or
                   /vmfs/volumes/<file_system_label>
    ```

- To specify a VMFS file, use this format:

  ```
  /vmfs/volumes/<file system label|file system UUID>/[dir]/myDisk.vmdk
  ```

  You don't need to enter the entire path if the current working directory is the parent directory of `myDisk.vmdk`.

For example,

```
/vmfs/volumes/datastore1/rh9.vmdk
```

-v Suboption

The `-v` suboption indicates the verbosity level of the command output. The format for this suboption is as follows:

```
-v --verbose <number>
```

You specify the `<number>` value as an integer from 1 through 10.

You can specify the `-v` suboption with any `vmkfstools` option. If the output of the option isn't suitable for use with the `-v` suboption, `vmkfstools` ignores the `-v` part of the command line.

NOTE Because you can include the `-v` suboption in any vmkfstools command line, the suboption is not specifically covered in any of the option descriptions.

vmkfstools Options

This section includes a list of all options used with the `vmkfstools` command. Some of the tasks in this section include options suggested for advanced users only.

The long and short (single letter) forms of options are equivalent. For example, the following commands are identical:

```
vmkfstools --createfs vmfs3 --blocksize 2m vmhba1:3:0:1
vmkfstools -C vmfs3 -b 2m vmhba1:3:0:1
```

See the following sections for more information:

- "File System Options" on page 284
- "Virtual Disk Options" on page 287
- "Device Options" on page 293

File System Options

File system options are tasks that you can perform when setting up a VMFS file system. These options do not apply to NFS. You can perform many of these tasks through the VI Client.

For more information, see the following sections:

- "Creating a VMFS File System" on page 284
- "Extending an Existing VMFS-3 Volume" on page 285
- "Listing Attributes of a VMFS Volume" on page 285
- "Upgrading a VMFS-2 to VMFS-3" on page 286

Creating a VMFS File System

```
-C --createfs vmfs3
        -b --blocksize <block_size>kK|mM
        -S --setfsname <fsName>
```

This option creates a VMFS-3 file system on the specified SCSI partition, such as `vmhba1:0:0:1`. The partition becomes the file system's head partition.

NOTE VMFS-2 file systems are read-only on any ESX Server 3. You cannot create or modify VMFS-2 file systems but are able to read files stored on VMFS-2 file systems. VMFS-3 file systems are not accessible from ESX 2.x hosts.

CAUTION Be aware that you can have only one VMFS volume for a LUN.

You can specify the following suboptions with the `-C` option:

- `-b --blocksize` – Define the block size for the VMFS-3 file system. The default file block size is 1MB. The `<block_size>` value you specify must be either 1MB, 2MB, 4MB, or 8MB. When entering a size, indicate the unit type by adding a suffix of `m` or `M`. The unit type is not case sensitive—`vmkfstools` interprets either `m` or `M` to mean megabytes.
- `-S --setfsname` – Define the volume label of a VMFS volume for the VMFS-3 file system you are creating. Use this suboption only in conjunction with the `-C` option.The label you specify can be up to 128 characters long and cannot contain any leading or trailing blank spaces.

  After you define a volume label, you can use it whenever specifying the VMFS volume for the `vmkfstools` command. You can also use the VMFS volume when referencing the volume in virtual machine configuration files. The volume name appears in listings generated for the Linux `ls -l` command and as a symbolic link to the VMFS volume under the `/vmfs/volumes` directory.

To change the VMFS volume label, use the Linux `ln -sf` command. Use the following as an example:

```
ln -sf /vmfs/volumes/<UUID> /vmfs/volumes/<fsName>
```

`<fsName>` is the new volume label you want to use for the `<UUID>` VMFS.

Example

```
vmkfstools -C vmfs3 -b 1m -S myVMFS vmhba1:3:0:1
```

This example illustrates creating a new VMFS-3 file system named `myvmfs` on the first partition of target 3, LUN 0 of vmhba adapter 1. The file block size is 1MB.

Extending an Existing VMFS-3 Volume

```
-Z --extendfs <extention-device> <existing-VMFS-volume>
```

This option adds another extent to a previously created VMFS volume `<existing-VMFS-volume>`. Each time you use this option, you extend a VMFS-3 volume with a new extent so that the volume spans multiple partitions. At most, a logical VMFS-3 volume can have 32 physical extents.

CAUTION By running this option, you lose all data that previously existed on the SCSI device you specified in `<extension-device>`.

Example

```
vmkfstools -Z vmhba0:1:2:4 vmhba1:3:0:1
```

This example illustrates extending the logical file system by allowing it to span to a new partition. The extended file system spans two partitions—`vmhba1:3:0:1` and `vmhba0:1:2:4`. In this example, `vmhba1:3:0:1` is the name of the head partition.

Listing Attributes of a VMFS Volume

```
-P --queryfs
        -h --human-readable
```

This option lists the attributes of the specified VMFS volume when used on any file or directory that resides on the VMFS volume. The listed attributes include the VMFS version number (VMFS-2 or VMFS-3), the number of extents comprising the specified

VMFS volume, the volume label if any, the UUID, and a listing of the device names where each extent comprising the VMFS volume resides.

NOTE If any device backing VMFS file system goes offline, the number of extents and available space change accordingly.

You can specify the `-h` suboption with the `-P` option. If you do so, `vmkfstools` lists the capacity of the volume in a more readable form—for example, `5k`, `12.1M`, or `2.1G`.

Upgrading a VMFS-2 to VMFS-3

You can upgrade the VMFS-2 file system to VMFS-3.

CAUTION

- The VMFS-2 to VMFS-3 conversion is a one-way process. Once the VMFS volume is converted to VMFS-3, you cannot revert it back to a VMFS-2 volume.
- To be able to upgrade the VMFS-2 file system, its file block size shouldn't exceed 8 MB.

When upgrading the file system, use the following options:

- `-T --tovmfs3`
  `-x --upgradetype [zeroedthick|eagerzeroedthick|thin]`

  This option converts the VMFS-2 file system VMFS-3 preserving all files on the file system. Before using the `-T` option, unload the vmfs2 and vmfs3 drivers and load the auxiliary file system driver, fsaux, with a module option `fsauxFunction=upgrade`.

  Use the `-x --upgradetype [zeroedthick|eagerzeroedthick|thin]` suboption with the `-T` option:

  - `-x zeroedthick` (default) – Retains the properties of VMFS-2 thick files. With the `zeroedthick` file format, disk space is allocated to the files for future use and the unused data blocks are not zeroed out.
  - `-x eagerzeroedthick` – Zeroes out unused data blocks in thick files during conversion. If you use this suboption, the upgrade process might take much longer than with the other options.
  - `-x thin` – Converts the VMFS-2 thick files into thin-provisioned VMFS-3 files. As opposed to thick file format, the thin-provisioned format doesn't allow files to have extra space allocated for their future use, but instead provides the space on demand. During this conversion, unused blocks of the thick files are discarded.

During conversion, the ESX Server file-locking mechanism ensures that no other local process is accessing the VMFS volume that is being converted, while you need to make sure that no remote ESX server is accessing this volume. The conversion might take several minutes and signals the completion by returning the command line prompt.

After conversion, unload the fsaux driver and load vmfs3 and vmfs2 drivers to resume normal operations.

- `-u --upgradefinish`

  This option completes the upgrade.

Virtual Disk Options

Virtual disk options are tasks that you can perform when setting up, migrating, and managing virtual disks stored in file systems VMFS-2, VMFS-3, and NFS. You can also perform most of these tasks through the VI Client.

See the following sections for more information:

- "Supported Disk Formats" on page 288
- "Creating a Virtual Disk" on page 288
- "Initializing a Virtual Disk" on page 289
- "Inflating a Thin Virtual Disk" on page 289
- "Deleting a Virtual Disk" on page 289
- "Renaming a Virtual Disk" on page 289
- "Cloning a Virtual or Raw Disk" on page 290
- "Migrating VMware Workstation and VMware GSX Server Virtual Machines" on page 290
- "Extending a Virtual Disk" on page 291
- "Migrating a VMFS-2 Virtual Disk to VMFS-3" on page 291
- "Creating a Virtual Compatibility Mode Raw Device Mapping" on page 291
- "Listing Attributes of an RDM" on page 292
- "Creating a Physical Compatibility Mode Raw Device Mapping" on page 292
- "Creating a Raw Device Descriptor File" on page 292
- "Displaying Virtual Disk Geometry" on page 293

Supported Disk Formats

When creating or cloning virtual disks, you can use the `-d --diskformat` suboption to specify format for your disk. Choose an appropriate format:

- `zeroedthick` (default) – Space required for the virtual disk is allocated during creation. Any data remaining on the physical device is not erased during creation, but will be zeroed out at a later time during virtual machine read and write operations.
- `eagerzeroedthick` – Space required for the virtual disk is allocated at creation time. Unlike with the `zeroedthick` format, the data remaining on the physical device is zeroed out during creation. Disks in this format might take much longer to create than other types of disks.
- `thick` – Space required for the virtual disk is allocated during creation. This type of formatting doesn't zero out any old data that might be present on this allocated space.
- `thin` – Thin-provisioned virtual disk. Unlike with the `thick` format, space required for the virtual disk is not allocated during creation, but is supplied, zeroed out, on demand at a later time.
- `rdm` – Virtual compatibility mode raw disk mapping.
- `rdmp` – Physical compatibility mode (pass-through) raw disk mapping.
- `raw` – Raw device.
- `2gbsparse` – A sparse disk with 2GB maximum extent size. Disks in this format can be used with other VMware products.

NOTE The only disk formats that can be used for NFS are `thin` and `2gbsparse`. By default, files and virtual disks are stored in `thin` format on NFS servers, with blocks allocated on demand as needed. No other options, including RDMs, are supported on NFS.

Creating a Virtual Disk

```
-c --createvirtualdisk <size>[kK|mM|gG]
        -a --adaptertype [buslogic|lsilogic] <srcfile>
        -d --diskformat [thin|zeroedthick|thick|eagerzeroedthick]
```

This option creates a virtual disk at the specified path on a VMFS volume. You need to specify the size of the virtual disk. When entering the value for `<size>`, you can indicate the unit type by adding a suffix of `k` (kilobytes), `m` (megabytes), or `g` (gigabytes). The unit type is not case sensitive—`vmkfstools` interprets either `k` or `K` to mean kilobytes. If you don't specify a unit type, `vmkfstools` defaults to bytes.

You can specify the following suboptions with the `-c` option.

- `-c` specifies the device driver that will be used to communicate with the virtual disks. You can choose between BusLogic and LSI Logic SCSI drivers.
- `-d` specifies disk formats. For detailed description of the disk formats, see "Supported Disk Formats" on page 288.

Example

```
vmkfstools -c 2048m /vmfs/volumes/myVMFS/rh6.2.vmdk
```

This example illustrates creating a two-gigabyte virtual disk file named `rh6.2.vmdk` on the VMFS file system named myVMFS. This file represents an empty virtual disk that can be accessed by a virtual machine.

Initializing a Virtual Disk

```
-w --writezeros
```

This option cleans the virtual disk by writing zeros over all its data. Depending on the size of your virtual disk and I/O bandwidth to the device hosting the virtual disk, completing this command might take a long time.

CAUTION When using this command, you lose any existing data on the virtual disk.

Inflating a Thin Virtual Disk

```
-j --inflatedisk
```

This option converts a `thin` virtual disk to `eagerzeroedthick` preserving all existing data. Any blocks which were not allocated initially will be allocated and zeroed out.

For more information on disc formats, see "Supported Disk Formats" on page 288.

Deleting a Virtual Disk

```
-U --deletevirtualdisk
```

This option deletes files associated with the virtual disk listed at the specified path on the VMFS volume.

Renaming a Virtual Disk

```
-E --renamevirtualdisk <oldName> <newName>
```

This option renames a file associated with the virtual disk listed in the path specification portion of the command line. For the `-E` option to work, you must indicate the original file name or file path <oldName> and define the new file name or file path <newName>.

Cloning a Virtual or Raw Disk

```
-i --importfile <srcfile>
    -d --diskformat [rdm:<device>|rdmp:<device>|raw:<device>|thin|2gbsparse]
```

This option creates a copy of a virtual disk or raw disk you specify.

You can use the `-d` suboption for the `-i` option. This suboption specifies the disk format for the copy you create. For detailed description of the disk formats, see "Supported Disk Formats" on page 288.

NOTE To clone the ESX Server Redo logs while preserving their hierarchy, use the `cp` command.

Example

```
vmkfstools -i /vmfs/volumes/templates/gold-master.vmdk
               /vmfs/volumes/myVMFS/myOS.vmdk
```

This example illustrates cloning the contents of a master virtual disk from the template repository to a virtual disk file named `myOS.vmdk` on the file system named `myVMFS`. You can configure a virtual machine to use this virtual disk by adding lines to the virtual machine configuration file, as in the following example:

```
scsi0:0.present = TRUE
scsi0:0.fileName = /vmfs/volumes/myVMFS/myOS.vmdk
```

Migrating VMware Workstation and VMware GSX Server Virtual Machines

You cannot use VI Client to migrate virtual machines created with VMware Workstation or VMware GSX Server into your ESX Server system. However, you can use the `vmkfstools -i` command to import the virtual disk into your ESX Server system and then attach this disk to a new virtual machine you create in ESX Server.

To Migrate Workstation and GSX Server Virtual Machines

1. Import a Workstation or GSX Server disk into your `/vmfs/volumes/myVMFS/` directory.
2. In the VI Client, create a new virtual machine using the **Custom** configuration option.
3. When configuring a disk, select **Use an existing virtual disk** option and attach the Workstation or GSX Server disk you imported.

Extending a Virtual Disk

`-X --extendvirtualdisk <newSize>[kK|mM|gG]`

This option extends the size of a disk allocated to a virtual machine after the virtual machine has been created. The virtual machine that uses this disk file must be powered off when you enter this command. Also, to take advantage of the extra space, the guest operating system must be able to recognize and use the new size of the disk, for example by updating the file system on the disk.

You specify the `newSize` parameter in kilobytes, megabytes, or gigabytes by adding a suffix of `k` (kilobytes), `m` (megabytes), or `g` (gigabytes), respectively. The unit type is not case sensitive—`vmkfstools` interprets either `k` or `K` to mean kilobytes. If you don't specify a unit type, `vmkfstools` defaults to kilobytes.

The `newSize` parameter defines the entire new size, not just the increment you add to the disk.

For example, to extend a 4 g virtual disk by 1 g, enter:

vmkfstools -X 5g

Migrating a VMFS-2 Virtual Disk to VMFS-3

`-M --migratevirtualdisk`

This option converts the specified virtual disk file from ESX Server 2 format to ESX Server 3 format.

Creating a Virtual Compatibility Mode Raw Device Mapping

`-r --createrdm <device>`

This option creates a Raw Device Mapping (RDM) file on a VMFS-3 volume and maps a raw disk to this file. After this mapping is established, you can access the raw disk as you would a normal VMFS virtual disk. The file length of the mapping is the same as the size of the raw disk it points to.

When specifying the `<device>` parameter, enter `0` for the partition indicating that the entire raw disk is used. Use the following format:

```
/vmfs/devices/disks/vmhbaA:T:L:0
```

See "vmkfstools Command Syntax" on page 282 for more information.

For more details on configuring and using RDMs, see "Raw Device Mapping" on page 151.

NOTE All VMFS-3 file-locking mechanisms apply to raw disk mappings.

Example

vmkfstools -r /vmfs/devices/disks/vmhba1:3:0:0 foo_rdm.vmdk

This example illustrates creating an RDM file named `foo_rdm.vmdk` and mapping the `vmhba1:3:0:0` raw disk to that file. You can configure a virtual machine to use the `foo_rdm.vmdk` mapping file by adding the following lines to the virtual machine configuration file:

```
scsi0:0.present = TRUE
scsi0:0.fileName = /vmfs/volumes/myVMFS/foo_rdm.vmdk
```

Listing Attributes of an RDM

`-q --queryrdm`

This option lets you list the attributes of a raw disk mapping.

When used with a `rdm:<device>` or `raw:<device>` specification, this option prints out the vmhba name of the raw disk, referenced by the `<device>`, that uses the mapping file. The option also prints out any existing identification information for the raw disk.

Creating a Physical Compatibility Mode Raw Device Mapping

`-z --createrdmpassthru <device>`

This option lets you map a pass-through raw device to a file on a VMFS volume. This mapping lets a virtual machine bypass ESX Server SCSI command filtering when accessing its virtual disk.This type of mapping is useful when the virtual machine needs to send proprietary SCSI commands, for example, when SAN-aware software is run inside the virtual machine.

After you establish this type of mapping, you can use it to access the raw disk just as you would any other VMFS virtual disk.

When specifying the `<device>` parameter, enter `0` for the partition indicating that the entire raw device is used. Use the following format:

```
/vmfs/devices/disks/vmhbaA:T:L:0
```

See "vmkfstools Command Syntax" on page 282 for more information.

Creating a Raw Device Descriptor File

`-Q --createrawdevice <device>`

This option creates a raw device descriptor file on a VMFS file system. This option should be used only for generic SCSI devices, such as tape drives.

When entering the <device> parameter, use the following format:

```
/vmfs/devices/generic/vmhbaA:T:L:P
```

See "vmkfstools Command Syntax" on page 282 for more information.

Displaying Virtual Disk Geometry

`-g --geometry`

This option gets information about the geometry of a virtual disk.

The output is in the form: `Geometry information C/H/S`, where `C` represents the number of cylinders, `H` represents the number of heads, and `S` represents the number of sectors.

NOTE When importing VMware Workstation virtual disks to ESX Server, you may see a disk geometry mismatch error message. A disk geometry mismatch may also be the cause of problems loading a guest operating system or running a newly created virtual machine.

Device Options

Device options let you perform administrative tasks for physical storage devices you are working with. You can perform most of these tasks through the VI Client.

This section covers the following topics:

- "Scanning Adapters" on page 293
- "Managing SCSI Reservations of LUNs" on page 294

Scanning Adapters

`-s --scan <adapterName>`

This option scans a specified adapter for newly added or changed devices or LUNs. The `-s` option is especially useful for adapters connected to storage area networks (SANs). If a new device or LUN becomes accessible through the adapter, ESX Server registers this new device for use by virtual machines. If an existing LUN is no longer available, then it is removed from use by virtual machines.

If you want to scan all adapters, use the following command:

```
esxcfg-rescan
```

You can see the results of the scan by using `ls /vmfs/devices/disks`.

Example

```
vmkfstools –s vmhba1
```

This example illustrates scanning the `vmhba1` adapter to determine whether any new targets or LUNs have been added. This command also determines if any targets or LUNs have been removed.

Managing SCSI Reservations of LUNs

```
–L ––lock [reserve|release|lunreset|targetreset|busreset]<device>
```

This option lets you reserve a SCSI LUN for exclusive use by an ESX Server host, release a reservation so that other hosts can access the LUN, and reset a reservation, forcing all reservations from the target to be released.

CAUTION Using the `-L` option can interrupt the operations of other servers on a storage area network (SAN). Use the `-L` option only when troubleshooting clustering setups.

Unless specifically advised by VMware, never use this option on a LUN hosting a VMFS volume.

You can specify the `-L` option in several ways:

- `-L reserve` – Reserves the specified LUN. After the reservation, only the server that reserved that LUN can access it. If other servers attempt to access that LUN, they will get a reservation error.
- `-L release` – Releases the reservation on the specified LUN. Any other server can access the LUN again.
- `-L lunreset` – Resets the specified LUN by clearing any reservation on the LUN and making the LUN available to all servers again. The reset does not affect any of the other LUNs on the device. If another LUN on the device is reserved, it remains reserved.
- `-L targetreset` – Resets the entire target. The reset clears any reservations on all the LUNs associated with that target and makes the LUNs available to all servers again.
- `-L busreset` – Resets all accessible targets on the bus. The reset clears any reservation on all the LUNs accessible through the bus and makes them available to all servers again.

When entering the <device> parameter, use the following format:

`/vmfs/devices/disks/vmhbaA:T:L:P`

See "vmkfstools Command Syntax" on page 282 for more information.

Examples Using vmkfstools

This section includes examples using the `vmkfstools` command with the different options described previously.

The section includes the following topics:

Create a New VMFS-3 File System

```
vmkfstools -C vmfs3 -b 1m -S myVMFS vmhba1:3:0:1
```

This example illustrates creating a new VMFS-3 file system named `myvmfs` on the first partition of target 3, LUN 0 of SCSI adapter 1. The file block size is 1MB.

Add a Partition to VMFS-3 File System

```
vmkfstools -Z vmhba0:1:2:4 vmhba1:3:0:1
```

This example illustrates extending the logical file system by allowing it to span to a new partition. The extended file system spans two partitions—`vmhba1:3:0:1` and `vmhba0:1:2:4`. In this example, `vmhba1:3:0:1` is the name of the head partition.

Create a New Virtual Disk

```
vmkfstools -c 2048m /vmfs/volumes/myVMFS/myOS.vmdk
```

This example illustrates creating a two-gigabyte virtual disk file named `myOS.vmdk` on the VMFS file system named myVMFS. This file represents an empty virtual disk that can be accessed by a virtual machine.

Clone a Virtual Disk

```
vmkfstools -i /vmfs/volumes/templates/gold-master.vmdk
               /vmfs/volumes/myVMFS/myOS.vmdk
```

This example illustrates cloning the contents of a master virtual disk from the template repository to a virtual disk file named `myOS.vmdk` on the file system named `myVMFS`. You can configure a virtual machine to use this virtual disk by adding lines to the virtual machine configuration file, as in the following example:

```
scsi0:0.present = TRUE
scsi0:0.fileName = /vmfs/volumes/myVMFS/myOS.vmdk
```

Create a Raw Device Mapping

```
vmkfstools -r /vmfs/devices/disks/vmhba1:3:0:0 foo_rdm.vmdk
```

This example illustrates creating an RDM file named `foo_rdm.vmdk` and maps the `vmhba1:3:0:0` raw disk to that file. You can configure a virtual machine to use the `foo_rdm.vmdk` mapping file as you did in the previous example. See "Clone a Virtual Disk" on page 296.

Scan an Adapter for Changes

```
vmkfstools -s vmhba1
```

This example illustrates scanning the `vmhba1` adapter to determine whether any new targets or LUNs have been added. This command also determines if any targets or LUNs have been removed.

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Updates for the Server Configuration Guide

Last Updated: August 14, 2009

This document provides updates to ESX Server 3.0.1 and VirtualCenter 2.0.1 version of the *Server Configuration Guide.* Updated descriptions, procedures, and graphics are organized by page number so that you can easily locate the areas of the guide that have changes. If the change spans multiple sequential pages, this document provides the starting page number only.

The following is a list of updates to the *Server Configuration Guide*:

Updates for the Discussion of Virtual Switches on Page 23

The note in the Virtual Switches section lists the incorrect maximum number of vSwitches on a host:

NOTE You can create a maximum of 248 vSwitches on a single host.

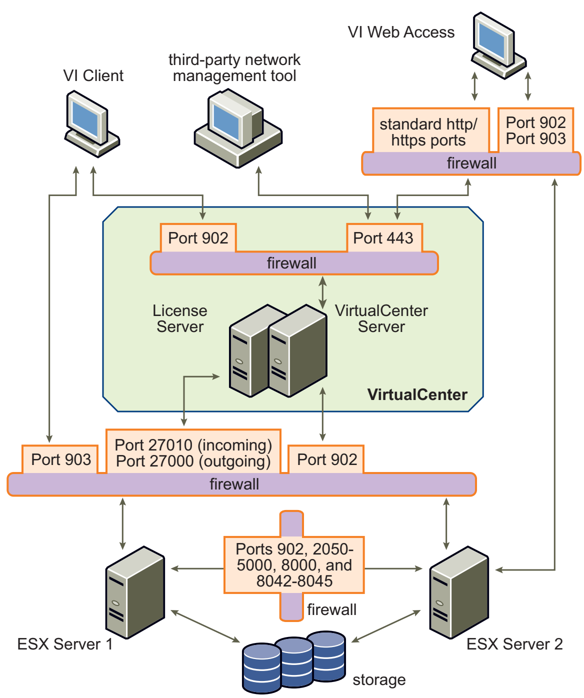
The corrected note reads:

NOTE You can create a maximum of 127 vSwitches on a single host.

Updates for the Firewall Configuration for ESX Server Networks Managed by a VirtualCenter Server Figure on Page 183

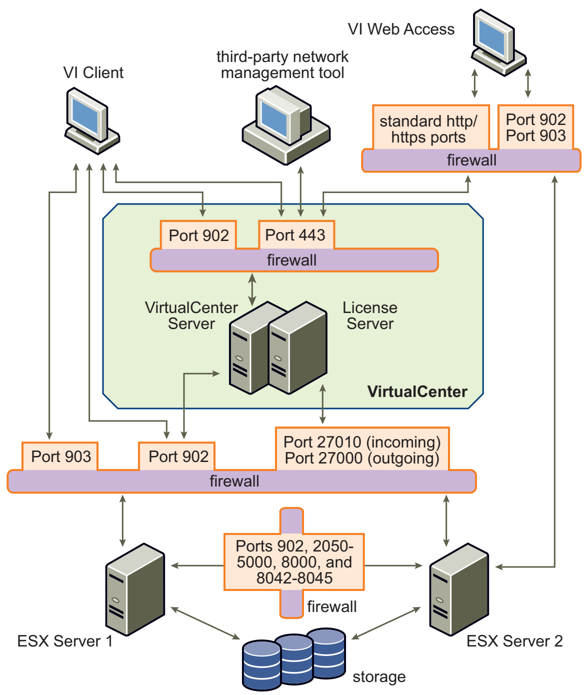
Figure 10-1 contains incorrect representation of ports 443 and 902. The following figure is the original Figure 10-1.

Figure 10-1—Original Version



The following figure replaces Figure 10-1. Port 443 also connects a VI Client to the VirtualCenter Server. Port 902 also connects a VI Client to virtual machine consoles.

Figure 10-1—Revised Version



Updates for the Table of TCP and UPD Ports for Management Access on Page 187

The information in Table 10-1 on port 443 is incomplete.

443	HTTPS access. The default SSL Web port. Use Port 443 for the following: ■ Connection to VI Web Access from the Web. ■ VI Web Access and third-party network management client connections to the VirtualCenter Server. ■ Direct VI Web Access and third-party network management clients access to ESX Server hosts.	Incoming TCP

The corrected table row reads:

443	HTTPS access. The default SSL Web port. Use Port 443 for the following: ■ Connection to VI Web Access from the Web. ■ VI Web Access and third-party network management client connections to the VirtualCenter Server. ■ Direct VI Web Access and third-party network management clients access to ESX Server hosts. ■ Connection from VI Client to the VirtualCenter Server.	Incoming TCP

Updates for the Table of TCP and UPD Ports for Management Access on Page 188

The information in Table 10-1 on port 902 is incomplete.

902	Authentication traffic for the ESX Server host and virtual machine configuration. Use Port 902 for the following: ■ VI Client access to the VirtualCenter Server. ■ VirtualCenter Server access to ESX Server hosts. ■ Direct VI Client access to ESX Server hosts. ■ ESX Server host access to other ESX Server hosts for migration and provisioning.	Incoming TCP, outgoing UDP

The corrected table row reads:

902	Authentication traffic for the ESX Server host and virtual machine configuration. Use Port 902 for the following: ■ VI Client access to the VirtualCenter Server. ■ VirtualCenter Server access to ESX Server hosts. ■ Direct VI Client access to ESX Server hosts. ■ ESX Server host access to other ESX Server hosts for migration and provisioning. ■ Connection from the VI Client to the VirtualCenter Server	Incoming TCP, outgoing UDP

Updates for the Table of TCP and UPD Ports on Page 188

The information in Table 10-1 about the Purpose and Traffic Type for port 27010 is incorrect.

27010	License transactions from the license server.	Incoming TCP

The corrected table row reads:

27010	License transactions from ESX Server to the license server.	Outgoing TCP

Update to the Connecting to the Virtual Machine Console Through a Firewall Section on Page 189

The information is incomplete in the Port 902 list item in Connecting to the Virtual Machine Console Through a Firewall.

- **Port 902** – The VirtualCenter Server uses this port to send data to the VirtualCenter managed hosts. Also, the VI Client, when connected directly to an ESX Server host, uses this port to support any management functions related to the server and its virtual machines. Port 902 is the port that the VirtualCenter Server and the VI Client assume is available when sending data to the ESX Server host. VMware does not support configuring a different port for these connections.

  Port 902 connects the VirtualCenter Server or client to the ESX Server host through the VMware Authorization Daemon (`vmware-authd`) running in the service console. The authorization daemon multiplexes port 902 data to the VMware Host Agent (`vmware-hostd`) for processing.

The corrected Port 902 list item is as follows:

- **Port 902** – The VirtualCenter Server uses this port to send data to the VirtualCenter managed hosts. Also, the VI Client, when connected directly to an ESX Server host, uses this port to support any management functions related to the server and its virtual machines. Port 902 is the port that the VirtualCenter Server and the VI Client assume is available when sending data to the ESX Server host. VMware does not support configuring a different port for these connections.

  Port 902 connects the VirtualCenter Server or client to the ESX Server host through the VMware Authorization Daemon (`vmware-authd`) running in the service console. Port 902 also connects the VI Client to the VirtualCenter Server. The authorization daemon multiplexes port 902 data to the VMware Host Agent (`vmware-hostd`) for processing.

Update to the Connecting to the Virtual Machine Console Through a Firewall Section on Page 190

The information is incomplete in the Port 443 list item in Connecting to the Virtual Machine Console Through a Firewall.

- **Port 443** – The VI Web Access Client and SDK use this port to send data to the VirtualCenter managed hosts. Also, the VI Web Access Client and SDK, when connected directly to an ESX Server host, use this port to support any management functions related to the server and its virtual machines. Port 443 is the port that the VI Web Access Client and the SDK assume is available when sending data to the ESX Server host. VMware doesn't support configuring a different port for these connections.

  Port 443 connects the VI Web Access Client or third-party network management client to the ESX Server host through the Tomcat Web service or the SDK, respectively. These processes multiplex port 443 data to `vmware-hostd` for processing.

The corrected Port 443 list item is as follows:

- **Port 443** – The VI Web Access Client and SDK use this port to send data to the VirtualCenter managed hosts. Also, the VI Web Access Client and SDK, when connected directly to an ESX Server host, use this port to support any management functions related to the server and its virtual machines. Port 443 is the port that the VI Web Access Client and the SDK assume is available when sending data to the ESX Server host. VMware does not support configuring a different port for these connections.

  Port 443 connects the VI Web Access Client or third-party network management client to the ESX Server host through the Tomcat Web service or the SDK, respectively. Port 443 also connects the VI Client to the VirtualCenter Server. These processes multiplex port 443 data to `vmware-hostd` for processing.

Update for the Password Aging Section on Page 244

The Password Aging section incorrectly states that the maximum number of days that a user can retain a password is 90 days. The corrected list item should appear as follows:

Maximum days — The number of days that a user can retain a password. By default, passwords are set to never expire.