iSCSI SAN Configuration Guide

ESX 4.1
ESXi 4.1
vCenter Server 4.1

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Contents

Updated Information

This *iSCSI SAN Configuration Guide* is updated with each release of the product or when necessary.

This table provides the update history of the *iSCSI SAN Configuration Guide*.

Revision	Description
EN-000288-01	"ESX/ESXi iSCSI SAN Restrictions," on page 30 has been updated to clarify multipathing support for different types of iSCSI adapters.
EN-000288-00	Initial release.

About This Book

The *iSCSI SAN Configuration Guide* explains how to use VMware® ESX™ and VMware ESXi systems with an iSCSI storage area network (SAN). The manual includes conceptual background information and installation requirements for ESX, ESXi, and VMware vCenter™ Server.

Intended Audience

This manual is written for experienced Windows or Linux system administrators who are familiar with virtual machine technology datacenter operations.

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The VMware vSphere documentation consists of the combined VMware vCenter Server and ESX/ESXi documentation set.

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Using ESX/ESXi with an iSCSI Storage Area Network

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You can use ESX/ESXi in conjunction with a storage area network (SAN), a specialized high-speed network that connects computer systems to high-performance storage subsystems. Using ESX/ESXi together with a SAN provides storage consolidation, improves reliability, and helps with disaster recovery.

To use ESX/ESXi effectively with a SAN, you must have a working knowledge of ESX/ESXi systems and SAN concepts. Also, when you set up ESX/ESXi hosts to use Internet SCSI (iSCSI) SAN storage systems, you must be aware of certain special considerations that exist.

This chapter includes the following topics:

Understanding Virtualization

The VMware virtualization layer is common across VMware desktop products (such as VMware Workstation) and server products (such as VMware ESX/ESXi). This layer provides a consistent platform for development, testing, delivery, and support of application workloads.

The virtualization layer is organized as follows:

- Each virtual machine runs its own operating system (the guest operating system) and applications.
- The virtualization layer provides the virtual devices that map to shares of specific physical devices. These devices include virtualized CPU, memory, I/O buses, network interfaces, storage adapters and devices, human interface devices, and BIOS.

Network Virtualization

The virtualization layer guarantees that each virtual machine is isolated from other virtual machines. Virtual machines can talk to each other only through networking mechanisms similar to those used to connect separate physical machines.

The isolation allows administrators to build internal firewalls or other network isolation environments so that some virtual machines can connect to the outside, while others are connected only through virtual networks to other virtual machines.

Storage Virtualization

ESX/ESXi provides host-level storage virtualization, which logically abstracts the physical storage layer from virtual machines.

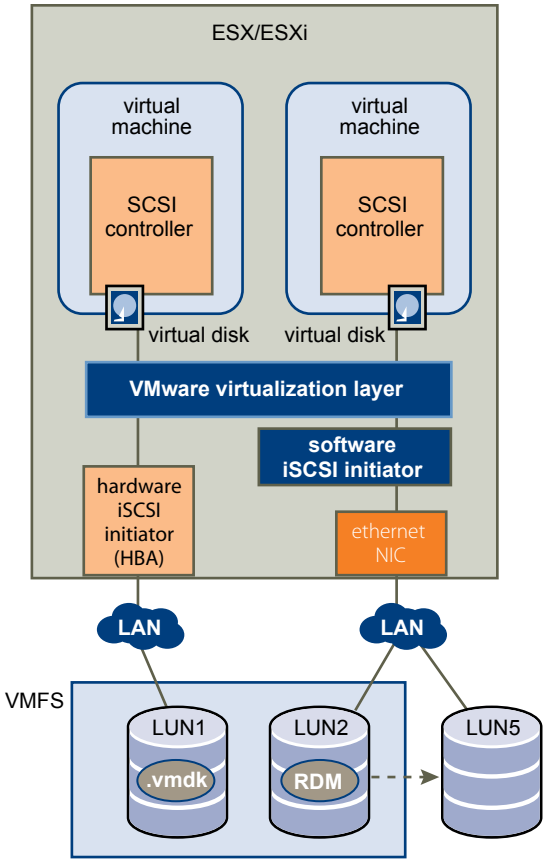
An ESX/ESXi virtual machine uses a virtual disk to store its operating system, program files, and other data associated with its activities. A virtual disk is a large physical file, or a set of files, that can be copied, moved, archived, and backed up as easily as any other file. You can configure virtual machines with multiple virtual disks.

To access virtual disks, a virtual machine uses virtual SCSI controllers. These virtual controllers include BusLogic Parallel, LSI Logic Parallel, LSI Logic SAS, and VMware Paravirtual. These controllers are the only types of SCSI controllers that a virtual machine can see and access.

Each virtual disk that a virtual machine can access through one of the virtual SCSI controllers resides on a VMware Virtual Machine File System (VMFS) datastore, an NFS-based datastore, or on a raw disk. From the standpoint of the virtual machine, each virtual disk appears as if it were a SCSI drive connected to a SCSI controller. Whether the actual physical disk device is being accessed through parallel SCSI, iSCSI, network, or Fibre Channel adapters on the host is transparent to the guest operating system and to applications running on the virtual machine.

Figure 1-1 gives an overview of storage virtualization. The diagram illustrates storage that uses VMFS and storage that uses raw device mapping. The diagram also shows how iSCSI storage is accessed through either iSCSI HBAs or by using a general-purpose NIC that uses iSCSI initiator software.

Figure 1-1. iSCSI SAN Storage Virtualization



iSCSI SAN Concepts

If you are an ESX/ESXi administrator who plans to set up ESX/ESXi hosts to work with SANs, you must have a working knowledge of SAN concepts. You can find information about SAN in print and on the Internet.

iSCSI SANs use Ethernet connections between computer systems, or host servers, and high performance storage subsystems. The SAN components include iSCSI host bus adapters (HBAs) or Network Interface Cards (NICs) in the host servers, switches and routers that transport the storage traffic, cables, storage processors (SPs), and storage disk systems.

iSCSI SAN uses a client-server architecture. The client, called iSCSI initiator, operates on your host. It initiates iSCSI sessions by issuing SCSI commands and transmitting them, encapsulated into iSCSI protocol, to a server. The server is known as an iSCSI target. The iSCSI target represents a physical storage system on the network. It can also be provided by a virtual iSCSI SAN, for example, an iSCSI target emulator running in a virtual machine. The iSCSI target responds to the initiator's commands by transmitting required iSCSI data.

Ports in the iSCSI SAN

A single discoverable entity on the iSCSI SAN, such as an initiator or a target, represents an iSCSI node. Each node has one or more ports that connect it to the SAN.

iSCSI ports are end-points of an iSCSI session. Each node can be identified in a number of ways.

IP Address — Each iSCSI node can have an IP address associated with it so that routing and switching equipment on your network can establish the connection between the server and storage. This address is just like the IP address that you assign to your computer to get access to your company's network or the Internet.

iSCSI Name — A worldwide unique name for identifying the node. iSCSI uses the iSCSI Qualified Name (IQN), Extended Unique Identifier (EUI), and Network Address Authority (NAA) formats.

By default, ESX/ESXi generates unique iSCSI names for your iSCSI initiators, for example, `iqn.1998-01.com.vmware:iscsitestox-68158ef2`. Usually, you do not have to change the default value, but if you do, make sure that the new iSCSI name you enter is worldwide unique.

iSCSI Alias — A more manageable name for an iSCSI device or port used instead of the iSCSI name. iSCSI aliases are not unique and are intended to be just a friendly name to associate with a port.

iSCSI Naming Conventions

iSCSI uses a special unique name to identify an iSCSI node, either target or initiator. This name is similar to the WorldWide Name (WWN) associated with Fibre Channel devices and is used as a way to universally identify the node.

iSCSI names are formatted in two different ways. The most common is the IQN format.

For more details on iSCSI naming requirements and string profiles, see RFC 3721, RFC 3722, and RFC 3980 on the IETF Web site.

iSCSI Qualified Name (IQN) Format

The IQN format takes the form `iqn.yyyy-mm.naming-authority:unique name`, where:

- *yyyy-mm* is the year and month when the naming authority was established.
- *naming-authority* is usually reverse syntax of the Internet domain name of the naming authority. For example, the iscsi.vmware.com naming authority could have the iSCSI qualified name form of iqn. 1998-01.com.vmware.iscsi. The name indicates that the vmware.com domain name was registered in January of 1998, and iscsi is a subdomain, maintained by vmware.com.
- *unique name* is any name you want to use, for example, the name of your host. The naming authority must make sure that any names assigned following the colon are unique, such as:
  - iqn.1998-01.com.vmware.iscsi:name1
  - iqn.1998-01.com.vmware.iscsi:name2
  - iqn.1998-01.com.vmware.iscsi:name999

Enterprise Unique Identifier (EUI) Format

The EUI format takes the form `eui.`*`16 hex digits`*.

For example, `eui.0123456789ABCDEF`.

The 16-hexadecimal digits are text representations of a 64-bit number of an IEEE EUI (extended unique identifier) format. The top 24 bits are a company ID that IEEE registers with a particular company. The lower 40 bits are assigned by the entity holding that company ID and must be unique.

iSCSI Initiators

To access iSCSI targets, your host uses iSCSI initiators. The initiators transport SCSI requests and responses, encapsulated into the iSCSI protocol, between the host and the iSCSI target.

VMware supports different types of initiators.

Software iSCSI Adapter

A software iSCSI adapter is a VMware code built into the VMkernel. It allows your host to connect to the iSCSI storage device through standard network adapters. The software iSCSI adapter handles iSCSI processing while communicating with the network adapter. With the software iSCSI adapter, you can use iSCSI technology without purchasing specialized hardware.

Hardware iSCSI Adapter

A hardware iSCSI adapter is a third-party adapter that offloads iSCSI and network processing from your host. Hardware iSCSI adapters are divided into categories.

Dependent Hardware iSCSI Adapter	Depends on VMware networking, and iSCSI configuration and management interfaces provided by VMware. This type of adapter can be a card that presents a standard network adapter and iSCSI offload functionality for the same port. The iSCSI offload functionality depends on the host's network configuration to obtain the IP, MAC, and other parameters used for iSCSI sessions. An example of a dependent adapter is the iSCSI licensed Broadcom 5709 NIC.
Independent Hardware iSCSI Adapter	Implements its own networking and iSCSI configuration and management interfaces. An example of an independent hardware iSCSI adapter is a card that either presents only iSCSI offload functionality or iSCSI offload functionality and standard NIC functionality. The iSCSI offload functionality has independent configuration management that assigns the IP, MAC, and other parameters used for the iSCSI sessions. An example of a independent adapter is the QLogic QLA4052 adapter.

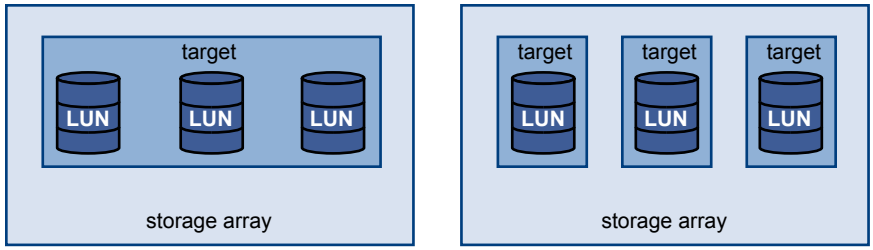
Hardware iSCSI adapters might need to be licensed. Otherwise, they will not appear in the vSphere Client or vSphere CLI. Contact your vendor for licensing information.

Target Compared to LUN Representations

In the ESX/ESXi context, the term target identifies a single storage unit that your host can access. The terms storage device and LUN describe a logical volume that represents storage space on a target. Typically, the terms device and LUN, in the ESX/ESXi context, mean a SCSI volume presented to your host from a storage target and available for formatting.

Different iSCSI storage vendors present storage to servers in different ways. Some vendors present multiple LUNs on a single target, while others present multiple targets with one LUN each. While the way the storage is used by an ESX/ESXi is similar, the way the information is presented through administrative tools is different.

Figure 1-2. Target Compared to LUN Representations



Three LUNs are available in each of these configurations. In the first case, ESX/ESXi detects one target but that target has three LUNs that can be used. Each of the LUNs represents individual storage volume. In the second case, the ESX/ESXi detects three different targets, each having one LUN.

ESX/ESXi-based iSCSI initiators establish connections to each target. Storage systems with a single target containing multiple LUNs have traffic to all the LUNs on a single connection. With a system that has three targets with one LUN each, a host uses separate connections to the three LUNs. This information is useful when you are trying to aggregate storage traffic on multiple connections from the ESX/ESXi host with multiple iSCSI HBAs, where traffic for one target can be set to a particular HBA, while traffic for another target can use a different HBA.

Multipathing and Path Failover

When transferring data between the host server and storage, the SAN uses a technique known as multipathing. Multipathing allows you to have more than one physical path from the ESX/ESXi host to a LUN on a storage system.

Generally, a single path from a host to a LUN consists of an iSCSI adapter or NIC, switch ports, connecting cables, and the storage controller port. If any component of the path fails, the host selects another available path for I/O. The process of detecting a failed path and switching to another is called path failover.

Storage System Types

ESX/ESXi supports different storage systems and arrays.

The types of storage that your host supports include active-active, active-passive, and ALUA-compliant.

Active-active storage system — Allows access to the LUNs simultaneously through all the storage ports that are available without significant performance degradation. All the paths are active at all times, unless a path fails.

Active-passive storage system — A system in which one storage processor is actively providing access to a given LUN. The other processors act as backup for the LUN and can be actively providing access to other LUN I/O. I/O can be successfully sent only to an active port for a given LUN. If access through the active storage port fails, one of the passive storage processors can be activated by the servers accessing it.

Asymmetrical storage system — Supports Asymmetric Logical Unit Access (ALUA). ALUA-complaint storage systems provide different levels of access per port. ALUA allows hosts to determine the states of target ports and prioritize paths. The host uses some of the active paths as primary while others as secondary.

Virtual port storage system — Allows access to all available LUNs through a single virtual port. These are active-active storage devices, but hide their multiple connections though a single port. The ESX/ESXi multipathing cannot detect the multiple connections to the storage. These storage systems handle port failover and connection balancing transparently. This is often referred to as transparent failover.

Discovery, Authentication, and Access Control

You can use several mechanisms to discover your storage and to limit access to it.

You must configure your host and the iSCSI storage system to support your storage access control policy.

Discovery

A discovery session is part of the iSCSI protocol, and it returns the set of targets you can access on an iSCSI storage system. The two types of discovery available on ESX/ESXi are dynamic and static. Dynamic discovery obtains a list of accessible targets from the iSCSI storage system, while static discovery can only try to access one particular target by target name.

Authentication

iSCSI storage systems authenticate an initiator by a name and key pair. ESX/ESXi supports the CHAP protocol, which VMware recommends for your SAN implementation. To use CHAP authentication, the ESX/ESXi host and the iSCSI storage system must have CHAP enabled and have common credentials.

Access Control

Access control is a policy set up on the iSCSI storage system. Most implementations support one or more of three types of access control:

- By initiator name
- By IP address
- By the CHAP protocol

Only initiators that meet all rules can access the iSCSI volume.

Error Correction

To protect the integrity of iSCSI headers and data, the iSCSI protocol defines error correction methods known as header digests and data digests.

Both parameters are disabled by default, but you can enable them. These digests pertain to, respectively, the header and SCSI data being transferred between iSCSI initiators and targets, in both directions.

Header and data digests check the end-to-end, noncryptographic data integrity beyond the integrity checks that other networking layers provide, such as TCP and Ethernet. They check the entire communication path, including all elements that can change the network-level traffic, such as routers, switches, and proxies.

The existence and type of the digests are negotiated when an iSCSI connection is established. When the initiator and target agree on a digest configuration, this digest must be used for all traffic between them.

Enabling header and data digests does require additional processing for both the initiator and the target and can affect throughput and CPU use performance.

NOTE Systems that use Intel Nehalem processors offload the iSCSI digest calculations, thus reducing the impact on performance.

Overview of Using ESX/ESXi with a SAN

Using ESX/ESXi with a SAN improves flexibility, efficiency, and reliability. Using ESX/ESXi with a SAN also supports centralized management, failover, and load balancing technologies.

The following are benefits of using ESX/ESXi with a SAN:

- You can store data securely and configure multiple paths to your storage, eliminating a single point of failure.
- Using a SAN with ESX/ESXi systems extends failure resistance to the server. When you use SAN storage, all applications can instantly be restarted on another host after the failure of the original host.
- You can perform live migration of virtual machines using VMware vMotion.
- Use VMware High Availability (HA) in conjunction with a SAN to restart virtual machines in their last known state on a different server if their host fails.
- Use VMware Fault Tolerance (FT) to replicate protected virtual machines on two different hosts. Virtual machines continue to function without interruption on the secondary host if the primary one fails.
- Use VMware Distributed Resource Scheduler (DRS) to migrate virtual machines from one host to another for load balancing. Because storage is on a shared SAN array, applications continue running seamlessly.
- If you use VMware DRS clusters, put an ESX/ESXi host into maintenance mode to have the system migrate all running virtual machines to other ESX/ESXi hosts. You can then perform upgrades or other maintenance operations on the original host.

The portability and encapsulation of VMware virtual machines complements the shared nature of this storage. When virtual machines are located on SAN-based storage, you can quickly shut down a virtual machine on one server and power it up on another server, or suspend it on one server and resume operation on another server on the same network. This ability allows you to migrate computing resources while maintaining consistent shared access.

ESX/ESXi and SAN Use Cases

You can perform a number of tasks when using ESX/ESXi with a SAN.

Using ESX/ESXi in conjunction with a SAN is effective for the following tasks:

Maintenance with zero downtime

When performing ESX/ESXi host or infrastructure maintenance, use VMware DRS or vMotion to migrate virtual machines to other servers. If shared storage is on the SAN, you can perform maintenance without interruptions to the users of the virtual machines.

Load balancing

Use vMotion or VMware DRS to migrate virtual machines to other hosts for load balancing. If shared storage is on a SAN, you can perform load balancing without interruption to the users of the virtual machines.

Storage consolidation and simplification of storage layout

If you are working with multiple hosts, and each host is running multiple virtual machines, the storage on the hosts is no longer sufficient and external storage is required. Choosing a SAN for external storage results in a simpler system architecture along with other benefits.

Start by reserving a large volume and then allocate portions to virtual machines as needed. Volume allocation and creation from the storage device needs to happen only once.

Disaster recovery	Having all data stored on a SAN facilitates the remote storage of data backups. You can restart virtual machines on remote ESX/ESXi hosts for recovery if one site is compromised.
Simplified array migrations and storage upgrades	When you purchase new storage systems or arrays, use storage vMotion to perform live automated migration of virtual machine disk files from existing storage to their new destination without interruptions to the users of the virtual machines.

Finding Further Information

In addition to this document, a number of other resources can help you configure your ESX/ESXi system in conjunction with a SAN.

- Use your storage array vendor's documentation for most setup questions. Your storage array vendor might also offer documentation on using the storage array in an ESX/ESXi environment.
- The VMware Documentation Web site.
- The *Fibre Channel SAN Configuration Guide* discusses the use of ESX/ESXi with Fibre Channel storage area networks.
- The *VMware I/O Compatibility Guide* lists the currently approved HBAs, HBA drivers, and driver versions.
- The *VMware Storage/SAN Compatibility Guide* lists currently approved storage arrays.
- The *VMware Release Notes* give information about known issues and workarounds.
- The *VMware Knowledge Bases* have information on common issues and workarounds.

Specifics of Using SAN Storage with ESX/ESXi

Using a SAN in conjunction with an ESX/ESXi host differs from traditional SAN usage in a variety of ways.

When you use SAN storage with ESX/ESXi, keep in mind the following considerations:

- You cannot directly access the virtual machine operating system that uses the storage. With traditional tools, you can monitor only the VMware ESX/ESXi operating system. You use the vSphere Client to monitor virtual machines.
- The HBA visible to the SAN administration tools is part of the ESX/ESXi system, not part of the virtual machine.
- Your ESX/ESXi system performs multipathing for you.

Third-Party Management Applications

You can use third-party management applications in conjunction with your ESX/ESXi host.

Most iSCSI storage hardware is packaged with storage management software. In many cases, this software is a web application that can be used with any web browser connected to your network. In other cases, this software typically runs on the storage system or on a single server, independent of the servers that use the SAN for storage.

Use this third-party management software for the following tasks:

- Storage array management, including LUN creation, array cache management, LUN mapping, and LUN security.
- Setting up replication, check points, snapshots, or mirroring.

If you decide to run the SAN management software on a virtual machine, you gain the benefits of running a virtual machine, including failover using vMotion and VMware HA. Because of the additional level of indirection, however, the management software might not be able to see the SAN. In this case, you can use an RDM.

NOTE Whether a virtual machine can run management software successfully depends on the particular storage system.

Understanding VMFS Datastores

To store virtual disks, ESX/ESXi uses datastores, which are logical containers that hide specifics of storage from virtual machines and provide a uniform model for storing virtual machine files. Datastores that you deploy on storage devices typically use the VMware Virtual Machine File System (VMFS) format, a special high-performance file system format that is optimized for storing virtual machines.

A VMFS datastore can run multiple virtual machines. VMFS provides distributed locking for your virtual machine files, so that your virtual machines can operate safely in a SAN environment where multiple ESX/ESXi hosts share the same VMFS datastore.

Use the vSphere Client to set up a VMFS datastore in advance on a block-based storage device that your ESX/ESXi host discovers. A VMFS datastore can be extended to span several physical storage extents, including SAN LUNs and local storage. This feature allows you to pool storage and gives you flexibility in creating the datastore necessary for your virtual machine.

You can increase the capacity of a datastore while virtual machines are running on the datastore. This ability lets you add new space to your VMFS datastores as your virtual machine requires it. VMFS is designed for concurrent access from multiple physical machines and enforces the appropriate access controls on virtual machine files.

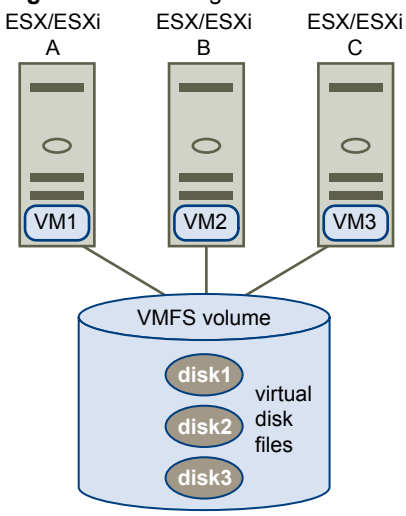
Sharing a VMFS Datastore Across ESX/ESXi Hosts

As a cluster file system, VMFS lets multiple ESX/ESXi hosts access the same VMFS datastore concurrently.

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

Figure 1-3 shows several ESX/ESXi systems sharing the same VMFS volume.

Figure 1-3. Sharing a VMFS Datastore Across ESX/ESXi Hosts



Because virtual machines share a common VMFS datastore, it might be difficult to characterize peak-access periods or to optimize performance. You must plan virtual machine storage access for peak periods, but different applications might have different peak-access periods. VMware recommends that you load balance virtual machines over servers, CPU, and storage. Run a mix of virtual machines on each server so that not all experience high demand in the same area at the same time.

Metadata Updates

A VMFS datastore holds virtual machine files, directories, symbolic links, RDM descriptor files, and so on. The datastore also maintains a consistent view of all the mapping information for these objects. This mapping information is called metadata.

Metadata is updated each time the attributes of a virtual machine file are accessed or modified when, for example, you perform one of the following operations:

- Creating, growing, or locking a virtual machine file
- Changing a file's attributes
- Powering a virtual machine on or off

Making LUN Decisions

You must plan how to set up storage for your ESX/ESXi systems before you format LUNs with VMFS datastores.

When you make your LUN decision, keep in mind the following considerations:

- Each LUN should have the correct RAID level and storage characteristic for the applications running in virtual machines that use the LUN.
- One LUN must contain only one VMFS datastore.
- If multiple virtual machines access the same VMFS, use disk shares to prioritize virtual machines.

You might want fewer, larger LUNs for the following reasons:

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

You might want more, smaller LUNs for the following reasons:

- 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.
- Better performance because there is less contention for a single volume.

When the storage characterization for a virtual machine is not available, there is often no simple method to determine the number and size of LUNs to provision. You can experiment using either a predictive or adaptive scheme.

Use the Predictive Scheme to Make LUN Decisions

When setting up storage for ESX/ESXi systems, before creating VMFS datastores, you must decide on the size and number of LUNs to provision. You can experiment using the predictive scheme.

Procedure

1 Provision several LUNs with different storage characteristics.

2 Create a VMFS datastore on each LUN, labeling each datastore according to its characteristics.

3 Create virtual disks to contain the data for virtual machine applications in the VMFS datastores created on LUNs with the appropriate RAID level for the applications' requirements.

4 Use disk shares to distinguish high-priority from low-priority virtual machines.

NOTE Disk shares are relevant only within a given host. The shares assigned to virtual machines on one host have no effect on virtual machines on other hosts.

5 Run the applications to determine whether virtual machine performance is acceptable.

Use the Adaptive Scheme to Make LUN Decisions

When setting up storage for ESX/ESXi hosts, before creating VMFS datastores, you must decide on the number and size of LUNS to provision. You can experiment using the adaptive scheme.

Procedure

1 Provision a large LUN (RAID 1+0 or RAID 5), with write caching enabled.

2 Create a VMFS on that LUN.

3 Create four or five virtual disks on the VMFS.

4 Run the applications to determine whether disk performance is acceptable.

If performance is acceptable, you can place additional virtual disks on the VMFS. If performance is not acceptable, create a new, large LUN, possibly with a different RAID level, and repeat the process. Use migration so that you do not lose virtual machines data when you recreate the LUN.

Use Disk Shares to Prioritize Virtual Machines

If multiple virtual machines access the same VMFS datastore (and therefore the same LUN), use disk shares to prioritize the disk accesses from the virtual machines. Disk shares distinguish high-priority from low-priority virtual machines.

Procedure

1 Start a vSphere Client and connect to vCenter Server.

2 Select the virtual machine in the inventory panel and click **Edit virtual machine settings** from the menu.

3 Click the **Resources** tab and click **Disk**.

4 Double-click the **Shares** column for the disk to modify and select the required value from the drop-down menu.

   Shares is a value that represents the relative metric for controlling disk bandwidth to all virtual machines. The values Low, Normal, High, and Custom are compared to the sum of all shares of all virtual machines on the server and, on an ESX host, the service console. Share allocation symbolic values can be used to configure their conversion into numeric values.

5 Click **OK** to save your selection.

NOTE Disk shares are relevant only within a given ESX/ESXi host. The shares assigned to virtual machines on one host have no effect on virtual machines on other hosts.

How Virtual Machines Access Data on a SAN

ESX/ESXi stores a virtual machine's disk files within a VMFS datastore that resides on a SAN storage device. When virtual machine guest operating systems issue SCSI commands to their virtual disks, the SCSI virtualization layer translates these commands to VMFS file operations.

When a virtual machine interacts with its virtual disk stored on a SAN, the following process takes place:

1 When the guest operating system in a virtual machine reads or writes to SCSI disk, it issues SCSI commands to the virtual disk.

2 Device drivers in the virtual machine's operating system communicate with the virtual SCSI controllers.

3 The virtual SCSI Controller forwards the command to the VMkernel.

4 The VMkernel performs the following tasks.

- Locates the file in the VMFS volume that corresponds to the guest virtual machine disk.
- Maps the requests for the blocks on the virtual disk to blocks on the appropriate physical device.
- Sends the modified I/O request from the device driver in the VMkernel to the iSCSI initiator (hardware or software).

5 If the iSCSI initiator is a hardware iSCSI adapter (both independent or dependent), the adapter performs the following tasks.

- Encapsulates I/O requests into iSCSI Protocol Data Units (PDUs).
- Encapsulates iSCSI PDUs into TCP/IP packets.
- Sends IP packets over Ethernet to the iSCSI storage system.

6 If the iSCSI initiator is a software iSCSI adapter, the following takes place.

- The iSCSI initiator encapsulates I/O requests into iSCSI PDUs.
- The initiator sends iSCSI PDUs through TCP/IP connections.
- The VMkernel TCP/IP stack relays TCP/IP packets to a physical NIC.
- The physical NIC sends IP packets over Ethernet to the iSCSI storage system.

7 Depending on which port the iSCSI initiator uses to connect to the network, Ethernet switches and routers carry the request to the storage device that the host wants to access.

Understanding Multipathing and Failover

To maintain a constant connection between an ESX/ESXi host and its storage, ESX/ESXi supports multipathing. Multipathing is a technique that lets you use more than one physical path that transfers data between the host and an external storage device.

In case of a failure of any element in the SAN network, such as an adapter, switch, or cable, ESX/ESXi can switch to another physical path, which does not use the failed component. This process of path switching to avoid failed components is known as path failover.

In addition to path failover, multipathing provides load balancing. Load balancing is the process of distributing I/O loads across multiple physical paths. Load balancing reduces or removes potential bottlenecks.

NOTE Virtual machine I/O might be delayed for up to sixty seconds while path failover takes place. These delays allow the SAN to stabilize its configuration after topology changes. In general, the I/O delays might be longer on active-passive arrays and shorter on activate-active arrays.

Managing Multiple Paths

To manage storage multipathing, ESX/ESXi uses a special VMkernel layer, the Pluggable Storage Architecture (PSA). The PSA is an open, modular framework that coordinates the simultaneous operation of multiple multipathing plug-ins (MPPs).

The VMkernel multipathing plug-in that ESX/ESXi provides by default is the VMware Native Multipathing Plug-In (NMP). The NMP is an extensible module that manages sub plug-ins. There are two types of NMP sub plug-ins, Storage Array Type Plug-Ins (SATPs), and Path Selection Plug-Ins (PSPs). SATPs and PSPs can be built-in and provided by VMware, or can be provided by a third party.

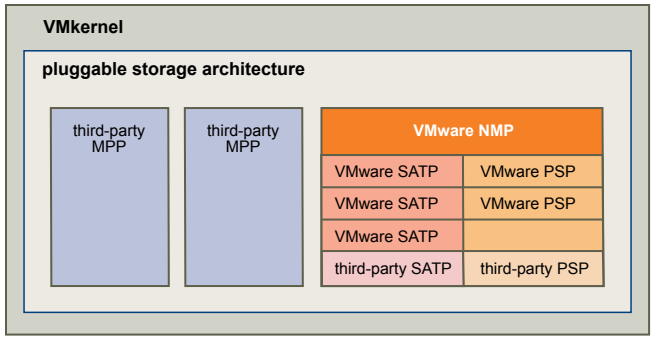
If more multipathing functionality is required, a third party can also provide an MPP to run in addition to, or as a replacement for, the default NMP.

When coordinating the VMware NMP and any installed third-party MPPs, the PSA performs the following tasks:

- Loads and unloads multipathing plug-ins.
- Hides virtual machine specifics from a particular plug-in.
- Routes I/O requests for a specific logical device to the MPP managing that device.
- Handles I/O queuing to the logical devices.
- Implements logical device bandwidth sharing between virtual machines.
- Handles I/O queueing to the physical storage HBAs.
- Handles physical path discovery and removal.
- Provides logical device and physical path I/O statistics.

As Figure 1-4 illustrates, multiple third-party MPPs can run in parallel with the VMware NMP. When installed, the third-party MPPs replace the behavior of the NMP and take complete control of the path failover and the load-balancing operations for specified storage devices.

Figure 1-4. Pluggable Storage Architecture



The multipathing modules perform the following operations:

- Manage physical path claiming and unclaiming.
- Manage creation, registration, and deregistration of logical devices.
- Associate physical paths with logical devices.
- Support path failure detection and remediation.
- Process I/O requests to logical devices:
  - Select an optimal physical path for the request.
  - Depending on a storage device, perform specific actions necessary to handle path failures and I/O command retries.
- Support management tasks, such as abort or reset of logical devices.

VMware Multipathing Module

By default, ESX/ESXi provides an extensible multipathing module called the Native Multipathing Plug-In (NMP).

Generally, the VMware NMP supports all storage arrays listed on the VMware storage HCL and provides a default path selection algorithm based on the array type. The NMP associates a set of physical paths with a specific storage device, or LUN. The specific details of handling path failover for a given storage array are delegated to a Storage Array Type Plug-In (SATP). The specific details for determining which physical path is used to issue an I/O request to a storage device are handled by a Path Selection Plug-In (PSP). SATPs and PSPs are sub plug-ins within the NMP module.

Upon installation of ESX/ESXi, the appropriate SATP for an array you use will be installed automatically. You do not need to obtain or download any SATPs.

VMware SATPs

Storage Array Type Plug-Ins (SATPs) run in conjunction with the VMware NMP and are responsible for array-specific operations.

ESX/ESXi offers a SATP for every type of array that VMware supports. It also provides default SATPs that support non-specific active-active and ALUA storage arrays, and the local SATP for direct-attached devices. Each SATP accommodates special characteristics of a certain class of storage arrays and can perform the array-specific operations required to detect path state and to activate an inactive path. As a result, the NMP module itself can work with multiple storage arrays without having to be aware of the storage device specifics.

After the NMP determines which SATP to use for a specific storage device and associates the SATP with the physical paths for that storage device, the SATP implements the tasks that include the following:

- Monitors the health of each physical path.
- Reports changes in the state of each physical path.
- Performs array-specific actions necessary for storage fail-over. For example, for active-passive devices, it can activate passive paths.

VMware PSPs

Path Selection Plug-Ins (PSPs) run with the VMware NMP and are responsible for choosing a physical path for I/O requests.

The VMware NMP assigns a default PSP for each logical device based on the SATP associated with the physical paths for that device. You can override the default PSP.

By default, the VMware NMP supports the following PSPs:

Most Recently Used (VMW_PSP_MRU) — Selects the path the ESX/ESXi host used most recently to access the given device. If this path becomes unavailable, the host switches to an alternative path and continues to use the new path while it is available. MRU is the default path policy for active-passive arrays.

Fixed (VMW_PSP_FIXED) — Uses the designated preferred path, if it has been configured. Otherwise, it uses the first working path discovered at system boot time. If the host cannot use the preferred path, it selects a random alternative available path. The host reverts back to the preferred path as soon as that path becomes available. Fixed is the default path policy for active-active arrays.

CAUTION If used with active-passive arrays, the **Fixed** path policy might cause path thrashing.

VMW_PSP_FIXED_AP — Extends the Fixed functionality to active-passive and ALUA mode arrays.

Round Robin (VMW_PSP_RR) — Uses a path selection algorithm that rotates through all available active paths enabling load balancing across the paths.

VMware NMP Flow of I/O

When a virtual machine issues an I/O request to a storage device managed by the NMP, the following process takes place.

1 The NMP calls the PSP assigned to this storage device.

2 The PSP selects an appropriate physical path on which to issue the I/O.

3 The NMP issues the I/O request on the path selected by the PSP.

4 If the I/O operation is successful, the NMP reports its completion.

5 If the I/O operation reports an error, the NMP calls the appropriate SATP.

6 The SATP interprets the I/O command errors and, when appropriate, activates the inactive paths.

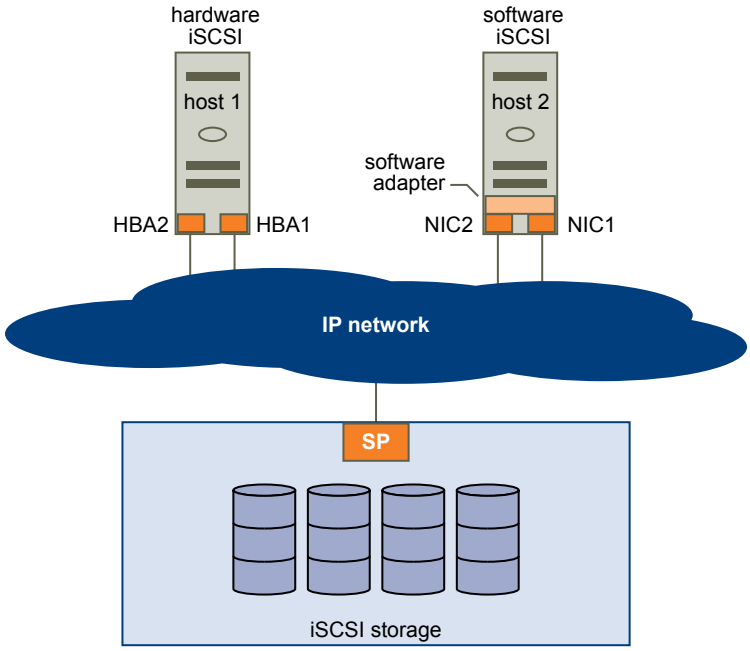
7 The PSP is called to select a new path on which to issue the I/O.

Host-Based Path Failover

When setting up your ESX/ESXi host for multipathing and failover, you can use multiple iSCSI HBAs or multiple NICs depending on the type of iSCSI initiators on your host.

Figure 1-5 shows multipathing setups possible with different types of iSCSI initiators.

Figure 1-5. Host-Based Path Failover



Failover with Hardware iSCSI

With the hardware iSCSI, the host typically has two or more hardware iSCSI adapters available, from which the storage system can be reached using one or more switches. Alternatively, the setup might include one adapter and two storage processors so that the adapter can use a different path to reach the storage system.

On the Figure 1-5 illustration, Host1 has two hardware iSCSI adapters, HBA1 and HBA2, that provide two physical paths to the storage system. Multipathing plug-ins on your host, whether the VMkernel NMP or any third-party MPPs, have access to the paths by default and can monitor health of each physical path. If, for example, HBA1 or the link between HBA1 and the network fails, the multipathing plug-ins can switch the path over to HBA2.

Failover with Software iSCSI

With the software iSCSI, as shown on Host 2 of Figure 1-5, you can use multiple NICs that provide failover and load balancing capabilities for iSCSI connections between your host and storage systems.

For this setup, because multipathing plug-ins do not have direct access to physical NICs on your host, you first need to connect each physical NIC to a separate VMkernel port. You then associate all VMkernel ports with the software iSCSI initiator using a port binding technique. As a result, each VMkernel port connected to a separate NIC becomes a different path that the iSCSI storage stack and its storage-aware multipathing plug-ins can use.

For information on how to configure multipathing for the software iSCSI, see "Networking Configuration for Software iSCSI and Dependent Hardware iSCSI," on page 36.

Array-Based Failover

Some iSCSI storage systems manage path use of their ports automatically and transparently to ESX/ESXi.

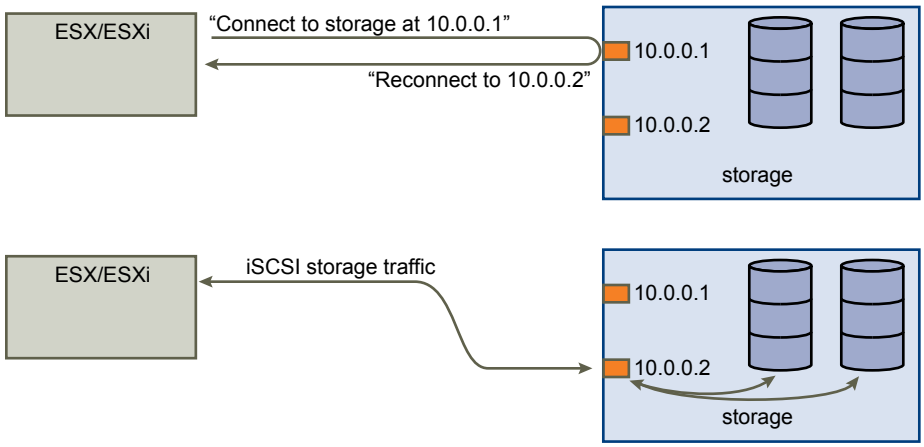
When using one of these storage systems, ESX/ESXi does not see multiple ports on the storage and cannot choose the storage port it connects to. These systems have a single virtual port address that ESX/ESXi uses to initially communicate. During this initial communication, the storage system can redirect ESX/ESXi to communicate with another port on the storage system. The iSCSI initiators in ESX/ESXi obey this reconnection request and connect with a different port on the system. The storage system uses this technique to spread the load across available ports.

If ESX/ESXi loses connection to one of these ports, it automatically attempts to reconnect with the virtual port of the storage system, and should be redirected to an active, usable port. This reconnection and redirection happens quickly and generally does not disrupt running virtual machines. These storage systems can also request that iSCSI initiators reconnect to the system, to change which storage port they are connected to. This allows the most effective use of the multiple ports.

Figure 1-6 shows an example of port redirection. ESX/ESXi attempts to connect to the 10.0.0.1 virtual port. The storage system redirects this request to 10.0.0.2. ESX/ESXi connects with 10.0.0.2 and uses this port for I/O communication.

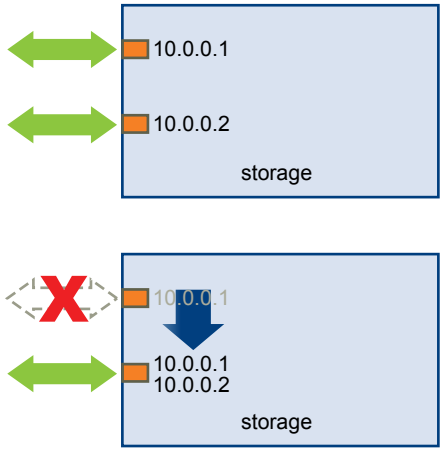
NOTE The storage system does not always redirect connections. The port at 10.0.0.1 could be used for traffic, also.

Figure 1-6. Port Redirection



If the port on the storage system that is acting as the virtual port becomes unavailable, the storage system reassigns the address of the virtual port to another port on the system. Figure 1-7 shows an example of this type of port reassignment. In this case, the virtual port 10.0.0.1 becomes unavailable and the storage system reassigns the virtual port IP address to a different port. The second port responds to both addresses.

Figure 1-7. Port Reassignment



With array-based failover, you can have multiple paths to the storage only if you use multiple ports on the ESX/ESXi host. These paths are active-active. For additional information, see "iSCSI Session Management," on page 49.

Choosing Virtual Machine Locations

When you're working on optimizing performance for your virtual machines, storage location is an important factor. A trade-off always exists between expensive storage that offers high performance and high availability and storage with lower cost and lower performance.

Storage can be divided into different tiers depending on a number of factors:

- High Tier. Offers high performance and high availability. Might offer built-in snapshots to facilitate backups and point-in-time (PiT) restorations. Supports replication, full SP redundancy, and SAS drives. Uses high-cost spindles.
- Mid Tier. Offers mid-range performance, lower availability, some SP redundancy, and SCSI or SAS drives. May offer snapshots. Uses medium-cost spindles.
- Lower Tier. Offers low performance, little internal storage redundancy. Uses low end SCSI drives or SATA (serial low-cost spindles).

Not all applications need to be on the highest-performance, most-available storage—at least not throughout their entire life cycle.

NOTE If you need some of the functionality of the high tier, such as snapshots, but do not want to pay for it, you might be able to achieve some of the high-performance characteristics in software. For example, you can create snapshots in software.

When you decide where to place a virtual machine, ask yourself these questions:

- How critical is the virtual machine?
- What are its performance and availability requirements?
- What are its PiT restoration requirements?
- What are its backup requirements?
- What are its replication requirements?

A virtual machine might change tiers throughout its life cycle because of changes in criticality or changes in technology that push higher-tier features to a lower tier. Criticality is relative and might change for a variety of reasons, including changes in the organization, operational processes, regulatory requirements, disaster planning, and so on.

Designing for Server Failure

The RAID architecture of SAN storage inherently protects you from failure at the physical disk level. A SAN provides multiple paths between servers and storage, which protects against network or port failures. The final step in making your whole environment failure resistant is to protect against server failure.

Using VMware HA

One of the failover options ESX/ESXi provides is VMware High Availability (HA).

VMware HA allows you to organize virtual machines into failover groups. When a host fails, all its virtual machines are immediately started on different hosts. When a virtual machine is restored on a different host, it loses its memory state, but its disk state is exactly as it was when the host failed (crash-consistent failover). Shared storage (such as a SAN) is required for HA.

NOTE You must be licensed to use VMware HA.

Server Failover and Storage Considerations

When you are configuring your ESX/ESXi host to work in conjunction with SAN, you must make your whole environment failure resistant and protect it against host failures.

For each type of server failover, you must follow these practices:

- Approaches to server failover work only if each server has access to the same storage. Because multiple servers require a lot of disk space, and because failover for the storage system complements failover for the server, SANs are usually employed in conjunction with server failover.
- When you design a SAN to work in conjunction with server failover, all ESX/ESXi hosts must see all datastores that the clustered virtual machines use.

  Although a datastore is accessible to a host, all virtual machines on that host do not necessarily have access to all data on that datastore. A virtual machine can access only the virtual disks for which it was configured. In case of a configuration error, virtual disks are locked when the virtual machine boots so no corruption occurs.

NOTE As a rule, when you boot from a SAN, each boot volume should be seen only by the host that is booting from that volume. An exception is when you try to recover from a failure by pointing a second host to the same volume. In this case, the SAN volume in question is not really for booting from a SAN. No host is booting from it because it is corrupted. The SAN volume is a regular non-boot volume that is made visible to a host.

LUN Display and Rescan

A SAN is dynamic, and which LUNs are available to a certain host can change based on a number of factors.

The VMkernel discovers LUNs when it boots, and those LUNs are then visible in the vSphere Client. If changes are made to the LUNs, you must rescan to see those changes.

- New LUNs created on the iSCSI storage
- Changes to LUN access control
- Changes in connectivity

Configuring iSCSI Initiators and Storage 2

Before ESX/ESXi can work with a SAN, you must set up your iSCSI initiators and storage.

To do this, you must first observe certain basic requirements and then follow best practices for installing and setting up hardware or software iSCSI initiators to access the SAN.

This chapter includes the following topics:

ESX/ESXi iSCSI SAN Requirements

You must meet several requirements for your ESX/ESXi host to work properly with a SAN.

- Verify that your SAN storage hardware and firmware combinations are supported in conjunction with ESX/ESXi systems. For an up-to-date list, see the Storage/SAN section of the online *Hardware Compatibility Guide*.
- Configure your system to have only one VMFS datastore for each LUN. In VMFS-3, you do not need to set accessibility.

- Unless you are using diskless servers (booting from a SAN), do not set up the diagnostic partition on a SAN LUN. In the case of diskless servers that boot from a SAN, a shared diagnostic partition is appropriate.
- Use RDMs for access to any raw disk.
- Set the SCSI controller driver in the guest operating system to a large enough queue. You can set the queue depth for the physical HBA during system setup.
- On virtual machines running Microsoft Windows, increase the value of the SCSI `TimeoutValue` parameter to allow Windows to better tolerate delayed I/O resulting from path failover.

ESX/ESXi iSCSI SAN Restrictions

Specific restrictions apply when you use ESX/ESXi with an iSCSI SAN.

- ESX/ESXi does not support iSCSI-connected tape devices.
- You cannot use virtual-machine multipathing software to perform I/O load balancing to a single physical LUN.
- ESX/ESXi does not support multipathing when you combine an independent hardware adapter with either software iSCSI adapter or dependent hardware iSCSI adapter.

Setting LUN Allocations

When preparing your ESX/ESXi system to use iSCSI SAN storage you need to set LUN allocations.

Note the following points:

- Storage Provisioning. To ensure that the ESX/ESXi host recognizes LUNs at startup time, configure all iSCSI storage targets so that your host can access them and use them. Also, configure your host so that it can discover all available iSCSI targets.
- vMotion and VMware DRS. When you use vCenter Server and vMotion or DRS, make sure that the LUNs for the virtual machines are provisioned to all ESX/ESXi hosts. This configuration provides the greatest freedom in moving virtual machines.
- Active-active versus active-passive arrays. When you use vMotion or DRS with an active-passive SAN storage device, make sure that all ESX/ESXi systems have consistent paths to all storage processors. Not doing so can cause path thrashing when a vMotion migration occurs.

  For active-passive storage arrays not listed in the Storage/SAN section of the online VMware Compatibility Guide, VMware does not support storage-port failover. You must connect the server to the active port on the storage system. This configuration ensures that the LUNs are presented to the ESX/ESXi host.

Network Configuration and Authentication

Before your ESX/ESXi can discover iSCSI storage, the iSCSI initiators must be configured and authentication might have to be set up.

- For software iSCSI and dependent hardware iSCSI, networking for the VMkernel must be configured. You can verify the network configuration by using the `vmkping` utility. For hardware iSCSI, network parameters, such as IP address, subnet mask, and default gateway must be configured on the HBA.
- Check and change the default initiator name if necessary.

- The discovery address of the storage system must be set and should be pingable using `vmkping`.
- For CHAP authentication, enable it on the initiator and the storage system side. After authentication is enabled, it applies for all of the targets that are not yet discovered, but does not apply to targets that are already discovered. After the discovery address is set, the new targets discovered are exposed and can be used at that point.

For details on how to use the `vmkping` command, search the VMware Knowledge Base.

Setting Up Independent Hardware iSCSI Adapters

An independent hardware iSCSI adapter is a specialized third-party adapter capable of accessing iSCSI storage over TCP/IP. This iSCSI adapter handles all iSCSI and network processing and management for your ESX/ESXi system.

The setup and configuration process for the independent hardware iSCSI adapters involves these steps:

1 Check whether the adapter needs to be licensed.

  See your vendor documentation.

2 Install the adapter.

  For installation information, see vendor documentation.

3 Verity that the adapter is installed correctly.

  See "View Independent Hardware iSCSI Adapters," on page 31.

4 Configure discovery addresses.

  See "Configuring Discovery Addresses for iSCSI Initiators," on page 43.

5 Configure CHAP parameters.

  See "Configuring CHAP Parameters for iSCSI Adapters," on page 44.

For your host to be able to access iSCSI storage, you must first install the hardware iSCSI adapter and configure discovery address and CHAP parameters.

View Independent Hardware iSCSI Adapters

View a hardware iSCSI adapter to verify that it is correctly installed and ready for configuration.

Prerequisites

After you install a hardware iSCSI adapter, it appears on the list of storage adapters available for configuration. You can view its properties.

Required privilege: **Host.Configuration.Storage Partition Configuration**

Procedure

1 Log in to the vSphere Client, and select a host from the inventory panel.

2 Click the **Configuration** tab and click **Storage Adapters** in the Hardware panel.

  If installed, the hardware iSCSI initiator should appear on the list of storage adapters.

3 Select the initiator to view.

The default details for the initiator appear, including the model, iSCSI name, iSCSI alias, IP address, and target and paths information.

4 Click **Properties**.

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

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

Change Name and IP Address for Independent Hardware Initiators

When you configure your independent hardware iSCSI initiators, make sure that their names and IP addresses are formatted properly.

Procedure

1 Access the iSCSI Initiator Properties dialog box.

2 Click **Configure**.

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

Make sure the name you enter is worldwide unique and properly formatted or some storage devices might not recognize the hardware iSCSI initiator.

4 (Optional) Enter the iSCSI alias.

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

5 Change the default IP settings.

You must change the default IP settings so that they are configured properly for the IP SAN. Work with your network administrator to determine the IP setting for the HBA.

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

If you change the iSCSI name, it is used for new iSCSI sessions. For existing sessions, new settings are not used until logout and re-login.

Setting Up and Configuring Dependent Hardware iSCSI Adapters

A dependent hardware iSCSI adapter is a third-party adapter that depends on VMware networking, and iSCSI configuration and management interfaces provided by VMware.

This type of adapter can be a card, such as a Broadcom 5709 NIC, that presents a standard network adapter and iSCSI offload functionality for the same port. The iSCSI offload functionality appears on the list of storage adapters as an iSCSI adapter. Although the iSCSI adapter is enabled by default, to make it functional, you must set up networking for the iSCSI traffic and bind the adapter and an appropriate VMkernel iSCSI port. You can then configure the adapter.

The entire setup and configuration process for the dependent hardware iSCSI adapters involves these steps:

1 View the dependent hardware adapters.

See “View Dependent Hardware iSCSI Adapters,” on page 33.

If your dependent hardware adapters do not appear on the list of storage adapters, check whether they need to be licensed. See your vendor documentation.

2 Determine the association between the dependent hardware adapters and physical NICs.

See "Determine Association Between Dependent Hardware iSCSI and Physical Network Adapters," on page 34

Make sure to note the names of the corresponding physical NICs. For example, the vmhba33 adapter corresponds to vmnic1 and vmhba34 corresponds to vmnic2.

3 Configure the iSCSI networking by creating ports for the iSCSI traffic.

See "Networking Configuration for Software iSCSI and Dependent Hardware iSCSI," on page 36.

Open a port for each NIC. For example, create the vmk1 port for the vmnic1 NIC and the vmk2 port for vmnic2.

4 Bind the iSCSI ports to corresponding dependent hardware iSCSI adapters. This step is necessary no matter whether you have multiple adapters or just one.

See "Bind iSCSI Ports to iSCSI Adapters," on page 40.

In this example, you bind port vmk1 to vmhba33 and port vmk2 to vmhba34.

5 Configure discovery addresses.

See "Configuring Discovery Addresses for iSCSI Initiators," on page 43.

6 Configure CHAP parameters.

See "Configuring CHAP Parameters for iSCSI Adapters," on page 44.

Dependent Hardware iSCSI Considerations

When you use dependent hardware iSCSI adapters with ESX/ESXi, certain considerations apply.

- When you use any dependent hardware iSCSI adapter, performance reporting for a NIC associated with the adapter might show little or no activity, even when iSCSI traffic is heavy. This behavior occurs because the iSCSI traffic bypasses the regular networking stack.
- The Broadcom iSCSI adapter performs data reassembly in hardware, which has a limited buffer space. When you use the Broadcom iSCSI adapter in a congested network or under load, enable flow control to avoid performance degradation.

  Flow control manages the rate of data transmission between two nodes to prevent a fast sender from overrunning a slow receiver. For best results, enable flow control at the end points of the I/O path, at the hosts and iSCSI storage systems.
- Broadcom iSCSI adapters do not support IPv6 and Jumbo Frames.

View Dependent Hardware iSCSI Adapters

View a dependent hardware iSCSI adapter to verify that it is correctly loaded.

If the dependent hardware adapter does not appear on the list of storage adapters, check whether it needs to be licensed. See your vendor documentation.

Procedure

1 Log in to the vSphere Client, and select a host from the Inventory panel.

2 Click the **Configuration** tab and click **Storage Adapters** in the Hardware panel.

If installed, the dependent hardware iSCSI adapter should appear on the list of storage adapters.

3 Select the adapter to view and click **Properties**.

The iSCSI Initiator Properties dialog box displays the default details for the adapter, including the iSCSI name and iSCSI alias.

Determine Association Between Dependent Hardware iSCSI and Physical Network Adapters

You need to determine the name of the physical NIC with which the dependent hardware iSCSI adapter is associated. You need to know the association to be able to perform the port binding correctly.

Procedure

1 Use the vSphere CLI command to determine the name of the physical NIC, with which the iSCSI adapter is associated.

```
esxcli swiscsi vmnic list –d vmhba#
```

vmhba# is the name of the iSCSI adapter.

2 In the output, find the `vmnic name: vmnic#` line.

vmnic# is the name of the network adapter that corresponds to the iSCSI adapter.

What to do next

After you determined the name of the NIC, create an iSCSI port on a vSwitch connected to the NIC. You then bind this port to the dependent hardware iSCSI adapter, so that your host can direct the iSCSI traffic through the NIC.

Setting Up and Configuring Software iSCSI Adapter

With the software-based iSCSI implementation, you can use standard NICs to connect your host to a remote iSCSI target on the IP network. The software iSCSI adapter that is built into ESX/ESXi facilitates this connection by communicating with the physical NICs through the network stack.

When you connect to a vCenter Server or a host with the vSphere Client, you can see the software iSCSI adapter on the list of your storage adapters. Only one software iSCSI adapter appears. Before you can use the software iSCSI adapter, you must set up networking, enable the adapter, and configure parameters such as discovery addresses and CHAP. The software iSCSI adapter configuration workflow includes these steps:

1 Configure the iSCSI networking by creating ports for iSCSI traffic.

See “Networking Configuration for Software iSCSI and Dependent Hardware iSCSI,” on page 36.

2 Enable the software iSCSI adapter.

See “Enable the Software iSCSI Adapter,” on page 35.

3 If you use multiple NICs for the software iSCSI multipathing, perform the port binding by connecting all iSCSI ports to the software iSCSI adapter.

See “Bind iSCSI Ports to iSCSI Adapters,” on page 40.

4 If needed, enable Jumbo Frames. Jumbo Frames must be enabled for each vSwitch through the vSphere CLI.

5 Configure discovery addresses.

See “Configuring Discovery Addresses for iSCSI Initiators,” on page 43.

6 Configure CHAP parameters.

See “Configuring CHAP Parameters for iSCSI Adapters,” on page 44.

Enable the Software iSCSI Adapter

You must enable your software iSCSI adapter so that your host can use it to access iSCSI storage.

Prerequisites

Before enabling the software iSCSI adapter, set up networking for iSCSI.

NOTE If you boot from iSCSI using the software iSCSI adapter, the adapter is enabled and the network configuration is created automatically at the first boot. If you disable the adapter, it is re-enabled each time you boot the host.

Procedure

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

2 Click the **Configuration** tab and click **Storage Adapters** in the Hardware panel.

The list of available storage adapters appears.

3 Select the iSCSI initiator to configure and click **Properties**.

4 Click **Configure**.

5 To enable the initiator, select **Enabled** and click **OK**.

After you enable the initiator, the host assigns the default iSCSI name to it. You can change the default name if needed.

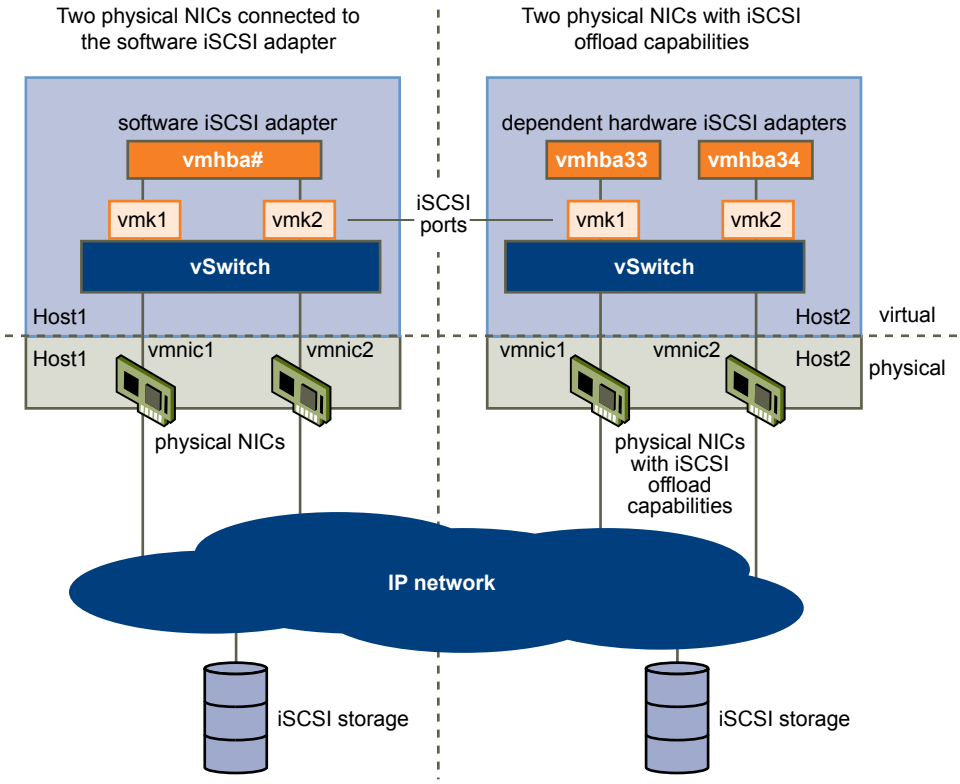
Networking Configuration for Software iSCSI and Dependent Hardware iSCSI

If you use the software iSCSI adapter or dependent hardware iSCSI adapters, you must set up the networking for iSCSI before you can enable and configure your iSCSI adapters. Networking configuration for iSCSI involves opening a VMkernel iSCSI port for the traffic between the iSCSI adapter and the physical NIC.

Depending on the number of physical NICs you use for iSCSI traffic, the networking setup can be different.

- If you have a single physical NIC, create one iSCSI port on a vSwitch connected to the NIC. VMware recommends that you designate a separate network adapter for iSCSI. Do not use iSCSI on 100Mbps or slower adapters.
- If you have two or more physical NICs for iSCSI, create a separate iSCSI port for each physical NIC and use the NICs for iSCSI multipathing. See Figure 2-1.

Figure 2-1. Networking with iSCSI



NOTE When you use a dependent hardware iSCSI adapter, performance reporting for a NIC associated with the adapter might show little or no activity, even when iSCSI traffic is heavy. This behavior occurs because the iSCSI traffic bypasses the regular networking stack.

- Create iSCSI Port for a Single NIC on page 37

  Use this task to connect the VMkernel, which runs services for iSCSI storage, to a physical NIC. If you have just one physical network adapter to be used for iSCSI traffic, this is the only procedure you must perform to set up your iSCSI networking.

- Using Multiple NICs for Software and Dependent Hardware iSCSI on page 37

  If your host has more than one physical NIC for iSCSI, for each physical NIC, create a separate iSCSI port using 1:1 mapping.

- Create Additional iSCSI Ports for Multiple NICs on page 38

  Use this task if you have two or more NICs you can designate for iSCSI and you want to connect all of your iSCSI NICs to a single vSwitch. In this task, you associate VMkernel iSCSI ports with the network adapters using 1:1 mapping.

Create iSCSI Port for a Single NIC

Use this task to connect the VMkernel, which runs services for iSCSI storage, to a physical NIC. If you have just one physical network adapter to be used for iSCSI traffic, this is the only procedure you must perform to set up your iSCSI networking.

Procedure

1 Log in to the vSphere Client and select the host from the inventory panel.

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

3 In the Virtual Switch view, click **Add Networking**.

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

5 Select **Create a virtual switch** to create a new vSwitch.

6 Select a NIC you want to use for iSCSI traffic.

IMPORTANT If you are creating a port for the dependent hardware iSCSI adapter, make sure to select the NIC that corresponds to the iSCSI component. See "Determine Association Between Dependent Hardware iSCSI and Physical Network Adapters," on page 34.

7 Click **Next**.

8 Enter a network label.

Network label is a friendly name that identifies the VMkernel port that you are creating, for example, iSCSI.

9 Click **Next**.

10 Specify the IP settings and click **Next**.

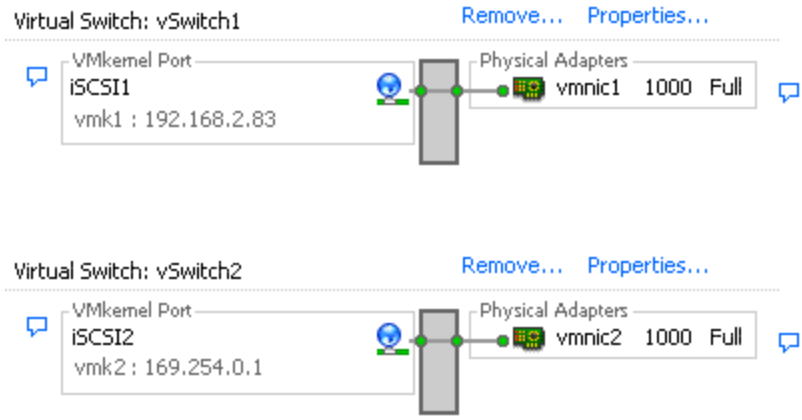
11 Review the information and click **Finish**.

Using Multiple NICs for Software and Dependent Hardware iSCSI

If your host has more than one physical NIC for iSCSI, for each physical NIC, create a separate iSCSI port using 1:1 mapping.

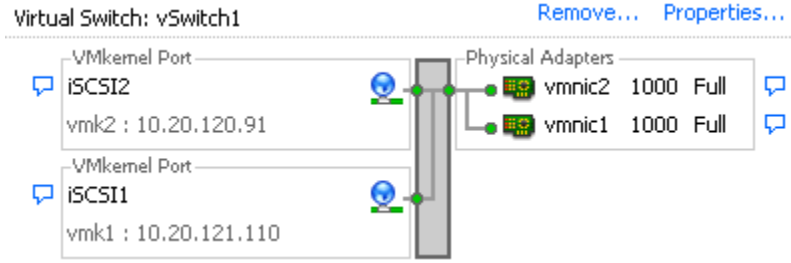
To achieve the 1:1 mapping, designate a separate vSwitch for each network adapter and iSCSI port pair. See Figure 2-2.

Figure 2-2. iSCSI Ports and NICs on Separate vSwitches



An alternative is to add all NIC and iSCSI port pairs to a single vSwitch. See Figure 2-3. You must override the default setup and make sure that each port maps to only one corresponding active NIC.

Figure 2-3. iSCSI Ports and NICs on a Single vSwitch



For information about adding the NIC and VMkernel port pairs to a vSwitch, see "Create Additional iSCSI Ports for Multiple NICs," on page 38.

After you map iSCSI ports to network adapters, use the `esxcli` command to bind the ports to the iSCSI adapters. With dependent hardware iSCSI adapters, perform port binding, whether you use one NIC or multiple NICs. For information, see "Bind iSCSI Ports to iSCSI Adapters," on page 40.

Create Additional iSCSI Ports for Multiple NICs

Use this task if you have two or more NICs you can designate for iSCSI and you want to connect all of your iSCSI NICs to a single vSwitch. In this task, you associate VMkernel iSCSI ports with the network adapters using 1:1 mapping.

You now need to connect additional NICs to the existing vSwitch and map them to corresponding iSCSI ports.

NOTE If you use a vNetwork Distributed Switch with multiple dvUplinks, for port binding, create a separate dvPort group per each physical NIC. Then set the team policy so that each dvPort group has only one active dvUplink.

For detailed information on vNetwork Distributed Switches, see the Networking section of the *ESX/ESXi Configuration Guide*.

Prerequisites

You must create a vSwitch that maps an iSCSI port to a physical NIC designated for iSCSI traffic.

Procedure

1 Log in to the vSphere Client and select the host from the inventory panel.

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

3 Select the vSwitch that you use for iSCSI and click **Properties**.

4 Connect additional network adapters to the vSwitch.

   a In the vSwitch Properties dialog box, click the **Network Adapters** tab and click **Add**.

   b Select one or more NICs from the list and click **Next**.

      With dependent hardware iSCSI adapters, make sure to select only those NICs that have a corresponding iSCSI component.

   c Review the information on the Adapter Summary page, and click **Finish**.

      The list of network adapters reappears, showing the network adapters that the vSwitch now claims.

5 Create iSCSI ports for all NICs that you connected.

   The number of iSCSI ports must correspond to the number of NICs on the vSwitch.

   a In the vSwitch Properties dialog box, click the **Ports** tab and click **Add**.

   b Select **VMkernel** and click **Next**.

   c Under **Port Group Properties**, enter a network label, for example iSCSI, and click **Next**.

   d Specify the IP settings and click **Next**.

      When you enter subnet mask, make sure that the NIC is set to the subnet of the storage system it connects to.

   e Review the information and click **Finish**.

CAUTION If the NIC you use with your iSCSI adapter, either software or dependent hardware, is not in the same subnet as your iSCSI target, your host is not able to establish sessions from this network adapter to the target.

6 Map each iSCSI port to just one active NIC.

   By default, for each iSCSI port on the vSwitch, all network adapters appear as active. You must override this setup, so that each port maps to only one corresponding active NIC. For example, iSCSI port vmk1 maps to vmnic1, port vmk2 maps to vmnic2, and so on.

   a On the **Ports** tab, select an iSCSI port and click **Edit**.

   b Click the **NIC Teaming** tab and select **Override vSwitch failover order**.

   c Designate only one adapter as active and move all remaining adapters to the **Unused Adapters** category.

7 Repeat the last step for each iSCSI port on the vSwitch.

What to do next

After performing this task, use the `esxcli` command to bind the iSCSI ports to the software iSCSI or dependent hardware iSCSI adapters.

Bind iSCSI Ports to iSCSI Adapters

Bind an iSCSI port that you created for a NIC to an iSCSI adapter. With the software iSCSI adapter, perform this task only if you set up two or more NICs for the iSCSI multipathing. If you use dependent hardware iSCSI adapters, the task is required regardless of whether you have multiple adapters or one adapter.

Prerequisites

Complete the following tasks:

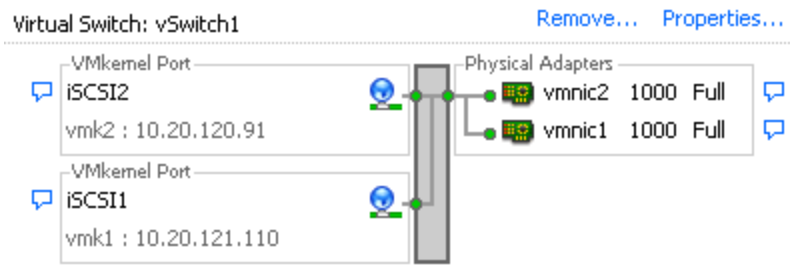
- For dependent hardware iSCSI adapters, have the correct association between the physical NICs and iSCSI adapters. See "View Dependent Hardware iSCSI Adapters," on page 33.
- Set up networking for the iSCSI traffic. See "Networking Configuration for Software iSCSI and Dependent Hardware iSCSI," on page 36.
- To use the software iSCSI adapter, enable it. See "Enable the Software iSCSI Adapter," on page 35.

Procedure

1 Identify the name of the iSCSI port assigned to the physical NIC.

The vSphere Client displays the port's name below the network label.

In the following graphic, the ports' names are vmk1 and vmk2.



2 Use the vSphere CLI command to bind the iSCSI port to the iSCSI adapter.

```
esxcli swiscsi nic add -n port_name -d vmhba
```

IMPORTANT For software iSCSI, repeat this command for each iSCSI port connecting all ports with the software iSCSI adapter. With dependent hardware iSCSI, make sure to bind each port to an appropriate corresponding adapter.

3 Verify that the port was added to the iSCSI adapter.

```
esxcli swiscsi nic list -d vmhba
```

4 Use the vSphere Client to rescan the iSCSI adapter.

Binding iSCSI Ports to iSCSI Adapters

Review examples about how to bind multiple ports that you created for physical NICs to the software iSCSI adapter or multiple dependent hardware iSCSI adapters.

Example 2-1. Connecting iSCSI Ports to the Software iSCSI Adapter

This example shows how to connect the iSCSI ports vmk1 and vmk2 to the software iSCSI adapter vmhba33.

1 Connect vmk1 to vmhba33: **`esxcli swiscsi nic add –n vmk1 –d vmhba33`**.

2 Connect vmk2 to vmhba33: **`esxcli swiscsi nic add –n vmk2 –d vmhba33`**.

3 Verify vmhba33 configuration: **`esxcli swiscsi nic list –d vmhba33`**.

Both vmk1 and vmk2 should be listed.

If you display the Paths view for the vmhba33 adapter through the vSphere Client, you see that the adapter uses two paths to access the same target. The runtime names of the paths are vmhba33:C1:T1:L0 and vmhba33:C2:T1:L0. C1 and C2 in this example indicate the two network adapters that are used for multipathing.

Example 2-2. Connecting iSCSI Ports to Dependent Hardware iSCSI Adapters

This example shows how to connect the iSCSI ports vmk1 and vmk2 to corresponding hardware iSCSI adapters vmhba33 and vmhba34.

1 Connect vmk1 to vmhba33: **`esxcli swiscsi nic add –n vmk1 –d vmhba33`**.

2 Connect vmk2 to vmhba34: **`esxcli swiscsi nic add –n vmk2 –d vmhba34`**.

3 Verify vmhba33 configuration: **`esxcli swiscsi nic list –d vmhba33`**.

4 Verify vmhba34 configuration: **`esxcli swiscsi nic list –d vmhba34`**.

Disconnect iSCSI Ports from iSCSI Adapters

If you need to make changes in the networking configuration that you use for iSCSI traffic, for example, remove a NIC or an iSCSI port, make sure to disconnect the iSCSI port from the iSCSI adapter.

IMPORTANT If active iSCSI sessions exist between your host and targets, you cannot disconnect the iSCSI port.

Procedure

1 Use the vSphere CLI to disconnect the iSCSI port from the iSCSI adapter.

```
esxcli swiscsi nic remove –n port_name –d vmhba
```

2 Verify that the port was disconnected from the iSCSI adapter.

```
esxcli swiscsi nic list –d vmhba
```

3 Use the vSphere Client to rescan the iSCSI adapter.

Using Jumbo Frames with iSCSI

Jumbo Frames allow ESX/ESXi to send larger frames out onto the physical network. The network must support Jumbo Frames end-to-end for Jumbo Frames to be effective. Jumbo Frames up to 9kB (9000 Bytes) are supported.

Table 2-1 explains the level of support ESX/ESXi provides to Jumbo Frames.

Table 2-1. Support of Jumbo Frames

Type of iSCSI Adapters	Jumbo Frames Support	Comment
Software iSCSI	Supported	Check with your vendors to ensure your physical network adapter and iSCSI storage support Jumbo Frames.
Dependent Hardware iSCSI	Supported	Broadcom dependent iSCSI adapters do not support Jumbo Frames.
Independent Hardware iSCSI	Not Supported	

Enabling Jumbo Frames for Software and Dependent Hardware iSCSI

Use the vSphere CLI to enable Jumbo Frames for each vSwitch designated for iSCSI traffic. Also, you must create a VMkernel network interface enabled with Jumbo Frames.

1 Enable Jumbo Frames on a vSwitch on page 42

To enable Jumbo Frames on a vSwitch, change the MTU configuration for that vSwitch.

2 Create a Jumbo Frames-Enabled VMkernel Interface on page 42

Use the vSphere CLI to create a VMkernel network interface that is enabled with Jumbo Frames.

Enable Jumbo Frames on a vSwitch

To enable Jumbo Frames on a vSwitch, change the MTU configuration for that vSwitch.

Procedure

1 On the vSphere CLI, run the **`vicfg-vswitch -m MTU`** ***`vSwitch`*** command.

This command sets the MTU for all physical NICs on that vSwitch. The MTU size should be set to the largest MTU size among all NICs connected to the vSwitch.

2 Run the **`vicfg-vswitch -l`** command to display a list of vSwitches on the host, and check that the configuration of the vSwitch is correct.

Create a Jumbo Frames-Enabled VMkernel Interface

Use the vSphere CLI to create a VMkernel network interface that is enabled with Jumbo Frames.

Procedure

1 On the vSphere CLI, run the `vicfg-vmknic` command to create a VMkernel connection with Jumbo Frame support.

`vicfg-vmknic -a -I` ***`ip address`*** **`-n`** ***`netmask`*** **`-m`** ***`MTU port group name`***

2 Run the `vicfg-vmknic -l` command to display a list of VMkernel interfaces and check that the configuration of the Jumbo Frame-enabled interface is correct.

3 Check that the VMkernel interface is connected to a vSwitch with Jumbo Frames enabled.

4 Configure all physical switches and any physical or virtual machines to which this VMkernel interface connects to support Jumbo Frames.

Configuring Discovery Addresses for iSCSI Initiators

Set up target discovery addresses so that the iSCSI initiator can determine which storage resource on the network is available for access.

The ESX/ESXi system supports these discovery methods:

Dynamic Discovery Also known as SendTargets discovery. Each time the initiator contacts a specified iSCSI server, the initiator sends the SendTargets request to the server. The server responds by supplying a list of available targets to the initiator. The names and IP addresses of these targets appear on the **Static Discovery** tab. If you remove a static target added by dynamic discovery, the target might be returned to the list the next time a rescan happens, the HBA is reset, or the host is rebooted.

Static Discovery The initiator does not have to perform any discovery. The initiator has a list of targets it can contact and uses their IP addresses and target names to communicate with them.

Set Up Dynamic Discovery

With Dynamic Discovery, each time the initiator contacts a specified iSCSI server, it sends the SendTargets request to the server. The server responds by supplying a list of available targets to the initiator.

When you set up Dynamic Discovery, you can only add a new iSCSI server. You cannot change the IP address, DNS name, or port number of an existing iSCSI server. To make changes, delete the existing server and add a new one.

Procedure

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

2 Click the **Configuration** tab and click **Storage Adapters** in the Hardware panel.

The list of available storage adapters appears.

3 Select the iSCSI initiator to configure and click **Properties**.

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

5 To add an address for the SendTargets discovery, click **Add**.

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

6 Enter the IP address or DNS name of the storage system and click **OK**.

After your host establishes the SendTargets session with this system, any newly discovered targets appear in the Static Discovery list.

7 To delete a specific SendTargets server, select it and click **Remove**.

After you remove a SendTargets server, it might still appear in the Inheritance field as the parent of static targets. This entry indicates where the static targets were discovered and does not affect the functionality.

What to do next

After configuring Dynamic Discovery for your iSCSI adapter, rescan the adapter.

Set Up Static Discovery

With iSCSI initiators, in addition to the dynamic discovery method, you can use static discovery and manually enter information for the targets.

When you set up Static Discovery, you can only add iSCSI targets. You cannot change the IP address, DNS name, iSCSI target name, or port number of an existing target. To make changes, remove the existing target and add a new one.

Procedure

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

2 Click the **Configuration** tab and click **Storage Adapters** in the Hardware panel.

The list of available storage adapters appears.

3 Select the iSCSI initiator to configure and click **Properties**.

4 In the iSCSI Initiator Properties dialog box, click the **Static Discovery** tab.

The tab displays all dynamically discovered targets and any static targets already entered.

5 To add a target, click **Add** and enter the target's information.

6 To delete a specific target, select the target and click **Remove**.

What to do next

After configuring Static Discovery for your iSCSI adapter, rescan the adapter.

Configuring CHAP Parameters for iSCSI Adapters

Because the IP networks that the iSCSI technology uses to connect to remote targets do not protect the data they transport, you must ensure security of the connection. One of the protocols that iSCSI implements is the Challenge Handshake Authentication Protocol (CHAP), which verifies the legitimacy of initiators that access targets on the network.

CHAP uses a three-way handshake algorithm to verify the identity of your host and, if applicable, of the iSCSI target when the host and target establish a connection. The verification is based on a predefined private value, or CHAP secret, that the initiator and target share.

ESX/ESXi supports CHAP authentication at the adapter level. In this case, all targets receive the same CHAP name and secret from the iSCSI initiator. For software and dependent hardware iSCSI adapters, ESX/ESXi also supports per-target CHAP authentication, which allows you to configure different credentials for each target to achieve greater level of security.

Choosing CHAP Authentication Method

ESX/ESXi supports one-way CHAP for all types of iSCSI initiators, and mutual CHAP for software and dependent hardware iSCSI.

Before configuring CHAP, check whether CHAP is enabled at the iSCSI storage system and check the CHAP authentication method the system supports. If CHAP is enabled, enable it for your initiators, making sure that the CHAP authentication credentials match the credentials on the iSCSI storage.

ESX/ESXi supports the following CHAP authentication methods:

One-way CHAP In one-way CHAP authentication, also called unidirectional, the target authenticates the initiator, but the initiator does not authenticate the target.

Mutual CHAP In mutual CHAP authentication, also called bidirectional, an additional level of security enables the initiator to authenticate the target. VMware supports this method for software and dependent hardware iSCSI adapters only.

For software and dependent hardware iSCSI adapters, you can set one-way CHAP and mutual CHAP for each initiator or at the target level. Hardware iSCSI supports CHAP only at the initiator level.

When you set the CHAP parameters, specify a security level for CHAP.

NOTE When you specify the CHAP security level, how the storage array responds depends on the array's CHAP implementation and is vendor specific. For example, when you select `Use CHAP unless prohibited by target`, some storage arrays use CHAP in response, while others do not. For information on CHAP authentication behavior in different initiator and target configurations, consult the array documentation.

Table 2-2. CHAP Security Level

CHAP Security Level	Description	Supported
Do not use CHAP	The host does not use CHAP authentication. Select this option to disable authentication if it is currently enabled.	Software iSCSI Dependent hardware iSCSI Independent hardware iSCSI
Do not use CHAP unless required by target	The host prefers a non-CHAP connection, but can use a CHAP connection if required by the target.	Software iSCSI Dependent hardware iSCSI
Use CHAP unless prohibited by target	The host prefers CHAP, but can use non-CHAP connections if the target does not support CHAP.	Software iSCSI Dependent hardware iSCSI Independent hardware iSCSI
Use CHAP	The host requires successful CHAP authentication. The connection fails if CHAP negotiation fails.	Software iSCSI Dependent hardware iSCSI

Set Up CHAP Credentials for an iSCSI Initiator

You can set up all targets to receive the same CHAP name and secret from the iSCSI initiator at the initiator level. By default, all discovery addresses or static targets inherit CHAP parameters that you set up at the initiator level.

Prerequisites

Before setting up CHAP parameters for software or dependent hardware iSCSI, determine whether to configure one-way or mutual CHAP. Independent hardware iSCSI adapters do not support mutual CHAP.

- In one-way CHAP, the target authenticates the initiator.
- In mutual CHAP, both the target and initiator authenticate each other. Make sure to use different secrets for CHAP and mutual CHAP.

When configuring CHAP parameters, make sure that they match the parameters on the storage side.

The CHAP name should not exceed 511 and the CHAP secret 255 alphanumeric characters. Some adapters, for example the QLogic adapter, might have lower limits, 255 for the CHAP name and 100 for the CHAP secret.

Procedure

1 Access the iSCSI Initiator Properties dialog box.

2 On the **General** tab, click **CHAP**.

3 To configure one-way CHAP, under CHAP specify the following:

   a Select the CHAP security level.

   - **Do not use CHAP unless required by target** (software and dependent hardware iSCSI only)
   - **Use CHAP unless prohibited by target**
   - **Use CHAP** (software and dependent hardware iSCSI only). To be able to configure mutual CHAP, you must select this option.

   b Specify the CHAP name.

   Make sure that the name you specify matches the name configured on the storage side.

   - To set the CHAP name to the iSCSI initiator name, select **Use initiator name**.
   - To set the CHAP name to anything other than the iSCSI initiator name, deselect **Use initiator name** and enter a name in the **Name** field.

   c Enter a one-way CHAP secret to be used as part of authentication. Make sure to use the same secret that you enter on the storage side.

4 To configure mutual CHAP, first configure one-way CHAP by following directions in Step 3.

   Make sure to select **Use CHAP** as an option for one-way CHAP. Then, specify the following under **Mutual CHAP**:

   a Select **Use CHAP**.

   b Specify the mutual CHAP name.

   c Enter the mutual CHAP secret. Make sure to use different secrets for the one-way CHAP and mutual CHAP.

5 Click **OK**.

6 Rescan the initiator.

If you change the CHAP or mutual CHAP parameters, they are used for new iSCSI sessions. For existing sessions, new settings are not used until you log out and login again.

Set Up CHAP Credentials for a Target

For software dependent hardware iSCSI adapters, you can configure different CHAP credentials for each discovery address or static target.

When configuring CHAP parameters, make sure that they match the parameters on the storage side. The CHAP name should not exceed 511 and the CHAP secret 255 alphanumeric characters.

Prerequisites

Before setting up CHAP parameters for software and dependent hardware iSCSI, determine whether to configure one-way or mutual CHAP.

- In one-way CHAP, the target authenticates the initiator.
- In mutual CHAP, both the target and initiator authenticate each other. Make sure to use different secrets for CHAP and mutual CHAP.

Procedure

1 Access the iSCSI Initiator Properties dialog box.

2 Select either **Dynamic Discovery** tab or **Static Discovery** tab.

3 From the list of available targets, select a target you want to configure and click **Settings > CHAP**.

4 Configure one-way CHAP in the CHAP area.

   a Deselect **Inherit from parent**.

   b Select one of the following options:

   - **Do not use CHAP unless required by target**
   - **Use CHAP unless prohibited by target**
   - **Use CHAP**. To be able to configure mutual CHAP, you must select this option.

   c Specify the CHAP name.

   Make sure that the name you specify matches the name configured on the storage side.

   - To set the CHAP name to the iSCSI initiator name, select **Use initiator name**.
   - To set the CHAP name to anything other than the iSCSI initiator name, deselect **Use initiator name** and enter a name in the **Name** field.

   d Enter a one-way CHAP secret to be used as part of authentication. Make sure to use the same secret that you enter on the storage side.

5 To configure mutual CHAP, first configure one-way CHAP by following directions in Step 4.

   Make sure to select **Use CHAP** as an option for one-way CHAP. Then, specify the following in the Mutual CHAP area:

   a Deselect **Inherit from parent**.

   b Select **Use CHAP**.

   c Specify the mutual CHAP name.

   d Enter the mutual CHAP secret. Make sure to use different secrets for the one-way CHAP and mutual CHAP.

6 Click **OK**.

7 Rescan the initiator.

If you change the CHAP or mutual CHAP parameters, they are used for new iSCSI sessions. For existing sessions, new settings are not used until you log out and login again.

Disable CHAP

You can disable CHAP if your storage system does not require it.

If you disable CHAP on a system that requires CHAP authentication, existing iSCSI sessions remain active until you reboot your ESX/ESXi host or the storage system forces a logout. After the session ends, you can no longer connect to targets that require CHAP.

Procedure

1 Open the CHAP Credentials dialog box.

2 For software and dependent hardware iSCSI adapters, to disable just the mutual CHAP and leave the one-way CHAP, select **Do not use CHAP** in the Mutual CHAP area.

3 To disable one-way CHAP, select **Do not use CHAP** in the CHAP area.

The mutual CHAP, if set up, automatically turns to **Do not use CHAP** when you disable the one-way CHAP.

4 Click **OK**.

Configuring Additional Parameters for iSCSI

You might need to configure additional parameters for your iSCSI initiators. For example, some iSCSI storage systems require ARP (Address Resolution Protocol) redirection to move iSCSI traffic dynamically from one port to another. In this case, you must activate ARP redirection on your host.

Table 2-3 lists advanced iSCSI parameters that you can configure using the vSphere Client. In addition, you can use the `vicfg-iscsi` vSphere CLI command to configure some of the advanced parameters. For information, see the *vSphere Command-Line Interface Installation and Scripting Guide and vSphere Command-Line Interface Reference*.

Do not make any changes to the advanced iSCSI settings unless you are working with the VMware support team or otherwise have thorough information about the values to provide for the settings.

Table 2-3. Additional Parameters for iSCSI Initiators

Advanced Parameter	Description	Configurable On
Header Digest	Increases data integrity. When header digest is enabled, the system performs a checksum over each iSCSI Protocol Data Unit's (PDU's) header part and verifies using the CRC32C algorithm.	Software iSCSI Dependent Hardware iSCSI
Data Digest	Increases data integrity. When data digest is enabled, the system performs a checksum over each PDU's data part and verifies using the CRC32C algorithm. **NOTE** Systems that use Intel Nehalem processors offload the iSCSI digest calculations for software iSCSI, thus reducing the impact on performance.	Software iSCSI Dependent Hardware iSCSI
Maximum Outstanding R2T	Defines the R2T (Ready to Transfer) PDUs that can be in transition before an acknowledge PDU is received.	Software iSCSI Dependent Hardware iSCSI
First Burst Length	Specifies the maximum amount of unsolicited data an iSCSI initiator can send to the target during the execution of a single SCSI command, in bytes.	Software iSCSI Dependent Hardware iSCSI
Maximum Burst Length	Maximum SCSI data payload in a Data-In or a solicited Data-Out iSCSI sequence, in bytes.	Software iSCSI Dependent Hardware iSCSI
Maximum Receive Data Segment Length	Maximum data segment length, in bytes, that can be received in an iSCSI PDU.	Software iSCSI Independent Hardware iSCSI
Session Recovery Timeout	Specifies the amount of time, in seconds, that can lapse while a session recovery is performed. If the timeout exceeds its limit, the iSCSI initiator terminates the session.	Software iSCSI Dependent Hardware iSCSI
No-Op Interval	Specifies the time interval, in seconds, between NOP-Out requests sent from your iSCSI initiator to an iSCSI target. The NOP-Out requests serve as the ping mechanism to verify that a connection between the iSCSI initiator and the iSCSI target is active.	Software iSCSI Dependent Hardware iSCSI
No-Op Timeout	Specifies the amount of time, in seconds, that can lapse before your host receives a NOP-In message. The message is sent by the iSCSI target in response to the NOP-Out request. When the no-op timeout limit is exceeded, the initiator terminates the current session and starts a new one.	Software iSCSI Dependent Hardware iSCSI

Table 2-3. Additional Parameters for iSCSI Initiators (Continued)

Advanced Parameter	Description	Configurable On
ARP Redirect	Allows storage systems to move iSCSI traffic dynamically from one port to another. ARP is required by storage systems that do array-based failover.	Software and Independent Hardware iSCSI (Configurable through vSphere CLI)
Delayed ACK	Allows systems to delay acknowledgment of received data packets.	Software iSCSI Dependent Hardware iSCSI

Configure Advanced Parameters for iSCSI

The advanced iSCSI settings control such parameters as header and data digest, ARP redirection, delayed ACK, and so on. Generally, you do not need to change these settings because your ESX/ESXi host works with the assigned predefined values.

CAUTION Do not make any changes to the advanced iSCSI settings unless you are working with the VMware support team or otherwise have thorough information about the values to provide for the settings.

Procedure

1 Access the iSCSI Initiator Properties dialog box.

2 To configure advanced parameters at the initiator level, on the General tab, click **Advanced**. Proceed to Step 4.

3 Configure advanced parameters at the target level.

At the target level, advanced parameters can be configured only for software and dependent hardware iSCSI adapters.

a Select either the **Dynamic Discovery** tab or **Static Discovery** tab.

b From the list of available targets, select a target to configure and click **Settings > Advanced**.

4 Enter any required values for the advanced parameters you want to modify and click **OK** to save your changes.

iSCSI Session Management

To communicate with each other, iSCSI initiators and targets establish iSCSI sessions. You can review and manage iSCSI sessions using vSphere CLI.

By default, software iSCSI and dependent hardware iSCSI initiators start one iSCSI session between each initiator port and each target port. If your iSCSI initiator or target have more than one port, your host can have multiple sessions established. The default number of sessions for each target equals the number of ports on the iSCSI adapter times the number of target ports. You can display all current sessions to analyze and debug them.

To create more paths to storage systems, you can increase the default number of sessions by duplicating existing sessions between the iSCSI adapter and target ports.

You can also establish a session to a specific target port. This can be useful if your host connects to a single-port storage system that, by default, presents only one target port to your initiator, but can redirect additional sessions to a different target port. Establishing a new session between your iSCSI initiator and another target port creates an additional path to the storage system.

CAUTION Some storage systems do not support multiple sessions from the same initiator name or endpoint. Attempts to create multiple sessions to such targets can result in unpredictable behavior of your iSCSI environment.

Review iSCSI Sessions

Use the vSphere CLI to display iSCSI sessions between an iSCSI adapter and a storage system.

Procedure

1 To list sessions for an adapter, use **esxcli swiscsi session list –d *vmhbaXX***.

vmhbaXX is the name of your iSCSI adapter.

2 To list sessions for a target, use **esxcli swiscsi session list –t *iqnXX* –d *vmhbaXX***.

iqnXX is the name of the target the iSCSI adapter connects to.

Example 2-3. Reviewing Sessions for a Specified Target

```
# esxcli swiscsi session list –t iqn.2001–05.com.equallogic:0–8a0906–cbcde0d02–6a445baadf44ab92–
vcli7 –d vmhba36
```

Add an iSCSI Session for a Specified Target

Use the vSphere CLI to add an iSCSI session for a target you specify.

Procedure

1 To add a session at the iSCSI adapter level, use **esxcli swiscsi session add –d *vmhbaXX***.

vmhbaXX is the name of your iSCSI adapter.

2 To add a session at the target level, use **esxcli swiscsi session add –t *iqnXX* –d *vmhbaXX***.

iqnXX is the name of the target the iSCSI adapter connects to.

Example 2-4. Adding an iSCSI Session for a Specified Target

```
# esxcli swiscsi session add –t iqn.2001–05.com.equallogic:0–8a0906–42f9b0401–7d40d28af2a4ade1–
vcli7 –d vmhba36
```

What to do next

Rescan the iSCSI adapter.

Duplicate iSCSI Sessions

Use the vSphere CLI to duplicate an iSCSI session between an iSCSI adapter and a target. By duplicating sessions, you increase the default number of sessions and create additional paths to storage systems.

Procedure

- To duplicate a session, use **esxcli swiscsi session add –d *vmhbaXX* –t *iqnXX* –s *session_isid***.
  - d -- The name of your iSCSI adapter, such as *vmhbaXX*.
  - t -- The name of the target to log in, such as *iqnXX*.
  - s -- The ISID of a session to duplicate, such as *session_isid*. You can find it by listing all session.

Example 2-5. Duplicating iSCSI Session

```
# esxcli swiscsi session add –t iqn.2001–05.com.equallogic:0–8a0906–cbcde0d02–6a445baadf44ab92–
vcli7 –s '00:02:3d:00:00:01' –d vmhba36
```

What to do next

Rescan the iSCSI adapter.

Remove iSCSI Sessions

Use the vSphere CLI to remove an iSCSI session between an iSCSI adapter and a target.

Procedure

- To remove a session, use **esxcli swiscsi session remove**. The command takes these options.
  - d -- The name of your iSCSI adapter, such as *vmhbaXX*.
  - t -- The name of the target to log in, such as *iqnXX*.
  - s -- The ISID of a session to duplicate, such as *session_isid*. You can find it by listing all session.

Example 2-6. Removing an iSCSI Session

```
# esxcli swiscsi session remove –t iqn.2001–05.com.equallogic:0–8a0906–cbcde0d02–6a445baadf44ab92–
vcli7 –s '00:02:3d:01:00:01'
```

What to do next

Rescan the iSCSI adapter.

Add iSCSI Storage

When you create a datastore on an iSCSI storage device, the Add Storage wizard guides you through the configuration.

Procedure

1. Log in to the vSphere Client and select a server from the inventory panel.
2. Click the **Configuration** tab and click **Storage**.
3. Click **Add Storage**.
4. Select the **Disk/LUN** storage type and click **Next**.

   The **Select Disk/LUN** page appears. This can take a few seconds depending on the number of targets.

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

6 Review the current disk layout and click **Next**.

7 Enter a datastore name and click **Next**.

The datastore name appears in the vSphere Client, and the label must be unique within the current VMware vSphere instance.

8 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.

9 Click **Next**.

The **Ready to Complete** page appears.

10 Review the datastore configuration information and click **Finish**.

A datastore is now available on the iSCSI storage device.

Modifying SAN Storage Systems for ESX/ESXi 3

After you configure your iSCSI initiators and storage, you might need to modify your storage system to ensure that it works properly with your ESX/ESXi implementation.

This section discusses many of the iSCSI storage systems supported in conjunction with VMware ESX/ESXi. For each device, it lists major known potential issues, points to vendor-specific information (if available), or includes information from VMware knowledge base articles.

NOTE Information in this section is updated only with each release. New information might already be available. Also, other iSCSI storage systems are supported but are not covered in this chapter. Consult the most recent *Storage/SAN Compatibility Guide*, check with your storage vendor, and explore the VMware knowledge base articles.

This chapter includes the following topics:

Testing ESX/ESXi SAN Configurations

ESX/ESXi supports a variety of SAN storage systems in different configurations. Generally, VMware tests ESX/ESXi with supported storage systems for basic connectivity, HBA failover, and so on.

Not all storage devices are certified for all features and capabilities of ESX/ESXi, and vendors might have specific positions of support with regard to ESX/ESXi.

VMware tests ESX/ESXi with storage systems in the following configurations:

Basic Connectivity	Tests whether ESX/ESXi can recognize and operate with the storage system. This configuration does not allow for multipathing or any type of failover.
iSCSI Failover	The server is equipped with multiple iSCSI HBAs or NICs. The server is robust to HBA or NIC failure.
Storage Port Failover	The server is attached to multiple storage ports and is robust to storage port failures and switch failures.
Booting from a SAN (with ESX hosts only)	The ESX host boots from a LUN configured on the SAN rather than from the server itself.

General Considerations for iSCSI SAN Storage Systems

When you prepare your iSCSI SAN storage system to work with ESX/ESXi, you need to follow specific general requirements that apply to all storage systems.

For all storage systems, the following general requirements exist:

- LUNs must be presented to each HBA of each host with the same LUN ID number. If different numbers are used, the ESX/ESXi hosts do not recognize different paths to the same LUN. Because instructions on how to configure identical SAN LUN IDs are vendor-specific, consult your storage documentation for more information.
- Unless specified for individual storage systems discussed in this chapter, set the host type for LUNs presented to ESX/ESXi to `Linux or Linux Cluster`, if applicable to your storage system. The method ESX/ESXi uses to access the storage system is most compatible with Linux access, however, this can vary depending on the storage system you are using.
- If you are using vMotion, DRS, or HA, make sure that source and target hosts for virtual machines can see the same LUNs with identical LUN IDs. SAN administrators might find it counterintuitive to have multiple hosts see the same LUNs because they might be concerned about data corruption. However, VMFS prevents multiple virtual machines from writing to the same file at the same time, so provisioning the LUNs to all required ESX/ESXi system is appropriate.
- If you do not have CHAP authentication set up on the LUNs that are being accessed, you must also disable CHAP on the ESX/ESXi host. Otherwise, authentication of the storage system fails, although the LUNs have no CHAP requirement.

EMC CLARiiON Storage Systems

EMC CLARiiON storage systems work with ESX/ESXi hosts in iSCSI SAN configurations. Generally, you use the EMC software to perform configurations.

For more information, see the EMC documentation.

This is an active-passive disk array, so any related issues that apply to all active-passive disk arrays are relevant. In addition, keep in mind the following:

- To avoid the possibility of path thrashing, the default multipathing policy is Most Recently Used, not Fixed. The ESX/ESXi system sets the default policy when it identifies the storage system.
- To boot from a SAN, choose the active storage processor for the boot LUN's target in the HBA BIOS.
- On EMC CLARiiON AX100i and AX150i systems, RDMs are supported only if you use the Navisphere Management Suite for SAN administration. Navisphere Express is not guaranteed to configure them properly.

  To use RDMs successfully, a given LUN must be presented with the same LUN ID to every ESX/ESXi host in the cluster. The AX100i and AX150i do not do this by default.

- When you use an AX100i or AX150i storage system, no host agent periodically checks the host configuration and pushes changes to the storage system. The `axnaviserverutil cli` utility is used to update the changes. This is a manual operation that you should perform as needed.
- Port binding support on EMC CLARiiON storage systems requires initiators in different subnets. See vendor documentation for additional details.
- For ESX/ESXi to support EMC CLARiiON with ALUA, check the HCLs to make sure that you use the correct firmware version on the storage array. For additional information, contact your storage vendor.

EMC Symmetrix Storage Systems

To work with ESX/ESXi, EMC Symmetrix storage systems require certain specific settings. Use EMC software to configure the storage system. For information, see your EMC documentation.

The following settings are required for ESX/ESXi operations on the Symmetrix networked storage system:

- Common serial number (C)
- Auto negotiation (EAN) enabled
- SCSI 3 (SC3) set (enabled)
- Unique world wide name (UWN)
- SPC-2 (Decal) (SPC2) SPC-2 flag is required

NOTE The ESX/ESXi host considers any LUNs from a Symmetrix storage system that have a capacity of 50MB or less as management LUNs. These LUNs are also known as pseudo or gatekeeper LUNs. These LUNs appear in the EMC Symmetrix Management Interface and should not be used to hold data.

Enable HP StorageWorks MSA1510i to Communicate with ESX/ESXi

This section describes the setup and configuration steps needed to allow an HP StorageWorks MSA1510i storage system to communicate with ESX/ESXi hosts.

Procedure

1 Install, connect, and power up the network devices as detailed in the vendor installation document.

2 Obtain the IP address assigned to the MSA1510i controller management port.

   a Scroll through the messages on the LCD panel until the following message appears: `603 Port MA0 IP address`

   b Record the management port IP address that appears in **Basic MSA1510i information**.

3 From the server or a workstation on the MSA1510i LAN segment, open a Web browser and enter the address obtained in Step 2.

4 When prompted, enter the default access permissions.

   - User name: `root`
   - Password: `root`

5 When prompted, set a unique user name and password.

6 Using the wizard, complete the following actions.

Option	Description
Storage configuration	a Set the Fault Tolerant mode (RAID mode). b Assign a spare disk for appropriate RAID level.
iSCSI configuration (configure an iSCSI portal)	a Select a data port. b Assign an IP address to the data port. c VLANs are set up on the switch and are used as one method of controlling access to the storage. If you are using VLANs, enter the VLAN ID to use (0 = not used). d The wizard suggests a default iSCSI Target Name and iSCSI Target Alias. Accept the default or enter user-defined values. **NOTE** To configure the remaining data ports, complete the Initial System Configuration Wizard process, and then use tasks available on the **Configure** tab.
Login settings	Enter login settings.
Management settings	Enter management settings.

7 Click **Finish** to apply the configuration settings.

NOTE Wizards are available for basic configuration tasks only. Use the **Manage** and **Configure** tabs to view and change your configuration.

What to do next

After initial setup, perform the following tasks to complete the configuration:

- Create an array.
- Create a logical drive.
- Create a target.
- Create a portal group.
- Associate or assign the portals created using the wizard with the portal group created.
- Map logical drives to the target.
- Add initiators (initiator IQN name and alias).
- Update the ACLs of the logical drives to provide access to initiators (select the list of initiators to access the logical drive).

HP StorageWorks EVA Storage Systems

The two types of HP StorageWorks EVA systems are EVA_GL, an active-passive system, and EVA_XL, an active-active system. For the systems to work with ESX/ESXi, certain specific settings are required.

Set the connection type to **Custom** when you present a LUN to an ESX/ESXi host. The value is one of the following:

- For HP EVAgl 3000/5000 (active-passive), use the `000000002200282E` host mode type.
- For HP EVAgl firmware 4.001 (active-active firmware for GL series) and above, use the `VMware` host mode type.
- For EVA4000/6000/8000 active-active arrays with firmware earlier than 5.031, use the `000000202200083E` host mode type.
- For EVA4000/6000/8000 active-active arrays with firmware 5.031 and later, use the `VMware` host mode type.

Otherwise, EVA systems do not require special configuration changes to work with an ESX/ESXi system.

NetApp Storage Systems

For NetApp storage systems to communicate within an ESX/ESXi environment, you must perform specific configuration steps.

For additional documentation on NetApp and VMware best practices and SAN solutions, search the NetApp web page.

Table 3-1. Configuration Steps

Configuration Step	Description
Disable ALUA.	If any of your iSCSI initiators are a part of an initiator group (igroup), disable ALUA on the NetApp filter.
Set up multipathing.	When you set up multipathing between two iSCSI HBAs and multiple ports on a NetApp storage system, give the two HBAs different dynamic or static discovery addresses to connect to the storage. The NetApp storage system only permits one connection for each target and each initiator. Attempts to make additional connections cause the first connection to drop. Therefore, a single HBA should not attempt to connect to multiple IP addresses associated with the same NetApp target.
Set LUN type and initiator group type.	Set the appropriate LUN type and initiator group type for the storage system: ■ LUN type – VMware (if VMware type is not available, use Linux). ■ Initiator group type – VMware (if VMware type is not available, use Linux).
Provision storage.	Use either FilerView or CLI.

Provision Storage by Using FilerView Storage Management

You can use FilerView to provision storage on a NetApp storage system.

Procedure

1 Log in to NetApp storage system management (FilerView).

2 Create a volume.

   a Select **Volumes** and click **Add**.

   b Click **Next**.

   c Select **Flexibility** (Default) or **Traditional**, then click **Next**.

   d Enter a **Volume Name**, select a **Language**, and click **Next**.

   e Enter values for **Containing Aggregate**, **Total Volume Size**, and **Space Guarantee** and click **Next**.

   f Click **Commit** to create the volume.

3 Create LUNs.

   a Select **LUNs** and click **Add**.

   b Enter the following:

   - **Path**: Enter a path, for example, `/vol/vol1/lun1`.
   - **LUN Protocol Type**: VMware.
   - **Description**: A brief description.
   - **Size and Unit**: Enter a size, for example, 10GB and select **Space Reserved**.

4 Create an initiator group.

   a Select **LUNs > Initiator Group** and click **Add**.

   b Enter the following:

   - **Group Name**: Enter a group name
   - **Type**: Choose **iSCSI**.
   - **Operating System**: Enter `VMware`.
   - **Initiators**: Enter fully qualified initiator names. If there is more than one initiator, each initiator has to be separated with a return carriage.

   c Click **Add**.

5 Map the LUN to the initiator group.

   a Select **LUNs** and click **Manage**.

   A LUNs list appears.

   b From this list, click the label on the **Maps** row for the specific LUNs.

   c Click **Add Groups to Map**.

   d Select the initiator group and click **Add**.

   e When prompted, enter the LUN ID (any number from 0 to 255) and click **Apply**.

Provision Storage by Using Command-Line Interface

You can use command-line interface to provision storage on a NetApp storage system.

Procedure

1 Use command-line interface to create an aggregate if required.

```
aggr create vmware-aggrnumber of disks
```

2 Create a flexible volume.

```
vol create aggregate namevolume size
```

3 Create a Qtree to store each LUN.

```
qtree create path
```

4 Create a LUN.

```
lun create -s size -t vmware path
```

5 Create an initiator group.

```
igroup create -f -t vmware igroup name
```

6 Map the LUN to the initiator group you created.

```
lun map (path) igroup nameLUN ID
```

EqualLogic Storage Systems

When setting up your EqualLogic storage systems to work in an ESX/ESXi implementation, you must address certain specific issues.

The following are specific requirements for EqualLogic storage systems to work with ESX/ESXi:

- Multipathing. No special setup is needed because EqualLogic storage systems support storage-processor failover that is transparent to iSCSI. Multiple iSCSI HBAs or NICs can connect to the same target or LUN on the storage side.
- Creating iSCSI LUNs. From the EqualLogic web portal, right-click **Volumes**, and then select **Create Volume**.
- Enable ARP redirection for ESX/ESXi hardware iSCSI HBAs.
- EqualLogic storage systems impose a maximum limit of 512 iSCSI connections per storage pool and 2048 connections per storage group.

For more information about configuring and using EqualLogic storage systems, see the vendor's documentation.

LeftHand Networks SAN/iQ Storage Systems

SAN/iQ SANs support ESX/ESXi iSCSI connections from a software initiator and hardware initiator.

When configuring SAN/iQ, enable automatic volume resignaturing for SAN/iQ storage devices to allow access to SAN/iQ snapshots and remote copies.

For more information on configuring LeftHand Networks SANs for VMware vSphere, see the vendor documentation related to VMware.

Basic configuration steps include several tasks.

1 Install SAN/iQ storage nodes.

2 Create SAN/iQ management groups and clusters.

3 Create volumes.

4 Assign volumes to authentication groups and volume lists.

5 Enable ARP redirection on hardware iSCSI HBAs.

As a best practice, configure virtual IP load balancing in SAN/iQ for all ESX/ESXi authentication groups.

Dell PowerVault MD3000i Storage Systems

When you configure mutual CHAP for the MD3000i iSCSI storage systems, special considerations that apply.

When you configure mutual CHAP for the MD3000i iSCSI array, follow these guidelines:

- On the MD3000i storage system, mutual CHAP configuration requires only a CHAP secret.
- On the ESX/ESXi host, mutual CHAP configuration requires both the name and CHAP secret. When configuring mutual CHAP on the ESX/ESXi host, enter the IQN name of the target as the mutual CHAP name. Make sure the CHAP secret matches the one set on the array.

iSCSI Targets in vApps

If you use an iSCSI target in a virtual appliance, for example HP LeftHand P4000 VSA, the host should connect to the target through the software iSCSI adapter rather than a hardware iSCSI adapter.

Booting from iSCSI SAN

4

When you set up your host to boot from a SAN, your host's boot image is stored on one or more LUNs in the SAN storage system. When the host starts, it boots from the LUN on the SAN rather than from its local disk.

You can use boot from the SAN if you do not want to handle maintenance of local storage or have diskless hardware configurations, such as blade systems.

ESX and ESXi hosts support different methods of booting from the SAN.

Table 4-1. Boot from iSCSI SAN support

Type of Host	Independent Hardware iSCSI	Software iSCSI and Dependent Hardware iSCSI
ESX Host	Supported. An iSCSI HBA is required to boot from the SAN.	Not supported.
ESXi Host	Not supported.	Supported. The network adapter must support the iBFT.

Booting your host from a SAN provides numerous benefits.

- Cheaper servers. Servers can be more dense and run cooler without internal storage.
- Easier server replacement. You can replace servers and have the new server point to the old boot location.
- Less wasted space.
- Easier backup processes. The system boot images in the SAN can be backed up as part of the overall SAN backup procedures.
- Improved management. Creating and managing the operating system image is easier and more efficient.

This chapter includes the following topics:

General Boot from iSCSI SAN Recommendations

If you plan to set up and use an iSCSI LUN as the boot device for your host, you need to follow certain general guidelines.

These guidelines apply to booting from software and dependent iSCSI, and independent hardware iSCSI.

- Review any vendor recommendations for the hardware you use in your boot configuration.
- For installation prerequisites and requirements, review an appropriate ESX/ESXi Installation Guide.
- Use static IP addresses to reduce the chances of DHCP conflicts.
- Use different LUNs for VMFS datastores and boot partitions.
- Configure proper ACLs on your storage system.
  - The boot LUN should be visible only to the host that uses the LUN. No other host on the SAN should be permitted to see that boot LUN.
  - If a LUN is used for a VMFS datastore, it can be shared by multiple hosts. ACLs on the storage systems can allow you to do this.
- Configure a diagnostic partition.
  - With independent hardware iSCSI only, you can place the diagnostic partition on the boot LUN. If you configure the diagnostic partition in the boot LUN, this LUN cannot be shared across multiple hosts. If a separate LUN is used for the diagnostic partition, it can be shared by multiple hosts.
  - If you boot an ESXi host from SAN using iBFT, you cannot set up a diagnostic partition on a SAN LUN. Instead, you use the vSphere Management Assistant (vMA) to collect diagnostic information from your host and store it for analysis.

    See “Collecting Diagnostic Information for ESXi Hosts,” on page 69.

Prepare the iSCSI SAN

Before you configure your ESX/ESXi host to boot from an iSCSI LUN, prepare and configure your storage area network.

CAUTION If you use scripted installation to install ESX when booting from a SAN, you must take special steps to avoid unintended data loss.

Procedure

1 Connect network cables, referring to any cabling guide that applies to your setup.

2 Ensure IP connectivity between your storage system and server.

This includes proper configuration of any routers or switches on your storage network. Storage systems must be able to ping the iSCSI adapters in your hosts.

3 Configure the storage system.

a Create a volume (or LUN) on the storage system for your host to boot from.

b Configure the storage system so that your host has access to the assigned LUN.

This could involve updating ACLs with the IP addresses, iSCSI names, and the CHAP authentication parameter you use on your host. On some storage systems, in addition to providing access information for the ESX/ESXi host, you must also explicitly associate the assigned LUN with the host.

c Ensure that the LUN is presented to the host correctly.

d Ensure that no other system has access to the configured LUN.

e Record the iSCSI name and IP addresses of the targets assigned to the host.

You must have this information to configure your iSCSI adapters.

Configure ESX Hosts to Boot from iSCSI SAN

With the ESX host, you can boot from the iSCSI SAN only if the host uses an independent hardware iSCSI adapter, such as QLogic HBA. You need to configure the independent hardware iSCSI adapter for booting from the SAN.

This procedure discusses how to enable the QLogic iSCSI HBA to boot from the SAN. For more information and more up-to-date details about QLogic adapter configuration settings, see the QLogic web site.

Prerequisites

Because you first need to boot from the VMware installation media, set up your host to boot from DVD-ROM. To achieve this, change the system boot sequence in your system BIOS setup.

Procedure

1 Insert the installation DVD in the DVD-ROM drive and reboot the host.

2 Use the BIOS to set the host to boot from the DVD-ROM drive first.

3 During server POST, press Crtl+q to enter the QLogic iSCSI HBA configuration menu.

4 Select the I/O port to configure.

By default, the Adapter Boot mode is set to Disable.

5 Configure the HBA.

a From the **Fast!UTIL Options** menu, select **Configuration Settings > Host Adapter Settings**.

b Configure the following settings for your host adapter: initiator IP address, subnet mask, gateway, initiator iSCSI name, and CHAP (if required).

6 Configure iSCSI settings.

See “Configure iSCSI Boot Settings,” on page 64.

7 Save your changes and restart the system.

Configure iSCSI Boot Settings

When setting up your ESX host to boot from iSCSI, you need to configure iSCSI boot settings.

Procedure

1 From the **Fast!UTIL Options** menu, select **Configuration Settings > iSCSI Boot Settings**.

2 Before you can set SendTargets, set Adapter Boot mode to **Manual**.

3 Select **Primary Boot Device Settings**.

   a Enter the discovery **Target IP** and **Target Port**.

   b You can leave the **Boot LUN** and **iSCSI Name** fields blank if only one iSCSI target and one LUN are at the specified address to boot from. Otherwise, you must specify these fields to ensure that you do not boot from a volume for some other system. After the target storage system is reached, these fields will be populated after a rescan.

   c Save changes.

4 From the **iSCSI Boot Settings** menu, select the primary boot device. An auto rescan of the HBA is made to find new target LUNS.

5 Select the iSCSI target.

NOTE If more then one LUN exists within the target, you can choose a specific LUN ID by pressing **Enter** after you locate the iSCSI device.

6 Return to the **Primary Boot Device Setting** menu. After the rescan, the **Boot LUN**and **iSCSI Name** fields are populated. Change the value of **Boot LUN** to the desired LUN ID.

iBFT iSCSI Boot Overview

ESXi hosts can boot from an iSCSI SAN using the software or dependent hardware iSCSI adapters and network adapters.

To deploy ESXi and boot from the iSCSI SAN, the host must have an iSCSI boot capable network adapter that supports the iSCSI Boot Firmware Table (iBFT) format. The iBFT is a method of communicating parameters about the iSCSI boot device to an operating system.

Before installing ESXi and booting from the iSCSI SAN, configure the networking and iSCSI boot parameters on the network adapter and enable the adapter for the iSCSI boot. Because configuring the network adapter is vendor specific, review your vendor documentation for instructions.

When you first boot from iSCSI, the iSCSI boot firmware on your system connects to an iSCSI target. If login is successful, the firmware saves the networking and iSCSI boot parameters in the iBFT and stores the table in the system's memory. The system uses this table to configure its own iSCSI connection and networking and to start up.

The following list describes the iBFT iSCSI boot sequence.

1 When restarted, the system BIOS detects the iSCSI boot firmware on the network adapter.

2 The iSCSI boot firmware uses the preconfigured boot parameters to connect with the specified iSCSI target.

3 If the connection to the iSCSI target is successful, the iSCSI boot firmware writes the networking and iSCSI boot parameters in to the iBFT and stores the table in the system memory.

NOTE The system uses this table to configure its own iSCSI connection and networking and to start up.

4 The BIOS boots the boot device.

5 The VMkernel starts loading and takes over the boot operation.

6 Using the boot parameters from the iBFT, the VMkernel connects to the iSCSI target.

7 After the iSCSI connection is established, the system boots.

iBFT iSCSI Boot Considerations

When you boot an ESXi host from iSCSI using iBFT-enabled network adapters, certain considerations apply.

The iBFT iSCSI boot does not support the following items:

- IPv6
- Failover for the iBFT-enabled network adapters

NOTE Update your NIC's boot code and iBFT firmware using vendor supplied tools before trying to install and boot VMware ESXi 4.1 release. Consult vendor documentation and VMware HCL guide for supported boot code and iBFT firmware versions for VMware ESXi 4.1 iBFT boot. The boot code and iBFT firmware released by vendors prior to the ESXi 4.1 release might not work.

After you set up your host to boot from iBFT iSCSI, the following restrictions apply:

- You cannot disable the software iSCSI adapter. If the iBFT configuration is present in the BIOS, the host re-enables the software iSCSI adapter during each reboot.
- You cannot remove the iBFT iSCSI boot target using the vSphere Client. The target appears on the list of adapter static targets.

Setting Up ESXi Host to Boot from iSCSI

With ESXi hosts, you can boot from iSCSI using the software iSCSI adapter or a dependent hardware iSCSI adapter and a network adapter.

When you set up your host to boot from iSCSI, you perform a number of tasks.

1 Configure iSCSI Boot Parameters on page 65

To begin an iSCSI boot process, a network adapter on your host must have a specially configured iSCSI boot firmware. When you configure the firmware, you specify the networking and iSCSI parameters and enable the adapter for the iSCSI boot.

2 Change Boot Sequence in BIOS on page 66

When setting up your host to boot from iBFT iSCSI, change the boot sequence to force your host to boot in an appropriate order.

3 Install ESXi to iSCSI Target on page 66

When setting up your host to boot from iSCSI, install the ESXi image to the target LUN.

4 Boot ESXi from iSCSI Target on page 67

After preparing the host for an iSCSI boot and copying the ESXi image to the iSCSI target, perform the actual boot.

Configure iSCSI Boot Parameters

To begin an iSCSI boot process, a network adapter on your host must have a specially configured iSCSI boot firmware. When you configure the firmware, you specify the networking and iSCSI parameters and enable the adapter for the iSCSI boot.

Configuration on the network adapter can be dynamic or static. If you use the dynamic configuration, you indicate that all target and initiator boot parameters are acquired using DHCP. For the static configuration, you manually enter data that includes your host's IP address and initiator IQN, and the target parameters.

Procedure

- On the network adapter that you use for the boot from iSCSI, specify networking and iSCSI parameters.

  Because configuring the network adapter is vendor specific, review your vendor documentation for instructions.

Change Boot Sequence in BIOS

When setting up your host to boot from iBFT iSCSI, change the boot sequence to force your host to boot in an appropriate order.

For ESXi installation, change the BIOS boot sequence to the following sequence:

- iSCSI
- DVD-ROM

Because changing the boot sequence in the BIOS is vendor specific, refer to vendor documentation for instructions. The following sample procedure explains how to change the boot sequence on a Dell host with a Broadcom network adapter.

Procedure

1. Turn on the host.
2. During Power-On Self-Test (POST), press F2 to enter the BIOS Setup.
3. In the BIOS Setup, select **Boot Sequence** and press Enter.
4. In the Boot Sequence menu, arrange the bootable items so that iSCSI precedes the DVD-ROM.
5. Press Esc to exit the Boot Sequence menu.
6. Press Esc to exit the BIOS Setup.
7. Select **Save Changes** and click **Exit** to exit the BIOS Setup menu.

Install ESXi to iSCSI Target

When setting up your host to boot from iSCSI, install the ESXi image to the target LUN.

Prerequisites

- Configure iSCSI boot firmware on your boot NIC to point to the target LUN that you want to use as the boot LUN.
- Change the boot sequence in the BIOS so that iSCSI precedes the DVD-ROM.
- If you use Broadcom adapters, set **Boot to iSCSI target** to **Disabled**.

Procedure

1. Insert the installation media in the DVD-ROM drive and restart the host.
2. When the installer starts, follow the typical installation procedure.
3. When prompted, select the iSCSI LUN as the installation target.

   The installer copies the ESXi boot image to the iSCSI LUN.
4. After the system restarts, remove the installation DVD.

Boot ESXi from iSCSI Target

After preparing the host for an iSCSI boot and copying the ESXi image to the iSCSI target, perform the actual boot.

Prerequisites

- Configure the iSCSI boot firmware on your boot NIC to point to the boot LUN.
- Change the boot sequence in the BIOS so that iSCSI precedes the boot device.
- If you use Broadcom adapters, set **Boot to iSCSI target** to **Enabled**

Procedure

1 Restart the host.

   The host boots from the iSCSI LUN using iBFT data. During the first boot, the iSCSI initialization script sets up default networking. The network setup is persistent after subsequent reboots.

2 (Optional) Adjust networking configuration using the vSphere Client.

Networking Best Practices

To boot an ESXi host from iSCSI using iBFT, you must properly configure networking.

To achieve greater security and better performance, have redundant network adapters on the host.

How you set up all the network adapters depends on whether your environment uses shared or isolated networks for the iSCSI traffic and host management traffic.

Shared iSCSI and Management Networks

Configure the networking and iSCSI parameters on the first network adapter on the host. After the host boots, you can add secondary network adapters to the default port group.

Isolated iSCSI and Management Networks

When you configure isolated iSCSI and management networks, follow these guidelines to avoid bandwidth problems.

- Your isolated networks must be on different subnets.
- If you use VLANs to isolate the networks, they must have different subnets to ensure that routing tables are properly set up.
- VMware recommends that you configure the iSCSI adapter and target to be on the same subnet. If you set up the iSCSI adapter and target on different subnets, the following restrictions apply:
  - The default VMkernel gateway must be able to route both the management and iSCSI traffic.
  - After you boot your ESXi host, you can use the iBFT-enabled network adapter only for iBFT. You cannot use the adapter for iSCSI traffic.
- Use the first physical network adapter for the management network.
- Use the second physical network adapter for the iSCSI network. Make sure to configure the iBFT.
- After the host boots, you can add secondary network adapters to both the management and iSCSI networks.

Change iBFT iSCSI Boot Settings

If settings, such as the IQN name, IP address, and so on, change on the iSCSI storage or your host, update the iBFT. This task assumes that the boot LUN and the data stored on the LUN remain intact.

Procedure

1 Shut down the ESXi host.

2 Change iSCSI storage settings.

3 Update the iBFT on the host with the new settings.

4 Restart the host.

The host boots using the new information stored in the iBFT.

Troubleshooting iBFT iSCSI Boot

The topics in this section help you to identify and solve problems you might encounter when using iBFT iSCSI boot.

Loss of System's Gateway Causes Loss of Network Connectivity

You lose network connectivity when you delete a port group associated with the iBFT network adapter.

Problem

A loss of network connectivity occurs after you delete a port group.

Cause

When you specify a gateway in the iBFT-enabled network adapter during ESXi installation, this gateway becomes the system's default gateway. If you delete the port group associated with the network adapter, the system's default gateway is lost. This action causes the loss of network connectivity.

Solution

Do not set an iBFT gateway unless it is required. If the gateway is required, after installation, manually set the system's default gateway to the one that the management network uses.

Changing iSCSI Boot Parameters Causes ESXi to Boot in Stateless Mode

Changing iSCSI boot parameters on the network adapter after the first boot does not update the iSCSI and networking configuration on the ESXi host.

Problem

If you change the iSCSI boot parameters on the network adapter after the first ESXi boot from iSCSI, the host will boot in a stateless mode.

Cause

The firmware uses the updated boot configuration and is able to connect to the iSCSI target and load the ESXi image. However, when loaded, the system does not pick up the new parameters, but continues to use persistent networking and iSCSI parameters from the previous boot. As a result, the ESXi host cannot connect to the target and boots in the stateless mode.

Solution

1 Use the vSphere Client to connect to the ESXi host.

2 Re-configure the iSCSI and networking on the host to match the iBFT parameters.

3 Perform a rescan.

Collecting Diagnostic Information for ESXi Hosts

If you boot from SAN using iBFT and your ESXi host does not have a local diagnostic partition, you need to set up the vSphere Management Assistant (vMA) to collect diagnostic information from your host and store it for analysis.

If your ESXi host experiences serious problems, it creates a file with diagnostic information that can be later analyzed to determine the cause of the problems.

You set up your ESXi host to act as a net dump client that transfers the diagnostic file over the network. vMA acts as the net dump server that collects the diagnostic information and saves it to `/var/core` on the server.

When you set up the net dump environment, follow these guidelines:

- Do not install vMA on the same physical host where you set up the net dump client.
- If you have multiple ESXi hosts that require the net dump configuration, configure each host separately. One vMA instance is sufficient for collecting the core dump files from multiple ESXi hosts.

Configure vSphere Management Assistant

The vSphere Management Assistant (vMA) is a virtual machine that you configure to act as a net dump server that collects diagnostic information from your ESXi host.

Prerequisites

Deploy and configure vMA on a physical server different form the server where you set up the net dump client. For information, see the *vSphere Management Assistant Guide* on http://www.vmware.com/support/pubs.

Procedure

1 Log in to vMA as administrator.

2 Enable the net dump server on vMA.

```
# sudo chkconfig vmware-netdumper on
```

3 Start the net dump server.

```
# sudo/etc/init.d/vmware-netdumper start

# sudo lokkit --quiet --port=6500:udp
```

Configure ESXi Host

Configure an ESXi host to act as the net dump client that transfers diagnostic information over the network.

Use vSphere CLI to configure your ESXi host.

Prerequisites

Configure vMA as the net dump server and obtain its IP address.

Procedure

1 Enter the IP address of the ESXi host.

```
# esxcfg-advcfg -s IP_address_ESXi /Net/NetdumpVmkIP
```

2 Specify the network adapter to use.

```
# esxcfg-advcfg -s vmnic /Net/NetdumpVmkNic
```

3 Specify the port group attached to the network adapter.

```
# esxcfg-advcfg -s portgroup /Net/NetdumpVmkPG
```

4 Specify the IP address of the net dump server.

```
# esxcfg-advcfg -s IP_address_netdump /Net/NetdumpServerIP
```

5 (Optional) Enter the IP address of gateway to reach the net dump server.

```
# esxcfg-advcfg -s IP_address_gateway /Net/NetdumpServerGateway
```

Managing ESX/ESXi Systems That Use SAN Storage

5

This section helps you manage your ESX/ESXi system, use SAN storage effectively, and perform troubleshooting. It also explains how to find information about storage devices, adapters, multipathing, and so on.

This chapter includes the following topics:

Viewing Storage Adapter Information

In the vSphere Client, you can display storage adapters that your host uses and review their information.

When you list all available adapters, you can see their models, types, such as Fibre Channel, Parallel SCSI, or iSCSI, and, if available, their unique identifiers.

As unique identifiers, iSCSI adapters use iSCSI names.

When you display details for each iSCSI adapter, you see the following information. Software iSCSI and dependent hardware iSCSI adapters need to be configured or enabled before you can view their information.

Table 5-1. Storage Adapter Information

Adapter Information	Description
Model	Model of the adapter.
iSCSI Name	A unique name formed according to iSCSI standards that identifies the iSCSI adapter.
iSCSI Alias	A friendly name used instead of the iSCSI name.

Table 5-1. Storage Adapter Information (Continued)

Adapter Information	Description
IP Address (independent hardware iSCSI)	An address assigned to the iSCSI adapter.
Connected Targets	Number of targets accessed through the adapter.
Devices	All storage devices or LUNs the adapter can access.
Paths	All paths the adapter uses to access storage devices.

View Storage Adapter Information

Use the vSphere Client to display storage adapters and review their information.

Procedure

1 In Inventory, select **Hosts and Clusters**.

2 Select a host and click the **Configuration** tab.

3 In Hardware, select **Storage Adapters**.

4 To view details for a specific adapter, select the adapter from the Storage Adapters list.

5 To list all storage devices the adapter can access, click **Devices**.

6 To list all paths the adapter uses, click **Paths**.

Copy Storage Adapter Names to Clipboard

You can copy the name of an adapter to a clipboard directly from the UI.

Procedure

1 In Inventory, select **Hosts and Clusters**.

2 Select a host and click the **Configuration** tab.

3 In Hardware, select **Storage Adapters**.

4 Select the adapter from the Storage Adapters list.

5 In the Details panel, highlight the value in the name field, and select **Copy** from the right-click menu.

Viewing Storage Device Information

You can use the vSphere Client to display all storage devices or LUNs available to your host, including all local and networked devices. If you use any third-party multipathing plug-ins, storage devices available through the plug-ins also appear on the list.

For each storage adapter, you can display a separate list of storage devices accessible just through this adapter. When you review a list of storage devices, you typically see the following information.

Table 5-2. Storage Device Information

Device Information	Description
Name	A friendly name that the host assigns to the device based on the storage type and manufacturer. You can change this name to a name of your choice.
Identifier	A universally unique identifier that is intrinsic to the storage device.
Runtime Name	The name of the first path to the device.
LUN	The LUN number that shows the position of the LUN within the target.

Table 5-2. Storage Device Information (Continued)

Device Information	Description
Type	Type of device, for example, disk or CD-ROM.
Transport	Transportation protocol your host uses to access the device.
Capacity	Total capacity of the storage device.
Owner	The plug-in, such as the NMP or a third-party plug-in, the host uses to manage the storage device.
Hardware Acceleration	Information on whether the storage device assists the host with various virtual machine management operations. The status can be Supported, Not Supported, or Unknown.
Location	A path to the storage device in the `/vmfs/devices/` directory.
Partitions	Primary and logical partitions, including a VMFS datastore, if configured.

Understanding Storage Device Naming

In the vSphere Client, each storage device, or LUN, is identified by several names.

Name A friendly name that the host assigns to a device based on the storage type and manufacturer. You can modify the name using the vSphere Client.

Identifier A universally unique identifier that the host extracts from the storage. Depending on the type of storage, the host uses different algorithms to extract the identifier.

Runtime Name The name of the first path to the device. The runtime name is created by the host. The runtime name is not a reliable identifier for the device, and is not persistent.

The runtime name has the following format:

vmhba#:C#:T#:L#, where

- vmhba# is the name of the storage adapter. The name refers to the physical adapter on the host, not to the SCSI controller used by the virtual machines.
- C# is the storage channel number.

  Software iSCSI initiators use the channel number to show multiple paths to the same target.
- T# is the target number. Target numbering is decided by the host and might change if there is a change in the mappings of targets visible to the host. Targets that are shared by different hosts might not have the same target number.
- L# is the LUN number that shows the position of the LUN within the target. The LUN number is provided by the storage system. If a target has only one LUN, the LUN number is always zero (0).

For example, `vmhba1:C0:T3:L1` represents LUN1 on target 3 accessed through the storage adapter vmhba1 and channel 0.

Display Storage Devices for a Host

You can use the vSphere Client to display all storage devices or LUNs available to your host, including all local and networked devices. If you use any third-party multipathing plug-ins, storage devices available through the plug-ins also appear on the list.

Procedure

1 In Inventory, select **Hosts and Clusters**.

2 Select a host and click the **Configuration** tab.

3 In Hardware, select **Storage**.

4 Click **Devices**.

5 To view additional details about a specific device, select the device from the list.

Display Storage Devices for an Adapter

For each storage adapter on your host, you can display a list of storage devices accessible just through this adapter.

Procedure

1 In Inventory, select **Hosts and Clusters**.

2 Select a host and click the **Configuration** tab.

3 In Hardware, select **Storage Adapters**.

4 Select the adapter from the Storage Adapters list.

5 Click **Devices**.

Copy Storage Device Identifiers to Clipboard

A storage device identifier is a universally unique ID that the host assigns to a storage device or LUN. Depending on the type of storage, the host uses different algorithms to create the identifier and it can become quite long and complex. You can copy the storage device identifier directly from the UI.

Procedure

1 Display a list of storage devices.

2 Right-click a device and select **Copy identifier to clipboard**.

Viewing Datastore Information

You can display all datastores available to your hosts and analyze their properties.

Datastores are added to the vSphere Client in the following ways:

- Created on an available storage device.
- Discovered when a host is added to the inventory. When you add a host to the inventory, the vSphere Client displays any datastores available to the host.

If your vSphere Client is connected to a vCenter Server system, you can see datastore information in the Datastores view. This view displays all datastores in the inventory, arranged by a datacenter. Through this view, you can organize datastores into folder hierarchies, create new datastores, edit their properties, or remove existing datastores.

This view is comprehensive and shows all information for your datastores including hosts and virtual machines using the datastores, storage reporting information, permissions, alarms, tasks and events, storage topology, and storage reports. Configuration details for each datastore on all hosts connected to this datastore are provided on the Configuration tab of the Datastores view.

NOTE The Datastores view is not available when the vSphere client connects directly to your host. In this case, review datastore information through the host storage configuration tab.

The following table describes the datastore details that you can see when you review datastores.

Table 5-3. Datastore Information

Datastore Information	Description
Identification	Editable friendly name that you assign to the datastore.
Device	Storage device, on which the datastore is deployed. If the datastore spans over multiple storage devices, only the first storage device is shown.
Capacity	Total formatted capacity of the datastore.
Free	Available space.
Type	File system that the datastore uses, either VMFS or NFS.
Storage I/O Control	Allows cluster-wide storage I/O prioritization. See the *vSphere Resource Management Guide*.
Hardware Acceleration	Information on whether the datastore assists the host with various virtual machine management operations. The status can be Supported, Not Supported, or Unknown.
Location	A path to the datastore in the `/vmfs/volumes/` directory.
Extents	Individual extents that the datastore spans and their capacity (VMFS datastores only).
Path Selection	Path selection policy the host uses to access storage (VMFS datastores only).
Paths	Number of paths used to access storage and their status (VMFS datastores only).

Review Datastore Properties

Use the vSphere Client to review datastore properties.

Procedure

1 Select a host in the inventory and click the **Configuration** tab.

2 In Hardware, select **Storage**.

3 Click the **Datastores** view.

4 To display details for a particular datastore, select the datastore from the list.

Resolving Storage Display Issues

When you use the vSphere Client to view storage devices available to your ESX/ESXi host and the output differs from what you expect, perform troubleshooting tasks.

Perform the following troubleshooting tasks if you have display issues.

Table 5-4. Troubleshooting iSCSI LUN Display

Troubleshooting Task	Description
Check cable connectivity.	If you do not see a port, the problem could be cable connectivity or routing. Check the cables first. Ensure that cables are connected to the ports and a link light indicates that the connection is good. If each end of the cable does not show a good link light, replace the cable.
Check routing settings.	Controls connectivity between different subnets on your Ethernet configuration. If your ESX/ESXi system and iSCSI storage are not on the same subnet, ensure that appropriate routing exists between the subnets. Also, ensure that the subnet mask and gateway address are set correctly on the iSCSI storage and the iSCSI initiator in the ESX/ESXi host.
Check access control configuration.	If the expected LUNs do not appear after rescan, access control might not be configured correctly on the storage system side: ■ If CHAP is configured, ensure that it is enabled on the ESX/ESXi host and matches the storage system setup. ■ If IP-based filtering is used, ensure that the iSCSI HBA or the VMkernel port group IP address and service console IP address are allowed. ■ If you are using initiator name-based filtering, ensure that the name is a qualified iSCSI name and matches the storage system setup. ■ For booting from a SAN, ensure that each host sees only required LUNs. Do not allow any host to see any boot LUN other than its own. Use storage system software to make sure that the host can see only the LUNs that it is supposed to see. ■ Ensure that the **Disk.MaxLUN** setting allows you to view the LUN you expect to see.
Check storage processor setup.	If a storage system has more than one storage processor, make sure that the SAN switch has a connection to the SP that owns the LUNs you want to access. On some storage systems, only one SP is active and the other SP is passive until a failure occurs. If you are connected to the wrong SP (the one with the passive path) you might not see the expected LUNs, or you might see the LUNs but get errors when trying to access them.
For software iSCSI, check network configuration.	The software iSCSI initiator in ESX/ESXi requires that a VMkernel network port have access to the iSCSI storage. The software initiator uses the VMkernel for data transfer between the ESX/ESXi system and the iSCSI storage.
Rescan your iSCSI initiator.	Perform a rescan each time you complete the following tasks: ■ Create new LUNs on a SAN. ■ Change the LUN masking on an ESX/ESXi host storage system. ■ Reconnect a cable. ■ Make a change to a host in a cluster. ■ Change CHAP settings or add new discovery addresses.

Datastore Refresh and Storage Rescan Operations

The datastore refresh operation updates the datastore lists and storage information, such as the datastore capacity, displayed in the vSphere Client. When you perform datastore management tasks or make changes in the SAN configuration, you might need to rescan your storage.

When you perform VMFS datastore management operations, such as creating a VMFS datastore or RDM, adding an extent, and increasing or deleting a VMFS datastore, your host or the vCenter Server automatically rescans and updates your storage. You can disable the automatic rescan feature by turning off the Host Rescan Filter. See "Turn off vCenter Server Storage Filters," on page 78.

In certain cases, you need to perform a manual rescan. You can rescan all storage available to your host, or, if you are using the vCenter Server, to all hosts in a folder, cluster, and datacenter.

If the changes you make are isolated to storage connected through a specific adapter, perform a rescan for this adapter.

Perform the manual rescan each time you make one of the following changes.

- Create new LUNs on a SAN.
- Change the path masking on a host.
- Reconnect a cable.
- Change CHAP settings.
- Add or remove discovery or static addresses.
- Add a single host to the vCenter Server after you have edited or removed from the vCenter Server a datastore shared by the vCenter Server hosts and the single host.

IMPORTANT If you rescan when a path is unavailable, the host removes the path from the list of paths to the device. The path reappears on the list as soon as it becomes available and starts working again.

Perform Storage Rescan

When you make changes in your SAN configuration, you might need to rescan your storage. You can rescan all storage available to your host. If the changes you make are isolated to storage accessed through a specific adapter, perform rescan for only this adapter.

Use this procedure if you want to limit the rescan to storage available to a particular host or accessed through a particular adapter on the host. If you want to rescan storage available to all hosts managed by your vCenter Server system, you can do so by right-clicking a datacenter, cluster, or folder that contains the hosts and selecting **Rescan for Datastores**.

Procedure

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

2 In the Hardware panel, select **Storage Adapters**, and click **Rescan** above the Storage Adapters panel.

You can also right-click an individual adapter and click **Rescan** to rescan just that adapter.

IMPORTANT On ESXi, it is not possible to rescan a single storage adapter. If you rescan a single adapter, all adapters are rescanned.

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

If new LUNs are discovered, they appear in the device list.

4 To discover new datastores or update a datastore after its configuration has been changed, select **Scan for New VMFS Volumes**.

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

Change the Number of Scanned LUNs

By default, the VMkernel scans for LUN 0 to LUN 255 for every target (a total of 256 LUNs). You can modify the **Disk.MaxLUN** parameter to improve LUN discovery speed.

IMPORTANT You cannot discover LUNs with a LUN ID number that is greater than 255.

Reducing the value can shorten rescan time and boot time. However, the time to rescan LUNs might depend on other factors, including the type of storage system and whether sparse LUN support is enabled.

Procedure

1 In the vSphere Client inventory panel, select the host, click the **Configuration** tab, and click **Advanced Settings** under Software.

2 Select **Disk**.

3 Scroll down to **Disk.MaxLUN**.

4 Change the existing value to the value of your choice, and click **OK**.

The value you enter specifies the LUN after the last one you want to discover.

For example, to discover LUNs from 0 through 31, set **Disk.MaxLUN** to 32.

Disable Sparse LUN Support

You can disable the default sparse LUN support to decrease the time ESX/ESXi needs to scan for LUNs.

The VMkernel provides sparse LUN support by default. The sparse LUN support enables the VMkernel to perform uninterrupted LUN scanning when a storage system presents LUNs with nonsequential LUN numbering, for example 0, 6, and 23. If all LUNs that your storage system presents are sequential, you can disable the sparse LUN support.

Procedure

1 In the vSphere Client inventory panel, select the host, click the **Configuration** tab, and click **Advanced Settings** under Software.

2 In the Advanced Settings dialog box, select **Disk**.

3 Scroll down to **Disk.SupportSparseLUN**, change the value to 0, and click **OK**.

Turn off vCenter Server Storage Filters

When you perform VMFS datastore management operations, vCenter Server uses default storage filters. The filters help you to avoid storage corruption by retrieving only the storage devices, or LUNs, that can be used for a particular operation. Unsuitable LUNs are not displayed for selection. You can turn off the filters to view all LUNs.

Before making any changes to the LUN filters, consult with the VMware support team. You can turn off the filters only if you have other methods to prevent LUN corruption.

Procedure

1 In the vSphere Client, select **Administration > vCenter Server Settings**.

2 In the settings list, select **Advanced Settings**.

3 In the **Key** text box, type a key.

Key	Filter Name
config.vpxd.filter.vmfsFilter	VMFS Filter
config.vpxd.filter.rdmFilter	RDM Filter
config.vpxd.filter.SameHostAndTransportsFilter	Same Host and Transports Filter
config.vpxd.filter.hostRescanFilter	Host Rescan Filter NOTE If you turn off the Host Rescan Filter, your hosts continue to perform a rescan each time you present a new LUN to a host or a cluster.

4 In the **Value** text box, type **`False`** for the specified key.

5 Click **Add**.

6 Click **OK**.

You are not required to restart the vCenter Server system.

vCenter Server Storage Filtering

vCenter Server provides storage filters to help you avoid storage device corruption or performance degradation that can be caused by an unsupported use of LUNs. These filters are available by default.

Table 5-5. Storage Filters

Filter Name	Description	Key
VMFS Filter	Filters out storage devices, or LUNs, that are already used by a VMFS datastore on any host managed by vCenter Server. The LUNs do not show up as candidates to be formatted with another VMFS datastore or to be used as an RDM.	config.vpxd.filter.vmfsFilter
RDM Filter	Filters out LUNs that are already referenced by an RDM on any host managed by vCenter Server. The LUNs do not show up as candidates to be formatted with VMFS or to be used by a different RDM. If you need virtual machines to access the same LUN, the virtual machines must share the same RDM mapping file. For information about this type of configuration, see *Setup for Failover Clustering and Microsoft Cluster Service*.	config.vpxd.filter.rdmFilter
Same Host and Transports Filter	Filters out LUNs ineligible for use as VMFS datastore extents because of host or storage type incompatibility. Prevents you from adding the following LUNs as extents: ■ LUNs not exposed to all hosts that share the original VMFS datastore. ■ LUNs that use a storage type different from the one the original VMFS datastore uses. For example, you cannot add a Fibre Channel extent to a VMFS datastore on a local storage device.	config.vpxd.filter.SameHostAndTransportsFilter
Host Rescan Filter	Automatically rescans and updates VMFS datastores after you perform datastore management operations. The filter helps provide a consistent view of all VMFS datastores on all hosts managed by vCenter Server. **NOTE** If you present a new LUN to a host or a cluster, the hosts automatically perform a rescan no matter whether you have the Host Rescan Filter on or off.	config.vpxd.filter.hostRescanFilter

Path Scanning and Claiming

When you start your ESX/ESXi host or rescan your storage adapter, the host discovers all physical paths to storage devices available to the host. Based on a set of claim rules defined in the `/etc/vmware/esx.conf` file, the host determines which multipathing plug-in (MPP) should claim the paths to a particular device and become responsible for managing the multipathing support for the device.

By default, the host performs a periodic path evaluation every 5 minutes causing any unclaimed paths to be claimed by the appropriate MPP.

The claim rules are numbered. For each physical path, the host runs through the claim rules starting with the lowest number first. The attributes of the physical path are compared to the path specification in the claim rule. If there is a match, the host assigns the MPP specified in the claim rule to manage the physical path. This continues until all physical paths are claimed by corresponding MPPs, either third-party multipathing plug-ins or the native multipathing plug-in (NMP).

For general information on multipathing plug-ins, see "Managing Multiple Paths," on page 22.

For the paths managed by the NMP module, a second set of claim rules is applied. These rules determine which Storage Array Type Plug-In (SATP) should be used to manage the paths for a specific array type, and which Path Selection Plug-In (PSP) is to be used for each storage device. For example, for a storage device that belongs to the EMC CLARiiON CX storage family and is not configured as ALUA device, the default SATP is VMW_SATP_CX and the default PSP is Most Recently Used.

Use the vSphere Client to view which SATP and PSP the host is using for a specific storage device and the status of all available paths for this storage device. If needed, you can change the default VMware PSP using the vSphere Client. To change the default SATP, you need to modify claim rules using the vSphere CLI.

You can find some information about modifying claim rules in "Managing Storage Paths and Multipathing Plug-Ins," on page 103.

For detailed descriptions of the commands available to manage PSA, see the *vSphere Command-Line Interface Installation and Scripting Guide* and the *vSphere Command-Line Interface Reference*.

Viewing the Paths Information

Use the vSphere Client to determine which SATP and PSP the ESX/ESXi host uses for a specific storage device and the status of all available paths for this storage device. You can access the path information from both, the Datastores and Devices views. For datastores, you review the paths that connect to the device the datastore is deployed on.

The path information includes the SATP assigned to manage the device, the path selection policy (PSP), and a list of paths with their physical characteristics, such as an adapter and target each path uses, and the status of each path. The following path status information can appear:

Active — Paths available for issuing I/O to a LUN. A single or multiple working paths currently used for transferring data are marked as Active (I/O).

NOTE For hosts that run ESX/ESXi 3.5 or earlier, the term active means the only path that the host is using to issue I/O to a LUN.

Standby — The path is operational and can be used for I/O if active paths fail.

Disabled — The path is disabled and no data can be transferred.

Dead — The software cannot connect to the disk through this path.

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

View Datastore Paths

Use the vSphere Client to review the paths that connect to storage devices the datastores are deployed on.

Procedure

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

2 Click the **Configuration** tab and click **Storage** in the Hardware panel.

3 Click **Datastores** under View.

4 From the list of configured datastores, select the datastore whose paths you want to view or configure.

The Details panel shows the total number of paths being used to access the device and whether any of them are broken or disabled.

5 Click **Properties > Manage Paths** to open the Manage Paths dialog box.

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

View Storage Device Paths

Use the vSphere Client to view which SATP and PSP the host uses for a specific storage device and the status of all available paths for this storage device.

Procedure

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

2 Click the **Configuration** tab and click **Storage** in the Hardware panel.

3 Click **Devices** under View.

4 Click **Manage Paths** to open the Manage Paths dialog box.

Setting a Path Selection Policy

For each storage device, the ESX/ESXi host sets the path selection policy based on the claim rules defined in the `/etc/vmware/esx.conf` file.

By default, VMware supports the following path selection policies. If you have a third-party PSP installed on your host, its policy also appears on the list.

Fixed (VMW_PSP_FIXED)	The host always uses the preferred path to the disk when that path is available. If the host cannot access the disk through the preferred path, it tries the alternative paths. The default policy for active-active storage devices is Fixed.
Fixed AP (VMW_PSP_FIXED_AP)	Extends the Fixed functionality to active-passive and ALUA mode arrays.
Most Recently Used (VMW_PSP_MRU)	The host selects the path that it used recently. When the path becomes unavailable, the host selects an alternative path. The host does not revert back to the original path when that path becomes available again. There is no preferred path setting with the MRU policy. MRU is the default policy for active-passive storage devices.
Round Robin (VMW_PSP_RR)	The host uses an automatic path selection algorithm rotating through all active paths when connecting to active-passive arrays, or through all available paths when connecting to active-active arrays. This implements load balancing across the physical paths available to your host. Load balancing is the process of spreading I/O requests across the paths. The goal is to optimize performance in terms of throughput, such as I/O per second, megabytes per second, or response times.

Table 5-6 summarizes how the behavior of host changes, depending on the type of array and the failover policy.

Table 5-6. Path Policy Effects

Policy/Controller	Active/Active	Active/Passive
Most Recently Used	Administrator action is required to fail back after path failure.	Administrator action is required to fail back after path failure.
Fixed	VMkernel resumes using the preferred path when connectivity is restored.	VMkernel attempts to resume using the preferred path. This can cause path thrashing or failure when another SP now owns the LUN.
Round Robin	No fail back.	Next path in round robin scheduling is selected.
Fixed AP	For ALUA arrays, VMkernel picks the path set to be the preferred path. For both A/A and A/P and ALUA arrays, VMkernel resumes using the preferred path, but only if the path-thrashing avoidance algorithm allows the fail-back.	

Change the Path Selection Policy

Generally, you do not have to change the default multipathing settings your host uses for a specific storage device. However, if you want to make any changes, you can use the Manage Paths dialog box to modify a path selection policy and specify the preferred path for the Fixed policy.

Procedure

1 Open the Manage Paths dialog box either from the Datastores or Devices view.

2 Select a path selection policy.

By default, VMware supports the following path selection policies. If you have a third-party PSP installed on your host, its policy also appears on the list.

- **Fixed (VMW_PSP_FIXED)**
- **Fixed AP (VMW_PSP_FIXED_AP)**
- **Most Recently Used (VMW_PSP_MRU)**
- **Round Robin (VMW_PSP_RR)**

3 For the fixed policy, specify the preferred path by right-clicking the path you want to assign as the preferred path, and selecting **Preferred**.

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

Disable Paths

You can temporarily disable paths for maintenance or other reasons. You can do so using the vSphere Client.

Procedure

1 Open the Manage Paths dialog box either from the Datastores or Devices view.

2 In the Paths panel, right-click the path to disable, and select **Disable**.

3 Click **OK** to save your settings and exit the dialog box.

You can also disable a path from the adapter's Paths view by right-clicking the path in the list and selecting **Disable**.

Path Management and Manual, or Static, Load Balancing

Balancing loads among available paths improves performance. If your array supports the ALUA protocol, your host uses that protocol to perform load balancing. If your array does not support the ALUA protocol and you want your host to do automatic load balancing, configure your devices to use the Round Robin PSP. If you want to do the load balancing yourself, you can perform manual load balancing.

With both active-active and active-passive storage arrays, you can set up your host to use different paths to different LUNs so that your adapters are being used evenly. If a path fails, the surviving paths carry all the traffic. Path failover might take a minute or more, because the SAN might converge with a new topology to try to restore service. This delay is necessary to allow the SAN to stabilize its configuration after topology changes.

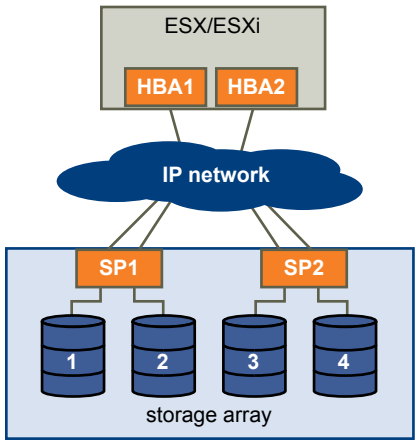
You can configure your ESX/ESXi host to load balance traffic across multiple adapters by assigning preferred paths to your LUNs. Path policy must be set to Fixed.

The following example demonstrates how manual load balancing is performed with an active-active array.

Assume the following setup, shown in Figure 5-1.

- Active/Active SPs
- An ESX/ESXi system
- Two iSCSI HBAs

Figure 5-1. Manual Load Balancing with iSCSI



For load balancing, set the preferred paths as follows.

- For LUN 1: HBA1-SP1-LUN1
- For LUN 2: HBA2-SP1-LUN2
- For LUN 3: HBA1-SP2-LUN3
- For LUN 4: HBA2-SP2-LUN4

With active-passive arrays, you can perform load balancing if the array supports two active paths and the HBA ports can access both SPs in an array.

You can use the VMW_PSP_FIXED_AP path selection policies to do static path load balancing on active-passive arrays.

Set Guest Operating System Timeout

Increase the standard disk timeout value so that a Windows guest operating system is not extensively disrupted during a path failover.

Path failover occurs when the active path to a LUN is changed from one path to another, usually because of some SAN component failure along the current path.

I/O might pause for 30 to 60 seconds until the iSCSI driver determines that the link is unavailable and until failover is complete. As a result, the virtual machines (with their virtual disks installed on SAN storage) can appear unresponsive. If you attempt to display the host, its storage devices, or its adapter, the operation might appear to stall. After failover is complete, I/O resumes normally.

In case of multiple breakages, all connections to SAN storage devices might be lost. If none of the connections to the storage device is working, some virtual machines might encounter I/O errors on their virtual SCSI disks.

For Windows 2000 and Windows Server 2003 guest operating systems, you can set operating system timeout by fusing the registry.

Procedure

1 Back up your Windows registry.

2 Select **Start > Run**.

3 From the command prompt type **`regedit.exe`**, and click **OK**.

4 In the left-panel hierarchy view, double-click **HKEY_LOCAL_MACHINE**, then **System**, then **CurrentControlSet**, then **Services**, and then **Disk**.

5 Select the **TimeOutValue** and set the data value to x03c (hexadecimal) or 60 (decimal).

After you make this change, Windows waits at least 60 seconds for delayed disk operations to complete before it generates errors.

6 Click **OK** to exit the **Registry Editor**.

Sharing Diagnostic Partitions

Generally, you use the local disk of your ESX/ESXi host as a diagnostic partition. If you have diskless ESX servers that boot from a SAN, multiple hosts can share one diagnostic partition on the same SAN LUN.

If more than one ESX/ESXi system uses the same LUN as the diagnostic partition, that LUN must be zoned so that all the servers can access it.

Each server needs 100MB of space, so the size of the LUN determines how many servers can share it. Each ESX/ESXi system is mapped to a diagnostic slot. VMware recommends at least 16 slots (1600MB) of disk space if servers share a diagnostic partition.

If there is only one diagnostic slot on the device, all ESX/ESXi systems sharing that device map to the same slot. This setup can easily create problems. If two ESX/ESXi systems perform a core dump at the same time, the core dumps are overwritten on the diagnostic partition.

Avoiding and Resolving SAN Problems

When using ESX/ESXi in conjunction with a SAN, you must follow specific guidelines to avoid SAN problems.

You should observe these tips for avoiding and resolving problems with your SAN configuration:

- Place only one VMFS datastore on each LUN. Multiple VMFS datastores on one LUN is not recommended.
- Do not change the path policy the system sets for you unless you understand the implications of making such a change.

- Document everything. Include information about configuration, access control, storage, switch, server and iSCSI HBA configuration, software and firmware versions, and storage cable plan.
- Plan for failure:
  - Make several copies of your topology maps. For each element, consider what happens to your SAN if the element fails.
  - Cross off different links, switches, HBAs and other elements to ensure you did not miss a critical failure point in your design.
- Ensure that the iSCSI HBAs are installed in the correct slots in the ESX/ESXi host, based on slot and bus speed. Balance PCI bus load among the available busses in the server.
- Become familiar with the various monitor points in your storage network, at all visibility points, including ESX/ESXi performance charts, Ethernet switch statistics, and storage performance statistics.
- Be cautious when changing IDs of the LUNs that have VMFS datastores being used by your ESX/ESXi host. If you change the ID, virtual machines running on the VMFS datastore will fail.

  If there are no running virtual machines on the VMFS datastore, after you change the ID of the LUN, you must use rescan to reset the ID on your host. For information on using rescan, see "Perform Storage Rescan," on page 77.

Optimizing SAN Storage Performance

Several factors contribute to optimizing a typical SAN environment.

If the network environment is properly configured, the iSCSI components provide adequate throughput and low enough latency for iSCSI initiators and targets. If the network is congested and links, switches or routers are saturated, iSCSI performance suffers and might not be adequate for ESX/ESXi environments.

Storage System Performance

Storage system performance is one of the major factors contributing to the performance of the entire iSCSI environment.

If issues occur with storage system performance, consult your storage system vendor's documentation for any relevant information.

When you assign LUNs, remember that you can access each shared LUN through a number of ESX/ESXi hosts, and that a number of virtual machines can run on each host. One LUN used by an ESX/ESXi host can service I/O from many different applications running on different operating systems. Because of this diverse workload, the RAID group that contains the ESX/ESXi LUNs should not include LUNs that other hosts use that are not running ESX/ESXi for I/O intensive applications.

Enable read caching and write caching.

Load balancing is the process of spreading server I/O requests across all available SPs and their associated host server paths. The goal is to optimize performance in terms of throughput (I/O per second, megabytes per second, or response times).

SAN storage systems require continual redesign and tuning to ensure that I/O is load balanced across all storage system paths. To meet this requirement, distribute the paths to the LUNs among all the SPs to provide optimal load balancing. Close monitoring indicates when it is necessary to manually rebalance the LUN distribution.

Tuning statically balanced storage systems is a matter of monitoring the specific performance statistics (such as I/O operations per second, blocks per second, and response time) and distributing the LUN workload to spread the workload across all the SPs.

NOTE Dynamic load balancing is not currently supported with ESX/ESXi.

Server Performance

You must consider several factors to ensure optimal server performance.

Each server application must have access to its designated storage with the following conditions:

- High I/O rate (number of I/O operations per second)
- High throughput (megabytes per second)
- Minimal latency (response times)

Because each application has different requirements, you can meet these goals by choosing an appropriate RAID group on the storage system. To achieve performance goals, perform the following tasks:

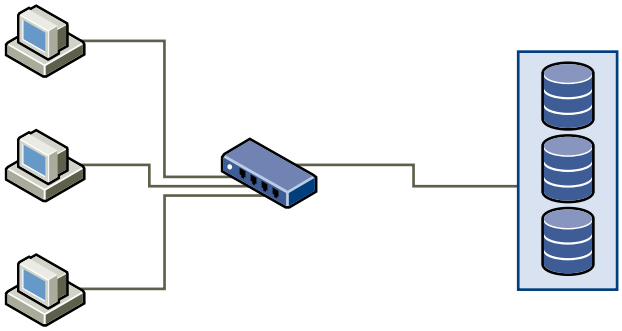
- Place each LUN on a RAID group that provides the necessary performance levels. Pay attention to the activities and resource utilization of other LUNS in the assigned RAID group. A high-performance RAID group that has too many applications doing I/O to it might not meet performance goals required by an application running on the ESX/ESXi host.
- Provide each server with a sufficient number of network adapters or iSCSI hardware adapters to allow maximum throughput for all the applications hosted on the server for the peak period. I/O spread across multiple ports provides higher throughput and less latency for each application.
- To provide redundancy for software iSCSI, make sure the initiator is connected to all network adapters used for iSCSI connectivity.
- When allocating LUNs or RAID groups for ESX/ESXi systems, multiple operating systems use and share that resource. As a result, the performance required from each LUN in the storage subsystem can be much higher if you are working with ESX/ESXi systems than if you are using physical machines. For example, if you expect to run four I/O intensive applications, allocate four times the performance capacity for the ESX/ESXi LUNs.
- When using multiple ESX/ESXi systems in conjunction with vCenter Server, the performance needed from the storage subsystem increases correspondingly.
- The number of outstanding I/Os needed by applications running on an ESX/ESXi system should match the number of I/Os the SAN can handle.

Network Performance

A typical SAN consists of a collection of computers connected to a collection of storage systems through a network of switches. Several computers often access the same storage.

Figure 5-2 shows several computer systems connected to a storage system through an Ethernet switch. In this configuration, each system is connected through a single Ethernet link to the switch, which is also connected to the storage system through a single Ethernet link. In most configurations, with modern switches and typical traffic, this is not a problem.

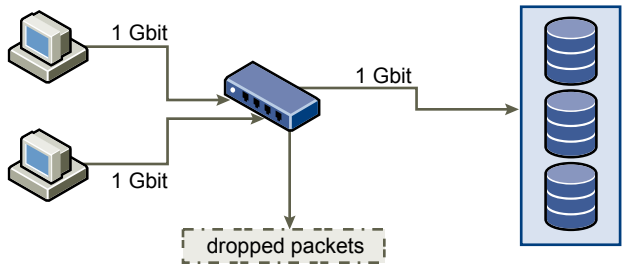
Figure 5-2. Single Ethernet Link Connection to Storage



When systems read data from storage, the maximum response from the storage is to send enough data to fill the link between the storage systems and the Ethernet switch. It is unlikely that any single system or virtual machine gets full use of the network speed, but this situation can be expected when many systems share one storage device.

When writing data to storage, multiple systems or virtual machines might attempt to fill their links. As Figure 5-3 shows, when this happens, the switch between the systems and the storage system has to drop data. This happens because, while it has a single connection to the storage device, it has more traffic to send to the storage system than a single link can carry. In this case, the switch drops network packets because the amount of data it can transmit is limited by the speed of the link between it and the storage system.

Figure 5-3. Dropped Packets



Recovering from dropped network packets results in large performance degradation. In addition to time spent determining that data was dropped, the retransmission uses network bandwidth that could otherwise be used for current transactions.

iSCSI traffic is carried on the network by the Transmission Control Protocol (TCP). TCP is a reliable transmission protocol that ensures that dropped packets are retried and eventually reach their destination. TCP is designed to recover from dropped packets and retransmits them quickly and seamlessly. However, when the switch discards packets with any regularity, network throughput suffers significantly. The network becomes congested with requests to resend data and with the resent packets, and less data is actually transferred than in a network without congestion.

Most Ethernet switches can buffer, or store, data and give every device attempting to send data an equal chance to get to the destination. This ability to buffer some transmissions, combined with many systems limiting the number of outstanding commands, allows small bursts from several systems to be sent to a storage system in turn.

If the transactions are large and multiple servers are trying to send data through a single switch port, a switch's ability to buffer one request while another is transmitted can be exceeded. In this case, the switch drops the data it cannot send, and the storage system must request retransmission of the dropped packet. For example, if an Ethernet switch can buffer 32KB on an input port, but the server connected to it thinks it can send 256KB to the storage device, some of the data is dropped.

Most managed switches provide information on dropped packets, similar to the following:

```
*: interface is up
IHQ: pkts in input hold queue     IQD: pkts dropped from input queue
OHQ: pkts in output hold queue    OQD: pkts dropped from output queue
RXBS: rx rate (bits/sec)          RXPS: rx rate (pkts/sec)
TXBS: tx rate (bits/sec)          TXPS: tx rate (pkts/sec)
TRTL: throttle count
```

Table 5-7. Sample Switch Information

Interface	IHQ	IQD	OHQ	OQD	RXBS	RXPS	TXBS	TXPS	TRTL
* GigabitEthernet0/1	3	9922	0	0	476303000	62273	477840000	63677	0

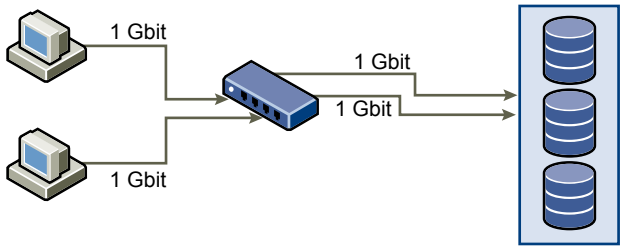
In this example from a Cisco switch, the bandwidth used is 476303000 bits/second, which is less than half of wire speed. In spite of this, the port is buffering incoming packets and has dropped quite a few packets. The final line of this interface summary indicates that this port has already dropped almost 10,000 inbound packets in the IQD column.

Configuration changes to avoid this problem involve making sure several input Ethernet links are not funneled into one output link, resulting in an oversubscribed link. When a number of links transmitting near capacity are switched to a smaller number of links, oversubscription is a possibility.

Generally, applications or systems that write a lot of data to storage, such as data acquisition or transaction logging systems, should not share Ethernet links to a storage device. These types of applications perform best with multiple connections to storage devices.

Figure 5-4 shows multiple connections from the switch to the storage.

Figure 5-4. Multiple Connections from Switch to Storage



Using VLANs or VPNs does not provide a suitable solution to the problem of link oversubscription in shared configurations. VLANs and other virtual partitioning of a network provide a way of logically designing a network, but do not change the physical capabilities of links and trunks between switches. When storage traffic and other network traffic end up sharing physical connections, as they would with a VPN, the possibility for oversubscription and lost packets exists. The same is true of VLANs that share interswitch trunks. Performance design for a SANs must take into account the physical limitations of the network, not logical allocations.

Resolving Performance Issues

The vSphere Client offers extensive facilities for collecting performance information. The information is graphically displayed in the vSphere Client. The vSphere Client updates its display periodically.

You can also use the `resxtop` vSphere CLI command that allows you to examine how ESX/ESXi hosts use resources. For information about `resxtop`, see the *Resource Management Guide* or the *vSphere Command-Line Interface Installation and Scripting Guide*.

Checking Ethernet Switch Statistics

Many Ethernet switches provide different methods for monitoring switch health.

Switches that have ports operating near maximum throughput much of the time do not provide optimum performance. If you have ports in your iSCSI SAN running near the maximum, reduce the load. If the port is connected to an ESX/ESXi system or iSCSI storage, you can reduce the load by using manual load balancing.

If the port is connected between multiple switches or routers, consider installing additional links between these components to handle more load. Ethernet switches also commonly provide information about transmission errors, queued packets, and dropped Ethernet packets. If the switch regularly reports any of these conditions on ports being used for iSCSI traffic, performance of the iSCSI SAN will be poor.

Resolving Path Thrashing

If your server is unable to access a LUN, or access is very slow, you might have a problem with path thrashing, also called LUN thrashing. Path thrashing might occur when two hosts access the LUN through different SPs and, as a result, the LUN is never actually available.

Only specific SAN configurations in conjunction with the following conditions can cause the path thrashing:

- You are working with an active-passive array. Path thrashing only occurs on active-passive arrays. For active-active arrays or arrays that provide transparent failover, path thrashing does not occur.
- Two hosts access the same LUN using different storage processors (SPs). This can happen in two ways.
  - For example, the LUN is configured to use the Fixed PSP. On Host A, the preferred path to the LUN is set to use a path through SP A. On Host B, the preferred path to the LUN is configured to use a path through SP B.
  - Path thrashing can also occur if Host A can access the LUN only with paths through SP A, while Host B can access the LUN only with paths through SP B.

This problem can also occur on a direct connect array (such as AX100) with HBA failover on one or more nodes.

Path thrashing is a problem that you typically do not experience with other operating systems. No other common operating system uses shared LUNs for more than two servers. That setup is typically reserved for clustering.

If only one server is issuing I/Os to the LUN at a time, path thrashing does not become a problem. In contrast, multiple ESX/ESXi systems might issue I/O to the same LUN concurrently.

Understanding Path Thrashing

The SPs in a storage array are like independent computers that have access to some shared storage. Algorithms determine how concurrent access is handled.

For active-passive arrays, only one SP at a time can access all the sectors on the storage that make up a given LUN. The ownership is passed between the storage processors. Storage systems use caches and SP A must not write anything to disk that invalidates the SP B cache. Because the SP has to flush the cache when it finishes the operation, it takes a little time to move the ownership. During that time, neither SP can process I/O to the LUN.

For active-active arrays, the algorithms allow more fine-grained access to the storage and synchronize caches. Access can happen concurrently through any SP without extra time required.

Consider how path selection works:

- On an active-active array the ESX/ESXi system starts sending I/O down the new path.
- On an active-passive arrays, the ESX/ESXi system checks all standby paths. The SP of the path that is currently under consideration sends information to the system on whether it currently owns the LUN.
  - If the ESX/ESXi system finds an SP that owns the LUN, that path is selected and I/O is sent down that path.
  - If the ESX/ESXi host cannot find such a path, the ESX/ESXi host picks one of the standby paths and sends the SP of that path a command to move the LUN ownership to the SP.

  Path thrashing can occur as a result of the following path choice: If server A can reach a LUN only through one SP, and server B can reach the same LUN only through a different SP, they both continually cause the ownership of the LUN to move between the two SPs, effectively ping-ponging the ownership of the LUN. Because the system moves the ownership quickly, the storage array cannot process any I/O (or can process only very little). As a result, any servers that depend on the LUN will experience low throughput due to the long time it takes to complete each I/O request.

Resolve Path Thrashing

Use this procedure to resolve path thrashing. Path thrashing occurs on active-passive arrays when two hosts access the LUN through different SPs and, as a result, the LUN is never actually available.

Procedure

1 Ensure that all hosts sharing the same set of LUNs on the active-passive arrays use the same storage processor.

2 Correct any cabling or masking inconsistencies between different ESX/ESXi hosts and SAN targets so that all HBAs see the same targets.

3 Configure the path to use the Most Recently Used PSP (the default) or VMW_PSP_FIXED_AP.

Equalize Disk Access Between Virtual Machines

You can adjust the maximum number of outstanding disk requests with the `Disk.SchedNumReqOutstanding` parameter in the vSphere Client. When two or more virtual machines are accessing the same LUN, this parameter controls the number of outstanding requests that each virtual machine can issue to the LUN. Adjusting the limit can help equalize disk access between virtual machines.

This limit does not apply when only one virtual machine is active on a LUN. In that case, the bandwidth is limited by the queue depth of the storage adapter.

Procedure

1 In the vSphere Client, select the host in the inventory panel.

2 Click the **Configuration** tab and click **Advanced Settings** under Software.

3 Click **Disk** in the left panel and scroll down to **Disk.SchedNumReqOutstanding**.

4 Change the parameter value to the number of your choice and click **OK**.

This change can impact disk bandwidth scheduling, but experiments have shown improvements for disk-intensive workloads.

What to do next

If you adjust this value in the VMkernel, you might also want to adjust the queue depth in your storage adapter.

Set Maximum Queue Depth for Software iSCSI

If you notice unsatisfactory performance for your software iSCSI LUNs, you can change their maximum queue depth by using the `vicfg-module` command.

Procedure

1 On the vSphere CLI, run the following command:

```
vicfg-module -s iscsivmk_LunQDepth=value iscsi_vmk
```

The `iscsivmk_LunQDepth` parameter sets the maximum number of outstanding commands, or queue depth, for each LUN accessed through the software iSCSI adapter. The default value is 128.

2 Reboot your system.

CAUTION Setting the queue depth to a value higher than the default can decrease the total number of LUNs supported.

Reducing SCSI Reservations

Operations that require getting a file lock or a metadata lock in VMFS result in short-lived SCSI reservations. SCSI reservations lock an entire LUN. Excessive SCSI reservations by a server can cause performance degradation on other servers accessing the same VMFS.

Examples of operations that require getting file locks or metadata locks include:

- Virtual machine power on.
- vMotion.
- Virtual machines running with virtual disk snapshots.
- File operations that require opening files or doing metadata updates.

NOTE ESX/ESXi uses the SCSI reservations mechanism only when a LUN is not VAAI capable. If a LUN is VAAI capable and supports Hardware Acceleration, ESX/ESXi uses atomic test and set (ATS) algorithm to lock the LUN.

Performance degradation can occur if such operations occur frequently on multiple servers accessing the same VMFS. For instance, VMware recommends that you do not run many virtual machines from multiple servers that are using virtual disk snapshots on the same VMFS. Limit the number of VMFS file operations when many virtual machines run on the VMFS.

SAN Storage Backup Considerations

In the SAN environment, backups have two goals. The first goal is to archive online data to offline media. This process is repeated periodically for all online data on a time schedule. The second goal is to provide access to offline data for recovery from a problem. For example, database recovery often requires retrieval of archived log files that are not currently online.

Scheduling a backup depends on a number of factors:

- Identification of critical applications that require more frequent backup cycles within a given period of time.
- Recovery point and recovery time goals. Consider how precise your recovery point needs to be, and how long you are willing to wait for it.
- The rate of change (RoC) associated with the data. For example, if you are using synchronous/ asynchronous replication, the RoC affects the amount of bandwidth required between the primary and secondary storage devices.
- Overall impact on SAN environment, storage performance (while backing up), and other applications.
- Identification of peak traffic periods on the SAN (backups scheduled during those peak periods can slow the applications and the backup process).
- Time to schedule all backups within the datacenter.
- Time it takes to back up an individual application.
- Resource availability for archiving data; usually offline media access (tape).

Include a recovery-time objective for each application when you design your backup strategy. That is, consider the time and resources necessary to reprovision the data. For example, if a scheduled backup stores so much data that recovery requires a considerable amount of time, examine the scheduled backup. Perform the backup more frequently, so that less data is backed up at a time and the recovery time decreases.

If a particular application requires recovery within a certain time frame, the backup process needs to provide a time schedule and specific data processing to meet this requirement. Fast recovery can require the use of recovery volumes that reside on online storage to minimize or eliminate the need to access slow offline media for missing data components.

Snapshot Software

Snapshot software allows an administrator to make an instantaneous copy of any single virtual disk defined within the disk subsystem.

Snapshot software is available at different levels:

- ESX/ESXi hosts allow you to create snapshots of virtual machines. This software is included in the basic ESX/ESXi package.
- Third-party backup software might allow for more comprehensive backup procedures and might contain more sophisticated configuration options.

Administrators make snapshots for a variety of reasons:

- Backup
- Disaster recovery
- Availability of multiple configurations, versions, or both
- Forensics (looking at a snapshot to find the cause of problems while your system is running)
- Data mining (looking at a copy of your data to reduce load on production systems)

Using a Third-Party Backup Package

Using third-party software has the advantage of a uniform environment. However, the additional cost of the third-party snapshotting software can become higher as your SAN grows.

If you are using third-party backup software, make sure that the software is supported with ESX/ESXi hosts.

If you use snapshots to back up your data, consider the following points:

- Some vendors support snapshots for both VMFS and RDMs. If both are supported, you can make either a snapshot of the whole virtual machine file system for a host, or snapshots for the individual virtual machines (one per disk).
- Some vendors support snapshots only for a setup using RDM. If only RDM is supported, you can make snapshots of individual virtual machines.

See your storage vendor's documentation.

NOTE ESX/ESXi systems also include a Consolidated Backup component.

Layered Applications

SAN administrators customarily use specialized array-based software for backup, disaster recovery, data mining, forensics, and configuration testing.

Storage providers typically supply two types of advanced services for their LUNs: snapshotting and replication.

When you use an ESX/ESXi system in conjunction with a SAN, you must decide whether array-based or host-based tools are more suitable for your particular situation.

Array-Based (Third-Party) Solution

When you use an ESX/ESXi system in conjunction with a SAN, you must decide whether array-based tools are more suitable for your particular situation.

When you consider an array-based solution, keep in mind the following points:

- Array-based solutions usually result in more comprehensive statistics. With RDM, data always takes the same path, which results in easier performance management.
- Security is more transparent to the storage administrator when you use RDM and an array-based solution because with RDM, virtual machines more closely resemble physical machines.
- If you use an array-based solution, physical compatibility RDMs are often used for the storage of virtual machines. If you do not intend to use RDM, check the storage vendor documentation to see if operations on LUNs with VMFS volumes are supported. If you use array operations on VMFS LUNs, carefully read the section on resignaturing.

File-Based (VMFS) Solution

When you use an ESX/ESXi system in conjunction with a SAN, you must decide whether host-based tools are more suitable for your particular situation.

When you consider a file-based solution that uses VMware tools and VMFS instead of the array tools, be aware of the following points:

- Using VMware tools and VMFS is better for provisioning. One large LUN is allocated and multiple `.vmdk` files can be placed on that LUN. With RDM, a new LUN is required for each virtual machine.
- Snapshotting is included with your ESX/ESXi host at no extra cost. The file-based solution is therefore more cost-effective than the array-based solution.
- Using VMFS is easier for ESX/ESXi administrators.
- ESX/ESXi administrators who use the file-based solution are more independent from the SAN administrator.

Managing Duplicate VMFS Datastores

When a LUN contains a VMFS datastore copy, you can mount the datastore with the existing signature or assign a new signature.

Each VMFS datastore created in a LUN has a unique UUID that is stored in the file system superblock. When the LUN is replicated or snapshotted, the resulting LUN copy is identical, byte-for-byte, with the original LUN. As a result, if the original LUN contains a VMFS datastore with UUID X, the LUN copy appears to contain an identical VMFS datastore, or a VMFS datastore copy, with exactly the same UUID X.

ESX/ESXi can determine whether a LUN contains the VMFS datastore copy, and either mount the datastore copy with its original UUID or change the UUID, thus resignaturing the datastore.

Mounting VMFS Datastores with Existing Signatures

You might not have to resignature a VMFS datastore copy. You can mount a VMFS datastore copy without changing its signature.

For example, you can maintain synchronized copies of virtual machines at a secondary site as part of a disaster recovery plan. In the event of a disaster at the primary site, you can mount the datastore copy and power on the virtual machines at the secondary site.

IMPORTANT You can mount a VMFS datastore copy only if it does not collide with the original VMFS datastore that has the same UUID. To mount the copy, the original VMFS datastore has to be offline.

When you mount the VMFS datastore, ESX/ESXi allows both reads and writes to the datastore residing on the LUN copy. The LUN copy must be writable. The datastore mounts are persistent and valid across system reboots.

Because ESX/ESXi does not allow you to resignature the mounted datastore, unmount the datastore before resignaturing.

Mount a VMFS Datastore with an Existing Signature

If you do not need to resignature a VMFS datastore copy, you can mount it without changing its signature.

Prerequisites

Before you mount a VMFS datastore, perform a storage rescan on your host so that it updates its view of LUNs presented to it.

Procedure

1 Log in to the vSphere Client and select the server from the inventory panel.

2 Click the **Configuration** tab and click **Storage** in the Hardware panel.

3 Click **Add Storage**.

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

5 From the list of LUNs, select the LUN that has a datastore name displayed in the VMFS Label column and click **Next**.

The name present in the VMFS Label column indicates that the LUN is a copy that contains a copy of an existing VMFS datastore.

6 Under Mount Options, select **Keep Existing Signature**.

7 In the Ready to Complete page, review the datastore configuration information and click **Finish**.

What to do next

If you later want to resignature the mounted datastore, you must unmount it first.

Unmount Datastores

When you unmount a datastore, it remains intact, but can no longer be seen from the hosts that you specify. It continues to appear on other hosts, where it remains mounted.

You can unmount only the following types of datastores:

- NFS datastores
- VMFS datastore copies mounted without resignaturing

You cannot unmount an active mounted datastore.

Procedure

1 Display the datastores.

2 Right-click the datastore to unmount and select **Unmount**.

3 If the datastore is shared, specify which hosts should no longer access the datastore.

   a If needed, deselect the hosts where you want to keep the datastore mounted.

     By default, all hosts are selected.

   b Click **Next**.

   c Review the list of hosts from which to unmount the datastore, and click **Finish**.

4 Confirm that you want to unmount the datastore.

Resignaturing VMFS Copies

Use datastore resignaturing to retain the data stored on the VMFS datastore copy. When resignaturing a VMFS copy, ESX/ESXi assigns a new UUID and a new label to the copy, and mounts the copy as a datastore distinct from the original.

The default format of the new label assigned to the datastore is `snap-`*`snapID`*`-`*`oldLabel`*, where *snapID* is an integer and *oldLabel* is the label of the original datastore.

When you perform datastore resignaturing, consider the following points:

- Datastore resignaturing is irreversible.
- The LUN copy that contains the VMFS datastore that you resignature is no longer treated as a LUN copy.
- A spanned datastore can be resignatured only if all its extents are online.
- The resignaturing process is crash and fault tolerant. If the process is interrupted, you can resume it later.
- You can mount the new VMFS datastore without a risk of its UUID colliding with UUIDs of any other datastore, such as an ancestor or child in a hierarchy of LUN snapshots.

Resignature a VMFS Datastore Copy

Use datastore resignaturing if you want to retain the data stored on the VMFS datastore copy.

Prerequisites

To resignature a mounted datastore copy, first unmount it.

Before you resignature a VMFS datastore, perform a storage rescan on your host so that the host updates its view of LUNs presented to it and discovers any LUN copies.

Procedure

1 Log in to the vSphere Client and select the server from the inventory panel.

2 Click the **Configuration** tab and click **Storage** in the Hardware panel.

3 Click **Add Storage**.

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

5 From the list of LUNs, select the LUN that has a datastore name displayed in the VMFS Label column and click **Next**.

   The name present in the VMFS Label column indicates that the LUN is a copy that contains a copy of an existing VMFS datastore.

6 Under Mount Options, select **Assign a New Signature** and click **Next**.

7 In the Ready to Complete page, review the datastore configuration information and click **Finish**.

What to do next

After resignaturing, you might have to do the following:

- If the resignatured datastore contains virtual machines, update references to the original VMFS datastore in the virtual machine files, including `.vmx`, `.vmdk`, `.vmsd`, and `.vmsn`.
- To power on virtual machines, register them with vCenter Server.

Storage Hardware Acceleration

The hardware acceleration functionality enables your host to offload specific virtual machine and storage management operations to compliant storage hardware. With the storage hardware assistance, your host performs these operations faster and consumes less CPU, memory, and storage fabric bandwidth.

To implement the hardware acceleration functionality, the Pluggable Storage Architecture (PSA) uses a combination of special array integration plug-ins, called VAAI plug-ins, and an array integration filter, called VAAI filter. The PSA automatically attaches the VAAI filter and vendor-specific VAAI plug-ins to those storage devices that support the hardware acceleration.

To view and manage the VAAI filter and VAAI plug-ins available on your host, use the vSphere CLI commands.

You can find some information about managing the VAAI filter and VAAI plug-ins in "Managing Hardware Acceleration Filter and Plug-Ins," on page 110.

For descriptions of the commands, see the *vSphere Command-Line Interface Installation and Scripting Guide* and the *vSphere Command-Line Interface Reference*.

Hardware Acceleration Requirements and Benefits

The hardware acceleration functionality works only if you use an appropriate host and storage array combination.

Use the following hosts and storage arrays:

- ESX/ESXi version 4.1 or later.
- Storage arrays that support storage-based hardware acceleration. ESX/ESXi version 4.1 does not support hardware acceleration with NAS storage devices.

On your host, the hardware acceleration is enabled by default. To enable the hardware acceleration on the storage side, check with your storage vendor. Certain storage arrays require that you explicitly activate the hardware acceleration support on the storage side.

When the hardware acceleration functionality is supported, the host can get hardware assistance and perform the following operations faster and more efficiently:

- Migration of virtual machines with Storage vMotion
- Deployment of virtual machines from templates
- Cloning of virtual machines or templates
- VMFS clustered locking and metadata operations for virtual machine files
- Writes to thin provisioned and thick virtual disks
- Creation of fault-tolerant virtual machines

Hardware Acceleration Support Status

For each storage device and datastore, the vSphere Client displays the hardware acceleration support status in the Hardware Acceleration column of the Devices view and the Datastores view.

The status values are Unknown, Supported, and Not Supported. The initial value is Unknown. The status changes to Supported after the host successfully performs the offload operation. If the offload operation fails, the status changes to Not Supported.

When storage devices do not support or provide only partial support for the host operations, your host reverts to its native methods to perform unsupported operations.

Turn off Hardware Acceleration

If your storage devices do not support the hardware acceleration functionality, you can turn it off by using the vSphere Client advanced settings.

As with any advanced settings, before disabling the hardware acceleration, consult with the VMware support team.

Procedure

1 In the vSphere Client inventory panel, select the host.

2 Click the **Configuration** tab, and click **Advanced Settings** under **Software.**

3 Click VMFS3 and change the value in the **VMFS3.HardwareAcceleratedLocking** field to zero.

4 Click **DataMover** and change the values in each of the following fields to zero:

- **DataMover.HardwareAcceleratedMove**
- **DataMover.HardwareAcceleratedInit**

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

iSCSI SAN Configuration Checklist

A

This topic provides a checklist of special setup requirements for different storage systems and ESX/ESXi hosts.

Table A-1. iSCSI SAN Configuration Requirements

Component	Comments
All storage systems	Write cache must be disabled if not battery backed.
Topology	No single failure should cause HBA and SP failover, especially with active-passive storage arrays.
EMC Symmetrix	Enable the SPC2 and SC3 settings. Contact EMC for the latest settings.
EMC Clariion	Set the EMC Clariion failover mode to 1 or 4. Contact EMC for details.
HP MSA	No specific requirements
HP EVA	For EVA3000/5000 firmware 4.001 and later, and EVA4000/6000/8000 firmware 5.031 and later, set the host type to `VMware`. Otherwise, set the host mode type to `Custom`. The value is: ■ EVA3000/5000 firmware 3.x: 000000002200282E ■ EVA4000/6000/8000: 000000202200083E
NetApp	If any of your iSCSI initiators are a part of an initiator group (igroup), disable ALUA on the NetApp array.
EqualLogic	Make sure ARP Redirect is enabled on hardware iSCSI adapters.
LeftHand	Make sure ARP Redirect is enabled on hardware iSCSI adapters.
ESX/ESXi Configuration	Set the following Advanced Settings for the ESX/ESXi host: ■ Set **Disk.UseLunReset** to **1** ■ Set **Disk.UseDeviceReset** to **0** A multipathing policy of Most Recently Used must be set for all LUNs hosting clustered disks for active-passive arrays. A multipathing policy of Most Recently Used or Fixed may be set for LUNs on active-active arrays. Allow ARP redirection if the storage system supports transparent failover.

VMware vSphere Command-Line Interface

B

In most cases, the vSphere Client is well-suited for monitoring an ESX/ESXi host connected to SAN storage. Advanced users might, at times, want to use some VMware vSphere Command-Line Interface (vSphere CLI) commands for additional details.

For more information, see *vSphere Command-Line Interface Installation and Scripting Guide*.

This appendix includes the following topics:

resxtop Command

The `resxtop` command provides a detailed look at ESX/ESXi resource use in real time.

For detailed information about `resxtop`, see the *Resource Management Guide* and *vSphere Command-Line Interface Installation and Scripting Guide*.

vicfg-iscsi Command

The `vicfg-iscsi` command allows you to configure software or hardware iSCSI on ESX/ESXi hosts, set up CHAP parameters, and set up iSCSI networking.

For details, see the *vSphere Command-Line Interface Installation and Scripting Guide* and the *vSphere Command-Line Interface Reference*.

vicfg-mpath Command

Use the `vicfg-mpath` command to view information about storage devices, paths, and multipathing plug-ins.

For details, see the *vSphere Command-Line Interface Installation and Scripting Guide* and the *vSphere Command-Line Interface Reference*.

esxcli corestorage claimrule Command

Use the `esxcli corestorage claimrule` command to manage claim rules. Claim rules determine which multipathing module should claim paths to a particular device and manage the device.

For details, see the *vSphere Command-Line Interface Installation and Scripting Guide* and the *vSphere Command-Line Interface Reference*.

vmkping Command

The `vmkping` command allows you to verify the VMkernel networking configuration.

Usage example:

```
vmkping [options] [host|IP address]
```

Table B-1. vmkping Options

Option	Description
`-6`	Use IPv6 - ICMPv6 Echo request.
`-4`	Use IPv4 (default).
`-I`	Outgoing interface - for IPv6 scope.
`-D`	VMkernel TCP stack debug mode.
`-c` ***`count`***	Set packet count.
`-I` ***`interval`***	Set interval.
`-s` ***`size`***	Set send size.
`-d`	Set DF bit on IPv4 packets.
`-v`	Verbose.

Managing Multipathing Modules and Hardware Acceleration Plug-Ins

C

Use the vSphere CLI to manage the Pluggable Storage Architecture (PSA) multipathing plug-ins and Hardware Acceleration plug-ins.

This appendix includes the following topics:

Managing Storage Paths and Multipathing Plug-Ins

Using the vSphere CLI you can manage the PSA multipathing plug-ins and storage paths assigned to them.

You can display all multipathing plug-ins available on your host. You can list any third-party MPPs, as well as your host's NMP and SATPs and review the paths they claim. You can also define new paths and specify which multipathing plug-in should claim the paths.

For more information about commands available to manage PSA, see the *vSphere Command-Line Interface Installation and Scripting Guide* and the *vSphere Command-Line Interface Reference*.

List Multipathing Claim Rules for the Host

Use the vSphere CLI to list available multipathing claim rules.

Claim rules indicate which multipathing plug-in, the NMP or any third-party MPP, manages a given physical path. Each claim rule identifies a set of paths based on the following parameters:

- Vendor/model strings
- Transportation, such as SATA, IDE, Fibre Channel, and so on
- Adapter, target, or LUN location
- Device driver, for example, Mega-RAID

Procedure

- Use the `esxcli corestorage claimrule list --claimrule-class=MP` to list the multipathing claim rules.

  Example C-1 shows the output of the command.

Example C-1. Sample Output of the esxcli corestorage claimrule list Command

```
Rule Class  Rule   Class    Type       Plugin     Matches
MP          0      runtime  transport  NMP        transport=usb
MP          1      runtime  transport  NMP        transport=sata
MP          2      runtime  transport  NMP        transport=ide
MP          3      runtime  transport  NMP        transport=block
MP          4      runtime  transport  NMP        transport=unknown
MP          101    runtime  vendor     MASK_PATH  vendor=DELL model=Universal Xport
MP          101    file     vendor     MASK_PATH  vendor=DELL model=Universal Xport
MP          200    runtime  vendor     MPP_1      vendor=NewVend model=*
MP          200    file     vendor     MPP_1      vendor=NewVend model=*
MP          201    runtime  location   MPP_2      adapter=vmhba41 channel=* target=* lun=*
MP          201    file     location   MPP_2      adapter=vmhba41 channel=* target=* lun=*
MP          202    runtime  driver     MPP_3      driver=megaraid
MP          202    file     driver     MPP_3      driver=megaraid
MP          65535  runtime  vendor     NMP        vendor=* model=*
```

This example indicates the following:

- The NMP claims all paths connected to storage devices that use the USB, SATA, IDE, and Block SCSI transportation.
- The MASK_PATH module by default claims all paths returning SCSI inquiry data with a vendor string of DELL and a model string of Universal Xport. The MASK_PATH module is used to mask paths from your host.
- The MPP_1 module claims all paths connected to any model of the NewVend storage array.
- The MPP_3 module claims the paths to storage devices controlled by the Mega-RAID device driver.
- Any paths not described in the previous rules are claimed by NMP.
- The Rule Class column in the output describes the category of a claim rule. It can be MP (multipathing plug-in), Filter, or VAAI.
- The Class column shows which rules are defined and which are loaded. The `file` parameter in the Class column indicates that the rule is defined. The `runtime` parameter indicates that the rule has been loaded into your system. For a user-defined claim rule to be active, two lines with the same rule number should exist, one line for the rule with the `file` parameter and another line with `runtime`. Several low numbered rules have only one line with the Class of `runtime`. These are system-defined claim rules that you cannot modify.

Display Multipathing Modules

Use the vSphere CLI to list all multipathing modules loaded into the system. Multipathing modules manage physical paths that connect your host with storage.

Procedure

- To list all multipathing modules, run the following command:

  ```
  esxcli corestorage plugin list --plugin-class=MP
  ```

At a minimum, this command returns the NMP and the MASK_PATH modules. If any third-party MPPs have been loaded, they are listed as well.

Display SATPs for the Host

Use the vSphere CLI to list all VMware NMP SATPs loaded into the system.

Procedure

- To list all VMware SATPs, run the following command.

  ```
  esxcli nmp satp list
  ```

For each SATP, the command displays information that shows the type of storage array or system this SATP supports and the default PSP for any LUNs using this SATP.

Keep in mind the following:

- If no SATP is assigned to the device by the claim rules, the default SATP for iSCSI or FC devices is VMW_SATP_DEFAULT_AA. The default PSP is VMW_PSP_FIXED.
- If VMW_SATP_ALUA is assigned to a specific storage device, but the device is not ALUA-aware, there is no claim rule match for this device. In this case, the device is claimed by the default SATP based on the device's transport type.
- The default PSP for all devices claimed by VMW_SATP_ALUA is VMW_PSP_MRU. The VMW_PSP_MRU selects an active/optimized path as reported by the VMW_SATP_ALUA, or an active/unoptimized path if there is no active/optimized path. This path is used until a better path is available (MRU). For example, if the VMW_PSP_MRU is currently using an active/unoptimized path and an active/optimized path becomes available, the VMW_PSP_MRU will switch the current path to the active/optimized one.

Display NMP Storage Devices

Use vSphere CLI to list all storage devices controlled by the VMware NMP and display SATP and PSP information associated with each device.

Procedure

1. To list all storage devices, run the following command:

   ```
   esxcli nmp device list
   ```

2. To show information for a specific device, run the following:

   ```
   esxcli nmp device list –d device_ID
   ```

Add Multipathing Claim Rules

Use the vSphere CLI to add a new multipathing PSA claim rule to the set of claim rules on the system. For the new claim rule to be active, you first define the rule and then load it into your system.

You add a new PSA claim rule when, for example, you load a new multipathing plug-in (MPP) and need to define which paths this module should claim. You may need to create a claim rule if you add new paths and want an existing MPP to claim them.

CAUTION When creating new claim rules, be careful to avoid a situation when different physical paths to the same LUN are claimed by different MPPs. Unless one of the MPPs is the MASK_PATH MPP, this configuration will cause performance problems.

Procedure

1 To define a new claim rule, on the vSphere CLI, run the following command:

```
esxcli corestorage claimrule add
```

For information on the options that the command requires, see "esxcli corestorage claimrule Options," on page 113.

2 To load the new claim rule into your system, run the following command:

```
esxcli corestorage claimrule load
```

This command loads all newly created multipathing claim rules from your system's configuration file.

Example C-2. Defining Multipathing Claim Rules

- Add rule # 500 to claim all paths with the NewMod model string and the NewVend vendor string for the NMP plug-in.

```
# esxcli corestorage claimrule add –r 500 –t vendor –V NewVend –M NewMod –P NMP
```

After you load the claim rule and run the **`esxcli corestorage claimrule list`** command, you can see the new claim rule appearing on the list.

NOTE The two lines for the claim rule, one with the Class of `runtime` and another with the Class of `file`, indicate that the new claim rule has been loaded into the system and is active.

```
Rule Class  Rule   Class    Type       Plugin     Matches
MP          0      runtime  transport  NMP        transport=usb
MP          1      runtime  transport  NMP        transport=sata
MP          2      runtime  transport  NMP        transport=ide
MP          3      runtime  transport  NMP        transport=block
MP          4      runtime  transport  NMP        transport=unknown
MP          101    runtime  vendor     MASK_PATH  vendor=DELL model=Universal Xport
MP          101    file     vendor     MASK_PATH  vendor=DELL model=Universal Xport
MP          500    runtime  vendor     NMP        vendor=NewVend model=NewMod
MP          500    file     vendor     NMP        vendor=NewVend model=NewMod
```

- Add rule # 321 to claim the path on adapter vmhba0, channel 0, target 0, LUN 0 for the NMP plug-in.

```
# esxcli corestorage claimrule add –r 321 –t location –A vmhba0 –C 0 –T 0 –L 0 –P NMP
```

- Add rule # 1015 to claim all paths provided by Fibre Channel adapters for the NMP plug-in.

```
# esxcli corestorage claimrule add –r 1015 –t transport –R fc –P NMP
```

- Add a rule with a system assigned rule id to claim all paths provided by Fibre Channel type adapters for the NMP plug-in.

```
# esxcli corestorage claimrule add ––autoassign –t transport –R fc –P NMP
```

Delete Multipathing Claim Rules

Use the vSphere CLI to remove a multipathing PSA claim rule from the set of claim rules on the system.

Procedure

1 Delete a claim rule from the set of claim rules.

```
esxcli corestorage claimrule delete –r claimrule_ID
```

For information on the options that the command takes, see "esxcli corestorage claimrule Options," on page 113.

NOTE By default, the PSA claim rule 101 masks Dell array pseudo devices. Do not delete this rule, unless you want to unmask these devices.

2 Remove the claim rule from the ESX/ESXi system.

```
esxcli corestorage claimrule load
```

Mask Paths

You can prevent the ESX/ESXi host from accessing storage devices or LUNs or from using individual paths to a LUN. Use the vSphere CLI commands to mask the paths.

When you mask paths, you create claim rules that assign the MASK_PATH plug-in to the specified paths.

Procedure

1 Check what the next available rule ID is.

```
esxcli corestorage claimrule list
```

The claim rules that you use to mask paths should have rule IDs in the range of 101 – 200. If this command shows that rule 101 and 102 already exist, you can specify 103 for the rule to add.

2 Assign the MASK_PATH plug-in to a path by creating a new claim rule for the plug-in.

```
esxcli corestorage claimrule add –P MASK_PATH
```

For information on command-line options, see "esxcli corestorage claimrule Options," on page 113.

3 Load the MASK_PATH claim rule into your system.

```
esxcli corestorage claimrule load
```

4 Verify that the MASK_PATH claim rule was added correctly.

```
esxcli corestorage claimrule list
```

5 If a claim rule for the masked path exists, remove the rule.

```
esxcli corestorage claiming unclaim
```

6 Run the path claiming rules.

```
esxcli corestorage claimrule run
```

After you assign the MASK_PATH plug-in to a path, the path state becomes irrelevant and is no longer maintained by the host. As a result, commands that display the masked path's information might show the path state as dead.

Example C-3. Masking a LUN

In this example, you mask the LUN 20 on targets T1 and T2 accessed through storage adapters vmhba2 and vmhba3.

1 `#esxcli corestorage claimrule list`

2
```
#esxcli corestorage claimrule add –P MASK_PATH –r 109 –t location –A vmhba2 –C 0 –T 1 –L 20
#esxcli corestorage claimrule add –P MASK_PATH –r 110 –t location –A vmhba3 –C 0 –T 1 –L 20
#esxcli corestorage claimrule add –P MASK_PATH –r 111 –t location –A vmhba2 –C 0 –T 2 –L 20
#esxcli corestorage claimrule add –P MASK_PATH –r 112 –t location –A vmhba3 –C 0 –T 2 –L 20
```

3 `#esxcli corestorage claimrule load`

4 `#esxcli corestorage claimrule list`

5
```
#esxcli corestorage claiming unclaim –t location –A vmhba2
#esxcli corestorage claiming unclaim –t location –A vmhba3
```

6 `# esxcli corestorage claimrule run`

Unmask Paths

When you need the host to access the masked storage device, unmask the paths to the device.

Procedure

1 Delete the MASK_PATH claim rule.

esxcli *conn_options* corestorage claimrule delete –r *rule#*

2 Verify that the claim rule was deleted correctly.

esxcli *conn_options* corestorage claimrule list

3 Reload the path claiming rules from the configuration file into the VMkernel.

esxcli *conn_options* corestorage claimrule load

4 Run the `esxcli corestorage claiming unclaim` command for each path to the masked storage device.

For example:

esxcli *conn_options* corestorage claiming unclaim –t location –A vmhba0 –C 0 –T 0 –L 149

5 Run the path claiming rules.

esxcli *conn_options* corestorage claimrule run

Your host can now access the previously masked storage device.

Define NMP SATP Rules

The NMP SATP claim rules specify which SATP should manage a particular storage device. Usually you do not need to modify the NMP SATP rules. If you need to do so, use vSphere CLI to add a rule to the list of claim rules for the specified SATP.

You might need to create an SATP rule when you install a third-party SATP for a specific storage array.

Procedure

1 To add a claim rule for a specific SATP, run the `esxcli nmp satp addrule` command. The command takes the following options.

Option	Description
-c|--claim-option	Set the claim option string when adding a SATP claim rule. This string is passed to the SATP when the SATP claims a path. The contents of this string, and how the SATP behaves as a result, are unique to each SATP. For example, some SATPs support the claim option strings `tpgs_on` and `tpgs_off`. If `tpgs_on` is specified, the SATP will claim the path only if the ALUA Target Port Group support is enabled on the storage device.
-e|--description	Set the claim rule description when adding a SATP claim rule.
-d|--device	Set the device when adding SATP claim rules. Device rules are mutually exclusive with vendor/model and driver rules.
-D|--driver	Set the driver string when adding a SATP claim rule. Driver rules are mutually exclusive with vendor/model rules.
-f|--force	Force claim rules to ignore validity checks and install the rule anyway.
-h|--help	Show the help message.
-M|--model	Set the model string when adding SATP a claim rule. Vendor/Model rules are mutually exclusive with driver rules.
-o|--option	Set the option string when adding a SATP claim rule.
-P|--psp	Set the default PSP for the SATP claim rule.
-O|--psp-option	Set the PSP options for the SATP claim rule.
-s|--satp	The SATP for which a new rule will be added.
-R|--transport	Set the claim transport type string when adding a SATP claim rule.
-V|--vendor	Set the vendor string when adding SATP claim rules. Vendor/Model rules are mutually exclusive with driver rules.

NOTE When searching the SATP rules to locate a SATP for a given device, the NMP searches the driver rules first. If there is no match, the vendor/model rules are searched, and finally the transport rules. If there is still no match, NMP selects a default SATP for the device.

2 To delete a rule from the list of claim rules for the specified SATP, run the following command.

You can run this command with the same options you used for addrule.

```
esxcli nmp satp deleterule
```

3 Reboot your host.

Example C-4. Defining an NMP SATP Rule

The following sample command assigns the VMW_SATP_INV plug-in to manage storage arrays with vendor string NewVend and model string NewMod.

```
# esxcli nmp satp addrule –V NewVend –M NewMod –s VMW_SATP_INV
```

If you run the **`esxcli nmp satp listrules –s VMW_SATP_INV`** command, you can see the new rule added to the list of VMW_SATP_INV rules.

Managing Hardware Acceleration Filter and Plug-Ins

The hardware acceleration, or VAAI, filter in combination with vendor-specific VAAI plug-ins are attached to storage devices that support the hardware acceleration. Using the vSphere CLI you can display and manipulate the VAAI filter and VAAI plug-ins.

Display Hardware Acceleration Filter

Use the vSphere CLI to view the hardware acceleration, or VAAI, filter currently loaded into your system.

Procedure

- Run the `esxcli corestorage plugin list --plugin-class=Filter` command.

The output of this command is similar to the following:

```
Plugin name  Plugin class
VAAI_FILTER  Filter
```

Display Hardware Acceleration Plug-Ins

Use the vSphere CLI to view hardware acceleration plug-ins, also called VAAI plug-ins, currently loaded into your system.

Procedure

- Run the `esxcli corestorage plugin list --plugin-class=VAAI` command.

The output of this command is similar to the following:

```
Plugin name         Plugin class
VMW_VAAIP_EQL       VAAI
VMW_VAAIP_NETAPP    VAAI
VMW_VAAIP_CX        VAAI
```

Verify Hardware Acceleration Status of a Storage Device

Use the vSphere CLI to verify the hardware acceleration support status of a particular storage device. This command also helps to determine which VAAI filter is attached to the device.

Procedure

- Run the **`esxcli corestorage device list --d`** ***`device_ID`*** command.

The output shows the hardware acceleration, or VAAI, status that can be unknown, supported, or unsupported. If the device supports the hardware acceleration, the output also lists the VAAI filter attached to the device.

```
# esxcli corestorage device list --d naa.60a98000572d43595a4a52644473374c
naa.60a98000572d43595a4a52644473374c
 Display Name: NETAPP Fibre Channel Disk(naa.60a98000572d43595a4a52644473374c)
 Size: 20480
 Device Type: Direct-Access
 Multipath Plugin: NMP
 Devfs Path: /vmfs/devices/disks/naa.60a98000572d43595a4a52644473374c
 Vendor: NETAPP
 Model: LUN
 Revision: 8000
 SCSI Level: 4
 Is Pseudo: false
 Status: on
```

```
Is RDM Capable: true
Is Local: false
Is Removable: false
Attached Filters: VAAI_FILTER
VAAI Status: supported
Other UIDs: vml.020003000060a98000572d43595a4a52644473374c4c554e202020
```

View Hardware Acceleration Plug-In for a Device

Use the vSphere CLI to view the hardware acceleration, or VAAI, plug-in attached to a storage device that supports the hardware acceleration.

Procedure

- Run the **esxcli vaai device list --d *device_ID*** command.

  For example:

  ```
  # esxcli vaai device list –d naa.6090a028d00086b5d0a4c44ac672a233
  naa.6090a028d00086b5d0a4c44ac672a233
   Device Display Name: EQLOGIC iSCSI Disk (naa.6090a028d00086b5d0a4c44ac672a233)
   VAAI Plugin Name: VMW_VAAIP_EQL
  ```

List Hardware Acceleration Claim Rules

For each storage device that supports the hardware acceleration functionality, the claim rules specify the hardware acceleration filter and the hardware acceleration plug-in to manage this storage device. You can use the vSphere CLI to list the hardware acceleration filter and plug-in claim rules.

Procedure

1 To list the filter claim rules, run the `esxcli corestorage claimrule list --claimrule-class=Filter` command.

  In this example, the filter claim rules specify devices that should be claimed by the VAAI_FILTER filter.

  ```
  # esxcli corestorage claimrule list --claimrule-class=Filter
  Rule Class   Rule   Class   Type   Plugin      Matches
  Filter       65430  runtime vendor VAAI_FILTER vendor=EMC model=SYMMETRIX
  Filter       65430  file    vendor VAAI_FILTER vendor=EMC model=SYMMETRIX
  Filter       65431  runtime vendor VAAI_FILTER vendor=DGC model=*
  Filter       65431  file    vendor VAAI_FILTER vendor=DGC model=*
  ```

2 To list the VAAI plug-in claim rules, run the `esxcli corestorage claimrule list --claimrule-class=VAAI` command.

  In this example, the VAAI claim rules specify devices that should be claimed by a particular VAAI plug-in.

  ```
  esxcli corestorage claimrule list --claimrule-class=VAAI
  Rule Class   Rule   Class   Type    Plugin         Matches
  VAAI         65430  runtime vendor  VMW_VAAIP_SYMM vendor=EMC model=SYMMETRIX
  VAAI         65430  file    vendor  VMW_VAAIP_SYMM vendor=EMC model=SYMMETRIX
  VAAI         65431  runtime vendor  VMW_VAAIP_CX   vendor=DGC model=*
  VAAI         65431  file    vendor  VMW_VAAIP_CX   vendor=DGC model=*
  ```

Add Hardware Acceleration Claim Rules

To configure hardware acceleration for a new array, you need to add two claim rules, one for the VAAI filter and another for the VAAI plug-in. For the new claim rules to be active, you first define the rules and then load them into your system.

Procedure

1 Define a new claim rule for the VAAI filter by using the `esxcli corestorage claimrule add --claimrule-class=Filter --plugin=VAAI_FILTER` command.

For information about the options that the command requires, see "esxcli corestorage claimrule Options," on page 113.

2 Define a new claim rule for the VAAI plug-in by using the `esxcli corestorage claimrule add --claimrule-class=VAAI` command.

3 Load both claim rules by using the following commands:

```
esxcli corestorage claimrule load --claimrule-class=Filter
esxcli corestorage claimrule load --claimrule-class=VAAI
```

4 Run the VAAI filter claim rule by using the `esxcli corestorage claimrule run --claimrule-class=Filter` command.

NOTE Only the Filter-class rules need to be run. When the VAAI filter claims a device, it automatically finds the proper VAAI plug-in to attach.

Example C-5. Defining Hardware Acceleration Claim Rules

To configure Hardware Acceleration for IBM arrays using the VMW_VAAI_T10 plug-in, use the following sequence of commands:

```
# esxcli corestorage claimrule add --claimrule-class=Filter --plugin=VAAI_FILTER --type=vendor --vendor=IBM --autoassign
# esxcli corestorage claimrule add --claimrule-class=VAAI --plugin=VMW_VAAI_T10 --type=vendor --vendor=IBM --autoassign
# esxcli corestorage claimrule load --claimrule-class=Filter
# esxcli corestorage claimrule load --claimrule-class=VAAI
# esxcli corestorage claimrule run --claimrule-class=Filter
```

Delete Hardware Acceleration Claim Rules

Use the vSphere CLI to delete existing hardware acceleration claim rules.

Procedure

- Use the following commands:

```
esxcli corestorage claimrule delete -r claimrule_ID --claimrule-class=Filter
esxcli corestorage claimrule delete -r claimrule_ID --claimrule-class=VAAI
```

esxcli corestorage claimrule Options

Certain `esxcli corestorage claimrule` commands, for example the commands that you run to add new claim rules, remove the rules, or mask paths, require that you specify a number of options.

Table C-1. esxcli corestorage claimrule Options

Option	Description
-A|--adapter	Indicate the adapter of the paths to use in this operation.
-u|--autoassign	The system will auto assign a rule ID.
-C|--channel	Indicate the channel of the paths to use in this operation.
-c|--claimrule-class	Indicate the claim rule class to use in this operation. Valid values are: MP, Filter, VAAI
-d|--device	Indicate the device Uid to use for this operation.
-D|--driver	Indicate the driver of the paths to use in this operation.
-f|--force	Force claim rules to ignore validity checks and install the rule anyway.
-h|--help	Show the help message.
-L|--lun	Indicate the LUN of the paths to use in this operation.
-M|--model	Indicate the model of the paths to use in this operation.
-P|--plugin	Indicate which PSA plug-in to use for this operation.
-r|--rule	Indicate the claim rule ID to use for this operation.
-T|--target	Indicate the target of the paths to use in this operation.
-R|--transport	Indicate the transport of the paths to use in this operation. Valid values are: block, fc, iscsi, iscsivendor, ide, sas, sata, usb, parallel, unknown.
-t|--type	Indicate which type of matching is used for claim/unclaim or claimrule. Valid values are: vendor, location, driver, transport, device.
-V|--vendor	Indicate the vendor of the paths to use in this operation.

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