HP 3PAR VMware ESX Implementation Guide

Abstract

This implementation guide provides information for establishing communications between an HP 3PAR StoreServ Storage and a VMware ESX host. General information is also provided on the basic steps required to allocate storage on the HP 3PAR StoreServ Storage that can then be accessed by the ESX host.

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Contents

1 Introduction

This implementation guide provides information for establishing communications between an HP 3PAR StoreServ Storage and a VMware ESX host. General information is also provided on the basic steps required to allocate storage on the HP 3PAR StoreServ Storage that can then be accessed by the ESX host.

The information contained in this implementation guide is the outcome of careful testing of the HP 3PAR StoreServ Storage with as many representative hardware and software configurations as possible.

Required

For predictable performance and results with your HP 3PAR StoreServ Storage, you must use the information in this guide in concert with the documentation set provided by HP 3PAR for the HP 3PAR StoreServ Storage and the documentation provided by the vendor for their respective products.

Supported Configurations

The following types of host connections are supported between the HP 3PAR StoreServ Storage and hosts running a VMware ESX OS:

Fibre Channel connections are supported between the HP 3PAR StoreServ Storage and the ESX host in both a fabric-attached and direct-connect topology.

For information about supported hardware and software platforms, see the HP Single Point of Connectivity Knowledge (HP SPOCK) website:

http://www.hp.com/storage/spock

For more information about HP 3PAR storage products, follow the links in "HP 3PAR Storage Products" (page 6).

Table 1 HP 3PAR Storage Products

Product	See...
HP 3PAR StoreServ 7000 Storage	http://h20000.www2.hp.com/bizsupport/TechSupport/Home.jsp?lang=en&cc=us&prodTypeId=12169&prodSeriesId=5335712&lang=en&cc=us
HP 3PAR StoreServ 10000 Storage	http://h20000.www2.hp.com/bizsupport/TechSupport/Home.jsp?lang=en&cc=us&prodTypeId=12169&prodSeriesId=5157544&lang=en&cc=us
HP 3PAR Storage Systems	http://h20180.www2.hp.com/apps/Nav?h_pagetype=s-001&h_lang=en&h_cc=us&h_product=5044012&h_client=S-A-R163-1&h_page=hpcom&lang=en&cc=us
HP 3PAR StoreServ Software — Device Management	http://h20180.www2.hp.com/apps/Nav?h_pagetype=s-001&h_lang=en&h_cc=us&h_product=5046476&h_client=S-A-R163-1&h_page=hpcom&lang=en&cc=us
HP 3PAR StoreServ Software—Replication	http://h20180.www2.hp.com/apps/Nav?h_pagetype=s-001&h_lang=en&h_cc=us&h_product=5053605&h_client=S-A-R163-1&h_page=hpcom&lang=en&cc=us

Required

All installation steps should be performed in the order described in this implementation guide.

HP 3PAR OS Upgrade Considerations

For information about planning an online HP 3PAR Operating System (HP 3PAR OS) upgrade, see the *HP 3PAR Operating System Upgrade Pre-Planning Guide*, which is available on the HP Business Support Center (BSC) website:

http://www.hp.com/go/bsc

For complete details about supported host configurations and interoperability, consult the HP SPOCK website:

http://www.hp.com/storage/spock

Audience

This implementation guide is intended for system and storage administrators who perform and manage the system configurations and resource allocation for the HP 3PAR StoreServ Storage.

This guide provides basic information that is required to establish communications between the HP 3PAR StoreServ Storage and the VMware ESX host and to allocate the required storage for a given configuration. However, the appropriate HP documentation must be consulted in conjunction with the ESX host and host bus adapter (HBA) vendor documentation for specific details and procedures.

NOTE: This implementation guide is not intended to reproduce or replace any third-party product documentation. For details about devices such as hosts, HBAs, fabric switches, and non-HP 3PAR software management tools, consult the appropriate third-party documentation.

2 Configuring the HP 3PAR StoreServ Storage for Fibre Channel

This chapter explains how to establish a Fibre Channel connection between the HP 3PAR StoreServ Storage and a VMware ESX host and covers HP 3PAR OS 3.1.x, OS 2.3.x, and 2.2.x versions. For information on setting up the physical connection for a particular HP 3PAR StoreServ Storage, see the appropriate HP 3PAR installation manual.

Configuring the HP 3PAR StoreServ Storage Running HP 3PAR OS 3.1.x or OS 2.3.x

This section describes how to connect the HP 3PAR StoreServ Storage to an ESX host over a Fibre Channel network when running HP 3PAR OS 3.1.x or OS 2.3.x.

By default, the QLogic, Emulex, and Brocade drivers for the VMware ESX host support failover. For failover support using the QLogic, Emulex, or Brocade driver, virtual volumes should be simultaneously exported down multiple paths to the host. To do this, create a host definition on the HP 3PAR StoreServ Storage that includes the WWNs of multiple HBA ports on the host and then export the VLUNs to that host definition. If each ESX host within a cluster has its own host definition, the VLUNs must be exported to multiple host definitions.

Required

The following setup must be completed before connecting the HP 3PAR StoreServ Storage port to a device.

NOTE: When deploying HP Virtual Connect direct-attach FC storage for HP 3PAR storage systems, where the HP 3PAR StoreServ Storage ports are cabled directly to the uplink ports on the HP Virtual Connect FlexFabric 10 Gb/24-port Module for c-Class BladeSystem, follow the steps for configuring the HP 3PAR StoreServ Storage ports for a fabric connection.

For more information about HP Virtual Connect, HP Virtual Connect interconnect modules, and the HP Virtual Connect direct-attach feature, see HP Virtual Connect documentation and the *HP SAN Design Reference Guide*. This documentation is available on the HP BSC website:

http://www.hp.com/go/bsc

Setting Up the Ports

Before connecting the HP 3PAR StoreServ Storage to a host, the connection type and mode must be specified. To set up the HP 3PAR StoreServ Storage ports for a direct or fabric connection, complete the following steps for each port.

1. To determine if a port has already been configured in host mode, issue the HP 3PAR OS CLI `showport -par` command. A host port is essentially a target mode port where the initiator or host can log in to the HP 3PAR StoreServ Storage.

```
# showport -par
N:S:P Connmode  ConnType  CfgRate MaxRate Class2 UniqNodeWwn VCN   IntCoal
2:0:1 disk    loop    auto  4Gbps  disabled disabled  disabled enabled
2:0:2 disk    loop    auto  4Gbps  disabled disabled  disabled enabled
2:4:1 disk    loop    auto  4Gbps  disabled disabled  disabled enabled
2:4:2 disk    loop    auto  4Gbps  disabled disabled  disabled enabled
3:0:1 disk    loop    auto  4Gbps  disabled disabled  disabled enabled
3:0:2 disk    loop    auto  4Gbps  disabled disabled  disabled enabled
3:4:1 disk    loop    auto  4Gbps  disabled disabled  disabled enabled
3:4:2 disk    loop    auto  4Gbps  disabled disabled  disabled enabled
```

2. If the port has not been configured, take the port offline before configuring it for the ESX host by issuing the following HP 3PAR OS CLI command:

```
controlport offline [node:slot:port]
```

△ **CAUTION:** Before taking a port offline in preparation for a direct or fabric connection, you should verify that the port has not been previously defined and that it is not already connected to a host as this would interrupt the existing host connection.

If an HP 3PAR StoreServ Storage port is already configured for a direct or fabric connection, you can ignore this step, as you do not have to take the port offline.

3. To configure the port for the host, issue the following command, with the appropriate option for the `-ct` parameter:

```
controlport config host -ct [loop | point] [node:slot:port]
```

For a direct connection:

Use the `-ct loop` parameter to specify a direct connection.

For a fabric connection:

Use the `-ct point` parameter to specify a fabric connection.

4. Issue the `controlport rst` command to reset and register the new port definitions.

The following example shows how to set up a fabric connected port.

```
% controlport offline 1:5:1
% controlport config host -ct point 1:5:1
% controlport rst 1:5:1
```

Creating the Host Definition

Before connecting the ESX host to the HP 3PAR StoreServ Storage, a host definition needs to be created that specifies a valid host persona for each HP 3PAR StoreServ Storage port that is to be connected to a host HBA port through a fabric or direct connection. ESX/ESXi uses the generic legacy host persona of 6 for HP 3PAR OS 3.1.1 or earlier.

As of HP 3PAR OS 3.1.2, a second host persona 11 (VMware), which enables asymmetric logical unit access (ALUA) is available. Host persona 11 (VMware) is recommended for new ESX/ESXi installations and is required for ESX/ESXi hosts configured as part of a HP 3PAR Peer Persistence configuration. For ESX/ESXi with HP 3PAR Remote Copy, refer to the *Remote Copy Users Guide* for the appropriate host persona to use in specific Remote Copy configurations.

NOTE: When changing an existing host persona from 6 to 11, a host reboot is required for the change to take effect. This is an offline process. See "Configuring ESX/ESXi Multipathing for Round Robin via SATP PSP" (page 40) for the detailed procedure, as the host persona change should coincide with changing the SATP rules on the host as well.

For both host persona 6 and persona 11, see the appropriate chapters in this guide for iSCSI, Fibre Channel, or FCoE setup considerations.

1. To display available host personas, issue the following command:

```
# showhost -listpersona
```

2. To create host definitions, issue the `createhost` command with the `-persona` option to specify the persona and the host name.

    For HP 3PAR OS 3.1.1 or earlier:

    ```
    # createhost -persona 6 ESXserver1 10000000C9724AB2 10000000C97244FE
    ```

    For HP 3PAR OS 3.1.2:

    ```
    # createhost -persona 11 ESXserver1 10000000C9724AB2 10000000C97244FE
    ```

3. To verify that the host has been created, issue the `showhost` command.

    For HP 3PAR OS 3.1.1 or earlier, using persona 6:

    ```
    # showhost
    Id Name       Persona          -WWN/iSCSI_Name-  Port
    0  ESXserver1 Generic-legacy   10000000C9724AB2  --- 10000000C97244FE ---
    ```

    For HP 3PAR OS 3.1.2, using persona 11:

    ```
    # showhost
    Id Name       Persona          -WWN/iSCSI_Name-  Port
    0  ESXserver2 VMware           100000051EC33E00  --- 100000051EC33E01 ---
    ```

    Use `showhost -persona` to show the persona name and Id relationship.

    ```
    # showhost -persona
    Id Name           Persona_Id    Persona_Name      Persona_Caps
    0 ESXserver1      6             Generic-legacy    --
    1 Esxserver2      11            VMware            SubLun, ALUA
    ```

    NOTE: If the persona is not correctly set, then use the `sethost -persona <host number> <hostname>` command to correct the issue, where host number is `6` (for HP 3PAR OS 3.1.1 or earlier) or `11` (for HP 3PAR OS 3.1.2).

    A reboot of the ESX host is required if host persona is changed to 11.

    NOTE: See the *HP 3PAR Command Line Interface Reference* or the *HP 3PAR Management Console Users Guide* for complete details on using the `controlport`, `createhost`, and `showhost` commands.

    These documents are available on the HP BSC website:

    http://www.hp.com/go/bsc

Configuring the HP 3PAR StoreServ Storage Running HP 3PAR OS 2.2.x

This section describes the steps that are required to connect the HP 3PAR StoreServ Storage to an ESX host over a Fibre Channel network and to create the host definitions when running HP 3PAR OS 2.2.x.

NOTE: For configurations that are intended to have more than one host type (for example, an ESX host and a Windows host) connected to a shared HP 3PAR StoreServ Storage HBA port via fabric connections, see to the *Heterogeneous Host Support Guide* on the HP BSC website for the required HP 3PAR StoreServ Storage port settings and interoperability considerations:

http://www.hp.com/go/bsc

NOTE: By default, the VMware ESX host supports failover. For failover support, VVs should be simultaneously exported down multiple paths to the host. To do this, create a host definition on the HP 3PAR StoreServ Storage that includes the WWNs of multiple HBA ports on the hostand then export the VLUNs to that host definition.

Required

The following setup must be completed before connecting the HP 3PAR StoreServ Storage port to a device.

Setting Up the Ports

Before connecting the HP 3PAR StoreServ Storage to a host, the HP 3PAR StoreServ Storage port persona must be specified. To set up the HP 3PAR StoreServ Storage ports for a direct or fabric connection, issue the appropriate set of HP 3PAR OS CLI `controlport` commands for each port.

For direct connections, use persona 1 with VCN disabled.

```
# controlport persona 1 <node:slot:port>
# controlport vcn disable -f <node:slot:port>
```

Verify port persona 1, connection type loop, using the HP 3PAR OS CLI `showport -par` command.

```
# showport -par

N:S:P ConnType CfgRate MaxRate Class2 VCN ----------Persona-----------IntCoal

(...)

1:4:2 loop auto 2Gbps disable disabled #(1) g_ven, g_hba, g_os, 0, DC    enabled

(...)
```

For a fabric connection, use persona 7 with VCN disabled.

```
# controlport persona 7 <node:slot:port>
# controlport vcn disable -f <node:slot:port>
```

Verify port persona 7, connection type point, using the HP 3PAR OS CLI `showport -par` command.

```
# showport -par
N:S:P ConnType CfgRate MaxRate Class2 VCN ----------Persona-----------IntCoal
(...)
1:4:2 point auto 2Gbps disable disabled #(7) g_ven, g_hba, g_os, 0, FA  enabled
(...)
```

Creating the Host Definition

Before connecting the ESX host to the HP 3PAR StoreServ Storage, create a host definition for each HP 3PAR StoreServ Storage that is to be connected to a host HBA port through a fabric or a direct connection.

1. To create host definitions, issue the HP 3PAR OS CLI `createhost` command with the appropriate host name. For example:

```
# createhost ESXserver1 10000000C9724AB2 10000000C97244FE
```

2. To verify that the host has been created, issue the HP 3PAR OS CLI `showhost` command.

```
# showhost -persona
Id Name     -WWN/iSCSI_Name- Port
0  ESXserver1    10000000C9724AB2 ---
                 10000000C97244FE ---
```

3. (Optional) You can create a host set using `createhostset`, which allows the addition of multiple host names as a host definition set. A host set gives the convenience of exporting storage volume to hosts which are in a cluster. The same storage volumes need to be exported individually to each of the hosts, or they can be exported to a host set, which in turn will be exported to each of the hosts defined in the host set.

```
# createhostset ESXCluster
# createhost -add ESXCluster ESXserver1
# createhost -add ESXCluster ESXserver2

# showhostset
Id Name        Members
0  ESXCluster ESXServer1 ESXServer2
```

NOTE: See the *HP 3PAR Command Line Interface Reference* or the *HP 3PAR Management Console Users Guide* for complete details on using the `controlport`, `createhost`, and `showhost` commands.

These documents are available on the HP BSC website:

http://www.hp.com/go/bsc

Setting Up and Zoning the Fabric

NOTE: This section does not apply when deploying HP Virtual Connect direct-attach FC storage for HP 3PAR storage systems, where the HP 3PAR StoreServ Storage ports are cabled directly to the uplink ports on the HP Virtual Connect FlexFabric 10 Gb/24-port Module for c-Class BladeSystem. Zoning is automatically configured based on the Virtual Connect SAN Fabric and server profile definitions.

For more information about HP Virtual Connect, HP Virtual Connect interconnect modules, and the HP Virtual Connect direct-attach feature, see HP Virtual Connect documentation and the *HP SAN Design Reference Guide*. This documentation is available on the HP BSC website:

http://www.hp.com/go/bsc

Fabric zoning controls which Fibre Channel end-devices have access to each other on the fabric. Zoning also isolates the hostand HP 3PAR StoreServ Storage ports from Registered State Change Notifications (RSCNs) that are irrelevant to these ports.

You can set up fabric zoning by associating the device World Wide Names (WWNs) or the switch ports with specified zones in the fabric. Although you can use either the WWN method or the port zoning method with the HP 3PAR StoreServ Storage, the WWN zoning method is recommended because the zone survives the changes of switch ports when cables are moved around on a fabric.

Required

Employ fabric zoning, using the methods provided by the switch vendor, to create relationships between hostHBA ports and storage server ports before connecting the host HBA ports or HP 3PAR StoreServ Storage ports to the fabric(s).

Fibre Channel switch vendors support the zoning of the fabric end-devices in different zoning configurations. There are advantages and disadvantages with each zoning configuration. Choose a zoning configuration based on your needs.

The HP 3PAR arrays support the following zoning configurations:

- One initiator to one target per zone

- One initiator to multiple targets per zone (zoning by HBA). This zoning configuration is recommended for the HP 3PAR StoreServ Storage. Zoning by HBA is required for coexistence with other HP Storage arrays.

    NOTE: For high availability/clustered environments that require multiple initiators to access the same set of target ports, HP recommends that separate zones be created for each initiator with the same set of target ports.

    NOTE: The storage targets in the zone can be from the same HP 3PAR StoreServ Storage, multiple HP 3PAR StoreServ Storages , or a mixture of HP 3PAR and other HP storage systems.

For more information about using one initiator to multiple targets per zone, see Zoning by HBA in the Best Practices chapter of the *HP SAN Design Reference Guide*. This document is available on the HP BSC website:

http://www.hp.com/go/bsc

If you use an unsupported zoning configuration and an issue occurs, HP may require that you implement one of the supported zoning configurations as part of the troubleshooting or corrective action.

After configuring zoning and connecting each host HBA port and HP 3PAR StoreServ Storage port to the fabric(s), verify the switch and zone configurations using the HP 3PAR OS CLI `showhost` command, to ensure that each initiator is zoned with the correct target(s).

HP 3PAR Coexistence

The HP 3PAR StoreServ Storage array can coexist with other HP array families.

For supported HP arrays combinations and rules, see the *HP SAN Design Reference Guide*, available on the HP BSC website:

http://www.hp.com/go/bsc

Configuration Guidelines for Fabric Vendors

Use the following fabric vendor guidelines before configuring ports on fabric(s) to which the HP 3PAR StoreServ Storage connects.

- Brocade switch ports that connect to a host HBA port or to an HP 3PAR StoreServ Storage port should be set to their default mode. On Brocade 3xxx switches running Brocade firmware

3.0.2 or later, verify that each switch port is in the correct mode using the Brocade telnet interface and the `portcfgshow` command, as follows:

```
brocade2_1:admin> portcfgshow
Ports              0  1  2  3    4  5  6  7
----------------+--+--+--+--+----+--+--+--+--
Speed             AN AN AN AN   AN AN AN AN
Trunk Port        ON ON ON ON   ON ON ON ON
Locked L_Port     .. .. .. ..   .. .. .. ..
Locked G_Port     .. .. .. ..   .. .. .. ..
Disabled E_Port   .. .. .. ..   .. .. .. ..
where AN:AutoNegotiate, ..:OFF, ??:INVALID.
```

The following fill-word modes are supported on a Brocade 8 G/s switch running FOS firmware 6.3.1a and later:

```
admin>portcfgfillword
Usage: portCfgFillWord PortNumber  Mode  [Passive]
Mode: 0/-idle-idle    - IDLE in Link Init, IDLE as fill word (default)
               1/-arbff-arbff - ARBFF in Link Init, ARBFF as fill word
               2/-idle-arbff  - IDLE  in Link Init, ARBFF as fill word (SW)
               3/-aa-then-ia  - If ARBFF/ARBFF failed, then do IDLE/ARBFF
```

HP recommends that you set the fill word to mode 3 (`aa-then-ia`), which is the preferred mode using the `portcfgfillword` command. If the fill word is not correctly set, `er_bad_os` counters (invalid ordered set) will increase when you use the `portstatsshow` command while connected to 8 G HBA ports, as they need the `ARBFF-ARBFF` fill word. Mode 3 will also work correctly for lower-speed HBAs, such as 4 Gb/2 Gb HBAs. For more information, see the *Fabric OS command Reference Manual supporting FOS 6.3.1a* and the FOS release notes.

In addition, some HP switches, such as the HP SN8000B 8-slot SAN backbone director switch, the HP SN8000B 4-slot SAN director switch, the HP SN6000B 16 Gb FC switch, or the HP SN3000B 16 Gb FC switch automatically select the proper fill-word mode 3 as the default setting.

- McDATA switch or director ports should be in their default modes as **G** or **GX-port** (depending on the switch model), with their speed setting permitting them to autonegotiate.

- Cisco switch ports that connect to HP 3PAR StoreServ Storage ports or host HBA ports should be set to **AdminMode = FX** and **AdminSpeed = auto port**, with the speed set to **auto negotiate**.

- QLogic switch ports should be set to port type **GL-port** and port speed **auto-detect**. QLogic switch ports that connect to the HP 3PAR StoreServ Storage should be set to I/O Stream Guard **disable** or **auto**, but never **enable**.

Target Port Limits and Specifications

To avoid overwhelming a target port and ensure continuous I/O operations, observe the following limitations on a target port:

- Maximum of 32 host ports per HP 3PAR StoreServ Storage port, with a maximum total of 1,024 host ports per HP 3PAR StoreServ Storage.

- I/O queue depth on each HP 3PAR StoreServ Storage HBA model, as follows:

  ○ QLogic 2G: 497

  ○ LSI 2G: 510

  ○ Emulex 4G: 959

◦ HP 3PAR HBA 4G: 1638

◦ HP 3PAR HBA 8G: 3276 (HP 3PAR StoreServ 10000 and HP 3PAR StoreServ 7000 systems only)

- The I/O queues are shared among the connected host HBA ports on a first-come, first-served basis.

- When all queues are in use and a host HBA port tries to initiate I/O, it receives a target queue full response from the HP 3PAR StoreServ Storage port. This condition can result in erratic I/O performance on each host. If this condition occurs, each host should be throttled so that it cannot overrun the HP 3PAR StoreServ Storage port's queues when all hosts are delivering their maximum number of I/O requests.

NOTE: When host ports can access multiple targets on fabric zones, the assigned target number assigned by the host driver for each discovered target can change when the host is booted and some targets are not present in the zone. This situation may change the device node access point for devices during a host reboot. This issue can occur with any fabric-connected storage, and is not specific to the HP 3PAR StoreServ Storage.

HP 3PAR Priority Optimization

The HP 3PAR Priority Optimization feature introduced in HP 3PAR OS versions 3.1.2.MU2 is a more efficient and dynamic solution for managing server workloads and can be utilized as an alternative to setting host I/O throttles. Using this feature, a storage administrator is able to share storage resources more effectively by enforcing quality of service limits on the array. No special settings are needed on the host side to obtain the benefit of Priority Optimization although certain per target or per adapter throttle settings may need to be adjusted in rare cases. For complete details of how to use Priority Optimization (Quality of Service) on HP 3PAR arrays, please read the *HP 3PAR Priority Optimization* technical white paper available at http://www.hp.com/go/bsc.

Persistent Ports

NOTE: The Persistent Ports feature is supported only on HP 3PAR OS 3.1.2.

The Persistent Ports (or virtual ports) feature minimizes I/O disruption during an HP 3PAR Storage online upgrade or node-down event. Currently, persistent ports are supported only with Fibre Channel connections. Persistent Ports allows a Fibre Channel HP 3PAR Storage port to assume the identity (port WWN) of a failed port while retaining its own identity. The solution uses the NPIV feature for Fibre Channel. This feature does not work in direct-connect mode and is supported only on Fibre Channel target ports that connect to Fibre Channel fabric and are in point-to-point mode where both the active and partner ports share the same fabric.

Each Fibre Channel port has a partner port automatically assigned by the system. Where a given physical port assumes the identity of its partner port, the assumed port is designated as a persistent port. Array port failover and failback with Persistent Ports is transparent to most host-based multipathing software which, in most cases, can keep all its I/O paths active.

The Persistent Ports feature is activated by default during node-down events (online upgrade or node reboot). Port shutdown or reset events do not trigger this feature. Persistent Ports is enabled by default starting with the HP 3PAR OS 3.1.2 software.

In the event that an HP 3PAR Storage node is downed during an online upgrade or node-down event, the Fibre Channel target ports fail over to their partner ports. For example, in a two-node HP 3PAR Storage array configuration, if ports 0:1:1, 0:5:1 and 1:1:1, 1:5:1 are connected to the fabric, then if node 0 goes down, ports 0:1:1, 0:5:1 fail over to ports 1:1:1, 1:5:1 and become active while ports 1:1:1, 1:5:1 remain active.

In HP 3PAR Storage arrays with more than two nodes, failover behavior occurs on node pairs; that is, if node 0 goes down, ports on node 0 fail over to node 1, if node 2 goes down, ports on node 2 fail over to node 3, and so on. Conversely, when node 1 goes down, ports on node 1 fail over to node 0, and when node 3 goes down, ports on node 3 fail over to node 2. When the downed node is up again, the failed-over ports automatically fail back to their original ports. During the failover and failback process, a short pause in I/O could be experienced by the host.

Persistent Ports Setup and Connectivity Guidelines

For Persistent Ports to function properly, specific cabling setup and connectivity guidelines that need to be followed can be found in the *HP 3PAR Command Line Interface Administrator's Manual*, "Using Persistent Ports for Nondisruptive Online Software Upgrades." See this document for other information about Persistent Ports as well.

The fabric switch ports connecting to the HP 3PAR array ports must support NPIV and have the feature enabled in order for Persistent Ports to work.

The `showport` command output includes `Partner` and `FailoverState` columns that display the partner port `<node>:<slot>:<port>` information and failover state information, respectively. `FailoverState` values represent the failover state of the two ports listed in the `N:S:P` and `Partner` columns. The `FailoverState` value can be one of the following:

- `none`: No failover in operation
- `failover_pending`: In the process of failing over to partner
- `failed_over`: Failed over to partner
- `active`: The partner port is failed over to this port
- `active_down`: The partner port is failed over to this port, but this port is down
- `failback_pending`: In the process of failing back from partner

Use the `showport` HP 3PAR CLI commands to get the state of the persistent ports. In the output of the `showport` command shown below, under the `Partner` column, port 1:1:1 is the partner port that 0:1:1 would fail over to and 0:1:1 is the partner port to which 1:1:1 would fail over. When Persistent Ports is not active, the `FailoverState` for the ports would indicate `none`.

```
# showport
N:S:P  Mode       State   ----Node_WWN----   - Port_WWN/HW_Addr- Type   Protocol Label
Partner Failover State
0:0:1  initiator ready   50002ACFF70185E1   50002ACFF70185E1      disk   SAS       -
  -      -
0:1:1  target     ready   2FF70002AC0185E1   2FF70002AC0185E1      host   FC        -
1:1:1   none
```

When a node is down during an online upgrade or node reboot, from the output of the `showport` command, the `FailoverState` column would show that Persistent Ports is active. In the example below, node 1 has gone down, Persistent Ports for 1:1:1 has become active on port 0:1:1, and all filesystem I/O for port 1:1:1 is physically served by port 0:1:1.

```
# showport
N:S:P  Mode       State   ----Node_WWN----   - Port_WWN/HW_Addr- Type   Protocol Label
Partner Failover State
0:0:1  initiator ready   50002ACFF70185E1   50002ACFF70185E1      disk   SAS       -
  -      -
0:1:1  target     ready   2FF70002AC0185E1   2FF70002AC0185E1      host   FC        -
1:1:1   active
```

Before Persistent Ports is active, the output of the `showhost` command displays as follows:

```
# showhost
Id Name     Persona          ---------------WWN/iSCSI_Name-------------- Port
 1 server1  Generic          5001438009AE770E                               0:1:1
                             5001438009AE770C                               0:1:1
                             5001438009AE770E                               1:1:1
                             5001438009AE770C                               1:1:1
```

When Persistent Ports is active, the output of the `showhost` command, under the `Port` column, shows both the physical port and the physical port where Persistent Ports is active. In the example below, port 0:1:1, logged in from each of the host HBA ports, appears twice, once for the physical port and once again for the persistent port that is active on the physical port.

```
# showhost
Id Name     Persona          ---------------WWN/iSCSI_Name-------------- Port
 1 server1  Generic          5001438009AE770E                               0:1:1
                             5001438009AE770C                               0:1:1
                             5001438009AE770E                               0:1:1
                             5001438009AE770C                               0:1:1
```

After the controller node has been successfully rebooted, the `FailoverState` for the ports changes back to none, as shown in the following example:

```
inservvm cli% showport
N:S:P Mode        State   ----Node_WWN----  -Port_WWN/HW Addr-  Type  Protocol Label  Partner FailoverState
0:0:1 initiator ready   50002ACFF7000F99  50002AC001000F99    disk  SAS      DP -1  -       -
0:0:2 initiator ready   50002ACFF7000F99  50002AC002000F99    disk  SAS      DP -2  -       -
0:1:1 target    ready   28110002AC000F99  20110002AC000F99    host  FC       -      1:1:1   none
0:1:2 target    ready   2FF70002AC000F99  20120002AC000F99    host  FC       -      1:1:2   none
1:0:1 initiator ready   50002ACFF7000F99  50002AC101000F99    disk  SAS      DP-1   -       -
1:0:2 initiator ready   50002ACFF7000F99  50002AC102000F99    disk  SAS      DP -2  -       -
1:1:1 target    ready   29110002AC000F99  21110002AC000F99    host  FC       -      0:1:1   none
1:1:2 target    ready   29120002AC000F99  21120002AC000F99    host  FC       -      0:1:2   none
```

After the node has been successfully rebooted, the node entry of node 0 reappears in the GUI and I/O is still in progress.

Manually, you can perform failover and failback using the `controlport failover <N:S:P>` and `controlport failback <N:S:P>` command options.

Persistent Ports Limitations

Persistent Ports Technical White Paper

To learn more about Persistent Ports, refer to the following White Paper:

http://h20195.www2.hp.com/V2/GetPDF.aspx/4AA4-4545ENW.pdf

Unsupported Configurations

The Persistent Ports feature is not supported with iSCSI and FCoE.

3 Configuring the HP 3PAR StoreServ Storage for iSCSI

This chapter explains how to establish an iSCSI connection between the HP 3PAR StoreServ Storage and the VMware ESX host. If you are running specific CNA cards, a software or hardware iSCSI initiator can be used. For details about hardware iSCSI configuration, see "Hardware iSCSI Support" (page 25).

Software iSCSI Support

Setting Up the Ports for an iSCSI Connection

To establish an iSCSI connection between the HP 3PAR StoreServ Storage and the ESX host, you need to set up each HP 3PAR StoreServ Storage iSCSI target port that will be connected to an iSCSI initiator as described in the following steps.

1. A 10 Gb iSCSI connection, which is supported in the HP 3PAR StoreServ 10000 Storage and the HP 3PAR StoreServ 7000 Storage, requires a one-time configuration using the `controlport` command.

    Issue the `showport` and `showport -i` commands to check the current CNA configuration. For example:

    ```
    # showport
    N:S:P       Mode        State ----Node_WWN---- -Port_WWN/HW_Addr- Type Protocol
    0:1:1 suspended config_wait              -                  - cna         -
    1:1:1 suspended config_wait              -                  - cna         -

    # showport -i
    N:S:P Brand  Model    Rev Firmware    Serial        HWType
    0:1:1 QLOGIC QLE8242  58  0.0.0.0     PCGLT0ARC1K3SK CNA
    1:1:1 QLOGIC QLE8242  58  0.0.0.0     PCGLT0ARC1K3SK CNA
    ```

2. If `State=config_wait` or `Firmware=0.0.0.0`, use the `controlport config iscsi <n:s:p>` command to configure, and then use the `showport` and `showport -i` commands to verify the configuration setting.

    For example:

    ```
    # controlport config iscsi 0:1:1
    # controlport config iscsi 1:1:1
    # showport
    N:S:P       Mode        State ----Node_WWN---- -Port_WWN/HW_Addr- Type Protocol
    ...
    0:1:1    target      ready             -        2C27D7521F3E iscsi     iSCSI
    ...
    1:1:1    target      ready             -        2C27D7521F3A iscsi     iSCSI

    # showport -i
    ...
    N:S:P Brand  Model    Rev Firmware     Serial        HWType
    ...
    0:1:1 QLOGIC QLE8242  58  4.8.76.48015 PCGLT0ARC1K3SK CNA
    1:1:1 QLOGIC QLE8242  58  4.8.76.48015 PCGLT0ARC1K3SK CNA
    ```

3. Issue the HP 3PAR OS CLI `showport -iscsi` command to check the current settings of the iSCSI ports:

```
# showport -iscsi
N:S:P State    IPAddr  Netmask Gateway TPGT  MTU   Rate  DHCP iSNS_Prim iSNS_Sec
iSNS_Port
0:1:1 offline 0.0.0.0 0.0.0.0 0.0.0.0  11    1500 n/a   0 0.0.0.0 0.0.0.0.0
3205
1:1:1 offline 0.0.0.0 0.0.0.0 0.0.0.0  12    1500 n/a   0 0.0.0.0 0.0.0.0.0
3205
0:1:1 offline 0.0.0.0 0.0.0.0 0.0.0.0  111   1500 n/a   0 0.0.0.0 0.0.0.0.0
3205
1:1:1 offline 0.0.0.0 0.0.0.0 0.0.0.0  112   1500 n/a   0 0.0.0.0 0.0.0.0.0
3205
```

4. Issue the HP 3PAR OS CLI `controliscsiport` command to set up the IP address and netmask address of the iSCSI target ports.

```
# controliscsiport addr 10.1.1.100 255.255.255.0 -f 0:1:1
# controliscsiport addr 10.1.1.102 255.255.255.0 -f 0:1:1
# controliscsiport addr 10.1.1.101 255.255.255.0 -f 0:1:2
# controliscsiport addr 10.1.1.103 255.255.255.0 -f 0:1:2
```

NOTE: Make sure the IP switch ports where the HP 3PAR StoreServ Storage iSCSI target port(s) and iSCSI initiator host are connected are able to communicate with each other by using the `vmkping` command on the ESX host. (The VMware ESX host iSCSI initiator must be configured to perform this operation in accordance with "Configuring the Host for an iSCSI Connection" (page 65).)

To verify that the ESX host can see the HP 3PAR StoreServ Storage, use the `vmkping`command:

```
# vmkping 10.1.1.100
```

To verify that the HP 3PAR StoreServ Storage can see the ESX host, issue the following command:

```
# controliscsiport ping 10.1.1.10 0:1:1
```

NOTE: A maximum of 64 host iSCSI initiator ports can be connected to any one HP 3PAR StoreServ Storage target port.

NOTE: When the host initiator port and the HP 3PAR OS target port are in different IP subnets, the gateway address for the HP 3PAR OS port should be configured in order to avoid unexpected behavior.

Creating the iSCSI Host Definition on an HP 3PAR StoreServ Storage Running HP 3PAR OS 3.1.x and OS 2.3.x

Create a host definition that ties all of the connections from a single host to a host name. Prior to creating a host definition using the following steps, the HP 3PAR StoreServ Storage iSCSI target ports must have been set up and an iSCSI connection/session must be established. The iSCSI connection/session is established by following the steps in "Setting Up the Ports for an iSCSI Connection" (page 18) and the steps in "Configuring the Host for an iSCSI Connection" (page 65) through "Configuring the VMware iSCSI Initiator" (page 72) (ESX host setup).

ESX/ESXi uses the generic legacy host persona of 6 for HP 3PAR OS 3.1.1 or earlier. As of HP 3PAR OS 3.1.2, a second host persona 11 (VMware), which enables asymmetric logical unit access (ALUA) is available. Host persona 11 (VMware) is recommended for new ESX/ESXi installations and is required for ESX/ESXi hosts configured as part of a HP 3PAR Peer Persistence configuration. For ESX/ESXi with HP 3PAR Remote Copy, refer to the *Remote Copy Users Guide* for the appropriate host persona to use in specific Remote Copy configurations.

The following example of host definition creation depicts a VMware iSCSI initiator `iqn.1998-01.com.vmware:sqahpbc02icm5-40e25c56` on an ESX host (the only iSCSI initiator for this server in this case) connecting through a VLAN to a pair of HP 3PAR StoreServ Storage iSCSI ports. The host definition is given the name `ESX1` and the host persona is set to `6` (Generic-legacy).

1. Issue the HP 3PAR OS CLI `showhost` command to verify that the host iSCSI initiators are connected to the HP 3PAR StoreServ Storage iSCSI target ports.

```
# showhost
Id Name Persona ---------------WWN/iSCSI_Name--------------- Port
-- -- iqn.1998-01.com.vmware:sqahpbc02icm5-40e25c56 0:1:2
-- -- iqn.1998-01.com.vmware:sqahpbc02icm5-40e25c56 1:1:2
-- -- iqn.1998-01.com.vmware:dl360g8-02-42b20fff    0:1:2
-- -- iqn.1998-01.com.vmware:dl360g8-02-42b20fff    1:1:2
```

2. Issue the HP 3PAR OS CLI `createhost` command to create the appropriate host definition entry.

```
# createhost -iscsi -persona  6 ESX1 iqn.1998-01.com.vmware:sqahpbc02icm5-40e25c56
```

or:

```
# createhost -iscsi -persona 11 ESX2 iqn.1998-01.com.vmware:dl360g8-02-42b20fff
```

3. Issue the HP 3PAR OS CLI `showhost` command to verify that the host entry has been created.

```
# showhost
Id Name Persona ---------------WWN/iSCSI_Name--------------- Port
0 ESX1 Generic-legacy   iqn.1998-01.com.vmware:sqahpbc02icm5-40e25c56 0:1:2
                        iqn.1998-01.com.vmware:sqahpbc02icm5-40e25c56 1:1:2

1 ESX2 VMware           iqn.1998-01.com.vmware:dl360g8-02-42b20fff    0:1:2
                        iqn.1998-01.com.vmware:dl360g8-02-42b20fff    1:1:2
```

4. To test the connection, create some temporary virtual volumes and export the VLUNs to the host.

> **NOTE:** See "Allocating Storage for Access by the ESX Host" (page 78) for complete details on creating, exporting and discovering storage for an iSCSI connection.

5. On the ESX iSCSI initiator host, perform a rescan and verify that the disks have been discovered.

Creating the iSCSI Host Definition on an HP 3PAR StoreServ Storage Running HP 3PAR OS 2.2.x

Create a host definition that ties all of the connections from a single host to a host name. Prior to creating a host definition using the following steps, the HP 3PAR StoreServ Storage iSCSI target

ports must have been set up and an iSCSI connection/session must be established. The iSCSI connection/session is established by following the steps in "Setting Up the Ports for an iSCSI Connection" (page 18) and the steps in "Configuring the Host for an iSCSI Connection" (page 65) through section "Configuring the VMware iSCSI Initiator" (page 72) (ESX host setup).

The following example of host definition creation depicts a VMware iSCSI initiator `iqn.1998-01.com.vmware:sqahpbc02icm5-40e25c56`on an ESX host (the only iSCSI initiator for this server in this case) connecting through a VLAN to a pair of HP 3PAR StoreServ Storage iSCSI ports. The host definition is given the name `ESX1`.

1. Issue the HP 3PAR OS CLI `showhost` command to verify that the host iSCSI initiators are connected to the HP 3PAR StoreServ Storage iSCSI target ports.

```
# showhost
Id Name Persona ----------------WWN/iSCSI_Name---------------- Port
 -- --    iqn.1998-01.com.vmware:sqahpbc02icm5-40e25c56  0:1:2
 -- --    iqn.1998-01.com.vmware:sqahpbc02icm5-40e25c56  1:1:2
```

2. Issue the HP 3PAR OS CLI `createhost` command to create the appropriate host entry.

```
# createhost -iscsi ESX1 iqn.1998-01.com.vmware:sqahpbc02icm5-40e25c56
```

3. Issue the HP 3PAR OS CLI `showhost` command to verify that the host entry has been created.

```
# showhost
Id Name ----------------WWN/iSCSI_Name---------------- Port
 0 ESX1  iqn.1998-01.com.vmware:sqahpbc02icm5-40e25c56  0:1:2
       iqn.1998-01.com.vmware:sqahpbc02icm5-40e25c56  1:1:2
```

4. To test the connection, create some temporary virtual volumes and export the VLUNs to the host.

   NOTE: See "Allocating Storage for Access by the ESX Host" (page 78) for complete details on creating, exporting and discovering storage for an iSCSI connection.

5. On the ESX iSCSI initiator host, perform a rescan and verify that the disks have been discovered.

Setting Up and Configuring CHAP Authentication

Enabling Host CHAP is an option that can be set up at the ESX system administrator's discretion. The following example outlines the procedures for host (initiator) CHAP which is available as of ESX 3.x. As of ESX 4.0, mutual (bidirectional, initiator-target) CHAP is also available.

NOTE: CHAP is available in ESX 3.x, also in ESX 4.x and ESX 5.x.

1. Issue the HP 3PAR OS CLI `showhost` command to verify that a host definition has been created on HP 3PAR StoreServ Storage for the ESX host that will have CHAP enabled.

```
# showhost
Id Name         ---------------WWN/iSCSI_Name--------------- Port
 0 ESX1       iqn.1998-01.com.vmware:hpdl380-01-11a38a59    0:1:2
             iqn.1998-01.com.vmware:hpdl380-01-11a38a59    1:1:2
```

The following example uses the CHAP secret (CHAP password) `host_secret3` for the ESX host. Be aware that the CHAP secret must be at least 12 characters long.

2. On the ESX host's VI/vSphere client, open the **Storage Adapters** tab, then select the iSCSI Software Adapter, and select the **Properties** link. Then, on the General tab, click **CHAP**.

    For ESX 3.5, select the **CHAP Authentication** tab, and then select the **Use the following CHAP credentials** radio button.

Figure 1 CHAP Authentication in ESX 3.5
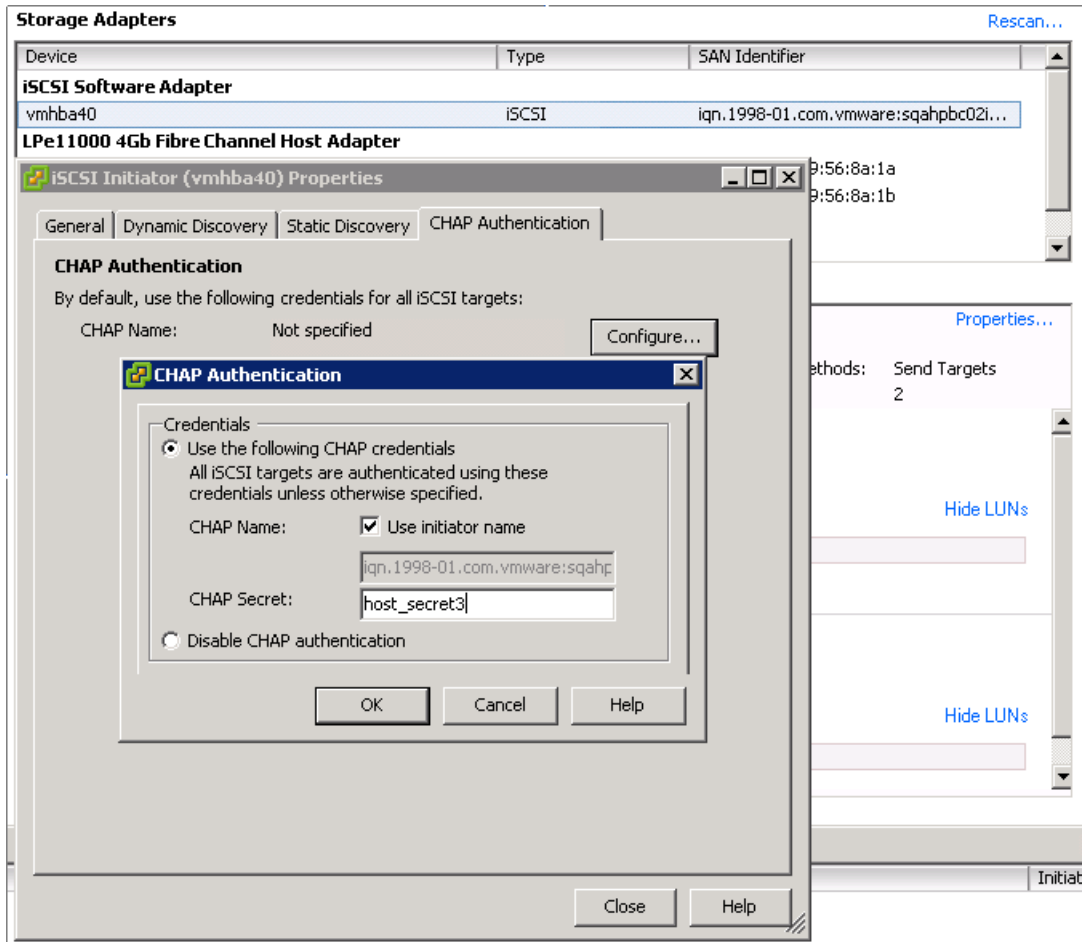
For ESX/ESXi 4.x or ESX/ESXi 5.x, select the **Use initiator name** check box.

Figure 2 CHAP Credentials in ESX/ESXi 4.x or ESX/ESXi 5.x
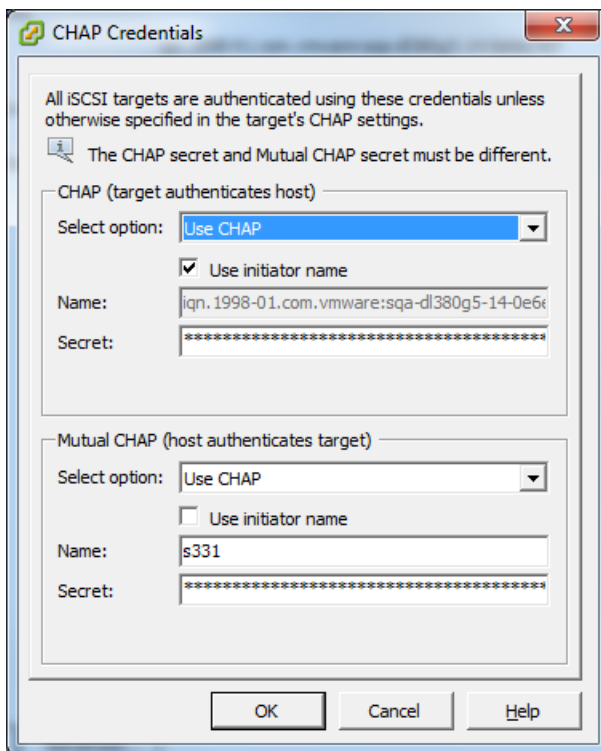
3. Enter the CHAP **Secret** (must be at least 12 characters long). Use the same secret that you enter on the storage side.

4. Click **OK** when you are done. A warning screen appears indicating that a reboot of the ESX host is required.

   NOTE: A server reboot is required for ESX 3.5. For ESX 4.x and ESXi 5.x, a rescan of the HBA should pick up the changes.
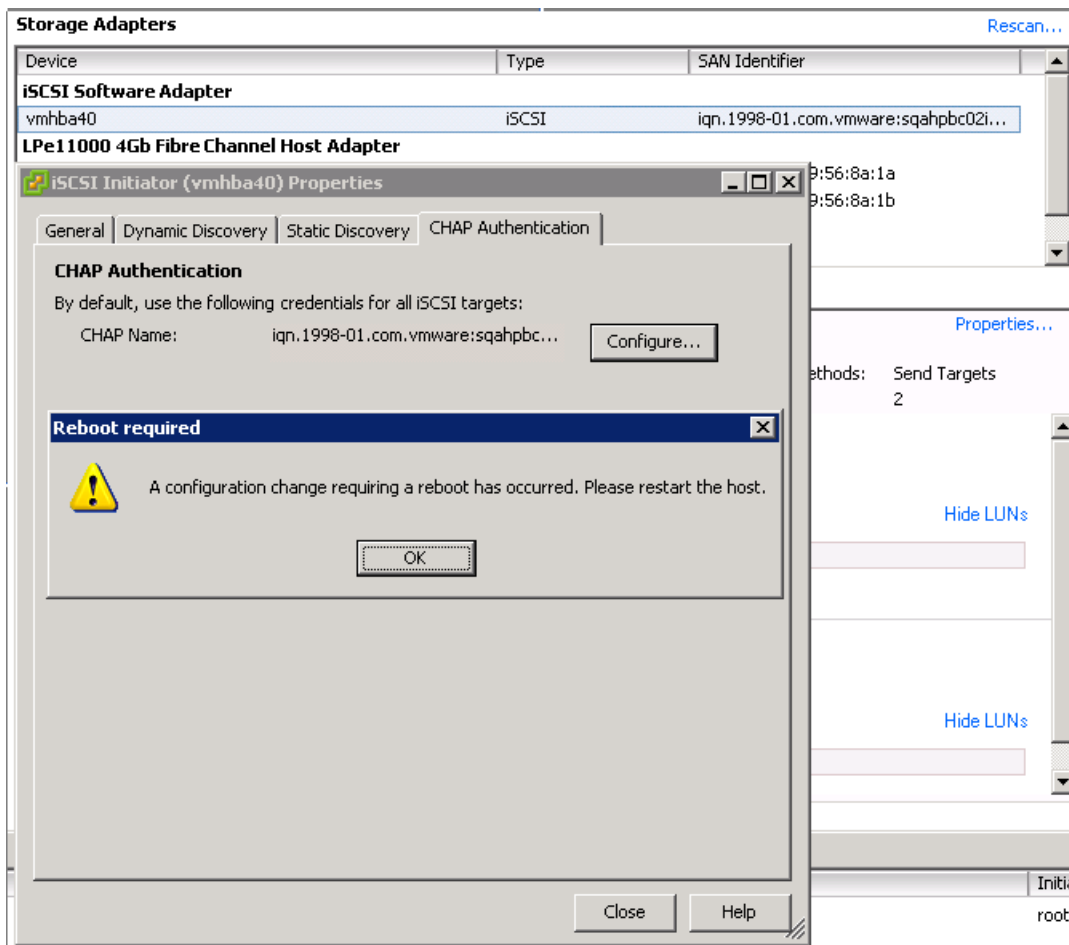
5. Click **OK** again to confirm.

6. On the HP 3PAR StoreServ Storage, issue the HP 3PAR OS CLI `sethost` command with the `initchap` parameter to set the CHAP secret for the ESX host.

```
# sethost initchap -f host_secret3 ESX1
```

NOTE: If mutual CHAP on ESX is being configured, then target CHAP will need to be configured on the HP 3PAR StoreServ Storage as well as initiator CHAP. Set target CHAP secret using the HP 3PAR OS CLI `sethost` command with the `targetchap` parameter.

```
# sethost targetchap -f host_secret3 ESX1
```

a. For the target CHAP, make sure to give the storage system name as the `Name` field variable. The storage name is obtained using the `showsys` output, as shown below.

```
# showsys
---------------(MB)----------------
ID   -Name-    ---Model---  -Serial-  Nodes   Master    TotalCap  AllocCap  FreeCap  FailedCap
331  s331      InServ F200  1300331   2       1         6094848   1336320   4758528  0
```

b. For ESX 4.x and 5.x:

Figure 3 CHAP Credentials in ESX 4.x and 5.x
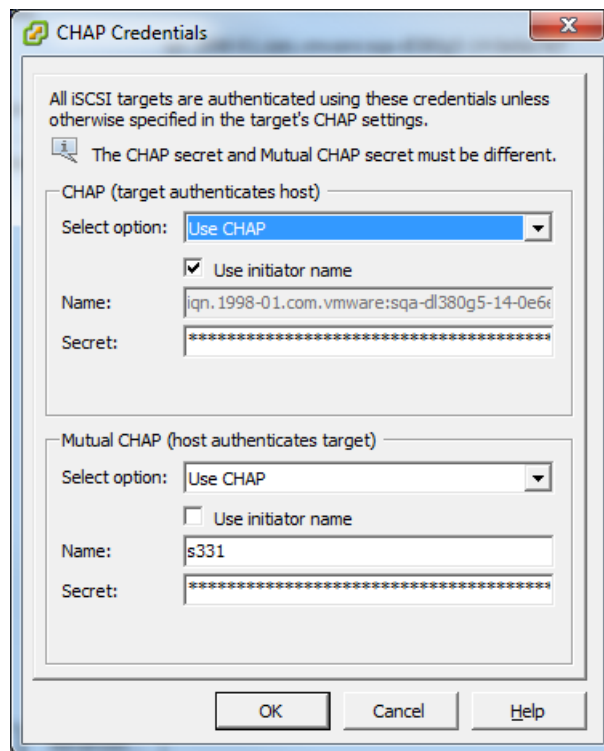
Issue the HP 3PAR OS CLI `showhost -chap` command to verify that the specified CHAP secret has been set for the host definition.

```
For Initiator chap

# showhost -chap
Id Name -Initiator_CHAP_Name- -Target_CHAP_Name-
 0 ESX1 ESX1 --

For mutual chap

# showhost -chap
Id Name -Initiator_CHAP_Name- -Target_CHAP_Name-
0   ESX1 ESX1                                s331
```

Hardware iSCSI Support

At ESX 5.0 and above, hardware iSCSI is supported using the CN1100E CNA card and other Emulex BE3 models. This CNA can be configured using either Dependent iSCSI (the IP address of the system is obtained from the host NIC connections) or Independent iSCSI (the IP address is entered into the CNA card). The CN1100E can be configured to boot from SAN; SCSI targets are entered into the card.

For general information about the CN1100E and other BE3 models supported, see the HP SPOCK website:

http://www.hp.com/storage/spock

To set a static IP address, follow these steps:

1. After installing the CN1100E, boot the system. The following text appears :

```
Emulex 10Gb iSCSI Initiator BIOS..
Press <Ctrl> <S>  for iSCSISelect(TM) Utility
```

2. Press **Ctrl+S** to enter the utility.

Figure 4 iSCSI Utility
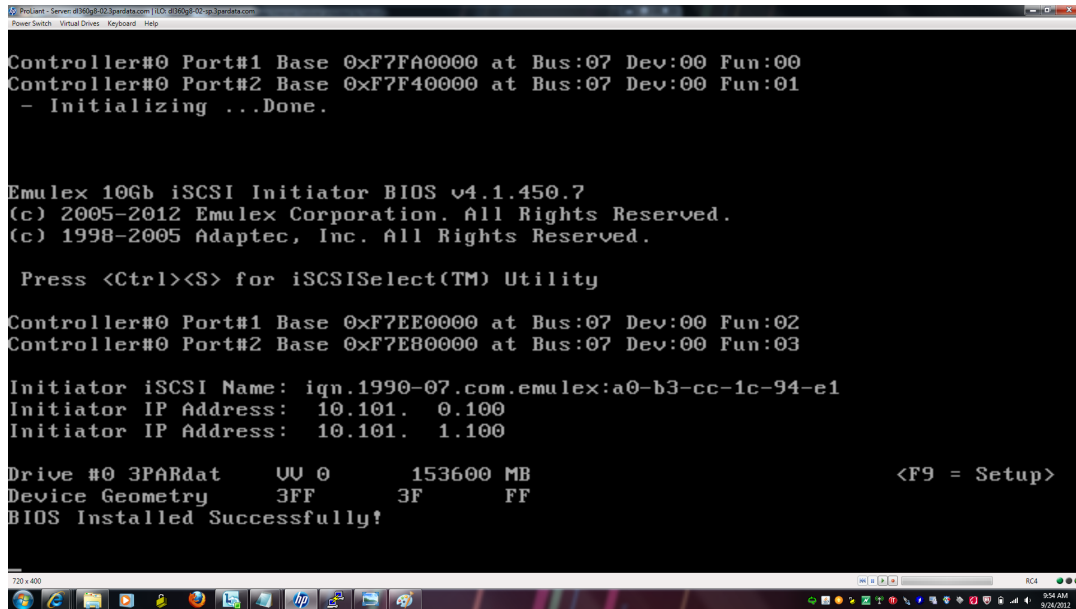
3. Select a controller and press **Enter**.
4. From the **Controller Configuration** screen, select **Network Configuration** and press **Enter**.
5. In the **Network Configuration** screen, select **Configure Static IP Address** and press **Enter**. The screen for setting a static IP address displays.

Figure 5 Setting a Static IP Address
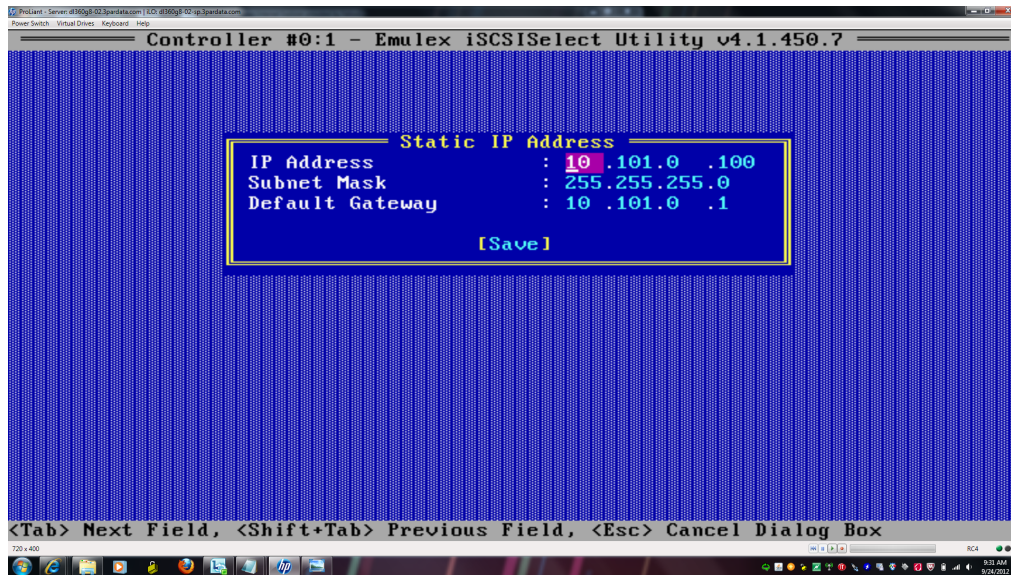
6. After entering the IP address, subnet mask, and default gateway, click **Save** to return to the **Controller Configuration** menu.

If the configuration being set up will be booted from SAN rather than from the host, follow these steps.

1. After entering the **iSCSI Initiator Configuration** screen, which will be the first screen displayed, obtain the IQN for the card and create a host definition on the HP 3PAR StoreServ Storage. For example:

```
# createhost –iscsi –persona 11 Esx50Sys1 iqn.1990-07.com.emulex:a0-b3-cc-1c-94-e1
```

2. Assign a VLUN to this host definition to be used as the SAN boot LUN.
3. From the **Controller Configuration** menu, select **Controller Properties**.
4. In the properties screen, verify that boot support is enabled. If it is not, scroll to **Boot Support** and enable it, then save and exit this screen.
5. from the **Controller Configuration** menu, select **iSCSI Target Configuration**.
6. In the **iSCSI Target Configuration** menu, select **Add New iSCSI Target** and press **Enter**.
7. Fill in the information for the first iSCSI target. Make sure **Boot Target** is set to **Yes**.

Figure 6 Adding an iSCSI Target
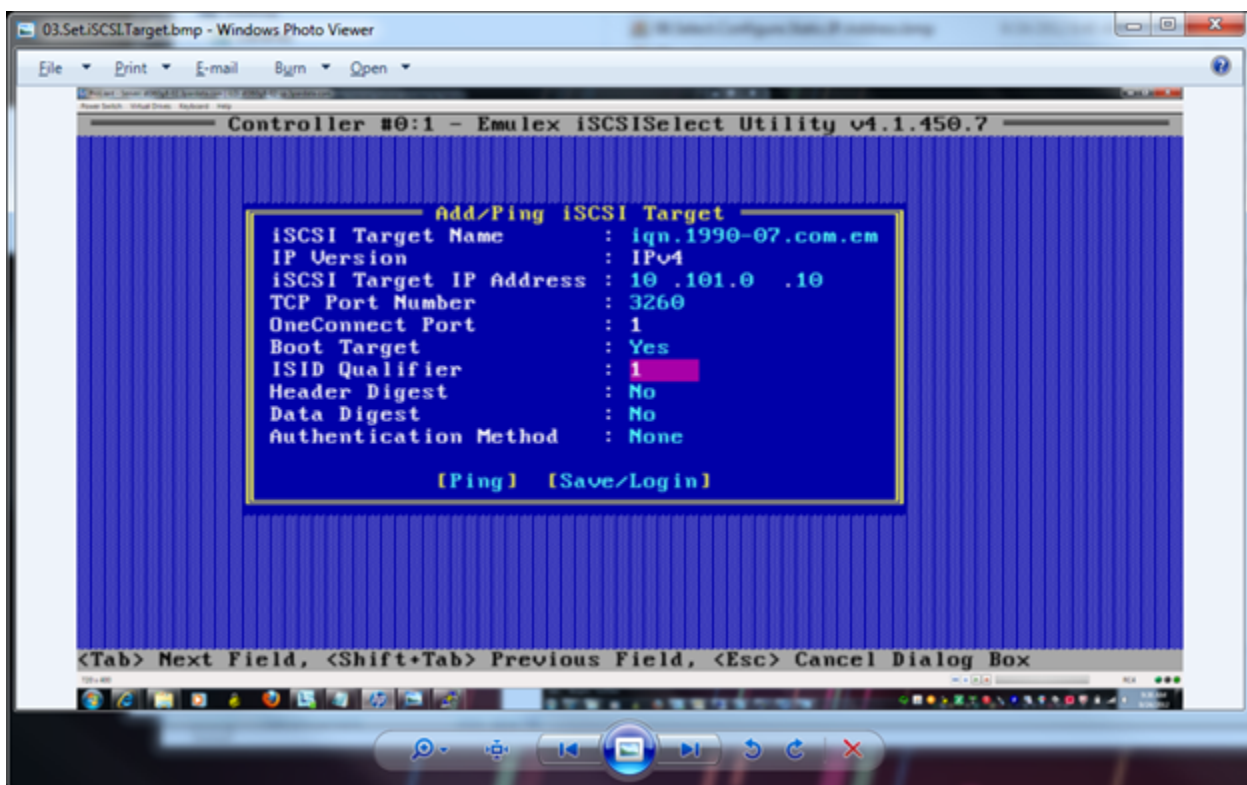
8. After the information is filled in, click **Ping** to verify connectivity.
9. After a successful ping, click **Save/Login**.
10. After both controllers have been configured, issue the `showiscsisession` command to display the iSCSI sessions on the HP 3PAR StoreServ Storage and the host. If everything is configured correctly, the displays should appear as follows:

```
root@jnodec103140:S99814# showiscsisession
0:2:1   10.101.0.100   21   15      1 iqn.1990-07.com.emulex:a0-b3-cc-1c-94-e1
2012-09-24 09:57:58 PDT
1:2:1   10.101.1.100  121   15      1 iqn.1990-07.com.emulex:a0-b3-cc-1c-94-e1
2012-09-24 09:57:58 PDT
root@jnodec103140:S99814# showhost -d Esx50Sys1
1 Esx50Sys1   VMware  iqn.1990-07.com.emulex:a0-b3-cc-1c-94-e1 0:2:1 10.101.0.100
1 Esx509Sys1  VMware  iqn.1990-07.com.emulex:a0-b3-cc-1c-94-e1 1:2:1 10.101.1.100
```

11. If you do not want to use CHAP as an authentication method, exit the CN1100E setup screens and reboot now.

If you would like to use CHAP as an authentication method, return to the **Add/Ping iSCSI Target** screen as shown in "Adding an iSCSI Target" (page 27), select **Authentication Method**, and then choose one of the following options:

- Select **One-Way CHAP** (see "One-Way CHAP" (page 28)).

Figure 7 One-Way CHAP
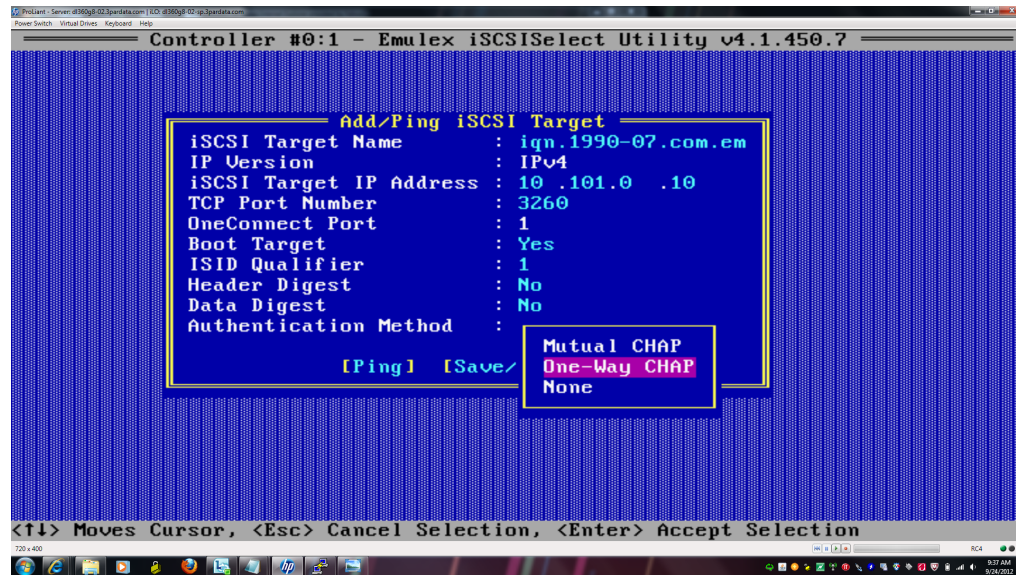
The **CHAP Configuration** screen appears (see "CHAP Configuration for One-Way CHAP" (page 28)).

Figure 8 CHAP Configuration for One-Way CHAP
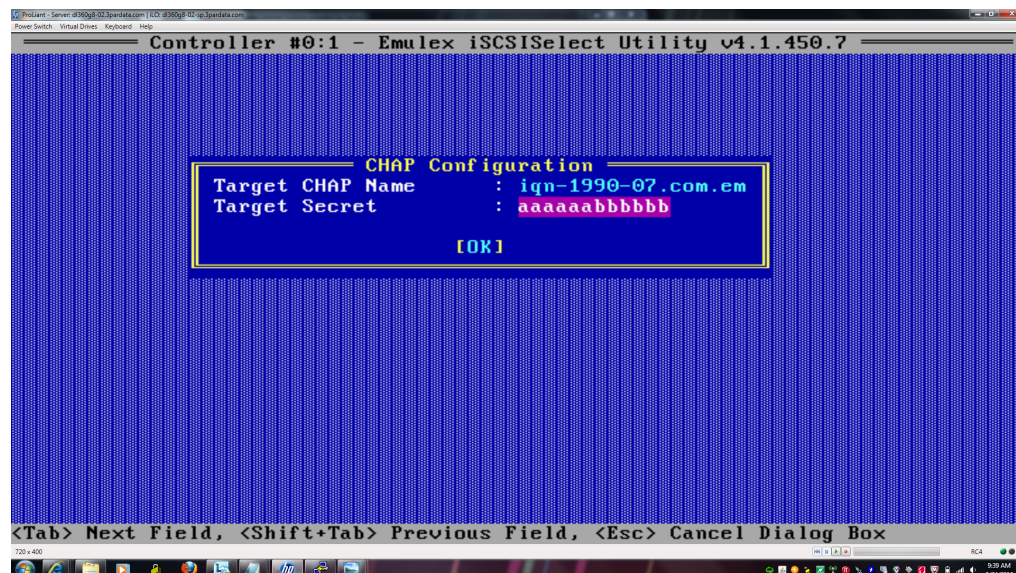
Fill in the **Target CHAP Name** (the initiator IQN name) and **Target Secret**, then click **OK**.

- In the **Authentication Method** setting on the **Add-Ping iSCSI Target** screen ("One-Way CHAP" (page 28)), select **Mutual CHAP**. The **CHAP Configuration** screen appears (see "CHAP Configuration for Mutual CHAP" (page 29)).

Figure 9 CHAP Configuration for Mutual CHAP
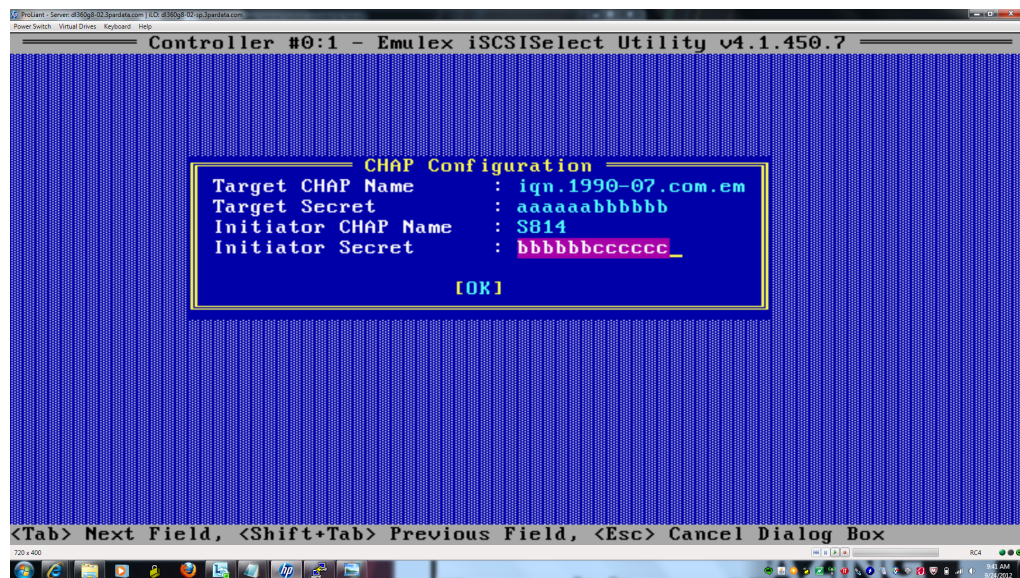
Fill in the **Target CHAP Name** (the initiator IQN name), the **Target Secret**, the **Initiator CHAP Name** (which is the DNS name of the storage), and an **Initiator Secret**, and then click **OK**.

- If you want to remove CHAP authentication later on, in the **Authentication Method** setting on the **Add-Ping iSCSI Target** screen ("One-Way CHAP" (page 28)), select **None**.

12. If you have set up CHAP authentication, then before rebooting the host system, make sure to set the matching CHAP parameters for the host in the HP 3PAR StoreServ Storage.

NOTE: If you do not want to configure CHAP using BIOS, you can alter the iSCSI initiator properties after the system is booted.

- If one-way CHAP has been selected, enter the matching CHAP secret as follows:

```
root@jnodec103140:S99814# sethost  initchap -f aaaaaabbbbbb EsxHost1
root@jnodec103140:S99814# showhost -chap
```

- If mutual CHAP has been selected, enter the mutual CHAP secret as follows:

```
root@jnodec103140:S99814# sethost  targetchap -f bbbbbbcccccc EsxHost1
root@jnodec103140:S99814#
root@jnodec103140:S99814# showhost -chap
Id Name          -Initiator_CHAP_Name- -Target_CHAP_Name-
1 EsxHost1       EsxHost1              S814
root@jnodec103140:S99814#
```

After entering the CHAP secret, exit the BIOS and reboot the host.

Target Port Limits and Specifications

To avoid overwhelming a target port and ensure continuous I/O operations, observe the following limitations on a target port:

- I/O queue depth on each HP 3PAR StoreServ Storage HBA model, as follows:

    ◦ QLogic 1G: 512

    ◦ QLogic 10G: 2048 (HP 3PAR StoreServ 10000 and HP 3PAR StoreServ 7000 systems only)

- The I/O queues are shared among the connected host HBA ports on a first-come, first-served basis.

- When all queues are in use and a host HBA port tries to initiate I/O, it receives a target queue full response from the HP 3PAR StoreServ Storage port. This condition can result in erratic I/O performance on each host. If this condition occurs, each host should be throttled so that it cannot overrun the HP 3PAR StoreServ Storage port's queues when all hosts are delivering their maximum number of I/O requests.

HP 3PAR Priority Optimization

The HP 3PAR Priority Optimization feature introduced in HP 3PAR OS versions 3.1.2.MU2 is a more efficient and dynamic solution for managing server workloads and can be utilized as an alternative to setting host I/O throttles. Using this feature, a storage administrator is able to share storage resources more effectively by enforcing quality of service limits on the array. No special settings are needed on the host side to obtain the benefit of Priority Optimization although certain per target or per adapter throttle settings may need to be adjusted in rare cases. For complete details of how to use Priority Optimization (Quality of Service) on HP 3PAR arrays, please read the *HP 3PAR Priority Optimization* technical white paper available at http://www.hp.com/go/bsc.

4 Configuring the HP 3PAR StoreServ Storage for FCoE

Setting Up the FCoE Switch, FCoE Initiator, and FCoE target ports

Connect the ESX host FCoE initiator port(s) and the HP 3PAR StoreServ Storage FCoE target ports to the FCoE switch(es).

NOTE: FCoE switch VLANs and routing setup and configuration is beyond the scope of this document. Consult your switch manufacturer's documentation for instructions of how to set up VLANs and routing.

1. CNA ports on HP 3PAR StoreServ 10000 and HP 3PAR StoreServ 7000 arrays require a one time configuration using the `controlport` command. (HP 3PAR T-class, and F-class arrays do not require this one-time setting.)

   For Example on a new FCoE config:

   ```
   # showport
   N:S:P Mode State ----Node_WWN---- -Port_WWN/HW_Addr- Type Protocol
   0:3:1 suspended config_wait - - cna -
   0:3:2 suspended config_wait - - cna -
   ```

   ```
   # showport -i
   N:S:P Brand Model Rev Firmware Serial HWType
   0:3:1 QLOGIC QLE8242  58  0.0.0.0   PCGLT0ARC1K3U4 CNA
   0:3:2 QLOGIC QLE8242  58  0.0.0.0   PCGLT0ARC1K3U4 CNA
   ```

2. If `State=config_wait` or `Firmware=0.0.0.0`, use the `controlport config fcoe <n:s:p>` command to configure. Use the `showport` and `showport -i` commands to verify the configuration setting.

   For example:

   ```
   # controlport config fcoe 0:3:1
   # controlport config fcoe 0:3:2
   # showport 0:3:1 0:3:2
   N:S:P    Mode      State ----Node_WWN---- -Port_WWN/HW_Addr- Type Protocol Label
   Partner FailoverState
   0:3:1 target    ready 2FF70002AC000121   20310002AC000121 host   FCoE      -
        -     -
   0:3:2 target    ready 2FF70002AC000121   20320002AC000121 free   FCoE      -
        -     -
   # showport -i 0:3:1 0:3:2
   N:S:P Brand  Model   Rev Firmware Serial       HWType
   0:3:1 QLOGIC QLE8242 58  4.11.122 PCGLT0ARC1K3U4 CNA
   0:3:2 QLOGIC QLE8242 58  4.11.122 PCGLT0ARC1K3U4 CNA
   ```

3. Check the current settings of the FCoE ports by issuing `showport -fcoe`.

   For example:

   ```
   # showport -fcoe
   N:S:P ENode_MAC_Address PFC_Mask
   0:3:1 00-02-AC-07-01-21     0x08
   0:3:2 00-02-AC-06-01-21     0x00
   ```

NOTE: If changing the config from iSCSI to FCoE, follow the steps below.

1. Issue the `showport` command.

```
# showport
0:3:1    target   ready   -    000E1E05BEE6 iscsi  iSCSI      -         -         -
0:3:2    target   ready   -    000E1E05BEE2 iscsi  iSCSI      -         -         -
```

2. Turn off the iSCSI ports:

```
# controlport offline 0:3:1
# controlport offline 0:3:2

showport
0:3:1 target offline  -  000E1E05BEE2 iscsi iSCSI0:3:2 target offline -
000E1E05BEE2 iscsi iSCSI
```

3. Change the topology to FCoE:

```
# controlport config fcoe 0:3:1
# controlport config fcoe 0:3:2

controlport rst 0:3:1
controlport rst 0:3:2
0:3:1 target offline  -  000E1E05BEE2 iscsi iSCSI0:3:2 target offline -
000E1E05BEE2 iscsi iSCSI
showport
0:3:1    target     ready 2FF70002AC000121   20310002AC000121   host     FCoE
  -      -      -
0:3:2    target     ready 2FF70002AC000121   20320002AC000121   free     FCoE
  -      -      -
```

4. Check the current settings of the FCoE ports by issuing `showport -fcoe`.
   For example:

```
# showport -fcoe
N:S:P ENode_MAC_Address PFC_Mask
0:3:1 00-02-AC-07-01-21     0x08
0:3:2 00-02-AC-06-01-21     0x00
```

Creating the Host Definition

Before connecting the ESX host to the HP 3PAR StoreServ Storage, a host definition needs to be created that specifies a valid host persona (host mode) for each HP 3PAR StoreServ Storage port that is to be connected to a host HBA port through a fabric or direct connection.

- ESX/ESXi uses the generic legacy host persona of 6 for HP 3PAR OS 3.1.1 or earlier.
- As of HP 3PAR OS 3.1.2, a second host persona 11 (VMware), which enables asymmetric logical unit access (ALUA) is available.
  - Host persona 11 (VMware) is recommended for new ESX/ESXi installations and is required for ESX/ESXi hosts configured as part of a HP 3PAR Peer Persistence configuration.
  - Host persona 11 (VMware) is required for FCoE end-to-end (FCoE target) configurations.
- For ESX/ESXi with HP 3PAR Remote Copy, refer to the *Remote Copy Users Guide* for the appropriate host persona to use in specific Remote Copy configurations.

NOTE: When changing an existing host persona from 6 to 11, a host reboot is required for the change to take effect. This is an offline process. See "Configuring ESX/ESXi Multipathing for Round Robin via SATP PSP" (page 40) for the detailed procedure, as the host persona change should coincide with changing the SATP rules on the host as well.

For both host persona 6 and persona 11, see the appropriate chapters in this guide for host server FCoE setup considerations.

1. To display available host personas, issue the following command:

```
# showhost -listpersona
```

2. To create host definitions, issue the `createhost` command with the `-persona` option to specify the persona and the host name.

   For HP 3PAR OS 3.1.1 or earlier:

```
# createhost -persona 6 ESXserver1 10000000C9724AB2 10000000C97244FE
```

   For HP 3PAR OS 3.1.2:

```
# createhost -persona 11 ESXserver1 10000000C9724AB2 10000000C97244FE
```

3. To verify that the host has been created, issue the `showhost` command.

   For HP 3PAR OS 3.1.1 or earlier, using persona 6:

```
# showhost
Id Name        Persona          -WWN/iSCSI_Name-  Port
0  ESXserver1 Generic-legacy   10000000C9724AB2  --- 10000000C97244FE ---
```

   For HP 3PAR OS 3.1.2, using persona 11:

```
# showhost
Id Name        Persona         -WWN/iSCSI_Name-  Port
0  ESXserver2 VMware          100000051EC33E00  --- 100000051EC33E01 ---
```

Use `showhost -persona` to show the persona name and Id relationship.

```
# showhost -persona
Id Name          Persona_Id     Persona_Name     Persona_Caps
0 ESXserver1     6              Generic-legacy   --
1 Esxserver2     11             VMware           SubLun, ALUA
```

NOTE: If the persona is not correctly set, then use the `sethost -persona <host number> <hostname>` command to correct the issue, where host number is `6` (for HP 3PAR OS 3.1.1 or earlier) or `11` (for HP 3PAR OS 3.1.2).

A reboot of the ESX host is required if host persona is changed to 11.

NOTE: See the *HP 3PAR Command Line Interface Reference* or the *HP 3PAR Management Console Users Guide* for complete details on using the `controlport`, `createhost`, and `showhost` commands.

These documents are available on the HP BSC website:

http://www.hp.com/go/bsc

Target Port Limits and Specifications

To avoid overwhelming a target port and ensure continuous I/O operations, observe the following limitations on a target port:

- I/O queue depth on each HP 3PAR StoreServ Storage HBA model, as follows:

  ○ QLogic CNA: 1748 (HP 3PAR StoreServ 10000 and HP 3PAR StoreServ 7000 systems only)

- The I/O queues are shared among the connected host HBA ports on a first-come, first-served basis.

- When all queues are in use and a host HBA port tries to initiate I/O, it receives a target queue full response from the HP 3PAR StoreServ Storage port. This condition can result in erratic I/O performance on each host. If this condition occurs, each host should be throttled so that it cannot overrun the HP 3PAR StoreServ Storage port's queues when all hosts are delivering their maximum number of I/O requests.

NOTE: When host ports can access multiple targets on fabric zones, the assigned target number assigned by the host driver for each discovered target can change when the host is booted and some targets are not present in the zone. This situation may change the device node access point for devices during a host reboot. This issue can occur with any fabric-connected storage, and is not specific to the HP 3PAR StoreServ Storage.

HP 3PAR Priority Optimization

The HP 3PAR Priority Optimization feature introduced in HP 3PAR OS versions 3.1.2.MU2 is a more efficient and dynamic solution for managing server workloads and can be utilized as an alternative to setting host I/O throttles. Using this feature, a storage administrator is able to share storage resources more effectively by enforcing quality of service limits on the array. No special settings are needed on the host side to obtain the benefit of Priority Optimization although certain per target or per adapter throttle settings may need to be adjusted in rare cases. For complete details of how to use Priority Optimization (Quality of Service) on HP 3PAR arrays, please read the *HP 3PAR Priority Optimization* technical white paper available at http://www.hp.com/go/bsc.

5 Configuring the Host for a Fibre Channel Connection

This chapter describes the procedures and considerations that are required to set up an ESX host to communicate with an HP 3PAR StoreServ Storage over a Fibre Channel connection.

Installing the HBA and Drivers

Before setting up the ESX host, make sure the host adapters are installed and operating properly. If necessary, consult the documentation provided by the HBA vendor for instructions.

Drivers for VMware supported HBAs are included as part of the ESX OS installation package supplied by VMware. Updates and/or patches for the HBA drivers can be acquired through VMware support.

For Brocade FC HBA, the default Path TOV (Time-out Value) parameter is set to 30 seconds. It is recommended to change this value to 14 seconds with VMware Native Multipathing Plugin (NMP). To change the value of this parameter, it is required to use Brocade BCU command line utility. See the see VMware website for more information:

http://kb.vmware.com/selfservice/microsites/search.do?cmd=displayKC&docType=kc&docTypeID=DT_KB_1_1&externalId=2001842

The BCU tool is available for download from the Brocade web site.

To display the list of adapter ports, run the following command

```
# esxcli brocade bcu --command="port --list"
-----------------------------------------------------------------------------
Port#   FN    Type   PWWN/MAC                      FC Addr/    Media    State        Spd
                                                               Eth dev
-----------------------------------------------------------------------------
1/0     -     fc     10:00:00:05:1e:dc:f3:2f       091e00      sw       Linkup       8G

        0     fc     10:00:00:05:1e:dc:f3:2f       091e00      sw       Linkup       8G
1/1     -     fc     10:00:00:05:1e:dc:f3:30       673000      sw       Linkup       8G

        1     fc     10:00:00:05:1e:dc:f3:30       673000      sw       Linkup       8G
```

To query a port# from the above output, run the following command:

```
# esxcli brocade bcu --command="vhba --query 1/0"
PCI Function Index        : 1/0/0
Firmware Ver             : 3.0.0.0
Port type                : FC
Bandwidth                : 8 Gbps
IOC state                : operational
PWWN                     : 10:00:00:05:1e:dc:f3:2f
NWWN                     : 20:00:00:05:1e:dc:f3:2f
Path TOV                 : 30 seconds
Portlog                  : Enabled
IO Profile               : Off
Interrupt coalescing     : on
Interrupt delay          : 0 us
Interrupt latency        : 0 us
```

To change Path TOV value (repeat for all ports) follow the example below. Also this command can be included in ESX host startup such that it will be run automatically.

```
# esxcli brocade bcu --command="fcpim --pathtov 1/0 14"
path timeout is set to 14
```

To query a port# after a change was made, follow the example below:

```
# esxcli brocade bcu --command="vhba --query 1/0"
PCI Function Index       : 1/0/0
Firmware Ver             : 3.0.0.0
Port type                : FC
Bandwidth                : 8 Gbps
IOC state                : operational
PWWN                     : 10:00:00:05:1e:dc:f3:2f
NWWN                     : 20:00:00:05:1e:dc:f3:2f
Path TOV                 : 14 seconds
Portlog                  : Enabled
IO Profile               : Off
Interrupt coalescing     : on
Interrupt delay          : 0 us
Interrupt latency        : 0 us
```

Installing Virtual Machine Guest Operating System

The VMware ESX host documentation lists recommended virtual machine guest operating systems (GOS) and their installation and setup as virtual machines (VMs). Refer to the VMware ESX host documentation for information on setting up your virtual machine configuration.

△ **CAUTION:** In VMware KB 51306, VMware identifies a problem with RHEL 5 (GA), RHEL 4 U4, RHEL 4 U3, SLES 10 (GA), and SLES 9 SP3 guest operating systems. Their file systems may become read-only in the event of busy I/O retry or path failover of the ESX host's SAN or iSCSI storage. KB 51306 is available on the VMware Knowledge Base website:

http://kb.vmware.com

Because of this known issue, HP does not recommend, and does not support the usage of RHEL 5 (GA), RHEL 4 U4, RHEL 4 U3, SLES 10 (GA), and SLES 9 SP3 as guest operating systems for virtual machines on VMware ESX hosts attached to HP 3PAR StoreServ Storage systems.

CAUTION: The use of the N-Port ID Virtualization (NPIV) feature introduced with VMware ESX 3.5 - 5.0, allowing virtual ports/WWNs to be assigned to individual virtual machines, is not recommended and not supported with the HP 3PAR OS.

NOTE: VMware and HP recommend the LSI logic adapter emulation for Windows 2003 Servers. The LSI Logic adapter is also the default option for Windows 2003 when creating a new virtual machine. HP testing has noted a high incidence of Windows 2003 virtual machine failures during an ESX multipath failover/failback event when the BUS Logic adapter is used with Windows 2003 VMs.

NOTE: HP testing indicates that the SCSI timeout value for virtual machine guest operating systems should be 60 seconds in order to successfully ride out path failovers at the ESX layer. Most guest operating systems supported by VMware have a default SCSI timeout value of 60 seconds, but this value should be checked and verified for each GOS installation. In particular, Red Hat 4.x guest operating systems should have their SCSI timeout value changed from their default value of 30 seconds to 60 seconds.

This command line can be used to set the SCSI timeout on all SCSI devices presented to a Red Hat 4.x virtual machine to 60 seconds:

```
find /sys -name timeout | grep "host.*target.*timeout" | xargs -n 1
echo "echo 60 >"|sh
```

This must be added as a line in `/etc/rc.local` of the Red Hat 4.x guest OS in order for the timeout change to be maintained with a virtual machine reboot.

Example of a modified `/etc/rc.local` file:

```
# cat /etc/rc.local
#!/bin/sh
#
# This script will be executed *after* all the other init scripts.
# You can put your own initialization stuff in here if you don't
# want to do the full Sys V style init stuff.

find /sys -name timeout | grep "host.*target.*timeout" | xargs -n 1 echo "echo 60
>"|shtouch /var/lock/subsys/local
```

Multipath Failover Considerations and I/O Load Balancing

NOTE: This section about multipathing and configuring to Round Robin policy applies to all connectivity types: FC, FCoE, and iSCSI.

VMware ESX 3.0 - 3.5 includes failover with multipath support to maintain a constant connection between the ESX host and the HP 3PAR StoreServ Storage array. VMware terms this multipath support with a choice of two "path policies" called "FIXED" or "MRU". As of ESX 4.0, a third path policy choice of "round robin" is available. The path policies can be modified on a per-HP 3PAR StoreServ Storage-volume (LUN) basis by right-clicking the device listing and selecting the "properties" function from the VI/vSphere client menu. A pop-up window allows you to 'manage paths' whereby the properties of the paths to the volume that was previously selected can be modified. Using this control, you can select the path policy, and specify which path is the active preferred path to a volume on the storage array, or which path is the standby path within the FIXED path policy scheme. Additionally, paths can be disabled to prevent any traffic over a specific path to a volume on the storage array.

The VI/vSphere client GUI allows for settings to be changed only on a volume-by-volume (LUN-by-LUN) basis. The GUI is appropriate and preferred for use in managing I/O paths within the FIXED path policy scheme. See "Configuring Round Robin Multipathing on ESX 4.x or later for

Fibre Channel" (page 39) for procedures on implementing and configuring the round-robin path policy on ESX/ESXi 4.0 and later with an HP 3PAR StoreServ Storage.

- A path policy of "round-robin" is the preferred multipath implementation for ESX/ESXi 4.0 and later. For procedures on implementing and configuring the round-robin path policy on ESX/ESXi 4.0 and later with an HP 3PAR StoreServ Storage, see "Configuring Round Robin Multipathing on ESX 4.x or later for Fibre Channel" (page 39).

- A path policy of "fixed" and the preferred/active paths manually set to balance I/O load evenly across all paths is the preferred multipath implementation for ESX 3.0 - 3.5.

  - In the event the active path is detected as having failed or has been disabled either at the fabric switch, or on the storage array, all ESX host I/O to the storage array continues by failing over to a 'standby' path. When the ESX host detects that the preferred path has been recovered or is enabled, I/O from the ESX host then resumes on the preferred path -- assuming a preferred path policy had previously been set to that path.

  - I/O from the ESX host should be manually distributed or balanced when two or more paths exist to more than one HP 3PAR StoreServ Storage volume on the storage array. Manually balancing the loads across available paths may improve I/O performance. This path load balancing to the storage array is dependant on the number of I/Os that are targeted for specific volumes on the storage array. Tuning I/Os to specific volumes on specific paths to the storage array varies from configuration to configuration and is totally dependant on the workload from the ESX host and the virtual machines to the devices on the storage array.

The following vSphere client screen shot depicts a LUN with five I/O paths in a FIXED I/O policy scheme. The path marked Active (I/O) with the '*' in the **Preferred** column is the path chosen as preferred, and is the path to which all I/O is currently assigned for the given LUN. The other paths listed are active, but in 'standby' mode. The paths in active 'standby' will not be used for I/O traffic for this LUN unless the preferred path fails.
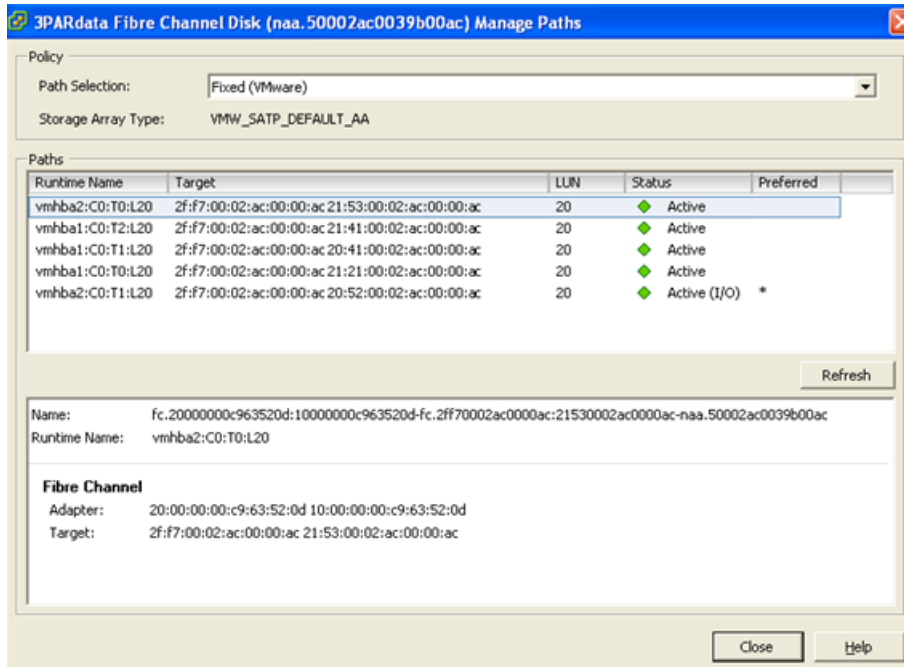
- A path policy of MRU (most recently used) does not maintain or reinstate balancing of I/O load after a failover/failback multipath event. This could leave I/O in an unplanned for and unbalanced state which may yield significant I/O performance issues. Implementation of an MRU path policy is not recommended by HP.

NOTE: If I/O is active to a LUN and an attempt is made to modify the path policy, a failure can occur, indicating:

```
"error during the configuration of the host: sysinfoException;
Status=Busy: Message=Unable to Set".
```

If this problem occurs while attempting to change the path policy, reduce the I/Os to that LUN and then try making the desired changes.

For additional information on this topic, refer to the chapter on "Multipathing" contained in the VMware *SAN Configuration Guide*.

Configuring Round Robin Multipathing on ESX 4.x or later for Fibre Channel

With ESX version 4.0 and later, VMware supports a round-robin I/O path policy for active/active storage arrays such as HP 3PAR StoreServ Storage. A round-robin I/O path policy is the preferred configuration for ESX 4.0 and later; however, this path policy is not enabled by default for HP 3PAR devices.

⚠ **CAUTION:** If you are running Windows Server 2012 or Windows Server 2008 VM Cluster with RDM shared LUNs, then individually change these specific RDM LUNs from **Round Robin** policy to **FIXED** or **MRU** path policy.

which is output from a Fibre Channel configuration, shows a LUN with a path that has been set to **Round Robin (VMware)**.

NOTE: Note that each path status is shown as **Active (I/O)**. The path status for an iSCSI configuration would be the same.

Figure 10 LUN Set to Round Robin
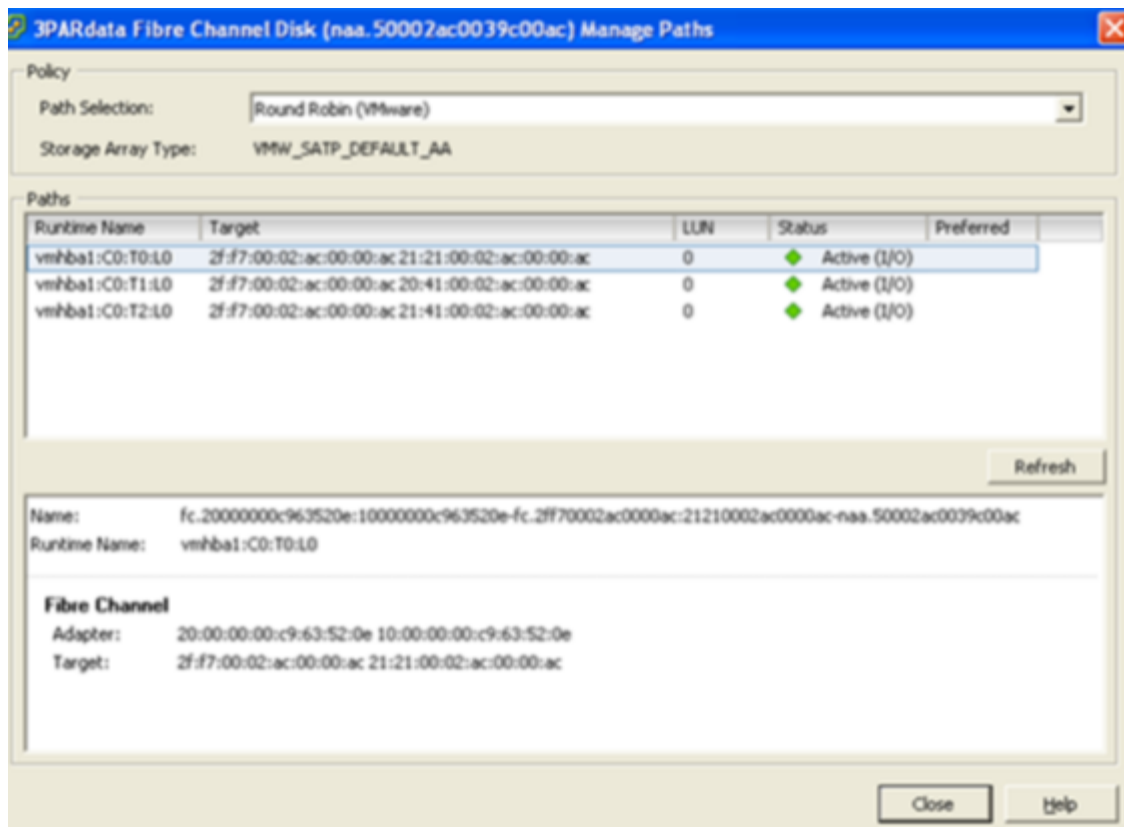
Managing a round robin I/O path policy scheme through the VI/vSphere client GUI for a large network can be cumbersome and challenging to maintain because the policy must be specified for each LUN individually and updated whenever new devices are added. Alternatively, VMware provides a mechanism whereby the server administrator can use esxcli, vCLI, or vSphere Management Assistant (vMA) commands to manage I/O path policy for storage devices on a per-host basis using parameters defined within a set of native ESX/ESXi storage plugins.

The VMware native multipathing has two important plugins: a Storage Array Type Plugin (SATP) that handles path failover and monitors path health, and a path-selection plugin (PSP) that chooses the best path and routes I/O requests for a specific logical device (PSP defines the path policy).

The correct ESX/ESXi host Storage Array Type Plugin (SATP) to be used is related to the HP 3PAR array host persona in use. When HP 3PAR host persona 6/`Generic-legacy` is the host persona in use with an ESX/ESXi host, the SATP `VMW_SATP_DEFAULT_AA` should be used. When HP 3PAR host persona 11/`VMware` is the host persona in use with an ESX/ESXi host, the SATP `VMW_SATP_ALUA` should be used.

For ESX/ESXi 4.0 versions (4.0 GA through all 4.0 updates), the *default* SATP rules must be edited in order to automatically achieve a round robin I/O path policy for storage devices.

As of ESX/ESXi 4.1, additional custom SATP rules can be created that target SATP/PSP to specific vendors while leaving the default SATP rules unmodified. The custom SATP can be used to automatically achieve a round robin I/O path policy for storage devices.

Configuring ESX/ESXi Multipathing for Round Robin via SATP PSP

△ **CAUTION:** VMware specifically warns not to directly edit the `esx.conf` file.

NOTE:

- SATP rule changes cannot be affected through vSphere GUI.
- SATP rule changes through esxcli commands populate the `esx.conf` file.
- A custom SATP rule is an added SATP rule that modifies or redefines parameters of an existing SATP default rule, defines the targeted devices to be affected, and is given a unique custom rule name.
- A custom SATP rule cannot be changed/edited. A custom SATP rule must be removed and then a new one created with the desired changes added to affect a change in the parameters of the custom rule.
- SATP and PSP creation, changes, additions, or removals will take effect for any new devices presented afterward without the need for server reboot.
- The host must be rebooted for SATP rule creation, changes, additions, or removals to take effect on existing, previously presented devices.
- Path policy changes done on an individual device basis, either done via vCenter or esxcli command, supersede the PSP path policy defined in a SATP rule, and such path policy changes to individual devices are maintained through host reboots.
- Valid PSP for SATP `VMW_SATP_DEFAULT_AA` rules are:
  - `VMW_PSP_RR`
  - `VMW_PSP_FIXED`
  - `VMW_PSP_MRU`

  `VMW_PSP_RR` is preferred.
- Valid PSP for SATP `VMW_SATP_ALUA` rules are:
  - `VMW_PSP_RR`
  - `VMW_PSP_MRU`

  `VMW_PSP_FIXED` is not a valid PSP to be defined within an ALUA SATP rule. `VMW_PSP_RR` is preferred.

Changing from HP 3PAR host persona 6/`Generic-legacy` to host persona 11/`VMware` or vice versa:

- A change from persona 6 to 11, or from 11 to 6, requires that the array ports affected be taken offline, or that the host for which the persona is being changed is not connected (not logged in). This is an HP 3PAR OS requirement.
- For existing devices targeted in a custom SATP rule to be claimed by the rule, the host must be rebooted. This is an ESX/ESXi OS requirement.

Because of the items required for this persona change listed above, the following procedure is recommended for changing from persona 6 to 11, or from 11 to 6:

1. Stop all host I/O and apply the necessary SATP changes (create custom SATP rule and/or modify default SATP rule PSP defaults) to the ESX/ESXi host.
2. Shut down the host.
3. Change the host persona on the array.
4. Boot the host.
5. Verify that the target devices have been claimed properly by the SATP rule as desired.

NOTE:

- Though ESX 4.0 GA - 4.0 Ux supports custom SATP rules, the `-P` options for setting PSP (path policy) within the custom rule are not supported. PSP must be defined within the default SATP rules.

- ESX 4.0 GA - 4.0 Ux has a known issue wherein no attempt should be made to change `iops` from its default value of 1000 (`iops = 1000`). If the `iops` value is changed, upon the next host reboot, an invalid value for `iops` is picked up and `iops` are then unpredictable.

- If the custom rule is not created for ALUA, 3PARdata VV's are claimed by the `VMW_SATP_DEFAULT_AA` SATP rule even though the array persona is 11/VMware (ALUA compliant array port presentation).

HP 3PAR SATP rules for use with **persona 6/Generic-legacy** (Active-Active array port presentation)

A "custom" SATP rule is not used. The PSP (path policy) is changed on the default active-active SATP rule. The default multipath policy for `VMW_SATP_DEFAULT_AA` is `VMW_PSP_FIXED (Fixed path)`. The default is changed to the preferred PSP (path policy) of round-robin.

```
# esxcli nmp satp setdefaultpsp -s VMW_SATP_DEFAULT_AA -P VMW_PSP_RR
```

HP 3PAR SATP rules for use with **persona 11/VMware** (ALUA compliant array port presentation)

```
# esxcli nmp satp setdefaultpsp -s VMW_SATP_ALUA -P VMW_PSP_RR
```

```
# esxcli nmp satp addrule -s "VMW_SATP_ALUA" -c "tpgs_on" -V "3PARdata" -M "VV" -e
"HP 3PAR Custom iSCSI/FC/FCoE ALUA Rule"
```

To remove the above ALUA custom SATP rule:

```
# esxcli nmp satp deleterule -s "VMW_SATP_ALUA" -c "tpgs_on" -V "3PARdata" -M "VV" -e
 "HP 3PAR Custom iSCSI/FC/FCoE ALUA Rule"
```

> **CAUTION:** The procedure for changing the default SATP rules to use the round robin I/O multipathing policy is intended to apply only to VMware hosts using HP 3PAR StoreServ Storage LUNs. If the host is sharing storage from other vendors, then before making any I/O policy changes, consideration should be given to the effect that changing the default rules will have on the storage environment as a whole.

A change of the default PSP for a given SATP affects all storage devices (FC, FCoE, iSCSI) that use the same default SATP rule. If a host is sharing multiple storage vendors together with an HP 3PAR StoreServ Storage, and if the other connected storage does not support active/active round robin multipathing using the same SATP rule, such as `VMW_SATP_DEFAULT_AA` or `VMW_DEFAULT_ALUA`, then its multipathing will be also be affected.

If the other storage uses a different SATP of its own, then SATP VMW_SATP_DEFAULT_AA mapping should be changed to VMW_PSP_RR to take advantage of round-robin multipathing. You can check the SATP-PSP relationship of a given device for ESX 4.0 by using the `esxcli nmp device list` or `esxcli nmp device list -d <device id>` command.

For example, If the HP 3PAR StoreServ Storage and storage X are connected to the same host using `VMW_SATP_DEFAULT_AA`, and if storage X does not have its own SATP, then it might cause an issue if storage X does not support round-robin multipathing. If the HP 3PAR StoreServ Storage and storage Y are sharing the same host, and if storage Y has its own SATP `VMW_SATP_Y` and HP uses `VMW_SATP_DEFAULT_AA`, then there will be no conflict, and the change can be made.

ESX/ESXi 4.1 GA - 4.1 Ux

HP 3PAR custom SATP rule for use with **persona 6/Generic-legacy** (Active-Active array port presentation)

```
# esxcli nmp satp addrule -s "VMW_SATP_DEFAULT_AA" -P "VMW_PSP_RR" -O iops=100 -c
"tpgs_off" -V "3PARdata" -M "VV" -e "HP 3PAR Custom iSCSI/FC/FCoE Rule"
```

To remove the above active-active custom SATP rule:

```
# esxcli nmp satp deleterule -s "VMW_SATP_DEFAULT_AA" -P "VMW_PSP_RR" -O iops=100 -c
 "tpgs_off" -V "3PARdata" -M "VV" -e "HP 3PAR Custom iSCSI/FC/FCoE Rule"
```

HP 3PAR custom SATP rule for use with **persona 11/VMware** (ALUA compliant array port presentation)

```
# esxcli nmp satp addrule -s "VMW_SATP_ALUA" -P "VMW_PSP_RR" -O iops=100 -c "tpgs_on"
 -V "3PARdata" -M "VV" -e "HP 3PAR Custom iSCSI/FC/FCoE ALUA Rule"
```

To remove the above ALUA custom SATP rule:

```
# esxcli nmp satp deleterule -s "VMW_SATP_ALUA" -P "VMW_PSP_RR" -O iops=100 -c "tpgs_on"
 -V "3PARdata" -M "VV" -e "HP 3PAR Custom iSCSI/FC/FCoE ALUA Rule"
```

ESXi 5.x

HP 3PAR custom SATP rule for use with **persona 6/Generic-legacy** (Active-Active array port presentation)

```
# esxcli storage nmp satp rule add -s "VMW_SATP_DEFAULT_AA" -P "VMW_PSP_RR" -O iops=100
 -c "tpgs_off" -V "3PARdata" -M "VV" -e "HP 3PAR Custom iSCSI/FC/FCoE Rule"
```

To remove the above Active-Active custom SATP rule:

```
# esxcli storage nmp satp rule remove -s "VMW_SATP_DEFAULT_AA" -P "VMW_PSP_RR" -O
iops=100 -c "tpgs_off" -V "3PARdata" -M "VV" -e "HP 3PAR Custom iSCSI/FC/FCoE Rule"
```

HP 3PAR custom SATP rule for use with **persona 11/VMware** (ALUA compliant array port presentation)

```
# esxcli storage nmp satp rule add -s "VMW_SATP_ALUA" -P "VMW_PSP_RR" -O iops=100 -c
 "tpgs_on" -V "3PARdata" -M "VV" -e "HP 3PAR Custom iSCSI/FC/FCoE ALUA Rule"
```

To remove the above ALUA custom SATP rule:

```
# esxcli storage nmp satp rule remove -s "VMW_SATP_ALUA" -P "VMW_PSP_RR" -O iops=100
 -c "tpgs_on" -V "3PARdata" -M "VV" -e "HP 3PAR Custom iSCSI/FC/FCoE ALUA Rule"
```

SATP Info Commands

Default SATP Rules and Their Current Default PSP

To list default SATP rules and their current default PSP (path policy), issue the following commands:

ESXi 5.x example

```
# esxcli storage nmp satp list
Name                   Default PSP     Description
--------------------   -------------   ----------------------------------------------------
VMW_SATP_ALUA          VMW_PSP_MRU     Supports non-specific arrays that use the ALUA protocol
VMW_SATP_MSA           VMW_PSP_MRU     Placeholder (plugin not loaded)
VMW_SATP_DEFAULT_AP    VMW_PSP_MRU     Placeholder (plugin not loaded)
VMW_SATP_SVC           VMW_PSP_FIXED   Placeholder (plugin not loaded)
VMW_SATP_EQL           VMW_PSP_FIXED   Placeholder (plugin not loaded)
VMW_SATP_INV           VMW_PSP_FIXED   Placeholder (plugin not loaded)
VMW_SATP_EVA           VMW_PSP_FIXED   Placeholder (plugin not loaded)
VMW_SATP_ALUA_CX       VMW_PSP_FIXED   Placeholder (plugin not loaded)
VMW_SATP_SYMM          VMW_PSP_FIXED   Placeholder (plugin not loaded)
VMW_SATP_CX            VMW_PSP_MRU     Placeholder (plugin not loaded)
VMW_SATP_LSI           VMW_PSP_MRU     Placeholder (plugin not loaded)
VMW_SATP_DEFAULT_AA    VMW_PSP_FIXED   Supports non-specific active/active arrays
VMW_SATP_LOCAL         VMW_PSP_FIXED   Supports direct attached devices
```

ESX/ESXi 4.x example

```
# esxcli nmp satp list
Name                   Default PSP     Description
VMW_SATP_ALUA_CX       VMW_PSP_FIXED   Supports EMC CX that use the ALUA protocol
VMW_SATP_SVC           VMW_PSP_FIXED   Supports IBM SVC
VMW_SATP_MSA           VMW_PSP_MRU     Supports HP MSA
VMW_SATP_EQL           VMW_PSP_FIXED   Supports EqualLogic arrays
VMW_SATP_INV           VMW_PSP_FIXED   Supports EMC Invista
VMW_SATP_SYMM          VMW_PSP_FIXED   Supports EMC Symmetrix
VMW_SATP_LSI           VMW_PSP_MRU     Supports LSI and other arrays compatible with the SIS 6.10 in non-AVT mode
VMW_SATP_EVA           VMW_PSP_FIXED   Supports HP EVA
VMW_SATP_DEFAULT_AP    VMW_PSP_MRU     Supports non-specific active/passive arrays
VMW_SATP_CX            VMW_PSP_MRU     Supports EMC CX that do not use the ALUA protocol
VMW_SATP_ALUA          VMW_PSP_RR      Supports non-specific arrays that use the ALUA protocol
VMW_SATP_DEFAULT_AA    VMW_PSP_RR      Supports non-specific active/active arrays
VMW_SATP_LOCAL         VMW_PSP_FIXED   Supports direct attached devices
```

SATP Custom Rules and Associated Defined Parameters

To list SATP custom rules and associated defined parameters, issue the following commands:

ESXi 5.x example

For persona 11:

```
# esxcli storage nmp satp rule list | grep -i 3par
VMW_SATP_ALUA 3PARdata    VV    user    tpgs_on
VMW_PSP_RR iops=100 HP 3PAR Custom iSCSI/FC/FcoE ALUA Rule
```

For persona 6:

```
# esxcli storage nmp satp rule list | grep -i 3par
VMW_SATP_DEFAULT_AA 3PARdata VV user tpgs_off
VMW_PSP_RR iops=100 HP 3PAR Custom iSCSI/FC/FCoE Rule
```

ESX/ESXi 4.x example

```
# esxcli nmp satp listrules | grep -i 3par
VMW_SATP_ALUA        3PARdata  VV
tpgs_on        HP 3PAR Custom iSCSI/FC/FCoE ALUA Rule
```

Show Device Information

To show device information, issue the following commands:

ESXi 5.x example

```
# esxcli storage nmp device list
naa.50002ac0000a0124
    Device Display Name: 3PARdata iSCSI Disk (naa.50002ac0000a0124)
    Storage Array Type: VMW_SATP_ALUA
    Storage Array Type Device Config: {implicit_support=on;explicit_support=on;
explicit_allow=on;alua_followover=on;{TPG_id=256,TPG_state=AO}}
    Path Selection Policy: VMW_PSP_RR
    Path Selection Policy Device Config:
{policy=rr,iops=100,bytes=10485760,useANO=0;lastPathIndex=1:
NumIOsPending=0,numBytesPending=0}
    Path Selection Policy Device Custom Config:
    Working Paths: vmhba3:C0:T1:L73, vmhba2:C0:T0:L73, vmhba2:C0:T1:L73, vmhba3:C0:T0:L73
```

ESX/ESXi 4.x example

The command is the same for ESX/ESXi 4.x. The output shown is for ESX 4.0:

```
# esxcli nmp device list
naa.50002ac000b40125
    Device Display Name: 3PARdata Fibre Channel Disk (naa.50002ac000b40125)
    Storage Array Type: VMW_SATP_DEFAULT_AA
    Storage Array Type Device Config:
    Path Selection Policy: VMW_PSP_RR
    Path Selection Policy Device Config:
{policy=rr,iops=1000,bytes=10485760,useANO=0;lastPathIndex=3:
NumIOsPending=0,numBytesPending=0}
    Working Paths: vmhba5:C0:T0:L25, vmhba5:C0:T1:L25, vmhba4:C0:T0:L25,
vmhba4:C0:T1:L25
```

For ESX 4.1, the `iops` will be 100 for the device list output shown above.

Script Alternative for Path Policy Changes on Storage Devices without a Host Reboot

If a reboot of the ESX/ESXi host to affect path policy changes through SATP on a large number of existing, previously presented storage devices is not desirable, the path policy changes on a batch of LUNs can be made by scripting esxcli commands.

Create a script that uses the following commands:

1. List all the HP 3PAR devices present on the host:

   ### ESXi 5.x

   ```
   # esxcli storage nmp device list | grep -i naa.50002ac | grep -v Device
   naa.50002ac0005800ac
   naa.50002ac003b800ac
   naa.50002ac0039300ac
   ```

   ### ESX/ESXi 4.x

   ```
   # esxcli nmp device list | grep -i naa.50002ac | grep -v Device
   naa.50002ac0005800ac
   naa.50002ac003b800ac
   naa.50002ac0039300ac
   ```

2. Change the I/O path policy to round robin for *each* device identified in the previous output:

   ### ESXi 5.x

   ```
   # esxcli storage nmp device set -d naa.50002ac0005800ac -P VMW_PSP_RR
   ```

   ### ESX/ESXi 4.x

   ```
   # esxcli nmp device setpolicy -d naa.50002ac0005800ac -P VMW_PSP_RR
   ```

3. Verify that the change has been made.

   ### ESXi 5.x

   ```
   # esxcli storage nmp device list -d naa.50002ac0005800ac
   ```

```
# esxcli nmp device list -d naa.50002ac0005800ac
```

NOTE: If I/O is active to a LUN and an attempt is made to modify the path policy, a failure can occur:

```
error during the configuration of the host: sysinfoException;
Status=Busy: Message=Unable to Set
```

If this problem occurs during an attempt to change the path policy, reduce the I/Os to that LUN and then try making the desired changes.

Performance Considerations for Multiple Host Configurations

The information in this section should be considered when using multiple ESX hosts, (or other hosts in conjunction with ESX hosts), that are connected in a fan-in configuration to a pair of HP 3PAR StoreServ Storage ports.

NOTE: For ESX 4.0 systems, HP recommends changing the ESX **Scsi.ConflictRetries** from its default value of 80 to a value of 200 when connected to an HP 3PAR StoreServ Storage running HP 3PAR OS version 2.2.4 or earlier. This change lengthens the time allowed for I/O retries due to ESX SCSI-2 reservation conflicts on VMFS LUNs caused by delayed processing of SCSI-2 reservation commands on the HP 3PAR StoreServ Storage, thereby helping to avoid VM I/O failure.

You can change this value using the VMware ESX VI/vSphere client: In the ESX host, select the **Configuration** tab, select **Advanced Settings** for software, select **Scsi**, scroll to **Scsi.ConflictRetries**, and change the value in the field. Click **OK** to complete the change. A reboot is not required for the change to take effect.

This does not have to be done for ESX 4.1 or ESXi 5.x systems.

ESX/ESXi Handling SCSI Queue Full and Busy Messages from the HP 3PAR StoreServ Storage Array

VMware ESX Releases through ESX 3.5 Update 3

The default behavior of an ESX 3.5 update 3 and older servers to Queue Full and Busy SCSI messages from the HP 3PAR StoreServ Storage is to treat them as valid commands and to continue sending data. When continued outstanding commands are being sent to an HP 3PAR StoreServ Storage port, the port cannot recover and stops responding for attached hosts.

This type of action is critical where QLogic HBAs are used on the HP 3PAR StoreServ Storage because, when the storage port stops responding, the QLogic driver on the HP 3PAR StoreServ Storage has to issue a reset of the affected port.

The time in which the HP 3PAR StoreServ Storage port is at full capacity and the reset time of the port does not trigger a failover in the ESX host, since the ESX host never detects the port going away. This results in a virtual machine crash. There are two solutions:

- Upgrade to ESX 3.5 Update 4 or later.

- Control the IO that each array port receives by manipulating the HBA queue depth (see "Modifying the Tuneable Parameters for Queue Depth Throttling in ESX 3.x" (page 49)).

VMware ESX Release 3.5 Update 4 through ESX 4.x and ESXi 5.0

As of VMware ESX release 3.5 update 4, and including ESX 4.0 GA and ESX 4.1 (with all ESX 4.x updates) , and ESXi 5.0 (with all updates), an algorithm has been added that allows ESX to respond to Queue Full and Busy SCSI messages from the storage array. The Queue Full or Busy response by ESX is to back off of I/O for a period of time, thus helping to prevent overdriving of the HP 3PAR StoreServ Storage ports. This feature should be enabled as part of an ESX - HP 3PAR StoreServ Storage deployment.

The **Queue Full** and **Busy** LUN-throttling algorithm is disabled by default. To enable the algorithm, complete the following steps:

1. From the VI/vSphere client, select the ESX host. In the **Configuration** tab, select **Advanced Settings** for software, and then select **Disk**.
2. Scroll to find and adjust the following HP-recommended settings:

   QFullSampleSize = 32

   QFullThreshold = 4

With the algorithm enabled, no additional I/O throttling scheme on ESX 3.5 update 4 and newer ESX release is necessary. Consult the additional information regarding the ESX **Queue Full**/**Busy** response algorithm found in KB 1008113, which is available on the VMware Knowledge Base website:

http://kb.vmware.com

VMware ESXi Release 5.1

The **Advanced Settings** parameters **QFullSampleSize** and **QFullSampleSize** are required to enable the adaptive queue-depth algorithm.

In ESXi releases earlier than ESXi 5.1, these parameters are set globally; that is, they are set on all devices seen by the ESXi host. In VMware ESXi 5.1, however, these parameters are set in a more granular fashion, on a per-device basis.

VMware patch ESXi510-201212001, dated 12/20/2012 (KB 2035775), restores the ability to set the values of these parameters globally. The patch is available on the VMware Knowledge Base website:

http://kb.vmware.com

To set the parameters globally, install the patch and follow the instructions in "VMware ESX Release 3.5 Update 4 through ESX 4.x and ESXi 5.0" (page 48).

You can also use the `esxcli` command to set these values on a per-device basis. If both options (the `esxcli` and the advanced parameters) are used, the per-device values take precedence.

To set `QFullSampleSize` and `QFullThreshold` on a per-device level, issue the following `esxcli` command:

```
# esxcli storage core device set --device  device_name -q Q -s S
```

The settings do not require a reboot to take effect and are persistent across reboots.

You can retrieve the values for a device by using the corresponding list command:

```
# esxcli storage core device list
```

The command supports an optional `--device` parameter:

```
#
esxcli storage core device list --device device_name
```

Follow-up Actions/Recommendations for ESX 3.5 Update 3 and Earlier

The behavior of the HP 3PAR StoreServ Storage port being overrun is limited only to ESX 3.5 update 3 and earlier servers.

Other HP-supported operating systems handle Queue Full notifications by backing off on I/O for a period of time. HP currently does not have any HP 3PAR StoreServ Storage firmware to address this issue but there are recommendations that can help prevent this problem from occurring as detailed in the following sections.

Considering that the ESX 3.5 update 3 and older server default behavior with regard to "Queue Full" messages does not initiate a pause or throttling of I/O, it is important to plan your ESX environments accordingly. This involves tuning the work load of the total number of ESX hosts so they do not overrun the Queue Depth of the target HP 3PAR StoreServ Storage HBA Ports.

Recommendations for ESX Hosts Attached to a Storage Port on the HP 3PAR StoreServ Storage

For performance and stability, HP recommends that no more than 16 hosts be attached to any one 2 Gbps HP 3PAR StoreServ Storage port, and no more than 32 hosts attached to any one 4 Gbps or 8 Gbps HP 3PAR StoreServ Storage port. This is due to the HP recommendation to throttle the total aggregate of the outstanding commands from all hosts to be less than the queue depth of the HP 3PAR StoreServ Storage port and throughput.

NOTE: These recommendations are guidelines for best practice. Adding more than the recommended ESX hosts should only be attempted when the total expected workload is calculated and shown not to overrun either the queue depth or throughput of the storage port.

Modifying the Tuneable Parameters for Queue Depth Throttling in ESX 3.x

The default settings for `target port queue depth` on the ESX host can be modified to ensure that the total workload of all servers will not overrun the total queue depth of the target HP 3PAR StoreServ Storage port. The method endorsed by HP is to `limit the queue depth on a per-target basis`. This recommendation comes from the simplicity in limiting the number of outstanding commands on a target (HP 3PAR StoreServ Storage port) per ESX host.

The following values can be set on the instances of an HBA in an ESX operating system. These values limit the total number of outstanding commands that the operating system routes to one target.

1. ESX Emulex HBA Target Throttle = tgt_queue_depth
2. ESX QLogic HBA Target Throttle = ql2xmaxdepth

The formula is as follows:

```
(3PAR port queue depth) / (total number of ESX severs attached) = recommended target
 port queue depth.
```

The HP 3PAR port queue depth limitations used for the calculations are from the listings in "Target Port Limits and Specifications" (page 14).

Example 1 (set up as follows):

- QLogic 2G FC HBAs installed on the HP 3PAR StoreServ Storage

- 16 ESX hosts attached to a QLogic port on the HP 3PAR StoreServ Storage

Formula:

```
497 / 16 = 31.xxx (recommended max target port queue depth = 31)
```

Example 2 (set up as follows):

- LSI 2G FC HBA installed on the HP 3PAR StoreServ Storage
- 12 ESX hosts attached to a LSI port on the HP 3PAR StoreServ Storage

Formula:

```
510 / 12 = 42.xxx (recommended max target port queue depth = 42)
```

Setting tgt_queue_depth for Emulex in ESX 3.x (example)

To set the `tgt_queue_depth` for an Emulex FC HBA in ESX 3.x to something other than the default requires a multistep process:

1. Shut down all of the virtual machines.
2. Log into the ESX service console as root.
3. Make a backup copy of `/etc/vmware/esx.conf`.

```
cp /etc/vmware/esx.conf /etc/vmware/esx.conf.orig
```

4. Identify the Emulex HBA module that is currently loaded.

```
vmkload_mod -l | grep -i lpfc
```

Depending on the module of the HBA, the module can be one of the following:

- `lpfcdd_7xx`
- `lpfcdd_732`
- `lpfc_740`

5. The target queue depth can now be modified via the command line using VMware supplied binaries.

The example shows the `lpfc_740` module. Use the appropriate module based on the outcome of Step 4.

```
esxcfg-module -s "lpfc_tgt_queue_depth=31" lpfc_740
esxcfg-boot -b
```

6. You can check to see that the change has been implemented as follows:

```
esxcfg-module -q
```

7. Reboot the ESX host for the changes to take effect.

Upon bootup, the ESX host will now be throttled to a maximum of 31 outstanding commands (as in the example shown in Step 5) to the target HP 3PAR StoreServ Storage port).

Setting ql2xmaxdepth for QLogic in ESX 3.x (example)

To set the `ql2xmaxdepth` for an QLogic FC HBA in ESX 3.x to something other than the default requires a multi step process.

1. Shut down all of the virtual machines.
2. Log into the ESX service console as root.

3. Make a backup copy of `/etc/vmware/esx.conf`.

```
cp /etc/vmware/esx.conf /etc/vmware/esx.conf.orig
```

4. Identify the QLogic HBA module that is currently loaded.

```
vmkload_mod -l | grep qla2300
```

Depending on the model of the HBA, the module can be one of the following:

`qla2300_707` (ESX 3.0.x)

`qla2300_707_vmw` (ESX 3.5)

5. The target port queue depth can now be modified via the service console command line using VMware supplied binaries.

The example shows the `qla2300_707` module. Use the appropriate module based on the outcome of Step 4.

```
esxcfg-module -s ql2xmaxqdepth=42 qla2300_707
esxcfg-boot –b
```

The server must now be rebooted for the changes to take effect.

6. Reboot the ESX host.

Upon boot up, the ESX host will now be throttled to a maximum of 42 outstanding commands (as per the example in Step 5) to the target (HP 3PAR StoreServ Storage port).

NOTE: For additional information on changing the queue depth for HBAs, refer to the *VMware Fibre Channel SAN Configuration Guide*.

ESX/ESXi 4.1, ESXi 5.x Additional Feature Considerations

ESX/ESXi 4.1 and ESXi 5.x introduce new features related to storage I/O control and integration with storage arrays. HP recommends the usage of features SIOC and vStorage APIs for Array Integration (VAAI) with ESX/ESXi 4.1, ESXi 5.x - HP 3PAR StoreServ Storage configurations.

NOTE: This section about VAAI and new additional features applies to all connectivity types: FC, FCoE and iSCSI.

Storage I/O Control

The SIOC feature allows for a new level of monitoring and control of I/O from individual virtual machines to an HP 3PAR StoreServ Storage array at the datastore level and across ESX/ESXi hosts in a VMware cluster.

Further information regarding the SIOC feature and considerations for its deployment may be found in the VMware technical white paper, *Storage I/O Control Technical Overview and Considerations for Deployment*:

http://www.vmware.com/files/pdf/techpaper/VMW-vSphere41-SIOC.pdf

vStorage APIs for Array Integration (VAAI)

In partnership with VMware, HP has developed an ESX/ESXi 4.1 plugin that enables a new set of SCSI commands to be used by ESX/ESXi 4.1 in conjunction with HP 3PAR StoreServ Storage. VMware refers to this newly incorporated set of SCSI commands as the "primitives".

ESX extensions that make use of these primitives are collectively referred to as vStorage APIs for Array Integration (VAAI). The VMware primitives enable an ESX/ESXi host to convey virtual machine operations to storage hardware at a meta level instead of at the traditional data level. This reduces operational latency and traffic on the FC fabric/iSCSI network. Some of these primitives enable the storage hardware to participate in block allocation and de-allocation functions for virtual machines. These primitives are also known as hardware offloads.

A brief description of the "primitives":

- Full Copy (XCOPY) enables the storage array to make full copies of data within the array without having to have the ESX host read and write the data. This offloads some data copy processes to the storage array.

- Block Zeroing (WRITE-SAME) enables the storage array to zero-out a large number of blocks within the array without having to have the ESX host write the zeros as data and helps expedite the provisioning of VMs. This offloads some of the file space zeroing functions to the storage array.

- Hardware Assisted Locking (ATS) provides an alternative to SCSI reservations as a means to protect the metadata for VMFS cluster file systems and helps improve the scalability of large ESX host farms sharing a datastore.

HP 3PAR VAAI Plugin 1.1.1 for ESXi 4.1

Support for VMware VAAI functionality is available via installation of the HP 3PAR VAAI Plugin 1.1.1 on ESX/ESXi 4.1 in combination with HP 3PAR HP 3PAR OS version 2.3.1 MU2 (minimum).

For further information on VMware VAAI, the HP 3PAR VAAI Plugin for ESX/ESXi 4.1 installation package, and the *HP 3PAR VAAI Plug-in 1.1.1 for VMware vSphere 4.1 User's Guide*, go to:

https://h20392.www2.hp.com/portal/swdepot/displayProductInfo.do?productNumber=HP3PARVAAI&jumpid=reg_r1002_usen

HP 3PAR VAAI Plugin 2.2.0 for ESXi 5.x

HP 3PAR VAAI Plugin 2.2.0 on ESXi 5.x needs to be installed if the HP 3PAR StoreServ Storage HP 3PAR OS is 2.3.1 MU2 or a higher version of HP 3PAR OS 2.3.1, to take advantage of the storage array primitives or hardware offloads (mainly XCOPY, Write-Same, and ATS).

HP 3PAR VAAI Plug 2.2.0 should not be installed on the ESXi 5.x if connected to an HP 3PAR StoreServ Storage running HP 3PAR OS 3.1.1 or later, because the VAAI primitives are handled by the default T10 VMware plugin and do not require the HP 3PAR VAAI plugin.

The following table summarizes the HP 3PAR VAAI Plugin installation requirements.

Table 2 HP 3PAR VAAI Plugin Installation Requirements

VMware ESX Features/Primitives	ESX 4.1	ESX 4.1	ESXi 5.x	ESXi 5.x
	HP 3PAR OS 2.3.1 MU2 or later	HP 3PAR OS 3.1.1 or later	HP 3PAR OS 2.3.1 MU2 or later	HP 3PAR OS 3.1.1 or later
ATS	Needs HP 3PAR VAAI 1.1.1 plugin	Needs HP 3PAR VAAI 1.1.1 plugin	Needs HP 3PAR VAAI 2.2.0 plugin	Supported. Does not require HP 3PAR VAAI plugin (supported by Standard T10 ESX plugin).
XCOPY				
WRITE_SAME				

NOTE: VAAI Plugin 2.2.0 is required if the ESXi 5.x server is connected to two or more arrays that are running a mix of OS HP 3PAR OS 2.3.1.x and OS 3.1.x. For LUNs on HP 3PAR OS 3.1.x, the default VMware T10 plugin will be effective, and for storage LUNs on HP 3PAR OS 2.3.x, HP 3PAR VAAI Plugin 2.2.0 will be effective.

For more information, refer to the *HP 3PAR VAAI Plug-in Software for VMware vSphere User's Guide* (HP part number QL226-96072).

To download the HP 3PAR VAAI Plugin software, go to:

https://h20392.www2.hp.com/portal/swdepot/displayProductInfo.do?productNumber=HP3PARVAAI&jumpid=reg_r1002_usen

UNMAP (Space Reclaim) Storage Hardware Support for ESXi 5.x

HP 3PAR OS 3.1.1 or later supports the UNMAP storage primitive for space reclaim, which is supported starting with ESXi 5.0 update 1 with default VMware T10 VAAI plugin. Installation of the HP 3PAR VAAI plugin is not required.

NOTE: To avoid possible issues described in VMware KB 2007427 and 2014849, *automatic* VAAI Thin Provisioning Block Space Reclamation (UNMAP) should be disabled on ESXi 5.0 GA.

The KB articles are available on the VMware Knowledge Base website:

http://kb.vmware.com

ESXi 5.0 update 1 and later includes an updated version of `vmkfstools` that provides an option `[-y]` to send the UNMAP command regardless of the ESXi host's global setting. You can use the `[-y]` option as follows:

```
# cd /vmfs/volumes/<volume-name>
vmkfstools -y <percentage of deleted block to reclaim>
```

NOTE: The `vmkfstools -y` option does not work in ESXi 5.0 GA.

UNMAP will also free up space if files are deleted on UNMAP-supported VMs such as Red Hat Enterprise 6, provided it is a RDM LUN on a TPVV storage volume-—for example, for RDM volumes on a Red Hat VM using the `ext4` filesystem and mounted using the discard option.

```
# mount —t ext4 —o discard /dev/sda2 /mnt
```

This will cause the RH6 VM to issue the `UNMAP` command and cause space to be released back on the array for any deletes in that `ext4` file system.

Out-of-Space Condition for ESX 4.1 and ESXi 5.x

The out-of-space condition, aka "VM STUN", is implemented in ESX 4.1 and ESXi 5.x and is supported as of HP 3PAR OS 2.3.1 MU2. This OS feature has no dependency on the VAAI plugin and applies to TPVV volume types.

When the TPVV volume cannot allocate additional storage space or cannot grow because the storage system has run out of disk space, it sends Check condition with "DATA PROTECT" sense key hard error and additional sense "SPACE ALLOCATION FAILED WRITE PROTECT". As a result, ESX pauses the VM and displays an 'Out of Space' message to the user in the **Summary** tab of the VM on vSphere, with the options of **Retry** or **Cancel**. In the pause-VM condition, read requests and rewrites to the allocated LUN blocks are allowed, but writing to a new space is not allowed. Ping, telnet and ssh requests to the VM are not honored. The storage administrator needs to add additional disk space or use storage vMotion to migrate other unaffected VMs from the LUN. After

additional disk space is added, use the **Retry** option on the warning message to bring the VM back to the read-write state. If you select the **Cancel** option, the VM is rebooted.

In the following example, an HP 3PAR StoreServ Storage TPVV volume was created with a warning limit of 60%, as shown in the `showvv -alert` command.

```
# showvv -alert
-----------Alerts----------- -- (MB)-- -Snp(%VSize)- -Usr(%VSize)- Adm ----Snp----- ---- Usr-----
Id Name Prov Type VSize Used Wrn Lim Used Wrn Lim Fail Fail Wrn Lim Fail Wrn Lim
612 nospace1 tpvv base 102400 0.0 -- -- 61.1 60 - - - - - - - - Y
```

When the warning limit is reached, the HP 3PAR StoreServ Storage sends a soft threshold error asc/q: 0x38/0x7 and ESX continues to write.

```
InServ debug log:
1 Debug Host error undefined Port 1:5:2 -- SCSI status 0x02 (Check
condition) Host:sqa-dl380g5-14-esx5 (WWN 2101001B32A4BA98) LUN:22 LUN
WWN:50002ac00264011c VV:0 CDB:280000AB082000000800 (Read10) Skey:0x06 (Unit attention)
asc/q:0x38/07 (Thin provisioning soft threshold reached) VVstat:0x00 (TE_PASS
-- Success) after 0.000s (Abort source unknown) toterr:74882, lunerr:2

# showalert
Id:       193
State:     New
Message Code:  0x0270001
Time:    2011-07-13 16:12:15 PDT
Severity:   Informational
Type:     TP VV allocation size warning
Message:    Thin provisioned VV nospace1 has reached allocation
warning of 60G (60% of 100G)
```

When the HP 3PAR StoreServ Storage runs out of disk space, a hard permanent error asc/q: 0x27/0x7 is sent. Use `showspace`, `showvv -r`, and `showalert` to see the warning and space usage. The ESX responds by stunning the VM.

```
InServ debug log:
1 Debug Host error undefined Port 1:5:2 -- SCSI status 0x02 (Check
condition) Host:sqa-dl380g5-14-esx5 (WWN 2101001B32A4BA98) LUN:22 LUN
WWN:50002ac00264011c VV:612 CDB:2A00005D6CC800040000 (Write10) Skey:0x07 (Data protect)
asc/q:0x27/07 (Space allocation failed write protect) VVstat:0x41 (VV_ADM_NO_R5
-- No space left on snap data volume) after 0.302s (Abort source unknown)
toterr:74886, lunerr:3
```

The following figure shows the VM warning displayed on the vSphere with the **Retry** and **Cancel** options.

Figure 11 Virtual Machine Message — Retry and Cancel options
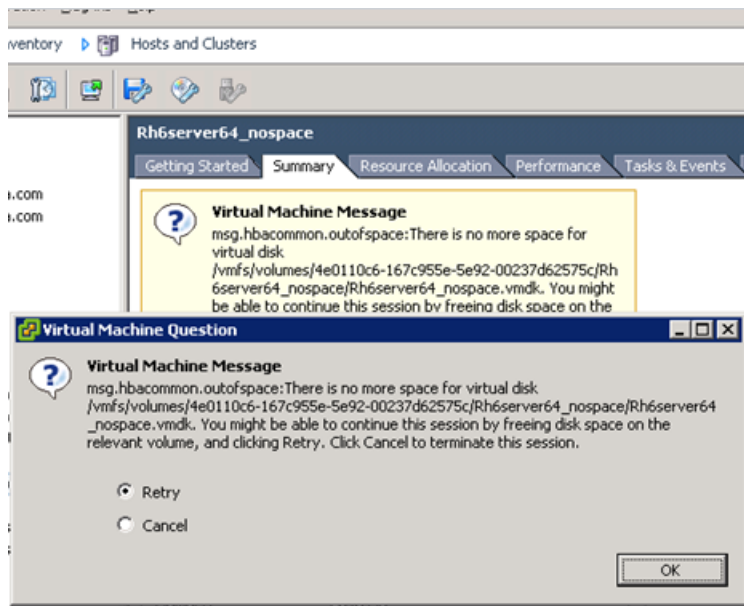
Additional New Primitives Support on ESXi 5.x

HP 3PAR OS 3.1.1 or later supports additional new primitives, called TP LUN Reporting, where the ESXi 5.x is notified that a given LUN is a thin provisioning LUN by enabling the TPE bits of the READ Capacity (16) and enables the host to use features such as sending the UNMAP command to these LUNs. The TPE bit is enabled for TPVVs and R/W snapshot of TPVV base.

The Quota Exceeded Behavior present in ESXi 5.x is accomplished through the "Thin Provisioning Soft Threshold Reached" check condition, providing alerts and warnings.

VAAI and New Feature Support Table

The following table summarizes the VAAI plugin requirements and New Primitives support.

Table 3 HP 3PAR VAAI Plugin Installation Requirements

VMware ESX Features/Primitives	ESX 4.1	ESX 4.1	ESXi 5.x	ESXi 5.x
	HP 3PAR OS 2.3.1 MU2 or later	HP 3PAR OS 3.1.1 or later	HP 3PAR OS 2.3.1 MU2 or later	HP 3PAR OS 3.1.1 or later
ATS	Needs HP 3PAR VAAI 1.1.1 plugin	Needs HP 3PAR VAAI 1.1.1 plugin	Needs HP 3PAR VAAI 2.2.0 plugin	Supported. Does not require HP 3PAR VAAI plugin (supported by Standard T10 ESX plugin).
XCOPY				
WRITE_SAME				
UNMAP	Not supported by ESX 4.1 or later. Not supported by HP 3PAR OS 2.3.1	Not supported by ESX 4.1 or later	Not supported by HP 3PAR OS 2.3.1	
Out-of-space condition (aka "VM STUN")	Supported. HP 3PAR VAAI 1.1 plugin recommended, but not required for this specific feature.	Supported. HP 3PAR VAAI 1.1 plugin recommended, but not required for this specific feature.	Supported. HP 3PAR VAAI 1.1 plugin recommended, but not required for this specific feature.	
Quota Exceeded Behavior	Not supported by ESX 4.1 or later. Not supported by HP 3PAR OS 2.3.1	Not supported by ESX 4.1 or later	Not supported by HP 3PAR OS 2.3.1	
TP LUN Reporting				

VAAI Plugin Verification

NOTE: VAAI Plugin 2.2.0 must be installed if an ESXi 5.x server is connected to two or more arrays that are running a mix of HP 3PAR OS 2.3.x and 3.1.x. For LUNs from HP 3PAR OS 3.1.x, the default VMware T10 plugin will be effective, and for storage LUNs from HP 3PAR OS 2.3.x, HP 3PAR VAAI Plugin 2.2.0 will be effective.

To verify that VAAI 2.2.0 is installed on ESXi 5.x and enabled for HP 3PARdata vendor, use the following commands (only contents that are applicable to vendor HP 3PARdata are shown in the output):

- To show that the plugin has been installed:

```
# esxcli storage core plugin list
          Plugin name        Plugin class
          -----------------  ------------
          3PAR_vaaip_InServ  VAAI
```

The vSphere shows that hardware acceleration is supported on the HP 3PAR devices.

- To show the version of the plugin:

```
# esxcli software vib list | grep -i 3par
Name                          Version          Vendor  Acceptance Level    Install Date
-----------------------       ---------------  ------  --------------      -----------
vmware-esx-3PAR_vaaip_InServ 2.2-2 3PAR VMwareCertified
```

To show that the plugin is active in the `claimrule`, which runs for each of the devices discovered:

```
# esxcli storage core claimrule list -c VAAI
Rule           Class      Rule     Class    Type               Plugin Matches
----------     -----      -------  ------   ----------------   --------------------------
VAAI 5001 runtime vendor 3PAR_VAAIP_INSERV vendor=3PARdata model=*
VAAI 5001 file vendor 3PAR_VAAIP_INSERV vendor=3PARdata model=*
```

- To show that the VAAI is enabled for the HP 3PAR data device:

```
# esxcfg-scsidevs -l
naa.50002ac0002200d7
   Device Type: Direct-Access
   Size: 51200 MB
   Display Name: 3PARdata Fibre Channel Disk (naa.50002ac0002200d7)
   Multipath Plugin: NMP
   Console Device: /vmfs/devices/disks/naa.50002ac0002200d7
   Devfs Path: /vmfs/devices/disks/naa.50002ac0002200d7
   Vendor: 3PARdata  Model: VV                   Revis: 0000
   SCSI Level: 5  Is Pseudo: false Status: on
   Is RDM Capable: true  Is Removable: false
   Is Local: false Is SSD: false
   Other Names:
      vml.020022000050002ac0002200d7565620202020
VAAI Status: supported
```

- On ESX 4.1, you can verify that the VAAI Plugin is installed and enabled on devices using the following commands:
- To show the version of the installed VAAI plugin:

```
# esxupdate --vib-view query | grep 3par
         cross_3par-vaaip-inserv_410.1.1-230815
             installed
```

- To show that the claim rule is in effect for the HP 3PAR devices discovered:

```
# esxcli corestorage claimrule list -c VAAI
Rule    Class  Rule      Class   Type              Plugin Matches
VAAI    5001   runtime   vendor  3PAR_vaaip_InServ vendor=3PARdata model=*
VAAI    5001   file      vendor  3PAR_vaaip_InServ vendor=3PARdata model=*
```

- To show that the VAAI is supported on the device:

```
# esxcfg-scsidevs -l
    naa.50002ac003da00eb
   Device Type: Direct-Access
   Size: 512000 MB
   Display Name: 3PARdata iSCSI Disk (naa.50002ac003da00eb)
   Multipath Plugin: NMP
   Console Device: /dev/sdx
   Devfs Path: /vmfs/devices/disks/naa.50002ac003da00eb
   Vendor: 3PARdata   Model: VV               Revis: 3110
   SCSI Level: 5   Is Pseudo: false Status: on
   Is RDM Capable: true   Is Removable: false
   Is Local: false
   Other Names:
       vml.020001000050002ac003da00eb565620202020
VAAI Status: supported
```

ESXi 5.x with HP 3PAR OS 3.1.1 uses the native T10 plugin, and should not show any HP 3PAR plugin.

```
# esxcli storage core plugin list
Plugin name  Plugin class
-----------  ------------
NMP          MP
```

The following outputs shows that Hardware Acceleration is enabled on HP 3PAR LUNs to take advantage of the storage primitives on ESX 4.1 and ESXi 5.x. Use the esxcfg-advcfg command to check that the options are set to 1 (enabled):

```
# esxcfg-advcfg -g /DataMover/HardwareAcceleratedMove
# esxcfg-advcfg -g /DataMover/HardwareAcceleratedInit
# esxcfg-advcfg -g /VMFS3/HardwareAcceleratedLocking
```

Figure 12 Hardware Acceleration for HP 3PAR devices

VMware All Paths Down

All Paths Down (APD), a feature of the VMware ESXi host used in cases where all paths to the VM go down because of storage failure or administrative error, is properly handled in ESX 5.1 as a result of feature enhancement performed by VMware. Previously, in ESX versions 5.0 or 4.1, the host would try continuously to revive the storage links and, as a result, performance would be impacted for working VMs. A host reboot was required to clear this error.

6 Configuring the Host as an FCoE Initiator Connecting to a FC target or an FCoE Target

All contents of the Fibre Channel section of this guide apply to FCoE connectivity as well. See the following sections:

- "Multipath Failover Considerations and I/O Load Balancing" (page 37)
- "Performance Considerations for Multiple Host Configurations" (page 47)
- "ESX/ESXi 4.1, ESXi 5.x Additional Feature Considerations" (page 51)

This chapter describes the procedures for setting up an ESX software Fibre Channel over Ethernet (FCoE) configuration with an HP 3PAR StoreServ Storage. The instructions in this chapter should be used in conjunction with the *VMware vSphere Storage Guide*. These instructions cover both end-to-end FCoE and FCoE initiator to FC target.

Configuring the FCoE Switch

Connect the ESX (FCoE Initiator) host ports and HP 3PAR StoreServ Storage server (FCoE target) ports to an FCoE-enabled switch.

NOTE: FCoE switch VLANs and routing setup and configuration is beyond the scope of this document. Consult your switch manufacturer's documentation for instructions of how to set up VLANs and routing.
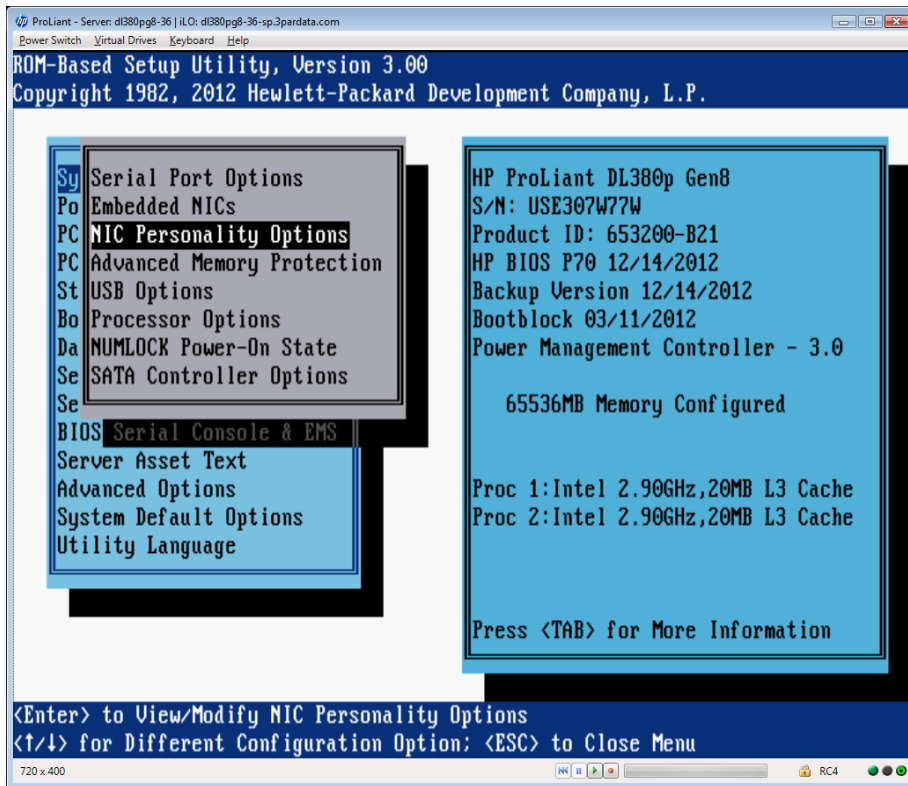
Using system BIOS to configure FCoE

1. Enter the setup menu. The combination of keys to press to enter setup may be different depending on the host being configured. The example below is for an HP ProLiant:
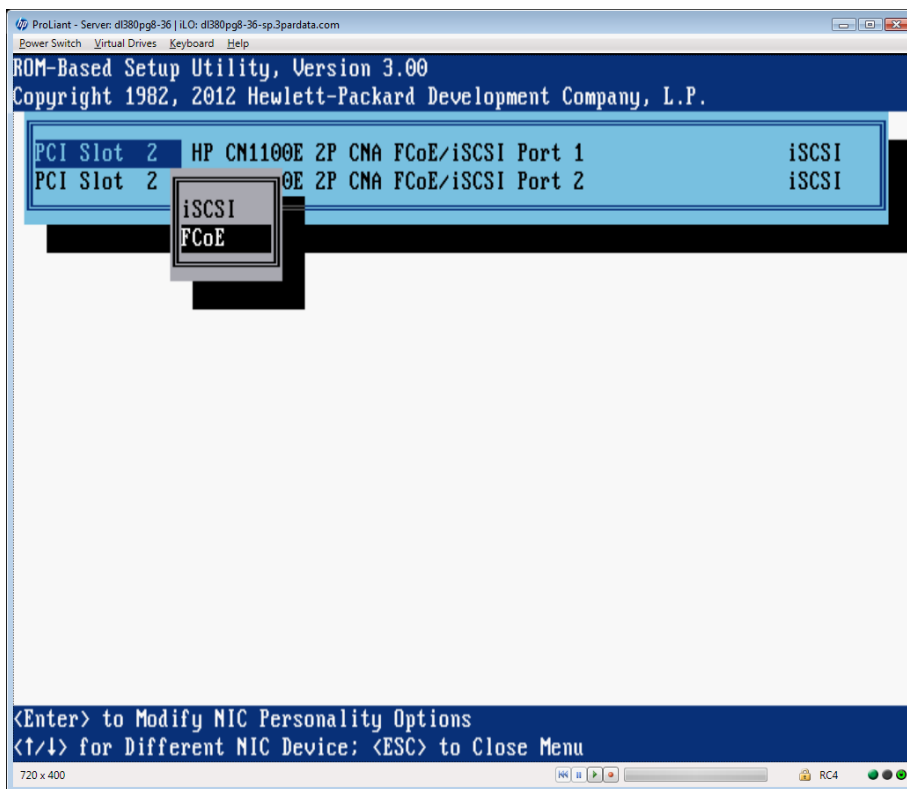
Figure 13 Configuring FCoE
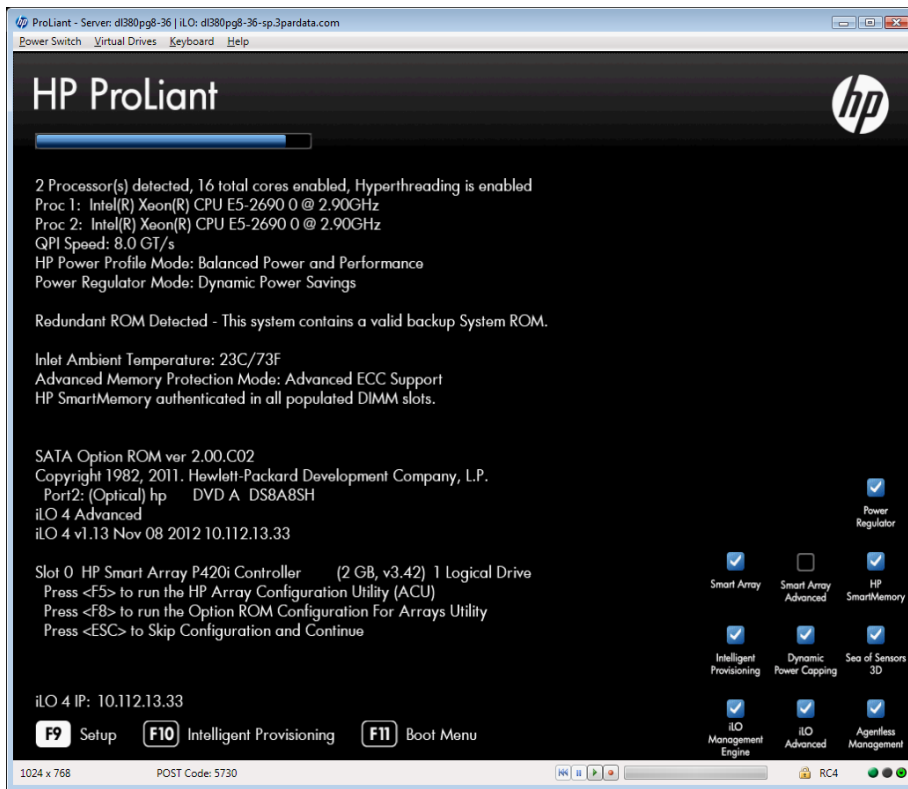
2. In the **System Options** pane, select **NIC Personality Options**.
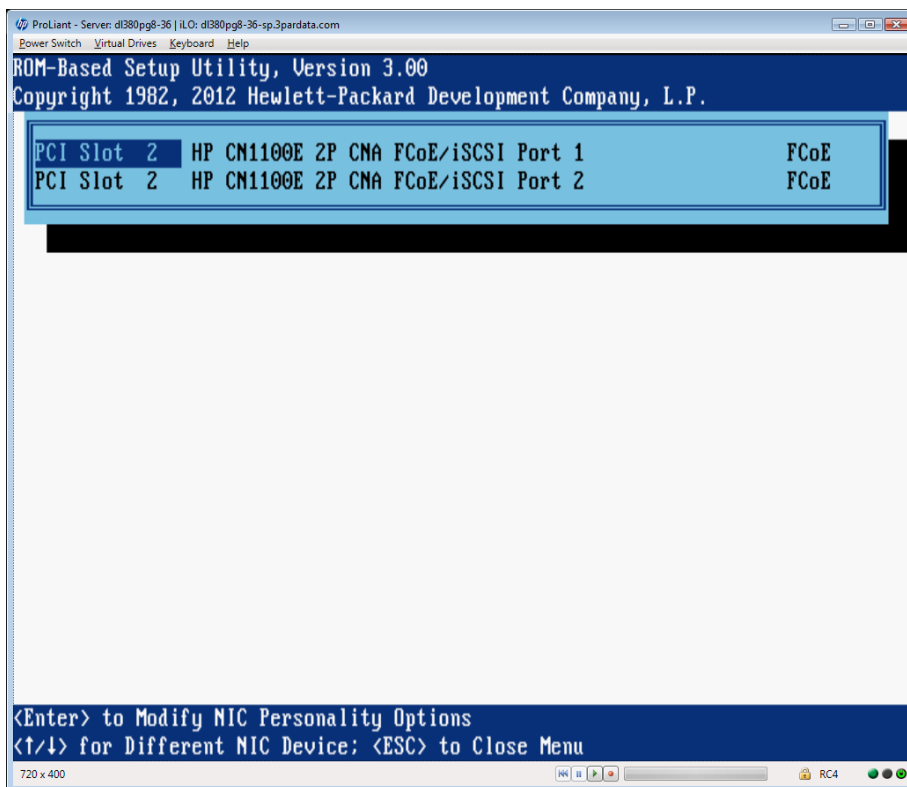
Figure 14 NIC Personality Options

3. In the **PCI Slot 2** Pane, select **FCoE** for both **Port 1** and **Port 2**.
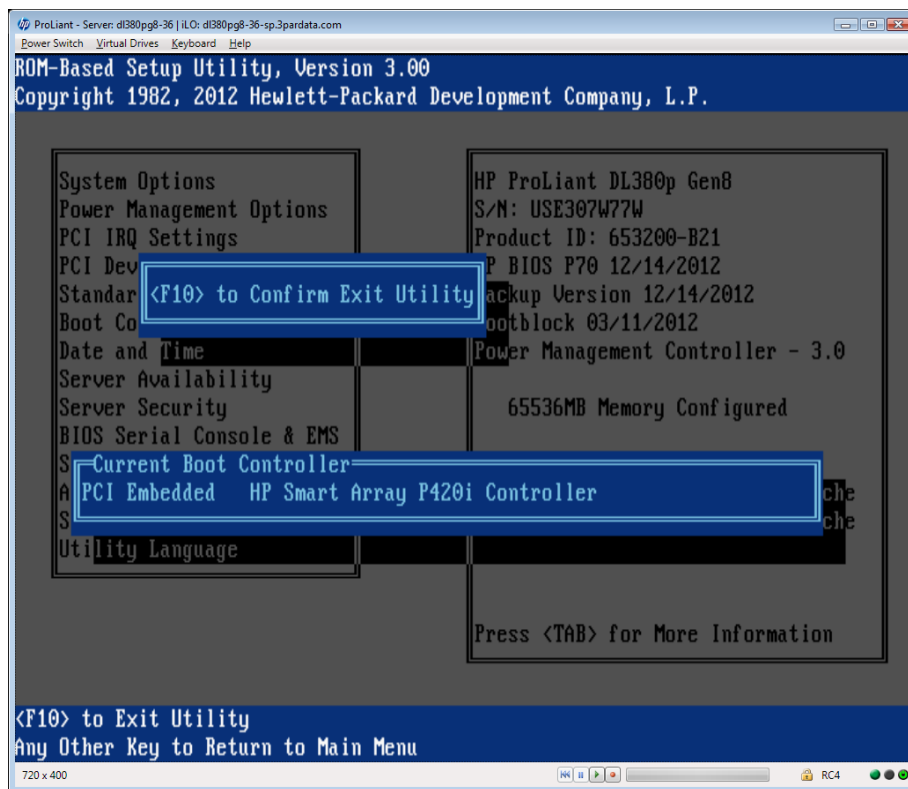
Figure 15 Configuring the PCI Slots

4. **PCI Slot 2 Port 1** and **Port 2** now display **FCoE**.

Figure 16 PCI Slot 1 and Slot 2 Configured for FCoE

5. Save the changes and exit the BIOS.

Figure 17 Exiting the BIOS Utility

Configuring an HP 3PAR StoreServ Storage Port for a FCoE Host Connection

When setting up FCoE initiator to FC target, there is nothing unique that needs to be configured on the HP 3PAR StoreServ Storage. The initiator coming from the host adapters through the FCoE Forwarder switch is treated as just another Fibre Channel device connecting to the HP 3PAR StoreServ Storage ports. The same guidelines described in "Configuring the HP 3PAR StoreServ Storage for Fibre Channel" (page 8) and "Configuring the Host for a Fibre Channel Connection" (page 35) must be followed when a server with a host CNA card configured with FCoE is connected to HP 3PAR StoreServ Storage ports.

When setting up FCoE initiator to FCoE target, the StoreServ ports must be configured for FCoE. See Chapter 4, "Configuring the HP 3PAR StoreServ Storage for FCoE" (page 31), for notes on how to configure FCoE ports on the StoreServ.

NOTE: For specific configurations that support FCoE CNAs and forwarder switches, refer to the appropriate HP 3PAR OS release version on the HP SPOCK website:

http://www.hp.com/storage/spock

Configuring Initiator FCoE to FC Target

If an FCoE to FC configuration is being set up, the following figure summarizes the general steps you should follow to configure a CNA and FCoE Forwarder Switch.

Figure 18 Initiator FCoE to FC Target
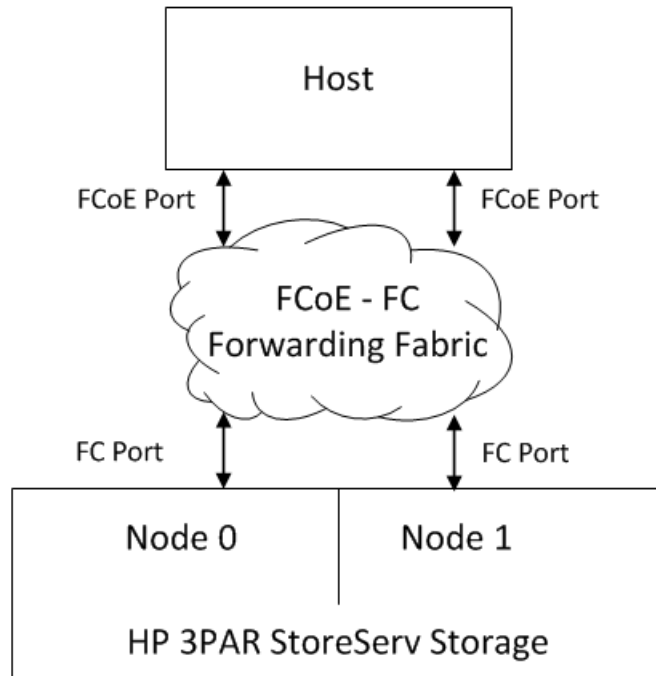
NOTE: For complete and detailed instructions for configuring a server with a given Converged Network Adapter, refer to the CNA manufacturer documentation.

The FCoE switch or FCoE forwarder must be able to convert FCoE traffic to FC and also be able to trunk this traffic to the fabric that the HP 3PAR StoreServ Storage target ports are connected to.
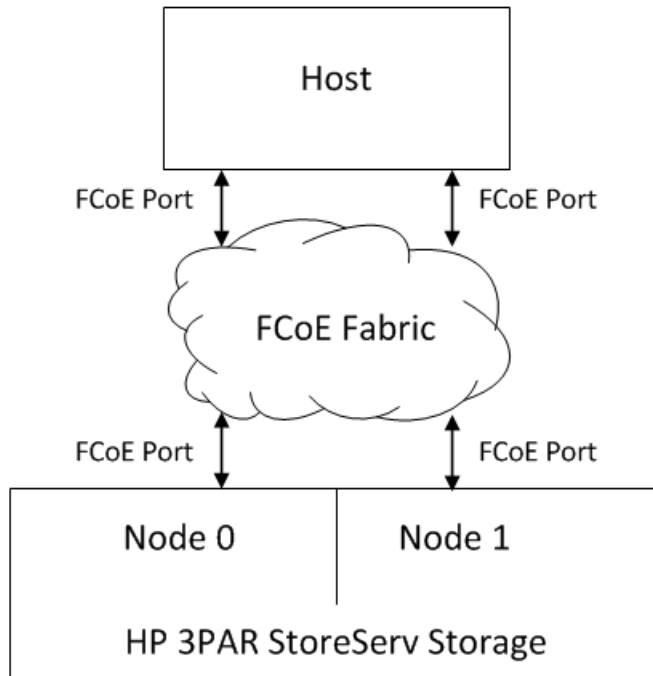
1. Install the CNA card in the server just like any other PCIe card - refer to the server vendor documentation.
2. Install the CNA card driver following the CNA card installation instructions (it assumes the server is already running a supported operating system).
3. Physically connect the server CNA card ports to the FCoE Forwarder switch and configure the FCoE Forwarder switch ports - refer to the switch vendor documentation.
4. Configure the HP 3PAR StoreServ Storage ports in accordance with the guidelines in section "Configuring the HP 3PAR StoreServ Storage Running HP 3PAR OS 3.1.x or OS 2.3.x" (page 8) and connect the HP 3PAR StoreServ Storage port either to the FCoE Forwarder FC switch ports or the Fibre Channel fabric connected to the FCoE Forwarder.
5. Create FC zones for the host initiator's ports and the HP 3PAR StoreServ Storage target port. Once the initiators have logged in to the HP 3PAR StoreServ Storage target ports, create a host definition and provision storage to the host.

   NOTE: It is not possible to connect a server with a CNA directly to the HP 3PAR StoreServ Storage. A FCoE Forwarder switch must be used.

Configuring Initiator FCoE to Target FCoE

If an FCoE to FCoE configuration is being set up, the following figure summarizes the general steps you should follow . When setting up FCoE initiator to FCoE target, the StoreServ ports must be configured for FCoE. See Chapter 4, "Configuring the HP 3PAR StoreServ Storage for FCoE" (page 31), for notes on how to configure FCoE ports on the StoreServ.

Figure 19 Initiator FCoE to Target FCoE

1. Install the CNA card in the server just like any other PCIe card - refer to the server vendor documentation.
2. Install the CNA card driver following the CNA card installation instructions (it assumes the server is already running a supported operating system).
3. Physically connect the server CNA card ports to the FCoE fabric.
4. Configure the HP 3PAR StoreServ Storage ports in accordance with the guidelines in section "Configuring the HP 3PAR StoreServ Storage for FCoE" (page 31) and connect the HP 3PAR StoreServ Storage ports to the FCoE fabric.
5. Create VLANs for the host initiator's ports and the HP 3PAR StoreServ Storage target port. Once the initiators have logged in to the HP 3PAR StoreServ Storage target ports, create a host definition and provision storage to the host.

NOTE: FCoE switch VLANs and routing setup and configuration are beyond the scope of this document. Consult your switch manufacturer's documentation for instructions of how to set up VLANs and routing

7 Configuring the Host for an iSCSI Connection

This chapter describes the procedures for setting up an ESX software iSCSI configuration with an HP 3PAR StoreServ Storage. The instructions in this chapter should be used in conjunction with the *VMware vSphere Storage Guide*.

Setting Up the Switch, iSCSI Initiator, and iSCSI target ports

Connect the ESX host iSCSI initiator port(s) and the HP 3PAR StoreServ Storage iSCSI target ports to the switch(es).

If you are using VLANs, make sure that the switch ports which connect to the HP 3PAR StoreServ Storage iSCSI target ports and iSCSI initiator ports reside in the same VLANs and/or that you can route the iSCSI traffic between the iSCSI initiator ports and the HP 3PAR StoreServ Storage iSCSI target ports. Once the iSCSI initiator and HP 3PAR StoreServ Storage iSCSI target ports are configured and connected to the switch, you can use the `ping` command on the iSCSI initiator host to make sure it sees the HP 3PAR StoreServ Storage iSCSI target ports.

NOTE: Setting up the switch for VLAN and routing configuration is beyond the scope of this document. Consult your switch manufacturer's guide for instructions about setting up VLANs and routing.

The procedures in this chapter assume that you have completed the following tasks:

- Set up and configuration of the host Network Interface Card (NIC) or converged network adapter (CNA) as Initiator port that will be used by the iSCSI Initiator software to connect to the HP 3PAR StoreServ Storage iSCSI target ports.

- Installation of the iSCSI initiator software package.

Installing iSCSI on VMware ESX

Software iSCSI drivers for VMware supported NICs are included as part of the ESX OS installation package supplied by VMware. Updates and/or patches for the software iSCSI drivers can be acquired through VMware support.

The following illustration shows an example of an ESX iSCSI Software initiator configuration with two servers:
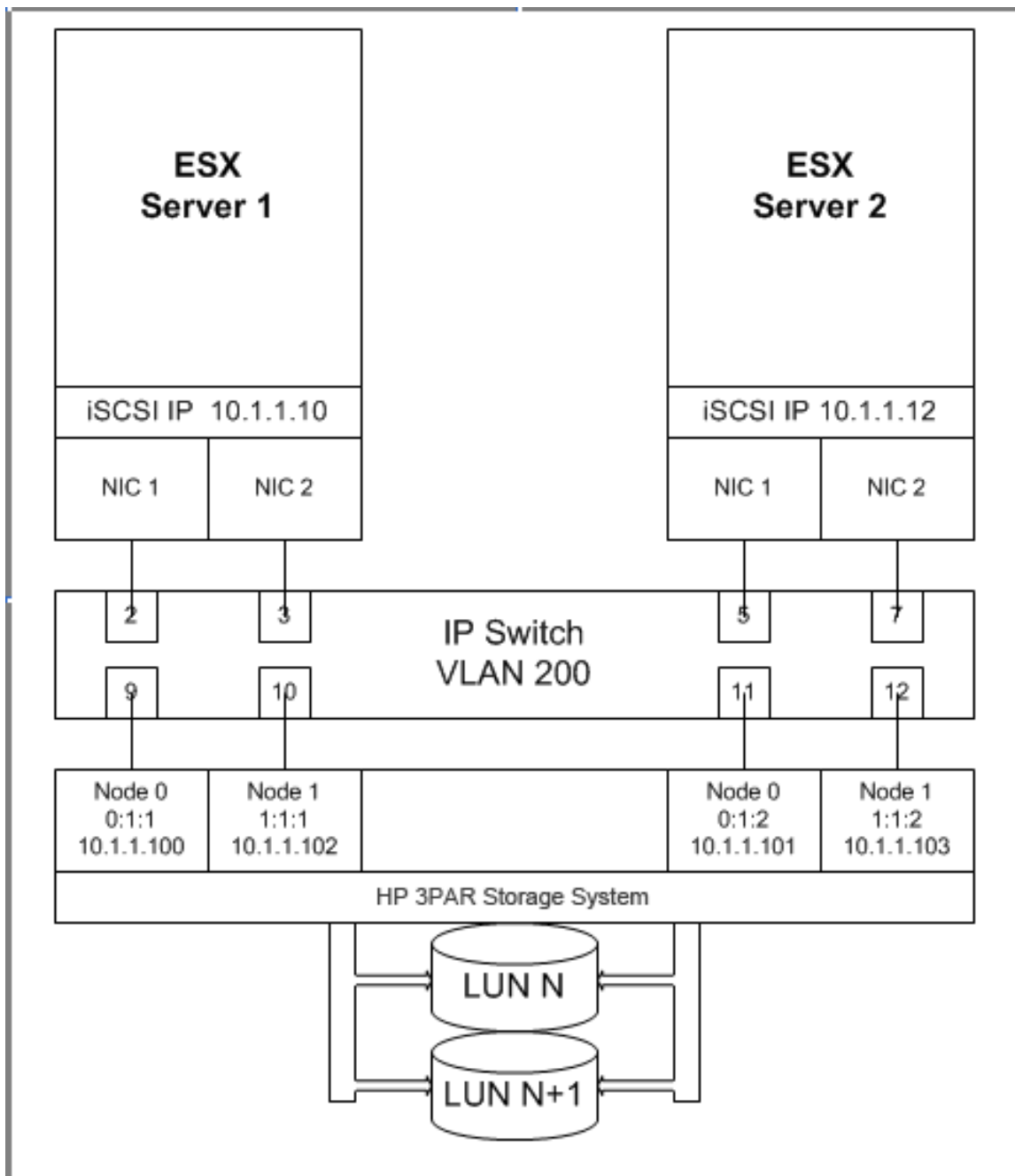
NOTE: When multiple teamed NICs are configured, all HP 3PAR StoreServ Storage iSCSI ports and ESX iSCSI NICs must be in the same VLAN of the IP switch.

NOTE: NIC teaming is not supported in ESXi 5.x

Installing Virtual Machine Guest Operating System

The VMware ESX documentation lists recommended virtual machine guest operating systems (GOS) and their installation and setup as virtual machines. Refer to the VMware ESX documentation for information on setting up your virtual machine configuration.

> △ **CAUTION:** In VMware KB 51306, VMware identifies a problem with RHEL 5 (GA), RHEL 4 U4, RHEL 4 U3, SLES 10 (GA), and SLES 9 SP3 guest operating systems. Their file systems may become read-only in the event of busy I/O retry or path failover of the ESX host's SAN or iSCSI storage. KB 51306 is available on the VMware Knowledge Base website:
>
> http://kb.vmware.com
>
> Because of this known issue, HP does not recommend, and does not support the usage of RHEL 5 (GA), RHEL 4 U4, RHEL 4 U3, SLES 10 (GA), and SLES 9 SP3 as guest operating systems for virtual machines on VMware ESX hosts attached to HP 3PAR StoreServ Storage systems.

> **NOTE:** VMware and HP recommend the LSI logic adapter emulation for Windows 2003 Servers. The LSI Logic adapter is also the default option for Windows 2003 when creating a new virtual machine. HP testing has noted a high incidence of Windows 2003 virtual machine failures during an ESX multipath failover/failback event when the BUS Logic adapter is used with Windows 2003 VMs.

> **NOTE:** HP testing indicates that the SCSI timeout value for virtual machine guest operating systems should be 60 seconds in order to successfully ride out path failovers at the ESX layer. Most guest operating systems supported by VMware have a default SCSI timeout value of 60 seconds, but this value should be checked and verified for each GOS installation. In particular, Red Hat 4.x guest operating systems should have their SCSI timeout value changed from their default value of 30 seconds to 60 seconds.

This command line can be used to set the SCSI timeout on all SCSI devices presented to a Red Hat 4.x virtual machine to 60 seconds:

```
find /sys -name timeout | grep "host.*target.*timeout" | xargs -n 1
echo "echo 60 >"|sh
```

This must be added as a line in `/etc/rc.local` of the Red Hat 4.x guest OS in order for the timeout change to be maintained with a virtual machine reboot.

Example of a modified `/etc/rc.local` file:

```
# cat /etc/rc.local
#!/bin/sh
#
# This script will be executed *after* all the other init scripts.
# You can put your own initialization stuff in here if you don't
# want to do the full Sys V style init stuff.

find /sys -name timeout | grep "host.*target.*timeout" | xargs -n 1
echo "echo 60 >"|shtouch /var/lock/subsys/local
```

Creating a VMkernel Port

The following steps describe how to set up a VMkernel port. Refer to the *VMware vSphere Installation and Setup Guide* for detailed instructions regarding these settings.

1. Log into the VI/vSphere client and select the server from the inventory panel. The hardware configuration page for this server appears.
2. Click the **Configuration** tab and click **Networking**.

3. Click the **Add Networking** Link. The Add Network wizard appears.
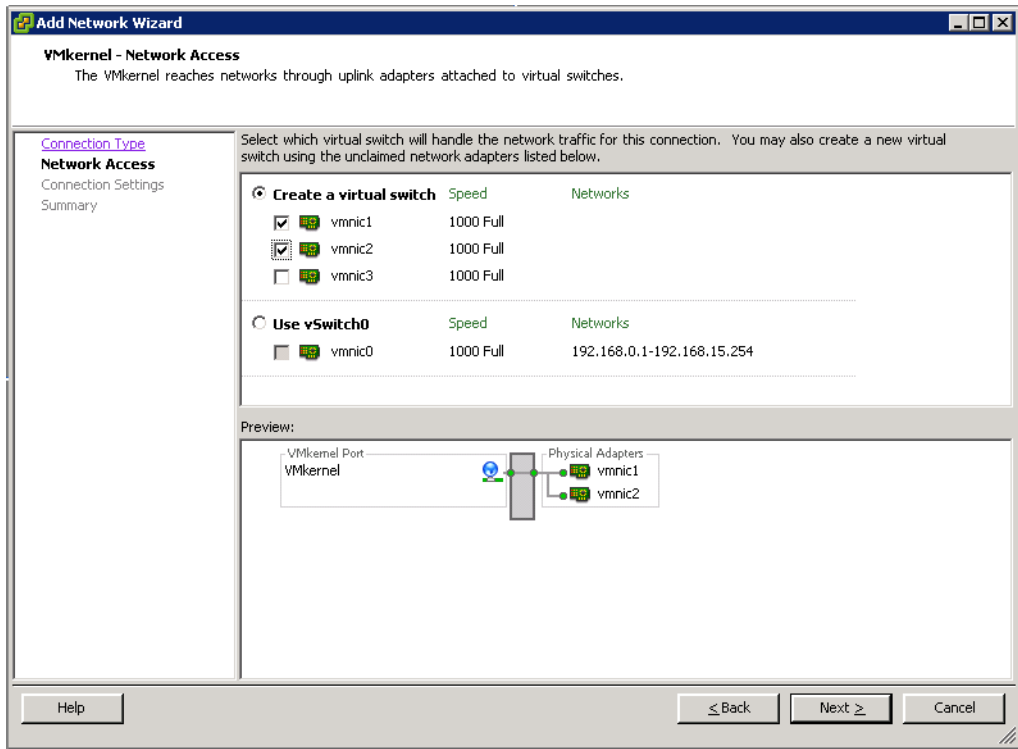
4. Select VMkernel and click **Next**. This lets you connect to the VMkernel which runs services for iSCSI storage to the physical network. The Network Access page appears.
5. Select **Create a Virtual Switch** and select the NICs that will be used for iSCSI. (In this example, 2 NICs are selected to configure an active/active teamed NICs that will connect to the HP 3PAR storage array.)
6. Click **Next.**
7. In ESX 4.x, configure Active/Active NIC teaming by bringing up all of the NIC adapters being used as "Active Adapters" in the **vSwitch Properties**. For each ESX host, use the VI/vSphere client **Configuration tab**→**Networking**→**Properties**, click the **Edit** radio button, and then highlight and use the **Move Up** radio button to bring each of the NIC adapters being used for NIC teaming from the **Standby Adapters** or **Unused Adapters** section to the **Active Adapters** section.

The screen below shows that this has been completed for NIC adapters **vmnic1** and **vmnic2**.
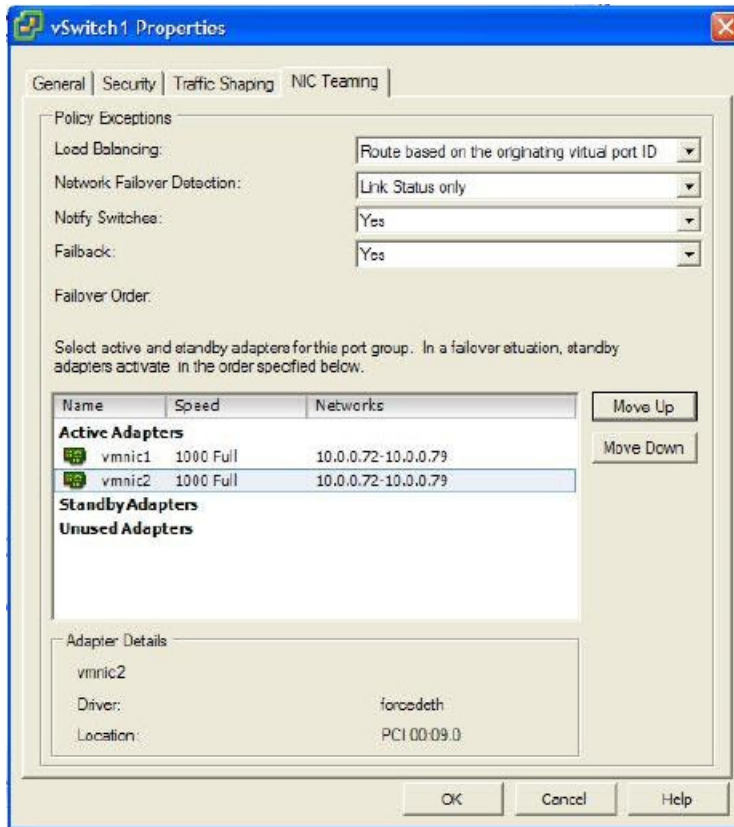
8. Click **OK** to complete.

> **NOTE:** HP recommends an Active/Active NIC Teaming configuration for best failover performance. NIC Teaming however, is *not* supported with ESXi 5.x.
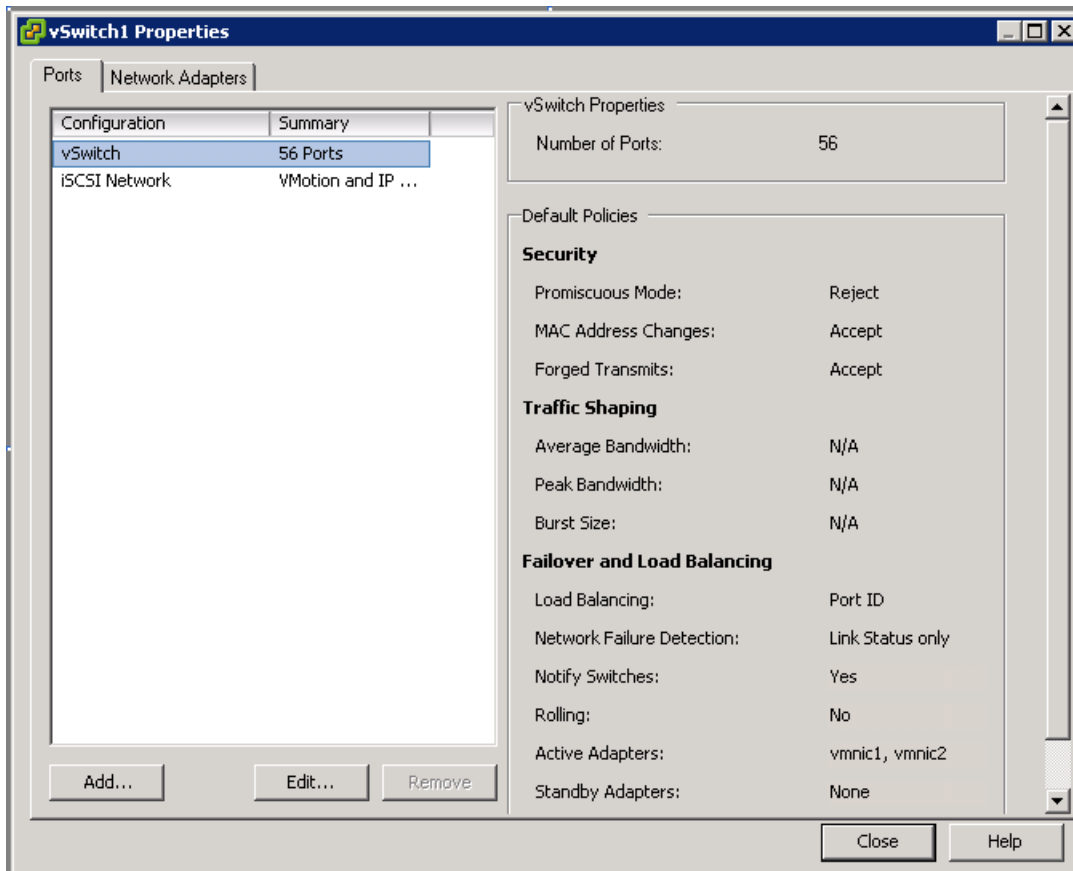
9. Click **Next**.
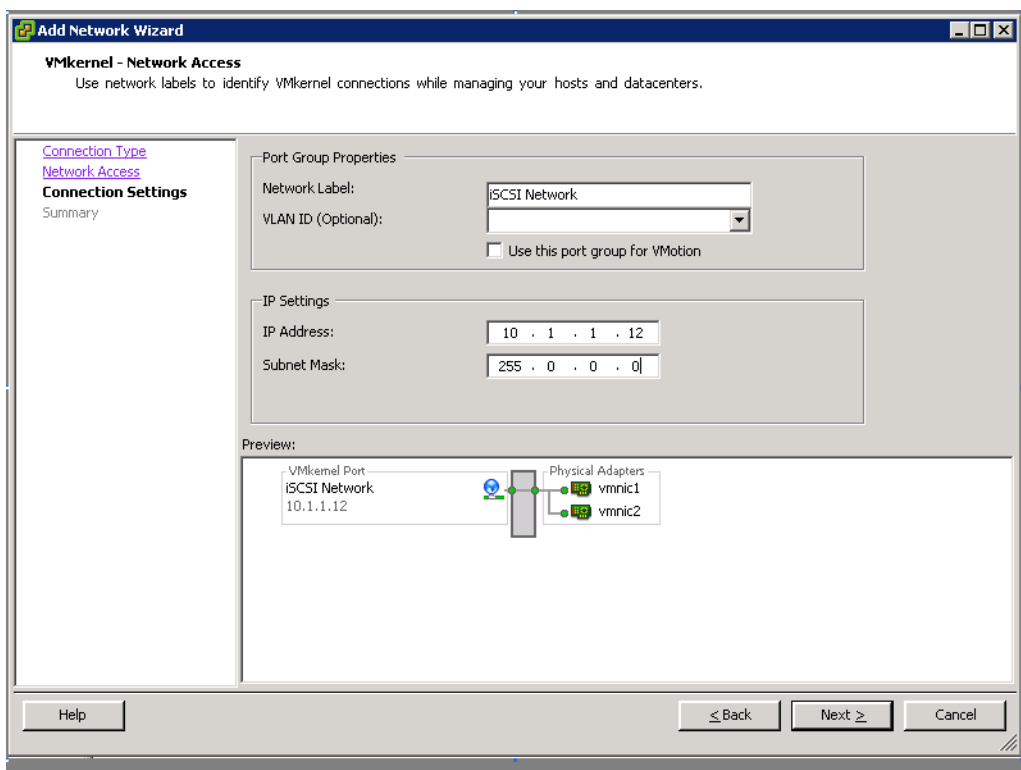
10. Enter a network label. Click **Next**.
11. Specify the IP settings that will be used for the iSCSI network. Click **Next**.
12. Review the information. Click **Finish** .

Configuring a Service Console Connection for the iSCSI Storage

The following steps describe how to configure the Service Console connection for the iSCSI storage.

1. From the **Configuration** tab, and the **Networking** tab, click **Properties** for the vSwitch associated with the VMkernel port you just created for the iSCSI network.

2. Click **Add**.
3. Select the radio button for **VMkernel** to add support for host management traffic.
4. Click **Next**.
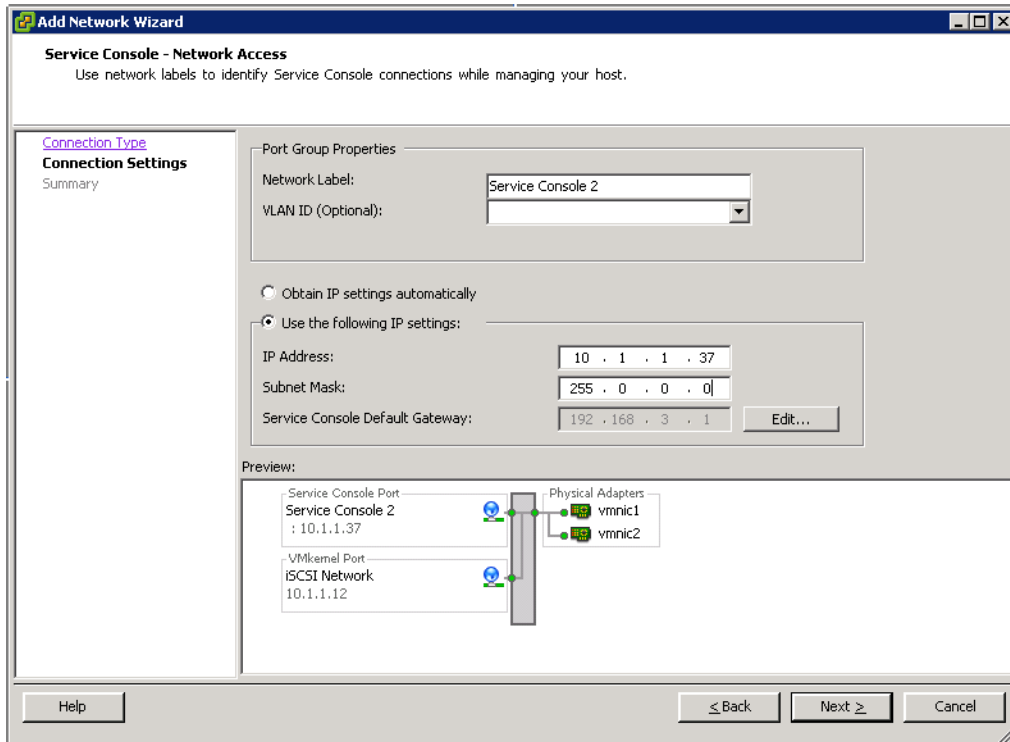
5. Enter the Network Label and IP address for the Service console used to communicate with the iSCSI software initiator. The IP address must be in the same subnet as the iSCSI.

6. Click **Next**. A window appears showing the changes/additions that have been made.
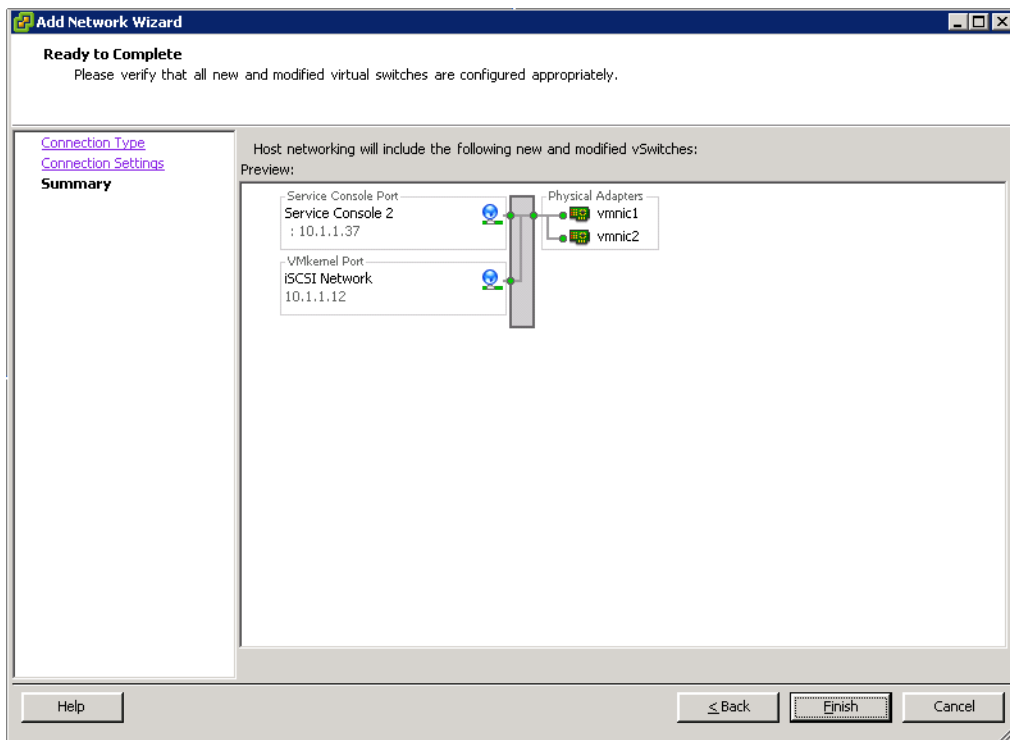
7. Click **Finish**.

8. Close all windows associated with the network configuration.

9. Check the **Configuration** display.

The new network configuration is displayed with the addition of the iSCSI network.

You should now be able to ping the HP 3PAR StoreServ Storage ports that were previously defined from the COS.
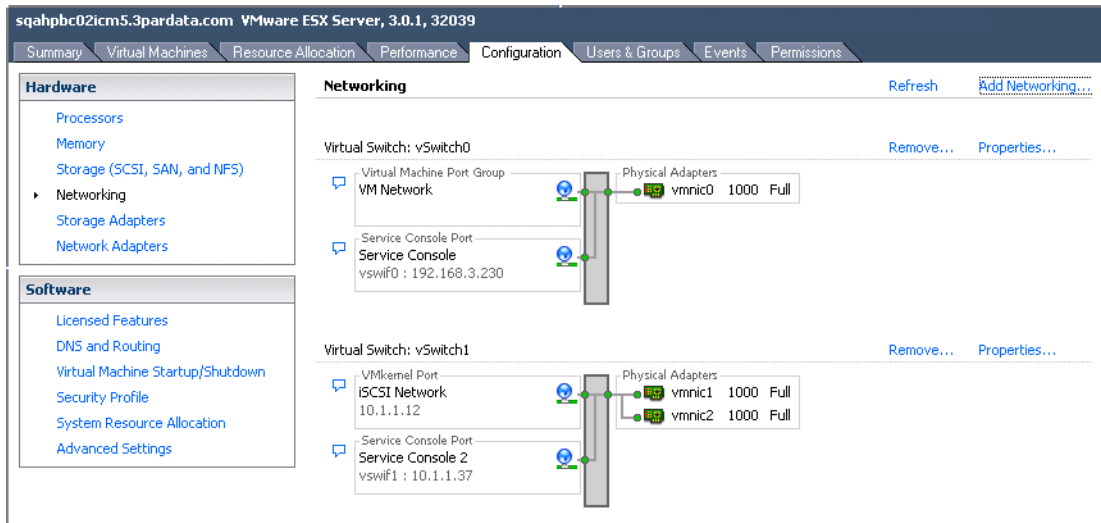
Configuring the VMware iSCSI Initiator

The following steps show how to configure the VMware iSCSI initiator.

1. With the **Configuration** tab selected, click the **Security Profile→Firewall Properties** option from the **Software** menu box.
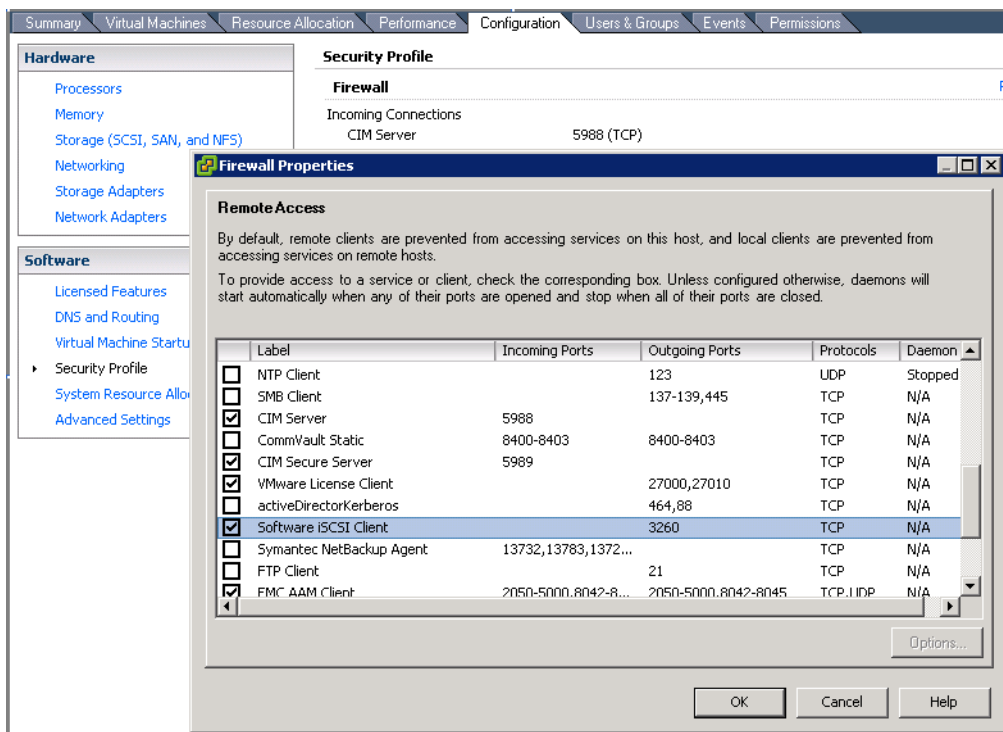
2. Open up the ports that will be used for the iSCSI connection, then click **OK**.
3. The iSCSI software initiator needs to be enabled before the ESX host can use it. Click the **Storage Adapters** option in the **Hardware** menu box.

Storage Adapters   Rescan...

Device	Type	SAN Identifier
vmhba1	Fibre Channel	10:00:00:00:c9:56:8a:1a
vmhba2	Fibre Channel	10:00:00:00:c9:56:8a:1b
Smart Array E200i		
vmhba0	Block SCSI	
iSCSI Software Adapter		
iSCSI Software Adapter	iSCSI	

iSCSI Initiator (vmhba40) Properties

General | Dynamic Discovery | Static Discovery | CHAP Authentication

iSCSI Properties
iSCSI name:
iSCSI alias:
Target discovery methods:

Software Initiator Properties

Properties...

General Properties

Status
☑ Enabled

iSCSI Properties
iSCSI Name:
iSCSI Alias:

Configure...

OK   Cancel   Help

4. In the ESX host, select the **Configuration** tab. Then select **iSCSI Software Adapter** in **Storage Adapter**.
5. Click the **Properties** tab.
6. Select the **General** tab.
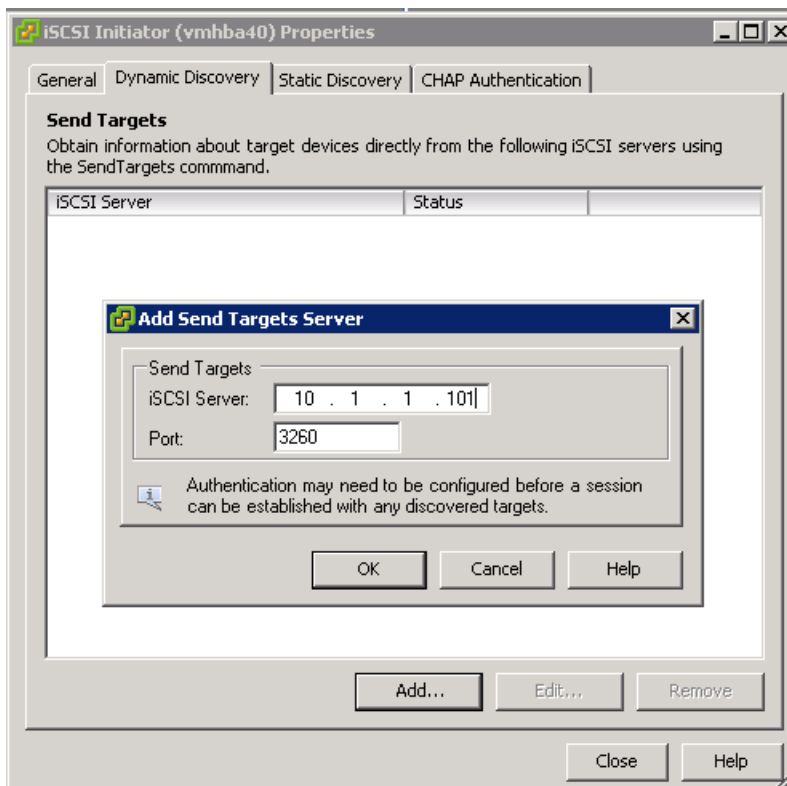7. Click **Configure...**.
8. Select the **Enabled** check box for the status.
9. Click **OK**.
10. Click the **Dynamic Discovery** tab. Dynamic discovery enables the **Send Targets** discovery method, where the initiator sends the Send Targets request to discover and log into the targets.

11. Click **Add...**.
12. Enter the IP address of one of the previously defined HP 3PAR StoreServ Storage iSCSI ports.
13. Click **OK**.
14. Add additional HP 3PAR StoreServ Storage iSCSI ports if they exist and have been defined on the system.
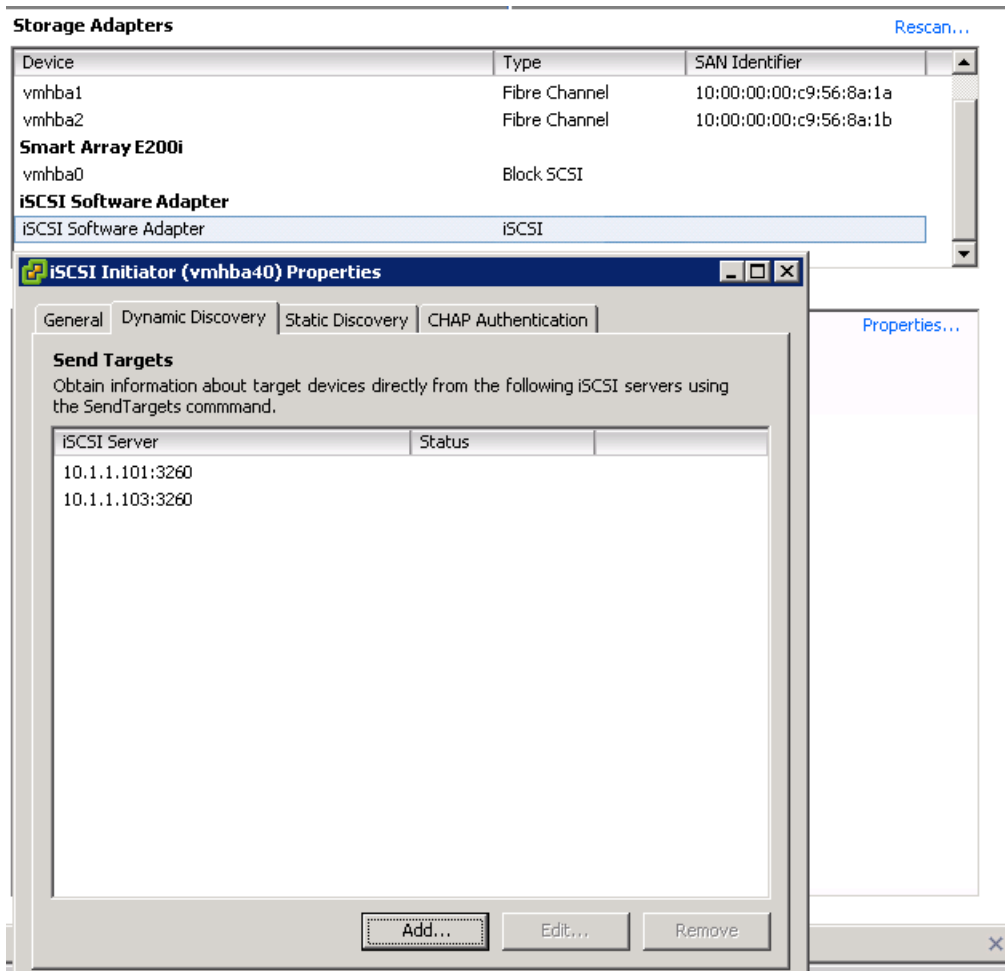
15. When all of the desired HP 3PAR StoreServ Storage iSCSI ports have been added to the **Dynamic Discovery** tab, close this window.

16. Reboot the ESX host. If virtual machines are active, shut them down or suspend them.

The ESX host and HP 3PAR StoreServ Storage should now be configured for use. Using the `showhost` command on the HP 3PAR StoreServ Storage, the new iSCSI connections should now show as present.

```
# showhost
Id Name          ---------------WWN/iSCSI_Name---------------- Port
   --            iqn.1998-01.com.vmware:hpdl380-01-11a38a59     0:1:2
                 iqn.1998-01.com.vmware:hpdl380-01-11a38a59     1:1:2
```

As new LUNs are exported to the ESX iSCSI host, a rescan must be performed on the iSCSI software adapter. This is accomplished in the same manner that Fiber Channel LUNs would be rescanned.
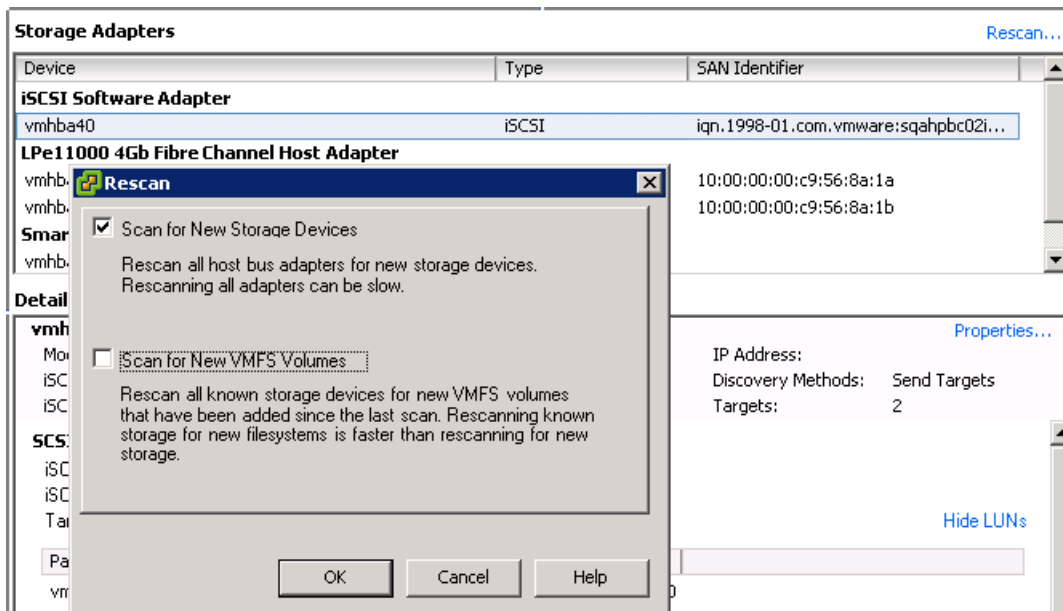
Click **Rescan**, select the **Scan for New Storage Devices** check box, then click **OK** to rescan for new LUNs exported to the ESX iSCSI host.

iSCSI Failover Considerations and Multipath Load Balancing

NOTE: For information about multipathing and configuring to Round Robin policy for all connectivity types (FC, FCoE, and iSCSI, see "Multipath Failover Considerations and I/O Load Balancing" (page 37).

Performance Considerations for Multiple Host Configurations

The information in this section should be considered when using multiple ESX hosts, (or other hosts in conjunction with ESX hosts), that are connected in a fan-in configuration to a pair of HP 3PAR StoreServ Storage ports.

NOTE: If you are running W2K8 VM Cluster with RDM-shared LUNs, then individually change these specific RDM LUNs from Round Robin policy to Fixed Path policy.

NOTE: HP recommends changing the ESX **Scsi.ConflictRetries** from its default value of 80 to a value of 200 when connected to an HP 3PAR StoreServ Storage running HP 3PAR OS version 2.2.4 or prior. This change lengthens the time allowed for I/O retries due to ESX SCSI-2 reservation conflicts on VMFS LUNs caused by delayed processing of SCSI-2 reservation commands on the HP 3PAR StoreServ Storage, thereby helping to avoid VM I/O failure.

You can change this value using the VMware ESX VI/vSphere client: In the ESX host, select the **Configuration** tab, select **Advanced Settings** for software, select **Scsi**, scroll to **Scsi.ConflictRetries**, and change the value in the field. Click **OK** to complete the change. A reboot is not required for the change to take effect.

ESX/ESXi Additional Feature Considerations

To install the VAAI plugin and to take advantage of new ESX/ESXi and HP 3PAR StoreServ Storage features, see .

8 Allocating Storage for Access by the ESX Host

This chapter describes the basic procedures that are required to create and export virtual volumes so they can be utilized by the VMware ESX host. For complete details on creating and managing storage on the HP 3PAR StoreServ Storage, consult the appropriate HP 3PAR documentation.

Creating Storage On the HP 3PAR StoreServ Storage

This section describes the general recommendations and restrictions for exporting storage from the HP 3PAR StoreServ Storage to an ESX host.

Consult the *HP 3PAR Management Console Users Guide* and the *HP 3PAR Command Line Interface Reference* for complete details on creating virtual volumes for a given HP 3PAR OS. In addition, for a detailed discussion on using thinly-provisioned virtual volumes and strategies for creating VLUNs, consult *3PAR Utility Storage with VMware vSphere*.

To obtain a copy of this documentation, see the HP BSC website:

http://www.hp.com/go/bsc

NOTE: To create thinly-provisioned virtual volumes, an HP 3PAR Thin Provisioning license is required.

Creating Virtual Volumes for HP 3PAR OS 2.2.4 and Later

After devising a plan for allocating space for the ESX host, you need to create the required virtual volumes on the HP 3PAR StoreServ Storage. Volumes can be fully provisioned from a CPG or can be thinly provisioned.

Using the HP 3PAR Management Console:

1. From the Menu bar, select:

    Actions→Provisioning→Virtual Volume→Create Virtual Volumes

2. Use the **Create Virtual Volume** wizard to create a base volume.

3. Select one of the following options from the **Allocation** list:

    • **Fully Provisioned**

    • **Thinly Provisioned**

Using the HP 3PAR OS CLI:

To create a fully-provisioned or thinly-provisioned virtual volume, issue the following HP 3PAR OS CLI command:

```
# createvv [options] <usr_CPG> <VV_name> [.<index>] <size>[g|G|t|T]
```

Here is an example:

```
# createvv -tpvv -cnt 5 TESTLUNs 5g
```

Creating Virtual Volumes for HP 3PAR OS 2.2.3 or Earlier

When running HP 3PAR OS 2.2.3 or earlier, the `createaldvv` command can be used to create virtual volumes on the HP 3PAR StoreServ Storage that can then be exported and discovered by the ESX host. Here is the general form of the command:

```
# createaldvv [options] <vvname>[.<index>] <size>[g|G|t|T]
```

Here is an example:

```
# createaldvv -cnt 5 TESTLUNs 5G
```

This will create five virtual volumes of 5 Gb each in size, fully provisioned from PDs.

NOTE: To create a fully-provisioned or thinly-provisioned virtual volume, consult the *HP 3PAR Command Line Interface Reference*, which is available on the HP BSC website:

http://www.hp.com/go/bsc

Exporting LUNs to an ESX Host

This section explains how to export virtual volumes created on the HP 3PAR StoreServ Storage as VLUNs for the ESX host.

When exporting VLUNs to the VMware ESX host, you should observer the following guidelines:

- New VLUNs that are exported while the host is running will not be registered until a Bus Rescan is initiated. This may be performed from the VI/vSphere client Management Interface. Some versions of ESX will automatically scan for newly exported LUNs.

- Disks can be added to a virtual machine with the virtual machine powered up. However, to remove a disk, the virtual machine must be powered off. This is a limitation of ESX.

- The maximum number of LUNs on a single ESX HBA port is 256, and 256 total LUNs on the ESX host. Internal devices, such as local hard drives and CD drives, are counted as a LUN in the ESX host LUN count.

- VLUNs can be created with any LUN number in the range from 0 to 255 (VMware ESX limitation).

- iSCSI LUNs and FC LUNs are treated as any other LUN on the ESX host. No special requirements or procedures are needed to use iSCSI LUNs. HP does not recommend or support same storage LUN being exported on different protocol interfaces, such as exporting to FC interface on one host and iSCSI on another host, because the timing and error recovery of the protocols would be different.

- The ESX limitation for the largest LUN that can be utilized by the ESX host is 2047 GB. For ESXi 5.x, the maximum LUN size is 16 T or 16384 GB.

- Sparse LUN numbering (meaning that LUN numbers can be skipped), is supported by VMware ESX host. A LUN 0 is not required.

For failover support using the QLogic or Emulex drivers, virtual volumes should be exported down multiple paths to the host simultaneously. To facilitate this task, create a host definition on the HP 3PAR StoreServ Storage that includes the WWNs of multiple HBA ports on the host and export the VLUNs to that host definition.

It has been noted by HP that provisioning several VMs to a smaller number of large LUNs, versus a single VM per single LUN, provides better overall results. Further examination and explanation of this recommendation is outlined in the document *3PAR Utility Storage with VMware vSphere*, which is available on the HP BSC website:

Concerning TPVVs, ESX VMFS-3 does not write data to the entire volume at initialization and it can be used with TPVVs without any configuration changes to VMFS. A further examination of this subject, recommendations, and limitations are explored in the HP document *3PAR Utility Storage with VMware vSphere*.

Creating a VLUN for Export

Creation of a VLUN template enables export of a VV as a VLUN to one or more ESX hosts. There are four types of VLUN templates:

- `port presents - created` when only the `node:slot:port` are specified. The VLUN is visible to any initiator on the specified port.
- `host set - created` when a host set is specified. The VLUN is visible to the initiators of any host that is a member of the set.
- `host sees - created` when the `hostname` is specified. The VLUN is visible to the initiators with any of the host's WWNs.
- `matched set - created` when both `hostname` and `node:slot:port` are specified. The VLUN is visible to initiators with the host's WWNs only on the specified port.

You have the option of exporting the LUNs through the HP 3PAR Management Console or the HP 3PAR OS CLI.

Using the HP 3PAR Management Console

1. From the Menu bar, select **Actions→Provisioning→VLUN→Create VLUN**.
2. Use the **Export Virtual Volume** dialog box to create a VLUN template.

Using the HP 3PAR OS CLI

To create a port presents VLUN template, issue the following command:

```
# createvlun [options] <VV_name | VV_set> <LUN> <node:slot:port
```

To create a host sees or host set VLUN template, issue the following command:

```
# createvlun [options] <VV_name | VV_set> <LUN> <host_name/set>
```

To create a matched set VLUN template, issue the following command:

```
# createvlun [options] <VV_name | VV_set> <LUN> <node:slot:port>/<host_name>
```

To create a host set VLUN template, issue the following command:

```
# createvlun [options] <VV_name | VV_set> <LUN> <host_set>
```

Here is an example:

```
# createvlun -cnt 5 TESTLUNs.0 0 hostname/hostdefinition
```

or:

```
# createvlun -cnt 5 TESTVLUN.0 0 set:hostsetdefination
```

Consult the *HP 3PAR Management Console Users Guide* and the *HP 3PAR Command Line Interface Reference* for complete details on exporting volumes and available options for the HP 3PAR OS version that is being used on the HP 3PAR StoreServ Storage. These documents are available on the HP BSC website:

http://www.hp.com/go/bsc

NOTE: The commands and options available for creating a virtual volume may vary for earlier versions of the HP 3PAR OS.

Discovering LUNs on VMware ESX Hosts

This section provides tips for discovering LUNs that are being utilized by the ESX host.

Once the host is built, the preferred method for configuring and managing the use of the ESX host is through a VI/vSphere client Management Interface and VMware vCenter Server.

New VLUNs that are exported while the host is running will not be registered until a Bus Rescan is initiated. This may be performed from the VI/vSphere client Management Interface. If failover support is utilized (recommended), view all LUNs and their respective paths using the menu from the ESX (**Configuration** tab →**Storage Adapter**).

Disks can be added to a virtual machine with the virtual machine powered up. However, to remove a disk, the virtual machine must be powered off. This is a limitation of ESX.

The maximum number of LUNs on a single ESX HBA port is 256, and 256 total LUNs on the ESX host. Internal devices, such as local hard drives and CD drives, are counted as a LUN in the ESX host LUN count.

Removing Volumes

After removing a VLUN exported from the HP 3PAR StoreServ Storage, perform a ESX host bus adapter rescan. ESX will update the disk inventory upon rescan. This applies to both Fibre Channel and iSCSI.
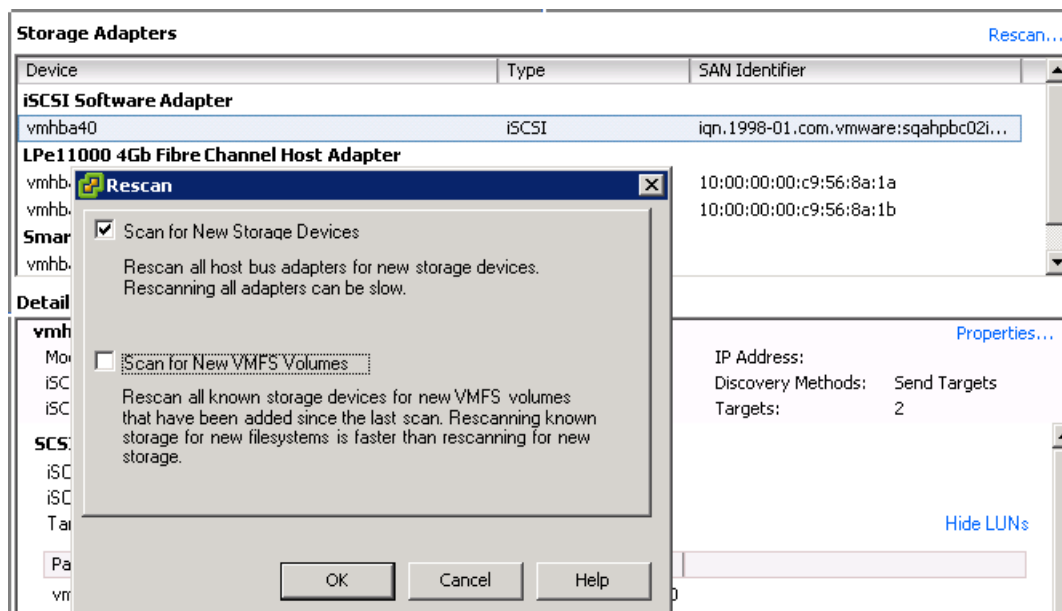
It is advisable to remove the disk/LUN from the virtual machine inventory, detach from the ESX host, and then remove it from the HP 3PAR StoreServ Storage using the `removevlun` and `removevv` HP 3PAR OS CLI commands or using the HP 3PAR Management Console. If a LUN is not detached but is removed from the HP 3PAR StoreServ Storage, it appears as a device in an error state, and is cleared after an ESX host reboot.

Figure 20 Detaching a LUN
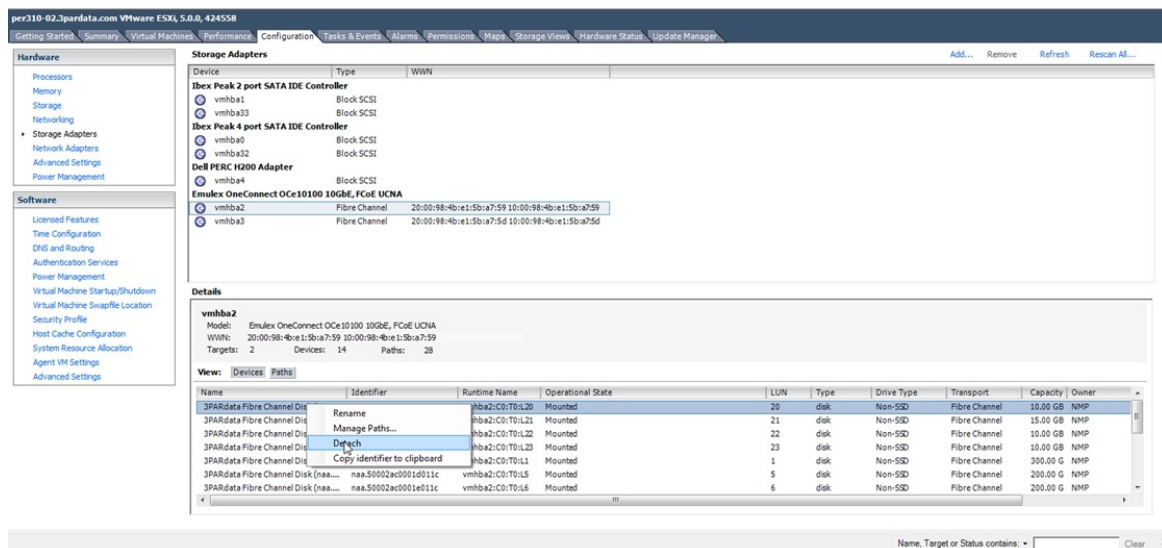
Host and Storage Usage

Eventlog and Host Log Messages

All HP 3PAR system debug messages can be seen using the `showeventlog -debug cli` command. On the ESX host, errors are reported in `/var/log/vmkernel` files. Use the `showalert` HP 3PAR OS CLI command to see alerts and warnings posted from the HP 3PAR StoreServ Storage. Some examples of storage server posted messages:

- If the user has set the space allocation warning for a TPVV volume, the system eventlog will show the `Thin provisioning soft threshold reached` message when the limit is hit.

  Example:

```
1 Debug         Host error      undefined  Port 1:5:2 -- SCSI status 0x02 (Check
 condition) Host:sqa-dl380g5-14-esx5 (WWN 2101001B32A4BA98) LUN:22 LUN
WWN:50002ac00264011c VV:0 CDB:280000AB082000000800 (Read10) Skey:0x06 (Unit
attention) asc/q:0x38/07 (Thin provisioning soft threshold reached) VVstat:0x00
(TE_PASS          -- Success) after 0.000s (Abort source unknown) toterr:74882,
 lunerr:2
```

- If the user has set a hard limit on the HP 3PAR StoreServ Storage volume when using HP 3PAR OS 2.3.1 MU2 or later, the HP 3PAR StoreServ Storage will post the write protect error (`ASC/Q: 0x27/0x7`) when the limit is reached. This is considered a hard error, and the VM is stunned in ESX 4.x and ESXi 5.x. Additional space needs to be added to the storage to clear the error condition.

```
PDT       1 Debug             Host error      undefined  Port 1:5:2 -- SCSI status
 0x02 (Check condition) Host:sqa-dl380g5-14-esx5 (WWN 2101001B32A4BA98) LUN:22
LUN WWN:50002ac00264011c VV:612 CDB:2A00005D6CC800040000 (Write10) Skey:0x07 (Data
 protect) asc/q:0x27/07 (Space allocation failed write protect) VVstat:0x41
(VV_ADM_NO_R5      -- No space left on snap data volume) after 0.302s (Abort
source unknown) toterr:74886, lunerr:3
```

For ESX 4.x or ESXi 5.x, an ESX host managed by vSphere client or vCenter Server will scan for LUNs at 5-minute intervals by issuing the `REPORT LUN` command and discovering any new LUNs.

At an interval of every 5 minutes, an ESX host such as ESXi 5.x sends REPORT LUN commands and discovers any new LUNs.

On ESXi 5.x, the following vmkernel log message is not harmful and can be ignored:

```
34:41.371Z cpu0:7701)WARNING: ScsiDeviceIO: 6227: The
device naa.50002ac00026011b does not permit the system to change the sitpua bit
to 1.
```

For ESXi 5.x, the Virtual Disk max disk can be only 2 TB, even though the physical LUN seen on the system is 16 TB.

9 Booting the VMware ESX Host from the HP 3PAR StoreServ Storage

This chapter provides a general overview of the procedures that are required to boot the VMware ESX operating system from the SAN.

In a boot-from-SAN environment, each ESX host's operating system is installed on a the HP 3PAR StoreServ Storage, rather than on the host's internal disk. In this situation, you should create a separate virtual volume for each ESX host to be used for the boot image.

Here are the general steps in this process:

- Perform the required zoning
- Create a virtual volume and export it as a VLUN to the ESX host
- Boot the system and enter the HBA bios
- Enable the HBA port to boot
- Discover the LUN and designate it as bootable through the HBA BIOS

For detailed information, consult the VMware Fibre Channel *SAN Configuration Guide*.

For information about setting a CN1100E CNA to boot the host from SAN, see "Hardware iSCSI Support" (page 25).

The VMware ESX host has an option that allows the VMware Base OS to be installed and booted from a SAN or HP 3PAR StoreServ Storage virtual storage device. You can choose this option during the initial installation phase of the VMware Server Installation. Refer to the VMware documentation for further information regarding 'SANboot'.

HP makes the following general recommendations for preparing the host HBAs for a SAN boot deployment:

NOTE: The NVRAM settings on HBAs can be changed by any server in which they are installed. These settings will persist in the HBA even after it is removed from a server. To obtain the correct settings for this configuration, you must return all NVRAM settings to their default values.

1. After installation of the HBAs, reset all of the HBA NVRAM settings to their default values.

   NOTE: Each host adapter port is reported as a host bus adapter and the HBA settings should be set to default.

2. Enter the host adapter setup program during server boot by pressing the combination of keys indicated by the host adapter.

   Change and save all HBA settings to their default settings.

   NOTE: When using a McDATA fabric, set the HBA topology to 'point to point'.

   There may be other vendor HBAs not listed here with different setup entry key combinations.

3. Reboot the host computer.

10 Support and Other Resources

Contacting HP

For worldwide technical support information, see the HP support website:

http://www.hp.com/support

Before contacting HP, collect the following information:

- Product model names and numbers
- Technical support registration number (if applicable)
- Product serial numbers
- Error messages
- Operating system type and revision level
- Detailed questions

Specify the type of support you are requesting:

HP 3PAR storage system	Support request
HP 3PAR StoreServ 7200, 7400, and 7450 Storage systems	StoreServ 7000 Storage
HP 3PAR StoreServ 10000 Storage systems HP 3PAR T-Class storage systems HP 3PAR F-Class storage systems	3PAR or 3PAR Storage

HP 3PAR documentation

For information about:	See:
Supported hardware and software platforms	The Single Point of Connectivity Knowledge for HP Storage Products (SPOCK) website: http://www.hp.com/storage/spock
Locating HP 3PAR documents	The HP 3PAR StoreServ Storage site: http://www.hp.com/go/3par To access HP 3PAR documents, click the **Support** link for your product.
HP 3PAR storage system software	
Storage concepts and terminology	*HP 3PAR StoreServ Storage Concepts Guide*
Using the HP 3PAR Management Console (GUI) to configure and administer HP 3PAR storage systems	*HP 3PAR Management Console User's Guide*
Using the HP 3PAR CLI to configure and administer storage systems	*HP 3PAR Command Line Interface Administrator's Manual*
CLI commands	*HP 3PAR Command Line Interface Reference*
Analyzing system performance	*HP 3PAR System Reporter Software User's Guide*
Installing and maintaining the Host Explorer agent in order to manage host configuration and connectivity information	*HP 3PAR Host Explorer User's Guide*
Creating applications compliant with the Common Information Model (CIM) to manage HP 3PAR storage systems	*HP 3PAR CIM API Programming Reference*

For information about:	See:
Migrating data from one HP 3PAR storage system to another	*HP 3PAR-to-3PAR Storage Peer Motion Guide*
Configuring the Secure Service Custodian server in order to monitor and control HP 3PAR storage systems	*HP 3PAR Secure Service Custodian Configuration Utility Reference*
Using the CLI to configure and manage HP 3PAR Remote Copy	*HP 3PAR Remote Copy Software User's Guide*
Updating HP 3PAR operating systems	*HP 3PAR Upgrade Pre-Planning Guide*
Identifying storage system components, troubleshooting information, and detailed alert information	*HP 3PAR F-Class, T-Class, and StoreServ 10000 Storage Troubleshooting Guide*
Installing, configuring, and maintaining the HP 3PAR Policy Server	*HP 3PAR Policy Server Installation and Setup Guide* *HP 3PAR Policy Server Administration Guide*

For information about:	See:
Planning for HP 3PAR storage system setup	
Hardware specifications, installation considerations, power requirements, networking options, and cabling information for HP 3PAR storage systems	
HP 3PAR 7200, 7400, and 7450 storage systems	*HP 3PAR StoreServ 7000 Storage Site Planning Manual* *HP 3PAR StoreServ 7450 Storage Site Planning Manual*
HP 3PAR 10000 storage systems	*HP 3PAR StoreServ 10000 Storage Physical Planning Manual* *HP 3PAR StoreServ 10000 Storage Third-Party Rack Physical Planning Manual*
Installing and maintaining HP 3PAR 7200, 7400, and 7450 storage systems	
Installing 7200, 7400, and 7450 storage systems and initializing the Service Processor	*HP 3PAR StoreServ 7000 Storage Installation Guide* *HP 3PAR StoreServ 7450 Storage Installation Guide* *HP 3PAR StoreServ 7000 Storage SmartStart Software User's Guide*
Maintaining, servicing, and upgrading 7200, 7400, and 7450 storage systems	*HP 3PAR StoreServ 7000 Storage Service Guide* *HP 3PAR StoreServ 7450 Storage Service Guide*
Troubleshooting 7200, 7400, and 7450 storage systems	*HP 3PAR StoreServ 7000 Storage Troubleshooting Guide* *HP 3PAR StoreServ 7450 Storage Troubleshooting Guide*
Maintaining the Service Processor	*HP 3PAR Service Processor Software User Guide* *HP 3PAR Service Processor Onsite Customer Care (SPOCC) User's Guide*
HP 3PAR host application solutions	
Backing up Oracle databases and using backups for disaster recovery	*HP 3PAR Recovery Manager Software for Oracle User's Guide*
Backing up Exchange databases and using backups for disaster recovery	*HP 3PAR Recovery Manager Software for Microsoft Exchange 2007 and 2010 User's Guide*
Backing up SQL databases and using backups for disaster recovery	*HP 3PAR Recovery Manager Software for Microsoft SQL Server User's Guide*
Backing up VMware databases and using backups for disaster recovery	*HP 3PAR Management Plug-in and Recovery Manager Software for VMware vSphere User's Guide*
Installing and using the HP 3PAR VSS (Volume Shadow Copy Service) Provider software for Microsoft Windows	*HP 3PAR VSS Provider Software for Microsoft Windows User's Guide*
Best practices for setting up the Storage Replication Adapter for VMware vCenter	*HP 3PAR Storage Replication Adapter for VMware vCenter Site Recovery Manager Implementation Guide*
Troubleshooting the Storage Replication Adapter for VMware vCenter Site Recovery Manager	*HP 3PAR Storage Replication Adapter for VMware vCenter Site Recovery Manager Troubleshooting Guide*
Installing and using vSphere Storage APIs for Array Integration (VAAI) plug-in software for VMware vSphere	*HP 3PAR VAAI Plug-in Software for VMware vSphere User's Guide*

Typographic conventions

Table 4 Document conventions

Convention	Element
Bold text	- Keys that you press - Text you typed into a GUI element, such as a text box - GUI elements that you click or select, such as menu items, buttons, and so on
`Monospace text`	- File and directory names - System output - Code - Commands, their arguments, and argument values
`<Monospace text in angle brackets>`	- Code variables - Command variables
`Bold monospace text`	- Commands you enter into a command line interface - System output emphasized for scannability

⚠ **WARNING!**   Indicates that failure to follow directions could result in bodily harm or death, or in irreversible damage to data or to the operating system.

⚠ **CAUTION:**   Indicates that failure to follow directions could result in damage to equipment or data.

NOTE: Provides additional information.

Required

Indicates that a procedure must be followed as directed in order to achieve a functional and supported implementation based on testing at HP.

HP 3PAR branding information

- The server previously referred to as the "InServ" is now referred to as the "HP 3PAR StoreServ Storage system."
- The operating system previously referred to as the "InForm OS" is now referred to as the "HP 3PAR OS."
- The user interface previously referred to as the "InForm Management Console (IMC)" is now referred to as the "HP 3PAR Management Console."
- All products previously referred to as "3PAR" products are now referred to as "HP 3PAR" products.

11 Documentation feedback

HP is committed to providing documentation that meets your needs. To help us improve the documentation, send any errors, suggestions, or comments to Documentation Feedback (**docsfeedback@hp.com**). Include the document title and part number, version number, or the URL when submitting your feedback.

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Golf course search by state

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http://emailbydomain.com

Auto manuals search

http://auto.somanuals.com

TV manuals search

http://tv.somanuals.com