Sun StorEdge™ SAN Foundation Configuration Guide

Version 4.1

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Part No. 817-0057-10
November 2002, Revision A

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Preface

The *Sun StorEdge SAN Foundation Configuration Guide* is for system administrators who need instructions for configuring the switch for the Sun StorEdge™ SAN Foundation release.

Setting up a Storage Area Network (SAN) is a linear process. To set up a SAN, you must follow these basic steps:

1. **Physically install all the switches, hosts, storage devices and cables.**
2. **Identify the configuration requirements for hooking up all the devices and hosts to the switches.**
3. **Configure the switch ports and configure the switch to your zoning requirements.**
4. **Ensure all the hosts recognize all the switches and attached storage devices.**

By the time you read this book, you should have already completed the hardware and software installation for your SAN with the help of the *Sun StorEdge SAN Foundation Installation Guide*. This book helps you with the last three steps.

This guide explains initial configuration of a switch, identifying hosts and storage and handling multiple paths to storage using the Sun StorEdge Traffic Manager software (STMS).

Using UNIX Commands

This document may not contain information on basic UNIX® commands and procedures such as shutting down the system, booting the system, and configuring devices.

See one or more of the following for this information:

- *Solaris Handbook for Sun Peripherals*
- AnswerBook2™ online documentation for the Solaris™ operating environment
- Other software documentation that you received with your system

Typographic Conventions

TABLE P-1

Typeface	Meaning	Examples
`AaBbCc123`	The names of commands, files, and directories; on-screen computer output	Edit your `.login` file. Use `ls -a` to list all files. `% You have mail.`
`AaBbCc123`	What you type, when contrasted with on-screen computer output	`% su` `Password:`
AaBbCc123	Book titles, new words or terms, words to be emphasized	Read Chapter 6 in the *User's Guide.* These are called *class* options. You *must* be superuser to do this.
	Command-line variable; replace with a real name or value	To delete a file, type `rm` *filename.*

Shell Prompts

TABLE P-2

Shell	Prompt
C shell	*machine_name*%
C shell superuser	*machine_name*#
Bourne shell and Korn shell	$
Bourne shell and Korn shell superuser	#

Related Documentation

TABLE P-3 Sun StorEdge SAN Foundation Release Related Documentation

Product	Application	Title	Part Number
Sun StorEdge Network SAN Foundation Release	Installation	*Sun StorEdge SAN Foundation Installation Guide*	817-0056
	Documentation information	*Sun StorEdge SAN Foundation Network 2 Gb FC Switch-8 Guide to Documentation*	817-0061
	Documentation information	*Sun StorEdge SAN Foundation 2 Gb Brocade Silkworm Fabric Switch Guide to Documentation*	817-0062
	Documentation information	*Sun StorEdge SAN Foundation 2 Gb McData Intrepid Director Switch Guide to Documentation*	817-0063
	Latest information	*Sun StorEdge SAN Foundation Release Notes*	817-0071
	Safety and Compliance	*Sun StorEdge SAN Foundation Regulatory and Safety Compliance Manual*	816-7190
man pages	cfgadm utility	cfgadm_fp (1M)	n/a
	format utility	format (1M)	n/a
	luxadm utility	luxadm (1M)	n/a

Accessing Sun Documentation Online

A broad selection of Sun system documentation is located at:

`http://www.sun.com/products-n-solutions/hardware/docs`

A complete set of Solaris documentation and many other titles are located at:

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CHAPTER 1

Requirements and Guidelines

To set up a storage area network (SAN), you must follow these basic steps:

1. **Physically install all the switches, hosts, storage devices and cables.**
2. **Identify the zone and port requirements for hooking up all the devices and hosts to the switches.**
3. **Configure the switch ports and switch to your zoning requirements.**
4. **Ensure that all the hosts recognize the switch and all attached devices.**

By now, you should have completed the hardware installation with the help of the *Sun StorEdge SAN Foundation Installation Guide.* This chapter helps you with the second step, identifying the configuration requirements. It contains guidelines for configuring your Sun StorEdge Foundation release with one or more hosts and storage. At this stage, you can also configure your ports and zones according to the instructions in your vendor-specific documentation:

New In This Release

This section covers:

Sun StorEdge 9840b FC Tape Drive Support

The Sun StorEdge Network Foundation software now supports connection of the Fibre Channel tape drives in your SAN. You can now use the Sun StorEdge 9840b FC tape drive with the Sun StorEdge L180, L700, L5500, and L6000 tape libraries. If you want to connect the tape drive to a 2-Gbit switch in fabric mode, connect the tape drives to F or TL ports and libraries to TL ports on the switch.

SNIA and FCSM Packages

The SAN Foundation release now includes the Storage Networking Industry Association (SNIA) Fibre Channel host bus adapter(HBA) library. Some of these interfaces are provided through the Fibre Channel Switch Management (FCSM) driver. The SNIA library uses the FCSM driver to send Fibre Channel Common Transport (CT) requests to Fibre Channel switches. This allows client applications to get detailed information about the SAN topology and switch configurations.

The SNIA HBA application programming interfaces (APIs) enable you to manage Fibre Channel HBAs in your SAN. You can use the interfaces to access detailed information about the HBAs on a host and switches and storage devices connected to the SAN in an industry standard-compliant way. Specifically, SNIA and FCSM enable you to integrate the Sun StorEdge Enterprise Storage Manager Topology Reporter (ESM) and other third-party SAN management tools with the Sun StorEdge SAN Foundation software required for devices that Sun supports.

The SNIA HBA API is divided into two functional components. The first is a Common Library, to which applications are linked. The second is one or more Vendor Specific Libraries (VSLs), which the Common Library dynamically loads to manage individual vendor HBAs.

Man pages for the common SNIA API are included in the Sun StorEdge SAN Foundation software. The formal specification (FC-MI) is available at `http://www.t11.org`. TABLE 1-1 outlines which APIs are included in the vendor library for this release:

TABLE 1-1 Supported and Unsupported SNIA Interfaces

SNIA API	Sun StorEdge SAN Foundation Software Support
GetVersion	Yes
LoadLibrary	Yes
FreeLibrary	Yes
GetNumberofAdapters	Yes
GetAdapterName	Yes
OpenAdapter	Yes
CloseAdapter	Yes
GetAdapterAttributes	Yes
GetAdapterPortAttributes	Yes
GetDiscoveredPortAttributes	Yes
GetPortAttributesbyWWN	Yes

TABLE 1-1 Supported and Unsupported SNIA Interfaces *(Continued)*

SNIA API	Sun StorEdge SAN Foundation Software Support
SendCTPassThru	Yes
RefreshInformation	Yes
GetFcpTargetMapping	Yes
SendScsiInquiry	Yes
SendReportLuns	Yes
SendReadCapacity	Yes
GetPortStatistics	No
ResetStatistics	No
GetFcpPersistentBinding	No
GetEventBuffer	No
SetRNIDMgmtInfo	No
GetRNIDMgmtInfo	No
SendRNID	No

SNIA packages are now part of the Sun StorEdge SAN Foundation software stack. See the *Sun StorEdge SAN Foundation Installation Guide* and *Sun StorEdge SAN Foundation Release Notes* for more information on the location of the packages and how to install them. The package names are:

- SNIA common library: SUNWcfclr, SUNWcfcl, SUNWcfclx
- SAN Foundation Vendor Library: SUNWfchbr, SUNWfchba, SUNWfchbx
- FCSM driver: SUNWfcsm, SUNWfcsmx

Comparison of the Sun StorEdge SAN 3.x and 4.x Releases

TABLE 1-2 compares the features and functionality between the SAN StorEdge 3.x and 4.x releases. Some features and functions included in the Sun StorEdge 3.x release were carried over to the Sun StorEdge 4.x release, and others were not. The Sun StorEdge 4.x releases also added several new features.

TABLE 1-2 Comparison of the SAN 3.x and SAN 4.x Releases

Feature	SAN 3.*x* Features Not Supported in SAN 4.*x*	SAN 3.x Features Included In SAN 4.*x*	SAN 4.*x* Features
Supported Configurations	Cascaded configurations limited to three linear connected switches, or two ISL links between switches.	N/A	Cascaded configuration limit increased to eight linear connected switches, or seven ISL links between switches. Two of the ISL links can use long-wave transceivers and cables. Configurations support up to 239 switches. Check with the vendor-specific switch documentation for details
	SAN configurations limited to single-switch or simple cascades.	Support for local host and storage device attachment with short- or long-wave cables and transceivers for disaster tolerant configurations.	SAN configuration restrictions lifted. Meshes and other configurations are now possible.
	Limited partial fabric supported for connections between hosts and switches.	N/A	Full fabric support for connections between storage devices, hosts and switches.

TABLE 1-2 Comparison of the SAN 3.x and SAN 4.x Releases *(Continued)*

Feature	SAN 3.*x* Features Not Supported in SAN 4.*x*	SAN 3.*x* Features Included In SAN 4.*x*	SAN 4.*x* Features
Ports and Zones	Configurations limited to use of Segmented Loop (SL) or Name Server (NS) port-based zoning.	NS port-based zoning supported for fabric capability.	WWN-based zoning supported for interoperability mode among FC-SW2 standard compliant switches.
	N/A	Overlapping port-based NS zones supported.	WWN-based zones supported on all switches.
	Nested port-based zoning supported.	N/A	Nested zoning supported but not required.
	Hard zones supported.	N/A	N/A
	SL port connections to arrays supported.	TL port connections to the Sun StorEdge T3 and T3+ arrays supported for fibre channel-arbitrated loop and fabric configurations.	G and GL ports supported for connections to arrays. (G and GL ports automatically negotiate in inter-switch connections to E ports. TL ports should be manually configured for loop connections to storage devices.)
ISLs	N/A	Short- and long-wave cables and transceivers supported.	Same.
	Long-wave only 1-Gbit GBICs supported for connectivity.	N/A	Long-wave and short-wave Small Form-factor Pluggable (SFP) 2-Gbit transceivers replace GBICs.
	Long-wave only SC-SC cables supported.	Long-wave and short-wave SC cables supported.	Long-wave and short-wave SC-SC, SC-LC, and LC-LC cables supported.

TABLE 1-2 Comparison of the SAN 3.x and SAN 4.x Releases *(Continued)*

Feature	SAN 3.*x* Features Not Supported in SAN 4.*x*	SAN 3.x Features Included In SAN 4.*x*	SAN 4.*x* Features
Supported Switches	Switch hardware limited to Sun 1-Gbit 8- and 16-port switches.	SAN 3.0 switches can be upgraded with the SAN 4.0 firmware. If you do not upgrade the firmware, the 1-Gbit switches can exist on the same host as the 2-Gbit switches, but they can not connect to each other.	New 2-Gbit switches introduced.
Tools	SANbox switch management application manages the 1-Gbit switches with old firmware only.	N/A	New switch management tools are available. See the vendor-specific documentation for details.
	N/A	Multipathing and load balancing supported with the Sun StorEdge Traffic Manager application.	Multipathing and load balancing through the Sun StorEdge Traffic Manager application with SunCluster 3.0 or VERITAS Cluster Server.

TABLE 1-2 Comparison of the SAN 3.x and SAN 4.x Releases *(Continued)*

Feature	SAN 3.*x* Features Not Supported in SAN 4.*x*	SAN 3.x Features Included In SAN 4.*x*	SAN 4.*x* Features
HBAs	N/A	1-Gbit HBAs supported include: • Sun StorEdge PCI Dual Fibre Channel Network Adapter • Sun StorEdge PCI Single Fibre Channel Network Adapter, • Sun StorEdge CPCI Dual Fibre Channel Network Adapter • Sun StorEdge SBus Dual Fibre Channel Network Adapter	Newly supported host bus adapters include: • Sun Sun StorEdge 2G FC PCI Single Channel Network Adapter card • Sun StorEdge 2G FC PCI Dual Channel Network Adapter card
Supported Storage Devices	Sun StorEdge A5200 and A3500FC arrays supported.	Sun StorEdge T3 and T3+ arrays supported.	New Sun StorEdge T3+ array firmware is supported. The Sun StorEdge 39x0, 69x0 and 99x0 series, and the Sun StorEdge 9840b tape drive are also supported.
Third-party Compatibility	N/A	N/A	Interoperability compliance with FC-SW2 mode on the new switches.

Supported Hardware

The switches and drivers in the Sun StorEdge Foundation release function with the following fabric-capable storage devices:

- Sun StorEdge T3 and T3+ arrays
- Sun StorEdge 39*x*0 series

- Sun StorEdge 69*x*0 series
- Sun StorEdge 99x0 series
- Sun StorEdge 9840b FC tape drive for the L180, L700, L5500 and L6000 tape libraries

Additional hardware components from Sun that the switch supports are listed in TABLE 1-3. Check with your service representative for updates to this list.

TABLE 1-3 Supported Hardware

Model, Part Number or System Code	Description
T3BES-RR-22-655R5 T3BWG-RR-11-327R5	Sun StorEdge T3 and T3+ arrays
3910, 3960	Sun StorEdge 39x0 storage series
6910, 6960	Sun StorEdge 69x0 storage series
9910, 9960	Sun StorEdge 99x0 storage series
SG-XTAP9840FC-DRV	Sun StorEdge 9840A tape drive for the Sun StorEdge L180/L700 tape libraries*
SG-XTAP9840BFC-DRV	Sun StorEdge 9840b tape drive for the Sun StorEdge L180/L700 tape libraries
SG-XL6000-9840FC	Sun StorEdge 9840A tape drive for the Sun StorEdge L5500/L6000 tape libraries†
SG-XL5500-9840BFC	Sun StorEdge 9840b tape drive for the Sun StorEdge L5500/L6000 tape libraries
X6799A	Sun StorEdge PCI Single Fibre Channel Network Adapter
X6727A	Sun StorEdge PCI Dual Fibre Channel Network Adapter+
X6748A	Sun StorEdge CPCI Dual Fibre Channel Network Adapter
X6757A	Sun StorEdge SBus Dual Fibre Channel Host Bus adapter
X6767A	Sun StorEdge 2G FC PCI Single Channel Network Adapter
X6768A	Sun StorEdge 2G FC PCI Dual Channel Network Adapter
XSFP-SW-2Gb	Short-wave SFP
XSFP-LW-2Gb	Long-wave SFP (up to 10 km with no modifications to the switch or up to 40 km with modifications to the switch port buffer credits)
x973A	Two-meter fiber-optic cable (SC-SC)

TABLE 1-3 Supported Hardware *(Continued)*

Model, Part Number or System Code	Description
x9715A	Five-meter fiber-optic cable (SC-SC)
X978A	15-meter fiber-optic cable (SC-SC)
X9720A	SC-SC cable coupler
X9721A	0.4 meter fiber cable (LC-SC)
X9722A	two-meter fiber cable (LC-SC)
X9723A	five-meter fiber cable (LC-SC)
X9724A	15-meter fiber cable (LC-SC)
X9732a	two-meter fiber cable (LC-LC)
X9733a	five-meter fiber cable (LC-LC)
X9734a	15-meter fiber cable (LC-LC)

* Supported with the 1-Gb switch only.

† Supported with the 1-Gb switch only.

[1.] Use long-wave SFPs and fibre cables to cascade more than 500 meters in 1-Gbit mode or 300 meters in 2-Gbit mode.

Zones and Ports

Understanding zoning and use of ports is fundamental to understanding the use of configuration rules with the supported hardware. This section explains the use of zones and ports in preparation of the next section, which covers the configuration rules. Topics covered include:

- "Zone Types" on page 10
- "Port Types" on page 11

Zone Types

Zoning is a function of the switch that allows segregation of devices by ports or World Wide Names (WWNs). You can create zones for a variety of reasons, such as security, simplicity, performance, or dedication of resources. Previous releases supported hard zones, segmented loop (SL) zones and name server (NS) zones. The

current release now supports industry-standard port-based and WWN-based NS zones. See your third-party vendor documentation for more information. The two types of NS zones discussed most frequently in this documentation include:

- Port-based NS zones
- WWN-based NS zones

Name Server Zones

NS zones use fabric protocols to communicate with Fibre Channel devices. NS zones contain F, FL, G, GL, and E ports for fabric devices. Each NS zone defines which ports or devices receive NS information. GL and FL ports are not supported for Sun devices in this release. The Sun StorEdge T3 and T3+ arrays with firmware levels 1.18 and 2.0 support TL port connections.

Segmented Loop Zones

The current SAN 4.0 release does not support Segmented Loop (SL) zones or ports. If you have a SAN that requires SL connectivity to private loop devices, connect a new switch from SAN 4.0 release to the same host as an old switch from previous releases. The two SANs must, however, each have separate directories on the host for their respective management tools.

Port Types

TABLE 1-4 Switch Port Types

Port Type	Description	Supported Devices
TL Ports	Translated loop	storage devices
FL Ports	Public loop	N/A
F Ports	Point-to-point fabric	host bus adapters, storage devices
E Ports	Inter-switch port	cascaded switches acting as ISLs, which are configured initially in fabric port mode
G Ports	General ports	automatically configure to F or E ports to support hosts or switches
GL Ports	General loop ports	automatically configure to F, FL or E ports to support hosts or switches

Guidelines

This section covers guidelines for the following topics:

Cascading Guidelines

- Hub-to-switch connectivity is not supported in a fabric.
- Cascading requires connection of E ports from switch to switch with either a shortwave or longwave Small Form Factor Pluggable (SFP) 2-Gbit transceiver. The use of shortwave SFPs allows a higher port count in a local configuration. The use of longwave SFPs and long haul fiber optics allows users to reach geographically separated storage and servers, perhaps for disaster recovery purposes.
- You can have a maximum of eight switches cascaded in a linear series. In other words, you can have seven ISLs between switches. Two of the ISLs can be long-wave connections. Check with your switch vendor for specific ISL count limitations.
- Long-wave and short-wave ISLs can be used to cascade switches. The maximum distance for an ISL hop is 10 km. Multiple hops and switch port buffer credits might allow distances up to 40 km. Check with your third-party vendor documentation for details.
- If 1- and 2-Gbit switches are used together, a maximum of 16 switches can be cascaded.
- If only 2-Gbit switches are used, a maximum of 64 switches can be cascaded.
- Any number of ISL hops can be used between two switches. ISL hops do not include the connections between hosts and switches or between switches and storage.

Host and Operating Environment Guidelines

TABLE 1-5 Sun StorEdge SAN Foundation Release Sun Operating Environment Compatibility Matrix

Operating Environment	Version	Notes
Sun Solaris 2.6		Not supported
Sun Solaris 7		Not supported
Sun Solaris 8	Update 4 or later	
Sun Solaris 9 5/02		
Sun Solaris 9 9/02	Update 1	

All Solaris hosts in a zone must be running the Solaris 8 release update 4 or later operating environment with all appropriate patches installed. You can download the patches from the following web site:
`http://sunsolve.Sun.COM/pub-cgi/show.pl?target=patches/patch-access`

TABLE 1-6 Sun StorEdge SAN Foundation Release Server Compatibility Matrix

Server	Bus Architecture	HBAs	Physical Connection	Required Sun Software Packages and Patches
Sun Enterprise 3x00 - 6x00, and 10000 servers	SBus	X6757A*	1-Gbit FC	Sun StorEdge Network Foundation Software 6.0 or later with the following unbundled packages: • SUNWsan • SUNWcfpl • SUNWcfplx • SUNWcfclr • SUNWcfcl • SUNWcfclx • SUNWfchbr • SUNWfchba • SUNWfchbx • SUNWfcsm • SUNWfcsmx found at the Download Center: http://www.sun.com/storage To find all required patches: http://sunsolve.Sun.COM/ → Product Patches → PatchPro: • → Network Storage Products, or • → Solaris Recommended Patch Cluster Describe your system, then click Generate Patch List.
	PCI	X6799A† X6727A‡	1-Gbit FC	
	PCI	X6767A§ X6768A**	2-Gbit FC	
Sun Fire 3800 server	cPCI	X6748A††	1-Gbit FC	
Sun Fire 4800—6800 server	cPCI	X6748A	1-Gbit FC	
	PCI	X6799A X6727A	1-Gbit FC	
		X6767A X6768A	2-Gbit FC	
Sun Fire 280R, 480, V880, 15000 and 12000 servers SunBlade 1000 and 2000 servers Netra 1125 and 140X servers	PCI	X6799A X6727A	1-Gbit FC	
		X6767A X6768A	2-Gbit FC	

* Sun StorEdge SBus Dual Fibre Channel Host Bus Adapter

† Sun StorEdge PCI Single Fibre Channel Network Adapter

‡ Sun StorEdge PCI Dual Fibre Channel Network Adapter+

§ Sun StorEdge 2G FC PCI Single Channel Network Adapter

** Sun StorEdge 2G FC PCI Dual Channel Network Adapter

††Sun StorEdge cPCI Dual Fibre Channel Network Adapter

TABLE 1-7 Sun StorEdge SAN Foundation HBA Compatibility Matrix

FW-Code Levels for HBAs and I/O Boards	Version
X6757A, Sun StorEdge SBus Dual Fibre Channel Host Bus Adapter	1.13.06 or higher
X6799A, Sun StorEdge PCI Single Fibre Channel Network Adapter	1.13 or higher
X6727A, Sun StorEdge PCI Dual Fibre Channel Network Adapter+	1.13 or higher
X6767A, Sun StorEdge 2G FC PCI Single Channel Network Adapter	1.13.08 or higher
X6768A, Sun StorEdge 2G FC PCI Dual Channel Network Adapter	1.13.08 or higher
X6748A, Sun StorEdge cPCI Dual Fibre Channel Network Adapter	1.13 or higher

FCIP Guidelines

FCIP devices are supported for use with Network File System (NFS) software, Network Attached Storage (NAS) devices and Sun StorEdge Network Data Replicator (SNDR), or Sun StorEdge Availability Suite 3.1 remote mirror software.

TABLE 1-8 FCIP (NFS/NAS and SNDR)

Feature	Supported
Cascading	Yes, with Fabric NS zones only
Zone type	Fabric NS zone (with the HBA configured as an F port point-to-point connection)
Maximum number of device ports per zone	4*

* With the Sun StorEdge PCI Dual Fibre Channel Network Adapter+, only physical port 2 can be used for FCIP. With the Sun StorEdge cPCI Dual Fibre Channel Network Adapter, only physical port 1 can be used for FCIP.

The following restrictions apply:

- Use only physical port 2 for FCIP if you are using a Sun StorEdge PCI Dual Fibre Channel Network Adapter+.
- Use only physical port 1 for FCIP if you are using a Sun StorEdge cPCI Dual Fibre Channel Network Adapter.
- Promiscuous mode is not supported. The `snoop` (1M) utility cannot be used.
- Multicasting is supported through broadcasting only.
- Assign the IP address of the FCIP port to a subnet different from that of the Ethernets on the same system.
- Network cards using FCIP can not be used as routers. The `/etc/notrouter` file must be present on the host.

- When using FCIP, storage devices and hosts should be in separate name server zones. The storage device should have one path to one zone and another path to another zone for failover and redundancy. The host can have more than one path to a specified zone, and it should have at least one path to each zone so that it can see the respective storage.

Multipathing Guideline

Before you configure port-based zones to storage devices, you might want to set up volumes, or LUNs, for those devices. If you want high availability, you should also enable multipathing capability for load balancing of I/O traffic between hosts and arrays in the SAN. The multipathing driver described in this section is called the STMS and runs in the Solaris operating environment. See the *Sun StorEdge Traffic Manager Software Installation and Configuration Guide* for details about the component. If you are using another multipathing application, see the documentation for it.

Storage Device Guidelines

TABLE 1-9 lists various requirements for supported storage devices.

TABLE 1-9 Sun StorEdge SAN 4.x Release Storage Device Compatibility

Storage Devices	Firmware Version	Notes
Sun StorEdge T3 array	1.17b or later controller firmware	Requires translated loop (TL) switch mode
Sun StorEdge T3+ array	2.1 or later controller firmware	Requires TL or fabric switch mode
Sun StorEdge 39x0 array	2.1 or later controller firmware	Requires fabric switch mode
Sun StorEdge 69x0 array	2.1 or later controller firmware	Requires switch hardware or firmware upgrade to use SAN Foundation capabilities.
Sun StorEdge 9960 & 9910 arrays	01-16-60-00/00 or later	Requires loop or fabric mode

TABLE 1-9 Sun StorEdge SAN 4.x Release Storage Device Compatibility *(Continued)*

Sun StorEdge 9980 & 9970 arrays	21-01-24-00/00 or later	Requires loop or fabric mode
Sun StorEdge 9840A tape drive	1.30.112 or later	Requires Sun StorEdge L180/L700 tape libraries. Supported with the 1-Gb switch only with SL ports.
Sun StorEdge 9840b tape drive	1.30.322 or later	Requires Sun StorEdge L180/L700 tape libraries. Supported on 2-Gb switches with F ports.

CHAPTER 2

Adding and Removing SAN Devices

To set up a SAN, you must follow these basic steps:

1. **Physically install all the switches, hosts, storage devices and cables.**
2. **Identify the zone and port requirements for hooking up all the devices and hosts to the switches.**
3. **Configure the switch ports and switch to your zoning requirements.**
4. **Ensure that all the hosts recognize the switch and all attached devices.**

By now, you should have identified requirements and guidelines for connecting devices and hosts to the switches. This chapter helps you with the third step, setting up the devices in the zones on your switches. If you have not already done so, configure your ports and zones according to the instructions in your vendor-specific documentation.

This section covers addition of the supported storage devices, such as the Sun StorEdge T3+ array and Sun StorEdge 39x0, 69x0, and 99x0 series, to a SAN. Topics include:

Special Considerations

This section covers:

Port Choices

When configuring a Sun StorEdge T3 or T3+ array, the host port is connected to an F port and the array is connected to an F or TL port on the switch. The TL port, or translation loop port, represents eight-bit addressing devices as 24-bit addressing devices and vice versa. Although you may connect a Sun StorEdge T3 array with a TL port, the host bus adapter recognizes it as a fabric device. Sun StorEdge T3+ arrays and the Sun StorEdge 39x0, 69x0, and 99x0 series should be connected with F ports as a 24-bit addressing device for fabric connectivity. The STK 9840b tape drive and supported libraries also require F ports when connected to 2 Gbit switches.

Multipathing

You can connect the Sun StorEdge T3 or T3+ array to the SAN with or without multipathing capability. The multipathing driver discussed in this book is called the STMS and runs on the Solaris operating environment. For detailed information about the STMS or other multipathing utilities, see the STMS documentation or other third-party manuals.

Virtual Private Fabric Zones

You can add a Sun StorEdge T3 or T3+ array to another Virtual Private Fabric (VPF) zone on the original host or to a new zone on a new host. To do so, you must first remove the storage unit from the original zone and then add it back to the new zone. The following procedures explain how to do this when you have volume manager disk groups on your system.

Note – The following procedures are not necessary when you are using soft zones.

Adding and Removing Devices

This section covers:

Adding a Storage Device

- If the STMS is not enabled, read the section "Creating and Removing Individual Device Nodes Without Multipathing Enabled" on page 26. See "Creating and Removing Multiple Device Nodes Without Multipathing Enabled" on page 33 for specific information.
- If the STMS is enabled, read the section "Creating and Removing Individual Device Nodes With Multipathing Enabled" on page 37. See "Creating and Removing Multiple Device Nodes With Multipathing Enabled" on page 49 for specific information.

Note – If you use the `format` command when the STMS is enabled, as shown in FIGURE 2-1, you see only one instance of a device identifier for each LUN. Without the STMS, you see one identifier for each path. The `format` command is shown in FIGURE 2-1 but is not further described in the manual because it is an established utility.

▼ To Add a Storage Device

1. **If necessary, configure all paths to the storage device using the `cfgadm -c configure` command on all the host bus adapters that have a path to the storage device.**

   The `cfgadm -c configure` command creates device nodes. This step is necessary if the storage device is connected in an NS zone and is accessed by a host port connected to a switch F port.

2. **Import any volume manager disk groups.**

3. **Mount any existing file systems available on the storage device's LUNs or disk groups.**

   You might need to run the `fsck` command to repair any errors in the LUNs listed in the `/etc/vfstab` file.

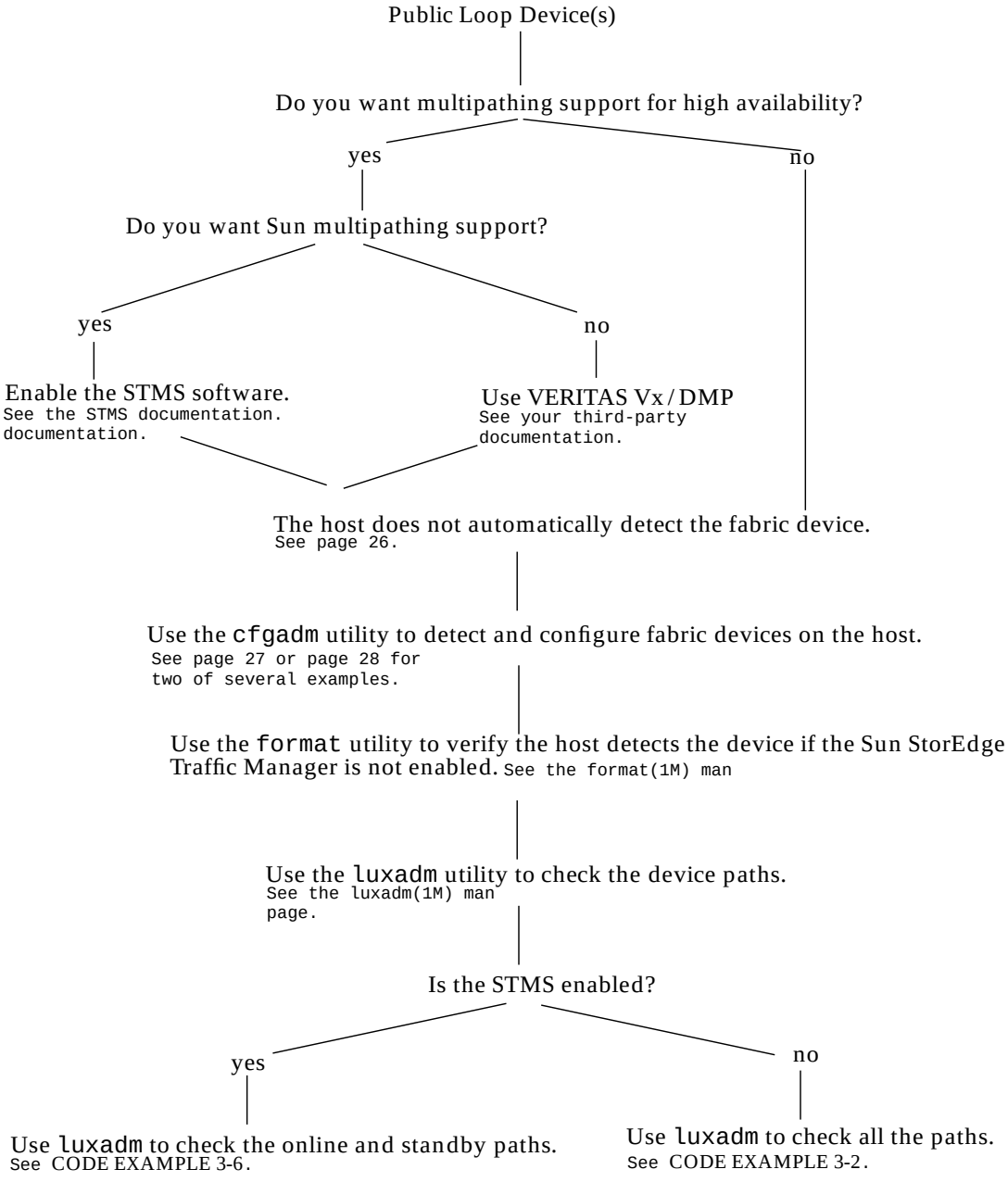

FIGURE 2-1 Decision Tree For Adding Public Devices

Removing a Storage Device

- If the STMS is not enabled, read the section “Creating and Removing Individual Device Nodes Without Multipathing Enabled” on page 26. See “To Unconfigure a Fabric Device” on page 32 for specific information.
- If the STMS is enabled, read the section “Creating and Removing Individual Device Nodes With Multipathing Enabled” on page 37. See “To Unconfigure a Fabric Device Associated With Multipathing Enabled Devices” on page 43 for specific information.

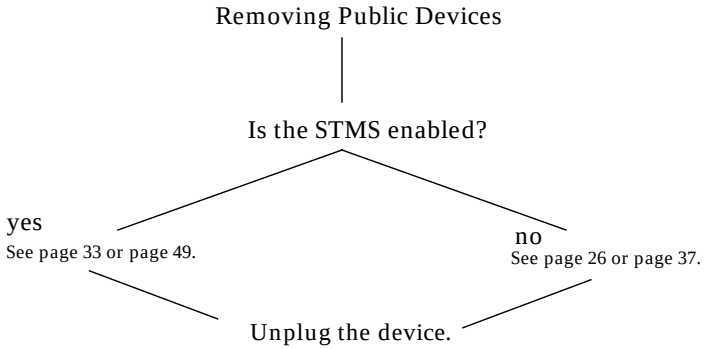

FIGURE 2-2 Decision Tree For Removing Public Devices

▼ To Remove a Storage Device

1. **Stop all LUN activity to the storage device.**
2. **Unmount any file systems currently using the storage device’s LUNs.**
3. **Deport any volume manager disk groups.**
4. **Unconfigure paths to the storage device using the** `cfgadm -c unconfigure` **command.**

   This step is necessary if the storage device is connected in an NS zone and is accessed by a host port connected to an F port on the switch.

CHAPTER 3

Public Device Node Recognition

To set up a SAN, you must follow these basic steps:

1. **Physically install all the switches, hosts, storage devices and cables.**
2. **Identify the zone and port requirements for hooking up all the devices and hosts to the switches.**
3. **Configure the switch ports and switch to your zoning requirements.**
4. **Ensure that all the hosts recognize the switch and all attached devices.**

After you configure the ports and zones in your SAN, you must ensure the hosts recognize the switches and devices. This chapter helps you complete the fourth step. It explains host recognition of fabric devices, also known as 24-bit Fibre Channel addressing devices on the SAN. After configuring the devices, ports and zones in your SAN, you need to make sure that the host is aware of the devices and their switch connections. You can have up to 16 million fabric devices connected together on a SAN with Fibre Channel support.

This chapter provides generic instructions for adding and removing all supported devices in this release. For example output of a Sun StorEdge 99x0 series device configuration, see Appendix A. This chapter includes:

There are a variety of ways in which you can ensure the host recognizes storage devices you add on your SAN. The decision trees in FIGURE 2-1 and FIGURE 2-2 help guide you through the process.

Note – You can connect a Sun StorEdge T3 array as an FC-AL device to a switch, but the Sun StorEdge host bus adapters supported in the SAN Foundation release recognize the array as a fabric device.

The scope of this chapter is limited to the operations required from the perspective of the Solaris operating environment. It does *not* cover other aspects, such as device availability and device-specific management. If devices are managed by other software, such as a volume manager, refer to the volume manager product documentation for additional instructions.

Creating and Removing Individual Device Nodes Without Multipathing Enabled

This section describes fabric device configuration tasks on a host that does not have the STMS enabled.

The procedures in this section use specific devices as examples to illustrate how to use the `cfgadm`(1M) command to detect and configure fabric devices.

The devices attached to the fabric-connected host port are not configured by default, thus those devices are not available to the host using the Solaris operating environment. Use the `cfgadm`(1M) `configure` and `unconfigure` commands to manage device node creation for fabric devices. See the `cfgadm_fp`(1M) man page for additional information.

The procedures in this section illustrate how to detect fabric devices that are visible on a host and to configure and make them available to a host using the Solaris operating environment.

The device information that you supply and that is displayed by the `cfgadm`(1M) command depends on your system configuration.

This section contains the following topics:

▼ To Detect Fabric Devices Visible on a Host

This procedure uses Fibre Channel host ports `c0` and `c1`, and the devices attached to them, to provide an example of detecting fabric devices. This procedure also shows the device configuration information that is displayed with the `cfgadm(1M)` command.

Note – If you do not install the proper software patches and packages for this release, Fibre Channel devices do not display in the `cfgadm(1M)` command output. In the following examples, only failover path attachment point IDs (Ap_Ids) are listed. The Ap_Ids displayed on your system depend on your system configuration.

---

1. **Become superuser.**
2. **Display the information about the attachment points on the system.**

```
# cfgadm -l
Ap_Id              Type        Receptacle   Occupant     Condition
c0                 fc-private  connected    unconfigured unknown
c1                 fc-private  connected    configured   unknown
```

In this example, `c0` represents a fabric-connected host port, and `c1` represents a private, loop-connected host port. Use the `cfgadm(1M)` command to manage the device configuration on fabric-connected host ports.

By default, the device configuration on private, loop-connected host ports is managed by a host using the Solaris operating environment.

3. **Display information about the host ports and their attached devices.**

```
# cfgadm -al
Ap_Id              Type        Receptacle   Occupant     Condition
c0                 fc-fabric   connected    unconfigured unknown
c0::50020f2300006077 disk      connected    unconfigured unknown
c0::50020f23000063a9 disk      connected    unconfigured unknown
c0::50020f2300005f24 disk      connected    unconfigured unknown
c0::50020f2300006107 disk      connected    unconfigured unknown
c1                 fc-private  connected    configured   unknown
c1::220203708b69c32b disk      connected    configured   unknown
c1::220203708ba7d832 disk      connected    configured   unknown
c1::220203708b8d45f2 disk      connected    configured   unknown
c1::220203708b9b20b2 disk      connected    configured   unknown
```

Note – The `cfgadm -l` command displays information about Fibre Channel host ports. Also use the `cfgadm -al` command to display information about Fibre Channel devices. The lines that include a port World Wide Name (WWN) in the Ap_Id field associated with `c0` represent a fabric device. Use the `cfgadm configure` and `unconfigure` commands to manage those devices and make them available to hosts using the Solaris operating environment. The Ap_Id devices with port WWNs under `c1` represent private-loop devices that are configured through the `c1` host port.

To identify which device nodes represent the same storage device on your own system, log in to your Sun StorEdge T3 array and use `port list` to list the WWNs of the array controllers attached to your SAN.

Ensuring LUN Level Information Is Visible

If you issue the `cfgadm -al -o show_FCP_dev` <*controller_id*> command immediately after a system boots up, the output might not show the Fibre Channel Protocol (FCP) SCSI LUN level information. The information does not appear because the storage device drivers, such as the `ssd` and `st` driver, are not loaded on the running system. Use the `modinfo` command to check if the drivers are loaded. After you load the drivers, the LUN level information is visible in the `cfgadm` output.

▼ To Configure a Fabric Device Without Multipathing Enabled On the Host

This procedure describes how to configure a fabric device that is attached to the fabric-connected host port `c0`.

1. **Become superuser.**
2. **Identify the device to be configured.**

Only devices on a fabric-connected host port can be configured.

```
# cfgadm -al
Ap_Id                Type         Receptacle   Occupant     Condition
c0                    fc-fabric   connected    unconfigured unknown
c0::50020f2300006077 disk         connected    unconfigured unknown
c0::50020f23000063a9 disk         connected    unconfigured unknown
c0::50020f2300005f24 disk         connected    unconfigured unknown
c0::50020f2300006107 disk         connected    unconfigured unknown
c1                   fc-private   connected    configured   unknown
c1::220203708b69c32b disk         connected    configured   unknown
c1::220203708ba7d832 disk         connected    configured   unknown
c1::220203708b8d45f2 disk         connected    configured   unknown
c1::220203708b9b20b2 disk         connected    configured   unknown
```

3. **Configure the fabric device.**

```
# cfgadm -c configure c0::50020f2300006077
```

4. **Verify that the selected fabric device is configured.**

```
# cfgadm -al
Ap_Id                Type         Receptacle   Occupant     Condition
c0                     fc-fabric  connected    configured   unknown
c0::50020f2300006077 disk         connected    configured   unknown
c0::50020f23000063a9 disk         connected    unconfigured unknown
c0::50020f2300005f24 disk         connected    unconfigured unknown
c0::50020f2300006107 disk         connected    unconfigured unknown
c1                     fc-private connected    configured   unknown
c1::220203708b69c32b disk         connected    configured   unknown
c1::220203708ba7d832 disk         connected    configured   unknown
c1::220203708b8d45f2 disk         connected    configured   unknown
c1::220203708b9b20b2 disk         connected    configured   unknown
```

Notice that the Occupant column for both `c0` and `c0::50020f2300006077` displays as configured, indicating that the `c0` port has a configured occupant and that the `c0::50020f2300006077` device is configured.

Use the show_FCP_dev option to display FCP SCSI LUN information for multi-LUN SCSI devices. From CODE EXAMPLE 3-1, the physical devices connected through ap_id c2::50020f2300006107 and ap_id c2::50020f2300005f24 have two LUNs configured respectively.

CODE EXAMPLE 3-1 show_FCP_dev Output Showing Two LUNs

```
# cfgadm -al -o show_FCP_dev c2
Ap_Id                Type        Receptacle   Occupant     Condition
c2                    fc-fabric  connected    configured   unknown
c2::50020f2300005f24,0 disk     connected    configured   unknown
c2::50020f2300005f24,1 disk     connected    configured   unknown
c2::50020f2300006107,0 disk     connected    configured   unknown
c2::50020f2300006107,1 disk     connected    configured   unknown
```

The device is now available on the host using the Solaris operating environment. CODE EXAMPLE 3-2 is an example of the luxadm(1M) output. Notice that four devices are listed under Paths:

```
/dev/rdsk/c0t50020F2300006077d3s2
/dev/rdsk/c0t50020F2300006077d2s2
/dev/rdsk/c0t50020F2300006077d1s2
/dev/rdsk/c0t50020F2300006077d0s2
```

The paths represent each SCSI LUN in the physical device represented by c0::50020f2300006077.

CODE EXAMPLE 3-2 luxadm Output For Four Devices and a Single Array

```
# luxadm display 50020f2300006077
DEVICE PROPERTIES for disk: 50020f2300006077
 Status(Port A):       O.K.
 Vendor:               SUN
Product ID:           T300
 WWN(Node):            50020f2000006077
 WWN(Port A):          50020f2300006077
 Revision:             0117
 Serial Num:           Unsupported
 Unformatted capacity: 558448.000 MBytes
Write Cache:          Enabled
Read Cache:           Enabled
 Minimum prefetch:   0x0
 Maximum prefetch:   0x0
Device Type:          Disk device
 Path(s):
/dev/rdsk/c0t50020F2300006077d3s2
```

CODE EXAMPLE 3-2 `luxadm` Output For Four Devices and a Single Array *(Continued)*

```
/devices/pci@1f,2000/pci@1/SUNW,qlc@4/fp@0,0/ssd@w50020f23000060
77,3:c,raw
DEVICE PROPERTIES for disk: 50020f2300006077
 Status(Port A):       O.K.
 Vendor:               SUN
 Product ID:           T300
WWN(Node):            50020f2000006077
 WWN(Port A):          50020f2300006077
 Revision:             0117
 Serial Num:           Unsupported
Unformatted capacity: 558448.000 MBytes
 Write Cache:          Enabled
Read Cache:           Enabled
 Minimum prefetch:   0x0
 Maximum prefetch:   0x0
Device Type:          Disk device
Path(s):
/dev/rdsk/c0t50020F2300006077d2s2
/devices/pci@1f,2000/pci@1/SUNW,qlc@4/fp@0,0/ssd@w50020f23000060
77,2:c,raw
DEVICE PROPERTIES for disk: 50020f2300006077
 Status(Port A):       O.K.
Vendor:               SUN
Product ID:           T300
WWN(Node):            50020f2000006077
WWN(Port A):          50020f2300006077
Revision:             0117
Serial Num:           Unsupported
Unformatted capacity: 558448.000 MBytes
Write Cache:          Enabled
Read Cache:           Enabled
Minimum prefetch:   0x0
Maximum prefetch:   0x0
Device Type:          Disk device
Path(s):
/dev/rdsk/c0t50020F2300006077d1s2
/devices/pci@1f,2000/pci@1/SUNW,qlc@4/fp@0,0/ssd@w50020f23000060
77,1:c,raw
DEVICE PROPERTIES for disk: 50020f2300006077
 Status(Port B):       O.K.
Vendor:               SUN
 Product ID:           T300
WWN(Node):            50020f2000006077
 WWN(Port B):          50020f2300006077
```

CODE EXAMPLE 3-2 `luxadm` Output For Four Devices and a Single Array *(Continued)*

```
Revision:             0117
Serial Num:           Unsupported
Unformatted capacity: 558448.000 MBytes
Write Cache:          Enabled
Read Cache:           Enabled
Minimum prefetch:   0x0
Maximum prefetch:   0x0
Device Type:          Disk device
 Path(s):

/dev/rdsk/c0t50020F2300006077d0s2
/devices/pci@1f,2000/pci@1/SUNW,qlc@4/fp@0,0/ssd@w50020f23000060
77,0:c,raw
```

▼ To Unconfigure a Fabric Device

This procedure describes how to unconfigure a fabric device that is attached to the fabric-connected host port `c0`.

Note – Before you unconfigure a fabric device, stop all activity to the device and unmount any file systems on the fabric device. See the administration documentation for the Solaris operating environment for unmounting instructions. If the device is under any volume manager's control, see the documentation for your volume manager for maintaining the fabric device

---

1. **Become superuser.**
2. **Identify the device to be unconfigured.**

   Only devices on a fabric-connected host port can be unconfigured.

```
# cfgadm -al
Ap_Id                Type         Receptacle   Occupant    Condition
c0                    fc-fabric   connected    configured   unknown
c0::50020f2300006077 disk         connected    configured   unknown
c0::50020f23000063a9 disk         connected    configured   unknown
c0::50020f2300005f24 disk         connected    configured   unknown
c0::50020f2300006107 disk         connected    configured   unknown
c1                    fc-private  connected    configured   unknown
c1::220203708b69c32b disk         connected    configured   unknown
c1::220203708ba7d832 disk         connected    configured   unknown
c1::220203708b8d45f2 disk         connected    configured   unknown
c1::220203708b9b20b2 disk         connected    configured   unknown
```

3. **Unconfigure the fabric device.**

```
# cfgadm -c unconfigure c0::50020f2300006077
```

4. **Verify that the selected fabric device is unconfigured.**

```
# cfgadm -al
Ap_Id                Type         Receptacle   Occupant     Condition
c0                   fc-fabric     connected    configured   unknown
c0::50020f2300006077 disk          connected    unconfigured unknown
c0::50020f23000063a9 disk          connected    configured   unknown
c0::50020f2300005f24 disk          connected    configured   unknown
c0::50020f2300006107 disk          connected    configured   unknown
c1                   fc-private    connected    configured   unknown
c1::220203708b69c32b disk          connected    configured   unknown
c1::220203708ba7d832 disk          connected    configured   unknown
c1::220203708b8d45f2 disk          connected    configured   unknown
c1::220203708b9b20b2 disk          connected    configured   unknown
```

Creating and Removing Multiple Device Nodes Without Multipathing Enabled

Procedures for creating and removing multiple devices are similar to those described in “Creating and Removing Individual Device Nodes Without Multipathing Enabled” on page 26. This section explains the finer differences. Make sure you first identify the devices visible to the host with the procedure “To Detect Fabric Devices Visible on a Host” on page 27. This section covers:

- “To Configure All Fabric Devices on a Fabric-Connected Host Port” on page 33
- “To Unconfigure All Fabric Devices on a Fabric-Connected Host Port” on page 35

▼ To Configure All Fabric Devices on a Fabric-Connected Host Port

This procedure describes how to configure all unconfigured fabric devices that are attached to a fabric-connected host port. The port used as an example is `c0`.

1. **Become superuser.**

2. **Identify the devices to be configured.**

```
# cfgadm -al
Ap_Id              Type        Receptacle   Occupant     Condition
c0                 fc-fabric    connected    unconfigured unknown
c0::50020f2300006077 disk        connected    unconfigured unknown
c0::50020f23000063a9 disk        connected    unconfigured unknown
c0::50020f2300005f24 disk        connected    unconfigured unknown
c0::50020f2300006107 disk        connected    unconfigured unknown
c1                  fc-private  connected    configured   unknown
c1::220203708b69c32b disk        connected    configured   unknown
c1::220203708ba7d832 disk        connected    configured   unknown
c1::220203708b8d45f2 disk        connected    configured   unknown
c1::220203708b9b20b2 disk        connected    configured   unknown
```

3. **Configure all of the unconfigured devices on the selected port.**

```
# cfgadm -c configure c0
```

Note – This operation repeats the `configure` operation of an individual device for all the devices on `c0`, and can be time consuming if the number of devices on `c0` is large.

---

4. **Verify that all devices on `c0` are configured.**

```
# cfgadm -al
Ap_Id              Type        Receptacle   Occupant     Condition
c0                   fc-fabric   connected   configured   unknown
c0::50020f2300006077 disk        connected   configured   unknown
c0::50020f23000063a9 disk        connected   configured   unknown
c0::50020f2300005f24 disk        connected   configured   unknown
c0::50020f2300006107 disk        connected   configured   unknown
c1                   fc-private  connected   configured   unknown
c1::220203708b69c32b disk        connected   configured   unknown
c1::220203708ba7d832 disk        connected   configured   unknown
c1::220203708b8d45f2 disk        connected   configured   unknown
c1::220203708b9b20b2 disk        connected   configured   unknown
```

The show_FCP_dev option displays FCP SCSI LUN information for multiple LUN SCSI devices. From the example in CODE EXAMPLE 3-3, the physical devices represented by c0::50020f2300006077 and c0::50020f2300006107 have four LUNs configured respectively. The physical devices represented by c0::50020f23000063a9 and c0::50020f2300005f24 have two LUNs configured respectively.

CODE EXAMPLE 3-3 show_FCP_dev Output For Multiple LUNs and Two Devices

```
# cfgadm -al -o show_FCP_dev c0
Ap_Id                Type         Receptacle   Occupant     Condition
c0                    fc-fabric   connected    configured   unknown
c0::50020f2300006077,0 disk       connected    configured   unknown
c0::50020f2300006077,1 disk       connected    configured   unknown
c0::50020f2300006077,2 disk       connected    configured   unknown
c0::50020f2300006077,3 disk       connected    configured   unknown
c0::50020f23000063a9,0 disk       connected    configured   unknown
c0::50020f23000063a9,1 disk       connected    configured   unknown
c0::50020f2300005f24,0 disk       connected    configured   unknown
c0::50020f2300005f24,1 disk       connected    configured   unknown
c0::50020f2300006107,0 disk       connected    configured   unknown
c0::50020f2300006107,1 disk       connected    configured   unknown
c0::50020f2300006107,2 disk       connected    configured   unknown
c0::50020f2300006107,3 disk       connected    configured   unknown
```

▼ To Unconfigure All Fabric Devices on a Fabric-Connected Host Port

This procedure describes how to unconfigure all configured fabric devices that are attached to a fabric-connected host port.

1. **Become superuser.**

2. **Identify the fabric devices to be unconfigured.**

   Only devices on a fabric-connected host port can be unconfigured.

```
# cfgadm -al
Ap_Id              Type         Receptacle   Occupant     Condition
c0                 fc-fabric    connected    configured   unknown
c0::50020f2300006077 disk       connected    configured   unknown
c0::50020f23000063a9 disk       connected    configured   unknown
c0::50020f2300005f24 disk       connected    configured   unknown
c0::50020f2300006107 disk       connected    configured   unknown
c1                 fc-private   connected    configured   unknown
c1::220203708b69c32b disk       connected    configured   unknown
c1::220203708ba7d832 disk       connected    configured   unknown
c1::220203708b8d45f2 disk       connected    configured   unknown
c1::220203708b9b20b2 disk       connected    configured   unknown
```

3. **Unconfigure all of the configured fabric devices on a selected port.**

Note – Stop all activity to each fabric device on the selected port and unmount any file systems on each fabric device. If the device is under any volume manager's control, see the documentation for your volume manager for maintaining the fabric device.

```
# cfgadm -c unconfigure c0
```

Note – This operation repeats the `unconfigure` operation of an individual device for all the devices on `c0` and it can be time-consuming if the number of devices on `c0` is large.

---

4. **Verify that all the devices on `c0` are unconfigured.**

```
# cfgadm -al
Ap_Id              Type         Receptacle   Occupant     Condition
c0                  fc-fabric    connected    unconfigured unknown
c0::50020f2300006077 disk        connected    unconfigured unknown
c0::50020f23000063a9 disk        connected    unconfigured unknown
c0::50020f2300005f24 disk        connected    unconfigured unknown
c0::50020f2300006107 disk        connected    unconfigured unknown
c1                  fc-private   connected    configured   unknown
c1::220203708b69c32b disk        connected    configured   unknown
c1::220203708ba7d832 disk        connected    configured   unknown
c1::220203708b8d45f2 disk        connected    configured   unknown
c1::220203708b9b20b2 disk        connected    configured   unknown
```

Notice that the Occupant column of `c0` and all the fabric devices attached to it are displayed as unconfigured.

Creating and Removing Individual Device Nodes With Multipathing Enabled

This section describes how to perform fabric device configuration steps on a host that has the Sun StorEdge Traffic Manager multipathing software enabled.

The devices that are attached to fabric-connected HBA ports are not configured by default. These devices are thus not available to the host using the Solaris operating environment when a host port is initially connected to a fabric. The procedures in this section illustrate steps to detect fabric devices that are visible on a host and to configure them as Sun StorEdge Traffic Manager devices to make them available to the host using the Solaris operating environment.

The device information that you supply, and that which is displayed by the `cfgadm`(1M) command, depends on your system configuration. (For more information on the `cfgadm` command, see the `cfgadm_fp`(1M) and `cfgadm`(1M) man pages.)

This section contains the following procedures:

- "To Configure Fabric-Connected Device Nodes With Multipathing Enabled Devices" on page 40
- "To Unconfigure a Fabric Device Associated With Multipathing Enabled Devices" on page 43
- "To Unconfigure One Path to a Multipathed Device" on page 45
- "To Configure All Fabric-Connected Devices With Multipathing Enabled" on page 49
- "To Unconfigure All Fabric-Connected Devices With Multipathing Enabled" on page 54

▼ To Detect Fabric Devices Visible to a Host

This procedure shows Fibre Channel host ports `c0`, `c1`, and `c2` and the devices attached to them. It illustrates fabric device detection and device configuration using the `cfgadm`(1M) command.

Note – If the proper `cfgadm` support for Fibre Channel devices is not installed, Fibre Channel devices do not display in the `cfgadm`(1M) command output. In the following examples, only failover path attachment points (Ap_Ids) are listed. The Ap_Ids displayed on your system depend on your system configuration.

---

1. **Become superuser.**
2. **Display information about the attachment points on the system.**

```
# cfgadm -l
Ap_Id              Type        Receptacle   Occupant     Condition
c0                  fc-fabric    connected    unconfigured unknown
c1                  fc-private   connected    configured   unknown
c2                  fc-fabric    connected    unconfigured unknown
```

An Ap_Id on a fabric-connected host port is a path to a Sun StorEdge Traffic Manager device. In this example, `c0` and `c2` represent fabric-connected host ports. Also, `c1` represents a private, loop-connected host port. Use the `cfgadm`(1M) command to manage the device configuration on fabric-connected host ports.

By default, the device configuration on private, loop-connected host ports are managed by a host using the Solaris operating environment.

3. **Display information about the host ports and their attached devices.**

```
# cfgadm -al
Ap_Id                Type         Receptacle   Occupant     Condition
c0                    fc-fabric    connected    unconfigured unknown
c0::50020f2300006077 disk         connected    unconfigured unknown
c0::50020f23000063a9 disk         connected    unconfigured unknown
c1                    fc-private   connected    configured   unknown
c1::220203708b69c32b disk         connected    configured   unknown
c1::220203708ba7d832 disk         connected    configured   unknown
c1::220203708b8d45f2 disk         connected    configured   unknown
c1::220203708b9b20b2 disk         connected    configured   unknown
c2                    fc-fabric    connected    unconfigured unknown
c2::50020f2300005f24 disk         connected    unconfigured unknown
c2::50020f2300006107 disk         connected    unconfigured unknown
```

Note – The `cfgadm -l` command displays information about Fibre Channel host ports. Also use the `cfgadm -al` command to display information about Fibre Channel devices. The lines that include a port World Wide Name (WWN) in the Ap_Id field associated with `c0` represent a fabric device. Use the `cfgadm configure` and `unconfigure` commands to manage those devices and make available to hosts using the Solaris operating environment. The Ap_Id devices with port WWNs under `c1` represent private-loop devices that are configured through the `c1` host port.

In the previous example, host ports `c0` and `c2` are connected to the two ports of a Sun StorEdge T3 enterprise array that has two port WWNs associated with it: Ap_Ids `50020f2300006077` and `50020f2300006107`.

If your storage device is a Sun StorEdge T3 array and you want to identify which device nodes represent the same storage device on your own system, log in to the array and use `port list` to list the WWNs of the array controllers attached to your SAN.

Ensuring LUN Level Information Is Visible

If you issue the `cfgadm -al -o show_FCP_dev` <*controller_id*> command immediately after a system boots up, the output might not show the Fibre Channel Protocol (FCP) SCSI LUN level information. The information does not appear because the storage device drivers, such as the `ssd` and `st` driver, are not loaded on the running system. Use the `modinfo` command to check if the drivers are loaded. After you load the drivers, the LUN level information is visible in the `cfgadm` output.

▼ To Configure Fabric-Connected Device Nodes With Multipathing Enabled Devices

This procedure uses fabric-connected host ports `c0` and `c2` to configure fabric devices as Sun StorEdge Traffic Manager devices on a host that has the STMS enabled.

Note – Whether the STMS is enabled or not, the `cfgadm -c unconfigure` command for Fabric devices is identical, but the result is different. When the Sun Storage Traffic Manager software is enabled, the host using the Solaris operating environment creates device-node and path information that includes STMS information. The devices are still listed as `fc-fabric` devices, but the specific Ap_Ids are marked as `unconfigured` in the Occupant column.

---

1. **Become superuser.**

2. **Identify the port WWN of the device to be configured as a Sun StorEdge Traffic Manager device.**

   Look for devices on a fabric-connected host port, marked as `fc-fabric`. These are the devices you can configure with the `cfgadm -c configure` command.

   CODE EXAMPLE 3-4 `cfgadm` Listing of fabric and Private-Loop Devices

```
 # cfgadm -al
Ap_Id                Type        Receptacle   Occupant     Condition
c0                    fc-fabric  connected    unconfigured unknown
c0::50020f2300006077 disk        connected    unconfigured unknown
c0::50020f23000063a9 disk        connected    unconfigured unknown
c1                    fc-private connected    configured   unknown
c1::220203708b69c32b disk        connected    configured   unknown
c1::220203708ba7d832 disk        connected    configured   unknown
c1::220203708b8d45f2 disk        connected    configured   unknown
c1::220203708b9b20b2 disk        connected    configured   unknown
c2                    fc-fabric  connected    unconfigured unknown
c2::50020f2300005f24 disk        connected    unconfigured unknown
c2::50020f2300006107 disk        connected    unconfigured unknown
```

   In CODE EXAMPLE 3-4, the `c0::50020f2300006077` and `c2::50020f2300006107` Ap_Ids represent the same storage device with different port WWNs for the storage device controllers. The `c0` and `c2` host ports are enabled for use by the STMS.

3. **Configure the fabric device and make Sun StorEdge Traffic Manager devices available to the host.**

```
# cfgadm -c configure c0::50020f2300006077 c2::50020f2300006107
```

4. **Verify that the selected devices are configured.**

```
# cfgadm -al
Ap_Id                Type         Receptacle   Occupant     Condition
c0                    fc-fabric    connected    configured   unknown
c0::50020f2300006077 disk         connected    configured   unknown
c0::50020f23000063a9 disk         connected    unconfigured unknown
c1                   fc-private   connected    configured   unknown
c1::220203708b69c32b disk         connected    configured   unknown
c1::220203708ba7d832 disk         connected    configured   unknown
c1::220203708b8d45f2 disk         connected    configured   unknown
c1::220203708b9b20b2 disk         connected    configured   unknown
c2                    fc-fabric    connected    configured   unknown
c2::50020f2300005f24 disk         connected    unconfigured unknown
c2::50020f2300006107 disk         connected    configured   unknown
```

Notice that the Occupant column of `c0` and `c0::50020f2300006077` specifies configured, which indicates that the `c0` port has at least one configured occupant and that the `c0::50020f2300006077` device is configured. The same change has been made in `c2` and `c2::50020f2300006107`.

After completing the configure operation without an error, STMS enabled devices are created on the host using the Solaris operating environment. If the physical device represented by `c0::50020f2300006077` and `c2::50020f2300006107` has multiple SCSI LUNs configured, each LUN is configured as a Sun StorEdge Traffic Manager device. CODE EXAMPLE 3-5 shows that two LUNs are configured through `c0::50020f2300006077` and `c2::50020f2300006107`. Each `ap_id` is associated with a path to those Sun StorEdge Traffic Manager devices.

CODE EXAMPLE 3-5 `show_FCP_dev` Output For Two LUNs On a Device

```
# cfgadm -al -o show_FCP_dev c0::50020f2300006077
c2::50020f2300006107
Ap_Id                Type         Receptacle   Occupant     Condition
c0::50020f2300006077,0 disk     connected    configured   unknown
c0::50020f2300006077,1 disk     connected    configured   unknown
c2::50020f2300006107,0 disk     connected    configured   unknown
c2::50020f2300006107,1 disk     connected    configured   unknown
```

In CODE EXAMPLE 3-6, notice that two STMS enabled devices

```
/dev/rdsk/c6t60020F20000061073AC8B52D000B74A3d0s2
/dev/rdsk/c6t60020F20000061073AC8B4C50004ED3Ad0s2
```

are created for the device represented by `c0::50020f2300006077` and `c2::50020f2300006107`.

CODE EXAMPLE 3-6 `luxadm(1M)` Output For Multiple Device Nodes With the STMS Enabled

```
# luxadm display 50020f2300006077
DEVICE PROPERTIES for disk: 50020f2300006077
  Status(Port A):       O.K.
  Status(Port B):       O.K.
  Vendor:               SUN
  Product ID:           T300
  WWN(Node):            50020f2000006077
  WWN(Port A):          50020f2300006077
  WWN(Port B):          50020f2300006107
  Revision:             0117
  Serial Num:           Unsupported
  Unformatted capacity: 558448.000 MBytes
  Write Cache:          Enabled
  Read Cache:           Enabled
    Minimum prefetch:   0x0
    Maximum prefetch:   0x0
  Device Type:          Disk device
  Path(s):
  /dev/rdsk/c6t60020F20000061073AC8B52D000B74A3d0s2
  /devices/scsi_vhci/ssd@g60020f20000061073ac8b52d000b74a3:c,raw
   Controller        /devices/pci@1f,2000/pci@1/SUNW,qlc@4/fp@0,0
     Device Address     50020f2300006107,1
     Class              secondary
     State              STANDBY
   Controller        /devices/pci@1f,2000/pci@1/SUNW,qlc@5/fp@0,0
     Device Address     50020f2300006077,1
     Class              primary
     State              ONLINE

DEVICE PROPERTIES for disk: 50020f2300006077
  Status(Port A):       O.K.
  Status(Port B):       O.K.
  Vendor:               SUN
  Product ID:           T300
  WWN(Node):            50020f2000006107
```

CODE EXAMPLE 3-6 `luxadm(1M)` Output For Multiple Device Nodes With the STMS Enabled *(Continued)*

```
   WWN(Port A):          50020f2300006107
   WWN(Port B):          50020f2300006077
   Revision:             0117
   Serial Num:           Unsupported
   Unformatted capacity: 558448.000 MBytes
   Write Cache:          Enabled
   Read Cache:           Enabled
     Minimum prefetch:   0x0
     Maximum prefetch:   0x0
   Device Type:          Disk device
   Path(s):
   /dev/rdsk/c6t60020F20000061073AC8B4C50004ED3Ad0s2
   /devices/scsi_vhci/ssd@g60020f20000061073ac8b4c50004ed3a:c,raw
    Controller        /devices/pci@1f,2000/pci@1/SUNW,qlc@4/fp@0,0
      Device Address     50020f2300006107,0
      Class              primary
      State              ONLINE
    Controller        /devices/pci@1f,2000/pci@1/SUNW,qlc@5/fp@0,0
      Device Address     50020f2300006077,0
      Class              secondary
      State              STANDBY
```

Note – The `luxadm` (1M) output on device `50020f2300006107` shows the same information as the previous display.

▼ To Unconfigure a Fabric Device Associated With Multipathing Enabled Devices

This procedure shows fabric-connected host ports `c0` and `c2` to illustrate how to unconfigure fabric devices associated with Sun StorEdge Traffic Manager devices.

Note – Whether the STMS is enabled or not, the `cfgadm -c unconfigure` command for Fabric devices is identical, but the result is different. When the Sun Storage Traffic Manager software is enabled, the host using the Solaris operating environment creates device-node and path information that includes STMS information. The devices are still listed as fc-`fabric` devices, but the specific Ap_Ids are marked as `unconfigured` in the Occupant column.

1. **Become superuser.**

2. **Identify the port WWN of the fabric device to be unconfigured.**

```
# cfgadm -al
Ap_Id                Type         Receptacle   Occupant    Condition
c0                   fc-fabric    connected    configured   unknown
c0::50020f2300006077 disk         connected    configured   unknown
c0::50020f23000063a9 disk         connected    configured   unknown
c1                   fc-private   connected    configured   unknown
c1::220203708b69c32b disk         connected    configured   unknown
c1::220203708ba7d832 disk         connected    configured   unknown
c1::220203708b8d45f2 disk         connected    configured   unknown
c1::220203708b9b20b2 disk         connected    configured   unknown
c2                   fc-fabric    connected    configured   unknown
c2::50020f2300005f24 disk         connected    configured   unknown
c2::50020f2300006107 disk         connected    configured   unknown
```

In this example, the `c0::50020f2300006077` and `c2::50020f2300006107` Ap_Ids represent different port WWNs for the same device associated with a Sun StorEdge Traffic Manager device. The c0 and c2 host ports are enabled for use by the STMS.

Note – Stop all device activity to each fabric device on the selected port and unmount any file systems on each fabric device. If the device is under any volume manager's control, see the documentation for your volume manager for maintaining the fabric device.

---

3. **Unconfigure fabric devices associated with the Sun StorEdge Traffic Manager device.**

   Only devices on a fabric-connected host port can be unconfigured through the `cfgadm -c unconfigure` command.

```
# cfgadm -c unconfigure c0::50020f2300006077 c2::50020f2300006107
```

Note – You can remove a device from up to eight paths individually, as in the example command `cfgadm -c unconfigure c0::1111, c1::2222, c3::3333`, etc. As an alternative, you can remove an entire set of paths from the host, as in the example `cfgadm -c unconfigure c0.`

---

4. **Verify that the selected devices are unconfigured.**

```
# cfgadm -al
Ap_Id                Type         Receptacle   Occupant     Condition
c0                   fc-fabric     connected    configured   unknown
c0::50020f2300006077 disk          connected    unconfigured unknown
c0::50020f23000063a9 disk          connected    configured   unknown
c1                   fc-private    connected    configured   unknown
c1::220203708b69c32b disk          connected    configured   unknown
c1::220203708ba7d832 disk          connected    configured   unknown
c1::220203708b8d45f2 disk          connected    configured   unknown
c1::220203708b9b20b2 disk          connected    configured   unknown
c2                   fc-fabric     connected    configured   unknown
c2::50020f2300005f24 disk          connected    configured   unknown
c2::50020f2300006107 disk          connected    unconfigured unknown
```

Notice that the Ap_Ids `c0::50020f2300006077` and `c2::50020f2300006107` are unconfigured. The Occupant column of `c0` and `c2` still displays those ports as configured because they have other configured occupants.

The Sun StorEdge Traffic Manager devices associated with the Ap_Ids `c0::50020f2300006077` and `c2::50020f2300006107` are no longer available to the host using the Solaris operating environment. The two Sun StorEdge Traffic Manager devices,

`/dev/rdsk/c6t60020F20000061073AC8B52D000B74A3d0s2`

and

`/dev/rdsk/c6t60020F20000061073AC8B4C50004ED3Ad0s2`

are removed from the host.

▼ To Unconfigure One Path to a Multipathed Device

In “To Unconfigure a Fabric Device Associated With Multipathing Enabled Devices” on page 43, a storage device is connected to the host using the Solaris operating environment by two Ap_Ids, `c0::50020f2300006077` and `c2::50020f2300006107`. For the STMS enabled host, each Ap_Id is associated with the path to a Sun StorEdge Traffic Manager device that represents the physical storage device. This procedure shows how to unconfigure a device associated with `c2::50020f2300006107` and leave the other Ap_Id, `50020f2300006077`, configured.

1. **Become superuser.**

2. **Identify the Ap_Id of the Sun StorEdge Traffic Manager device to be unconfigured.**

   An Ap_Id on a fabric-connected host port is a path to a Sun StorEdge Traffic Manager device. Only devices on a fabric-connected host port can be unconfigured through the `cfgadm unconfigure` command.

   CODE EXAMPLE 3-7 `cfgadm` Listing of Port WWNs For Physical Devices To Unconfigure

```
# cfgadm -al
Ap_Id                Type         Receptacle   Occupant    Condition
c0                   fc-fabric    connected    configured   unknown
c0::50020f2300006077 disk         connected    configured   unknown
c0::50020f23000063a9 disk         connected    configured   unknown
c1                  fc-private    connected    configured   unknown
c1::220203708b69c32b disk         connected    configured   unknown
c1::220203708ba7d832 disk         connected    configured   unknown
c1::220203708b8d45f2 disk         connected    configured   unknown
c1::220203708b9b20b2 disk         connected    configured   unknown
c2                   fc-fabric    connected    configured   unknown
c2::50020f2300005f24 disk         connected    configured   unknown
c2::50020f2300006107 disk         connected    configured   unknown
```

   In CODE EXAMPLE 3-7, `c0::50020f2300006077` and `c2::50020f2300006107` Ap_Ids represent different port WWNs for the same device.

3. **Unconfigure the Ap_Id associated with Sun StorEdge Traffic Manager device.**

Note – If the Ap_Id represents the last configured path to the Sun StorEdge Traffic Manager device, stop all activity to the path and unmount any file systems on it. If the multipathed device is under any volume manager's control, see the documentation for your volume manager for maintaining the fabric device

---

   In the example that follows, the path represented as `c2::50020f2300006107` is unconfigured, and `c0::50020f2300006077` remains configured to show how you can unconfigure just one of multiple paths for a multipathed device.

```
# cfgadm -c unconfigure c2::50020f2300006107
```

4. **Verify that the selected path** `c2::50020f2300006107` **is unconfigured.**

```
# cfgadm -al
Ap_Id                Type         Receptacle   Occupant     Condition
c0                     fc-fabric  connected    configured   unknown
c0::50020f2300006077 disk         connected    configured   unknown
c0::50020f23000063a9 disk         connected    configured   unknown
c1                     fc-private connected    configured   unknown
c1::220203708b69c32b disk         connected    configured   unknown
c1::220203708ba7d832 disk         connected    configured   unknown
c1::220203708b8d45f2 disk         connected    configured   unknown
c1::220203708b9b20b2 disk         connected    configured   unknown
c2                     fc-fabric  connected    configured   unknown
c2::50020f2300005f24 disk         connected    configured   unknown
c2::50020f2300006107 disk         connected    unconfigured unknown
```

The Sun StorEdge Traffic Manager devices associated with that Ap_Id are still available to a host using the Solaris operating environment through the other path, represented by `c0::50020f2300006077`. A device can be connected to multiple Ap_Ids and an Ap_Id can be connected to multiple devices.

CODE EXAMPLE 3-8 shows example output you would see for the Sun StorEdge Traffic Manager devices if you use the `luxadm(1M)` command after performing this procedure. Although the path represented by `c2::50020f2300006107` is no longer listed, the path represented by `c0::50020f2300006077` is displayed for Sun StorEdge Traffic Manager devices

`/dev/rdsk/c6t60020F20000061073AC8B52D000B74A3d0s2`

and

`/dev/rdsk/c6t60020F20000061073AC8B4C50004ED3Ad0s2`.

CODE EXAMPLE 3-8 `luxadm` (1M) Output For Two Device Nodes With a Single Path Available With the Sun StorEdge Traffic Manager Software Enabled

```
# luxadm display 50020f2300006077
DEVICE PROPERTIES for disk: 50020f2300006077
  Status(Port A):       O.K.
  Vendor:               SUN
  Product ID:           T300
  WWN(Node):            50020f2000006077
  WWN(Port A):          50020f2300006077
  Revision:             0117
  Serial Num:           Unsupported
  Unformatted capacity: 558448.000 MBytes
  Write Cache:          Enabled
```

CODE EXAMPLE 3-8 `luxadm` (1M) Output For Two Device Nodes With a Single Path Available With the Sun StorEdge Traffic Manager Software Enabled

```
   Read Cache:            Enabled
     Minimum prefetch:    0x0
     Maximum prefetch:    0x0
   Device Type:           Disk device
   Path(s):

   /dev/rdsk/c6t60020F20000061073AC8B52D000B74A3d0s2

   /devices/scsi_vhci/ssd@g60020f20000061073ac8b52d000b74a3:c,raw
    Controller         /devices/pci@1f,2000/pci@1/SUNW,qlc@5/fp@0,0
       Device Address     50020f2300006077,1
       Class              primary
       State              ONLINE

DEVICE PROPERTIES for disk: 50020f2300006077
   Status(Port B):        O.K.
   Vendor:                SUN
   Product ID:            T300
   WWN(Node):             50020f2000006077

   WWN(Port B):           50020f2300006077

   Revision:              0117
   Serial Num:            Unsupported
   Unformatted capacity:  558448.000 MBytes
   Write Cache:           Enabled
   Read Cache:            Enabled
     Minimum prefetch:    0x0
     Maximum prefetch:    0x0
   Device Type:           Disk device
   Path(s):

   /dev/rdsk/c6t60020F20000061073AC8B4C50004ED3Ad0s2

   /devices/scsi_vhci/ssd@g60020f20000061073ac8b4c50004ed3a:c,raw
    Controller         /devices/pci@1f,2000/pci@1/SUNW,qlc@5/fp@0,0
       Device Address     50020f2300006077,0
       Class              secondary
       State              ONLINE
```

Creating and Removing Multiple Device Nodes With Multipathing Enabled

The procedures for creating and removing multiple device nodes is similar to those in the section “Creating and Removing Individual Device Nodes With Multipathing Enabled” on page 37. This section explains the finer differences. Make sure you have first identified the the fabric devices by using the procedure “To Detect Fabric Devices Visible to a Host” on page 38 before you configure or remove device nodes. This section covers:

- “To Configure All Fabric-Connected Devices With Multipathing Enabled” on page 49
- “To Unconfigure All Fabric-Connected Devices With Multipathing Enabled” on page 54

▼ To Configure All Fabric-Connected Devices With Multipathing Enabled

In this example, an Ap_Id on a fabric-connected host port is a path to a Sun StorEdge Traffic Manager device. For example, all devices with a path through `c2` are to be configured, but none through `c0` are to be configured. `c2` is an attachment point from the host to the fabric, whereas `c2::50020f2300006107` is an attachment point from the storage to the fabric. A host detects all the storage devices in a fabric for which it is configured.

Configuring an Ap_Id on a Sun StorEdge Traffic Manager device that has already been configured through another Ap_Id results in an additional path to the previously configured device. Note that a new Solaris device is not created in this case. A Solaris device is created only the first time an Ap_Id to a corresponding Sun StorEdge Traffic Manager device is configured.

1. **Become superuser.**

2. Identify the fabric-connected host port to be configured.

```
# cfgadm -al
Ap_Id                Type         Receptacle   Occupant     Condition
c0                     fc-fabric   connected   configured   unknown
c0::50020f2300006077 disk         connected   configured   unknown
c0::50020f23000063a9 disk         connected   configured   unknown
c1                     fc-private  connected   configured   unknown
c1::220203708b69c32b disk         connected   configured   unknown
c1::220203708ba7d832 disk         connected   configured   unknown
c1::220203708b8d45f2 disk         connected   configured   unknown
c1::220203708b9b20b2 disk         connected   configured   unknown
c2                     fc-fabric   connected   unconfigured unknown
c2::50020f2300005f24 disk         connected   unconfigured unknown
c2::50020f2300006107 disk         connected   unconfigured unknown
```

Devices represented by Ap_Ids `c0::50020f2300006077` and `c2::50020f2300006107` are two paths to the same physical device, with `c0::50020f2300006077` already configured. The `luxadm` output in CODE EXAMPLE 3-9 shows the Solaris device associated with this path. One path is configured.

CODE EXAMPLE 3-9 `luxadm` (1M) Output for Multiple Device Nodes Associated With One Device Path and STMS Enabled

```
# luxadm display 50020f2300006077
DEVICE PROPERTIES for disk: 50020f2300006077
  Status(Port A):       O.K.
  Vendor:               SUN
  Product ID:           T300
  WWN(Node):            50020f2000006077
  WWN(Port A):          50020f2300006077
  Revision:             0117
  Serial Num:           Unsupported
  Unformatted capacity: 558448.000 MBytes
  Write Cache:          Enabled
  Read Cache:           Enabled
    Minimum prefetch:   0x0
    Maximum prefetch:   0x0
  Device Type:          Disk device
  Path(s):
  /dev/rdsk/c6t60020F20000061073AC8B52D000B74A3d0s2
  /devices/scsi_vhci/ssd@g60020f20000061073ac8b52d000b74a3:c,raw
   Controller         /devices/pci@1f,2000/pci@1/SUNW,qlc@5/fp@0,0
     Device Address     50020f2300006077,1
```

CODE EXAMPLE 3-9 `luxadm` (1M) Output for Multiple Device Nodes Associated With One Device Path and STMS Enabled *(Continued)*

```
      Class              primary
      State              ONLINE


DEVICE PROPERTIES for disk: 50020f2300006077
   Status(Port B):       O.K.
   Vendor:               SUN
   Product ID:           T300
   WWN(Node):            50020f2000006077
   WWN(Port B):          50020f2300006077
   Revision:             0117
   Serial Num:           Unsupported
   Unformatted capacity: 558448.000 MBytes
   Write Cache:          Enabled
   Read Cache:           Enabled
     Minimum prefetch:   0x0
     Maximum prefetch:   0x0
   Device Type:          Disk device
   Path(s):
   /dev/rdsk/c6t60020F20000061073AC8B4C50004ED3Ad0s2
   /devices/scsi_vhci/ssd@g60020f20000061073ac8b4c50004ed3a:c,raw
    Controller         /devices/pci@1f,2000/pci@1/SUNW,qlc@5/fp@0,0
      Device Address     50020f2300006077,0
      Class              secondary
      State              ONLINE
```

3. **Configure the unconfigured devices on the selected port.**

```
# cfgadm -c configure c2
```

Note – This operation repeats the `configure` command of an individual device for all the devices on `c2` and it can be time-consuming if the number of devices on `c2` is large.

---

4. **Verify that all devices on `c2` are configured.**

```
# cfgadm -al
Ap_Id                Type         Receptacle   Occupant     Condition
c0                     fc-fabric  connected    configured   unknown
c0::50020f2300006077 disk         connected    configured   unknown
c0::50020f23000063a9 disk         connected    configured   unknown
c1                     fc-private connected    configured   unknown
c1::220203708b69c32b disk         connected    configured   unknown
c1::220203708ba7d832 disk         connected    configured   unknown
c1::220203708b8d45f2 disk         connected    configured   unknown
c1::220203708b9b20b2 disk         connected    configured   unknown
c2                     fc-fabric  connected    configured   unknown
c2::50020f2300005f24 disk         connected    configured   unknown
c2::50020f2300006107 disk         connected    configured   unknown
```

Notice that the Occupant column of `c2` and all of the devices under `c2` is marked as configured.

The `show_FCP_dev` option displays FCP SCSI LUN information for multiple LUN SCSI devices. In CODE EXAMPLE 3-10, the physical devices connected through by `c2::50020f2300006107` and `c2::50020f2300005f24` have two LUNs configured respectively.

CODE EXAMPLE 3-10 `show_FCP_dev` Output For Multiple LUNs and Multiple Physical Devices

```
# cfgadm -al -o show_FCP_dev c2
Ap_Id                Type         Receptacle   Occupant     Condition
c2                     fc-fabric  connected    configured   unknown
c2::50020f2300005f24,0 disk       connected    configured   unknown
c2::50020f2300005f24,1 disk       connected    configured   unknown
c2::50020f2300006107,0 disk       connected    configured   unknown
c2::50020f2300006107,1 disk       connected    configured   unknown
```

In CODE EXAMPLE 3-11, notice that two STMS enabled devices

```
/dev/rdsk/c6t60020F20000061073AC8B52D000B74A3d0s2
/dev/rdsk/c6t60020F20000061073AC8B4C50004ED3Ad0s2
```

are created for the device represented by `c0::50020f2300006077` and `c2::50020f2300006107`.

CODE EXAMPLE 3-11 `luxadm(1M)` Output For Multiple Device Nodes With the STMS Enabled

```
# luxadm display 50020f2300006077
DEVICE PROPERTIES for disk: 50020f2300006077
  Status(Port A):       O.K.
  Status(Port B):       O.K.
  Vendor:               SUN
  Product ID:           T300
  WWN(Node):            50020f2000006077
  WWN(Port A):          50020f2300006077
  WWN(Port B):          50020f2300006107
  Revision:             0117
  Serial Num:           Unsupported
  Unformatted capacity: 558448.000 MBytes
  Write Cache:          Enabled
  Read Cache:           Enabled
    Minimum prefetch:   0x0
    Maximum prefetch:   0x0
  Device Type:          Disk device
  Path(s):
  /dev/rdsk/c6t60020F20000061073AC8B52D000B74A3d0s2
  /devices/scsi_vhci/ssd@g60020f20000061073ac8b52d000b74a3:c,raw
   Controller        /devices/pci@1f,2000/pci@1/SUNW,qlc@4/fp@0,0
     Device Address     50020f2300006107,1
     Class              secondary
     State              STANDBY
   Controller        /devices/pci@1f,2000/pci@1/SUNW,qlc@5/fp@0,0
     Device Address     50020f2300006077,1
     Class              primary
     State              ONLINE

DEVICE PROPERTIES for disk: 50020f2300006077
  Status(Port A):       O.K.
  Status(Port B):       O.K.
  Vendor:               SUN
  Product ID:           T300
  WWN(Node):            50020f2000006107
  WWN(Port A):          50020f2300006107
  WWN(Port B):          50020f2300006077
  Revision:             0117
  Serial Num:           Unsupported
```

CODE EXAMPLE 3-11 `luxadm(1M)` Output For Multiple Device Nodes With the STMS Enabled *(Continued)*

```
   Unformatted capacity: 558448.000 MBytes
   Write Cache:          Enabled
   Read Cache:           Enabled
     Minimum prefetch:   0x0
     Maximum prefetch:   0x0
   Device Type:          Disk device
   Path(s):
   /dev/rdsk/c6t60020F20000061073AC8B4C50004ED3Ad0s2
   /devices/scsi_vhci/ssd@g60020f20000061073ac8b4c50004ed3a:c,raw
    Controller         /devices/pci@1f,2000/pci@1/SUNW,qlc@4/fp@0,0
       Device Address     50020f2300006107,0
       Class              primary
       State              ONLINE
    Controller         /devices/pci@1f,2000/pci@1/SUNW,qlc@5/fp@0,0
       Device Address     50020f2300006077,0
       Class              secondary
       State              STANDBY
```

Note – The `luxadm` (1M) output on device `50020f2300006107` shows the same information as the previous display.

▼ To Unconfigure All Fabric-Connected Devices With Multipathing Enabled

Note – Whether or not the Sun StorEdge Traffic Manager multipathing software is enabled, the `cfgadm -c unconfigure` command for fabric devices is identical, but the result of the operation is different. When the STMS is enabled, the host using the Solaris operating environment removes Sun StorEdge Traffic Manager-related path or device-node information.

An Ap_Id on a fabric-connected host port is a path to a Sun StorEdge Traffic Manager device.

When a Sun StorEdge Traffic Manager device has multiple Ap_Ids connected to it, the device is still available to the host using the Solaris operating environment after you unconfigure an Ap_Id. After you unconfigure the last Ap_Id, no additional paths remain and the Sun StorEdge Manager device is unavailable to the host using the Solaris operating environment.

1. **Become superuser.**

2. **Identify the devices to be unconfigured.**

   Only devices on a fabric-connected host port can be unconfigured.

```
# cfgadm -al
Ap_Id                Type         Receptacle   Occupant     Condition
c0                     fc-fabric  connected    configured   unknown
c0::50020f2300006077 disk         connected    configured   unknown
c0::50020f23000063a9 disk         connected    configured   unknown
c1                     fc-private connected    configured   unknown
c1::220203708b69c32b disk         connected    configured   unknown
c1::220203708ba7d832 disk         connected    configured   unknown
c1::220203708b8d45f2 disk         connected    configured   unknown
c1::220203708b9b20b2 disk         connected    configured   unknown
c2                     fc-fabric  connected    configured   unknown
c2::50020f2300005f24 disk         connected    configured   unknown
c2::50020f2300006107 disk         connected    configured   unknown
```

3. **Unconfigure all of the configured devices on the selected port.**

```
# cfgadm -c unconfigure c2
```

Note – This operation repeats the `unconfigure` command of an individual device for all devices on `c2` and it can be time-consuming if the number of devices on `c2` is large.

---

4. **Verify that all devices on `c2` are unconfigured.**

   Notice that the Occupant column lists `c2` and all the devices attached to `c2` as unconfigured.

```
# cfgadm -al
Ap_Id              Type        Receptacle   Occupant     Condition
c0                   fc-fabric  connected   configured   unknown
c0::50020f2300006077 disk       connected   configured   unknown
c0::50020f23000063a9 disk       connected   configured   unknown
c1                   fc-private connected   configured   unknown
c1::220203708b69c32b disk       connected   configured   unknown
c1::220203708ba7d832 disk       connected   configured   unknown
c1::220203708b8d45f2 disk       connected   configured   unknown
c1::220203708b9b20b2 disk       connected   configured   unknown
c2                   fc-fabric  connected   unconfigured unknown
c2::50020f2300005f24 disk       connected   unconfigured unknown
c2::50020f2300006107 disk       connected   unconfigured unknown
```

CHAPTER 4

FCIP Management

To set up a SAN, you must follow these basic steps:

1. **Physically install all the switches, hosts, storage devices and cables.**
2. **Identify the zone and port requirements for hooking up all the devices and hosts to the switches.**
3. **Configure the switch ports and switch to your zoning requirements.**
4. **Ensure that all the hosts recognize the switch and all attached devices.**

In order to configure FCIP, you should have already completed the fourth step. This chapter covers host recognition of FCIP devices and implementation of IP over Fibre Channel in a SAN. The FCIP driver is based on RFC 2625 and it allows IP traffic to run over Fibre Channel. Configuration of FCIP depends on the instance of the fabric port (fp) driver for the Fibre Channel adapter ports. This chapter contains the following topics:

Loading FCIP

Configuration of FCIP depends on the instance of fp, or host bus adapter ports. If multiple host bus adapters are present, plumb manually after identifying the fp instance on which IP should be plumbed. The following two procedures determine fp instances.

Determining Fibre Channel Adpater Port Instances

There are two basic ways to determine Fibre Channel adapter port instances to which IP can be plumbed. The first way, which is a short procedure, requires that you know the WWN of the card. In the second way, which is a longer procedure, you do not know the WWN but you do know the physical location of the card. The procedures include:

- "To Determine All Fibre Channel Adapter Port Instances To Which IP Can Be Plumbed With a WWN" on page 58
- "To Determine an FP Instance for a Known HBA Port Physical Device Path" on page 59

▼ To Determine All Fibre Channel Adapter Port Instances To Which IP Can Be Plumbed With a WWN

1. **Become superuser.**
2. **Determine the fp driver instances in your system.**

   In the example below, there are four instances (0-3) of fp present in the system.

```
# prtconf -v | grep fp

fp (driver not attached)
fp, instance #0
fp (driver not attached)
fp, instance #1
fp (driver not attached)
fp, instance #2
fp (driver not attached)
fp, instance #3
```

3. **Manually load FCIP to the desired fp instances.**

   Use the `ifconfig fcip`*interface* `plumb` command, where *interface* is a variable for the desired fp instance number. For example:

```
# ifconfig fcip0 plumb
```

   If the command succeeds, the following message appears on the console and messages file:

```
Sep 13 15:52:30 bytownite ip: ip: joining multicasts failed (7) on
fcip1 - will use link layer broadcasts for multicast
```

   If no other error message is displayed, manual plumbing has succeeded. Repeat this step for the other fp instances identified in Step 2.

Note – Additional options can be provided to the `ifconfig` command too. See `ifconfig`(1M) for more information. Currently, FCIP can be plumbed on only one port on Fibre Channel adapters with multiple ports. See "FCIP Guidelines" on page 15 for details. An error occurs if a plumb operation is attempted on other ports.

▼ To Determine an FP Instance for a Known HBA Port Physical Device Path

Use this procedure when there is no cable connected to the HBA port. Otherwise, you can use the shorter procedure "To Plumb an FCIP Instance" on page 60.

1. **Determine the HBA PCI adapter slot and the I/O board PCI slot.**

   You need this information to perform the calculation in Step 2.

   For example, assume you have an array with an HBA card located in PCI adapter slot 5, and the PCI adapter is in slot one of the I/O board.

2. **Determine the `fp` instance number.**

   a. **Use an editor to search for the `fp` driver binding name in the `/etc/path_to_inst` file.**

      Entries have `fp` on the line.

   b. **Narrow the search by using the I/O board and slot information from Step 1.**

      i. **Multiply the PCI adapter slot number by the number of adapter ports.**

         For example, if the HBA has two ports, multiply by two. Using the array with an HBA in the PCI adapter slot five, multiply five by two to get 10.

ii. Add the PCI adapter I/O board slot number to the number derived in Step i.

Using the array with an HBA in PCI adapter slot five and PCI slot one of the I/O board, add one to 10 for a sum of 11.

iii. Convert the number derived in Step ii to hexadecimal.

The number 11 converts to b in hexadecimal.

iv. Search for the `fp` entry with pci@*hex* where *hex* is the number you derived in Step iii.

CODE EXAMPLE 4-1 shows a single Fibre Channel network adapter device path. TABLE 4-1 defines the significance of the device path. The instance number for this device path is 7.

CODE EXAMPLE 4-1 PCI Single Fibre Channel Network Adapter Device Path

```
"/pci@b,2000/SUNW,qlc@2/fp@0,0" 7 "fp"
```

TABLE 4-1 PCI Single Fibre Channel Network Adapter `/etc/path_to_inst` Device Path Entry

Entry Item	Entry Value
Physical Name	pci@b,2000/SUNW,qlc@2/fp@0.0
Instance Number	7
Driver Binding Name	fp

3. Manually plumb the fp instance.

Use the `ifconfig` <*interface*> `plumb` command. In this example, *interface* is `fcip7`.

```
# ifconfig fcip7 plumb
```

If no error message is displayed, manual plumbing has succeeded. Repeat this step for the other `fp` instances identified in Step 2.

▼ To Plumb an FCIP Instance

Use this procedure to load and plumb FCIP.

1. **Each FP instance on the system has an entry in** `/dev/fc`**. If HBAs have been removed, some stale links might exist.**

   For each entry in `/dev/fc`, issue a `luxadm -e dump_map` command to view all the devices that are visible through that HBA:

```
# luxadm -e dump_map /dev/fc/fp0
Pos  Port_ID Hard_Addr Port WWN         Node WWN         Type
0    610100  0         210000e08b049f53 200000e08b049f53 0x1f
(Unknown Type)
1    620d02  0         210000e08b02c32a 200000e08b02c32a 0x1f
(Unknown Type)
2    620f00  0         210000e08b03eb4b 200000e08b03eb4b 0x1f
(Unknown Type)
3    620e00  0         210100e08b220713 200100e08b220713 0x1f
(Unknown Type,Host Bus Adapter)
# luxadm -e dump_map /dev/fc/fp1
 No FC devices found. - /dev/fc/fp1
```

2. **Based on the list of devices, determine which destination HBAs are visible to the remote host with which you want to establish FCIP communications.**

   In the example for this procedure, the destination HBAs have port IDs 610100 and 620d02. The originating HBA's port ID is 62e00.

3. **List the physical path of the originating HBA port from which you can see the destination HBA port , where** *originating-hba-link* **is a variable for the link determined in Step 1:**

```
# ls -l /dev/fc/fporiginating-hba-link
```

   For example, 0 is the number for the *originating-hba-link*:

```
# ls -l /dev/fc/fp0
lrwxrwxrwx   1 root     root         51 Sep  4 08:23 /dev/fc/fp0 ->
../../devices/pci@8,600000/SUNW,qlc@1/fp@0,0:devctl
```

4. **Search the physical path identified in Step 3.**

   You must remove the leading ../../devices from the pathname output. For example

```
# grep pci@8,600000/SUNW,qlc@1/fp@0,0 /etc/path_to_inst
"/pci@8,600000/SUNW,qlc@1/fp@0,0" 0 "fp"
```

5. **Determine the fp instance for the originating HBA port from the output of the command in Step 4.**

   The instance number precedes “fp” in the output. In the following example output, the instance number is 0.

```
"/pci@8,600000/SUNW,qlc@1/fp@0,0" 0 "fp"
```

6. **Use the instance number from Step 5 to load FCIP and plumb the FCIP interface.**

   In this example, the instance is 0.

```
# ifconfig fcip0 plumb
```

FCIP Invocation, Configuration and Usage

Immediately after installation, start FCIP manually with the `ifconfig` command. On subsequent reboots, the FCIP network interface starts automatically. This section covers:

▼ To Start a Network Interface Manually

Use this procedure when you want to plumb FCIP with specific netmask values and get the FCIP interface up and running.

1. **Use the** `ifconfig` **command with the appropriate interface.**

   For example, to enable an FCIP interface associated with fp instance 0 and an IP address of 192.9.201.10, enter:

```
# ifconfig fcip0 plumb 192.9.201.10 netmask 255.255.255.0 up
```

   The `ifconfig` command is described in more detail in the `ifconfig(1M)` manpage. Ask your network administrator for an appropriate IP address and netmask information.

2. **Use the command** `ifconfig -a` **to verify the network is functioning.**

   The output of `ifconfig -a` should look like this:

```
lo0: flags=1000849<UP,LOOPBACK,RUNNING,MULTICAST,IPv4> mtu 8232
index 1
inet 127.0.0.1 netmask ff000000
fcip0: flags=
1001843<UP,BROADCAST,RUNNING,MULTICAST,MULTI_BCAST,IPv4>
mtu 1500 index 2
inet 192.9.201.10 netmask ffffff00 broadcast 192.9.201.255
ether 0:e0:8b:1:3c:f7
hme0: flags=1000843<UP,BROADCAST,RUNNING,MULTICAST,IPv4> mtu 1500
index
3
inet 192.9.200.70 netmask ffffff00 broadcast 192.9.200.255
ether 8:0:20:fc:e9:49
```

▼ To Configure the Host for Automatic Plumbing Upon Reboot

Each network interface must have an `/etc/hostname.`*interface* file defining the name of the IP address associated with it. For example, FCIP network *interface* fcip0 has a file named `/etc/hostname.fcip0`.

1. **Manually create a** `/etc/hostname.`*interface* **file with a text editor so it contains a single line that identifies the host name or interface IP address.**

2. **Use a text editor to make any additional entries to the** `/etc/inet/hosts` **file.**

   The Solaris installation program creates the `/etc/inet/hosts` file with minimum entries. You must manually make additional entries with a text editor. (See the `hosts(4)` man page for additional information.)

The `/etc/inet/hosts` file contains the hosts database. This file contains the host names and the primary network interface IP addresses, other network interfaces attached to the system, and any other network interface that the machine must know about.

CODE EXAMPLE 4-2 `sun1 machine /etc/inet/hosts`

```
127.0.0.1      localhost     loghost
192.9.200.70   sun1     #This is the local host name
192.9.201.10 fcip0 #Interface to network 192.9.201.10
```

3. **Edit the `/etc/nsswitch.conf` file so that all the uncommented entries has the word `files` before any other nameservice.**

   The `/etc/nsswitch.conf` specifies which name service to use for a particular machine.

CODE EXAMPLE 4-3 `sun1 machine /etc/nsswitch.conf` File

```
hosts:     files nis
```

FCIP Usage

Any standard network commands can be used after FCIP is attached. There are not any usage differences when these commands (`telnet`, `ping`, or `ftp`) are used in an Ethernet setup.

CHAPTER 5

Dynamic Reconfiguration On the SAN

When you want to change an existing SAN configuration, Dynamic Reconfiguration (DR) adjusts your system configuration. DR is straight forward with FC-AL devices, and only slightly more complicated for fabric devices.

With previously configured FC-AL devices, DR happens automatically upon addition or removal of devices to a host I/O port. With the STMS enabled, the Solaris operating environment host configures the devices as Sun StorEdge Traffic Manager devices. However, DR is more complex with fabric devices. This section covers:

DR and Fabric Devices

Previously configured fabric devices are not automatically reconfigured. Fabric device configurations are not persistent when you remove a system component on which switch-connected host ports reside, and then add that system component back to a host through DR operations. The discussion of on-demand node creation in these sections applies to fabric devices, such as a host port connected to an F port on a switch and an array connected to an F port or TL port on a switch.

▼ To Remove a Fabric Device Before DR

- **Unconfigure the fabric devices that were configured through host ports on the system component with on-demand node creation.**
  - If the STMS is not enabled, see “To Unconfigure a Fabric Device” on page 32.
  - If the STMS is enabled, see “To Unconfigure a Fabric Device Associated With Multipathing Enabled Devices” on page 43.

▼ To Maintain a Fabric Device Configuration With DR

1. **Reconfigure the device through on-demand node creation.**
2. **Perform DR operations according to the instructions in the documentation for the host.**

▼ To Reconfigure Fabric Devices With DR

1. **Add the system component and make it available to the host.**
2. **Reconfigure the device(s) through on-demand node creation.**
   - If the STMS is not enabled, see “To Configure a Fabric Device Without Multipathing Enabled On the Host” on page 28.
   - If the STMS is enabled, see“To Configure Fabric-Connected Device Nodes With Multipathing Enabled Devices” on page 40.

▼ To Reconfigure the Sun Enterprise 10000 Server With a Fabric Connection

The following procedure gives the sequence of operations for a Sun Enterprise 10000 server board with a fabric connection.

1. **Unconfigure the fabric devices on fabric-connected host ports on the board to be detached.**
2. **Start the DR detach operations for the board.**

   See the *Sun Enterprise 10000 Dynamic Reconfiguration Configuration Guide.*
3. **Start the DR attach operations when the board is ready.**

   See the *Sun Enterprise 10000 Dynamic Reconfiguration Configuration Guide.*

4. **Configure any fabric devices on the attached boards.**

   See the sections in Chapter 3 that explain how to recognize the storage devices on the host. On the newly attached board, the devices could be the same or completely new devices.

Glossary

This glossary defines SAN teminology used in this book.

A

AL_PA Arbitrated Loop Physical Address. An AL_PA is an eight-bit value used to identify a device attached to a Fibre Channel arbitrated loop.

Ap_Id Attachment Point Identifier. The port identifier for either a host or a storage device connected to a switch. For example, `c0` identifies the host port and `c0::50020f23000063a9` identifies an array.

B

Bridge ports (B port) When a G port is attached to a McDATA ES-1000 Switch, it is a bridge port (B port). The B port connects an arbitrated loop device (switch) to a multiswitch fabric. Director B ports are not assigned a domain ID and do not participate in fabric path selection processes.

C

Cascade

Broadcast Zone Zone type used to filter broadcast traffic away from end nodes that cannot use or interpret it. A port will broadcast to all ports in the same Broadcast Zone(s) in which the port is defined. Broadcast zoning is primarily used for doing IP over Fibre Channel or when mixing IP and SCSI traffic on the switch.

Cascade Connection of two or more switches together to increase the number of available ports or to allow for increased distances between components of the SAN.

E

Expansion ports (E port) Port used to connect FC-SW2 compliant switches to one another.

F

Fabric ports (F port) Fabric port on a Fibre Channel switch. Switch ports used to connect to the fabric capable storage devices, such as the Sun StorEdge T3+ array or Sun StorEdge 39x0, 69x0 and 99x0 series, tape drives and host bus adapters.

Fabric One or more switches in a Fibre Channel network. It is also common to refer to something as a "fabric device" or being in "fabric mode."

Fabric Loop ports (FL port) A port that is able to transmit under fabric protocol and also has arbitrated loop capabilities.

FC-SW-2 The second generation of the Fibre Channel Switch Fabric Standard defined by ANSI.

G

Generic port (G port) A port that can operate as either an E port or F port. A port is defined as a G port when it is not yet connected or has not yet assumed a specific function in the fabric.

I

Initiator Each host bus adapter port connection that provides a path to a storage device.

Inter-Switch Link (ISL) A segment or cable connecting two cascaded switches. Does not include cables from host to the switch or from storage devices to the switch.

N

N port A Fibre Channel port that supports point-to-point or fabric connections.

Name Server Zones (NS zones) A set of name server (NS) ports that can contain F , FL , G , GL and E ports. The ports receive name server information (port number, type, address, WWN, etc). NS zones can be port-based or WWN-based.

P

Private Loop Fibre Channel Arbitrated Loop (FC-AL) with 8-bit addressing that supports up to 126 device connections with no fabric attachment (F and FL ports). Private loops are closed systems incapable of seeing outside the loop.

Public Loop Arbitrated loop that supports fabric login and services. Provides 24-bit Fibre Channel addressing and up to 16 million node connections fabric wide. Uses name server (NS) ports.

S

Segmented Loop ports (SL ports) A port connected to a private loop device. SL ports make a switch behave like a hub, but with the advantage of better performance and the ability to segment the private loop into SL Zones for ease of administration and isolation of resources. Ports in SL zones do not communicate with ports in NS zones. Supports the Sun StorEdge A5200, A3500FC arrays and FC tape devices. SL zones contain SL ports only. SL ports are are not supported in the SAN 4.0 release but were in earlier releases.

Segmented Loop Zones (SL zones) A set of SL ports on the switch that behave as a single private loop. This grouping behaves like a hub, but with the advantage of better performance and the ability to segment the private loop into SL zones for ease of administration and isolation of resources. SL zones are are not supported in the SAN 4.0 release but were in earlier releases.

T

Transfer or Trunk ports (T ports) Switch ports from the SAN 3.0 release used to connect to other switches in a cascade. T ports are used to attach a port on one switch to a port on another switch. Replaced by E ports in SAN 4.0 release.

Translative Loop ports (TL ports) Ports on the switch that allow private-to-public and public-to-private loop connectivity. TL ports present private devices to a fabric as if they were public so they can communicate with the off-loop devices, such as public devices connected to F ports and FL ports and private devices on other TL port loops. Supports the Sun StorEdge T3 arrays. Hosts recognize arrays that use TL ports as fabric devices.

Z

Zone A set of ports or WWNs and their connected devices that have been grouped together to control information exchange.

Zoning Function of the switch that allows segregation of devices. Zoning is done for a variety of reasons, such as security, simplicity, performance, or dedication of resources.

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