Overview of Fibre Channel Storage Area Networks

Challenges for SCSI

- Distance
  - 3 Meters SE
  - 25 Meters FWD
- Bandwidth
  - 40MB/sec UltraSCSI
  - 100MB/sec FCAL
- Throughput
  - 12000 IOs/sec UltraSCSI
  - 20000+ IOs/sec FCAL
- Scalability
  - 8 or 16 SCSI Ids
  - 128 nodes/FCAL
  - Virtually unlimited Switched Fibre

Fibre Channel - What is it?

- Integrated Set of Standards
  - Being developed by committees accredited by ANSI T11 committee (http://www.t11.org)
- New Protocol for Information transfer
  - Industry Standard interconnect
  - High performance serial I/O protocol
  - Media independent
  - Supports transfer of multiple protocols

* Information on technology and industry
  http://www.fibrechannel.com

SANs - What are they?

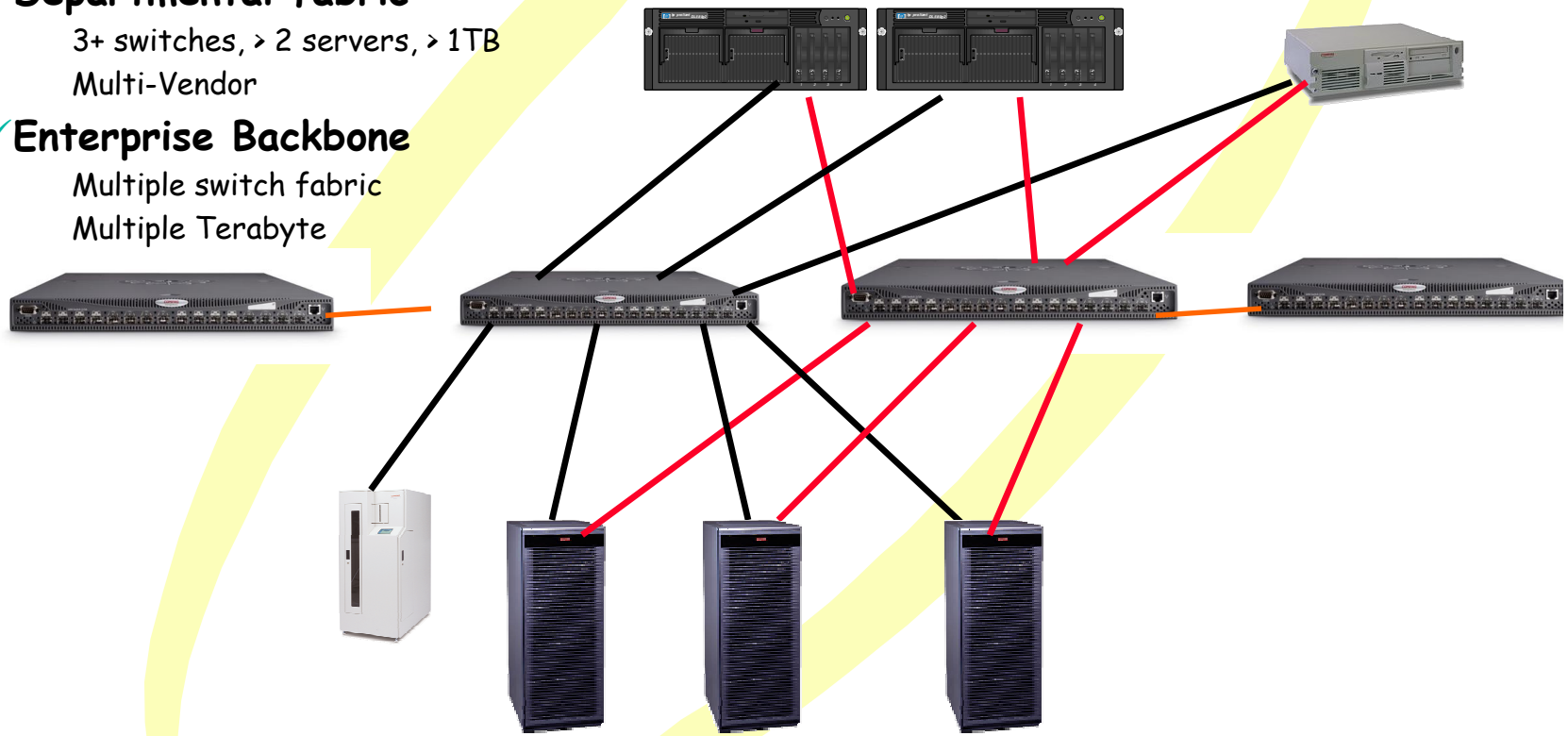
- Storage Area Networks
  - Dedicated networks that connect one or more systems to storage devices and subsystems
  - Synonymous with fibre channel, however, fibre channel not a required component
    - Any networking or serial SCSI technology can be used to create a SAN
  - Extends the capabilities of server I/O channels by using standard networking technologies as a transport for high bandwidth data transfers.

Distinguishing Fibre Channel Networks from SANs

- Fibre channel, a networking technology, was initially developed to be a high speed backbone technology for several purposes, including ip data networks.
- SANs are more an implementation of storage I/O methods over network transports (like fibre channel).
- SANs can be architected to provide the flexibility to implement the technology that fits best.
- Fibre channel is merely one of the transports chosen for a SAN implementation.

SANs Provide a Flexible Architecture

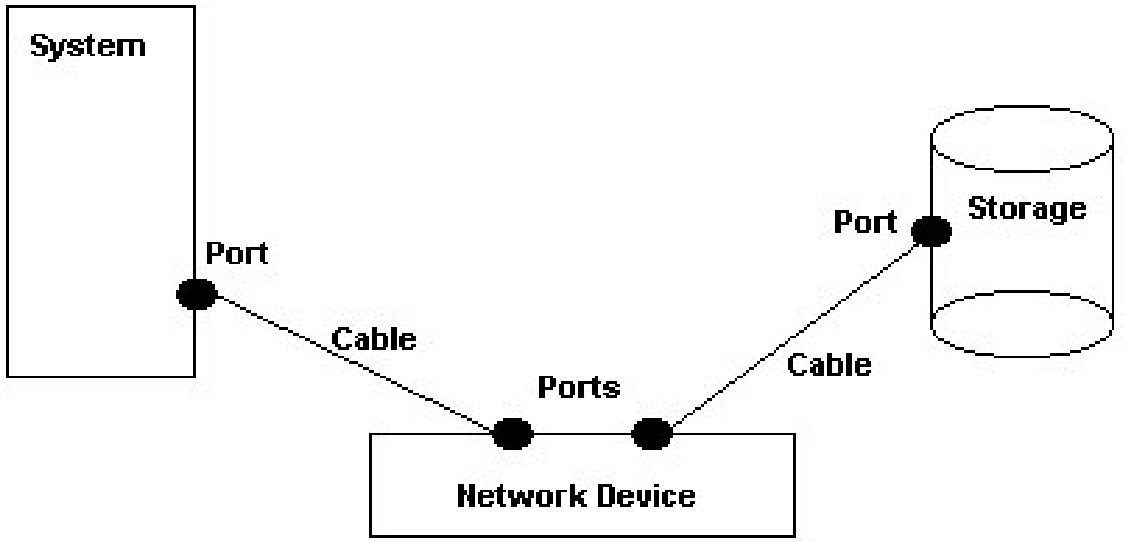
- ✓**Small clusters**
  - 1 to 2 switches, 2 servers < 1TB
- ✓**Departmental fabric**
  - 3+ switches, > 2 servers, > 1TB
  - Multi-Vendor
- ✓**Enterprise Backbone**
  - Multiple switch fabric
  - Multiple Terabyte

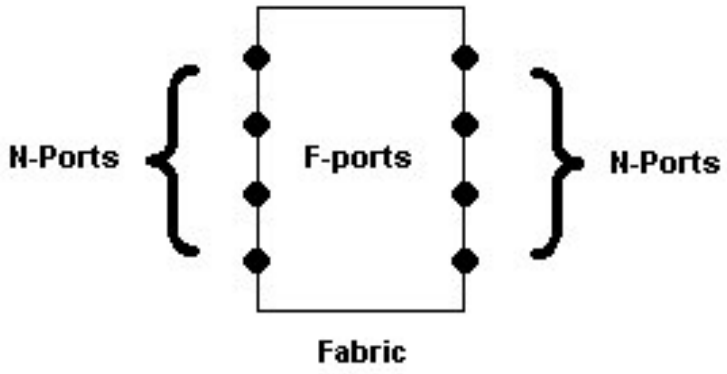


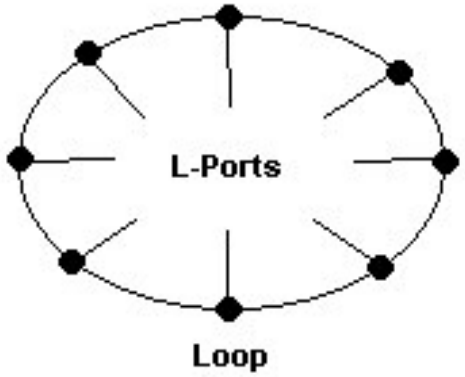
The Physical Fibre Channel Network

- Consists of ports, networking devices, and cabling
- Ports on systems and storage nodes are called N-ports or L-ports, depending on whether they're connected to switched or loop networks.
- Ports that work on both are called NL-ports
- Network devices are switches, hubs, bridges, and routers.
- Ports in networking devices are:
  - F-ports for N- port initiators
  - E-ports for switch to switch connections
  - FL-ports for connecting to loops

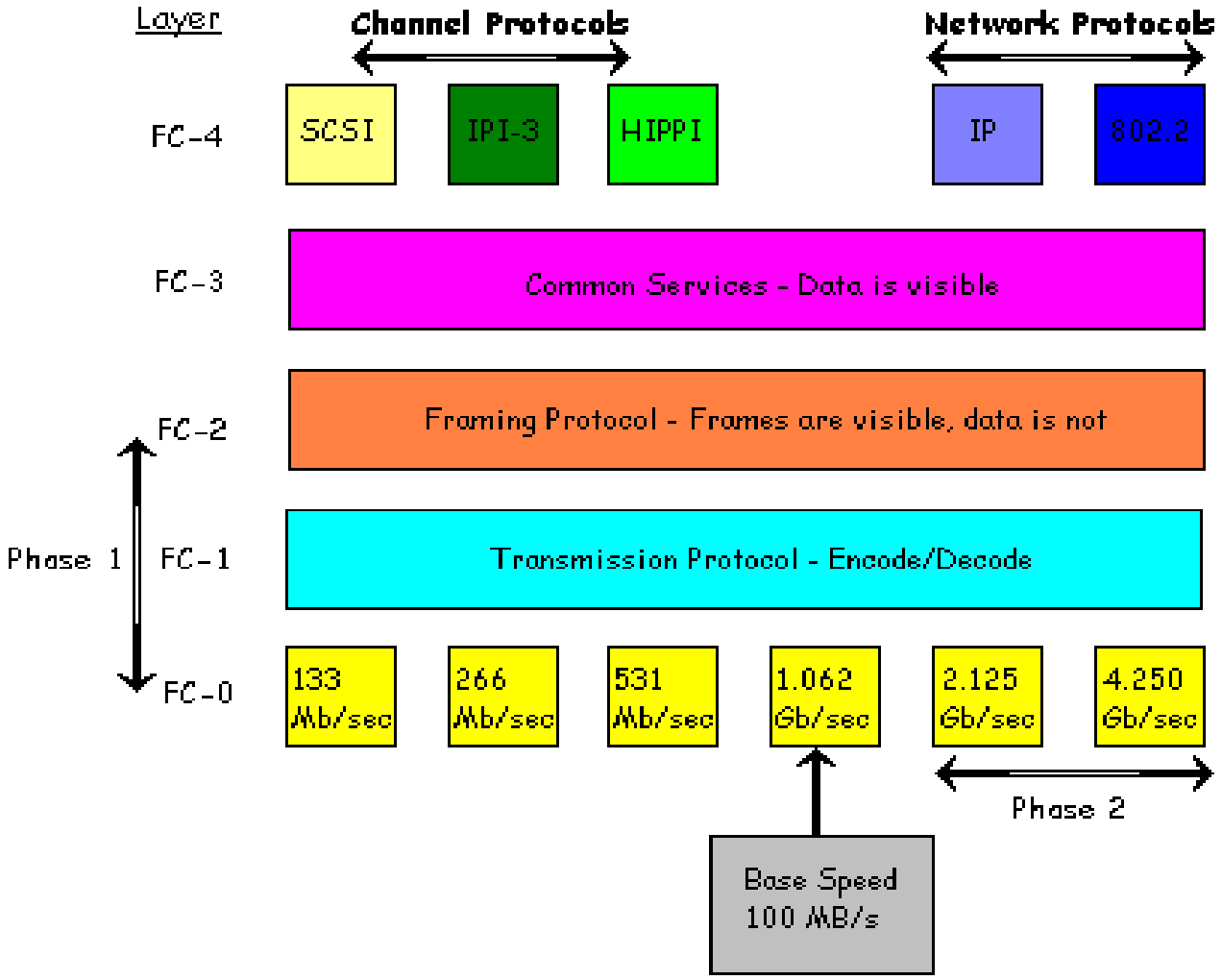
The Physical Fibre Channel Network







Fibre Channel Protocol Stack



Protocol Stack

- FC-4 - Mapping
- FC-3 - Common Services
- FC-2 - Framing Protocol
- FC-1 - Encode / Decode
- FC-0 - Physical

Protocol Stack FC-0 (Physical)

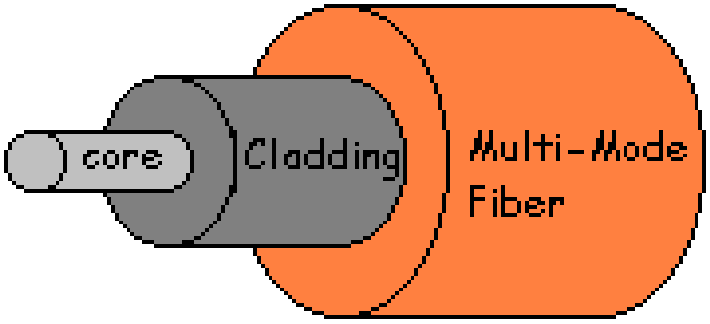
Distance (m) at 100MB/s	Signal Source	Transmission Media	Source Wavelength	Fibre Core Diameter
10,000	Laser	SM Fiber	1300nm	9.0um
500	Laser/VCSEL	MM Fiber	780 to 850nm	50um
300	Laser/VCSEL	MM Fiber	780 to 850nm	62.5um
500	VCSEL	MM Fiber	980nm	62.5um
NA	LED	MM Fiber	1300nm	62.5um
25	ECL	Video Coax		
10	ECL	Mini Coax		
NA	ECL	Twisted Pair		

VCSEL = Vertical Cavity Surface Emitting Laser

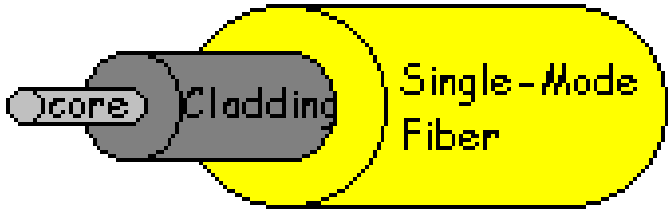
NA - Cannot Achieve 100MB/s data rate

Fiber Optic Cable

50 / 62.5 micron Dia.

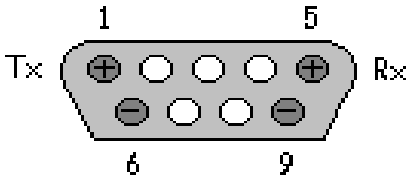


9 micron Dia.



Connectors

Copper Connectors

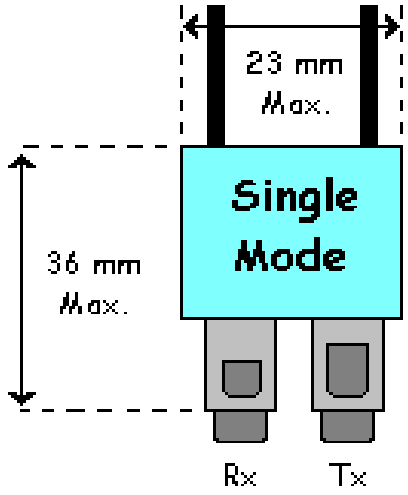


9 Pin STP Connector

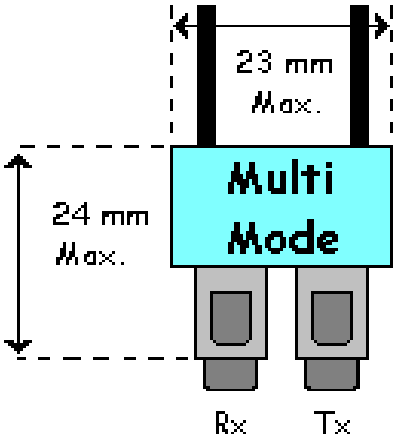
BNC

Twisted Pair

Optical Connectors



Single Mode SC Connector



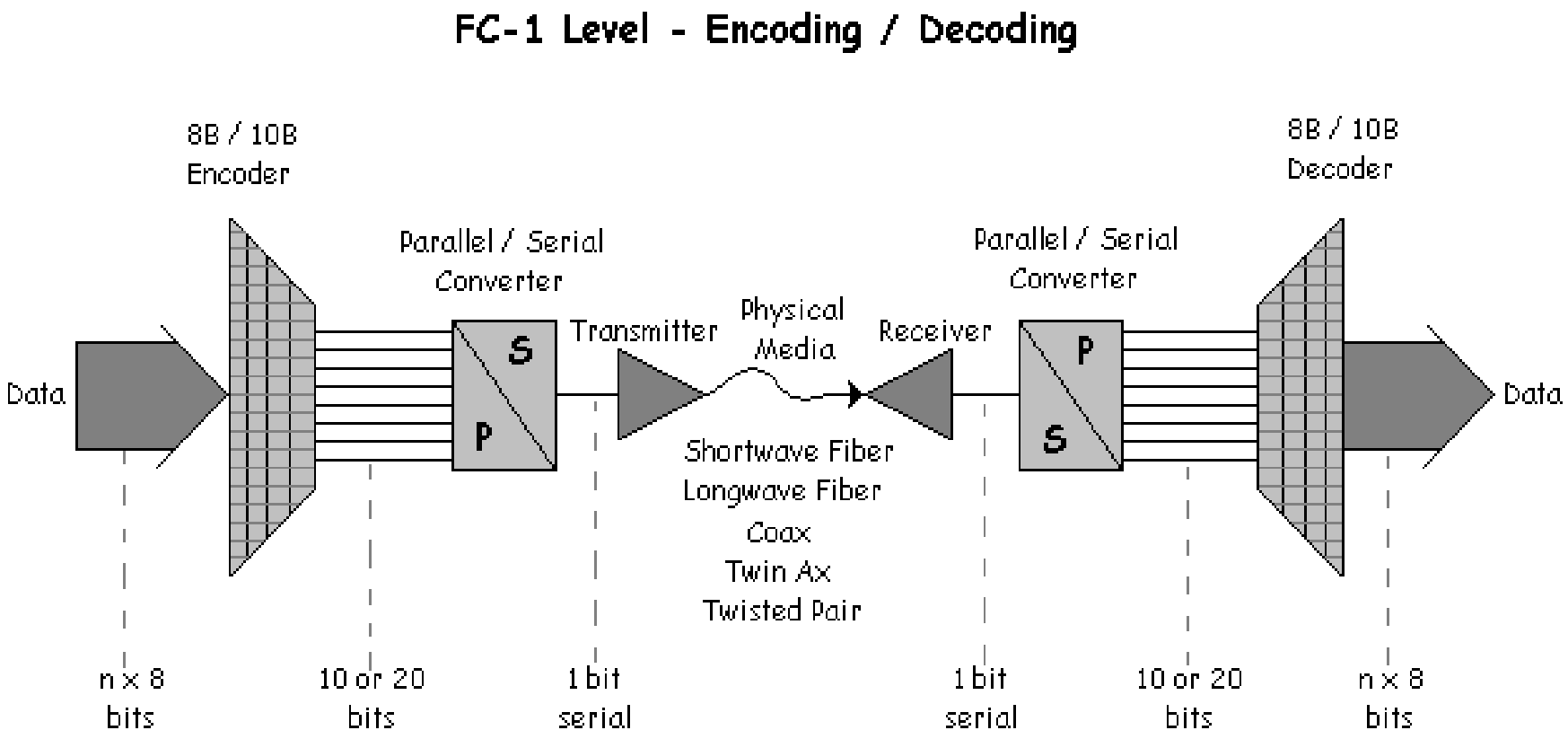
Multimode SC Connector

Transceivers

- Electrical
  - EL: ECL Level
- Optical
  - LL: longwave laser (1300nm)
  - SL: shortwave laser (780 to 850 nm)
  - LE: LED (1300nm)

The electrical signal is sent through a parallel-to-serial converter, converted into an optical signal, transmitted over the fiber media, changed back into an electrical signal and sent through a serial-to-parallel converter.

FC-1 Level -Encoding/Decoding



FC-2 Level - Framing

- A frame is a string of transmission words containing only data bytes,prefixed by a SOF (start of frame) delimiter and followed by an EOF (end of frame) delimiter.
- Several frames make a sequence, and several related sequences make an exchange. The following is the structure of each:
  - A *frame* is the smallest unit of information transfer
  - A *sequence* has at least one frame
  - An *exchange* has at least one sequence

SOF	Frame Header	Data Field	CRC	EOF
1TW	6TW	0-528 TW or 0-2112 Bytes	1 TW	1 TW

537 Transmission Words
or
2148 Bytes

FC-3 Level - Common Services

- FC-3 is in the process of being defined. It is intended to provide the common services required for advanced features such as striping (to multiply bandwidth) and hunt groups (the ability for more than one port to respond to the same alias address). A hunt group can be referenced to a business that has 10 telephone lines, but requires only a single number to be dialed.

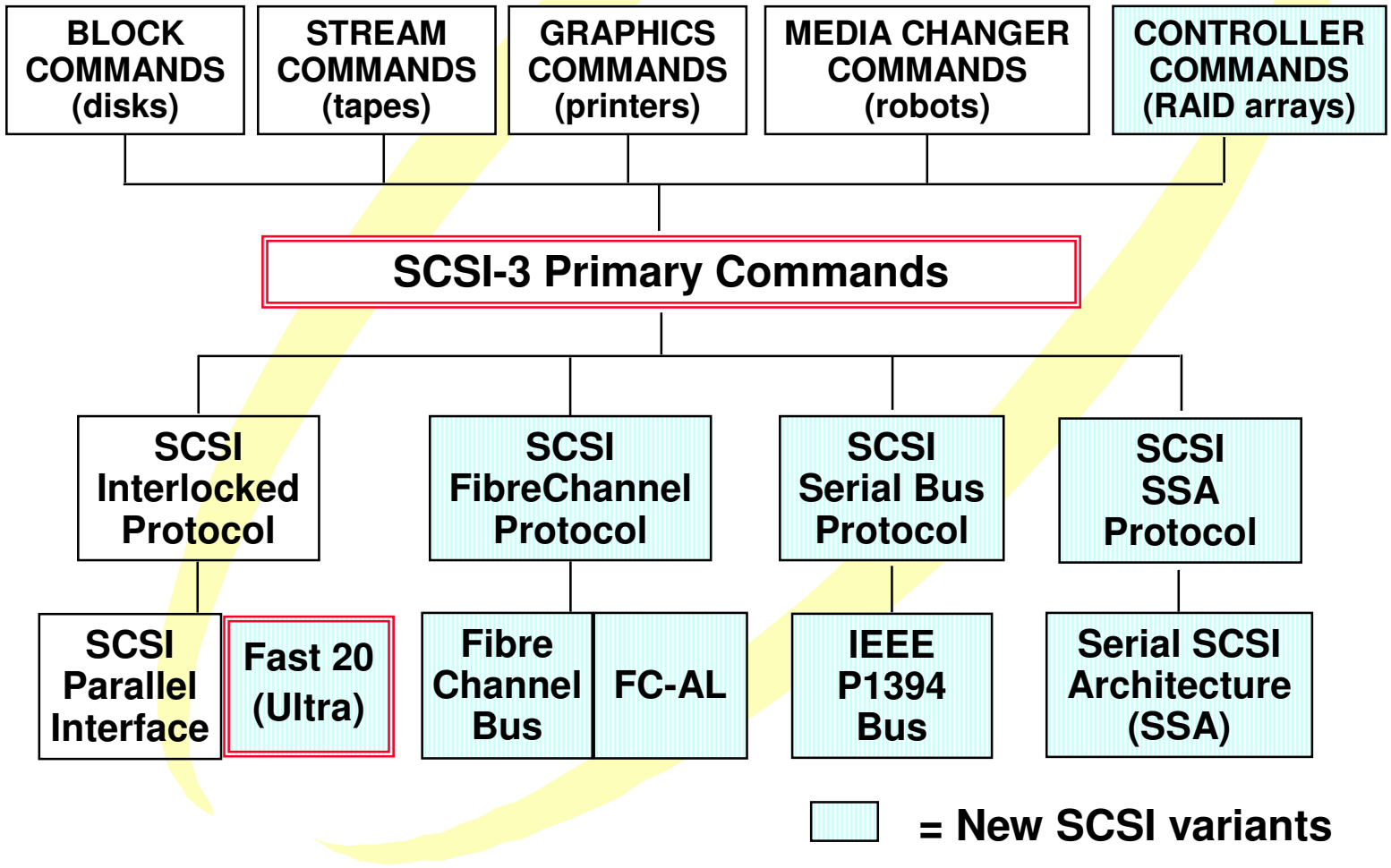
FC-4 Level - Mapping

- FC-4 defines the mapping of protocols between the lower levels of Fibre Channel and the command sets that use Fibre Channel.
- Here you will find separate standards for SCSI-3, IPI-3, HIPPI, FDDI, IP, and more.
- SCSI will retain its command set and a big portion of the device drivers and peripheral device codes, but instead of using 50-wire or 68-wire cables, connectors, and SCSI protocol chips, this lower level will be handled by Fibre Channel

SCSI-3 Architecture Structure

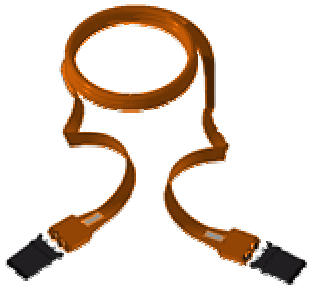
(Each box represents a separate SCSI-3 specification)

SCSI 3 Architecture Model



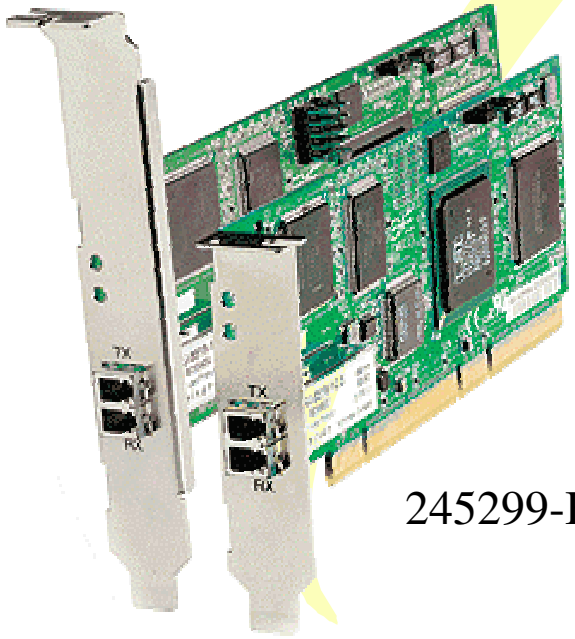
Optical Cables

- Multi-Mode Optical Cable Interconnect
  - Used with short wave optical transceivers, for distances up to 500 meters (300m for 2Gb)
  - Recommended as interconnect from hubs or switches to hosts and array controllers
  - In 2,5,15,30 and 50m lengths (longer cables must be custom made)
- Single-Mode Optical Cable Interconnect
  - Used with long wave optical transceivers, for distances of up to 10,000 meters
  - Fibre typically leased from telco supplier



Adapters

- Enhanced PCI-to-FC adapter for selected systems
- Provides optical cable support with FC-AL or fabric switches



245299-B21/FCA2101

168794-B21/KGPSA-CA

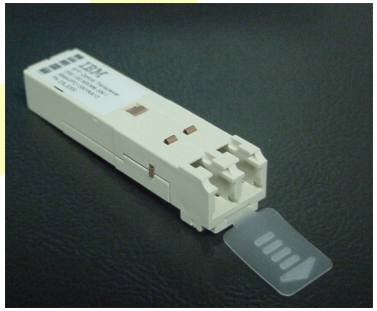
Transceivers (1Gb)

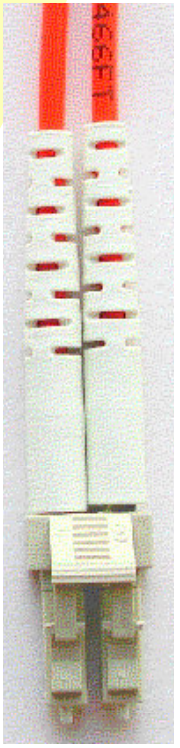
- Gigabit Interface Converter (GBIC)
  - Short-wave-based GBIC with SC cable connectors (380561-B21)
  - Long-wave-based GBIC with SC connector (127508-B21)
  - Hot-plug-able in optical hubs and switches.

- Gigabit Link Module (GLM)
  - modular media connectors
  - mount on HBA daughter card and HSG80 controller module
  - can be used to work with copper, long-wave and short-wave optical cables (HSG80 GLMs work with short-wave only)
- Connection Kits
  - FC Connection Kit
    3 short-wave GBIC's and 2 2m cables (380579-B21)
  - FC Connection Kit
    2 short-wave GBIC's and 2 2m cables (380596-B21)

Transceivers (2Gb)

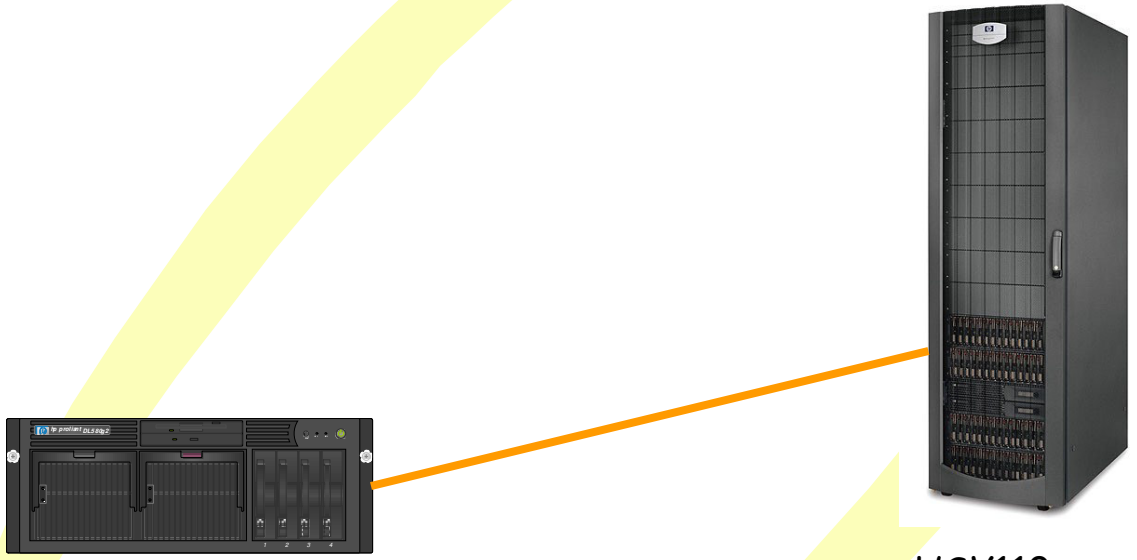
- SFP Optical Transceivers
  - 221470-B21 (Brocade shortwave)
  - 300834-B21 (McData shortwave)
  - 300835-B21 (McData 10km transceiver)
  - 300836-B21 (McData 35km transceiver)
  - 332312-B21 (Cisco shortwave)
  - 332313-B21 (Cisco longwave)
- Optical cables (longer lengths available)
  - 221691-B21 (2m LC to SC)
  - 221691-B22 (5m LC to SC)
  - 221692-B21 (2m LC to LC)
  - 221692-B21 (5m LC to LC





Fibre Channel Network Topologies

- Point-to-point topology



Emulex LP9000
N-Port

HSV110
N-Port

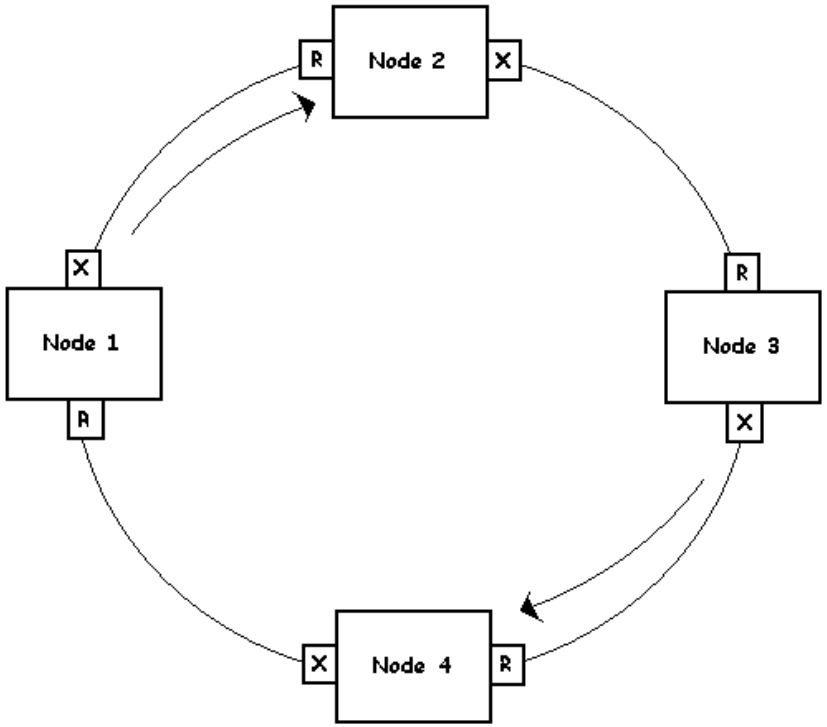
* HP does not support using point-to-point on HSV controllers at this time

Fibre Channel Arbitrated Loop Topology

- FC-AL was developed to fill the gap between the limited access of point to point topology and the expensive switched fabric topology.
- Allows 126 node ports and 1 fabric port to be connected
- If more ports are connected to the loop - they are unable to be addressed
- The topology allows a single connection between one pair of ports at any point in time.
- Once a session (2 devices communicating) is started, the other devices on the loop must wait until the connection ends.
- Since all active ports on the loop share the loop's bandwidth, an individual port may only be able to recognize a small portion of the rated bandwidth.
- As a result, the total bandwidth available is limited to the bandwidth of the loop itself

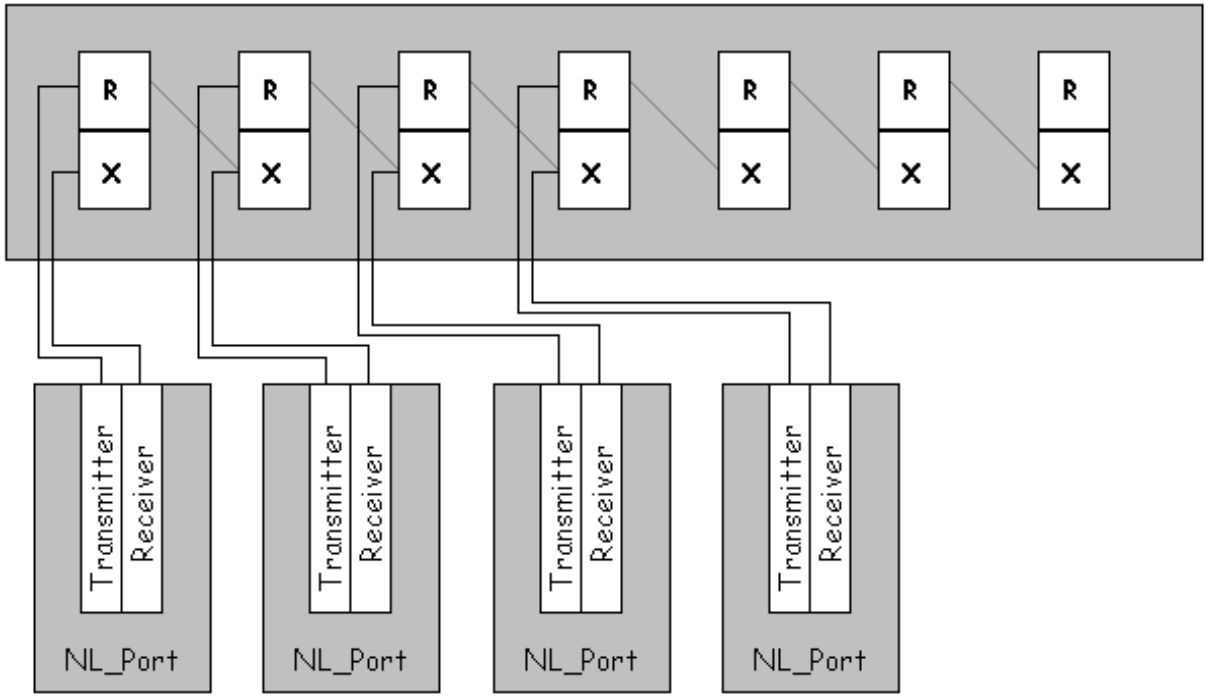
Fibre Channel Arbitrated Loop (Logical View)

- In an arbitrated loop topology, the routing function is distributed to each loop port.



Fibre Channel Arbitrated Loop (Physical View)

- The Fibre Channel Storage Hub is the central device that routes transmissions around the arbitrated loop.



Fibre Channel Switched Topology

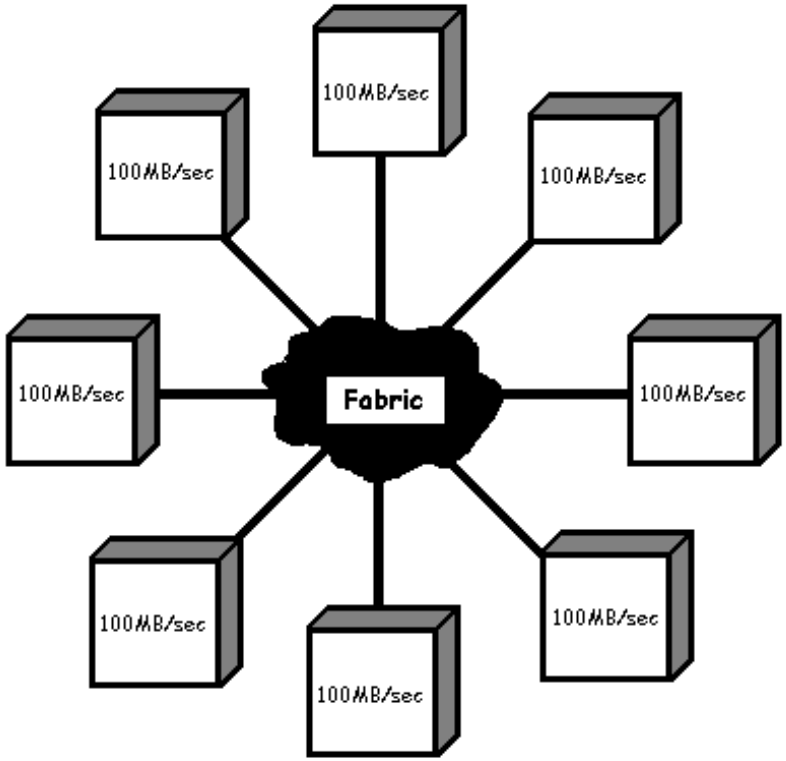
- Basis for Fibre Channel Fabric
- Provides high system bandwidth in multi-host systems
- Provides Name Server for node registration
- Requires Operating System support (more than FC-AL)
- Requires adapter, controller support (more than FC-AL)

Switched Fibre Channel Fabrics

- Fibre channel networks built around switches are referred to as *fabrics*.
- The term fabric is used to distinguish the operations of the whole network as opposed to the operations of a single switch
- Ports on fabric networks connect nodes to switches on low-latency, point-to-point connections
- Each port has 2 complete 100MB/sec uni-directional connections that follow the same path on the network
- A node with multiple ports can have 200MB/s, 400MB/sec, 800MB/sec of aggregate bandwidth.
- To support this kind of bandwidth, fibre channel switches utilize high-speed integrated circuit and backplane technology that has the capability to support gigabit transmissions for multiple concurrent sessions

Switched Fibre Channel

- Each node on the Fibre Channel switch gets full bandwidth



Addressing and Naming

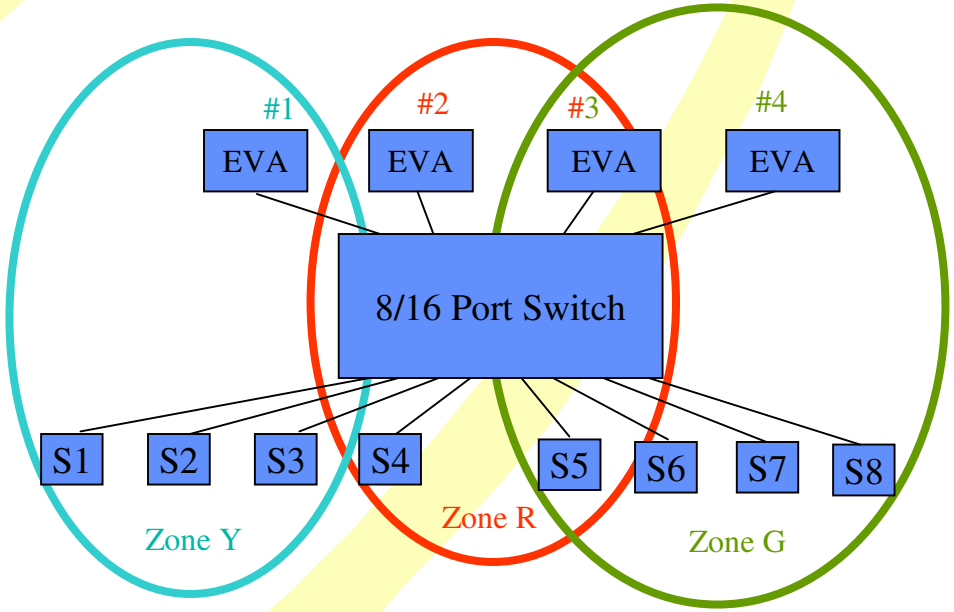
- World Wide Name
  - 128 bit unique identifier (subsets implemented)
  - address stored in NVRAM
  - determined by IEEE
  - used to log into fabric
    - process called "registration" occurs
    - address is placed in simple name server
- Port Address
  - unique address for each port in network
  - 3 bytes long (24 bits)
  - defined by switch at fabric login
- Simple Name Server
  - directory service implemented in the switches
  - used by nodes, fabrics and applications for accessing port information

Zoning

- A technique used to segregate storage I/O traffic between groups of servers and their storage subsystems
- Implemented in the switch firmware
- Soft Zoning
  - filtering used to mask ports belonging to one zone from ports that don't belong
  - Can be assigned by WWN, port name, or alias name
- Hard Zoning
  - also known as port zoning
  - implemented in hardware
  - ports are physically blocked by port number

Zoning

- Hardware or Software restricted communications paths
- Can include/exclude any nodes in SAN



Zoning Illustration

Servers in a zone are restricted to accessing RA8000 in their zone.
As illustrated:

- S1,S2,S3 can access RA8000 #1
- S4,S5 can access RA8000 #2 and #3
- S5,S6,S7,S8 Can access #3 and #4

SAN Infrastructure Product Portfolio

Infrastructure alternatives that span the enterprise

Business enterprise

Business mid-range

Business entry


core 2/64


director 2/64


director 2/140


MDS-9509
MDS-9506


switch 2/32


edge 2/32


MDS-9216


switch 2/16


switch 2/8 EL


blade 2/8

edge 2/24


edge 2/12

New!


MDS 9120 &
MDS 9140

B-Series **M-Series** **C-Series**

B-Series Product Line

- Common 2Gbit/sec Fibre Channel ASIC
- Common Advanced Fabric Services
- Common Open Management
- Compatible with entire SAN Switch family
- >1000 total port SAN topologies & Growing
- Software Power Pack options on all switches (except embedded blade)

SAN core 2/64

SAN core 2/128

SAN switch 2/32

SAN switch 2/16
SAN switch 2/16 EL

SAN switch 2/8
SAN switch 2/8 EL

MSA SAN switch 2/8
(Embedded in
HP MSA1000 only)

BROCADE

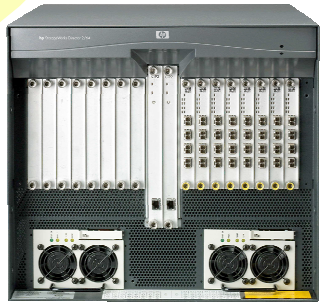
M-Series Product Line

hp StorageWorks edge switch 2/24

- departmental /edge level connectivity
- capacity on demand (Flexport)
- 8/16/24 port configurations
- call-home features
- high performance
- Optional software: HA Fabric Manager & SANtegrity Binding security software

hp StorageWorks edge switch 2/32

- departmental /edge level connectivity
- capacity on demand (Flexport)
- 16/24/32 port configurations
- call-home features
- high performance
- Optional software: HA Fabric Manager & SANtegrity Binding security software



hp StorageWorks director 2/64

- full HA in a single box
- call-home features
- online upgrades – no impact to applications
- soft zoning
- Optional software: HA Fabric Manager & SANtegrity Binding security software

hp StorageWorks director 2/140

C-Series Product Line

MDS 9509

Director-Class Switch with 9 expansion slots

Fully Redundant hot swappable hardware

Expandable up to 224 FC ports

Supports up seven,16 or 32 port FC expansion modules

Supports FC/IP 8 Port expansion Module

Management software included

MDS 9506

Director-Class Switch with 6 expansion slots

Fully Redundant hot swappable hardware

Expandable up to 224 FC ports

Supports up seven,16 or 32 port FC expansion modules

Supports FC/IP 8 Port expansion Module

Management software included

MDS 9216

Includes 16 Port Fabric Switch with single expansion slot

Expandable up to 48 FC ports with no disruptions

Supports one,16 or 32 port FC expansion module

Supports FC/IP 8 Port expansion Module

Management software included

MDS 9140

MDS 9120

StorageWorks SAN Switch 2/8-EL

- Key Features/Benefits
  - Eight High Performance auto-sensing 1 and 2 Gb ports.
  - May be optionally programmed to a fixed 1 Gb or 2 Gb speed if desired.
  - Universal, self-configuring ports (F, FL, E) with new industry-standard removable Small Form Factor Pluggable optical transceivers (SFP) (ordered separately).
  - Four Switch SAN fabric support.
  - Fully non-blocking for all 8 ports Full 16 Gb switching capacity for uncongested fully sustained, 2 Gb full duplex throughput.
  - One fixed power supply.
  - N+ 1 redundant fan.
  - Rack optimized design: 1U (1.75") tall for high density rack installations.
  - SAN Switch 2/8-EL includes Web Tools, Advanced Zoning, and Quickloop.
  - Part number: 322120-B21
  - SAN Switch 2/8 PowerPak (322121-B21) includes: SAN Switch 2/8-EL, Fabric Watch, ISL Trunking, Advanced Performance Monitor, Remote Switch, Extended Fabric, full fabric, and Quickloop.

StorageWorks SAN Switch 2/16

- Key Features/Benefits
  - Sixteen High Performance auto-sensing 1 and 2 Gb ports.
  - May be optionally programmed to a fixed 1Gb or 2 Gb speed if desired
  - Universal, self-configuring ports (F, FL, E) with new industry-standard removable Small Form Factor Pluggable optical transceivers (SFP) (ordered separately)
  - Fully non-blocking for all 16-ports Full 32 Gb switching capacity for uncongested fully sustained, 2 Gb full duplex throughput
  - High availability design
  - Redundant, hot swappable power supplies
  - Hot-swappable cooling unit
  - Refer to the SAN Design Guide Addendum for 2 Gb switch configuration information
  - Rack optimized design: 1U (1.75") tall for high density rack installations
  - Part number: 322118-B21
- PowerPack bundle (322119-B21) includes:
  - QuickLoop, Remote Switch, Fabric Manager, Extended Fabric, ZBun

StorageWorks SAN Switch 2/32

- Key Features/Benefits
  - Delivers 32-ports in a 1.5U enclosure and up to 384-ports in a single 42U cabinet, facilitating manageable SAN fabrics composed of thousands of ports
  - Meets enterprise level availability requirements with redundant, hot pluggable components, no-single-points-of-failure within the switch
  - Provides 1 Gb and 2 Gb operation today
  - Employs optional Inter-Switch Link (ISL) Trunking to provide a high-speed data path between switches
  - Redundant hot swappable N+ 1 cooling Fans (three units Standard)
  - Redundant, hot swappable power supplies (two units Standard)
  - Part Number: 240603-B21
- PowerPack bundle (333764-B21) includes:
  - QuickLoop, Remote Switch, Fabric Manager, Extended Fabric, ZBun

StorageWorks Core Switch 2/64

- Key Features/Benefits
  - New Core Switch base model switch which ships with Advanced Zoning and Web Tools
  - 2 Gb up to 64-port connectivity
  - Investment protection for previous SAN Switch installations
  - Full suite of software tools offers the most comprehensive software bundle for maximum performance and complete SAN management
  - Easily integrated into core-to-edge SAN Switch configurations
  - Investment protection with backward compatibility with presently installed 1 Gb and 2 Gb SAN
- PowerPack bundle (332178-B21) includes:
  - Fabric Watch, Advanced Performance Monitor, Remote Switch, Extended Fabric, ISL Trunking

StorageWorks edge switch 2/16

- Outstanding support for mission critical applications by providing a rich set of high availability features
- Key Features/Benefits
  - Hot plug redundant power supply
  - Hot plug redundant fans
  - Hot plug optics
  - On-line diagnostics
  - On-line, non-disruptive firmware load and activation
  - Fault isolation tools for network-wide activity
  - Call-home and e-mail automatic notification
- Optional Software
  - Product Manager License (300659-B21), Fabric Manager (287406-B21)
- Part number: 286811-B21

StorageWorks edge switch 2/32

- Outstanding support for mission critical applications by providing a rich set of high availability features
- Key Features/Benefits
  - Hot plug redundant power supply
  - Hot plug redundant fans
  - Hot plug optics
  - On-line diagnostics
  - On-line, non-disruptive firmware load and activation
  - Fault isolation tools for network-wide activity
  - Call-home and e-mail automatic notification
- Optional Software
  - Product Manager (300658-B21), 8-flexport upgrade (302660-B21), Fabric Manager (302660-B21)
- Part number: 286810-B21

StorageWorks Director 2/64

- Ensures Business Continuance through 99.999% availability
- Key Features/Benefits
  - Redundancy of all major hardware components
  - Automatic failover of active components
  - Fully hot swappable components
  - Non-disruptive code load/code activation
  - Configurations start at 32-ports increasing up to 64-ports, in four port increments.
  - Call home capabilities
- Optional Software and components
  - Fabric Manager (302660-B21), 8-port module kit (300833-B21)
- Part number: 286809-B21 (32 port configuration)

StorageWorks Director 2/140

- Ensures Business Continuance through 99.999% availability
- Key Features/Benefits
  - Redundancy of all major hardware components
  - Automatic failover of active components
  - Fully hot swappable components
  - Non-disruptive code load/code activation
  - Configurations start at 64-ports increasing up to 140-ports, in four port increments.
  - Call home capabilities
- Optional Software and components
  - Fabric Manager (287406-B23), 4-port module kit (316094-B21)
- Part number: 316093-B21 (64 port configuration)

Cisco MDS 9216 Multilayer Fabric Switch

Key Features/Benefits

- Modular, scalable Fabric Switch – 2 slots; 1 optional line card
- High port density – 16-48 Auto-Sensing 2/1 Gb Fibre Channel ports in a single chassis
- Multi-protocol Support – Fibre Channel, iSCSI, FCIP
- Virtual SANs (VSANs)
- QoS
- Embedded Diagnostics – Fibre Channel ping and trace route, protocol analysis and decoding, SPAN, Call Home capability
- Security – RBACs, ACLs, Hardware-Enforced Zoning, FC-SP, SNMPv3, RADIUS
- Open Platform for Enabling Network-based Intelligent Storage Applications
- Integrated Management – embedded Fabric Manager, integration with HP OpenView -SAM and CiscoWorks RME
- Part Number: 332315-B21

The Cisco MDS 9216 Multilayer Fabric Switch shares a consistent architecture with the MDS 9509 Director and offers the same multilayer intelligence in a modular fabric switch.

Cisco MDS 9509 Multilayer Director

- Key Features/Benefits
  - Modular, scalable Director – 9 slots
  - High port density – 16-224 Auto-Sensing 2/1 Gb Fibre Channel ports in a single chassis and 672-ports in a single rack
  - High Availability
  - Multi-protocol Support – Fibre Channel, iSCSI, FCIP
  - High Performance – 1.44 Terabit/sec internal system throughput ensure 10-Gbps readiness
  - Virtual SANs (VSANs)
  - PortChannels
  - QoS
  - Embedded Diagnositcs – Fibre Channel ping and trace route, protocol analysis and decoding, SPAN, Call Home capability
  - Security – RBACs, ACLs, hardware, enforced Zoning, FC-SP, SNMPv3, RADIUS
  - Open Platform for Enabling Network-based Intelligent Storage Applications
  - Integrated Management – embedded Fabric Manager, integration with HP OpenView -SAM and CiscoWorks RME
  - Part Number: 332306-B21 (base with 0 ports)

The MDS 9509 delivers industry-leading performance (1.44 Terabits internal system throughput), port density (up to 224 ports) and high availability, to lower TCO and enable integrated SAN infrastructures.

Host Bus Adapters and Connections

Host Bus Adapters and Connections

- HBA Models
- HBA Installation and Setup
  - Physical installation
  - Cabling and connections
  - Configuring the adapter
  - General Setup Instructions
  - OS specific Instructions

Fibre Channel Adapters - Models

HP-UX Supported HBAs

- A6685A (1 Gbps, 32-bit 40 MHz HSC)
- A6795A (2 Gbps, 64-bit 66 MHz PCI)
- A5158A (1 Gbps, 32/64-bit 66 MHz PCI)
- A6826A (2 Gbps, 64-bit PCI Dual Channel)
- A9782A (2 Gbps, 64-bit PCI Dual Channel combo)
- A9784A (2 Gbps, 64-bit PCI Dual Channel combo)

Fibre Channel Adapters - Models

- **OpenVMS and Tru64 Unix**
  - 168794-B21 [DS-KGPSA-CA] (1 Gbps, 64-bit/33 MHz PCI)
  - FCA2354 261329-B21 [DS-KGPSA-DA] (2 Gbps, 64-bit/66 MHz PCI)
  - FCA2384 302784-B21 [DS-KGPSA-EA] (2 Gbps, 64-bit/133 MHz PCI-X)

Fibre Channel Adapters - Models

- **Windows NT (4.0, 2000, 2003)**
  - A7388A, A7387A,
  - Emulex LP1050, LP1050DC
  - Emulex LP10000, LP10000DC
  - FCA2404, FCA2404DC, FCA2408
  - Emulex LP9802, LP9802DC
  - Emulex LP982
  - FCA2214, FCA2214DC
  - QLogic 2340, QLogic 2342

Fibre Channel Adapters – Models

- **SUN Solaris**
  - SWSA4-SC 123503-001 (1 Gbps, 64-bit Sbus)
  - SWSA4-PC 380576-001 (1 Gbps, 32-bit PCI)
  - FCA2257P 254456-B21 (2 Gbps, 64-bit/66 MHz PCI)
  - FCA2257S 254458-B21 (1 Gbps, 64-bit/25 MHz Sbus Dual Channel)
  - FCA2257C 254457-B21 (1 Gbps, 64-bit/33 MHz cPCI Dual Channel)

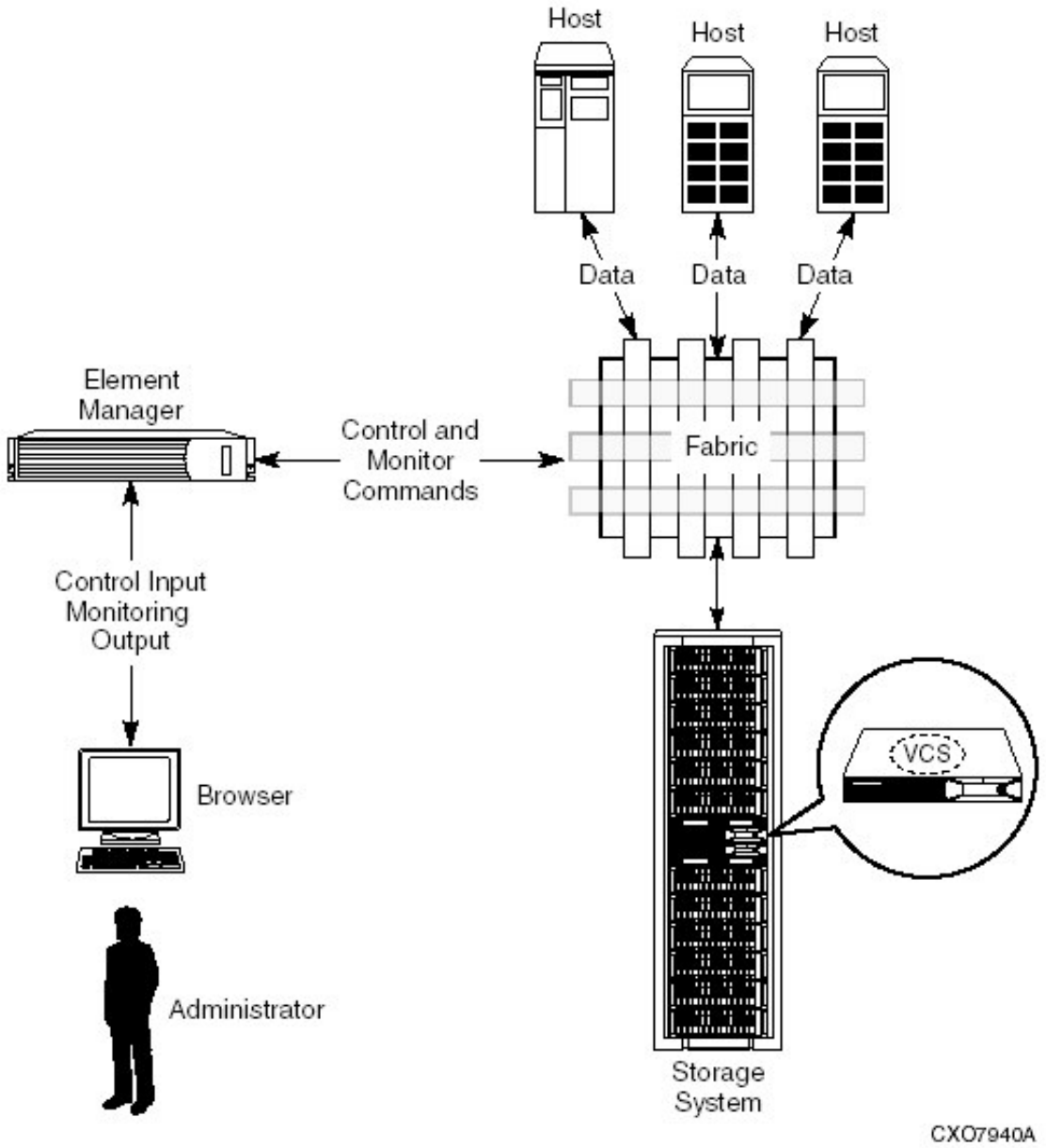
Fibre Channel Adapters – Models

- **IBM AIX**
  - 197819-B21 DS-SWIA1-PD (1 Gbps, 32/64-bit 66MHz PCI)
  - PC2000LC-HPSP (2 Gbps, 32/64-bit 66MHz PCI)
- **Netware**
  - FCA2210 281540-B21 (2 Gbps, 64-bit/133 MHz PCI-X)
- **Linux (RedHat, SuSE)**
  - FCA2214 281541-B21 (2 Gbps, 64-bit PCI-X)
  - FCA2214DC 321835-B21 (2 Gbps, 64-bit PCI-X, Dual
  - Channel)
  - FC Mezzanine Card for BL20P

Host Bus Adapter -Physical Installation

- Shut down the O.S.
- Power system off
- Record the 64 bit World Wide ID IEEE address
  - located on a sticker on the back of the adapter
  - may need later to identify connection in multihost environment
- Install adapter into available PCI slot
- Run cables to hub/switch (don't crimp!!)
- Configure storage
- Boot O.S.

Fibre Channel Cabling



Fibre Channel Cabling

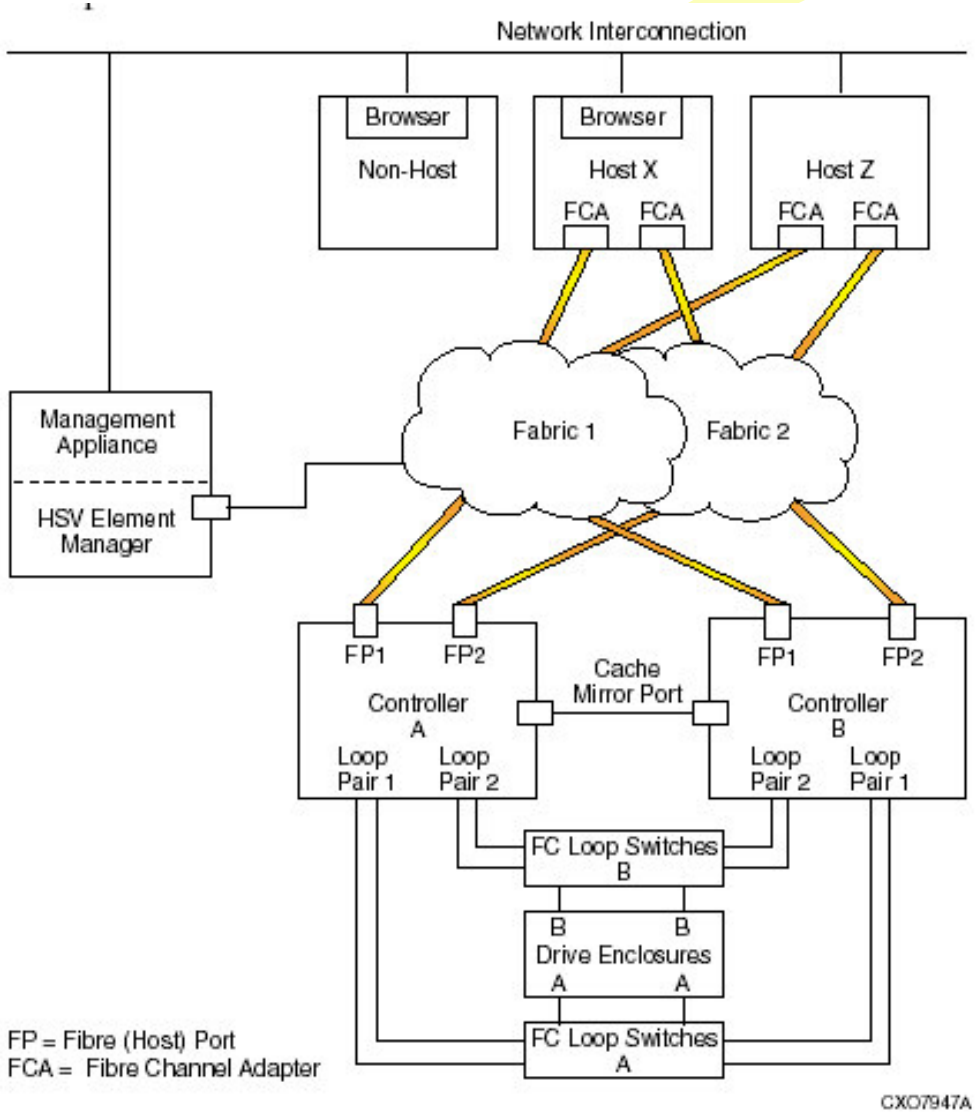
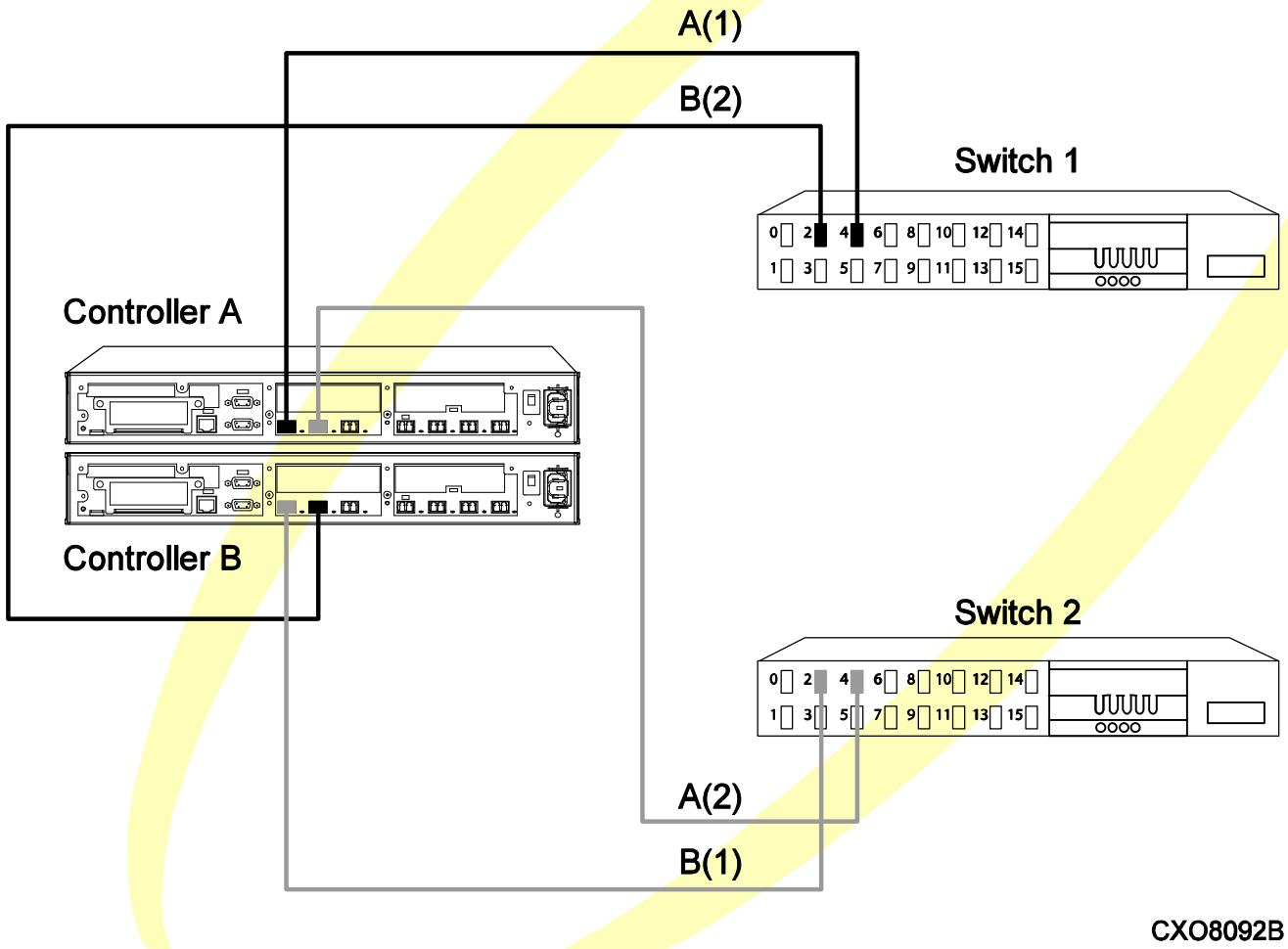


Figure 2–1: Block diagram of the storage system's connections

Fibre Channel Cabling



Host Bus Adapter – General Setup

- Install HBA driver
  - Adapter driver and installation procedures included on Platform Solution Kit CD.
  - Review the procedures – they may change with new releases.
- Name hosts or connections and present storage to the hosts.
- Rescan SCSI bus (or reboot) to connect to newly visible storage volume.

Host Bus Adapter – W2K setup

- Check most recent Installation manual for changes.
- W2K Plug and Play may install a default driver.
- Insert Windows Solution Platform Kit for appropriate storage array.
- CD should autoplay. If not, look in autorun.inf and run "demo.exe".
- Select "Update driver" from menu screen to update driver.
- Rebooting is optional here…

Installing Array Device Driver –W2K

- Select the Fibre Channel Software Setup option from the menu that appears after the driver upgrade is completed.
- Choose the setup that matches your system configuration from the four options that are presented.
- The Fibre Channel Software performs as follows:
  - Automatically installs the correct SCSI filter Driver.
  - Automatically sets registry for proper operational use of the FCA Fibre Channel host adapter with the Storage Array.
  - Enables "Extended Configuration" settings to be specified in a Fibre Channel Switch (FC-SW) topology and Fibre Channel Arbitrated Loop (FC-AL) topology.
  - Copies the appropriate driver to the%systemroot%\system32\drivers folder.

Host Bus Adapter – OpenVMS

- Install the FC HBA and boot the OS
- OpenVMS uses unique identifier (LUN ID alias) to assign unit a device name.
  - Set unit identifier = NN (from Command View EVA)
  - Set d3 identifier = 3 (becomes 1DGA3)

Host Bus Adapter – OpenVMS (cont)

- FC implemented on Alpha only
  - 7.2 requires TIMA VMS72_HW01
  - 7.2-1 requires VMS721_FIBRECHAN_V0300
  - 7.2-2 requires VMS722_FIBRE_SCSI-V0200
  - 7.3 requires VMS73_FIBRE_SCSI-V0300
  - No FC-AL support
- OpenVMS FC Drivers:
  - SYS$PGADRIVER – FC SCSI Port Driver
  - SYS$FGEDRIVER – Emulex HBA Driver
  - SYS$DKDRIVER - SCSI Class Driver for HSG LUN's
  - SYS$GKDRIVER - Generic SCSI Class driver for CCL

Heterogeneous SAN Configurations

Topology Positioning and Rollout

Enterprise SAN
(~1000s Ports)

Med-Large SAN
(~400 Ports)

Small-Med SAN
(~100 Ports)

Fabric Topology Designs

"Standard Topologies" & "Rules Based Topologies"

~300/~600 Total Ports
200/400 Device Ports
- **20 Switch Backbone SAN Topology**
- **20 Switch SAN Topologies**

"Defined" Configurations

52/104 Usable Ports
- **4 Switch SANs**

Integrated SANs, Long Distance Support

- Common CA and Non-CA SAN
- Common SAN with EBS
- Distances up to 100km
  - CA, General SAN, HP OpenVMS Host-based Shadowing

SAN Topologies & Fabric Rules

SAN Design Support Levels

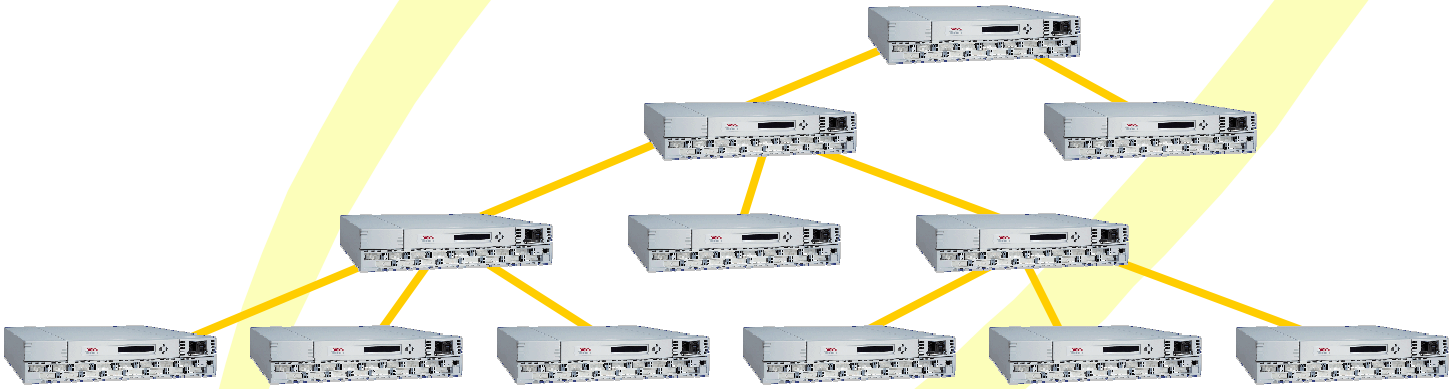
- "Standard" Topologies
  - Four SAN topology designs
  - Defined inter-switch connectivity
  - Different topologies optimized for specific data locality need
- "Modified" Topologies
  - Rules allow for deviations within the standard topologies
- "Rules Based" Topologies
  - Other topologies possible based on qualified rules

HP Standard Topologies

- SAN Fabric Topologies
  - "Cascaded" SAN
    - Local Access
  - Switch "Meshed" SAN
    - Distributed, Local, Centralized Access
  - Switch Ring SAN
    - Local, Centralized Access
  - Switch "Skinny Tree" Backbone SAN
    - Distributed, Centralized, Local Access

Cascaded SAN Fabric

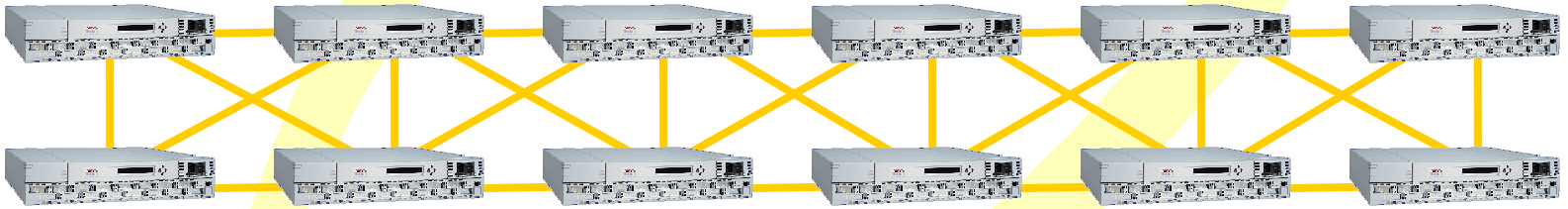
- Accommodates diverse geographic conditions
- Scales easily for additional connectivity
- Shared backup is supported
- Shared management is supported
- Optimal local access is inherent in the design



12 Switch Cascaded Fabric Example

Meshed SAN Fabric

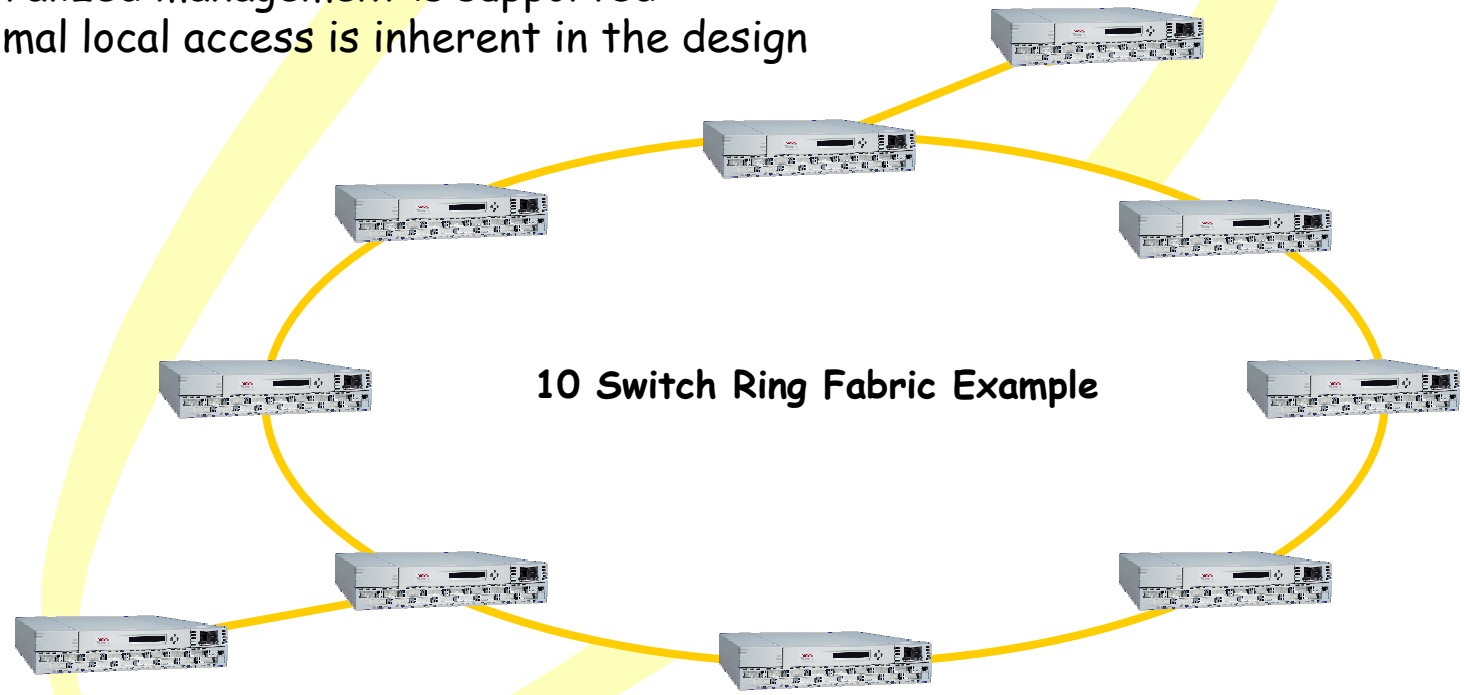
- Can be configured for many to many or local access, or a mix
- Provides protection against link and switch port failures
- Scales easily for additional connectivity
- Shared backup is supported
- Centralized management is supported
- Optimal distributed access is inherent in the design



12 Switch Meshed Fabric Example

Ring SAN Fabric

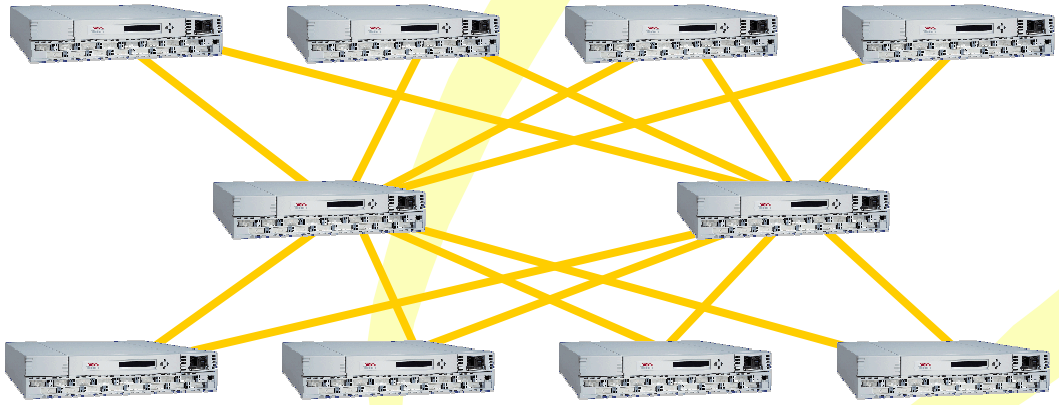
- Easy to build
- Modular design
- Scaling is simple and non-disruptive
- Shared backup is supported
- Centralized management is supported
- Optimal local access is inherent in the design



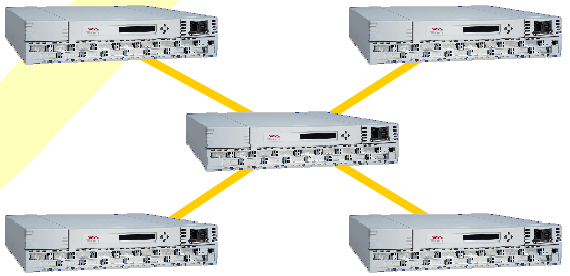
10 Switch Ring Fabric Example

Skinny Tree Backbone SAN Fabric

- Efficient port expansion
- All edge switches are only two hops apart
- Shared backup is supported
- Centralized management is supported
- With two backbone switches, provides switch redundancy
- Maximum flexibility for mixed data access types
- Best-suited to take full advantage of expected future technological developments such as storage virtualization

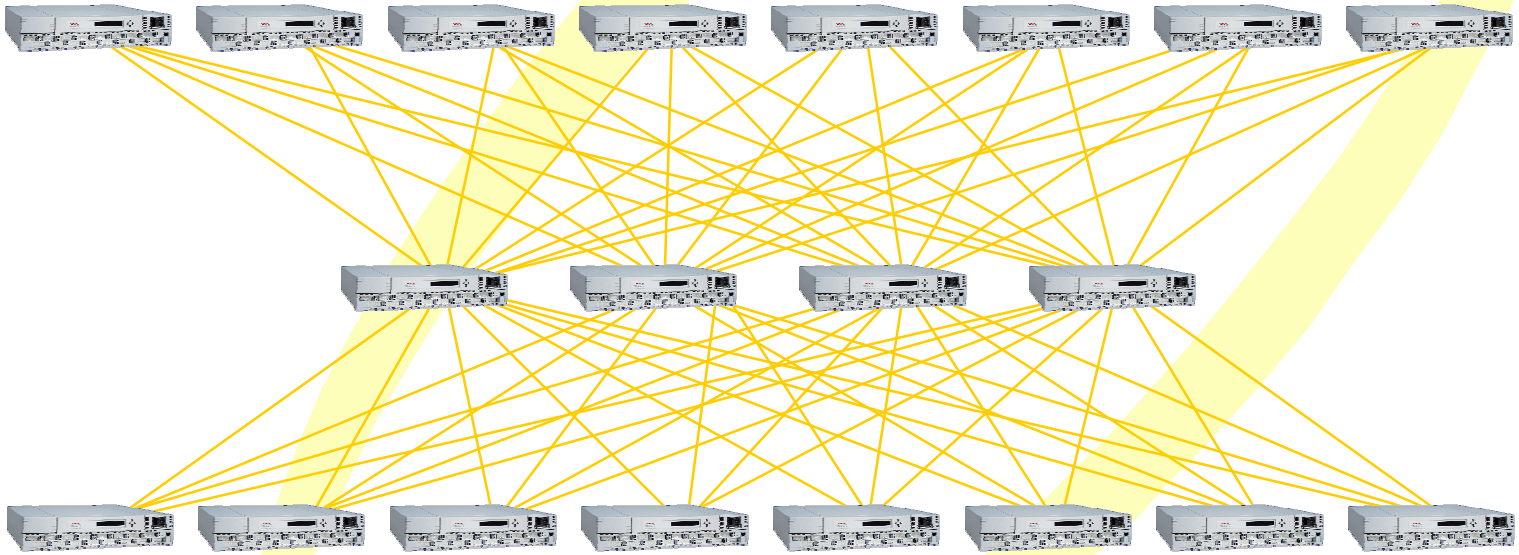


10 Switch Tree Backbone Fabric Example



5 Switch Tree Backbone Fabric Example

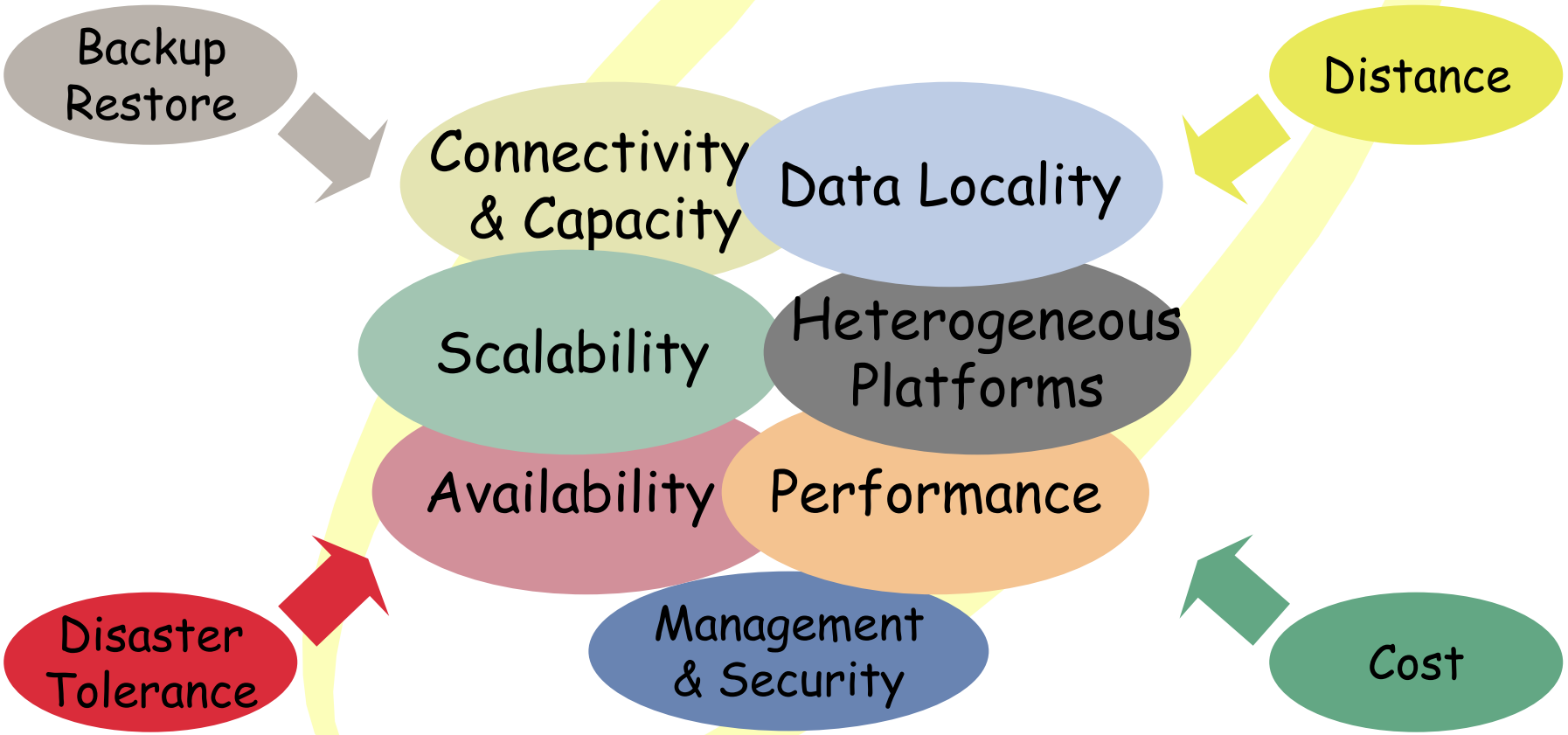
Skinny Tree Backbone SAN Fabric



20 Switch Tree Backbone Fabric Example

SAN Design Considerations

Design Requirements for a SAN



SAN Topology Metrics

- Data Locality or "Locality of Allocation"
  - The location of storage LUNs relative to servers
- Connectivity & Capacity Efficiency
  - The percentage of ports available for devices
  - The amount of storage available
- Fabric Performance
  - The cross-sectional bandwidth
- Growth Efficiency
  - Scalability
- Availability Levels
  - Fabric and server/storage availability

Locality of Allocation - 2 Factors

- Specific application-driven access requirements
- Where the storage is deployed or located relative to the servers that require data access
  - Local or "One to One"
    - Servers and storage typically on the same switch
  - Centralized or "Many to One"
    - All servers distributed across multiple switches throughout the fabric accessing a centralized storage pool
  - Distributed or "Many to Many"
    - Servers and storage pools are distributed across multiple switches throughout the fabric

Availability Levels

- Level 1: Maximum Connectivity
  - A single fabric with single server and storage paths (equivalent to single path parallel SCSI)
- Level 2: Fabric Resiliency
  - A single fabric with multiple fabric paths and single server and storage paths
- Level 3: High Availability/Multi-Path
  - A single fabric with multiple fabric paths, and multiple server and multiple storage paths
- Level 4: High Availability/Multi-Path/Fault Tolerant/No Single Point of Failure
  - Two (or more) redundant fabrics

Design Rules for HP Standard and Rules-Based SAN Topologies

- Must adhere to all "Fabric Rules"
  - Performance Recommendations - #ISL's
  - Minimize "Oversubscription"
- Must adhere to all "Interconnect Rules"
  - F-Port, FL-Port (public & private), E-Port usage
  - Media/Interconnects/Interface Components
    - Fiber optic cable types: 50, 62.5, & 9 micron
    - Short-wave GLM (HSG60/80 only)
    - Short-wave GBIC & Long-wave GBIC (switch to switch)
    - Very long distance GBIC (switch to switch)
  - Distances/GBIC/Loss Budgets
    - 50u/500 meters/SW: 4db
    - 62.5u/200 meters/SW: 3 db
    - 9u/10km/LW: 7.8 db
    - 9u/100km/VLD: 23 db

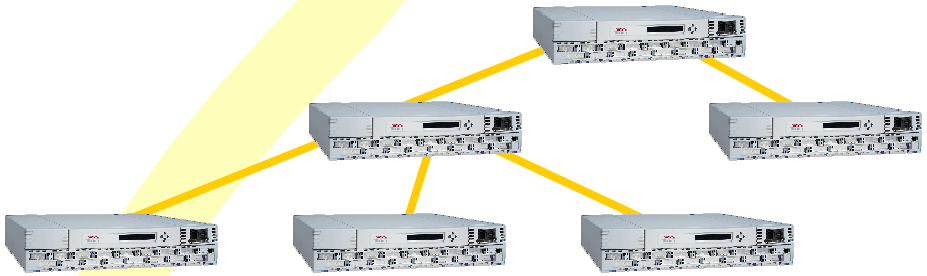
SAN Scaling and Migration

SAN Scaling

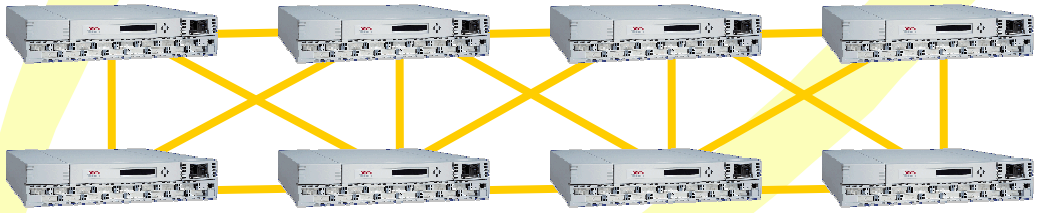
SAN Topology	Scalability (For All Topologies)	Migration
Cascaded	• Increase the number of switches • Use higher port count switches • Deploy multiple fabrics • Transition to a different topology	Convert to Meshed, Ring or Tree
Meshed		Convert to Ring or Tree
Ring		Convert to Meshed or Tree
Tree		Add additional backbone switches

- Scaling
  - Refer to Chapter 10 OpenSAN Design Guide, Best Practices
  - Provides an overview of the expansion process for each topology

SAN Scaling

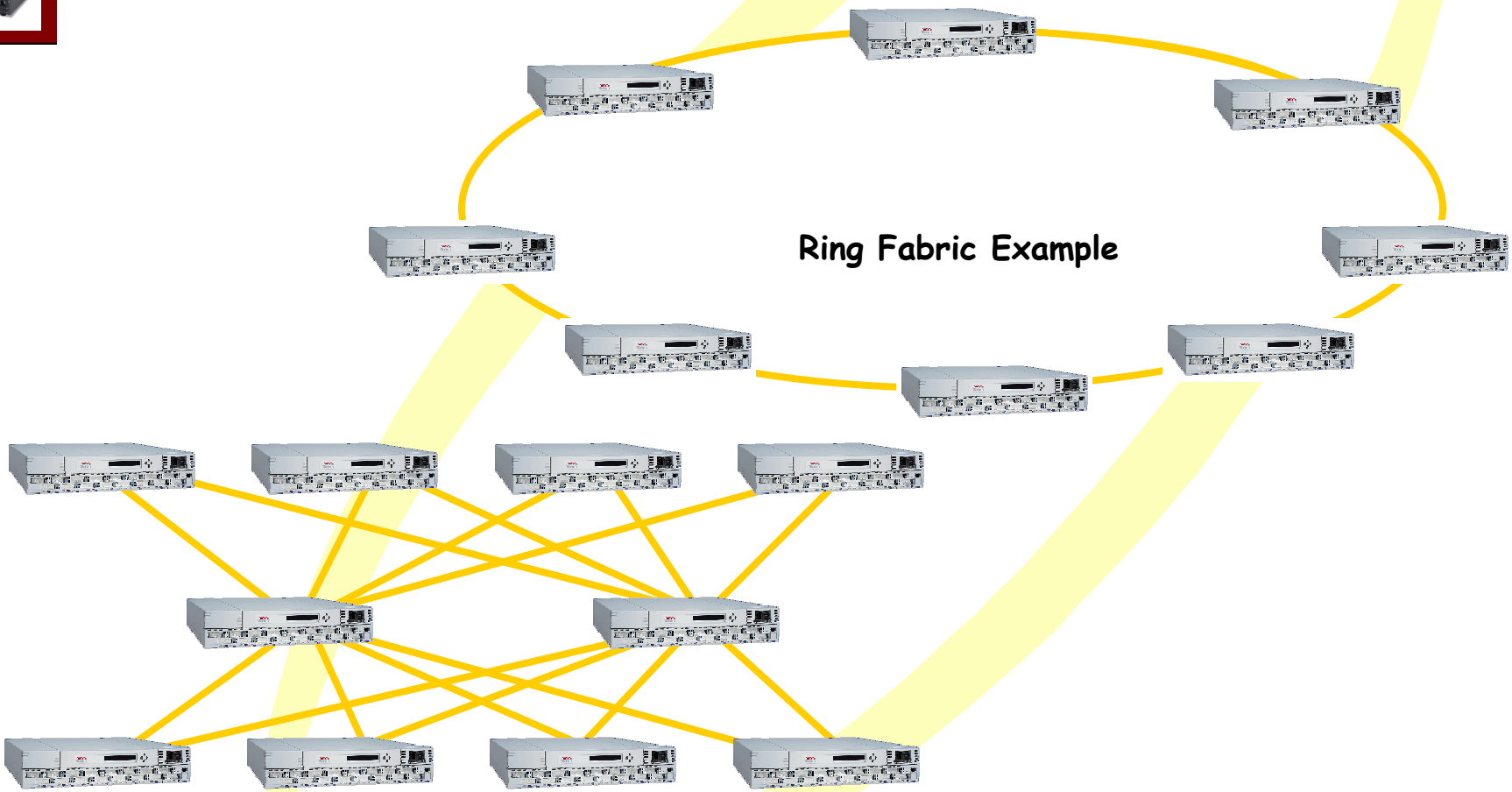


Cascaded Fabric Example



Meshed Fabric Example

SAN Scaling



Ring Fabric Example

Tree Backbone Fabric Example

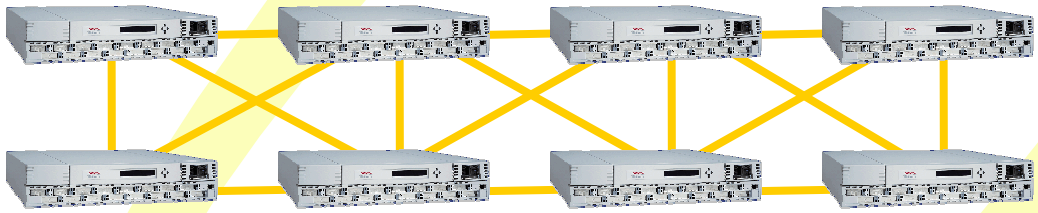
SAN Migration

SAN Topology	Scalability (For All Topologies)	Migration
Cascaded	• Increase the number of switches • Use higher port count switches • Deploy multiple fabrics • Transition to a different topology	Convert to Meshed, Ring or Tree
Meshed		Convert to Ring or Tree
Ring[1]		Convert to Meshed or Tree
Tree		Add additional backbone switches

1 The Ring fabric can be scaled by adding switches to the ring (up to 14) or by adding switches outside the ring (maximum of 20 in the fabric).

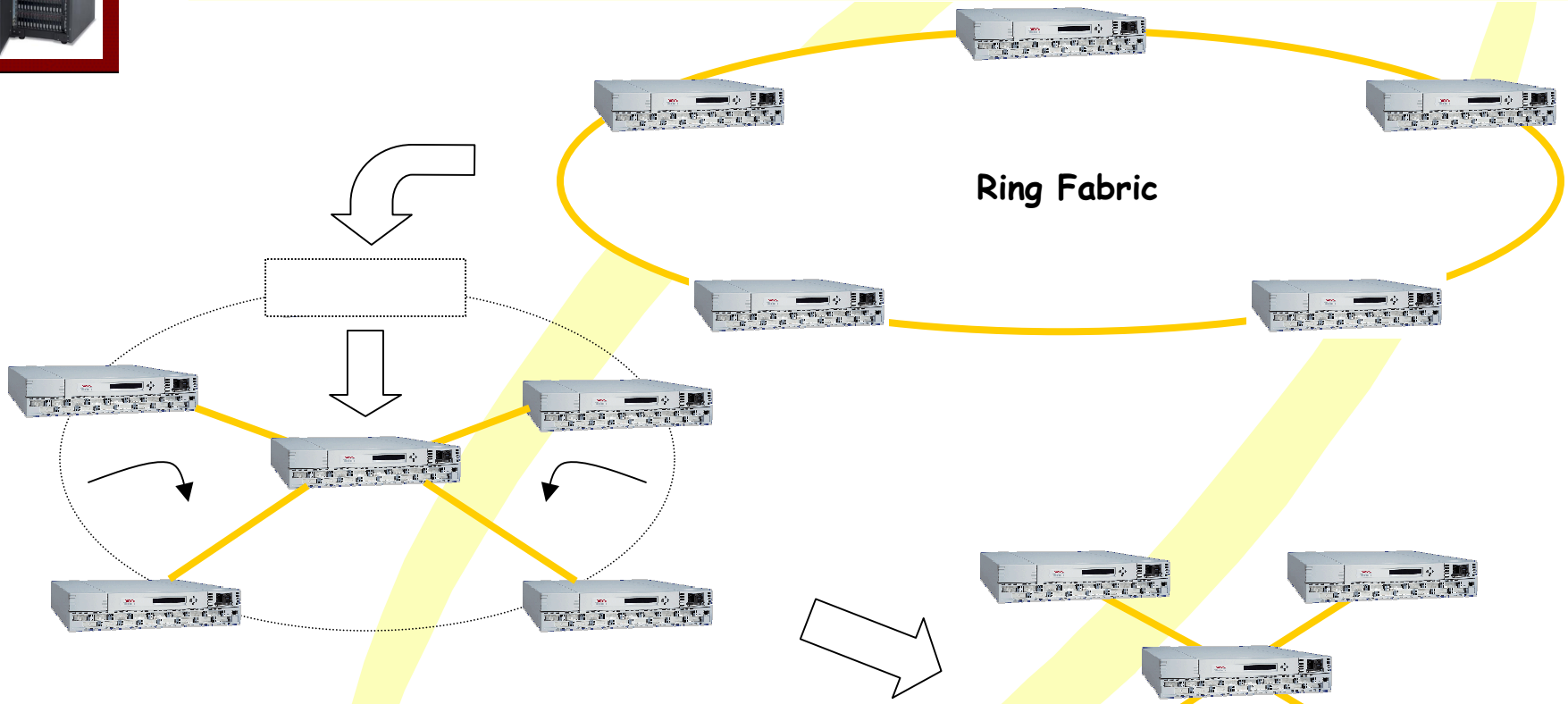
- Migration
  - Refer to Chapter 10 OpenSAN Design Guide, Best Practices
  - Provides an overview of the migration process available for each topology
  - Some migrations are easy…some are very difficult

SAN Migration



Meshed Fabric Example

SAN Migration



HP StorageWorks SAN Design Reference Guide

SAN Design Guide:

1. Understanding SAN
2. SAN Topologies
3. SAN Fabric Design Rules
4. Heterogeneous SAN Platform and Storage System Rules
5. Enterprise Backup Solution
6. SAN Management
7. Network Attached Storage
8. SAN Extension
9. SAN Security
10. Continuous Access Storage Appliance

* http://h18006.www1.hp.com/storage/saninfrastructure.html