Storage for Networking Professionals

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Agenda

• Overview of Storage Approaches
  • Traditional
  • Emerging

• Storage Basics and Terms

• Fibre Channel SAN Architectures

• Cisco’s Family of Storage Products
The World of Storage

• Cisco is in the Storage Business
• Leverage Experience in Switching
• Data is Data Regardless of the Transport
• Four Fundamental Approaches to Storage

• Traditional
  • Direct Attached Storage
  • Network Attached Storage
  • Storage Area Networks

• Emerging
  • IP Storage Area Networks
Storage Basics and Terms
I/O Channel

Simply stated, it is the technology which resides between a computer and the device used to store its data.

This relationship can exist either internal to the computer casing or can extend to external storage devices.

Storage device is only accessible by attached host computer.

Examples are SCSI, Fibre Channel, ESCON.
Small Computer System Interface (SCSI)

Parallel interface I/O technology
Maximum cable run length is 25 meters
Speeds up to 320 MB/sec (Ultra-320 on 16 bit wide bus)
Maximum of 16 (I/O controller + devices) SCSI devices per bus
Several standards: SCSI-1, SCSI-2, and SCSI-3(Ultra-2&3)
Scalability and distance limitations rule out support of large scale storage systems requiring disaster recovery
What Is Fibre Channel?

Initial effort started in 1988
Developed by ANSI
Combines the benefits of both channel and network technologies
SCSI and IP are the only upper layer protocols commercially available on Fibre Channel
Benefits of mapping SCSI onto Fibre Channel include:
  • Faster speed
  • Ability to connect more devices together
  • Greater distances allowed between devices
Runs on copper (coax) or glass (fiber optic) cable
Fibre Channel Offers...

- Multiple protocol support (today - mainly IP and SCSI)
- Networking capability and functionality
- Heterogeneous interconnect
- Speed: 1 and 2 Gbps. 10 Gbps in near future
- Boasts: bandwidth, availability, reliability, integrity, and scalability
Fibre Channel - Port Types

‘N’ port: Node ports used for connecting peripheral storage devices to switch fabric or for point to point configurations

‘F’ port: Fabric ports reside on switches and allow connection of storage peripherals (‘N’ port devices)

‘L’ port: Loop ports are used in arbitrated loop configurations to build storage peripheral networks without FC switches. These ports often also have ‘N’ port capabilities and are called ‘NL’ ports.

‘E’ port: Expansion ports are essentially trunk ports used to connect two Fibre Channel switches

‘G’ port: A generic port capable of operating as either an ‘E’ or ‘F’ port. If also capable of acting in an ‘L’ port capacity - known as a ‘GL’ port.
Fibre Channel Topologies

Point To Point

Arbitrated Loop

Switched Fabric
Switched Fabric

- Max nodes = 16 million (24 bits)
- Max bandwidth = 200 MB/sec
- Nodes (N ports) connect to fabric (F ports)
- End to end connection managed by N ports
- Routing and addressing handled by fabric
- E port provides trunk connectivity to another Fibre Channel switch.
I/O Channels

I/O Channel (SCSI)

- Few devices
- Static
  - Low latency
- Short distances
  - Hardware-based delivery management
Data Networks

I/O Channel (SCSI)
- Few devices
- Static
- Low latency
- Short distances
- Hardware-based delivery management

Network (Ethernet)
- Many devices
- Dynamic
- High latency
- Long distances
- Software-based delivery management
Fibre Channel: The Best of Both Worlds

I/O Channel
- Few devices
- Static
- Low latency
- Short distances
- Hardware-based delivery management

Fibre Channel
- Many devices
- Dynamic
- Low latency
- Long distances
- Hardware-based delivery management

Network
- Many devices
- Dynamic
- High latency
- Long distances
- Software-based delivery management
Fibre Channel Summary

- Nodes are "transparent" devices
- Ports are intelligent interface points
- Standard port types:
  - N_Port
  - F_Port
  - E_Port
  - NL_Port
  - FL_Port
  - B_Port
- Cisco port types:
  - TL_Port
  - SD_Port
  - TE_Port
  - Fx_Port
- Automatic port configuration: U_Prot/G_Prot
Just a Bunch Of Disks (JBOD)

- Drives are independently attached to I/O channel
- Scalable, but requires servers to manage multiple volumes
- No protection in the event of drive failure
- Drives share common power supplies and physical chassis
Redundant Array of Inexpensive Disks (RAID)

Fault-tolerant grouping of disks that server views as a single disk volume.

Combination of striping, mirroring, and parity checking

Self Contained, manageable unit of storage

Management: One file system across entire virtual disk

RAID delivers Capacity, performance, reliability, and availability benefits.
RAI RAID Levels

RAID levels 0 through 6 were defined in the original University of California Berkeley RAID project. RAID 2, 4, and 6 are rarely seen in commercial products. RAID 0 is merely disk striping, which has some performance advantages but stores no parity information and thus does not offer true RAID data protection.

RAID 1 offers complete duplication of data, and this 100 percent data redundancy provides the best protection—but it is much too expensive for most applications. RAID 3 and RAID 5 each use one extra disk to store parity information needed to recreate data in the event of a single disk failure. RAID 3 uses a dedicated parity disk and is typically faster for throughput-oriented applications, such as file transfer and other sequential applications. RAID 5 distributes the parity information across all disks in the array and is typically faster for transaction processing and other random access applications. These results are relevant mostly in arrays that have little or no controller cache memory. In products with significant cache memory (64MB or more) on-board the controller, performance will be higher in all cases due to the distinctly higher abilities of the controller; these products will perform in a vastly superior manner regardless of RAID mode.
What is DAS?

DAS = Direct Attached Storage

DAS solutions provide:

• Low-cost, slow to medium speed storage for use in home computers and small businesses
DAS Architecture

- DAS uses an I/O Channel architecture, which resides between a computer (initiator) and the device (target) used to store its data.
- Storage device is only accessible by attached host computer.
- Block level access to data.
DAS Options

The "typical" storage environment

Server CPU handles I/O requests and:
- User DB inquiries
- User file/print serving
- Data integrity checks
- Comm with other devices

Direct Attached Storage

less expensive more expensive
What is Network Attached Storage?

NAS = Network Attached Storage

NAS devices are network attached “appliances”

NAS is the attachment of storage devices to the Local Area Network (LAN)
Client systems require a protocol to communicate with NAS devices:

- Windows systems use the Common Internet File System (CIFS) protocol
- Unix systems (and others) use the Network File System (NFS)
SAN: What Is It?

“A reliable transport for running the SCSI protocol”
SAN Components

Servers with Host Bus Adapters (HBAs)
Storage systems
  - RAID
  - JBOD
  - Tape
  - Optical
Hubs (managed and unmanaged)
Switches (loop and fabric)
Bridges and channel extenders
SAN management software
SANs: Scalability and Performance

Storage Expansion
• No impact on servers

Server Expansion
• No impact on storage

Load Balancing
• Active parallel paths

Bandwidth on Demand
• Robust topology
SAN and NAS - When To Use What??

**NAS and SAN solutions solve different application storage requirements**

Use SAN for DBMS (OLTP) storage and most application scenarios

Use NAS for file serving and file sharing applications

...Very few storage vendors or products can meet all business needs
IP SAN Storage Overview
SAN Definition

“A SAN is a reliable transport for running the SCSI protocol”.

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IP SANs carry block I/O traffic on top of IP
- Leverage Gigabit Ethernet performance for local traffic
- Use TCP: A reliable transport for delivery in MAN/WANs

Two primary protocols:
- iSCSI—"IP-SCSI" IP-native transport of SCSI CDBs and data within TCP/IP connections
- FCIP—"Fibre-Channel-over-IP"— Tunneling of Fibre Channel frames within TCP/IP connections, including FC fabric management frames
What is an iSCSI Router?

Purpose is to link iSCSI-enabled servers on IP networks with Fibre Channel based storage subsystems

- The iSCSI router *terminates* iSCSI Command Descriptor Blocks (CDBs) and *re-initiates* Fibre Channel FCP CDBs
iSCSI Communication

- iSCSI Server
- Fibre Channel Hub or Switch
- iSCSI Router
- TCP/IP
- Gigabit Ethernet
- Fibre Channel
- SCSI Driver
- SCSI Disk
- SCSI Generic
- SCSI Tape
- iSCSI Driver
- File System
- Host TCP/IP
- Network Drivers
- NIC
- NIC
- HBA
- UNIX or NT Host
iSCSI Host Implementations

- iSCSI device driver
- Legacy NIC
- Legacy software based TCP/IP stack

iSCSI Host Implementation (1)
iSCSI Host Implementations

iSCSI device driver

TCP Offload Engine (TOE)
- Processing implemented in NIC
- CPUs used to be faster than networks, but not anymore
- Fewer interrupts
- Eliminates memory copies

iSCSI Host Implementation (2)
iSCSI and TOE both implemented in NIC
IP Storage Network

- Front-side IP Network
- iSCSI-enabled Hosts
- Clients
- Dedicated IP Network
- Catalyst Switches
- iSCSI Routers
- FC Fabric
- Storage Pool
- FC Attached Hosts with HBAs
What is FCIP (Fibre Channel over IP)?

IT creates one logical fabric between remote SANS, and the switches think they are connected. IP is only used for tunneling through the WAN.
What is FCIP (Fibre Channel over IP)?

- Remote FC resources are viewed as local
- FCIP creates a Virtual FC Inter-Switch Link (ISL)
- Fabric service information is extended across the FCIP ISLs
An FCIP Application Topology

- FCIP Gateways perform Fibre Channel encapsulation process into IP Packets and reverse that process at the other end
- FC Switches connect to the FCIP gateways through an E_Port for SAN fabric extension to remote location
- A tunnel connection is set up through the existing IP network routers and switches across LAN/WAN/MAN
IP Storage Advantages

Numerous services exist within IP to secure IP storage traffic, many of which are not available in Fibre Channel

- IPSec
- VLANs
- Access Control Lists (ACLs)
- Authentication, Authorization and Accounting
- Firewalls
Many services exist within IP to ensure performance in an IP SAN as well as protect IP storage traffic from potential bottlenecks

- QoS
- EtherChannel
- Gigabit Ethernet
- Multi-Protocol Label Switching (MPLS)
IP Storage Disadvantages

- IP Storage is an emerging technology
- Extended distance may affect application performance
- Security needs to be considered
Fibre Channel SAN Architectures
Comparing Fabric Designs

Cascade:
- Very limited inter-switch bandwidth
- No resilience to failures
- Suitable for 2- or 3-switch fabrics where performance and availability are less of a concern than cost

Cascade ring:
- Better performance and availability than cascade design
- Suitable for 3- to 5-switch fabrics with limited scalability, performance, and availability requirements
Comparing Fabric Designs

Mesh:
- Highly available
- Performance varies according to full/partial configuration
- Suitable for 4- to 8-switch fabrics with limited scalability requirements

Core-edge:
- Highly scalable solution for large fabrics
- Strong performance
Collapsed Fabric Design

Director-Class Switch
Collapsed Fabric Design

Collapsed Architecture:

• Lack of ISLs means:
  – All purchased ports are available for nodes
  – Increased reliability
  – Simplified management

• Scales easily (hot-swap blade architecture)
• Fixed latency between ports = highest performance
• Single management interface
• Cost-effective for large SANs when ISL ports and management costs are added up
• Not all “director-class switches” are the same
Building Scalable Fabrics

- To get 176 device ports with 4Gb/s of ISL bandwidth, you need...

Fourteen 16-port switches:
- 24 ISLs (not load-balanced)
- 78% of ports available
- $1000 per port
- $1545 per node port

or

Four 48-port MDS 9216 switches:
- 8 ISLs (load-balanced)
- 92% of ports available
- $1000 per port
- $1181 per node port
Cisco’s Family of Intelligent Storage Network Devices
Cisco SN5428-2 Storage Router

Increased port density and performance
Integrated 8-port Fibre Channel Switch
ISCSI + FCIP
Combined with a Catalyst switch yields cost-effective, small storage network
SAN+LAN connectivity for application hosts and storage

SN5428 Sample Application
Block Access via iSCSI for Front-End Servers

Web Server
Catalyst 3500XL

Database Server

Tape Array
Disk Array

Block Access via FC for Back-End Servers

SN5428 Storage Router
Introducing the
Cisco MDS 9216 Multilayer Fabric Switch

Full-featured fabric switch with expandability

• Base configuration is 16 ports fixed
• Expansion slot allows growth to 48 ports
• 1 / 2 Gbps auto-sensing SFP/LC interfaces
• Compatible with all MDS 9000 Family switching modules
  – 16 and 32-port FC Switching Module
  – 8-port IP Storage Services Module
• Hardware-based services
  – Security services—VSANs, VLANs, ACLs
  – Traffic management—QoS, FCC
  – Enhanced services—PortChannel, load balancing
  – Diagnostics—SPAN, FC Traceroute, FC Ping, Cisco Fabric Analyzer
Introducing the Cisco MDS 9500 Multilayer Director

Redefining director-class storage switching
- Non-blocking fabric—1.44 Tbps
- 1 / 2 Gbps auto-sensing ports—10Gbps ready
- Platform for storage management software
- Hardware-based services
  - Security services—VSANs, VLANs, ACLs
  - Traffic management—QoS, FCC
  - Diagnostics—SPAN, FC Traceroute, Fabric Analyzer
  - Enhanced services—PortChannel, load balancing

Multitransport switch—FC, iSCSI, FCIP
Highly-Scalable MDS 9500 Series Supervisor Module

Integrated crossbar has many benefits

• Investment protection—ability to support new line cards including new transports
• Multiprotocol support in one system
• Highly-scalable system—1.44Tbps

High port density means fewer devices to purchase and manage

• Increase in usable ports due to minimal switch interconnects
• Common equipment amortized over more ports (power supplies, supervisors, chassis)
Cisco MDS 9000 Family
Switching Module Summary

16-Port Fibre Channel
• 16-port 1 / 2-Gbps auto-sensing Fibre Channel (SFP/LC)

32-Port Fibre Channel
• 32-port 1 / 2-Gbps auto-sensing Fibre Channel (SFP/LC)

8-Port IP Storage Services
• 8-port 1-Gbps Ethernet with iSCSI and FCIP Gateway functionality (SFP/LC)
16 and 32-Port
Fibre Channel Switching Module Features

Interfaces

• 16 or 32-port 1 / 2 Gbps auto-sensing Fibre Channel (E, F, FL, SD, TE, and TL ports) with SFP/LC optical interfaces

Security Features

• Hardware ACL-based Port Security, Virtual SANs (VSANs), Port Zoning and LUN Zoning

Performance Features

• Up to 80 Gbps fabric bandwidth available per line card
• Up to 255 Buffer Credits per Port
• PortChannel, Multi-Path Load Balancing
• Forward Congestion Control (FCC)
• Quality of Service
MDS 9000 Family
IP Storage Services Module Features

Interfaces
• 8-port 1 Gbps Ethernet with SFP/LC optical interfaces

iSCSI Feature Highlights
• iSCSI Initiator-Fibre Channel Target
• Transparent view of all allowed hosts/targets
• iSCSI to Fibre Channel zone mapping

FCIP
• Up to 3 FCIP tunnels per port on all ports (24 tunnels per line card)

Fibre Channel Features
• All standard Fibre Channel line card features (interfaces N/A)
• Leverages Fibre Channel interfaces on other switch modules

Multiprotocol Flexibility
• iSCSI and FCIP on each port concurrently – software configurable
• Investment protection – seamless migration to new technologies
Cisco Fabric Manager

Simplifies Management of Multiple Switches and Fabrics

Switch-embedded Java-based Application

Discovery and Topology Mapping

Multiple Views
  • Fabric View
  • Summary View
  • Physical View

Configuration

Monitoring and Alerts

Network Diagnostics

Security
  • SNMPv3
  • SSH
  • RBAC

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Integration with CiscoWorks

Resource Manager Essentials (RME)

Software image and configuration management
- Scheduled downloads with rollback
- Configuration file editing and difference checking

Archive switch software images and configuration files

Provide change auditing and syslog analysis

Integrates with CCO to simplify support
Empowering the Internet Generation