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G20 - SAN Basics for Mainframers

<http://www.ibm.com/storage>

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Alert, Alert, Alert!

- This presentation mainly covers that other stuff besides mainframes - yeah, you know - AIX, Windows, Solaris, Linux on RISC and z/900 and Intel, etc ...
- The industry is trying to take what we learned from mainframes and apply it to the non-mainframe systems under the name of Storage Area Network (SAN)
- z/OS is already a very good homogeneous, multivendor SAN
- This session will show how non-mainframe SANs are rolling out, using MVS terminology as a "Rosetta Stone" for translation purposes

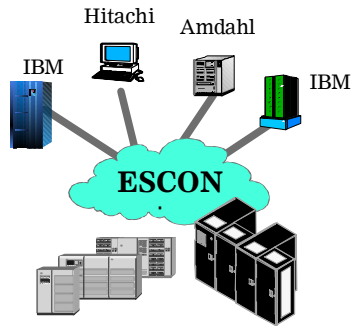
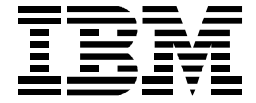
Storage Management Challenge

- Costs of Storage Management
 - Distributed UNIX/NT costs 1 Person per 250 GB
 - Centralized UNIX/NT costs 1 Person per 500 GB
 - IDC 1999
 - A Well Managed SAN in 2004 costs 1 Person per Terabyte
 - z/OS w/Automated Storage Policies costs 1 Person per 3 to 17 Terabytes
 - Customer quotes

Data Size!

- ◆ Gigabytes (10^9) (Billion) of disk storage - small customers
- ◆ Terabytes (10^{12}) (Trillion) of disk storage - most customers and many individuals
- ◆ Petabytes (10^{15}) (Quadrillion) of disk storage - a few customers today!
- ◆ Petabytes (10^{15}) (Quadrillion) of tape storage - large customers
- ◆ Exabytes (10^{18}) (Quintillion) of tape storage - a few accounts by 2004
- ◆ Zettabytes (10^{21}) (Sextillion) WW digital data by 2004 - IDC
- ◆ Yottabytes (10^{24}) (Septillion) - How Long will it take?

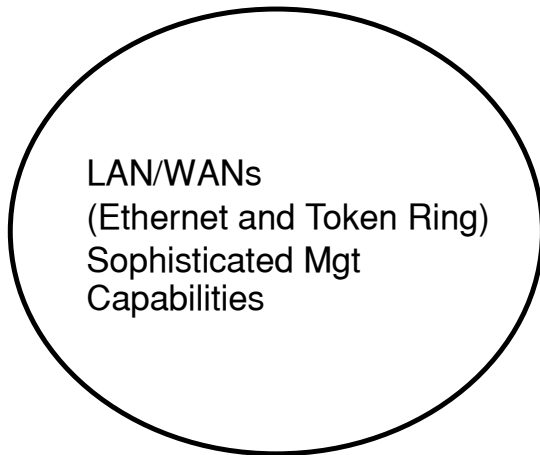
IBM SAN Evolution



Mature technology
with Automated Policy
Mgt and Device/Data
Sharing Technology



Heterogeneous Server and
Storage SANs being built
with technology from
S/390s and LANs/WANs



- IBM
- Experience
 - Road map

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Storage Area Network (SAN)

- ◆ **SAN - Centrally managed** high speed networks of **multivendor** storage subsystems, applications servers, clients and networking hardware that allow companies to exploit the **value of their business information via universal access and sharing of resources.**

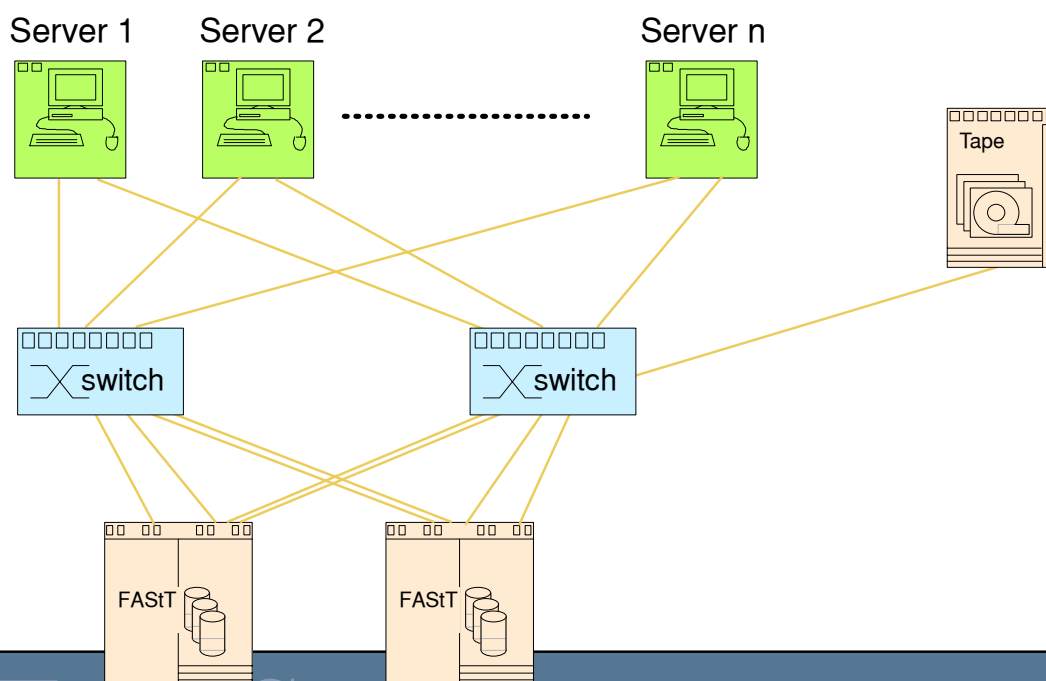


Information used to belong to the server....
 NOW it belongs to the Enterprise !

- ◆ **SAN** - A network whose primary purpose is the transfer of data between computer systems and storage elements and among storage elements. A SAN consists of a communications structure, which provides physical connections, and a management layer, which organizes the connections, storage elements and computer systems so that data transfer is secure and robust. (**SNIA**)

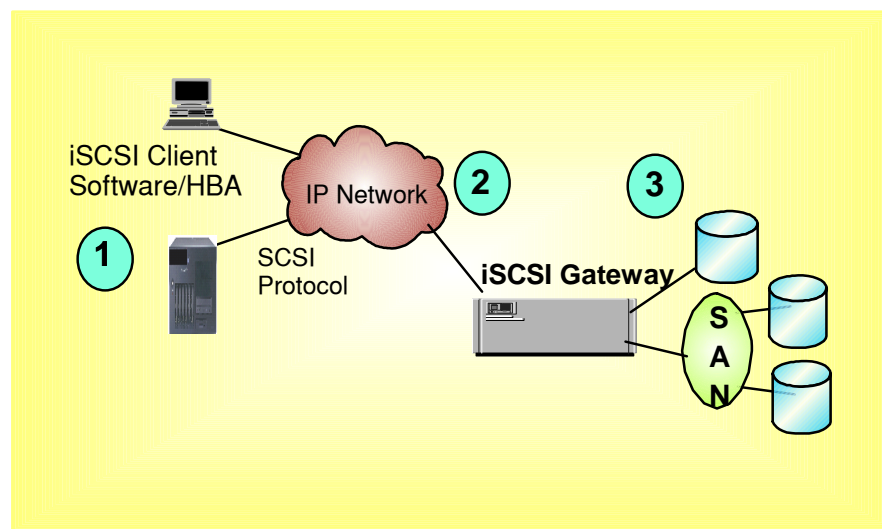
SAN - A Technical Definition

- A Storage Area Network is a highspeed dedicated network (usually Fibre Channel based) that offloads the backup/archive/restore/retrieve data I/O stream off the LAN.
- The SAN de-couples the ownership of the storage control unit from the attached servers in order to provide "storage pooling" allowing a higher utilization of the storage. It does not break the relationship of the file systems from the operating systems without special software.
- Because no one server is in control of the "pooled storage", the SAN needs to provide a "traffic cop" function between the servers when they access the pool of storage. The functions the SAN provides are called Zoning (path blocking) and LUN masking (LUN assignment). These mechanisms work in conjunction with each other to provide orderly access to data.



What is iSCSI?

- iSCSI - internet SCSI - is a complementary technology that allows remote ethernet attached servers to access SAN storage
- The iSCSI protocol provides for the most efficient "packing" of storage data into TCP/IP packets
- Cisco, Nishan and several other companies offer an iSCSI gateway functionality that will provide the physical and logical connection between the ethernet attached servers and the fibre channel storage



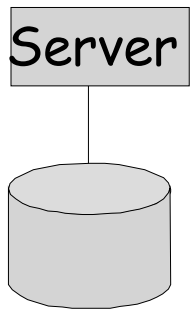
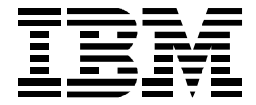
What Does A SAN Enable?

- Any-server to any-storage connectivity
- Resource sharing
 - Entire device (e.g. tape pool sharing)
 - Physical partitioning (e.g. library)
 - Logical partitioning (e.g. file systems)
 - File Sharing (e.g. Tivoli SANergy)
- Server-free data transfer
- LAN-free backups
- Outboard storage management
- Decoupled processor/storage growth
- Single Point of Control for Management

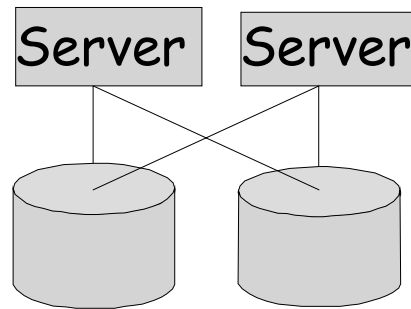
z/OS ESCON/FICON SAN

- z/OS is the most advanced SAN in the industry:
 - The "Switch" is the ESCON or FICON Director
 - Device Sharing (including the equivalents of "Zoning" and "LUN Masking") was built into the operating system during the 70's and 80's (DASD Sharing)
 - Storage Pooling came along with System-Managed Storage in the late 80's and early 90's - also supports multivendor storage devices
 - Generalized Data Sharing and additional Device Sharing came into being with the Parallel Sysplex during the mid 90's
 - z/OS SAN provides workload balancing, priority queuing and the industry leading continuous availability and data integrity
 - z/OS SAN (FICON) will be able to share fabric resources with other SANS - FICON/FCP Intermix
 - z/OS SAN - FICON Cascading now supported

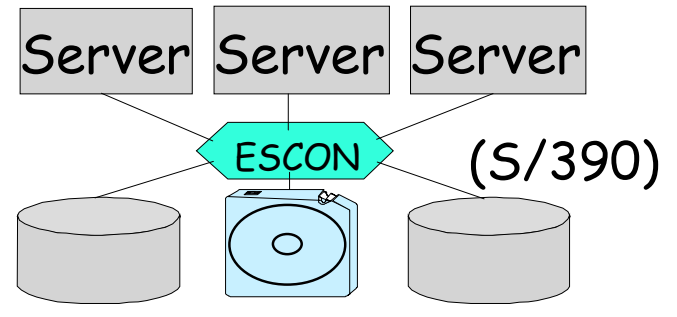
SAN Evolution



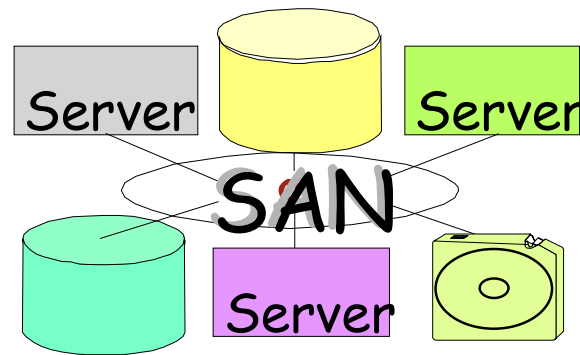
1956



1980



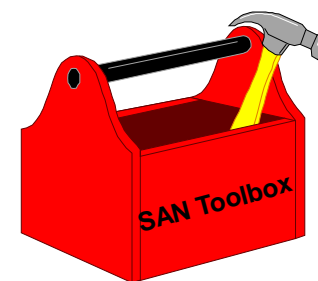
1990



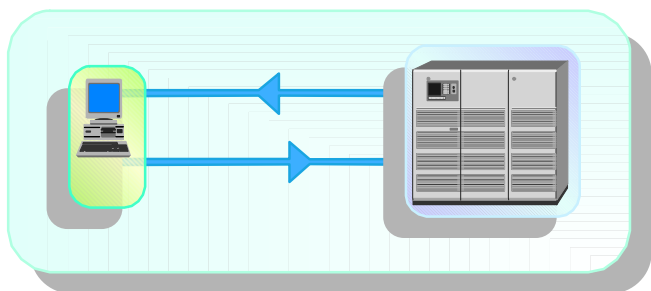
2003

SAN Solution Building Blocks

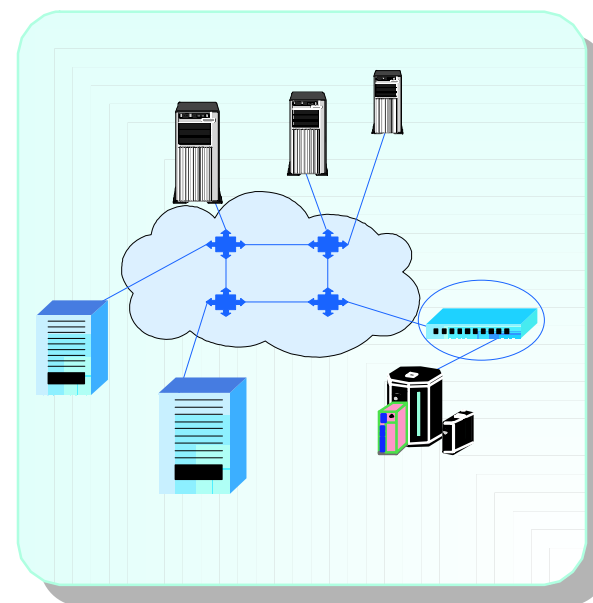
- **Servers**
 - UNIX, Windows, Novell, LINUX, z/OS
- **SAN Fabric Components**
 - Switches/Directors, Hubs, Gateways/Routers
- **Storage Virtualization Engines**
 - Symmetric and Asymmetric Block Virtualization/LUN Mgt
- **Storage**
 - Disk Control Units, Tape Drives, Tape Libraries
- **Software**
 - SAN Management, SAN Exploitation
- **Services**
 - Planning, Testing and Implementation, Education



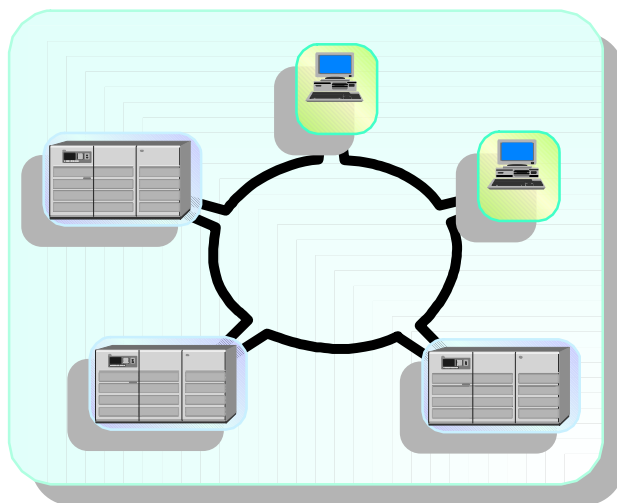
SAN Topologies



FC Point to Point

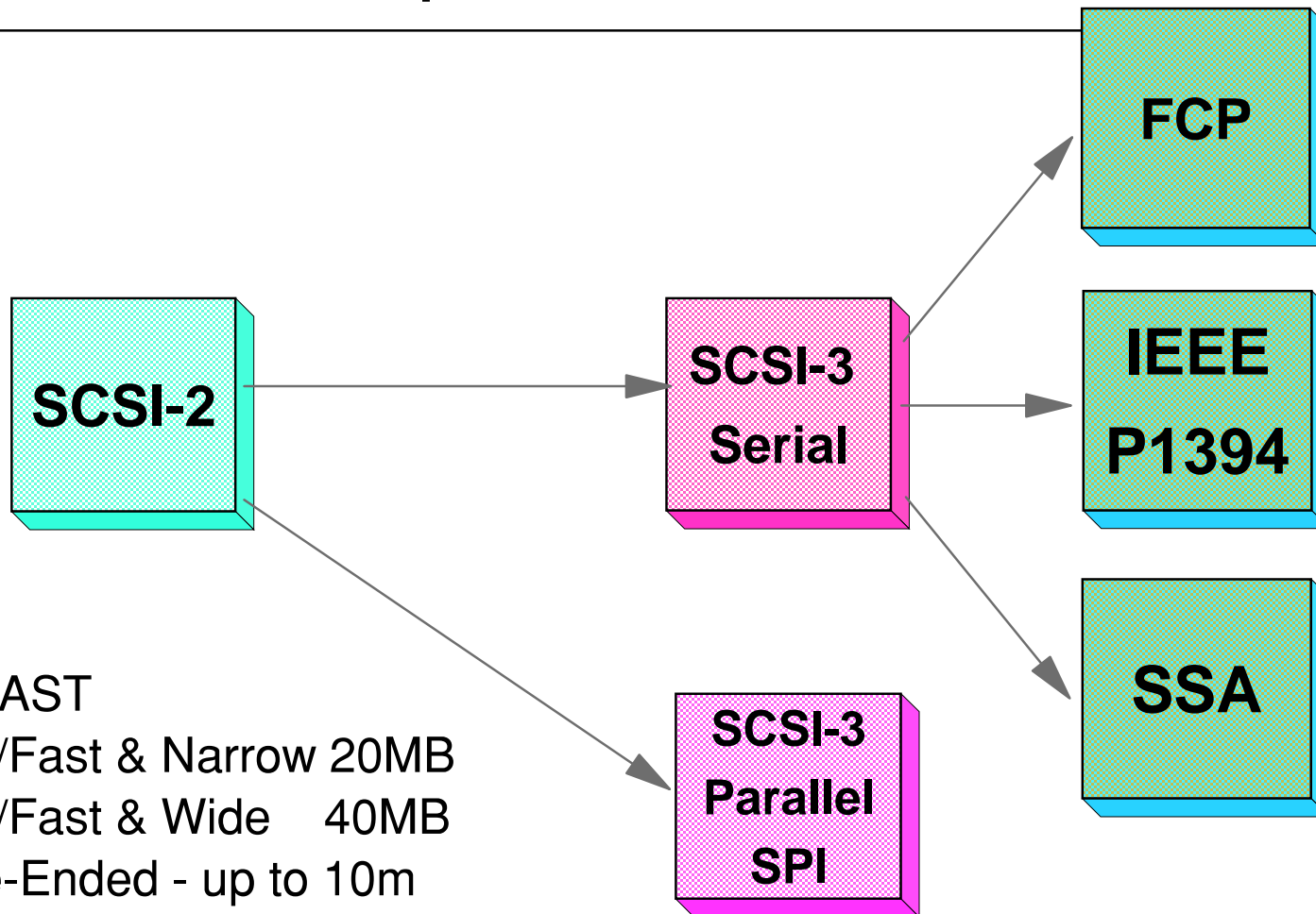


Switched Fabric



FC Arbitrated Loop

SCSI Roadmap



SCSI-FAST
SCSI-II/Fast & Narrow 20MB
SCSI-II/Fast & Wide 40MB
- Single-Ended - up to 10m
- Differential - up to 25m

Ultra2SCSI 80MB
Ultra3SCSI 160MB
Ultra4SCSI 320MB

FCP Topologies Characteristics

■ Point to Point

- Direct connection
- Full Duplex supported
- Up to 10 km distance

■ Arbitrated Loop

- Shared loop
 - up to 126 devices
- Cabling with hubs
- Scalable, resource sharing
- Hot plugging reconfiguration
- 100MB/s total bandwidth
- Latency affected by loop size
- Up to 10 km distance

■ Switched Fabric

- Higher Bandwidth
 - 100 MB/s per switched node
- Very large addressability
 - 16M nodes in domain
- High availability with redundant paths
- High performance
- Latency affected by path and workload
- Up to 10 km distance
- Scalable, flexible reconfiguration
- Loops attachable to fabric
- Fabric management required for optimal performance

The Fibre Channel Architecture



■ Fibre Channel Architecture

- An integrated set of rules (FC-0 thru FC-4) for serial data transfer between computers, devices and peripherals developed by INCITS (ANSI)

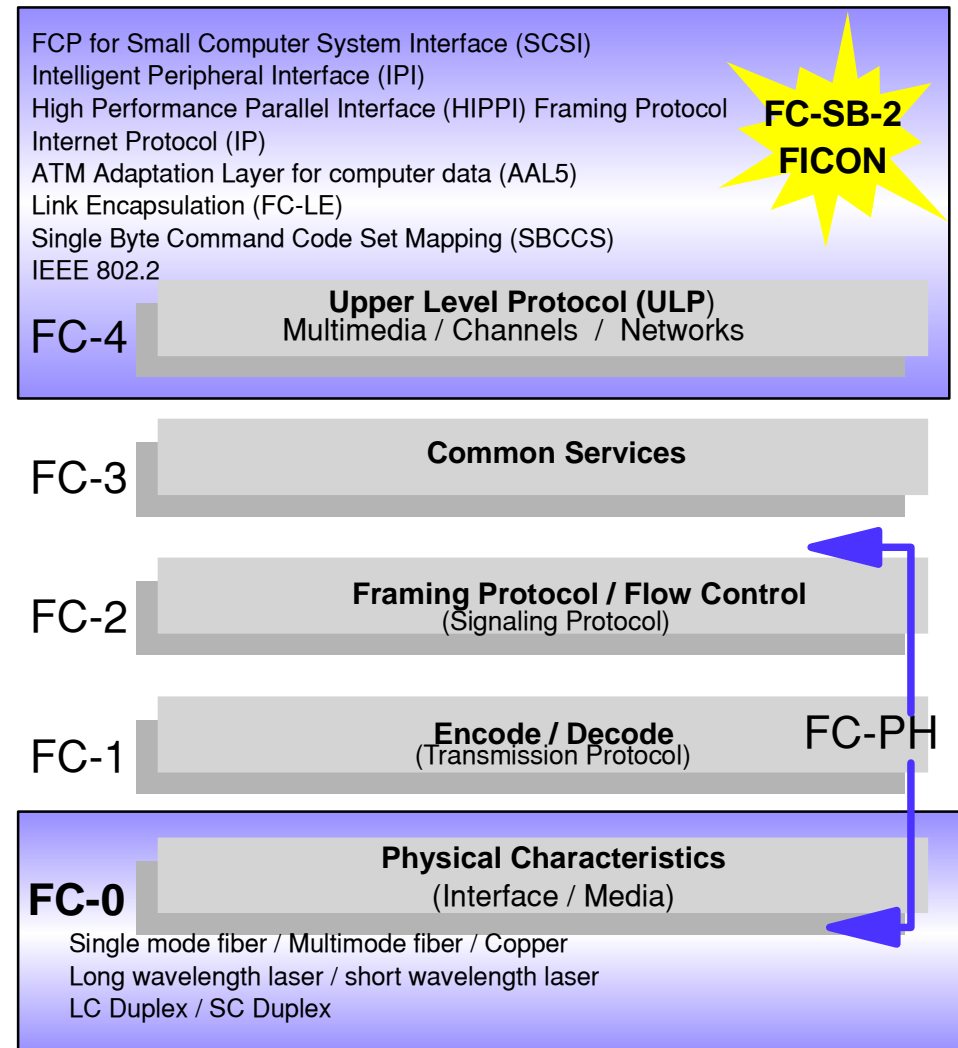
See also www.t11.org

■ FICON

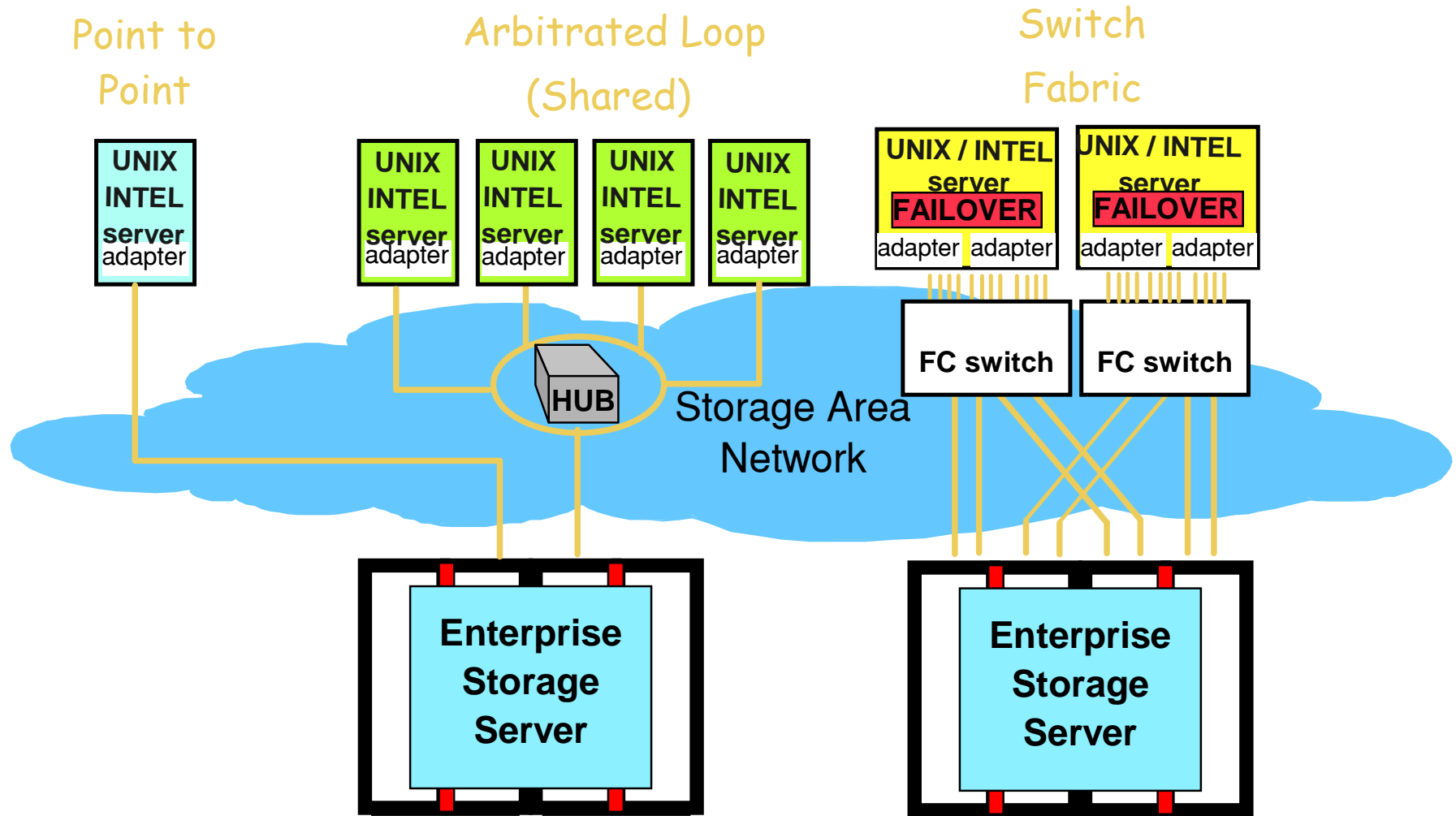
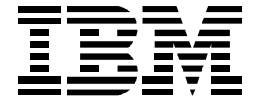
- IBM [^]™ zSeries™ implementation of Fibre Channel Architecture
- An industry standard under the name FC-SB-2

■ FCP

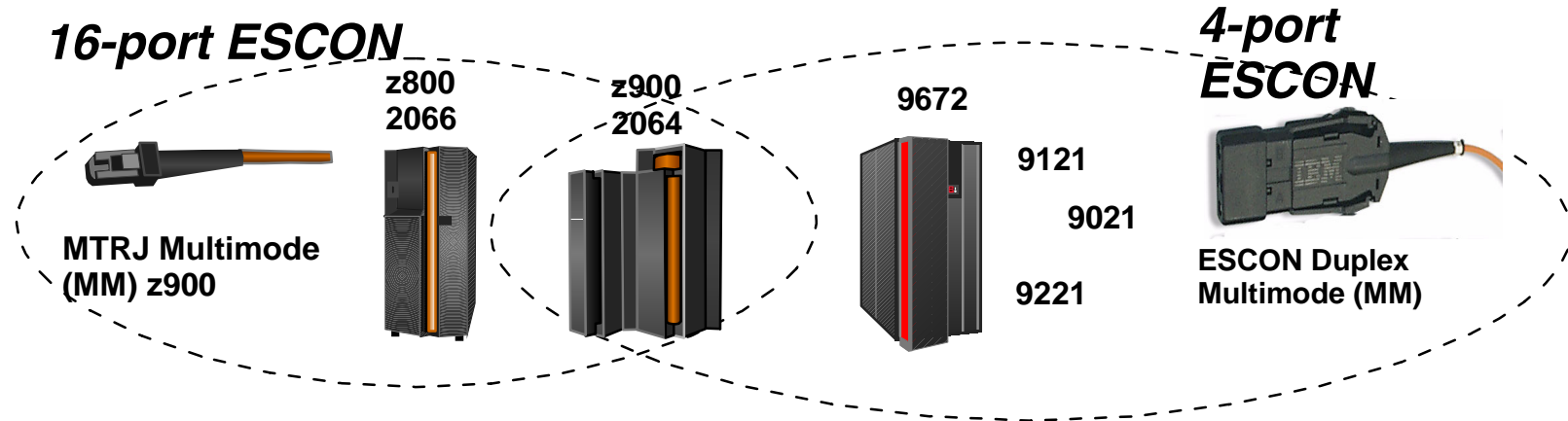
- Fibre Channel Protocol for SCSI
- Mapping of the SCSI command protocol onto the Fibre Channel Architecture



FCP Topologies



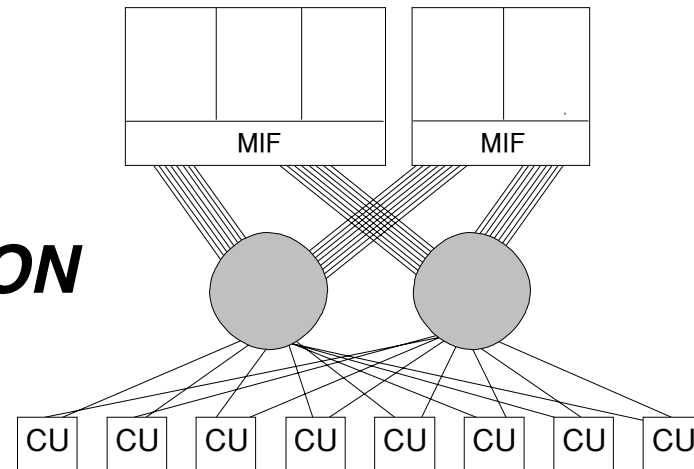
IBM Enterprise Systems CONnection = ESCON



■ ESCON using fiber optics

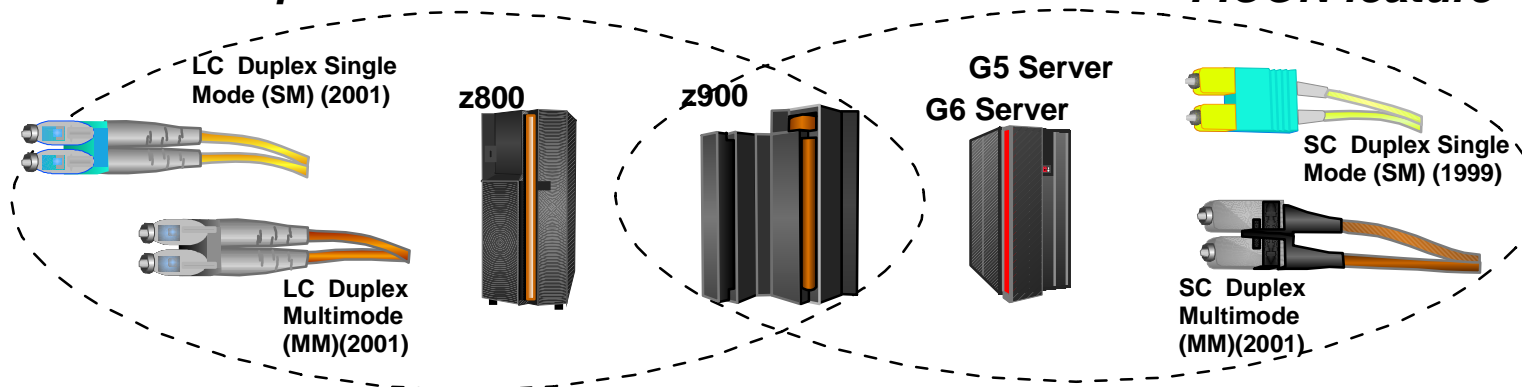
- Light weight
- Long distance
- Nondisruptive changes
- Up to 120 CUs
- Up to 1 K devices
(512 devices for CTC)

ESCON



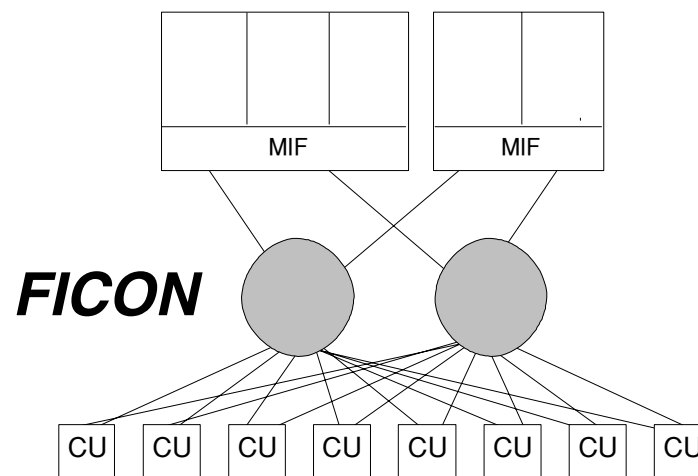
IBM Fibre CONnection = FICON

FICON Express Feature



■ FICON and FICON Express

- Greater bandwidth
- Configuration flexibility
- Longer extended distance
- Up to 256 CUs
- Up to 16 K devices
(240 devices for FCP)



Why Use Native FICON Channels?

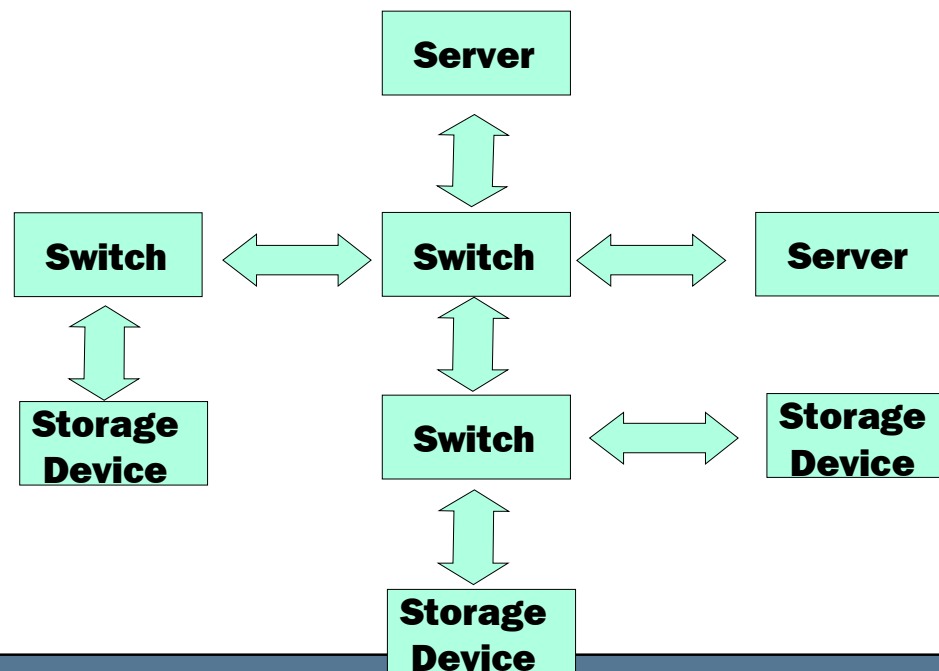
- FICON is more than just an I/O card or a channel type
 - FICON is at the heart of some very important solutions
- Performance
 - Faster backup/ recovery times, shorter batch windows, faster data access for large data queries
 - See the FICON and FICON Express Channel Performance white paper (February 2002) located at ibm.com/servers/eserver/zseries/connectivity/
- Distance
 - Extended distance and remote vaulting (up to 100 km)
 - Reduced data rate performance droop at extended distances
- Channel consolidation
 - Fewer channels, CHPIDs, ports, fiber optic cabling
- FICON support of Cascaded Directors
 - Integrity features integral to FICON architecture
 - 2 Gbps Inter Switch Link capability



Multiple - Cascading Switches

■ Cascading Switches

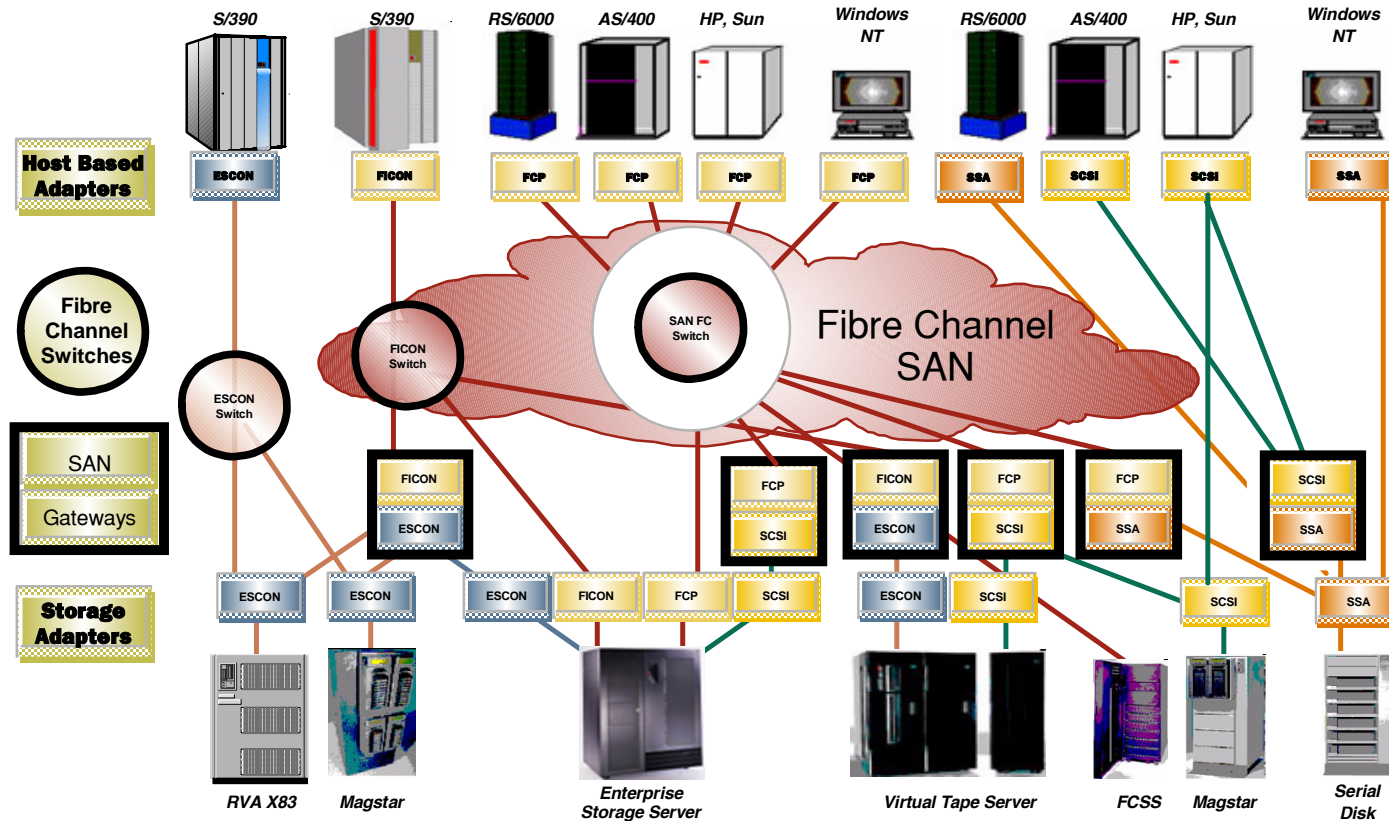
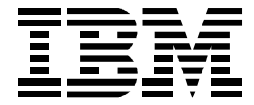
- Currently like switches only
- Communicate Fabric Topology to Each Other
- Switch manufacturers
 - working on standards for better interoperability (OSFI)



Types of Fibre Channel Ports

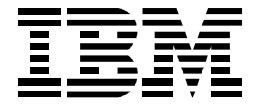
- E_Port - Expansion Port - a port on a switch used to link multiple switches together into a Fibre Channel Switch Fabric; May also be used to bridge a SAN into a ATM Frame Relay Wide Area Network (WAN)
- F_Node - a Fabric Attached Node; e.g. a server or a storage control unit
- F_Port - Fabric Port - a port used to attach a Node Port (N_Port) to a switch fabric (switch side of F_Node)
- FL_Port - The access point of the fabric for physically connecting the user's Node Loop port (NL_Port); e.g. FCAL FCSS
- G_Port - Generic Port - a generic switch port that functions as either a E_Port or F_Port.
- L_Port - Loop Port - a node or fabric port capable of performing FCAL functions and protocols. NL_Ports (node side) and FL_Ports (switch side) are loop capable ports.
- N_Port - Host attachment side of a fabric port (F_Port) attached to a switch
- NL_Port - Node Loop Port - a node port that supports FC-AL devices e.g. FC-AL port on a Storage Control Unit
- Private NL_Port - An NL_Port which does not attempt login with the fabric and only communicates with other NL_Ports on the same loop (e.g. HP uses this technology)
- Public NL_Port - An NL_Port that attempts login with the fabric and can observe the rules of either public or private loop behavior. A Public_NL Port may communicate with both both private and public NL ports (Dell Servers use this technology; Dell Storage uses private loops)
- U_Port - Universal Port - allows the attachment/function of any other industry standard port technology

Storage Area Network "Fabric"



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IBM TotalStorage SAN Switch (Brocade) Family Positioning



currently available 3Q 2004

Entry
Switches
& Hubs

SAN Switch H08
(2005-F08)
8 ports, 2 Gb

www.ibm.com/storage/fcswitch

Midrange
Switches

SAN Switch F32
(2109-F32)
32 ports, 2 Gb
www.ibm.com/storage/fcswitch

SAN Switch H16
(2005-H16)
16 ports, 2 Gb
www.ibm.com/storage/fcswitch

Enterprise
Core Fabric
Switch

SAN Switch M12
(2109-M12)
2 x 64 ports, 2 Gb
www.ibm.com/storage/fcswitch

SAN Switch M14
(2109-M12)
2 x 64 ports, 2 Gb
www.ibm.com/storage/fcswitch

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McDATA FICON/FCP Director and Fabric Switch Family Positioning



currently available - 3Q 2004

Entry
Switches
& Hubs

McDATA Sphereon 4500
(2031-224)
8/16/24 ports, 2 Gbps
www.ibm.com/storage/mcdata

McDATA 4300
(2031-232)
4/8/12 ports, 2 Gb
www.ibm.com/storage/mcdata

Midrange
Switches

McDATA Sphereon 3232
(2031-232)
32 ports, 2 Gb
www.ibm.com/storage/mcdata

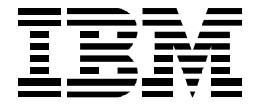
Enterprise
Core Switch
& Directors

McDATA Intrepid 6140
(2032-014)
140 ports, 2 Gb
www.ibm.com/storage/mcdata

McDATA Intrepid
(2032-064)
64 ports, 2 Gb
www.ibm.com/storage/mcdata

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INRANGE FICON/FCP Director Family Positioning

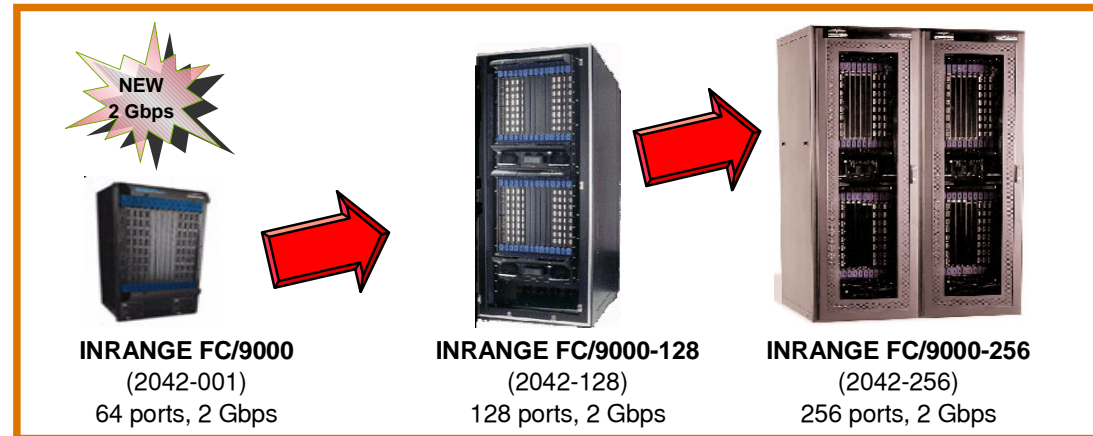


Entry
Switches
& Hubs

Midrange
Switches

Enterprise
Core Switch
& Directors

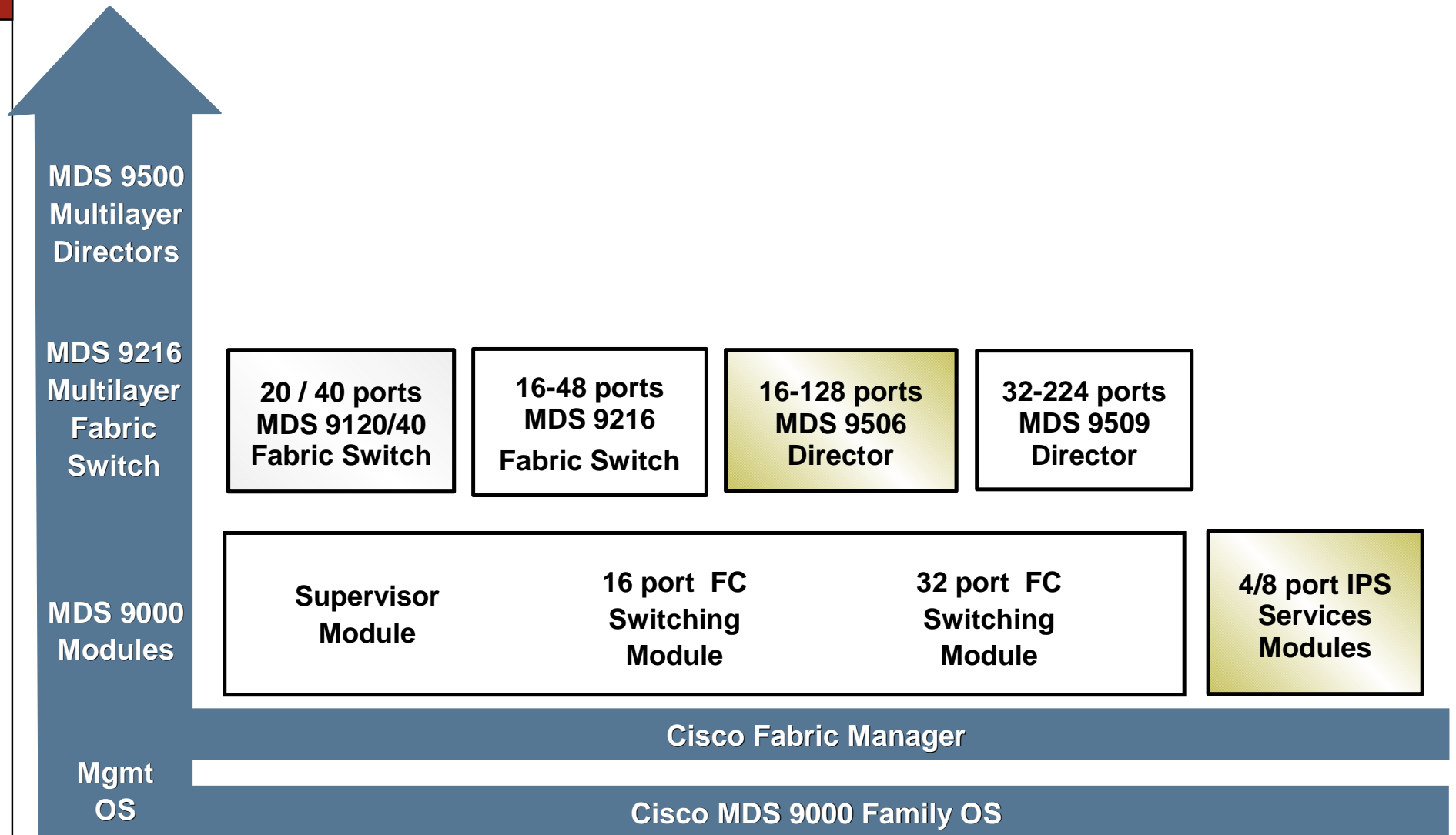
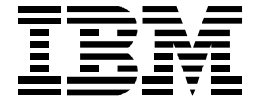
www.ibm.com/storage/inrange



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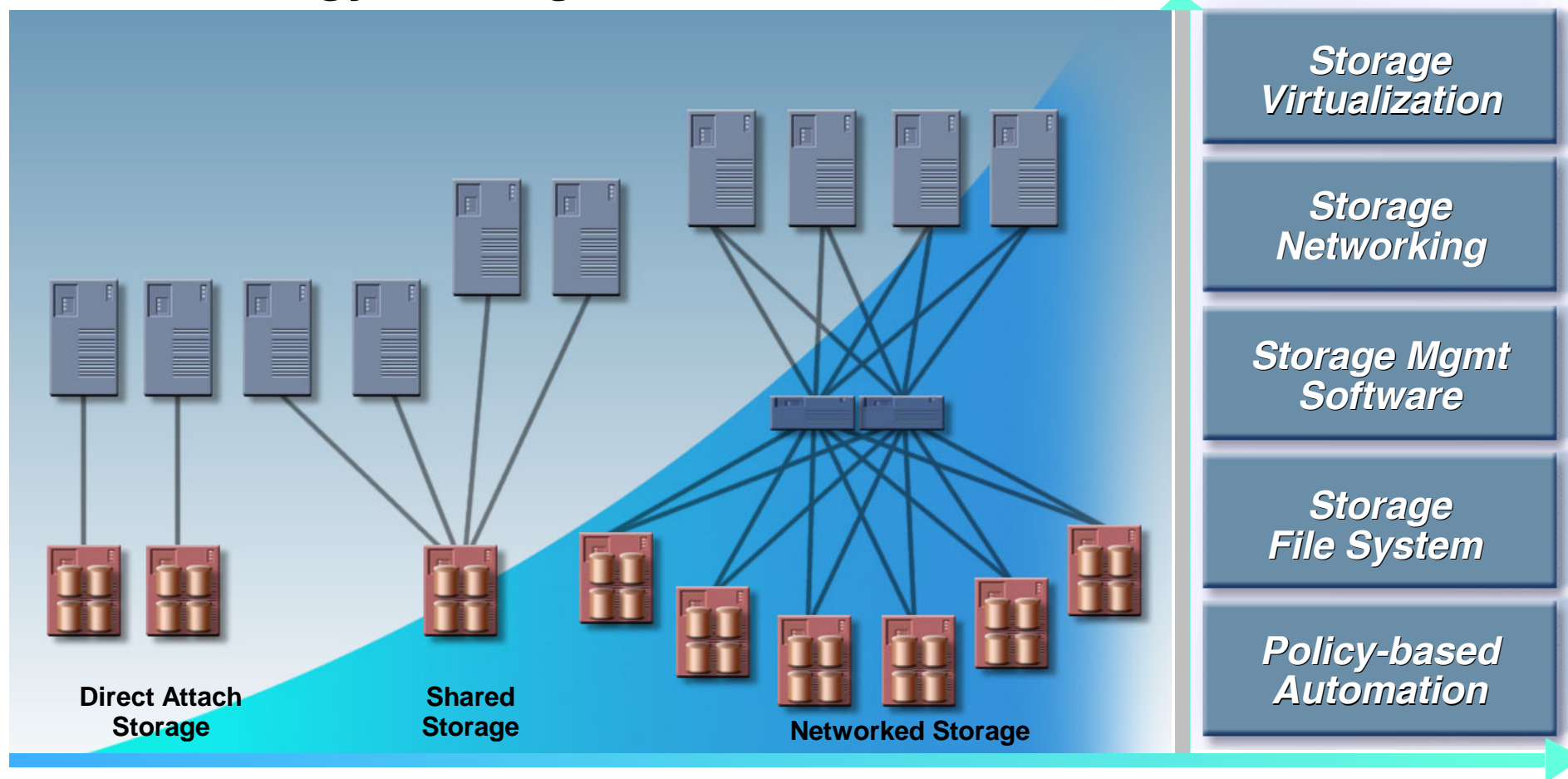
Cisco MDS 9000 Family



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Storage Evolution

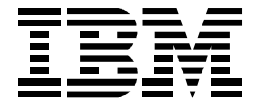
Technology Shifting Towards the Network and Software



Value in Network-based Storage Infrastructure Software

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Storage Virtualization Engines (SVE)

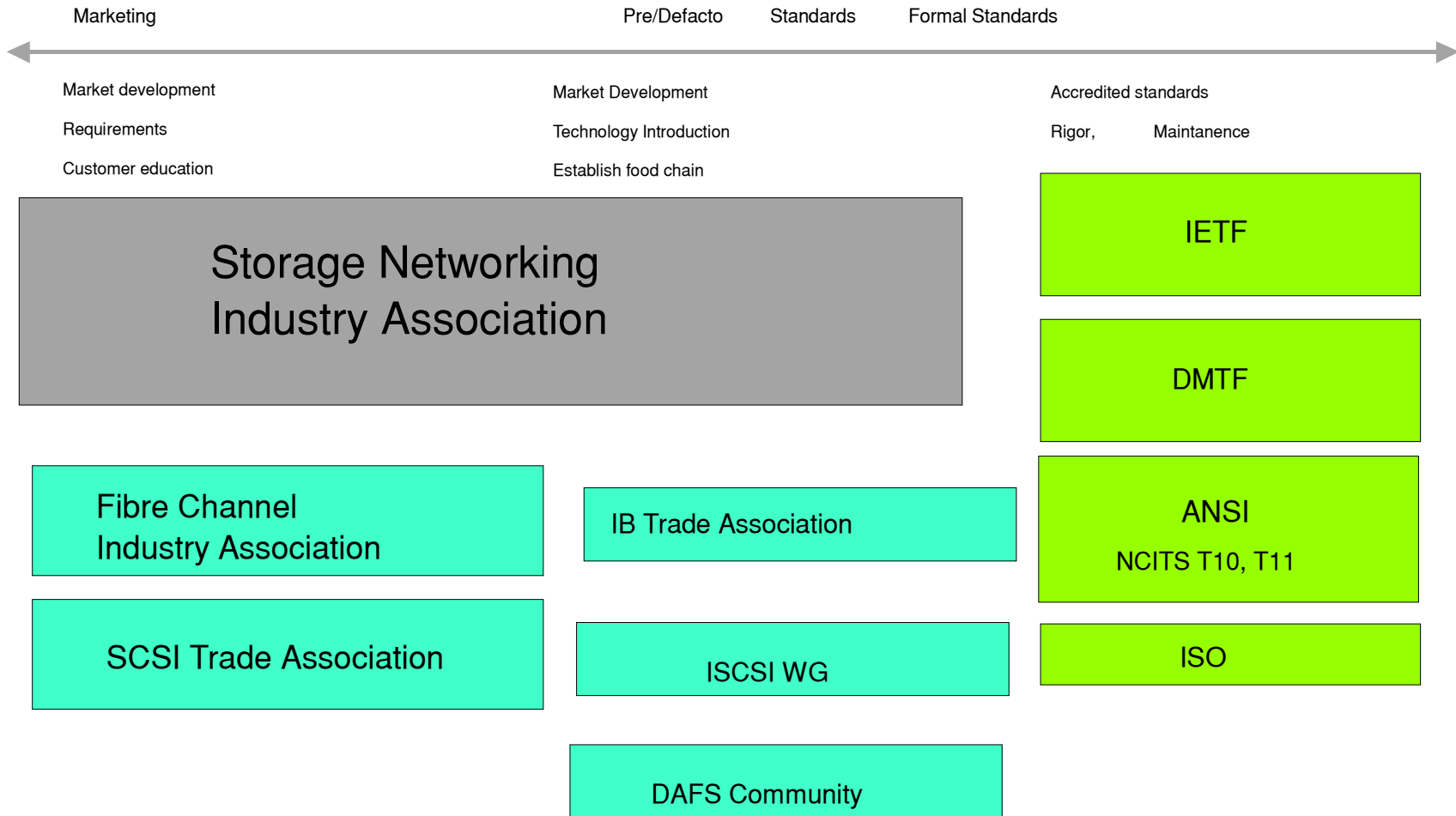
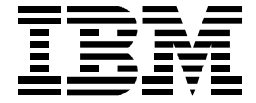


- Block Level Virtualization solutions w/wo storage - usually "in-band"
- Block Level Virtualization solution wo/ storage allow multiple vendors storage to attach and look as one large pool for better investment protection
- SAN-Wide File System (Storage Tank) provide file system virtualization for better availability, manageability and data access - uses "out-of-band" technology - also solves some NAS scalability issues

SAN Standards

- z/OS - Sure, it's open - anyone can code to IBM's standards and have an excellent chance of compatibility
- Windows/NT - Sure, it's open - anyone can code to Microsoft's standards and have some chance of compatibility
- Storage Area Networks - Sure, it's open - It's multi-vendor!
Easy - Right?

Storage Networking Standards



SAN Software Toolkit

- Framework Managers
 - Tivoli TEC, HP OpenView, CA TNG, BMC
- Storage Resource Managers (SRM)
 - Tivoli Storage Resource Manager
- SAN Fabric Managers
 - Tivoli Storage Area Network Manager
- Storage Element Managers
 - StorWatch FC Switch Specialist, McData EFC, Inrange IN-VSM Manager, StorWatch ESS Specialist, StorWatch ESS Expert, StorWatch 7133 Expert
- SAN Exploitation
 - Tivoli Storage Manager (LAN-Free Backup/Server-Free Backup)

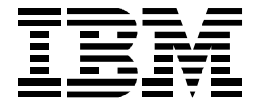
Software Equivalents

- Tivoli Storage Manager = a part of DFSMSHsm
- Tivoli Storage Area Network Manager = a small part of DFSMSdfp device support - also part of NetView
- Tivoli SAN Tape Resource Sharing = basic tape support + some DFSMSrmm
- Tivoli Decision Support products = RMF, SLR, etc.
- Storage Tank = a larger portion of SMS
- Tivoli SANergy = Logical Storage Pooling for NFS/CIFS data

OS/390 - UNIX/NT Interoperability

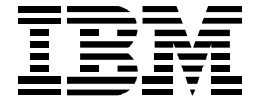
- Various Ethernet/GbE and Token Ring Implementations (including NFS clients/servers, TSM, DFM, DRDA, etc.) for Server to Server data transfer/access
- InfoSpeed (now owned by CNT) - Server to Server high speed access
- EMC/Innovation Data Processing - Symmetrix/FDRSOS - Direct read of UNIX/NT volumes to MVS tape for full volume backup
- HDS/Harbor - 7700E/Harbor - Direct read of UNIX/NT volumes to MVS Tape for full volume backup (IDP also does this now for HDS)
- EMC Infomover and HDS HMDE - FTP file transfer between UNIX/NT and OS/390 using control unit cache
- Encore/SUN - CD-ROM view (ISO 9660 Standard) read of OS/390 data from UNIX/NT systems (not in a current product)
- "Twin-Tailed" attachment of Storage Control units like the 3494 to OS/390 and AIX for storage hardware sharing (partitioning)
- UNIX Systems Services - HFS and OS/390 flat file transfers (IEBGENER + OGET/OPUT TSO Cmds + XSAM access method)
- EMC/BMC's DataReach (now called Data Extractor from EMC)
- Ex-XPE (9399) function

OS/390 SAN interoperability with FCP SANs - Generic Requirements



- Most customers want to gain painless and quick access to their data regardless of the server on which it resides
- Customers want to be able to manage all SAN elements from a single point of control across heterogeneous operating systems and multiple vendor storage control units
 - Consolidated Multi-Network Management
 - Automated Policy Management for Storage regardless of platform
- There are some storage software exploitation items of the ESCON SAN infrastructure like PPRC, but customers want more - like server free movement of data
- Some people confuse storage control unit functions with SAN functions - i.e. direct read of UNIX/NT volumes from OS/390 inside the ESS/Shark to do volume backup - but call this a SAN requirement
- Have OS/390 provide integrated Security coverage for itself and UNIX/NT
- Have a single unified Tape Management System for OS/390 and UNIX/NT
- Have easier ways of replicating data between OS/390 and UNIX/NT
 - Automated, works with scheduling software on both sides
 - Controllable from either OS/390 or UNIX/NT
 - "Conceptually Simple" - e.g. single step transfer (hiding data extract, data transformation, data loading processes)

SAN Summary



"Information is the currency of an e-business and must be managed as a valuable corporate asset. SANs are the digital bank for that information. This makes SANs one of the most important IT advancements since the emergence of Network Computing"

"Today's business environment is being driven, in large part, by the data explosion fueled by e-business, the commercialization of the Internet, the emergence of data-intensive technologies such as multimedia and data warehousing and the focus on server and storage consolidation. IBM's Storage Area Network initiative is the next step towards providing centrally managed, open software and hardware solutions designed to help companies get the most value out of their entire business information and IT infrastructures."

"IBM's Fibre Channel RAID Storage Server has not only provided Indiana University students with continuous and fast access to computing resources, it has also positioned us to utilize emerging SAN technologies," said **Raj Murday, IT Director of Indiana University at Pennsylvania**. "We are thrilled to be able to use this product knowing that our investment is protected by the scalability of industry-standard Fibre Channel."

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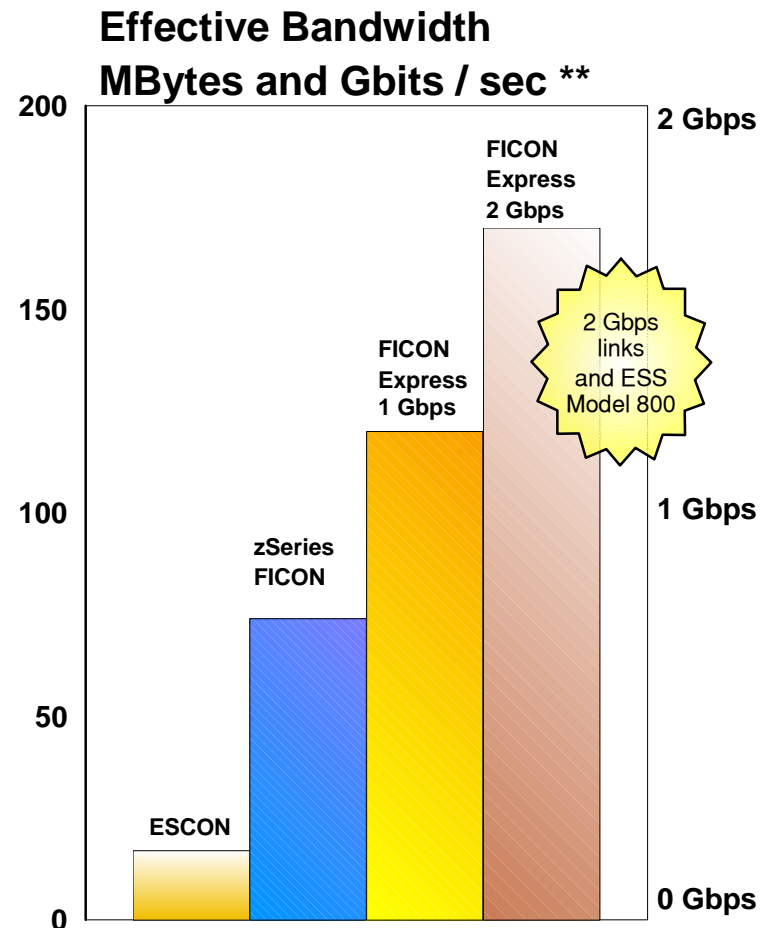
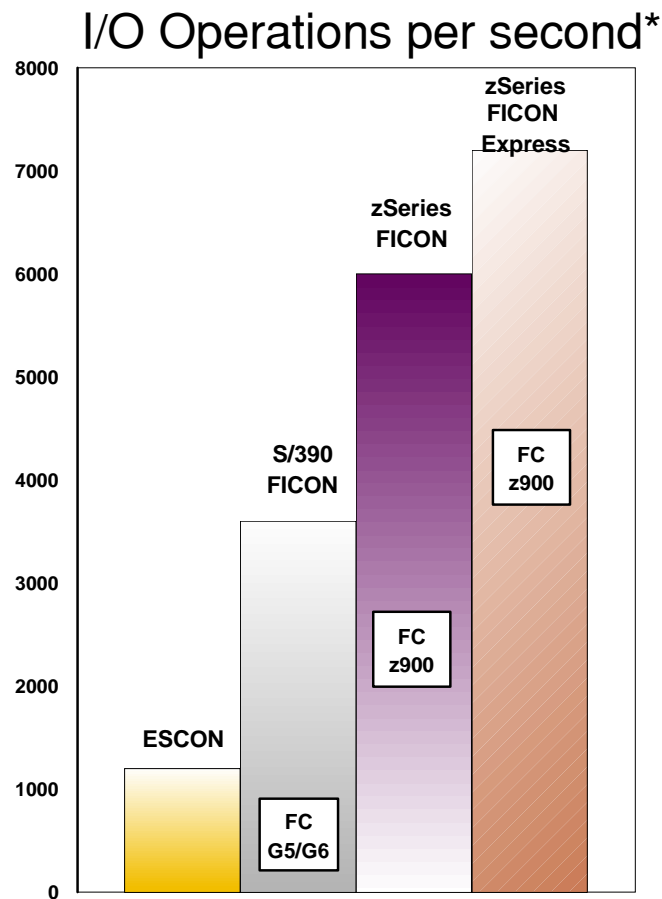
Definitions

- CIFS - Common Internet File System; commonly used as a replacement for Netbios on PC systems
- Fabric - A Fibre Channel network consisting of multiple devices interconnected by one or more switches that use Fibre Channel methodology to link nodes and route frames
- FC-AL - Fibre Channel Arbitrated Loop - a shared gigabit media for up to 127 nodes, one of which may be attached to a switch fabric. Uses arbitration to decide which node is using the loop at any one time
- FCP - Fibre Channel Protocol - the mapping of serial SCSI-3 commands to the physical Fibre Channel carrier
- FICON - Mapping an enhanced ESCON protocol onto the physical Fibre Channel carrier
- Gateway - a node of a network that interconnects two otherwise incompatible networks (e.g.. IBM SAN Data Gateway (2108-G07) SCSI - FCAL + LUN Masking function)
- GBIC - Gigabit Interface Converter - allows the optical fibre to be attached to the Host Bus Adapter (HBA) in a server (optical laser to copper)
- HBA - Host Bus Adapter - the I/O card that fits in a server and allows attachment of fibre channel media (optical cable or copper cable)
- Hub - A Fibre Channel device that connects nodes into a logical loop by using a physical star topology. Facilitates FC-AL loops and allows the FC-AL loops to be extended to 10 KM by connecting longwave GBICs.
- LAN/WAN - Local Area Network; Wide Area Network - usually using TCP/IP or CIFS protocols to carry end-user interactive traffic.

Definitions

- NAS - Network Attached Storage - a term used to describe technology where an integrated storage systems is usually attached to a LAN or WAN using TCP/IP or CIFS. There are two general types of NAS - File servers (e.g. NFS) or Backup/Archive servers (IBM 3466 Network Storage Manager)
- Node - An entity with one or more N_Ports or NL_Ports (e.g. Servers or Storage Devices)
- Point to Point - A Fibre Channel topology in which each point has physical links to only one neighbor resulting in a closed circuit. The available bandwidth is dedicated solely to this connection.
- Port - The hardware entity within a node that performs data communications over the Fibre Channel
- Router - A dedicated hardware and/or software package which manages the connection between two or more networks (e.g. IBM SAN Data Gateway Router(2108-R03) - SCSI to FCAL protocol conversion only)
- SAN - Centrally managed high speed networks of multivendor storage subsystems, applications servers, clients and networking hardware that allow companies to exploit the value of their business informations via universal access and sharing of resources.
- Switch - A hardware entity with multiple entry/exit points (ports) that provides dynamic connection between any two of these ports.

FICON Express - Breaking the Barrier

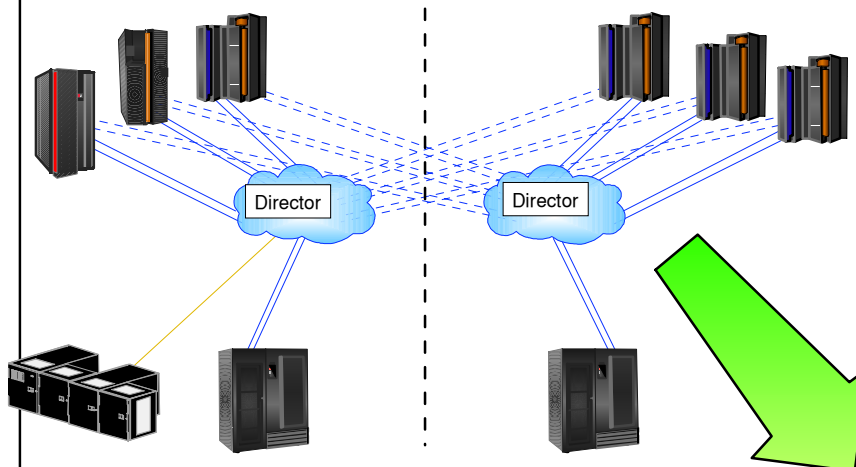


FICON Express Channel Card = Feature Code 2319 LX, and 2320 SX

* Channel 100% utilized, 4K block sizes, FC = Native, 1 or 2 GBit

** Using highly sequential 6x 27k block size, mixed reads and writes

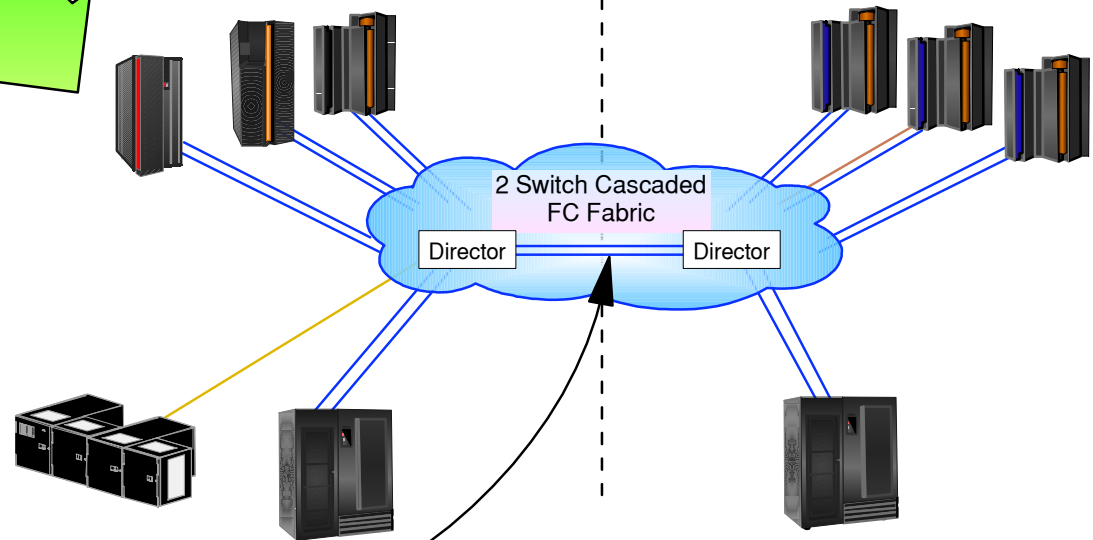
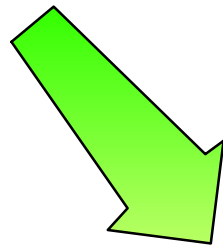
FICON Support of Cascaded Directors – Simplify Cross-Site Connectivity – Reduce Costs



Two site non-cascaded director topology
Each CEC connects to directors in both sites

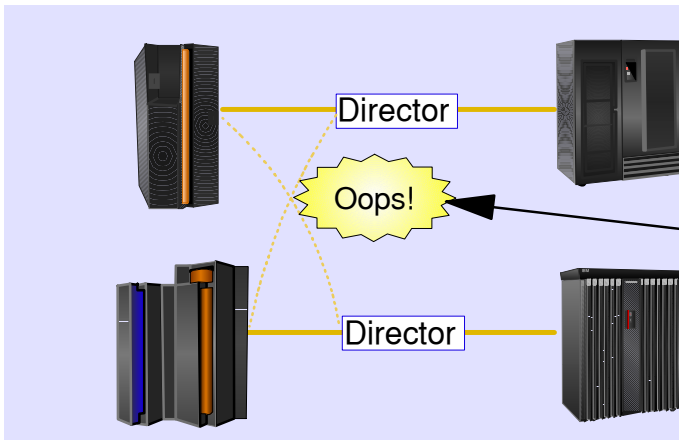
With 2 Gbps Inter Switch Links (ISLs), fewer fiber links may be needed for cross-site connectivity

- Dynamic – channels, ports, fiber shared
- Fewer cross site connections - Repeaters, DWDM, Fibers, Channels, Director Ports
- Reduce implementation cost for disaster recovery applications; GDPS and Remote Copy
- Support: z/OS V1.3 and V1.4 plus PTFs
- Requires single-vendor high integrity fabric
- Planned GA January 31, 2003

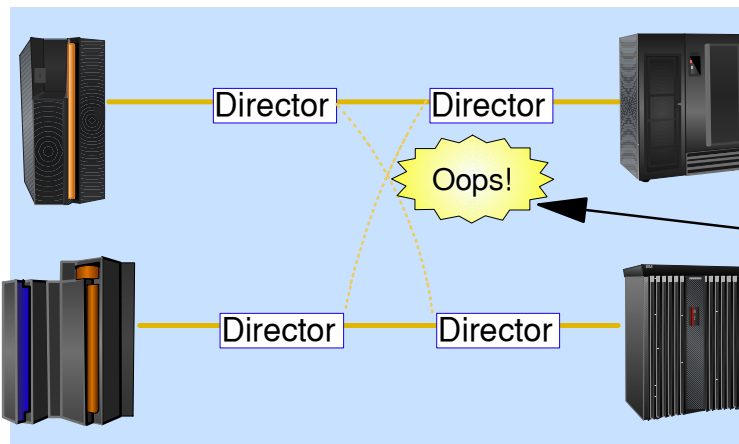


Two Site cascaded director topology
Each CEC connects to local directors only

Cascaded Directors - Enterprise Fabric



- In single-director configurations, [ESCON and] **FICON architecture** protects against mis-cabling and mis-directing of data stream.
- If an accidental cable swap occurs [S/390 and] zSeries automatically invoke logical path testing, reporting, isolation, and recovery.



- Now, in two-director cascading, **director architecture** also protects against mis-cabling and mis-directing of data streams.
- If an accidental cable swap occurs, directors interoperate with and invoke existing logical path testing, reporting, isolation, and recovery.

- End-to-end, FICON support of cascaded directors help to prevent data corruption and is considered a high integrity enterprise fabric.

A Comparison of Channels

ESCON Channel	Native FICON Channel	FCP Channel
Circuit Switching	Packet Switching	Packet Switching
Read or write Half-duplex data transfer	Simultaneous read and write full-duplex data transfers	Simultaneous read and write full-duplex data transfers
Connection-oriented	Connectionless	Connectionless
Dedicated path pre-established	Packets individually routed	Packets individually routed
When packet (frame) is sent, link is locked	When packet is sent, link is released	When packet is sent, link is released
Synchronous data transfer	Asynchronous data transfer	Asynchronous data transfer
Uses CCW Architecture	Uses CCW Architecture	Uses SCSI architecture
Traditional IODEVICE to access a logical volume	Traditional IODEVICE to access a logical volume	QDIO IODEVICE to access ALL logical units

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- Introducing
 - Scalable solutions
 - From single product to entire enterprise
 - Fiber optic connectivity expertise deploying a proven methodology
 - Personalized services to effectively plan and install the fiber optic cabling needed for your zSeries with the future in mind
- Addressing the requirements of
 - The Data Center
 - Open Systems Environment (Storage Area Network/ Local Area Network)
 - Parallel Sysplex (Coupling Links)
- Considering
 - Current fiber optic cabling, connectors, transceivers
 - New industry-standard Small Form Factor (SFF) connectors and transceivers
- Delivering
 - A custom or contracted service for your products as well as small, medium, or large enterprise
 - Analysis of your current fiber optic cabling and the zSeries configuration
 - Cabling options customized for your system environment

Flexible, cost-effective, tailored fiber cabling solutions



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