Session 12073

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Introduction to Storage Technologies SAN (**S**torage **A**rea **N**etworking) and a little FICON (**FI**ber **CON**nection)

Mike Blair   – Cisco   – mblair@cisco.com

David Lytle – Brocade – dlytle@brocade.com

SAN 101

SHARE in Anaheim 2012

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Notes as part of the online handouts

I have saved the PDF files for my presentations in such a way that all of the audience notes are available as you read the PDF file that you download.

If there is a little balloon icon in the upper left hand corner of the slide then take your cursor and put it over the balloon and you will see the notes that I have made concerning the slide that you are viewing.

This will usually give you more information than just what the slide contains.

I hope this helps in your educational efforts!

Agenda for Session 12073 and 12074

Session 12073 – 09:30am – 10:30am

- **Types and Components of Storage**

- **Let's talk Fibre Channel**

- **FC Buffer Credits**

- **Fabric Routing / Virtual Fabrics / Partitioning**

- **Security / Zoning**

Session 12074 – 11:00am – 12:15pm

- **History**

- **Terminology, Connectors, Cables, and Wavelengths**

- **Addressing in FICON**

- **ESCON Status, zHPF and NPIV**

- **Buffer Credits, CUP, RMF**

Complete your sessions evaluation online at SHARE.org/AnaheimEval

Agenda for Session 12073 and 12074

Session 12074

- **Types and Components of Storage**

- Let's talk Fibre Channel

- FC Buffer Credits

- Fabric Routing / Virtual Fabrics / Partitioning

- Security / Zoning

Storage Network Components

Multiple Infrastructure Vendors (eg. Brocade and Cisco)
Several components required to build a SAN

- Servers with Host Bus Adapters (HBAs)
- Mainframes with FICON Express Channels
- Storage systems
  - RAID (Redundant Array of Independent/Inexpensive Disks)
  - JBOD (Just A bunch of Disks)
  - Tape
  - VTS/VSM (Virtual Tape)
- Fibre Channel / FICON Switches or Directors
- Ethernet Switches (iSCSI / FCoE)
- SAN management software

Direct Attached Storage

- Direct Attached Storage (DAS)

- Storage is captive 'behind' the server, limited mobility

- Limited scalability due to limited devices

- No storage sharing possible

- Costly to scale

- Management can be complex

- Often cannot take full advantage of the technology

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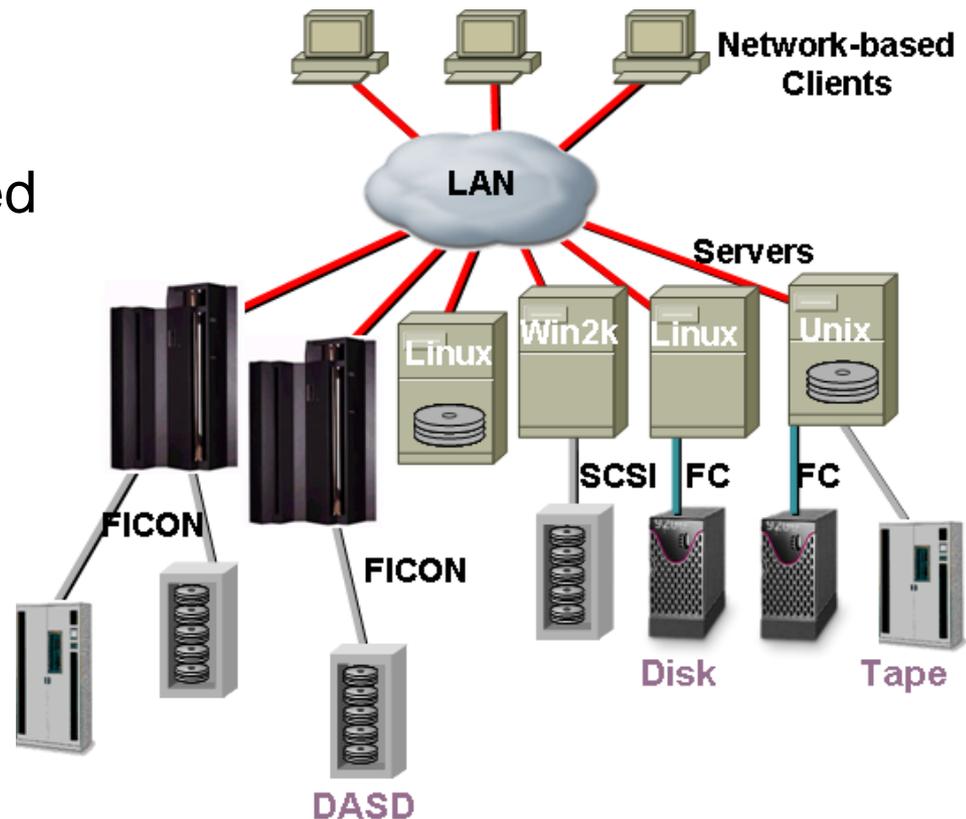
Network Attached Storage (NAS)

- Dedicated file server

- Optimized for file-based access to shared storage over an IP network

- Suitable for applications involving file serving/sharing

- High-performance access, data protection, and disaster recovery

- Capable of storage partitioning

- Uses network file system protocols such as NFS or CIFS

IP Network

NAS Appliance

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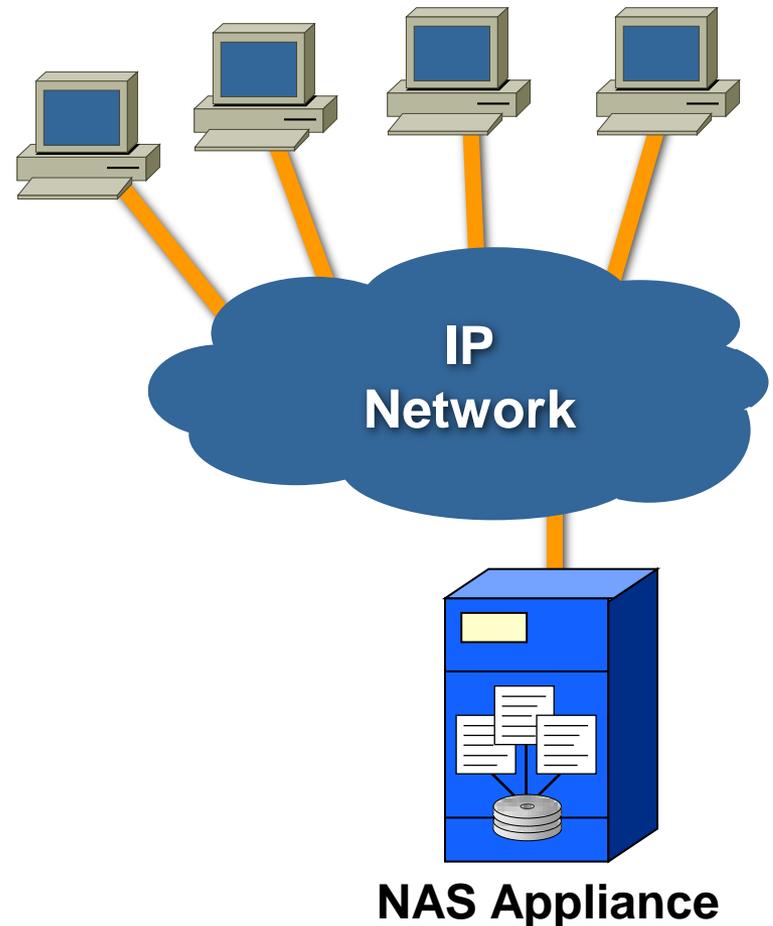
Storage Area Network (SAN)

Separation of Storage from the Server

- Storage is accessed Block-level via SCSI/FICON and can be in a switched environment

- High performance interconnect providing high I/O throughput

- Lower TCO relative to direct attached storage, storage can be shared

- Have to consider Vendor Interoperability / Qualifications

- More Complex management due to size/scale

Clients

LAN

Database/App Servers

FC/FICON SAN

Block Storage Devices
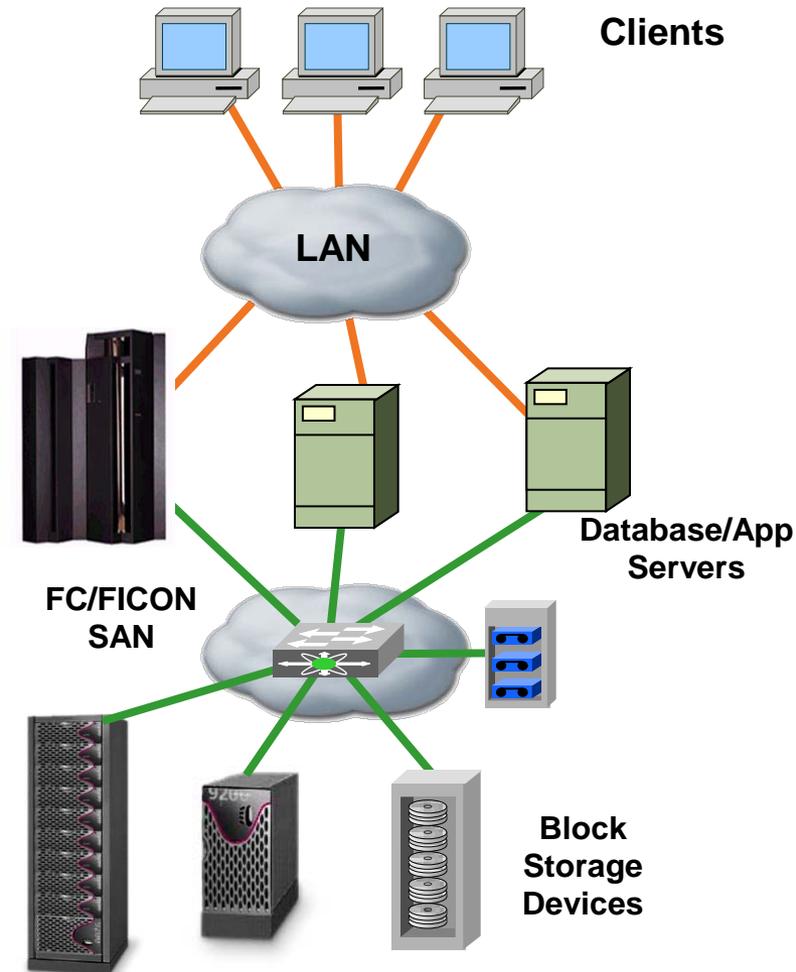
FICON or Storage Area Network (SAN)

SAN Terminology -- *Fiber Channel Link*
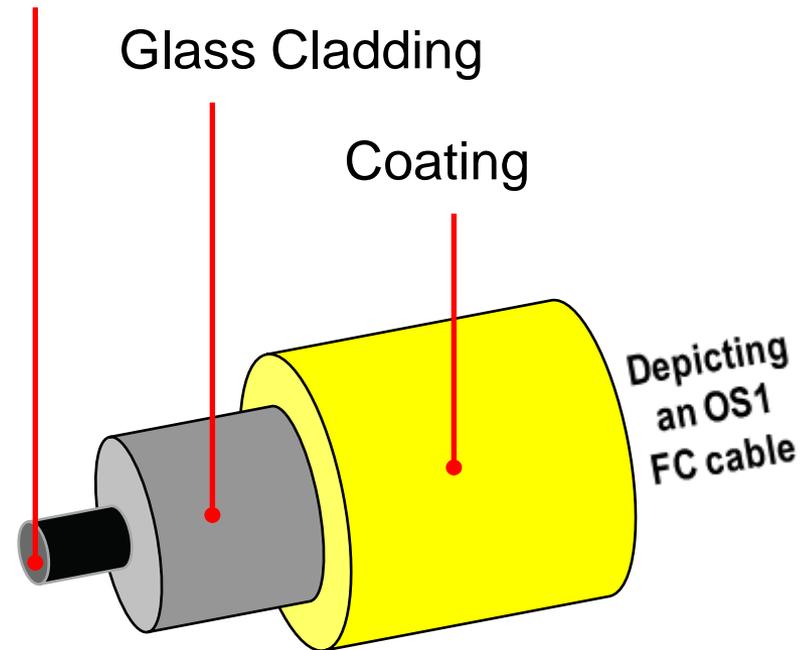
Glass Core
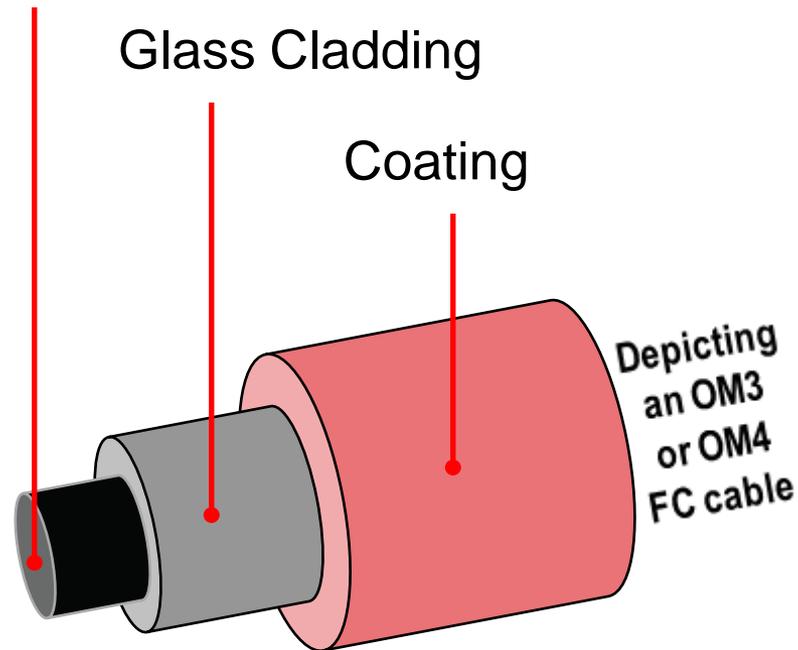
Glass Cladding

Coating

Depicting an OM3 or OM4 FC cable

Multimode Fiber
For local distances and/or
1/2/4/8/16Gbps
MM – use with short wave optics
62.5 micron, 50 micron
(62.5m has little value today)

Glass Core

Glass Cladding

Coating

Depicting an OS1 FC cable

Single-mode Fiber
For long distances and/or
8Gbps/16Gbps link rates
SM – use with long wave optics
9 micron

FC Storage Networking Terminology
Fiber Channel Links

- **Modal dispersion** is a distortion mechanism occurring in multimode fibers in which the signal is spread in time because the propagation velocity of the optical signal is not the same for all modes.

- Modal dispersion limits the bandwidth and distance of multimode fibers.

OM3 and OM4

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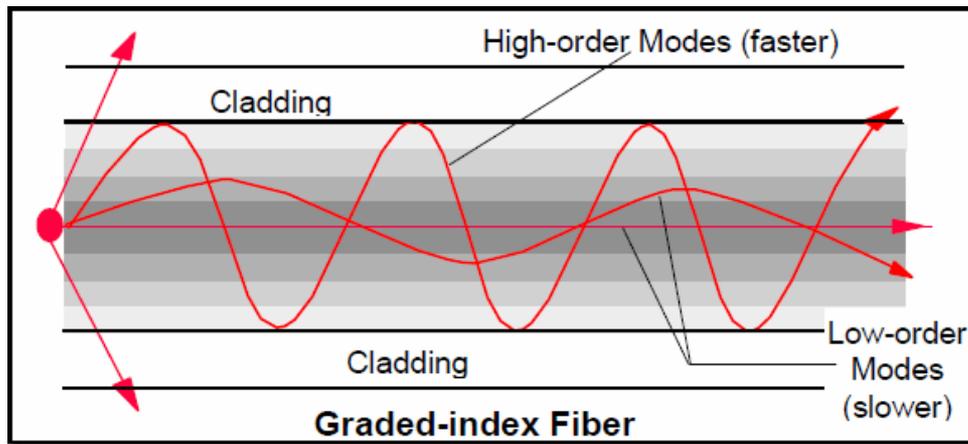
SAN Terminology -- *Fiber Channel Link*
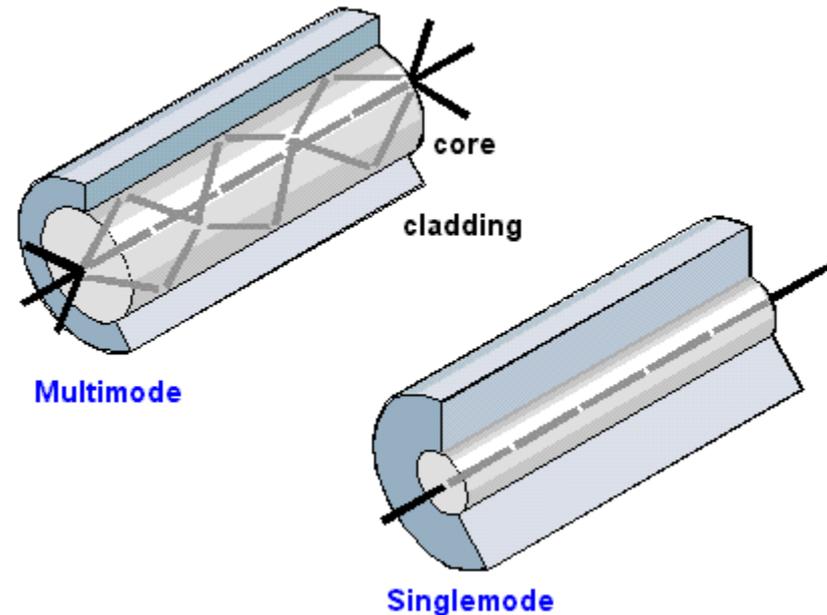
- **A link consists of**
  - 2 unidirectional "fibers" transmitting in opposite directions
    - May be either:
      - Optical fiber or Copper
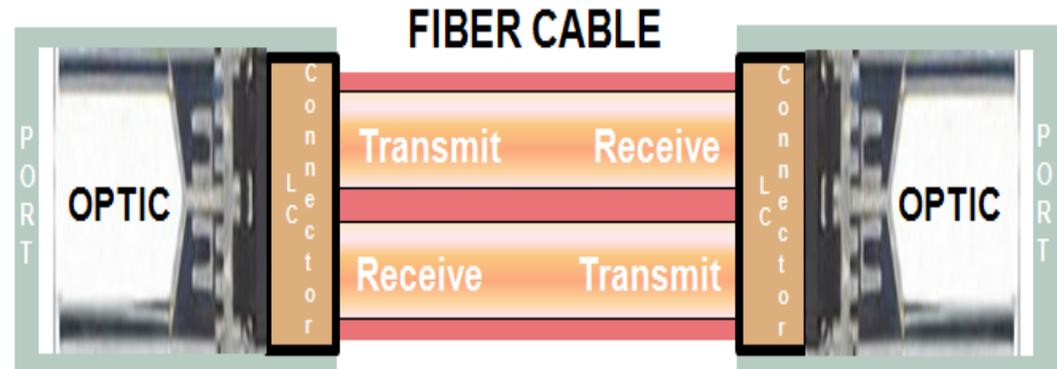
- **Transmitters may be:**
  - Long wave laser
    - There can be multiple distances for these – ie. 4km/10km
  - Short wave laser
  - LED
  - Electrical

Switched-FCP and Switched-FICON Director Chassis's Run At:

Brocade	Cisco
2Gbps	2Gbps
4Gbps	4Gbps
8Gbps	8Gbps
16Gbps	

2012

SAN Terminology -- *Fiber Channel Link*

OPTICAL

Performance:
2, 4, 8, 16 Gbps

- **LC Optical Connector**
  - **Standard on 2-8Gbps Switches**
  - **Most widely used connector**

  Cable Shown as Bonded Duplex

Performance:
1 Gbps

- **SC Optical Connector**
  - **Standard on 1 Gbps Switches**
  - **Little used any longer**

  Cable Shown as Bonded Duplex

COPPER

Performance:
2.125 Gbps

- **HSSDC Copper Connector**
  - **Smaller than older connectors**
  - **Easier to insert/remove**

Performance:
2.5 Gbps

- HSSDC2 Copper Connector
  - Fits in SFP Media Slots
  - Smaller than HSSDC

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SAN Terminology -- *Fibre Channel*
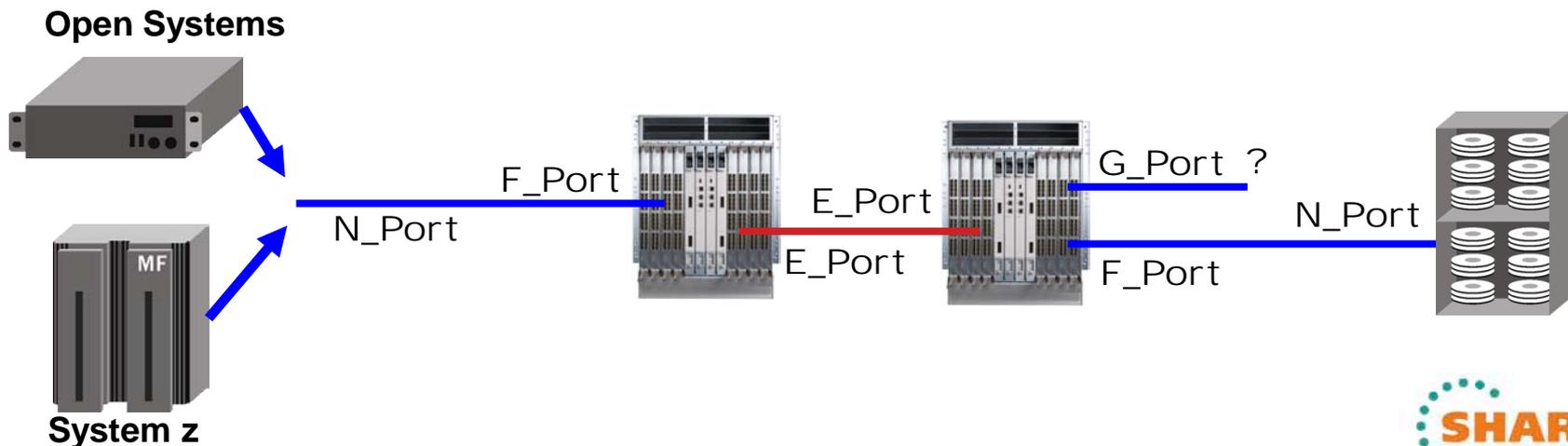
Device Ports

- N_Port – Node Port, a Fabric device directly attached

Switch Ports

- G_Port – Generic Port, a port waiting to become an E or F_Port
- F_Port – Fabric Port, a port to which an N_Port attaches
- E_Port – Expansion port used for inter-switch links

Open Systems

F_Port

N_Port

E_Port

E_Port

G_Port ?

N_Port

F_Port

System z

SAN Terminology -- *Fibre Channel*

- Interconnection between switches is called the Inter-Switch Link (ISL) or in FICON a Cascaded Link (uses Expansion Ports – E_Port)
  - E_Port to E_Port (aka ISL)
  - For FICON, a 10Gbps link can ONLY BE a cascaded link (ISL)

- Allows switches to be connected together to create a multi-switch Fabric

- Supports all classes of service
  - Class 1, 2, 3, and a special Class F

- The FC Standard permits consecutive frames of a sequence to be routed over different, parallel ISL links for maximum throughput
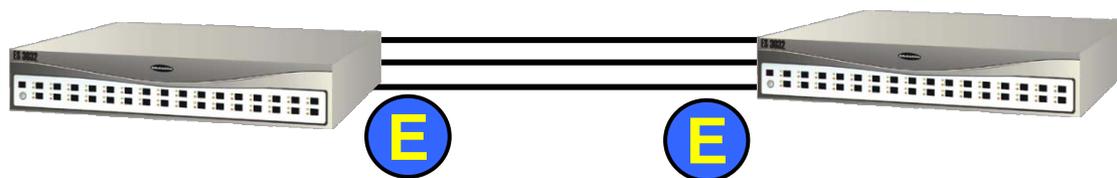
Agenda for Session 12073 and 12074

Session 12073

- Types and Components of Storage
- **Let's talk Fibre Channel**
- FC Buffer Credits
- Fabric Routing / Virtual Fabrics / Partitioning
- Security / Zoning

Fibre Channel Protocol

Fibre Channel (FC) provides high speed transport for Upper level (ie. FICON or SCSI) payloads

- FC is the "protocol" for a Storage Network – attributes are:
  - Highly Scale - Addressing for up to 16 million nodes
  - Various Switched Topologies
  - High Speeds - 100, 200, 400, 800 or 1600 MBps
  - 10Gb or 16Gb ISLs can be deployed
  - Segments of up to 100 Km between switches
  - Support for multiple protocols like FICON and OPEN (SAN)
  - Support for Security via Zoning and Prohibit/Allow Matrix

The Fibre Channel Protocol

- **FCP and FICON** are just a part of the upper layer (FC-4) protocol

- **They** are compatible with existing lower layers in the protocol stack

Layer		Description
FC-4	**Protocol Mapping Layer** Upper Level Protocol (ULP)	**FCP/FICON/HIPPI/Multi-media, etc.**
FC-3	**Common Services**	**Login Server, Name Server, Alias Server**
FC-2	**Framing Protocol / Flow Control**	**Data packaging, Class of service, Port Login / logout, Flow control...**
FC-1	**Transmission Protocol - Encode / Decode**	**Serial Interface (one bit after another) Frame Transfer (up to 2048 byte payload) 8b/10b or 64b/66b data encode / decode**
FC-0	**Interface/Media – The Physical Characteristics**	**Cables, Connectors, Transmitters & Receivers...**

Fibre Channel Overview

- Fibre Channel is primarily utilized as a networked form of SCSI (open systems - SAN) or CCWs (System z - FICON)

  - **Actually, the lower layers of Fibre Channel are generic**

    - Able to transport multiple data types such as video on demand and Internet Protocol

  - **But, most common deployment is Fibre Channel Protocol (FCP)**

    - FCP is an upper layer protocol that provides for the transmission of SCSI commands and data over the Fibre Channel transport layers

  - **Next most common deployment is Fiber Connection (FICON)**

    - FICON is an upper layer protocol that provides for the transmission of mainframe CCW commands and data over the Fibre Channel transport layers
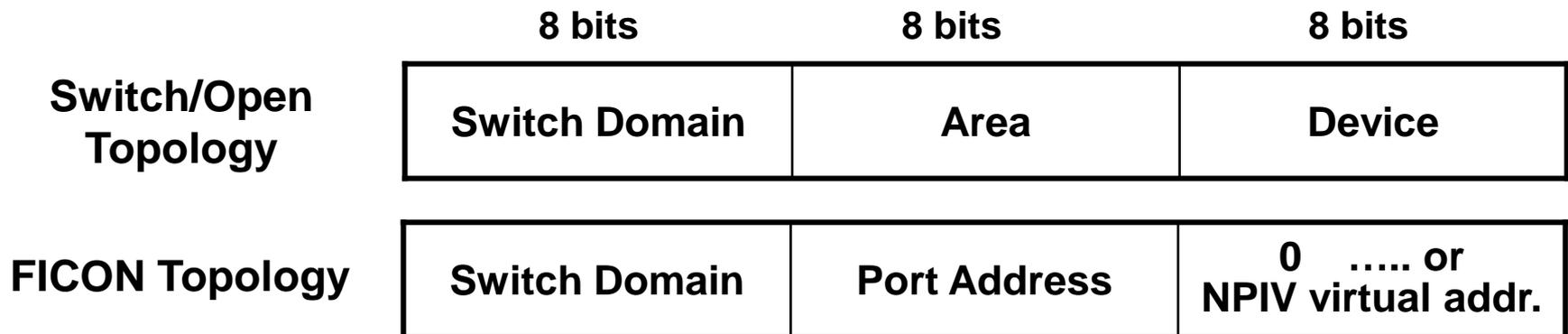
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World Wide Names

- Each switch element is assigned a 64 bit WWN at time of manufacture

- Each switch port is assigned a 64 bit WWPN at the time manufacture

- During Fabric Logon (FLOGI) the switch identifies the WWN in the service parameters of the accept frame

- After FLOGI/PLOGI the WWNs and WWPNs have been mapped to Fibre Channel Identification (FCID) addressing

These Address Assignments Can then Correlate
Each Fabric Port with Switch Routing and the Fiber
Channel ID (FCID)

Fabric Addressing

- The 24 bit Fiber Channel Identification (FCID) address is partitioned into 3 fields:
    - Device or NPIV
    - Area
    - Domain
- This partitioning helps speed up routing
- Switch element assigns the address to N_Ports
- Address portioning is transparent to N_Ports

	8 bits	8 bits	8 bits
Switch/Open Topology	Switch Domain	Area	Device
FICON Topology	Switch Domain	Port Address	0 ….. or NPIV virtual addr.

Fibre Channel Frame Format

- All FC-2 frames follow the general frame format as shown below

- Idle/ARB are 'Ordered Sets' used for synchronization and basic signaling (1, 2, 4 and10Gbps use Idle/Idle while 8Gb and 16Gbps use Idle/Arb)

- SOF – Start-of-Frame, EOF – End-of-Frame

- 8b/10b frame encoding for 1, 2, 4 and 8Gbps frames

- 64b/66b frame encoding for 10 and 16Gbps frames

General FC-2 Frame Format

Frame Content

Idle*	SOF	Frame Header	Data Field	CRC	EOF	Idle or Arb*
	(4)	(24)	(0-2112)	(4)	(4)	

0-528 Transmission Word
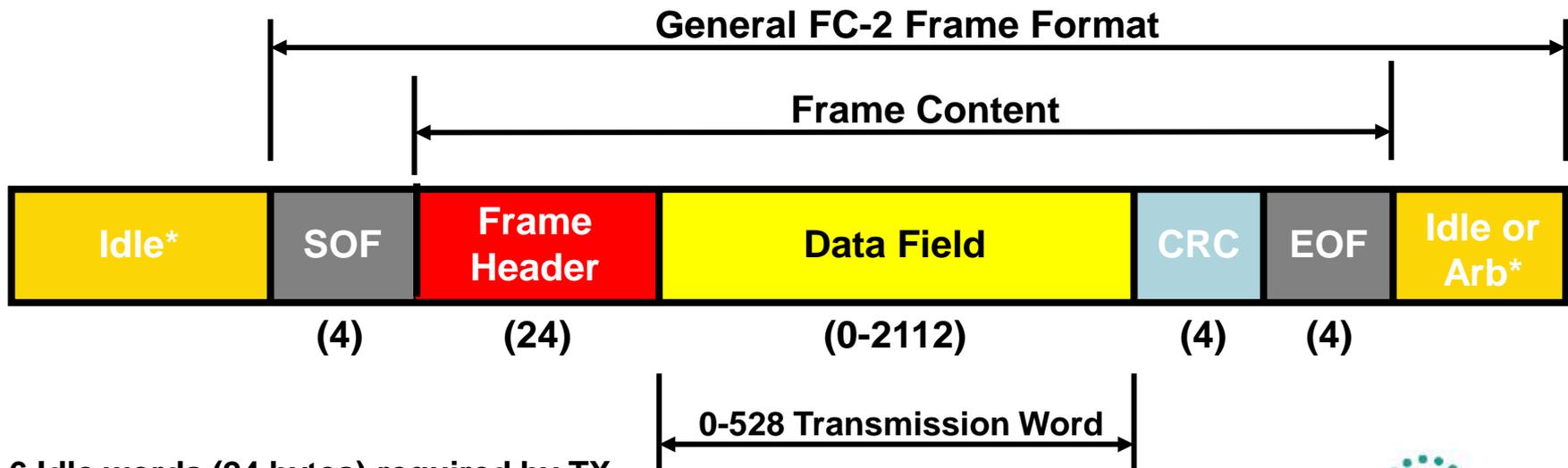
* 6 Idle words (24 bytes) required by TX
2 Idle words (8 bytes) guaranteed to RX

ISL Aggregation
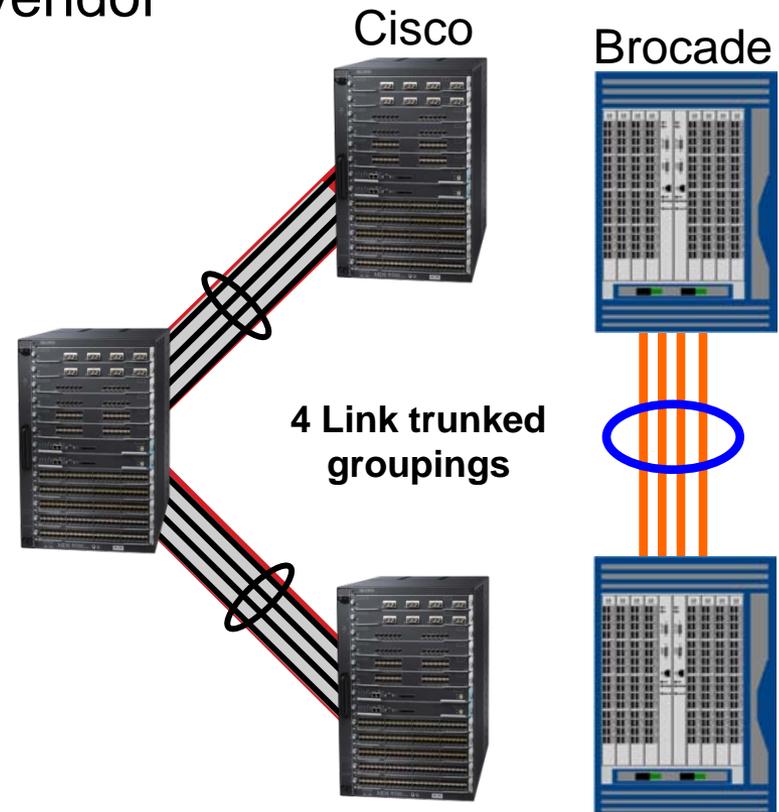
Port Aggregation Is Used to Create a Single Logical ISL from multiple Physical ISLs

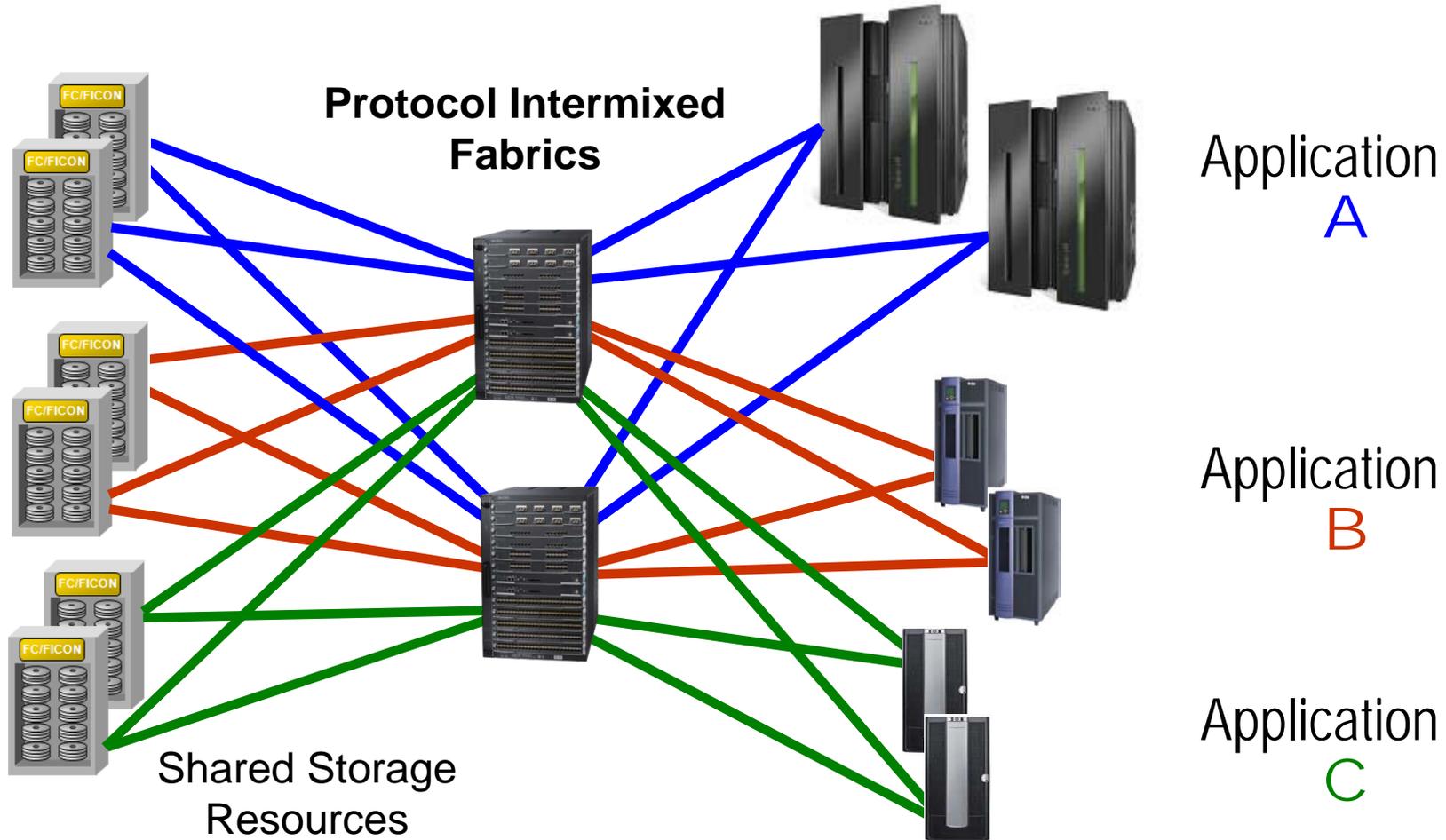Different names depending upon the vendor
>   Brocade = Trunking
>   Cisco = Port Channel

- Increases bandwidth and availability
- Simplifies Topology
- Usually some load balancing
- Interfaces can both be added and removed in a non-disruptive manner in production environments
- Preserves FC guarantee of in-order delivery (IOD)

Cisco

Brocade

4 Link trunked groupings

Storage Networking Topology
Dual Star (non-cascaded for FICON)

Protocol Intermixed Fabrics

Application **A**

Application **B**

Application **C**

Shared Storage Resources

FC/FICON

- Provides an opportunity to deploy fabrics to meet five-9's of availability
- Still must insure <=5 min/annual fabric downtime

Typical SAN Topology
Core-to-Edge (distributed systems only)

SAN
Fabrics

Application
B

Shared Storage
Resources

Storage
Resources

Application
C
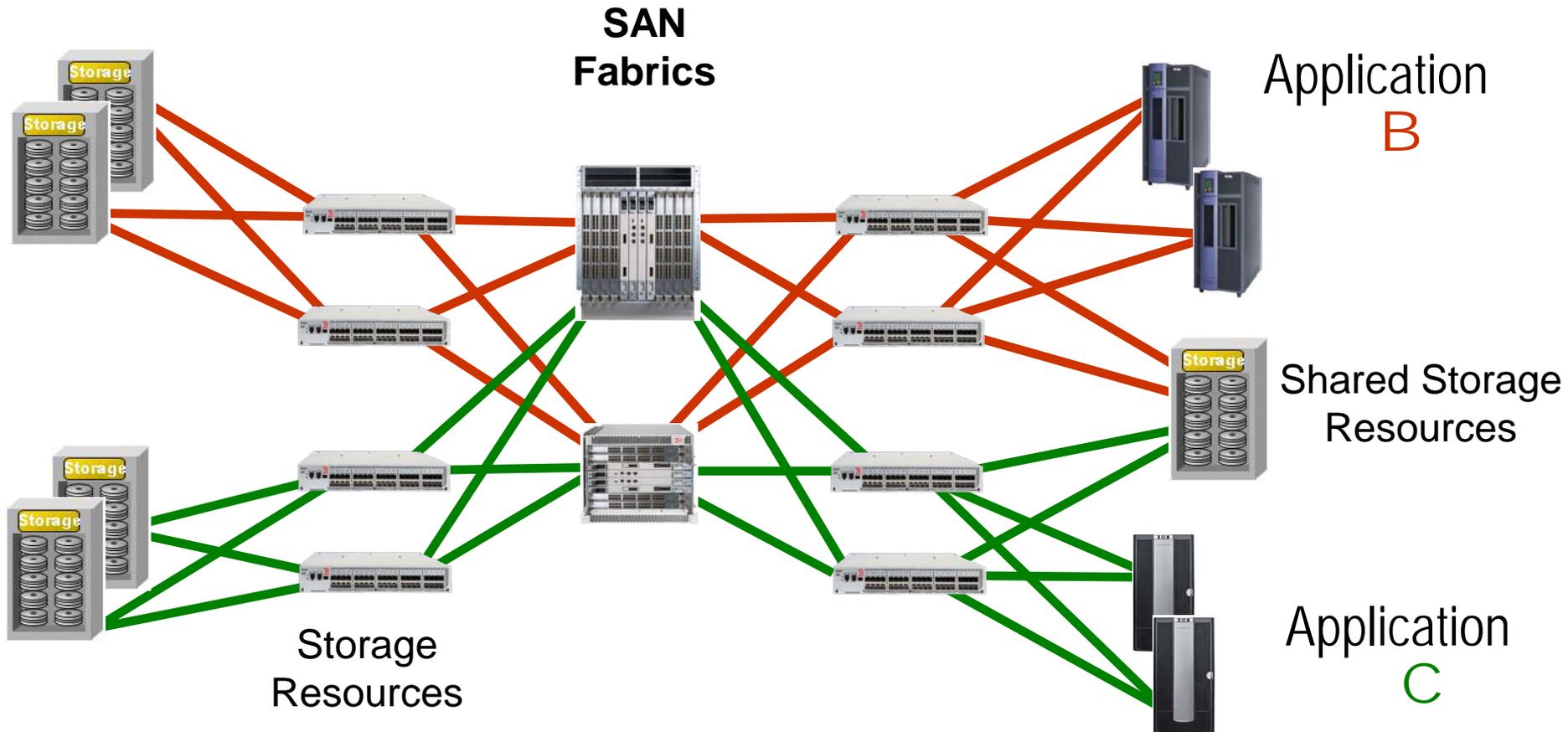
- Requires multi-hop so it is not currently supported for FICON
  due to IBM Qualification

Storage Networking Topology Cascaded FICON
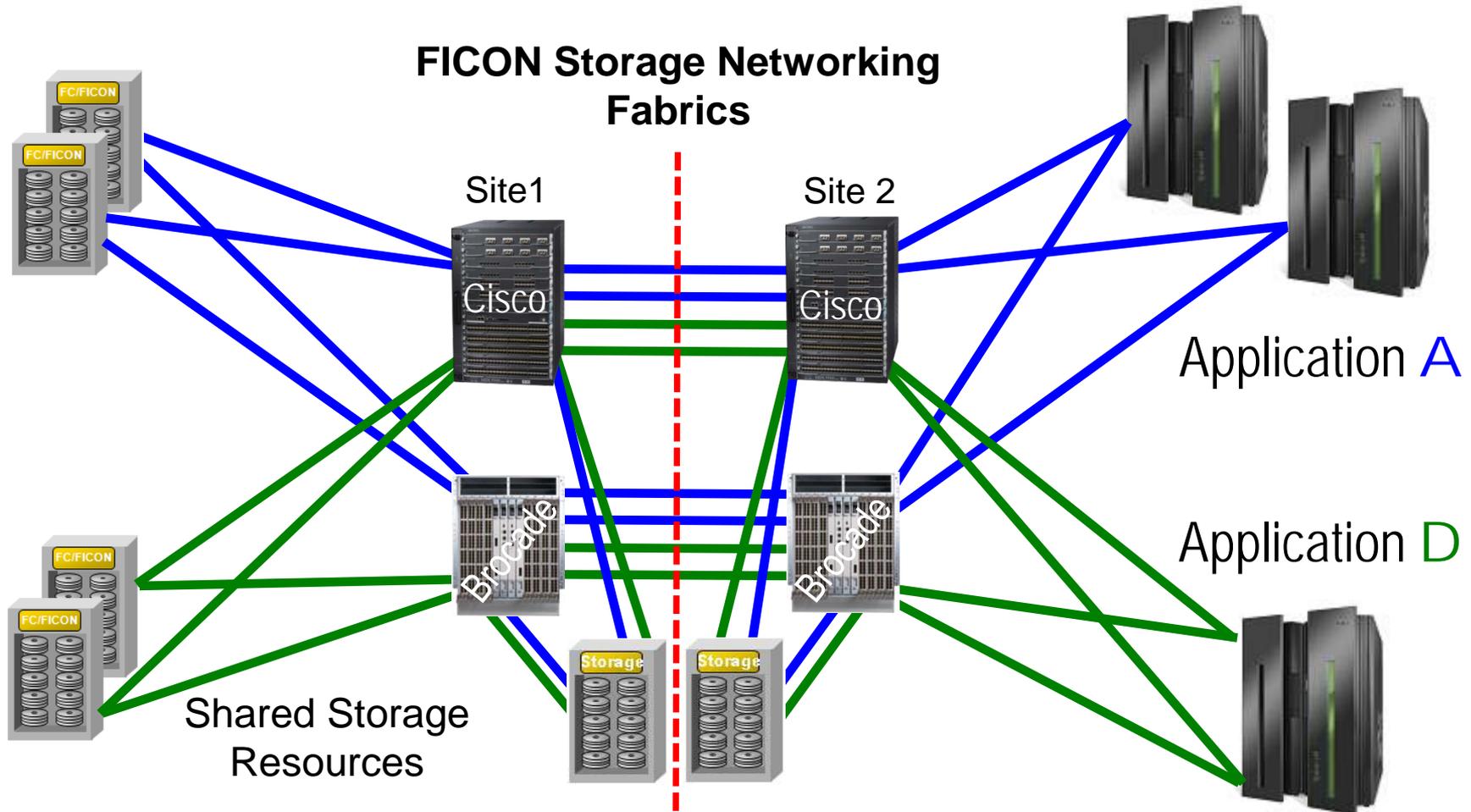
FICON Storage Networking Fabrics

Site1   Site 2

Cisco   Cisco

Brocade   Brocade

Application **A**

Application **D**

Shared Storage Resources

- Provides an opportunity to deploy fabrics to meet five-9's of availability
- Only one vendor per fabric and only one hop per fabric

Storage Networking Topology Cascaded FICON and FCP

Protocol Intermixed Fabrics

Cisco

Cisco

Brocade

Brocade

Application **A**

Application **D**

Shared Storage Resources

FC/FICON

- Provides an opportunity to deploy fabrics to meet five-9's of availability
- Only one vendor per fabric and Only one hop

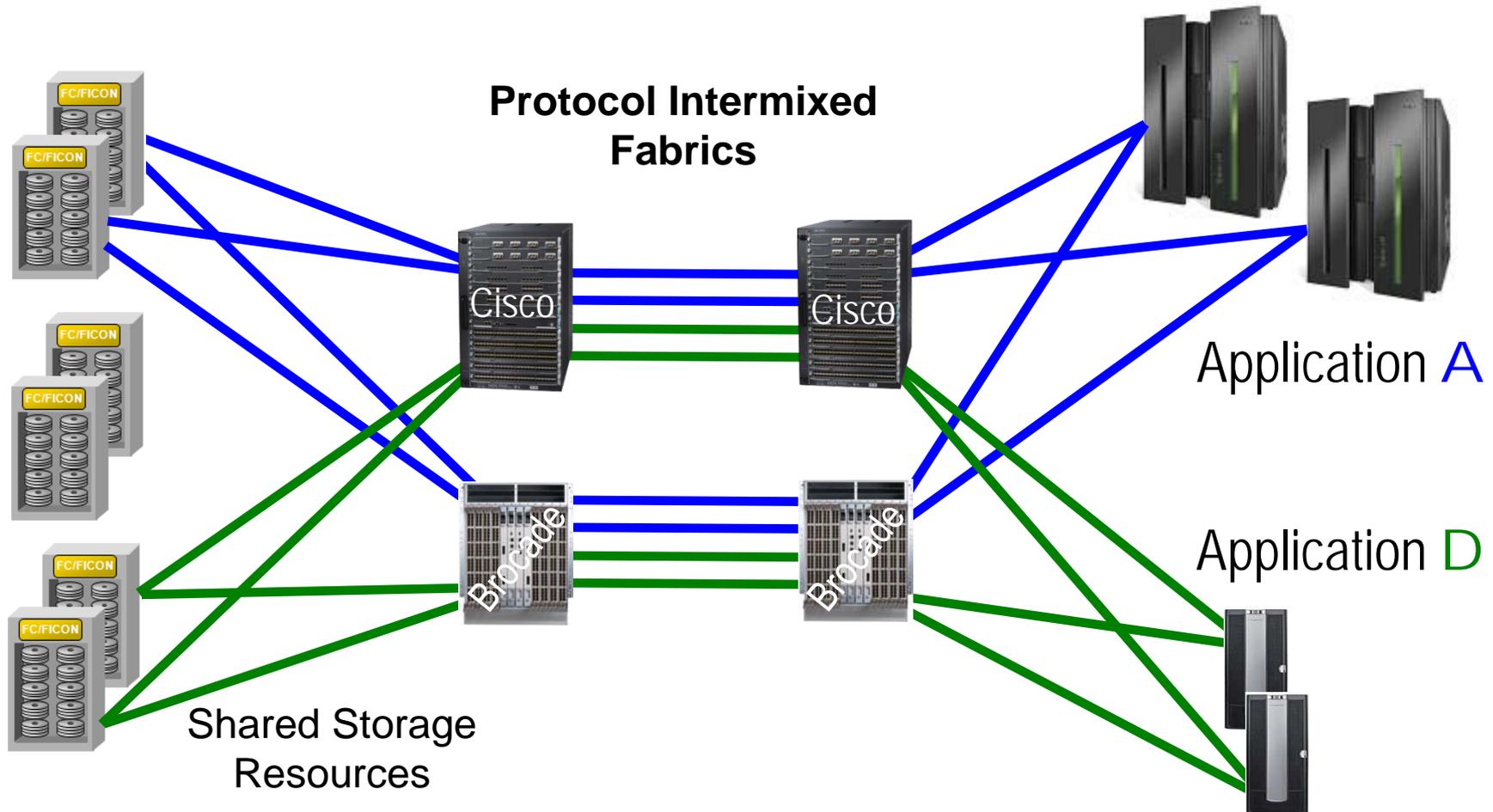# Agenda for Session 12073 and 12074

Session 12073

- Types and Components of Storage

- Let's talk Fibre Channel

- **FC Buffer Credits**

- Fabric Routing / Virtual Fabrics / Partitioning

- Security / Zoning

FC Buffer Credits and Flow Control

I can receive 40 frames (buffer credits) but after that you will have to stop sending frames until I acknowledge some or all of them.

We are long distance ISL links and therefore we need extra buffer credits in order to keep the link fully utilized.

Director or Switch

Storage

← 16

40 →

← 202

202 →

← 202

16 →

← 200
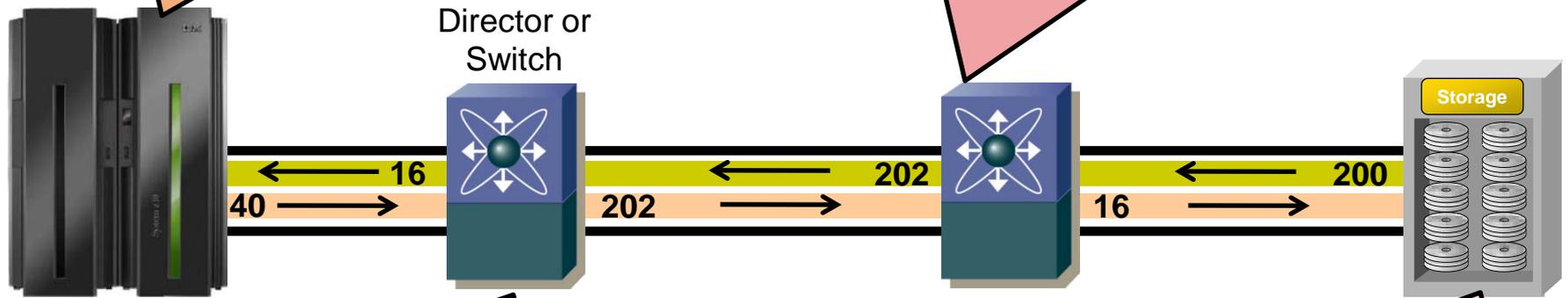
That is fine – I can only receive 16 frames myself. This is OK since we are only a few feet/meters apart anyway.
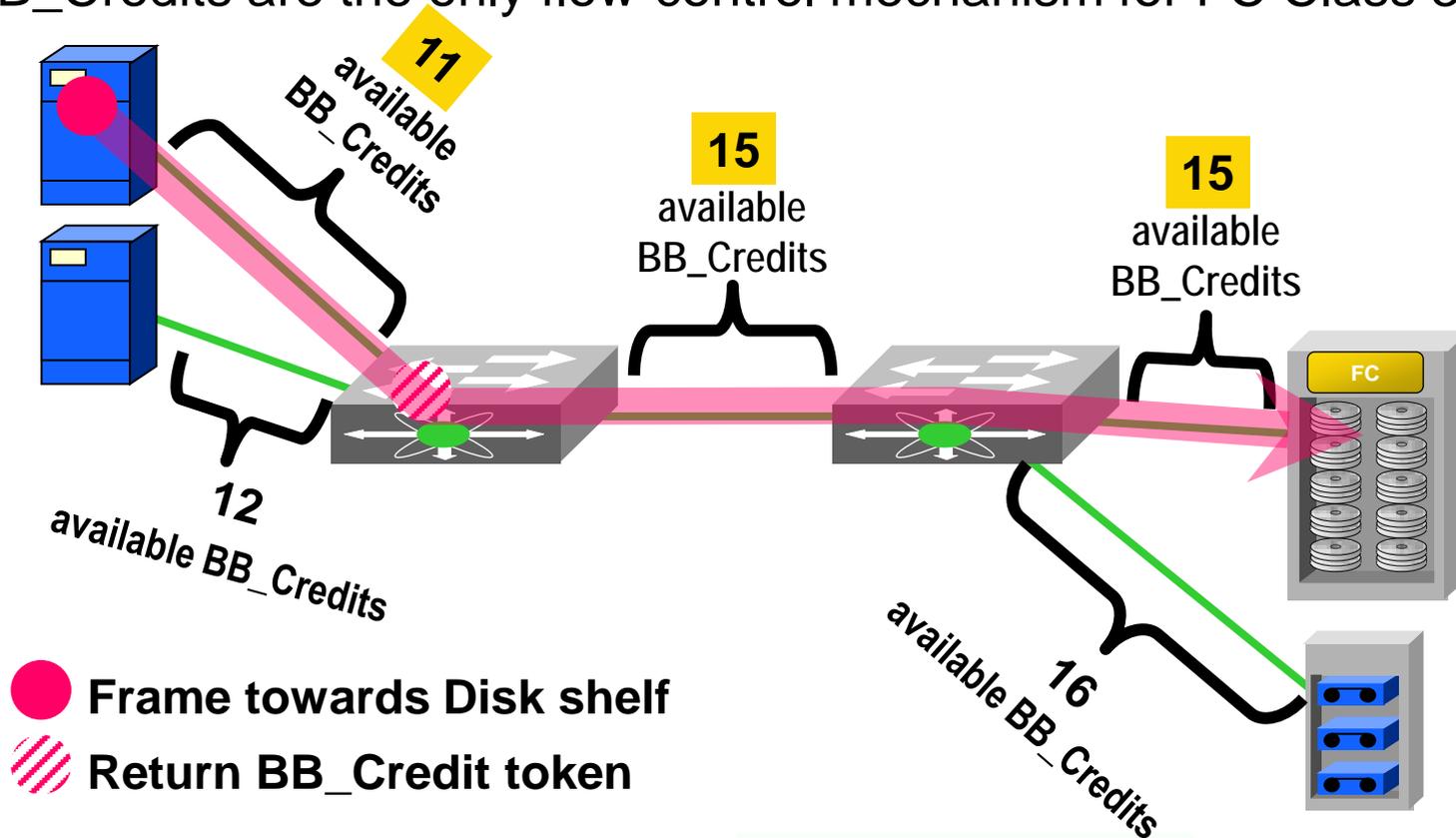
Like most modern DASD and Tape storage, I have a set number of frames that I can handle and I will let you know what the maximum BC limit will be.

Fiber Cable

| Strand 1 |
| Strand 2 |

FC Buffer Credits and Flow Control

- BB_Credits are the "admission control" mechanism in FC to ensure that FC switches don't run out of buffers (FC Switches cannot drop frames)

- For Devices operating at FC Class 3 (most devices), Buffer Credits are determined at login.

- BB_Credits are the only flow-control mechanism for FC Class 3.

11 available BB_Credits

15 available BB_Credits

15 available BB_Credits

12 available BB_Credits

16 available BB_Credits

FC

● **Frame towards Disk shelf**

▨ **Return BB_Credit token**

Buffer Credits (BB_Credits): Working Clean

Buffer Credits are a "Flow Control" mechanism to assure that frames are sent correctly

In an ideal FC network, there is no blocking in any device connected to the fabric. (All devices can process frames at the same rate and negotiate equal levels of BB_Credits)

FC

11/16
Available BB_Credits

7/16
Available BB_Credits

11/16
Available BB_Credits

Disk shelf capable of sustaining 8 Gbps data rate

Physical Tape capable of sustaining 4 Gbps data rate

⬤ **Frame towards Disk shelf**

⬤ **Frame towards Tape**

▨/▨ **Return BB_Credit token**
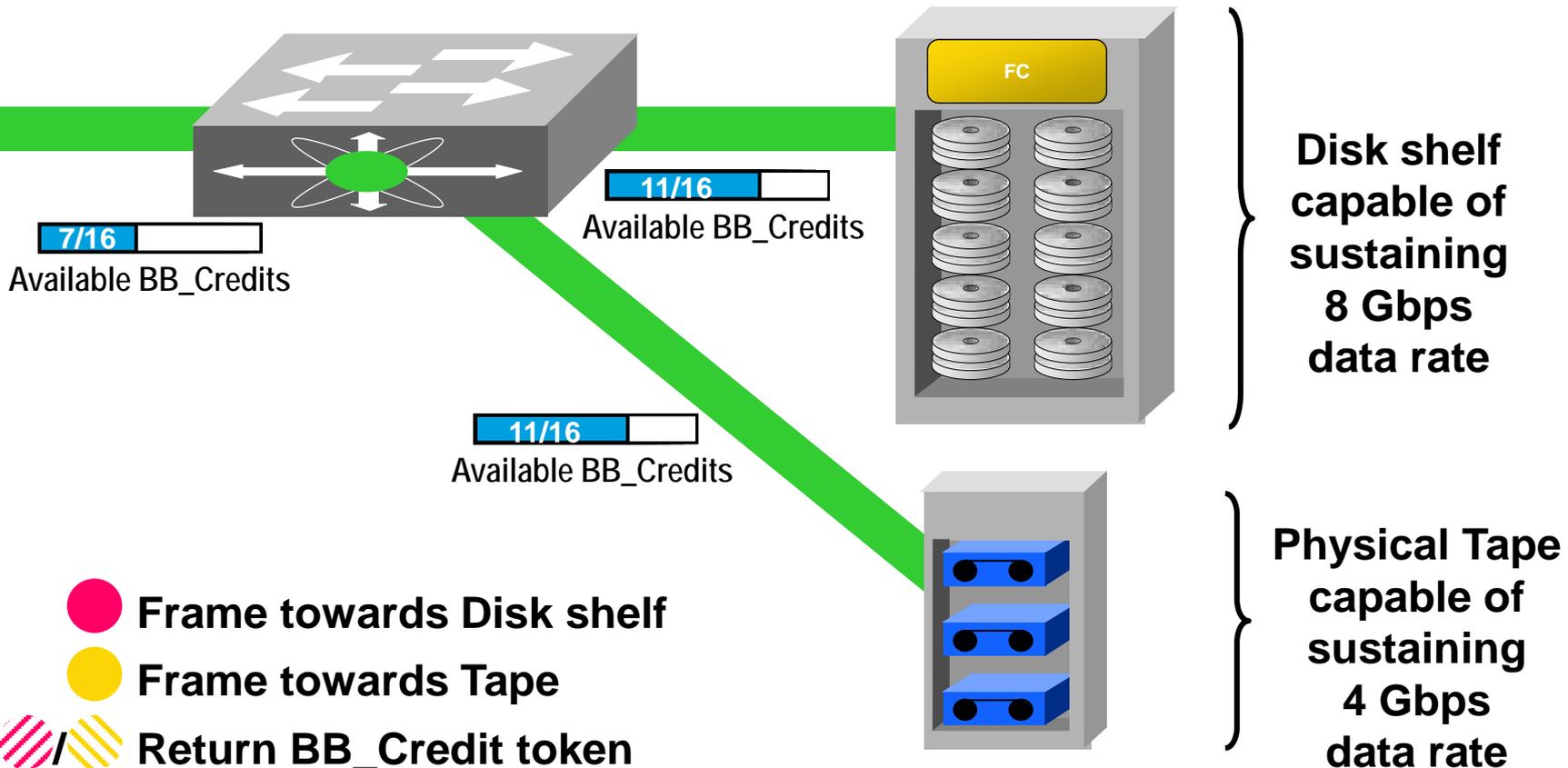
FC BB_Credits and Distance

1 Gbps FC

~2 km per Frame

32 Km

2 Gbps FC

~1 km per Frame

32 Km
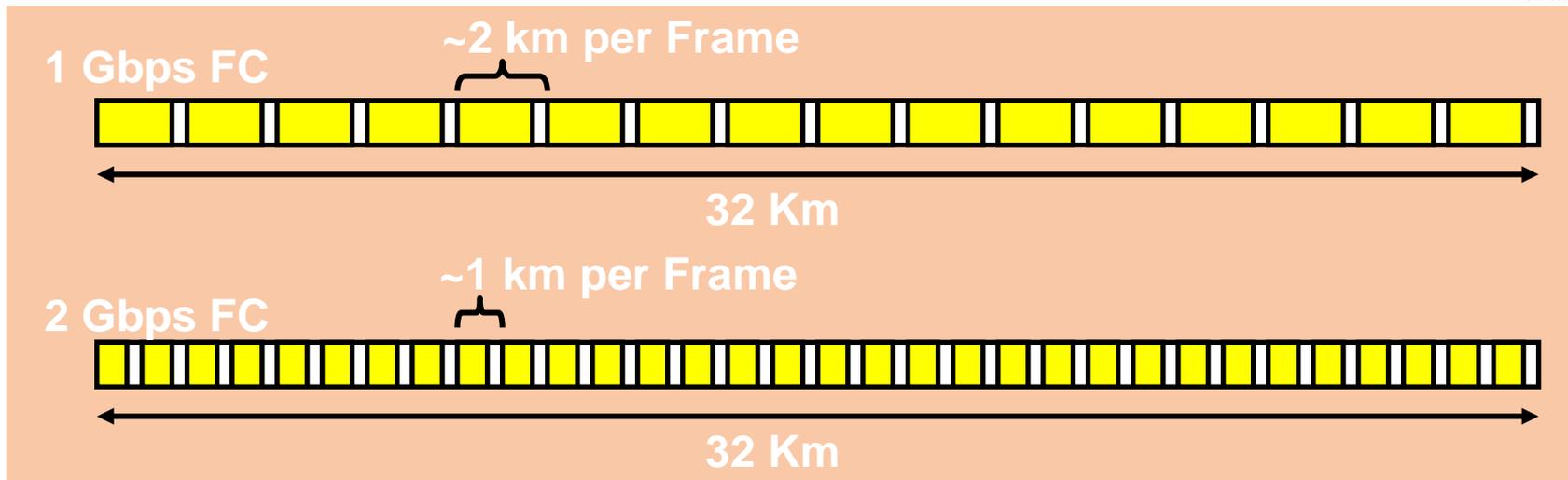
- BB_Credits are used to make sure that data frames do not overrun the receiver
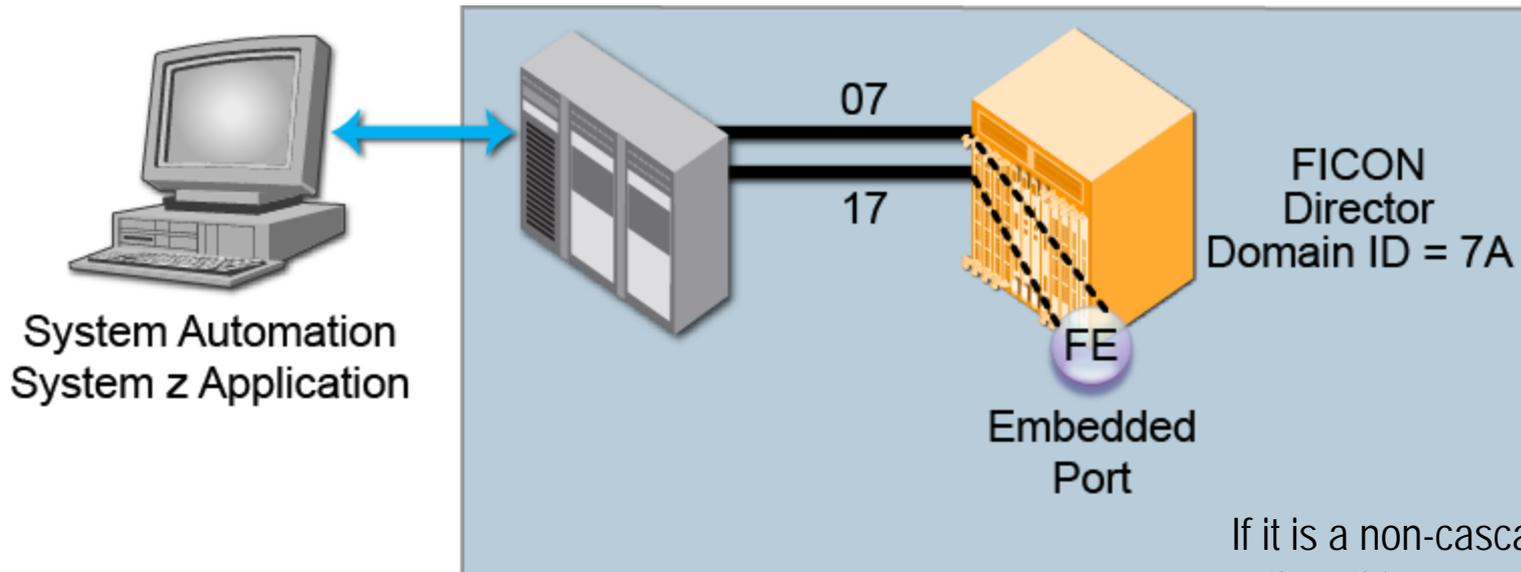
- BB_Credits are used to ensure high link utilization via enough FC frames in flight

- A full (2112 byte) FC frame is approximately 1 km long @ 2 Gbps and approximately .5 km long @ 4 Gbps and approximately .25 km long @ 8 Gbps, etc.

- As distance increases, the BB_Credits needed for high link utilization increase as well

- Shorter frames will require additional BB_Credits to ensure a "full pipe" – and *for most FC data* it is smaller frames that are sent!

- Insufficient BB_Credits will throttle performance—no data will be transmitted until a frame received acknowledge is returned (R_Rdy)

Buffer Credits Required
By Size of Frame and Link Speed

A distance of 20km with the link 100% utilized				2Gbps	4Gbps	8Gbps	10Gbps
SOF, Header, CRC, EOF	Payload	Total Frame Bytes	Smaller than full frame by x%	Buffer Credits Required 8b10b	Buffer Credits Required 8b10b	Buffer Credits Required 8b10b	Buffer Credits Required 64b66b
36	2112	2148	0.000%	20	40	80	117
36	2002	2038	5.138%	21	42	84	124
36	1902	1938	9.809%	22	44	88	130
36	1802	1838	14.481%	24	47	93	137
36	1702	1738	19.152%	25	49	98	145
36	1602	1638	23.823%	26	52	104	154
36	1502	1538	28.494%	28	56	111	164
36	1402	1438	33.165%	30	60	119	175
36	1302	1338	37.836%	32	64	128	188
36	1202	1238	42.507%	35	69	138	203
36	1102	1138	47.179%	38	75	150	221
36	1002	1038	51.850%	41	82	164	243
36	902	938	56.521%	46	91	182	268
36	819	855	60.398%	50	100	199	294
36	700	736	65.957%	58	116	232	342
36	600	636	70.628%	67	134	268	396
36	500	536	75.299%	80	159	318	469
36	400	436	79.970%	98	195	390	577
36	300	336	84.641%	127	254	507	748
36	200	236	89.312%	181	361	721	1065
36	100	136	93.984%	313	626	1251	1848
36	75	111	95.151%	383	766	1532	2264
36	50	86	96.319%	495	989	1978	2922

As distance link speed grows, so does the need for buffer credits!

Defining CUP in HCD

System Automation
System z Application

07

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FICON
Director
Domain ID = 7A

FE

Embedded
Port

If it is a non-cascaded fabric then this example could have used single byte LINK= addressing rather than 2-byte addressing.

CHPID PATH=(**07,17**),SHARED,TYPE=FC,SWITCH=7A

CNTLUNIT CUNUMBER=xxxx,PATH=(**07,17**),UNIT=2032,

UNITADD=((00,1)),LINK= (**7AFE,7AFE**)

IODEVICE ADDRESS=(xxxx,1),UNITADD=00,CUNUMBER=(xxxx),UNIT=2032

RMF 74-7 Records

- Enabling RMF 74 subtype 7 (RMF 74-7) records yields an RMF report called the "FICON Director Activity Report". This is for switches or Directors.

- Data is collected for each RMF interval if FCD is specified in the *ERBRMFnn* parmlib member …AND… in SYS1.Parmlib the IECIOSnn says FICON STATS=YES. (FCD/NOFCD can also be modified via an operator command)

- The FICON Director Activity Report captures information based on an interval which is set for RMF and tells it when to create this report along with others.
  - In essence, the report captures a snapshot of data and the counters based on an time interval, such as 20 minutes. Often, you need to run these reports more than once and change the interval periods for troubleshooting to determine if there is a trend .[1]

- This RMF report is often overlooked but contains very meaningful data concerning FICON I/O performance - in particular, frame pacing delay

- Frame pacing delay is the only fabric-wide method to indicate a BB_Credit starvation issue on a given port [2]

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Agenda for Session 12073 and 12074

Session 12073

- Types and Components of Storage

- Let's talk Fibre Channel

- FC Buffer Credits

- **Fabric Routing / Virtual Fabrics / Partitioning**

- Security / Zoning

Fabric Routing Across ISLs: FSPF

- For FSPF a domain ID identifies a single switch
  - This limits the max number of switches that can be supported in a Fabric to 239 when FSPF is supported
    - Each Cisco VSAN is treated as a separate Fabric
    - Each Brocade non-virtualized chassis is treated as a separate fabric
    - Each Brocade Virtual Fabric (DCX family) is treated as a separate fabric
    - Each Brocade Physical Partition (Mi10K) is treated as a separate fabric

- FSPF performs hop-by-hop routing
  - Each Cisco VSAN runs it's own FSPF process
    - Routing between VSAN's is done with Inter VSAN Routing (IVR)
  - Brocade will use FSPF routing if TRUNKING is not used
    - Old CNT/McDATA devices always use FSPF for initial ISL routing

- FSPF supports hierarchical path selection
  - Provides the scalable routing tables for large topologies

Deploying Virtual Fabrics / Virtual SANs

- Multiple Virtual SANs in a single hardware entity
  - Used to Converge SAN Islands
  - IETF RFC 4747
  - Although it is a Standard – Implementations are different per Vendor

- Brocade
  - Creating a Logical Switch creates a Virtual Fabric (VF)
  - Each Logical Switch will have a unique Domain ID

- Cisco
  - Virtual SANs (VSANs) are incorporated into the architecture
  - Each VSAN will have a unique Domain ID

Virtual Fabrics (VF) for DCX Family

Local Switching

Local Switching
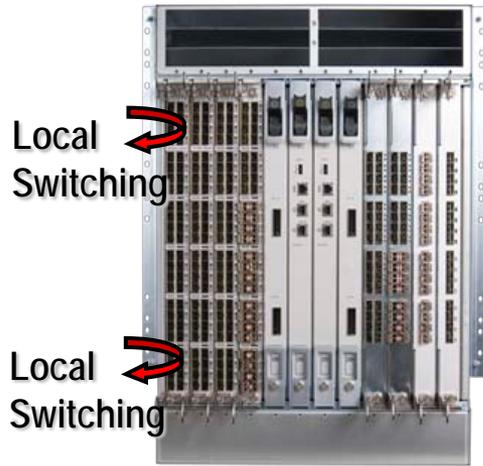
We expect most customers to deploy FICON on a non-virtualized chassis

An infrastructure that is supporting intermixed protocol use (FICON/FCP) or hosts different customers on the same infrastructure might desire virtualization

Local Switching

VF1 CUP

VF2 CUP

Local Switching

CUP CUP CUP CUP

VF1 VF2 VF3 VF4
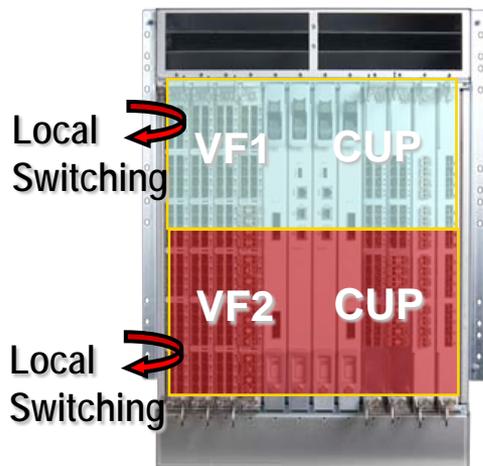
- VF is an OPTIONAL feature on all of the Brocade DCX family of FICON/SAN Directors

- But DCX 48-port blades for FICON can be used only when Virtual Fabrics are enabled on the DCX or DCX 8510-8
  - DCX-4S and the DCX 8510-4 never require the use of VF

- Creating a Logical Switch, which enables Virtual Fabric, began at FOS 6.2 and FOS 7.0 is current

- VFs create new services within each Virtual Fabric
  - Domain ID
  - Name Server, etc

- Provides additional isolation of ports within a chassis

Cisco's VSANs (Virtual SAN)

A way to Partition a Switch or SAN into a Virtual/Logical environment

- Virtual SANs created from larger cost-effective redundant physical fabric

- Reduces wasted ports of the older "island" approach

- Hardware-based isolation

- Statistics can be gathered per VSAN

- Management per VSAN

- Unique Serial Number / CUP per FICON VSAN

- Service and process level Isolation between VSANs
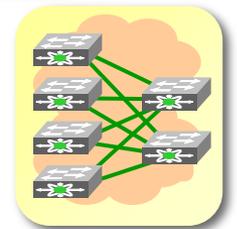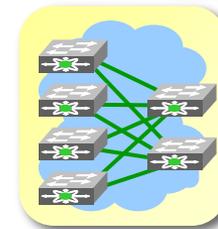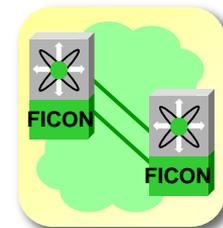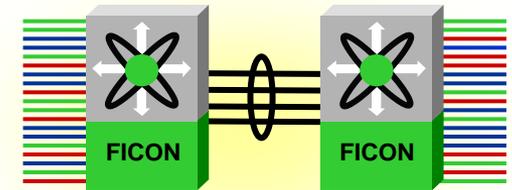
Agenda for Session 12073 and 12074

Session 12073

- Types and Components of Storage

- Let's talk Fibre Channel

- FC Buffer Credits

- Fabric Routing / Virtual Fabrics / Partitioning

- **Security / Zoning**

Zoning

- A logical grouping of fabric connected devices within a SAN (or virtual fabric)

- Zoning establishes access control
  - Devices within a zone can access each other

- Zoning increases security
  - Limiting access prevents unauthorized access

- Zone membership might be configured by:
  - Port World Wide Name (pWWN)—device
  - Fabric World Wide Name (fWWN)—fabric
  - Fibre Channel Identifier (FCID)
  - Fibre Channel Alias (FC_Alias)
  - IP address
  - Domain ID/port number
  - Interface

Physical Topology

VF 2

ZoneA

Disk2 Disk3
Host1 Disk1

ZoneC

ZoneB

Disk4 Host2

VF 3   ZoneD

Host4

ZoneA

Host3 Disk5
Disk6
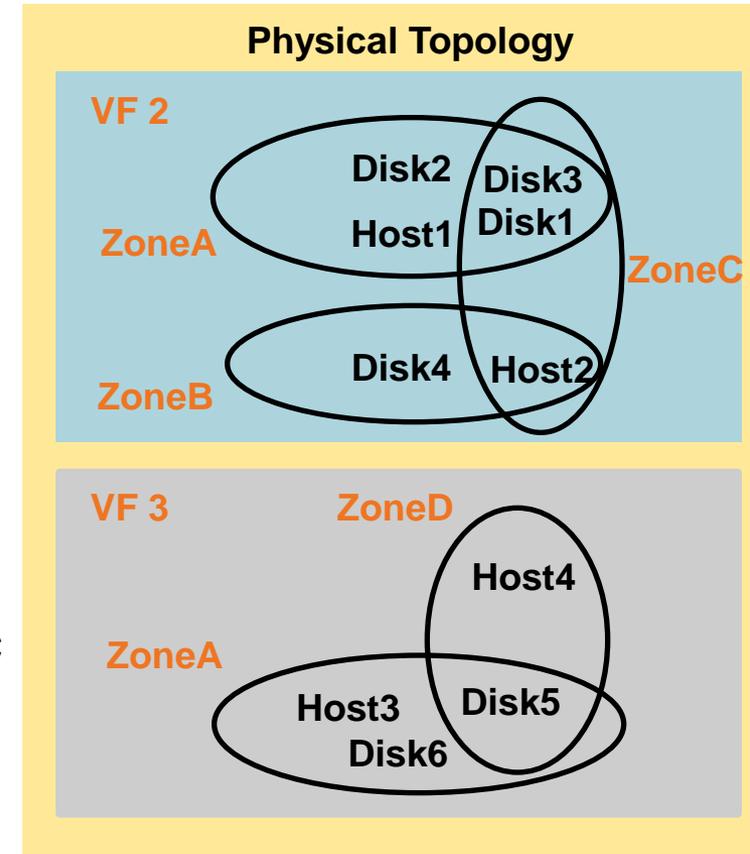
FICON Port Security

- Zoning
  - Able to be used with FICON (some vendors require it, others don't)

- Single Domain
  - Prohibit / Allow Matrix (ala. ESCON like port blocking/unblocking)

- Cascaded Configurations
  - Access to Cascaded resources controlled from IOCDS
  - Can also be done with Zoning but most choose not to

You can block or prohibit ports, eg:
- **05 is blocked and prohibited on all**
- **04 can reach 07 and 0C**
- **07 is prohibited from 0C**

SAN Sessions at SHARE this week

Monday:

Time-Session

1100 - 12074: <u>SAN (Storage Area Networking) Overview - Part 2</u>

1330 - 12078: <u>Why Customers Should Deploy Switches in Their SAN and FICON Environments</u>

Tuesday:

Time-Session

0930 – 11152: <u>DLm 'Tape on Disk' VTL Customer Experience & Benefits</u>

1330 - 12072: <u>A First Look at the Inner Workings and Hidden Mechanisms of FICON Performance</u>

1500 - 12071: <u>A Deeper Look Into the Inner Workings and Hidden Mechanisms of FICON Performance</u>

Wednesday:

Time-Session

0800 - 12076: <u>Buffer-to-Buffer Credits, Exchanges, and Urban Legends</u>

1330 - 12077: <u>ESCON I/O Will Not Be Supported On Future System z Platforms. What Do I Do?</u>

1500 - 12075: <u>zSeries FICON and FCP Fabrics - Intermixing Best Practices</u>

Thursday:

Time-Session

1630 - 12084: <u>Buzz Fibrechannel - To 16G and Beyond</u>

Complete your sessions evaluation online at SHARE.org/AnaheimEval

Mainframe/SAN Resources For You To Use

Visit Brocade's Mainframe Blog Page at:

http://community.brocade.com/community/brocadeblogs/mainframe

Visit Brocade's New Mainframe Communities Page at:

http://community.brocade.com/community/forums/products_and_solutions/mainframe_solutions

Visit Cisco's Storage Networking Page at:

http://www.cisco.com/en/US/products/hw/ps4159/index.html

This Is The End Of Part 1

The 2nd of this 2-part session is

Session 12074

Monday: 11:00AM – 12:15PM

THANK YOU FOR ATTENDING!

Session **12073**

Please fill out your evaluation forms

QR Code

Questions and Discussion

Session 12074

QR Code

**Introduction to Storage Technologies
FICON (FIber CONnection) and
a little SAN (Storage Area Networking)**

David Lytle – Brocade – dlytle@brocade.com
Mike Blair – Cisco   – mblair@cisco.com

SAN 201

Agenda for Session's 12073 and 12073

1st Session 12073 – 09:30am – 10:30am

- **Types and Components of Storage**
- **Let's talk Fibre Channel**
- **FC Buffer Credits**
- **Fabric Routing / Virtual Fabrics / Partitioning**
- **Security / Zoning**

…. then continued in the 2nd session…

2nd Session 12074 – 11:00am – 12:15pm

- **History**
- **Mainframe Terminology, Connectors, Cables, and Wavelengths**
- **Addressing in FICON**
- **ESCON Status, zHPF and NPIV**
- **Buffer Credits, CUP, RMF**

Brocade, Cisco and IBM Graphics are used throughout this presentation.

Agenda for Session 12073 and 12074

Session 12074

- **History**

- Mainframe Terminology, Connectors, Cables, and Wavelengths

- Addressing in FICON

- ESCON Status, zHPF and NPIV

- Buffer Credits, CUP, RMF

Mainframe And Open System Time Lines

1964
System 360

1973
Virtual Memory

1974
OS/VS 2 MVS

1980
Dynamic Channel Reconnect

1988
Physical Partitions

1988
ILM Storage Mgmt (HSM/SMS)

1989
Very First SAN was ESCON Directors

1998
248 port HA ESCON Director

2000
FICON Introduced

2008
FICON zHPF

2009
FICON Express8

2010
System z196

2011
System z114

2011
FICON Express8S

1964   1970   1980   1990   2000   2010

1974 Intel 8080

1981
IBM PC

1992
Win 3.1

1997
1st SAN Switch

1998
1st HA SAN Director

2001
Server VMWare

2006
1st FC Director with Physical Partitions

2007 Windows VISTA

2009
Windows 7

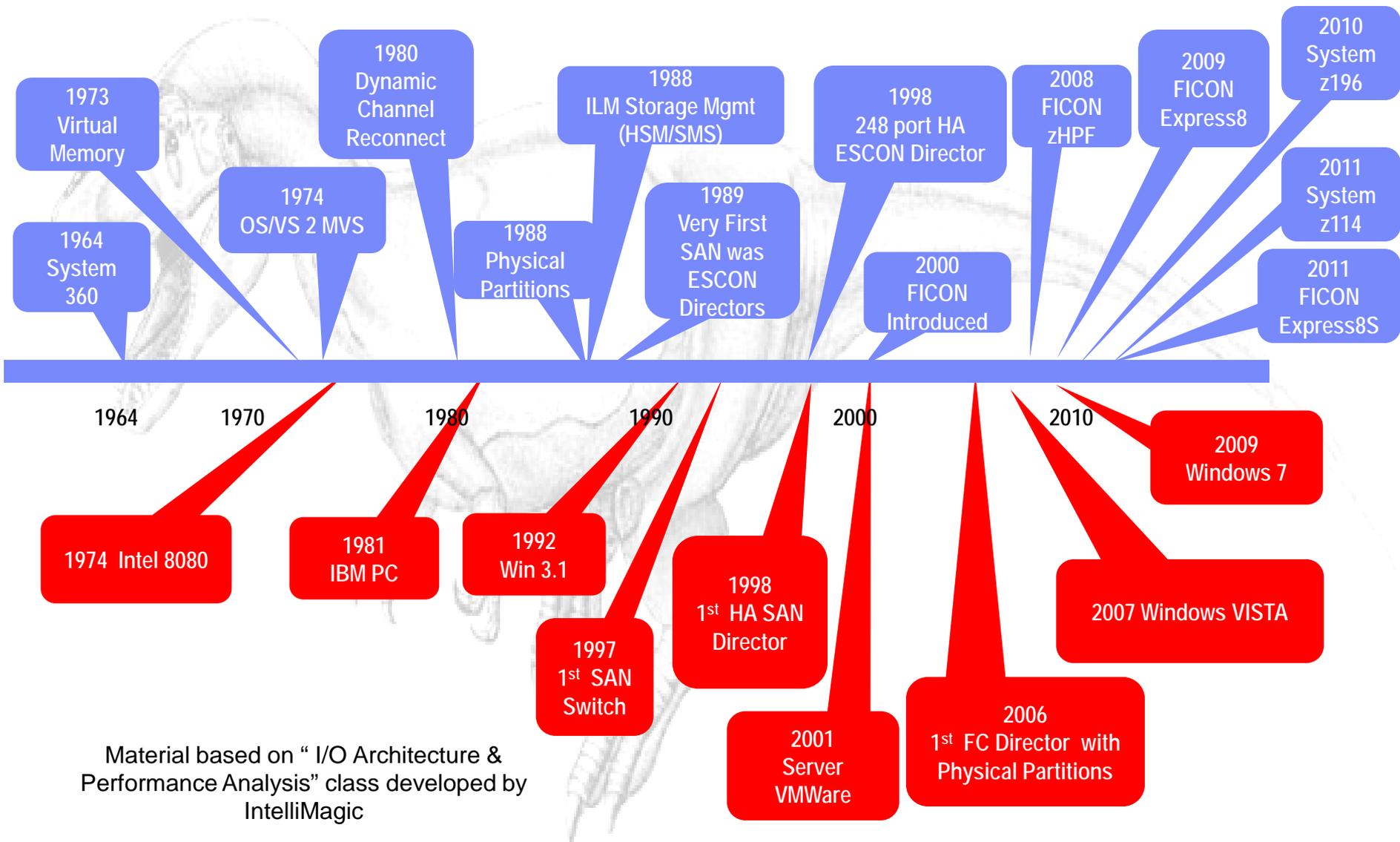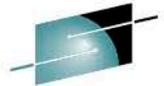Material based on " I/O Architecture & Performance Analysis" class developed by IntelliMagic

2012

Agenda for Session 12073 and 12074

Session 12074

- History

- **Terminology, Connectors, Cables, and Wavelengths**

- Addressing in FICON

- ESCON Status, zHPF and NPIV

- Buffer Credits, CUP, RMF

SAN Terminology -- *Definitions*

- "Fibre" is the protocol/architecture used to transport frames
  - As in "the fibre channel protocol"

- "Fiber" is the glass cable used to attach connections
  - As in "the fiber cable"

- Allows up to 16 million nodes of connectivity

- Historically has used 8-bit/10-bit encoding/decoding to translate an 8-bit byte of information to 10-bit format for serial transmission within the payload of a fibre channel frame
  - But 10Gbps and 16Gbps utilize 64b66b for more efficiency

- Variable frame size with a maximum user payload of 2112 bytes.

- Supports transfers of files that are blocked at up to 128MB in size.

- Supports full duplex transmission
  - Simultaneous send and receive

SAN Terminology -- *Fiber Channel Link*

- Light wavelengths in fiber are expressed in nanometers

- Speed of light in fiber cable is 2/3^{rds} the speed of light in a vacuum
  - Light travels at ~5 nanoseconds per meter (3.3 ft) of distance in glass

- **Multimode fiber** is used for numerous frequencies which are all short-wave frequencies (62.5, 50 micron) of laser light.
  - Always used with short wave optics (transceivers)
  - Used for local distance connectivity (~33-1,640 feet...or...10-500 meters)

- **Single-mode fiber** has a smaller core that allows only one frequency of light (9 micron) which is long-wave laser light.
  - Always used with long wave optics (transceivers)
  - This is used for longer distance connectivity (up to 15.5 miles or 25 km)

- Optical power budgets, or link loss budgets, measured in decibels (dBs), are used to manage optical signal loss.

Why Customers Use Mainframes

- Organizations that run an IBM System z platform have unique business requirements.

- They need a **very powerful, highly available, robust and scalable environment** that can support high-volume transaction processing with demanding batch windows and large, critical application portfolios.

- There are tremendous opportunities (like private cloud computing) for leveraging the vast computing power of System z to help greatly simplify the computing environment while substantially reducing overall costs and power consumption.

- All of this makes System z a critically important platform for the future of large enterprise-scale computing!

Mainframe Terminology

System z

This is one CHPID

4G

8G

Up to 336 FICON CHPIDs on z9 / z10
Up to 320 FICON CHPIDs on z196
Up to 128 FICON CHPIDs on z114

All CHPIDs on a channel card must be the same -- LX or SX – no mixture
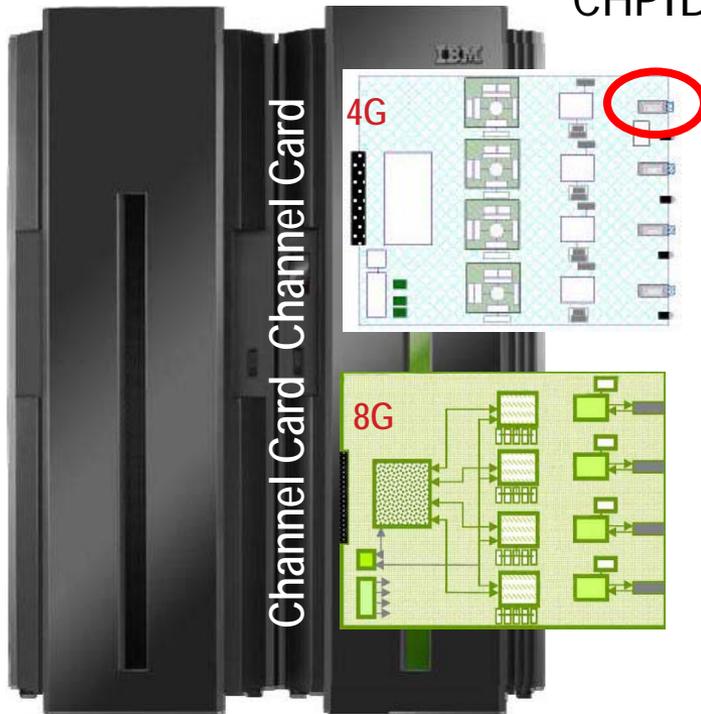
Channel or Channel Path Identifier (CHPID)

A physical connectivity port which is embedded in the mainframe processor's channel system

A CHPID will be either long wave or short wave and depending upon the installed channel card it could be 1Gbps, 2Gbps, 4Gbps or 8Gbps referred to as FICON Express or FICON ExpressX (where X is 2, 4 or 8) or FICON Express8S

Mainframe Terminology

System z Mainframe (M/F)

LPARs

From 1 to 60 LPARS on a System z
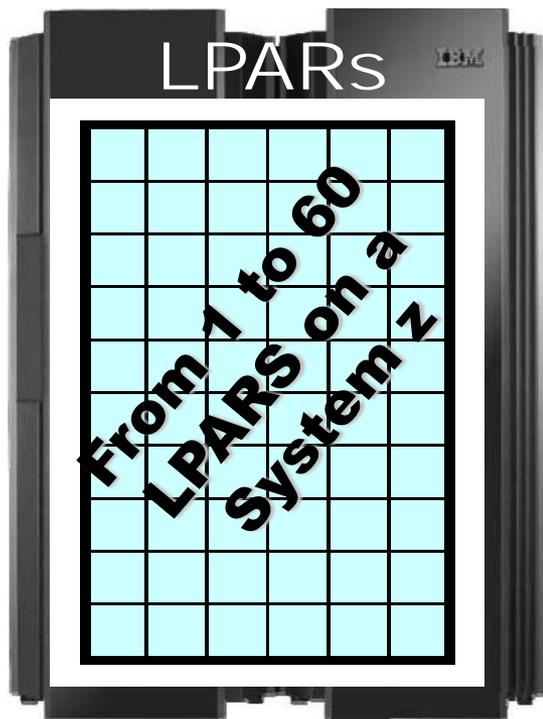
Each LPAR runs its own operating system and has some number of processors assigned to it as CPs and specialty engines

Logical Partitions (LPARs)

- Available since 1988 this is a way of dividing up a mainframe's capacity into **L**ogical **PAR**titions and isolating each LPAR from every other LPAR to ensure RAS.

- System 390 and zSeries could run up to 15 partitions per physical mainframe.

- System z can run up to 60 partitions per physical mainframe.

Mainframe Terminology

Channel Path

The fiber between the channel and the storage subsystem, as well as the interface adapter on the subsystem and any interleaving directors

A channel path can be Point-to-Point path or it can be a switched path

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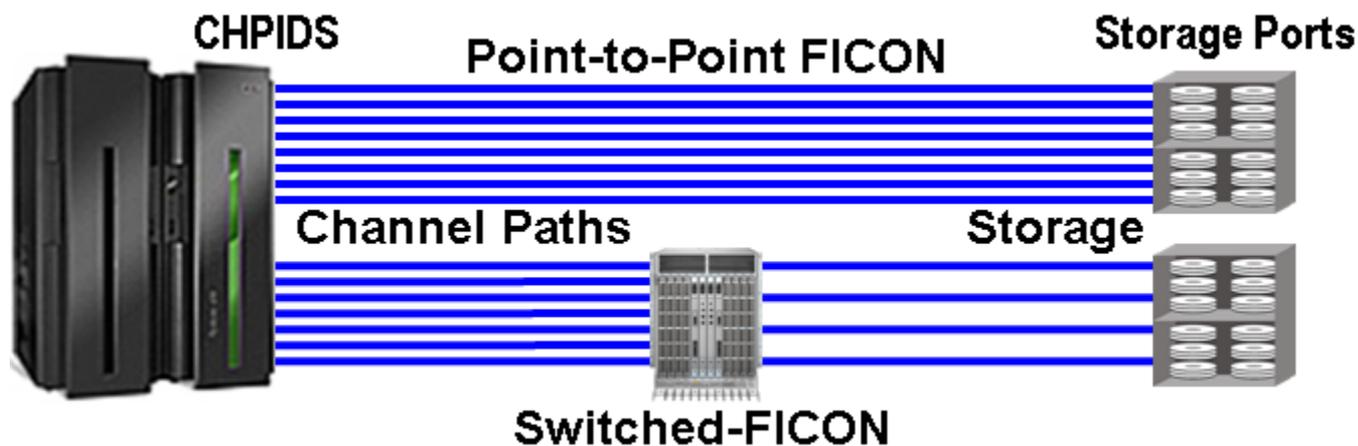
Mainframe Terminology

ESCON Channel Paths – 1990

- This old protocol provides a circuit switched, unidirectional data transfer mechanism.

- Once proprietary, it did become a FC standard – SBCON

- Once a data transfer for an I/O from channel to subsystem or subsystem to channel has begun, no other I/O operations can employ the channel until that transfer has been completed.

System z

Point-to-Point ESCON

ESCON CHPID

Unidirectional data flow only

Half duplex – about 3-12MBps

9032 ESCON Director

9032 ESCON Director Models 3 and 5 were HA models

CU-A
CU-B
CU-C
CU-D
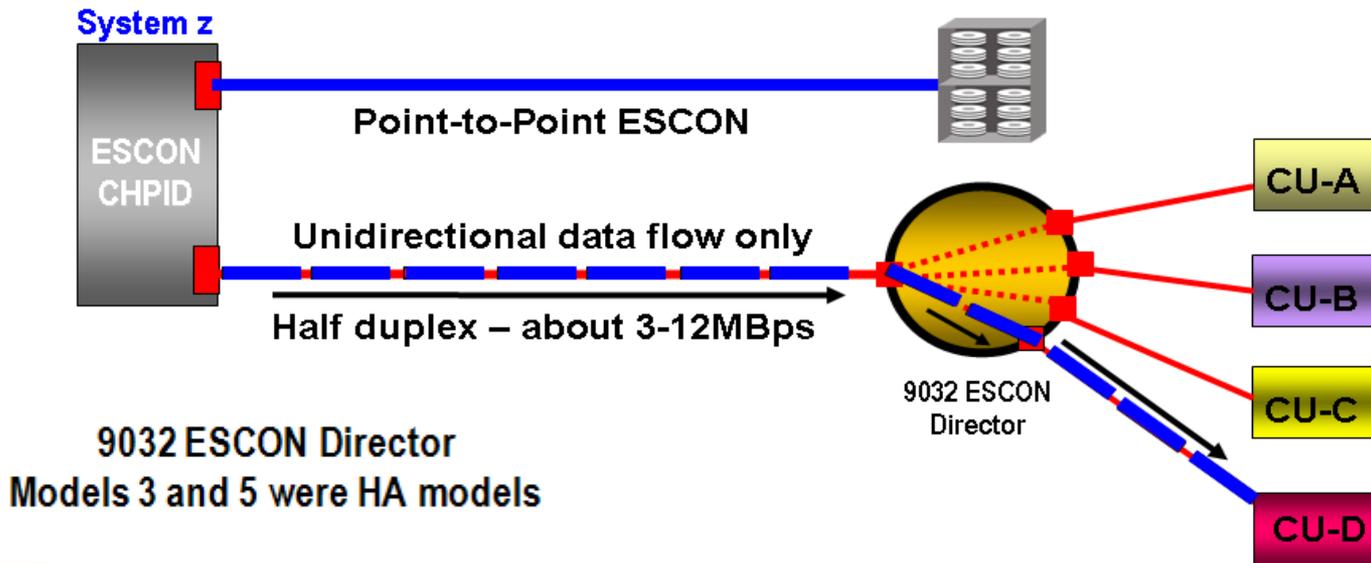
Mainframe Terminology

FICON Channel Paths - 2000

- This newer but mature protocol provides a very robust packet switched, bi-directional data transfer mechanism.

- System z10, z196 and z114 can do up to 64 open exchanges unless zHPF is driving the I/O in which case ~600 OEs can be active.
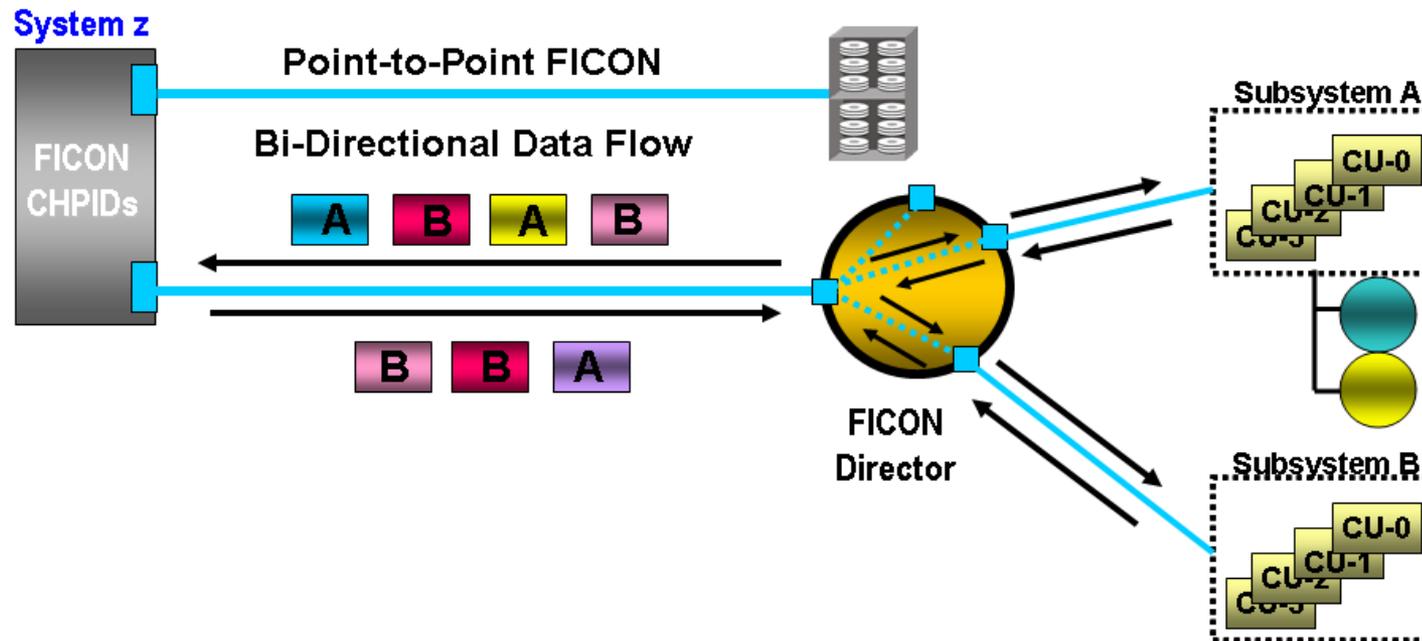
ESCON versus FICON I/O Protocol

- **ESCON among other things is:**

- Very old (September 1989)
- Proprietary protocol / now SBCON
- Half-Duplex at ~10-14 MBps
- Maximum of about 1,200 IOps
- Short distances of ~3-9 km
- Restricted number of control units per channel - 15
- Only 1,024 devices per channel allowed
- No channel consolidation going from bus-tag to ESCON
- Lots of multi-mode optical cables used for connectivity needed to be managed

- **FICON among other things is:**

- Most Current (December 2000)
- FC Standards-based protocol
- Full-Duplex at 130-1600 MBps
- 23,000 (CCW) or 92,000 (TCW) IOps
- Long distances of Local-to-25 km
- Better use of the 15 control units than ESCON
- 16,384 devices per channel are now allowed
- Channel consolidation from 2:1 up to 16:1 when going to FICON
- Fewer single-mode and/or multi-mode cables are needed makes management easier

So What Is FICON (**FI**ber **CON**nection)?

- FICON has always been non-proprietary – based upon Fibre Channel Standards

- FICON was a major technical improvement over ESCON and continues to mature and get better and faster all the time

- Worldwide, there are still about ~20 to 30% of ESCON users that still need to completely migrate to FICON
  - The z114 mainframe will be the last mainframe to host ESCON CHPIDs
  - ESCON Directors will soon go to End of Support

- Many factors are pushing end users towards FICON:
  - Mainframes are getting faster and more flexible
  - DASD and Tape storage is getting faster and faster
  - Customer requirements are much wider and deeper
  - IBM support for ESCON is waning

Mainframe Terminology

1971 / 1974
S/390 Mainframe (M/F)
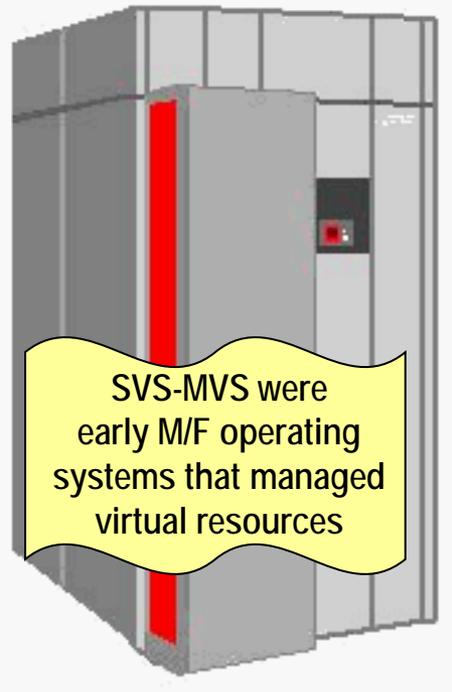
Single Virtual Storage (SVS): Multiple Virtual Storage (MVS)

SVS-MVS were early M/F operating systems that managed virtual resources

MVS was introduced in 1974, and it is often mentioned, even today, by old mainframer's as their primary operating system

MVS has become the de facto name for the mainframe operating system

This z/OS ancestor was a 24-bit, virtualized, batch processing-oriented operating system that managed lots of memory and DASD space for its time.

MVS could be run in up to 15 partitions on a M/F or could be intermixed with other operating systems running in other LPARs

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Mainframe Terminology

System z Mainframe (M/F)

z/OS is the most current M/F operating system that manages virtual resources

z/OS can run in up to 60 partitions on a M/F or it can be intermixed with other operating systems running in other LPARs

Z Operating System (z/OS)

- Was introduced in 2000 when the zSeries mainframes became available.

- z/OS is a 64-bit server operating system, the latest IBM mainframe operating system, combining MVS and UNIX System Services (formerly known as MVS Open Edition, or OpenMVS).

- Starting in 2010, on z196 and z114, z/OS can directly connect and manage an IBM BladeCenter with Power 7 and IBM System x blades

Mainframe Terminology

System z Mainframe (M/F)

TPF usually runs on its own mainframe to help insure availability but it can run with other OS's
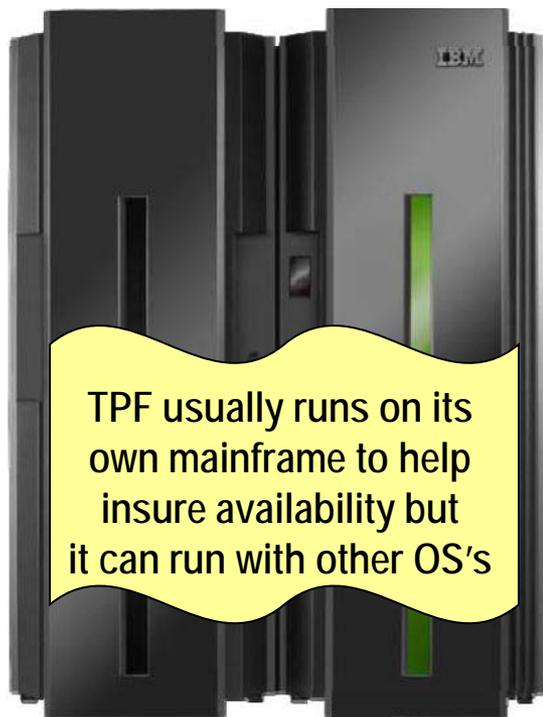
TPF is a risk adverse system that demands the highest performance and availability levels!

Transaction Processing Facility (TPF)

This is a mature real-time operating system that processes many requests very quickly and runs on mainframes like *zSeries* and *System z.*

Any company that needs to process very high volumes of transactions (hotels, airlines, cruise lines, etc.) often utilizes this operating system which requires very high availability.

Mainframe Terminology

System z Mainframe (M/F)

VM runs other operating systems, such as Linux, that are "guests" of the VM system
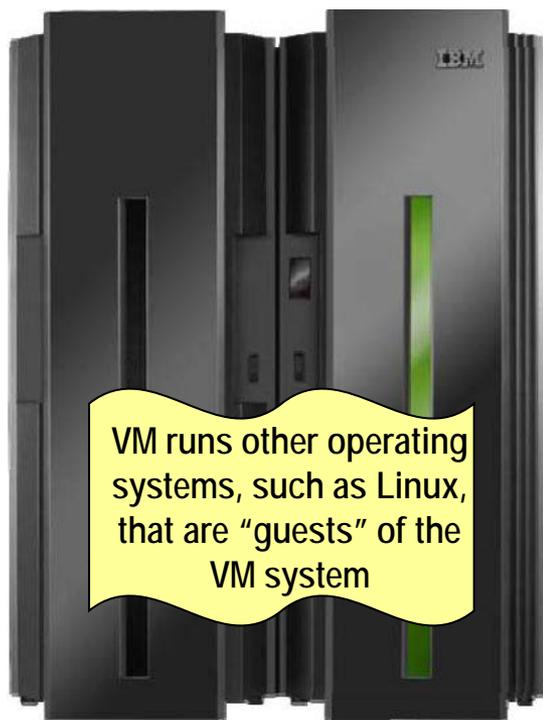
Linux on the System z is most often run as a "guest" under VM and VM actually does the I/O on behalf of Linux

Virtual Machine (VM)

Officially called VM/ESA (Enterprise Systems Architecture), it is an operating system for mainframes that can host other operating systems, including z/OS and Linux.

Each of the guest OS's seems to have its own complete system of software and hardware resources (data storage, processor,…) but are actually sharing resources via VM services.

Mainframe Terminology

System z Mainframe (M/F)
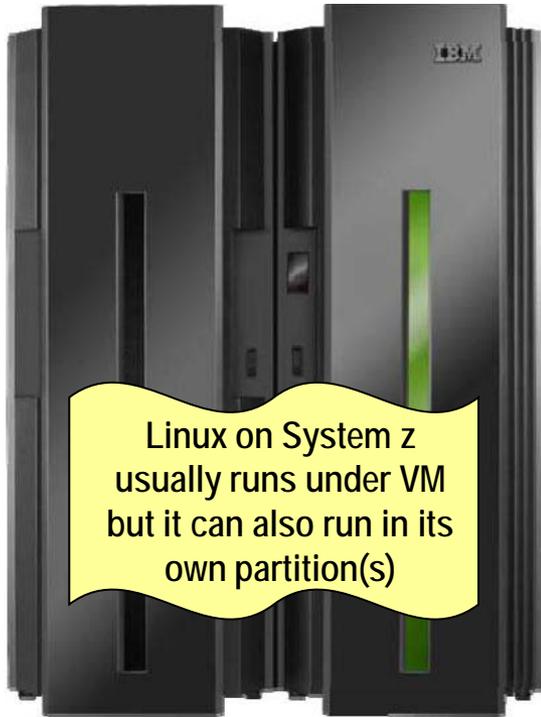
Linux On System z (zLinux)

Linux on System z usually runs under VM but it can also run in its own partition(s)

FICON channels in FCP mode for use with zLinux use the Queued Direct Input/Output (QDIO) I/O for communication with the operating system.

- Linux on System z allows a customer to leverage their highly available, reliable and scalable mainframe along with their highly available and powerful FCP and FICON infrastructure capabilities

- A Linux administrator now simply administers Linux on a "Big Server"

- Linux has been running on System z since 1999 – thirteen years ago!

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Mainframe Terminology

Hardware Configuration Definition (HCD)
Define the mainframe's computing and I/O environment

```
Example FICON IOCP

ID

RESOURCE PARTITION=(LP1,1),(LP2,2),(LP3,3)
CHIPID PATH=(AD),SHARED, SWITCH=01,TYPE=FC
CHIPID PATH=(B2),SHARED, SWITCH=01,TYPE=FC
CHIPID PATH=(B6),SHARED, SWITCH=01,TYPE=FC
CHIPID PATH=(BA),SHARED, SWITCH=01,TYPE=FC

CNTLUNIT CUNUMBER=5000, PATH (AD,B2,B6,BA),
    UNITADD=((00,256)),LINK=(0114,0116,011A,011C),
    CUADD=0,UNIT=2105

    *

CNTLUNIT CUNUMBER=5700, PATH (AD,B2,B6,BA),
    UNITADD=((00,256)),LINK=(0104,0106,010A,010C),
    CUADD=7,UNIT=2105

IODEVICE
```

LP1-1	LP2-2	LP3-3

System z

AD B2 B6 BA

FICON
Switch.ID 01
Switch.@01

14 16 1A 1C

CU
LCU-7
LCU-n
LCU-0
CU 5000

Devices

Devices

Devices
5000-50FF

HCD is an element of z/OS that provides the interactive tool which is used to define the hardware configuration for both a processor's channel subsystem and the operating system running on the processor.
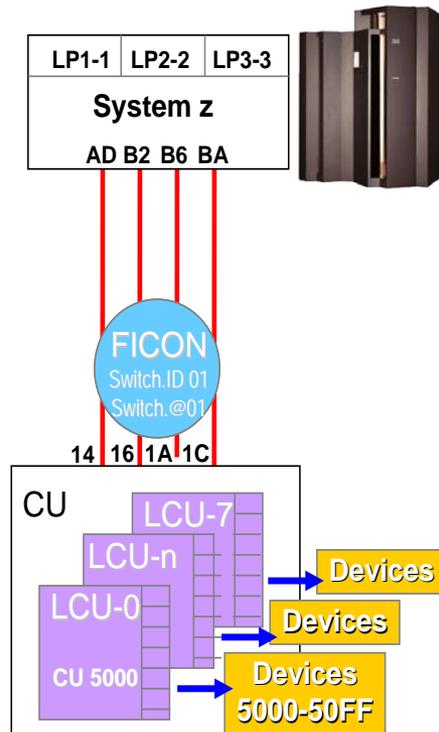
Hardware Configuration Definitions (HCD)

- HCD provides an interactive interface that allows customers to define the hardware configuration for both a processor's channel subsystem and the OS running on the processor.

- There really isn't a comparable facility in the distributed world.

Mainframe Terminology

Sysplex and Parallel Sysplex
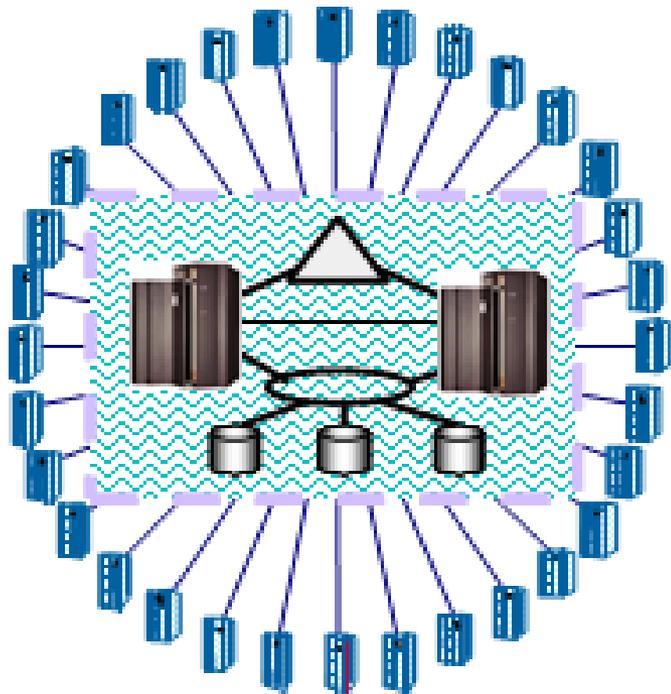
Sysplex

1 to 32 Mainframes

A Parallel Sysplex provides a clustered environment to provide both parallelism for application processing as well as better reliability/availability

- IBM's **SYS**tems Com**PLEX** was introduced in 1990 as a platform for the MVS/ESA operating system for IBM mainframe servers. The sysplex consists of the computer or multiple computers that make up the Computer Electronics Complex (*CEC*).

- *Parallel Sysplex* is a Sysplex evolution providing a clustering architecture that has improved communication capabilities and supports more connected Central Processing Complexes (*CPCs*) and more copies of the operating system and is often deployed with a *Workload Manager capability*.

Components of a SAN Connection

Server   **Channel**   **Transceiver**   **Connector**   **Fiber**   **Storage Network**   **Disk**   **Tape**

FC HBA or
FICON Channel
Card

LED (no longer used)
Laser-SX
Laser-LX

LC Duplex MM
LC Duplex SM
SC Duplex MM
SC Duplex SM

50 or 62.5 micron
Multimode (MM)

9 micron SM
 - Jumpers
 - Patch Cables
 - Conversion Kits

Switches
Directors

Storage   Storage
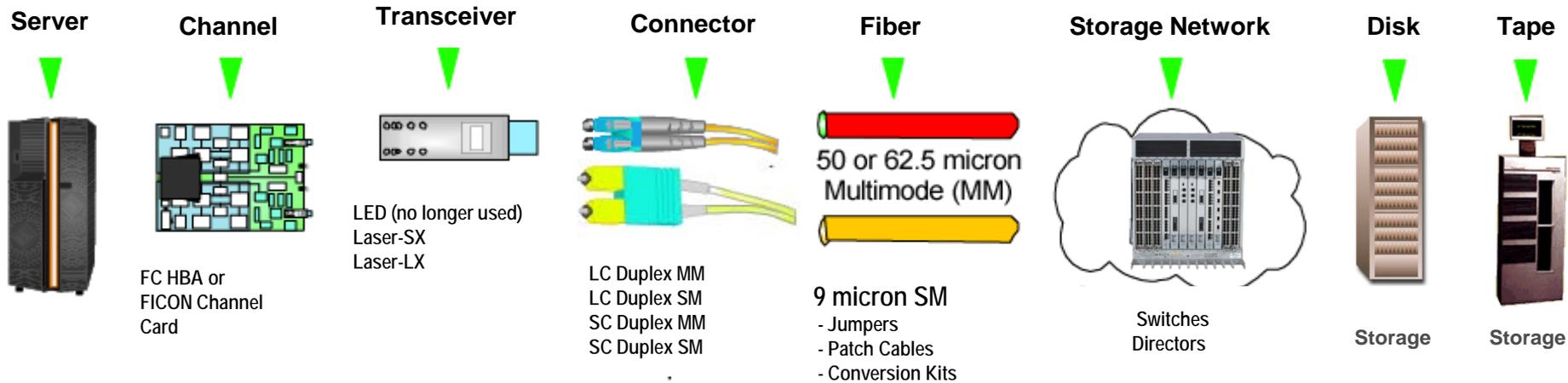
This is a component summary of how everything works together in order to effectively deploy a fibre channel I/O infrastructure.

Open Systems compared to Mainframe

HOSTS Open Systems

Server HBA

Uses Zoning, PDCM, Trunking and Virtual Fabrics

Switch / Director

Optic
2/4/8/16Gbps
SX / LX

Fibre Cable
MM / SM

Fibre Cable
SM / MM

Optic
2/4/8Gbps
LX / SX

Storage Adapter

Disk

LUNs

Path

2/4/8/10/16 Gbps

FICON Express Channel Card

Uses HCD, Zoning, PDCM, Trunking and Virtual Fabrics

Director / Switch

Optic
2/4/8Gbps
LX / SX

Fibre Cable
SM / MM

Fibre Cable
MM / SM

Optic
2/4/8Gbps
SX / LX

Storage Adapter

DASD

Volumes, Datasets, Unit Control Blocks (UCBs)

CHPID/Channel

Mainframe

2/4/8/10/16 Gbps

Multi-mode OM2
50 micron 500mHz
2/4 Gbps

Multi-mode OM3
50 micron 2000mHz
2/4/8/10/16Gbps

Multi-mode OM4
50 micron 4700mHz
2/4/8/10/16Gbps

Single-mode OS1
9 micron
2/4/8/10/16Gbps ~ 10k

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Agenda for Session 12073 and 12074

Session 12074

- History
- Terminology, Connectors, Cables, and Wavelengths
- **Addressing in FICON**
- ESCON Status, zHPF and NPIV
- Buffer Credits, CUP, RMF

FICON Traffic Routing – Single Switch
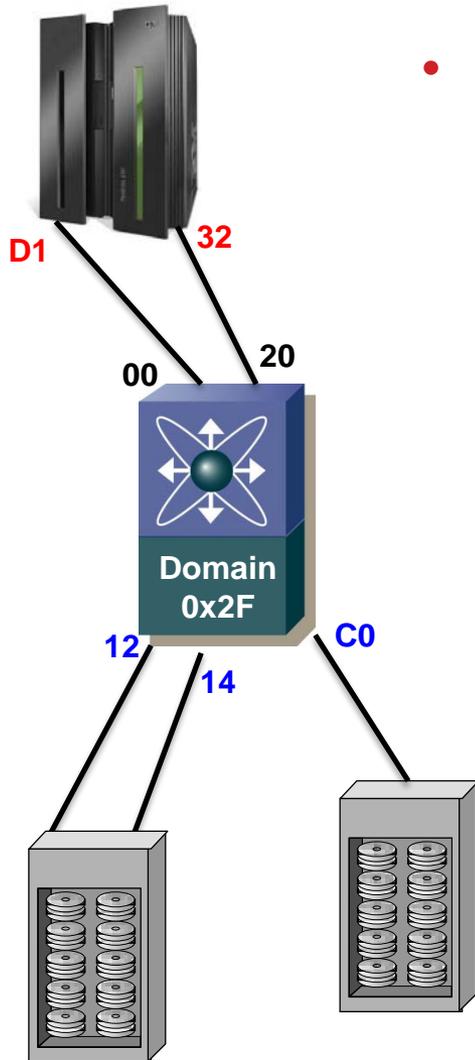
- Mainframe uses static FCID-based routing for devices
  - CHPIDs 32 and D1 are connected to a single switch
  - Switch has statically defined domain of 0x2F
  - Host IOCDS or HCD defines route to devices
  - Specifying the CHPID(s) and corresponding output port

D1

32

00

20

Domain 0x2F

12

14

C0

```
CHPID PATH=(CSS(0),D1),SHARED,                                    *
      PARTITION=((LPARMVSY),(LPARMVSX,LPARMVSA,LPARMVSB,VMLPAR*
      02)),SWITCH=2F,PCHID=1B1,TYPE=FC
CHPID PATH=(CSS(0),32),SHARED,                                    *
      PARTITION=((LPARMVSY),(LPARMVSX,LPARMVSA,LPARMVSB,VMLPAR*
      02)),SWITCH=2F,PCHID=1B3,TYPE=FC
```

FICON Traffic Routing – Single Switch
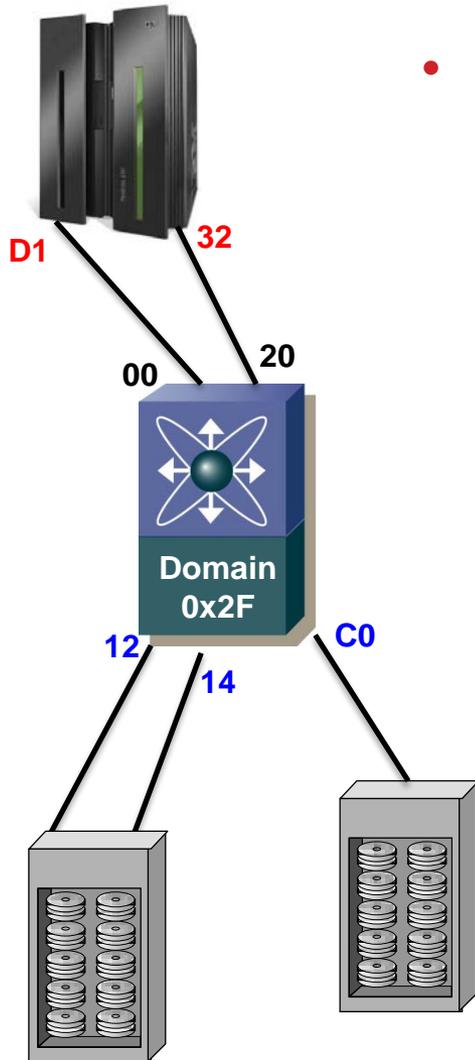
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  - Switch has statically defined domain of 0x2F
  - Host IOCDS or HCD defines route to devices
  - Specifying the CHPID(s) and corresponding output port

```
CHPID PATH=(CSS(0),D1),SHARED,                                   *
      PARTITION=((LPARMVSY),(LPARMVSX,LPARMVSA,LPARMVSB,VMLPAR*
      02)),SWITCH=2F,PCHID=1B1,TYPE=FC
CHPID PATH=(CSS(0),32),SHARED,                                   *
      PARTITION=((LPARMVSY),(LPARMVSX,LPARMVSA,LPARMVSB,VMLPAR*
      02)),SWITCH=2F,PCHID=1B3,TYPE=FC


CNTLUNIT CUNUMBR=0CC0,PATH=((CSS(0),D1,32)),                     *
      LINK=((CSS(0),12,14)),                                     *
      UNIT=2105,CUADD=B,UNITADD=((00,032))

CNTLUNIT CUNUMBR=0C00,PATH=((CSS(0),D1)),                        *
      LINK=((CSS(0),C0)),                                        *
      UNIT=2105,CUADD=C,UNITADD=((00,032))
```

D1   32

00   20

**Domain
0x2F**

12   C0

14

FICON Traffic Routing – Cascade

- Mainframe two switch routing
  - CHPIDs 32 and D1 connected to a host-side switch (0x2F)
  - DASD is attached to a different switch (0x2E)
  - Host IOCDS or HCD defines route to devices
    - Specifying the CHPID(s) and corresponding output domain/port
  - Mainframe is "blind" to the the ISL
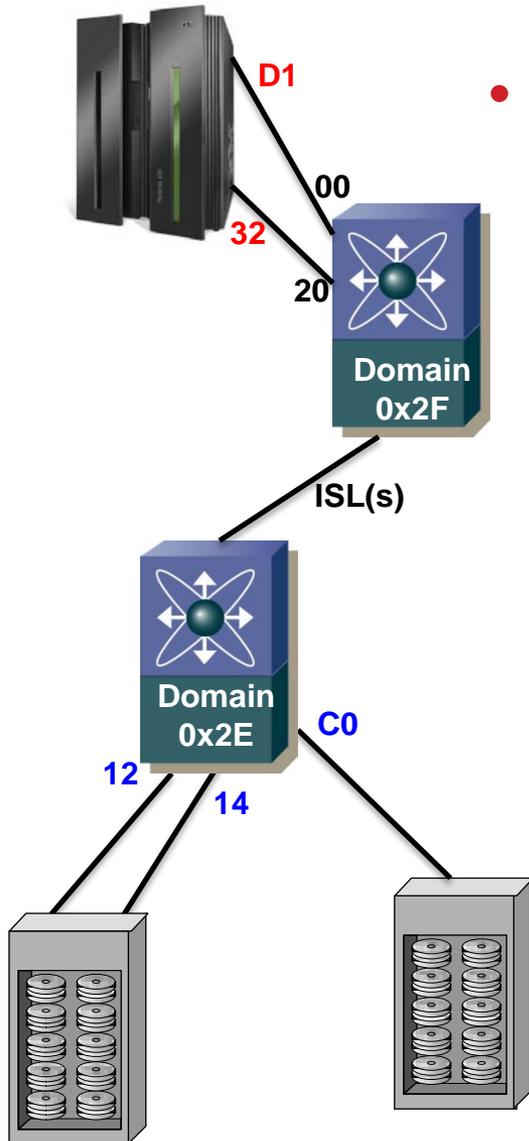
```
CHPID PATH=(CSS(0),D1),SHARED,                                   *
      PARTITION=((LPARMVSY),(LPARMVSX,LPARMVSA,LPARMVSB,VMLPAR*
      02)),SWITCH=2F,PCHID=1B1,TYPE=FC
CHPID PATH=(CSS(0),32),SHARED,                                   *
      PARTITION=((LPARMVSY),(LPARMVSX,LPARMVSA,LPARMVSB,VMLPAR*
      02)),SWITCH=2F,PCHID=1B3,TYPE=FC

CNTLUNIT CUNUMBR=0CC0,PATH=((CSS(0),D1,32)),                     *
      LINK=((CSS(0),2E12,2E14)),                                 *
      UNIT=2105,CUADD=B,UNITADD=((00,032))

CNTLUNIT CUNUMBR=0C00,PATH=((CSS(0),D1)),                        *
      LINK=((CSS(0),2EC0)),                                      *
      UNIT=2105,CUADD=C,UNITADD=((00,032))
```

Diagram labels: D1, 00, 32, 20, Domain 0x2F, ISL(s), Domain 0x2E, C0, 12, 14

Agenda for Session 12073 and 12074

Session 12074

- History

- Terminology, Connectors, Cables, and Wavelengths

- Addressing in FICON

- **ESCON Status, zHPF and NPIV**

- Buffer Credits, CUP, RMF

ESCON Statement of Direction

ESCON channels will be phased out

- *It is IBM's intent for ESCON channels to be phased out!*

- 1024 total channels are supported on z10 EC while 480 total channels are supported on the z10 BC …and…up to 960 of those channels could be ESCON channels if the customer desired it

- But only 240 ESCON channels are supported on z196 and z114

- System z196 and z114 will be the last mainframes to natively support ESCON channels

It is time to move to a FICON Infrastructure!!
…but…
What about the old ESCON devices that you still use?

FICON to ESCON Converter

Promotes FICON infrastructure modernization

Preserves ESCON infrastructure investments

Replaces ESCON directors, FICON bridge, and ESCON extenders
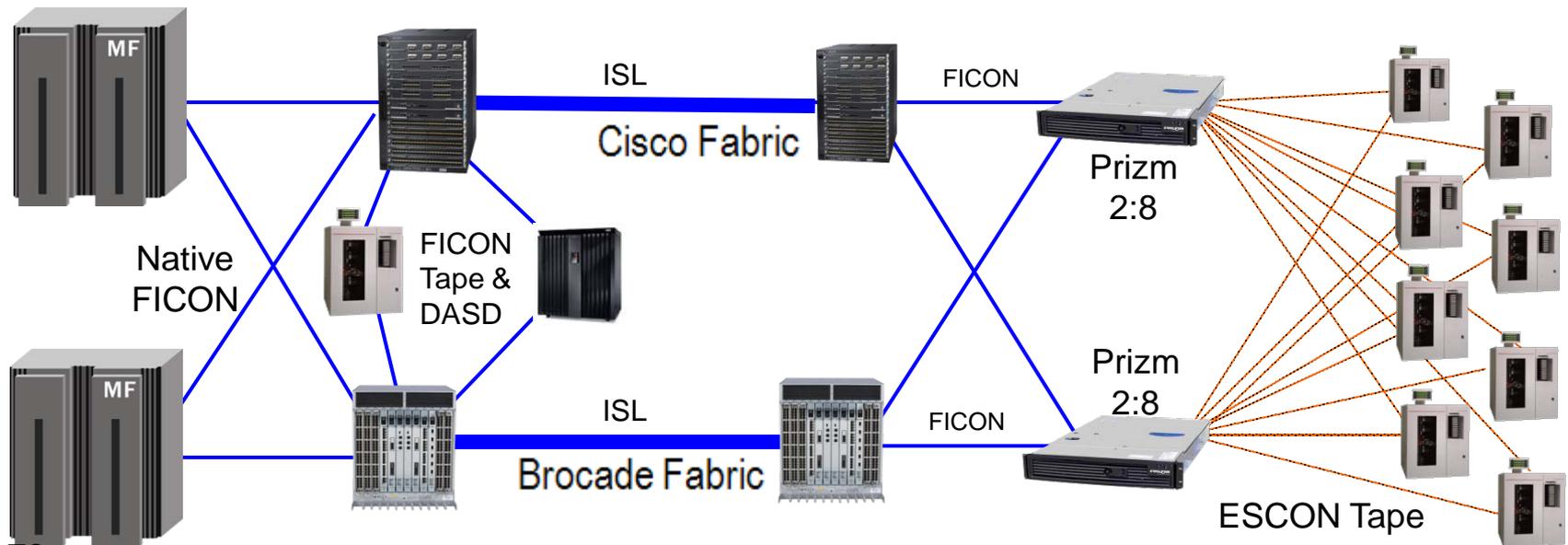
Complete your sessions evaluation online at SHARE.org/AnaheimEval

zHPF – High Performance FICON

It was first introduced in 2008

It continues to be enhanced

- Currently used for extended format data sets managed by Media Manager or by EXCP (DASD only – not tape)

- Encapsulates multiple FICON CCWs into a single frame

- z10, z196 or z114 must be the host

- Supported by the major storage vendors

- Goal: Enhanced Performance

FICON CCWs into FCP-like Frames

FICON

FICON

Complete your sessions evaluation online at SHARE.org/AnaheimEval

SHARE
in Anaheim
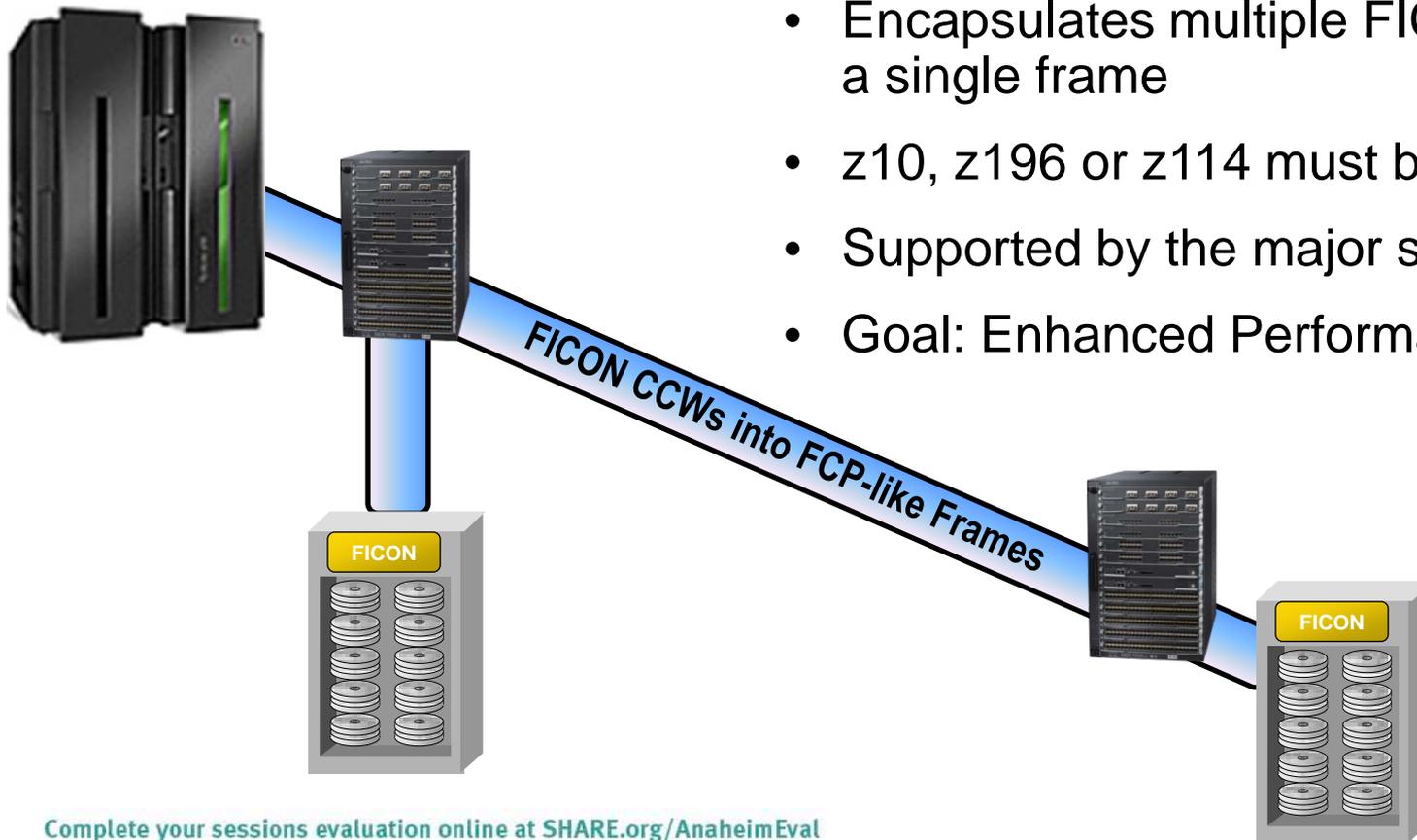
NPIV – Node_Port ID Virtualization

- NPIV is standards based

- NPIV is used on the mainframe when Linux utilizes FCP Ports

System z using NPIV

NPIV works only when using switched-FICON

NPIV enabled Switches and Directors

Linux Guests

Linux A

Linux B

Linux C

Linux n

One FCP channel for many Linux guests

Lots of Parallelism

Fewer switch ports required!

Much better I/O bandwidth utilization per path
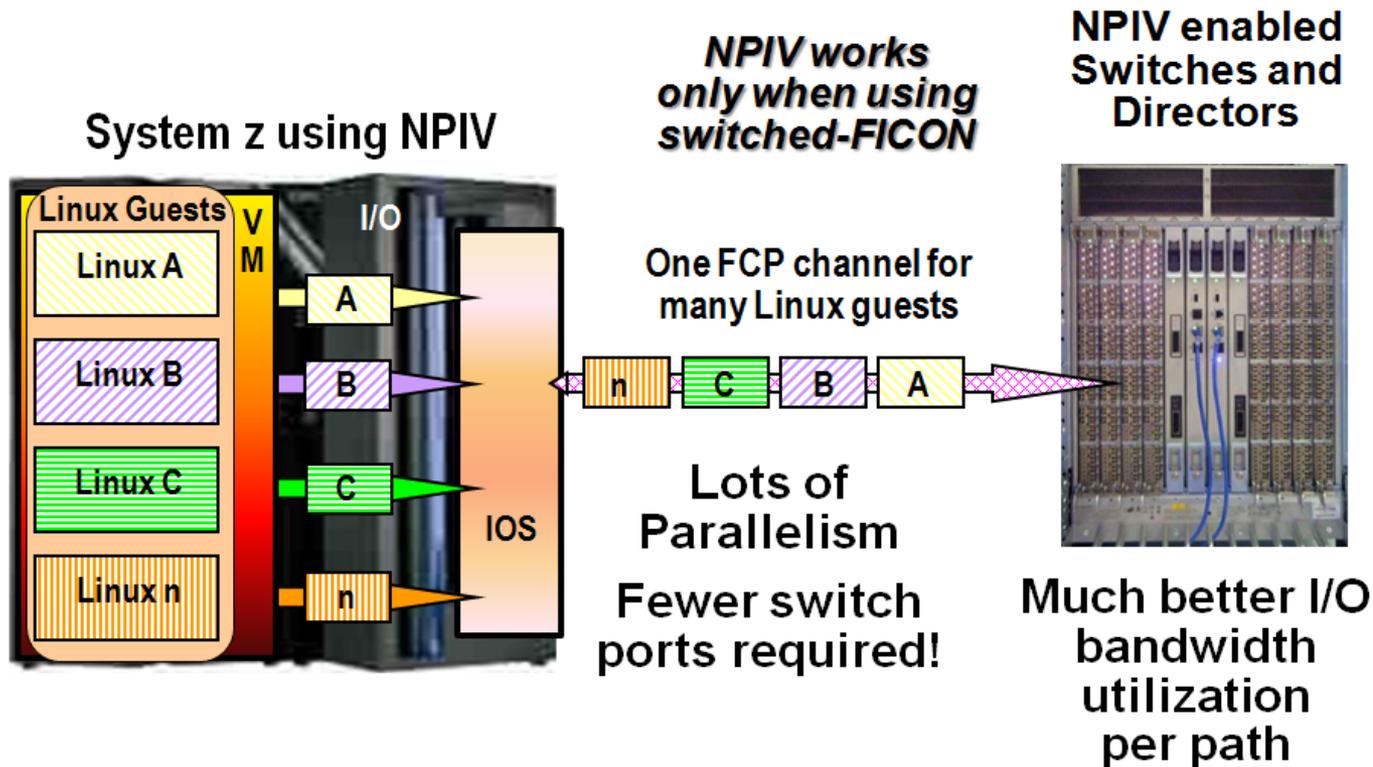
8 Gbps Is Great For NPIV!

Agenda for Session 12073 and 12074

Session 12074

- History
- Terminology, Connectors, Cables, and Wavelengths
- Addressing in FICON
- ESCON Status, zHPF and NPIV
- **Buffer Credits, CUP, RMF**

Mainframe
Number of Buffer Credits - Reality

Control   76

Write   2048   2048   72

Status Accept   68

- Simple 4K write
- Will not fit into 2 buffers because of headers for FC as well as SB3

Average = (76+2048+2048+72+68) / 5 = 862 Bytes

Mainframe Terminology

CUP should be deployed on every FICON Director! It allows you to provide the M/F environment with port performance information and buffer credit flow control information.
2 ports could be lost when CUP is used!
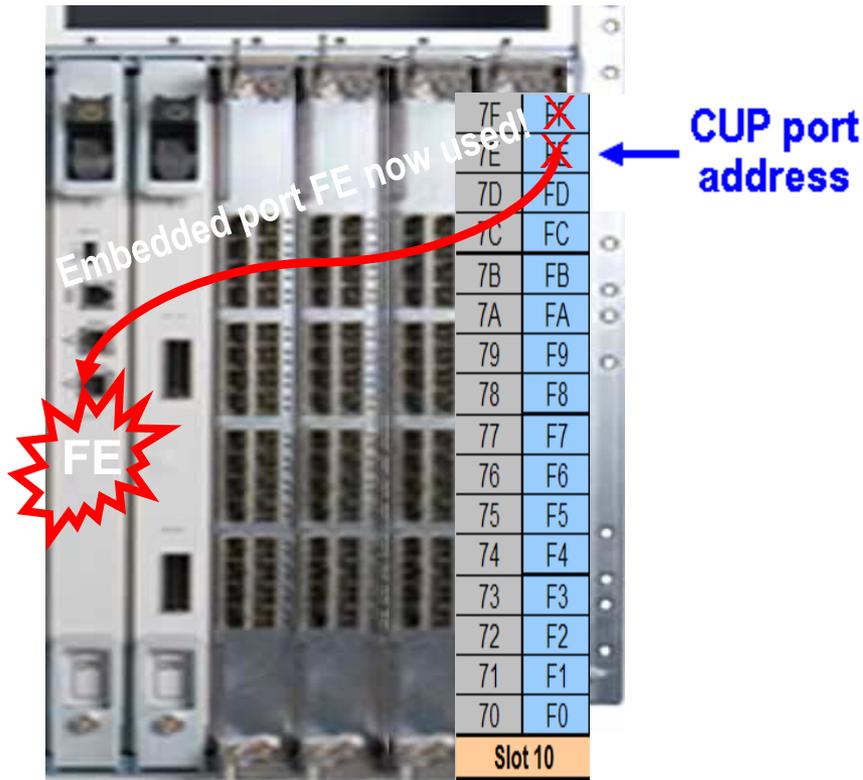
Control Unit Port (CUP)

- Customers install FICON Management Server (FMS) as a license on their FICON director.

- FMS enables CUP to be utilized for in-band management and FICON Director performance reporting up to the mainframe environment.

- Port address 0xFE is always the port address exclusively defined for the CUP – but it can also be a physical port which cannot be used for connectivity when CUP is enabled.

FICON Director Activity Report With Frame Delay

Using Buffer Credits is how FC does Flow Control, also called "Frame Pacing"

```
               F I C O N   D I R E C T O R   A C T I V I T Y                    PAGE    1
         z/OS V1R8          SYSTEM ID ABCD      START 04/12/2009-04.30.00  INTERVAL 000.15.00
                            RPT VERSION V1R8 RMF END   04/12/2009-04.45.00  CYCLE 1.000 SECONDS
  IODF = A2  CR-DATE: 03/27/2009  CR-TIME: 18.43.51   ACT: ACTIVATE
  SWITCH DEVICE: 032B   SWITCH ID: 2B    TYPE: 006140  MODEL: 001  MAN: MCD  PLANT: 01   SERIAL: 0000HIJKLMN
  PORT    -CONNECTION-    AVG FRAME    AVG FRAME SIZE    PORT BANDWIDTH (MB/SEC)    ERROR
  ADDR   UNIT      ID      PACING      READ    WRITE     -- READ --   -- WRITE --   COUNT
  05     CHP-H     05          0        849     1436         8.63        17.34        0
  07     CHP       6B          1       1681     1395        50.87        10.32        0
  09     CHP       15          0        833     1429        11.96        20.49        0
  0C     CHP-H     64          0        939     1099         0.39         0.50        0
  0D     CHP       6B          0       1328     1823         3.56        12.73        0
  0F     CHP-H     66          0       1496     1675         1.85         2.61        0
  10     CHP       64          0        644     1380         0.03         0.13        0
  13     CHP-H     19          0        907      885         0.58         0.45        0
  16     CU        C800        0       1241      738        20.97         5.72        0
         CU        CA00                                     70.10         3.82        0
  1A     CHP       15          0       1144     1664         0.65         1.18        0
  1B     CHP       0D          0        510     1759         0.12         1.72        0
  1E     CHP-H     05          0        918      894         0.59         0.45        0
  1F     CHP       21          0       1243     1736         0.97         1.70        0
  20     CU        E900        0       1429      849        17.66         8.85        0
         CU        E800
         CU        E700
  22     CHP       10          0        923     1753         0.55         2.78        0
  23     CHP       54          0       1805       69        20.80         7.30        0
  24     CHP       64          0         89     1345         0.00         0.00        0
  27     CHP       6B          0       1619       82         0.01         0.00        0
  28     SWITCH    95        270        998      789        50.32        10.56        0
  2B     CHP       70          0         69     2022         0.00         0.71        0
```

In the last 15 minutes

This port had a frame to send but did not have any Buffer Credits left to use to send them.

And this happened 270 times during the interval.

And this is an ISL Link!   Indicators of Buffer Credit Starvation

Fabric with zHPF Enabled

SHARE in Anaheim
2012

SAN Sessions at SHARE this week

Monday:

Time-Session

1330 - 12078: <u>Why Customers Should Deploy Switches in Their SAN and FICON Environments</u>

Tuesday:

Time-Session

0930 – 11152: <u>DLm 'Tape on Disk' VTL Customer Experience & Benefits</u>

1330 - 12072: <u>A First Look at the Inner Workings and Hidden Mechanisms of FICON Performance</u>

1500 - 12071: <u>A Deeper Look Into the Inner Workings and Hidden Mechanisms of FICON Performance</u>

Wednesday:

Time-Session

0800 - 12076: <u>Buffer-to-Buffer Credits, Exchanges, and Urban Legends</u>

1330 - 12077: <u>ESCON I/O Will Not Be Supported On Future System z Platforms. What Do I Do?</u>

1500 - 12075: <u>zSeries FICON and FCP Fabrics - Intermixing Best Practices</u>

Thursday:

Time-Session

1630 - 12084: <u>Buzz Fibrechannel - To 16G and Beyond</u>

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Mainframe/SAN Resources For You To Use

Visit Brocade's Mainframe Blog Page at:

http://community.brocade.com/community/brocadeblogs/mainframe

Visit Brocade's New Mainframe Communities Page at:

http://community.brocade.com/community/forums/products_and_solutions/mainframe_solutions

Visit Cisco's Storage Networking Page at:

http://www.cisco.com/en/US/products/hw/ps4159/index.html

THANK YOU FOR ATTENDING!

Session **12074**

Please fill out your evaluation forms

QR Code

Questions and Discussion