Session 13014

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

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SAN 101

SHARE in San Francisco 2013

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 13014

Session 13014 Part 1 – 11:00am – 12:00pm

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

Session 13014 Part 2 – 3:00pm – 4:00pm

- History
- Terminology, Connectors, Cables, and Wavelengths
- Addressing in FICON
- ESCON Status, zHPF and NPIV
- Buffer Credits, CUP, RMF, BC/DR Solutions

Agenda for Session 13014

Session 13014

- **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 & 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





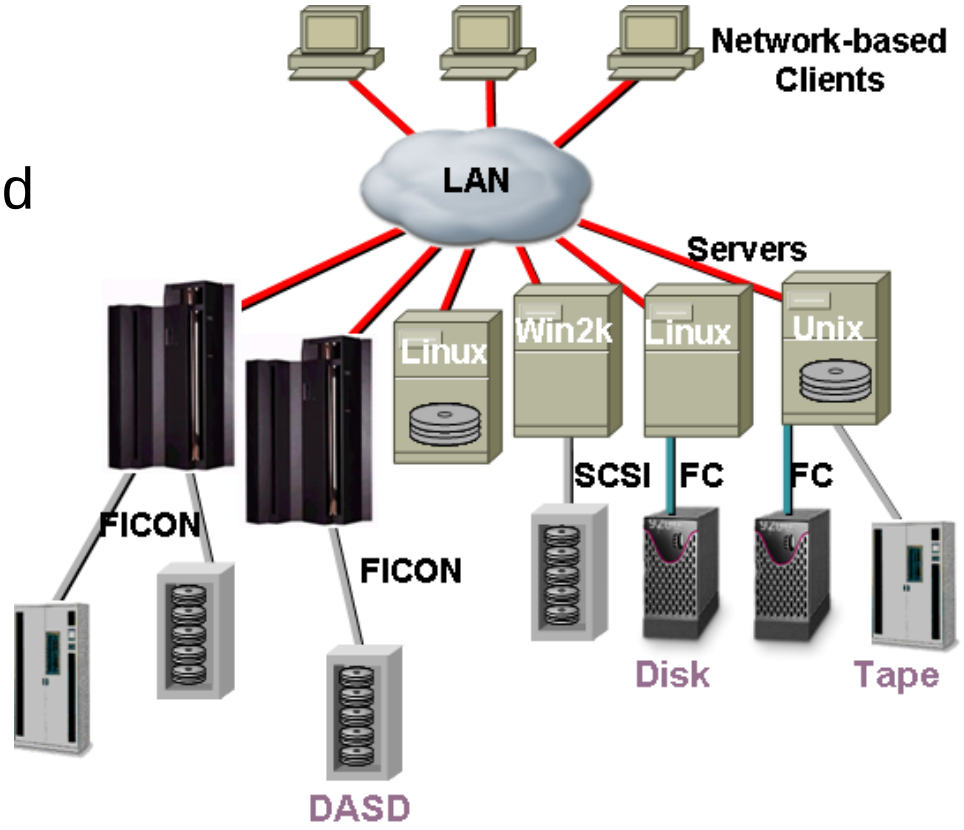






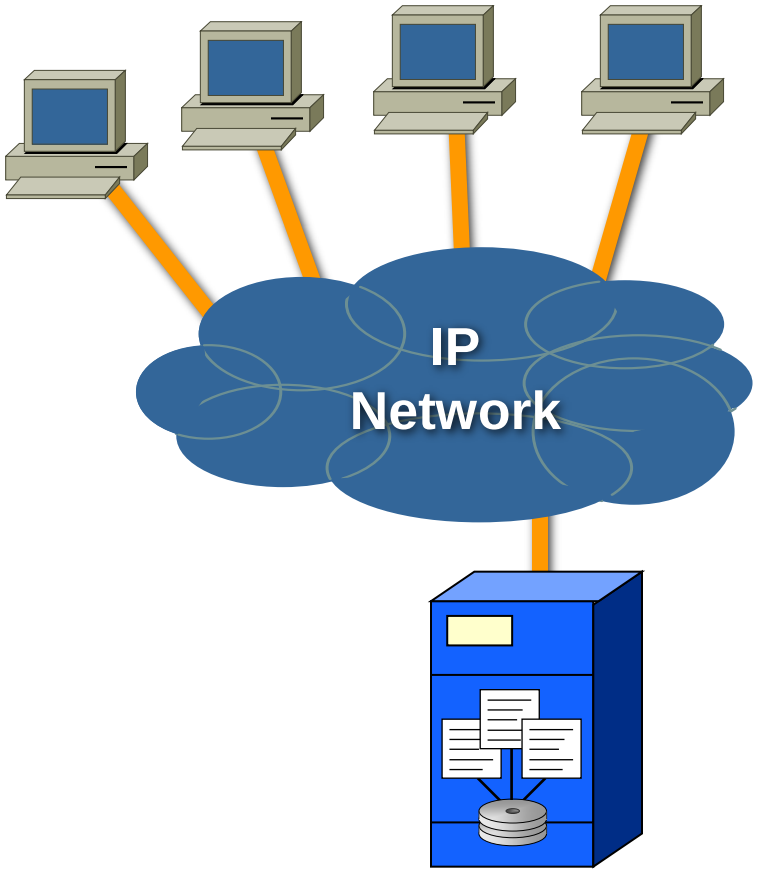

Direct Attached Storage

- 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



Network Attached Storage (NAS)

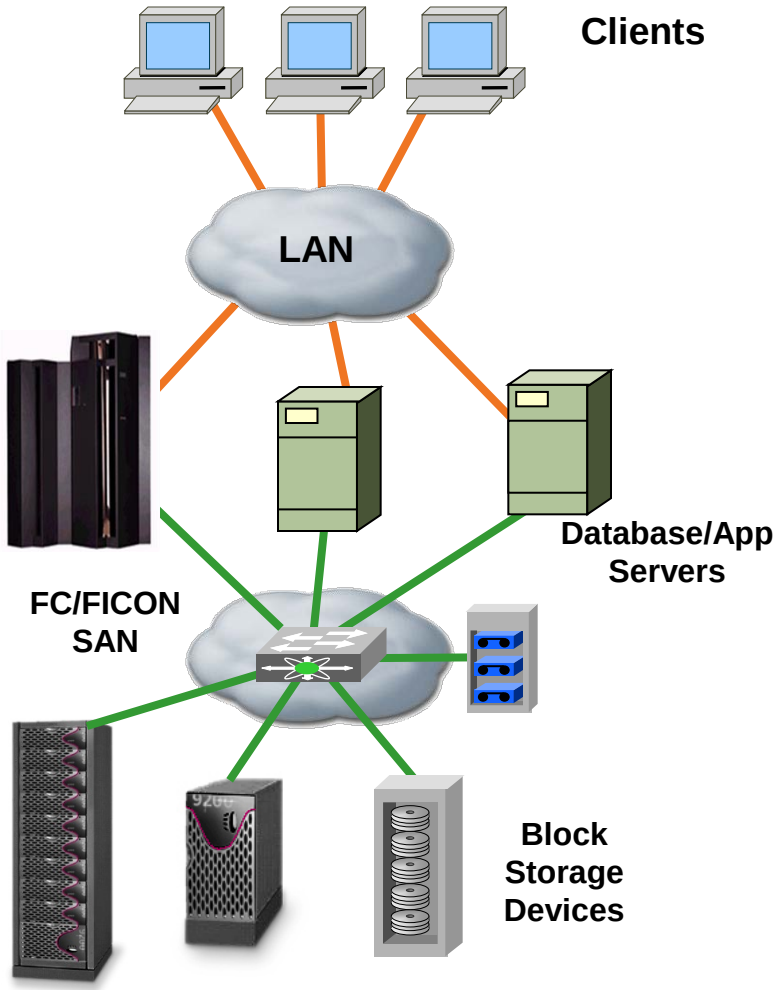
- Dedicated file server
- Optimized for file-based access to shared storage over an IP network
- Suitable for applications involving file serving/sharing
- High-performance access, data protection, and disaster recovery
- Capable of storage partitioning
- Uses network file system protocols such as NFS or CIFS



Storage Area Network (SAN)

Separation of Storage from the Server

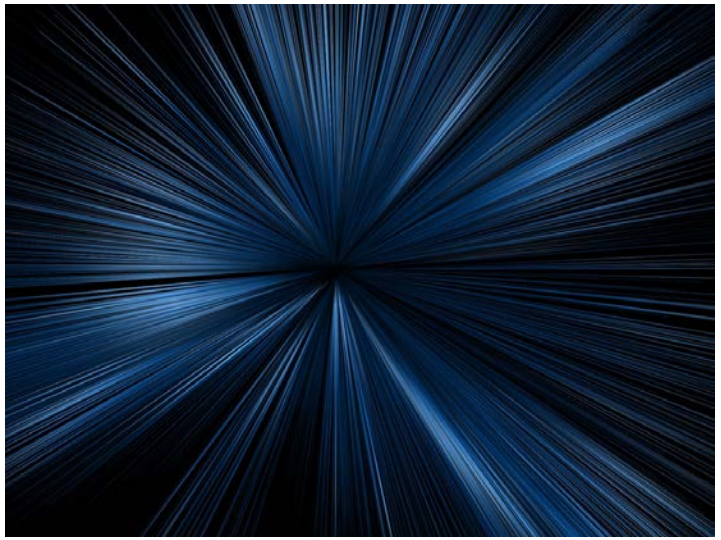
- Storage is accessed Block-level via SCSI/FICON and can be in a switched environment
- High performance interconnect providing high I/O throughput
- Lower TCO relative to direct attached storage, storage can be shared
- Have to consider Vendor Interoperability / Qualifications
- More Complex management due to size/scale



FICON or Storage Area Network (SAN)

FC Storage Networking Terminology
Light and Fibre Channel

- Light wavelengths in fiber are expressed in nanometers
- Speed of light (C) is about 3 x 10^8 microseconds (**µsec**) in a vacuum
- In fibre cable it is about 2/3^{rds} of C or 2 x 10^8 **µsec**
- Speed of light in fiber cable is slower than the speed of light in a vacuum so:
  - Light travels at ~5 nanoseconds per meter (3.3 ft) of distance in glass
  - A rough rule of thumb is 18 inches (45.72 millimeter) per nanosecond
  - It takes about 5 µsec to travel one kilometer (.621 of a mile) in FC cable
  - It takes about 5 milliseconds to travel 1,000 km (621.4 miles) in FC cable



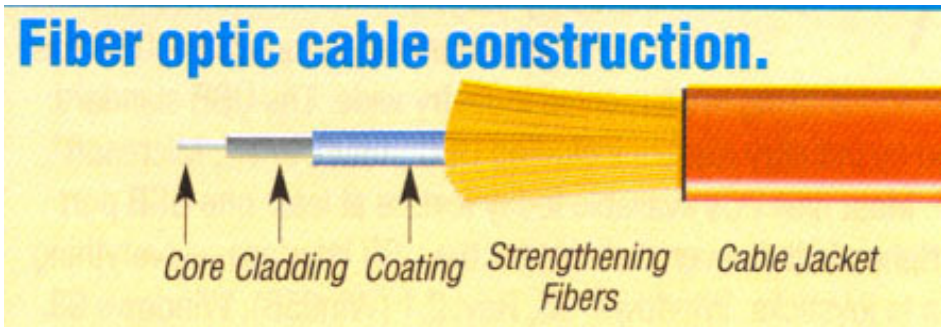
Latency Considerations:

- Switch is about 2.1 µsec, P-t-P
- Light is about 5 µsec/Km
- Inadequate BCs = more latency

FC Storage Networking Terminology

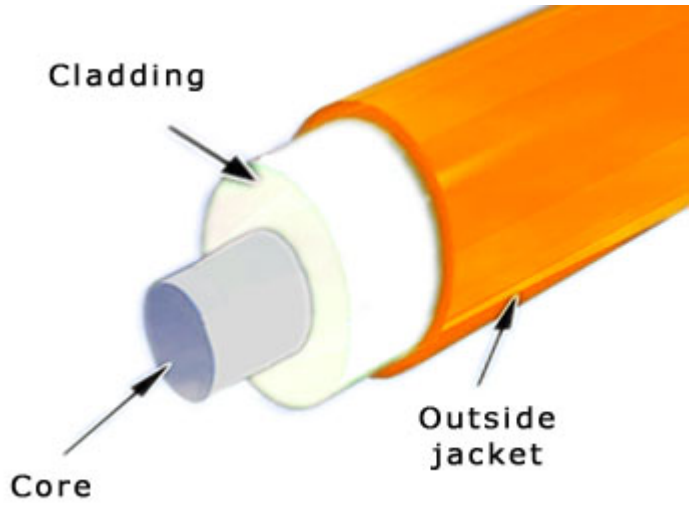
Fiber Channel Links

- **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.

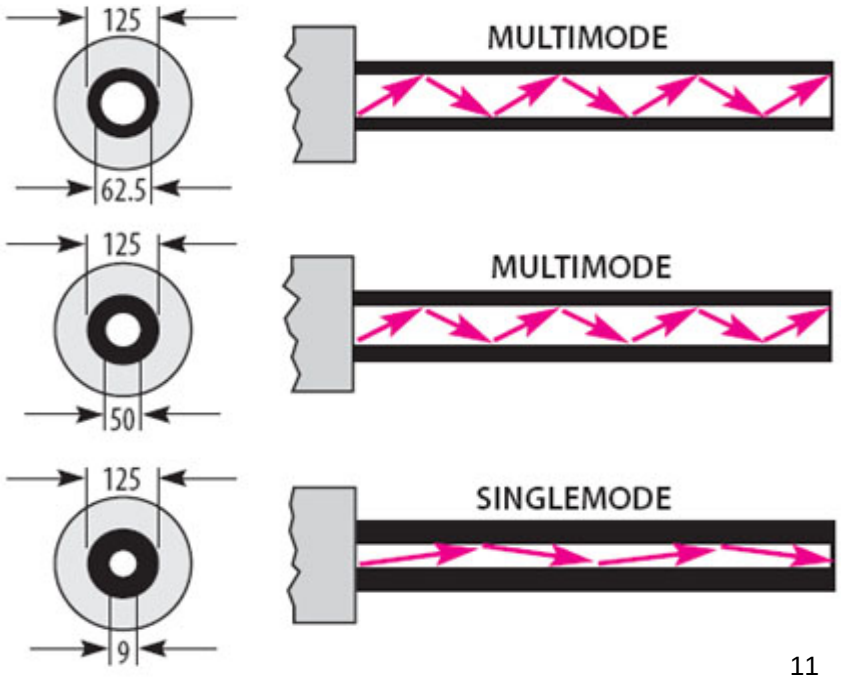


FC Storage Networking Terminology
Fiber Channel Links

- Fiber Optic cables transmit a digital signal via pulses of light through a very thin strand of glass. Fiber strands (the core of the fiber optic cable) are extremely thin, no thicker than a human hair. The core is surrounded by a cladding which reflects the light back into the core and eliminates light from escaping the cable.

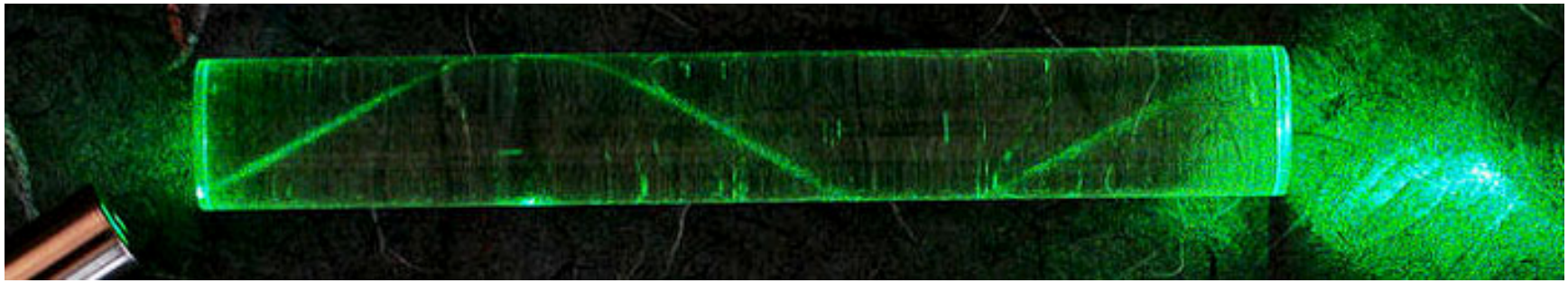


- A "mode" in Fiber Optic cable refers to the path in which light travels. Multimode cables have a larger core diameter than that of singlemode cables.
- Multimode fiber is available in two sizes, 50 micron and 62.5 micron. Singlemode fiber is available in a core diameter of 9 microns (actually 8.3 microns).



FC Storage Networking Terminology
Fiber Channel Links

- **Photo of Modal dispersion**
  - As you can see, a beam of light travels from side to side as it travels from one end of the cable to the other. This is how fibre optics can transmit data across long distances while not confined to being straight line of sight paths.



Light enters the cable

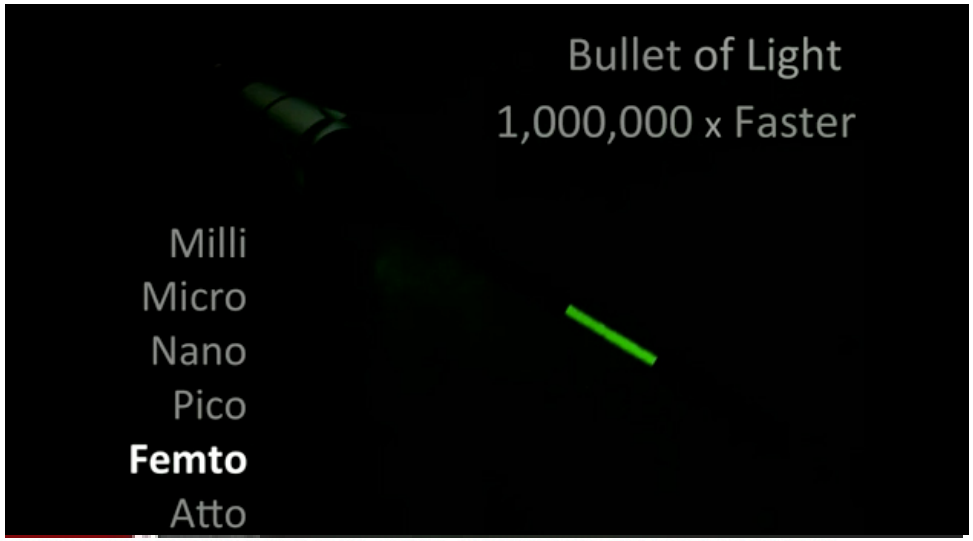
Light carries through the cable with a little dispersion

Without the cable light dispersion happens quickly

We send Data using Light

http://www.ted.com/talks/ramesh_raskar_a_camera_that_takes_one_trillion_frames_per_second.html

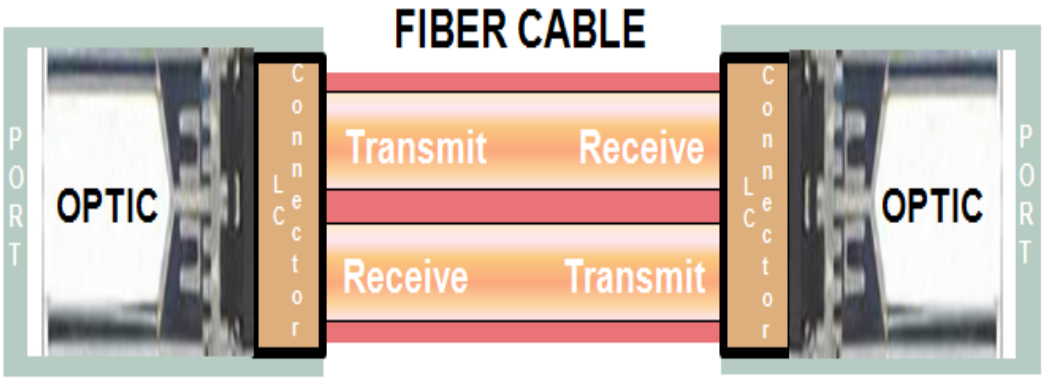
- **Light in Flight**
  - There is now a camera that can take a trillion frames per second. Below is a photo of light in flight from a laser pointer. The distance of the light shown below is the total distance that light travels in atmosphere in a Femtosecond.
  - A femtosecond (10^{-15} seconds) is one quadrillionth, or one millionth of one billionth of a second. Put another way: a femtosecond compares to a second, as a second compares to 30 million years.



Unit	Size	Notes
attosecond	10^{-18} s	shortest time now measurable by scientists
femtosecond	10^{-15} s	pulse width on world's fastest lasers
picosecond	10^{-12} s	switching time of the world's fastest transistor
nanosecond	10^{-9} s	time for molecules to fluoresce
microsecond	10^{-6} s	length of time of a high-speed, strobe light flash
millisecond	0.001 s	time for a housefly's wing flap

SAN Terminology -- *Fiber Channel Link*

- **A link consists of**
  - 2 unidirectional “fibers” transmitting in opposite directions
    - May be either:
      - Optical fiber or Copper



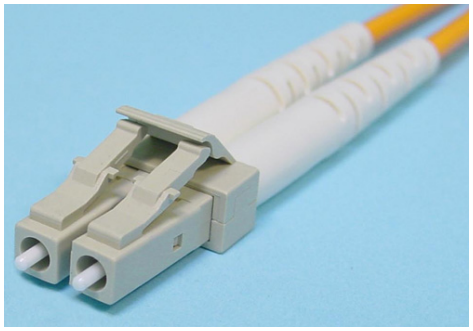
- **Transmitters may be:**
  - Long wave laser
    - There can be multiple distances for these – ie. 4km/10km
  - Short wave laser
  - LED
  - Electrical

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

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

SAN Terminology -- *Fiber Channel Link*

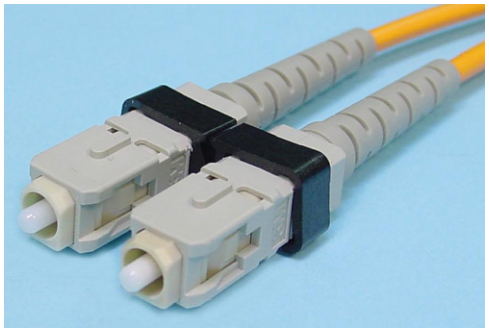
OPTICAL



Performance:
2, 4, 8, 16 Gbps

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

Cable Shown as Bonded Duplex

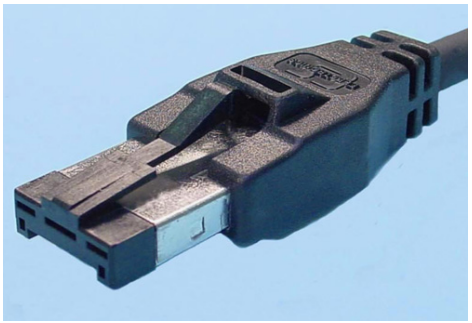


Performance:
1 Gbps

- **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

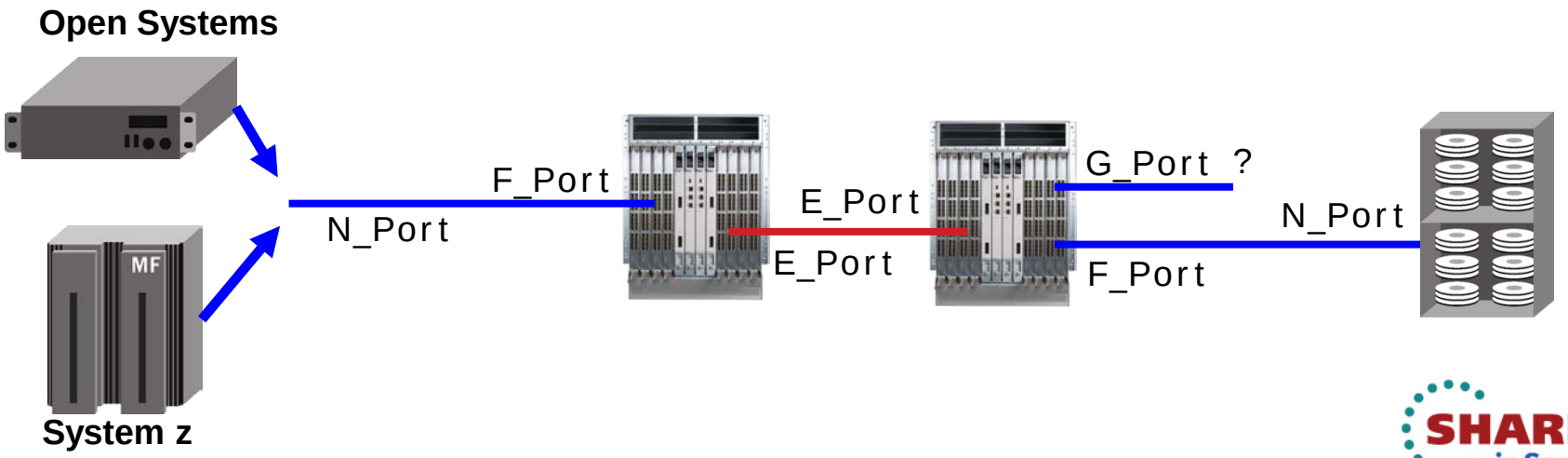
SAN Terminology -- *Fibre Channel*

Device Ports

- N_Port – Node Port, a Fabric device directly attached

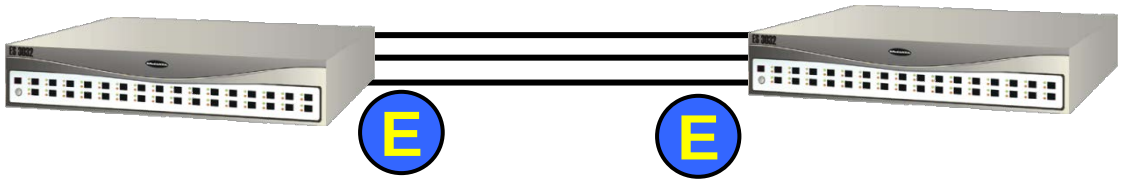
Switch Ports

- 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



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 13014

Session 13014

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

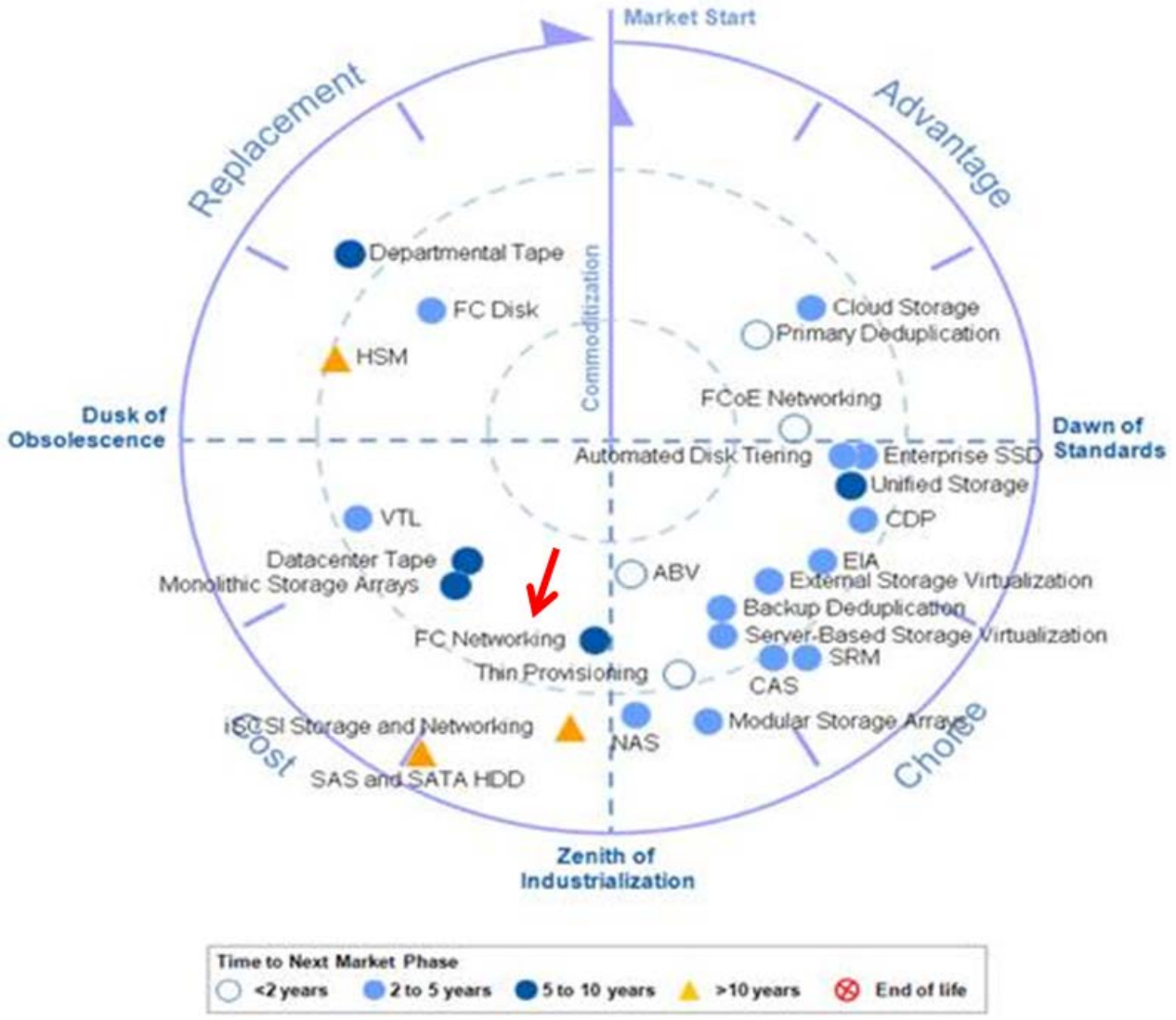
Fibre Channel Protocol

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
  - 8Gb, 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

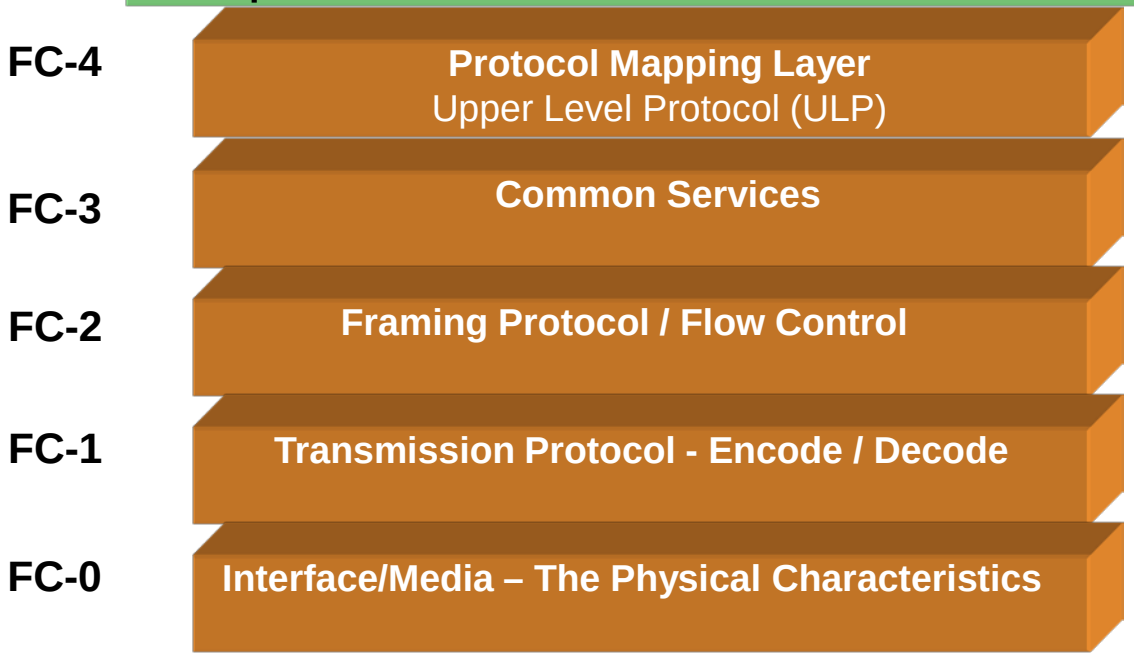
Fibre Channel Acceptance

- In September 2011 Gartner, Inc. analysts made an interesting update to their "IT Market Clock" series specifically for the Storage Technology market.
- What they show is that Fibre Channel Networking has just reached the Zenith of Industrialization of the technology lifecycle.



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



Fibre Channel Overview

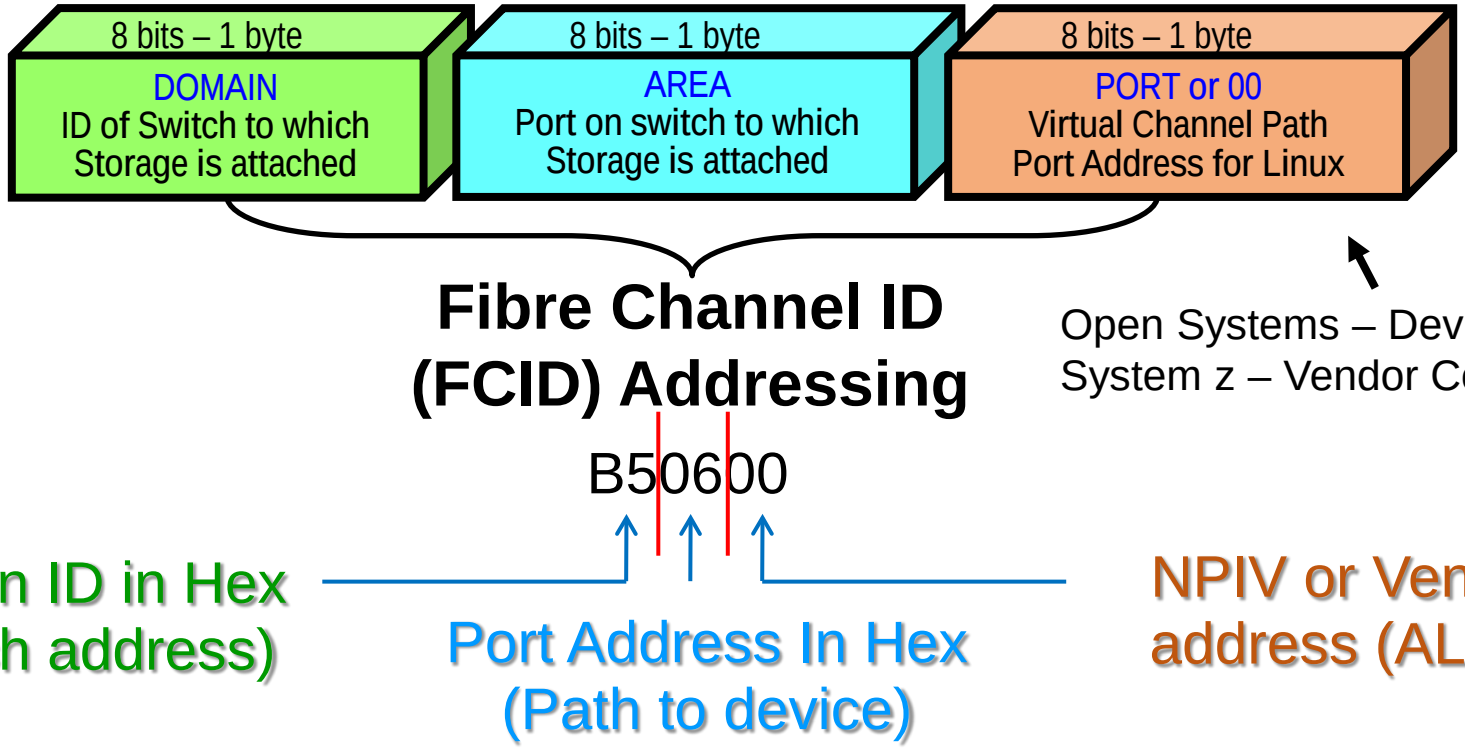
- Fibre Channel is primarily utilized as a networked form of SCSI (open systems - SAN) or CCWs (System z - FICON)
  - **Actually, the lower layers of Fibre Channel are generic**
    - Able to transport multiple data types such as video on demand and Internet Protocol
  - **But, most common deployment 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

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)

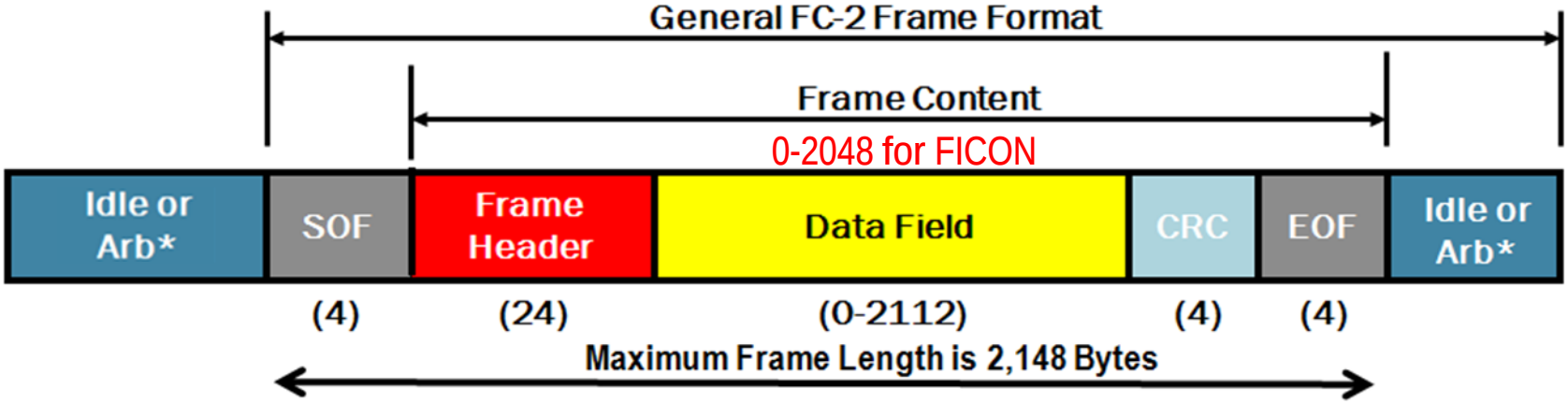
Fabric Addressing



- The 24 bit FCID address is partitioned into 3 fields:
  - Port (various uses); Area (connects to a device); Domain (which switch to find)
- This address partitioning helps speed up routing
- Switch element assigns the address to N_Ports
- Address portioning is transparent to N_Ports

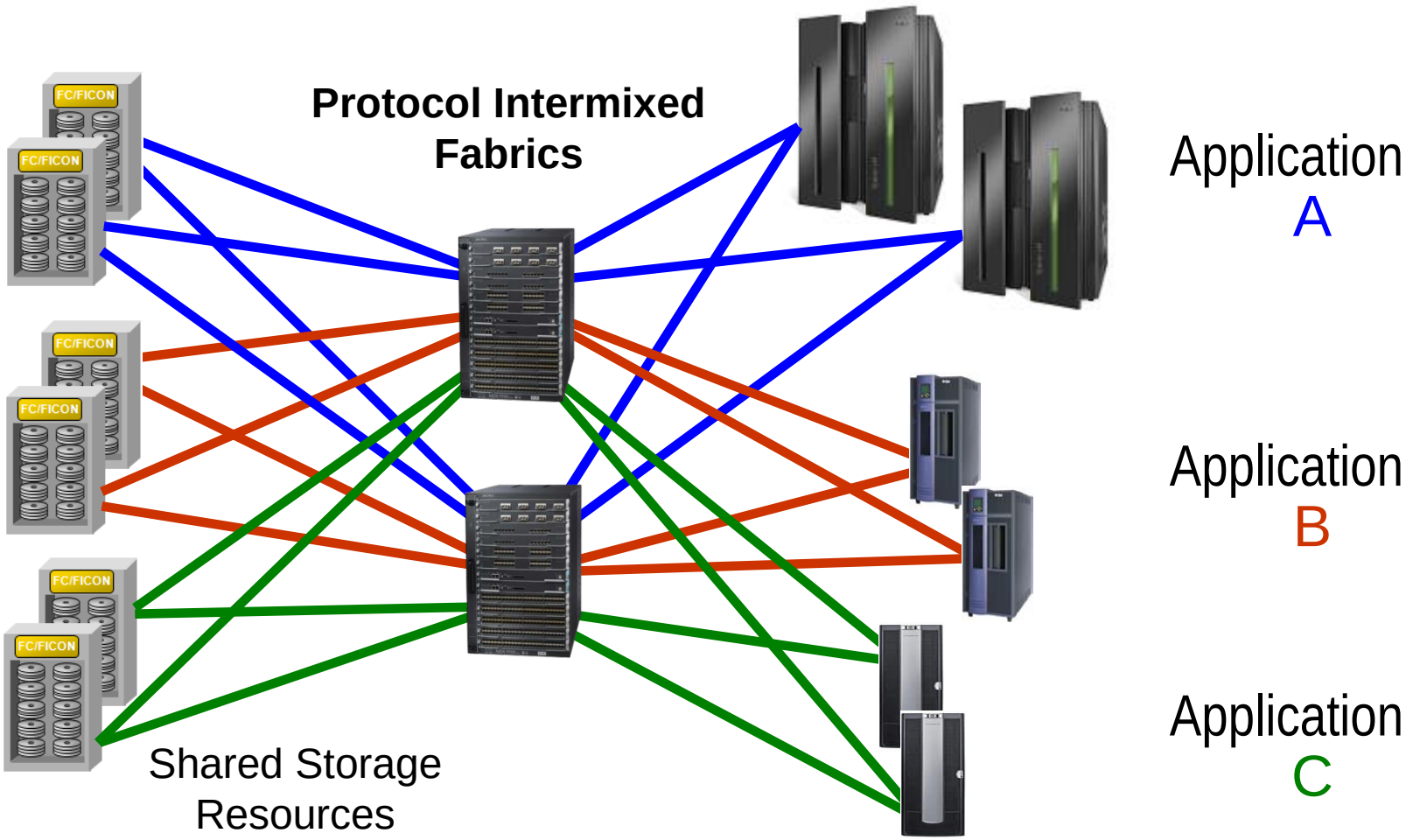
Fibre Channel Frame Format

- All FC-SBx frames follow the general frame format as shown below
- IDLE or ARB(ff) primitive characters are used during FLOGI link synchronization (these characters precede and follow each frame)
- IDLE or ARB primitives are 'Ordered Sets' used for basic signaling (1, 2, 4 and 10Gbps use IDLEs between frames while 8Gb and 16Gbps use Idles or ARBs)
- 8b/10b data encoding is used for 1, 2, 4 and 8Gbps frames – 20% overhead
- 64b/66b data encoding is used for 10Gbps and 16Gbps frames – 3%



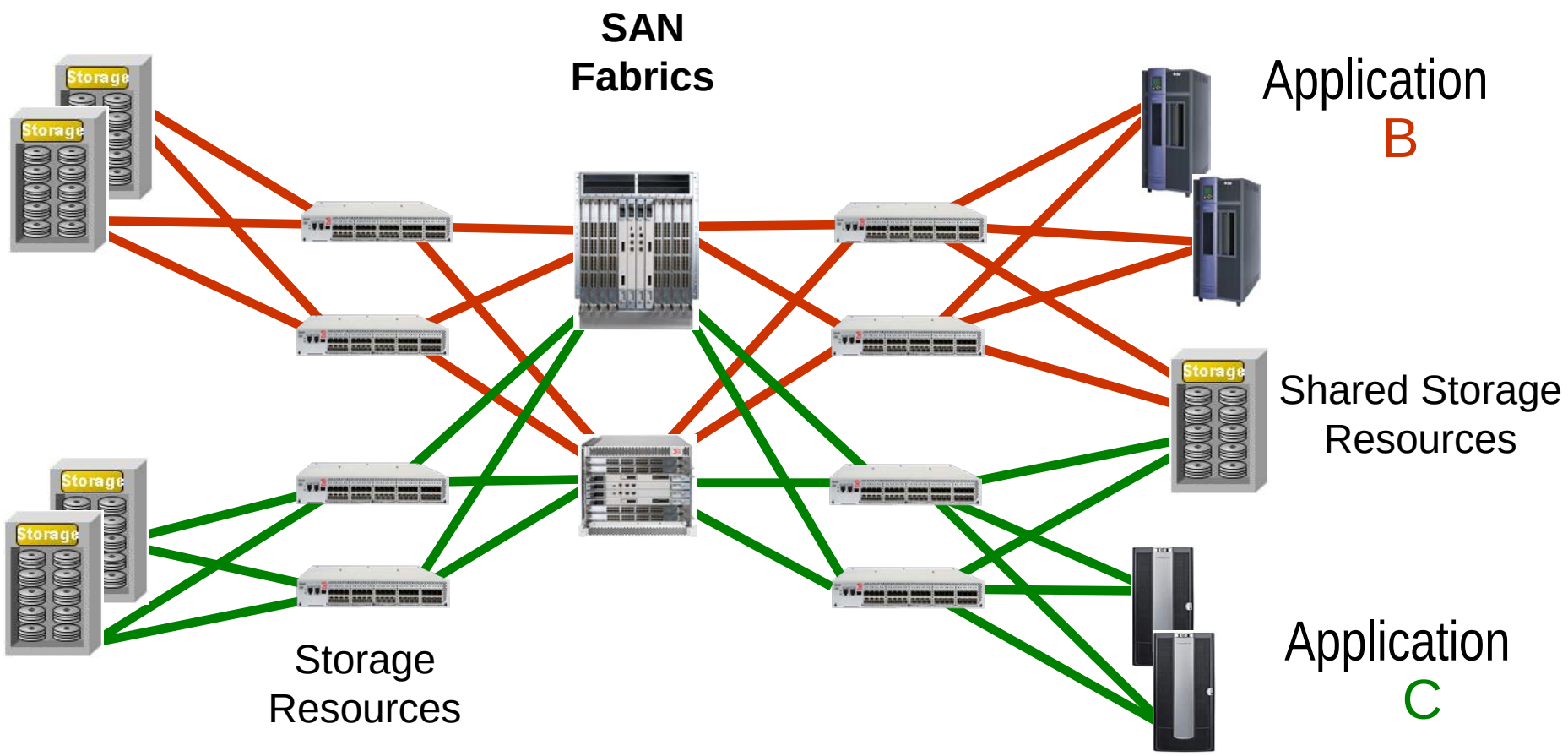
* 6 Idle or Arb words (24 bytes) are required of the transmitter (TX)
2 Idle or Arb words (8 bytes) are guaranteed to the receiver (RX)

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



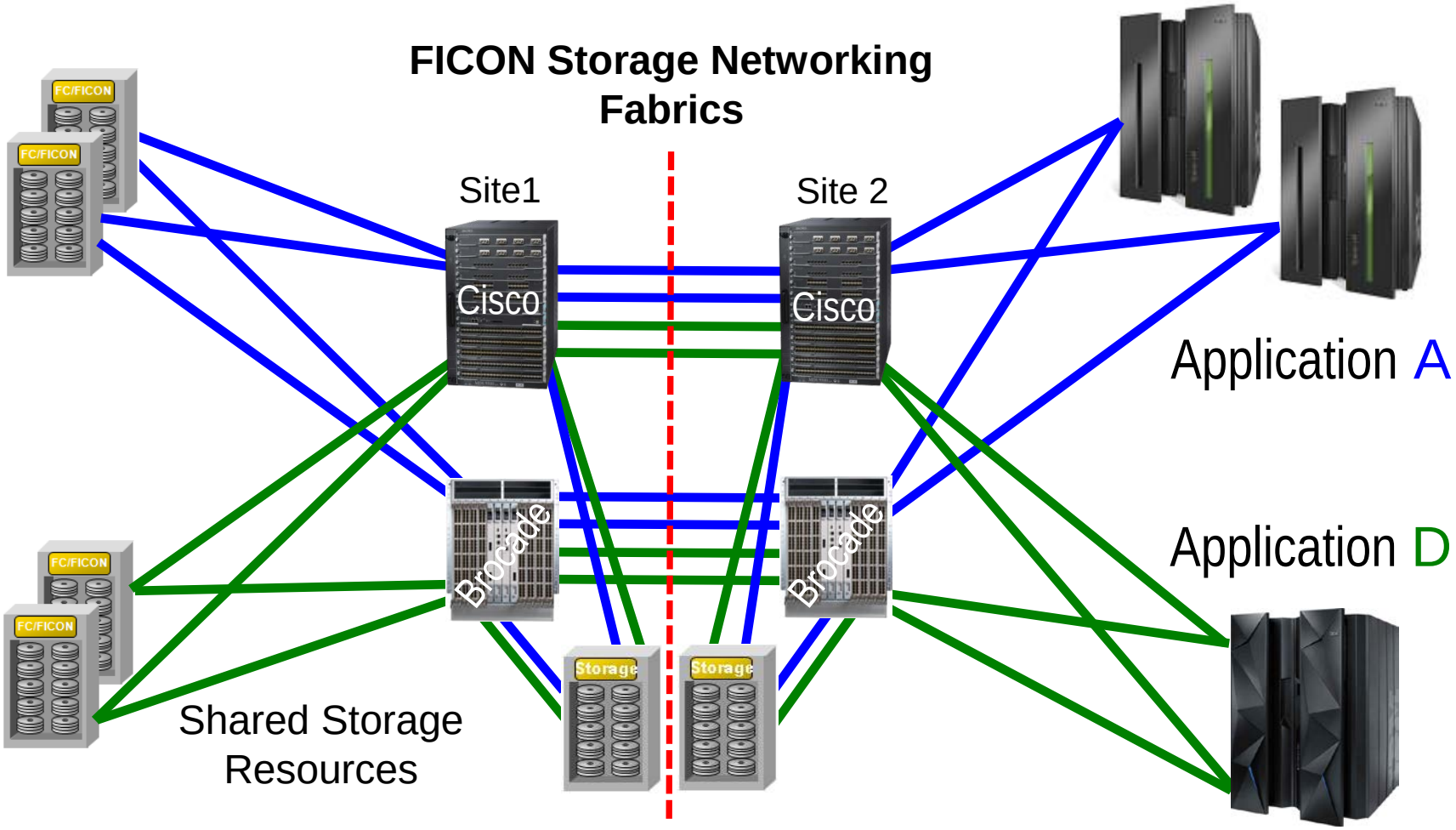
- Provides an opportunity to deploy fabrics to meet five-9's of availability
- Still must insure <=5 min/annual fabric downtime

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



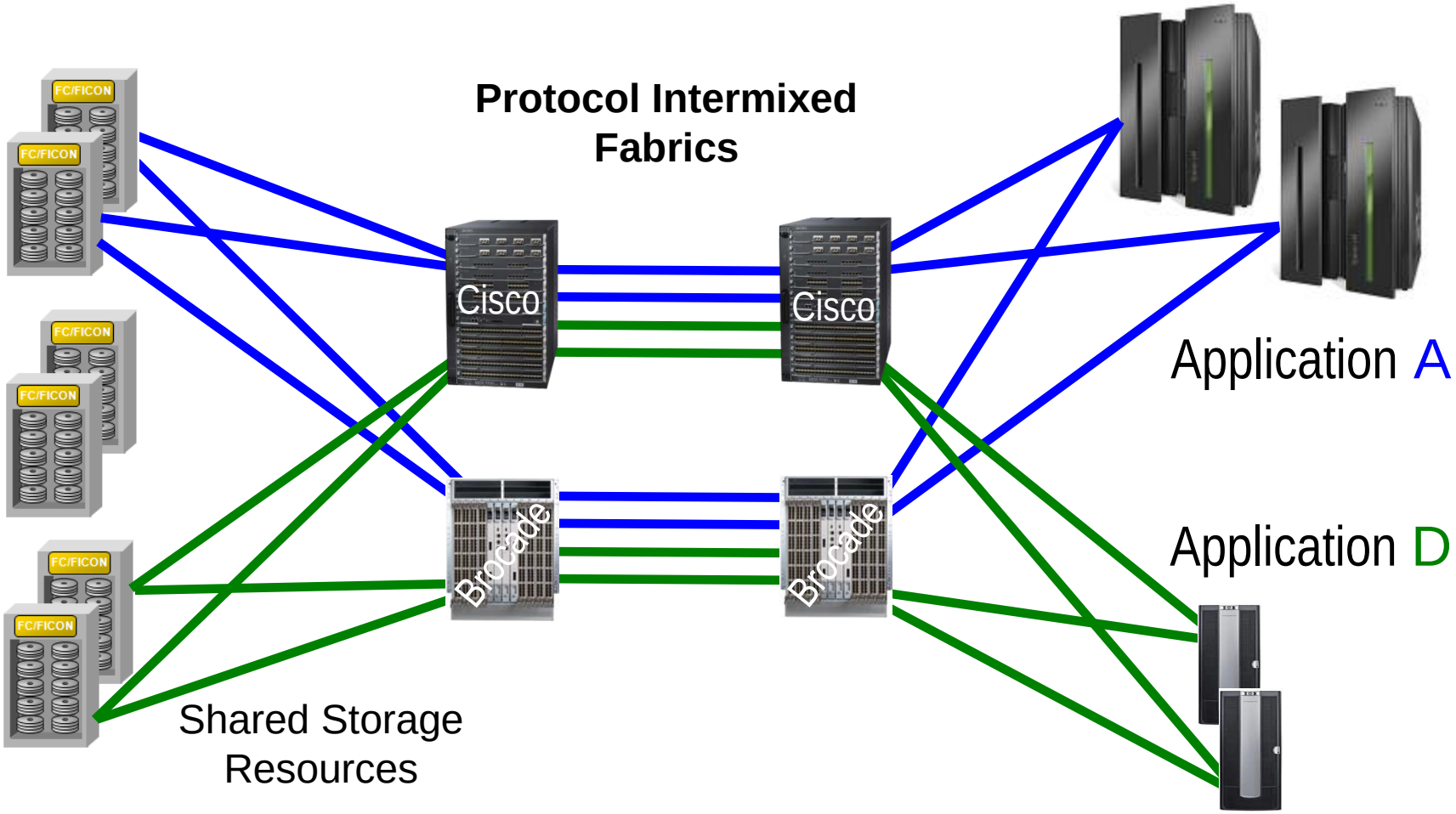
- Requires multi-hop so it is not currently supported for FICON due to IBM Qualification

Storage Networking Topology Cascaded FICON



- 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



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

ISL Aggregation

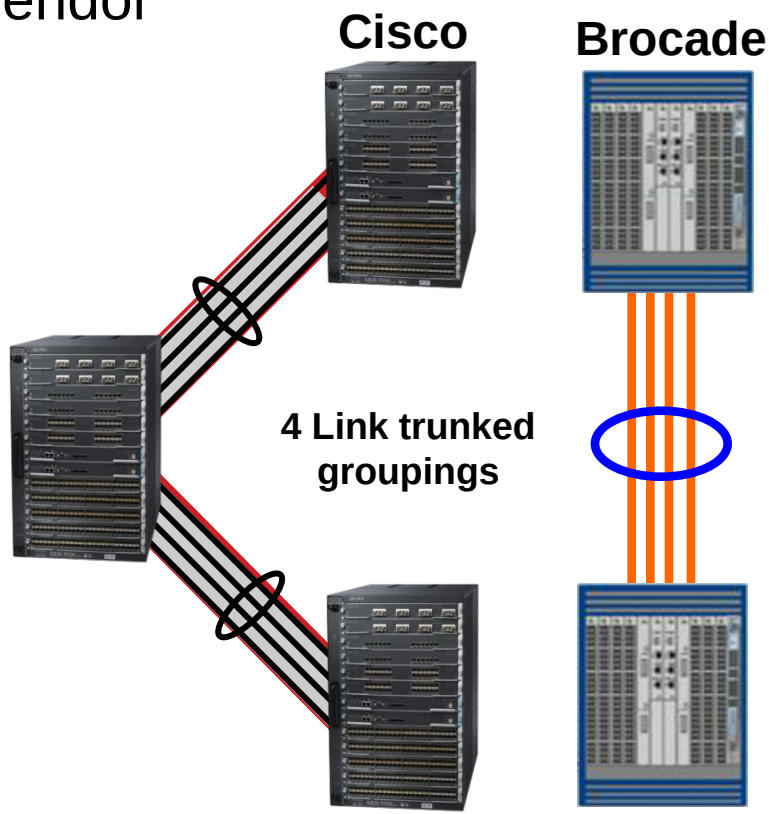
Port Aggregation Is Used to Create a Single Logical ISL from multiple Physical ISLs

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)



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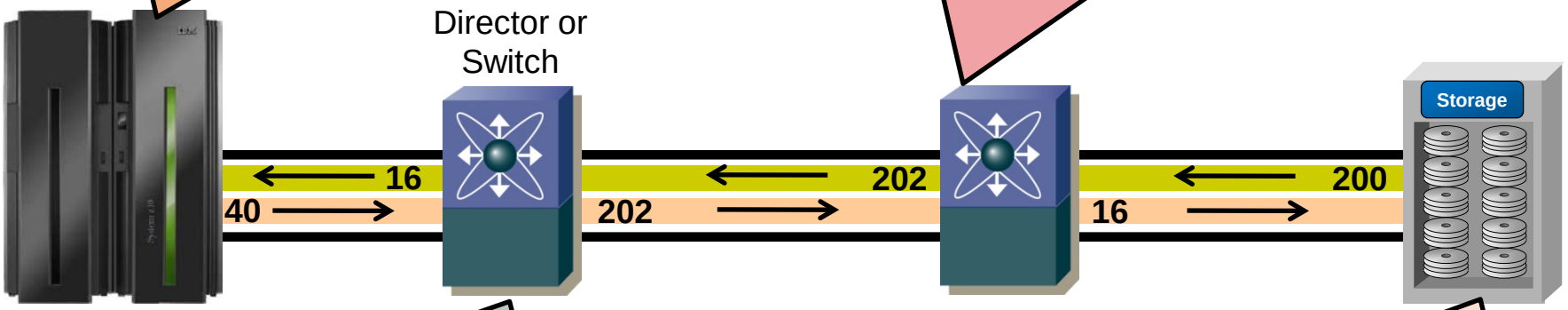
- Types and Components of Storage
- Let's talk Fibre Channel
- **FC Buffer Credits**
- Fabric Routing / Virtual Fabrics / Partitioning
- Security / Zoning

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.



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.

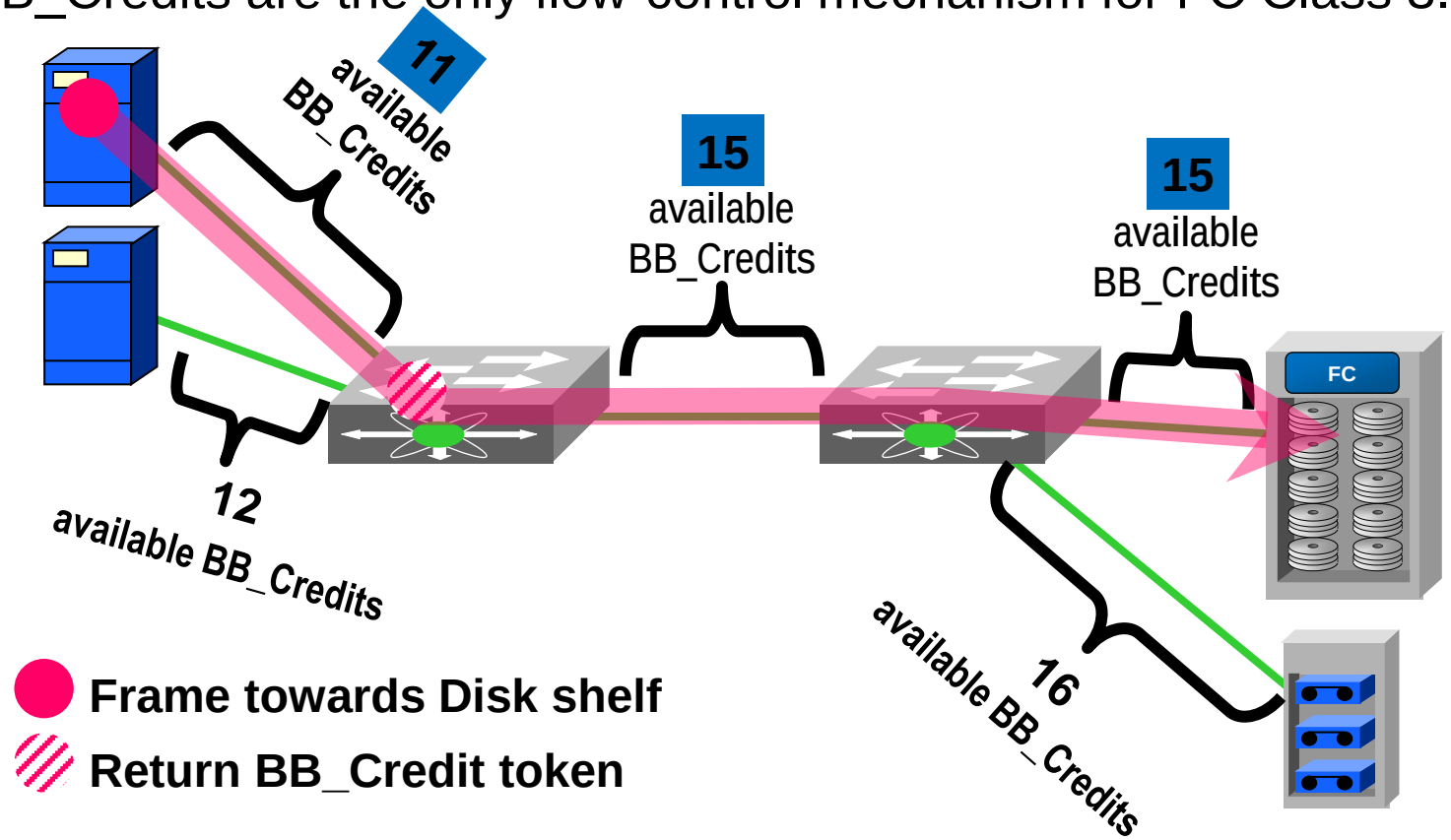
Fiber Cable

Strand 1

Strand 2

FC Buffer Credits and Flow Control

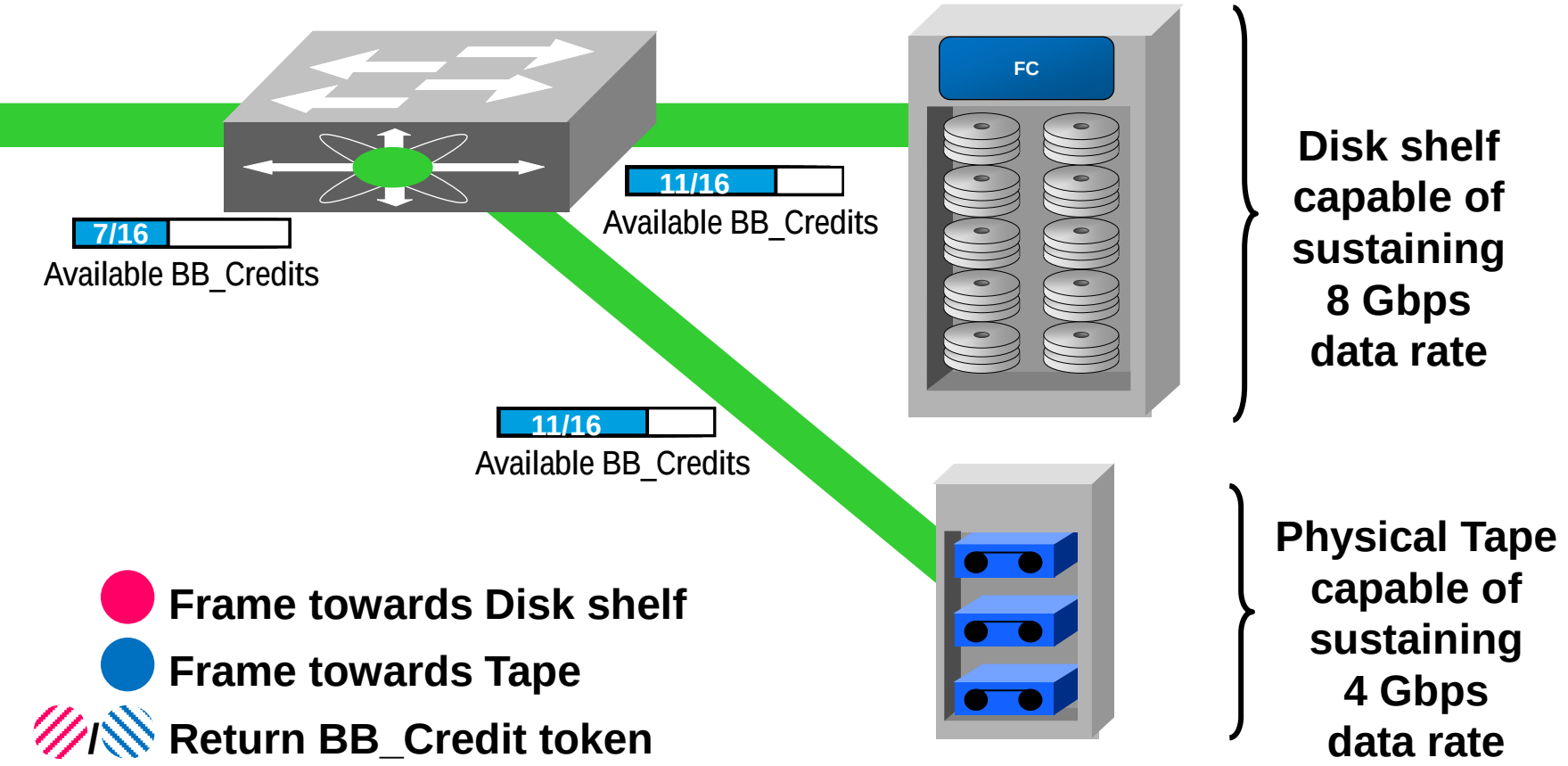
- BB_Credits are the “admission control” mechanism in FC to ensure that FC switches don’t run out of buffers (FC Switches cannot drop frames)
- For Devices operating at FC Class 3 (most devices), Buffer Credits are determined at login.
- BB_Credits are the only flow-control mechanism for FC Class 3.



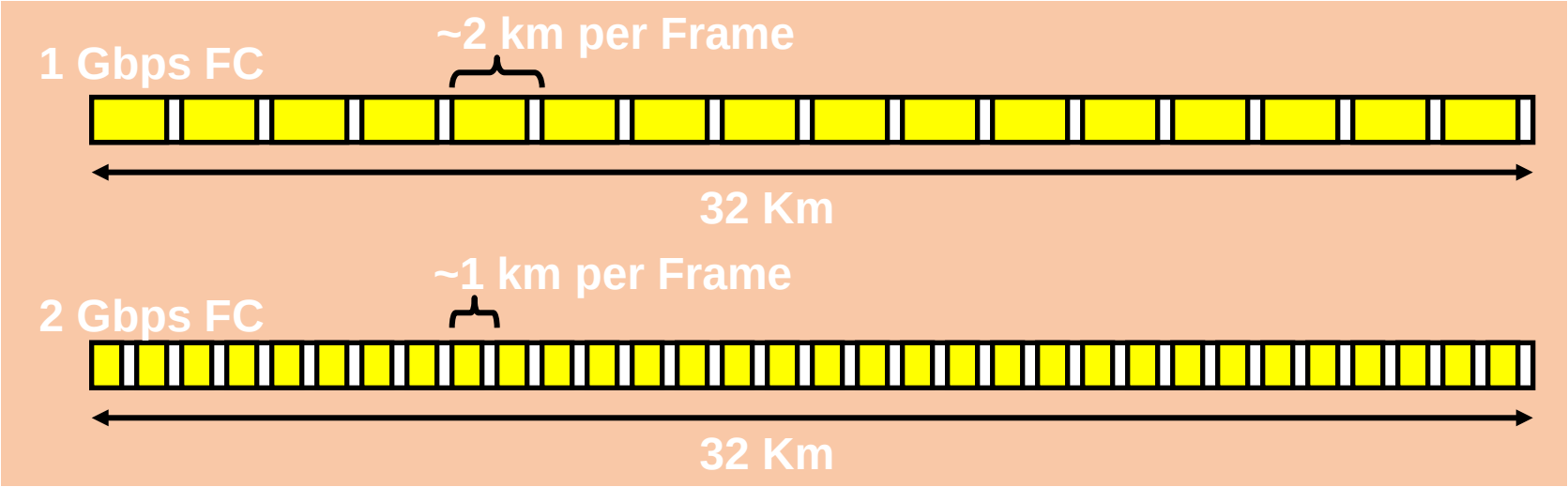
Buffer Credits (BB_Credits): Working Clean

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 BB_Credits and Distance



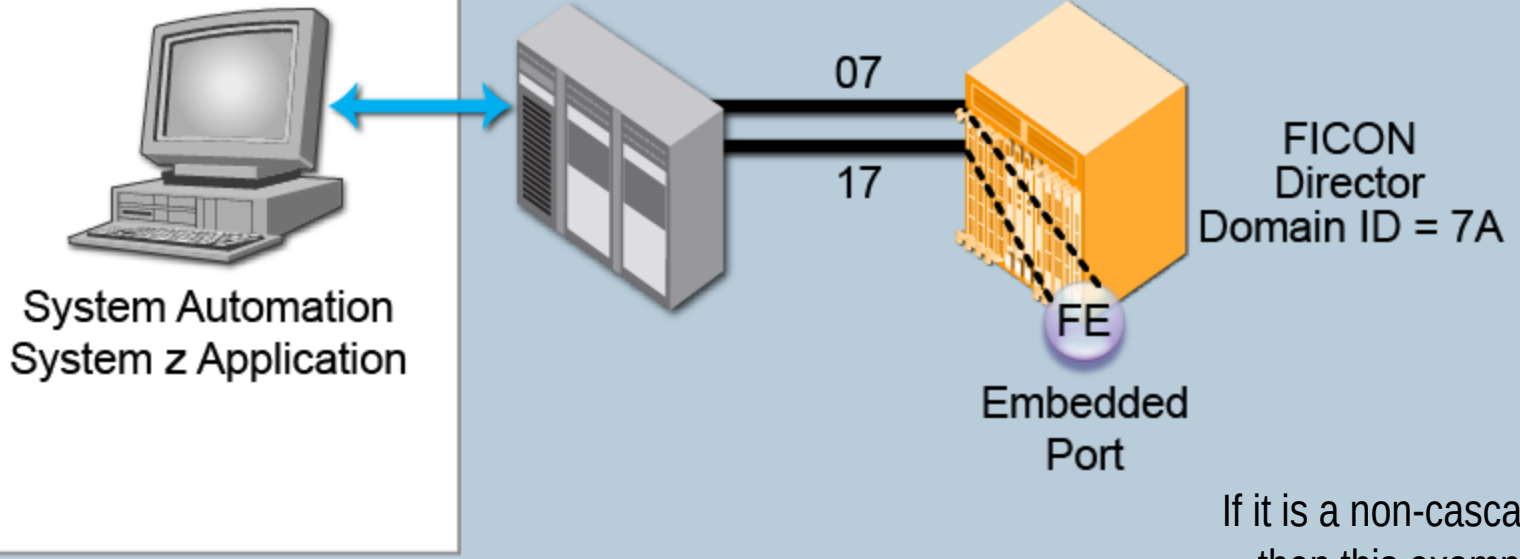
- BB_Credits are used to make sure that data frames do not overrun the receiver
- BB_Credits are used to ensure high link utilization via enough FC frames in flight
- A full (2112 byte) FC frame is approximately 1 km long @ 2 Gbps and approximately .5 km long @ 4 Gbps and approximately .25 km long @ 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



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

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

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]

Agenda for Session 13014

Session 13014

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

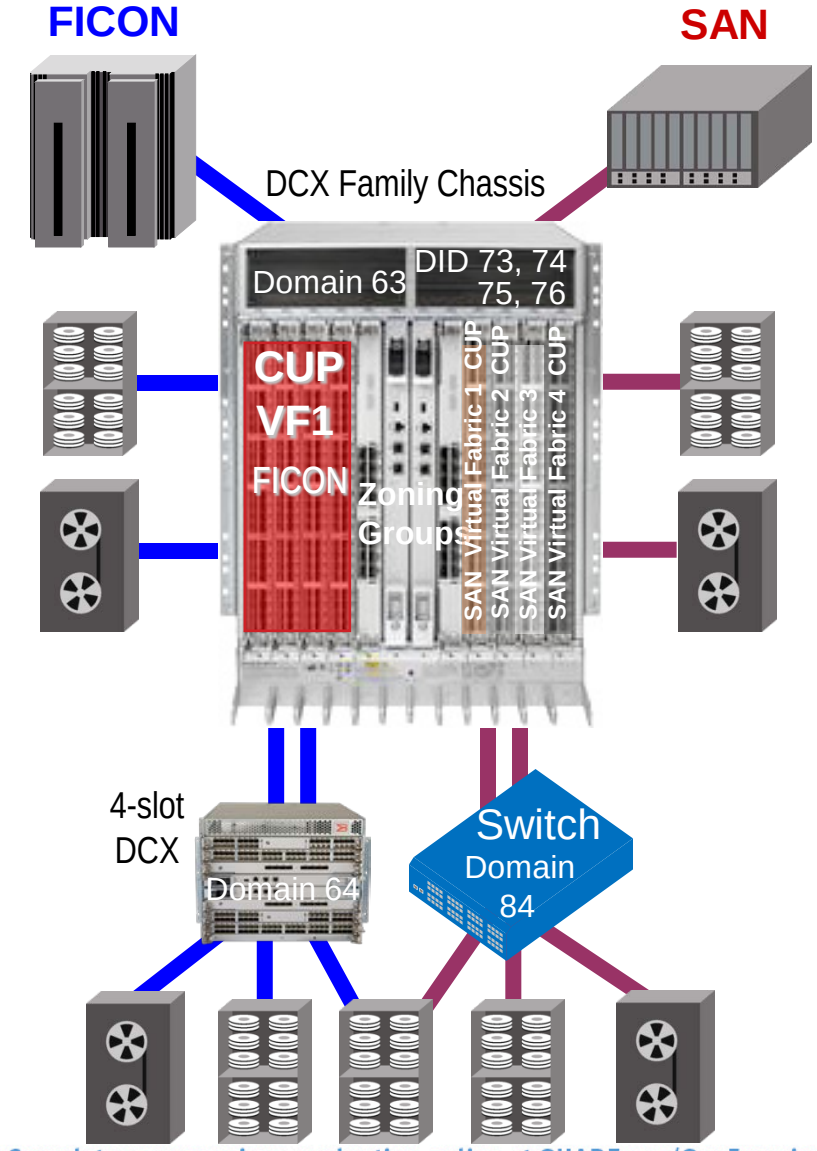
Fabric Routing Across ISLs: FSPF

- 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 an FSPF routing process called Dynamic Load Sharing (DLS) if TRUNKING is not used
    - Old CNT/McDATA devices always use FSPF for initial ISL routing
- FSPF (or DLS) 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 – optional configuration
  - Chassis can be either a physical switch or 1 or more logical switches (Virtual Fabrics disabled or enabled)
  - Creating a Logical Switch creates a Virtual Fabric (VF)
  - Each Logical Switch will have a unique Domain ID
- Cisco – required configuration
  - Virtual SANs (VSANs) are incorporated into the architecture
  - Each VSAN will have a unique Domain ID

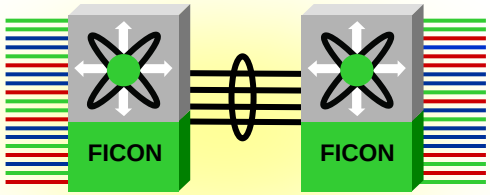
Virtual Fabrics (VF) and Brocade



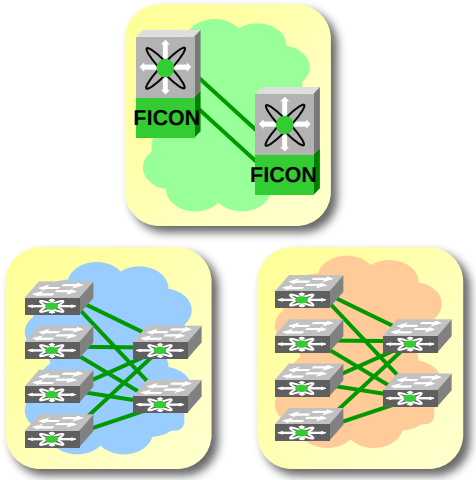
- VF is an OPTIONAL feature on all of the Brocade DCX family of FICON/SAN Directors and switches
- 48-port blades for FICON can be used only when Virtual Fabrics are enabled on the 8-slot DCX chassis
  - DCX-4S and the DCX 8510-4 never require the use of VF
- VFs creates new services within each Virtual Fabric
  - Domain ID
  - Name Server, etc
- Provides additional isolation of ports within a chassis
- Can provision up to 8 virtual fabrics and up to 4 CUP instances on a physical DCX family 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



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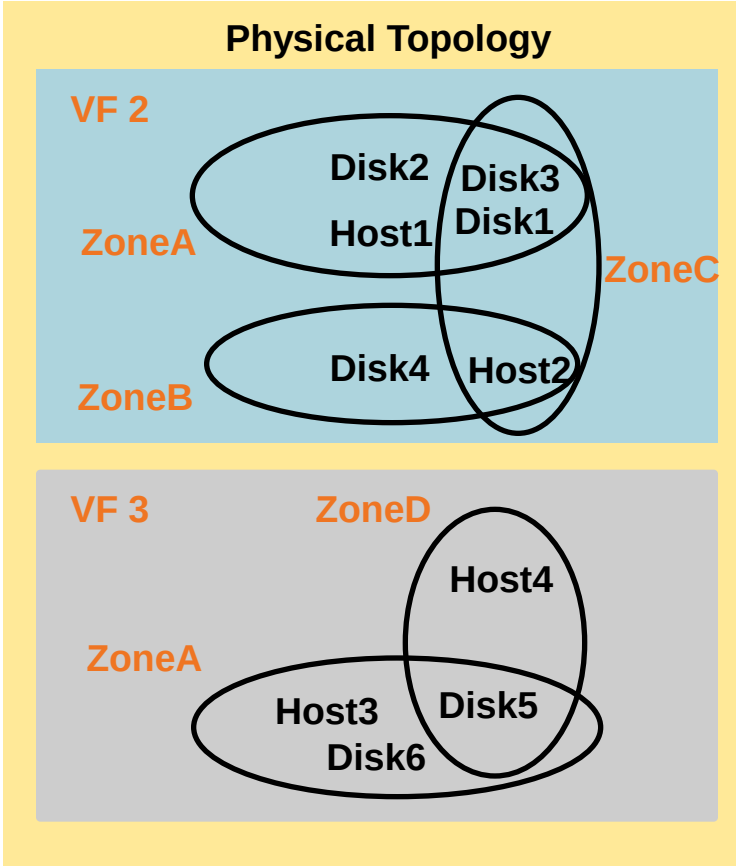
- **Security / Zoning**

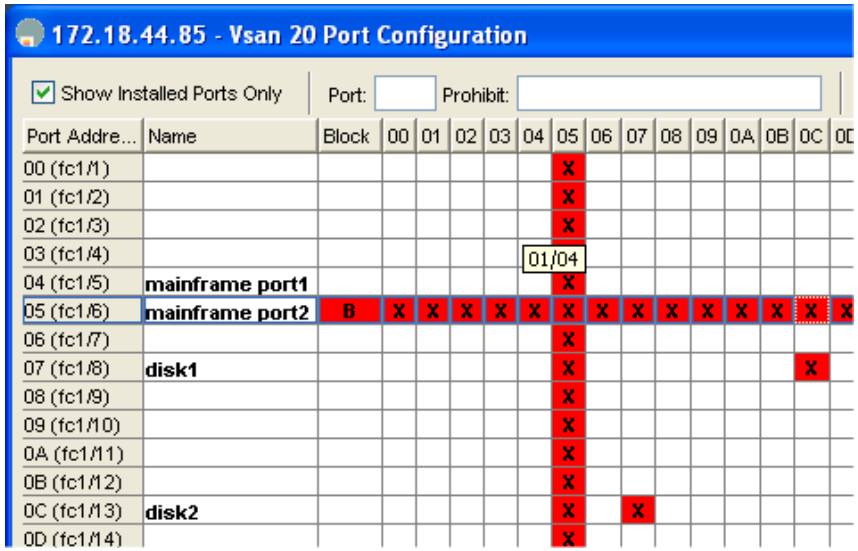
Zoning

- 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



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**

This Is The End Of Part 1

The 2nd of this 2-part session is

Session 13011

Monday: 3:00PM – 4:00PM

SAN Sessions at SHARE this week

Monday:

Time-Session

1330 - 13015: Why Customers Should Deploy Switches in Their SAN and FICON Environments
1500 - 13011: Further on SAN (Storage Area Networking) – continuation of this session

Tuesday:

Time-Session

1100 – 12166: What Every Mainframer Needs to Know About Networking

Wednesday:

Time-Session

0800 - 13062: FICON Channel Extension
0930 – 13013: Datacenter SAN & LAN Networking Convergence
1100 – 13117: Best Practices For SAN Management - For Both Open and FICON
1700 - 12734: Enhanced Availability and IT Resilience: An Integrated TS7700 Grid

Thursday:

Time-Session

0800 – 13010: A First Look at the Inner Workings and Hidden Mechanisms of FICON
0930 – 13009: A Deeper Look Into the Inner Workings and Hidden Mechanisms of FICON Performance
1300 – 13012: Buzz Fibrechannel - To 16G and Beyond

Complete your sessions evaluation online at SHARE.org/SanFranciscoEval

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

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This was session:

13014

Thank You For Attending Today!

5 = "Aw shucks. Thanks!"
4 = "Mighty kind of you!"
3 = "Glad you enjoyed this!"
2 = "A Few Good Nuggets!"
1 = "You Got a nice nap!"

And Please Indicate On Those Forms If There Are Other Presentations You Would Like To See In This Track At SHARE.

QR Code

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