IBM TRAINING

G05

FICON Express4 - FICON/FCP for System z9

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Glossary

Acronym	Full Name	Use
CCW	Channel Control Word	An architecture supporting I/O communications
CHPID	Channel Path Identifier	Indentifier for channel path type in I/O Control Program
CRH	Channel Request Handler	Internal host bus for communication between I/O & memory
CSS	Channel Subsystem	A group of resources for use by channels
CTC	Channel-To-Channel	Protocol for host-to-host communication; ESCON, FICON
dB	decibel	Metric used to measure signal strength in fiber
DWDM	Dense Wavelength Division Multiplexer	Technology that allows multiple protocols to flow over a single fiber
ESCON	Enterprise Systems Connection	Channel architecture used by switches, directors, storage, printers
EREP	Environmental Record Editing and Printing Program	Processes SYS1.LOGREC datasets
FCP	Fibre Channel Protocol	Fixed format protocol to communicate with SCSI devices
FICON	Fibre Connection	Channel architecture used by switches, directors, storage, printers
ISL	Inter-Switch Link	Data path between Directors to minimize cross-site fiber optic cabling
km	kilometer	Distance measurement identified with fiber optic cabing
LCSS	Logical Channel Subsystem	Architecture allowing more than one physical channel subsystem
LUN	Logical Unit Number	Associated with fixed block / SCSI devices
GBps	GigaBytes per second	Information transfer at one billion bytes per second (1,024 megabytes)
Gbps	Gigabits per second	Information transfer at one billion bits per second
LED	Light Emitting Diode	Light source for transceiver
LX	Long wavelength	Light source designed for use with single mode fiber

Glossary

Acronym	Full Name	Use
MBps	MegaByptes per second	Information transfer at one million bytes per second
MBA	Memory Bus Adapter	Building block of Central Electronic Complex and MCM
MCM	MultiChip Module	“Brick” containing Processor Units
MCP cable	Mode Conditioning Patch cable	Used with single mode fiber to reuse multimode fiber
MM	Multimode	Short form used in graphics; refers to multimode fiber
PCI	Peripheral Component Interconnect	Local bus standard used with Crypto, FICON, OSA hardware
PCI-X	PCI Extended	Faster than PCI
RAS	Reliability, Availability, Serviceability	
SAN	Storage Area Network	
SCSI	Small Computer System Interface	Fixed block architecture; communication between servers & devices
SM	Single mode	Short form used in graphics; refers to single mode fiber
STI	Self-Timed Interconnect	System z internal host bus for communication between I/O & memory
SX	Short wavelength	Light source designed for use with multimode fiber

Agenda

1	Overview
2	Modes of operation (CHPIDs)
3	The “bus” and I/O cage
4	Technology and performance
5	Architecture and hardware
6	CTC, cascading, intermix, functions
7	Distance
8	Switches / directors

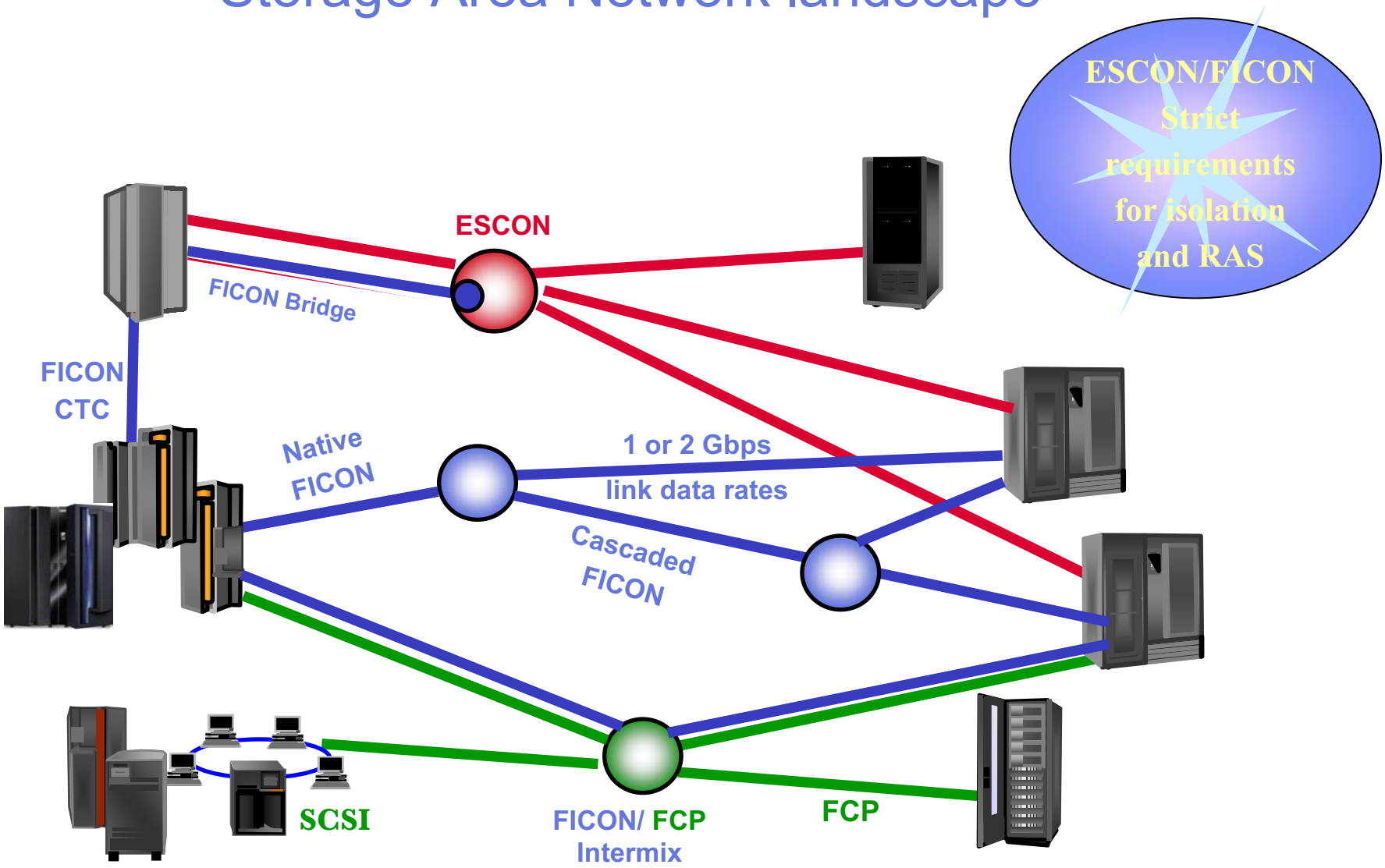
Agenda

1. Overview

FICON - it is more than an architecture

- Fibre - refers to an architecture
- Fiber or fibre - refers to a glass cable
- FICON = Fibre Connection
  - An architecture and an IBM registered trademark
  - IBM's implementation of Fibre Channel standard
- FICON - communicate with disks, tapes, printers
- FICON is a feature that supports
  - 1 or 2 Gigabits per second link data rate, auto-negotiated
- FC (native FICON) supported by five operating system environments
  - z/OS, z/VM, z/VSE, z/TPF, Linux on System z
- FCP (communication with SCSI devices)
  - z/VM, z/VSE, Linux on System z
- FCV – migration aid; Communicate with ESCON control units using ESCON Director Model 5 (withdrawn from marketing)
  - *Not supported on FICON Express4 and FICON Express2 features*

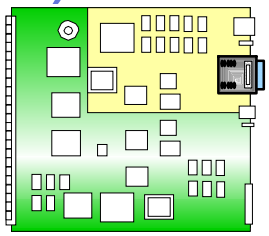
Storage Area Network landscape



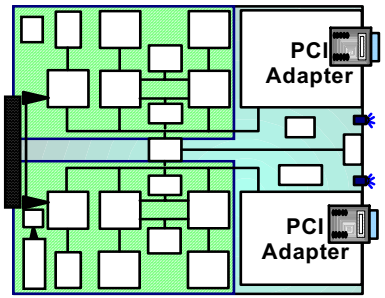
Fibre Connection (FICON)

1999 – **One channel, 1 Gbps**
LX – Bridge (March)
Native FICON and CTC (August)

G5/G6
FICON

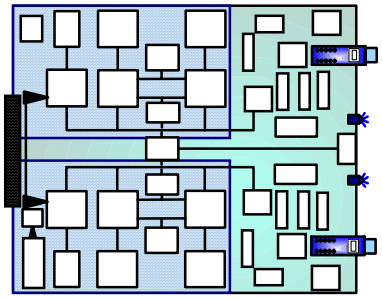


2000 – **2 channels** (December)
2001 – SX (October)



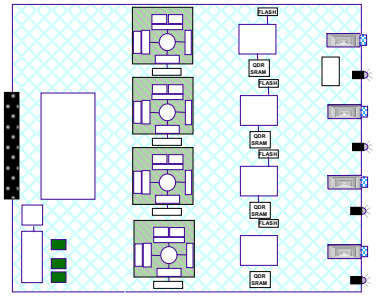
z900
FICON

2002 – **2 Gbps (August)**
Small form factor - LC Duplex
2003 – Cascading (January)
FCP (February), Intermix (March)



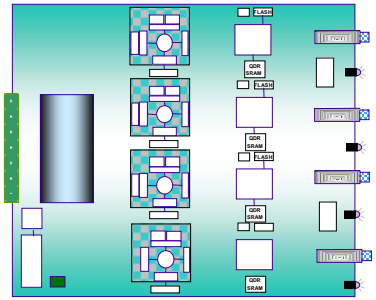
z990, z890
FICON Express

2005 – **2 Gbps 4 channels (January)**
Up to 336 FICON channels on z9 EC (Sept)



z9 EC, z990, z890
FICON Express2

2006 – **4 Gbps 4 channels (May)**



z9 EC, z9 BC
FICON Express4

FICON features over time

Feature	Feature name	Gbps	Ports	z900 12/00	z990 06/03	z9 EC 09/05	CHPIDs	Connector
2315	FICON LX	1	2	X	N / A	N / A	FCV, FC, FCP	*SC Duplex*
2318	FICON SX	1	2	X	N / A	N / A	FC, FCP	*SC Duplex*
2319	FICON Express LX	2	2	10/01	X	C	FCV, FC, FCP	LC Duplex
2320	FICON Express SX	2	2	10/01	X	C	FC, FCP	LC Duplex
3319	FICON Express2 LX	2	4	N / A	01/05	X	FC, FCP	LC Duplex
3320	FICON Express2 SX	2	4	N / A	01/05	X	FC, FCP	LC Duplex
NEW! 3321	FICON Express4 10 KM LX	4	4	N/A	N/A	05/06	FC, FCP	LC Duplex
3322	FICON Express4 SX	4	4	N/A	N/A	05/06	FC, FCP	LC Duplex
3324	FICON Express4 4KM LX	4	4	N/A	N/A	05/06	FC, FCP	LC Duplex

LX = Long wavelength transceiver, used with LX senders and receivers and single mode fiber
SX = Short wavelength transceiver, used with SX senders and receivers and multimode fiber
C = Carry forward on an upgrade from z900 or z990 to z9 EC
X = Available for ordering

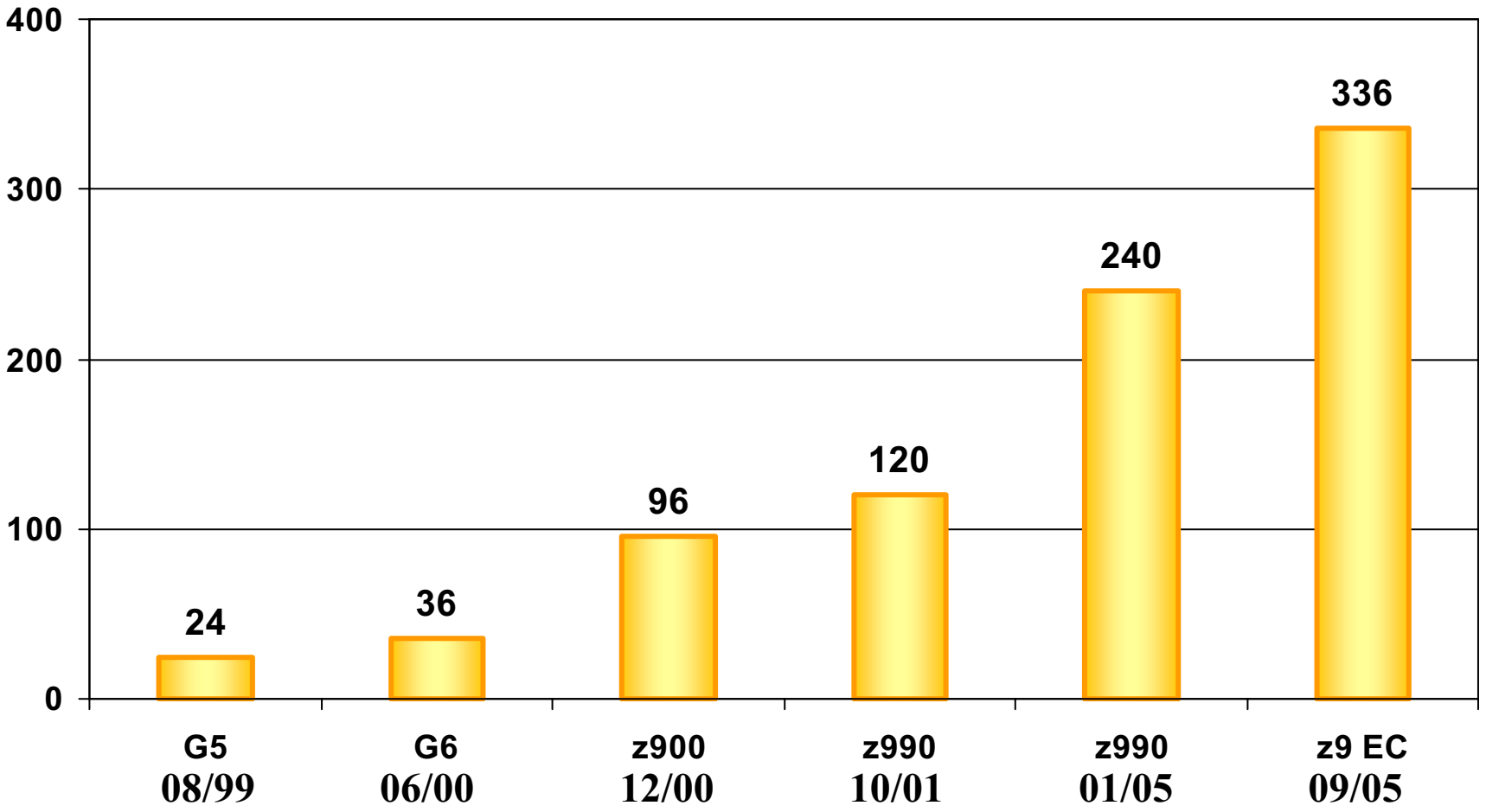
FICON features over time

Feature	Feature name	Gbps	Ports	z800 03/02	z890 05/04	z9 BC 05/06	CHPIDs	Connector
2315	FICON LX	1	2	N/A	N / A	N / A	FCV, FC, FCP	*SC Duplex*
2318	FICON SX	1	2	N/A	N / A	N / A	FC, FCP	*SC Duplex*
2319	FICON Express LX	2	2	X	X	C	FCV, FC, FCP	LC Duplex
2320	FICON Express SX	2	2	X	X	C	FC, FCP	LC Duplex
3319	FICON Express2 LX	2	4	N / A	01/05	C	FC, FCP	LC Duplex
3320	FICON Express2 SX	2	4	N / A	01/05	C	FC, FCP	LC Duplex
3321	FICON Express4 10 KM LX	4	4	N/A	N/A	X	FC, FCP	LC Duplex
3322	FICON Express4 SX	4	4	N/A	N/A	X	FC, FCP	LC Duplex
3323	FICON Express4-2C 4KM LX	4	2	N/A	N/A	X	FC, FCP	LC Duplex
3324	FICON Express4 4KM LX	4	4	N/A	N/A	X	FC, FCP	LC Duplex

NEW!

LX = Long wavelength transceiver, used with LX senders and receivers and single mode fiber
SX = Short wavelength transceiver, used with SX senders and receivers and multimode fiber
C = Carry forward on an upgrade from z800 or z890 to z9 BC
X = Available for ordering

FICON channel growth



Agenda

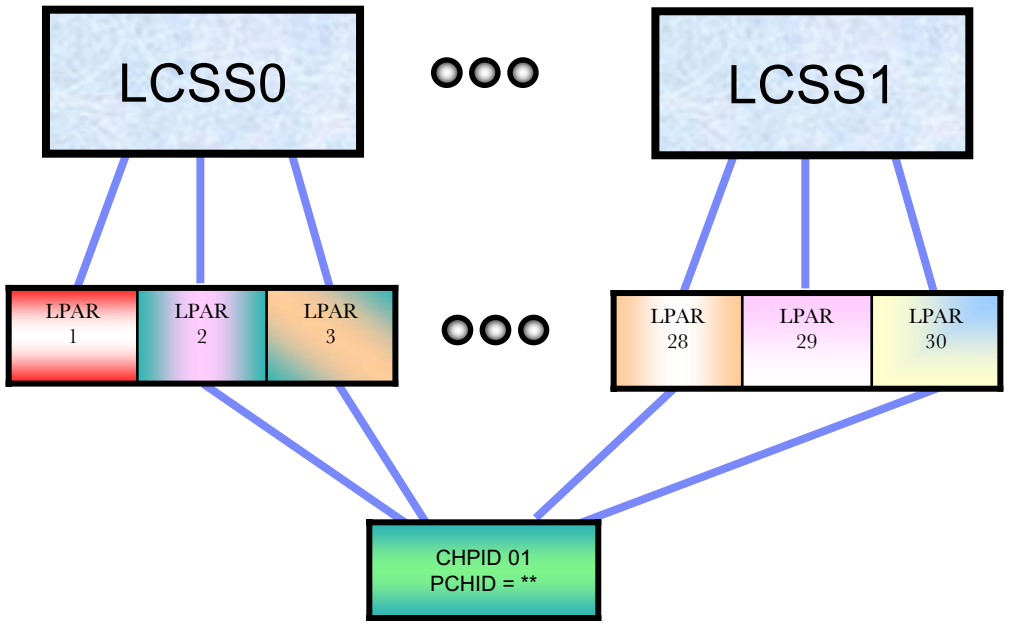
1. Overview
2. Modes of operation (CHPIDs)

Personalities of FICON features

Function	Native FICON CTC	SCSI	Bridge
Features	FICON Express4 FICON Express2 FICON Express FICON	FICON Express4 FICON Express2 FICON Express FICON	FICON Express FICON
CHPID type	FC	FCP	FCV
Link data rate	1 or 2 Gbps	1 or 2 Gbps	1 Gbps
Talks to	Disk (ECKD), Tape, Printers	SCSI devices	ESCON Control units
Cascading	Yes	Yes	N/A
Intermix FC/FCP	Intermix with FCP	Intermix with FC	N/A
CTC	Yes	N/A	N/A
Concurrent patch	Yes	Yes (May 04)	N/A

Spanned channels on z9 EC, z9 BC, z990, z890
Shared channels among LPARs across LCSSs

- **Internal spanned channels – First available October 2003**
  - **HiperSockets and Internal Coupling links (ICs)**
- **External spanned channels – First available May 2004**
  - **OSA-Express, OSA-Express2**
  - **FICON Express4, FICON Express2, FICON Express**
  - **ICB-3s, ICB-4s, ISC-3**

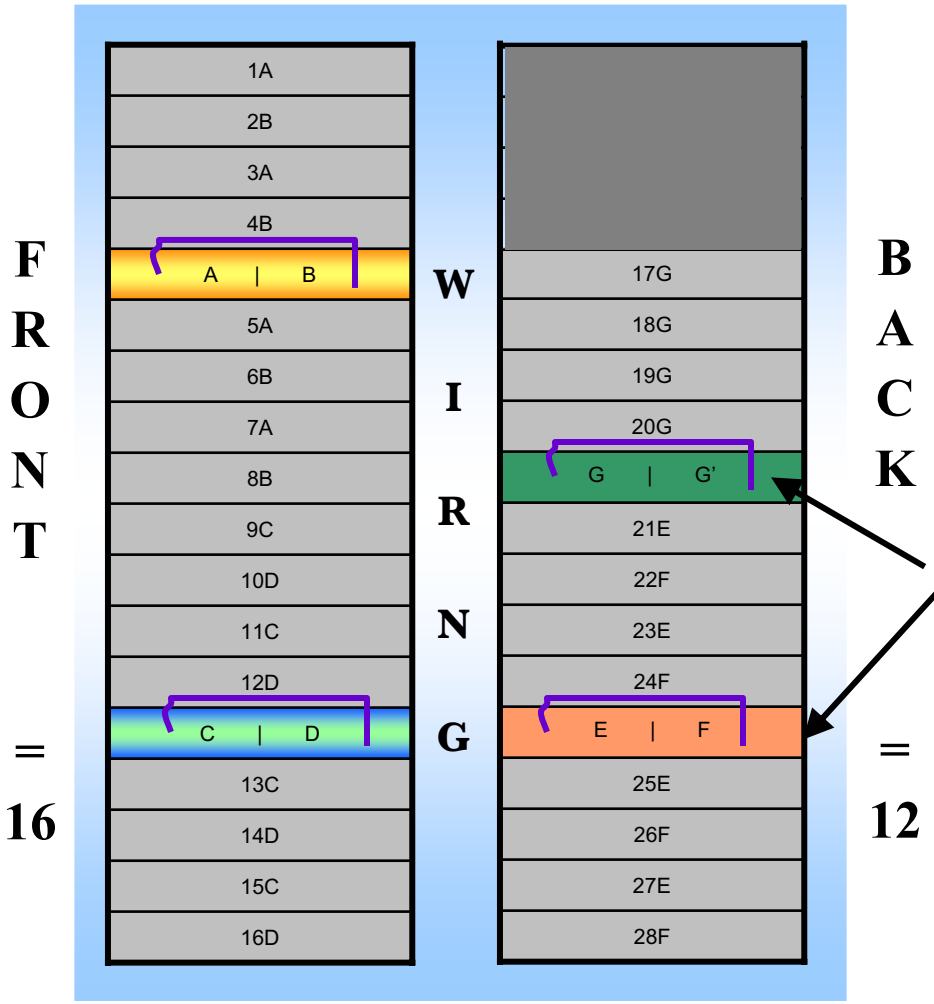


** No PCHID for HiperSockets and Internal Coupling links. PCHID required for FICON, ICs, ICBs, ISC-3, OSA
Spanning reduces the number of channels that can be defined for all LCSSs on server
Worst case - 256 if all channels are spanned between all LCSSs

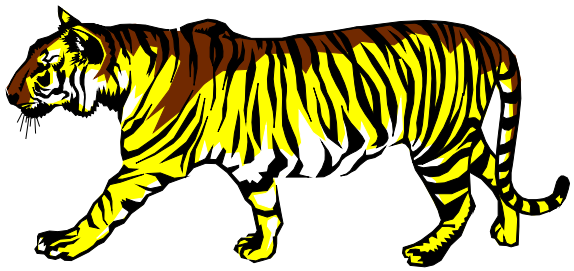
Agenda

1	Overview
2	Modes of operation (CHPIDs)
3	The “bus” and I/O cage

z9 EC, z9 BC with 8 STIs in I/O cage – Top view



- I/O cage
  - 8 STIs
    - G' is for redundancy
- STI speeds for downstream channels
  - 333 MBps – ESCON
  - 500 MBps
    - FICON Express
  - 1 GBps
    - FICON Express2
  - 2 GBps
    - FICON Express4

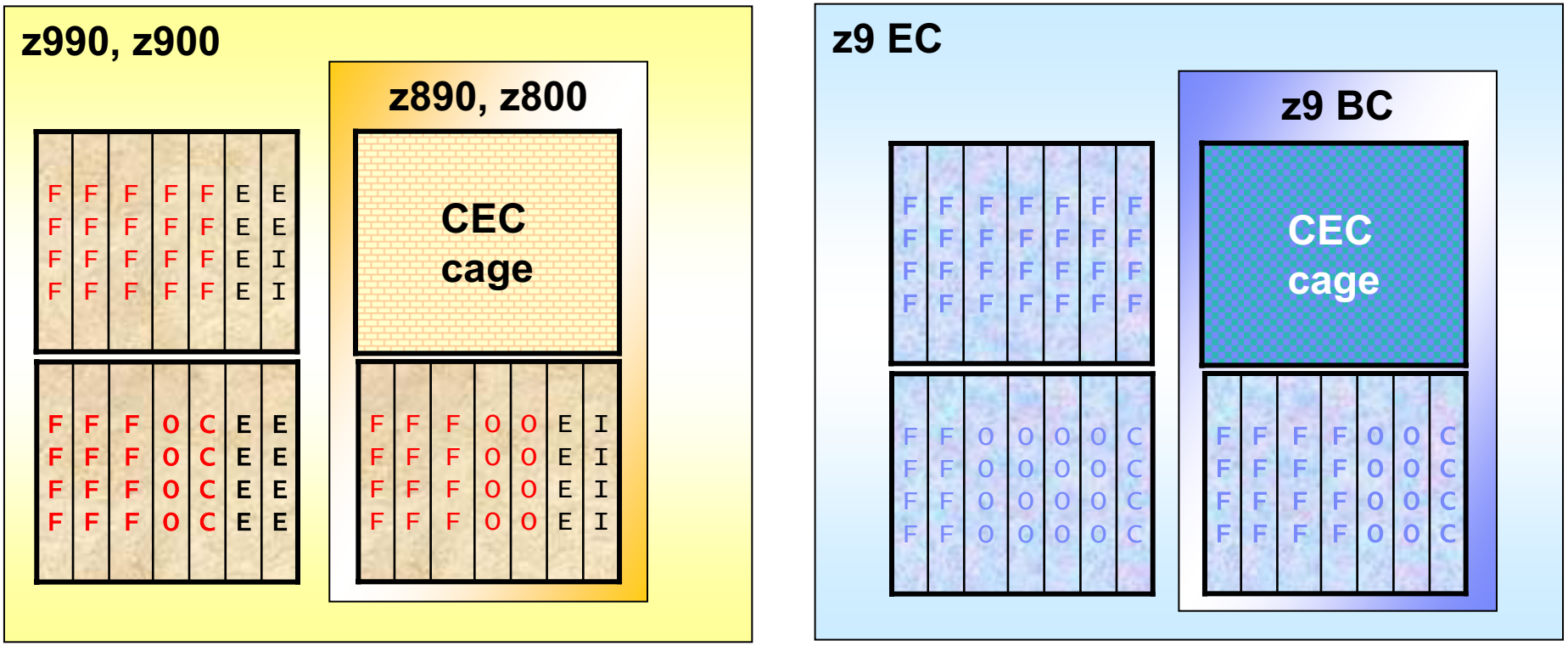


Increased connectivity per I/O cage on z9 EC, z9 BC

- All supported FICON features - up to 28 in one I/O cage, 84 per server
- OSA-Express2, OSA-Express, up to 24 per I/O cage or server
- Crypto Express2, up to 8 per I/O cage or server
- **Removed limitation of up to 20 FICON, OSAs, and Crypto in one I/O cage**

z900, z990, z990, z890
20 per I/O cage

z9 EC, z9 BC - 28 per I/O cage



E = ESCON, F = FICON, I = ISC-3, O = OSA, C = Crypto

Agenda

1	History
2	Modes of operation
3	The “bus” and I/O cage
4	Technology and performance

Refresh of FICON technology

Generation	1st Generation	2nd Generation	3rd Generation	3rd Generation
Servers	G5 LX, 08/99 G6, 06/00 SX, 03/01	z900 LX, 12/00 SX, 03/01	z900, 10/01 z800, 03/02	z900, 08/02 LIC update 08/02 z990, 06/03 z890, 05/04
Name	FICON	FICON	FICON Express	FICON Express
Feature numbers	2314 (LX) 2316 (SX)	2315 (LX) 2318 (SX)	2319 (LX) 2320 (SX	2319 (LX) 2320 (SX)
Channels per feature	One	Two	Two	Two
Maximum throughput	74 MBps full-duplex	74 MBps full-duplex	120 MBps full-duplex	170 MBps full-duplex
Microprocessor	166 MHz	333 MHz	333 MHz	333 MHz
PCI bus	32-bit 33 MHz	32-bit 33 MHz	64-bit 66 MHz	64-bit 66 MHz
Maximum features/channels	24 / 24 (G5) 36 / 36 (G6)	48 / 96	48 / 96	60 / 120 (z990)
Link data rate	1 Gbps	1 Gbps	1 Gbps	1 or 2 Gbps

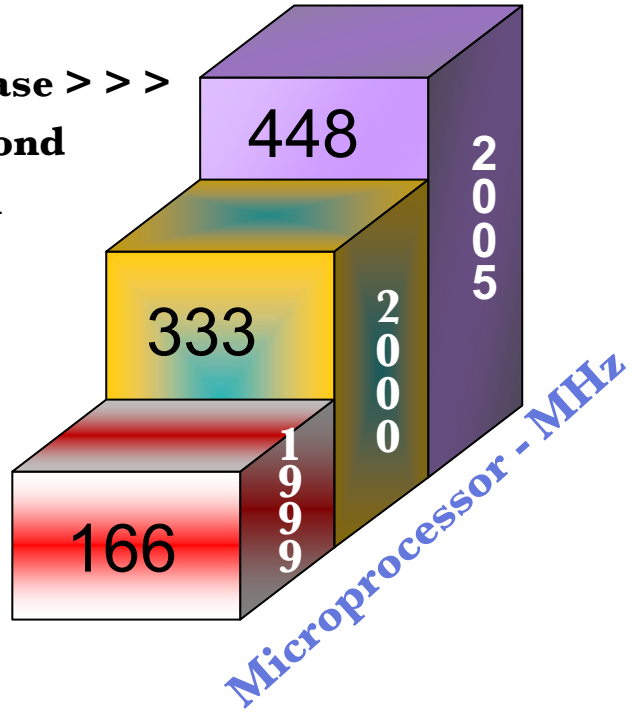
Refresh of FICON technology

Generation	4th Generation	4+ Generation
Servers	z990, z890, 01/05 z9 EC, 09/16/05	z9 EC 05/26/06 z9 BC 05/26/06
Name	FICON Express2	FICON Express4
Feature numbers	3319 (LX) 3320 (SX)	LX 10km – 3321 LX 4km - 3324 SX – 3322 2C LX 4km – 3323 (z9 BC)
Channels per feature	Four	Four – z9 EC Two / four – z9 BC
Maximum throughput	270 MBps full-duplex	350 MBps full-duplex
Microprocessor	448 MHz	448 MHz
PCI bus	PCI-X 64-bit 112 MHz	PCI-X 64-bit 112 MHz
Maximum features/channels	60 / 240, z990 20 / 60, z890 84 / 336, z9 EC	84 / 336, z9 EC 28 / 112, z9 BC S07 16 / 64, z9 BC R07
Link data rate	1 or 2 Gbps	1 / 2 / 4 Gbps
Optics	N/A	Individual repair

FICON - refresh of technology

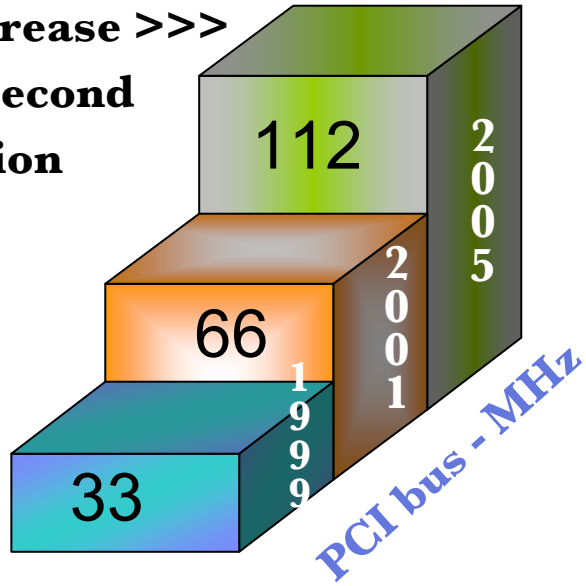
For more start I/Os

35% increase > > > versus second generation

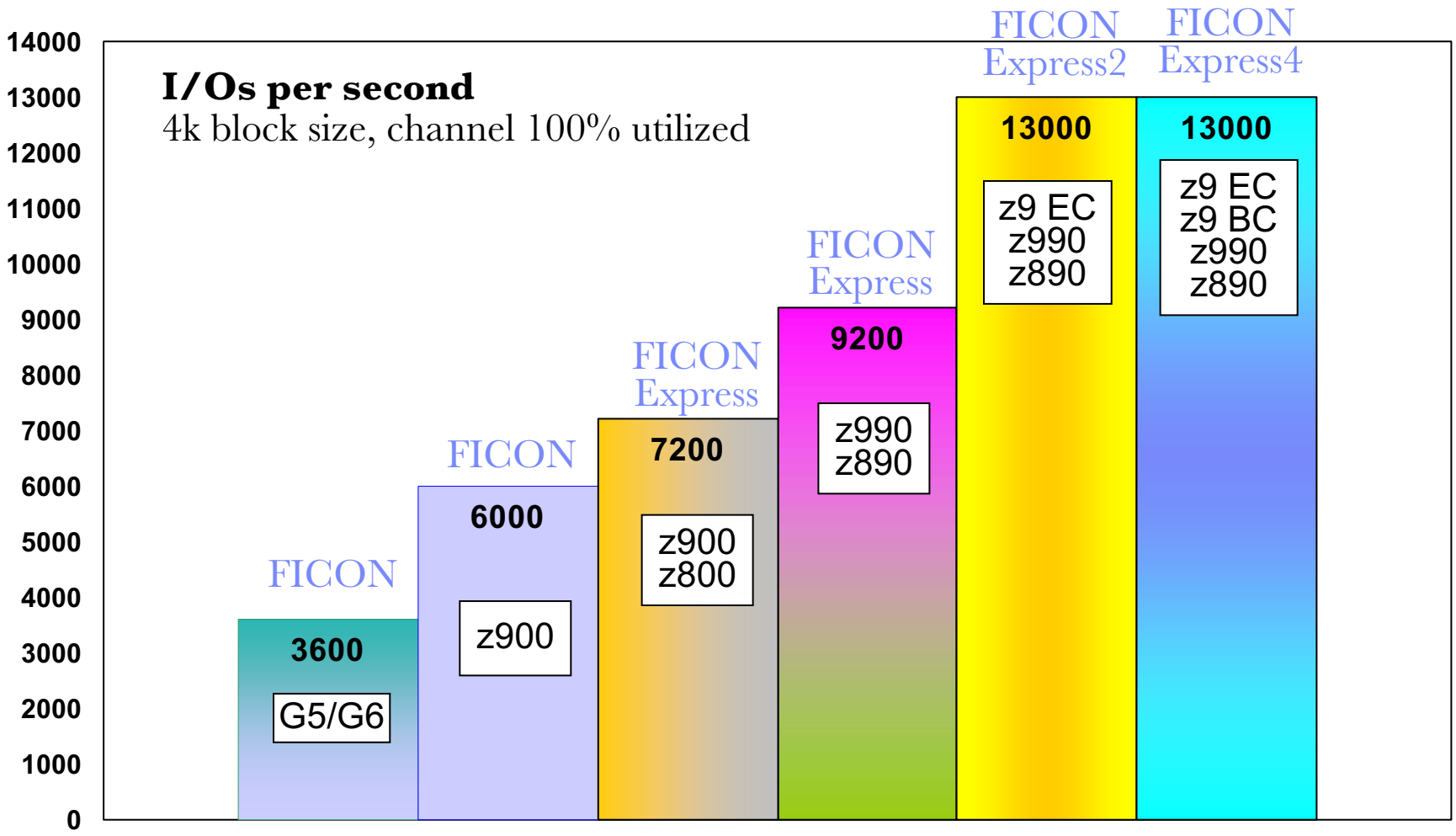


For greater throughput

70% increase >>> versus second generation



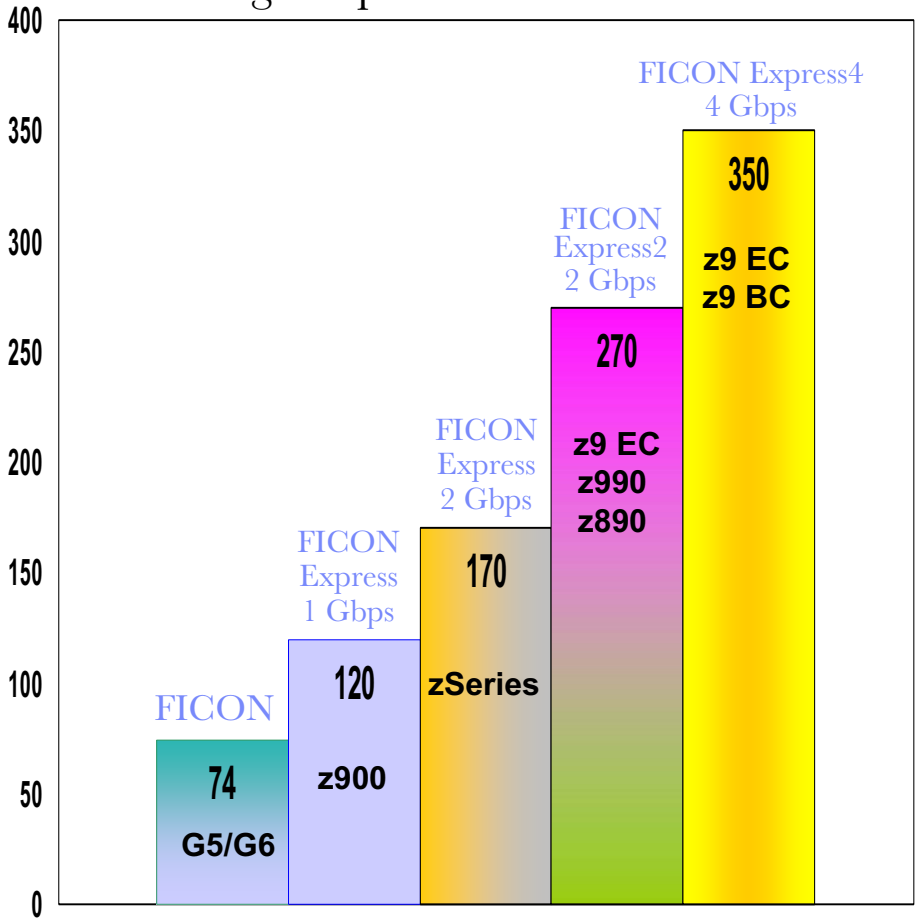
FICON performance – Start I/Os



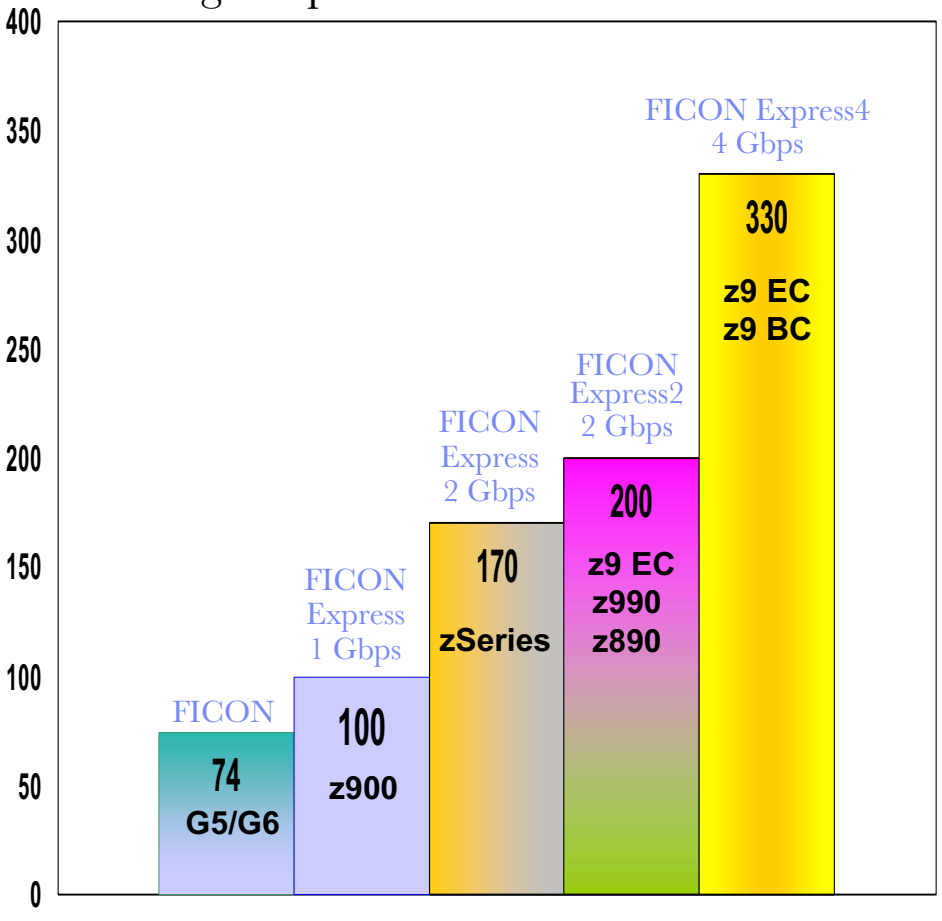
*This performance data was measured in a controlled environment running an I/O driver program under z/OS 1.7. The actual throughput or performance that any user will experience will vary depending upon considerations such as the amount of multiprogramming in the user's job stream, the I/O configuration, the storage configuration, and the workload processed.

FICON performance

Full duplex data transfers
MegaBytes per second (full duplex)
Large sequential read/write mix



Half duplex data transfers
MegaBytes per second (half duplex)
Large sequential all reads or all writes



*This performance data was measured in a controlled environment running an I/O driver program under z/OS 1.7. The actual throughput or performance that any user will experience will vary depending upon considerations such as the amount of multiprogramming in the user's job stream, the I/O configuration, the storage configuration, and the workload processed.

Compare FICON to ESCON

Increased number of start I/Os per second per channel						
ESCON	FICON G5, G6	FICON z900	FICON Express z900	FICON Express z990	FICON Express2 z990, z9 EC	FICON Express4 z9 EC, z9 BC
300	1800	3000	3600	4600	6500	6500
25%	50%	50%	50%	50%	50%	50%

Increased link data rate
Improved performance
Combined channel and CTC function
Reduced data rate droop
Increased unrepeated distances
Channel aggregation (ESCON to FICON), reducing infrastructure costs

Increased addressing				
	Unit addresses per channel	Unit addresses per Control Unit	Logical Control Units	CTC Unit addresses
ESCON, CNC	1024	1024	120	512
FCV, FC	16, 384	4096	256 *	16, 384

Agenda

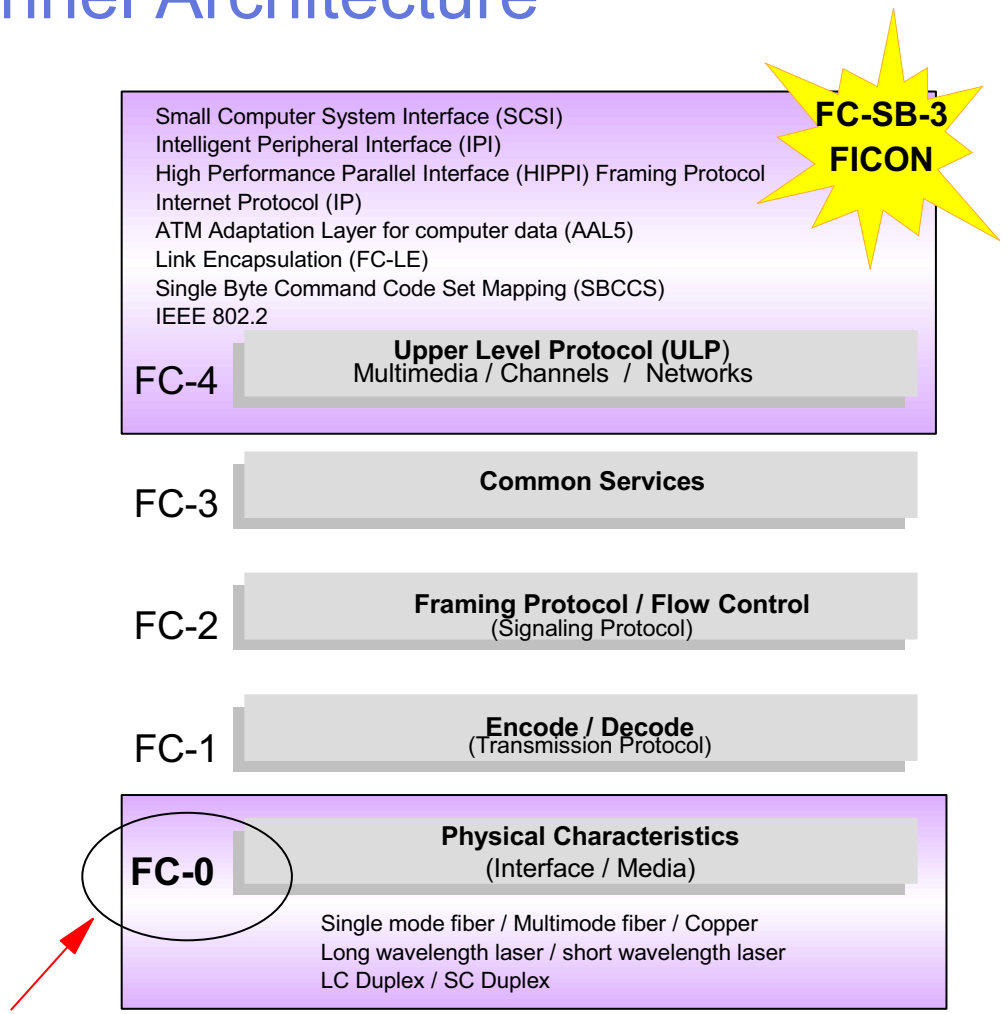
1	History
2	Modes of operation (CHPIDs)
3	The “bus” and I/O cage
4	Technology and performance
5	Architecture and hardware

Fibre Channel Architecture

Fibre Channel Architecture

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

- FICON
  - S/390 and System z implementation of Fibre Channel Architecture
    - Fibre Channel - Single-Byte-2 (FC-SB-2) ANSI/ INCITS standard
    - Fibre channel Single byte command code Sets-2 Mapping Protocol (FC-SB-2) ISO/IEC standard
- FCP
  - Fibre Channel Protocol for SCSI
  - Mapping of the SCSI command protocol onto the Fibre Channel architecture



Fiber Cabling for FICON & Fibre Channel Protocol (FCP)

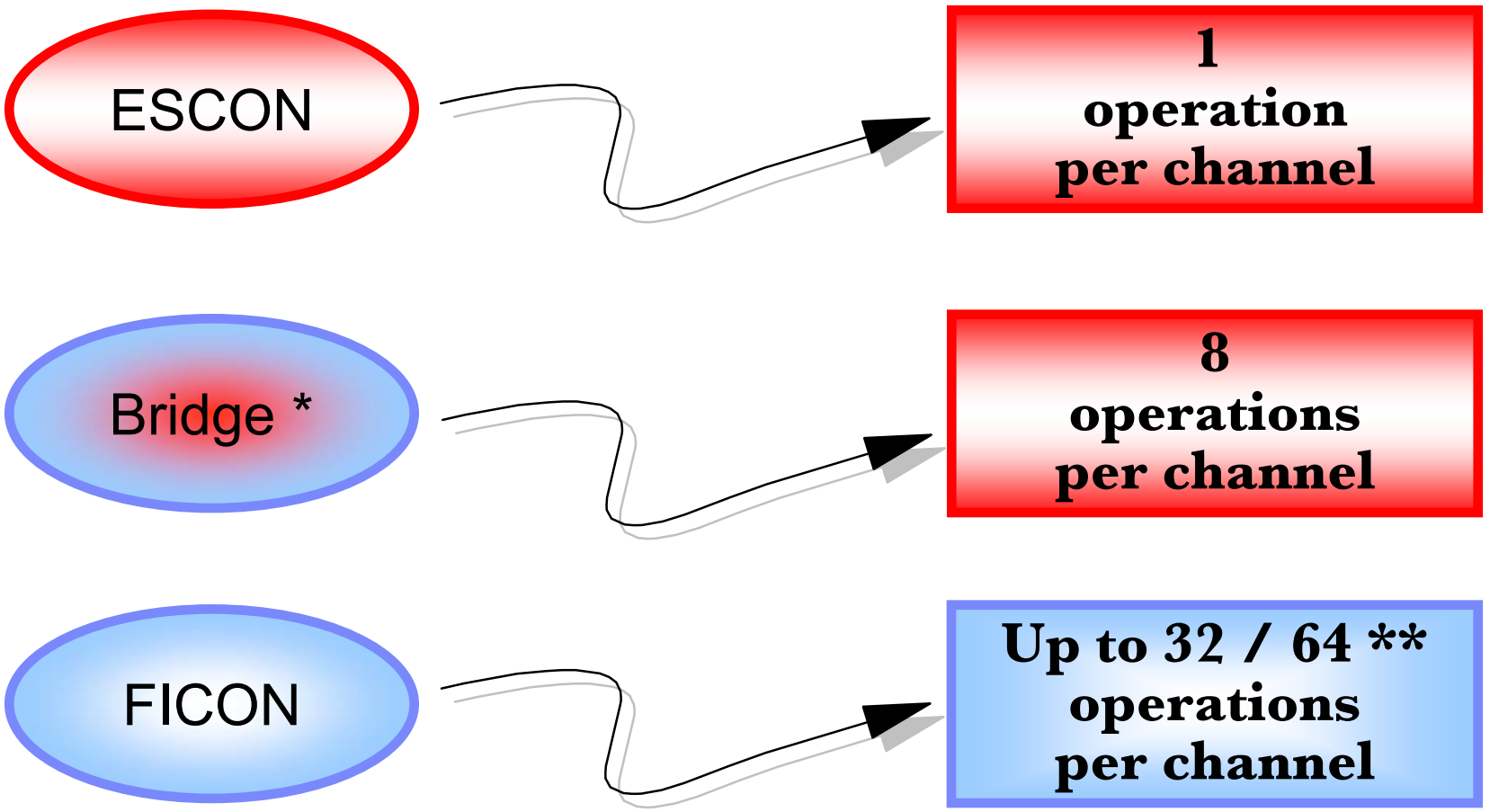
INCITS = InterNational Committee for Information Technology Standardization

Channel architecture comparisons

ESCON	FICON – native/CTC	FCP - SCSI
Circuit switching	Packet switching	Packet switching
Read or write Half-duplex data transfers	Simultaneous read and write Full-duplex data transfers	Simultaneous read and write Full-duplex data transfers
Connection-oriented	Connectionless	Connectionless
Pre-established dedicated path	Packets individually routed	Packets individually routed
Connection is locked when data sent	Connection released when data sent	Connection released when data sent
Synchronous transfers	Asynchronous transfers	Asynchronous transfers
CCW architecture	CCW architecture	QDIO architecture *

* Uses QDIO architecture for communication with the operating system. Defines data devices that represent QDIO queue pairs, consisting of a request queue and a response queue.

Concurrent I/O operations

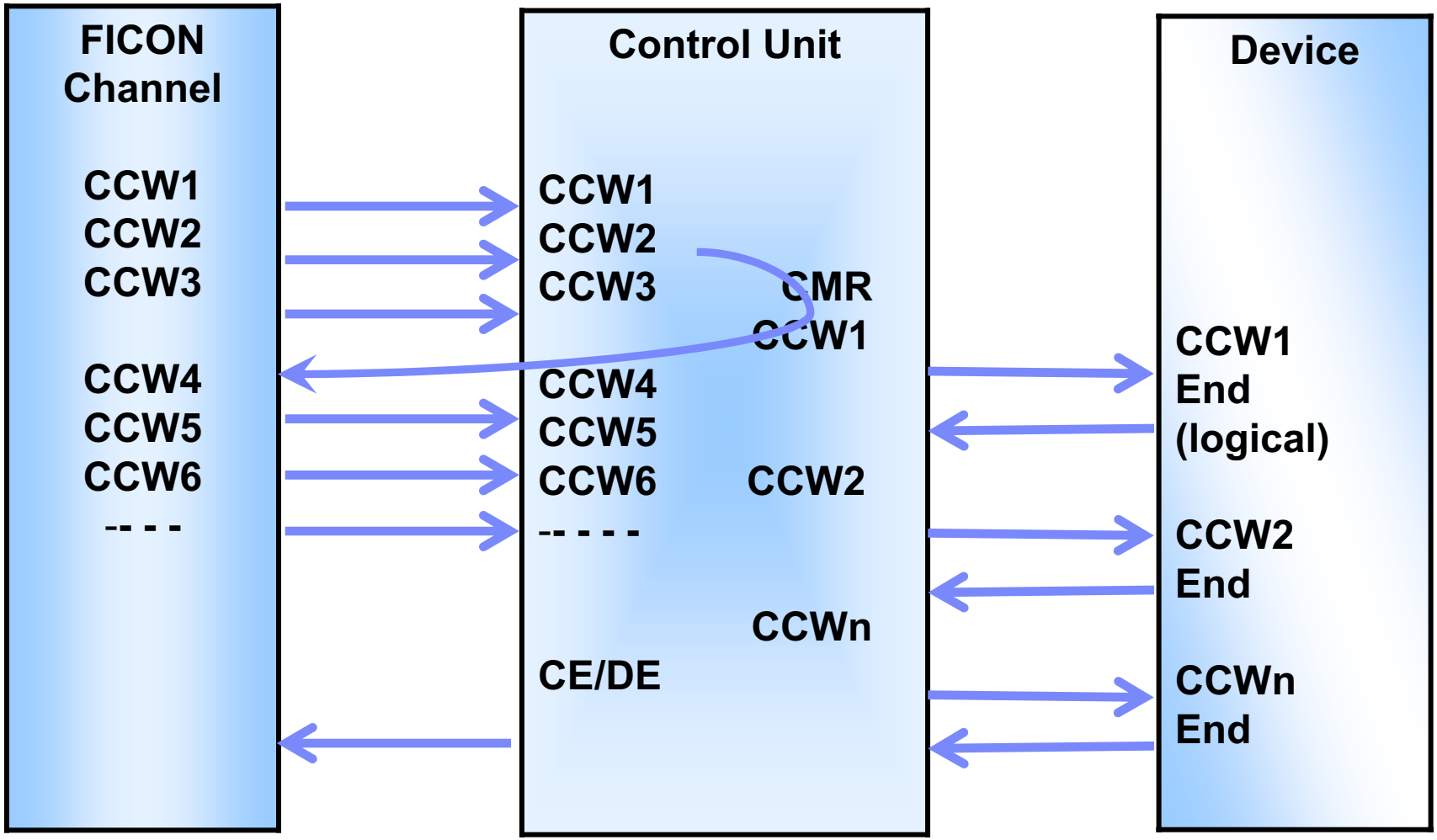


* Bridge (FCV) not supported on FICON Express4, FICON Express2

** Exclusive to FICON Express4, FICON Express2

FICON CCW chaining

- ✓No waiting for command response (CMR)
- ✓No waiting for CE/DE after each CCW execution



FICON Express4 on z9 EC, z9 BC

Small Form Factor Pluggable (SFP) optics
Concurrent repair/replace action for each SFP

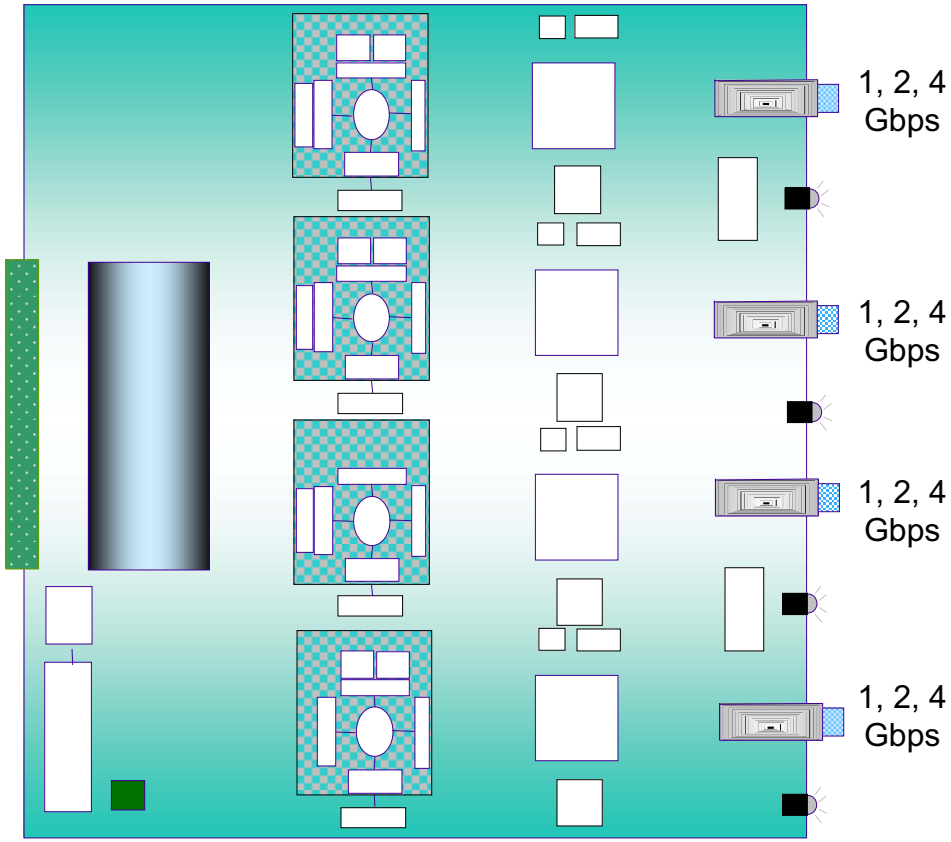
- **Ordering**
  - Four-channel increments
  - All channels - same type
    - LX (single mode fiber) or
    - SX (multimode fiber)

FC 3321 FICON Express4 10KM LX

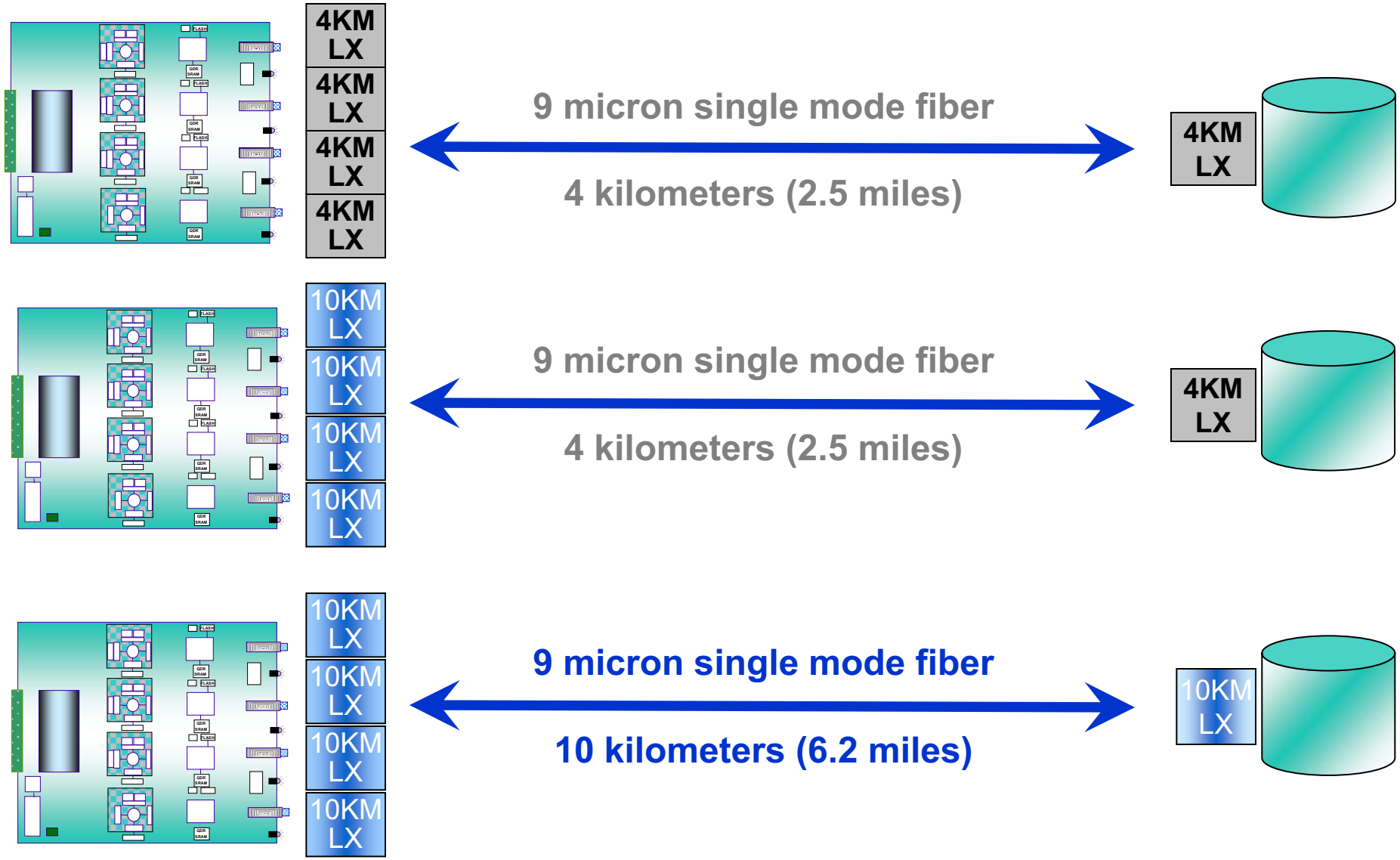
FC 3324 FICON Express4 4KM LX

FC 3322 FICON Express4 SX

FC 3323 FICON Express4-2C 4KM LX (exclusive to z9 BC)



FICON Express4 LX optics - unrepeated Distances



System z9 EC, z9 BC FICON/FCP 4 Gbps tested products

Product	Type	MT	Models	Mode	Gbps	Intermix ISL	Transceiver	Connector
IBM TotalStorage SAN256B Director	b-type	2109	M48	FICON FCP	1, 2, 4	Yes No	SX, LX	LC Duplex
IBM TotalStorage SAN32B-2	b-type	2005	B32	FICON FCP	1, 2, 4	Yes No	SX, LX	LC Duplex
Cisco MDS 9000 – 9506, 9509	c-type	2062	D04 , D07	FICON FCP	1, 2, 4	Yes,VSAN Yes	SX, LX CWDM *	LC Duplex
Cisco MDS 9000 – 9216a, 9216i	c-type	2062	D1A, D1H	FICON FCP	1, 2, 4	Yes, VSAN No	SX, LX CWDM *	LC Duplex
Cisco MDS 9513 Multilayer Director	c-type	2062	E11	FICON FCP	1, 2, 4	Yes, VSAN Yes	SX, LX CWDM *	Variable
IBM TotalStorage SAN16M-2	m-type	2026	416	FCP	1, 2, 4	NA No	SX, LX	LC Duplex
IBM TotalStorage SAN32M-2	m-type	2026	432	FICON FCP	1, 2, 4	Yes No	SX, LX	LC Duplex
IBM TotalStorage SAN140M	m-type	2027	140	FICON FCP	1, 2, 4	Yes No	SX, LX	LC Duplex

April / May 2006 announce

* ISL distance extended up to 100 km using CWDM

Summary – FICON support

	CHPID type	G5, G6 FICON	z900 FICON w/d 10/30/01	z990, z900 z890, z800 FICON Express	z9 EC, z990, z890 FICON Express2	z9 EC, z9 BC FICON Express4
Channels per feature	- - -	One	Two	Two	Four	Four
Link data rate	FC, FCP	1 Gbps	1 Gbps	1 or 2 Gbps	1 or 2 Gbps	1, 2, or 4 Gbps
FICON Bridge	FCV 1 Gbps	Yes LX only	Yes LX only	Yes LX only	No	No
FICON	FC	Yes	Yes	Yes	Yes	Yes
FICON CTC	FC	Yes	Yes	Yes	Yes	Yes
FCP for SCSI	FCP	No	Yes	Yes	Yes	Yes
Cascading High-integrity	FC	No	Yes	Yes	Yes	Yes
Intermix	FC, FCP	No	Yes	Yes	Yes	Yes

- ✓ Channel Path Identifier (CHPID)
- ✓ Channel-to-Channel (CTC)

Summary – FICON support

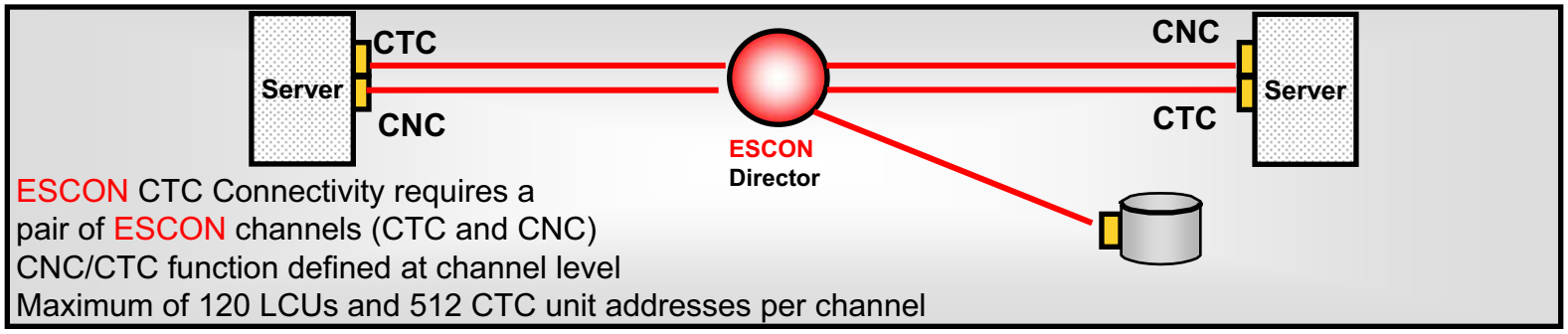
	CHPID type	z990, z900 z890, z800 FICON Express	z9 EC, z990, z890 FICON Express2	z9 EC, z9 BC FICON Express4
SCSI IPL # 9904	FCP	Yes, z990, z890	Yes	Yes
FCP SAN management	FCP	Yes	Yes	Yes
Concurrent patch	FC	Yes	Yes	Yes
Concurrent patch	FCP	Yes	Yes	Yes
Purge path extended	FC	Yes	Yes	Yes
FCP LUN access control	FCP	Yes	Yes	Yes
MIDAW facility	CNC, FCV, FC	No	Yes: z9 EC, z9 BC	Yes
Multiple subchannel sets	CNC, FC	Yes: z9 EC,z9 BC	Yes: z9 EC,z9 BC	Yes
63.75k subchannels	Transparent	No	Yes: z9 EC, z9BC	Yes
Open exchanges	FC	32	64: z9 EC, z9 BC	Yes
N_Port Virtualization ID	FCP	Yes:z9 EC, z9 BC	Yes: z9 EC, z9 BC	Yes
Point-to-point attach	FCP	Yes: z990, z890	Yes	Yes
Request Node ID data	FC	Yes: z9 EC,z9 BC	Yes	Yes
Link incident reporting	FC	Yes: z990, z890	Yes	Yes
Improved error recovery	FC	Yes	Yes	Yes
Pluggable optics	N/A	N/A	N/A	Yes

- Channel Path Identifier (CHPID)
- Channel-to-Channel (CTC)

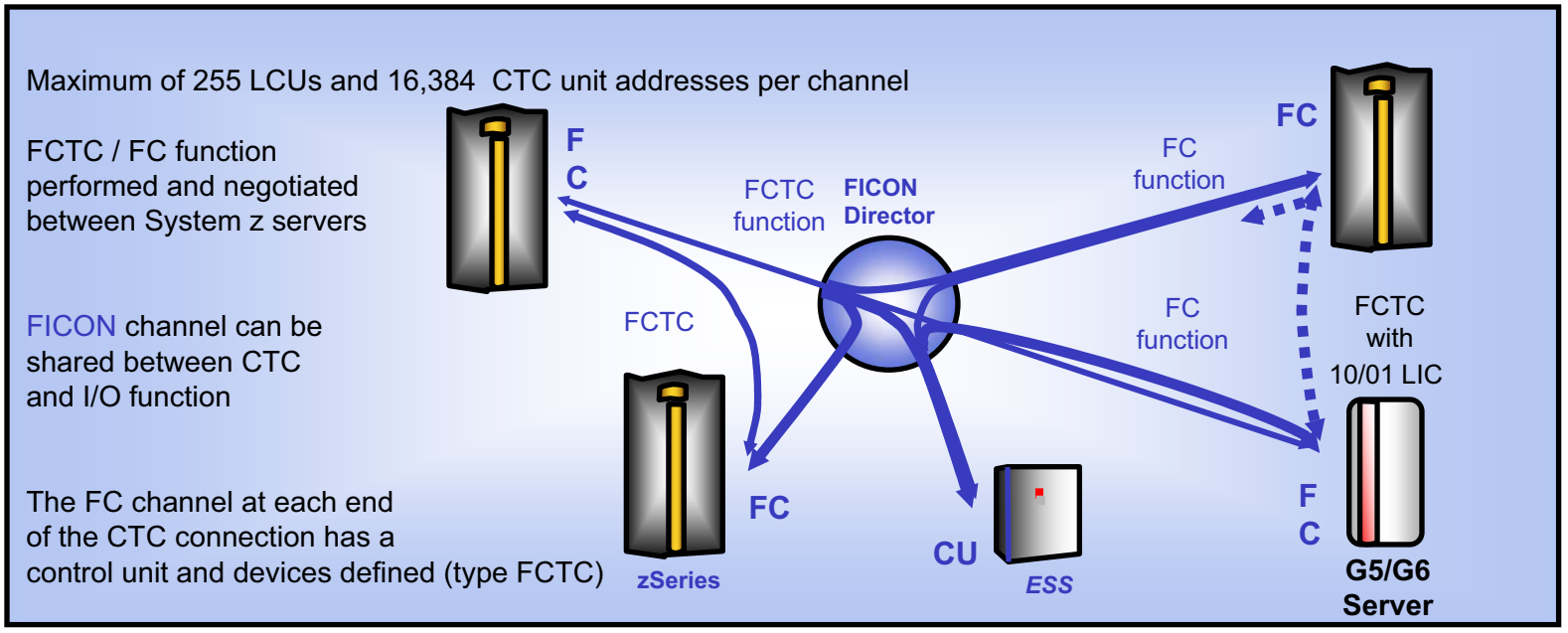
Agenda

1	History
2	Modes of operation (CHPIDs)
3	The “bus” and I/O cage
4	Technology and performance
5	Architecture and hardware
6	CTC, cascading, intermix, functions

Channel-to-Channel since October 2001



ESCON CTC Connectivity requires a pair of ESCON channels (CTC and CNC)
CNC/CTC function defined at channel level
Maximum of 120 LCUs and 512 CTC unit addresses per channel



FICON CTC versus ESCON CTC

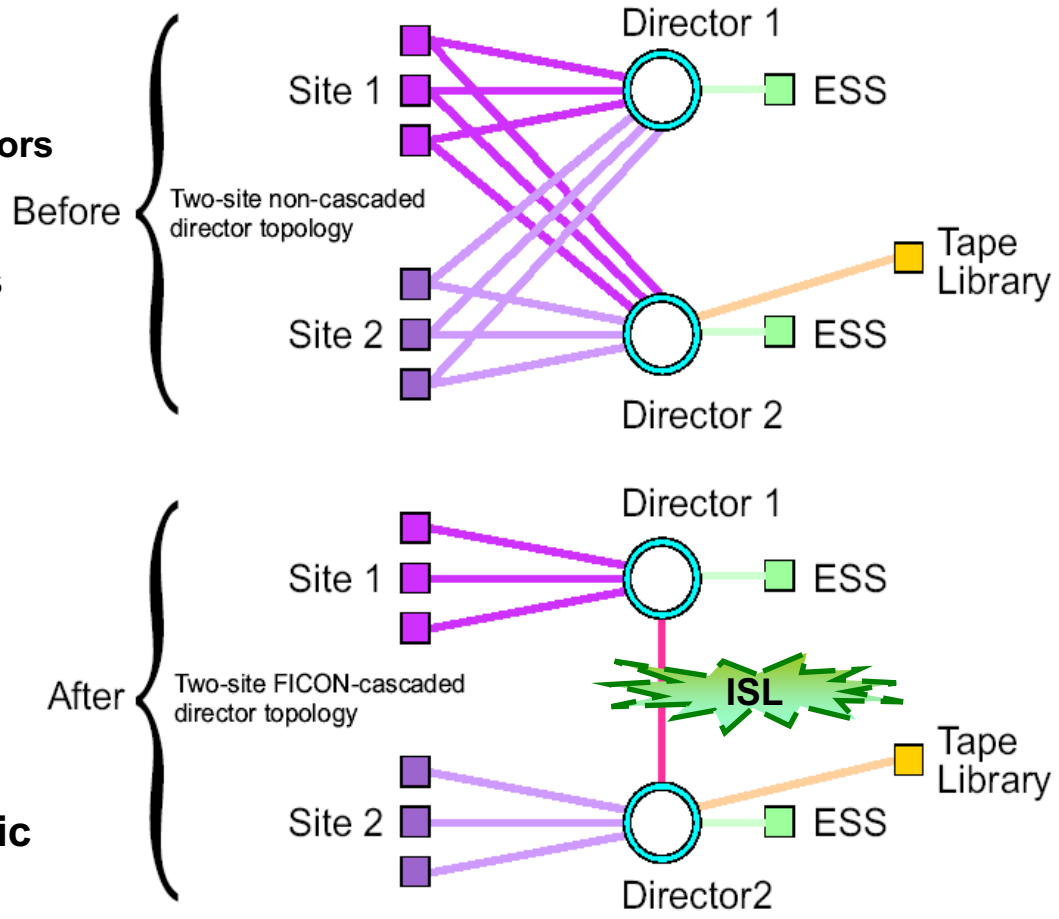
- **FICON Channel-to-Channel function is for host-to-host communication**
  - **The traffic can flow server-to-server or through a FICON Director**

- **Allows CTC function to be fully integrated within a native FICON channel (FC)**
  - **No unique CTC CHPID and CNC CHPID**
    - **Multiplexes CTC traffic with native FICON channel traffic**
    - **Channel is not dedicated to the Control Unit (CU) function**
  - **The CU function will always reside in a channel**
    - **With z900 10/01 Licensed Internal Code (LIC)**
    - **With z800 and later at availability level LIC**
  - **FC channel dynamically determines which side will contain the CU function**
    - **HCD does not need to verify CU end. Both sides are FC**
- **Load balancing**
  - **FICON channel automatically determines which System z server will provide the control unit function**
  - **Where the CU function resides is dependent upon the "load" of the channel (number of CTC CUs already operational)**
    - **Algorithm load-balances**

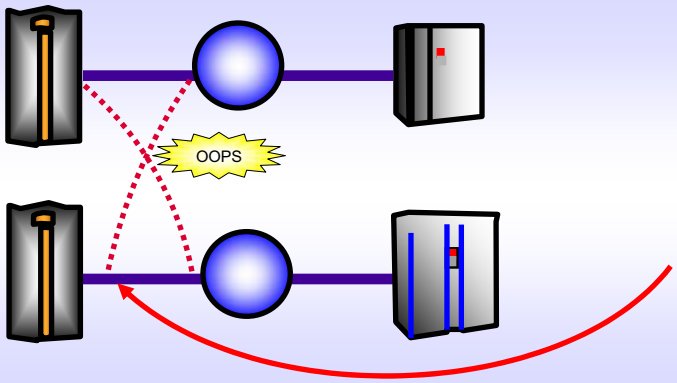
- **z/OS, z/VM**
- **Exploiters: XCF and VTAM MPC, IMS V7 Multiple Systems Coupling (MCS)**

Cascaded directors (Inter-switch links [ISLs]) since January 2003

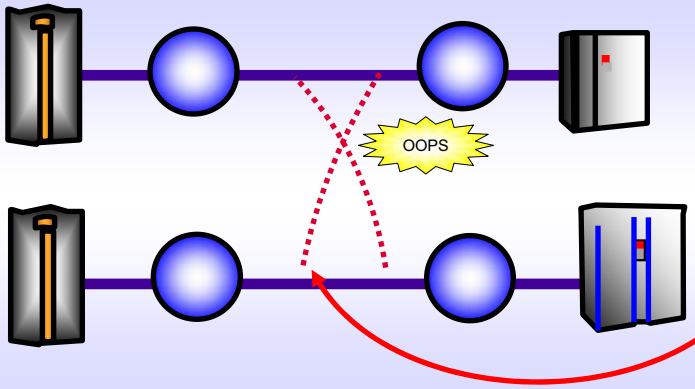
- **Before**
  - **Connect to local and remote directors**
- **After – connect to local directors**
- **Fewer cross-site connections**
- **Minimum supported OSs**
  - **z/OS V1.4**
  - **z/VM V4.4**
  - **VSE/ESA V2.7**
  - **TPF V4.1 at PUT 16**
  - **Linux (2.4 kernel)**
- **Single vendor high-integrity fabric**



Cascaded Directors - Enterprise Fabric



- **In single-director configurations the FICON architecture protects against miscabling and misdirecting of data stream.**
- **If accidental cable swap occurs server automatically invokes logical path testing, reporting, isolation, and recovery.**

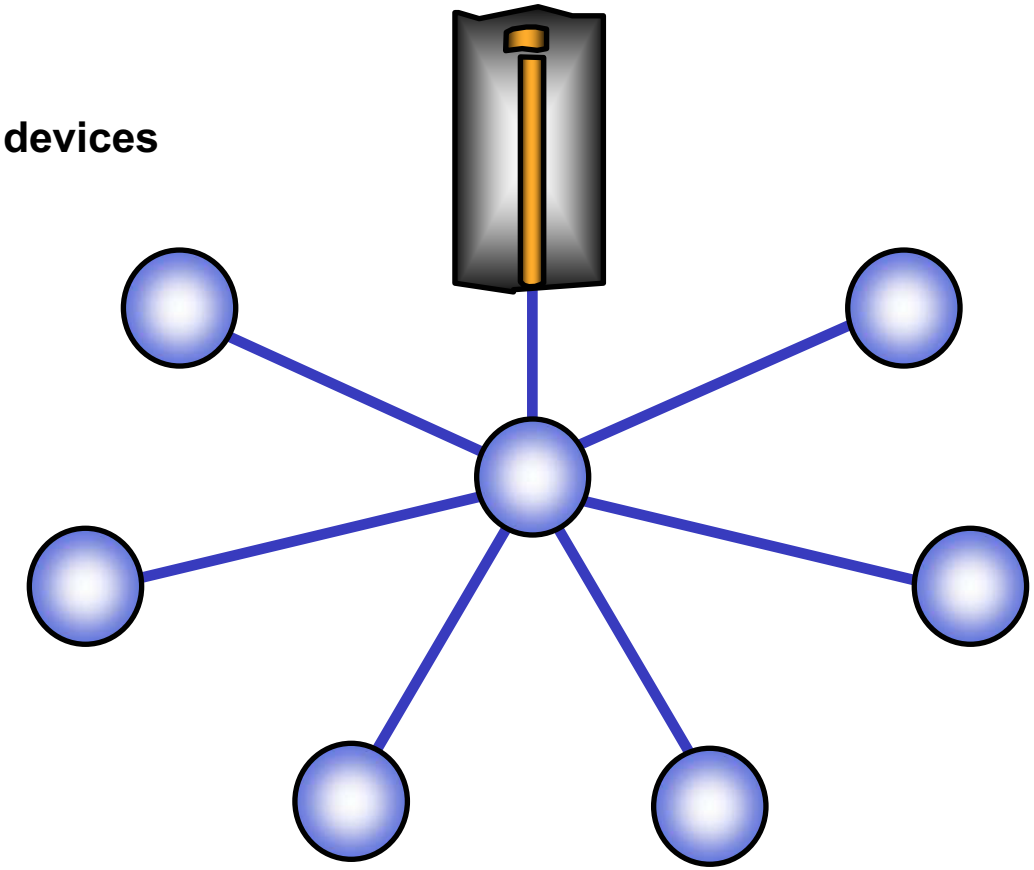


- **Now, in two-director cascading, the director architecture also protects against miscabling and misdirecting of data streams.**
- **If accidental cable swap occurs, directors interoperate with and invoke existing logical path testing, reporting, isolation, and recovery.**

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

Cascaded configuration

- **Single hop**
- **One core, multiple edge devices**
  - Vendor-dependent



Cascaded Directors - Enterprise Fabric Details

- Up to two directors are supported for cascaded switching FICON paths between System z FICON channels and control units (including FICON CTC)

- Directors participating in 'cascaded switching' must support "high integrity fabrics". Refer to vendor web sites for further information.

- High integrity fabric architecture support includes:
  - "Fabric binding" support

    The ability of the fabric to prevent a switch being added to the fabric that is not configured to support the "high integrity fabric“

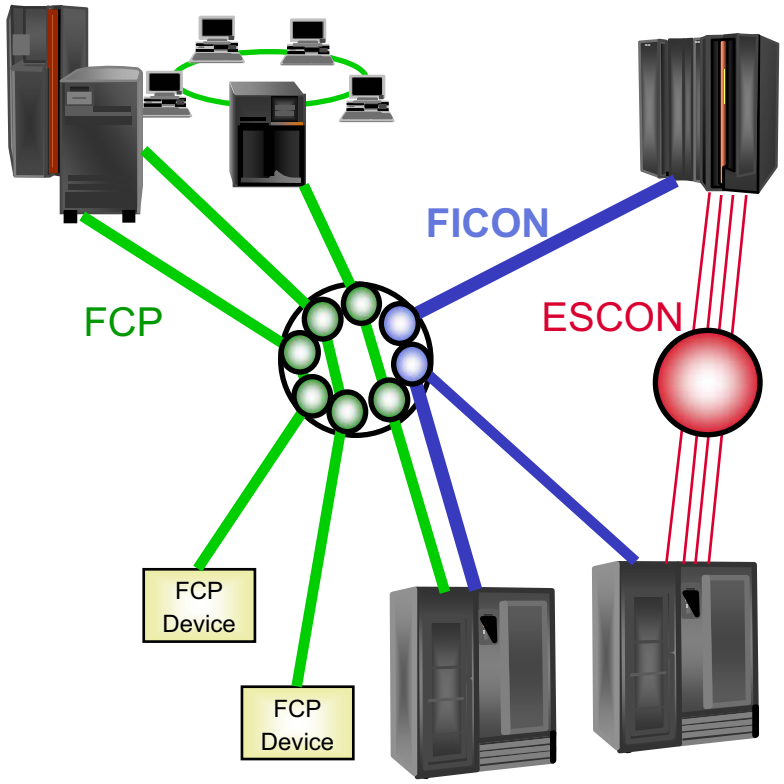
    All switches must be defined to all other switches via the switch console on each switch in the fabric.
  - "Insistent domain IDs" support

    Will not allow a switch address to be automatically changed when a duplicate switch address is added to the enterprise fabric. Would require overt operator action to change a switch address.

- Refer also to:
  - http:/www.ibm.com/servers/eserver/zseries/connectivity/ficon_cascaded.html

FICON and FCP intermix since March 2003

- **Intermix in same director**
  - **CHPID types FC and FCP**
- **Refer to intermix white papers**
  - **Contact preferred vendor**



- **For Linux on System z support of FCP**
  - ibm.com/developerworks/linux/linux390/

Agenda

1	History
2	Modes of operation (CHPIDs)
3	The “bus” and I/O cage
4	Technology and performance
5	Architecture and hardware
6	Functions

MIDAW facility for z9 EC, z9 BC

- **Modified Indirect Data Address Word (MIDAW) facility**
  - Designed to increase throughput and reduce link overhead
- **Alternative to using CCW data chaining in channel programs**
- **Breaks the 2k or 4k boundry restriction**
  - Channel Control Word (CCW) architecture is enhanced
    - Can handle larger blocks of data
    - Reduces the number of data moves
    - Reduced chained data
- **Design "in line" with Fibre Channel architecture**
- **Designed to reduce**
  - ESCON and FICON I/O processing
  - Control unit overhead
- Supported by
  - ESCON (CHPID type CNC)
  - FICON features supported on z9 EC, z9 BC (CHPID types FC, FCV)
- **Potential exploiters**
  - Applications that use: DB2, VSAM, PDSE, HFS, zFS
- z/OS V1.6 or V1.7 with PTFs

MIDAW facility 4k DB2 page comparisons

Non-EF datasets

- CCW READ 4K
- CCW READ 4K
- CCW READ 4K
- CCW READ 4K
- CCW READ 4K
- CCW READ 4K
- CCW READ 4K
- CCW READ 4K

…32 CCW's in total

EF datasets

- CCW READ 4K
- CCW READ 32 byte suffix
- CCW READ 4K
- CCW READ 32 byte suffix
- CCW READ 4K
- CCW READ 32 byte suffix
- CCW READ 4K
- CCW READ 32 byte suffix
- CCW READ 4K
- CCW READ 32 byte suffix

…64 CCW's in total

EF or non-EF datasets with MIDAWs

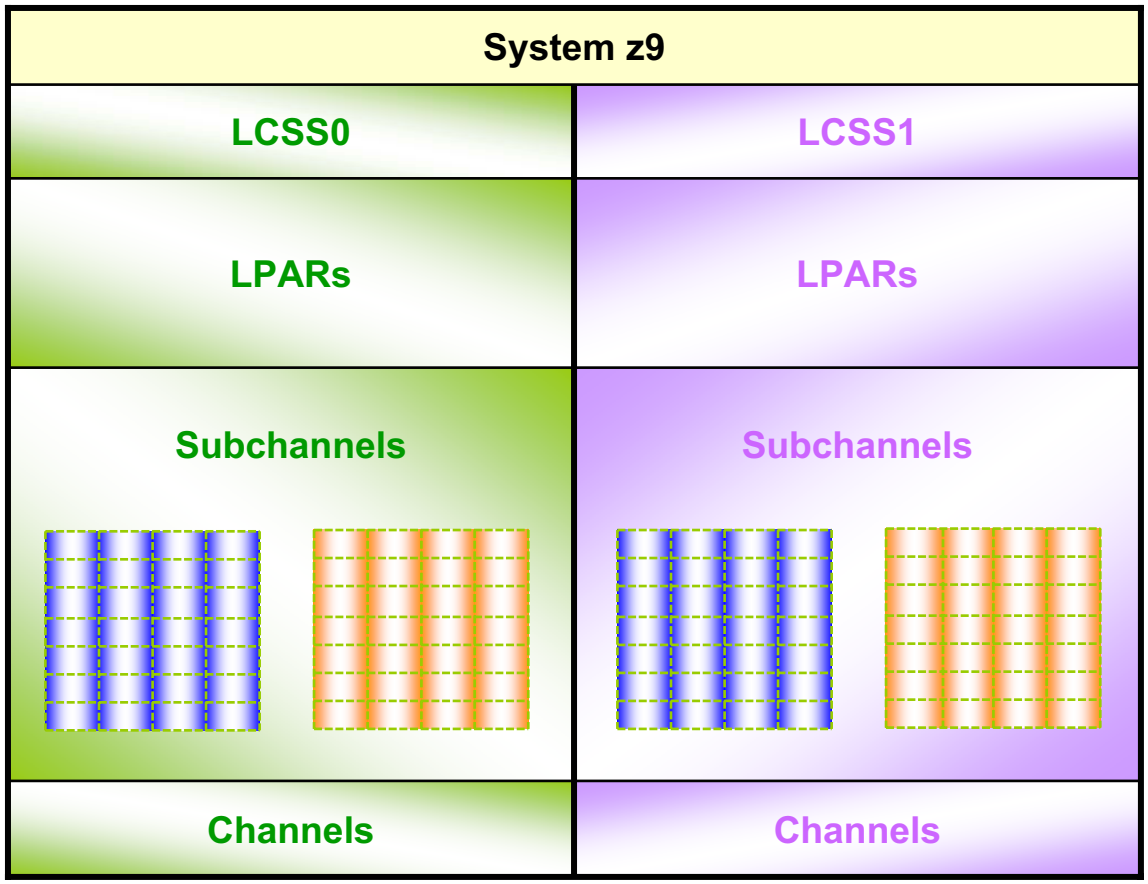
- Track level CCW
- Track level CCW
- Track level CCW
- Track level CCW

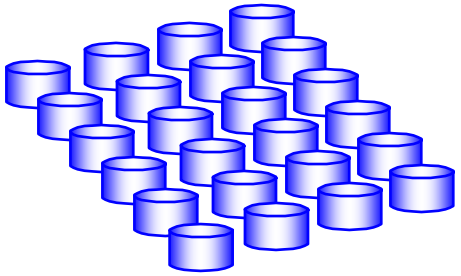
3 or 4 CCW's in total

Two subchannel sets on z9 EC, z9 BC

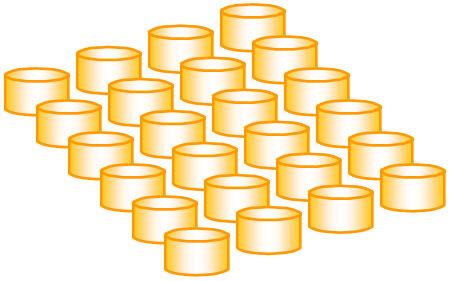
- **Subchannel – I/O device to hardware**
- **Used by System Control Program (SCP)**
  - Passes I/O requests from SCP to CSS
- **One or two subchannel sets per CSS**

- **PAV alias devices only in SS-1**
  - Designed to be compatible with existing storage CUs that support PAV





Base, SS-0
63.75k



Aliases, SS-1
64k

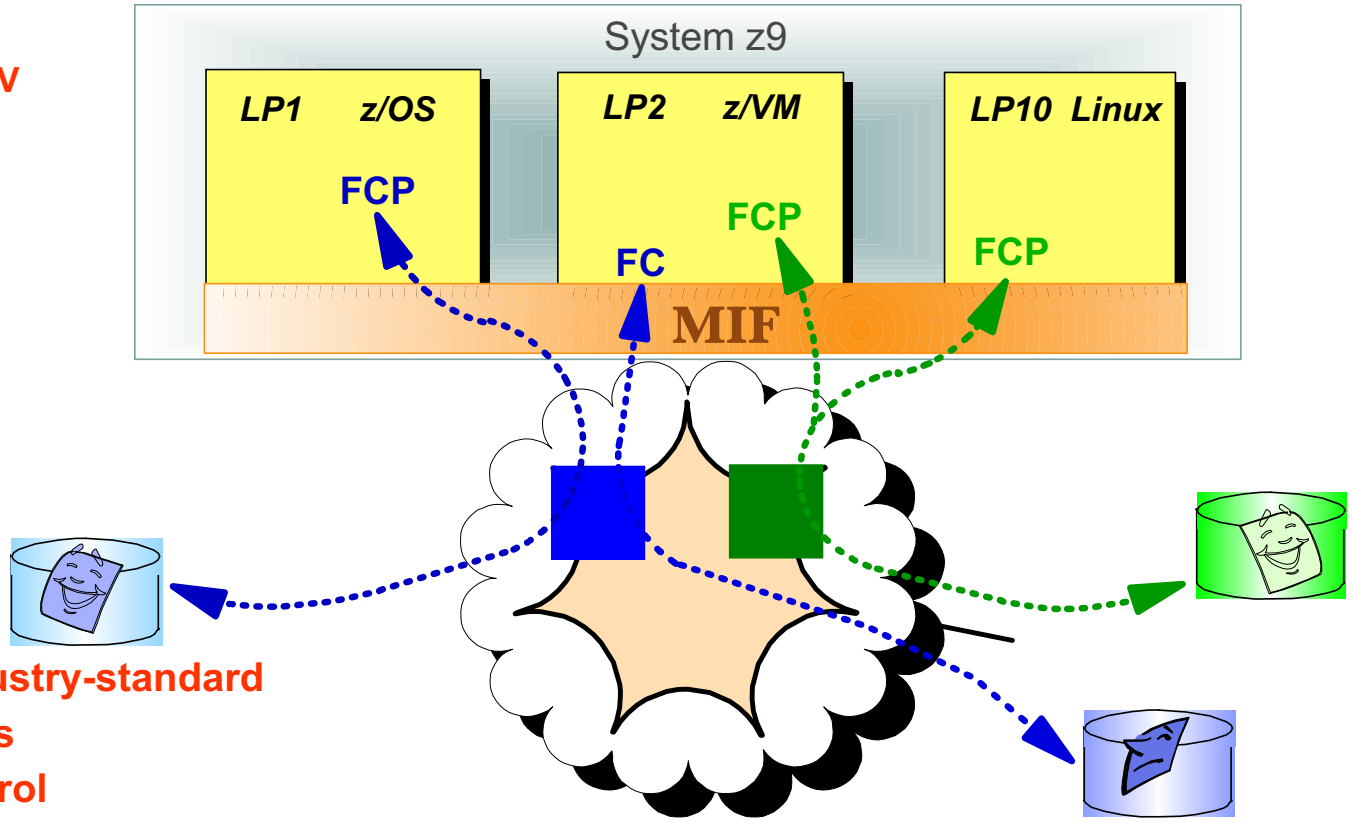
63.75k subchannels on z9 EC, z9 BC

- **64k-1 subchannels in set 0**
  - **Previously 1024 (1k) reserved for system use**
  - **Returning 768 of 1k**
  - **For increased addressable storage**
  - **Now symmetry – server and storage**
    - **63.75k, System z9**
    - **63.75k, IBM TotalStorage DS8000 Series**
  - **All channel types**
  - **z/OS V1.4 + PTFs**
  - **z/VM V4.4 (HCD PTF)**
  - **Linux on System z9**
    - **SUSE SLES9, Red Hat RHEL4 distributions**

  - *Example: 3390 volume sizes*
    - *768 volumes of 54 GB/volume = 41 terabytes of increased storage*
      - *54 GB/volume * 768 volumes = 41 TB*

N_Port ID Virtualization (NPIV) on z9 EC, z9 BC All supported FICON features

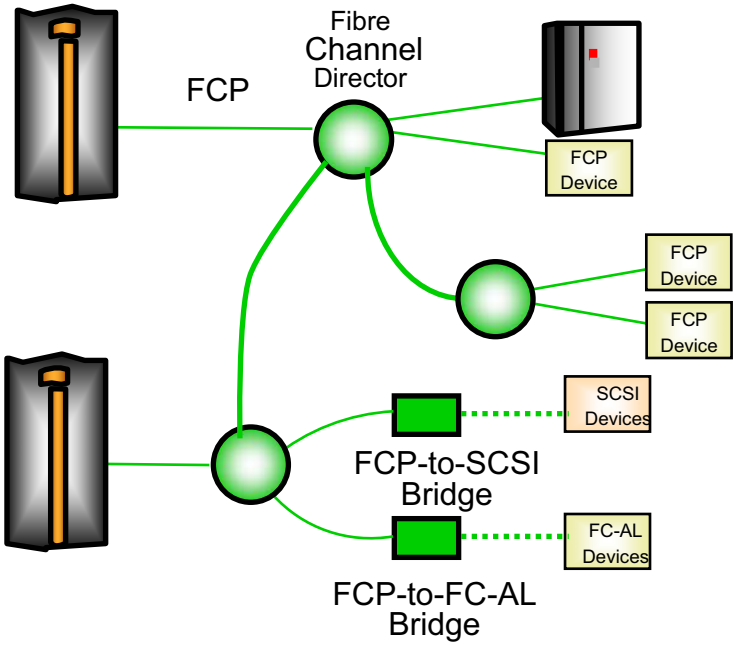
- **Multiple N_Port_Names (WWPNs) assigned to N_Port of FCP channel**
  - Each OS uses its own unique N_Port_Name to log into fabric
  - Unique FCP identifier (N_Port_ID) assigned to each OS
  - OS can access fabric with one or multiple N_Port_names
- **Extension to the Fibre Channel standard**
- **Entry point into fabric must also support NPIV**



NOTE: NPIV is the industry-standard solution. It supersedes FCP LUN Access Control

FCP point-to-point attachments on z9 EC, z9 BC, z990, z890

FCP full fabric
Connectivity through switch



- **Point-to-point attachments**
  - FICON Express4: z9 EC, z9 BC
  - FICON Express2: z9 EC, z990, z890
  - FICON Express: z9 EC, z990, z890
  - CHPID type FCP
  - Direct attach (point-to-point)
  - Co-req to IPL operating system from a device
    - No charge SCSI IPL feature #9904
  - **NPIV not applicable with point-to-point**
  - **Operating system support**
    - z/VM V4.4 and above for Linux guests
    - Linux on System z

FICON availability enhancements on z9 EC, z9 BC All supported FICON features

- Request Node Identification Data (RNID)
  - RNID data is stored in HSA for each control unit attached to FICON channels
  - Can now request RNID data for native FICON channels (CHPID type FC)
    - For each device or control unit attached to channel
    - Formatted and displayed on the SE "Analyze Control Unit Header" IOPD panel.
    - Provided to z/OS so it can display it on the "D M=DEV" (Display Device Matrix) command to help debug configuration/cabling problems.
    - z/OS V1.4 and above with PTFs
- FICON link incident reporting
  - Operating system image can register for link incident reports
    - Without operator intervention
  - Displayed on operator console
  - Saved in system log and LOGREC
  - z/OS V1.7

Program-directed re-IPL on z9 EC, z9 BC

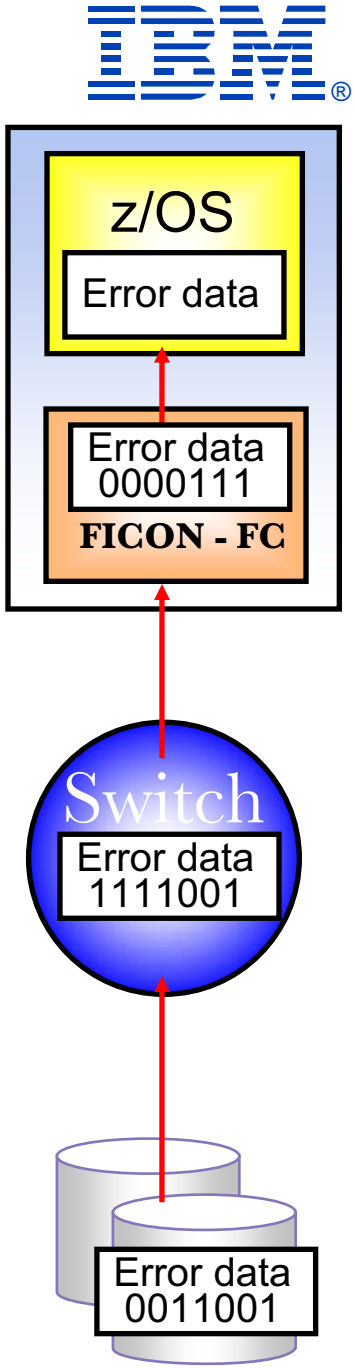
- **Linux running natively in a logical partition can re-IPL itself**
- **Supported for SCSI and ECKD devices**
- **To initiate a Re-IPL, Linux can determine**
  - **How it was loaded (i.e., via Channel Control Words (CCWs)) or via SCSI-type IPL,** and
  - **From where it was loaded in case of SCSI-type IPL**

  (World Wide Port Name (WWPN) and Logical Unit Number (LUN) of the load device).
- **Linux can request**
  - **That it be reloaded from the same load device**
  - **Using the same load parameters.**
- **Linux on System z9**
  - SUSE Linux SLES 9 SP3

Note: z/VM already supports an interface that allows a program running as a guest under z/VM to re-IPL itself.

FICON purge path extended for native FICON (CHPID type FC) since October 2004

- **For z9 EC, z9 BC, z990, z890**
- **Enhanced FICON problem determination**
- **Error-recovery function is extended**
  - Transfers error-related data and statistics
    - Between the channel and entry switch
    - Control unit and its entry switch
    - To the host operating system
      - ✓Reported in EREP
- **Supported by z/OS and z/OS.e V1.4, and later, with PTFs for APAR 0A06846 and EREP APAR IR51695**



Agenda

1	History
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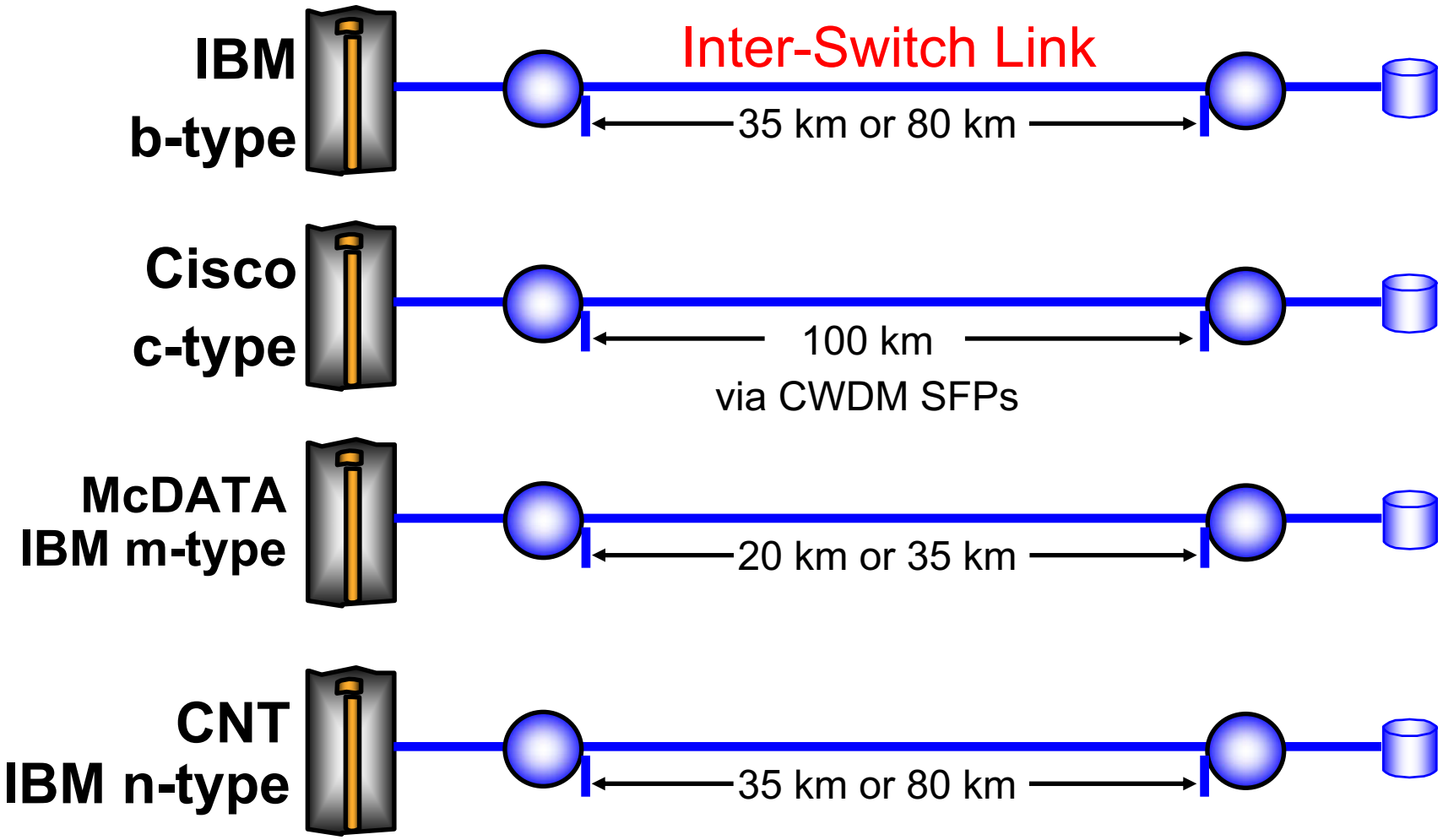
3	The “bus” and I/O cage
4	Technology and performance
5	Architecture and hardware
6	CTC, cascading, intermix, functions
7	Distance

Cascaded distances - - ISL distances



Light delay in fiber over distance

- **The limitation of the speed of light within a fiber optic cable will increase the delay in the response time by 100 microseconds (us) for 10 kilometers (km)**
  - Propagation delay is
    - 5 microseconds per kilometer one way
    - 10 microsecond per kilometer round trip
      - 5 us / km (one way) x 10 km x 2 (round trip) = 100 microseconds (0.1 milliseconds - ms)
- **There is an increased response time for every 10 km of distance and every interlocked handshake or round-trip per channel program**

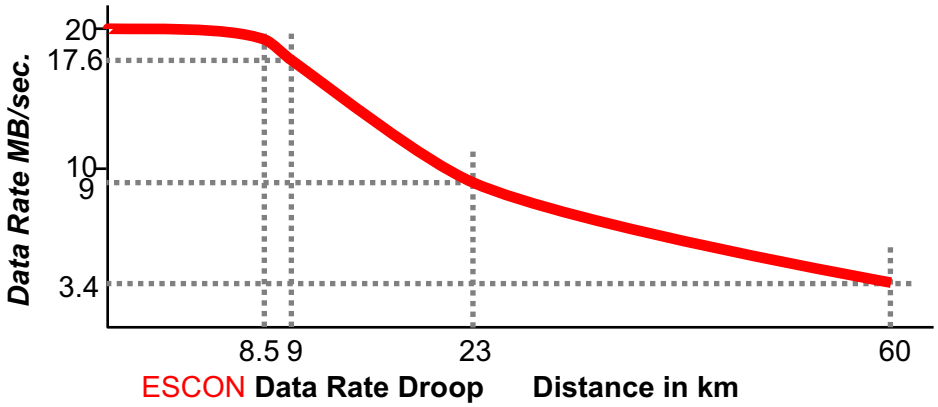
Channel type	Interlocked handshakes required [1]	Total "up to" Delay per 10 km (6.2 miles)
ESCON	6	0.6 milliseconds
FICON bridge - FCV	2	0.2 milliseconds
FICON native – FC	1	0.1 milliseconds

The numbers in the matrix reflect a simple channel program (4 KB read hit)

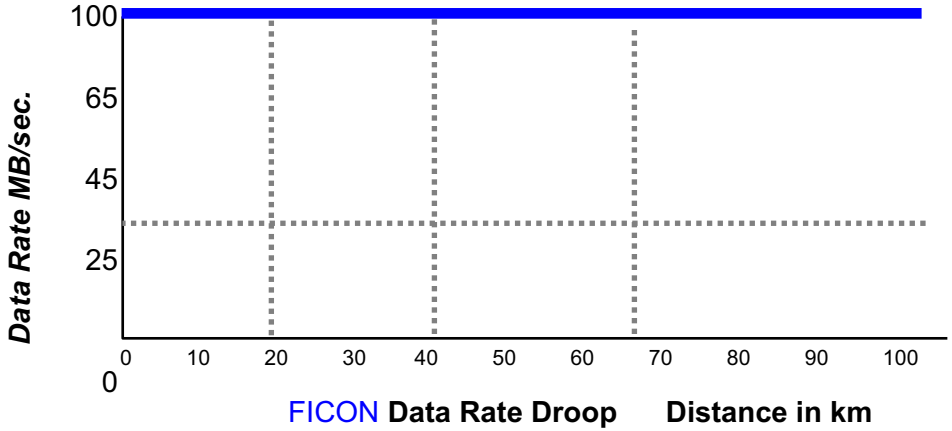
1. For channel programs that have more interlocked handshakes built into it, distance delays could be larger

Droop: Key ingredients

- **Droop begins when**
  - The link distance reaches the point where the time light takes to make one round trip on the link is equal to the time it takes to transmit the number of bytes that will fit in the receiver's buffer.



- **Key factors**
  - Speed of light through fiber
  - Link data rate
  - Buffer capacity
  - Packet size

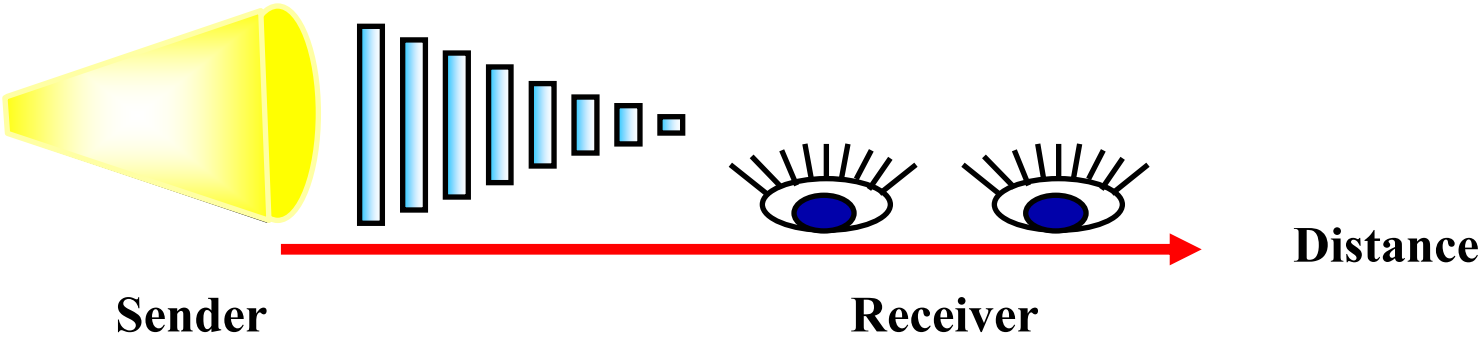


Distance?

Link speed **Link loss budget** **Unrepeated distance**

Link loss budget - What is it?

- **As a light signal travels through a fiber optic cable, the light signal loses strength**



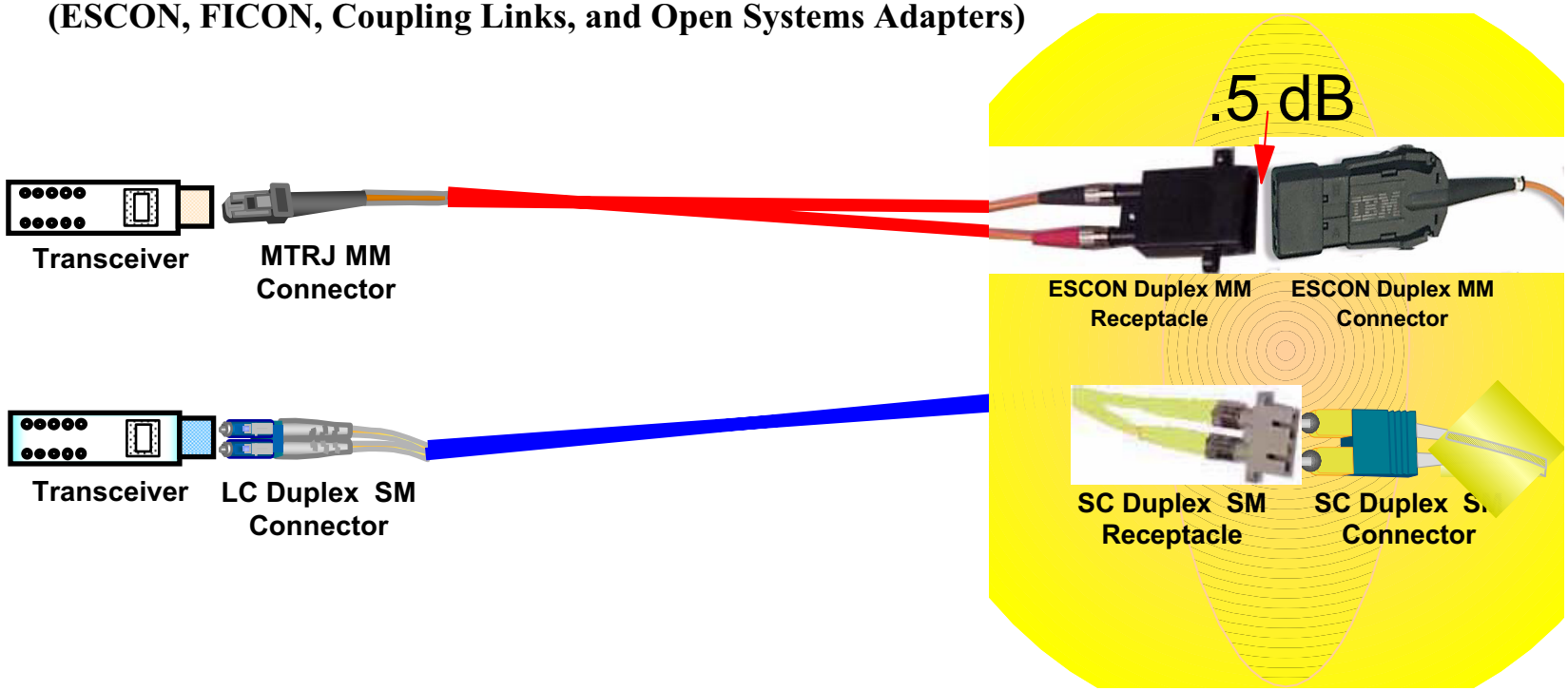
- **dB (deciBel) is the metric used to measure the signal strength (loss or gain)**
  - Result: A link loss budget
    - The maximum amount of link attenuation (loss), expressed in decibels (dB), that can exist without causing a possible failure condition (bit errors).

- **Factors that contribute to the loss of signal strength**
  - Number of connections (Conversion kits, MCP cables, jumpers, trunks, patch panels)
  - Length of the fiber optic cable

Calculating link loss budget

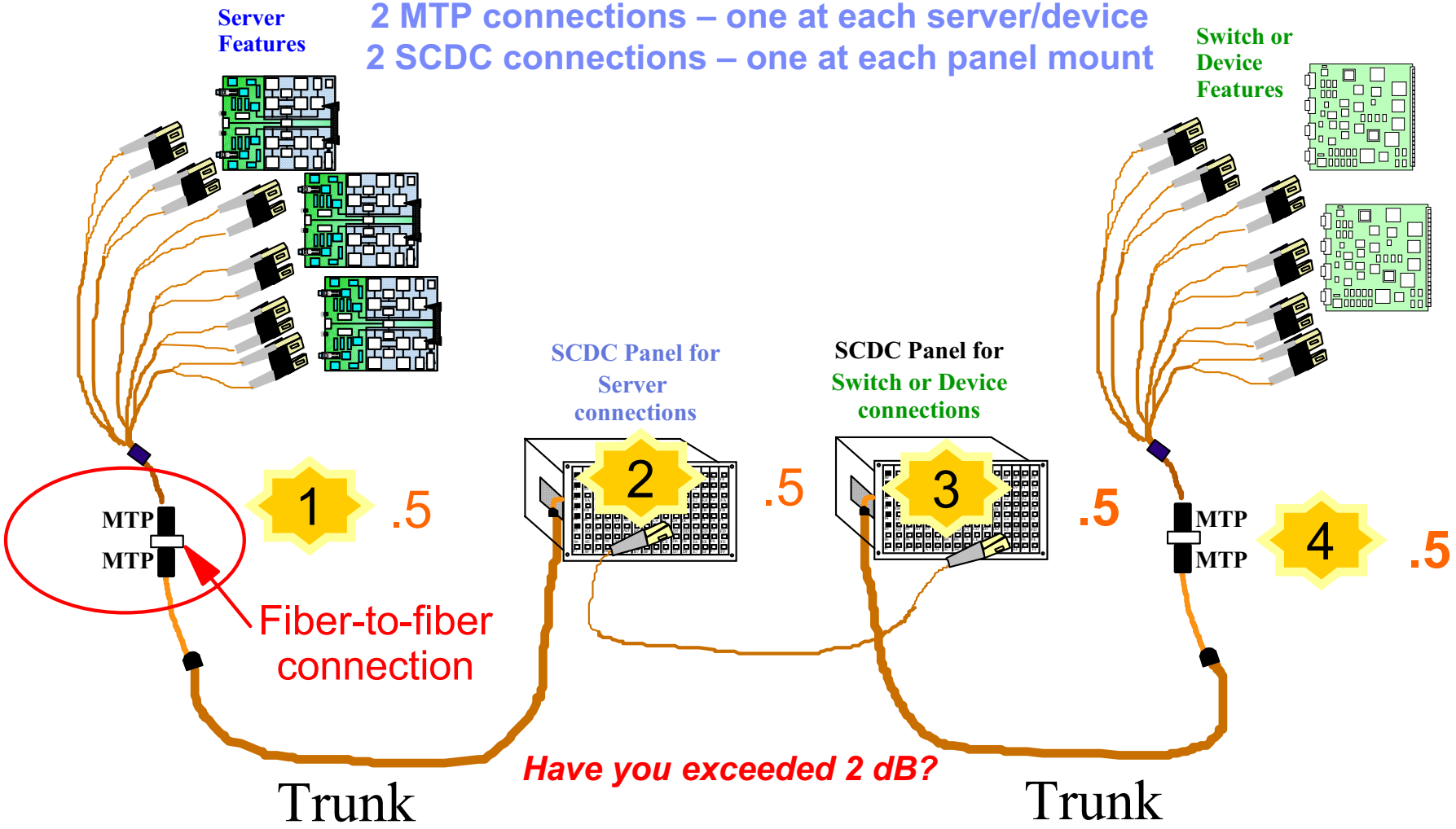
- **Fibre channel standard - no more than four fiber-to-fiber connections per link**
- **IBM position - if do not exceed link loss budget - OK**
- **Refer to: GA23-0367, Planning for Fiber Optic Links**

(ESCON, FICON, Coupling Links, and Open Systems Adapters)



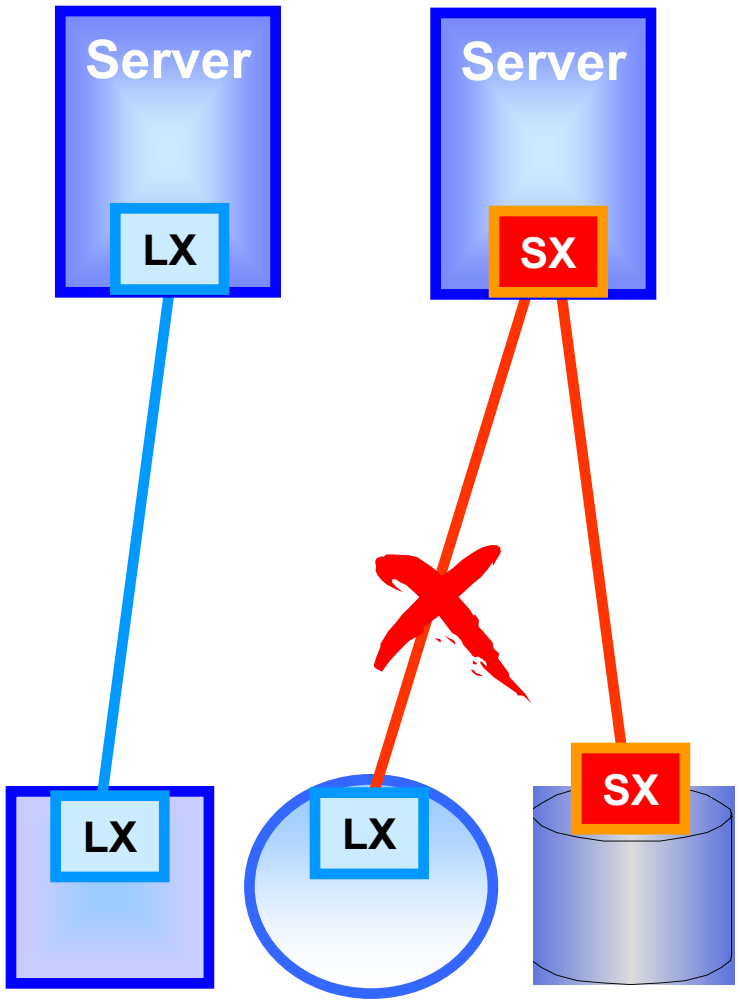
End-to-End: Count the connections

Fiber = 62.5µ multimode 160 MHz/km
2.2 dB Link Loss Budget at 2 Gbps
2 MTP connections – one at each server/device
2 SCDC connections – one at each panel mount

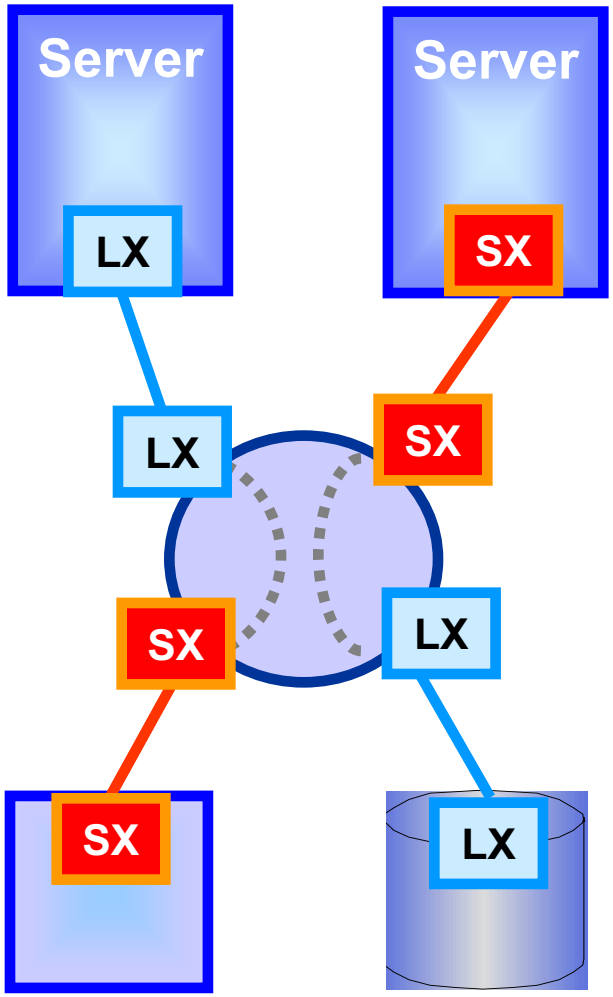


Like sender and receiver – LX to LX, SX to SX

Direct attach (FC, FCP)



Switched (FC, FCP)



ANSI Fibre Channel Physical Interface (FC-PI-2) standard

- Applies to FICON Express4, FICON Express2, FICON Express, and FICON
- CHPID types FC (native FICON) and FCP (Fibre Channel Protocol)

		1 Gigabit / sec		2 Gigabit / sec		4 Gigabit / sec	
Fiber Core (µ) Light source	Fiber Bandwidth @ wavelength	Unrepeated distance	* Link loss budget	Unrepeated distance	* Link loss budget	Unrepeated distance	* Link loss budget
9µ SM LX laser	@ 1310 nm	10 km 6.2 miles	7.8 dB	10 km 6.2 miles	7.8 dB	10 km 6.2 miles	7.8 dB
9µ SM LX laser	@ 13010 nm	4 km # 2.5 miles	4.8 dB #	4 km # 2.5 miles	4.8 dB #	4 km # 2.5 miles	4.8 dB #
9µ SM LX laser with MCP	**500 MHz km (62.5µ) 400 MHz km (50µ)**	550 meters 1804 feet	5.0 dB	N / A	N / A	N / A	N / A
50µ MM SX laser	2000 MHz km @ 850 nm	860 meters 2822 feet	4.6 dB	500 meters 1640 feet	3.4 dB	270 meters 886 feet	2.5 dB
50µ MM SX laser	500 MHz km @ 850 nm	500 meters 1640 feet	3.9 dB	300 meters 984 feet	2.8 dB	150 meters 492 feet	2.3 dB
62.5µ MM SX laser	200 MHz km @ 850 nm	300 meters 984 feet	3.0 dB	150 meters 492 feet	2.2 dB	70 meters 230 feet	2.0 dB
62.5µ MM SX laser	*** 160 MHz km @ 850 nm	250 meters 820 feet	2.8 dB	120 meters 394 feet	2.2 dB	55 meters 180 feet	2.1 dB

* The link loss budget is the channel insertion loss + the unallocated link margin as defined by the standard.

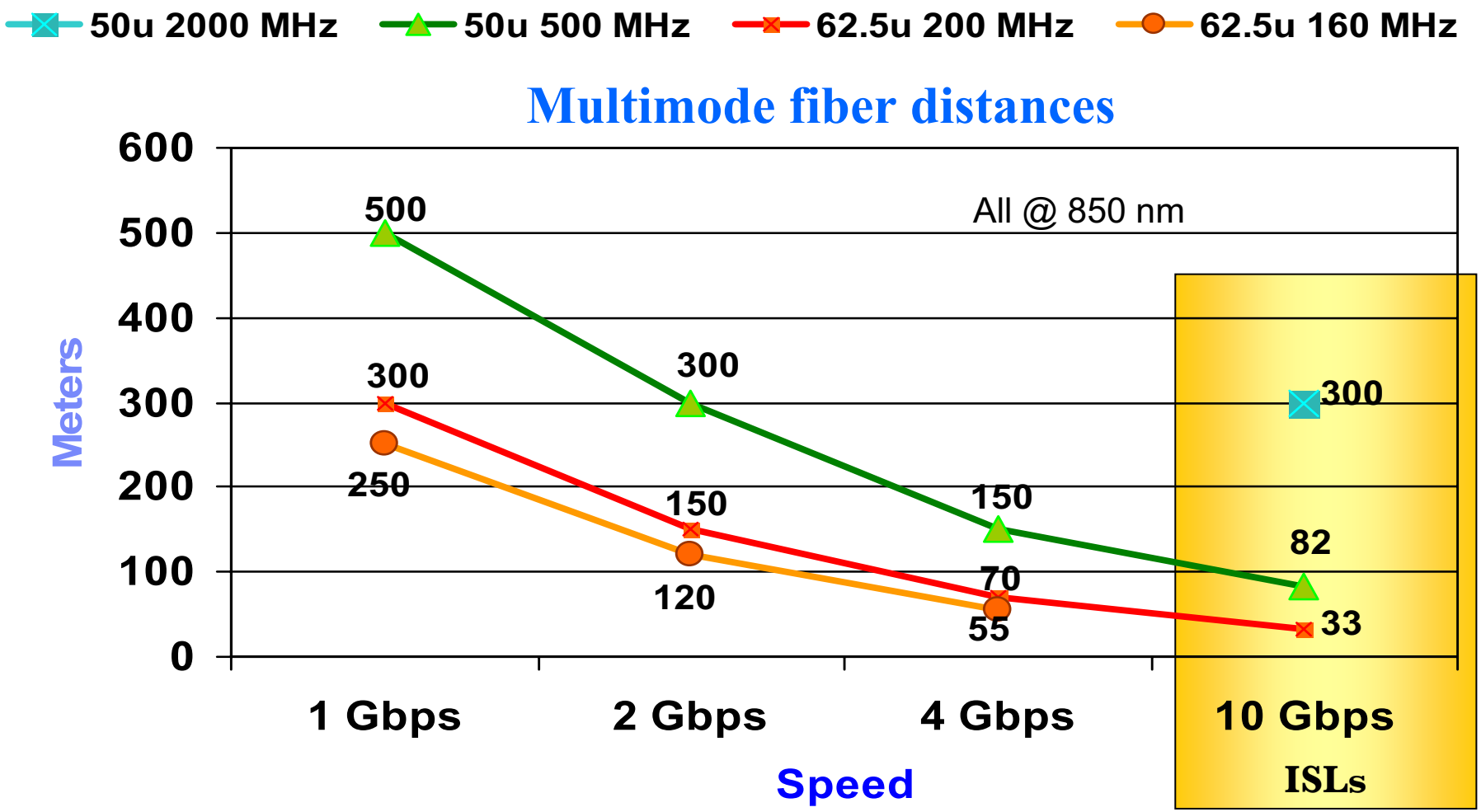
** The aqua 2000 MHz km multimode fiber became available September, 2003.

*** Most often applicable to currently installed ESCON environments

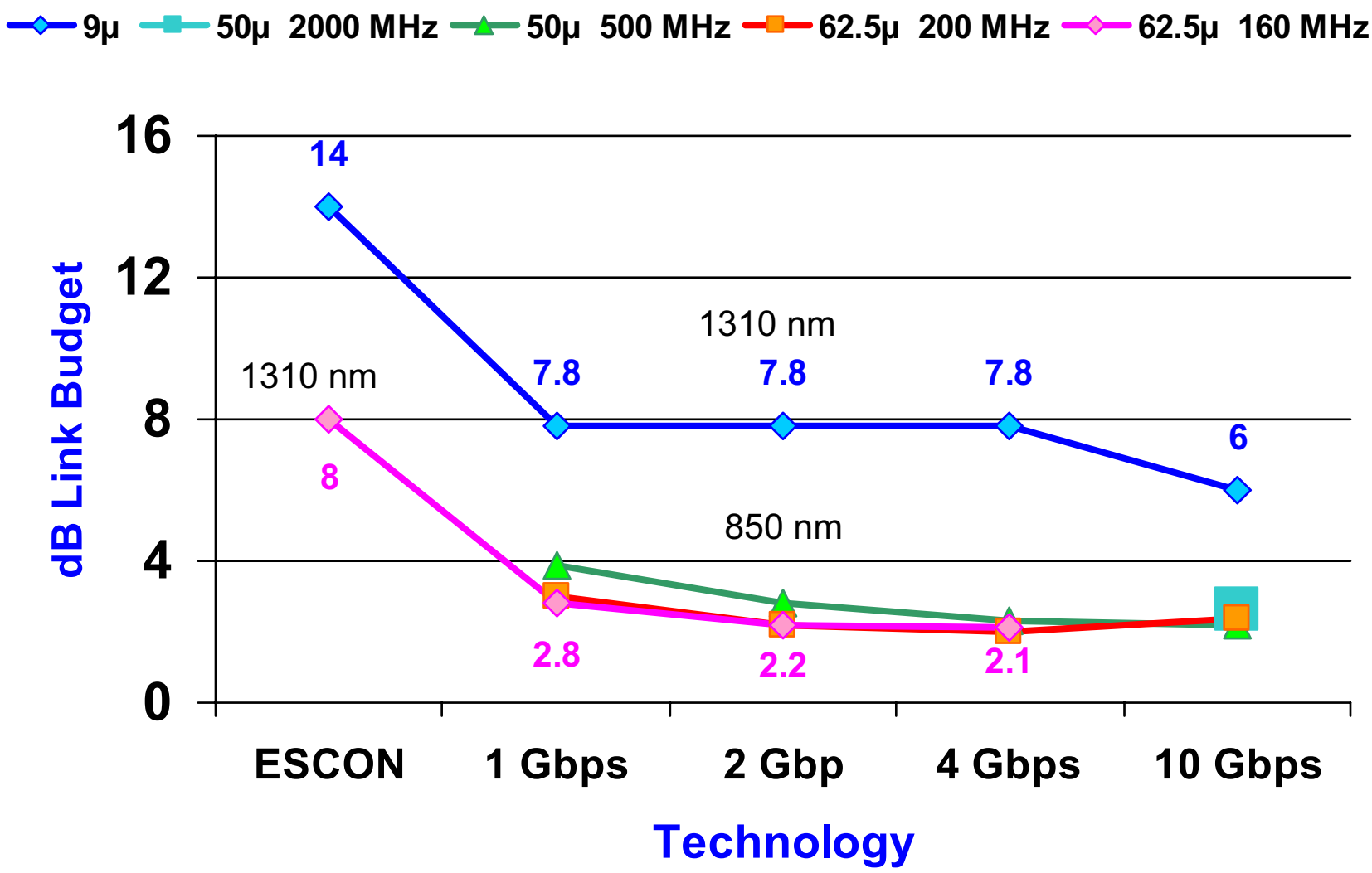
\# This distance and dB budget applies to FICON Express4 4KM LX features

Fibre Channel distances

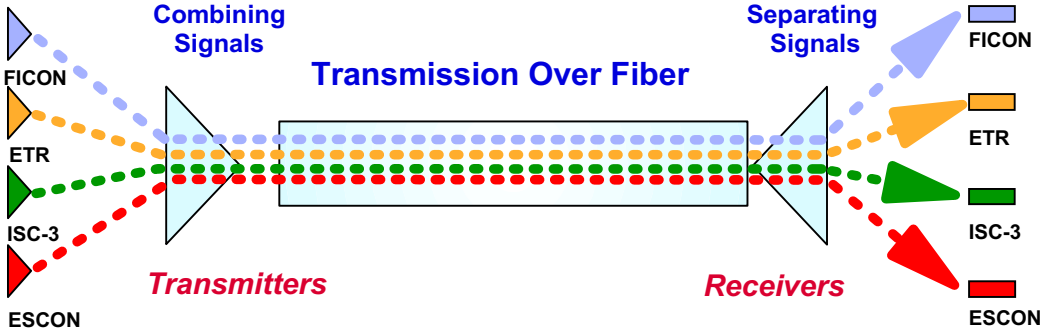
9u single mode fiber 10 km - 10,000 meters, 6.2 miles



Fibre Channel link loss budget at high data rates



DWDM support



- **Dense Wavelength Division Multiplexers (DWDMs)**
- **The DWDM qualification applies to distances from 40 km to 100 km**
- **The DWDM qualification applies to the following protocols**:
  - ESCON
  - FICON/Fibre Channel
  - ISC
  - Sysplex Timer (ETR and CLO)

Sign on to Resource Link and access this link for the qualification letters:

www.ibm.com/servers/resourcelink

Look under “Library”, “Hardware products for servers”,

zSeries Qualified Wavelength Division Multiplexer (WDM) products for GDPS

System z GDPS® / WDM Ecosystem

Nortel OPTical Metro
IBM 2029
Nortel 5200 / 5100

- Originally GDPS Qualified **1999**
- Current support
  - OM5200 Rel. 8.0
- IBM 2029 Withdrawn from Marketing (WFM)

Cisco ONS 15454
ONS 15530 /15540 (WFM)

- Originally GDPS Qualified **2001**
- Current support
  - ONS 15454 Rel. 7.0
  - ONS 15530/15540 Rel. 5.0 (WFM)

Lucent Metro EON

- Originally GDPS Qualified **2002** Rel.8.2

ADVA FSP 2000

- Originally GDPS Qualified **2003**
  - Current support Rel. 6.2

CIENA
ONLine & CN2000

- Originally GDPS Qualified **2005**
- Current support
  - ONLine Metro Rel. 7.1
  - CN2000 Rel. 4.0

Agenda

1	History
2	Modes of operation (CHPIDs)
3	The “bus” and I/O cage
4	Technology and performance
5	Architecture and hardware
6	CTC, cascading, intermix, functions
7	Distance
8	Switches / Directors

System z tested products

in support of FICON / FCP

For IBM TotalStorage products refer to:

http://www-1.ibm.com/servers/storage/san/

For consistency, all transceivers are identified as SX (short wavelength) and LX (long wavelength). These may also be referred to as SW and LW, in non-System z documentation.

A standardized term is also used for the connectors SC Duplex and LC Duplex. You may also see them referred to as SC or LC connector

System z FICON/FCP tested products

Product	Type	MT	Models	Mode	Gbps	Intermix ISL	Transceiver	Connector
IBM TotalStorage SAN32B-2	b-type	2005	B32	FICON FCP	1, 2, 4	Yes No	SX, LX	LC Duplex
FCP-to-SCSI Bridge IBM Storage Area Network Data Gateway	b-type	2108	G07, WFM	FCP	1	N/A	SX, LX	SC Duplex
IBM TotalStorage SAN Switch	b-type	2109	S08, WFM S16, WFM	FCP	1	N/A	SX	SC Duplex
IBM TotalStorage SAN Switch	b-type	2109	F16, WFM	FCP	1, 2	N/A	SX, LX	SC Duplex
IBM TotalSgtorage SAN Switch	b-type	2109	F32, WFM	FCP	1, 2	N/A	SX, LX	LC Duplex
IBM TotalStorage SAN Switch M12	b-type	2109	M12, WFM	FICON FCP	1, 2	Yes No	SX, LX	LC Duplex
IBM TotalStorage SAN Switch M14	b-type	2109	M14, WFM	FICON FCP	1, 2	Yes No	SX, LX	LC Duplex
IBM TotalStorage SAN256B Director	b-type	2109	M48	FICON FCP	1, 2, 4	Yes No	SX, LX	LC Duplex

09 May 2006 announce

* Cisco MDS 9216, 9506, and 9509 ISL distance extended up to 100 km using CWDM

System z FICON/FCP tested products

Product	Type	MT	Models	Mode	Gbps	Intermix ISL	Transceiver	Connector
Cisco MDS 9000 – 9216	c-type	2062	D01 WFM	FICON FCP	1, 2	Yes,VSAN Yes	SX, LX	LC Duplex
Cisco MDS 9000 – 9506, 9509	c-type	2062	D04 , D07	FICON FCP	1, 2, 4 10 ISL *	Yes,VSAN Yes	SX, LX	LC Duplex
Cisco MDS 9000 – 9216a, 9216i	c-type	2062	D1A, D1H	FICON FCP	1, 2, 4	Yes, VSAN Yes	SX, LX	LC Duplex
Cisco MDS 9513 Multilayer Director	c-type	2062	E11	FICON FCP	1, 2, 4 10 ISL *	Yes, VSAN Yes	SX, LX	Variable

27 April 2006 announce

* ISL distance extended up to 100 km using CWDM

System z FICON/FCP tested products

Product	Type	MT	Models	Mode	Gbps	Intermix ISL	Transceiver	Connector
FICON Bridge in ESCON Director	N/A	9032	005, WFM	FCV	1	N/A	LX only	SC Duplex
IBM TotalStorage SAN24M-1	m-type	2026	224, WFM	FCP	1, 2	N/A Yes	SX, LX	LC Duplex
IBM TotalStorage SAN16M-2	m-type	2026	416	FCP	1. 2, 4	Yes Yes	SX, LX	LC Duplex
IBM TotalStorage SAN32M-2	m-type	2026	432	FICON FCP	1, 2, 4	Yes Yes	SX, LX	LC Duplex
IBM TotalStorage SAN140M	m-type	2027	140	FICON FCP	1, 2, 4	Yes Yes	SX, LX	LC Duplex
IBM TotalStorage SAN32M-1	m-type	2027	232	FICON FCP	1, 2	Yes Yes	SX, LX	LC Duplex
IBM TotalStorage SAN256M	m-type	2027	256	FICON FCP	1, 2 10 ISL	Yes Yes	SX, LX	LC Duplex
McDATA Sphereon 4500 Fibre Channel Switch	m-type	2031	224, WFM	FCP	1, 2	N/A Yes	SX, LX	LC Duplex
McDATA Sphereon 3232 Fabric Switch	m-type	2031	232, WFM	FICON FCP	1, 2	Yes Yes	SX, LX	LC Duplex
McDATA ED-5000 Fibre Channel Director	m-type	2032	001, WFM	FICON FCP	1	N/A N/A	SX, LX	SC Duplex
McDATA Intrepid 6000 Series Directors	m-type	2032	064, 140 Both WFM	FICON FCP	1, 2	Yes Yes	SX, LX	LC Duplex

27 April 2006 announce

System z FICON/FCP tested products

Product	Type	MT	Models	Mode	Gbps	Intermix ISL	Transceiver	Connector
CNT FC/9000 Directors	n-type	2042	001,128,256 All WFM	FICON FCP	1, 2	Yes Yes	SX, LX	1 Gbps,SC Duplex 2 Gbps,LC Duplex
CNT TotalStorage SAN256N	n-type	2045	N16, WFM	FICON FCP	1, 2 10 ISL	Yes Yes	SX, LX	LC Duplex

Directors/switches withdrawn from marketing (WFM)

Product	Type	IBM MT	WFM	Replaced by
IBM TotalStorage SAN Switch M14	b-type	2109-M14	03-31-06	IBM TotalStorage SAN256B Director (2109-M48)
IBM TotalStorage Storage Area Network Switch	b-type	2109-F32	10-28-05	IBM TotalStorage SAN32B-2 (2005-B32)
IBM TotalStorage SAN Switch M12	b-type	2109-M12	02-25-05	IBM TotalStorage SAN Switch M14 (2109-M14)
IBM TotalStorage SAN Switch F16	b-type	2109-F16	02-25-05	None on System z
IBM TotalStorage SAN Fibre Channel Switch	b-type	2109-S16	01-30-03	IBM TotalStorage SAN Switch F16 (2109-F16) WFM, see above
IBM TotalStorage SAN Fibre Channel Switch	b-type	2109-S08	01-30-03	None on System z
FCP-to-SCSI Bridge IBM Storage Area Network Data Gateway	b-type	2108-G07	12-31-02	None on System z

Product	Type	IBM MT	WFM	Replaced by
Cisco MDS 9216 Multilayer Fabric Switch	c-type	2062-D01	03-25-05	Cisco MDS 9216A (IBM 2062-D1A)

Directors/switches withdrawn from marketing (WFM)

Product	Type	IBM MT	WFM	Replaced by
IBM TotalStorage SAN24M-1	m-type	2026-224	12-30-05	IBM TotalStorage SAN16M-2 (2026-416) or IBM TotalStorage SAN32M-2 (2026-432)
McDATA Intrepid 6000 Series Director	m-type	2032-064	12-31-04	IBM TotalStorage SAN140M (2027-140)
McDATA Intrepid 6000 Series Director	m-type	2032-140	10-28-04	IBM TotalStorage SAN140M (2027-140)
McDATA Sphereon 3232 Fabric Switch	m-type	2031-232	10-28-04	IBM TotalStorage SAN32M-1 (2027-232)
McDATA Sphereon 4500 Fibre Channel Switch	m-type	2031-224	10-28-04	IBM TotalStorage SAN24M-1 (2026-224)
McDATA ED-5000 Fibre Channel Director	m-type	2032-001	09-28-01	McDATA Intrepid 6000 (IBM 2032-064) WFM, see above

Product	Type	IBM MT	WFM	Replaced by
CNT FC/9000 Director	n-type	2042-128 2042-256	12-31-04	IBM TotalStorage SAN256N (2045-N16)
CNT FC/9000 Director	n-type	2045-N16	09-30-05	IBM TotalStorage SAN256M (2027-256)
CNT FC/9000 Director	n-type	2042-001	08-26-05	IBM TotalStorage SAN256N (2045-N16) WFM, see above

FICON Express4

FCV, FC, FCP

Distance

Switched fabric

Appendix

Publications

- **SA24-7172** **FICON I/O Interface Physical Layer**
- **GA23-0367** **Planning for Fiber Optic Links**
- **SG24-5444** **System z Connectivity Handbook (*Redbook*)**
- **SG24-6497** **FICON Implementation Guide (*Redbook*)**

On the Internet

- IBM Resource Link, Web-based tool
  - www.ibm.com/servers/resourcelink/
    - Services section: zSeries Fiber Cabling Service
    - Planning section/Physical Planning
      - Physical Planning manuals, GIM
    - Education section: System z9 and zSeries courses
      - General Information for Planning a Physical Site (GIM)
- http://www.ibm.com/services/networking/
  - IT services - Product and Enterprise cabling offerings
- http://www.redbooks.ibm.com
  - IBM Redbooks

- http://www.ibm.com/servers/eserver/zseries/networking
  - The network connectivity home page
- http://www.ibm.com/servers/eserver/zseries/connectivity
  - The I/O connectivity home page
  - Go to this location for a list of FICON/FCP supported devices
- http://www-306.ibm.com/common/ssi/OIX.wss
  - Announcement Letters, sales manual

On the Internet

IBM Resource Link
www.ibm.com/servers/resourcelink/

A fiber optic cabling presentation is available

Covers ISCs, ETR, ESCON, FICON/FCP, OSA
Overview of each feature with fiber optic cabling requirements
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Extended distance implications
IBM Networking Services
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