FICON Native Implementation and Reference Guide

Architecture, terminology, and topology concepts

Planning, implemention, and migration guidance

Realistic examples and scenarios

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Note: Before using this information and the product it supports, read the information in “Notices” on page vii.

Second Edition (October 2002)

This edition applies to FICON channel adaptors installed and running in FICON native (FC) mode in the IBM zSeries procressors (at hardware driver level 3G) and the IBM 9672 Generation 5 and Generation 6 processors (at hardware driver level 26).

Contents

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Preface

This IBM Redbook covers the planning and implementation of FICON channels, operating in FICON native (FC) mode for the IBM zSeries and 9672 Generation 5 (G5) and Generation 6 (G6) processors. It discusses the FICON and Fibre Channel architectures, terminology, and supported topologies.

This book provides information about FICON native system setup, availability and recovery considerations, and migration recommendations. You will find examples of the z/OS and OS/390 definitions required to support FICON native control units, FICON Channel-to-Channel (FCTC), and FICON Directors (including cascading), as well as migration scenarios for control units using ESCON (CNC) channels or FICON Bridge (FCV) mode channels to FICON native (FC) mode channels.

This redbook is intended for system programmers, hardware planners, and system engineers who will plan and install FICON native (FC) products in a zSeries and 9672 Generation 5 (G5) and Generation 6 (G6) environment. A good background in systems planning, hardware and cabling infrastructure planning, and I/O definitions (HCD or IOCP) is assumed.

The team that wrote this redbook

This redbook was produced by a team of specialists from around the world working at the International Technical Support Organization, Poughkeepsie Center.

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IBM FICON Switch Development

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Overview

This IBM Redbook discusses the planning and implementation of FICON channels operating in FICON native (FC) mode, for zSeries (z800 and z900) and 9672 Generation 5 (G5) and Generation 6 (G6) environments.

This guide includes detailed information on:

- FICON planning (considerations and recommendations)
- FICON topologies supporting the FICON architecture (FC-SB-2)
- ESCON and FICON intermixing support for the zSeries processors and the 9672 G5 and G6 processors
- Considerations and options for FICON fiber cabling
- z/OS or OS/390 definitions required to support FICON channels, FICON control units, and FICON Directors
- Migration of control units from ESCON (CNC) channels or FICON channels in FICON Bridge (FCV) mode, to FICON channels in FICON native (FC) mode

There is also a guide to aid in referencing the chapters in this redbook according to task, plus an introduction to FICON, including an overview of the benefits of a FICON environment.

1.1 How to use this redbook

The intent of this redbook is primarily to provide material to assist with the implementation of FICON native (FC) channels. It also contains technical reference material to provide background information on the Fibre Channel architecture, as well as information to assist those who provide ongoing technical support in a FICON environment.

Use Table 1-1 as a guide for referencing the material required for a specific task. FICON awareness is required at various levels to carry out each task.

Table 1-1 Task roadmap

Task	Chapter
FICON awareness	“FICON topology and terminology” on page 9 “FICON architecture and addressing” on page 25
FICON implementation	
Configuration design	“Processor support” on page 55 “FICON channel configurations” on page 91 “FICON migration” on page 141
Hardware readiness	“Processor support” on page 55 “FICON migration” on page 141 “FICON - Fibre Channel cabling” on page 69
Software readiness	“z/OS and OS/390 software support” on page 83 “FICON migration” on page 141 “FICON channel operation and performance” on page 187
FICON Director and control unit installation	“FICON Director configuration worksheet” on page 217 “FICON I/O definitions” on page 125
FCTC implementation	“FICON CTC implementation” on page 153
Performance monitoring	“FICON channel operation and performance” on page 187

1.2 Introduction to FICON

There are a number of characteristics and functional areas that need to be understood in designing an I/O configuration that will exploit FICON technology. This section introduces the basics of these areas for the FICON channel in FICON native (FC) mode. Later chapters cover these same areas in greater detail.

FICON channel support in the zSeries and S/390 9672 G5/G6 processors can operate in one of three modes:

1. A FICON channel in FICON Bridge (FCV*)* mode allows access to S/390 ESCON control units with ESCON interfaces by the FICON channel in FCV mode that is connected to a FICON Bridge adapter in a 9032-5 ESCON Director.
2. A FICON channel in FICON native (FC*)* mode allows access to FICON native interface control units either directly by a FICON channel in FC mode (point-to-point), or from a FICON channel in FC mode connected in series through one or two Fibre Channel switches (FICON Directors).

Note: The S/390 9672 G5/G6 processors only support a single switch topology, known as switched point-to-point, while the zSeries processors support single and dual switch topologies. A two switch configuration is known as cascaded FICON Directors.

3. A FICON channel in Fibre Channel Protocol (FCP) mode can access FCP devices in one of two ways:
   - Via a FICON channel in FCP mode through a single Fibre Channel switch or multiple switches to an FCP device
   - Via a FICON channel in FCP mode through a single Fibre Channel switch or multiple switches to a Fibre Channel-to-SCSI bridge

Note: The S/390 9672 G5/G6 processors *do not* support FICON channels in FCP mode. Point-to-point and arbitrated loop topologies *are not* supported as part of the zSeries FCP enablement.

1.3 zSeries and S/390 9672 G5/G6 I/O connectivity

Figure 1-1 shows the I/O connectivity support provided by the zSeries processors for FICON channels.

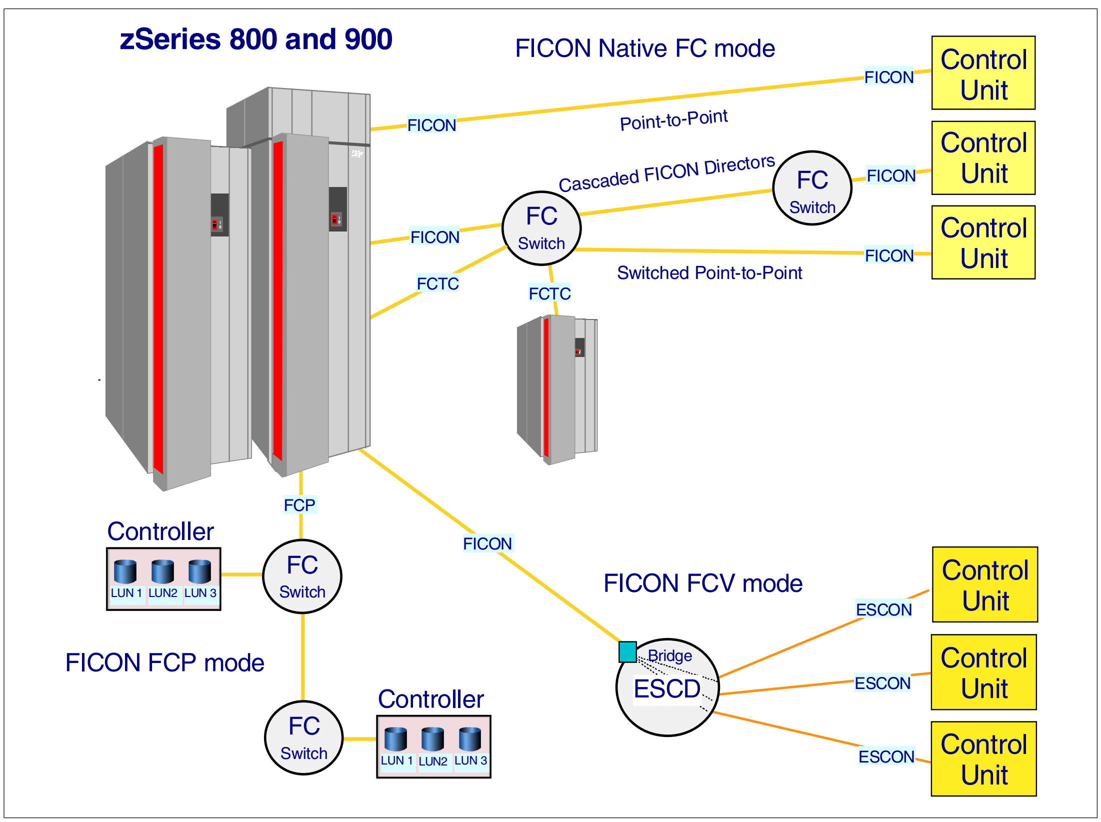

Figure 1-1 zSeries I/O connectivity for FICON

Figure 1-2 on page 4 shows the I/O connectivity support provided by the 9672 G5 and G6 family of processors for FICON channels.

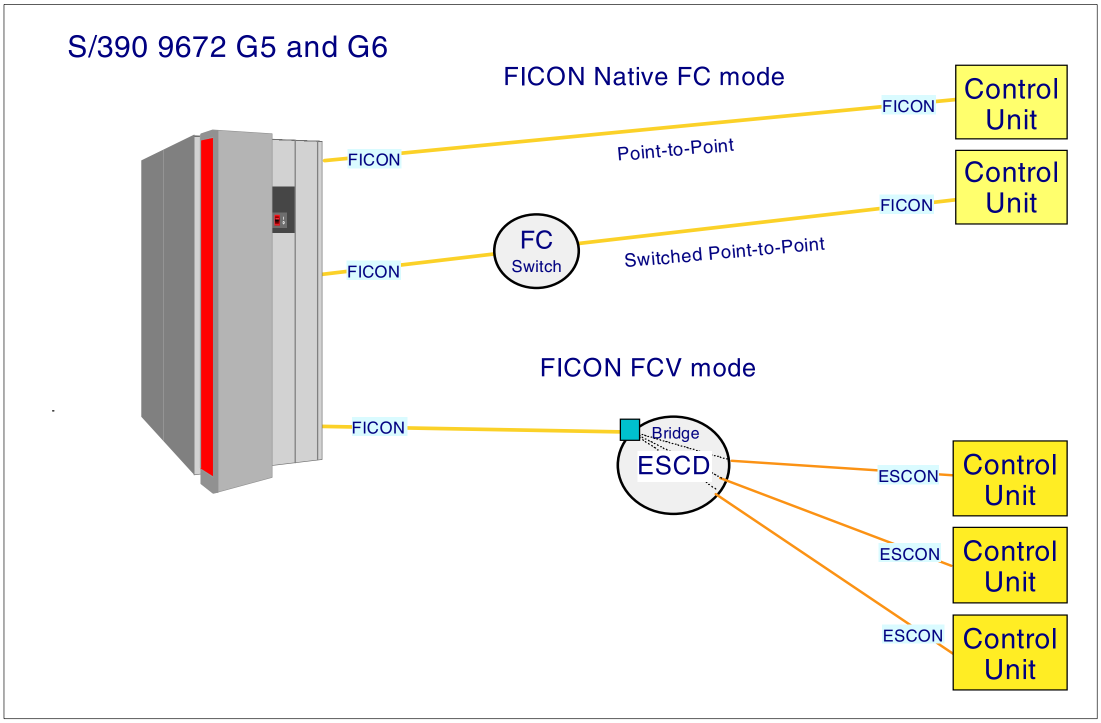

Figure 1-2   S/390 9672 G5/G6 I/O connectivity for FICON

The fiber connection serial channel-to-control unit support is provided by:

- FICON channel in FICON Bridge (FVC) mode

  FICON connection to a 9032 model 5 ESCON director FICON Bridge card supports conversion from a FICON channel to ESCON control units.

- FICON channel in FICON native (FC) mode

  The connection to a FICON native control unit is either direct (FICON point-to-point), through a FICON Director connection (FICON switched point-to-point), or with the zSeries, through up to two FICON Directors (Cascaded FICON Directors).

  These configurations are described further in Chapter 2, “FICON topology and terminology” on page 9.

Channel-to-channel communication in a FICON environment is provided between two FICON (FC) channel FCTC control units, with at least one of the two FCTC CUs being defined on a FICON (FC) channel on a zSeries processor, and the other defined on a FICON (FC) channel on any of the following processors:

- 9672 G5 or G6
- zSeries 800 or 900

Note: The FICON CTC CU function is only provided on the zSeries processors by use of the *FC* channel type and *FCTC* control unit type in the hardware definitions.

Implementation details for FCTC can be found in Chapter 10, “FICON CTC implementation” on page 153.

A FICON channel in FC mode and a FICON channel in FCV mode support different topologies and have different support requirements. This redbook covers planning and implementation for FICON channels in FICON native (FC) mode *only*. It does not cover the FICON channels in FICON FCV mode or FCP mode.

Refer to *FICON (FCV Mode) Planning Guide,* SG24-5445 for information about FICON operation in FCV mode.

For more information on FICON channel support for FCP mode, refer to:

`www.redbooks.ibm.com/redpapers/pdfs/redp0205.pdf`

FICON in FC mode

The protocol that describes the operation of a FICON channel when operating in FC mode is the FC-SB-2 protocol.

The terms (FC) and FC are used throughout this redbook when referring to either the mode of operation of the channel or parts of the Fibre Channel architecture. Examples of the use of (FC) and FC are:

- FICON native (FC) mode - the zSeries and 9672 G5 and G6 processor definition of a FICON channel defined to operate in FC-SB-2 mode
- FC-2 - the Fibre Channel (FC-FS) layer 2
- FC-4 - the Fibre Channel (FC-FS) layer 4
- FC-FS - Fibre Channel - Framing and Signalling protocol
- FC-PI - Fibre Channel - Physical Interface protocol

The term FC, when used in the phrase *FICON native (FC) mode,* refers to the mode that the FICON channel is defined to operate in. In this book it also means that the FICON channel, when operating in FICON native (FC) mode, uses the FC-4 layer rules as described in the FC-SB-2 and FC-FS protocol documents.

The FICON architecture is described in more detail in Chapter 3, “FICON architecture and addressing” on page 25.

1.4 zSeries and S/390 FICON channel benefits

A FICON channel operating in FICON native (FC) mode introduces a number of benefits.

Increased number of concurrent connections

FICON provides an increased number of channel-to-control unit concurrent I/O connections. ESCON supports one I/O connection at any one time while FICON native (FC) mode channels support multiple (up to 16 or more) concurrent I/O connections.

Increased distance

With FICON, the distance from channel to control unit, or channel to switch, or switch to CU link is increased using dark fiber. The distance for ESCON of 3 km is increased to up to 10 km (with RPQ; 20 km at 1Gbps and 12 km at 2 Gbps) for FICON channels using long wavelength lasers.

Another potential benefit is with cascaded FICON Directors, where the maximum unrepeated distance between data centers could be extended—providing more choices for business continuity solutions. With an additional FICON Director in the channel configuration the unrepeated distance between two sites could be extended to 30 km (10 km between each server and director) or up to 60 km with RPQ.

Increased FC link bandwidth

The link bandwidth is increased from 20 MBps for ESCON to 100 MBps for FICON and up to 200 MBps with FICON Express at 2 Gbps.

Increased distance to data droop effect

The end-to-end distance before data droop effect is increased from 9 km for ESCON to up to 100 km for FICON.

Increased channel device address support

From 1,024 devices for an ESCON channel and up to 16,384 for a FICON channel operating in either FICON Bridge (FCV) mode or FICON native (FC) mode.

Common use of Fibre Channel communication and topology

FICON implements common use of Fibre Channel channel-to-cu communication (FC-FS) and topology. FICON is an FC-4 layer protocol and uses the Fibre Channel standard Framing and Signalling (FC-FS) protocol for communication using the same topology (FC switched fabric) as other FC-4 ULPs (such as FC-FCP).

Greater exploitation of IBM ESS 2105 Parallel Access Volumes (PAV)

FICON allows for greater exploitation of the features of the IBM ESS 2105, such as Parallel Access Volumes (PAV), because more I/O operations can be started for a group of channel paths.

Greater exploitation of channel-to-channel capabilities (FCTC)

- ESCON CTC connectivity is provided by a pair of ESCON channels, one defined as CTC and the other as CNC. At least two ESCON channels are required. FICON CTC connectivity can be implemented using one or two FICON (FC) native channels.
- An ESCON channel defined as CTC can only support the CTC function. Only an SCTC control unit can be defined on an ESCON CTC channel. The FICON native (FC) channel supporting the FCTC control unit can communicate with an FCTC control unit on either the zSeries or 9672 G5/G6, and at the same time the same FICON (FC) channel can also support operations to other I/O control unit types such as disk and tape.
- An ESCON channel supports only one actively communicating I/O operation at a time, whereas the FICON channel supports up to 32 concurrent I/O operations.
- An ESCON channel operates in half-duplex mode, transferring data in one direction only at any given time. A FICON channel operates in full-duplex mode, sending and receiving data at the same time.

Greater exploitation of priority I/O queueing

FICON channels use frame and Information Unit (IU) multiplexing control to provide greater exploitation of the priority I/O queueing mechanisms within the FICON-capable control units.

Better utilization of the FC links

Frame multiplexing support by the FICON channels, FC switches, and FICON Control Units provides better utilization of the FC links.

The benefits of FICON channels operating in FICON native (FC) mode are the result of exploiting features of both the Fibre Channel infrastructure and the FICON (FC-SB-2) protocol. The Fibre Channel provides for higher link utilization through frame multiplexing and link pacing.

The link pacing is made possible through the use of buffer credits (this prevents the overrunning of the port capabilities at both ends of a link). The Fibre Channel switch introduces frame packet switching (frame multiplexing), which provides better utilization of the links than circuit switching does. The ESCON director uses circuit switching.

The FICON channel in FICON native (FC) mode provides benefits through the use of CCW and data prefetching and pipelining, which leads to a reduction in required communication and communication interlock hand-shaking. The pacing of operations between the channel and the control unit is controlled by channel Information Unit (IU) pacing support.

Cascaded FICON Directors can allow for shared links leading to the reduction in the number of channels between sites, and therefore improved utilization of inter-site connected resources and infrastructure. Even more channel consolidation can result from the use of 2 Gbps inter-site links between the cascaded FICON Directors. Solutions such as Geographically Dispersed Parallel Sysplex (GDPS) can benefit from the reduced inter-site configuration complexity that cascaded FICON Directors provide. While specific cost savings vary depending upon infrastructure, generally customers who have data centers at two separate sites may reduce the number of cross-site connections by using cascaded Dircascaded Directors. Further savings may be realized in the reduction of the number of channels and director ports.

2

FICON topology and terminology

This chapter introduces the topology supported by a FICON channel when in FICON native (FC) mode. The terminology used for describing components used in the Fibre Channel topology in the FICON channel-to-CU path, and for certain communication actions by the FICON channel is also included. There are a number of topologies associated with Fibre Channel, however, not all are supported by zSeries or the 9672 G5/G6 processors.

This chapter contains the following information:

- General Fibre Channel terminology
- FICON channel topologies that are currently supported by the zSeries and 9672 G5/G6 processors
- Switched fabric access control methods and terms
- Terminology used in FICON environments, based on topology

2.1 Basic Fibre Channel terminology

This section discusses some general terms used in the Fibre Channel (FC) environment when operating in a point-to-point, arbitrated loop, or switched configuration. These terms are also used in FICON environments.

Node

A node is an endpoint that contains information. It can be a computer (host), a device controller, or a peripheral device (such as, disk or tape drives). A node has a unique 64-bit identifier known as the Node_Name. The Node_Name is typically used for management purposes.

Port

Each node must have at least one port (hardware interface) to connect the node to the FC topology. This node port is referred to as an N_Port.

Each N_Port has a Port_Name, which is a unique 64-bit identifier that is assigned at the time it is manufactured. The N_Port is used to associate an access point to a node's resources.

Other port types include:

E_Port	An *expansion port* is used to interconnect switches and build a switched fabric.
F_Port	A *fabric port* is used to connect an N_Port to a switch that is not loop-capable.
FL_Port	A *fabric loop port* is used to connect NL_Ports to a switch in a loop configuration.
G_Port	A *generic port* is a port that has not assumed a role in the fabric.
L_Port	A *loop port* is a port in a Fibre Channel Arbitrated Loop (FC-AL) topology.
NL_Port	A *node loop port* is an N_Port with loop capabilities.

The port type is determined by the node's role in the topology, as shown in Figure 2-1 on page 11.

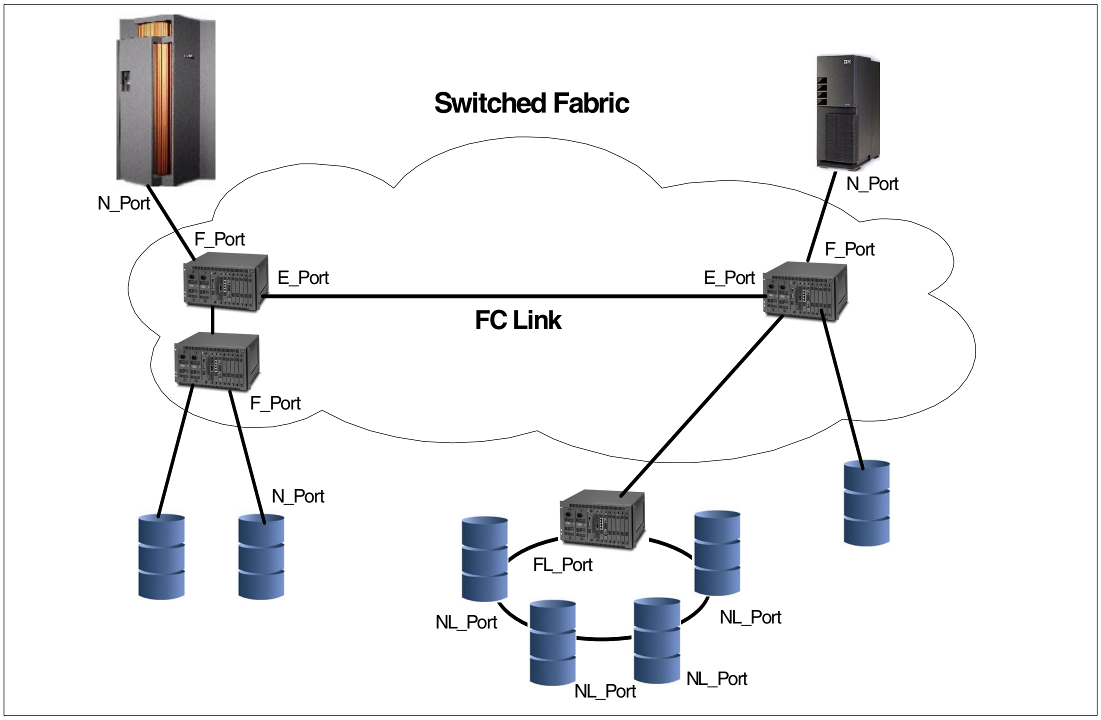

Figure 2-1 FC port types

Note: The zSeries and S/390 servers do not support the arbitrated loop topology.

Switched fabric

One or more switches are interconnected to create a fabric, to which the N_Ports are connected. A switched fabric takes advantage of aggregated bandwidth via switched connections between N_Ports.

FC link

The port connects to the topology through an FC link. The FC link is a fiber optic cable that has two strands, one used to transmit a signal and the other to receive a signal (see Figure 2-2). An FC link is used to interconnect nodes and/or switches.

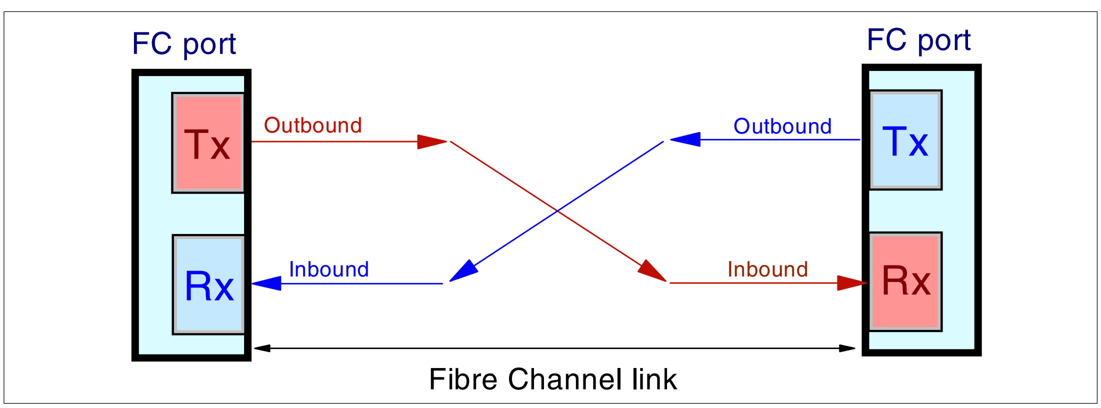

Figure 2-2 Fibre Channel link

For example, an FC link (port-to-port connection) can be:

- Node-to-node link (N_Port-to-N_Port)
- Node-to-switch link (N_Port-to-F_Port)
- Loop node-to-switch link (NL_Port-to-FL_Port)
- Switch-to-switch link (E_Port-to-E_Port)

World-Wide Names (WWN)

As mentioned, nodes and ports have unique 64-bit addresses that are used to identify them in an FC topology. These addresses are assigned by the manufacturer, with a vendor-specific portion defined by the IEEE standards committee. These addresses (in the FC standard) are called Node_Names and Port_Names, and when they are world-wide unique, they are referred to as:

- World-Wide Node_Name (WWNN)
- World-Wide Port_Name (WWPN)

A WWN (any WWNN or WWPN) is usually written in sets of two hex digits, separated by colons (for example, 08:45:12:56:43:00:D5:A0).

Figure 2-3 illustrates the use of WWNs.

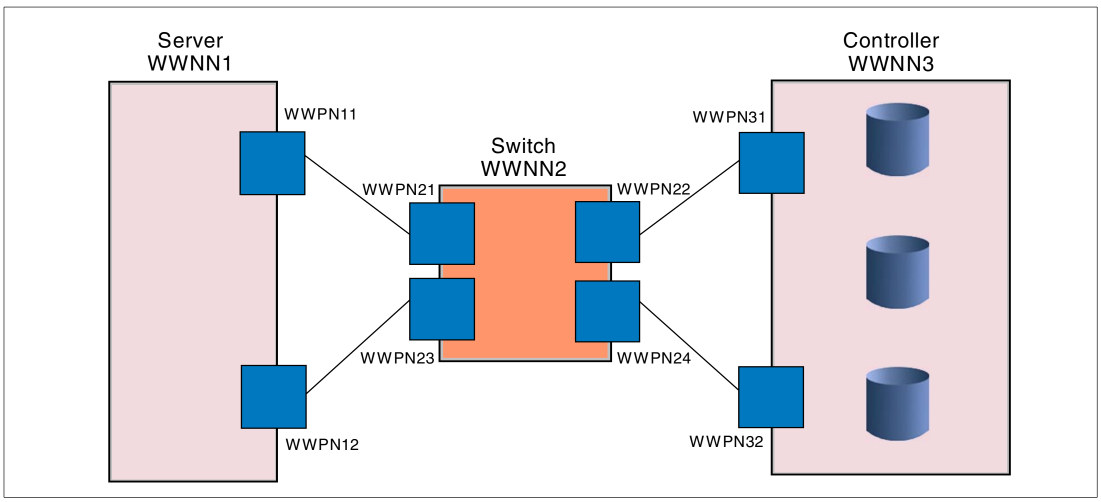

Figure 2-3   Example of World-Wide Names

2.2 FICON channel topology

A FICON channel in FICON native (FC) mode uses the Fibre Channel communication infrastructure supported by the zSeries and 9672 G5/G6 to transfer zSeries and S/390 channel programs (CCWs) and data via its FICON/FICON Express adapter to another FICON adapter node, such as a storage device, printer, or sever (channel-to-channel).

As shown in Figure 2-4 on page 13, a FICON native (FC) mode channel can operate in one of three topologies:

1. Point-to-point (directly connected to a FICON capable control unit)
2. Switched point-to-point (through a single Fibre Channel FICON capable switch to a FICON-capable control unit)

3. Cascaded FICON Directors (through two Fibre Channel FICON-capable switches to a FICON-capable control unit)

These topologies use the FC-SB-2 (FICON) architecture at the FC-4 layer.

Note that this publication refers to both a FICON capable Fibre Channel switch as a FICON switch or a FICON Director. FICON switch is a generic term for a switch that supports the transferring of frames containing FC-SB-2 architecture payloads and supports the FC-FS Extended Link Services (ELSs) that the FICON channel in FICON native (FC) mode requires, whereas the FICON Director requires all of the preceding items plus has an internal N_Port that supports the zSeries and S/390 feature called Control Unit Port (CUP) function.

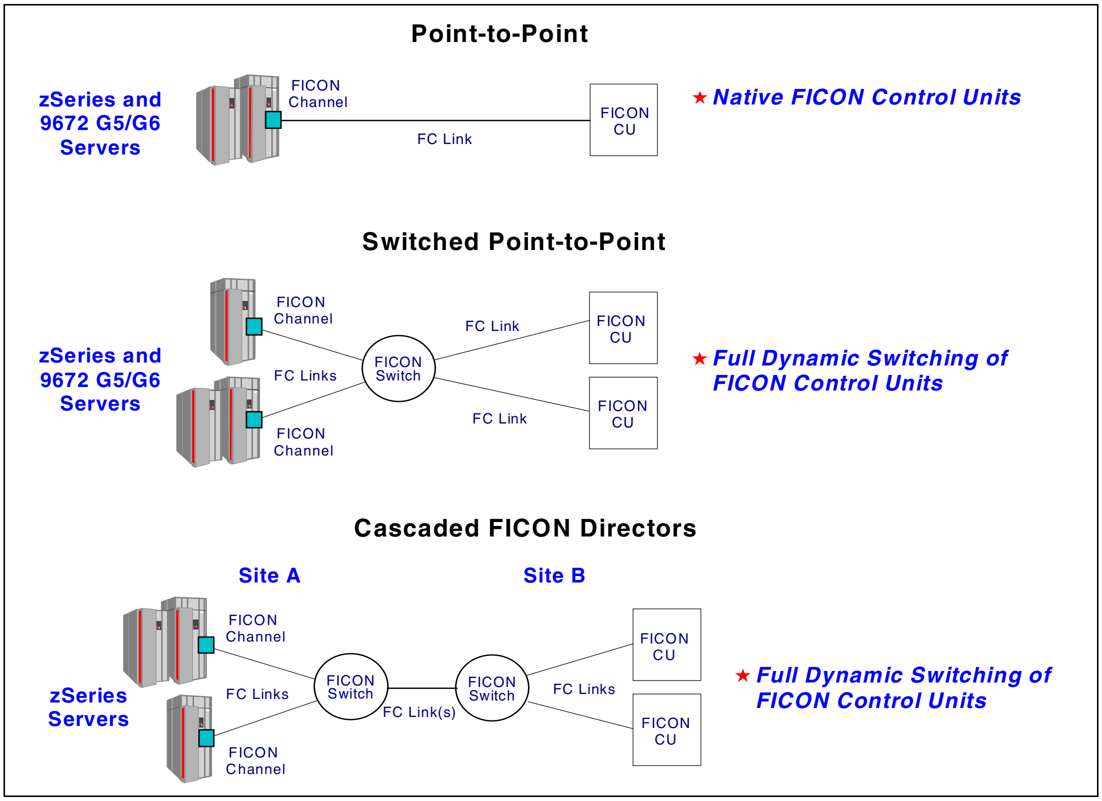

Figure 2-4 FICON connections and topologies

With a FICON channel in FICON native (FC) mode, the connectivity is from a zSeries or a 9672 G5/G6 processor FICON channel to a FICON-capable control unit. The connection is either from the FICON native (FC) mode channel directly to a FICON-capable control unit, or through one or two Fibre Channel switches and then onto a FICON control unit (see Figure 2-4).

In a point-to-point connection the Fibre Channel (FC) link is between the processor's FICON channel card (N_Port) and the FICON adapter card (N_Port) in the control unit.

In a switched point-to-point connection, two Fibre Channel (FC) links are needed. One is between the FICON channel card (N_Port) and the FICON switch (FC Switch) Fibre Channel adapter card (F_Port), then internally within the switch to another Fibre Channel adapter card (F_Port), and then via the second FC link to a FICON adapter card in the Control Unit (N_Port).

In a Cascaded FICON Directors connection, at least three Fibre Channel (FC) links are involved. One is between the FICON channel card (N_Port) and the FICON switch (FC

Switch) Fibre Channel adapter card (F_Port), then internally within the switch to another Fibre Channel adapter card (E_Port) that connects to a second FC switch E_Port via the second FC link, and then to a FICON adapter card in the Control Unit (N_Port) via the third FC link. With this configuration, the connection between sites can be multiple FC links.

The FICON channel in FICON native (FC) mode supports multiple concurrent I/O connections. Each of the concurrent I/O operations can be to the same FICON control unit (but to different devices) or to different FICON control units.

The following are required to establish connectivity between a processor's FICON channel and the FICON-capable control unit:

- A Fibre Channel cable type
  - 9 micron single-mode fiber cables (9 µm SM)
  - 50 micron multi-mode fiber cables (50 µm MM)
  - 62.5 micron multi-mode fiber cables (62.5 µm MM)
- A Transmission type
  - Short wavelength Laser 850 nanometers (SW laser 850 nm)
  - Long wavelength Laser 1300 nanometers (LW laser 1300 nm)
- Fibre Channel standard interface support
  - FC-PI physical interface architecture
- Fibre Channel standard protocol support
  - FC-FS Protocol architecture
  - FC-SB-2 Protocol architecture
- Channel-to-CU communication support
  - Command and data prefetching (z/Architecture)
  - CCW and data pipelining (FC-SB-2 architecture)

2.2.1 Point-to-point configuration

A channel path that consists of a single link interconnecting a FICON channel in FICON native (FC) mode to one or more FICON control unit images (logical control units) forms a point-to-point configuration. A point-to-point configuration is permitted between a channel and control unit only when a single control unit is defined on the channel path or when multiple control unit images (logical control units) share the same N_Port in the control unit. A FICON channel point-to-point configuration is shown in Figure 2-5 on page 15.

The channel N_Port and the control unit N_Port are responsible for managing the access to the link among the logical images.

A maximum of one link can be attached to the channel in a point-to-point configuration. The maximum number of control unit images that are supported by the FICON architecture over the FC link to Control Unit is 256, therefore the maximum number of devices that can be addressed over a channel path configured point-to-point is equal to 256 times 256, or 65,536. Refer to “FICON channel operation and performance” on page 187 for the number of supported control units by FICON.

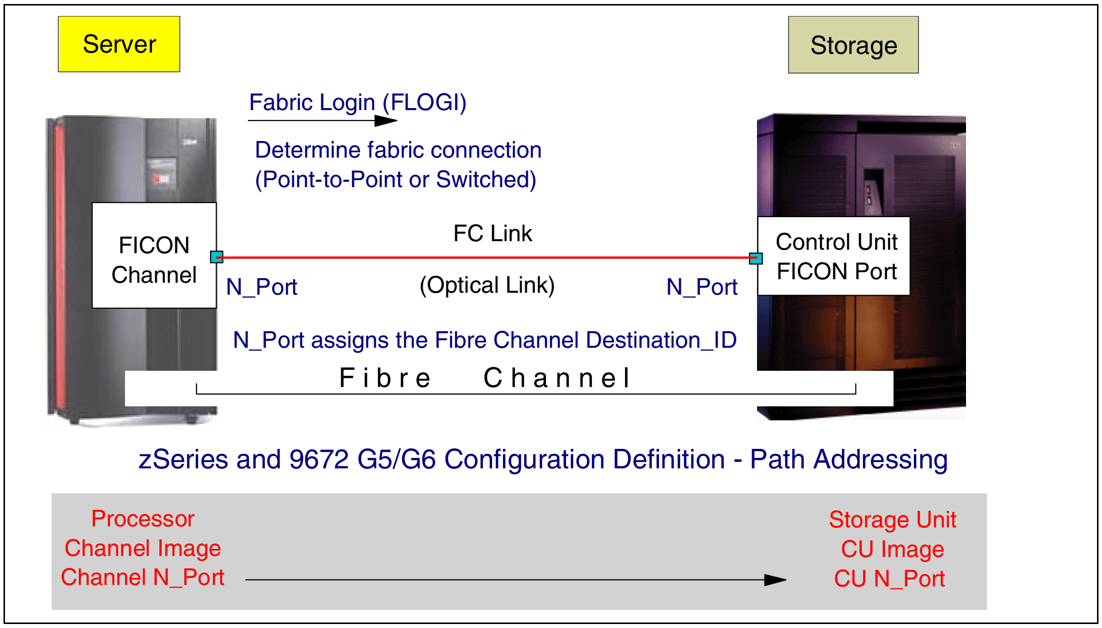

Figure 2-5 FICON native point-to-point configuration

The FICON channel determines whether the link that it is connected to is in a point-to-point or switched topology. It does this by logging into the fabric, fabric login (FLOGI ELS), and checking the accept response to the fabric login (ACC ELS). The FLOGI - ACC (accept) response will indicate whether the channel N_Port is connected to another N_Port (point-to-point) or an F_Port (fabric switch port).

2.2.2 Switched point-to-point configuration

A FICON channel in FICON native (FC) mode connects one or more processor images to a Fibre Channel link, which connects to a Fibre Channel switch, and then dynamically to one or more FC switch ports (internally within the switch). From the switch ports there is another Fibre Channel link to FICON CU ports, which interconnects with one or more control units and/or images (logical control units). This forms a switched point-to-point configuration; see Figure 2-6 on page 16.

Multiple channel images and multiple control unit images can share the resources of the Fibre Channel link and the Fibre Channel switch, such that multiplexed I/O operations can be performed.

Channels and control unit links can be attached to the Fibre Channel switch in any combination, depending on configuration requirements and on available resources in the Fibre Channel switch.

Sharing a control unit through a Fibre Channel switch means that communication from a number of channels to the control unit can take place either over one switch to CU link (in the case where a control unit has only one link to the Fibre Channel switch), or over multiple link interfaces in the case where a control unit has more than one link to the Fibre Channel switch.

Just one Fibre Channel link is attached to the FICON channel in a FICON switched point-to-point configuration, but from the switch the FICON channel can communicate with (address) a number of FICON CUs on different switch ports. Once at the control unit, the same control unit and device addressing capability exists as for the point-to-point configuration. However, the communication and addressing capability is increased for the channel when the channel is connected to a Fibre Channel switch with the ability to use the domain and port address portion of the 24-bit N_Port address (8 bits for the domain and 8 bits for the port) to access multiple control units.

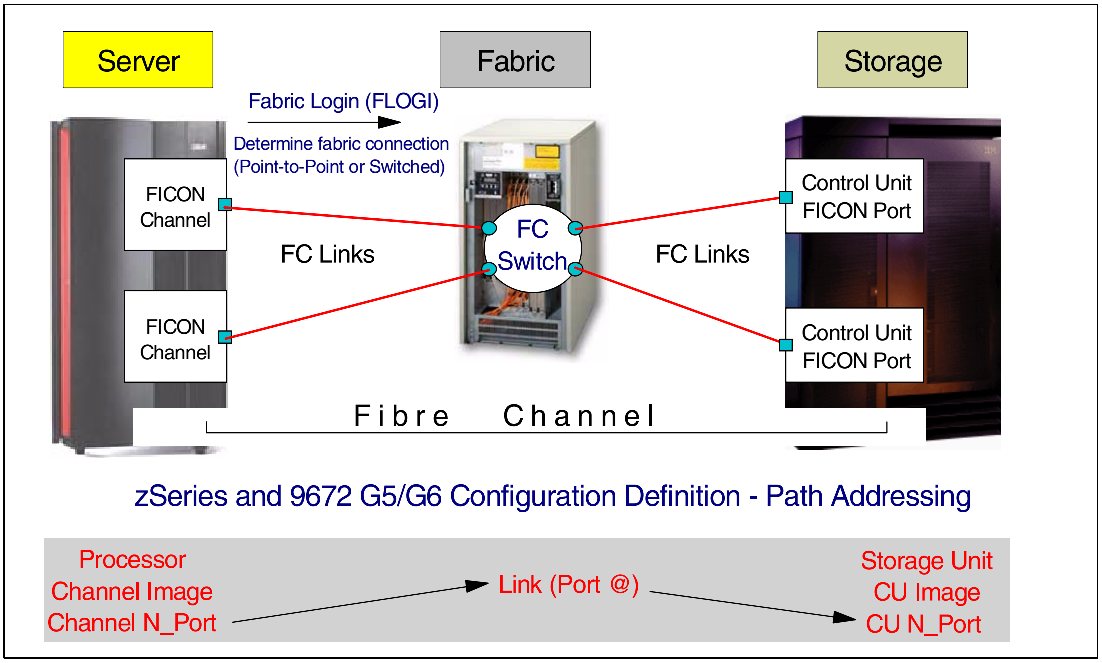

Figure 2-6 FICON native switched point-to-point configuration

The communication path between a channel and a control unit is composed of two different parts, the physical channel path and the logical path.

In a FICON switched point-to-point topology (with a single switch) the physical paths are the FC links, or interconnection of two FC links connected by a Fibre Channel switch, that provides the physical transmission path between a channel and a control unit.

A FICON (FC-SB-2) logical path is the relationship established between a channel image and a control unit image for communication during execution of an I/O operation and presentation of status.

2.2.3 Cascaded FICON Directors configuration

A FICON channel in FICON native (FC) mode connects one or more processor images to a Fibre Channel link, which connects to a Fibre Channel switch, and then dynamically through one or more FC switch ports (internally within the switch) to a second FC switch in a remote site via FC link(s). From the second FC switch ports, there are Fibre Channel links to FICON CU ports, which interconnect with one or more control units and/or images (logical control units). This forms a Cascaded FICON Directors configuration; see Figure 2-7 on page 17.

Multiple channel images and multiple control unit images can share the resources of the Fibre Channel link and the Fibre Channel switches, such that multiplexed I/O operations can be performed.

Channels and control unit links can be attached to the Fibre Channel switches in any combination, depending on configuration requirements and on available resources in the Fibre Channel switches.

Sharing a control unit through a Fibre Channel switch means that communication from a number of channels to the control unit can take place either over one switch-to-CU link (in the case where a control unit has only one link to the Fibre Channel switch), or over multiple link interfaces in the case where a control unit has more than one link to the Fibre Channel switch.

Just one Fibre Channel link is attached to the FICON channel in a Cascaded FICON Directors configuration. However, from the FC switch the FICON channel can communicate with (address) a number of FICON CUs on different ports of the second FC switch. Once at the control unit, the same control unit and device addressing capability exists as for the point-to-point configuration. However, the communication and addressing capability is greatly increased for the channel when the channel is connected to a Fibre Channel switch with the ability to use the domain and port address portion of the 24-bit N_Port address (8 bits for the domain and 8 bits for the port) to access multiple control units. Note the domain address portion of the FC 24-bit port address is different since there are two FC switches in the channel-to-control unit path. The Cascaded FICON Directors configuration is only supported by the zSeries processors.

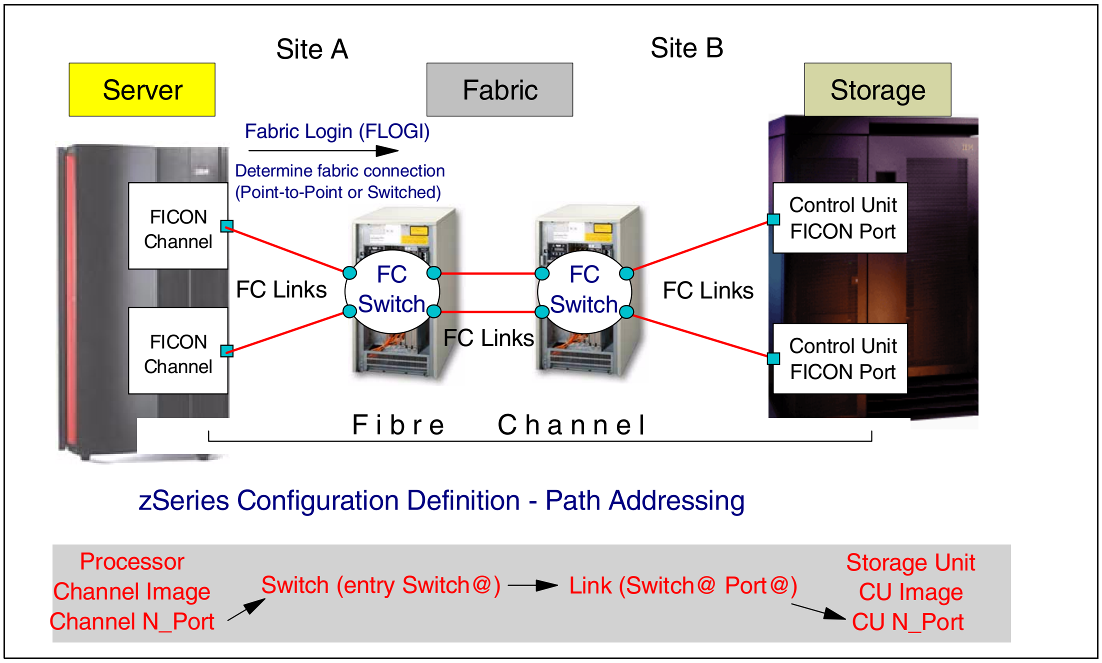

Figure 2-7 FICON native Cascaded FICON Directors configuration

The communication path between a channel and a control unit is composed of two different parts, the physical channel path and the logical path.

In a Cascaded FICON Directors topology (with two switches) the physical paths are the FC links, connected by Fibre Channel switches, that provide the physical transmission path between a channel and a control unit.

A FICON (FC-SB-2) logical path is the relationship established between a channel image and a control unit image for communication during execution of an I/O operation and presentation of status.

2.3 Access control

The ability to control access to nodes and/or switches is provided as features within the FC switch, known as zoning and binding. Zoning can be applied to prohibit servers from accessing storage that they are not permitted to access. Binding can be used to prevent nodes and/or switches from connecting to the switch. In this section we will introduce these features.

Zoning

Segmentation of a switched fabric is achieved through zoning. It can be used to partition off certain portions of the switched fabric, allowing only members of a zone to communicate within that zone. All others attempting to access from outside that zone are rejected, hence zoning provides a security function.

Zoning can be implemented in two ways: *hard zoning* or *soft zoning*:

- Hard zoning is based on the physical port number. A port number can belong to multiple zones.
- Soft zoning is defined in the name server of a switch, using WWNs. The WWN can belong to multiple zones.

Figure 8 illustrates an example of zoning. In this example, the group1 members are Server 1 and Target 4, Target 5, and Target 6. The group2 members are Server 2 and Target 5, hence communication between Server 2 and Target 4 and Target 6 is not permitted. The group3 members are Server 3 and Target 6, hence communication between Server 3 and Target 4 and Target 5 is not permitted.

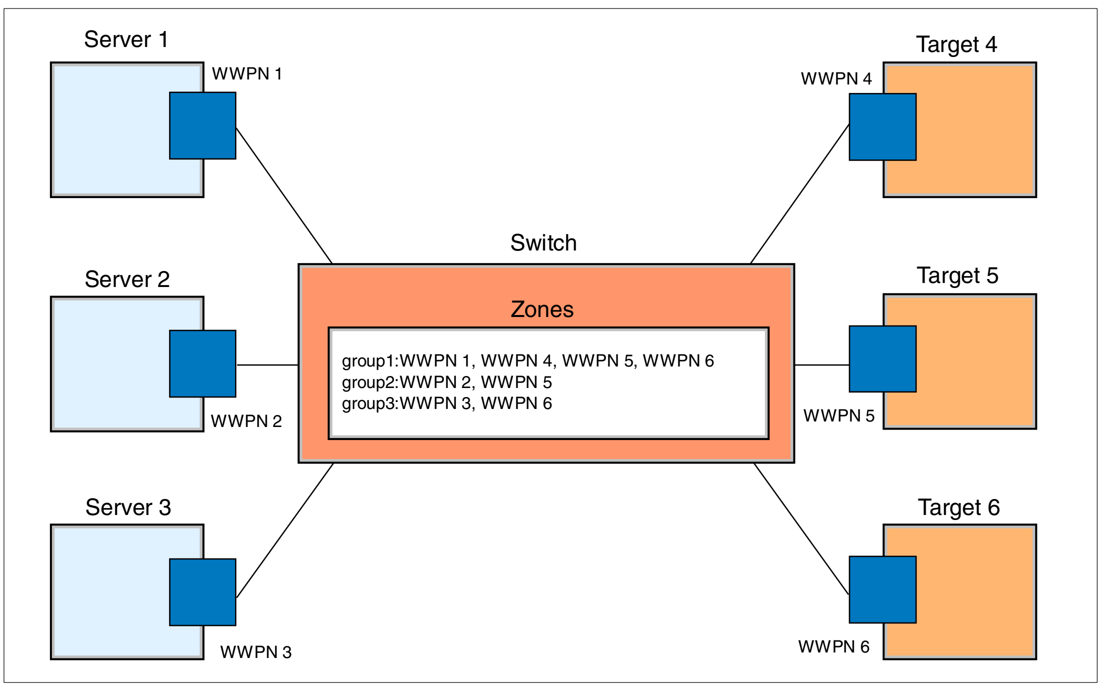

Figure 8 Zoning example

Binding and Insistent Domain IDs

Insistent Domain IDs prohibits the use of dynamic Domain IDs to ensure that predictable Domain IDs are being enforced within the fabric. For example, if a switch has this feature enabled and a new switch is connected to it (via an ISL) without the preferred Domain ID, then the new switch is segmented into a separate fabric and user data will not flow. The Insistent Domain IDs feature also ensures that duplicate Domain IDs are not being used within a fabric.

Binding is a method used in the switch to prevent devices and/or other switches from attaching to the switch, based on WWNs that are defined to a *membership list*. There are three levels of binding, depending on the degree of security/integrity desired:

1. Port binding

   A port membership list is defined in the switch with the WWPN of a port on that particular switch and the WWPN of the port of the authorized switch or device. This method is port dependent, which means the fiber connection cannot be moved from one port to another on the switch without changes to the port membership list.

2. Switch binding

   A switch membership list is defined to the switch with the WWNNs of the switches and/or devices that are authorized to attach to it. This method is port independent, which means the fiber connection can be attached to any port on the switch.

3. Fabric binding

   A fabric membership list is defined with WWNNs and Domain IDs of the switches that are authorized to attach to it. This method is port independent, which means the fiber connection can be attached to any port on the switch.

These binding types and Insistent Domain IDs are configured in the switch and are known as the *High Integrity* feature; they are independent of one another and can overlap.

Figure 2-9 on page 20 illustrates the concept of a high integrity fabric. In this example, FC Switch 1 allows the devices (4 and 5) and switches (7, 8, and 9) to attach as follows:

- Device 4 using switch binding can be attached via any port.
- Device 5 using port binding can only be attached through WWPN 16 via WWPN 51.
- FC Switch 7 using port binding can only be attached through WWPN 11via WWPN 71.
- FC Switch 8 using switch binding can be attached via any port.
- FC Switch 9 using fabric binding (WWNN 9 and Domain ID 9) can be attached via any port.

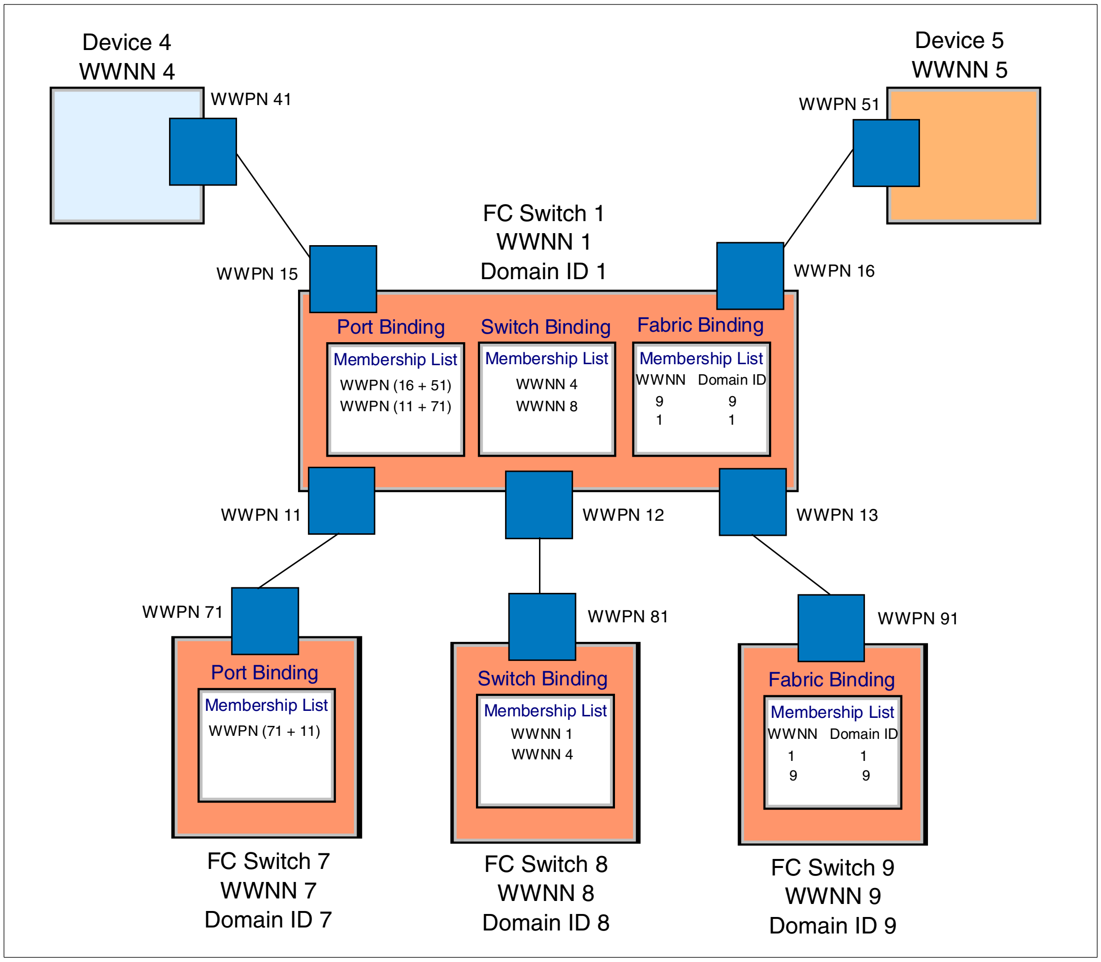

Figure 2-9 Example of the three binding types

For detailed information about FC topologies, as well as zoning, binding, and Insistent Domain IDs, refer to the following:

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www.t11.org
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A description of FICON usage of binding and Insistent Domain IDs can be found in 7.5.1, “Levels of binding” on page 103.

2.4 Fibre Channel and FICON terminology

This section describes some of the new terms used in a FICON native (FC) mode channel environment. The description covers the terminology used when the FICON channels are operating in a FICON channel point-to-point configuration and a FICON channel switched point-to-point configuration. The FICON topologies are discussed in more detail in the 2.2, “FICON channel topology” on page 12.

Fibre Channel support and the FICON channel using the FC-SB-2 protocol introduce the following topologies:

- Point-to-point - no switch between the channel (server) and the CU (storage device), supported by a FICON channel in FICON native (FC) mode

- Switched point-to-point - a single switch between the channel (server) and the CU (storage device), supported by a FICON channel in FICON native (FC) mode
- Cascaded FICON Directors - with two switches in the channel-to-CU path
- Cascade switching - with multiple switches in the channel-to-CU path
- FC fabric - consists of one or more fiber channel switches with interconnection switching routes

In the current zSeries and 9672 G5/G6 implementation, only point-to-point (no FC switch), switched point-to-point (one FC switch in the channel-to-CU path), and Cascaded FICON Directors (two FC switches in the channel-to-CU path), topologies are supported. Therefore, only those terms that apply to these three supported topologies are used in this document.

2.4.1 Point-to-point connection terms

Figure 2-10 on page 21 introduces the FICON native terms, which are used in a point-to-point topology.

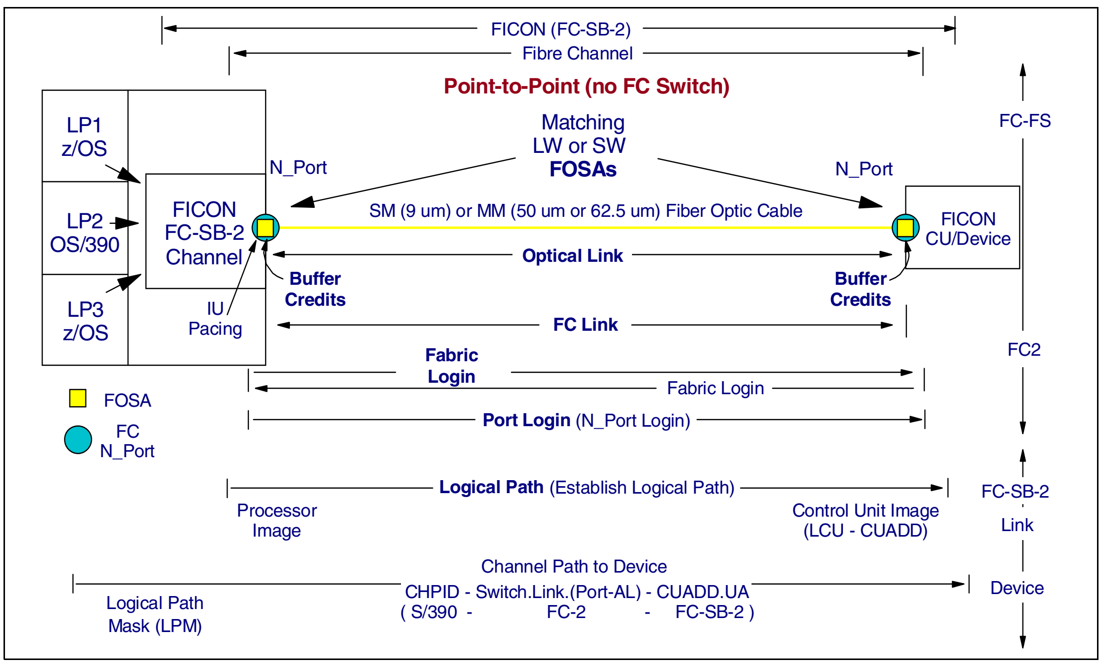

Figure 2-10 FICON native point-to-point topology

Buffer Credits The Fibre Channel FC-2 level uses the Buffer-to-Buffer credits flow control to pace the transfer of frames from one N_Port to the N_Port at the other end of the link.

IU Pacing This FICON (FC-SB-2) status parameter is sent by the control unit to the channel to indicate the maximum number of IUs a channel can send before a command response IU is expected.

FOSA The Fiber Optic SubAssembly consists of a transmitter that converts an electrical signal to an optical signal, and a receiver that converts an optical signal to an electrical signal. There are two FOSA types, long wavelength and short wavelength.

Optical Link The optical link is the physical link between 2 FOSAs of the same type (LW or SW Laser). The fibre cable connecting both FOSAs can be a SM

(9 µm) or a MM (50 µm or 62.5 µm) cable depending on the type of FOSA in the FICON adapter card. The maximum distance for the optical link depends on the type of FOSAs used (LW or SW) and on the type of fiber cables used to build the link (SM or MM, MCP). Refer to “FICON - Fibre Channel cabling” on page 69 for physical planning the optical link.

Fibre Channel Link (FC Link)
In a point-to-point connection the Fibre Channel link (FC link) is the Link between the two N_Ports. This may also include Fibre Extenders. The maximum distance for the FC link depends on the Buffer-to-Buffer credits provided by both N_Ports.

Fabric Login Both Ports connected by the FC Link have to do a Fabric Login (FLOGI) as described in the FC-FS architecture. Fabric Login determines the presence or absence of a fabric. If a fabric is not present, an Accept with the specification of N_Port in Common Service Parameters indicates that the requesting N_Port is attached in a point-to-point topology.

N_Port Login If a fabric is not present, as determined by performing the Fabric Login procedure, one of the two N_Ports proceeds with destination N_Port Login (PLOGI). This returns the Service Parameter of the responding N_Port.

Logical Path The Establish Logical Path function (FICON FC-SB-2) is performed from a channel image (processor Logical Partition image) to a control unit image (logical control unit) to request the establishment of a logical path. A channel attempts to establish a logical path to the control unit images that are described in its configuration definition.

2.4.2 Switched topology connection terms

Figure 2-11 on page 23 illustrates the FICON native channel (SB-2 mode) switched topology (switched point-to-point and Cascaded FICON Directors) and shows the various components that can be used in the FICON channel in FICON native (FC) mode channel-to-CU path.

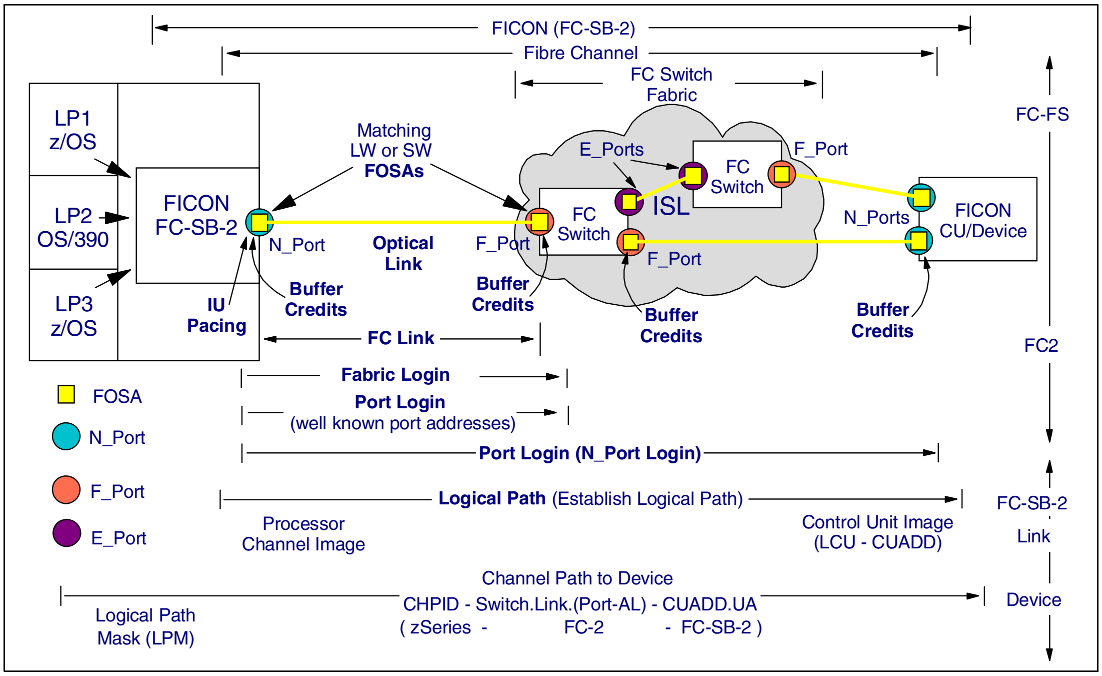

Figure 2-11 FICON native switched topology

Figure 2-11 introduces the FICON native terms, which are used in a switched (switched point-to point and Cascaded FICON Directors) topology.

Buffer Credits The Fibre Channel FC-2 level uses the Buffer-to-Buffer credits flow control to pace the transfer of frames from an N_Port to the F_Port at the other end of the link, and vice versa.

IU Pacing This FICON (FC-SB-2) status parameter is sent by the control unit to the channel to indicate the maximum number of IUs a channel can send before a command response IU is expected.

FOSA The Fiber Optic SubAssembly consists of a transmitter that converts an electrical signal to an optical signal, and a receiver that converts an optical signal to an electrical signal. There are two FOSA types, long wavelength and short wavelength.

Optical Link The optical link is the physical link between two FOSAs of the same wavelength and type (LW laser or SW Laser); the wavelengths used by the FOSAs must match. The fibre cable connecting the FOSAs can be a single-mode (9um) or a multi-mode (50 µm or 62.5 µm) cable depending on the type of FOSA in the FICON adapter card. The maximum distance for the optical link depends on the type of FOSAs used (LW or SW) and on the type of fiber cables (SM or MM, MCP) used to connect the FOSAs. Refer to Chapter 5, “FICON - Fibre Channel cabling” on page 69 for physical planning of the optical link.

Fibre Channel Link (FC Link)

In a FICON native (FC) mode switched connection, the Fibre Channel link (FC link) is a communication link between a FICON adapter in the processor (server) and a Fibre Channel switch port (N_Port-to-F_Port), also between a Fibre Channel switch port and a FICON adapter in a Control Unit (storage device) (F_Port-to-N_Port), as well as between FC switches (E_Port-to-E_Port). This includes any optical fiber extenders that may be in the FC link. The maximum distance for an FC link depends on the Buffer-to-Buffer credits provided by the FC adaptors at each end of the FC link, the N_Ports and the F_Ports.

Inter-Switch Link (ISL)
In a switched fabric, the FC link providing connectivity between two switches is referred to as an ISL. The switch ports that the ISL connect to are referred to as E_ Ports. Multiple ISLs can be used between two switches.

Fabric Login All N_Ports (FICON Channel ports and FICON CU ports) connected by the FC link to a FC switch must first successfully execute a Fabric Login (FLOGI) to the fabric (fabric F_Port), as described in FC-FS architecture, before the N_Ports can successfully execute any other FC-2 ELS or before sending any FC-4 protocol frame (for FICON an FC-FS - FC-SB-2 frame). The Fabric Login process determines the presence or absence of a Fabric. If a fabric is present, it assigns or confirms the N_Port identifier of the N_Port which initiated the Fabric Login.

Port Login If a fabric is present, as determined by the response to the Fabric Login procedure, an N_Port proceeds with destination N_Port Logins (PLOGI), and to Fabric Service well known port addresses (for a FICON channel switched point-to-point environment the channel performs this action).

Logical Path The FICON (FC-SB-2) Establish Logical Path (ELP) function is performed from a channel image (processor Logical Partition image) to a control unit image (logical control unit) to request the establishment of a logical path. A channel attempts to establish a logical path to the control unit images that are described in its configuration definition.

3

FICON architecture and addressing

This chapter describes the protocols that make up the Fibre Channel architecture:

- Fibre Channel - Framing and Signalling (FC-FS)
- Fibre Channel - Physical Interface (FC-PI)
- Fibre Channel - Single Byte-2 (FC-SB-2)
- Fibre Channel - Switch Fabric (FC-SW)

These protocols are used by the zSeries and 9672 G5 and G6 processors to support FICON channels in FICON native (FC) mode.

The zSeries processors support the z/Architecture, which provides the instruction and operation details for the start and subsequent completion of an I/O operation. The z/Architecture I/O operation consists of channel commands and data (data that is associated with the commands). The commands and data (Write operation) are transferred from the zSeries processor storage to the channel and then to the storage device (control unit). For Read operations the data is transferred from the storage device to the zSeries channel and then to processor storage.

This chapter covers the use of the zSeries and 9672 G5/G6 FICON channel in FICON native (FC) mode using the Fibre Channel architecture to support the zSeries I/O operations, as well as the addressing model and flow control used to support FICON channel-to-CU communications.

3.1 Fibre Channel architecture

The Fibre Channel (FC) architecture was developed by the National Committee for Information Technology Standards (NCITS).

Figure 3-1 illustrates the different levels (FC-0 to FC-4), described by the various Fibre Channel protocols (FC-PI, FC-FS and the ULPs).

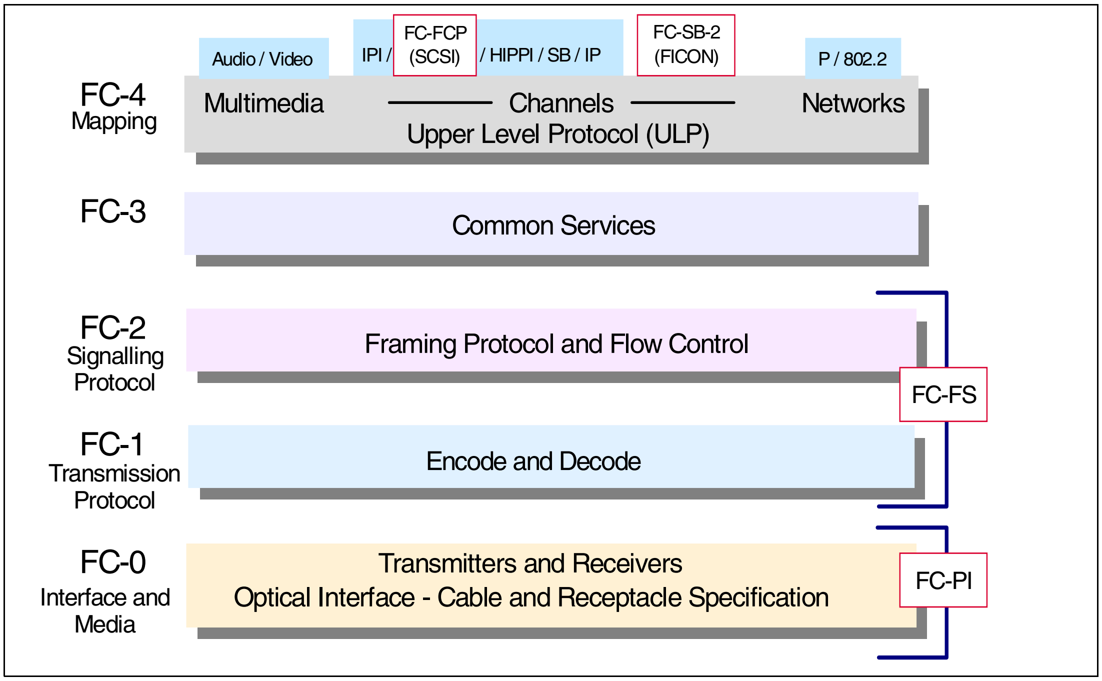

Figure 3-1 Fibre Channel standard architecture

The Fibre Channel (FC) architecture includes:

- FC-0 level: Interface and Media

  The fibre channel physical interface (FC-0), specified in FC-PI, consists of the transmission media, transmitters, receivers, and their interfaces. The physical interface specifies a variety of media and associated drivers and receivers capable of operating at various speeds.

  ANSI NCITS xxx-200x FC-PI T11/Project 1235D

- FC-1 level: Transmission Protocol

  This is a link control protocol that performs a conversion from the 8-bit EBCDIC code into a 10-bit transmission code; a unique bit-pattern is assigned to each known hexadecimal character. Encoding is done by the N_Port when sending the character stream over the fiber and decoding back to 8-bit EBCDIC code is performed by the receiving N_Port.

- FC-2 level: Signaling Protocol

  Fibre channel physical framing and signaling interface (FC-PH) describes the point-to-point physical interface, transmission protocol and signaling protocol of high-performance serial links for support of higher-level protocols associated with HIPPI, IPI, SCSI, FC-SB2 (FICON) and others.

  – Fibre Channel - Framing and Signalling (FC-FS)

    ANSI X3.230-1994

Describes the signaling protocol of the high-performance serial link for support of higher-level protocols associated with HIPPI, IPI, FC-FCP (SCSI), FC-SB2 (FICON) and others.

This architecture covers the fibre channel levels FC-1, FC-2, and some parts of the FC-3 level.

The FC-FS architecture consolidates the relevant clauses of FC-PH (the initial Fibre Channel architecture), its amendments 1 and 3, and FC-PH-2 and FC-PH-3 protocols, but does not replace those protocols. In this redbook the FC-FS architecture is referred to as the zSeries and 9672 G5/G6 processors, which comply with the FC-FS functions. These functions are described in more detail in the FC-FS architecture.

- FC-3 level: Common Services

  This level is reserved for future functions.

- FC-4 level: Mapping

  Channels Upper Level Protocol (ULP) is part of FC-4 and describes IPI/FC-FCP (SCSI)/ HIPPI/SB/IP and FC-SB-2 (FICON) protocols.

  Other standards used in the Fibre Channel architecture, and their references:

  – Fibre Channel - Switch Fabric (FC-SW)

    ANSI X3T11/Project 959-D/Rev 3.3

  – Single-Byte Command Code Sets Connection Architecture (SBCON)

    ANSI X3.296-199x

  – Fibre Channel Fabric Generic Requirements (FC-FG)

    Describes minimum requirements for a topology-independent interconnecting fabric to support FC-PH.

    ANSI X3.289-199x

  – Fibre Channel Switch Fabric (FC-SW)

    Specifies tools and algorithms for interconnection and initialization of FC switches to create a multi-switch Fibre Channel Fabric.

    ANSI X3T11/Project 959-D/Rev 3.3

  FC-SB2 (FICON) architecture information and all other documentation mentioned can be obtained from the following Web site:

  `www.t11.org`

3.2 Introduction to FC-FS and FC-SB-2

The following sections provide an overview of the structure, concepts and mechanisms used in Fibre Channel (FC), FC-FS and FC-SB-2.

Fibre Channel Node (channel) to Fibre Channel Node (control unit) communication over a Fibre Channel link takes place between a pair of Node Ports (N_Ports), one N_Port associated with a channel (for example, processor Node N_Port) and the other N_Port associated with the control unit (for example, disk control unit Node N_Port).

FC-FS (FC-1 and FC-2) defines all of the functions required to transfer information from one N_Port to another N_Port. The physical interface FC_PI (FC-0) consists of transmission media, transmitters, receivers, and associated interfaces.

FC-SB-2 is an FC-4 protocol and is based on the Single-Byte Command Code Set (SBCCS).

The FICON channel in FICON native (FC) mode provides communication to FICON control units. The connectivity from a zSeries or 9672 G5/G6 processor FICON channel to a FICON-capable control unit interface port can be established by using three different connection methods:

1. From the processor's FICON channel directly to a FICON control unit with a FICON adapter installed. This is a point-to-point topology and is illustrated in Figure 3-2.

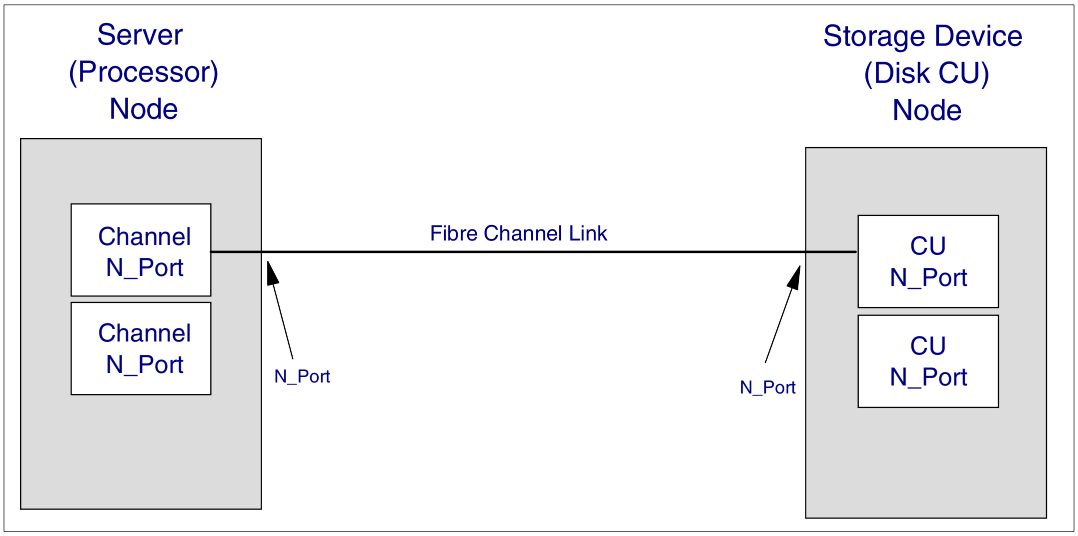

Figure 3-2 Point-to-Point N_Port to N_Port communication

2. From the processor's FICON channel to a Fibre Channel switch port (FC switch port) and then from another FC switch port in the same physical switch to a FICON control unit FICON port. This is a switched point-to-point topology. Refer to Figure 3-3.

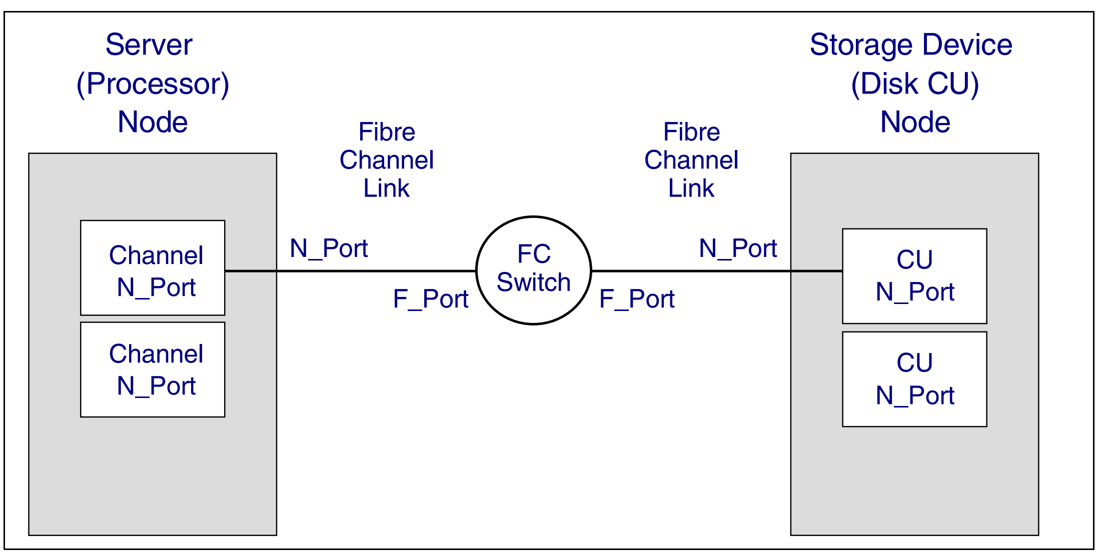

Figure 3-3 FICON switched point-to-point N_Port to N_Port communication

3. From the processor's FICON channel to a Fibre Channel switch port (FC entry switch port of a fabric) and then to an E_Port port in the same physical switch, from here to an E_Port of the second physical switch (communication between two E_Ports is called an Inter-Switch Link, ISL) and then to an FC switch port that connects to a FICON control unit. This is called Cascaded FICON Directors and is shown inFigure 3-4.

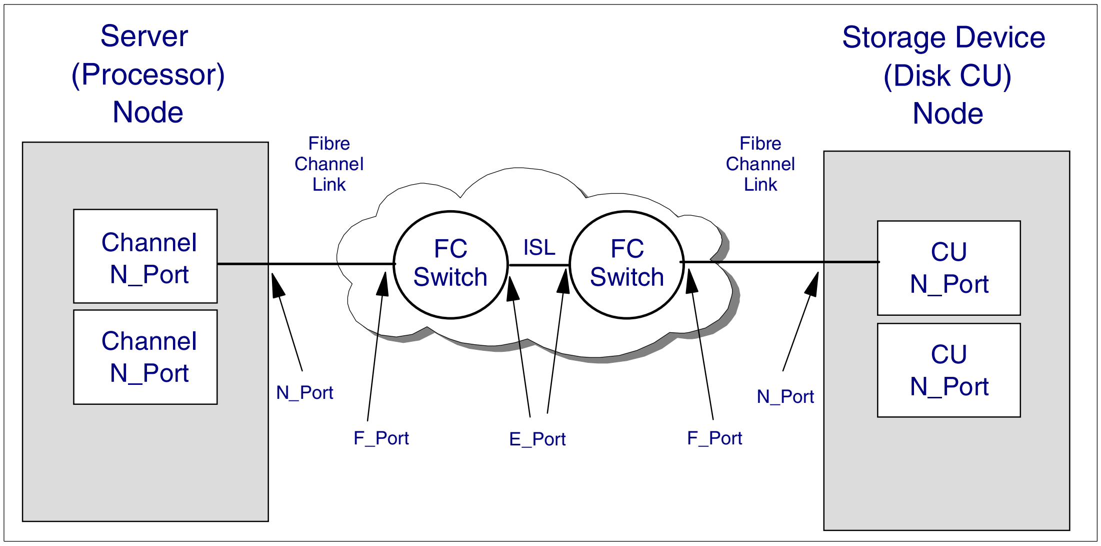

Figure 3-4 FICON cascaded N_Port to N_Port communication

The FICON channel in FICON native (FC) mode supports multiple concurrent I/O operations between the FICON channel and the FICON control unit (to different device addresses or device numbers), or between the FICON channel and multiple FICON control units (to devices in those control units). The number of concurrent I/O operations between the FICON channel in FICON native (FC) mode and FICON control units (control unit devices) depends on the processor model (Server), FICON Director, configuration definition, and the control unit (Storage Device) operation and performance.

Before a FICON channel in FICON native (FC) mode can perform normal command and data transfer operations from the channel to a FICON control unit, several initialization steps must first occur. Some of the initialization steps are part of the FC-FS architecture, and some are mandatory while others are optional. Also required are some initialization steps that are part of the FC-SB-2 architecture (FICON). These are described in subsequent sections.

3.2.1 F_Port Login (FLOGI)

Login with the fabric (FLOGI) is required for all Node Ports (N_Ports). Communication with other N_Ports is not allowed until the N_Port Fabric Login (FLOGI) procedure is complete. Also each Server N_Port is required to log in (PLOGI) with each Storage N_Port with which it intends to communicate; see 3.2.2, “N_Port Login (PLOGI)” on page 31.

The fabric login and port login are methods by which an N_Port establishes its operating environment with a fabric, if present, and other destination N_Ports with which it communicates.

In a switched point-to-point topology, the N_Port is first required to log in to the fabric. In the FC-FS architecture this function is the FLOGI Extended Link Service (ELS). The response from the fabric port to the FLOGI should be an ACC (accept) ELS with the assigned F_Port port address of the N_Port in the ACC (accept) FC-2 header; see “Fibre Channel FC-2 header format” on page 48 for details on the format of the FC-2 header. This action is performed separately by both the FICON channel N_Port and the FICON CU N_Port. This is how, in a switched point-to-point topology, an N_Port determines its port address from the F_Port that is at the other end of the Fibre Channel link. See Figure 3-5 on page 30.

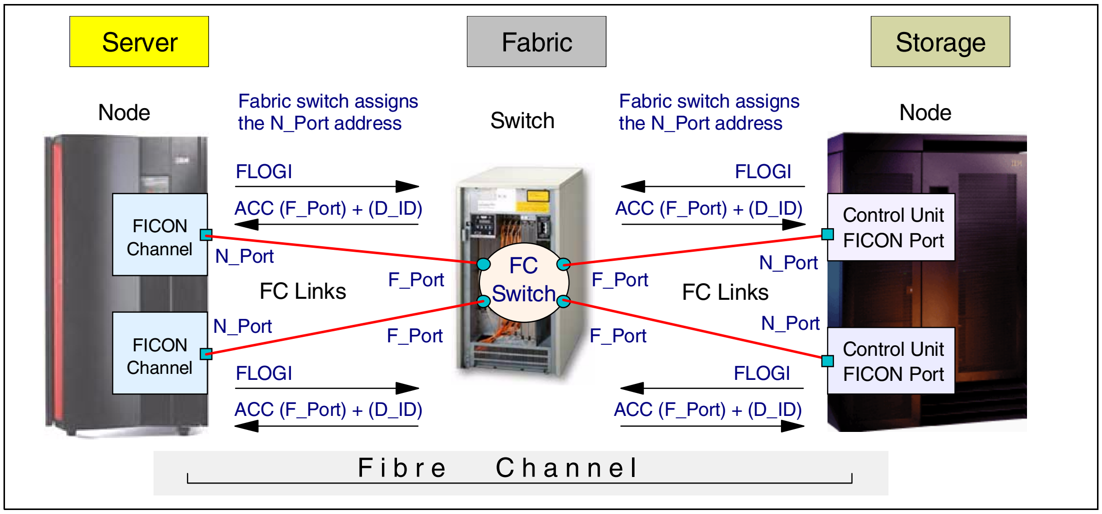

Figure 3-5 FICON native (FC) mode fabric login (FLOGI) - switched point-to-point

Later, when communication is required from the FICON channel port to the FICON CU port, the FICON channel (using FC-SB-2 and FC-FS protocol information) will provide both the address of its port, the source port address identifier (S_ID), and the address of the CU port, the destination port address identifier (D_ID) (when the communication is from the channel N_Port to the CU N_Port).

It is important to understand that the Fibre Channel architecture does not specify how a Server N_Port determines the destination port address of the Storage Device N_Port it requires to communicate to. This is Node and N_Port implementation dependent. Basically, there are two ways that a server can determine the address of the N_Port that it wishes to communicate to:

- The "discovery" method, by knowing the World Wide Name (WWN) of the target Node N_Port and then requesting a WWN for the N_Port port address from a Fibre Channel Fabric Service called the fabric Name Server.
- The "defined" method, by the Server (Processor channel) N_Port having a known predefined port address of the Storage Device (CU) N_Port that it requires to communicate to. This later approach is referred to as the "port address definition approach", and is the approach that is implemented for the FICON channel in FICON native (FC) mode by the zSeries and the 9672 G5/G6, using either the z/OS HCD function or an IOCP program to define a 1-byte switch port (1-byte FC "area" field of the 3-byte fiber channel N_Port port address).

Logging into the fabric (FLOGI) provides the N_Port with fabric characteristics for the entire fabric as defined in the fabric's service parameters. The service parameters specified by the N_Port provide the fabric with information regarding the type of support the N_Port requests.

The Fabric Login (FLOGI) and a successful ACC (accept) response accomplish five functions:

- They determine the presence or absence of a fabric.
- If a fabric is present, the ACC (accept) response provides a specific set of operating characteristics associated with the entire fabric.
- If a fabric is present, the fabric optionally assigns or confirms the native N_Port identifier (N_Port 24-bit FC port address) of the N_Port which initiated the Login.
- If a fabric is present, it initializes the buffer-to-buffer credit.

The buffer-to-buffer credit represents the number of receive buffers supported by a port (N_Port or F_Port) for receiving frames. The minimum value of buffer-to-buffer credits is one. The buffer-to-buffer credit value is used as a controlling parameter in the flow of frames over the FC link to avoid possible overrun at the receiver; see 3.4.3, “Buffer-to-buffer credit” on page 54.

- If a fabric is not present, an Accept with the specification of N_Port in common service parameters indicates that the requesting N_Port is attached to another N_Port (point-to-point topology); see Figure 3-6.

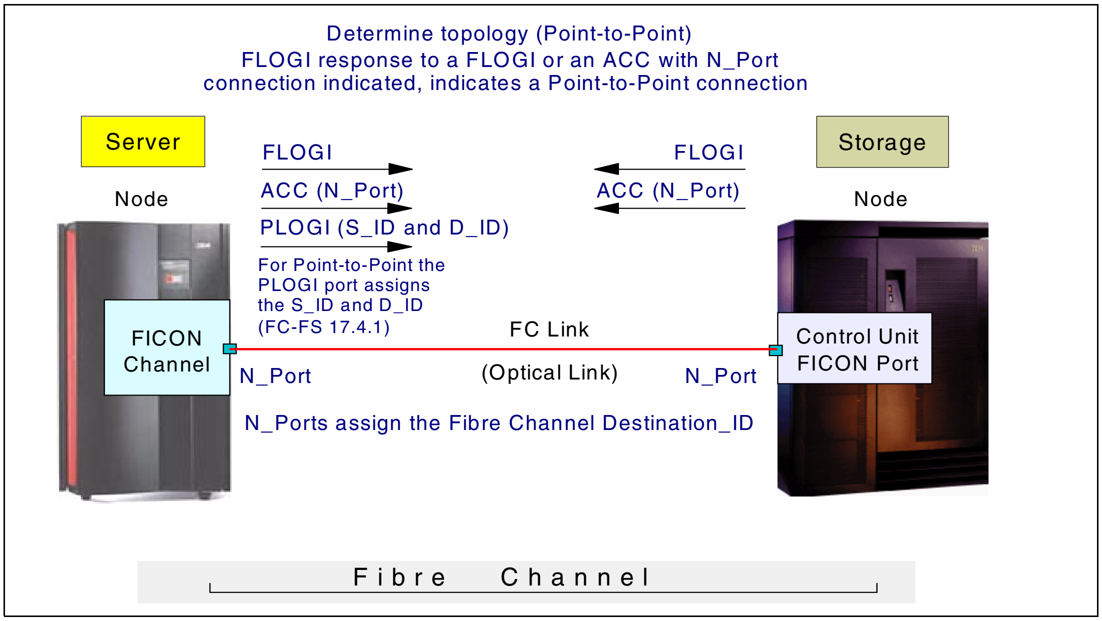

Figure 3-6 FICON native (FC) mode fabric login (FLOGI) - point-to-point

The same initial action (FLOGI), logging in to the fabric, is also required for an N_Port in a point-to-point topology, but that action will make the N_Port aware that it is connected in a point-to-point topology and then perform a different action to determine the two N_Port port addresses. For a FICON channel in FICON native (FC) mode point-to-point configuration, no N_Port port addresses are defined for the attached CU N_Port. The actual port address to use for this configuration is obtained by the channel.

3.2.2 N_Port Login (PLOGI)

Destination N_Port Login (PLOGI) follows the Fabric Login procedure. N_Port Login provides each N_Port with the other N_Port’s service parameters. Knowledge of a destination N_Port’s receive and transmit characteristics is required for data exchange.

If a fabric is present, as determined by performing the Fabric Login procedure, a FICON channel in FICON native (FC) mode proceeds with destination N_Port Login. The N_Port Login is performed to several fabric well-known addresses (’FFFFFx’), and to each CU N_Port defined on this FICON native (FC) mode channel. See Figure 3-7 on page 32.

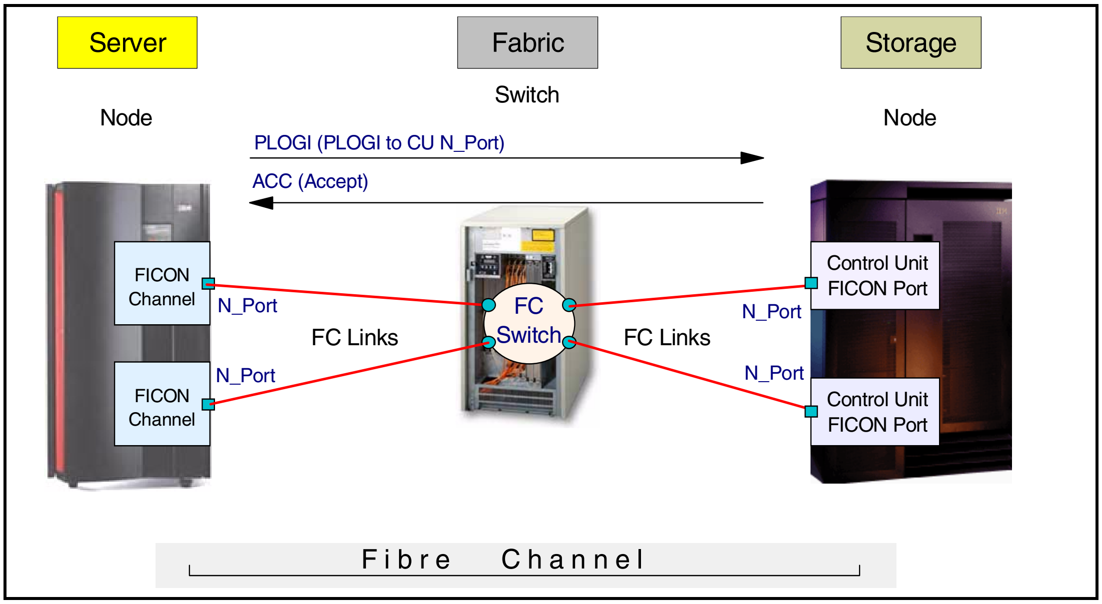

Figure 3-7 FICON native (FC) mode N_Port login (PLOGI) - switched point-to-point

Successful response to a PLOGI is an accept ELS (ACC). The accept to the PLOGI contains the N_Port's service parameters, which establish the operating environment between the two N_Ports. It includes attributes, such as the maximum frame size, that can be received.

If a fabric is not present, the N_Port Login procedure provides the service parameters of the responding N_Port.

In a FICON native (FC) mode channel switched point-to-point environment a PLOGI is performed by the channel to each link address defined to be accessed from the channel. 3.2.7, "Fabric address support (switched point-to-point)" on page 39 explains how the CU 1-byte link address definition is used in building the actual 24-bit Fibre Channel port address (the control unit's N_Port port address).

In a FICON native (FC) mode channel 2-switch cascaded environment a PLOGI is performed in the same way as described before for the switched point-to-point environment. "Fabric address support" (Figure 3-14 on page 42 and Figure 3-13 on page 41) explains how the CU 2-byte link address definition is used in building the actual 24-bit Fibre Channel port address (the control unit's N_Port port address).

In a FICON native (FC) mode channel point-to-point environment a PLOGI is performed by either the channel N_Port or the CU N_Port. Each N_Port looks at the service parameters of the others' N_Port, and whichever of the two N_Ports has the higher World Wide Name (WWN), that N_Port will assign the N_Port port addresses for both N_Ports and perform the PLOGI. Therefore, the other N_Port will be provided with its N_Port port address for an FC point-to-point connection when the PLOGI ELS is performed.

3.2.3 Point-to-Point FC-FS and FC-SB-2 communication initialization

The FC-FS and FC-SB-2 initialization steps between the nodes for a point-to-point connection are:

- Channel/control unit link initialization (FC-FS)
- Channel-to-control unit ELS and FC-4 Device Level (FC-FS and FC-SB-2)

Figure 3-8 shows the steps that are performed during the initialization process for a point-to-point connection.

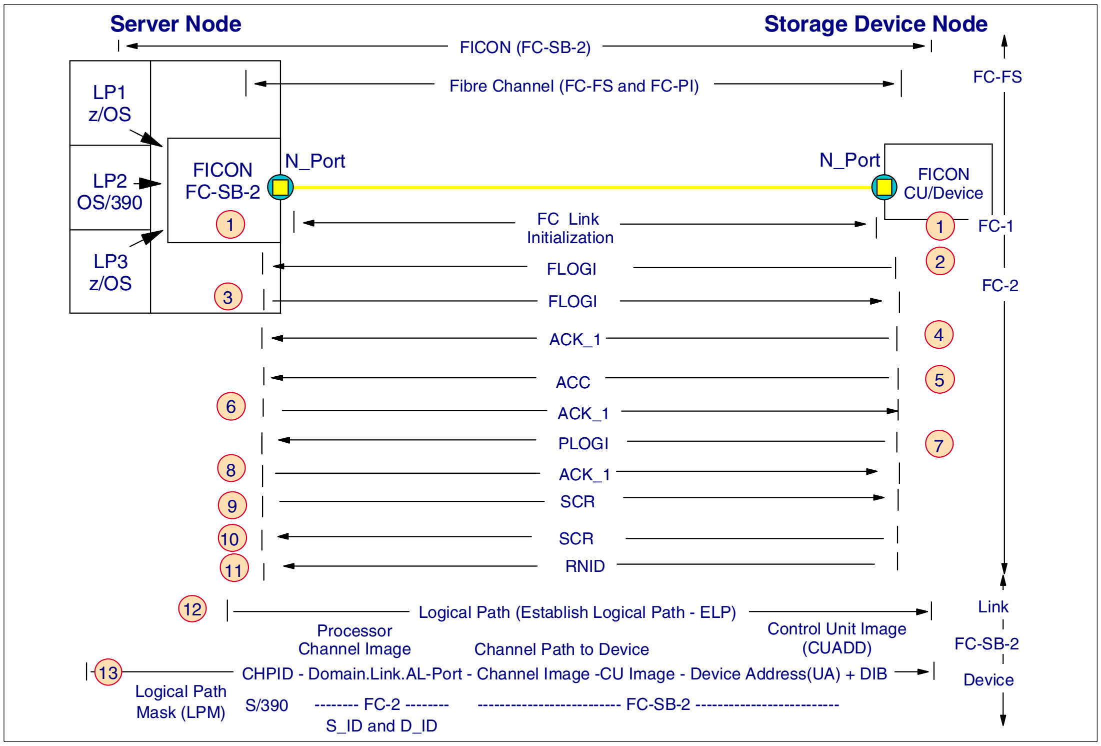

Figure 3-8 FICON channel and FICON Control Unit point-to-point initialization steps

1. Channel (N_Port) and CU N_Port link initialization (Idle/Idle).
2. Control Unit N_Port, Fabric login (FLOGI) to the attached port. The node with the highest WWN initiates the first FLOGI.

   Response to the FLOGI allows the Control Unit N_Port to determine if it is connected to an F_Port (FC Switch port) or an N_Port.
3. Channel N_Port, Fabric login (FLOGI) to the attached port.

   Response to the FLOGI will allow the Channel N_Port to determine if it is connected to an F_Port (FC Switch port) or an N_Port.
4. ACK_1 is sent back from the Control Unit to the channel port N_Port with info that the destination address is unidentified.
5. Control Unit answers with ACC to the channel.
6. Channel sends back ACK_1 to the Control Unit with an unidentified source address.

   This indicates to the Control Unit that a point-to-point connection to the channel exists. Address values are assigned now for channel and Control Unit for the ongoing communication if no link address was specified in HCD:

   – 000001 for the Control Unit
   – 000002 for the channel

     These values will be used as source and destination address for all communications between channel and Control Unit .
7. Control Unit port N_Port login (PLOGI) to the channel using source address 000001 (CU) and destination address 000002 (channel).

8. ACK_1 from channel back to Control Unit .
9. SCR extended link service from channel to Control Unit .
10. SCR extended link service from Control Unit to channel.
11. Control Unit N_Port performs RNID ELS requests to the attached N_Port (Channel N_Port).
12. Channel port performs an FC-SB-2 “Establish Logical Path” (ELP).

    The channel performs an ELP from each channel image that is defined to access the channel, and to the defined logical CU on this channel path link address.

3.2.4 Switched point-to-point FC-FS and FC-SB-2 communication initialization

The FC-FS and FC-SB-2 initialization steps between the nodes for a switched point-to-point connection are:

- Channel/Switch FC link initialization (FC-FS)
- Channel to the Switch ELSs- (FC-FS)
- Switch to the Channel ELS - (FC-FS)
- Control Unit/Switch FC link initialization (FC-FS)
- Control Unit to the Switch ELSs - (FC-FS)
- Switch to Control Unit ELS - (FC-FS)
- Channel to Control Unit ELS and FC-4 Device Level (FC-FS and FC-SB-2)

Figure 3-9 shows the steps that are performed during the initialization process for a switched point-to-point connection.

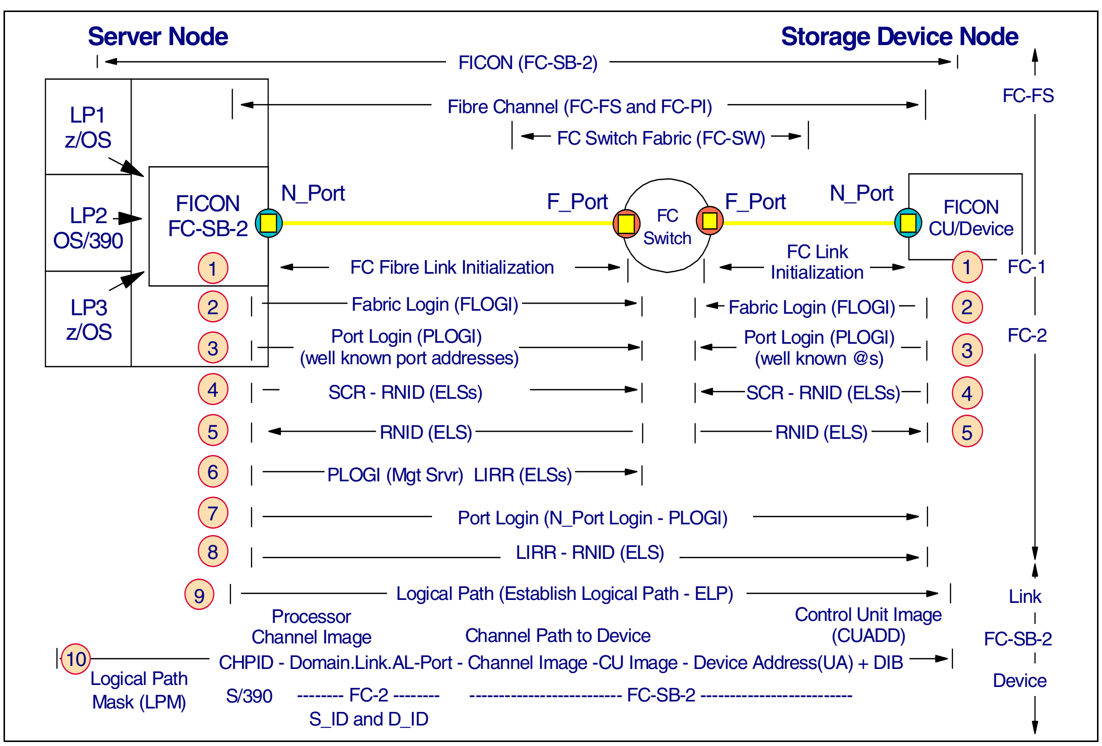

Figure 3-9 FICON channel and FICON Control Unit switched point-to-point initialization steps

- Step 1 - Channel (N_Port) and Switch F_Port link initialization (Idle/Idle).
- Step 1 - Control Unit (N_Port) and Switch F_Port link initialization (Idle/Idle).
- Step 2 - Channel N_Port, Fabric login (FLOGI) to the attached port.

  Response to the FLOGI will allow the Channel N_port to determine if it is connected to an F_Port or an N_port.
- Step 2 - Control Unit N_Port, Fabric login (FLOGI) to the attached fabric port.

  Response to the FLOGI will allow the Control Unit N_Port to determine if it is connected to an F_Port or an N_Port.
- Step 3 - Channel port N_Port login (PLOGI) to the FC switch well-known port addresses.” Refer to Table 3-1 on page 36.
  – Fabric Controller (well-known port address is x’FF FF FD’); see Table 3-1 on page 36.
- Step 3 - Control Unit port N_Port login (PLOGI) to the FC switch “well-known port addresses.”
  – Fabric Controller
- Step 4 - Channel port performs switch support ELS requests for SCR, and RNID.
- Step 4 - Control Unit port performs switch support ELS requests for SCR and RNID.
- Step 5 - Switch F_Port performs RNID ELS requests to the attached N_Port (Channel N_Port).
- Step 5 - Switch F_Port performs RNID ELS requests to the attached N_Port (Control Unit N_Port).
- Step 6 - Channel port N_Port login (PLOGI) to the FC switch “well-known port addresses” and an ELS for LIRR.
  – Management Server
  – LIRR ELS
- Step 7 - Channel port performs N_Port login (PLOGI) to “defined” Control Unit N_Port.

  The channel performs this for each Control Unit N_Port for each link address defined on this channel path.

  A FICON channel in FICON native (FC) mode link address is a 1-byte switch port address. It is the “area” field of the 24-bit FC F_Port address of the switch port that the CU is connected to.
- Step 8 - Channel port performs CU support ELS requests for LIRR and RNID.
- Step 9 - Channel port performs an FC-SB-2 “Establish Logical Path” (ELP).

  The channel performs an ELP from each channel image that is defined to access the channel, and to the defined logical CU on this channel path link address.
- Step 10 - Normal FICON FC-2 communication frames (FC-FS - FC-SB2 frames).

Table 3-1 Well-known port address identifiers

Address Value	Description
hex ‘FF FC 01’ to hex ‘FF FC FE’	Reserved for Domain Controllers
hex ‘FF FF F0’ to hex ‘FF FF F4’	Reserved
hex ‘FF FF F5’	Multicast Server
hex ‘FF FF F6’	Clock Synchronization Server
hex ‘FF FF F7’	Security Key Distribution Server
hex ‘FF FF F8’	Alias Server
hex ‘FF FF F9’	Quality of Service Facilitator (QoSF)
hex ‘FF FF FA’	Management Server
hex ‘FF FF FB’	Time Server
hex ‘FF FF FC’	Directory Server
hex ‘FF FF FD’	Fabric Controller
hex ‘FF FF FE’	F_Port
hex ‘FF FF FF’	Broadcast Alias_ID

3.2.5 Cascaded Director FC-FS and FC-SB-2 communication initialization

In addition to the previously listed steps there are a couple of new steps required to get a FICON-supported cascaded switch connection initialized between a processor’s FICON channel and a FICON Control Unit.

Be aware that the required 2-byte link address for cascaded switches is only supported by zSeries processors.

Figure 3-10 on page 37 shows the steps that are performed during the initialization process for a FICON cascaded director connection.

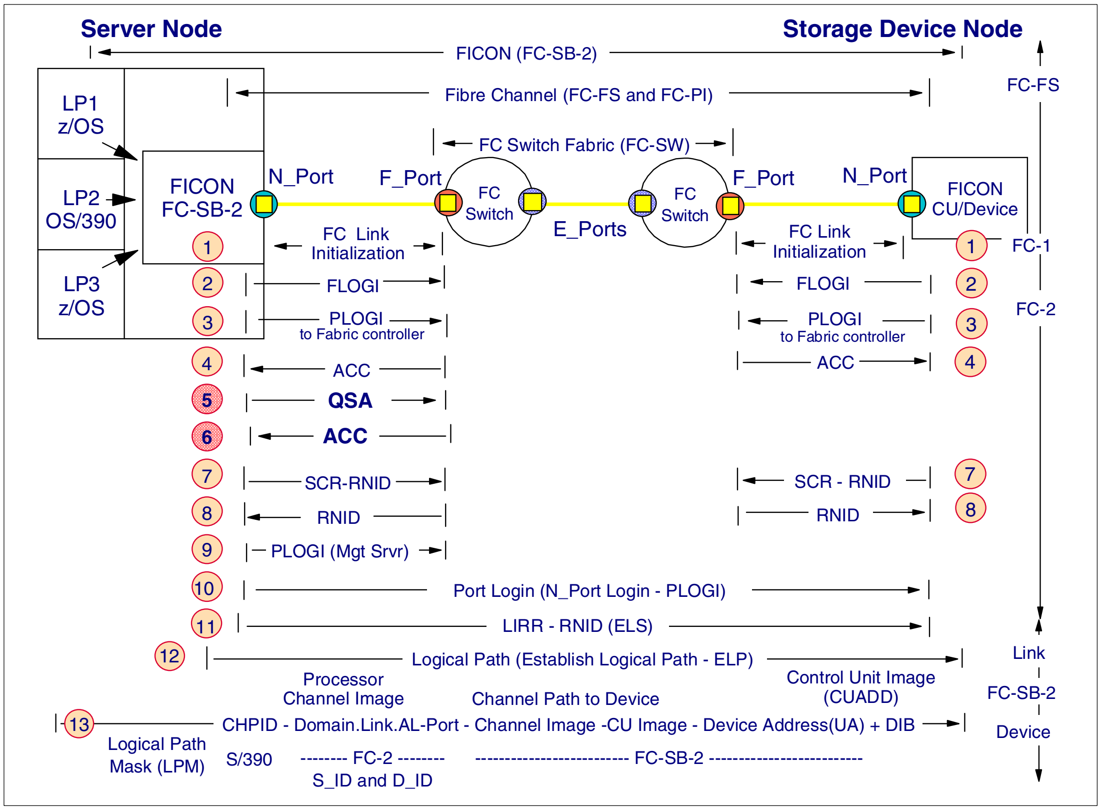

Figure 3-10 FICON channel and FICON Control Unit 2-switch cascaded initialization steps

- Step 1 - Channel (N_Port) and Switch F_Port link initialization (Idle/Idle).
- Step 1 - Control Unit (N_Port) and Switch F_Port link initialization (Idle/Idle).
- Step 2 - Channel N_Port, Fabric login (FLOGI) to the attached port.

  Response to the FLOGI is a ACK_1 and will allow the Channel N_port to determine if it is connected to an F_Port (FC Switch port) or an N_port. If connected to an F_Port contents of ACK_1 is presenting the well-known port address x'FF FF FE' which indicates connection to an F_Port, see Table 3-1 on page 36
- Step 2 - Control Unit N_Port, Fabric login (FLOGI) to the attached port.

  Response to the FLOGI will allow the Control Unit N_Port to determine if it is connected to an F_Port (FC Switch port) or an N_Port.
- Step 3 - Channel port N_Port login (PLOGI) to the FC switch “well-known port addresses”.
  – Fabric Controller

    The Fabric Controller sends back an ACK_1 to the channel with the well-known address of x'FF FF FD'.
- Step 3 - Control Unit port N_Port login (PLOGI) to the FC switch “well-known port addresses”.
  – Fabric Controller
- Step 4 - Accept (ACC) is returned by the switch to the channel after a successful login to the fabric controller.
- Step 4 - Accept (ACC) is returned by the switch to the control unit after a successful login to the fabric controller.

- **Step 5** - If there is a **2-byte** link address found in the CU macro in IOCDS a “Query Security Attribute” (QSA) command will be sent to the fabric controller to check if certain security features like Fabric Binding and Insistent Domain IDs are present in the switches.
- **Step 6** - If the required features are present, an ACCEPT will be returned by the fabric controller indicating channel initialization can continue.

  If the required features are not present, contents of the ACCEPT reflects that the features are not present and the channel is informed that no further initialization should be done.
- Step 7 - Channel port performs switch support ELS requests for SCR, and RNID.
- Step 7 - Control Unit port performs switch support ELS requests for SCR and RNID.
- Step 8 - Switch F_Port performs RNID ELS requests to the attached N_Port (Channel N_Port).
- Step 8 - Switch F_Port performs RNID ELS requests to the attached N_Port (Control Unit N_Port).
- Step 9 - Channel port N_Port login (PLOGI) to the FC switch “well-known port addresses” and an ELS for LIRR.
  - Management Server
  - LIRR ELS
- Step 10 - Channel port performs N_Port login (PLOGI) to “defined” Control Unit N_Port.

  The channel will perform this for each Control Unit N_Port for each link address defined on this channel path.

  A FICON channel in FICON native (FC) mode link address is a 2-byte switch port address. It is the “domain” field and the “area” field of the 24-bit FC F_Port address of the switch port that the CU is connected to.
- Step 11 - Channel port performs CU support ELS requests for LIRR and RNID.
- Step 12 - Channel port performs an FC-SB-2 “Establish Logical Path” (ELP).

  The channel performs an ELP from each channel image that is defined to access the channel, and to the defined logical CU on this channel path link address.
- Step 13 - Normal FICON FC-2 communication frames (FC-FS - FC-SB2 frames).

3.2.6 Fabric support Extended Link Services

Extended Link Services (ELS) provide a set of functions that are independent of the FC protocol functions and are used to perform specific functions or services at the port level.

The FICON channel N_Port will register/perform the following ELS:

- State Change Registration (SCR) is used to notify ports that an event has occurred.
- Link Incident Record Registration (LIRR) is used to request that the recipient add the requesting port to its list of ports.
- Request Node Identification Data (RNID) is used to acquire information about the associated node.

The Control Unit N_Port will register/perform the following ELS:

- SCR
- RNID

3.2.7 Fabric address support (switched point-to-point)

The Fibre Channel architecture (FC-FS) uses a 24-bit FC port address (3 bytes) for each port in an FC switch. The switch port addresses in a FICON native (FC) mode are always assigned by the switch fabric.

For the FICON channel in FICON native (FC) mode, the Accept (ACC ELS) response to the Fabric Login (FLOGI), in a switched point-to-point topology, provides the channel with the 24-bit N_Port address to which the channel is connected. This N_Port address is in the ACC destination address field (D_ID) of the FC-2 header.

The FICON CU port will also perform a fabric login to obtain its 24-bit FC port address. Figure 3-11 shows the FC-FS 24-bit FC port address identifier is divided into three fields:

- Domain
- Area
- AL Port

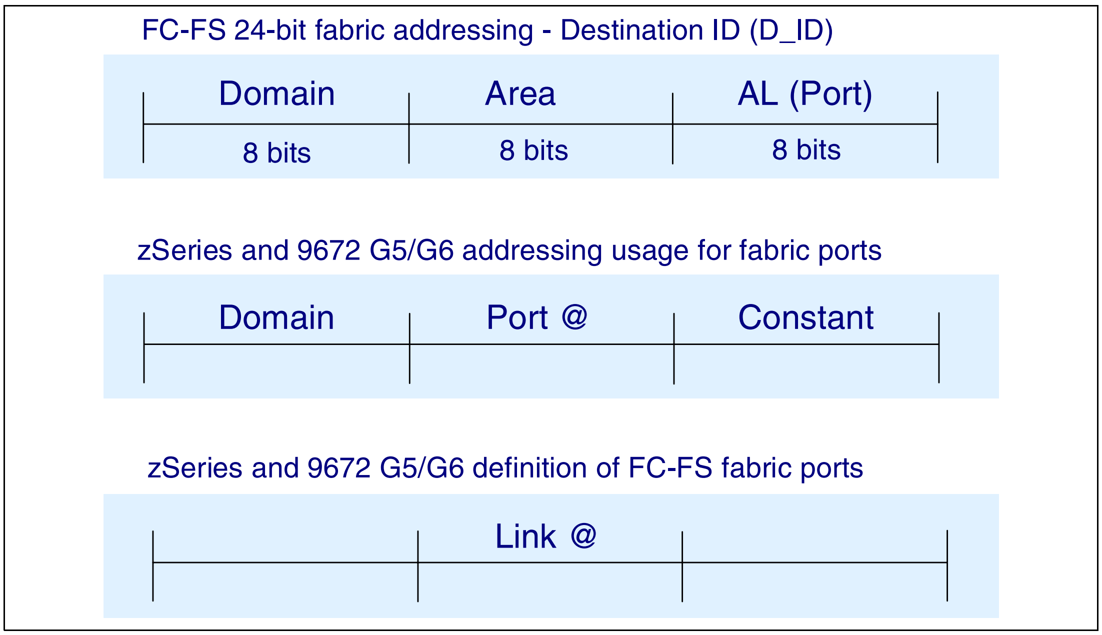

Figure 3-11 Fabric port addressing support

It shows the FC-FS 24-bit port address and the definition usage of that 24-bit address in a zSeries and 9672 G5/G6 environment. Only the 8 bits making up the FC port address are defined for the zSeries and 9672 G5/G6 to access a FICON CU. The FICON channel in FICON native (FC) mode working with a switched point-to-point FC topology (single switch) provides the other 2 bytes that make up the 3-byte FC port address of the CU to be accessed.

The zSeries and 9672 G5/G6 processors, when working with a switched point-to-point topology, require that the Domain and the AL_Port (Arbitrated Loop) field values be the same for all the FC F_Ports in the switch. Only the “area” field value will be different for each switch F_Port.

For the zSeries and 9672 G5/G6 the “area” field is referred to as the F_Port’s “port address” field. It is just a 1-byte value, and when defining access to a CU that is attached to this port (using the zSeries HCD or IOCP), the port address is referred to as the Link address.

As shown in Figure 3-12, the 8 bits for the domain address and the 8-bit constant field are provided from the Fabric Login initialization result, while the 8 bits (1 byte) for the port address (1-byte Link address) are provided from the zSeries or 9672 G5/G6 CU link definition (using HCD and/or IOCP).

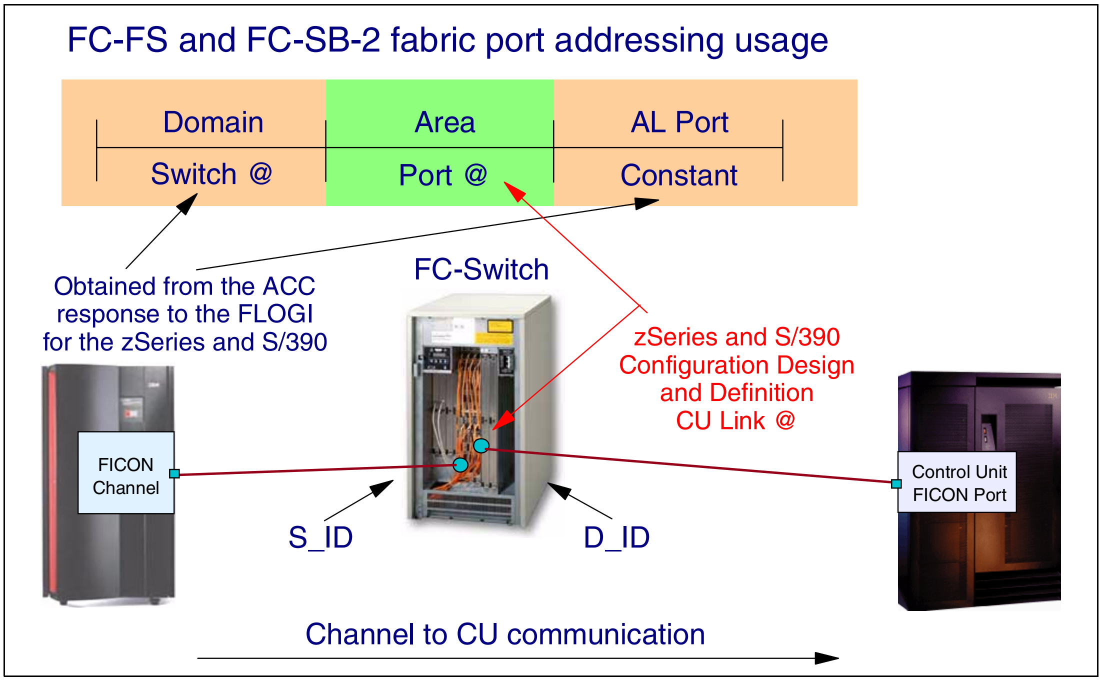

Figure 3-12 FICON single switch - switched point-to-point link address

3.2.8 Fabric address support (FICON support for cascaded Directors)

The Fibre Channel architecture (FC-FS) uses a 24-bit FC port address (3 bytes) for each port in an FC switch. The switch port addresses in a FICON native (FC) mode are always assigned by the switch fabric.

Note: The support of a cascaded FICON Directors is only provided by zSeries processors.

For the FICON channel in FICON native (FC) mode, the Accept (ACC ELS) response to the Fabric Login (FLOGI) in a 2-switch cascaded topology, provides the channel with the 24-bit N_Port address to which the channel is connected. This N_Port address is in the ACC destination address field (D_ID) of the FC-2 header.

The FICON CU port will also perform a fabric login to obtain its 24-bit FC port address.

Figure 3-13 on page 41 shows that the FC-FS 24-bit FC port address identifier is divided into three fields:

- Domain
- Area
- AL Port

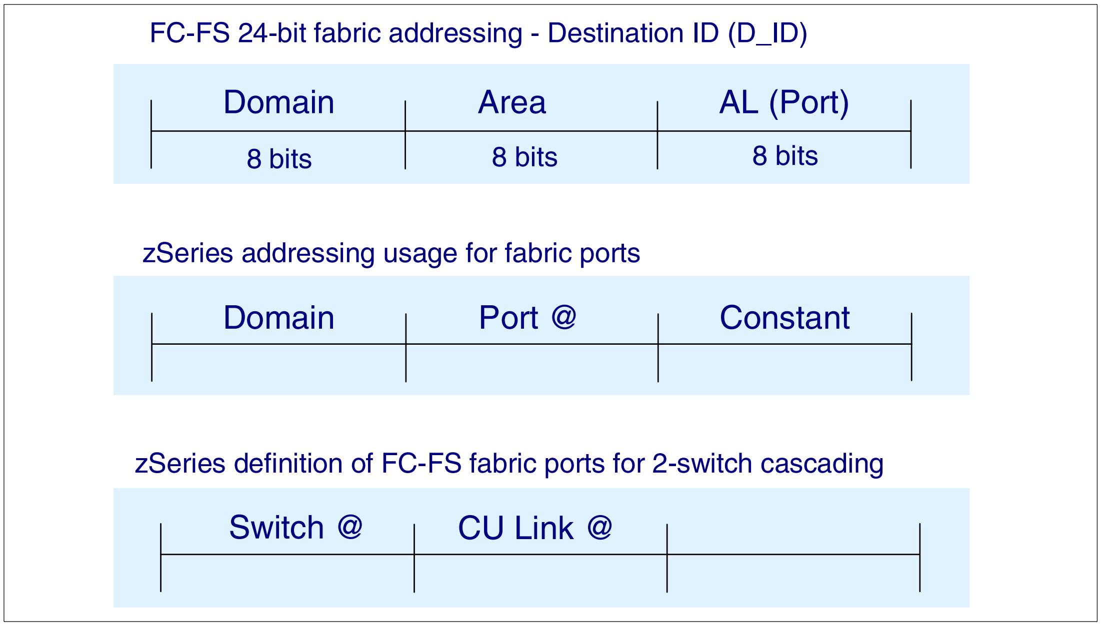

Figure 3-13 Fabric addressing support for 2-switch cascading

It shows the FC-FS 24-bit port address and the definition usage of that 24-bit address in a zSeries environment. Now 16 bits making up the FC port address must be defined for the zSeries to access a FICON CU in a cascaded environment. The FICON channel in FICON native (FC) mode working with a cascaded FC topology (2-switch) provides the remaining byte that make up the full 3-byte FC port address of the CU to be accessed.

It is required that the Domain (switch @) and the AL_Port (Arbitrated Loop) field value be the same for all the FC F_Ports in the switch. Only the “area” field value will be different for each switch F_Port.

The zSeries “domain” and “area” fields are referred to as the F_Port’s “port address” field. It is a 2-byte value, and when defining access to a CU that is attached to this port (using the zSeries HCD or IOCP), the port address is referred to as the Link address.

As shown in Figure 3-14 on page 42, the 8 bits for the constant field are provided from the Fabric Login initialization result, while the 16 bits for the port address (2-byte Link address) are provided from the zSeries CU link definition (using HCD and/or IOCP).

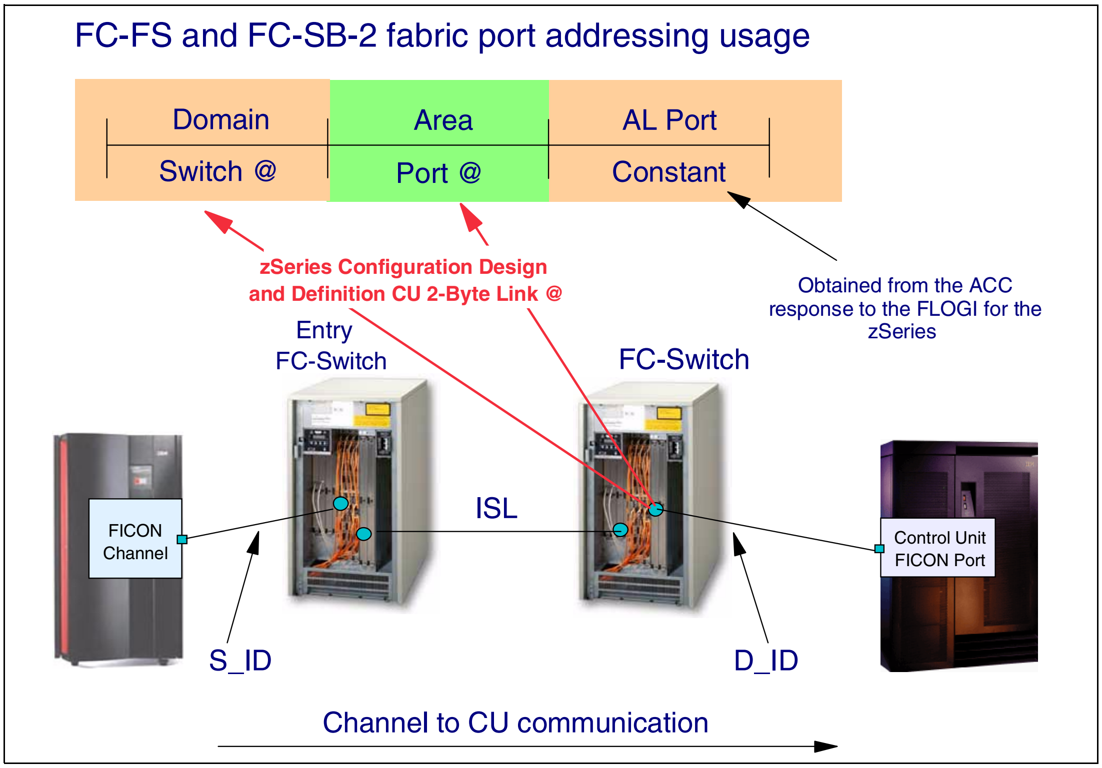

Figure 3-14 FICON 2-switch cascaded 2-byte link address

3.3 z/Architecture FICON channel I/O request flow

In a zSeries or 9672 G5/G6 processor running z/OS or OS/390, communication to a FICON CU/device occurs as a result of initiation of an I/O request from an application or a system component. A general flow of the I/O request is shown in Figure 3-15 on page 43.

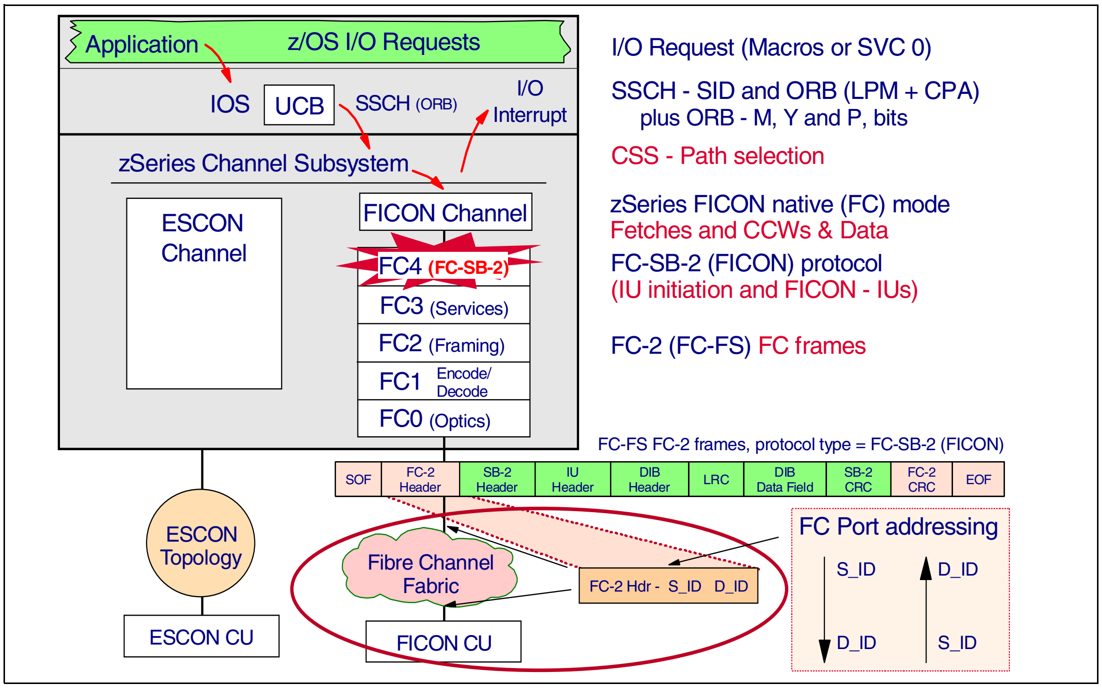

Figure 3-15 z/Architecture FICON channel I/O request flow

A FICON I/O request flow is as follows:

1. An application or system component invokes an I/O request.
2. The I/O request is passed to the SCP I/O supervisor (IOS).
3. IOS issues a Start Subchannel (SSCH) instruction to pass the I/O request to the zSeries 900 or 9672 G5/G6 channel subsystem (CSS).
4. The operands of the SSCH are the subchannel channel number (subsystem identification word - SID) and the Operations Request Block (ORB).
5. The ORB contains the starting address of the Channel Programs (CPA) Channel Command Word (CCW).
6. The CSS selects a channel and passes the I/O request to it.
7. The channel fetches from storage the Channel Command Words and associated data (for Write Operations).
8. The channel assembles the required parameters and fields of the FC-2 and FC-SB-2 for the I/O request and passes them to the Fibre Channel adapter (which is part of the FICON channel).
9. The Fibre Channel adapter builds the complete FC-FS FC-2 serial frame and transmits it into the Fibre Channel link, fibre cable.

   As part of building the FC-FS FC-2 frame for the I/O request, the FICON channel in FICON native (FC) mode constructs the 24-bit FC port address of the destination N_Port of the Control Unit, and the Control Unit Image and device address within the physical CU.

3.3.1 zSeries Channel Subsystem Port address generation

Whenever a FICON channel in FICON native (FC) mode requires access to a FICON CU/device (as when it receives an I/O request from the SCP), it builds a Fibre Channel serial frame. The frame contains two parts, the FC-FS FC-2 header part plus the payload part (the

FC-SB-2 parts). The FC-2 header part of the frame holds the source FC port address (S_ID) and the destination FC port address (D_ID). See “Fibre Channel FC-2 header format” on page 48 for more details on the FC-2 Header content. The FC-SB-2 header part of the frame holds the channel image address, the Control Unit Image address, and the Device Unit Address (UA). See “Fibre Channel FC-SB-2 frame format” on page 49 for more details on the FC-SB-2 header content.

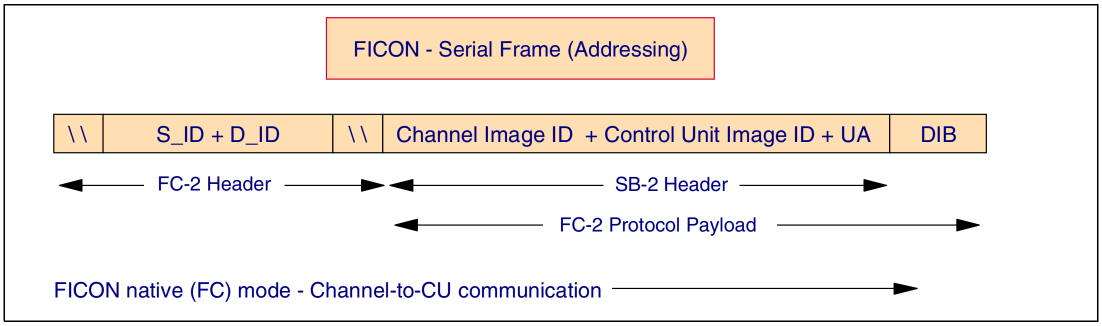

Figure 3-16 FICON native (FC) mode N_Port and device addressing

The D_ID is used in a point-to-point environment by the processor to route the FC frame to its destination N_Port. The S_ID allows the control unit N_Port to know the source port address of the incoming frame. For a point-to-point connection default values are assigned to both source and destination ports.

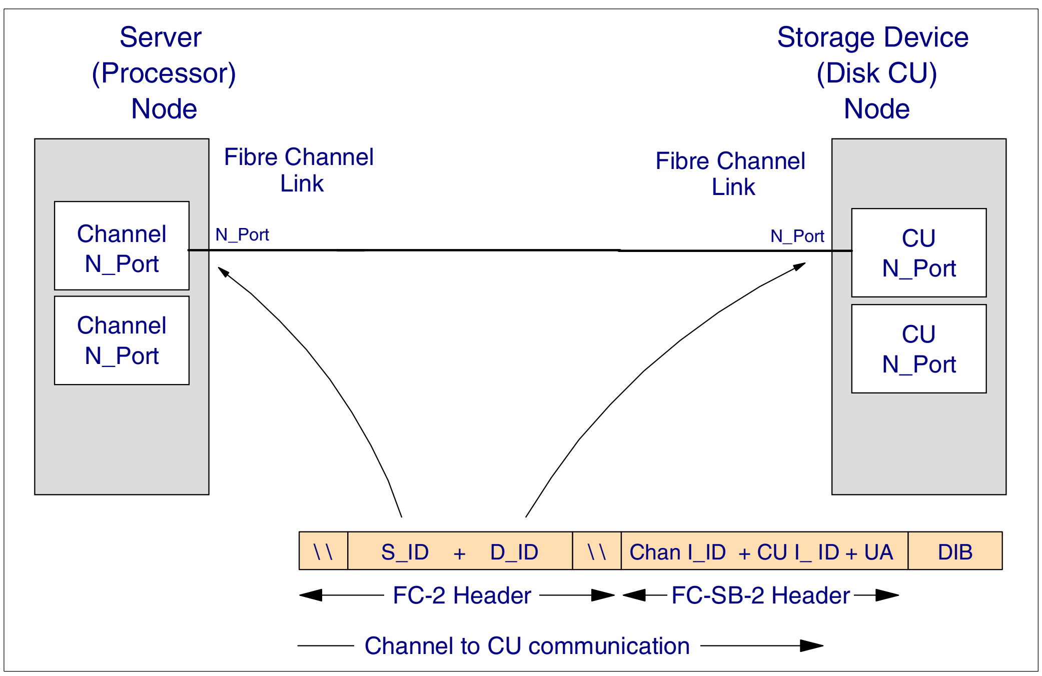

Figure 3-17 FICON point-to-point connection (S_ID and D_ID)

In a switched point-to-point environment the D_ID is used by the FC switch fabric to route the FC frame to its final N_Port destination. The S_ID allows the destination port to know the source port address of the incoming frame.

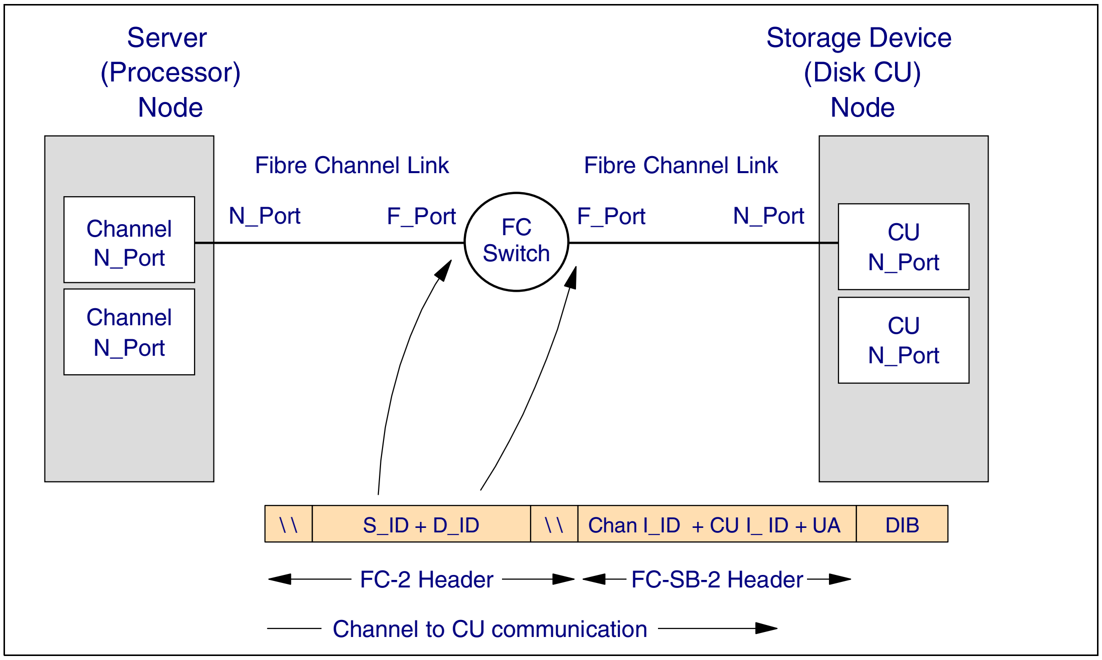

Figure 3-18 FICON switched point-to-point (S_ID and D_ID ports)

In a cascaded FICON Directors environment the D_ID is also used by the FC switch fabric to route the FC frame to its final N_Port destination. The S_ID allows the destination port to know the source port address of the incoming frame. The connection between the switches (ISL Links) is transparent to the protocol (see Figure 3-19).

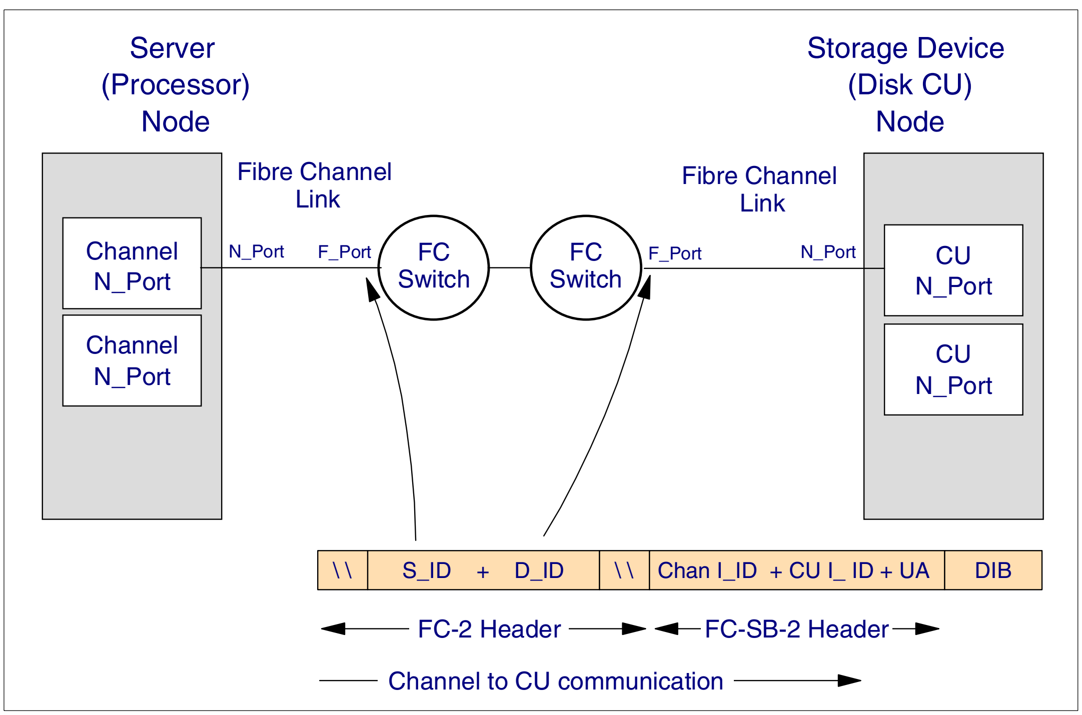

Figure 3-19 FICON 2-switch cascaded (S_ID and D_ID ports) generation

3.4 FICON FC-SB-2 communication

In a switched point-to-point topology, for a FICON channel operating in FC mode, the FC-FS (FC-2) communication frames are from the FICON channel (an N_Port) to the switch F_Port. The switch routes the communication frames to the destination F_Port. The definition F_Port then sends the FC-2 frames on the switch to a Control Unit port (another N_Port, the destination N_Port).

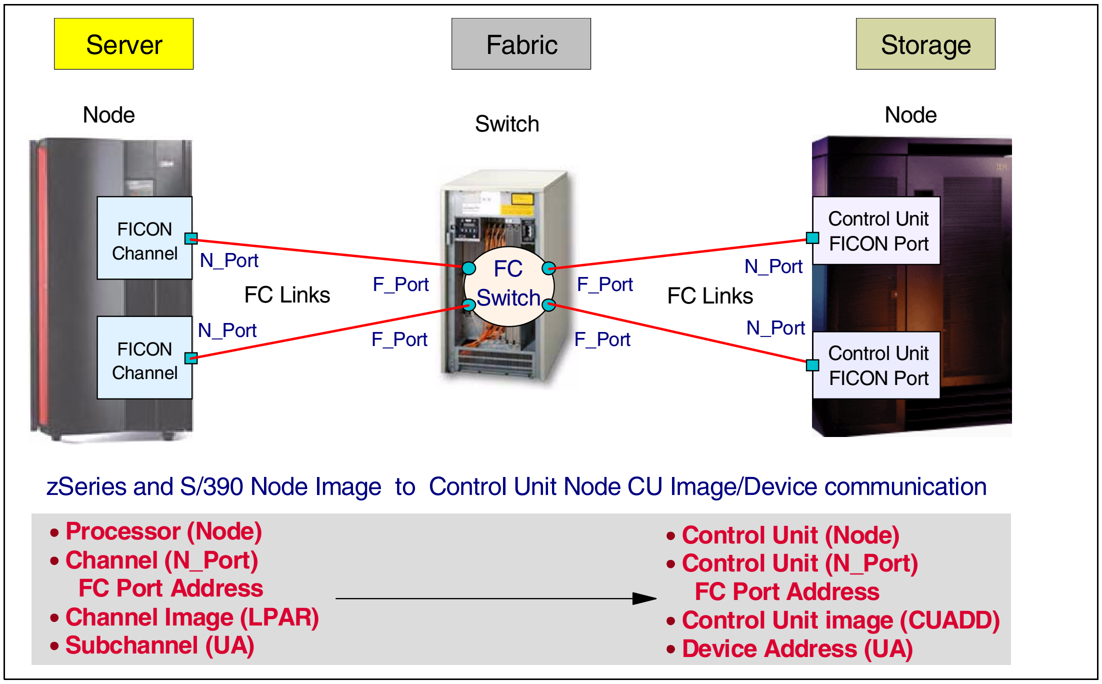

Figure 3-20 FICON native (FC) channel-to-CU communication

The addressing structure for supporting FC-SB-2 (FICON) communication from the channel N_port to a Control Unit N_Port consists of the following:

- The source and destination N_port addresses that are part of the FC-FS FC-2 header

  The destination N_Port address is used by the fabric to route the FC-2 frame through the fabric. It is checked at the receiving N_Port to ensure it has been delivered to the correct N_Port.

  The source N_Port address is used by the destination N_Port to be aware of where the source of the frame is, so that, for example, it knows where to communicate back to.

- The Channel image identifier and the Control Unit image identifier, which are part of the SB-2 header

  Going from the channel to the CU, the Channel image identifier allows the CU to know which Channel image the frame was from; and allows the CU image identifier to know who the frame is for.

  Going from the CU to the channel, the CU image identifier allows the channel to know who the frame is from; and allows the Channel image identifier who the frame is for.

- The device unit address

  This identifies which device in a CU image the communication is for.

The source information that the FICON channel uses for building the FC-2 frame is shown in Figure 3-21 on page 47.

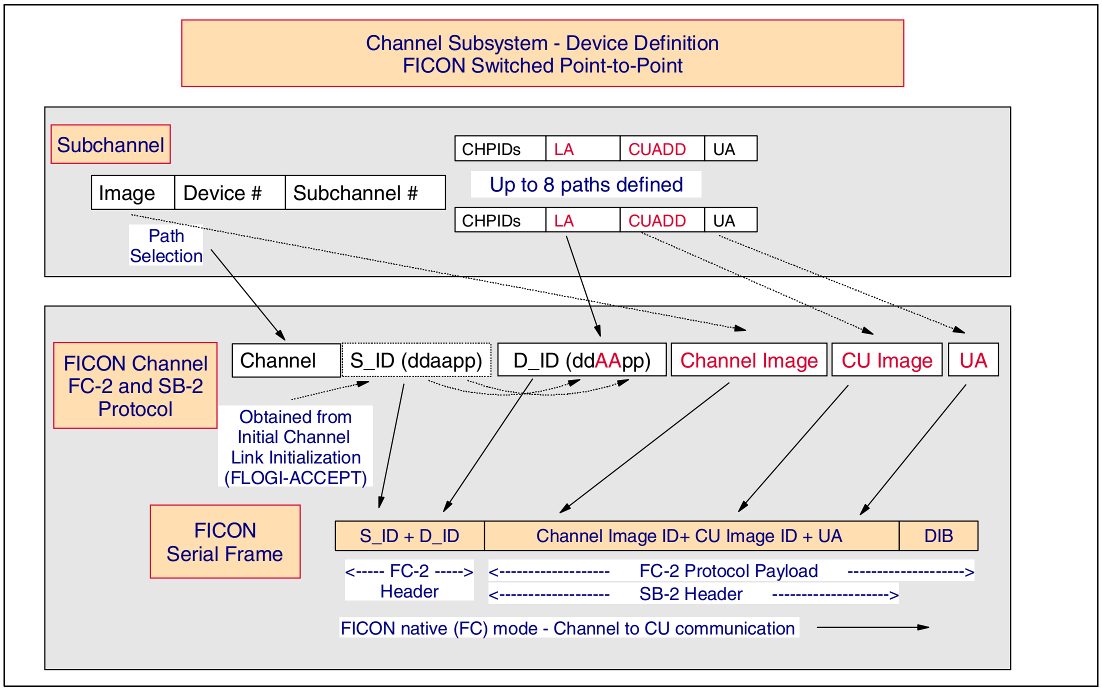

Figure 3-21 FICON native (FC) mode D_ID address generation

3.4.1 FICON frame format

FICON uses the Fibre Channel architecture (Fibre Channel serial frames) communication infrastructure of zSeries and 9672 G5/G6 Fibre Channel adapters to transfer z/Architecture and S/390 architecture channel programs and data from one FICON adapter node (server) to another FICON adapter node (storage device). The Fibre Channel frame contains the FC-FS FC-2 header part plus the payload part (the FC-SB-2 parts).

Fibre Channel FC-2 frame format

This requires the FICON Fibre Channel adapter node to use the Fibre Channel protocols (Fibre channel FC-2 layer) and the Fibre channel FC-4 layer that supports the FC-SB-2 protocols (FICON architecture) in building the FC frame.

Figure 3-22 on page 48 shows the frame format of an FC-2 frame.

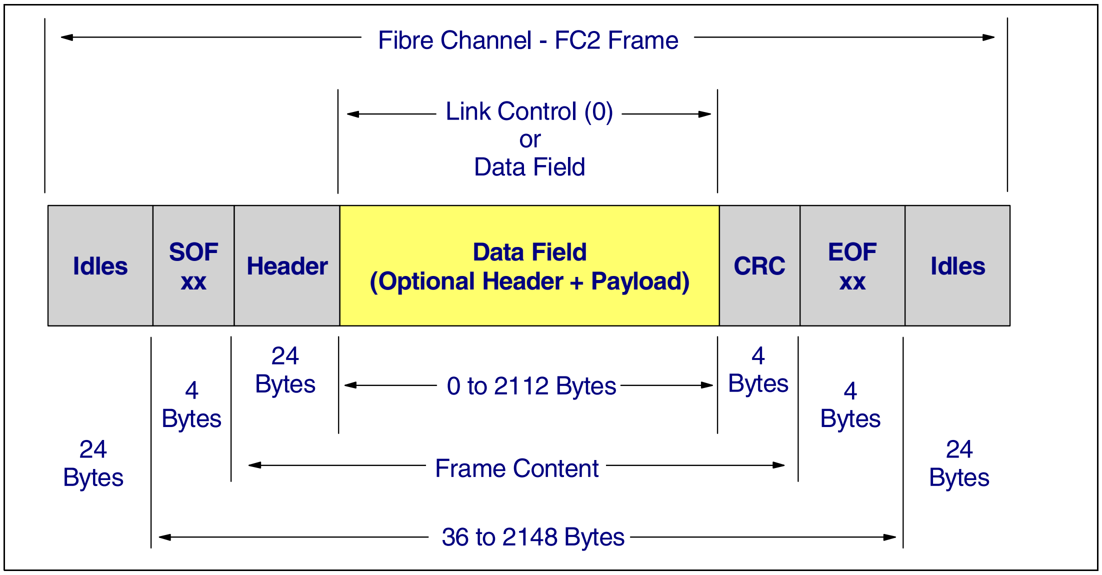

Figure 3-22 Fibre Channel FC-2 frame format

The frame content is composed of a frame header, data field, and CRC. When the FC-2 header controls indicate that the frame is an FC-4 frame, the content of the data field is the FC-4 layer (FC-SB-2). This field is aligned on a word boundary and must be equal to multiples of 4 bytes. The format of an FC-SB-2 data field is shown in Figure 3-24.

Fibre Channel FC-2 header format

All FC-2 ELS frames and FC-4 Device frames have an FC-2 header, which has various control information as well as the source port address and destination port address information.

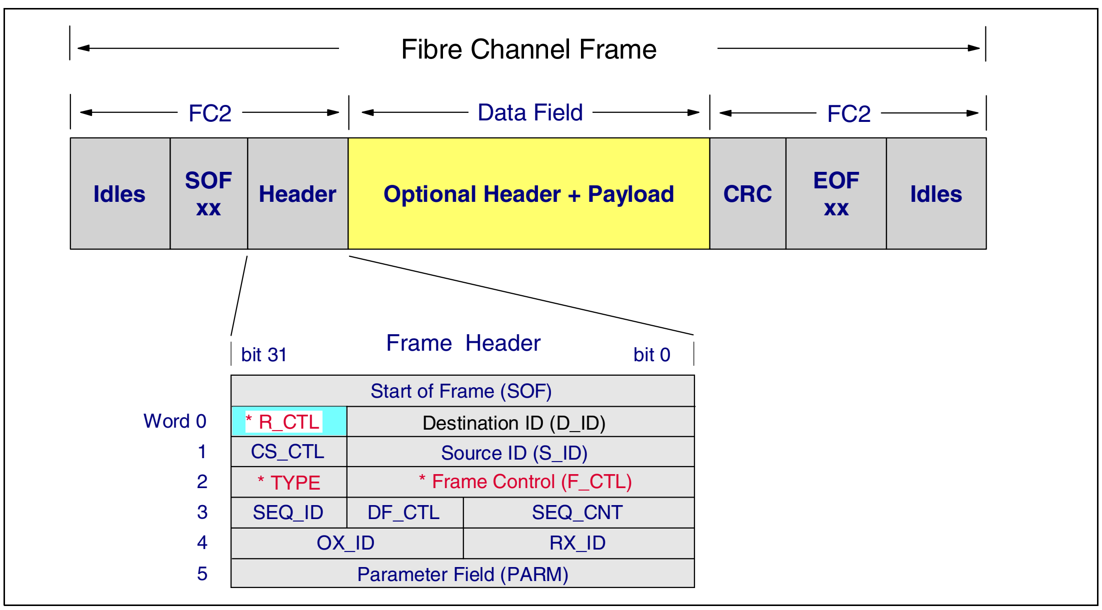

Figure 3-23 Fibre Channel - FC-2 header format

A complete description of the FC-2 header can be found in the FC-FS architecture. Two fields of interest here are the Source ID (S_ID), a 24-bit FC port address, and the Destination ID (D_ID), a 24-bit FC port address.

When FC frame communication is from the channel to the CU, the S_ID is the 24-bit FC port address of the Channel N_Port, and the D_ID is the 24-bit FC port address of the Control Unit N_Port.

When FC frame communication is from the CU to the channel, the S_ID is the 24-bit FC port address of the Control Unit N_Port, and the D_ID is the 24-bit FC port address of the Channel N_Port.

Fibre Channel FC-SB-2 frame format

FC-SB-2 is based upon the FC-4 Information Unit construct described by ANSI *Fibre Channel - Framing and Signaling* (FC-FS). Information associated with the execution of an I/O operation and the operation of a device is transferred between the channel and the control unit as Information Units.

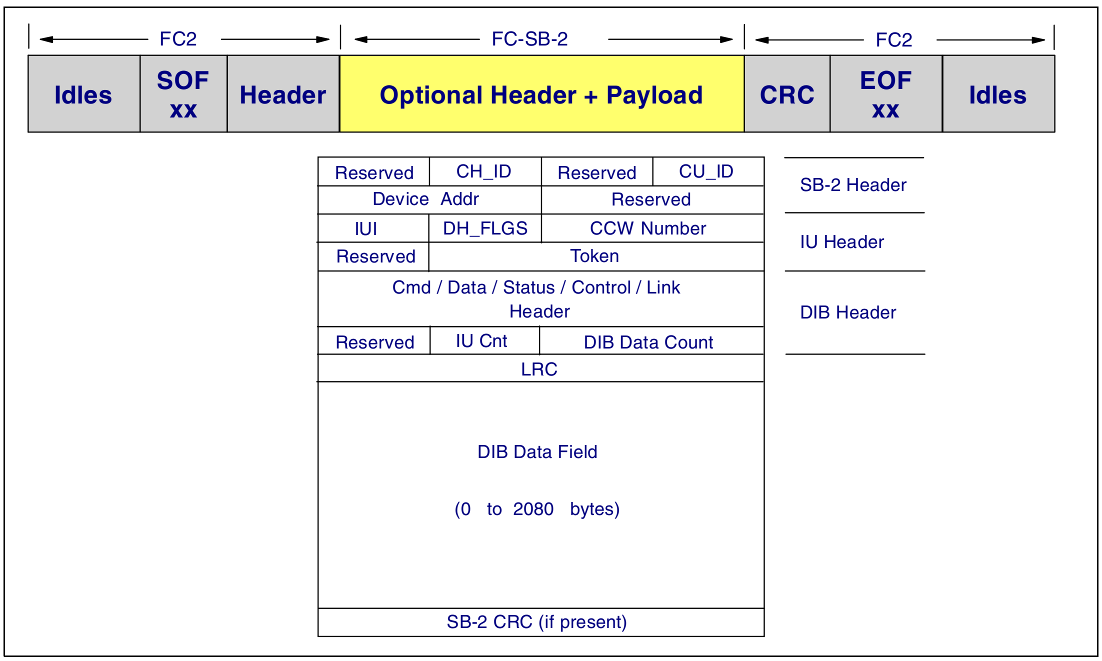

Figure 3-24 Fibre Channel Standard FC-SB-2 frame format

The FC-SB-2 frame contents are composed of an SB-2 header, the IU header, the DIB header, and the DIB data field. These fields provide all required information for addressing and control of the data transfer. The DIB data field is a variable-length field of up to 2080 bytes.

The SB-2 header contains the following:

- The Channel image source or destination address
- The Control Unit image source or destination address
- The device Unit Address
- IU Header
- DIB Header
- DIB Field

Detailed information about the Fibre Channel FC-2 protocol and the FC-SB-2 protocol can be obtained from the following Web site:

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www.t11.org
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3.4.2 Native FICON frame process

A conceptional view of frame processing in a switched point-to-point configuration is shown in Figure 3-25 for a multi-system environment and in Figure 3-26 on page 51 for a multi-Control Unit environment.

Multi-system environment

Figure 3-25 shows the frame process in a multi-system environment. FICON (FC-SB-2) architecture provides the protocol for CCW and Data pipelining. This eliminates the interlocked interface communication that exists in parallel and ESCON channels.

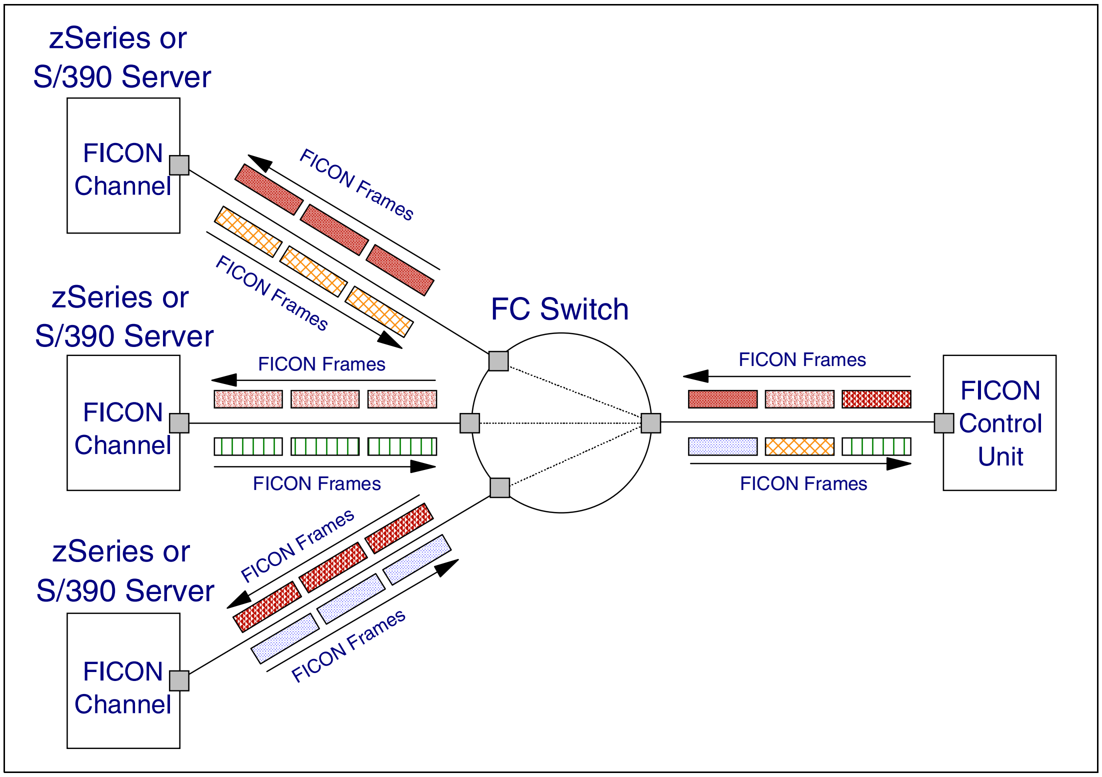

Figure 3-25 FICON frame transfer in a multi-system environment

Each system transfers its frames, containing commands and/or data (Write operation) to the FC Switch. The FC Switch then routes the incoming frames from each system to the CU's destination port by multiplexing the frames on the switch to the CU FC link.

When the CU responds to multiple Read request I/O operations, the CU data frames are transferred to the FC Switch port where the frames are demultiplexed to the destination ports (the ports the requesting systems are connected to).

Multiple control unit environment

Figure 3-26 on page 51 shows the FICON frame process to multiple control units.

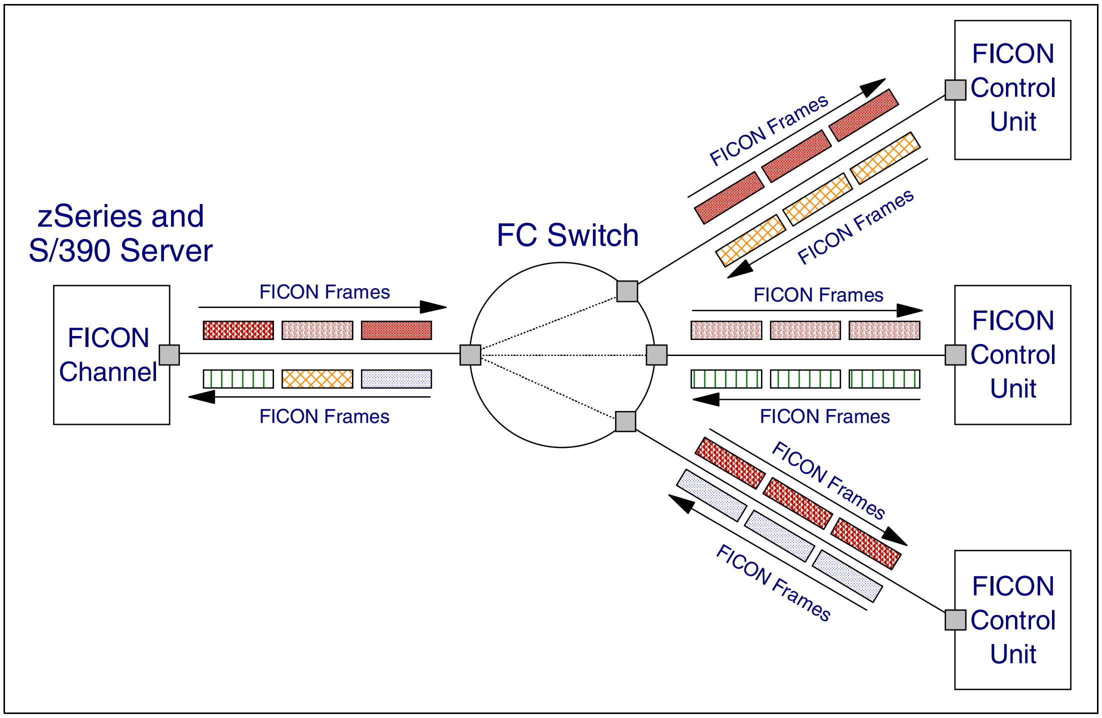

Figure 3-26 FICON frame transfer to multiple control units

Multiple I/O operations to different control units can be transferred at the same time from a single system through the FC link to the FC Switch. Each frame is routed to its destination port by the switch and transferred to the destination control unit.

In a response to the I/O request, each control unit can transfer its frames at the same time to the switch, where they are multiplexed to the destination port (requestor) before being transferred to the system. Figure 3-27 shows another view of the frame process between multiple S/390 servers and multiple control units.

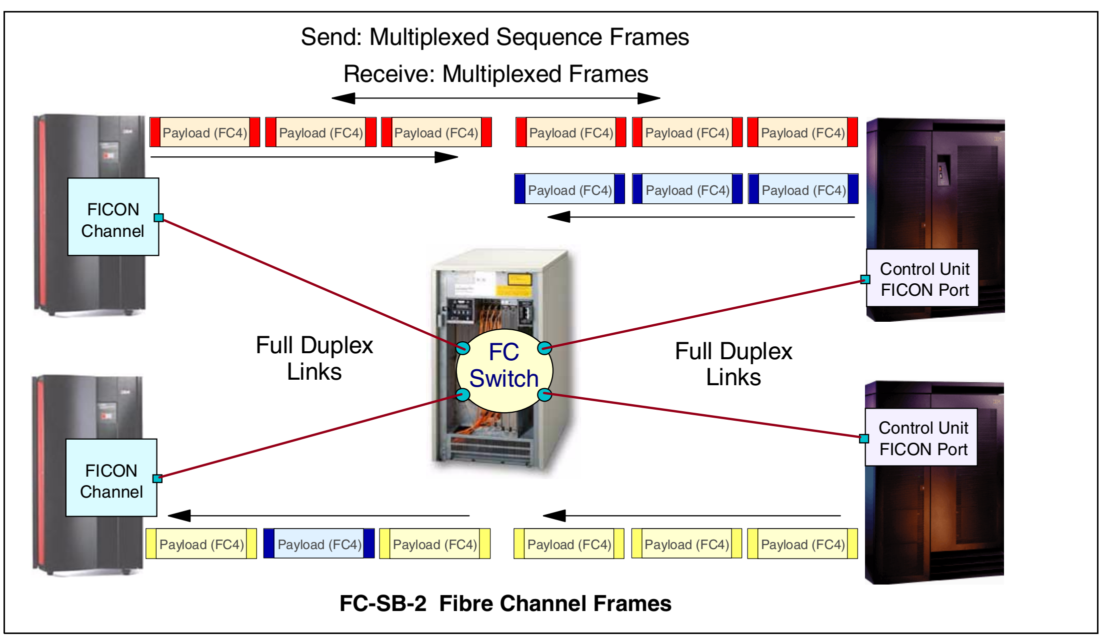

Figure 3-27 Fibre Channel frames

CCW and data pipelining

While ESCON channel program operation requires a Channel End/Device End (CE/DE) to be sent to the channel after execution of each CCW, the FICON native (FC) mode channel supports CCW and Data pipelining. The differences between ESCON and FICON in CCW operation, and the benefits of CCW and data pipelining are described in this section.

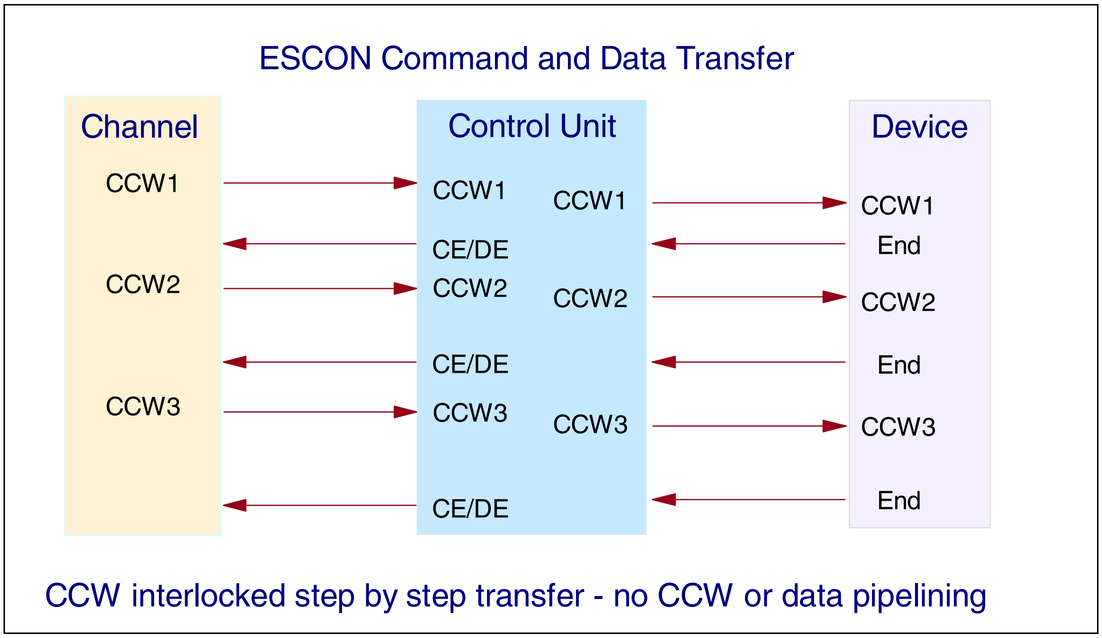

Figure 3-28 CCW operation on an ESCON channel

CCW operation (command and data transfer) on an ESCON channel is shown in Figure 3-28. The channel transfers the command and data to the control unit and waits for a Channel End/Device End presented by the control unit after execution of the command by the CU/device (CCW interlock). After receiving CE/DE for the previous command, the next command is transferred to the control unit for execution.

Figure 3-29 on page 53 shows a CCW operation for a FICON native (FC) mode channel, which exploits CCW and data pipelining.

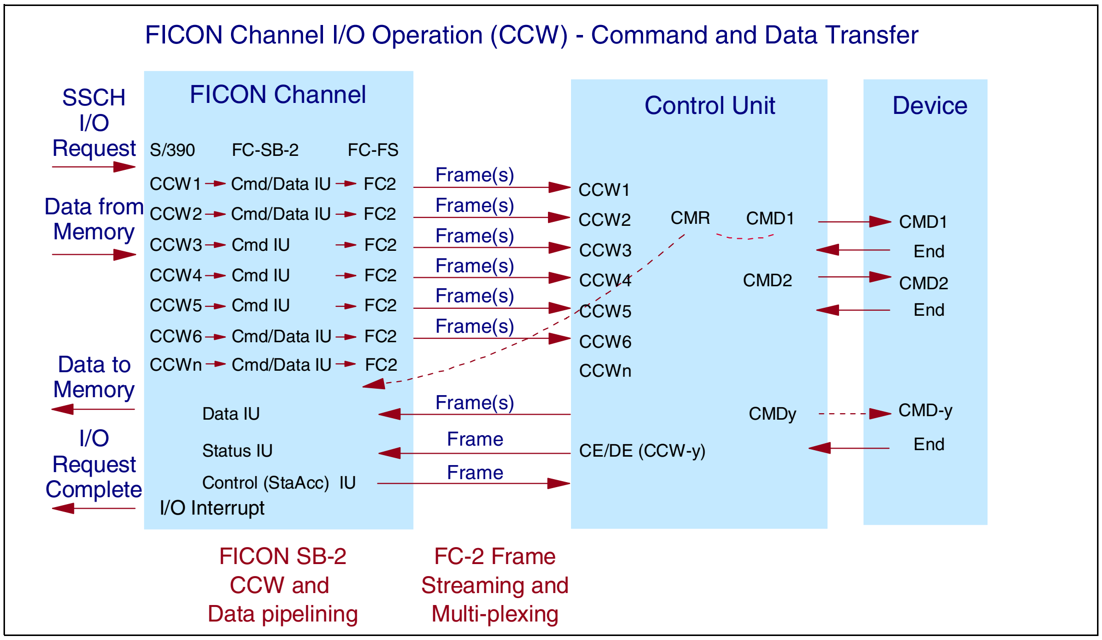

Figure 3-29   CCW operation on a FICON channel (CCW pipelining)

With a FICON channel, all CCWs (up to the FICON channel IU pacing limit) are transferred to the control unit without waiting for CE/DE after each I/O operation. The device presents an end to the control unit after each CCW execution. Once the last CCW of the CCW chain has been executed by the CU/device, the control unit presents CE/DE to the channel.

Benefits of CCW and data pipelining:

- IOQ (I/O queue time) is waiting for a software UCB resource and is measured by z/OS and OS/390.
  - PAV (Parallel Access Volume—a disk feature) reduces this by providing multiple UCBs and device addresses for the same volume.
- Pending time is waiting for a path to a device or the device itself, and is measured by the channel subsystem.
  - Reduced channel busy—multiple starts to the same channel path
  - Reduced/eliminated destination port busy—connectionless communication and switch port buffer credits
  - Reduced CU busy—CUs implement CU queuing; supports multiple I/O operations
  - Reduced device busy—CUs support multiple allegiance
- Connect time is time for the actual execution of the I/O request, and is measured by the channel subsystem.
  - Reduced for long records—more data per FC frame (packet)
  - FC frame multiplexing, allows for better link utilization, but may extend some connect times
- Disconnect time is waiting for access to the data or to reconnect, and is measured by the control unit and the channel subsystem.
  - Reduced destination port busy—connectionless communication and switch-port buffer credits

More detailed information about FICON channel operation can be found in Chapter 11, “FICON channel operation and performance” on page 187.

3.4.3 Buffer-to-buffer credit

To prevent an FC port transferring more frames than the receiving FC port can handle, both ports of the FC link must request each other’s *buffer credit* quantity. This request is performed during the initial initialization of the link. Each time a frame is transferred from a port onto the link, that port will reduce (by one) its current buffer credit value to the other port. When the port at the other end of the link receives the frame and moves it out of its buffer, it responds with an R_RDY response (ready response). When the ready response is received by the port that sent the frames, that port will then increment its current buffer credit by 1.The R_RDY signalling is shown in Figure 3-30.

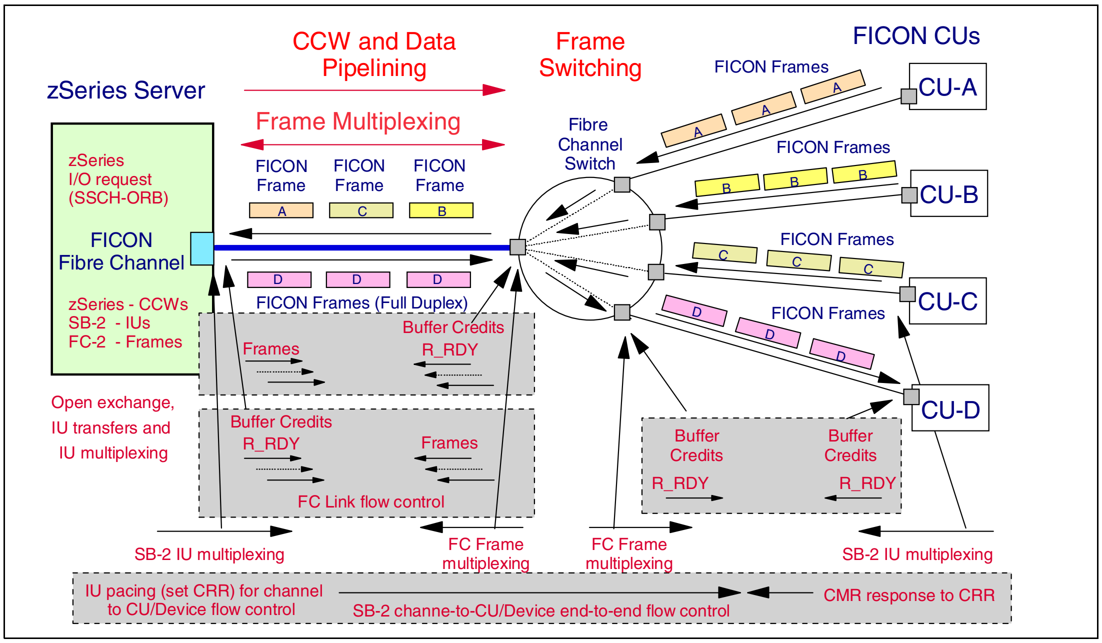

Figure 3-30 Fibre Channel buffer credits

Figure 3-30 shows the scope of each of the Fibre Channel architectures, and other Fibre Channel FC-4 level architectures, plus the z/Architecture and S/390, and the CU/Device architecture, used in support of FICON channel I/O operations (FICON in native (FC) mode).

4

Processor support

This chapter describes the support of the FICON channel in FICON native (FC) mode by the zSeries and 9672 G5/G6 processors.

It includes the following:

- Description of the FICON and FICON Express features
- Supported topologies based on the FICON and FICON Express features
- Number of supported FICON channels based on a processor
- Supported distances for the FICON and FICON Express features
- Supporting FICON native products
- Hardware code levels needed for cascaded FICON Directors

4.1 zSeries and 9672 G5/G6 processor support

Figure 4-1 illustrates the connectivity supported by the zSeries and 9672 G5/G6 processors for FICON native, based on the FICON and FICON Express features. It also shows the connector types needed for these features.

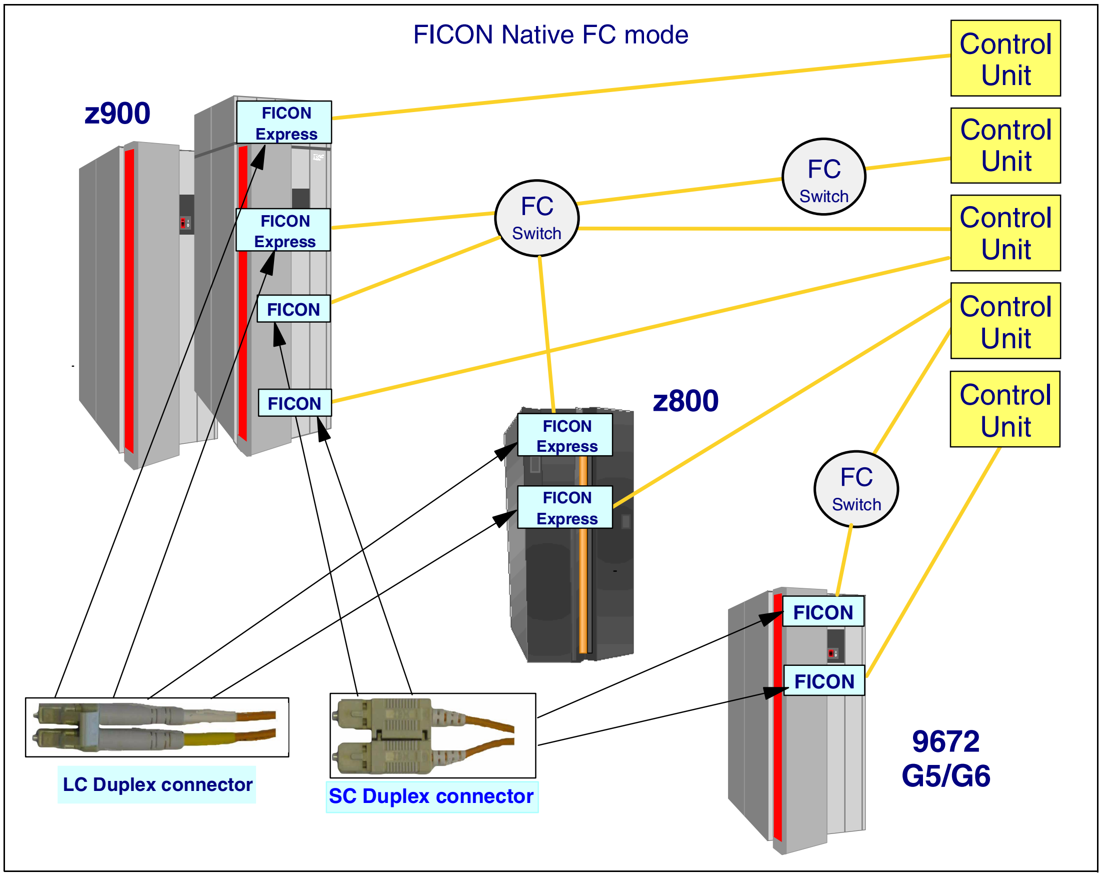

Figure 4-1 zSeries and 9672 processors with FICON native (FC) channels

FICON channels installed in the zSeries and the 9672 G5/G6 processors can be connected to a FICON-capable control unit either point-to-point, switched point-to-point, or through cascaded FICON Directors (zSeries only). The number of FICON channels supported by each processor type is as follows:

- Up to 24 FICON cards can be installed in a 9672 G5 processor.
- Up to 36 FICON cards can be installed in the 9672 G6 processor.
- A total of 96 FICON and/or FICON Express cards can be installed in the zSeries 900.
- Up to 16 FICON Express cards can be installed in the zSeries 800.

  The link bandwidth of the FICON features is 100 MBps (1 Gbps), whereas the link bandwidth of the FICON Express features is 100 MBps (1 Gbps) or 200 MBps (2 Gbps).

FICON and FICON Express features

Table 4-1 on page 57 lists the FICON and FICON Express feature codes with the appropriate laser type (short wavelength (SX) or long wavelength (LX)), number of ports per card, and the processor type that supports them.

Table 4-1 FICON and FICON Express feature codes

Feature Code	Ports per adapter	9672 G5/G6	z900[a]	z800[b]
FC 2314 (FICON LX)	one	X		
FC 2316 (FICON SX)	one	X		
FC 2315 (FICON LX)[c]	two		X	
FC 2318 (FICON SX)[c]	two		X	
FC 2319 (FICON Express LX)	two		X	X
FC 2320 (FICON Express SX)	two		X	X

a. Can intermix FICON and FICON Express cards at driver level 3C or later.
b. Only supports FICON Express cards.
c. Cannot be ordered after October 31, 2001.

Table 4-2 maps the supported FICON topologies to their corresponding FICON and FICON Express feature codes.

Table 4-2 FICON native topologies with supported FICON and FICON Express feature codes

FICON topology	FC 2314	FC 2316	FC 2315	FC 2318	FC 2319[a]	FC 2320[a]
Point-to-Point	Y	Y	Y	Y	Y	Y
Switched Point-to-Point	Y	Y	Y	Y	Y	Y
Cascaded FICON Directors	N	N	Y[b]	Y[b]	Y[c]	Y[c]
FICON CTC	Y	Y	Y	Y	Y	Y

a. Auto-negotiate (2 Gbps) support
b. LIC needed to be enabled
c. DRV3G with MCL(J11206) or later must be applied

Check with your local service representative to ensure your zSeries or S/390 server has the required code levels.

The preferred fiber cabling for a long wavelength laser FICON channel is 9-micron single-mode fiber. While 62.5-micron multi-mode or 50.0-micron multi-mode fiber cable may be used for a long wavelength laser FICON channel, the use of these multi-mode cables requires the use of mode conditioner patch (MCP) cables, one at each end of the fiber link, or between optical ports in the link. Use of the single-mode to multi-mode MCP cables reduces the supported optical distance.

The short wavelength laser FICON channel supports the use of both 62.5-micron and 50.0-micron multi-mode fibre channels.

In addition to wavelength differences, a number of different connectors exist for these cables. Furthermore, the types of connectors used varies with the base system type. The z800 and z900 use MT-RJ connectors for their 16-port ESCON channel cards, for example, whereas 9672 G5/G6 processors use IBM (ESCON) duplex connectors for ESCON channels. FICON Express channel ports adopt LC Duplex connectors, while older FICON channel ports adopt SC Duplex connectors. Connecting different types of ports with existing fiber connectors generally need conversion kits.

Chapter 5, “FICON - Fibre Channel cabling” on page 69 discusses the fiber cabling requirements in detail.

4.1.1 ESCON and FICON channel connectivity support

This section compares the channel connectivity support between ESCON and FICON.

ESCON and FICON channel equivalence support, as described below, is illustrated in Figure 4-2 on page 59 and Figure 4-3 on page 59 for the 9672 G5/G6 processors, and Figure 4-4 on page 60 and Figure 4-5 on page 60 for the zSeries processors.

Equivalent channel support

A 9672 G5 processor can support up to 256 ESCON channels, or up to 168 ESCON channels and up to 24 FICON channels. A 9672 G6 processor can support up to 256 ESCON channels, or up to 120 ESCON channels and up to 36 FICON channels. The zSeries 900 processor can support up to 256 ESCON channels, or up to160 ESCON channels and up to 96 FICON channels. The zSeries 800 processor can support up to 240 ESCON channels, or up to 16 FICON channels

ESCON channels do not support concurrent I/O connections, but a FICON channel in FICON native (FC) mode supports multiple concurrent I/O connections to FICON control units.

The number of concurrent I/O operation connections on a FICON channel in FICON native (FC) mode for a specific S/390 or zSeries environment depends on the following:

- Processor model
- FICON topology, including the FICON Director
- Configuration definition
- Performance of the control unit

Whereas the FICON Bridge (FCV) mode channel provided eight concurrent I/O operation connections (compared to one for an ESCON channel), the FICON channel in FICON native (FC) mode can provide up to 16 or more concurrent I/O operation connections by exploiting the FICON channel’s Information Unit (IU) operation multiplexing and FC frame multiplexing capability. However, the capability for concurrent I/O operation connectivity should not be confused with bandwidth capacity. The FICON channel bandwidth utilization depends entirely on the number and type of connected control units. The total available bandwidth on all installed FICON channels is also a function of the capacity of the channel subsystem.

On a 9672 G5 or G6 processor, a channel-constrained environment is one that has 60 or more of the 64 I/O slots on the 9672 G5/G6 full. The CHPID numbering cost to the channel-constrained customer of one FICON channel on a 9672 G5/G6 is four ESCON channel CHPID numbers since one I/O slot (that could support four ESCON channels) must be vacated for one FICON channel. In this case, the benefits to the customer of installing FICON channels will be related more to the additional connectivity, distance and addressability than to the increase in bandwidth. However, on the zSeries processor, where one FICON channel may only need to replace one ESCON channel (use the CHPID number that may have been assigned to the ESCON channel if there are no other CHPID numbers available), the benefits to the customer of installing FICON include increased distance and connectivity, increased addressability, and greater bandwidth.

To show the connectivity advantage of a FICON native channel compared to an ESCON channel, eight concurrent I/O operation connections on a FICON channel are assumed in the following examples.

A 9672 G5 processor with the maximum of 24 FICON channels operating in native (FC) mode can support 192 concurrent I/O operation connections in total on the 24 FICON channels. A 9672 G6 processor with the maximum of 36 FICON channels operating in native (FC) mode can support 288 concurrent I/O operation connections in total on the 36 FICON channels. A zSeries processor with the maximum of 96 FICON channels operating in FICON native (FC) mode can support 768 concurrent I/O operation connections on the 96 FICON channels.

9672 G5 equivalent channel support

The 9672 G5 processor can have the equivalent S/390 concurrent I/O connectivity of 360 ESCON channels, with 168 ESCON channels and 24 FICON channels installed, as illustrated in Figure 4-2.

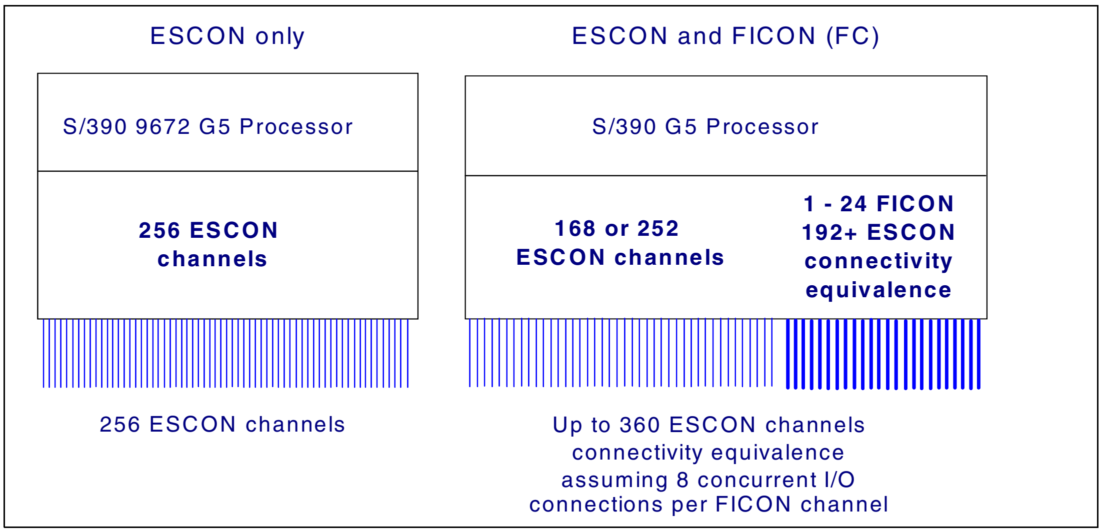

Figure 4-2 9672 G5 ESCON and FICON combined channel connectivity equivalence

9672 G6 equivalent channel support

The 9672 G6 processor can have the equivalent S/390 concurrent I/O connectivity of 408 ESCON channels, with 120 ESCON channels and 36 FICON channels installed, as illustrated in Figure 4-3.

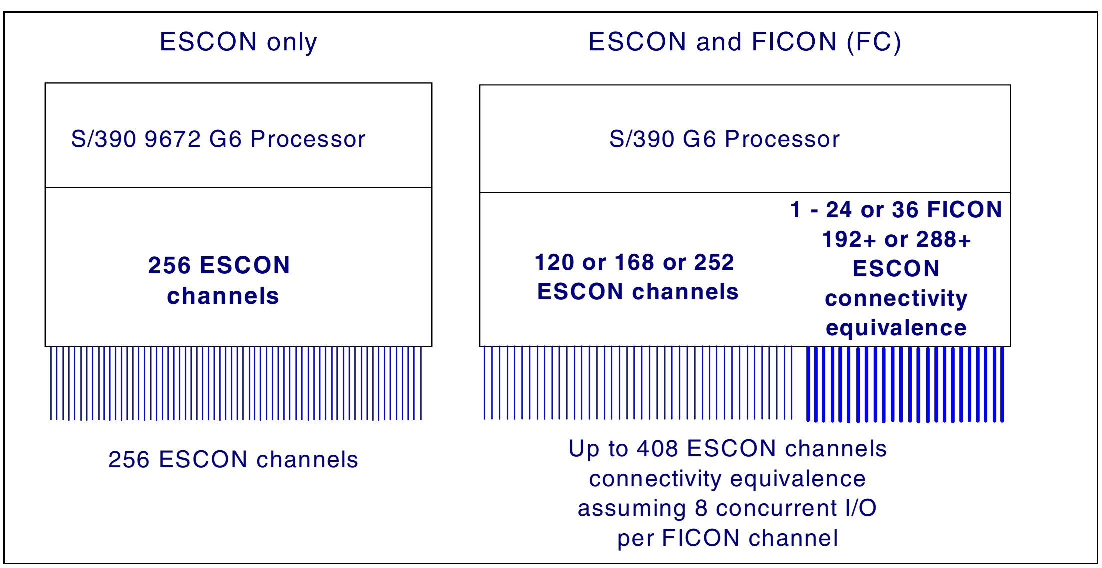

Figure 4-3 9672 G6 ESCON and FICON combined channel connectivity equivalence

zSeries 900 equivalent channel support

The zSeries 900 processor can have the equivalent S/390 concurrent I/O connectivity of 928 ESCON channels, with 160 ESCON channels and 96 FICON channels installed; see Figure 4-4.

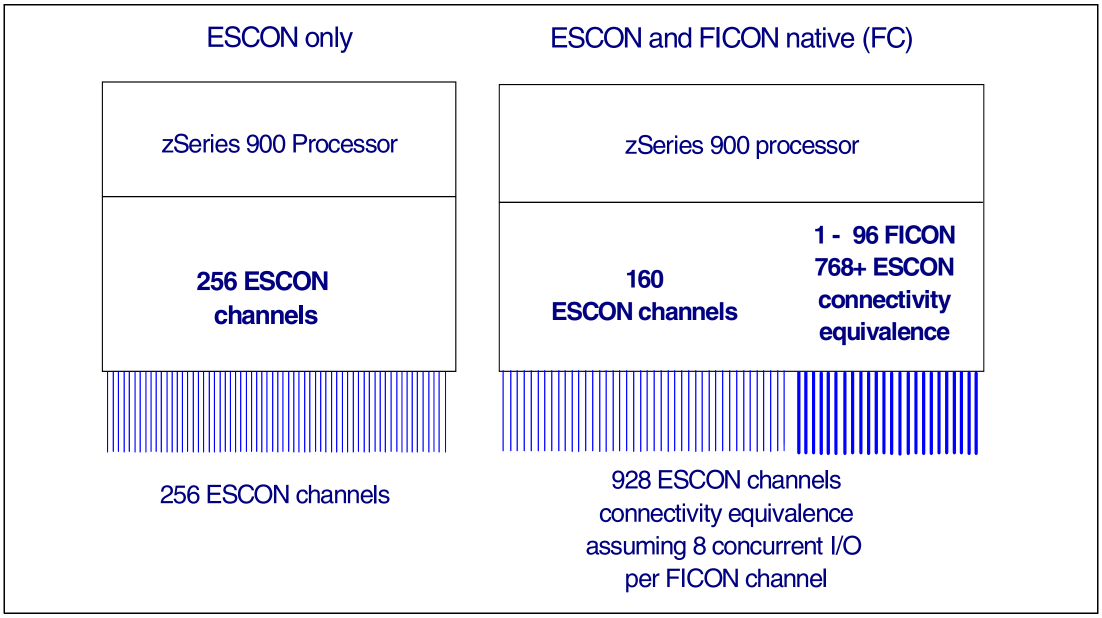

Figure 4-4 zSeries 900 ESCON and FICON combined channel connectivity equivalence

zSeries 800 equivalent channel support

The zSeries 800 processor can have the equivalent S/390 concurrent I/O connectivity of 256 ESCON channel connectivity equivalence with 16 FICON channels installed only; see Figure 4-5.

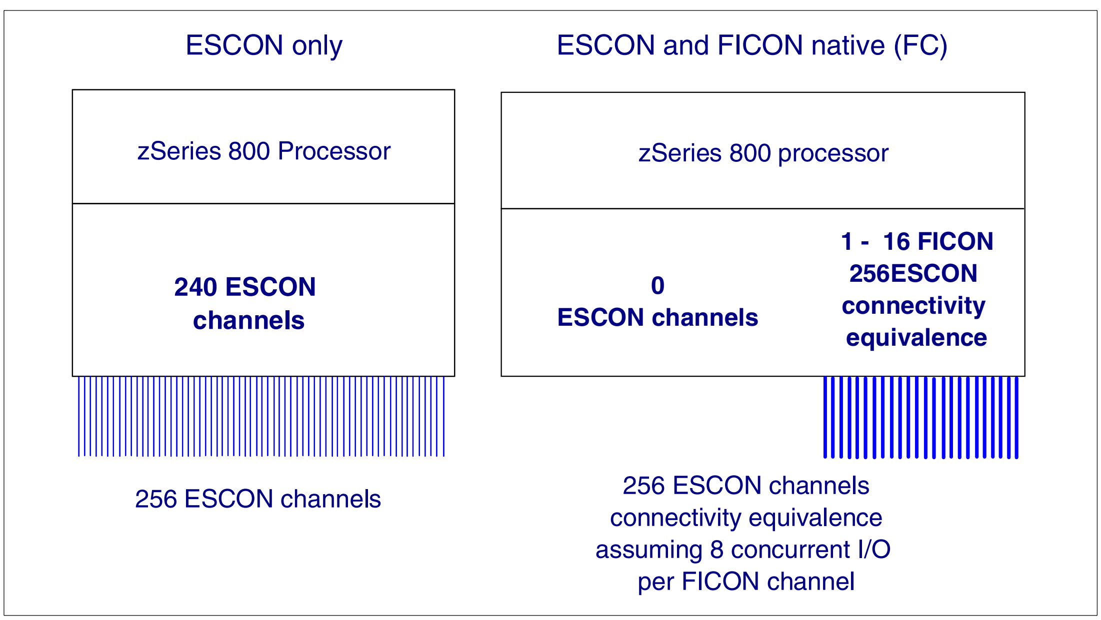

Figure 4-5 zSeries 800 ESCON and FICON channel connectivity equivalence

Channel device addressing support

An ESCON channel operating in CNC mode supports 1024 device addresses. This support is increased to 16K devices (16384) for a FICON native (FC) channel.

Distance support

The maximum unrepeated fiber connectivity distance for an ESCON CNC LED channel link using 62.5-micron multimode fiber is 3 km (or 2 km for 50-micron fiber). These same distances apply for ESCON Director to control unit links for ESCON Director LED ports.

Table 4-3 provides information on the different FICON and FICON Express features with their supported fiber types and distances.

Table 4-3 Supported fiber types and distances for FICON and FICON Express

Feature Code	Fiber type	Distance (unrepeated)
FC 2316 (FICON SX) FC 2318 (FICON SX)	50 micron multimode	500 meters (1,640 feet)
FC 2316 (FICON SX) FC 2318 (FICON SX)	62.5 micron multimode	175 meters (574 feet)
FC 2320 (FICON Express SX)	50 micron multimode	1 Gbps 500 meters (1,640 feet) 2 Gbps 300 meters (984 feet)
FC 2320 (FICON Express SX)	62.5 micron multimode	1 Gbps 250 meters (820 feet) 2 Gbps 120 meters (394 feet)
FC 2314 (FICON LX)[a] FC 2315 (FICON LX)[a]	50 micron multimode	550 meters (1,804 feet)
FC 2314 (FICON LX)[a] FC 2315 (FICON LX)[a]	62.5 micron multimode	550 meters (1,804 feet)
FC 2314 (FICON LX) FC 2315 (FICON LX)	9 micron single mode	10 kilometers (6.2 miles) 20 kilometers with RPQ
FC 2319 (FICON Express LX)[a]	50 micron multimode	1 Gbps 550 meters (1,804 feet) 2 Gbps[b]
FC 2319 (FICON Express LX)[a]	62.5 micron multimode	1 Gbps 550 meters (1,804 feet) 2 Gbps[b]
FC 2319 (FICON Express LX)	9 micron single mode	1 Gbps 10 kilometers (6.2 miles) 20 kilometers with RPQ 2 Gbps 10 kilometers (6.2 miles) 12 kilometers with RPQ

a. Mode Conditioning Patch (MCP) cables are required

b. The unrepeated distance for this feature, over multimode fiber using Mode Conditioning Patch (MCP) cables, will be degraded to the extent that this combination will not be supported at 2 Gbps. When connected to a switch port defined with auto negotiate, the link speed will be reduced to 1 Gbps.

For all FICON and FICON Express features using repeaters, the end-to-end distance between the FICON channel and the FICON Director port can be up to 100 km. The same end-to-end distance is also available between the FICON Director port and the FICON control unit port. However, the overall end-to-end distance between the FICON channel and FICON control unit should not exceed 100 km. The extended distance requires that each fiber channel port (F_Port and N_Port) support 60 buffer credits to avoid a data droop problem.

Data rate performance droop

Data rate performance droop occurs at extended distances (over 9 km) for ESCON links. For FICON channels in FICON native (FC) mode, the channel-to-control unit end-to-end distance can be increased to 100 km before data rate performance droop starts to occur. Other factors (for example, frame multiplexing) may sometimes affect the data rate performance; these are covered in Chapter 11, “FICON channel operation and performance” on page 187.

4.1.2 FICON channel support for zSeries processors

The zSeries 900 processor with an I/O cage (FC 2023 Cargo) installed supports the FICON and FICON Express adapter cards (two FICON channel ports per adapter card).

The zSeries 800 processor has a new style I/O cage (Cargo-lite) that supports only the FICON Express (two FICON channel ports per adapter card).

Up to 48 FICON channel adapter cards can be installed in the zSeries 900 processors (48 FICON adapter cards provide 96 FICON channels), using the I/O cages. Up to 16 FICON channel adapter cards can be installed in the zSeries 800 processors (16 FICON adapter cards provide 32 FICON channels), using the z800 unique style I/O cages (Cargo-lite).

The zSeries 900 processors may also have 9672 G5/G6-like older style I/O cages (IBM I/O cage feature code 2022) installed. The zSeries 900 allows a mixed installation of the zSeries 900 style I/O cages (FC 2023) and the 9672 G5/G6-like older style I/O cages in the same processor complex; the actual 9672 G5/G6 I/O cage and the zSeries 900 (FC 2022) older style I/O cages are not the same. Certain 9672 G5/G6 channel cards in the 9672 G5/G6 I/O cage can be moved from an existing 9672 G5/G6 to a zSeries 900 when upgrading the 9672 G5/G6 to a zSeries 900 processor. This would require that a zSeries 900 feature code 2022 I/O cage be installed in the zSeries 900 processor. A zSeries 900 FC 2022 I/O cage is always required for parallel channel cards and OSA2 (FDDI).

Table 4-4 on page 63 shows the maximum installable FICON channels in relation to the number of installed zSeries I/O cages and G5/G6-like old stye I/O cages. In a zSeries 900 processor FICON channel adapter cards are installed in the new style I/O cages only.

Table 4-4   FICON channels installable in the zSeries 900 processor I/O cages

Number of zSeries 900 new style I/O cages installed Feature code 2023	Number zSeries 900 old style I/O cages installed Feature code 2022	Maximum number of FICON channels that can be supported
1	0	32
1	1	32
1	2	32
2	0	64
2	1	64
3	0	96

Each zSeries 900 new style I/O cage (FC 2023) supports up to 16 FICON channel adapter cards. Each FICON channel card has two ports (two channels), so a maximum of 32 FICON channels can be installed in each zSeries 900 new style I/O cage (FC 2023). Any CHPID number can be assigned to any channel for any channel type card in any I/O slot in either of the two zSeries processor I/O cage styles. FICON channels are installed in the zSeries processor without the loss of CHPID numbers (CHPID numbers may be lost when FICON channels are installed in the 9672 G5/G6 processors), which allows the zSeries processor to have a larger number of ESCON and FICON channel cards installed. Therefore, a larger number of concurrent I/O connections can be maintained when FICON channels are installed, as compared to when FICON channels were installed on the 9672 G5/G6 processors.

4.1.3 zSeries-supported ESCON and FICON I/O types

The FICON (2-port) and ESCON (15/16 port) are always installed in the zSeries 900 new I/O cage (FC 2023). There is always one FC 2023 I/O cage and there can be up to two more FC 2023 I/O cages depending on the total channel requirements (FICON, ESCON (15/16 port), ISC-3 and OSA-Express) and the intermix of other channel types (Parallel, 4-port ESCON, and OSA-2) in zSeries 900. The first FC 2023 I/O cage is installed in the zSeries 900 A frame and additional I/O cages would be installed in the optional zSeries 900 second I/O frame, the Z frame. The FICON (2-port) and ESCON (15/16 port) channel cards also can be installed in the zSeries 800 new I/O cage (Cargo-lite). See Table 4-5.

Table 4-5   zSeries supported I/O channel type

I/O type	zSeries 900 I/O cage FC 2023	zSeries 900 I/O cage FC 2022	zSeries 800 I/O cage (Cargo-lite)
ESCON (4 ports)	No	Yes (upgrade MES)	No
ESCON (16 ports)	Yes	No	Yes
FICON (FC 2315 / 2318)[a]	Yes	No	No
FICON (FC 2319 / 2320)	Yes	No	Yes

a. Not available as of October 31, 2001.

4.1.4 FICON Express on the zSeries processors

FICON Express features, on both the z800 or z900, offer performance improvements over earlier FICON technology. I/O operations per second can be as high as 7200 with an effective bandwidth of up to 100 Mbps and up to 200 Mbps with FICON Express. These numbers assume 4 KB block sizes and mostly sequential operations. The internal bus used for a FICON Express card is 64 bits wide and has a 66 MHz clock, contrasted with the previous z900 FICON cards which were 32 bits wide with a 33 MHz clock.

The FICON Express features (2319 / 2320) in the zSeries can support 1 Gbps and 2 Gbps data rates, using auto-negotiation. This requires DRV3G. Speed selection on the FICON Express features is not possible, however, when the FICON Express card is connected to a FICON Director you have the option to select 1Gbps, 2 Gbps, or auto-negotiate at configuration time of the FICON Director.

With z/OS, you can check the data rate at which the FICON Express is connected, using RMF. For example, a number 1 in the Generation (G) field of the RMF Channel Path Activity report indicates that a FICON channel is operating at 1 Gbps, whereas a number 2 in this field implies a 2 Gbps data rate (see sample RMF information on page 208).

Table 4-6 lists the FICON native products that currently support 2 Gbps data rate.

Table 4-6 2 Gbps supportable products

Machine type and model	Laser type	FICON channel mode
IBM 2105-800	LX and SX	FC and FCP
McDATA 6064-64 / 140 (IBM 2032-064 / 140)	LX and SX	FC and FCP
INRANGE 9000-64 / 128 / 256 (IBM 2042-001 / 128 / 256)	LX and SX	FC only

IBM has reseller agreements with McDATA and INRANGE to supply FICON Directors. These include:

- McDATA ED-6064-64 Enterprise Fibre Channel Director, a 64-port unit
- McDATA ED-6064-140 Enterprise Fibre Channel Director, a 140-port unit
- INRANGE FC/9000-64 Fibre Channel Director, a 64-port unit
- INRANGE FC/9000-128 Fibre Channel Director, with 128 ports
- INRANGE FC/9000-256 Fibre Channel Director, a 256-port unit

Note: In a cascaded topology both FICON Directors must be from the same vendor.

As illustrated in Figure 4-6 on page 65, the FICON and FICON Express features may be used as follows:

- Direct connectivity to native FICON control units and/or a FICON port on a server
- Connectivity through one or two FICON Director(s) to native FICON control units and/or a FICON port on a server

  The FCTC functions are described further in “FICON CTC implementation” on page 153.

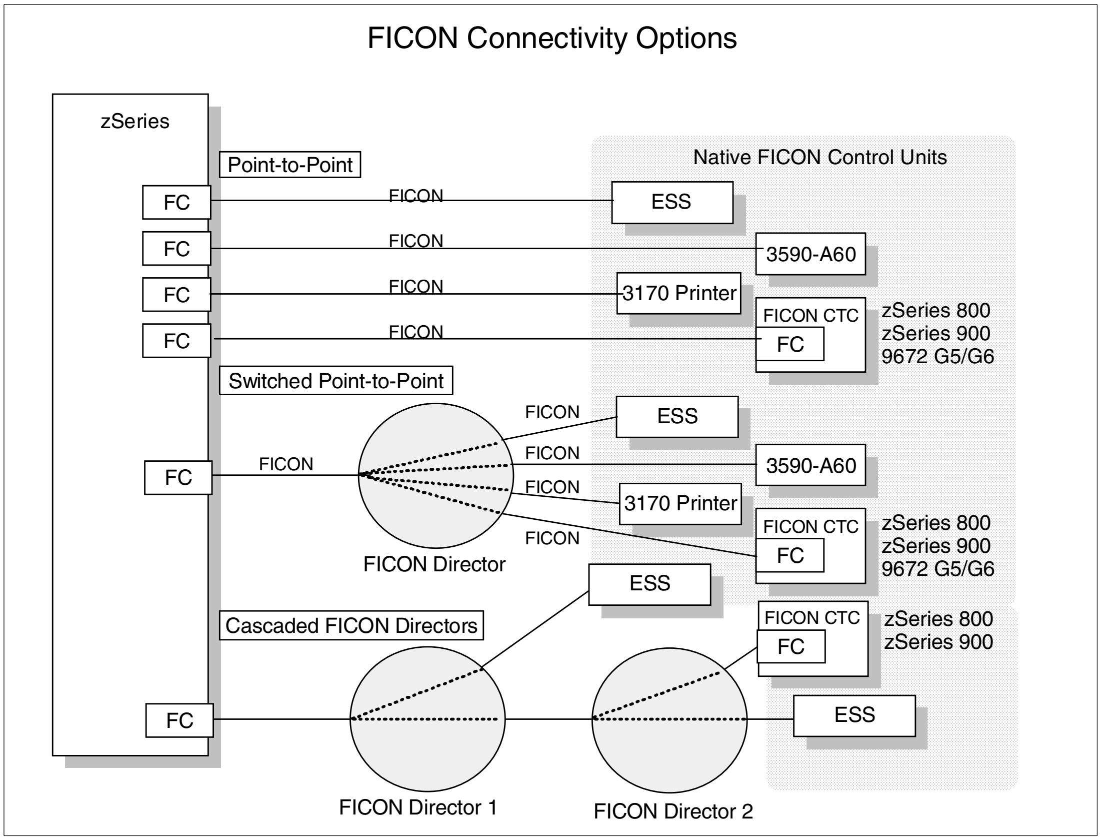

Figure 4-6 FICON connection options

The former FICON adapters (that is, not FICON Express cards) for z900 are no longer orderable and cannot be used with a z800.

Each port on a FICON Express card can be initialized with one of two microcode loads:

- One provides operation in bridge mode, and assumes the FICON is connected to an appropriate bridge unit in a 9032-005 ESCON Director. The bridge unit converts the FICON connection into a maximum of eight ESCON channels. This is an FCV channel type.
- The other causes the unit to operate in native FICON mode and works with native FICON control units and a single FICON Director. FICON CTC control unitsare supported at driver level 3C or later, and with driver level 3G cascaded FICON Directors are also supported.

A third microcode load is also available for open fiber connection (that is, SCSI over fiber) with Linux. This is an FCP channel type.

The microcode loading is done at Power-on-reset and can be reloaded by dynamic I/O reconfiguration changes initiated from a z/OS, z/OS.e, or OS/390 image running on the zSeries.

4.1.5 FICON-supporting products

Currently available FICON products are summarized in Table 4-7 on page 66.

Table 4-7 FICON-supported products

Product	Transceiver type	Connector type
ESCON Director FICON Bridge (IBM 9032-005)	LX	SC Duplex
McDATA FICON Director (IBM 2032-001)	LX	SC Duplex
	SX	SC Duplex
McDATA FICON Director (IBM 2032-064 / 140)	LX	LC Duplex
	SX	LC Duplex
INRANGE FICON Director (IBM 2042-001 / 128 / 256)	LX	LC Duplex
	SX	LC Duplex
Infoprint (IBM 3170-005)	LX	SC Duplex
Infoprint (IBM 4100, 2000 family)	LX	SC Duplex
	SX	SC Duplex
Enterprise Tape Controller (IBM 3590-A60)	LX	SC Duplex
	SX	SC Duplex
Enterprise Storage Server (IBM 2105-800)	LX	LC Duplex
	SX	LC Duplex

4.1.6 Support for cascaded FICON Directors

This section briefly describes the hardware and software support needed for cascaded FICON Directors. With cascaded FICON Directors a native FICON (FC) channel or a FICON CTC channel can connect a server, a device, or another server via two FICON Directors. The support is for a two-FICON-Director configuration only and is applicable to both the FICON and FICON Express features (see Table 4-2 on page 57).

Benefits of cascaded FICON Directors topology

This type of cascaded support is important for disaster recovery and business continuity solutions, because it can provide high availability, extended distance connectivity, and greater thoughput, particularly with the implementation of 2 Gbps Inter-Switch Links (ISL). It also has the potential for fiber infrastructure cost savings by reducing the number of channels for interconnecting the two sites.

FICON Directors in cascade mode have the added value of ensuring high integrity connectivity. New integrity features introduced within the FICON channel and the FICON Directors in cascaded fabric ensure the detection and reporting of any miscabling actions occurring within the fabric and prevent data from being delivered to the wrong end point.

Hardware and software requirements

For hardware:

- zSeries with FICON or FICON Express adapter cards.
- zSeries with DRV3G and MCL(J11206).
- FICON Directors in cascade mode require that the *High Integrity* feature be installed. Currently two vendors provide FICON Directors (see Table 4-8 on page 67).

Table 4-8 FICON High Integrity Feature in FICON Directors

Vendor/Machine	High Integrity FC	Firmware level
McDATA 6064 (IBM 2032)	FICON SANtegrity FC 6007	FW 3.0 or later
INRANGE 9000 (IBM 2042)	FICON Cascading FC 7203	FW 4.0 or later

For a description of High Integrity refer to "Binding and Insistent Domain IDs" on page 18.

For software:

- z/OS V1R4 or z/OS V1R3 with PTFs

  Refer to Chapter 6, "z/OS and OS/390 software support" on page 83 for more information.

5

FICON - Fibre Channel cabling

This chapter discusses FICON channel cabling options and specifications. It includes information describing the following:

- Basic cabling options and terms
- Fiber cable and connector types
- Supported distances based on laser and cable types
- Fiber cable planning items
- Fiber channel extenders and repeaters

5.1 Basic implementation options

Two Fiber Optic SubAssembly (FOSA) options for FICON channel port cards, Fibre Channel Director port cards and FICON control unit adapter cards are available:

- Long wavelength laser (LX) at 1300 nm
- Short wavelength laser (SX) at 850 nm

These two FOSA types (LX and SX), combined with the different fiber cable modes, provide five implementation options, as listed in Table 5-1.

Table 5-1 Fibre channel cabling implementation options

FOSA type	Single-mode (9/125)	Multimode (62.5/125)	Multimode (50/125)
Long wavelength LX	X	X[a]	X[a]
Short wavelength SX		X	X

a. Mode Conditioner Patch (MCP) cables are required.

The recommended and most flexible fiber cable option is based on 9 micron single-mode fiber cables with long wavelength FOSAs. However, the optimum cabling implementation option for any given installation depends on the environment and configuration requirements.

5.2 Basic FICON cabling terminology

The FC Link is the logical connection consisting of a pair of optical fibers between two fibre channel ports, see Figure 5-1. The FC Link can consist of one or more optical links (by using fiber extenders; for details, see 5.4, “Fiber extender and fiber repeater” on page 77).

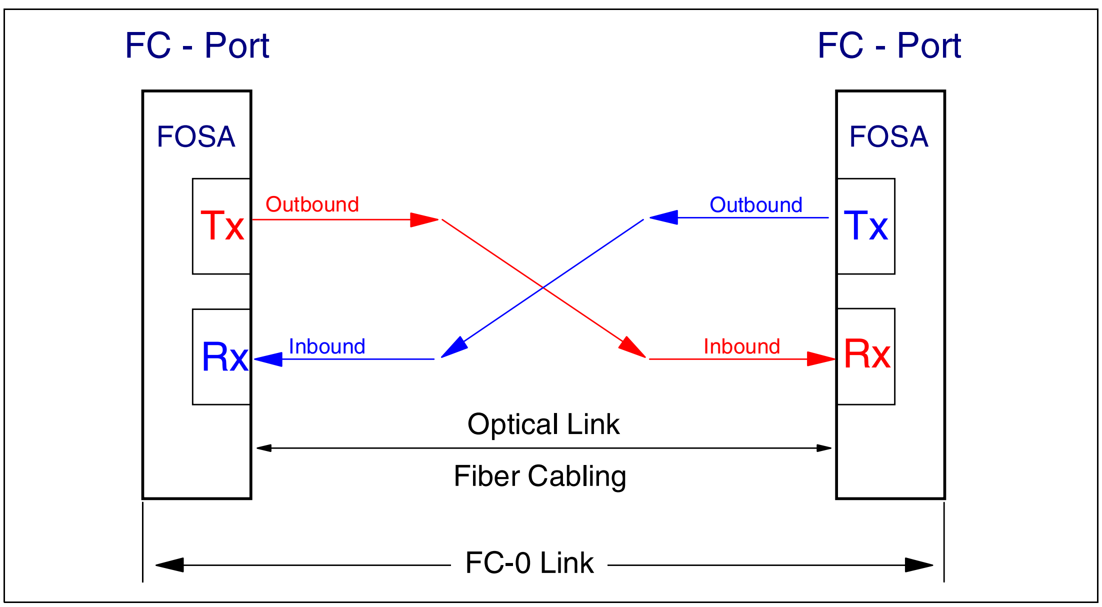

Figure 5-1 Fiber Channel Link

A Fiber Channel Link (port-to-port connection) can be:

- N_Port to N_Port - point-to-point topology
- N_Port to F_Port - switched point-to-point topology
- F_Port to N_Port - switched point-to-point topology
- E_Port to E_Port - fibre channel fabric Inter-Switch Link (ISL) for FICON support of cascaded Directors

Figure 5-2 introduces the basic terminology of a Fibre Channel from a cabling point of view.

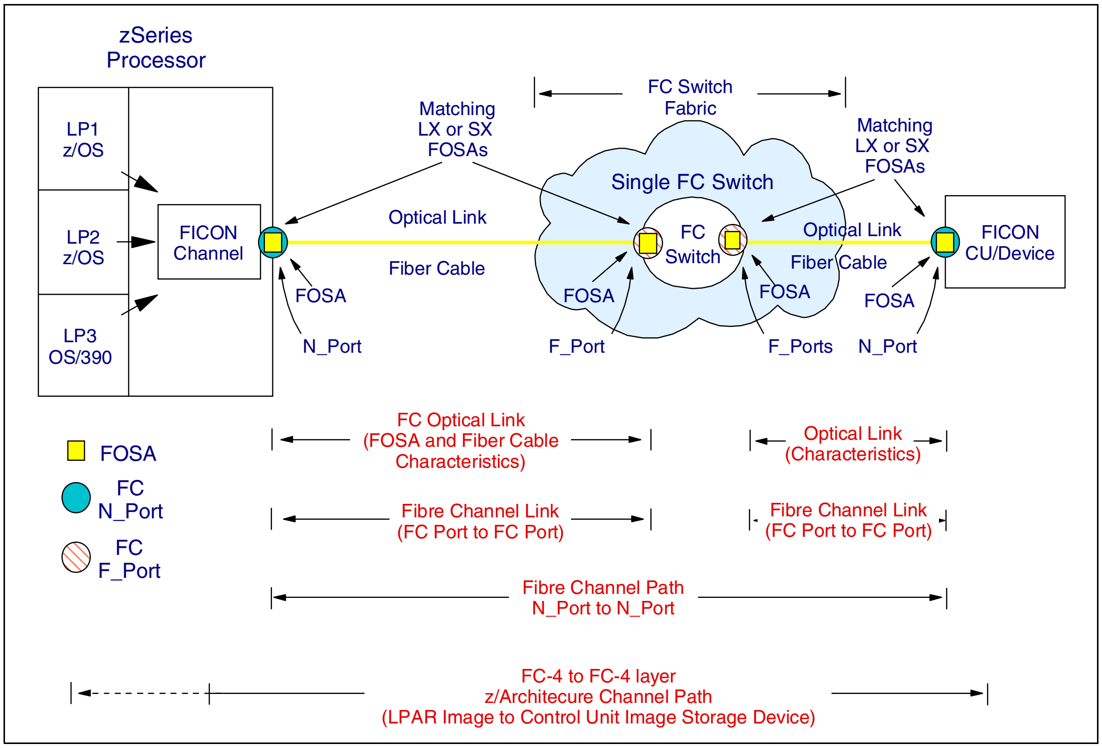

Figure 5-2 Basic FICON cabling terminology

Fibre Channel infrastructure terminology:

Optical link The connection between two FOSAs.

Fibre Channel link The connection between two fibre channel ports. For most installations an optical link and a FC Link would be the same. The case where it would be different is when there are optical extenders in the FC Link.

Fibre Channel path The logical connection between an N_Port to another N_Port (logically - because it may be physically connected by one or more fibre channel switches).

z/Architecture Channel Path
The logical connection between the device support within a zSeries processor image and an actual installed device.

From a cabling standpoint the most important factor of an FC Link is the selection of the FOSA type. This is based on requirements such as distance, attenuation, and fiber re-use for the optical link.

Note: Keep in mind that the FOSA types (LX or SX) at the ends of each optical link must match.

5.3 Key items for fiber cable planning

When planning for fiber cabling, certain criteria must be considered; for example:

- Distance considerations

  How far is it between the optical ports (FOSA) or FC ports?

- FOSA type

  Long wavelength (LX) or short wavelength (SX)?

- The type and specifications of the fiber cabling to be used

  Fiber cable modes; single-mode (SM) or multimode (MM)?

- Number of ISL links when using FICON support of cascaded Directors
- Reusing of existing fiber cables and trunks

  Generally this is meant as using 62.5 micron fiber to support LX FOSA ports, which also requires the use of Mode Conditioner Patch (MCP) cables.

- Patch panel connections between FOSA ports

  Each connection, depending on connector type, incurs a dB loss (on average between 0.3 and 0.5 dB).

- Maximum allowable link budget (dB) loss

  The actual link budget loss is based on how much dB loss the FOSA in the end device will tolerate.

5.3.1 FOSA types and fiber modes

Each FICON channel port, FICON Director port, and FICON CU adapter port has a FOSA, which consists of a transmitter and a receiver. The transmitter and receiver can operate independently (bidirectional—frames are to/from different N_Ports or storage devices) or in duplex mode (frames are to/from the same N_Port and storage device). The FOSAs are connected via a fiber cable that consists of two fiber strands. The fiber cable has one twist when the cable is installed, which allows the transmit port of the FOSA at one end of the cable to be connected to the receive port of the FOSA at the other end of the cable.

Either a long wavelength (LX) laser signal at 1300 nanometers or a short wavelength (SX) laser at 850 nanometers can be used for the FICON channel FOSA or the FICON control unit FICON port. The LX FOSA requires either a single-mode cable connection or an MCP multimode cable connection to allow re-use of either 62.5 µm or 50 µm fiber cables. The LX FOSA uses an SC Duplex connector. FICON Express LX and SX FOSAs are using LC type connectors.

Figure 5-3 on page 73 illustrates the five cabling options in conjunction with the FOSA types; these are:

1. LX FOSA - single-mode 9 µm fiber cable
2. LX FOSA - MCP and multimode fiber cable (50 µm)
3. LX FOSA - MCP and multimode fiber cable (62.5 µm)
4. SX FOSA - multimode 50 µm fiber cable
5. SX FOSA - multimode 62.5 µm fiber cable

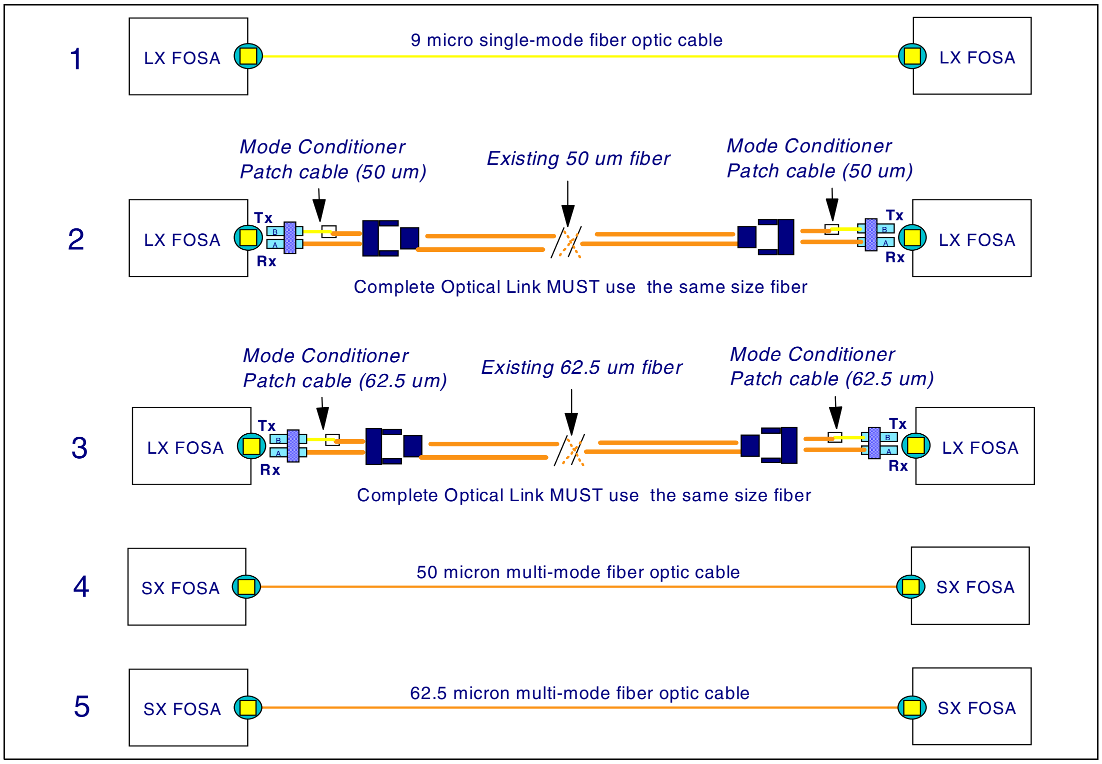

Figure 5-3 FICON fiber cabling options

5.3.2 Link loss budget

The term *link loss budget* is used to specify how much loss (attenuation) in signal strength can be tolerated and still allow the receiver to interpret an accurate signal. Many factors can reduce (attenuate) the signal strength through an optical link, such as:

- Fiber distance
- Fiber patch panel connections
- Broken, bent, or crimped fiber cables
- Fiber splices
- Dirty or damaged fiber connectors

The optical link will not function properly if too many of these combined factors attenuate the signal. It is important that the fibers do not have a link loss that exceeds the link budget of the optical link. The signal strength loss is measured in decibels (dB).

5.3.3 Distance considerations

When 9 micron single-mode fiber is used, which is a prerequisite for LX FOSAs, the maximum unrepeated fiber length distance supported is 10 km. An RPQ can be submitted to determine if the link environment (quality of signal) will support a distance of up to 20 km at 1 Gbps or up to 12 km at 2 Gbps. This requires that the attenuation of the signal does not exceed the allowable link loss budget.

The maximum supported link loss budget between two LX FOSAs connected via single-mode cables is 7 dB.

Note that when using MCP cables, the supported distance is reduced to 550 m for 62.5 micron and 50 micron multimode fiber between the two MCP cables, and the maximum supported link budget loss is 5 dB.

For SX FOSAs, either 62.5 micron or 50 micron multimode fiber cables are required. The main difference between the options is the maximum supported distance. For 62.5 µm the maximum distance is 250 m and for 50 µm the maximum distance is 500 m.

The maximum supported link loss budget between two SX FOSAs is 6 dB.

Key considerations for fiber connection distances are:

- Optical distance, which depends on:
  - Type of FOSA - long wavelength (LX) or short wavelength (SX)
  - Type of fiber optical cable used - 9 µm, 62.5 µm, 50.0 µm, or re-use with MCPs
- Fibre Channel link distance (performance impact), which depends on:
  - The number of buffer credits at the N_Port and/or F_Port. For example, 60 buffer credits are required to support a 100 km FC link distance.
- FICON Channel to CU end-to-end distance (performance impact):
  - The end-to-end (N_Port to N_Port) supported distance is 100 km.
  - For distances over 100 km, CCW and data pipelining droop can occur.
  - IU (Information Unit) pacing count for the FICON channel is 16

For example, an SX FOSA does not support FC Links over kilometer distances, whereas an LX FOSA does. Or if a FICON native product is selected that supports less than 60 buffer credits per FC port, performance will be impacted at a distance of 100 km. In addition, it should be noted that light takes time to travel over 100 km. At least a 2 ms response time increase should be assumed for each I/O operation, if the distance is 100 km.

Figure 5-4 on page 75 illustrates the maximum distance dependencies based on the FOSA type and fiber cable type. Along with the FOSA type and fiber cable type, the diagram also indicates which connector types are supported.

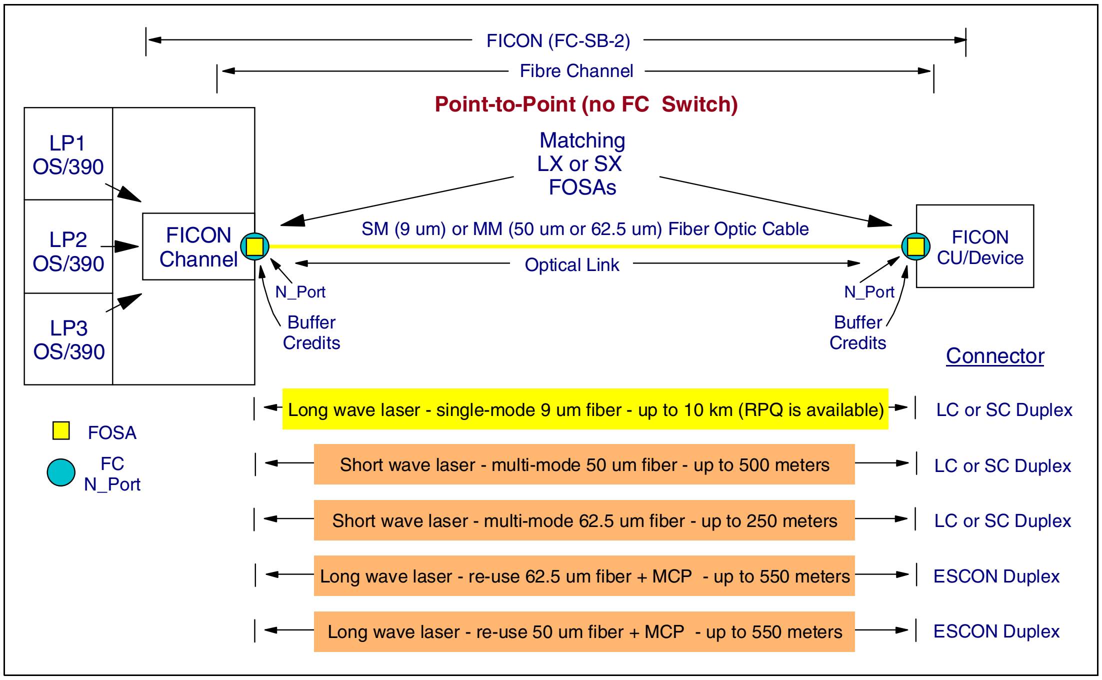

Figure 5-4 Distances, fiber mode, connectors

Figure 5-5 illustrates the distance and buffer credit dependencies for the optical link and the FC Link.

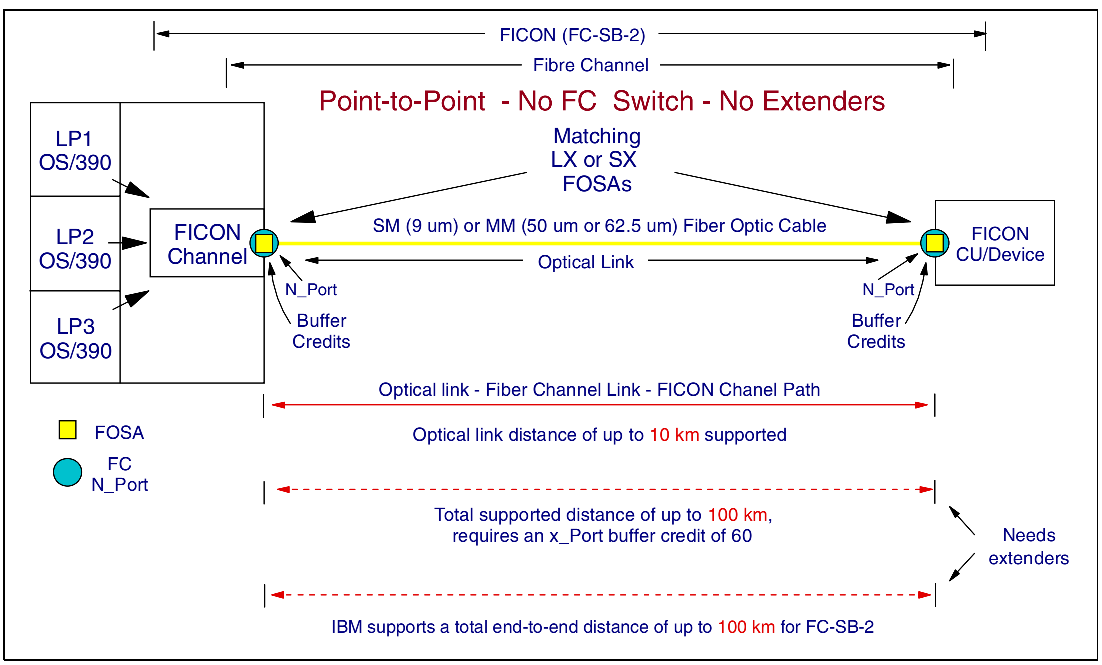

Figure 5-5 Point-to-point distances

Figure 5-6 on page 76 shows that different connections are possible using LX and SX FOSAs in a single FC switch. In this example, zSeries 1 and CU 1 can still communicate even though they both have dissimilar FOSA types. This is because the FOSA types need only match at the ends of each FC link.

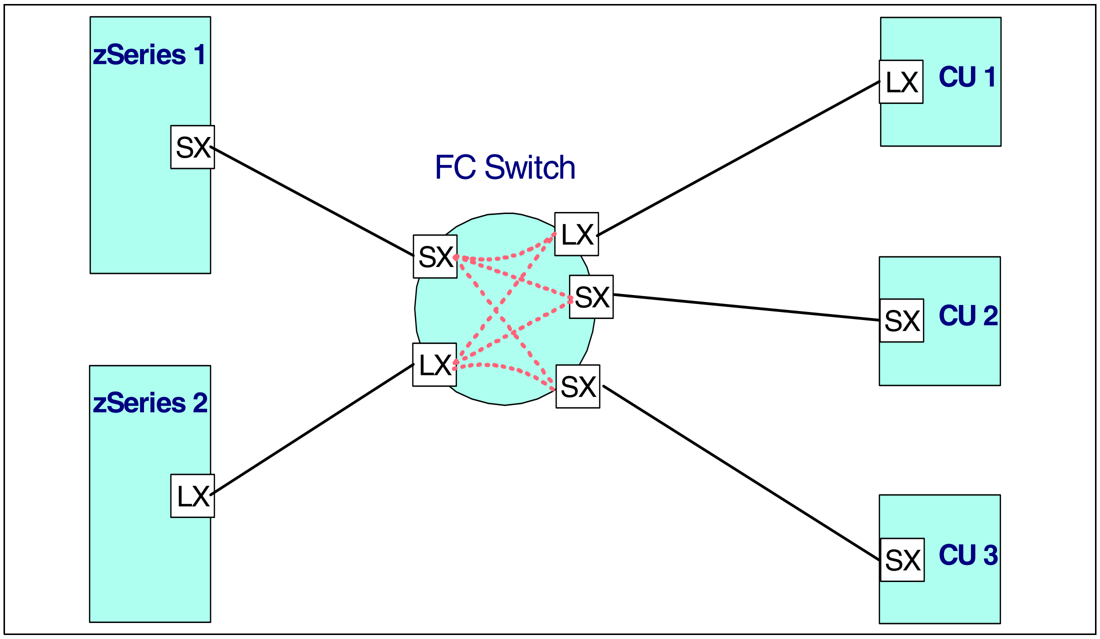

Figure 5-6 Mix of LX and SX FOSAs in a switched point-to-point environment

Table 5-2 summarizes the FICON cabling-specific items. It does not include specific information about fiber extender/repeaters.

Table 5-2 FICON cabling specifications

Channel/Use	FOSA	Trunk Fiber Specification	Plug Type	Distance (Unrepeated)	Loss Budget	Notes
FICON (1.063 Gb) LX FOSA	Laser LX-1300 nm	Single-mode: 9 um	SC-Duplex (sm)	10 km 20 km (RPQ)	7.8 dB	100 km via repeaters. Requires matching LX FOSA optics
FICON (1.063 Gb) LX FOSA **Mode Conditioner Cable (FC 0106)**	Laser LX-1300 nm	Multimode: 62.5 um Mode Conditioner Patch cable (Trunk Fiber re-use)	SC-Duplex (sm) and ESCON	550 m	5 dB	All Fiber between mode conditioners must be 62.5 um. Requires matching LX FOSA optics.
FICON (1.063 Gb) LX FOSA **Mode Conditioner Cable (FC 0103)**	Laser LX-1300 nm	Multimode: 50 um Mode Conditioner Patch cable (Trunk Fiber re-use)	SC-Duplex (sm) and ESCON	550 m	5 dB	All Fiber between mode conditioners must be 50 um. Requires matching LX FOSA optics.
FICON (1.063 Gb) SX FOSA	Laser SX-850 nm	Multimode: 50 um	SC-Duplex (mm)	500 m	3.8 dB	Requires matching SX FOSA optics.
FICON (1.063 Gb) SX FOSA	Laser SX-850 nm 200 MHz 160 MHz	Multimode: 62.5 um Multimode: 62.5 um	SC-Duplex (mm) SC-Duplex (mm)	up to 300 m up to 250 m	3.0 dB 2.8 dB	Requires matching SX FOSA optics.
FICON (2.125 Gb) LX FOSA	Laser LX-1300 nm	Single-mode: 9 um (Use of Mode Conditioner Patch cables is not supported)	LC-Duplex (sm)	10 km 12 km (RPQ)	7.8 dB	Requires matching LX FOSA optics
FICON (2.125 Gb) SX FOSA	Laser SX-850 nm	Multimode: 50 um	LC-Duplex (mm)	up to 300 m	2.78 dB	Requires matching SX FOSA optics
FICON (2.125 Gb) SX FOSA	Laser SX-850 nm	Multimode: 62.5 um	LC-Duplex (mm)	up to 120 m	2.22 dB	Requires matching SX FOSA optics

Note that the distances shown in Table 5-2 on page 76 are always dependent on the specification and quality of the fiber cable. Specifications for the fiber cable standards are documented in the Fibre Channel - Physical Interface (FC-PI) ANSI document ANSI NCITS xxx-200x FC-PI T11/Project 1235D. This document can be obtained from:

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www.t11.org
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5.4 Fiber extender and fiber repeater

Figure 5-7 shows the distance and buffer credit dependencies for the optical link and the FC link in a switched point-to-point configuration.

Note that when using a fiber extender, the short haul optical link distance between the attaching FICON FOSA N_Port (Channel Switch Port or FICON CU Port) and the fiber extender optical channel interface may be limited.

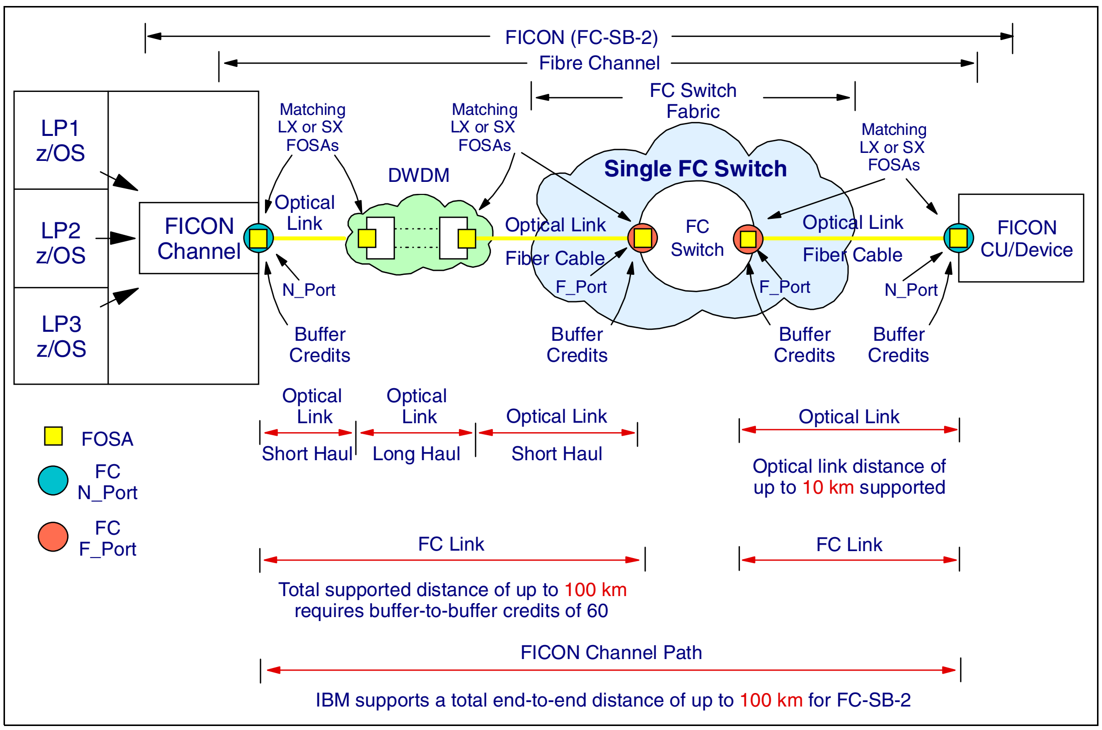


Figure 5-7 Switched point-to-point distances, using DWDM

Figure 5-7 and Figure 5-8 on page 78 show examples of FC Links using DWDMs. The connection between the DWDMs and the FC port (FICON channel FC port, or Switch FC port) is referred to as the “short haul” distance.

The short haul distance for the Finisar repeater is 200 m, and the short haul distance for DWDM is limited to 500 m for MM fiber and 1000 m for SM fiber.

The maximum long haul distance for FICON channels supported by the Finisar repeater is 120 km compared to 50 km (70 km RPQ) for the DWDM. The Finisar product and the IBM-certified DWDM vendors support both FOSA types (LX and SX) for their short haul connection.

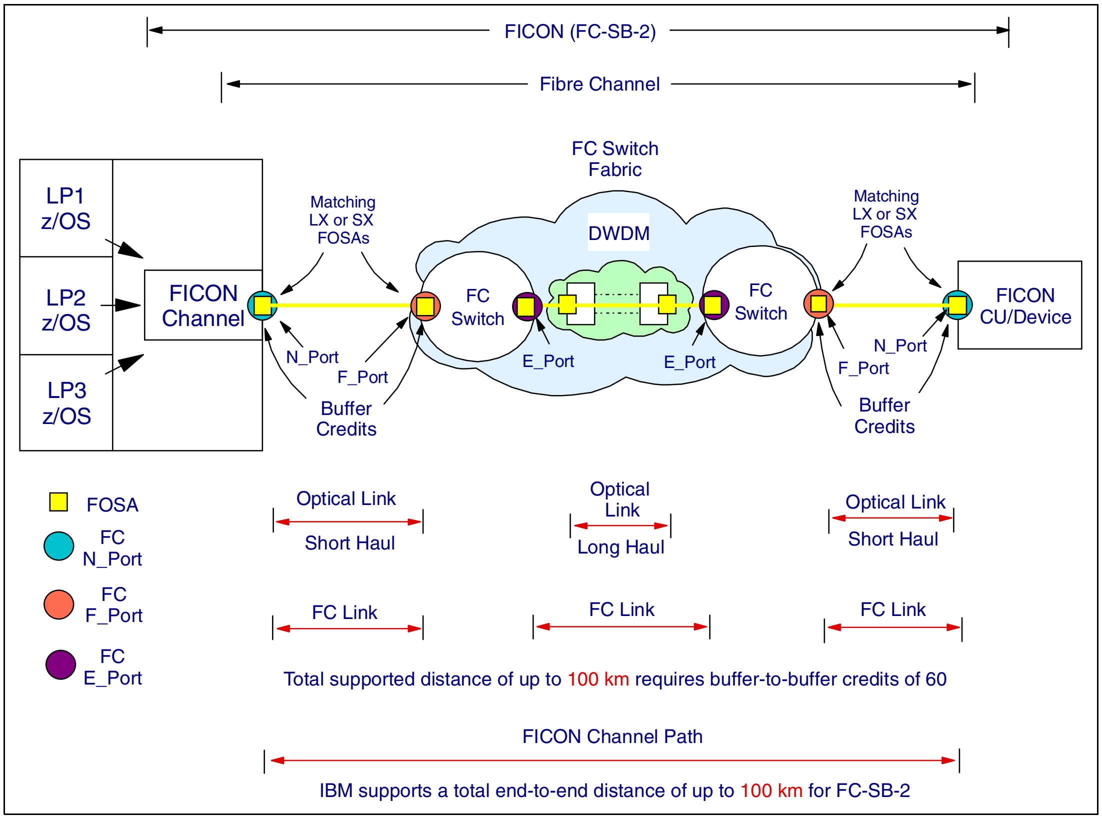


Figure 5-8 Cascaded FICON Directors, using DWDM

Figure 5-9 shows an example of an FC Link using a single FICON repeater such as the product available from Finisar Corporation.

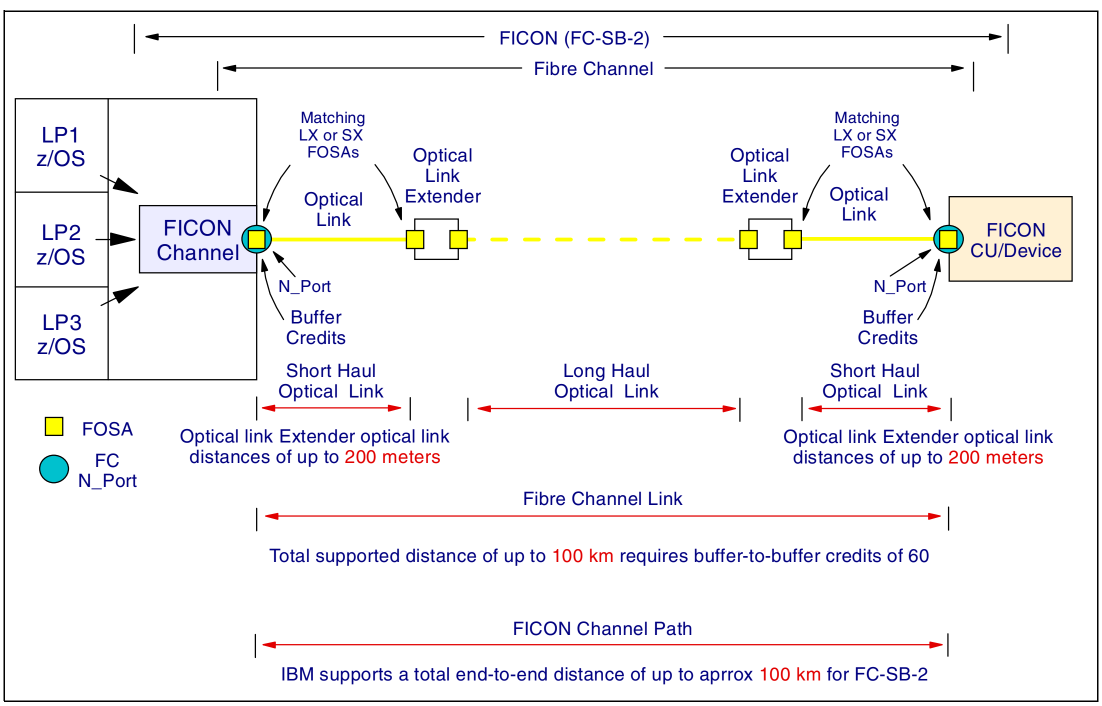


Figure 5-9 Optical link extender

5.5 Reusing of existing cables and trunks

FICON LX channels usually use a single-mode 9 micron fiber cable infrastructure. However, FICON LX channel configurations can also reuse an existing multimode fiber infrastructure, through the use of MCP cables.

Reusing existing 62.5 and 50 micron multimode fiber is supported for up to 550 m. This requires the use of the MCP cables, one at each end of the link. The MCP cables are available for the reuse of existing ESCON multimode fiber optic cables that have IBM ESCON type connectors on the end of the cables.

When the MCP cables are used, there is a reduced link loss budget of 5 dB versus 7 dB for normal use of single-mode fiber.

Two MCP cables are required per multimode optic link (a link as stated here is the connection between two fiber optical ports).

The MCP cables enable a single-mode laser signal to transfer to a multimode fiber with minimal impact to the transmission signal due to the modal noise problem caused by light dispersion of the 1300 nanometer laser signal being transmitted through a multimode fiber cable.

The construction of the MCP cable is shown in Figure 5-10.

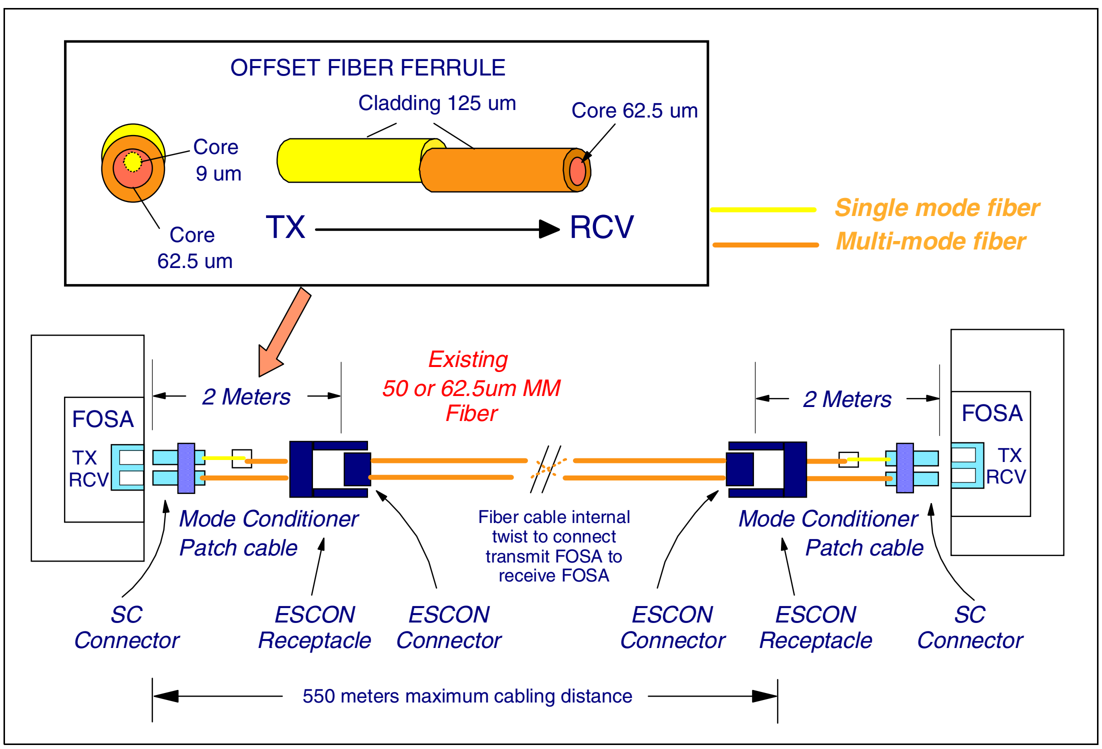


Figure 5-10 Mode Conditioner Patch cables for reusing ESCON multimode fiber

An MCP cable is 2 m in length and consists of three pieces of fiber cabling (fiber strands), an FCS Duplex connector, an MCP offset ferrule, and ESCON Duplex connector.

These are connected as follows:

- The Fiber Channel Standard (FCS) Duplex connector, which is equivalent to an SC Duplex connector, is connected to two fiber strands:

– A 9 micron single-mode fiber that is connected to the MCP offset ferrule.
– A multimode fiber that connects straight through to the ESCON Duplex connector.

- The ESCON Duplex connector is connected to two fiber stands:
  – A multimode fiber that is also connected to the MCP offset ferrule.
  – A multimode fiber that connects straight through to the FCS Duplex connector.

The purpose of the single-mode to multimode fiber offset ferrule is to allow the transit of a laser signal from a single-mode fiber to a multimode fiber. For this to happen, the two fibers are offset from one another where they join inside the encapsulated ferrule.

As the laser signal travels through the multimode fiber, there is a dispersion of the signal and therefore, effectively, an attenuation of the signal. Because of this attenuation, the supported distance between the two LX FOSAs is reduced to 550 m, as shown in Figure 5-11.

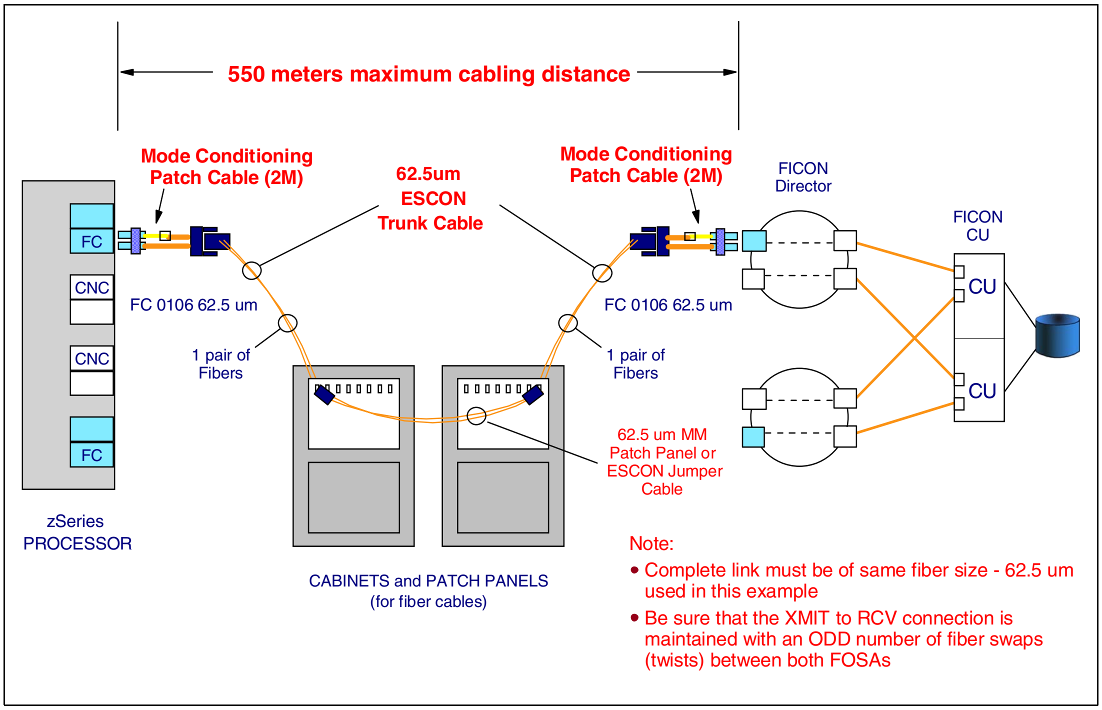


Figure 5-11 Mode Conditioner Patch cables - patch panels

Note that the patch panels may still be used in a multimode fiber cabling infrastructure. The conditions that must be observed are:

- The correct MCP cable (50 or 62.5) must be used to connect to the multimode fiber infrastructure.
- Only two MCP cables are ever required in the FICON fibre channel link.
- The same fiber size (62.5 micron or 50 micron) must be used all the way between the two MCP cables in the fibre channel link.
- Correct connectors at the MCP cable end (ESCON Duplex connector).
- There must still be an odd number of cable twists between the two FOSAs.

When MCP cables are used, they must be plugged directly in the LX-FOSA. No other fiber cable must be placed between the MCP and the FOSA, as shown in Figure 5-12 on page 81.

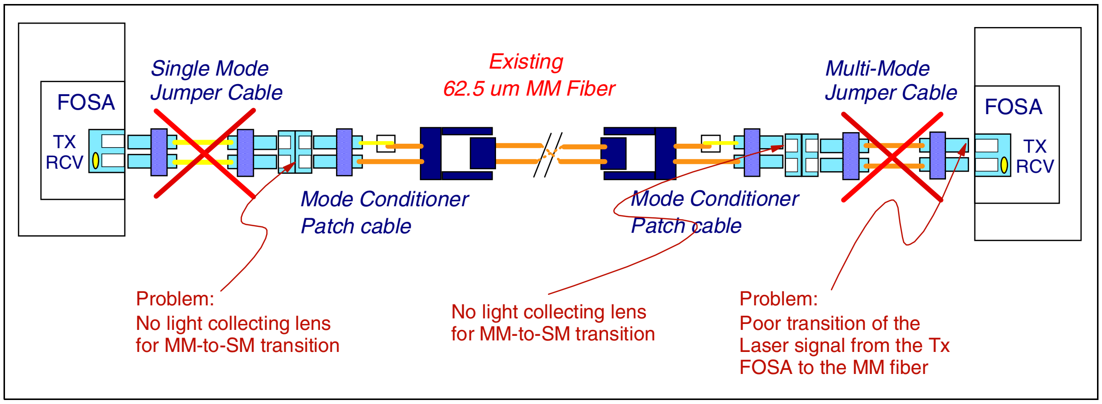


Figure 5-12 Mode Conditioner Patch cables - invalid use

If a 9 micron single-mode fiber cable is incorrectly placed between the MCP and the FOSA, then the incoming receive signal will not pass successfully between the end of the MCP and the 9 micron single-mode fiber. Normally the MCP is plugged into the FOSA, which has a receive signal lens, and it can collect most of the incoming signal, whereas most of the signal is lost when passing between the MCP and a single-mode fiber cable.

If a 62.5 multimode fiber cable is incorrectly placed between the MCP and the FOSA, then the outgoing transmit signal will not pass successfully between the FOSA and the end of the incorrectly placed multimode fiber cable. This is because a laser signal is trying to transit from a single-mode fiber cable to a multimode fiber cable without an offset between the two fibers.

5.6 Mixed cabling implementation example

Figure 5-13 on page 82 shows an example of cabling implementation options for the different FOSA connections. For example, an LX single-mode implementation for the FICON channel to FICON Director can be used at the same time as an SX multimode implementation between the FICON Director and the FICON control unit adapter. However, the different attenuation values and the different distance values must be taken into consideration. The configuration should be checked against the information shown in Table 5-2 on page 76.

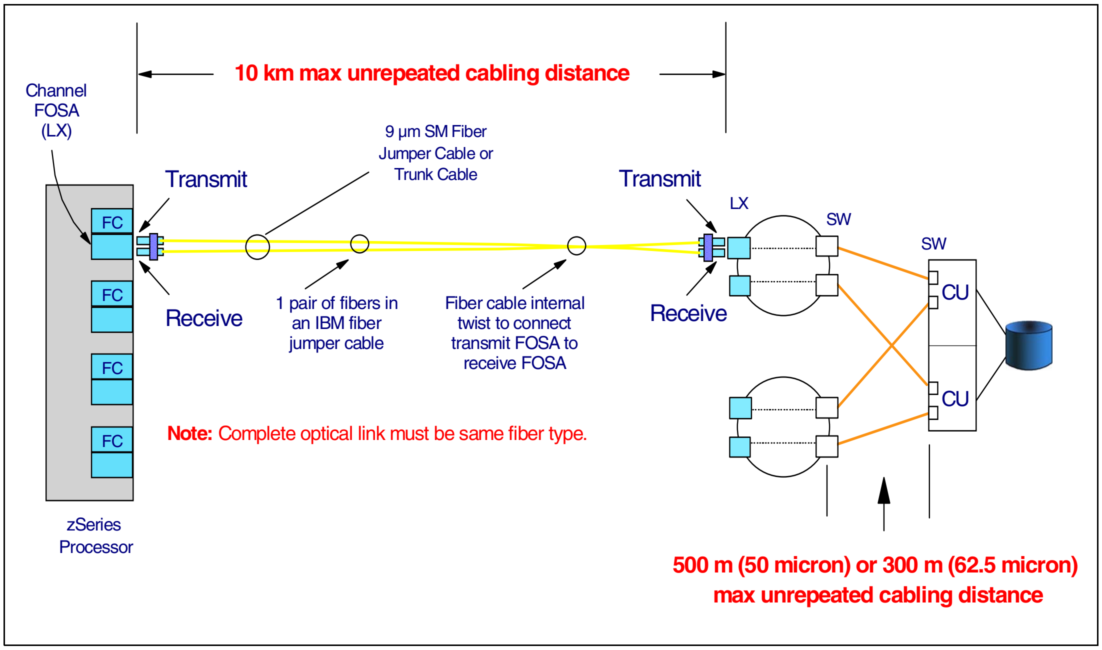


Figure 5-13 Mixed cabling implementation

Repeaters can be used to extend the distance between the FICON channel and the FICON control unit up to 100 km.

FICON links can also be extended via a Dense Wavelength Division Multiplexer, which can run a number of protocol-independent data channels over two pairs of optical fibers to distances of 50 km and more upon RPQ request and cascading.

Currently, IBM has certified the following DWDMs and optical amplifiers:

- Cisco ONS 15540 ESP (LX, SX) and optical amplifier (LX, SX)
- Nortel Optera Metro (5200 and 5300E) and optical amplifier

For migration purposes IBM supports an intermix of ESCON (CNC), FICON Bridge (FCV) and FICON (FC) channel paths defined from one z/OS image to the same CU image. Be aware of the specific characteristics (attenuation, distance) of the different FOSAs (LX and SX) and the different fiber cabling (SM, MM, MCP) usage.

6

z/OS and OS/390 software support

This chapter describes the software support available on the z/OS and OS/390 platforms for FICON native (FC) channels, control units, and devices that attach to FC channels. Only minor software changes are required in order to exploit the full functionality of FICON.

FICON channels provide enhanced performance for the execution of channel programs that allow the use of CCW and data prefetching and pipelining. The FICON channel protocols are fully compatible with existing channel programs and access methods. IBM software has been changed to exploit this function but an installation should review the readiness of its non-IBM software. Refer to 9.2.1, “Channel programming considerations” on page 143 for further software considerations in a FICON native (FC) environment.

Also be aware that vendor-written UIMs may need to be upgraded for FICON support. Refer to “Vendor UIMs” on page 144 for more information.

6.1 z/OS and OS/390 FICON APARs

FICON native (FC) channels are supported by z/OS R1 with APAR OW47844 and OS/390 V2.6 and later releases. Note that FICON Bridge (FCV) support has been available since OS/390 V1.3 and later releases.

FICON support of cascaded Directors is available with z/OS V1.4 and V1.3 plus PTFs. This support is only provided on the zSeries processors.

There is no unique PSP bucket for FICON. For both z/OS and OS/390, the FICON support information is contained in the PSP buckets for the processor and control units, listed in Table 6-1.

Table 6-1 Processor/CU PSP buckets for z/OS and OS/390 FICON support

Processor/CU	Upgrade	Subset
zSeries 800	2066device	2066/OS390 or 2066/ZOS
zSeries 900	2064device	2064/OS390 or 2064/ZOS
9672 G5/G6	9672device	9672OS390G5+
McDATA	2032device[a]	2032/OS390
INRANGE	2042device[a]	2042/OS390
IBM 2105	2105device	
IBM 3170		
IBM 3590	3590device	

a. Although the PSP upgrade name for the INRANGE FICON Director is 2042device, this device and the McDATA FICON Director are both defined as device type 2032 in HCD and IOCP.

Table 6-2 contains a list of APARs required by different z/OS and OS/390 components and products for FICON support or exploitation. Some of the APARs listed have been available for some time since they provide exploitation of CCW pipelining and other features that were introduced for the initial FICON implementation, FICON Bridge (FCV).

Table 6-2 APARs for support of FICON, including FICON native (FC)

Component	APAR
HCD	OW43131, OW48236[a], OW54246[a] (for zSeries) OW43132 (for 9672 G5/G6)
IOCP	OW46633, OW52993[a] (for zSeries) OW45473 (for 9672 G5/G6) II02369
IOS, EXCP	OW38541, OW41432, OW47844 OW44429, OW47519 (FICON Management Server Feature), OW49661[a], OW55513, OW55514[a], OW55515[a]
IPL/NIP	OW38549
DFSMS FICON ESS Device Support Code	OW47935, OW47937

Component	APAR
SA OS/390	OW40040 (for V1.3) OW47972 (for V2.1) OW54640
ESCON Director Device Support Code	OW38551, OW44017,OW48996 OW44428 (FICON Management Server Feature)
JES2	OW34568
OEM RDS Channel Extender	II12081
Standalone Dump	OW38669
ICKDSF	PQ20391
ASM	OW38547
JES3	OW31828
DFSMS (XRC)	OW35687
DFSMS	OW37135, OW34237, OW34073, OW34071, OW34231, OW40237
IEBCOPY	OW34232, OW39328
IEWFETCH	OW34234
DSS	OW34111
PSF 3.2 for OS/390	OW44362
OAM	OW34112
RMF	OW35586,OW46170, OW46825 (FICON Management Server Feature), OW52396[a]
SRM	OW38548
GTF	OW37986
HCM	IR39712 (FCV only), IR42956(FCS), IR46549[a]
RACF	OW34103
IMS	PQ26718

a. Required for FICON support of cascaded Directors.

This list of APARs may be incomplete. The latest copy of the Preventive Service Planning (PSP) bucket for the processor or control unit should always be reviewed prior to installation.

6.2 HCD

HCD support for the zSeries processors, including FICON native (FC) channels, is provided with APAR OW43131. The PTFs that implement APAR OW43131 for the different releases of HCD are listed in Table 6-3 on page 86.

Table 6-3 HCD support for FICON native (FC) channels on zSeries processors

HCD release	PTF for OW43131	PTF for OW48236	PTF for OW54246
R051	UW99341	UW99419	
R053	UW99342		
R054	UW99343		
R091	UW99344	UW99420	UW92937
R092		UW99422	
R094	UW99345	UW99421	UW92938

APAR OW43132 provides HCD support for FICON native (FC) channel paths starting with OS/390 R5 HCD on 9672 G5 and G6 machines. The PTFs that implement APAR OW43132 for the different releases of HCD are listed in Table 6-4.

Table 6-4 HCD support for FICON native (FC) channels on 9672 G5/G6 processors

HCD release	PTF for OW43132
R501	UW99287
R521	UW99288
R031	UW99289
R051	UW99290
R053	UW99291
R054	UW99292
R091	UW99293
R094	UW99294

6.2.1 HCM

No specific maintenance is required for FICON native (FC) support in HCM, other than UR90335 or UR90336 for support of cascaded FICON Directors. From HCM's perspective, a FICON native (FC) channel is just like any other channel. HCM uses HCD as a server on the host side, and any change in HCM that concerns the logic or structure of the configuration, such as creating, deleting, or changing an object, is validated by HCD. Also, the configuration diagram support does not need to be changed because connections between FC channels look exactly the same as ESCON channel connections.

To summarize, HCM supports FICON native (FC) channels but does not require additional maintenance for FC support; the support for FC channels is provided through HCD.

Two HCM APARs in the FICON area should be discussed in order to avoid confusion. They are APAR IR39712 and IR42956.

- APAR IR39712 introduced the conversion utilities to ease the customer migration to a FICON Bridge (FCV) environment. The Convert ESCON Port to FC utility enabled customers to easily adapt their configuration when a FICON Bridge (FCV) card is added in the 9032-5 ESCON Director. This utility does not work for FICON native (FC) channels, because an ESCON (CNC) channel can explicitly be converted to an FCV channel but never to an FC channel, for example.

- APAR IR42956 introduces HCM support for the generic Open Fibre Switch (FCS), with the following characteristics:
  – FCS switches do not support switch control units and devices, and port 'FE' is not an internal port for FCS.
  – No minimal port range needs to be installed.
  – Control units and channel paths can be connected to all ports.
  – Ports '00' - 'FF' are supported.

Neither the INRANGE nor the McDATA switches are ‘FCS’ switches; they are defined as 2032 FICON Directors, which includes support for a control unit port (CUP).

6.3 IOCP

This section describes the IOCP software requirements for the zSeries processors and the 9672 G5/G6 processors.

6.3.1 zSeries processors

IOCP support for the zSeries processors, including FICON native channels, is provided in a IOCP program, IYPIOCP 1.1.0, which is shipped in PTF UW90695 for APAR OW46633. In preparation for upgrading to a zSeries processor model, IOCP can write a zSeries processor IOCDS to a 9672 G5/G6 processor provided it has EC F99939 (driver 26) installed. The IOCP execution parameter CHECKCPC should be used. The IOCDS will not be usable until the processor is upgraded to a zSeries.

The publication *zSeries Input/Output Configuration Program User's Guide for IYP IOCP* , order number SB10-7029 is available at:

`http://www.ibm.com/servers/resourcelink`

Select **Library** -> **zSeries 900** -> **Hardware**.

Equivalent standalone IOCP for IYPIOCP version 1.1.0 is shipped in EC H25117 (DR36J/Version 1.7.0, driver 36) for the zSeries processor. UW99409 introduces version 1.2.0 for support of cascaded FICON Directors on the zSeries processors. The standalone IOCP version and release can be determined by looking at the header lines of the IOCP reports produced by standalone IOCP. The standalone IOCP version and release can also be determined from the Hardware Management Console or Support Element by following the procedure described in A.2, “Determining the stand-alone IOCP release” on page 210.

FICON native (FC) channel support on the zSeries processors is provided in an MCL for driver 38. FICON support of cascaded Directors is provided in an MCL for driver 3G. The EC level of the CPC can be determined from the Hardware Management Console or Support Element by following the procedure described in A.1, “Determining the EC level of the CPC” on page 210.

6.3.2 9672 G5/G6 processor

IOCP support for FICON native channels on the 9672 G5 and G6 models is provided by PTF UW72160 for APAR OW45473, which introduces IZPIOCP 1.8.2. The publication *Input/Output Configuration Program User's Guide and ESCON Channel-to-Channel Reference,* GC38-0401-12, deals with the 9672 G5 and G6 processors.

Equivalent standalone IOCP for IZPIOCP version 1.8.2 is shipped in EC F99918 (driver 26) for 9672 G5 and G6 models. The standalone IOCP version and release can be determined by looking at the header lines of the IOCP reports produced by standalone IOCP. The standalone IOCP version and release can also be determined from the Hardware Management Console or Support Element by following the procedure described in A.2, “Determining the stand-alone IOCP release” on page 210.

FICON native (FC) channel support on the 9672 G5/G6 processors is provided in an MCL for driver 26. The EC level of the CPC can be determined from the Hardware Management Console or Support Element by following the procedure described in A.1, “Determining the EC level of the CPC” on page 210.

6.4 System Automation I/O-Ops

System Automation for OS/390 (S/A) I/O-Ops is an important tool in an environment that includes ESCON and FICON channels. It enables the operator to manage an I/O configuration that includes ESCON and FICON Directors, and provides for faster and more focused problem determination in this environment.

SA I/O-Ops V2.1 includes support for FICON Native (FC) channels and FICON Directors. An additional APAR, OW47972, is required to correct problems with the FICON Director support.

SA I/O-Ops V1.3 adds support for FICON Native (FC) channels and FICON Directors with APAR OW40040 (PTFs UW69057 for RA30 and UW69058 for RA3U). APAR OW48434 is also recommended.

APAR OW49278 describes a problem with the I/O-Ops interface to the McDATA ED-5000 FICON Director. Before using I/O-Ops with a FICON configuration, check the latest maintenance recommendations in the product’s PSP buckets, as shown in Table 6-5:

Table 6-5 SA OS/390 I/O-Ops PSP buckets

Upgrade	Subset
HKYS100	HKYS100
JKYS103	JKYS103

Note that there are few changes to I/O-Ops for FICON Native (FC) support. There are no new commands, and the existing commands CONNECT/DISCONNECT and CHAIN/UNCHAIN are not allowed with FICON Directors because they do not support dedicated connections.

6.4.1 FICON Director management software

Both INRANGE and McDATA provide workstation software to manage the FICON Directors.

6.5 RMF

RMF has been changed to support FICON channels. With APAR OW35586, RMF extended the information in the Channel Path Activity reports of all monitors by reporting about data transfer rates and bus utilization values for FICON Bridge (FCV) and FICON native (FC) channels. There are five measurements reported by RMF in a FICON channel environment:

- Bus utilization
- Read bandwidth for a partition in MB/sec

- Read bandwidth total (all logical partitions on the processor) in MB/sec
- Write bandwidth for a partition in MB/sec
- Write bandwidth total in MB/sec

More information about the fields reported by RMF for FICON channels can be found in 11.4, “RMF reporting for FICON” on page 207. Details of the changes to SMF records are listed in Appendix B, “SMF record changes for FICON” on page 211.

RMF also provides the FICON Director Activity report when the APAR OW44428 in support of ESCON Director Device support and APAR OW52396 are applied, and the FICON Directors provide measurements. Note that this function is not available if the FICON Director is not defined as a device in HCD and IOCP (see 8.2.3, “FICON Director (2032)” on page 131).

6.6 DFSMS

FICON device support for the ESS 2105 is provided with DFSMS APARs OW47935 and OW47937.

The changes to DFSMS components, including IEBCOPY, IEWFETCH, ICKDSF, and so on, in support of FICON are to take advantage of the performance enhancements inherent in the operation of the FICON channel, including both FICON Bridge (FCV) and FICON native (FC). The operation of the FICON channel during the execution of a specific channel program is controlled by the setting of bits in the Operations Request Block (ORB), which is built by the I/O Supervisor for each SSCH instruction. The bits include the ORBP (allowing CCW and data pipelining), ORBY (controlling synchronization on read-write transition in the channel program) and ORBM (PCI synchronization). The changes are transparent to users of DFSMS components and IBM utilities. More information can be found in 11.1, “Fibre Channel FICON operation” on page 188.

6.7 z/VM and VM/ESA

z/VM and VM/ESA 2.4.0 contain support for FICON. VM/ESA 2.2.0 for guest operating systems requires APAR VM62090 for FICON support. VM/ESA 2.3.0 for native VM requires APAR VM62710 for FICON support. In addition, the APARs listed in Table 6-6 are recommended:

Table 6-6 z/VM and VM/ESA APARs for FICON support

APAR	Description
VM62643	McDATA and Inrange FICON Director support
VM62710	Second CCW support - tape error recovery
VM62665	IYPIOCP 1.1.0 for zSeries
VM62539	IZPIOCP 1.8.2 for 9672 G5/G6

This list of APARs may be incomplete. The latest copy of the PSP bucket for the processor or control unit should always be reviewed prior to installation. Table 6-7 on page 90 shows the PSP buckets:

Table 6-7 Processor PSP buckets for z/VM and VM/ESA FICON support

Processor	PSP upgrade	PSP subset
zSeries 800	2066device	2066Z/VM 2066VM/ESA
zSeries 900	2064device	2064Z/VM 2064VM/ESA
9672 G5/G6	9672device	9672VM/ESA

6.8 VSE/ESA

VSE/ESA 2.3 contains support for FICON. Table 6-8 lists the recommended APARs:

Table 6-8 z/VM and VM/ESA APARs for FICON support

APAR	Description
DY45543	IYPIOCP 1.1.0 for zSeries
DY45407	IZPIOCP 1.8.2 for 9672 G5/G6

This list of APARs may be incomplete. The latest copy of the PSP bucket for the processor or control unit should always be reviewed prior to installation. Table 6-9 shows the PSP buckets:

Table 6-9 Processor PSP buckets for z/VM and VM/ESA FICON support

Processor	PSP upgrade	PSP subset
zSeries 800	2066device	2066VSE/ESA
zSeries 900	2064device	2064VSE/ESA
9672 G5/G6	9672device	9672VSE/ESA

6.9 TPF

TPF Version 4 Release 1 and subsequent releases contain support for FICON.

7

FICON channel configurations

This chapter covers FICON configuration design aspects, including point-to-point, switched point-to-point, and FICON support for cascaded Directors topologies.

It also discusses FICON and ESCON intermixed environments, connectivity recommendations, and configuration examples.

7.1 Differences between FICON channels and ESCON channels

Although FICON channels operate very differently from ESCON channels (as discussed in Chapter 11, “FICON channel operation and performance” on page 187), from the configuration design point of view (topologies) they are similar. The most important differences are:

- FICON switch connections are dynamic. ESCON allows static and dynamic connections in a switch.
- FICON channels can have multiple I/O operations concurrently for each control unit port, even to the same logical control unit. ESCON allows only one actively communicating I/O operation at a time.
- A FICON channel can receive multiplexed I/O frames from different control units in a switched point-to-point and cascaded FICON Director topologies.
- FICON channels support greater link distances than ESCON channels and the FICON link data droop effect occurs at greater distances than for ESCON.
- Intermixing control unit types with different characteristics like disk and tape on the same FICON channel does not cause the same communications lockout impact as can occur on ESCON.
- The channel-to-channel (CTC) function is fully implemented in FICON channels. Other CTC connections must use an ESCON (CTC) channel, which can be connected either to another ESCON (CNC) channel or to a FICON Bridge (FCV) channel through an ESCON Director with a FICON Bridge card.

7.2 FICON channel configuration support

When designing an I/O configuration, it is necessary to be aware of the architecture rules, the processor implementation, the connectivity topologies supported, the fiber cabling requirements, the connectivity recommendations, and the performance requirements.

- z/Architecture and S/390 ESCON and FICON architectures
  - Pathing rules, for example, up to eight paths to a device
  - Maximum specified architected resources
- z/Series and S/390 processor resource rules
  - Maximum resources that are implemented (CHPIDs, links, subchannels, buffer credits)
  - Hardware plugging sequence and hardware-assigned CHPID numbers, if CHPID Renumbering is not being used
- Switches and control units resource rules
  - Maximum resources that are implemented (ports, buffer credits per port)
- Topologies:
  - Point-to-point
  - Switched point-to-point
  - FICON support of cascaded Directors
- Path availability (multi-path CUs):
  - Spread the CU paths between zSeries and S/390 processor channels across different channel cards
  - Spread CU paths across different switches

– Spread CU path switch ports across different switch cards

- Performance considerations and expectations
  – Number of paths to a control unit
  – Number of control units using the same channel path
  – Number of different processor paths using the same destination switch port
  – Distances

7.2.1 Design steps

There is a sequence of steps that need to be planned when designing and implementing a FICON channel configuration. These are:

1. Configuration design and ordering
   – Understand the zSeries and S/390 processor channel resources that are supported.
   – Understand the zSeries and S/390 channel-to-control unit topologies that are supported.
   – The addressing and connectivity characteristics of the control unit to be attached.
2. The differences between a FICON channel connection and an ESCON channel connection, and the benefits of one over the other
   – Addressing (from 1024 device addresses for ESCON to up to 16,384 for FICON)
   – Reduced number of channels and required fibers with increased bandwidth and I/O rate per FICON channel
   – More I/O concurrency (up to 16 or more) of the FICON channel
   – Greater channel and link bandwidth (from 17 MB/s for an ESCON channel and 20 MB/s for an ESCON link to up to 60 MB/s for the initial implementation of the FICON channel and 200 MB/s full-duplex for the FICON link)
   – FICON path consolidation using switched point-to-point topology
   – Greater un-repeated fiber link distances (from 3 km for ESCON to up to 10 km, or 20 km with an RPQ, for FICON)
   – Performance droop distance extended (from 9 km for ESCON to up to 100 km for FICON)
   – Intermixing of CU types with different channel usage characteristics, like disk and tape, on the same FICON channel
3. Configuration planning
   – zSeries and S/390 processor CHPID impact (CHPID numbers and number of FICON channel per processor)
   – Switch port impact, if used (reduced number of FICON ports)
   – Installation sequence
   – Installation phases
4. Implementation planning
   – Task list for each customer installation phase
5. Installation tasks
   – Installation of the IBM zSeries or S/390 processor FICON channels, switches (if required) and control units with FICON adapters, all of which are required to follow the IBM installation sequence and the customer installation phases

7.3 FICON point-to-point configuration design

FICON point-to-point configurations are implemented via connections between a FICON channel in the zSeries or S/390 server and FICON ports in the control unit without a switch in the path.

ESCON point-to-point configuration

Figure 7-1 shows a typical ESCON point-to-point configuration that is used as a base to be compared to a FICON point-to-point configuration.

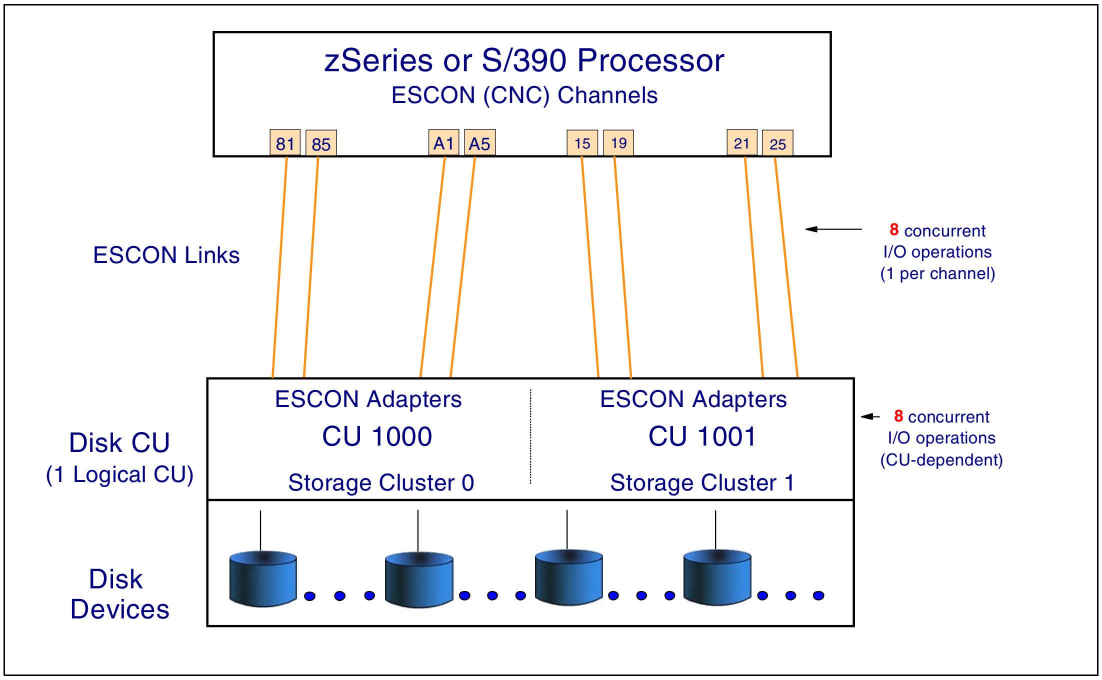


Figure 7-1 ESCON point-to-point configuration

For maximum I/O concurrency to a multipath control unit, it is recommended that the number of paths from a processor image that are defined to access (and be configured to) a control unit and device be equal to the maximum number of concurrent I/O operations that the control unit can sustain. The z/Architecture and S/390 architecture provide for a maximum of eight paths from a processor image to a control unit image.

Figure 7-1 shows the following:

- The need to ascertain from the control unit vendor the maximum number of concurrent I/O operations that are supported by the physical control unit

  Also determine if the physical control unit supports one or more logical control units (CUADD - CU addressing). The control unit vendor should be asked to provide all the control unit addressing and connectivity characteristics, because these affect how the control unit can be configured in a zSeries and S/390 environment.

- The number of ESCON interfaces that the control unit supports
- The connection of channel paths from a single processor image (these can be shared if the control unit supports shared channel paths) to up to eight interfaces on a multi-interface control unit

  Most ESCON-interfaced control units support shared channels.

- The use of eight ESCON channels

The ESCON configuration shown in Figure 7-1 on page 94 has the following I/O concurrency:

- Eight concurrent I/O operations are supported by the control unit.
- Eight control unit ESCON interfaces are used and these in total support eight concurrent I/O operations.
- Eight ESCON channels are used and these in total support eight concurrent I/O operations. Note that an ESCON channel can do only one I/O operation at a time.

FICON point-to-point configuration

The FICON point-to-point configuration shown in Figure 7-2 is based on the previous ESCON point-to-point configuration.

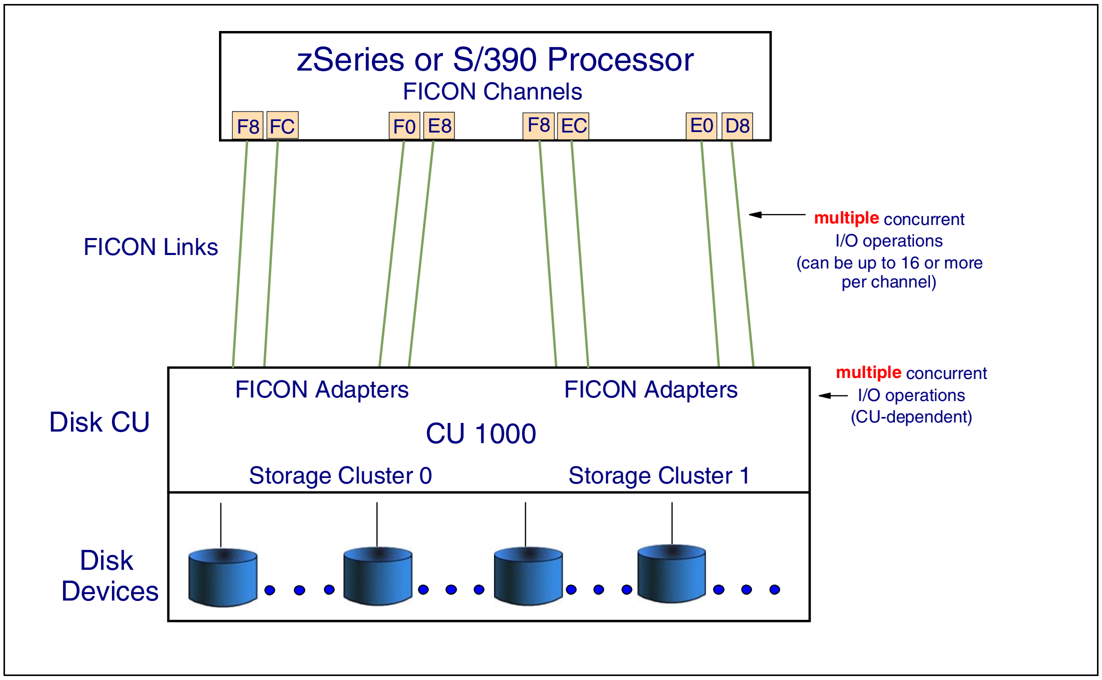


Figure 7-2 FICON point-to-point configuration

With the same number of processor channels (eight) and control unit adapters (eight), the I/O concurrency can be higher. Because one FICON channel is capable of doing up to 16 or more I/O operations at a time, even for the same logical control unit, the same configuration now has the capability of producing more concurrent I/Os, using a higher bandwidth. The number of concurrent I/O operations depends on the control unit characteristics.

The control unit vendor should be asked to provide all the control unit addressing and connectivity characteristics, because these affect how the control unit can be configured in a S/390 environment.

So, if the control unit and its adapters can do multiple I/O operations concurrently, the following are true:

- For the same I/O workload and throughput, fewer FICON channels and control unit adapters are required.
- Using the same number of resources (channels and adapters), a higher I/O workload and throughput can be sustained.

FICON channels can be shared between logical partitions, so multiple images running in the same zSeries or S/390 processor can use the same FICON channel simultaneously. This function is even more valuable in this environment as FICON channels have the capability of doing multiple I/O operations simultaneously. FICON-interfaced control units should support shared channels.

7.4 FICON switched point-to-point configuration design

FICON channels implement the switched point-to-point topology by using FICON switches (F_Ports) to connect FICON channels (N_Ports) to control unit FICON adapters (N_Ports). These connections are established as the server FICON channel Login Link Service FLOGI discovers that its N_Port is connected to a F_Port (switch port) and the control unit FICON port Login Link Service, FLOGI, discovers that its N_Port is also connected to an F_Port (switch port). For more details, see Chapter 3, “FICON architecture and addressing” on page 25.

This topology allows a much more flexible and dynamic environment and is required to exploit the I/O frame multiplexing capability of FICON channels.

All FICON switch connections are dynamic. So static connections, which are possible in an ESCON Director, are not supported in a FICON Director.

FICON protocol initially keeps its channel-to-CU path definition approach, which provides controlled access. It does not use a fabric port address discovery (N_Port) approach and requires a known fabric port address, which is the switch destination port.

Initially, FICON switched point-to-point topology does not implement switch cascading. Switch cascading is a switched point-to-point configuration with more than one dynamic connection in the path. Note that ESCON switched point-to-point configurations also do not support switch cascading, as one of the two possible switch connections must be static. This is a switch chaining configuration and there is no connectivity benefit other than distance extension for ESCON devices. FICON channels do not require any repeater or switch to reach up to 10 km (20 km with RPQ). So initially, only one FICON switch can be used between a FICON channel and a FICON control unit adapter.

zArchitecture and S/390 channel architecture rules

When designing a zSeries or S/390 I/O configuration, it is necessary to be aware of both the architecture and processor rules and recommendations.

The zSeries and S/390 processor channel path-to-control unit configuration architecture rules include:

- A logical CU and device cannot be accessed more than once from the same channel path (CHPID). This applies to both ESCON (CNC) channels and FICON channels.
- A physical control unit that has multiple logical control units (uses CUADD addressing) may be accessed more than once from the same FICON channel path, but to different logical control units (different CUADDs) within the physical control unit subsystem.

Figure 7-3 on page 97 shows an invalid configuration example that violates the single channel path to a logical control unit rule.

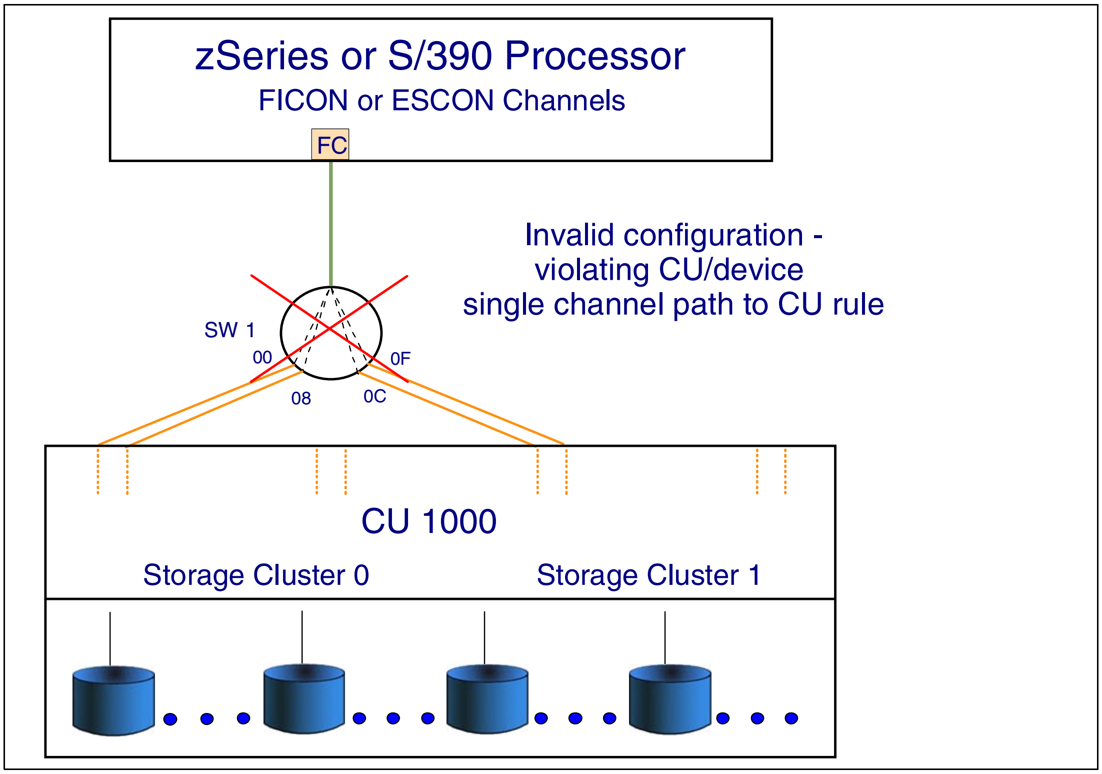


Figure 7-3 Invalid I/O configuration

ESCON switched point-to-point configuration

The typical ESCON switched point-to-point configuration, shown in Figure 7-4, is used as a base to be compared to the FICON switched point-to-point configuration.

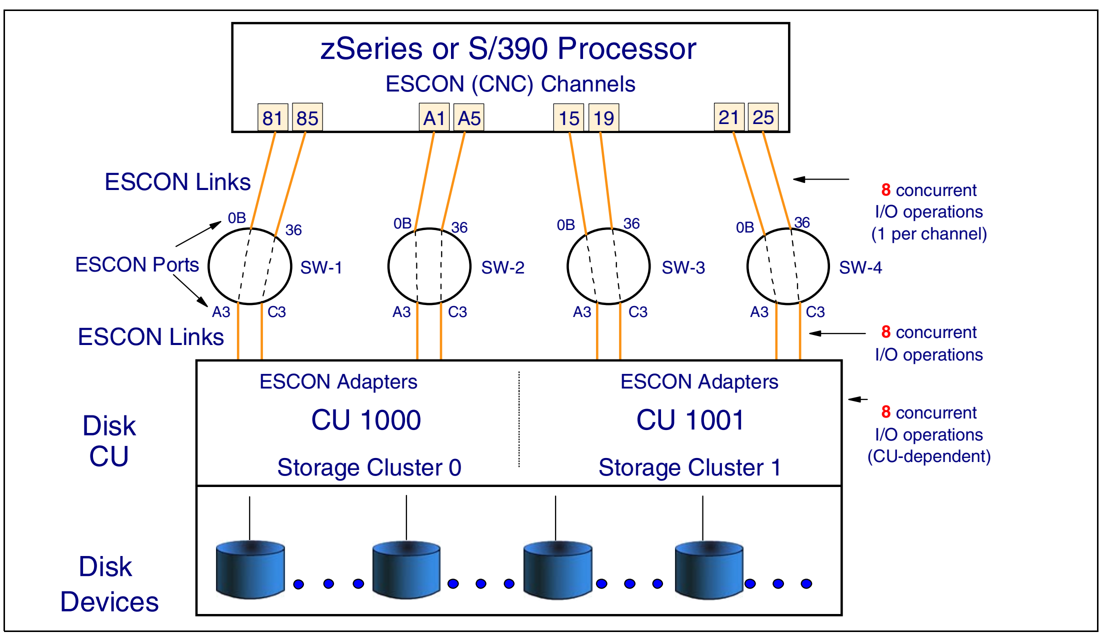


Figure 7-4 ESCON switched point-to-point configuration with eight paths

For maximum I/O concurrency to a multipath control unit, it is recommended that the number of paths from a processor image that are defined to access (and be configured) to a control unit or device is equal to the maximum number of concurrent I/O operations that the control unit can sustain. The zArchitecture and S/390 architecture supports a maximum of eight paths from a processor image to a logical control unit.

Figure 7-4 on page 97 shows the following:

- The need to ascertain from the control unit vendor the maximum number of concurrent I/O operations that are supported by the physical control unit

  Also determine if the physical control unit supports one or more logical control units (CUADD - CU addressing). The control unit vendor should be asked to provide all the control unit addressing and connectivity characteristics, because these affect how the control unit can be configured into a S/390 environment.
- The number of ESCON interfaces that the control unit supports
- The connection of channel paths from a single processor image (these can be shared if the control unit supports shared channel paths) to up to eight interfaces on a multi-interface control unit

  Most ESCON-interfaced control units support connection to shared channels.
- The use of eight ESCON channels

The ESCON configuration shown in Figure 7-4 has the following I/O concurrency.

- Eight concurrent I/O operations are supported by the control unit.
- Eight control unit ESCON interfaces are used and these in total will support eight concurrent I/O operations.
- Eight ESCON channels are used and these in total will support eight concurrent I/O operations. Note that an ESCON channel can do only one I/O operation at a time.

Figure 7-5 on page 99 shows the connectivity for a single ESCON channel. This channel uses dynamic connections in the ESCON Director, which provide access to this control unit and others. But this single ESCON channel can only address up to 1024 devices and can have only one I/O operation at a time.

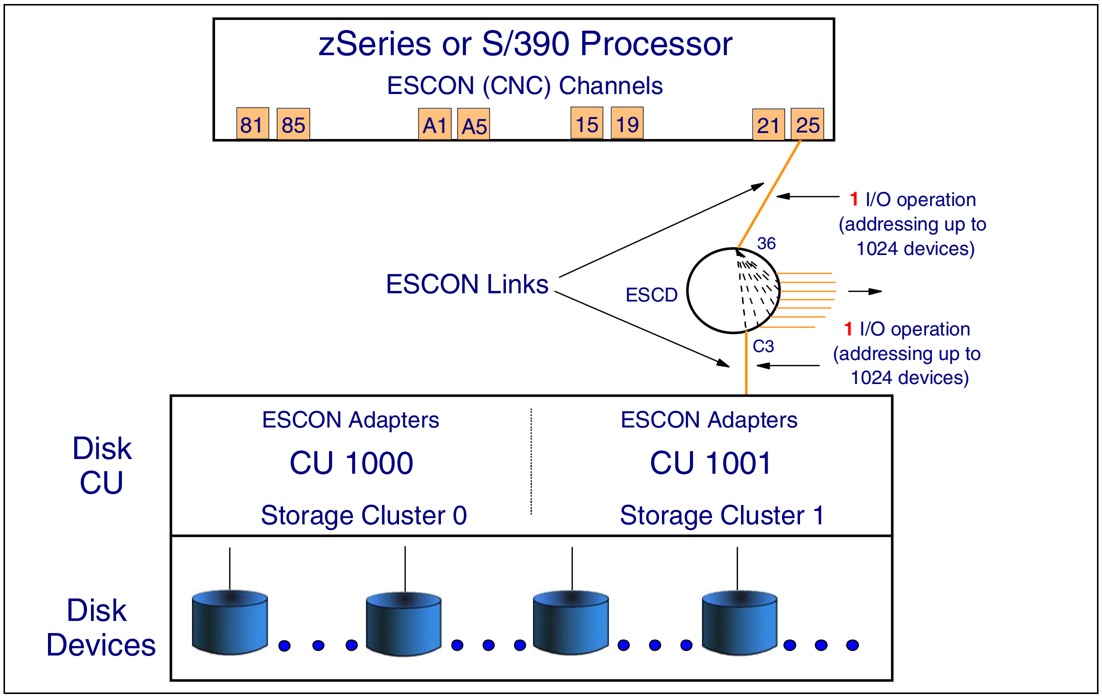


Figure 7-5 Single ESCON channel I/O concurrency

The ESCON adapter of this control unit can address up to 1024 devices and this ESCON link supports only one I/O operation at a time.

FICON Bridge (FCV) control unit configuration

This FICON Bridge (FCV) configuration is based on the previous ESCON point-to-point configuration, and it will be compared to the FICON switched point-to-point configuration.

The FICON Bridge (FCV) configuration shown in Figure 7-6 on page 100 has the following I/O concurrency:

- Eight concurrent I/O operations are supported by the control unit.
- Eight control unit ESCON interfaces are used and these in total support eight concurrent I/O operations.
- Eight FICON Bridge (FCV) channels are used and these support 64 concurrent I/O operations in total. Eight of these concurrent I/O operations are to the two control units numbered 1000 and 1001 (which make up one IOCP logical control unit), and 56 of the 64 possible concurrent I/O operations are to other control units.

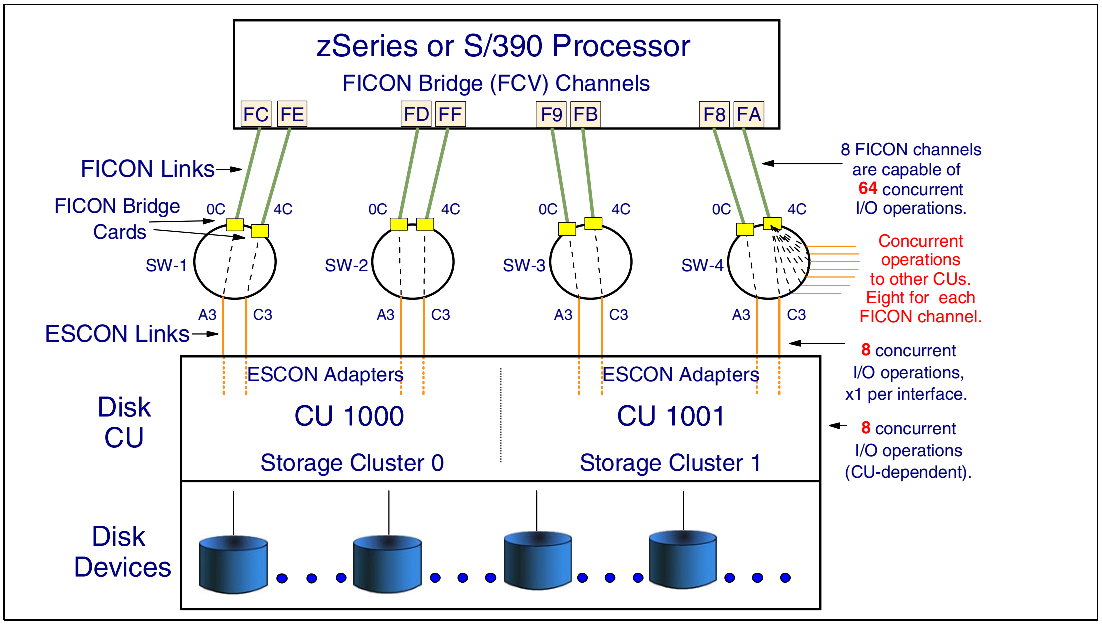


Figure 7-6 FICON Bridge (FCV) channel configuration - eight paths

FICON Bridge (FCV) channels can also be shared, so multiple images running in the same processor can use the same FICON Bridge (FCV) channel simultaneously. ESCON-interfaced control units should support the connection of shared channels.

Figure 7-7 shows the connectivity for a single FICON Bridge (FCV) channel. This channel can use a dynamic connection in the ESCON Director, via the FICON Bridge card, which provides access to up to eight control units. So this single FICON Bridge (FCV) channel can address up to 16,384 devices and can support up to eight I/O operations at a time.

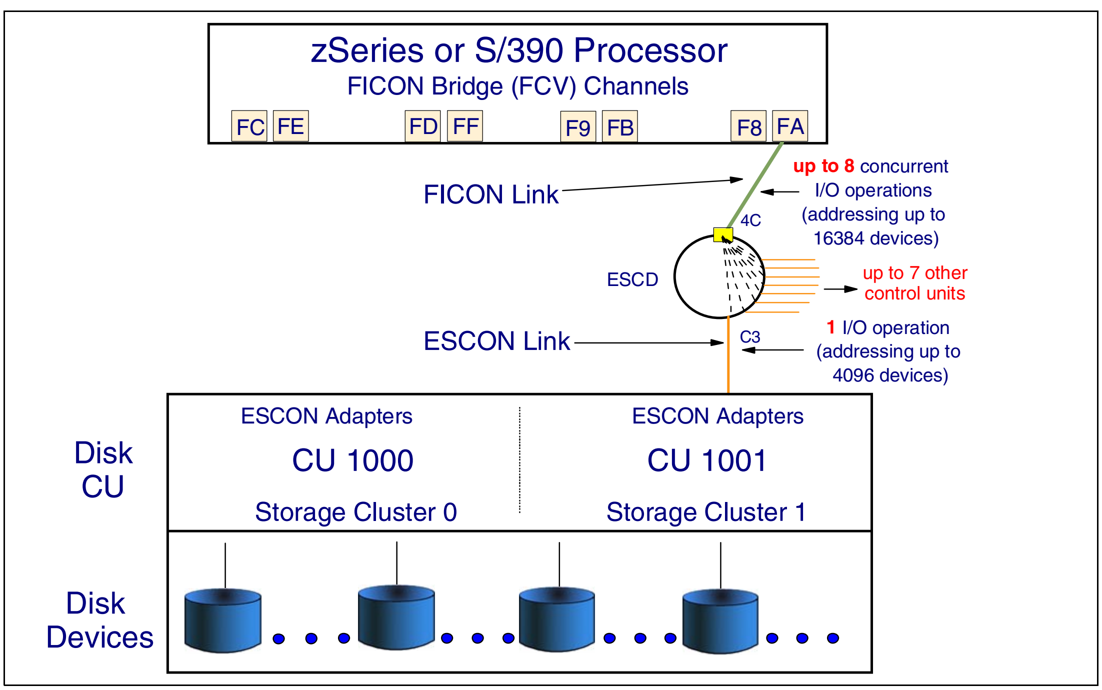


Figure 7-7 Single FICON Bridge (FCV) channel I/O concurrency

The ESCON adapter of this control unit can address up to 4,096 devices and this ESCON link can have only one I/O operation at a time.

FICON switched point-to-point configuration

This FICON switched point-to-point configuration (Figure 7-8) is based on the previous ESCON switched point-to-point and FICON Bridge (FCV) configurations.

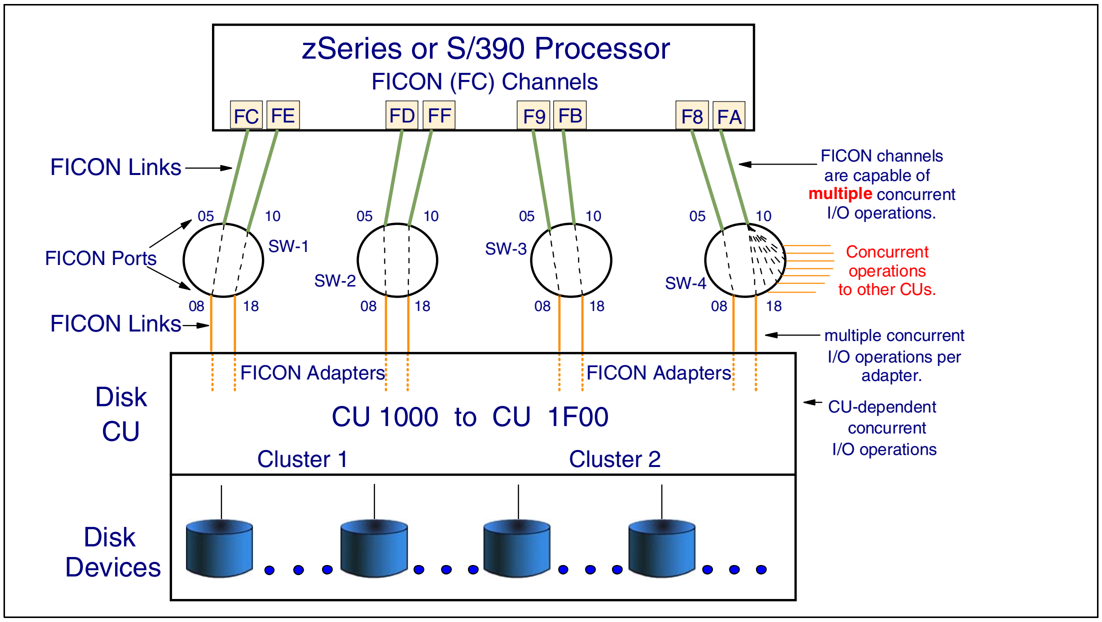


Figure 7-8 FICON switched point-to-point channel configuration with eight paths

With the same number of processor channels (eight), switch ports (four at each) and control unit adapters (eight), the I/O concurrency can be higher than for the ESCON switched point-to-point configuration. The FICON channel is capable of up to 16 or more concurrent I/O operations.

Because one FICON channel is capable of doing more than one I/O operation at a time, even for the same logical control unit, the same configuration now has the capability of producing more concurrent I/Os, using a higher bandwidth.

This configuration also exploits the I/O frame multiplexing capability of FICON channels, which is shown by the SW-4 switch in Figure 7-8. The FICON channel CHPID FA can send and receive intermixed sequence frames to and from multiple control units.

Note that FICON channels do not limit the maximum concurrent I/Os to eight per channel as a FICON Bridge FCV channel does, and that one control unit FICON adapter can also do multiple I/O operations at a time, even for the same logical control unit (FICON Bridge FCV uses ESCON links to the control unit, meaning only one I/O operation at a time).

The number of concurrent I/O operations depends on the control unit characteristics. So, if the control unit and its adapters can do multiple I/O operations concurrently:

- For the same I/O workload and throughput, fewer FICON channels, control unit adapters, and switch ports are required.
- Using the same number of resources (channels and control unit adapters), a higher I/O workload and throughput can be sustained.

FICON channels can also be shared so multiple images running on the same processor can use the same FICON channel simultaneously. This function is even more beneficial in this environment as FICON channels have the capability of doing multiple I/O operations simultaneously. FICON-interfaced control units should support connections to shared channels.

Figure 7-9 shows the connectivity for a single FICON channel. This channel uses a dynamic connection in the FICON switch, which provides access to this control units and others. So this single FICON channel can have I/O operations to many logical control units at the same time by using the FICON protocol frame multiplexing. This FICON channel can address up to 16,384 devices.

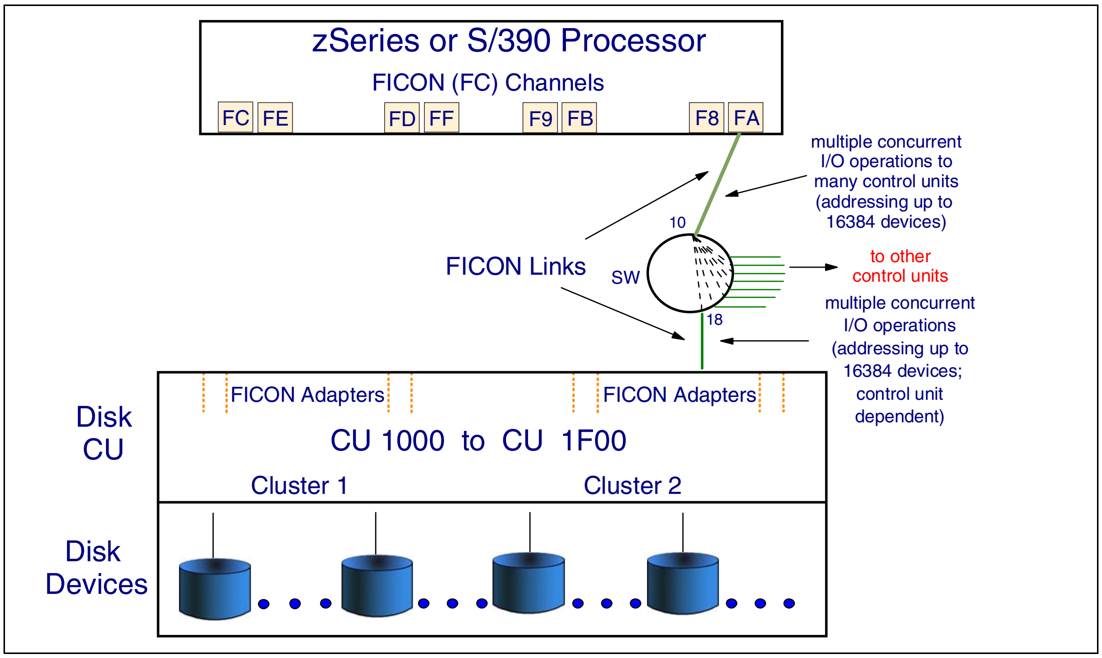


Figure 7-9 Single FICON channel I/O concurrency

The FICON adapter of this control unit can address up to 16,384 devices (control unit dependent) and this FC link can have multiple concurrent I/O operations.

FICON's CCW and data prefetching and pipelining, and frame multiplexing, also allow multiple I/O operations to the same logical control unit. As a result, multiple I/O operations can be done concurrently to any logical control unit, even within the same control unit. By using IBM ESS's Parallel Access Volumes (PAV) function, multiple I/O operations are possible even to the same volume.

7.5 Cascaded FICON Directors configuration

FICON support of Cascading Directors is a switched point-to-point configuration with two switches in the path. Therefore, all the rules discussed for FICON switched point-to-point also apply for the FICON support for cascaded Directors.

FICON channels implement the FICON support for cascaded switches topology by using two dynamic FICON switches (F_Ports) to connect FICON channels (N_Ports) to control unit FICON adapters (N_Ports). These connections are established as the server FICON channel Login Link Service FLOGI to the entry switch of the defined fabric and discovers that its

N_Port is connected to an F_Port (switch port) and the control unit FICON port Login Link Service, FLOGI, discovers that its N_Port is also connected to an F_Port (switch port) to the cascaded switch of the fabric.

A connection between both switches in the fabric is performed in the way that a switch's F_Port (in the entry switch) discovers that it is connected to another F_Port in the other switch (the cascaded switch). The result is that both ports will change their role to support the E_Port functions and form the Inter-Switch Link (ISL) connection.

More than one ISL can be established between both switches in the FICON-supported cascaded director environment. In that case balancing will be done between the multiple ISLs. Since balancing methodologies are vendor specific, refer to the FICON Director vendor documentation for details.

To ensure data security in the extended environment, both switches have to be in a High Integrity Fabric, which is created by configuring Fabric Binding and Insistent Domain ID in the FC switches.

This is checked during channel initialization time. If a 2-byte link address is found for a CU connected to a particular channel, a Query Security Attribute (QSA) is sent to the switch to check whether both are in a high integrity fabric. If it is found, normal channel initialization continues. If the high integrity fabric is not present, no further action is performed.

7.5.1 Levels of binding

Binding can be used to prevent nodes and/or switches from connecting to a FICON Director. In this section we will discuss the levels of security each binding type provides. As mentioned in 2.3, “Access control” on page 18, there are three levels of binding:

Port binding

This limits the N_Port that can be attached to an F_Port on the FICON Director by WWN.

Port binding requires a port membership list that contains the device's N_Port WWN (WWPN) that connects to a particular F_Port on the FICON Director.

Attaching an unauthorized N_Port to the FICON DIrector puts the F_Port into an “Invalid Attachment” state, and render the port unusable until the assigned N_Port is attached.

Since an N_Port is mapped directly to an F_Port within the FICON Director, there are some flexibility limitations with port binding. For example, port swapping within a FICON Director requires modifying the port membership list.

Switch binding

This limits the nodes that can be attached to a FICON Director by WWN.

Switch binding requires a switch membership list that contains all nodes' WWNs (WWNNs), of switches and/or devices that can attach to the FICON Director.

Attaching unauthorized nodes puts the FICON Director's port (F_Port) into an “Invalid Attachment” port state, because their WWNNs are not in the switch membership list.

This type of binding allows for more flexibility since an N_Port is not bound to an F_Port, and so port swapping can be done without changes to the switch membership list. However, moving a device from one FICON Director to another requires changes to the switch membership lists.

Fabric binding

This limits the FICON Directors allowed in the fabric by WWNN and Domain ID.

The FICON Directors that are allowed to connect to the fabric must be added to the fabric membership list of each FICON Director within the fabric. The fabric membership list is composed of the WWNN and Domain ID of the FICON Directors that are permitted to communicate within the fabric. The Domain ID ensures that there will be no address conflicts (duplicate Domain IDs) when fabrics are merged.

Exchanging fabric membership data is a Switch Fabric Internal Link Service (SW_ILS) function. The fabric membership list is exchanged between connected switches in the fabric before path selection is started.

If an unauthorized FICON Director port (E_Port) is attached to the fabric, then the port between the two switches will be placed in an “Invalid Attachment” state.

Fabric binding is a software-enforced security feature that permits an administrator to control the switch composition of a fabric by explicitly defining which switches are capable of forming a fabric. Thus an operator is able to prevent non-authorized switches access into a fabric. A non-authorized switch attempting to gain entry into a fabric becomes isolated by embedded software and is denied access to fabric resources.

Fabric binding also validates that the formation of any inter-switch link (ISL) between previously unconnected switches is not restricted. If the establishment of the ISL is not authorized the link is isolated and the state of the associated E_Port is updated to reflect the “Invalid Attachment”.

In addition to ISL verification, fabric binding provides in-band propagation of fabric membership data updates to all switches within a fabric thus ensuring a consistent, unified behavior across all potential fabric access points.

When an ISL link becomes available the switch on either end of the fiber may verify that fabric binding and insistent Domain ID is supported and enabled on the adjacent switch. If both sides of the ISL connection support fabric binding, each switch verifies that the newly connected neighbor switch and all switches in the adjacent fabric (of which the neighbor switch is a member) are authorized to form a fabric or expand the current fabric. If authorization is not granted the switch on which the authorization check failed will isolate the link and set the corresponding port state to “Invalid Attachment”.

Restriction: Fabric binding is required for FICON support of cascaded Directors.

Figure 7-10 on page 105 shows a cascaded environment with high integrity. The FICON Director prevents FC frames (user-data streams) from being delivered to the wrong destination if cables are incorrectly connected.

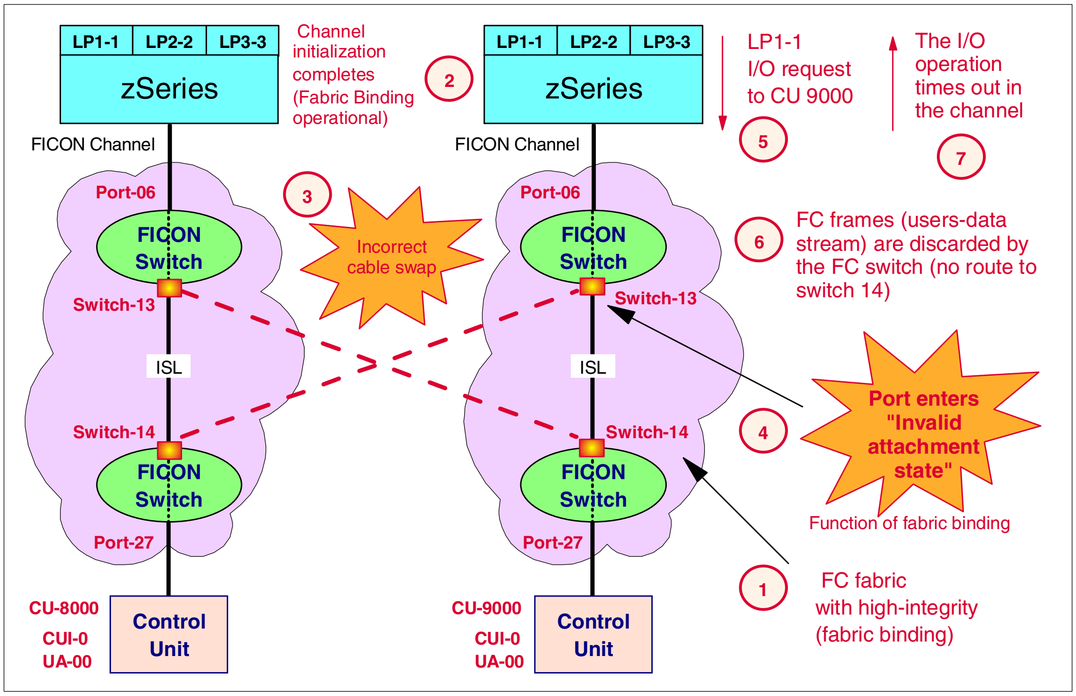


Figure 7-10 FICON-supported cascaded Directors with fabric binding

7.5.2 Design steps for a cascaded FICON Director environment

There is a sequence of steps that need to be planned when designing and implementing a FICON-supported cascaded Director configuration. These are:

1. Configuration design and ordering
   - Understand the zSeries processor channel resources that are supported.
   - Required features for FICON support of cascaded Directors (to establish Fabric Binding and Insistent Domain IDs):
     - Feature 7203 (FICON Cascading) for INRANGE Directors
     - Feature 6007 (SANtegrity) for McDATA Directors
     - CUP function feature
   - Required PTFs/MCLs to support 2-byte link addresses
2. Configuration planning
   - FICON Switch addresses/Switch IDs
   - Number of ISLs and ports used for ISL connections
   - Channels to be used for FICON support of cascaded Directors
   - Impact of the different levels of binding
   - CHPID impact when defining 2-byte link addresses for CUs
     - No intermix of 1-byte and 2-byte link addresses allowed on the same channel.
3. Implementation planning
   - Task list for each customer installation phase

4. Installation tasks
   – Installation/configuration of the switches and building a high integrity fabric
   – Connecting fiber to the switches

7.6 FICON design awareness areas

When designing a FICON channel-to-control unit configuration, the following considerations apply:

- zSeries and S/390 processor resources and packaging
- FICON switch resources and packaging
- Connection recommendations

  Number of paths to support the required number of concurrent I/O operations from a processor to a control unit
- Fiber cabling requirement (see Chapter 5, “FICON - Fibre Channel cabling” on page 69 for more details)

  Generally, long wavelength laser and single-mode 9 micron fibers are used for FICON optical links, which support up to 10 km (20 km at 1 Gbps and 12 km at 2 Gbps with an RPQ) un-repeated distances, or up to 100 km with repeaters.

  Note that some switches and control units may have shorter distance limitations.
- Pathing rules

  Only define the access to a logical control unit *once* on any given channel (this is a z/Architecture and S/390 architecture rule).
- Control unit characteristics
  – Addressing - logical control units (CUADD) and devices
  – Logical paths
  – Concurrent I/O

Figure 7-11 on page 107 shows the system’s “awareness areas”, required when designing connectivity from a zSeries or S/390 processor to a FICON-capable control unit.

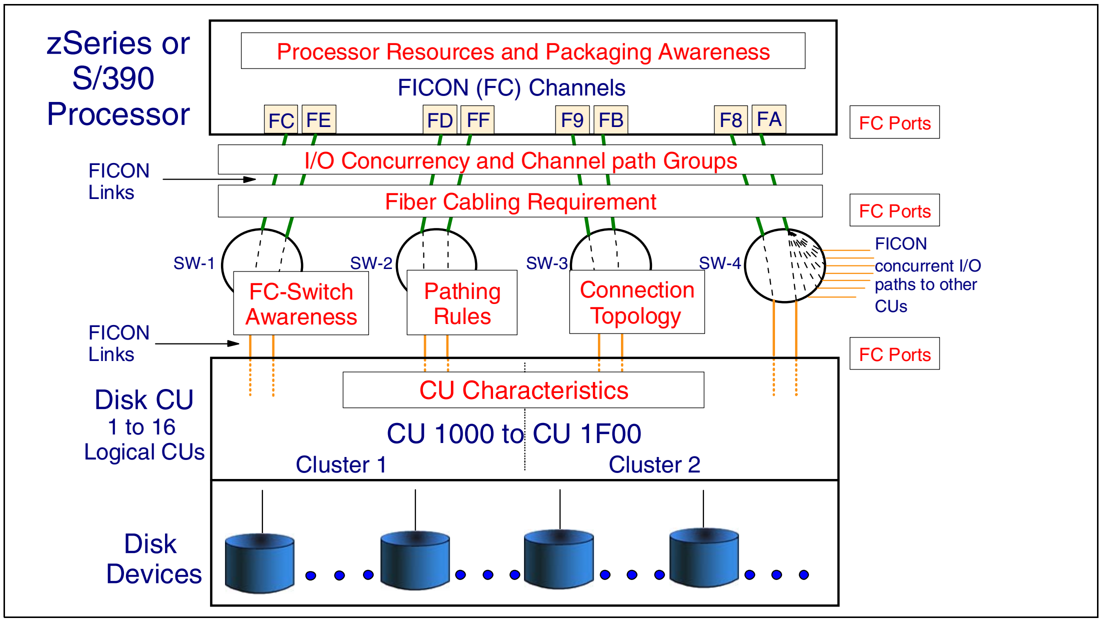


Figure 7-11 FICON system design awareness areas

7.6.1 S/390 architecture, FICON and ESCON implementations

In ESCON architecture, up to 253 control unit links per channel can be defined, but only up to 120 are implemented on ESCON, only up to 240 on FICON Bridge (FCV) and only up to 128 on FICON native (FC). The implementation is processor dependent.

The most important constraints relieved in the FICON implementation are:

- The maximum number of control unit images (CUADD) per channel and per control unit link goes from 16 on ESCON and FICON Bridge (FCV) implementations to 256 on FICON Native (FC) implementation (processor dependent).
- The maximum number of control units per channel goes from 120 on ESCON implementation to 256 on FICON Bridge (FCV) and FICON Native (FC) implementations (processor dependent).
- The maximum number of device addresses per control unit link goes from 1,024 on ESCON implementation to 16,384 on FICON Native (FC) implementation (current control units are implementing up to 4,096 device addresses per control unit link).
- The maximum number of device addresses per channel goes from 1,024 on ESCON implementation to 16,384 on FICON Native (FC) implementation.

For more information on the maximum number of FICON channels based on processor type, refer to Chapter 4, “Processor support” on page 55.

7.6.2 FICON channel to control unit characteristics

The control unit vendor must provide all the control unit addressing and connectivity characteristics, as these affect how the control unit can be configured in a FICON environment. The control unit vendor should also provide connectivity recommendations to allow the full exploitation of the control unit capability in a FICON environment.

The following items are dependent on the control unit characteristics:

- Number of installed FICON adapters at the control unit

- Number of logical paths supported by the control unit at each FICON adapter
- Number of logical paths supported by the control unit, when there is only one control unit function within the physical control unit
- Number of logical paths supported by each logical control unit within a physical control unit
- Number of logical control units supported and the LCU address for each LCU
- Number of concurrent I/O transfers per physical control unit
- Number of concurrent I/O transfers per logical control unit
- Number of devices and device unit addresses (UAs) supported per logical control unit

  Some devices may be supported by more than one unit address (UA), each device unit address being supported by a different device number (this is the case for the IBM ESS control unit that supports Base and Alias device addresses). This function is known as Parallel Access Volumes (PAV).
- For each LCU, the base device unit address (UA) and address range per LCU

7.7 FICON and ESCON channel connectivity differences

Channel-to-control unit connectivity is different for FICON channels than it is for ESCON (CNC) channels and for FICON Bridge (FCV) channels to the same control unit. The main differences are:

- One FICON channel can be used for multiple concurrent I/O transfers from the same physical control unit and even for the same logical control unit.
- One FICON Bridge (FCV) channel can be used for up to eight concurrent I/O transfers from the same physical control unit, where each transfer is from a device in a different logical control unit.
- One ESCON (CNC) channel path can be used for only one I/O transfer at a time.

The net effect of these differences is shown in the configuration diagrams in Figure 7-12 on page 109, Figure 7-13 on page 110, and Figure 7-14 on page 111, where the physical control unit has two or more logical control units. The diagrams for each configuration show the total number of the following:

- Concurrent I/O transfers for all the channel paths shown in the diagram
- Concurrent I/O transfers for the physical control unit
- Concurrent I/O transfers for a logical control unit (LCU)

An even greater advantage of FICON over ESCON channel connectivity is gained when there are few FICON channels to remote sites, or for local sites when a control unit can support more than eight concurrent I/O operations, for example the IBM ESS 2105.

7.7.1 ESCON (CNC) channel connectivity to LCUs

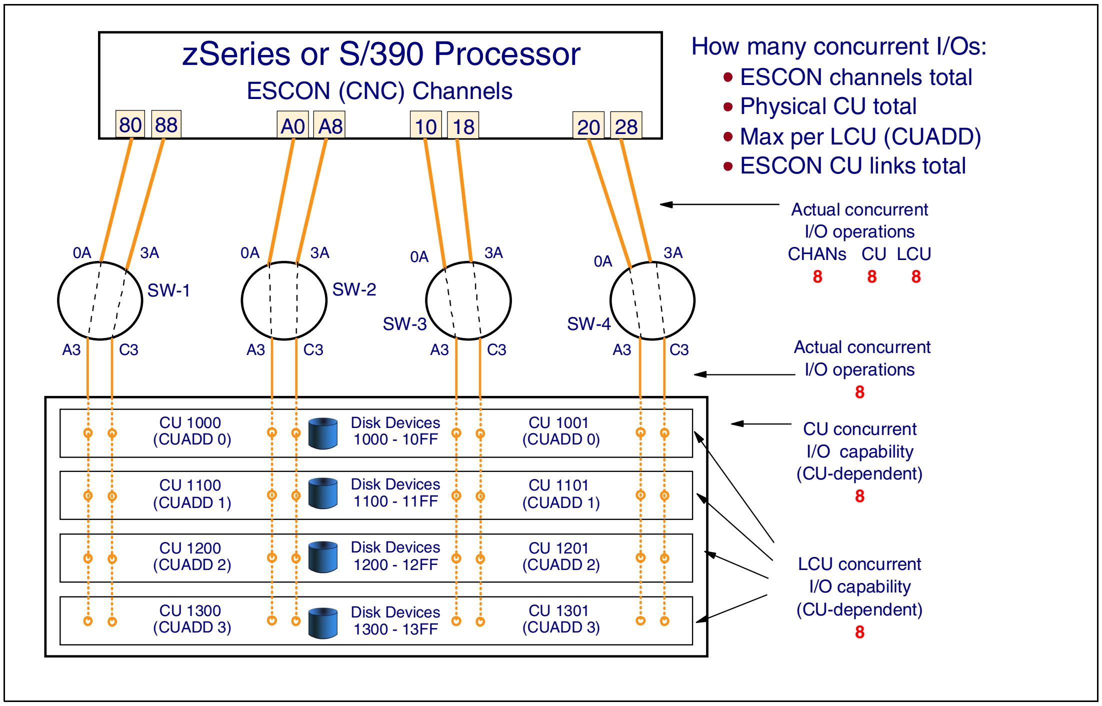


Figure 7-12 ESCON (CNC) channel configuration - 8 channel paths to 4 LCUs

The ESCON configuration shown in Figure 7-12 has the following I/O concurrency:

- Each of the eight ESCON paths can address all four of the logical control units shown in the configuration. This is the ESCON maximum addressability; an ESCON path can have up to 1024 device addresses (4 x 256 = 1024).
- Eight concurrent I/O operations are supported by any one of the four logical control units.

  Only eight concurrent I/O operations in total are supported by the physical control unit (this is the I/O concurrency characteristic of the control unit shown in this example).
- Eight control unit ESCON interfaces are used and these in total support eight concurrent I/O operations.
- Eight ESCON channels are used and these in total support eight concurrent I/O operations.

7.7.2 FICON Bridge (FCV) channel connectivity to LCUs

In a FICON Bridge (FCV) environment, the minimum number of recommended FICON Bridge (FCV) mode paths required to support an ESCON interface logical control unit should be equal to the maximum number of current I/O transfers that the ESCON logical control unit can perform on its ESCON interfaces. This provides for the maximum exploitation of concurrent I/O operations to any logical control unit.

It is possible to install and define more than eight paths to any physical control unit (from the same S/390 processor image) when the physical control unit has two or more logical control units. A maximum of only eight channel paths may be defined to any one logical control unit. This approach can be used for physical control units that support greater than eight concurrent I/O transfers and where there is a customer requirement for a high I/O rate when using ESCON channels.

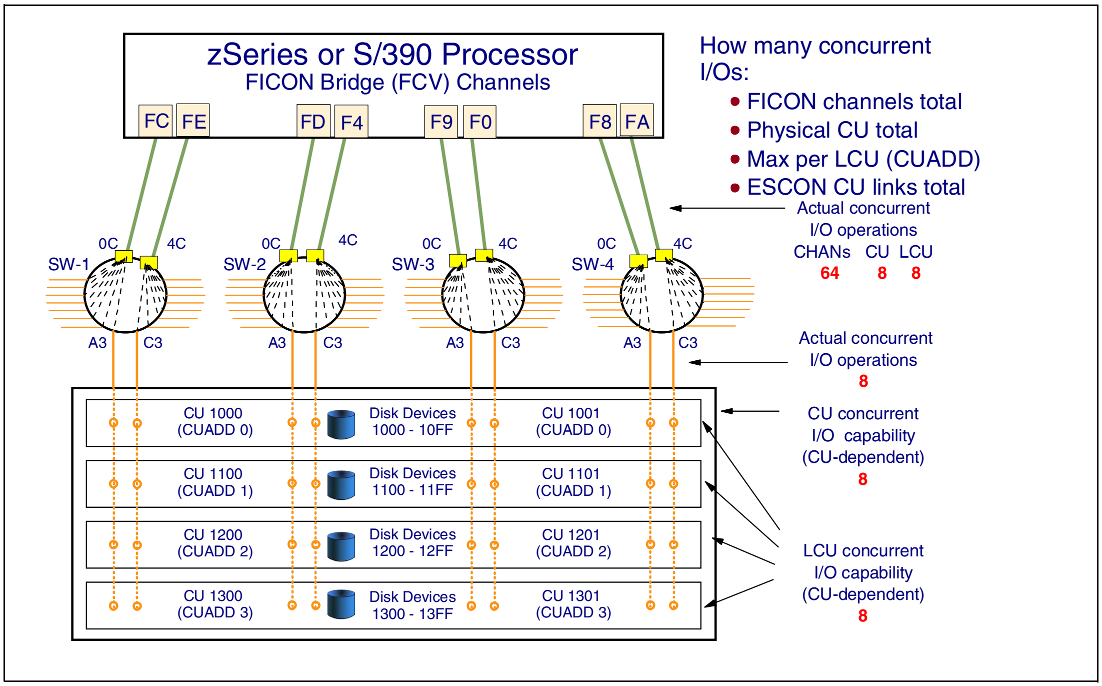


Figure 7-13 FICON Bridge (FCV) channel configuration - 8 channel paths to 4 LCUs

The FICON Bridge (FCV) configuration shown in Figure 7-13 has the following I/O concurrency:

- The exploitation of the possible I/O concurrency is dependent on the control unit characteristics. When a control unit supports more than eight concurrent I/O operations and the physical control unit has multiple logical control units, it would take more than eight ESCON channels to take advantage of this. It would take only eight FICON Bridge (FCV) channels to exploit this greater I/O concurrency (up to a limit of 64 concurrent I/O operations to the one physical control unit by the eight FICON Bridge (FCV) channels). A later example shows the exploitation by using fewer FICON Bridge (FCV) channels.
- Each of the eight FICON Bridge (FCV) paths are used to address all four logical control units.
- Eight concurrent I/O operations are supported by any one of the four logical control units.

  Only eight concurrent I/O operations in total are supported by the physical control unit (this is an I/O concurrency characteristic of the control unit shown in this example).
- Eight control unit ESCON interfaces are used and these in total support eight concurrent I/O operations.
- Eight FICON Bridge (FCV) channels are used and these support 64 concurrent I/O operations in total. Eight of these concurrent I/O operations can be to any of the defined (and configured) logical control units shown in Figure 7-13, and 56 of the 64 possible concurrent I/O operations may be to other control units.

7.7.3 FICON channel connectivity to LCUs

It is possible to install and define more than eight paths to any physical CU (from the same zSeries or S/390 processor image) when the physical control unit has two or more logical control units. A maximum of only eight channel paths may be defined to any one logical control unit. This approach can be used for physical control units that support greater than eight concurrent I/O transfers and that have a customer requirement for a high I/O rate when using ESCON channels.

The advantage in FICON operation is the capacity for multiple concurrent I/O operations on FICON channels and on FICON adapters, allowing a much higher I/O concurrency, as follows:

- A single FICON channel can have I/O operations to multiple logical control units at the same time, by using the FICON protocol frame multiplexing.
- FICON's CCW and data prefetching and pipelining, and protocol frame multiplexing also allow multiple I/O operations to the same logical control unit. As a result, multiple I/O operations can be done concurrently to any logical control unit, even within the same control unit. By using IBM ESS's Parallel Access Volumes (PAV) function, multiple I/O operations are possible even to the same volume.

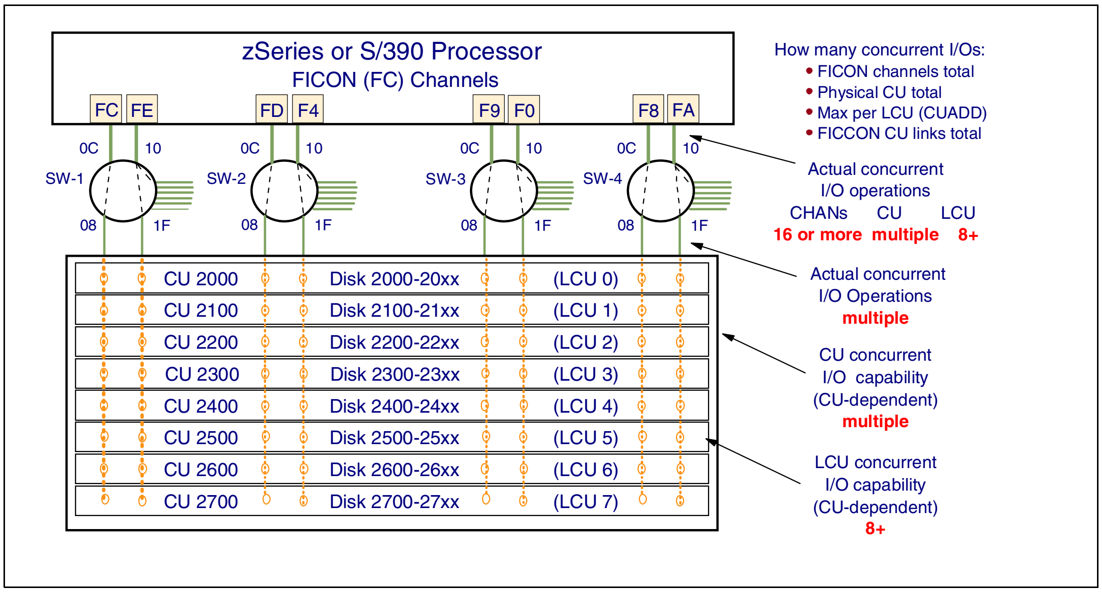


Figure 7-14 FICON channel configuration - 8 channel paths to 8 LCUs

The FICON configuration shown in Figure 7-14, using the IBM ESS (2105) as an example, has the following I/O concurrency:

- The exploitation of the I/O concurrency is dependent on the control unit characteristics. When a control unit supports more than eight concurrent I/O operations and the physical control unit has multiple logical control units, more than eight ESCON channels would be required to take advantage of this. It takes fewer FICON channels to exploit this greater I/O concurrency.
- Each of the eight FICON paths are used to address all eight logical control units. This is possible because each FICON path can address up to 16,384 device addresses.
- Multiple (more than eight) concurrent I/O operations are supported by each of the eight logical control units (this I/O concurrency depends on the control unit characteristics).
- Eight control unit FICON adapters are used and each one supports multiple concurrent I/O operations (this I/O concurrency depends on the control unit characteristics).
- Eight FICON channels are used and each one supports multiple - up to 16 or more - concurrent I/O operations.

7.8 ESCON and FICON connectivity intermix

Intermixing ESCON (CNC) channels and FICON native (FCV) channels to the same CU from the same operating system image is supported as a transitional step for migration only.

Access to any ESCON interface control unit from a processor image may be from ESCON and/or FICON Bridge (FCV) channels. Intermixing ESCON (CNC) channels, FICON Bridge (FCV) channels and FICON native (FC) channels to the same control unit from the same processor image is also supported. IBM recommends that FICON native (FC) channel paths only be mixed with CNC and FCV channel paths to ease migration from ESCON channels to FICON channels using dynamic I/O configuration.

The coexistence is very useful during the transition period from ESCON to FICON channels. The mixture allows you to dynamically add FICON native channel paths to a control unit while keeping its devices operational. A second dynamic I/O configuration change can then remove the CNC and FCV channels while keeping devices operational. The mixing of FICON native channel paths with CNC and FCV channel paths should only be for the duration of the migration to FICON.

The degree of intermix is installation-dependent and control unit-dependent:

In the case where a control unit can support more than eight concurrent I/O transfers, more than eight ESCON (CNC) paths would be required to exploit this, but it would require only eight FICON Bridge (FCV) paths and probably fewer FICON (FC) paths.

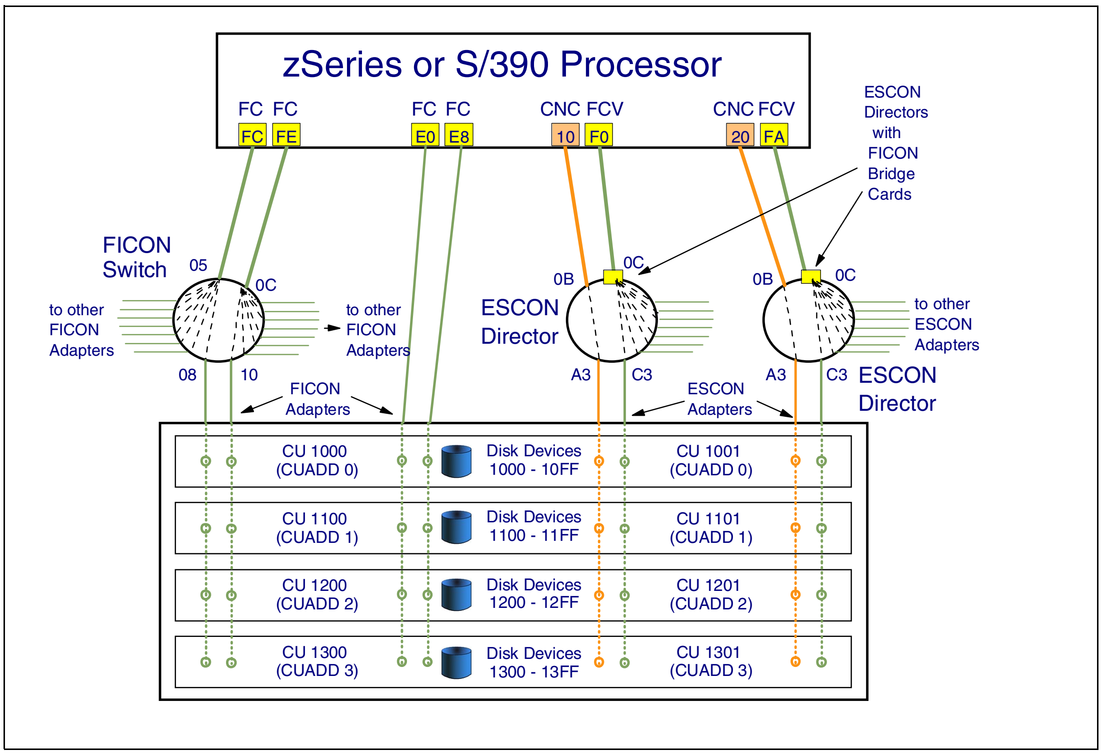


Figure 7-15 Intermixing CNC, FCV and FC channel paths

Figure 7-15 shows two ESCON channel paths, two FICON Bridge (FCV) channel paths and four FICON native (FC) channel paths from the same operating system image to the same control unit images.

7.9 Remote site connections and distances

Connecting a processor in one site to control units in another site can be expensive due to the cost of the fiber cables that connect the two sites. This may be a factor in the decision to use fewer fiber connections (fewer channels) between the two sites, that is, between the processor and control units.

Using fewer ESCON (CNC) channel connections than the supported I/O concurrency of the control unit means that the I/O concurrency achieved between the processor and the control unit drops. It would be equal to up to the number of channel path connections.

FICON channels potentially reduce the number of required channels, while still providing the required bandwidth and I/O concurrency.

Another benefit of FICON channels is their ability to reach long distances, which is very useful for remote site connections.

FICON channels can go up to 10 km with no repeaters (or 20 km via an RPQ) or up to 100 km using repeaters. Note that distances actually mean fiber lengths. With the new FICON support for cascaded Directors the flexibility was increased again and now allows, under special circumstances, a connection to a remote site without using DWDM due to the fact that both sides are connected by two dynamic switches. The current distance limitation is for FICON support of cascaded switches and using a 2 Gbps (FICON Express) channel. The maximum supported distance is 12 km at 2 Gbps with an RPQ.

Also important is that FICON channels can go up to 100 km before a data droop effect. ESCON channels are affected by data droop at 9 km.

DWDM technology supports FICON links, so it can be used as a repeater, not only to extend distances but also to multiplex many channels into two fiber pairs.

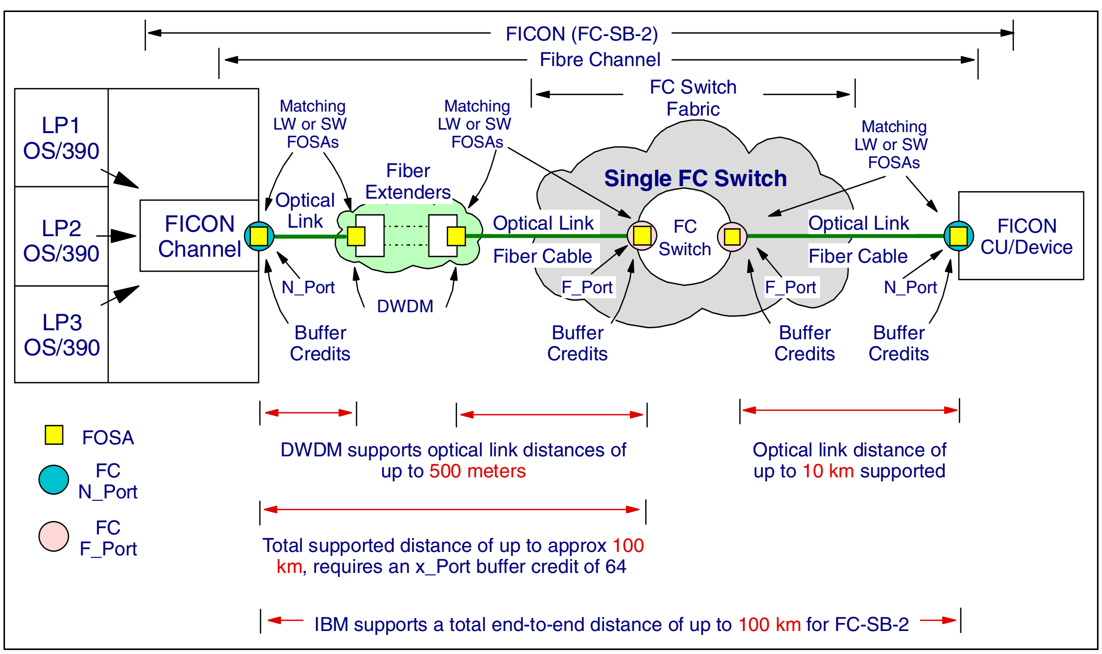


Figure 7-16 FICON channel path through an extender to a remote device

The FICON switched point-to-point configuration shown in Figure 7-16 illustrates all links used by the FICON channel path to a device, through fiber extenders and a single switch.

Usually the FICON switch is located at the remote location, so the fiber extenders are placed between the CPC and the switch. (A more generic recommendation is to place the switch at the location that has more connections).

Any FC link can reach up to 100 km, but the end-to-end distance (processor to control unit) cannot exceed 100 km. To achieve that distance:

- Fiber extenders must be used, as the FICON optical links can operate up to 10 km.
- For the FC link from the FICON channel to the FICON switch, both FICON channel and switch port should have enough buffer credits to avoid performance degradation at the link distance.
- For the FC link from the FICON switch port to the control unit FICON adapter, both the FICON channel and the FICON switch port should have enough buffer credits to avoid performance degradation at the link distance.

7.9.1 Remote site connections using ESCON channels

In Figure 7-17, Figure 7-18 on page 115, and Figure 7-19 on page 116 remote site scenarios using ESCON configurations are shown as examples for comparison with FICON configurations.

Note that ESCON channels start having data droop effect at 9 km, so the effective bandwidth is dramatically reduced after this distance.

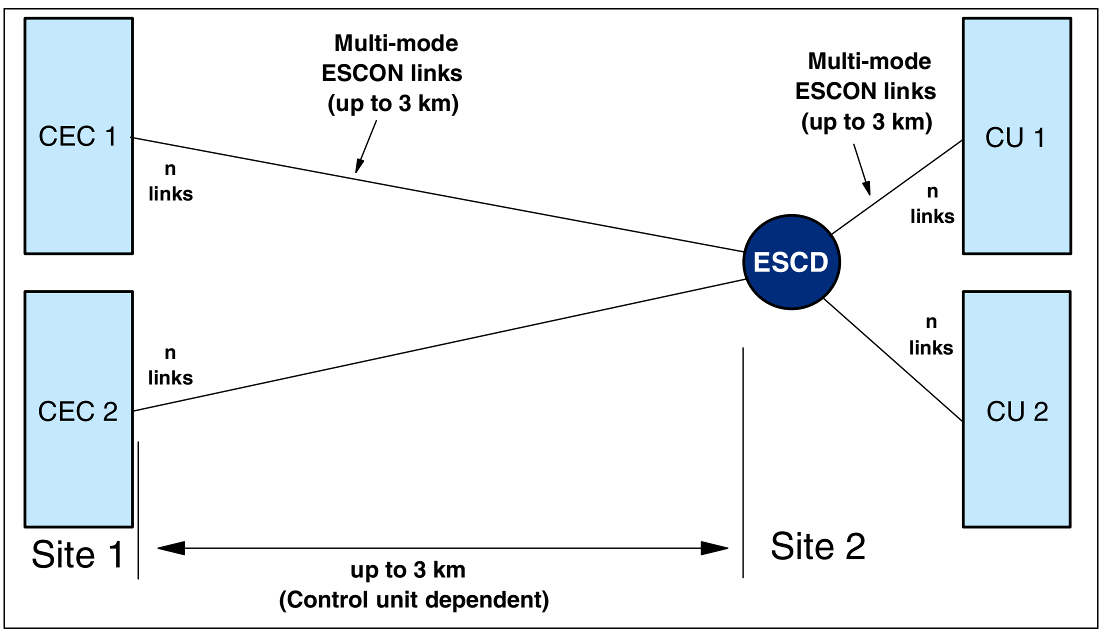


Figure 7-17 Remote site with ESCON channels - ESCD at remote site

Figure 7-17 shows a remote site with two control units accessed by two CECs from the primary site, all connected via an ESCON Director at the remote site.

In this case the maximum distance between the sites is up to 3 km (device dependent), and requires a fiber pair for each ESCON channel.

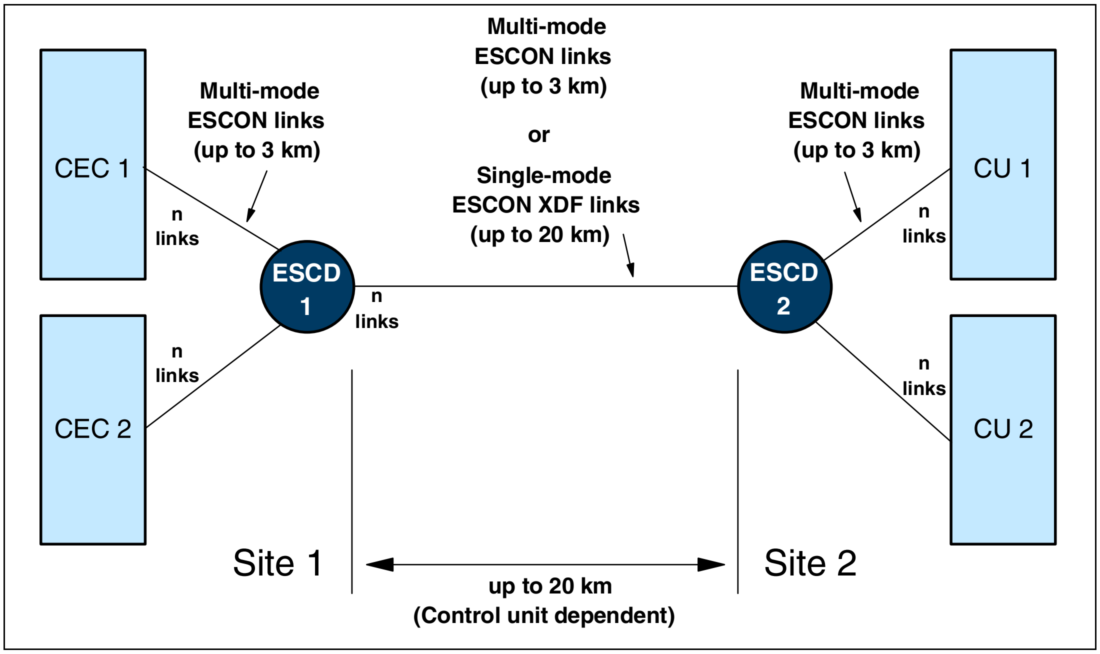


Figure 7-18   Remote site with ESCON channels - ESCDs at both sites

Figure 7-18 shows a remote site with two control units accessed by two CECs from the primary site through two ESCON Directors, one at each site. This design allows a greater distance between sites, as ESCON XDF ports can be used on both ESCON Directors. Using single-mode fibers, ESCON XDF links can go up to 20 km. It should be noticed that for this type of connection only one director can have a dynamic link for a specific channel, while on the other director this link must be dedicated to this switch. Only one dynamic switch is allowed in an ESCON environment.

In this scenario, the maximum distance between the sites is 20 km (device dependent), and requires a fiber pair for each port connection between both ESCON Directors.

Figure 7-19 on page 116 shows a remote site with two control units accessed by two CECs from the primary site through one ESCON Director, using fiber extenders (DWDM). This design allows an even greater distance between sites, as DWDM technology can extend and multiplex ESCON channels.

In this case, the maximum distance between sites is 50 km (device dependent), and requires only two fiber pairs between the sites. However, most ESCON devices support only up to 43 km and the bandwidth at this distance is reduced by the data droop effect.

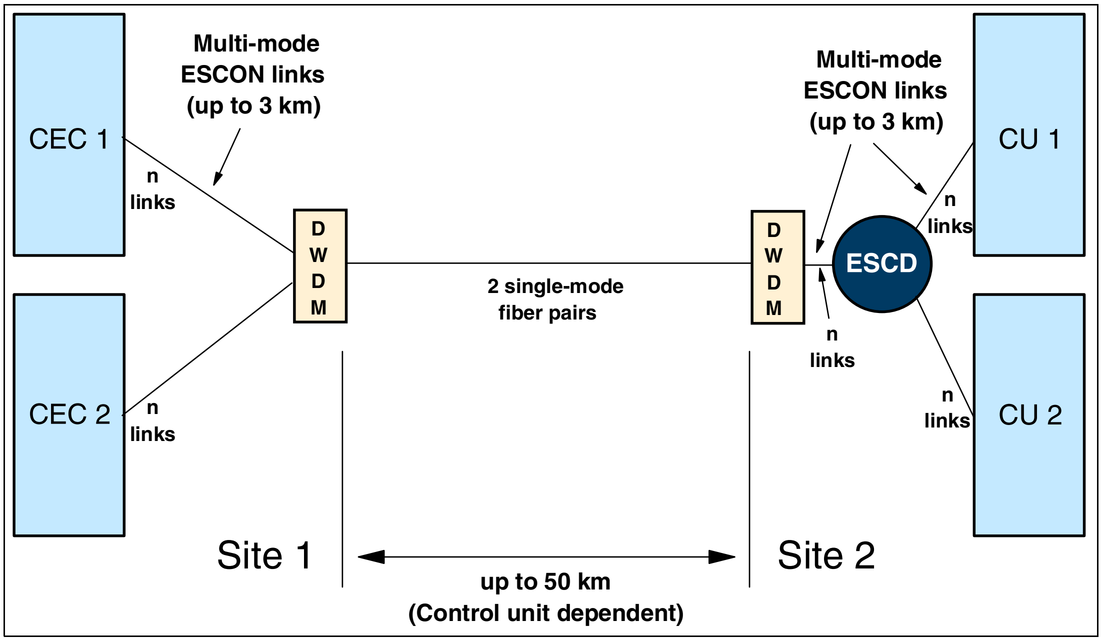


Figure 7-19 Remote site with ESCON channels using DWDMs

7.9.2 Remote site connections using FICON channels

This section contains sample configuration scenarios, based on the previous ESCON configurations, showing how FICON channels can help in remote site connections:

- Fewer FICON channels are required for the same workload and throughput.
- Distances increase to up to 10 km (20 km at 1 Gbps and 12 km at 2 Gbps with an RPQ) with no repeaters, or up to 100 km with repeaters. All these distances are control unit and device dependent.
- FICON channels have increased distance (up to 100 km) before the data droop effect, which means that the bandwidth can be sustained at this distance. However, the involved FICON ports (N_Ports and F_Ports) must have at least 60 buffer credits to achieve that distance with no performance degradation.

Figure 7-20 on page 117 shows a remote site with two control units accessed by two CECs from the primary site, all connected via a FICON switch at the remote site. In this case, the maximum distance between the sites is 10 km (device dependent), and requires fewer FICON channels (and fiber pairs).

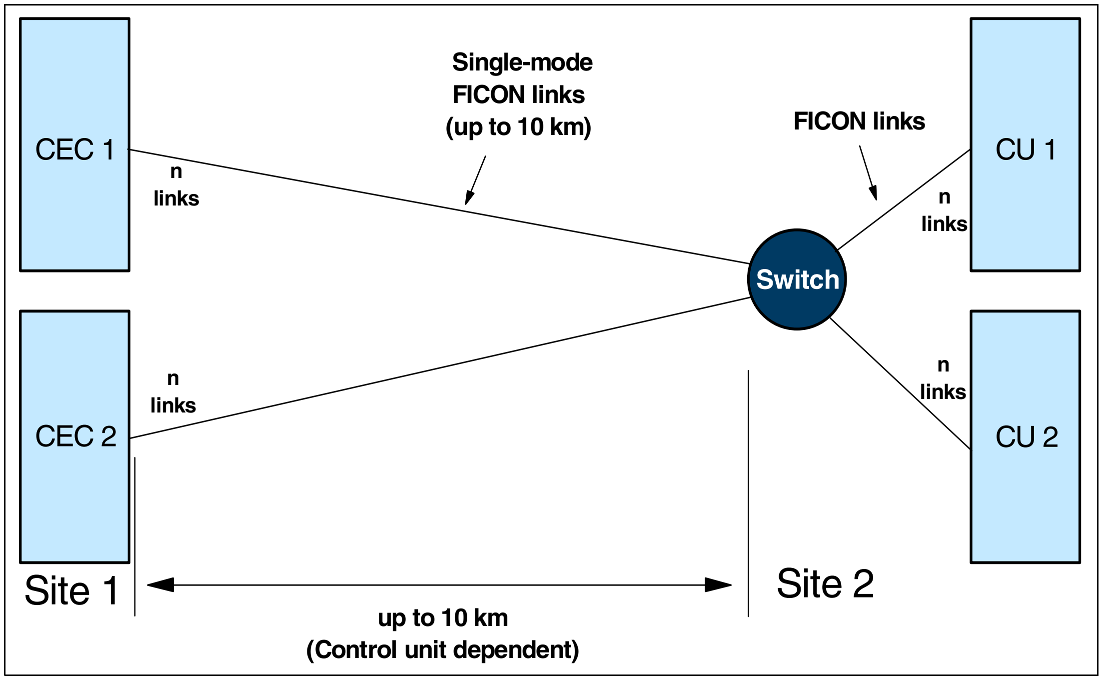


Figure 7-20 Remote site with FICON channels - switch at remote site

Figure 7-21 shows a remote site having two control units being accessed by two CECs from the primary site through one FICON switch, using fiber extenders (DWDM).

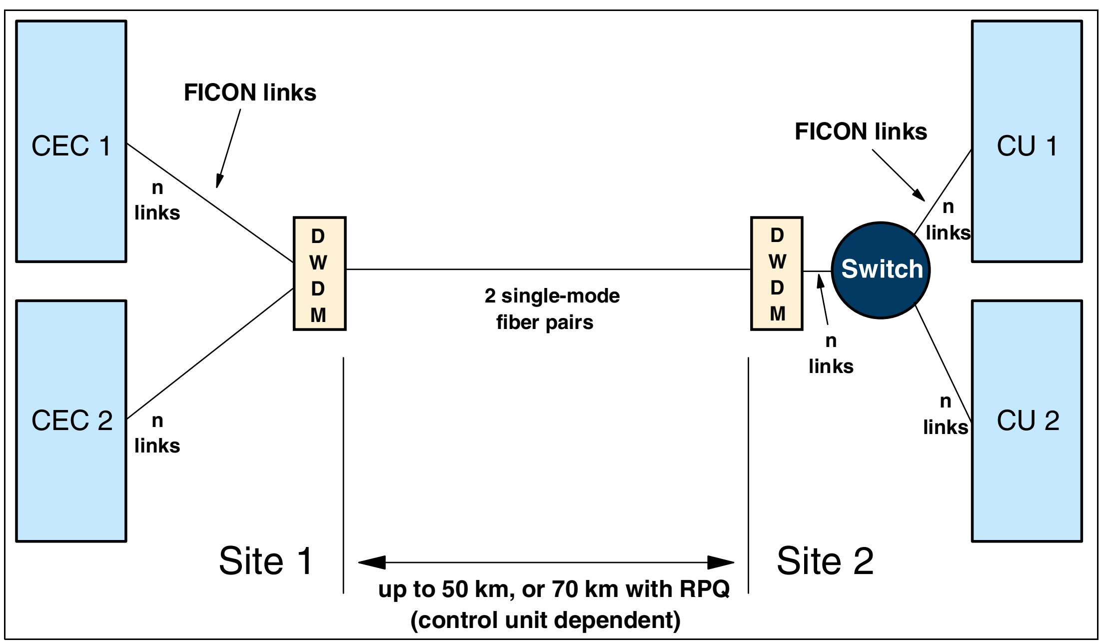


Figure 7-21 Remote site with FICON channels using DWDMs

This design allows the maximum distance between sites, because DWDM technology can extend and multiplex FICON channels up to 50 km or 70 km with an RPQ. In this case the maximum distance between sites is 50 km or 70 km with RPQ (device dependent), and requires only two fiber pairs between the sites. It is important to note that FICON channels do not have the data droop effect at those distances.

Fewer DWDM ports are required, as fewer FICON channels than ESCON channels are required.

Figure 7-22 shows a local and remote site with two control units at each site and accessed by one CEC from each site through cascaded FICON Directors, one at each site. This design does not need DWDM technology for a connection between the sites, and the Directors are fully dynamic, which provides higher flexibility at both sites compared to that having ESCON Directors at each site as demonstrated in Figure 7-18 on page 115. Each CEC can access the control units either from Site 1 or Site 2.

The current RPQ for distances above 10 km for a FICON channel does not include much higher distances than 12 km for FICON support of cascaded Directors when using 2 Gbps (FICON Express) channel cards.

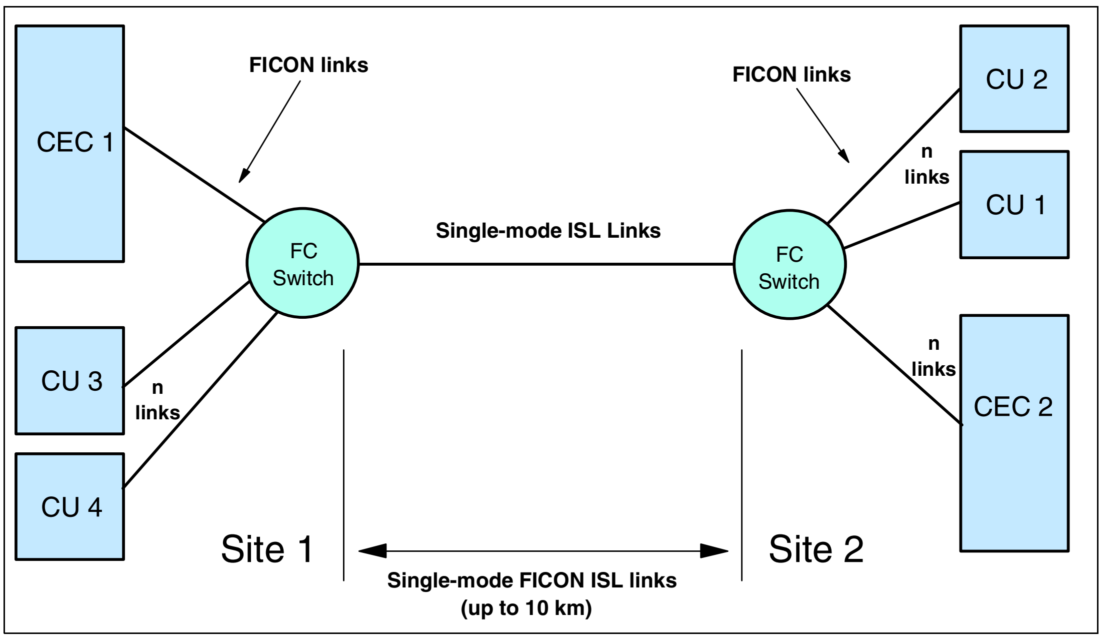


Figure 7-22 Remote site with FICON support for cascaded switches

7.9.3 GDPS and FICON channels

FICON native channels can participate in a Geographically Dispersed Parallel Sysplex (GDPS) environment, allowing for better I/O operation throughput.

The benefits of using FICON native (FC) channels in a GDPS environment are:

- For the same I/O workload and throughput, fewer DWDM ports are required for FICON channels than for ESCON channels. Using the same number of channels (and DWDM ports), the total bandwidth is increased, allowing a higher I/O workload and throughput.
- FICON channels operating at 40 km do not experience data droop effect, as occurs with ESCON channels at 9 km.
- GDPS customers who are not using DWDM technology will find an alternative solution when using FICON support for cascaded Directors.

  Note that the distance limitations for Sysplex Timer and Coupling Facility (CF) links still apply, and they will continue to require fiber extenders.

7.10 FICON connectivity recommendations

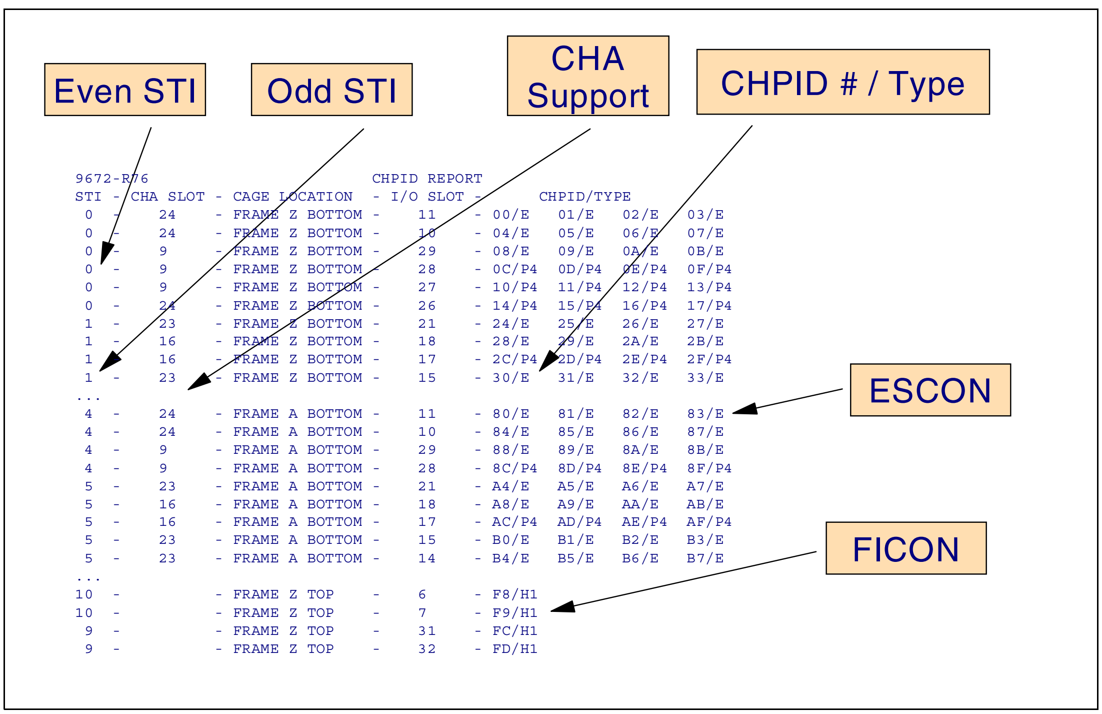
In an all ESCON (CNC) channel-to-control unit connectivity environment, the minimum number of recommended ESCON (CNC) channel paths required to support a physical control unit with all ESCON interfaces should be equal to the maximum number of concurrent I/O transfers that the ESCON physical control unit can perform on the ESCON interfaces (up to the zArchitecture maximum of eight for any LCU). This will allow the maximum exploitation of concurrent I/O operations to the physical control unit and any logical control unit in the physical CU.

In an all FICON Bridge (FCV) channel-to-control unit connectivity environment, the minimum number of recommended FICON Bridge (FCV) channel paths required to support an ESCON "logical CU" should be equal to the maximum number of concurrent I/O transfers that the ESCON-connected logical control unit can perform on the ESCON interfaces (up to the zArchitecture maximum of eight). This allows the maximum exploitation of concurrent I/O operations to any logical CU.

In an all FICON native (FC) channel-to-control unit connectivity environment, where all paths from a processor to a control unit are over FICON native (FC) channels, the minimum number of FICON native (FC) channel paths required is dependent on the control unit characteristics, particularly with respect to its concurrent I/O capability. So the control unit vendor must provide all the control unit I/O concurrency, addressing, and connectivity characteristics.

7.10.1 Channel path connections

The IBM CHPID Report shows the CHPID numbers and STI cables used. An example is shown in Figure 7-23. The report can be obtained from IBM and should be handed to the customer for all new or upgraded machines or channel MESs.




```
9672-R76                                  CHPID REPORT
STI  - CHA SLOT - CAGE LOCATION  - I/O SLOT -      CHPID/TYPE
 0   -     24   - FRAME Z BOTTOM -     11   - 00/E   01/E   02/E   03/E
 0   -     24   - FRAME Z BOTTOM -     10   - 04/E   05/E   06/E   07/E
 0   -     9    - FRAME Z BOTTOM -     29   - 08/E   09/E   0A/E   0B/E
 0   -     9    - FRAME Z BOTTOM -     28   - 0C/P4  0D/P4  0E/P4  0F/P4
 0   -     9    - FRAME Z BOTTOM -     27   - 10/P4  11/P4  12/P4  13/P4
 0   -     24   - FRAME Z BOTTOM -     26   - 14/P4  15/P4  16/P4  17/P4
 1   -     23   - FRAME Z BOTTOM -     21   - 24/E   25/E   26/E   27/E
 1   -     16   - FRAME Z BOTTOM -     18   - 28/E   29/E   2A/E   2B/E
 1   -     16   - FRAME Z BOTTOM -     17   - 2C/P4  2D/P4  2E/P4  2F/P4
 1   -     23   - FRAME Z BOTTOM -     15   - 30/E   31/E   32/E   33/E
...
 4   -     24   - FRAME A BOTTOM -     11   - 80/E   81/E   82/E   83/E
 4   -     24   - FRAME A BOTTOM -     10   - 84/E   85/E   86/E   87/E
 4   -     9    - FRAME A BOTTOM -     29   - 88/E   89/E   8A/E   8B/E
 4   -     9    - FRAME A BOTTOM -     28   - 8C/P4  8D/P4  8E/P4  8F/P4
 5   -     23   - FRAME A BOTTOM -     21   - A4/E   A5/E   A6/E   A7/E
 5   -     16   - FRAME A BOTTOM -     18   - A8/E   A9/E   AA/E   AB/E
 5   -     16   - FRAME A BOTTOM -     17   - AC/P4  AD/P4  AE/P4  AF/P4
 5   -     23   - FRAME A BOTTOM -     15   - B0/E   B1/E   B2/E   B3/E
 5   -     23   - FRAME A BOTTOM -     14   - B4/E   B5/E   B6/E   B7/E
...
10   -          - FRAME Z TOP    -     6    - F8/H1
10   -          - FRAME Z TOP    -     7    - F9/H1
 9   -          - FRAME Z TOP    -     31   - FC/H1
 9   -          - FRAME Z TOP    -     32   - FD/H1
```

Figure 7-23 9672 G5 and G6 CHPID Report

The CHPID Report is provided to the customer for each of their zSeries or 9672 G5/G6 processors. From this report the customer can see the following:

- What channel types and quantities are installed
- The location of each channel and the assigned CHPID number
- The channel adapter (CHA) used to support the channel (not all channel types need to be supported by a CHA)
- The STI connection used to support the channel

The customer would use the report to:

- Define the channel type and the channel mode for the channel, as well as the CHPID number
- Decide which channels to select as a group of channels to connect to a multipath control unit that provides the best availability, and then define that group as the channel group to a control unit.

Recommendations for connecting a multipath control unit to channels on zSeries or S/390 processors include:

- For redundancy reasons, spread the channel path (CHPID) selection (for the multipath CU) between CHPIDs that are on different channel cards. If you have to choose a CHPID that is connected to an STI that you have already selected (for connection to the same logical CU), then choose a CHPID that is supported by a different channel adapter card (CHA) on that same STI.
- For the zSeries 900 processor, even using CHPID renumbering, the previous recommendation still applies: spread the channel path (CHPID) selection (for the multipath CU) between CHPIDs that are on different channel cards. CHPID renumbering allows the customer to reassign another CHPID number to a channel path, but physically it remains in the same location.

7.10.2 How many FICON channels

Because not all the required control unit performance information is available, as a general rule for planning purposes we can start by recommending configuring about four times fewer FICON native (FC) channels than ESCON channels to a control unit.

The following considerations apply:

- Even with four times fewer channels, the FICON native configuration is capable of more I/O operation concurrency than the ESCON configuration.
- The FICON native configuration removes some ESCON addressing limitations, allowing higher device addressability (up to 16,384 devices per FICON native channel). This potentially increases the I/O workload of a control unit.

This approach can be better evaluated during migration time, when FICON native (FC) channels are added to an existing control unit with ESCON adapters. Having both channel types operating at the same time on the same control unit should provide valuable information regarding the capabilities for that specific configuration and I/O workload.

There are also some connectivity considerations that should be considered:

- The number of adapters required to exploit the control unit capability
- The connectivity requirements for a specific configuration, based on the number of switches and adapters
- Redundancies for availability reasons

Consider the following examples:

- Assume an existing control unit with four ESCON adapters. Using the conversion factor of four, this results in just one FICON adapter, which is not a good solution for high availability.
- Assume an existing disk control unit with eight ESCON adapters. This results in only two FICON adapters, which may be sufficient to sustain the same I/O workload and bandwidth, but may not be sufficient to exploit the control unit throughput capabilities. This number of FICON adapters may be four or even eight, but now this control unit can have a much better throughput.

It is very important to remember that the optimum number of channels and adapters is related to the control unit characteristics and implementation. Therefore, the control unit vendor should provide all the control unit characteristics.

So, in summary, the control unit vendor is the right source for precise connectivity recommendations for the control unit's maximum I/O concurrency exploitation in a FICON environment.

7.10.3 Maximum I/O concurrency exploitation

Control unit I/O concurrency

You may install and define more than eight channel paths to any physical control unit (from the same zSeries or S/390 processor image) when the physical control unit has two or more logical control units. But still a maximum of only eight channel paths may be defined to any one logical control unit.

You can use this approach for physical control units that support more than eight concurrent I/O transfers and that have a customer requirement for a high I/O rate when using ESCON channels.

Using FICON channels, it is possible to have more than eight concurrent I/O transfers even for the same logical control unit.

An example of this type of control unit is the IBM 2105 Enterprise Storage Server.

I/O device I/O concurrency

The IBM ESS also supports the Parallel Access Volumes (PAV) function. The PAV function provides for one or more concurrent I/O operations to the same disk volume. In addition to customizing the IBM ESS to provide the required number of base devices (3390B) and PAV devices (3390A - alias devices), the customer should also provide enough ESCON and/or FICON channel path connectivity to support the maximum I/O concurrency of the IBM ESS logical control units and its base devices and the PAV alias devices.

The following figures show an IBM ESS disk control unit configuration that supports eight or more concurrent channel I/O operations to any logical control unit within the physical control unit, and 16 or more concurrent channel I/O operations to the physical control unit. This is shown in Figure 7-24 on page 122 for ESCON (CNC), requiring 16 channels to exploit 16 concurrent I/O transfers, and in Figure 7-25 on page 122, where using only eight FICON channels it is possible to get greater exploitation of the control unit concurrent I/O transfer capabilities.

Some newer disk control unit Unit Information Modules (UIMs) only support the connection of a device to one control unit definition. Therefore, only one control unit definition is used in the IBM ESS configuration examples for ESCON and FICON.

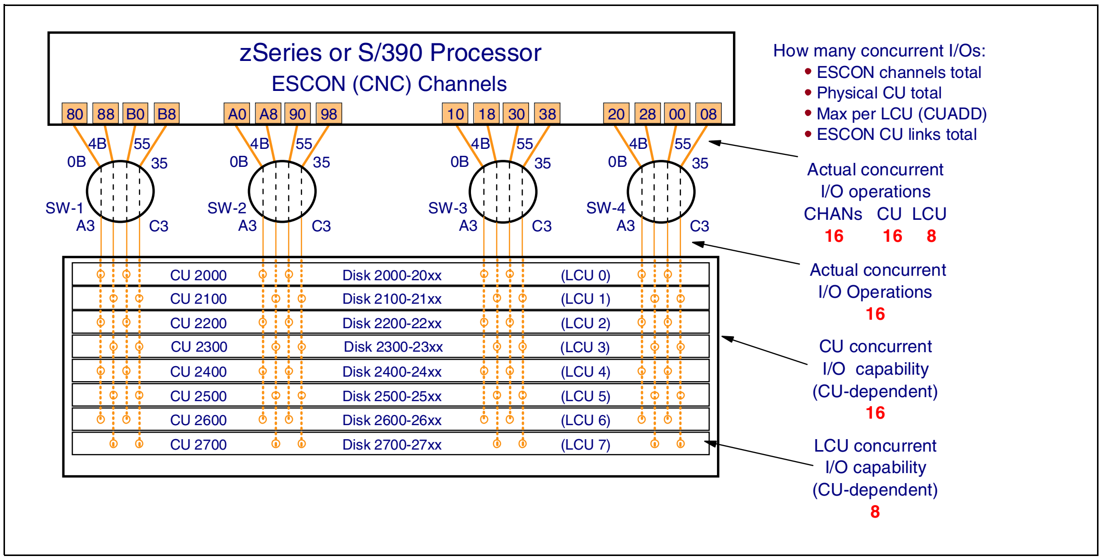


Figure 7-24 ESCON (CNC) channel configuration - 16 channel paths, 8 LCUs

In the configuration shown in Figure 7-24, there are 16 ESCON (CNC) channel paths configured to access the IBM ESS. Eight of the ESCON channel paths are defined to access all the even-addressed LCUs (CUADDs). The other eight ESCON channel paths are defined to access all the odd-addressed LCUs (CUADDs).

With this configuration, the 16 ESCON (CNC) channel paths can support up to 16 concurrent I/O transfers to the one physical control unit. Eight of the concurrent I/O transfers can be from any of the even-addressed LCUs, and the other eight concurrent I/O transfers can be from any of the odd-addressed LCUs.

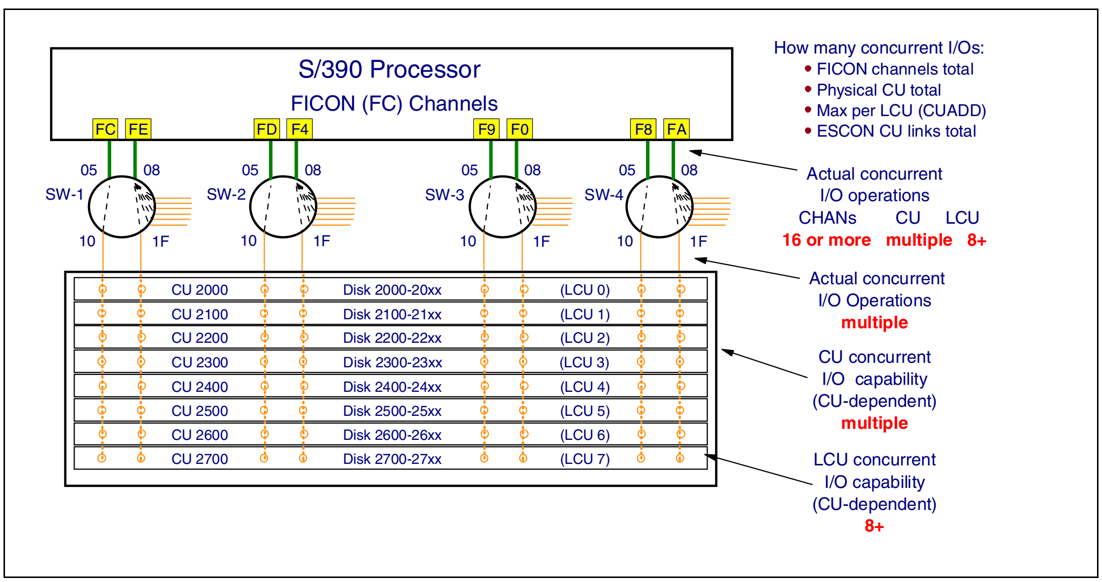


Figure 7-25 FICON channel configuration - 8 channels to 8 LCUs

In Figure 7-25 there are eight FICON channel paths configured to access all eight LCUs (CUADDs), as each one has the capability to address up to 16384 device addresses.

With this configuration, the eight FICON channel paths can support multiple concurrent I/O transfers to any and all logical control units to this physical control unit, as well as more I/O transfers to other physical and logical control units, using FICON frame multiplexing capability.

7.10.4 Mixing different control unit types

Determining whether you can intermix the same CU types and different CU types on the same channel requires knowledge of the control unit's operational characteristics and the channel characteristics.

Historically, it has been recommended not to intermix control units that you do not want to be locked out for periods of time with other control units (and their operations) that can cause lockout for certain types of channel operations.

Control units and device types that could cause lockouts are:

- Tapes
- Some old disk access channel programs (RYO)

Intermixing of control unit types with different channel usage characteristics, like disk and tape, on the same FICON channel is allowed.

Although FICON channels do not have the ESCON interlock problems, some performance characteristics should be taken into account. Tape control units normally transfer large data blocks, which may interfere with the response time of some control units requiring the best possible response time, such as disk control units.

Therefore, control units sensitive to response time should not be configured to use the same FICON channel as tape control units.

8

FICON I/O definitions

This chapter describes the IOCP definition requirements of the following resources:

- FICON channel in FICON native (FC) mode - A FICON channel in FICON native (FC) mode configured as point-to-point, switched point-to-point, FICON support for cascaded Directors
- FICON Director - A Fibre Channel switch that requires a control unit port (CUP) and supports attachment of FICON native (FC) channel paths and FICON control units
- FICON control unit - A control unit that attaches to FICON native (FC) channel paths
- FICON device - A device assigned to FICON native (FC) channel paths

8.1 FICON topologies versus ESCON topologies

This section depicts the possible FICON connectivity options and compares them with the existing ESCON connectivity options. It shows the physical and logical differences between ESCON channel and FICON channel connections. It also points out the distinctions in the use of the IOCP SWITCH and LINK keywords.

Figure 8-1 provides a review of ESCON Directors. When in a switched point-to-point configuration, only one ESCON Director can be defined and operating in “Dynamic” mode for a single PATH. Therefore, the control unit (CU) destination port address is the port address of the Dynamic ESCON Director.

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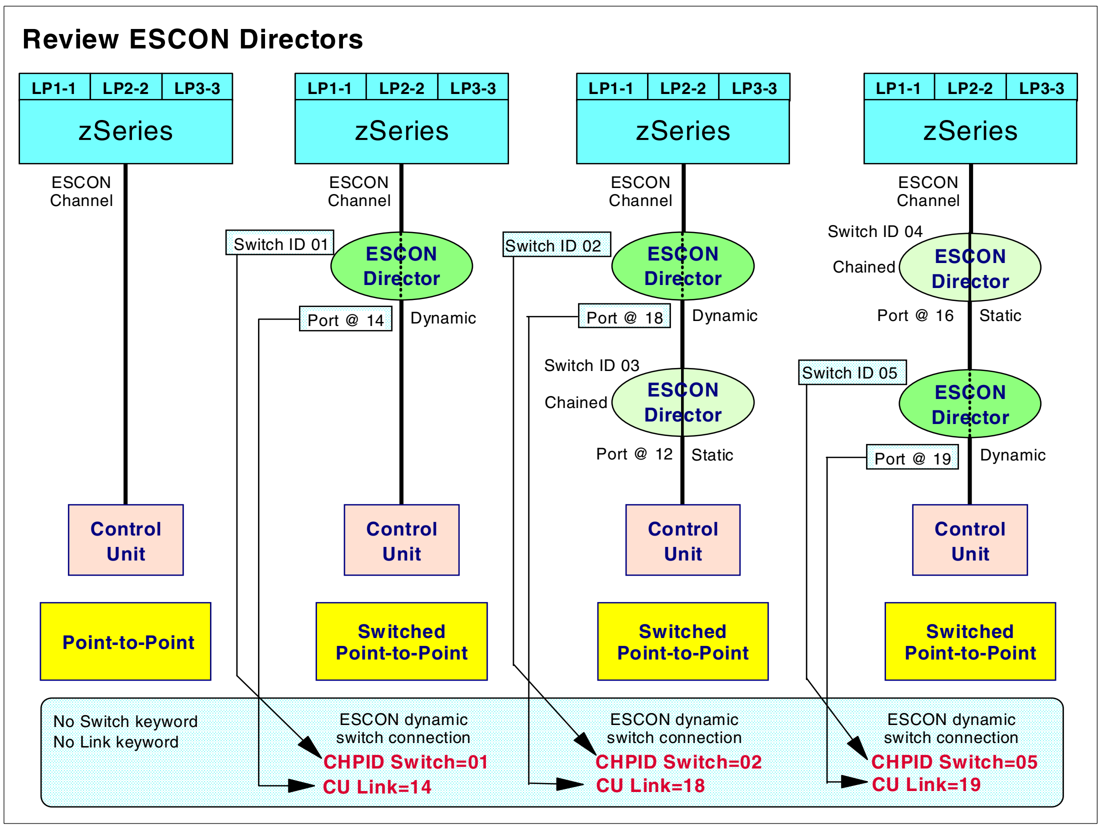

Figure 8-1 ESCON topologies with their Switch and Link keywords

Unlike ESCON Directors, all of the FICON Directors operate in “Dynamic” mode. Therefore, different rules are applied in defining the IOCP SWITCH and LINK keywords, as shown in Figure 8-2 on page 127. The IOCP definitions required for each of these topologies will be discussed in detail in subsequent sections.

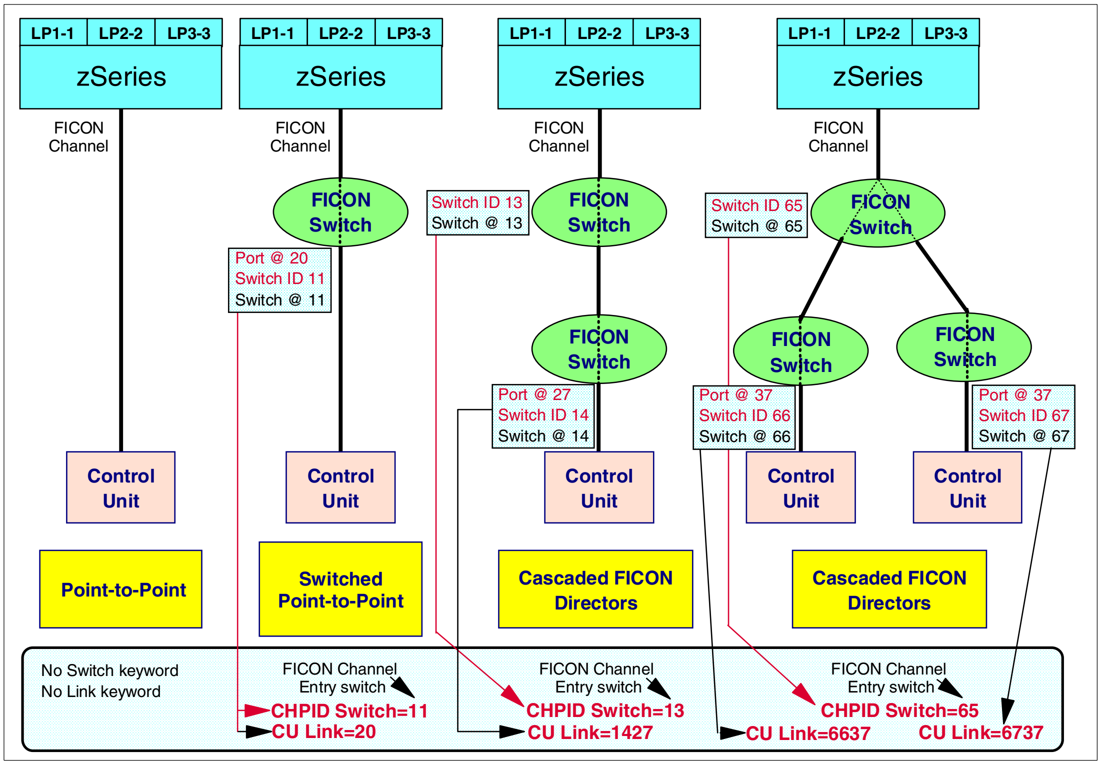

Figure 8-2 FICON topologies with their Switch and Link keywords

8.2 FICON IOCP definitions

This section provides FICON definitions based on the different topologies. It also shows how the IOCP definitions can be verified using HCD and Service Element (SE) panels.

For detailed FICON definition rules and limitations based on processor type, refer to *Input/Output Configuration Program Users Guide* at:

```
http://www.ibm.com/servers/resourcelink
```

Then select **Library** --> **z900**, **z800** or **G5/G6**).

For Support Element (SE) panel information, refer to *Support Element Operations Guide,* SC28-6818.

Appendix D, “HCD reference panels” on page 219 gives an overview of the new HCD panels available for FICON support of cascaded Directors.

Useful z/OS commands can be found in Appendix F, “z/OS commands and utilities” on page 239 to display the status of CHPIDs, control units, and devices.

Before configuring your FICON I/O definitions, we suggest you do the following:

- Review the supported topologies in 2.2, “FICON channel topology” on page 12.
- Ensure that the appropriate software prerequisites, such as APARs and PTFs are applied. These are listed in Chapter 6, “z/OS and OS/390 software support” on page 83.
- Document the port allocation of your FICON Directors (if you are configuring a switch point-to-point or cascaded configuration).

A worksheet is provided in Appendix C, “FICON Director configuration worksheet” on page 217. It can be use for planning, configuration and verification purposes.

8.2.1 Point-to-point topology

In this configuration, the FICON channel is connected directly to the CU’s FICON adapter. There is no FICON Director in the path (see Figure 8-3).

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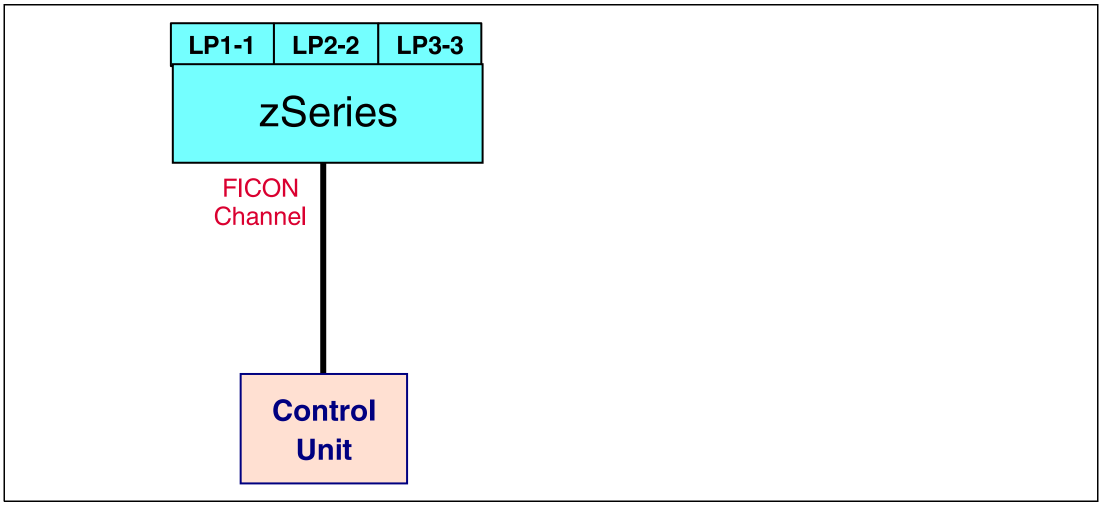

Figure 8-3 FICON point-to-point configuration

Keyword definitions and rules

This section describes the required keyword definitions and rules for a FICON point-to-point configuration.

PATH

The PATH keyword is required and is used to specify up to eight two-digit hexadecimal numbers for the FICON CHPID numbers. The CHPID numbers that can be specified for FICON channels are predetermined, based on the number and types of channels ordered for the specific processor.

The CHPID Report, provided by IBM with a new or upgrade machine order, identifies the default CHPID numbers of all installed channels and STI cables used. This report can be obtained from IBM and should be handed to the customer for all new or upgraded machines or channel MESs. Refer to Chapter 7, “FICON channel configurations” on page 91 for a sample of the CHPID Report.

Note that the zSeries processor provides a new function called Flexible CHPID Number Assignment. This function allows the customer to change a default CHPID number for a channel to any other CHPID number.

TYPE

The CHPID type for FICON channels in a point-to-point configuration is required and must be specified as TYPE=FC. This indicates that the FICON channel will operate in FICON native (FC) mode.

SWITCH

No SWITCH keyword is needed, because there is no FICON Director connected in the path.

LINK

No LINK keyword is needed, because there is no FICON Director connected in the path. A default value will be assigned.

Logical address (CUADD)

Prior to FICON native channel paths, the logical address for the control unit is specified as one hexadecimal digit in the range 0 - F for CNC, CTC, and FICON Bridge (FCV) channel paths. For FICON native (FC) channel paths, the logical address is specified as two hexadecimal digits in the range 00 - FE. However, if FC channel paths are mixed with CNC or FICON Bridge (FCV) channel paths on the same control unit, the logical address for the control unit must be in the range 0 - F.

Not all FICON control units support logical addressing. For a product's logical addressing information, contact your System Service Representative supporting the FICON control units.

Unit address

As with some ESCON-attached control units, some FICON control units also require that the unit address range begin with hexadecimal 00.

Figure 8-4 shows a sample IOCP definition for a point-to-point configuration.

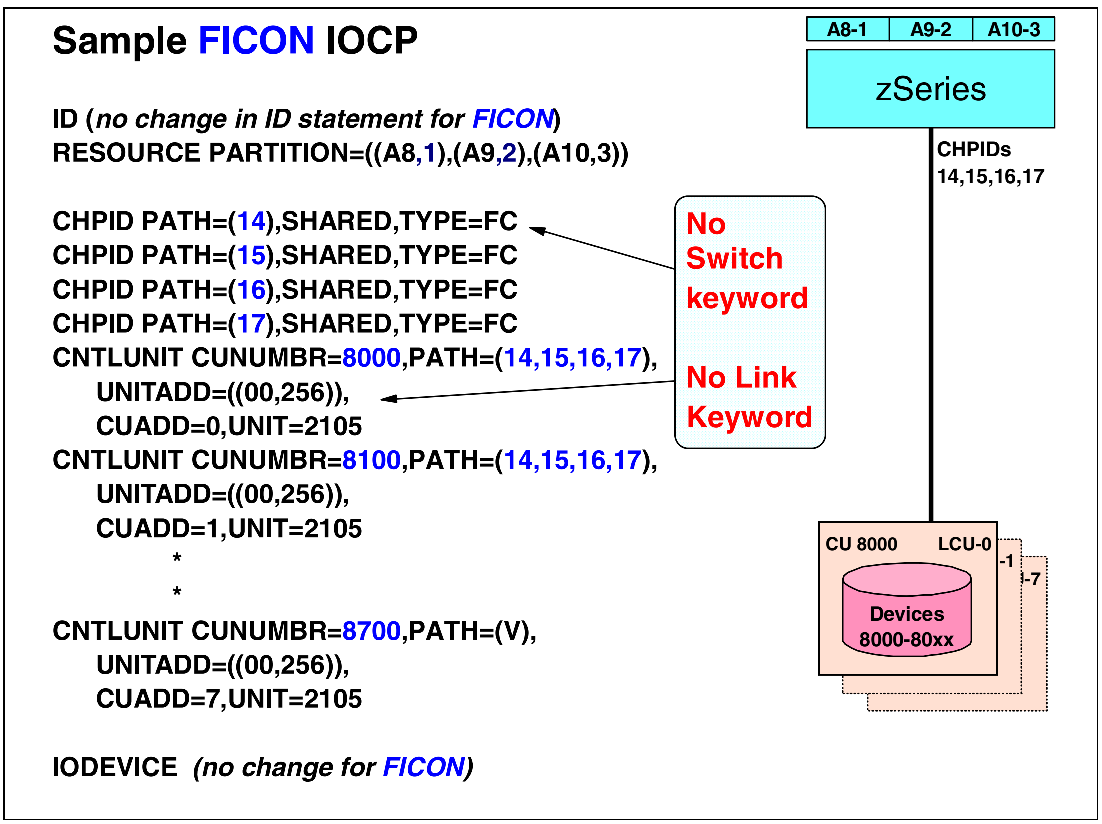

Figure 8-4 IOCDS sample for a FICON point-to-point connection

IOCP verification in HCD and Support Element (SE) panels

To verify IOCP definitions, refer to Figure 8-5 on page 130. For the SE panel display, refer to *Support Element Operation Guide,* SC28-6818, and for HCD panel access, refer to *Hardware Configuration Definition User's Guide,* SC33-7988.

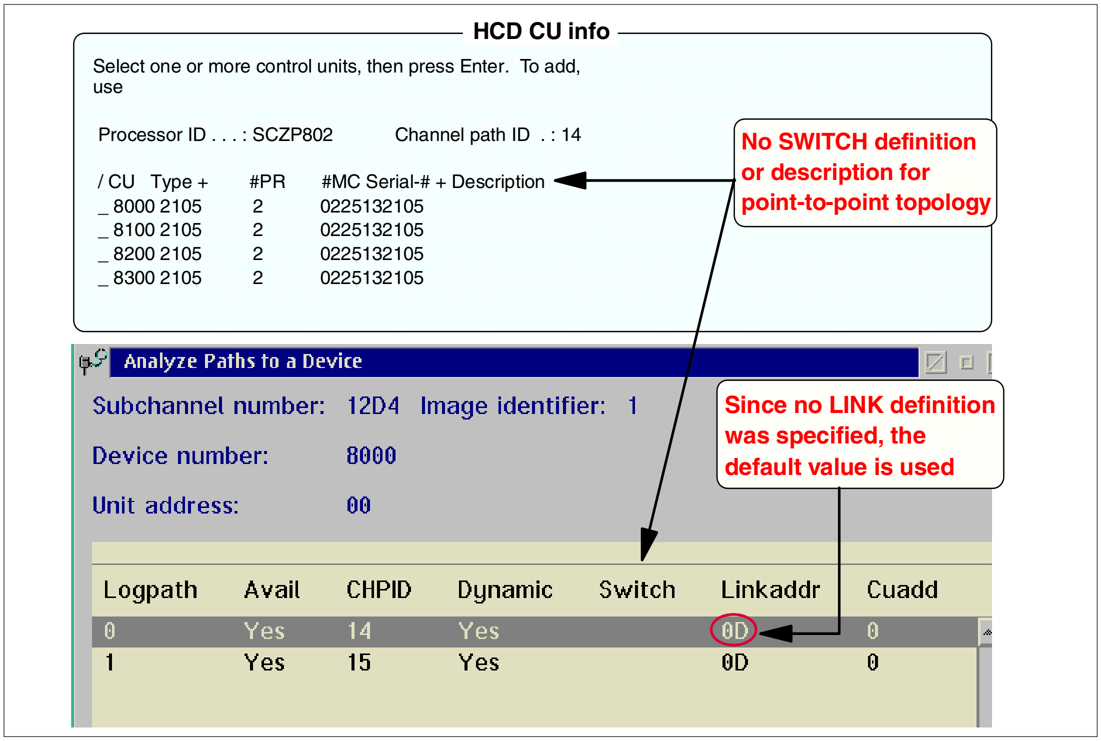

Figure 8-5 IOCP definition for point-to-point configuration in HCD and SE

8.2.2 Definition terms used with FICON Directors

It is important to point out that some definition terms used in IOCP and HCD were carried over from the ESCON environment. An example of the terms used and how they relate to the FICON environment is shown in Figure 8-6.

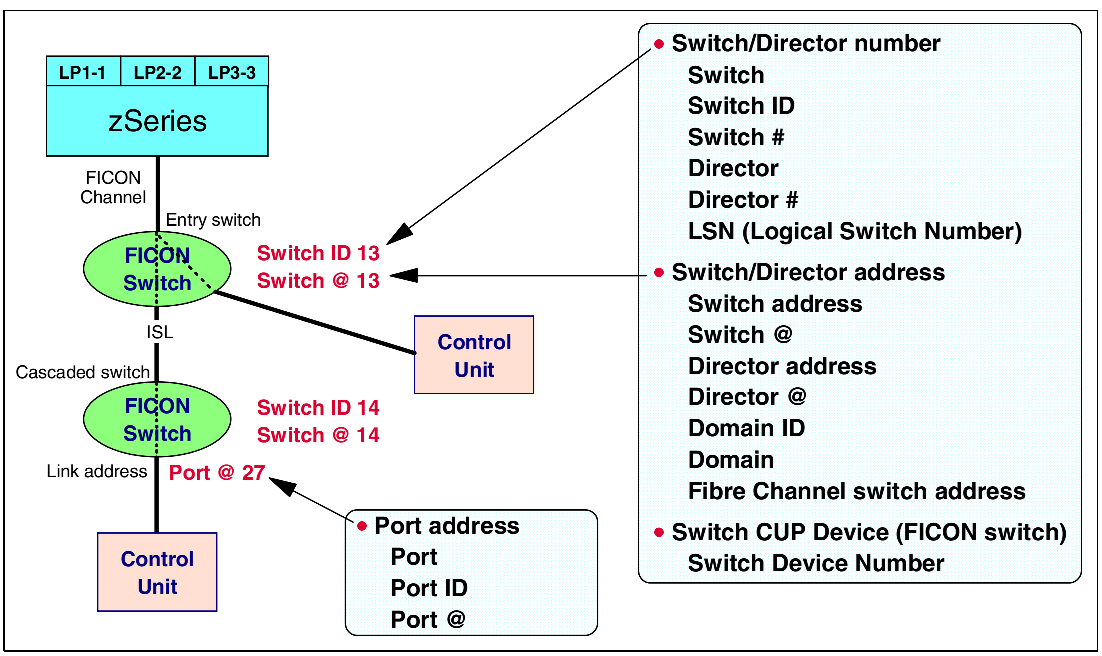

Figure 8-6 Term usage with FICON Directors

For clarity, we use the following terms throughout this section to describe the definitions needed in IOCP and HCD for cascaded FICON Directors and switched point-to-point configurations:

- An *entry switch* is the FICON Director that is directly connected to the processor's FICON channel and to the CU (destination) and/or another FICON Director.
- A *cascaded switch* is the FICON Director that connects to the CU (destination) and to the entry switch.
- The entry switch and cascaded switch are interconnected via an *Inter-Switch Link (ISL)*.
- *Switch ID* and *switch address* (1-byte value) are terms used to address a FICON Director.
- A port address (1- byte value) is used to address the physical port on the FICON Director.

The FICON Director requires the following to be defined for IOCP:

- A channel entry switch ID must be defined in the SWITCH keyword of the CHPID definition, when a FICON Director is involved.
- A must be defined in the LINK keyword of the CNTLUNIT definition as one of the following:
  – Define a 1-byte link address of the FICON Director port the CU is connected to in a switched point-to-point configuration.
  – Define a 2-byte link address (consisting of cascaded switch address and port address) of the FICON Director the CU is connected to in a cascaded FICON Directors configuration

The FICON Director requires the following for HCD:

- Add Switch - requires both the switch ID and switch address to be specified
- Add Channel Path - define the *Entry switch ID* and the *Dynamic switch ID* with the same value. A Link address must also be defined as a 1-byte or 2-byte address.

  For FICON Directors, it is recommended to assign the channel switch ID the same value (number) as the switch address in HCD. This way, the FICON Director will be known by a common designation. Hence, there are fewer potential errors that could be caused by having two different values (switch ID versus switch address).

Appendix D, "HCD reference panels" on page 219 describes the new HCD panels that apply to defining FICON Directors.

FICON Director highlights

- The switch ID has to be assigned by the user and must be unique within the scope of the definitions (IOCP and HCD).
- The switch address is assigned by the switch vendor and may be customized to a preplanned value. The switch address must be unique within the fabric.

> **Important:** A physical port on an FC switch has a port number, which does not always correspond with the port address; this is switch vendor specific. For more information about FICON Director port addressing and mapping, refer to the manufacturer's documentation.

8.2.3 FICON Director (2032)

The architectural characteristics of the FICON Director are described in Chapter 3, "FICON architecture and addressing" on page 25. The specific characteristics of the McDATA and

INRANGE FICON Directors can be found in their respective product documentation. This section describes the resources and definition requirements for the FICON Director, which is defined to the processor and host software as a type 2032. This definition information is applicable to both the McDATA FICON Director and the INRANGE FICON Director.

Like the ESCON Director, the 2032 FICON Director supports one device (UA=x’00’) to address the control unit port, or CUP. It has a single logical control unit, which supports up to 256 logical paths. This information is summarized in Table 8-1.

Table 8-1 2032 FICON Director (CUP) resources

Resource	Number
Maximum number of logical paths	256
Maximum number of devices	1
Unit address base and range	x’00’
Number of logical control units	1, id=0

As with the ESCON Director, the definition of the CUP to IOCP and HCD remains optional for the FICON Director. That is, it is not necessary to define the FICON Director as a device in HCD and IOCP, but without this definition, the following functions cannot work:

- System Automation for z/OS or OS/390 (S/A) I/O-Ops, which is used to display the status of, and manage, the FICON Director
- Some RMF reports, such as the FICON Director Activity report

The FICON Director must be defined as UNIT=2032. It attaches device type 2032.

Defining a FICON Director

The recommendations for defining the FICON Director include:

- Define the 2032 FICON Director as a device.

  Although the switch is transparent to the operating system in the path to a FICON control unit or device during the execution of an I/O operation, it is recommended that the FICON Director be defined as an I/O device for the following reasons:

  – Error reporting

    Switch-related hardware errors are reported to the operating system against a device number. If the switch is not defined as an I/O device, and that I/O device is not online to the operating system, then switch-related errors cannot be surfaced and, therefore, actioned.

  – System Automation for z/OS or OS/390 access

    System Automation for OS/390 I/O-Ops (for managing an ESCON and FICON Directors) provide operational tools for “safe switching”, as well as displaying routing information for a device. Safe switching refers to the ability to manipulate ports and adjust path status non-disruptively. In order for S/A I/O-Ops to assure safe switching, it must have access to all switches. That is, all the switches must be online as I/O devices on all the systems where S/A I/O-Ops Manager is running.

- Define at least two paths to the 2032 FICON Director I/O device.

  Two paths are required for availability. If one of the CHPIDs supporting a path to the FICON Director is unavailable, then the FICON Director device can remain accessible over the alternate path.

As mentioned, the FICON Director provides a control unit port (CUP) function. The CUP is identified as (internal) port number 'FE'. The definition of this control unit port is optional.

The IOCP coding for the sample 2032 FICON Director configuration is shown in Figure 8-7.

```
ID MSG1='2064-112',MSG2='FICON SWITCH INSTALLATION',
               SYSTEM=(2064,1)

CHPID PATH=(E8,F8),TYPE=FC,SHARED,SWITCH=18,
      PARTITION=((LPAR1,LPAR2,LPAR3),(LPAR1,LPAR2,LPAR3))

*******************************************************************
** FICON Director CU F008 and Device F008
*******************************************************************
      CNTLUNIT CUNUMBR=F008,PATH=(E8,F8),UNIT=2032,
            UNITADD=((00,1)),LINK=(FE,FE)
      IODEVICE ADDRESS=(F008,1),UNITADD=00,CUNUMBR=(F008),
            UNIT=2032
```

Figure 8-7 Sample FICON Director IOCP definitions

The sample configuration is shown for a zSeries processor with FICON native (FC) channels connected to a FICON Director with a switch address of 18.

8.2.4 Switched point-to-point topology

The FICON channel in this type of configuration is connected through a FICON Director to the CU's FICON adapter (see Figure 8-8).

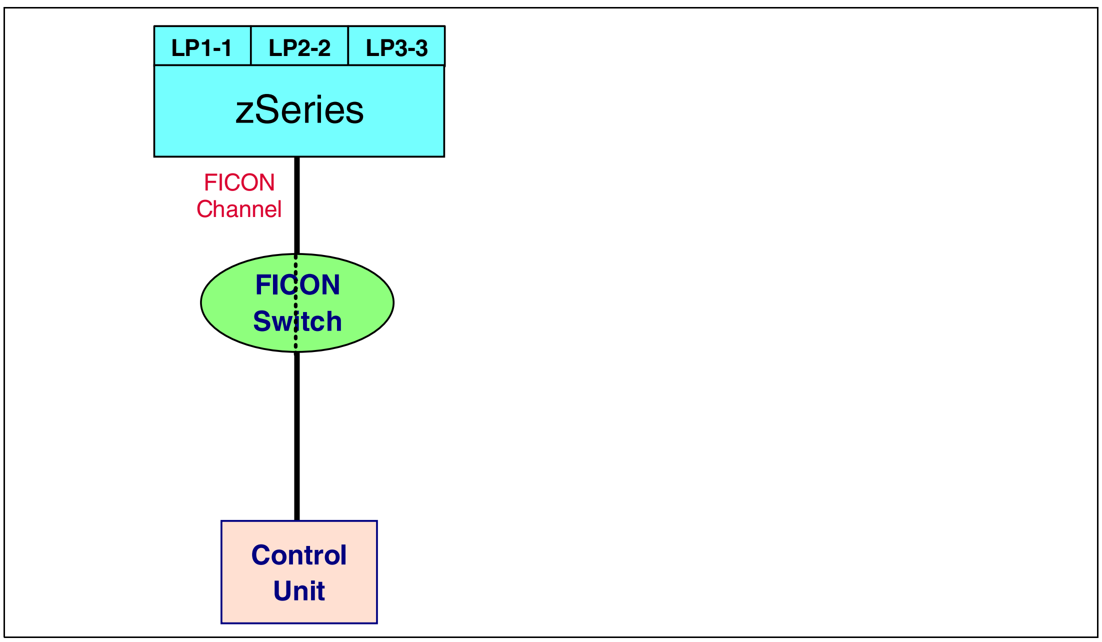

Figure 8-8 FICON switched point-to-point configuration

Keyword definitions and rules

This section describes the required keyword definitions and rules for a FICON switched point-to-point configuration. The LINK and SWITCH keywords must be defined for this configuration.

PATH

The PATH keyword is required and is used to specify up to eight two-digit hexadecimal numbers for the FICON CHPID numbers. The CHPID numbers that can be specified for FICON channels are predetermined, based on the number and types of channels ordered for the specific processor.

The CHPID Report, provided by IBM as a result of a new or upgrade machine order, identifies the default CHPID numbers of all installed channels and STI cables used. This report can be obtained from IBM and should be handed to the customer for all new or upgraded machines or channel MESs. Refer to Chapter 7, “FICON channel configurations” on page 91 for a sample of the CHPID Report.

Note that the zSeries processor provides a new function called Flexible CHPID Number Assignment. This function allows the customer to change a default CHPID number for a channel to any other CHPID number.

TYPE

The CHPID type for FICON channels in a switched point-to-point configuration is required and must be specified as TYPE=FC. This indicates that the FICON channel will operate in FICON native (FC) mode.

SWITCH

Since the FICON channel is connected to a FICON Director, a SWITCH keyword value must be specified. This value must be in the hexadecimal range of 00-FF.

We recommend that this value to be set to the switch address of the FICON Director (entry switch), which is defined to the FICON Director at installation time. This will help simplify the configuration and reduce confusion by having a common designation across all definitions.

> **Important:** Keep in mind that the switch addresses of the FICON Directors must be unique across all of the processor’s CHPIDs.

LINK

A 1-byte destination link address value must be defined with the LINK keyword. This value is the FICON Director port address of the physical port that the CU is attached to. The physical port has a port number which does not always correspond with the port address (this is switch vendor specific).

> **Important:** It is possible to define a 2-byte link address (switch address and port address). However, the FICON Director must have the Fabric Binding and Insistent Domain ID feature installed and configured. Refer to 7.5.1, “Levels of binding” on page 103 for more details.
>
> Also, once a 2-byte link address is defined to a channel path, all link addresses defined to be accessed from that same channel path must be 2-byte link addresses.

Logical address (CUADD)

Prior to FICON native channel paths, the logical address for the control unit is specified as one hexadecimal digit in the range 0 - F for CNC, CTC, and FICON Bridge (FCV) channel paths. For FICON native (FC) channel paths, the logical address is specified as two hexadecimal digits in the range 00 - FE. However, if FC channel paths are mixed with CNC or FICON Bridge (FCV) channel paths on the same control unit, the logical address for the control unit must be in the range 0 - F.

Unit addresses

As with some ESCON-attached control units, some FICON control units also require that the unit address range begin with hexadecimal 00.

Figure 8-9 shows an IOCP sample coding for a switched point-to-point configuration.

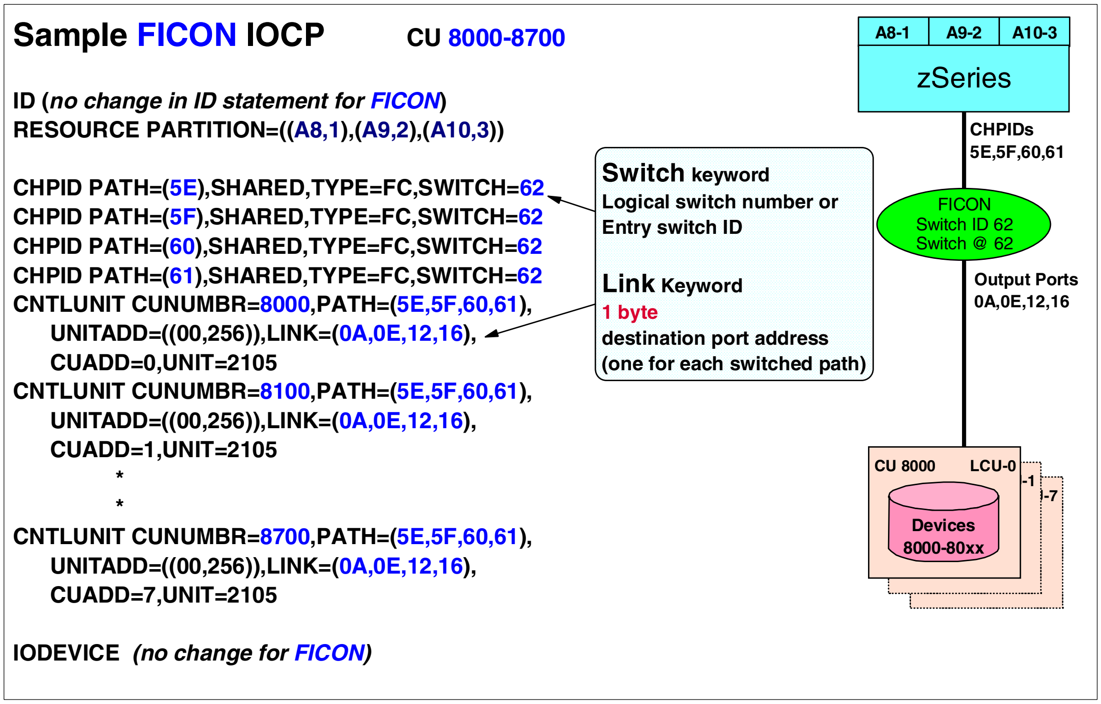

Figure 8-9 Sample IOCP coding for FICON switched point-to-point configuration

IOCP verification in HCD and Support Element (SE) panels

Figure 8-10 on page 136 shows how to verify your IOCP definitions. The FICON destination link address is shown in both HCD and SE panels using the sample IOCP coding as in Figure 8-9.

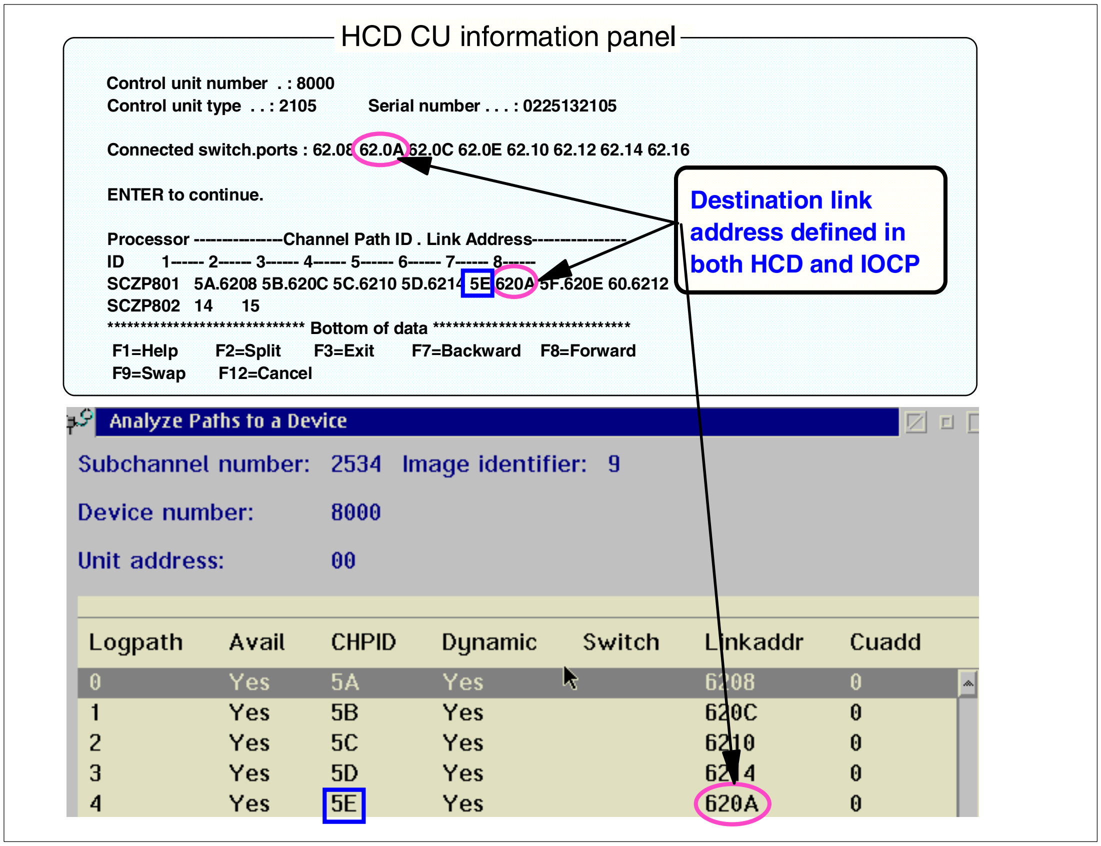

Figure 8-10 IOCP definition for a switched point-to-point configuration in HCD and SE

Looking to the IOCP example (Figure 8-9 on page 135) for this configuration you will see that there is only a 1-byte link address specified under the CU macro, but the HCD and SE panel display shows a 2-byte link address. This happens due to the channel architecture when a FLOGI is performed to the switch from both the channel and the CU. A detailed description of the FLOGI is in Chapter 3, “FICON architecture and addressing” on page 25.

For SE panel guidance, refer to *Support Element Operation Guide,* SC28-6818, and for HCD panel access refer to *Hardware Configuration Definition User’s Guide,* SC33-7988.

8.2.5 FICON support for the cascaded Directors topology

A FICON channel can be connected to a FICON CU (control unit) through two FICON Directors (cascaded), as shown Figure 8-11 on page 137. An apparent difference from the two ESCON Director chained topology is that both FICON Directors in a cascaded configuration are operating in *dynamic* mode, unlike one static and one dynamic for a chained ESCON Director. Other changes in defining IOCP keywords for a cascaded configuration are described in detail in this section.

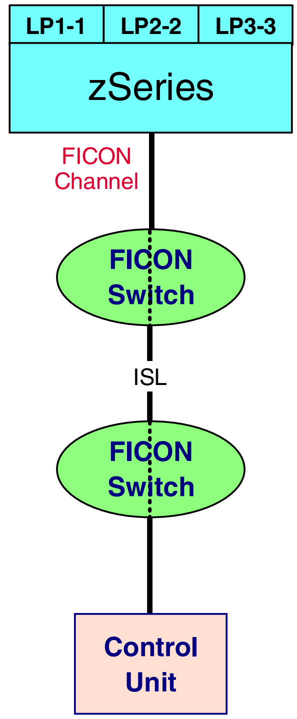

Figure 8-11 FICON cascaded Directors configuration

Keyword definition and rule description

This section describes keyword definition and its rules for cascaded FICON Directors configuration. The LINK and SWITCH keywords must be defined for this configuration.

PATH

The PATH keyword is required and is used to specify up to eight two-digit hexadecimal numbers for the FICON CHPID numbers. The CHPID numbers that can be specified for FICON channels are predetermined, based on the number and types of channels ordered for the specific processor.

The CHPID Report, provided by IBM as a result of a new or upgrade machine order, identifies the default CHPID numbers of all installed channels and STI cables used. This report can be obtained from IBM and should be handed to the customer for all new or upgraded machines or channel MESs. Refer to Chapter 7, “FICON channel configurations” on page 91 for a sample of the CHPID Report.

Note that the zSeries processor provides a new function called Flexible CHPID Number Assignment. This function allows the customer to change a default CHPID number for a channel to any other CHPID number.

TYPE

The CHPID type for FICON channels in a cascaded FICON Directors configuration is required and must be specified as TYPE=FC. This indicates that the FICON channel will operate in FICON native (FC) mode.

SWITCH

Since the FICON channel is connected to a FICON Director, a SWITCH keyword value must be specified. This value must be in the hexadecimal range of 00-FF.

We recommend this value to be set to the switch address of the FICON Director (entry switch), which is defined to the FICON Director at installation time. This will help simplify the configuration and reduce confusion by having a common designation across all definitions.

> **Important:** Keep in mind that the switch addresses of the FICON Directors must be unique across all of the processor's CHPIDs.

LINK

For a control unit (CU) connected through cascaded FICON Directors, we must define a 2-byte link address value in the LINK keyword.

Rules and recommendations for the LINK keyword:

- CNTLUNIT statement (LINK keyword)
  - The 2-byte link address consists of the cascaded switch address and the port address to which the CU is connected.
  - Once a 2-byte link address is defined to a channel path, all link addresses defined to be accessed from that same channel path must be 2-byte link addresses.

5. Recommendation
   - IOCP

     Once a 2-byte link address has been specified for a channel path, try to specify 2-byte link addresses for all paths, from the same CEC, that have the same entry switch.

     This will allow IOCP to perform better checking of the switch configuration
   - HCD

     HCD requires additional information and performs a different checking method. Therefore, the above is an IOCP recommendation only.

Logical address (CUADD)

Prior to FICON native channel paths, the logical address for the control unit is specified as one hexadecimal digit in the range 0 - F for CNC, CTC, and FICON Bridge (FCV) channel paths. For FICON native (FC) channel paths, the logical address is specified as two hexadecimal digits in the range 00 - FE. However, if FC channel paths are mixed with CNC or FICON Bridge (FCV) channel paths on the same control unit, the logical address for the control unit must be in the range 0 - F.

Unit addresses

As with some ESCON-attached control units, some FICON control units also require that the unit address range begin with hexadecimal 00.

Sample IOCP coding for FICON cascaded Directors configuration

Figure 8-12 on page 139 shows a typical FICON-supported cascaded Directors configuration with a sample IOCP.

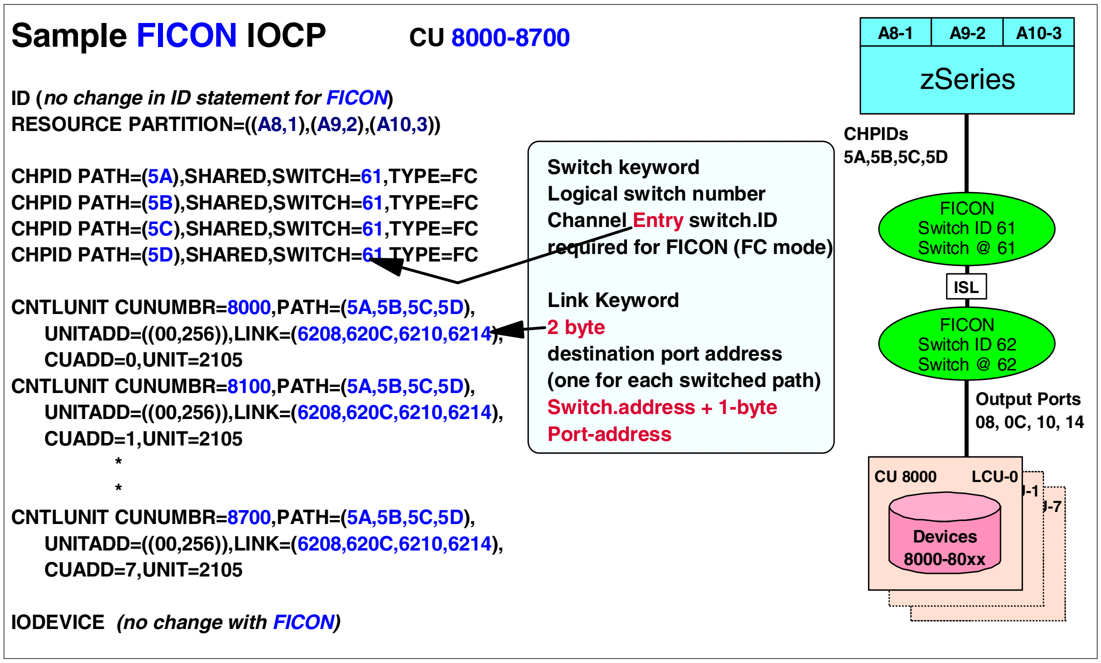

Figure 8-12 Sample IOCP coding for FICON cascaded Directors configuration

IOCP verification in HCD and Support Element (SE) panels

To verify IOCP definitions, refer to Figure 8-13. For SE panel displays, refer to *Support Element Operation Guide,* SC28-6818, and for HCD panel access, refer to *Hardware Configuration Definition User's Guide,* SC33-7988.

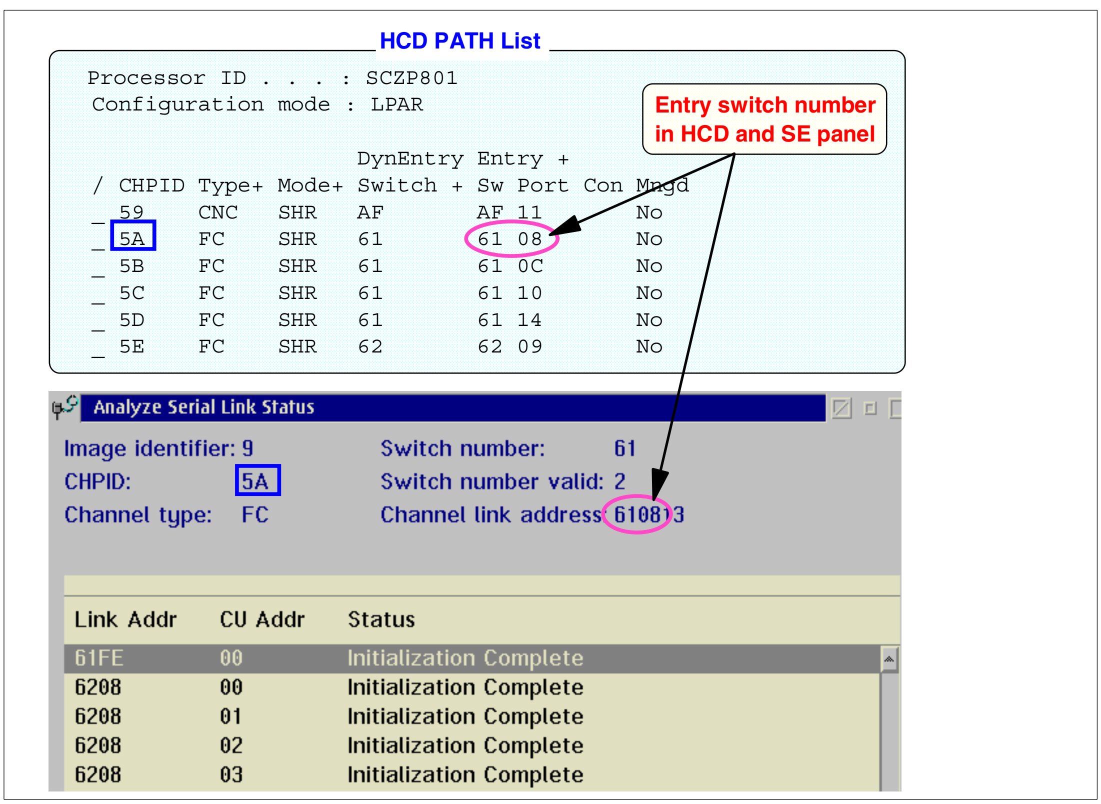

Figure 8-13 Entry switch number definition in HCD and SE panel

As shown in Figure 8-13 on page 139, we can see that FICON channel 5A is attached to port 08 of entry switch 61 in both HCD and SE panels.

In Figure 8-14 the 2-byte destination link address (1-byte switch address plus 1-byte port address) is shown in both HCD and SE panels referring to sample IOCP coding in Figure 8-12 on page 139.

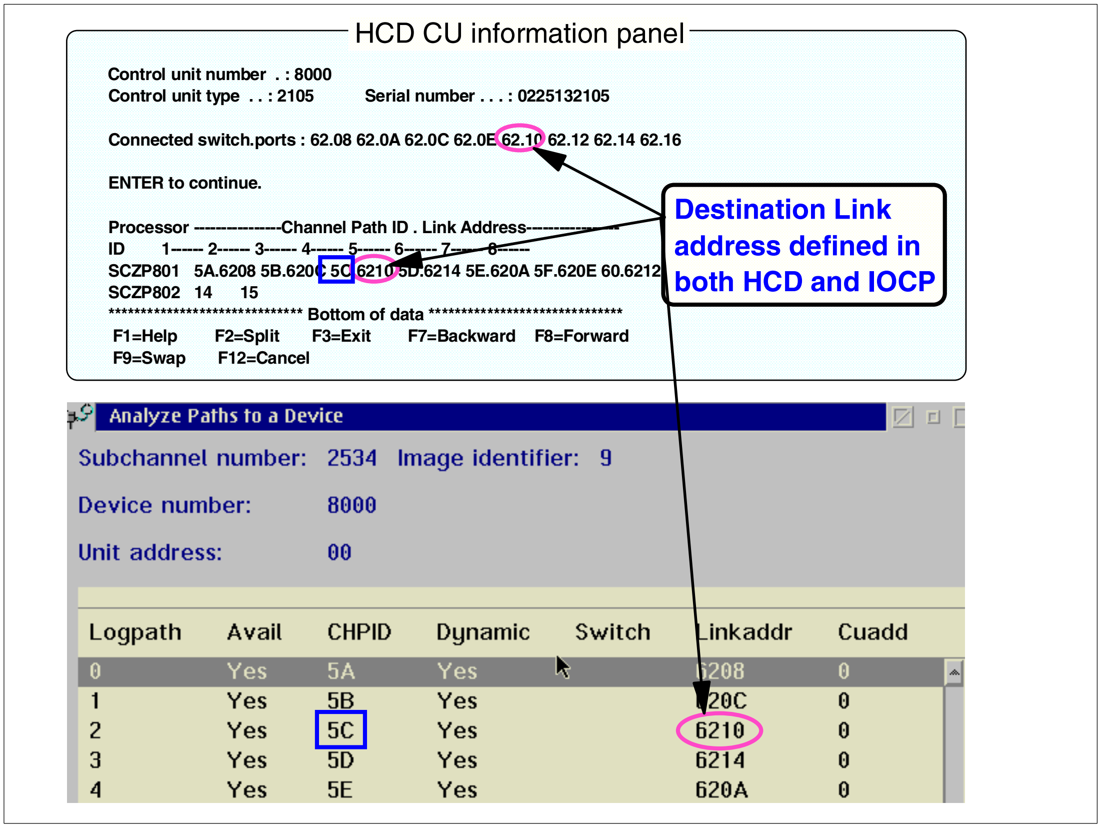

Figure 8-14 IOCP definition for the cascaded Directors configuration in HCD and SE

For details on how link addresses are generated, refer to Chapter 3, “FICON architecture and addressing” on page 25.

For additional cascaded FICON Directors configuration examples, go to Appendix E, “Cascaded FICON Directors” on page 235.

9

FICON migration

This chapter discusses the hardware and software considerations for migration from an ESCON or FICON Bridge (FCV) environment to a FICON native (FC) environment.

It describes the changes to non-IBM software channel programs that may be required to perform optimally in a FICON environment. Note that the introduction of FICON native (FC) channels is transparent to software and programs that use standard software interfaces.

It also describes requirements for some vendor-written UIMs to support FICON.

Scenarios for migration from an ESCON or FICON Bridge (FCV) environment to a FICON native (FC) environment are also included.

9.1 Hardware considerations

This section describes the hardware considerations for migration to a FICON native (FC) environment.

9.1.1 FICON processors

The IBM S/390 G5 and G6 and zSeries servers support FICON native attachment at the following microcode levels:

- S/390 G5 - Driver 26W (FCS EC F99907).
- S/390 G6 - Driver 26W (FCS EC F99907).
- zSeries - Driver 3G (FCS EC F25105) is recommended.

We recommend that the latest available MCLs be installed.

Refer to Chapter 4, “Processor support” on page 55 for FICON and FICON Express feature information and CMOS DRV details.

9.1.2 Machine definition limits and rules in IOCP and IOCDS

There are limitations and rules in defining ESCON and FICON I/O definition based on channel and machine types, which can affect logical paths and control units during migrations. For details about definition limitations and rules, refer to 7.6.1, “S/390 architecture, FICON and ESCON implementations” on page 107. For more information on machine limitations and rules, refer to “Input/Output Configuration Program Guide ” at:

`http://www.ibm.com/servers/resourcelink`

Then select **Library** -> **z900**, **z800** or **G5/G6**).

9.1.3 FICON Directors

FICON Directors support many different topologies (switched point-to-point, FICON CTC and FICON support for cascaded Directors). For cascaded FICON Directors the High Integrity Feature must be installed in the FICON Directors. Refer to 7.5.1, “Levels of binding” on page 103 for a description of the High Integrity Feature. Also refer to Table 4-8 on page 67 for the High Integrity Feature codes.

For FICON Director product-specific information, contact your switch manufacturer.

9.1.4 FICON control units

You can see the currently available IBM FICON I/O products in Table 4-7 on page 66.

9.2 Software considerations

This section discusses the software considerations for migration to a FICON native (FC) environment.

9.2.1 Channel programming considerations

IBM software has been modified to take full advantage of the performance benefits of command and data prefetching and pipelining with FICON channels. The I/O requests of applications that use standard I/O interfaces automatically benefit from CCW and data prefetching and pipelining also, because they cannot be self-modifying. However, it is necessary to check in-house and ISV software to determine whether it will continue to operate optimally in a FICON native (FC) environment. If the standard IBM programming interfaces are used, then the transition to FICON is transparent. However, programs that build their own channel programs should be reviewed with the following considerations in mind:

- Can the program take advantage of command and data prefetching and pipelining?
- Does the program require read-write transition synchronization?
- Does the program require PCI synchronization?

CCW and data prefetch

The Fibre Channel architecture provides for prefetching and pipelining of CCW commands and data, which allow more efficient I/O. However, prefetching may cause problems for self-modifying channel programs and for recovery routines that restart a failed read CCW from the point of failure. Some software components, such as the Auxiliary Storage Manager (ASM) and Standalone Dump, only modify their channel programs to change ending NOOP CCWs to TIC CCWs. This modification does not cause a problem since this condition (a non-command-chained NOOP CCW) is detected and handled by the FICON channel.

Other self-modifying channel programs alter CCWs as a result of channel program execution. For example, a CCW in a channel program may read data into a buffer that is used by a CCW later in the same CCW chain.

For more information on the FICON channel operation and the software controls, refer to 11.1.2, “CCW and data prefetch and pipelining” on page 191.

Synchronization of read-write transition

The FICON channel synchronizes on the transition from an input to an output operation within the channel program. That is, whenever the current command in execution in the FICON channel is an input operation (read) and a subsequent fetched CCW describes an output operation (write), the FICON channel indicates to the control unit that status must be presented at the completion of the input operation by the device. This is required to guarantee data integrity.

Being able to override the synchronization that occurs on transition from read CCWs to write CCWs improves the performance of the I/O operation and allows maximum benefits to be gained from the CCW and data prefetching and pipelining capabilities of the FICON channel. However, overriding the synchronization on read-to-write transitions should only be specified if the buffers used for reading are separate from those used for writing, or the read channel programs are separate from the write channel programs.

For more information on the FICON channel synchronization and the software controls, refer to “Synchronization of read-write transition” on page 143.

PCI synchronization

The FICON channel performs PCI synchronization on CCWs that specify a PCI (Program Controlled Interrupt). This is known as modification control. When the FICON channel executes a command with the PCI and command-chain flags set to one in the CCW, command synchronization is forced for the subsequent command by setting the Synchronize Send Status (SSS) flag. The channel subsystem temporarily suspends command chaining and does not fetch the next command-chained CCW until after normal ending status is received from the device for the last command that had been sent.

Modification control provides the capability to optimize dynamically modified channel programs that use the PCI flag in the CCW to initiate channel program modification. It allows the program to delay the channel subsystem fetching and transfer of commands until after status is received for the command following the command with the PCI bit set.

On systems where FICON channels are supported, overriding the synchronization that occurs on PCI interrupts improves the performance of the I/O operation and allows maximum benefits to be gained from the CCW and data prefetching and pipelining capabilities of the FICON channel. However, overriding PCI synchronization should only be specified if the PCI interrupt is not used to modify the CCW chain following the CCW where the PCI is requested.

For more information on the FICON channel operation and synchronization, refer to 11.1.4, “PCI synchronization” on page 195.

9.2.2 Vendor UIMs

In support of FICON, including FICON Bridge (FCV), the length of the device class extension portion of the UCB for tape devices was increased. If the installation has OEM tape drives or other hardware products that are defined in HCD as tape devices, such as Channel Extenders and some optical devices, and those products use manufacturer-written Unit Information Modules (UIMs), then the OEM hardware vendor must be contacted to obtain the latest version of the UIM that supports FICON.

9.3 Migration recommendations from ESCON or FCV to FC

When planning the migration from an existing ESCON or FICON Bridge (FCV) configuration to a FICON native (FC) configuration, consider the following rules:

- Configure at least two channel paths to a logical control unit for high availability. (More channel paths may be required depending on throughput requirements.)
- A logical control unit or device cannot be defined to be accessed more than once from the same channel path.
- A physical control unit that has multiple logical control units (specified by the CUADD parameter in IOCP/HCD) may be accessed more than once from the same FICON (FC) channel path, but the access is to different CUADDs (different logical control units) within the physical control unit.
- Configure the channel paths according to the quantity of resources available in the FICON channel and control unit.

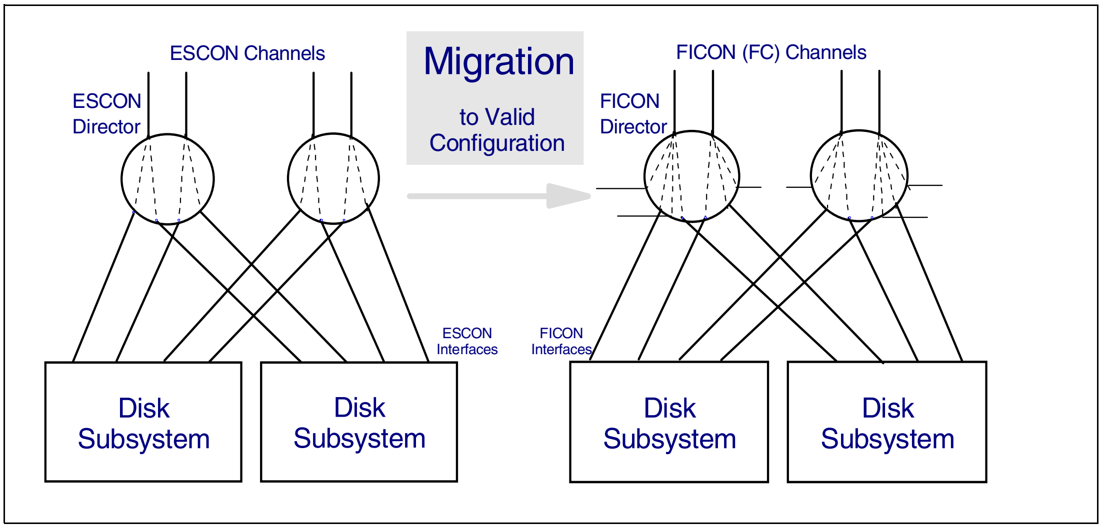

Figure 9-1 ESCON (CNC) to FICON native (FC) migration

Figure 9-1 shows a valid migration from ESCON (CNC) channels to FICON native (FC) channels. There are four paths from the operating system image to the disk subsystem in both the ESCON configuration and the FICON configuration, but the advantages of the FICON configuration include:

- More concurrent I/Os to the same control unit
- Concurrent I/Os with other control units

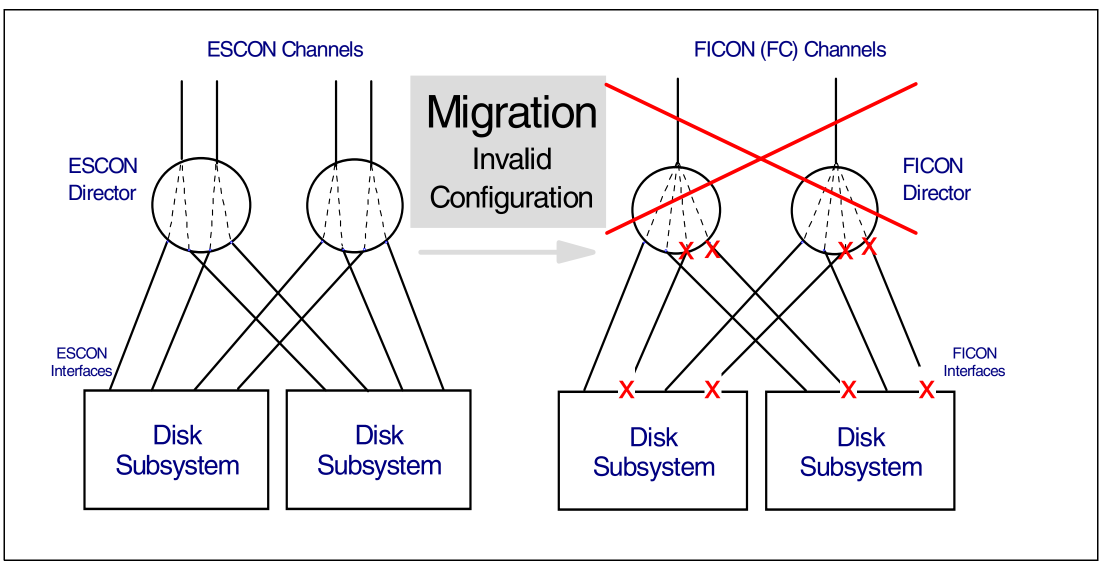

Figure 9-2 ESCON (CNC) to FICON native (FC) invalid migration

As Figure 9-2 shows, when migrating access to a control unit from ESCON (CNC) channels to FICON native (FC) channels, it is not possible to aggregate two or more ESCON channel paths that access the same logical control unit into only one FICON native (FC) channel path. This rule applies to ESCON, FICON Bridge (FCV), and FICON native (FC) channels.

9.3.1 Migration scenario #1 - ESCON to FICON native (FC)

When planning the migration to FICON native (FC) channels, it is necessary to observe the limits of the FICON resources provided by the FICON native (FC) channel, FICON Director and the FICON control unit.

Consider the ESCON configuration shown in Figure 9-3.

In this ESCON configuration, each image on each of the four CECs has eight paths to each logical control unit (LCU) on two ESS D/T2105 subsystems. The paths are configured through four ESCON Directors, each with 248 ports. This configuration requires the following resources:

- 32 ESCON (CNC) channels per CEC
- 40 ESCON Director ports per ESCON Director (32 for channels, eight for CU adapters)
- 16 ESCON adapters per control unit

  Only eight of the 16 adapters can be used to access a specific logical control unit from any logical partition, and there are eight logical control units per physical control unit.

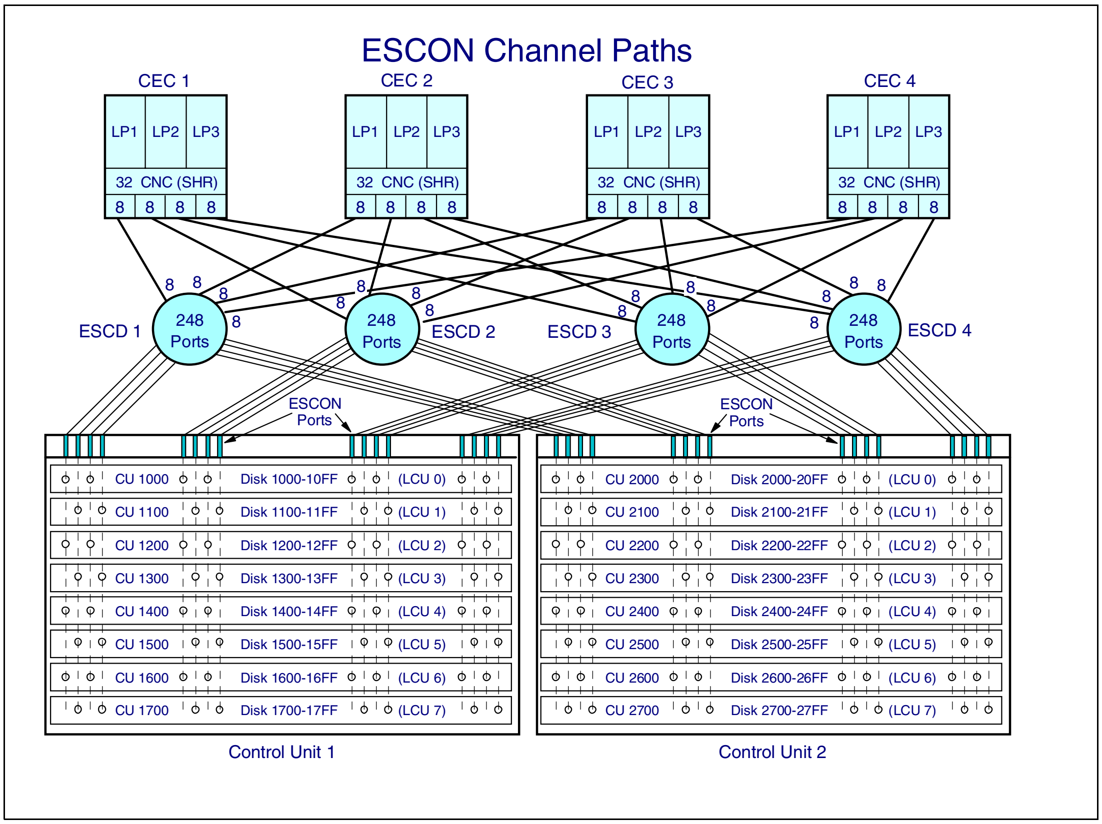

Figure 9-3 Migration scenario #1 - sample ESCON configuration

The maximum I/O connectivity for a single ESCON channel in this configuration includes only one control unit link with its 1,024 device address limitation. Each control unit adapter can access four logical control units, each with 256 volumes (4 x 256 = 1,024).

A single ESCON channel can do only one active I/O operation to one of the four logical control units at a time.

A sample FICON native (FC) migration configuration for this ESCON configuration is shown in Figure 9-4. In this configuration, each of the three logical partitions on each of the four CECs still has eight paths to each LCU on two ESS D/T2105 subsystems. The paths, over FICON native (FC) channels, are configured through two 64-port FICON Directors. Each CEC has eight FICON native (FC) channels, which are shared by all images that access all LCUs.

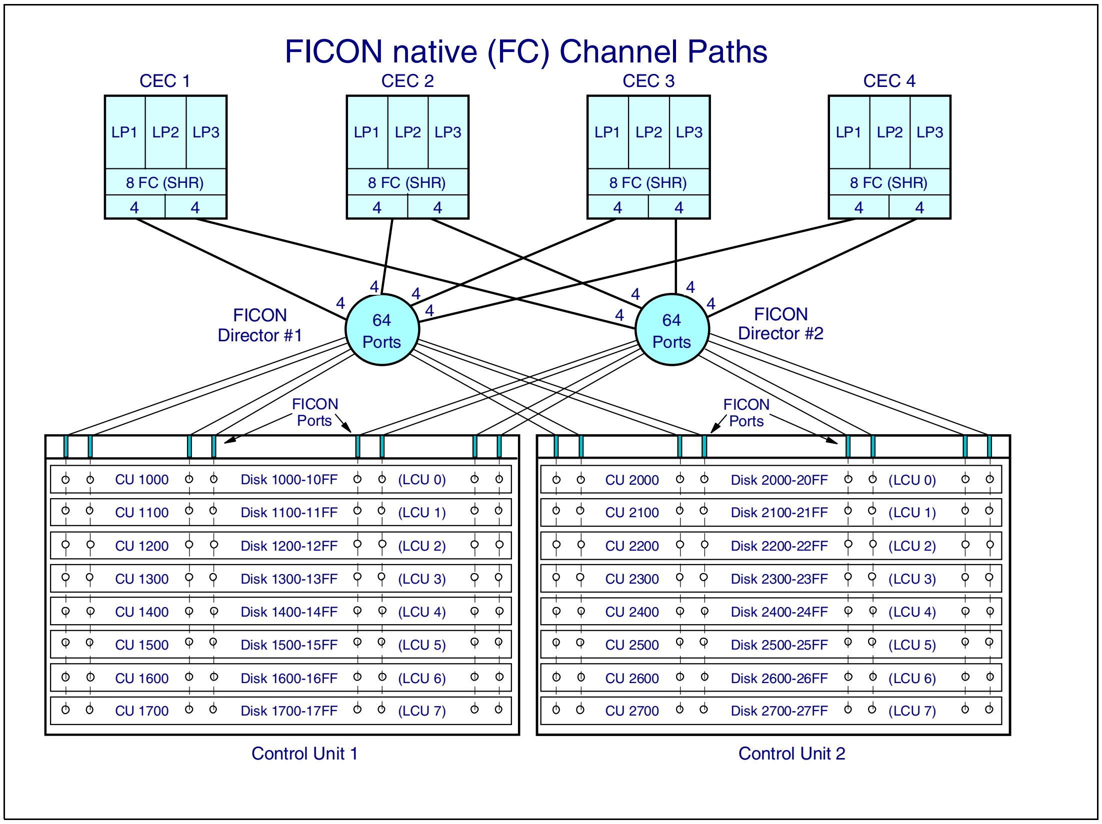

Figure 9-4 Migration scenario #1 - sample FICON native (FC) configuration

There are two control units, each with eight FICON adapters and eight logical control units configured. All adapters can be used by all logical control units (conforming to the maximum of eight paths per LCU limit) and each logical control unit has 256 device addresses. All control unit FICON host adapters are connected through two FICON Directors.

There are two FICON Directors and each is connected to four FICON native (FC) channels of each CEC, resulting in 16 ports on each switch for channel connectivity. Each of the FICON Directors is also connected to four adapters of each control unit, resulting in 24 ports in total for each switch.

The resources used by this configuration are:

- 8 FICON native (FC) channels per CEC
- 24 FICON Director ports per FICON Director (16 for channels, 8 for CU adapters)
- 8 FICON adapters per control unit
- Number of subchannels per image = 4,096

  This part of the configuration has 4,096 subchannels per image, because there are two control units, and each control unit has eight logical control units and 256 devices (the maximum) per logical control unit (2 x 8 x 256 = 4,096).

The maximum number of subchannels is CEC dependent. The zSeries 900 processor supports up to 63K subchannels per image, and the 9672 G5 and G6 processors support up to 36K subchannels per image. Refer to Table 9-1 on page 149 regarding limitations and rules.

- Number of subchannels per CEC = 12,288

  This part of the configuration has all three images accessing all devices from all logical control units, so the number of subchannels per CEC is three times the number of subchannels per image (3 x 4,096 = 12,288). Note that this number does not take into consideration any ESS PAV alias devices that may be configured. Each ESS PAV alias device requires a subchannel.

  The maximum number of subchannels is CEC dependent. The zSeries 900 processor supports up to 512K per CEC, while the 9672 G5 and G6 processors support up to 288K subchannels per CEC.

- Number of subchannels per FICON native (FC) channel

  As each FICON native (FC) channel is connected to all eight logical control units on each control unit, and each logical control unit has 256 devices (the maximum), the number of subchannels per channel is 4,096, or 4K (2 x 8 x 256).

  The maximum number of devices per FICON native (FC) channel is 16,384 (16K) for both the zSeries 900 processor and the 9672 G5/G6 processors.

The control unit resources used in this environment include:

- Number of Fibre Channel N_Port logins per adapter = 4.

  There are four CECs and all control unit host adapters are accessed by a channel to all CECs, so there are four N_Port logins per control unit adapter.

  The maximum number of N_Port logins is control unit dependent. For example, the IBM FICON ESS 2105 subsystem supports up to 128 N_Port logins per control unit FICON host adapter.

- Number of logical paths per control unit host adapter = 96.

  There are 12 images and each image has eight logical paths through a control unit FICON adapter, one per logical control unit.

  The maximum number of logical paths per control unit host adapter is control unit dependent. For example, the IBM FICON ESS 2105 subsystem supports up to 256 logical paths per host FICON adapter.

- Number of logical paths per logical control unit = 96.

  There are eight paths per logical control unit for each host image. In all four CECs there are 12 images, so there are 96 (8 x 12) logical paths per logical control unit.

  The maximum number of logical paths per logical control unit is control unit dependent. As an example, the IBM ESS 2105 subsystem supports up to 128 logical paths per logical control unit.

So this FICON native (FC) configuration is within the FICON resource limits and in fact requires less channel and connectivity resources than the corresponding ESCON configuration. In this migration scenario, four ESCON CHPIDs have been aggregated into one FICON CHPID.

The remainder of this section discusses the considerations for the connectivity and I/O operation concurrency of this FICON configuration. A single FICON channel uses a dynamic connection in the FICON Director, which provides concurrent access to both control units. Each control unit FICON adapter can access any of the eight configured logical control units.

So this single FICON native (FC) channel can have I/O operations to all 16 logical control units at the same time, by using the FICON protocol frame multiplexing, FICON IU multiplexing, and CCW and data pipelining.

This also means that this FICON native (FC) channel is addressing 4,096 volumes (256 volumes per logical control unit). The FICON implementation allows up to 16,384 device addresses per FICON channel.

FICON's IU multiplexing, pipelining and frame multiplexing also allows multiple I/O operations to the same logical control unit. As a result, multiple I/O operations can be done concurrently to any logical control unit, even within the same control unit. By using IBM ESS's Parallel Access Volume (PAV) function, multiple concurrent I/O operations are possible even to the same volume.

Comparing I/O operation concurrency

Table 9-1 compares the resources and I/O concurrency numbers of the ESCON and FICON multi-system configurations shown.

Table 9-1 Resources and I/O concurrency

	ESCON	FICON
Number of channels per CEC	32	8
Number of adapters per control unit	16	8
Number of ports per Director	40 (x 4 switches)	24 (x 2 switches)
Number of concurrent I/Os per CEC	32	Multiple per channel: if 8 concurrently = 64 if 4 concurrently = 32
Number of concurrent I/Os per control unit	16	Multiple per adapter: if 8 concurrently = 64 if 4 concurrently = 32

The actual number of concurrent I/O operations per CEC depends on the FICON channel implementation on the CEC, and the actual number of concurrent I/O operations per control unit also depends on the FICON adapter implementation on the control unit.

As an example, Table 9-1 is comparing the FICON and ESCON I/O concurrency assuming that channels and adapters can have four or eight concurrent I/O operations.

Using four times fewer FICON channels than ESCON channels, the FICON configuration can have more concurrent I/O operations in each control unit and in each CEC.

9.3.2 Migration scenario #2 - control unit resources exceeded

In the following migration scenario, the starting configuration is the ESCON configuration shown in Figure 9-5 on page 150.

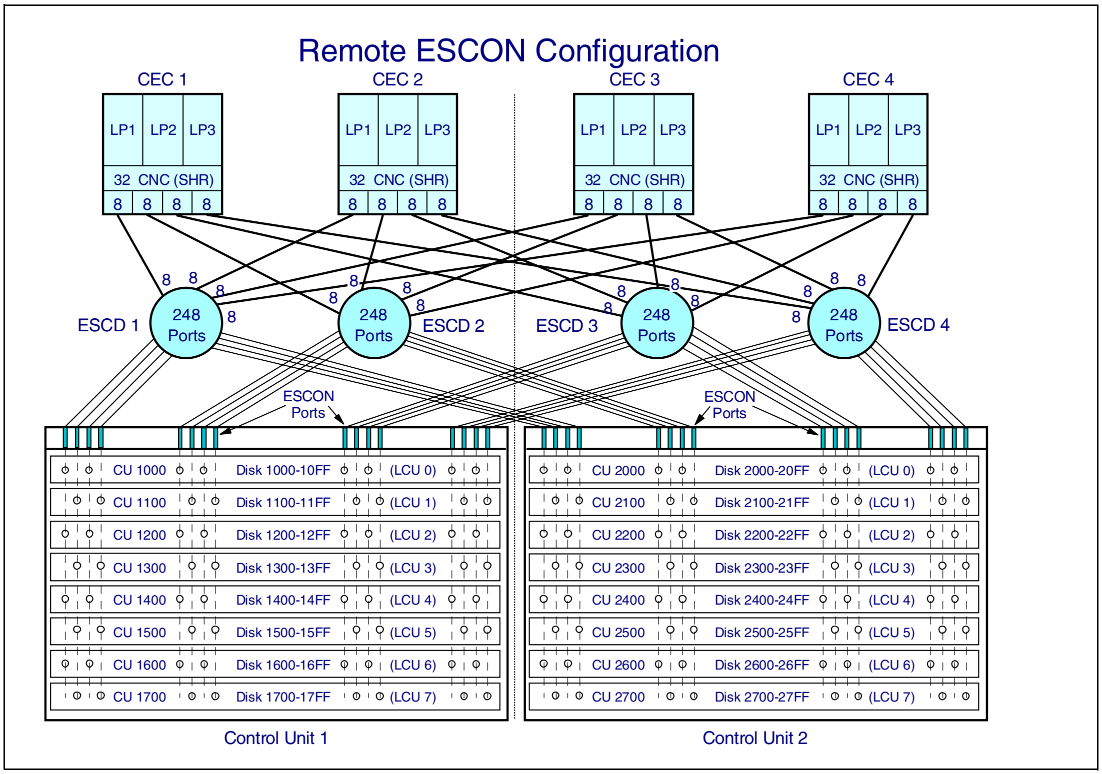

Figure 9-5 Migration scenario #2 - remote ESCON configuration

This configuration uses the following resources:

- 32 ESCON (CNC) channels per CEC
- 40 ESCON Director ports per ESCON Director (32 for channels, 8 for CU adapters)
- 16 ESCON adapters per control unit

The target FICON installation is to have six CECs installed. Three CECs are in one machine room, and three CECs are in a machine room at another location. A poorly-designed (over-defined) FICON native (FC) configuration is shown in Figure 9-6 on page 151. There are 18 host images (three on each of the six CECs), and each image is configured with eight paths per control unit LCU. Therefore, the total number of logical paths configured (18* 8 = 144) exceeds the capacity of a logical control unit. The FICON ESS 2105 control unit shown supports up to 128 logical paths per LCU. Note that the same problem of an over-defined configuration can also occur in an ESCON environment.

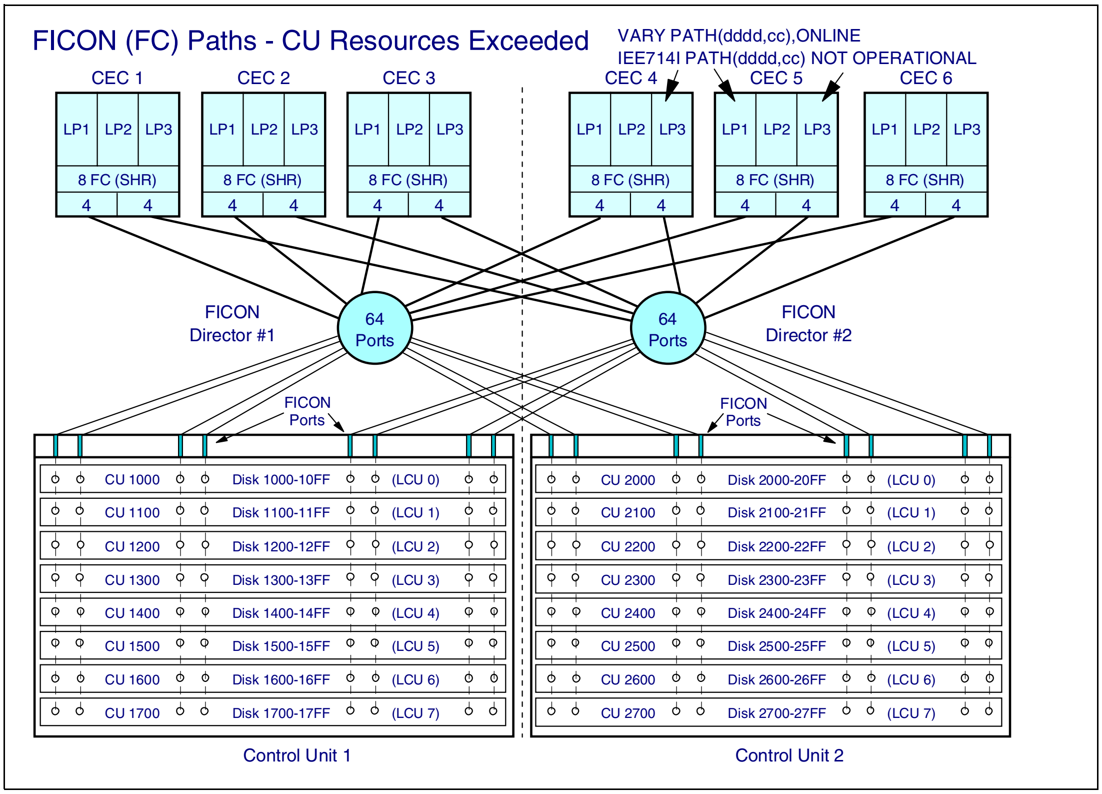

Figure 9-6 Migration scenario #2 - FICON CU resources exceeded

Let’s assume that two more CECs are now required, each of them having three images, resulting in a total of 18 images. The new control unit resource calculations are:

- Number of N_Port logins per adapter = 6.

  Now there are 6 CECs and all control unit adapters are connected to all CECs, so there are 6 N_Port logins per control unit adapter.

  This number is significantly less than the ESS 2105 limit, which is 128 N_Port logins per control unit port.

- Number of logical paths per adapter = 72.

  There are 18 images and each image has four logical paths to a control unit FICON adapter.

  The IBM ESS 2105 limit is 256 logical paths per FICON adapter.

- Number of logical paths per logical control unit = 144.

  There are eight paths per logical control unit for each host image. In all six CECs there are 18 images, so 144 (8 x 18) logical paths per logical control unit.

  This number is *higher* than the ESS 2105 limit, which is 128 logical paths per logical control unit.

This is an example of an over-defined migration configuration that will have problems because it cannot have more than 128 logical paths online to any logical control unit. Any attempt to vary more logical paths online will fail.

The problem with the over-defined configuration may not surface until an attempt is made to vary online paths to the devices beyond the already established limit of logical paths for the logical control unit or the adapter. The following message is issued to reject the vary path processing:

```
VARY PATH(dddd,cc),ONLINE
IEE714I  PATH(dddd,cc) NOT OPERATIONAL
```

Note that there is no additional indication of the cause of the `NOT OPERATIONAL` condition. To identify the source of the problem, it is necessary to display the Analyze Serial Link Status frame in the CHPID Problem Determination Task at the HMC. In this case, the ICKDSF logical path report can be run to identify which channel images have established logical paths to the logical control unit. Refer to F.4, "ICKDSF logical paths report" on page 247 for information on interpreting the report.

In order to overcome this problem, the number of paths for some less important images should be reduced from eight.

9.4 Migration recommendations for cascaded FICON Directors

The purpose of this section is to list the migration considerations for FICON support of cascaded Directors. General FICON native channel rules should be followed as described in 9.3, "Migration recommendations from ESCON or FCV to FC" on page 144.

For FICON CTC migration, refer to Chapter 10, "FICON CTC implementation" on page 153, where this is discussed in detail.

Hardware and software requirements for cascaded FICON Directors

- For Hardware
  - zSeries with FICON or FICON Express features at DRV3G with MCL (J11206) is required to support cascaded FICON Directors (refer to Table 4-2 on page 57).
  - FICON Directors in cascaded mode require the High Integrity Fabric and Insistent Domain ID features installed in the Directors. Currently two Directors are available (McDATA 6064 with LIC 3.0 and INRANGE 9000 with LIC 4.0) supporting cascading configurations. Refer to Table 4-8 on page 67 for High Integrity Features for each FICON Director.
  - Number of Inter-Switch Links (ISL) must be carefully planned based on the existing ESCON or FICON topology, data-traffic flow, and system performance. In this case the FICON Director manufacturers should ensure that there is a data-traffic balancing methodology implemented in the switch firmware.
- For Software
  - For APAR and PTF information, refer to Chapter 6, "z/OS and OS/390 software support" on page 83.
  - If a 2-byte link address has been defined on a channel, then all defined link addresses on the same channel must have 2-byte link addresses defined. Intermixing of 1-byte and 2-byte link addresses on the same channel is not allowed.
  - There can be multiple ISLs between the cascaded FICON Directors based on bandwidth requirements. ISLs are transparent to the operating system, so they are not defined in IOCP and not required to be defined to HCD. However, if you are using HCD, we recommend (for tracking purposes) that the ISLs be added to the port description to avoid them from being assigned to a port used for a FICON control unit or vice versa. For an HCD (Port List) example, go to Figure D-3 on page 222.

10

FICON CTC implementation

This chapter provides an overview of the features and benefits of FICON CTC, and the information necessary to implement the CTC function with FICON channels. Using the information in this chapter, a configuration planner and/or systems programmer can design and define a high availability CTC configuration in a FICON environment. Migration from ESCON CTCs to FICON CTCs is described, along with information on operations and performance of FICON CTC.

The following topics are discussed:

- Review of CTC support
- ESCON CTC review
- Overview and benefits of FICON CTC
- FCTC topology options
- FCTC hardware and software support
- Recommendations for FCTC device numbering scheme
- FCTC configuration and definition examples
- FICON CTC control unit function balancing
- Migration considerations
- FCTC operations and recovery - configuring for high availability recommendations
- FCTC functional characteristics and performance

10.1 Review of CTC support

Channel-to-channel (CTC) control units and associated devices provide the infrastructure for intersystem communication. z/OS, OS/390 and z/VM exploiters of CTC communication include:

- Cross-System Coupling Facility (XCF) pathin and pathout devices for sysplex intersystem communication (z/OS and OS/390)
- VTAM read/write devices
- TCP/IP read/write devices
- IMS read/write devices

In the past, CTC control unit support has been provided by the parallel channel-attached 3088 control unit, and with the introduction of ESCON in the early 1990s, by the ESCON CTC channel. Now, the FICON channel on the z900 at driver level 3C or later provides enhanced CTC control unit support, with increased connectivity and more flexible channel usage.

To provide background information for the description of the FICON CTC enhancements, a brief review of existing channel-to-channel control unit support follows.

10.1.1 Parallel 3088 CTC

Prior to the availability of ESCON, the 3088 control unit provided parallel channel-attached CTC support. The 3088 control unit, defined as “CTC”, is no longer supported.

10.1.2 ESCON CTC

CTC support in the ESCON environment is provided with a pair of connected ESCON channels (either in a point-to-point or switched point-to-point configuration), where one ESCON channel is defined as TYPE=CNC and the other ESCON channel is defined as TYPE=CTC. The CTC control unit (CU) function is implemented by the microcode supporting the ESCON channel TYPE=CTC. The ESCON CTC and CNC channels can be connected point-to-point, or switched point-to-point through an ESCON Director, which provides the switching function. Both shared (EMIF) and non-shared ESCON channels support the ESCON CTC function.

10.2 ESCON CTC Review

In this section, the topology options available for implementing ESCON CTC, along with sample configurations and supporting definitions, are reviewed to provide a basis for the comparison with FICON CTC.

ESCON CTC topologies

ESCON CTC communication requires a pair of ESCON channels, where one channel is defined as an ESCON *CTC* channel and the other channel is defined as an ESCON *CNC* channel. The ESCON CTC control unit (CU) function is provided in the microcode of the ESCON CTC channel.

SCTC control units are defined on the ESCON CTC channel to communicate with SCTC control units defined on the ESCON CNC channel, which in turn are defined to communicate to the SCTC control units defined on the ESCON CTC channel. The control units are defined as type SCTC, and they support ESCON CTC devices where the devices are defined as type SCTC.

Important: For some older exploiters, *BCTC* devices were supported by ESCON SCTC control units. The FICON CTC CU function does *not* support the BCTC definition for FICON CTC devices.

Note the following:

- The ESCON channel defined as CTC can only support the ESCON CTC CU function and CTC devices. It cannot be used for other I/O device support, such as disk, tape and so on.
- The ESCON channel defined as CNC can support ESCON CTC control unit definitions and other I/O control unit type definitions, such as disk and tape, if the channel is connected in a *switched* point-to-point topology.

The ESCON CTC channel supports a maximum of 512 unit addresses (or devices) and up to 120 logical control units. This limitation means that multiple pairs of CTC and CNC channels must be used in an installation with a large number of interconnected LPARs on the same physical processor or with LPARS (images) on other processors.

Point-to-point

ESCON CTC and CNC channels can be connected point-to-point, as shown in Figure 10-1 and Figure 10-2.

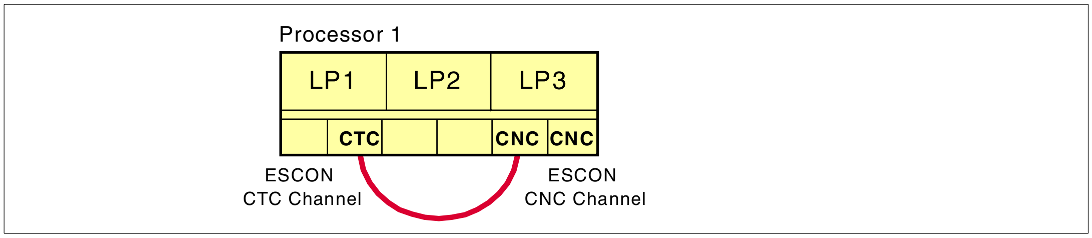

Figure 10-1 ESCON point-to-point CTC, single processor

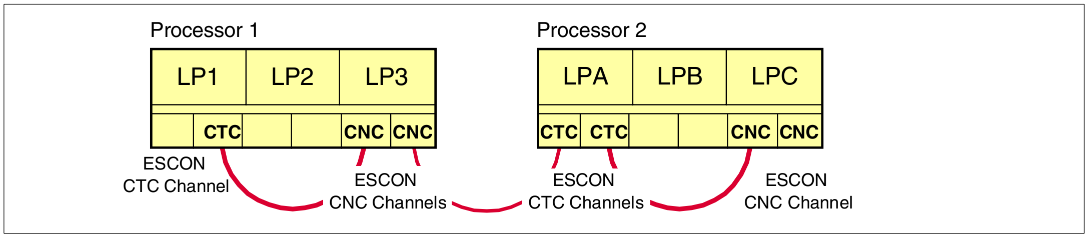

Figure 10-2 ESCON point-to-point CTC connection, multiple processors

In a point-to-point configuration, the ESCON CTC-CNC channels (either on the same or different processors) are directly connected to one another; neither channel is connected to an ESCON Director. A CNC channel connected point-to-point to a CTC channel can only support CTC control units. It cannot be used, for example, to support disk or tape control units. For this reason, point-to-point ESCON CTC-CNC configurations are not commonly used.

Switched point-to-point

ESCON CTC and CNC channels, on one or more processors, are usually connected in a switched point-to-point configuration, where the pairs of CTC-CNC channels are connected to the same ESCON Director. A simple ESCON switched point-to-point connection is shown in Figure 10-3 on page 156.

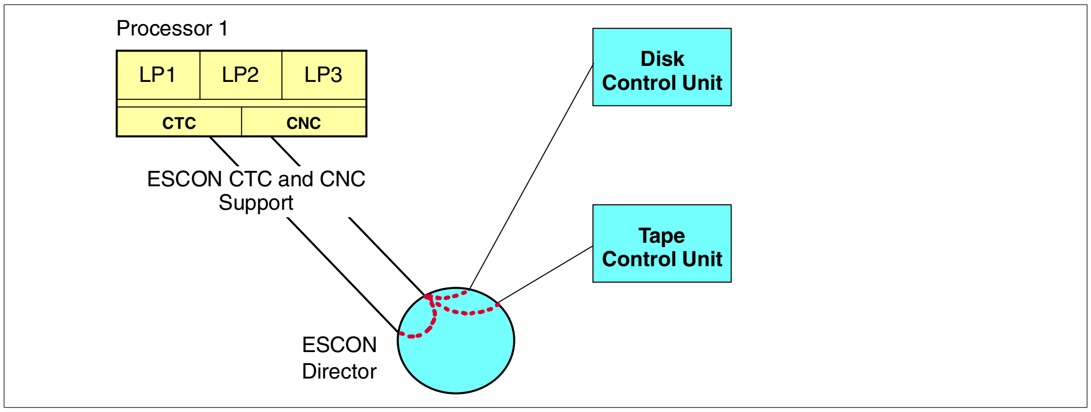

Figure 10-3 ESCON switched point-to-point CTC connections - one processor

An ESCON CTC and CNC channel pair is needed for communicating between images (LPARs) on the same processor. With the CNC channel connected to an ESCON Director, it can also be used to communicate with other ESCON control unit types, such as disk and tape control units.

A more common example of a switched point-to-point CTC configuration between systems on one processor and systems on a second processor is shown in Figure 10-4.

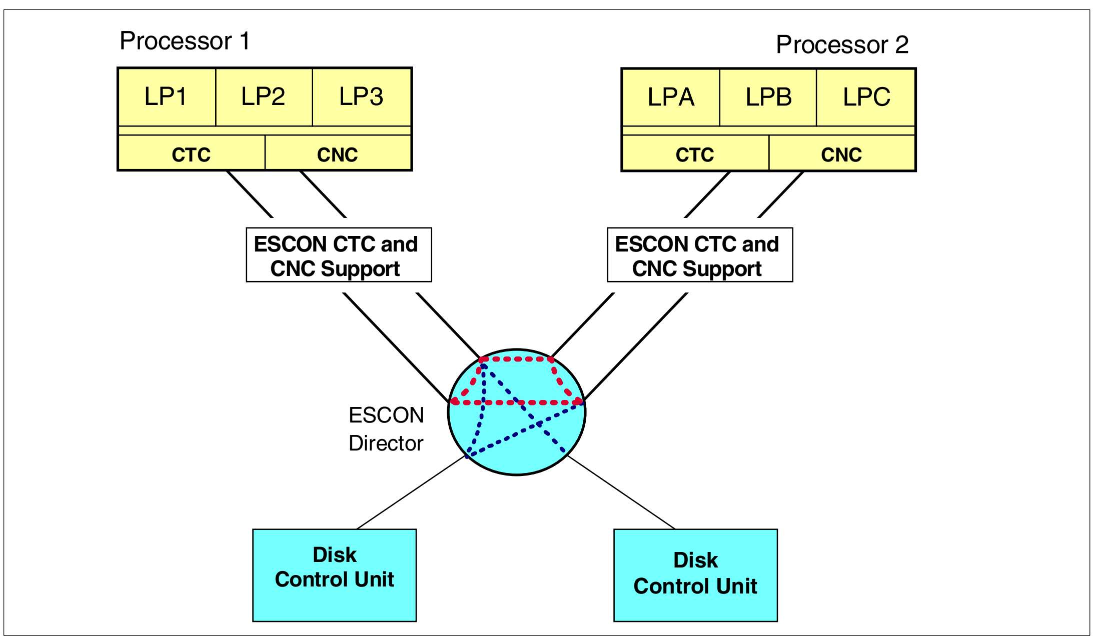

Figure 10-4 ESCON switched point-to-point connections

This figure, and the previous figures, show the minimum or *prime* CTC configuration. An ESCON CTC and CNC channel pair is needed on each processor for communicating between systems (logical partitions) on the same processor, or for communicating to logical partitions (LPARs) on other physical processors. A duplicated configuration (not shown) is required for availability reasons and should be connected through different ESCON channels and a different ESCON Director.

Sample ESCON CTC configurations and definitions

Defining ESCON or FICON CTC configurations requires an understanding of the use of CTCs by the different subsystems. For example, VTAM and TCP/IP require multiple read/write CTC device pairs, XCF requires multiple pathin/pathout CTC device pairs, and so on.

CTC hardware support allows the same CTC device to be used for both sending and receiving data, but most subsystems that use CTC devices for intersystem communications use a pair of devices: one for sending and the other for receiving. As a result, there could be up to eight CTC devices required for one image to communicate with one other image in the complex.

These eight CTC devices represent just the primary communication paths which should be duplicated for availability reasons. So, in a complex of 16 fully-interconnected images, up to 3,480 CTC devices may be required. This number is derived from the following calculation:

```
((((16 images-1) x 8 devices) x 16 images) x 2 for availability) = 3840 CTC devices
```

ESCON CTC device numbering scheme

Such a large number of CTC devices means that it can be both difficult and complex to design and define the CTC connections for a large CTC configuration. To help minimize the complexity, IBM developed a CTC device numbering scheme for use with ESCON CTC devices when ESCON was introduced in the early 1990s. This device numbering scheme is documented in *MVS/ESA HCD and Dynamic I/O Reconfiguration Primer,* SG24-4037.

The method makes use of the 4-digit z/Architecture device number where:

- First digit
  - An even hexidecimal number is used for the send CTC control unit and device.
  - An odd hexidecimal number is used for the receive CTC control unit and device.
- Second and third digits

  These represent an assigned CTC image-ID (that is, assigned on paper) for the LPAR image, and can be any unique value within the CTC complex. This CTC image-ID is used as a target identifier (for the image) that you use when defining how all other images access this image.
- Fourth digit

  This digit is used to indicate whether the CTC connection is the primary or alternate (backup for availability purposes). A value of 0 to 7 is used for the primary CTC connection devices, and a value of 8 to F is used for the alternate CTC connection devices.

There are many advantages to using this device numbering scheme. For instance, operations and systems programmers can easily identify the use (send or receive) and target system for any given CTC device. It also simplifies the CTC definition process in that the same operating system CTC device definitions can be used by all z/OS and OS/390 operating systems, independent of the image and processor where that operating system runs.

Because this numbering scheme is also being recommended for FICON CTC configurations, a sample configuration and definition is discussed. Figure 10-5 on page 158 shows the sample ESCON CTC configuration.

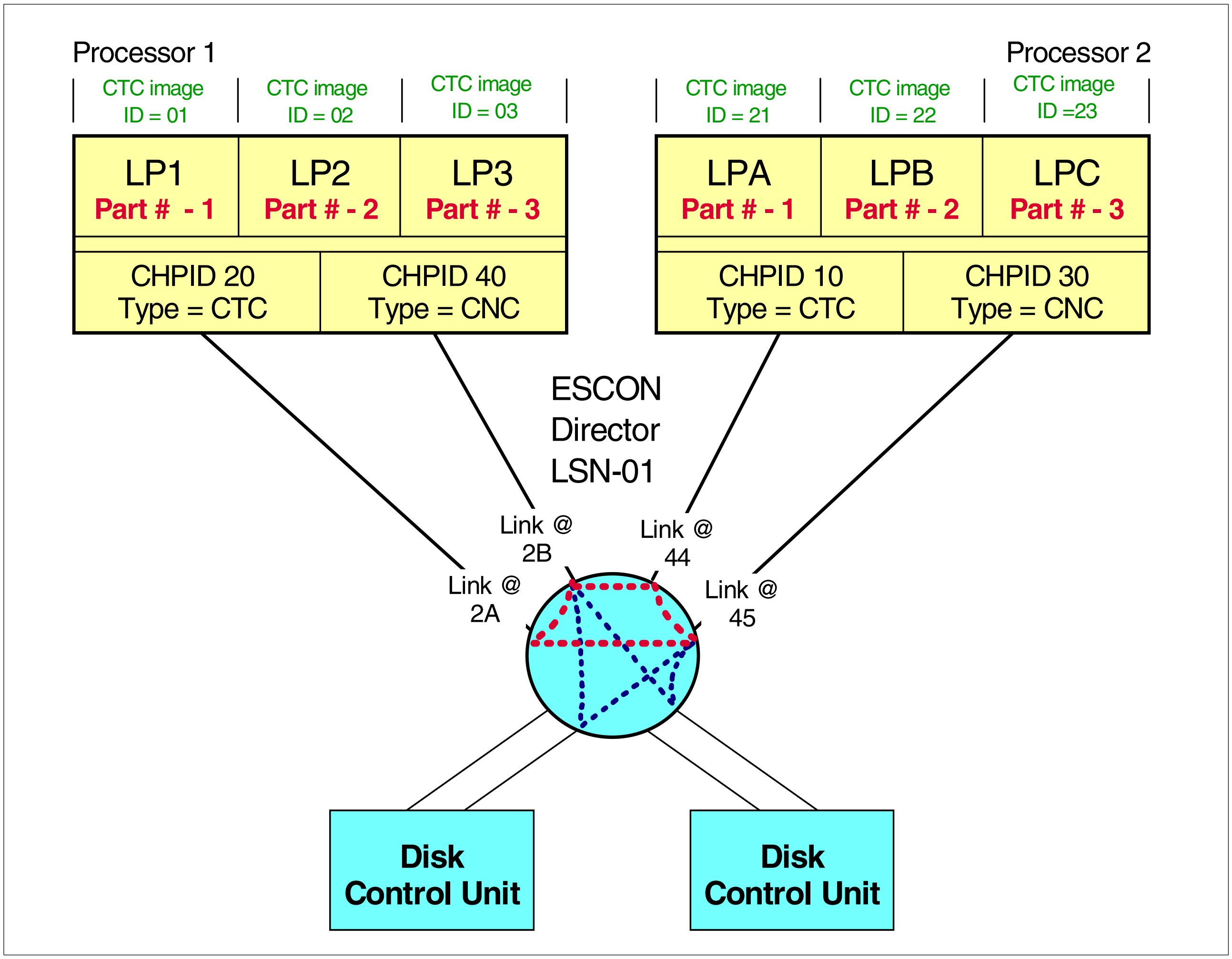

Figure 10-5 Sample ESCON CTC configuration

Two processors, each with three logical partitions, have full intersystem connectivity provided by an ESCON CTC and CNC channel on each processor. The channels are connected through an ESCON Director. Only the prime CTC configuration is shown.

The device number design for this configuration is shown in Figure 10-6 on page 159. Note that the disk control units can be accessed only from the ESCON CNC channels. The ESCON CTC channels cannot be used to access normal I/O devices.

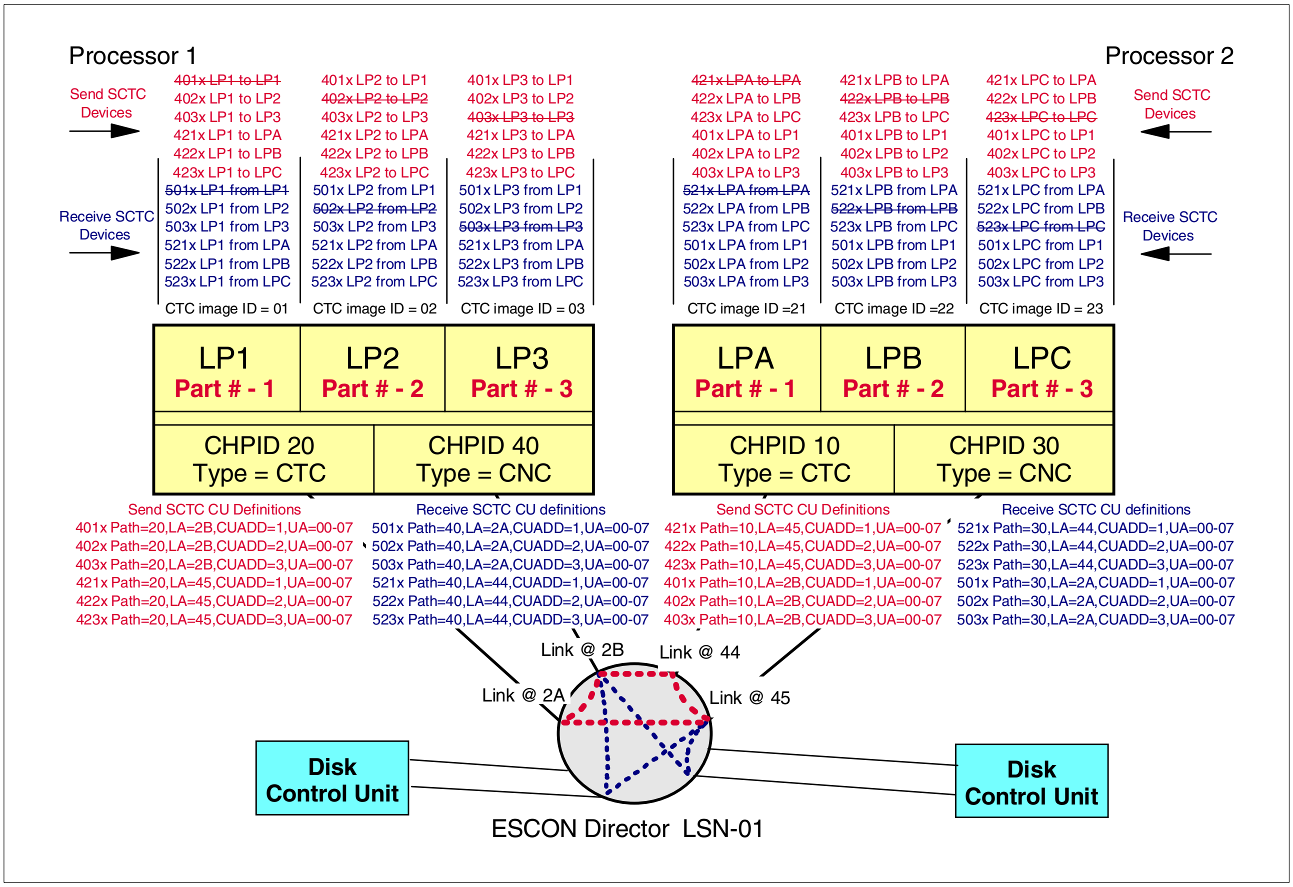

Figure 10-6 Sample ESCON CTC configuration CTC definitions

Figure 10-6 shows that all the send control units and devices are defined with numbers of the form 4xxx, and all the receive control units and devices are defined with numbers of the form 5xxx.

Specifically:

- Device number 4230 is used by LP1 on processor 1 to communicate as a send CTC device with logical partition LPC on processor 2.
- LPC has been assigned CTC image-ID 23, which is a unique CTC image-ID across the whole CTC complex.
- The CTC image-ID, here 23, forms the second and third digits of the device number.
- LPC has been defined with an LPAR partition number of 3, but the defined partition number is only unique on the processor and is therefore not used as part of the external device numbering scheme. It is used in the configuration definitions for the CTC CU - CUADD=x.

Using the same device numbering method, device number 5010 is used by LPC on processor 2 to communicate (as a receive CTC device) with logical partition LP1 on processor 1. LP1 on processor 1 has been assigned CTC image-ID 01, and here forms the second and third digits of the device number.

However, the choice of device numbers is not sufficient to ensure working CTC connections. The CTC control unit and device definitions must follow the z/Architecture and S/390 Architecture channel-to-device incoming request mapping rules. That is, the incoming source identifier is mapped to a defined destination identifier and unit address. This is explained in more detail in the ESCON SCTC-to-SCTC mapping from LP1 on processor 1 to LPC on processor 2, shown in Figure 10-7.

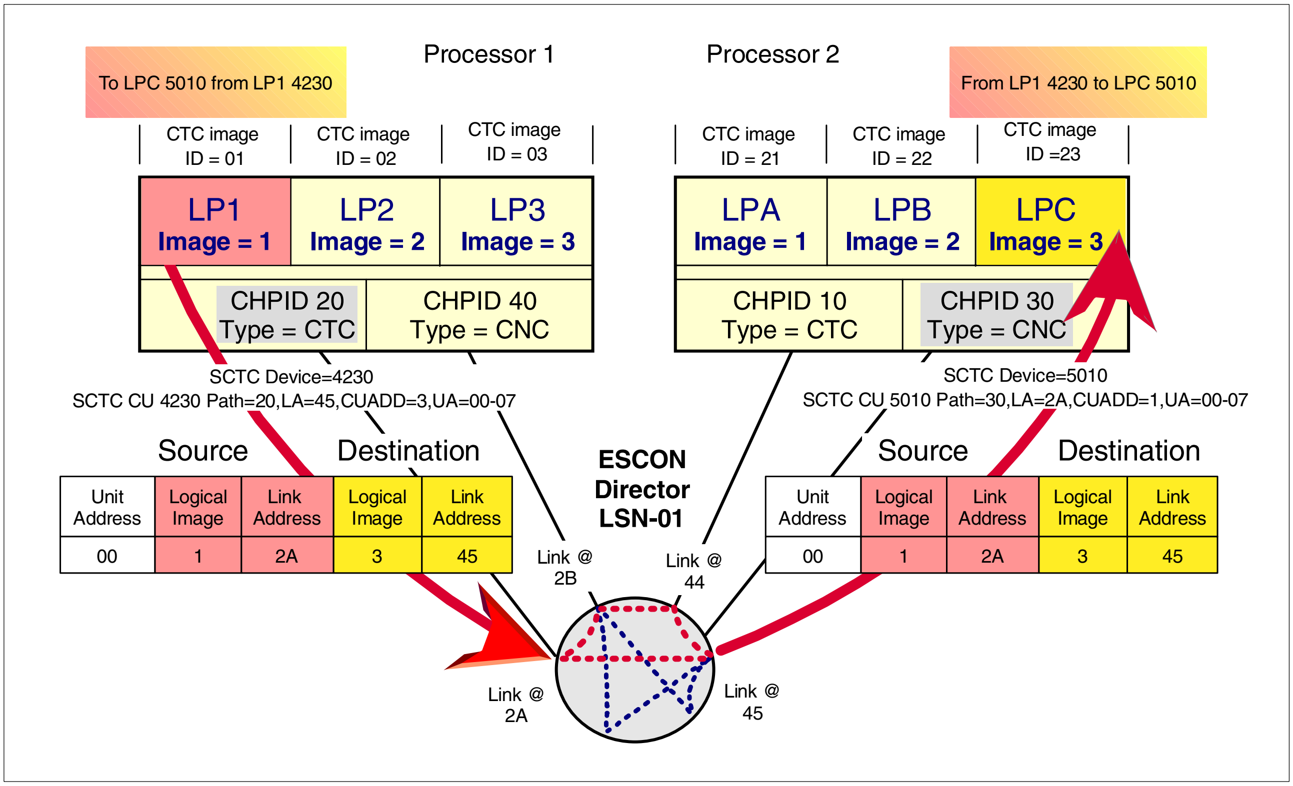

Figure 10-7 ESCON SCTC to SCTC mapping LP1 processor 1 to LPC processor 2

As shown in Figure 10-7:

- Device number 4230 is defined on processor 1 on SCTC control unit number 4230 with unit address 00. CU 4230 is defined to use CTC CHPID 20, link address (DLA) 45 and CUADD (destination control unit image) 3. On processor 2, SCTC control unit 5010 is defined to use CHPID 30, which is connected to link address 45. LPC, which is in the access list for CHPID 30, has LPAR partition number (image number) of 3.
- Device number 5010 is defined on processor 3 SCTC control unit number 5010 with unit address 00. CU 5010 is defined to use CTC CHPID 30, link address (DLA) 2A and CUADD (destination control unit image) 1. On processor 1, SCTC control unit 4230 is defined to use CHPID 20, which is connected to link address 2A. LP1, which is in the access list for CHPID 20, has LPAR partition number (image number) of 1.

  So, the incoming source ID is mapped to a defined destination ID consisting of destination link address (DLA), destination control unit image, and unit address.

The ESCON SCTC-to-SCTC mapping from LPC on processor 2 to LP1 on processor 1 is shown in Figure 10-8 on page 161. In this example, device 4010 in LPC on processor 2 has been defined to provide a source identifier matching device 5230 in LP1 on processor 1.

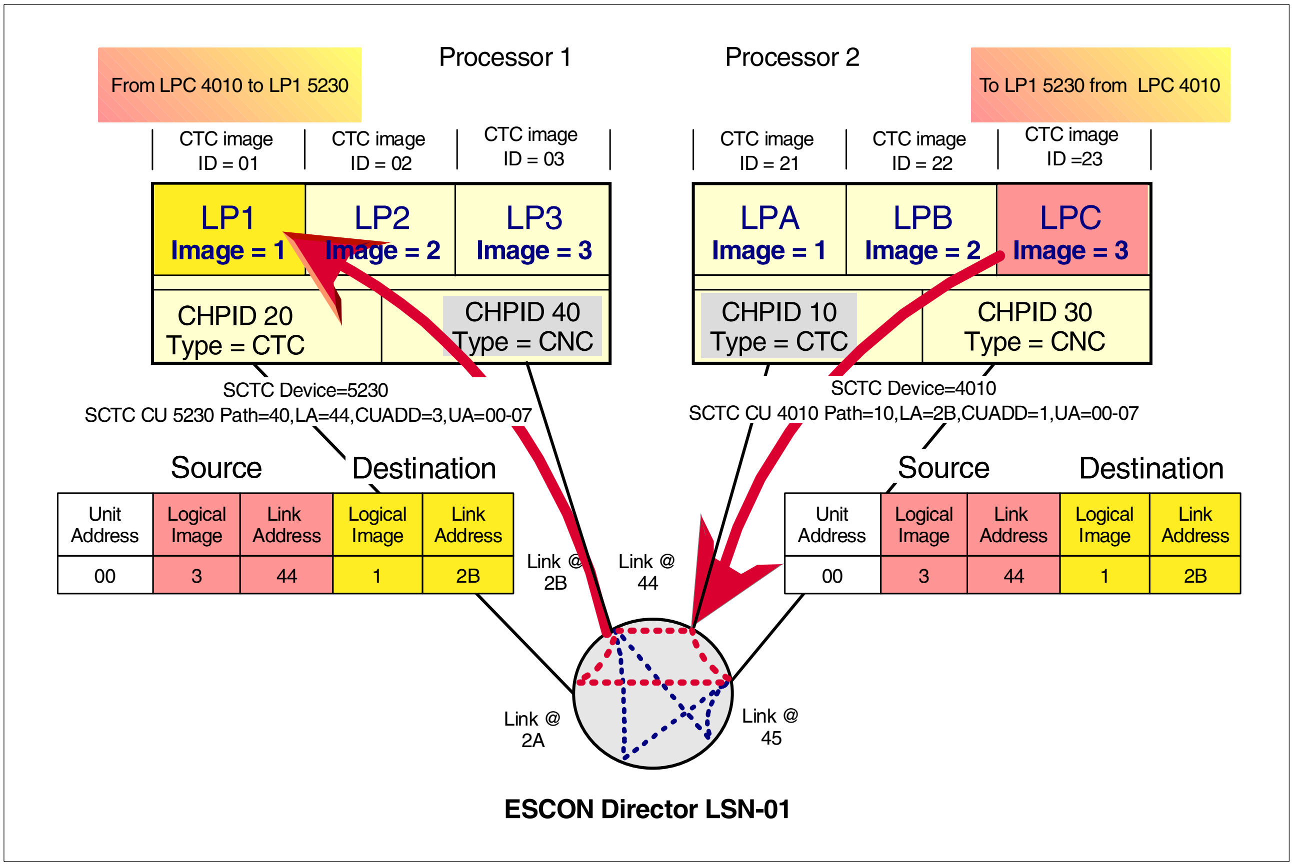

Figure 10-8 ESCON SCTC to SCTC mapping LPC processor 2 to LP1 processor 1

The definitions for this configuration are shown in Figure 10-9 on page 162 for processor 1, and in Figure 10-10 on page 163 for processor 2.

```
ID    MSG1='current escon 4xxx and 5xxx CTC Image_ID definition method',
      MSG2='escon does not support full duplex communication',
      SYSTEM=(2064,1)
RESOURCE PARTITION=((LP1,1),(LP2,2),(LP3,3))
CHPID PATH=(20),SHARED,PARTITION=((LP1,LP2,LP3),(LP1,LP2,LP3)),SWITCH=01,TYPE=CTC
CHPID PATH=(40),SHARED,PARTITION=((LP1,LP2,LP3),(LP1,LP2,LP3)),SWITCH=01,TYPE=CNC
CHPID PATH=(70),SHARED,PARTITION=((LP1,LP2,LP3),(LP1,LP2,LP3)),SWITCH=02,TYPE=CTC
CHPID PATH=(A0),SHARED,PARTITION=((LP1,LP2,LP3),(LP1,LP2,LP3)),SWITCH=02,TYPE=CNC
CNTLUNIT CUNUMBR=4010,PATH=(20),UNITADD=((00,008)),LINK=(2B),
         CUADD=1,UNIT=SCTC
CNTLUNIT CUNUMBR=4020,PATH=(20),UNITADD=((00,008)),LINK=(2B),
         CUADD=2,UNIT=SCTC
CNTLUNIT CUNUMBR=4030,PATH=(20),UNITADD=((00,008)),LINK=(2B),
         CUADD=3,UNIT=SCTC
CNTLUNIT CUNUMBR=4210,PATH=(20),UNITADD=((00,008)),LINK=(45),
         CUADD=1,UNIT=SCTC
CNTLUNIT CUNUMBR=4220,PATH=(20),UNITADD=((00,008)),LINK=(45),
         CUADD=2,UNIT=SCTC
CNTLUNIT CUNUMBR=4230,PATH=(20),UNITADD=((00,008)),LINK=(45),
         CUADD=3,UNIT=SCTC
CNTLUNIT CUNUMBR=5010,PATH=(40),UNITADD=((00,008)),LINK=(2A),
         CUADD=1,UNIT=SCTC
CNTLUNIT CUNUMBR=5020,PATH=(40),UNITADD=((00,008)),LINK=(2A),
         CUADD=2,UNIT=SCTC
CNTLUNIT CUNUMBR=5030,PATH=(40),UNITADD=((00,008)),LINK=(2A),
         CUADD=3,UNIT=SCTC
CNTLUNIT CUNUMBR=5210,PATH=(40),UNITADD=((00,008)),LINK=(44),
         CUADD=1,UNIT=SCTC
CNTLUNIT CUNUMBR=5220,PATH=(40),UNITADD=((00,008)),LINK=(44),
         CUADD=2,UNIT=SCTC
CNTLUNIT CUNUMBR=5230,PATH=(40),UNITADD=((00,008)),LINK=(44),
         CUADD=3,UNIT=SCTC
IODEVICE ADDRESS=(4010,008),UNITADD=00,CUNUMBR=(4010),STADET=Y,
      PARTITION=(LP2,LP3),UNIT=SCTC
IODEVICE ADDRESS=(4020,008),UNITADD=00,CUNUMBR=(4020),STADET=Y,
      PARTITION=(LP1,LP3),UNIT=SCTC
IODEVICE ADDRESS=(4030,008),UNITADD=00,CUNUMBR=(4030),STADET=Y,
      PARTITION=(LP1,LP2),UNIT=SCTC
IODEVICE ADDRESS=(5010,008),UNITADD=00,CUNUMBR=(5010),STADET=Y,
      PARTITION=(LP2,LP3),UNIT=SCTC
IODEVICE ADDRESS=(5020,008),UNITADD=00,CUNUMBR=(5020),STADET=Y,
      PARTITION=(LP1,LP3),UNIT=SCTC
IODEVICE ADDRESS=(5030,008),UNITADD=00,CUNUMBR=(5030),STADET=Y,
      PARTITION=(LP1,LP2),UNIT=SCTC
IODEVICE ADDRESS=(4210,008),UNITADD=00,CUNUMBR=(4210),STADET=Y,
      PARTITION=(LP1,LP2,LP3),UNIT=SCTC
IODEVICE ADDRESS=(4220,008),UNITADD=00,CUNUMBR=(4220),STADET=Y,
      PARTITION=(LP1,LP2,LP3),UNIT=SCTC
IODEVICE ADDRESS=(4230,008),UNITADD=00,CUNUMBR=(4230),STADET=Y,
      PARTITION=(LP1,LP2,LP3),UNIT=SCTC
IODEVICE ADDRESS=(5210,008),UNITADD=00,CUNUMBR=(5210),STADET=Y,
      PARTITION=(LP1,LP2,LP3),UNIT=SCTC
IODEVICE ADDRESS=(5220,008),UNITADD=00,CUNUMBR=(5220),STADET=Y,
      PARTITION=(LP1,LP2,LP3),UNIT=SCTC
IODEVICE ADDRESS=(5230,008),UNITADD=00,CUNUMBR=(5230),STADET=Y,
      PARTITION=(LP1,LP2,LP3),UNIT=SCTC
```

Figure 10-9   ESCON CTC channel, CU and device definitions for processor 1

The SCTC CU starting unit address range for each control unit is defined to start at x'00'. The I/O devices are also defined with the starting unit address (for the range) of x'00'.

This is a key point for this definition method. The device unit addresses are defined as starting at x'00' so that devices with different device numbers can be matched. For example, device number 4230 on processor 1 is defined with unit address x'00' and matches device number 5010 on processor 2, which is defined with a matching unit address of x'00'.

```
ID    MSG1='current escon 4xxx and 5xxx CTC Image_ID definition method',
      MSG2='escon does not support full duplex communication',
      SYSTEM=(2064,1)
RESOURCE PARTITION=((LPA,1),(LPB,2),(LPC,3))
CHPID PATH=(10),SHARED,PARTITION=((LPA,LPB,LPC),(LPA,LPB,LPC)),SWITCH=01,TYPE=CTC
CHPID PATH=(20),SHARED,PARTITION=((LPA,LPB,LPC),(LPA,LPB,LPC)),SWITCH=01,TYPE=CNC
CHPID PATH=(54),SHARED,PARTITION=((LPA,LPB,LPC),(LPA,LPB,LPC)),SWITCH=02,TYPE=CTC
CHPID PATH=(55),SHARED,PARTITION=((LPA,LPB,LPC),(LPA,LPB,LPC)),SWITCH=02,TYPE=CNC
CNTLUNIT CUNUMBR=4010,PATH=(10),UNITADD=((00,008)),LINK=(2B),
         CUADD=1,UNIT=SCTC
CNTLUNIT CUNUMBR=4020,PATH=(10),UNITADD=((00,008)),LINK=(2B),
         CUADD=2,UNIT=SCTC
CNTLUNIT CUNUMBR=4030,PATH=(10),UNITADD=((00,008)),LINK=(2B),
         CUADD=3,UNIT=SCTC
CNTLUNIT CUNUMBR=4210,PATH=(10),UNITADD=((00,008)),LINK=(45),
         CUADD=1,UNIT=SCTC
CNTLUNIT CUNUMBR=4220,PATH=(10),UNITADD=((00,008)),LINK=(45),
         CUADD=2,UNIT=SCTC
CNTLUNIT CUNUMBR=4230,PATH=(10),UNITADD=((00,008)),LINK=(45),
         CUADD=3,UNIT=SCTC
CNTLUNIT CUNUMBR=5010,PATH=(30),UNITADD=((00,008)),LINK=(2A),
         CUADD=1,UNIT=SCTC
CNTLUNIT CUNUMBR=5020,PATH=(30),UNITADD=((00,008)),LINK=(2A),
         CUADD=2,UNIT=SCTC
CNTLUNIT CUNUMBR=5030,PATH=(30),UNITADD=((00,008)),LINK=(2A),
         CUADD=3,UNIT=SCTC
CNTLUNIT CUNUMBR=5210,PATH=(30),UNITADD=((00,008)),LINK=(44),
         CUADD=1,UNIT=SCTC
CNTLUNIT CUNUMBR=5220,PATH=(30),UNITADD=((00,008)),LINK=(44),
         CUADD=2,UNIT=SCTC
CNTLUNIT CUNUMBR=5230,PATH=(30),UNITADD=((00,008)),LINK=(44),
         CUADD=3,UNIT=SCTC
IODEVICE ADDRESS=(4010,008),UNITADD=00,CUNUMBR=(4010),STADET=Y,
      PARTITION=(LPA,LPB,LPC),UNIT=SCTC
IODEVICE ADDRESS=(4020,008),UNITADD=00,CUNUMBR=(4020),STADET=Y,
      PARTITION=(LPA,LPB,LPC),UNIT=SCTC
IODEVICE ADDRESS=(4030,008),UNITADD=00,CUNUMBR=(4030),STADET=Y,
      PARTITION=(LPA,LPB,LPC),UNIT=SCTC
IODEVICE ADDRESS=(5010,008),UNITADD=00,CUNUMBR=(5010),STADET=Y,
      PARTITION=(LPA,LPB,LPC),UNIT=SCTC
IODEVICE ADDRESS=(5020,008),UNITADD=00,CUNUMBR=(5020),STADET=Y,
      PARTITION=(LPA,LPB,LPC),UNIT=SCTC
IODEVICE ADDRESS=(5030,008),UNITADD=00,CUNUMBR=(5030),STADET=Y,
      PARTITION=(LPA,LPB,LPC),UNIT=SCTC
IODEVICE ADDRESS=(4210,008),UNITADD=00,CUNUMBR=(4210),STADET=Y,
      PARTITION=(LPB,LPC),UNIT=SCTC
IODEVICE ADDRESS=(4220,008),UNITADD=00,CUNUMBR=(4220),STADET=Y,
      PARTITION=(LPA,LPC),UNIT=SCTC
IODEVICE ADDRESS=(4230,008),UNITADD=00,CUNUMBR=(4230),STADET=Y,
      PARTITION=(LPA,LPB),UNIT=SCTC
IODEVICE ADDRESS=(5210,008),UNITADD=00,CUNUMBR=(5210),STADET=Y,
      PARTITION=(LPB,LPC),UNIT=SCTC
IODEVICE ADDRESS=(5220,008),UNITADD=00,CUNUMBR=(5220),STADET=Y,
      PARTITION=(LPA,LPC,UNIT=SCTC
IODEVICE ADDRESS=(5230,008),UNITADD=00,CUNUMBR=(5230),STADET=Y,
      PARTITION=(LPA,LPB),UNIT=SCTC
```

Figure 10-10 ESCON CTC channel, CU and device definitions for processor 2

10.3 Overview and benefits of FICON CTC

In this section, FICON CTC is introduced, along with a description of the benefits of implementing the CTC function using FICON channels.

10.3.1 FICON CTC

Channel-to-channel communication in a FICON environment is provided between two FICON (FC) channel FCTC control units, with at least one of the two FCTC CUs being defined on an FC channel on a z900 processor at driver level 3C or later, and the other defined on an FICON (FC) channel on any of the following processors:

- 9672 G5/G6 CPC
- z900 CPC
- z900 CPC at driver level 3C or later

The FICON CTC CU function is provided by the FICON (FC) channel FCTC control unit on the z900 CPC only at z900 hardware driver level 3C or later levels.

10.3.2 Differences between ESCON and FICON CTC

There are several differences between the ESCON and FICON CTC implementations, as shown in Table 10-1.

Table 10-1 ESCON and FICON CTC differences

Characteristic	ESCON	FICON
# of required channels	At least 2	1 or 2
Channel dedicated to CTC function	Yes	No
# of unit addresses supported	Up to 512	Up to 16384
Data transfer bandwidth	12 - 17 MBps	60 - 90+ MBps
# of concurrent I/O operations	1	Up to 32
Data transfer mode	Half duplex	Full duplex

The details of these differences are as follows:

- ESCON CTC connectivity is provided by a pair of ESCON channels, one defined as CTC and the other defined as CNC. At least two ESCON channels are required.

  FICON CTC connectivity can be implemented using one or two FICON (FC) native channels.

- An ESCON channel defined as CTC can only support the CTC function. Only an SCTC control unit can be defined on an ESCON CTC channel.

  The FICON native (FC) channel supporting the FCTC control unit can communicate with an FCTC control unit on either the z900 or 9672 G5/G6, and at the same time the same FICON (FC) channel can also support operations to other I/O control unit types such as disk and tape.

- An ESCON CTC channel supports a maximum of 512 unit addresses (devices).

  A FICON native (FC) channel supports a maximum of 16,384 unit addresses (devices).

- An ESCON channel has a data transfer bandwidth of 12 - 17 MB, significantly less than the 60 - 90 + MB of a FICON channel.

- An ESCON channel supports only one actively communicating I/O operation at a time, whereas the FICON channel supports up to 32 concurrent I/O operations.

- An ESCON channel operates in half duplex mode, transferring data in one direction only at any given time. A FICON channel operates in full duplex mode, sending and receiving data at the same time.

10.4 FCTC topology options

A FICON CTC configuration can be implemented in different ways, as discussed in more detail later in this section. However, the following considerations apply to all FICON CTC configurations:

- The processor at each end of a FICON CTC connection uses a FICON native (FC) channel.
  - The FICON channel is defined as FC (FICON native).
- The FC channel at each end of the CTC connection has a FICON CTC control unit defined. An FCTC control unit can be defined on a FICON native (FC) channel on a 9672 G5, 9672 G6 or z900, but the FCTC control unit function is provided only by a z900 at driver level 3C or later.
  - The FICON CTC control unit is defined as FCTC.
  - The FICON CTC devices on the FCTC control unit are defined as FCTC.
- The FCTC control function on the z900 at driver level 3C or later can communicate with an FCTC control unit defined on a FICON native (FC) channel on any of the following:
  - 9672 G5 or G6
  - z900
  - z900 at driver level 3C or later
- The FICON channel at each end of the FICON CTC connection, supporting the FCTC control units, can also communicate with other FICON native control units, such as disk and tape.

The diagram in Figure 10-11 summarizes the different CTC connectivity options available in the zSeries and 9672 G5/G6 environment.

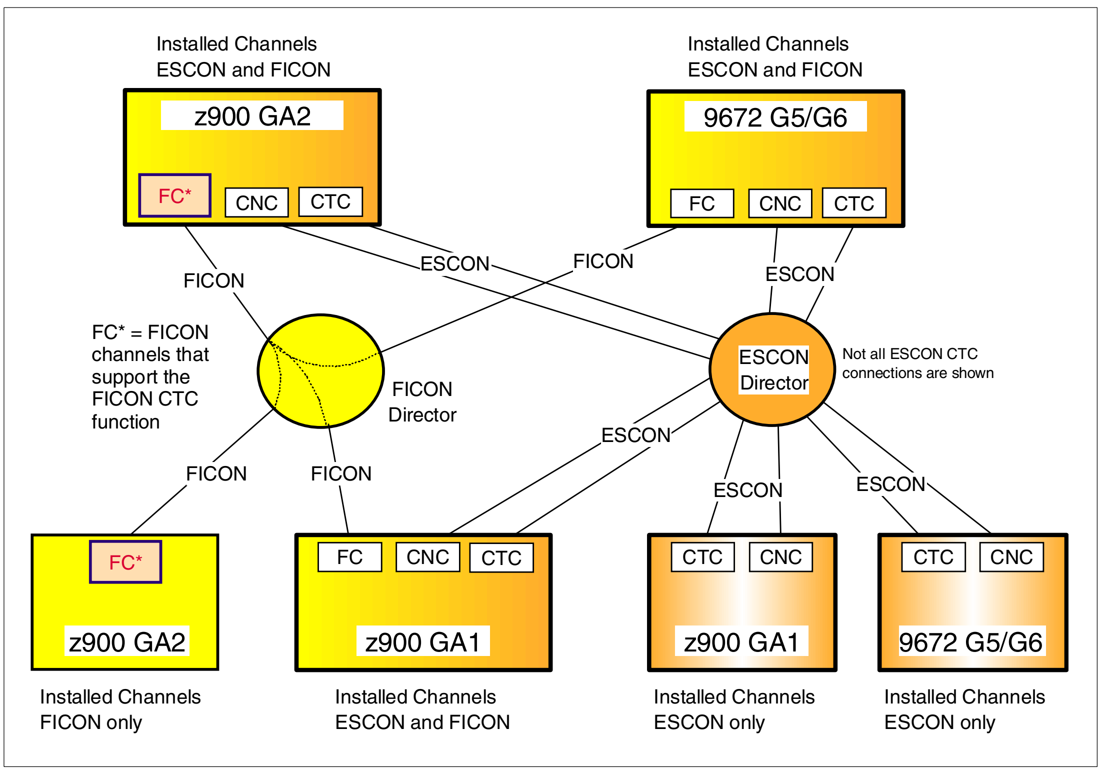

Figure 10-11 ESCON and FICON CTC connectivity options

In a FICON CTC configuration, although FICON CTC control units are defined at each end, only one end provides the FICON CTC control unit function. During initialization of the logical connection between two ends of a FICON CTC connection, the channel that will provide the FICON CTC control unit function is determined using an algorithm that, where possible, results in balancing of the number of FCTC CU functions that each end of the logical connection is providing. The establishment algorithm is discussed in more detail in 10.8, “FICON CTC control unit function balancing” on page 179.

The FICON (FC mode) channel CTC configuration can use:

- One FICON (FC mode) channel in a point-to-point, switched point-to-point configuration, or cascaded FICON Directors configuration
- Two FICON (FC mode) channels in a point-to-point, switched point-to-point configuration, or cascaded FICON Directors configuration

10.4.1 CTC communication using one FICON channel per processor

Unlike the ESCON channel CTC communication, which uses a pair of ESCON CTC-CNC channels, the FICON (FC mode) channel CTC communication does *not* require a pair of channels because it can communicate with any FICON (FC mode) channel that has a corresponding FCTC control unit defined. This means that FICON CTC communications can be provided using only a single FICON (FC mode) channel per processor.

Single FICON FCTC CU function channel on one processor

A single FICON channel connected to a FICON Director can provide the FICON CTC communications between the systems in the logical partitions on a single processor, as well as images on other processors. It can also be used to communicate to other I/O control units. A sample configuration is shown in Figure 10-12 on page 167.

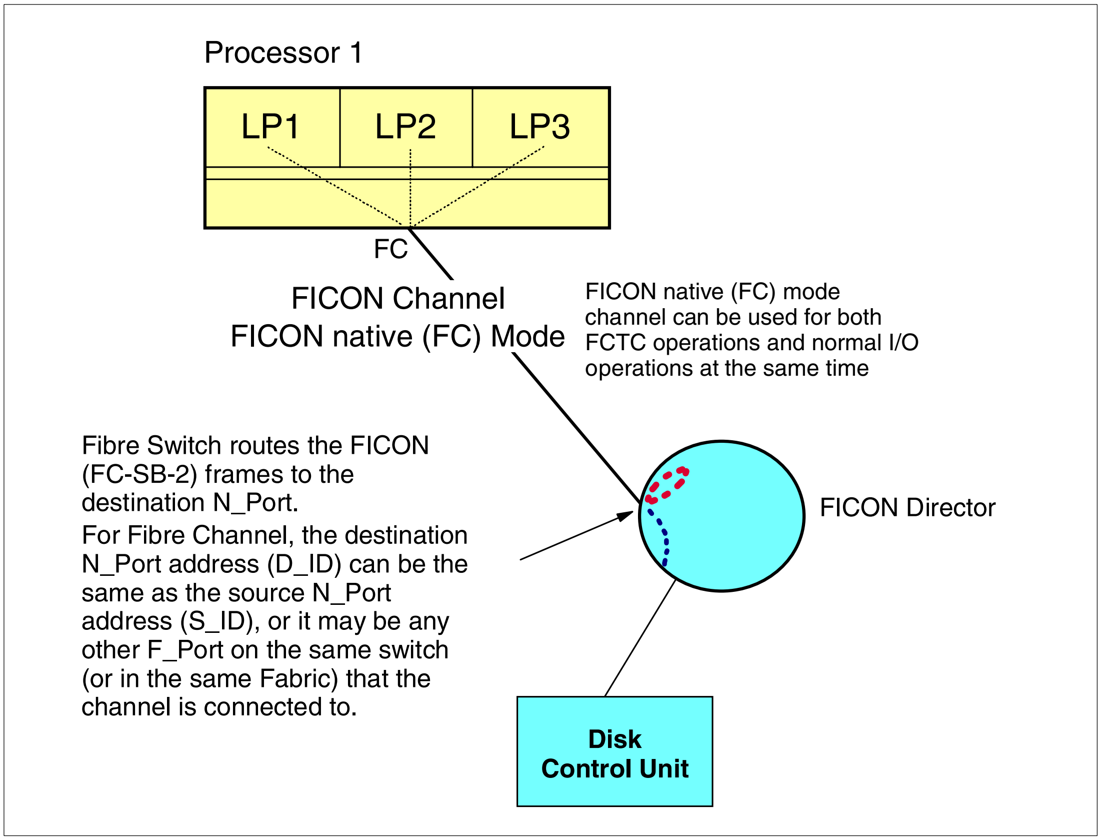

Figure 10-12 Single FICON channel on one processor

Single FICON channel between two or more processors

A single native FICON (FC) channel with FICON control units defined can be used to communicate between images (LPARs) on the same processor, as well as images on other processors. It can also be used to communicate to other I/O control units. The FC channels are connected to a FICON Director. A sample configuration is shown in Figure 10-13 on page 168.

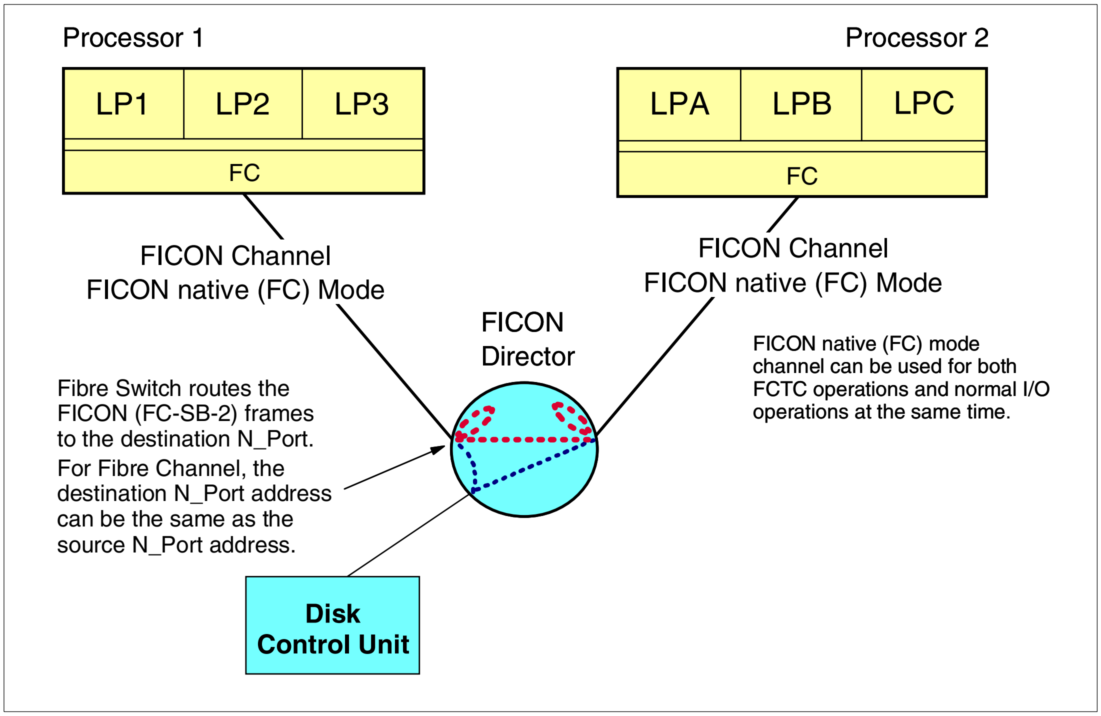

Figure 10-13 Single FICON channel per processor

10.4.2 CTC communication using two FICON channels per processor

Although a single FICON native (FC) channel per processor can provide CTC connections across multiple processors, for large FICON configurations, we recommend using at least one pair of FICON native (FC) mode channels. Using a pair of FICON native (FC) mode channels allows the installation to maintain the same CTC device definition methodology for FICON as was previously used for ESCON. But the FICON channels can support the definition of FCTC control units as well as other I/O control units, such as disk and tape, at the same time.

Two FICON channels on one processor

A sample configuration with two FICON (FC) mode channels providing FCTC-to-FCTC communications is shown in Figure 10-14 on page 169. A FICON (FC) channel supports up to 255 LCUs and up to 16K unit addresses per channel. Since the FICON native (FC) channel supports a larger number of devices, installations with a high number of logical partitions in an FCTC complex are easier to design and define.

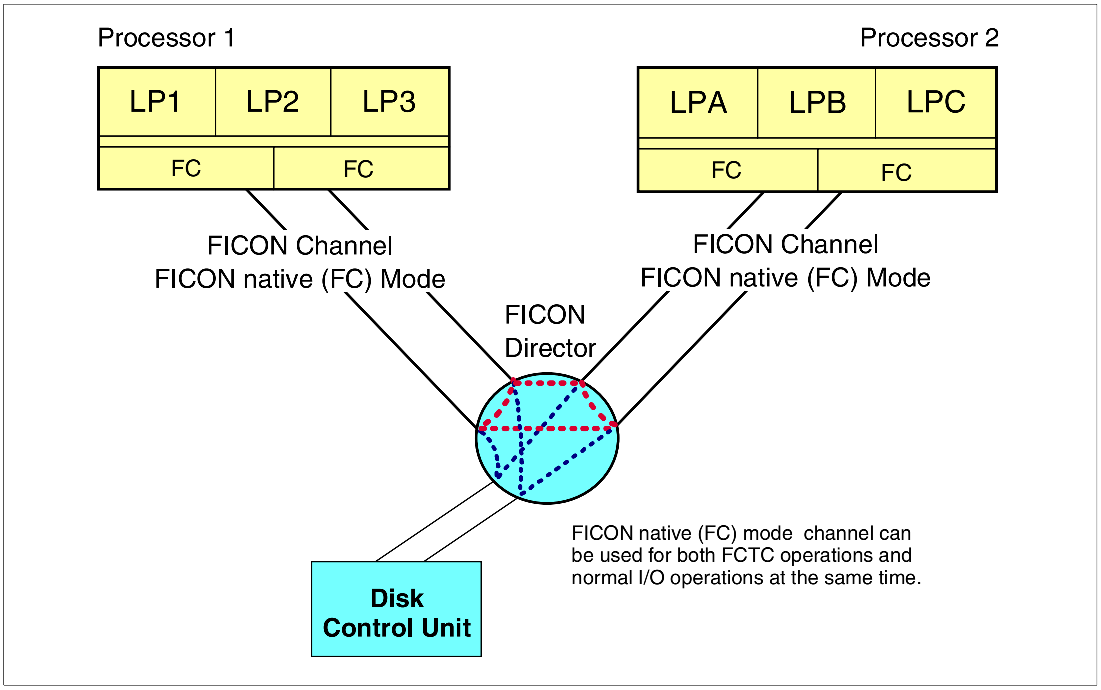

Figure 10-14 Two FICON channels between two processors

10.5 FCTC hardware and software support

Note the following hardware and software requirements.

10.5.1 Hardware support

The FICON native (FC) channel provides FICON CTC (FCTC) support. FICON CTC connections require that at least one end of the connection be on a zSeries CPC at driver level 3C or later. The other end of the FICON CTC connection can be on any processor that supports FICON native (FC) channel paths, including:

- 9672 G5/G6 FICON channel defined with an FCTC control unit
- zSeries FICON channel defined with an FCTC control unit

10.5.2 Software support

IOS

IOS provides the UIM required for FCTC definition and initialization support in APAR OW48283.

HCD

HCD support for the definition of FCTC control units and devices is provided in APAR OW45976. This APAR is applicable to FMIDs HCS6051 and HCS6091, and the PTFs that implement this APAR are listed in Table 10-2 on page 170.

Table 10-2 HCD FCTC APAR OW45976 PTFs

HCD Release	PTF
R051	UW99391
R053	UW99392
R054	UW99393
R091	UW99394

HCM

HCM APAR IR45358 provides support for FCTC definitions. The PTFs that implement this APAR are listed in Table 10-3.

Table 10-3 HCM FCTC APAR IR45358 PTFs

HCM Release	PTF
R210	UR90332
R310	UR90333
R410	UR90334

IOCP

IYP IOCP Version 1 Release 1 Level 1 (1.1.1) provides support for FICON channel-to-channel (FCTC) communication. Note that one end of the FICON CTC connection must be on a CPC at EC J10638 for the connection to be successfully established.

There is a new release of the publication *zSeries 900 Input/Output Configuration Program User's Guide for IYP IOCP*, SB10-7029-01. It is available at:

```
http://www.ibm.com/servers/resourcelink
```

by selecting **Library** -> **zSeries 900** -> **Hardware**.

Information on equivalent standalone IOCP, OS/390 IOCP, VM IOCP, and VSE IOCP follows:

- Equivalent standalone IOCP for IYP IOCP version 1.1.1 is in EC J10638 for machine type 2064 (1xx models).
- Equivalent z/OS, OS/390, VM, and VSE IOCP is shipped via the APARs listed in Table 10-4.

Table 10-4 IOCP APARs for FCTC Support

Operating System	APAR
z/OS and OS/390	OW50966
VM	VM62942
VSE	DY45702

10.6 Recommendations for FCTC device numbering scheme

There are a number of schemes that can be used for developing the device numbers for the FICON CTC devices. This section discusses different schemes and provides recommendations for different configurations. Defining ESCON or FICON CTC configurations requires an understanding of CTC operations and the different methods available for defining the connections. It is also necessary to take into consideration the subsystem requirements for using CTC connections. As the number of images in a complex grows, the CTC definition process becomes increasingly complex.

The factors affecting the design and definition of the FCTC configuration are similar to those for ESCON SCTC control units and devices, but with these additional considerations:

- A single FICON (FC) channel per processor can be used for supporting FCTC connections between images on one or more processors, while an ESCON CNC-CTC channel requires a pair.
- The FICON (FC) channel can operate in full duplex mode.

10.6.1 FICON CTC device number recommendations

There are a number of different device numbering schemes that can be used for the FICON CTC configuration. The choice depends on the installation's hardware configuration supporting the FICON CTC configuration, and the degree of simplicity required in the definition process. The following discussion offers different methods that depend on whether the installation chooses to implement FCTC with one FICON (FC) channel per processor or two.

ESCON device numbering scheme enhancement for FICON

One of the device numbering schemes that can be used for FICON CTC devices is based on the method developed by IBM and recommended for use with ESCON CTC devices when ESCON was introduced in the early 1990s. This device numbering scheme is discussed in detail in "ESCON CTC device numbering scheme" on page 157.

There are many advantages to continuing to use this device numbering scheme when the CTC configuration includes FICON CTC devices. Apart from ease of migration, operations and systems programmers can easily identify the use (send or receive) and target system for any given CTC device. It also simplifies the CTC definition process in that the same operating system CTC device definitions can be used by all z/OS and OS/390 operating systems, independent of the image and processor where that operating system runs.

In a FICON environment, the ESCON device numbering technique can be modified in the following ways:

- Using two FICON (FC) channels per processor, define all send FCTC control units and devices (with numbers of the form 4xxx) on one FICON (FC) channel and define all receive FCTC control units and devices (with numbers of the form 5xxx) on a second FC channel. This technique provides the easiest migration path.
- Using two FICON (FC) channels per processor, evenly spread the send CU/device definitions (4xxx) across the two FC channels, and evenly spread the receive CU/device definitions (5xxx) across the two FC channels. This method exploits the Fibre Channel full duplex data flow used by FICON, but has the disadvantage that there is a large amount of customization required for this technique.

Matching device number scheme

Another approach is to define matching device numbers for each end of the CTC connection. For example, device number 4300 in image LP-1 on processor 1 is used to communicate with device number 4300 in image LP-B on processor 2.

This scheme has a number of disadvantages. It does not enable the operator or systems programmer to identify the use or target system for a given CTC device number. It also makes it difficult to relocate operating systems between logical partitions on the same or a different processor.

Although this scheme appears simple to use at first, it is the most impractical of all possible approaches for defining CTC configurations and is not recommended.

10.7 FCTC configuration and definition examples

Based on the device numbering scheme discussed in "FICON CTC device number recommendations" on page 171, this section provides some sample FICON CTC configurations and I/O definitions.

10.7.1 FICON CTC using two FC channels per processor

A sample configuration with FICON CTC connections between six operating systems, three in logical partitions on each of two processors, is shown in Figure 10-15. Note that this implementation scheme, using two FC channels per processor, is based on the ESCON device numbering method and significantly eases the migration to FICON CTC.

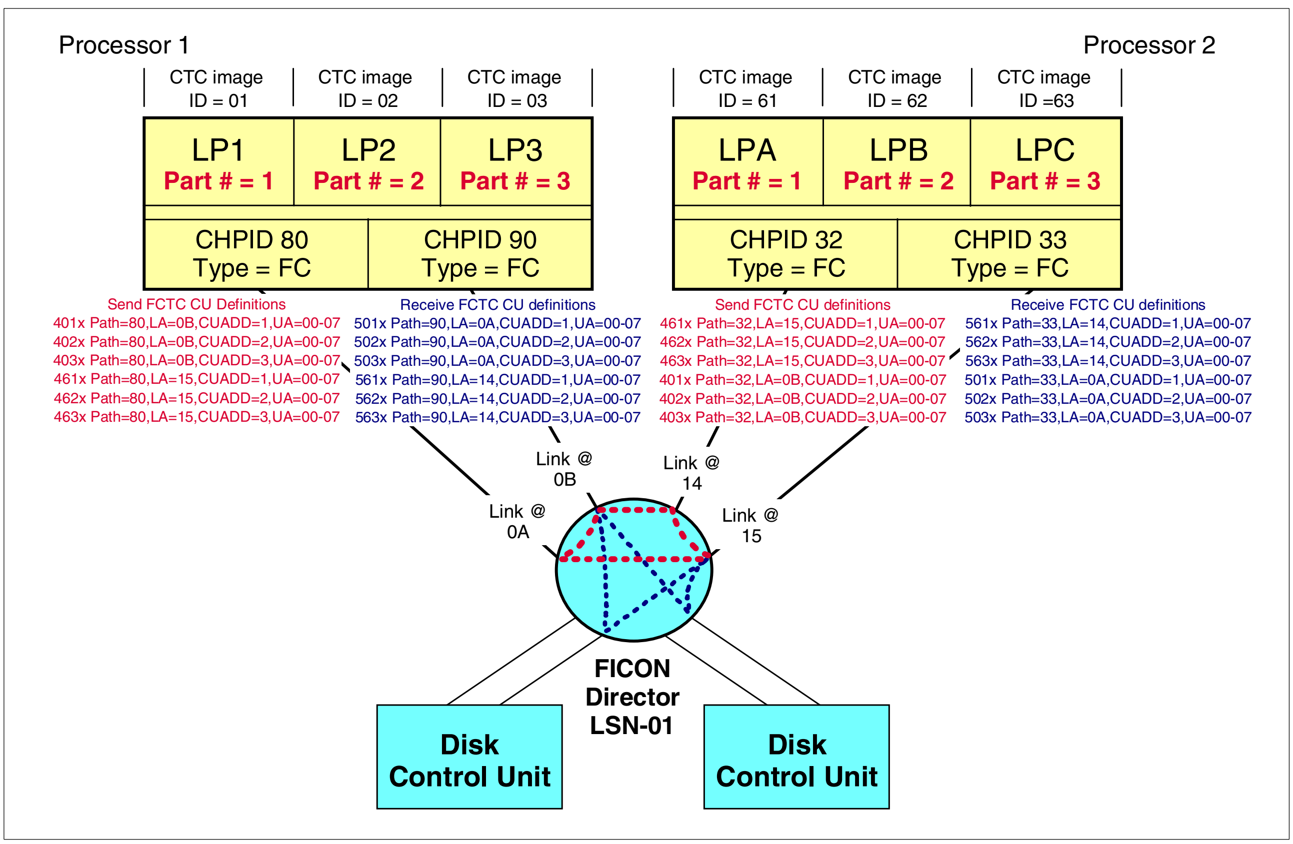

Figure 10-15 FICON CTC configuration using two FC channels per processor

This configuration and definition example has the following characteristics:

- All sending FCTC control units and devices (with FCTC CUs and FCTC Device using definition numbers 4xxx) are configured on one FICON (FC) channel, and all the receiving FCTC control units and devices (with FCTC CUs and FCTC Devices using definition numbers 5xxx) are configured on another FICON (FC) channel.
- The FICON (FC) channel may operate in half duplex mode for the CTC communication (either all the I/O requests will be for sending data, or all the I/O requests will be for receiving data) but it will operate in full duplex mode for communication to other (non-CTC) control units and devices, such as disk and tape (the I/O requests will be for both sending and receiving data).

The device number method shown here uses the middle two digits of the 4xxx and 5xxx device numbers to represent a processor's image CTC-image-ID. This allows the same operating system's subsystem CTC definitions to be used by all operating system instances, regardless of the supporting logical partition that is used.

A detailed example of the FCTC mapping for two devices in this configuration is shown in Figure 10-16.

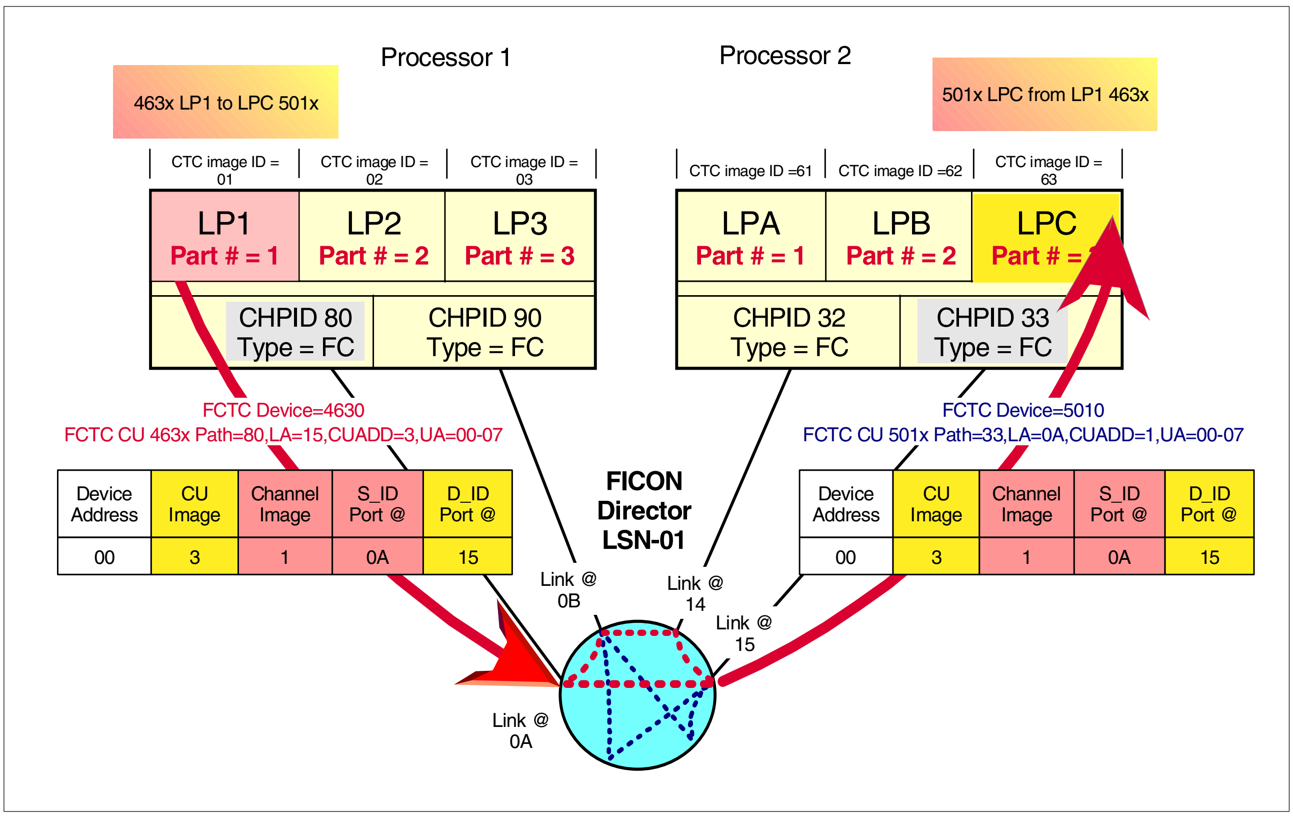

Figure 10-16 FCTC mapping example - from LP1 on processor 1 to LPC on processor 2

Here, sending device number 463x in LP1, defined to logical partition number 1 on processor 1, communicates with device number 501x in LPC (defined logical partition number 3 on processor 2). The definition for the control unit supporting device numbers 463x includes the following essential elements:

- Path=80, a Type=FC channel connected to LSN-01
- DLA=14, the FICON (FC) channel one-byte destination link address

- CUADD=3, the target logical partition number in processor 2 (the processor associated with the CHPID that is connected to FICON switch LSN 01 and Link Address 14 (switch Port Address 14))
- UA=00, the unit address, which must match the target device unit-address

Communication in the opposite direction, from LPC on processor 2 to LP1 on processor 1, is shown in Figure 10-17. Here, the sending device number 401x on LPC, defined to logical partition number 3 on processor 2, communicates with device number 563x on LP1, defined to logical partition number 1 on processor 1. The definition for the control unit supporting device numbers 401x includes the following essential elements:

- Path=32, a Type=FC channel connected to LSN-01
- DLA=0B, the FICON (FC) channel one-byte destination link address
- CUADD=1, the target logical partition number in processor 1 (the processor associated with the CHPID that is connected to FICON switch LSN 01 and Link Address 0B (switch Port Address 0B))
- UA=00, the unit address, which must match the target device unit address

The z/Architecture and s/390 Architecture channel-to-device mapping rules dictate that the incoming source identifier (S_ID-Channel Image) is mapped to a defined destination identified (D_ID-Control Unit Image), along with the device address (UA).

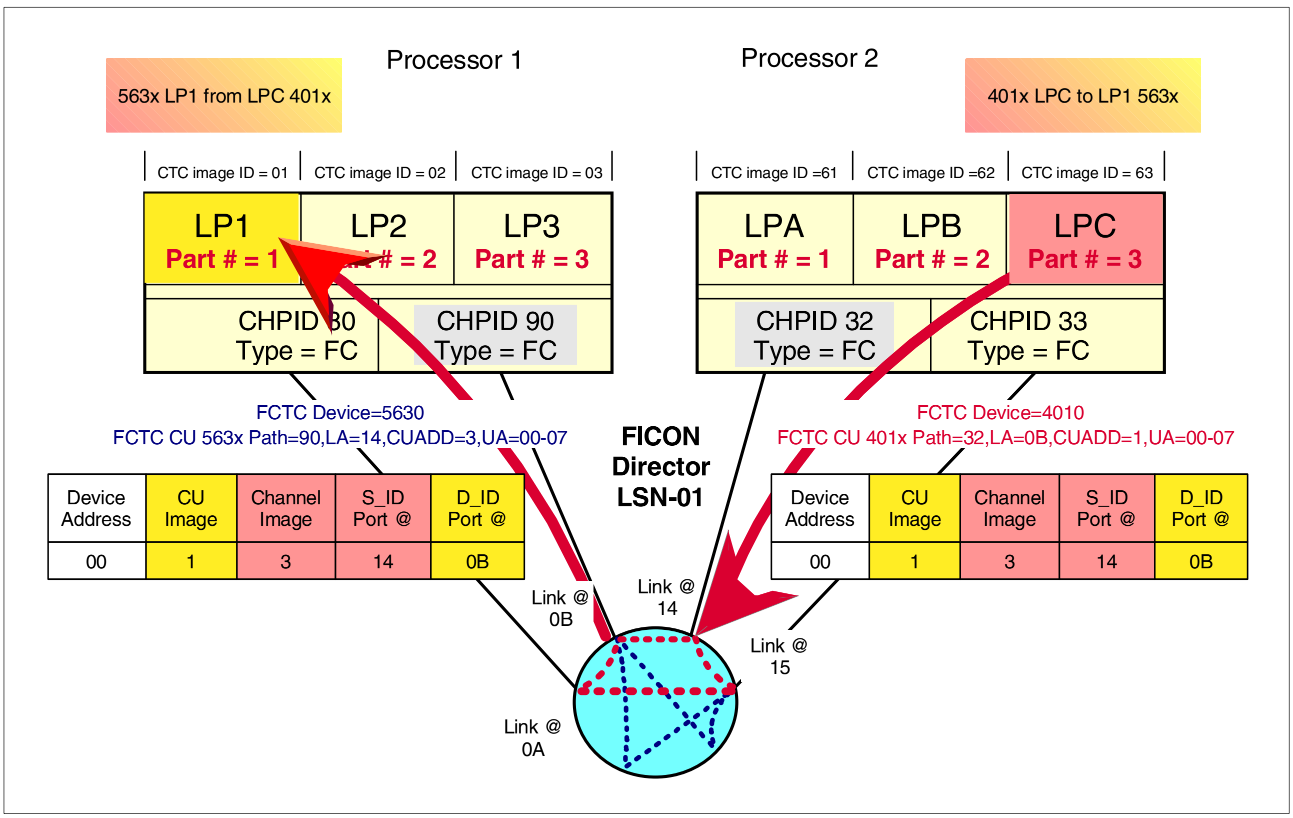

Figure 10-17 FCTC mapping example - from LPC on processor 2 to LP1 on processor 1

The definition requirements for FICON CTC control units and devices are:

- Processor:
  - Mode can be either Basic or LPAR
  - In LPAR mode, each logical partition is assigned a name and a logical partition number (single hexadecimal digit, unique within the processor)
- CHPID:
  - Define CHPID type as FC
  - Mode can be shared or un-shared in LPAR mode
- Control unit:
  - Define CU address (CUADD), which is the target logical partition's partition number
  - Type is FCTC
- I/O device:
  - Type is FCTC
  - Device Unit Address, which will be matched to the same unit address value at the target FCTC CU end

The I/O definitions for processor 1 in this configuration are shown in Figure 10-18 on page 176. The I/O definitions for processor 2 in this configuration are shown in Figure 10-19 on page 177.

```
ID    MSG1='ficon fctc definition using the 4xxx and 5xxx CTC Image_ID definition method',
      MSG2='does not take advantage of the FICON channel full duplex capability',
      SYSTEM=(2064,1)
RESOURCE PARTITION=((LP1,1),(LP2,2),(LP3,3))
CHPID PATH=(80),SHARED,PARTITION=((LP1,LP2,LP3),(LP1,LP2,LP3)),SWITCH=21,TYPE=FC
CHPID PATH=(90),SHARED,PARTITION=((LP1,LP2,LP3),(LP1,LP2,LP3)),SWITCH=21,TYPE=FC
CHPID PATH=(20),SHARED,PARTITION=((LP1,LP2,LP3),(LP1,LP2,LP3)),SWITCH=22,TYPE=FC
CHPID PATH=(30),SHARED,PARTITION=((LP1,LP2,LP3),(LP1,LP2,LP3)),SWITCH=22,TYPE=FC
CNTLUNIT CUNUMBR=4010,PATH=(80),UNITADD=((00,008)),LINK=(0B),
         CUADD=1,UNIT=FCTC
CNTLUNIT CUNUMBR=4020,PATH=(80),UNITADD=((00,008)),LINK=(0B),
         CUADD=2,UNIT=FCTC
CNTLUNIT CUNUMBR=4030,PATH=(80),UNITADD=((00,008)),LINK=(0B),
         CUADD=3,UNIT=FCTC
CNTLUNIT CUNUMBR=4610,PATH=(80),UNITADD=((00,008)),LINK=(15),
         CUADD=1,UNIT=FCTC
CNTLUNIT CUNUMBR=4620,PATH=(80),UNITADD=((00,008)),LINK=(15),
         CUADD=2,UNIT=FCTC
CNTLUNIT CUNUMBR=4630,PATH=(80),UNITADD=((00,008)),LINK=(15),
         CUADD=3,UNIT=FCTC
CNTLUNIT CUNUMBR=5010,PATH=(90),UNITADD=((00,008)),LINK=(0A),
         CUADD=1,UNIT=FCTC
CNTLUNIT CUNUMBR=5020,PATH=(90),UNITADD=((00,008)),LINK=(0A),
         CUADD=2,UNIT=FCTC
CNTLUNIT CUNUMBR=5030,PATH=(90),UNITADD=((00,008)),LINK=(0A),
         CUADD=3,UNIT=FCTC
CNTLUNIT CUNUMBR=5610,PATH=(90),UNITADD=((00,008)),LINK=(14),
         CUADD=1,UNIT=FCTC
CNTLUNIT CUNUMBR=5620,PATH=(90),UNITADD=((00,008)),LINK=(14),
         CUADD=2,UNIT=FCTC
CNTLUNIT CUNUMBR=5630,PATH=(90),UNITADD=((00,008)),LINK=(14),
         CUADD=3,UNIT=FCTC
IODEVICE ADDRESS=(4010,008),UNITADD=00,CUNUMBR=(4010),STADET=Y,
      PARTITION=(LP2,LP3),UNIT=FCTC
IODEVICE ADDRESS=(4020,008),UNITADD=00,CUNUMBR=(4020),STADET=Y,
      PARTITION=(LP1,LP3),UNIT=FCTC
IODEVICE ADDRESS=(4030,008),UNITADD=00,CUNUMBR=(4030),STADET=Y,
      PARTITION=(LP1,LP2),UNIT=FCTC
IODEVICE ADDRESS=(5010,008),UNITADD=00,CUNUMBR=(5010),STADET=Y,
      PARTITION=(LP2,LP3),UNIT=FCTC
IODEVICE ADDRESS=(5020,008),UNITADD=00,CUNUMBR=(5020),STADET=Y,
      PARTITION=(LP1,LP3),UNIT=FCTC
IODEVICE ADDRESS=(5030,008),UNITADD=00,CUNUMBR=(5030),STADET=Y,
      PARTITION=(LP1,LP2),UNIT=FCTC
IODEVICE ADDRESS=(4610,008),UNITADD=00,CUNUMBR=(4610),STADET=Y,
      PARTITION=(LP1,LP2,LP3),UNIT=FCTC
IODEVICE ADDRESS=(4620,008),UNITADD=00,CUNUMBR=(4620),STADET=Y,
      PARTITION=(LP1,LP2,LP3),UNIT=FCTC
IODEVICE ADDRESS=(4630,008),UNITADD=00,CUNUMBR=(4630),STADET=Y,
      PARTITION=(LP1,LP2,LP3),UNIT=FCTC
IODEVICE ADDRESS=(5610,008),UNITADD=00,CUNUMBR=(5610),STADET=Y,
      PARTITION=(LP1,LP2,LP3),UNIT=FCTC
IODEVICE ADDRESS=(5620,008),UNITADD=00,CUNUMBR=(5620),STADET=Y,
      PARTITION=(LP1,LP2,LP3),UNIT=FCTC
IODEVICE ADDRESS=(5630,008),UNITADD=00,CUNUMBR=(5630),STADET=Y,
      PARTITION=(LP1,LP2,LP3),UNIT=FCTC
```

Figure 10-18   Processor 1 definitions

```
ID    MSG1='ficon fctc definition using the 4xxx and 5xxx CTC Image_ID definition method',
      MSG2='does not take advantage of the FICON channel full duplex capability',
      SYSTEM=(2064,1)
RESOURCE PARTITION=((LPA,1),(LPB,2),(LPC,3))
CHPID PATH=(32),SHARED,PARTITION=((LPA,LPB,LPC),(LPA,LPB,LPC)),SWITCH=21,TYPE=FC
CHPID PATH=(33),SHARED,PARTITION=((LPA,LPB,LPC),(LPA,LPB,LPC)),SWITCH=21,TYPE=FC
CHPID PATH=(54),SHARED,PARTITION=((LPA,LPB,LPC),(LPA,LPB,LPC)),SWITCH=22,TYPE=FC
CHPID PATH=(55),SHARED,PARTITION=((LPA,LPB,LPC),(LPA,LPB,LPC)),SWITCH=22,TYPE=FC
CNTLUNIT CUNUMBR=4010,PATH=(32),UNITADD=((00,008)),LINK=(0B),
         CUADD=1,UNIT=FCTC
CNTLUNIT CUNUMBR=4020,PATH=(32),UNITADD=((00,008)),LINK=(0B),
         CUADD=2,UNIT=FCTC
CNTLUNIT CUNUMBR=4030,PATH=(32),UNITADD=((00,008)),LINK=(0B),
         CUADD=3,UNIT=FCTC
CNTLUNIT CUNUMBR=4610,PATH=(32),UNITADD=((00,008)),LINK=(15),
         CUADD=1,UNIT=FCTC
CNTLUNIT CUNUMBR=4620,PATH=(32),UNITADD=((00,008)),LINK=(15),
         CUADD=2,UNIT=FCTC
CNTLUNIT CUNUMBR=4630,PATH=(32),UNITADD=((00,008)),LINK=(15),
         CUADD=3,UNIT=FCTC
CNTLUNIT CUNUMBR=5010,PATH=(33),UNITADD=((00,008)),LINK=(0A),
         CUADD=1,UNIT=FCTC
CNTLUNIT CUNUMBR=5020,PATH=(33),UNITADD=((00,008)),LINK=(0A),
         CUADD=2,UNIT=FCTC
CNTLUNIT CUNUMBR=5030,PATH=(33),UNITADD=((00,008)),LINK=(0A),
         CUADD=3,UNIT=FCTC
CNTLUNIT CUNUMBR=5610,PATH=(33),UNITADD=((00,008)),LINK=(14),
         CUADD=1,UNIT=FCTC
CNTLUNIT CUNUMBR=5620,PATH=(33),UNITADD=((00,008)),LINK=(14),
         CUADD=2,UNIT=FCTC
CNTLUNIT CUNUMBR=5630,PATH=(33),UNITADD=((00,008)),LINK=(14),
         CUADD=3,UNIT=FCTC
IODEVICE ADDRESS=(4010,008),UNITADD=00,CUNUMBR=(4010),STADET=Y,
      PARTITION=(LPA,LPB,LPC),UNIT=FCTC
IODEVICE ADDRESS=(4020,008),UNITADD=00,CUNUMBR=(4020),STADET=Y,
      PARTITION=(LPA,LPB,LPC),UNIT=FCTC
IODEVICE ADDRESS=(4030,008),UNITADD=00,CUNUMBR=(4030),STADET=Y,
      PARTITION=(LPA,LPB,LPC),UNIT=FCTC
IODEVICE ADDRESS=(5010,008),UNITADD=00,CUNUMBR=(5010),STADET=Y,
      PARTITION=(LPA,LPB,LPC),UNIT=FCTC
IODEVICE ADDRESS=(5020,008),UNITADD=00,CUNUMBR=(5020),STADET=Y,
      PARTITION=(LPA,LPB,LPC),UNIT=FCTC
IODEVICE ADDRESS=(5030,008),UNITADD=00,CUNUMBR=(5030),STADET=Y,
      PARTITION=(LPA,LPB,LPC),UNIT=FCTC
IODEVICE ADDRESS=(4610,008),UNITADD=00,CUNUMBR=(4610),STADET=Y,
      PARTITION=(LPB,LPC),UNIT=FCTC
IODEVICE ADDRESS=(4620,008),UNITADD=00,CUNUMBR=(4620),STADET=Y,
      PARTITION=(LPA,LPC),UNIT=FCTC
IODEVICE ADDRESS=(4630,008),UNITADD=00,CUNUMBR=(4630),STADET=Y,
      PARTITION=(LPA,LPB),UNIT=FCTC
IODEVICE ADDRESS=(5610,008),UNITADD=00,CUNUMBR=(5610),STADET=Y,
      PARTITION=(LPB,LPC),UNIT=FCTC
IODEVICE ADDRESS=(5620,008),UNITADD=00,CUNUMBR=(5620),STADET=Y,
      PARTITION=(LPA,LPC),UNIT=FCTC
IODEVICE ADDRESS=(5630,008),UNITADD=00,CUNUMBR=(5630),STADET=Y,
      PARTITION=(LPA,LPB),UNIT=FCTC
```

Figure 10-19 Processor 2 definitions

10.7.2 FICON CTC using one FC channel per processor

A sample FICON CTC configuration using one FC channel per processor is shown in Figure 10-20 on page 178.

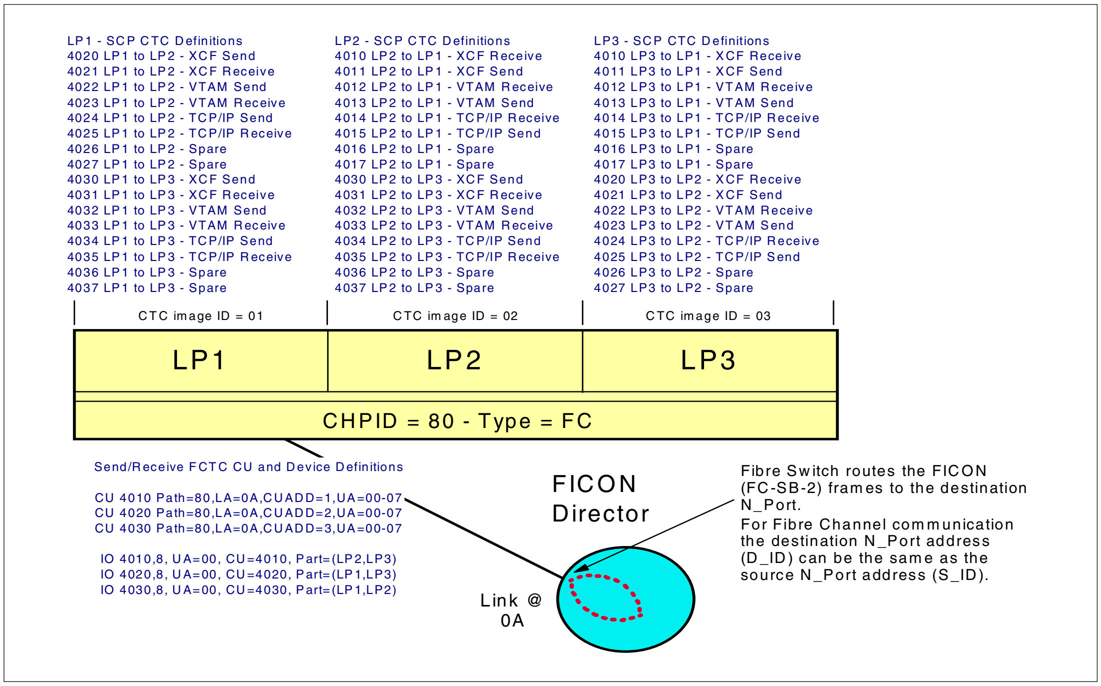

Figure 10-20 FICON CTC configuration using one FC channel per processor

In the Fibre Channel switch environment, it is the Fibre Channel switch that routes the Fibre Channel FICON (FC-SB-2) frames to the destination N_Port (D_ID).

For Fibre Channel communication, the destination N_Port address (D_ID) (the target port) can be the same as the source N_Port address (S_ID) (the originating port).

This means that an FCTC CU destination link address (the fibre channel switch port address where the FICON frame is being sent to) will be the same link address (port address) that the channel is connected to. For Fibre Channel, because the destination port address can be the same as the source port address, this allows communication between LPARs on the same processor using only a single FICON (FC) channel.

FCTC definition using a single FICON (FC) channel

The FCTC hardware definition method used when there is only a single FICON (FC) channel in the FCTC configuration can be the same as when using two FICON (FC) channels for FCTC to FCTC communication. See the FCTC CU and device definitions within Figure 10-20 on page 178.

However, when only a single FICON (FC) channel is used in a FCTC configuration, each operating system’s CTC usage definition would need to be customized for the partition that it is running on. These are also shown within Figure 10-20 on page 178.

Because of the requirement of having to define the operating system’s CTC use for the image that the operating system is running in, the same flexibility of movement of operating systems using a common operating system CTC definition does not exist. Most large installations like the idea of having a common operating system CTC definition, as well as the flexibility of movement of the operating system between LPARs on the same processor (or even to LPARs on any processor) without having to change the operating system definition.

If installations still want the flexibility of movement of the operating system using a single operating system CTC definition, then it is recommended to use two FICON (FC) channels on each processor for CTC configurations. Remember that when using two FICON (FC) channels for FCTC communication, these same two FICON (FC) channels can still be defined to be used for I/O operations to other CU types, in addition to FCTC CUs (at the same time). In reality, it does not cost the large system user more FICON channels in total, because the existing FICON (FC) channels can be used by CTC I/O, as well as for disk and tape I/O requests.

10.8 FICON CTC control unit function balancing

In a FICON CTC configuration, although FICON CTC control units are defined at each FICON (FC) channel end, only one of the two ends (that form the FCTC logical connection) provides the FICON FCTC control unit function. During initialization of the logical connection between two ends of a FICON CTC connection, the FICON (FC) channel that is to provide the FICON CTC control unit function (one of the two that makes up the logical connection) is determined using an algorithm that takes the following into consideration:

- FICON CTC control unit support

  FICON CTC control unit support is only provided in the FICON native (FC) channel on a zSeries at driver level 3C or later. If one end of the connection is a zSeries CPC at driver level 3C or later, and the other end is a zSeries at an earlier level or 9672 G5/G6 processor, the zSeries driver level 3C or later processor provides the FICON CTC control unit function.

- FICON CTC CU function, count

  If both ends of the connection support the FICON CTC control unit function, that is, both ends of the FICON CTC connection are on a zSeries CPC at driver level 3C or later, then the count of FCTC CU functions already supported is taken into consideration. The FC channel with fewer FCTC CU functions being supported is selected to provide the FICON CTC control unit function.

- Fibre Channel Node/Port, WWN

  If both ends of the connection are on a zSeries CPC at driver level 3C or later and each has an equal CTC CU function count, then the FC channel with the lower WWN (FC World Wide Name) provides the FICON CTC control unit function. The WWN is provided during Port Log_in (PLOGI) time. In the initialization sequence, the PLOGI precedes the ELP and the channel remembers the WWN for each N_Port that has logged into it.

The FICON CTC control unit function establishment algorithm is summarized in Figure 10-21 on page 180.

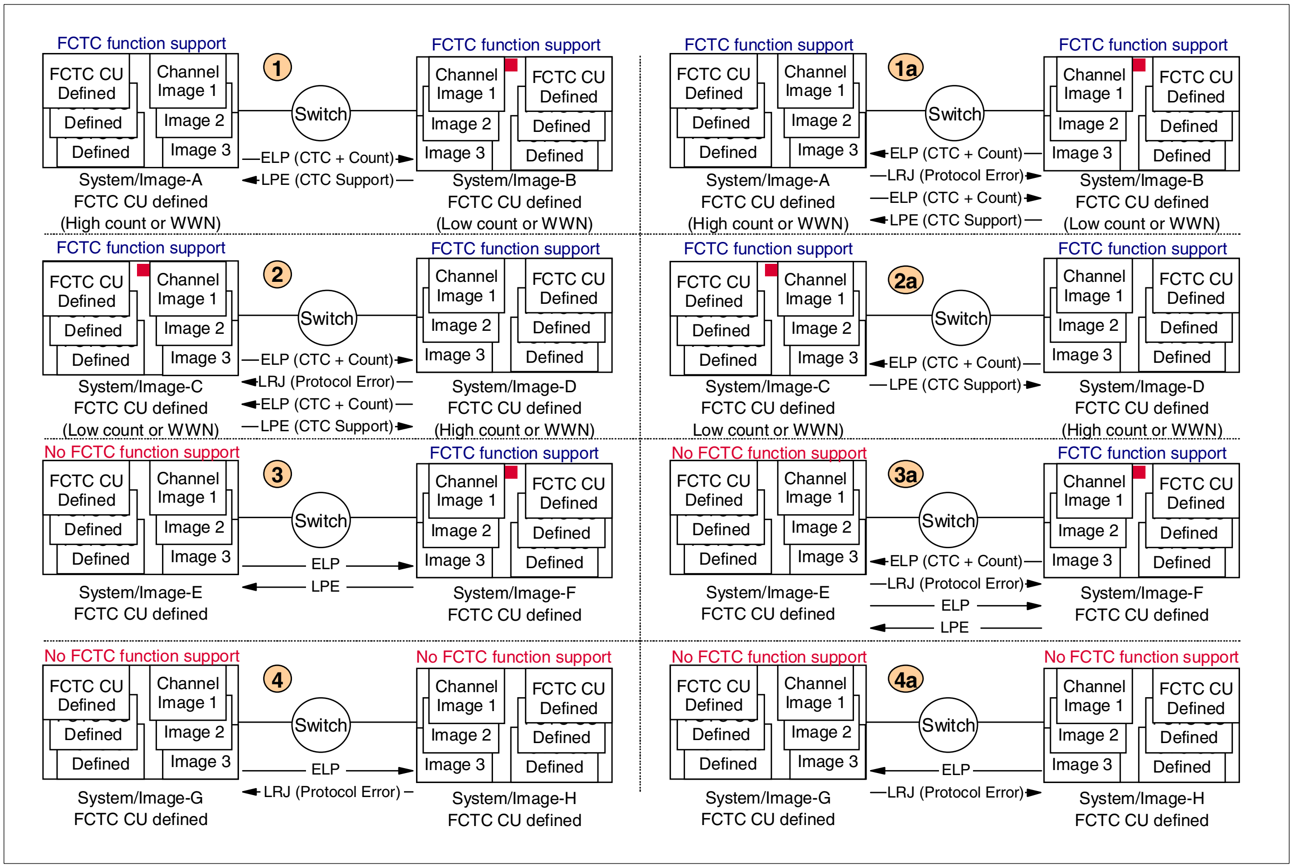

Figure 10-21 FICON CTC control unit establishment algorithm

The eight sections of the figure illustrate the possible scenarios for establishing the FICON CTC CU function. For each sequence, note that the ELP originating from a zSeries CPC at driver 3C or later contains both the CTC bit (which indicates FCTC CU function support), and the count of FCTC CU functions already supported by that channel.

1. In diagram 1, systems A and B are both FCTC CU function-capable. System A has a high FCTC CU function count and a higher WWN than system B.

   If an ELP is sent from system A with the CTC bit on, and if the receiving end (system B) accepts the ELP with an LPE with the CTC bit set, then the receiving end (system B) provides the FCTC CU function and a logical path is established. The receiving end (system B) accepts the ELP, indicated by sending the LPE back to system A. System A, on receipt of the LPE, will then know that the FCTC CU function is being provided at the B end. This happens because all of the following conditions are met:

   – It has a matching FCTC CU definition. That is, at the receiving channel, the incoming frame sources, namely the port-identifier (source port address) and the channel image identifier (source logical partition number) each match a defined destination.

   – It supports the FCTC CU function.

   – It has the lower FCTC CU function count, or the counts were equal and the receiving end has the lower WWN.

   Diagram 1a shows the flow when system B initiates the establishment sequence by sending an ELP with the CTC bit on. The ELP also contains the established FCTC CU function count for the system B channel.

System A is capable of establishing the FCTC CU function. However, because either its FCTC CU function count is higher or the counts are equal and its WWN is higher, system A (the receiving end) rejects the ELP with an LRJ indicating a protocol error. System A then sends an ELP with the CTC bit set and the FCTC CU function count. System B, the receiving end, accepts the ELP with an LPE with the CTC bit set. System B, the receiving end, provides the FCTC CU function and a logical path is established.

2. In diagram 2, systems C and D are both FCTC CU-capable. System C has a low FCTC CU function count or WWN.

   If an ELP is sent from system C with the CTC bit on, and if the receiving end (system D) rejects the ELP with an LRJ indicating a protocol error, then the sending end (system C) provides the FCTC CU function. In this scenario, the receiving end (system D) rejects the ELP because of one of the following conditions:

   – It supports the FCTC CU function but there is no matching CU definition; the incoming source does not match a defined destination.

   – It has the higher FCTC CU function count.

   – The FCTC CU function counts are equal, but the sending end (system C) has the WWN advantage.

   In diagram 2a, if system D initiates the sequence by sending an ELP with the CTC bit and count, the receiving end (system C) accepts the ELP with an LPE because it had the lower FCTC CU function count or WWN.

3. In diagram 3, system E is not FCTC CU-capable, and system F is FCTC CU-capable.

   If system E sends an ELP without the CTC bit, indicating the FICON channel does not support the FCTC CU function, and system F, the receiving system, has been defined to support the FCTC CU function and has a matching CU definition, then the receiving end accepts the ELP with an LPE without the CTC bit.

   System F, the receiving end of the ELP, now provides the FCTC CU function, and a logical path is established between the ends of the FICON CTC logical connection. The sending end (system E) treats this as a normal ELP-LPE sequence.

   In diagram 3a, if system F initiates the sequence with an ELP with the CTC bit and count, then system E, where the FICON channel does not support FCTC CU function, responds with an LRJ indicating protocol error. Eventually system E will send an ELP without the CTC bit, and system F responds with an LPE. A logical path is established and the FICON channel on system F will provide the FCTC CU function.

4. Neither system G nor H are FCTC CU-capable.

   If system G sends an ELP without the CTC bit, indicating the FICON channel does not support the FCTC CU function, and system H, the receiving system, also does not support the FCTC CU function, then the receiving system (system H) responds with an LRJ. This means that neither end of the logical connection supports the FCTC CU function. No logical path is established.

   If system H initiates the flow with an ELP without the CTC bit, then system G (the receiving end) rejects it with an LRJ because it does not support the FCTC CU function.

The output of the z/OS operator command D M=DEV(dddd) for any FICON CTC device can be used to determine which FICON CHPID of the pair is providing the FCTC control unit function. Sample output is shown in 10.10.1, “z/OS commands” on page 182.

10.9 Migration considerations

Migration from ESCON SCTC devices (using ESCON channels) to FICON FCTC devices (using FICON channels) can be achieved with a minimum of disruption. The migration only requires that different control unit numbers and device numbers are used. As stated previously, the hardware support of the FCTC CU function by the zSeries requires the driver level 3C or later. The newly defined FICON FCTC configuration can coexist with the existing ESCON SCTC configuration. Exploiters, such as XCF, can use both FICON CTCs and ESCON CTCs at the same time (FCTC versus SCTC). For example, XCF supports signalling paths on both FCTC devices and SCTC devices at the same time.

10.10 Operations, availability and recovery

This section describes the external operations, configuring for availability, and recovery of error conditions, for FICON FCTC devices.

10.10.1 z/OS commands

The Display Units command for FICON CTC devices shows the device type FCTC. Sample outputs are shown in the following two screens.

The device type shown for FICON CTC devices is FCTC, and the device type for ESCON CTC devices would be shown as SCTC. BCTC devices may also be defined on an ESCON CHPID for older applications using basic CTC operating mode (basic CTC command set).

Note: The FICON FCTC CU function only supports the extended CTC operating mode (extended CTC command set); it does not support the basic CTC operating mode (basic CTC command set).

The FCTC device types for FICON, along with the SCTC and BCTC device types for ESCON, all belong in the IOS CTC device class.

Example 10-1 shows the use of the display unit CTC command:

Example 10-1 The display unit CTC command

```
D U,CTC,,4000,4
IEE457I 20.32.46 UNIT STATUS 372
UNIT TYPE STATUS        VOLSER     VOLSTATE
4010 FCTC A-BSY
4011 FCTC O
4012 FCTC O
4013 FCTC O
```

Example 10-2 shows the use of the display device command for four devices, starting from unit address 4000.

Example 10-2 The display device command for four devices

```
D U,,,4000,4
IEE457I 20.32.46 UNIT STATUS 372
UNIT TYPE STATUS        VOLSER     VOLSTATE
4010 FCTC A-BSY
4011 FCTC O
4012 FCTC O
4013 FCTC O
```

Apart from the device type (FCTC) and the channel type (FC) shown in the z/OS and OS/390 command displays, there is no difference operationally in the management of FICON FCTC devices from ESCON SCTC devices. For example, FICON FCTC devices can be managed using z/OS or OS/390 VARY and SETXCF commands, just like ESCON SCTC devices.

The z/OS or OS/390 Display Matrix Device command for FICON FCTC devices is similar to that for ESCON SCTC devices, but has the enhancement of also displaying information in the device Node Element Descriptor (NED), indicating at which end of the FCTC logical connection the FCTC CU function is provided.

Example 10-3 The Display Matrix Device command (5630)

```
D M=DEV(5630)
IEE174I 20.33.27 DISPLAY M 376
DEVICE 5630   STATUS=ONLINE
CHP                   90
DEST LINK ADDRESS     14
DEST LOGICAL ADDRESS  03
PATH ONLINE           Y
CHP PHYSICALLY ONLINE Y
PATH OPERATIONAL      Y
ND         = NOT AVAILABLE
DEVICE NED = 002064.CTC.IBM.02.148AA0010ECB
                                    *
```

Example 10-3 shows the output of the z/OS (or OS/390) Display Matrix Device command, which includes the display of the device Node Element Descriptor (NED) for the FICON FCTC device 5630 in image LP1 on processor 1. Alpha character A in the device NED (which we marked with an * underneath it) indicates that the FCTC control unit function is supported by the CHPID (90) at this end of the FCTC-to-FCTC logical connection (LP1 to LPC) for the image that the command was entered from.

Example 10-4 shows the display of the device NED for the FICON CTC device number 4010 in image LPC on processor 2. Alpha character B in the device NED (which we marked with an * underneath it) indicates that the FCTC control unit function is supported by the CHPID at the other end of the FCTC connection for this image, 3, (LPC) to the other image, 1, (LP1).

Example 10-4 The Display Matrix Device command (4010)

```
D M=DEV(4010)
IEE174I 20.38.44 DISPLAY M 386
DEVICE 4010 STATUS=ONLINE
CHP                   32
DEST LINK ADDRESS     0B
DEST LOGICAL ADDRESS  01
PATH ONLINE           Y
CHP PHYSICALLY ONLINE Y
PATH OPERATIONAL      Y
ND         = NOT AVAILABLE
DEVICE NED = 002064.CTC.IBM.02.143AB0013487
                                    *
```

There is no difference in the output of the z/OS Display Matrix CHPID command for a FICON native (FC) channel supporting FICON FCTC control units from that of the same FICON (FC) channel supporting disk or tape control units, as shown in Example 10-5 on page 184.

Example 10-5 The Display Matrix Device with CHPID command

```
D M=CHP(32)
IEE174I 20.34.06 DISPLAY M 378
CHPID 32:  TYPE=1B, DESC=FICON SWITCHED, ONLINE
DEVICE STATUS FOR CHANNEL PATH 32
     0  1  2  3  4  5  6  7  8  9  A  B  C  D  E  F
4010 +  +  +  +  +  +  +  +  .  .  .  .  .  .  .  .
4020 +  +  +  +  +  +  +  +  .  .  .  .  .  .  .  .
4030 +  +  +  +  +  +  +  +  .  .  .  .  .  .  .  .
4610 +  +  +  +  +  +  +  +  .  .  .  .  .  .  .  .
4620 +  +  +  +  +  +  +  +  .  .  .  .  .  .  .  .
4630 +  +  +  +  +  +  +  +  .  .  .  .  .  .  .  .
SWITCH DEVICE NUMBER = NONE
*********************** SYMBOL EXPLANATIONS *******************
+ ONLINE    @ PATH NOT VALIDATED   - OFFLINE    . DOES NOT EXIST
* PHYSICALLY ONLINE   $ PATH NOT OPERATIONAL
```

10.10.2 Configuring for availability

The recommendations for configuring FICON FCTC devices for high availability are the same as those for ESCON SCTC devices:

- Provide redundant FICON FCTC connections with as few common hardware elements as possible. That is, configure redundant FICON FCTC connections on:
  - Different channels
  - Channels in different channel groups
  - Through different switches/fabrics
- Spread the receiving CTC devices across different physical hardware CTC connections.
- Spread the sending CTC devices across different physical hardware CTC connections.
- Spread the CTC devices for an exploiter across different physical hardware CTC connections.

Redundant CTC connections can be mixed across ESCON and FICON channels and provide the same functionality. Exploiters of CTC infrastructure for intersystem communication, such as XCF and VTAM, have no reliance on whether the CTC device is FCTC or SCTC; however, FICON CTCs provide a number of benefits over ESCON CTCs, including increased performance and connectivity.

10.11 FCTC operational and functional characteristics

This section covers some of the FCTC operational and functional characteristics.

10.11.1 Operational characteristics

The FICON native (FC) channel supporting a FICON CTC control unit has the same operational and functional characteristics as any FC channel supporting other types of control units. To summarize:

- The FICON native (FC) channel supports a maximum of 32 concurrent I/O connections.
- The link bandwidth for the FICON native (FC) channel is 100 MBps.

- The distance from the channel to control unit or channel to switch or switch to control unit link is up to 10 km (20 km with an RPQ) for FICON channels using long wavelength laser FOSAs.
- The channel-to-CU end-to-end distance before data droop is up to 100 km for FICON.
- The FICON channel supports up to 16,384 devices.
- FICON channels use frame and Information Unit (IU) multiplexing control to provide greater exploitation of the priority I/O queueing mechanisms within the FICON-capable control units, such as the IBM ESS 2105, and the 2064 Channel Subsystem priority queueing hardware function.
- Frame multiplexing support by the FICON channels, FICON switches, and FICON control units offers optimum utilization of the FC links.

More detailed information can be found in *FICON Native Implementation and Reference Guide,* SG24-6266.

10.11.2 Considerations for mixing control units on FICON channels

As described in “FICON CTC control unit function balancing” on page 179, if the FICON channel at each end of a FCTC connection is on a processor that supports the FICON CTC CU function, the channel that initiates the establishment of the FCTC CU function indicates the number of FCTC CUs that it currently supports. The receiving FC channels uses this number to determine which channel provides the FICON CTC CU function. The channel with the fewest FCTC number of FCTC CU functions supported will provide the FCTC CU function for the connection. This is an attempt to balance the load that FCTC connections place on each channel.

The FICON native (FC) channels supporting FCTC control units can also be used to support I/O operations to other control units, such as disk and tape. Note, however, that the establishment of logical paths to control units other than FCTC control units are *not* taken into consideration in the automatic FCTC CU function establishment balancing algorithm.

Performance

Detailed performance information will be provided by IBM at a later date. This information will include recommendations for the amount of CTC activity and mix of CTC and other I/O activity that is supported on a native FICON or FICON Express (FC) channel.

In general, zSeries FICON Express channels have better performance characteristics than previous versions of FICON channels; therefore, it is recommended that FICON Express be implemented wherever possible, particularly for performance-critical applications.

11

FICON channel operation and performance

This chapter describes FICON channel operational characteristics and performance considerations; you will find:

- FICON operational flow using Fibre Channel architecture
- FICON (FC-SB-2) protocol
  - CCW and data prefetching
  - CCW and data pipelining
  - frame multiplexing
- Comparison (ESCON versus FICON)
- FICON channel benefits
- Reporting for FICON channels

11.1 Fibre Channel FICON operation

FICON channels are designed to maximize the efficiency of channel operations by using the CCW and data pipelining channel program protocol and frame multiplexing protocol.

CCW and data pipelining and frame multiplexing are fully compatible with existing programs and z/OS and OS/390 Access Methods.

Figure 11-1 shows the flow of a FICON channel operation.

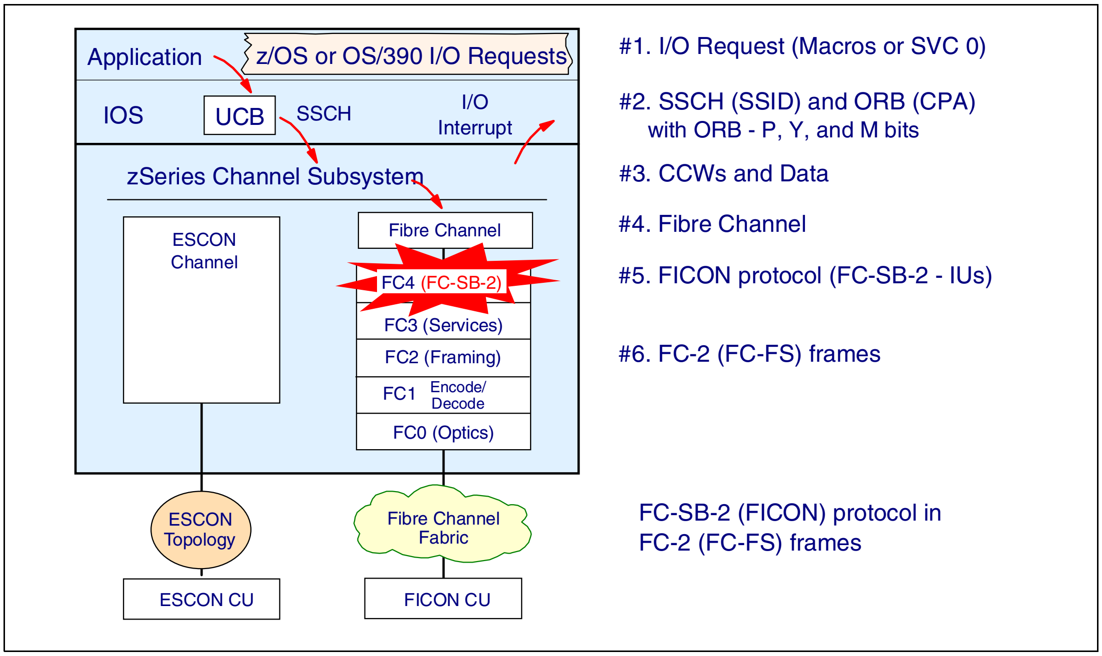

Figure 11-1 S/390 FICON channel operation flow

The flow of a FICON channel operation is explained in more detail using the numbered steps:

1. Application I/O requests

To request I/O operations to a device, regular unauthorized users issue macros such as GET and PUT that invoke Access Methods and use the standard EXCP SVC 0 interface, while supervisor routines and system components use a privileged I/O driver interface.

The IOBE is an optional control block for users of EXCP or the I/O driver interface. It is used as a communication area between the user, IOS and device dependent code such as Error Recovery Procedures (ERPs). For I/O drivers, the IOBE is an extension of the IOSB extension (IOSBE).

When the IOBE is used by EXCP users, the IOBE is pointed to by register 0 at entry to EXCP. EXCP then saves the address of the IOBE in the Request Queue Element (RQE).

The IOBE and IOSB have flags that allow exploitation of the FICON functions during the execution of the channel program:

- IOBEP/IOSP - Prefetching of CCWs and data is allowed. These bits are discussed in more detail in “CCW and data prefetch and pipelining” on page 191.
- IOBEPCIS/IOSXPCIS - PCI Synchronization. Set on by the I/O driver to indicate that the channel must synchronize after the next CCW following the PCI (CCW+8) when

prefetching (IOSP) is also set. These bits are discussed in more detail in “PCI synchronization” on page 195.

- IOBNORWS/IOSNORWS - No Read/write Synchronization. Set on by the driver to indicate that the channel should not synchronize on read/write transitions when prefetching (IOSP) is also set. The driver insures that the reads and writes are from different I/O buffers. These bits are discussed in more detail in “Synchronization of read-write transition” on page 194.
- IOBECPNM/IOSXCPNM - When set, the Channel program is not modified by the driver during execution, other than to add CCWs at the end.
- IOS2CSWS - Two Channel Status Words. Set on by the I/O driver to indicate that when CCW prefetch is requested (IOSP is set), if an error occurs where the control unit executes ahead of the channel, two ending CCW addresses should be presented to the driver. The second ending CCW address is contained in the IEDB. If this bit is off, an invalid ending CCW address is simulated by IOS.

2. I/O Supervisor Requests

The I/O Supervisor (IOS) initiates an I/O operation at a device by issuing the Start Subchannel (SSCH) instruction to the Channel Subsystem. There are two operands associated with the SSCH instruction. One operand is the Subsystem ID (SSID) containing the subchannel number identifying the target device. The second operand is a control block called the Operations Request Block (ORB) whose contents include flags and a pointer to the channel program to be executed at the device.

By setting the ORBP bit, IOS can control prefetching and pipelining of CCW commands and data for more efficient I/O. The ORBP bit set on indicates to the channel that CCW and data prefetching is allowed.

Two previously reserved ORB bits are now used for synchronization control with FICON support:

- ORBY bit is set to override the synchronization on read-to-write transitions that would otherwise occur. The FICON channel performs synchronization on the transition from a read CCW to a write CCW in the channel program. If the channel program is not self-modifying, and the builder has ensured that the write data buffers are separate from the read data buffers, then the ORBY bit can be set to override the read-to-write transition synchronization, thereby allowing the FICON channel to operate more efficiently.
- ORBM bit is set to override the synchronization on CCWs that call for a PCI interrupt to occur. Frequently, a PCI interrupt is requested by a channel program builder to allow modification of the channel program during its execution. The PCI interrupt is used as a signal to check whether additional CCWs need to be appended to the current channel program.

3. zSeries Channel Subsystem

The SSCH request issued by IOS is processed by the Channel Subsystem, which is responsible for selecting the channel over which the I/O operation is initiated.

4. S/390 Fibre Channel

zSeries Fibre Channel implementation is based on the Fibre Channel Single-Byte Command Code Sets-2 (FC-SB-2) Protocol. FC-SB-2 is an FC-4 mapping protocol that maps this particular SB-2 Upper Level Protocol (ULP) instance to FC-PH.

5. FC-SB-2 Protocol

FICON (FC-SB-2) architecture provides Information Units (UIs) processing. Information associated with the execution of an I/O operation and the operation of a device is transferred between the channel and control unit as Information Units. SB-2 Information Units (UIs) contain SB-2 device-level commands, status, data, or control information or SB-2 link-level control information. All SB-2 IUs are sent as FC-4 device-data frames.

6. FC-2 Frames

Fibre Channel architecture (FC-2) frame multiplexing allows for multiple simultaneous exchanges, each concurrently transferring information, between a channel and control unit over the same link interface to different devices.

Communication over the Fibre Channel takes place between a pair of N_Ports, one N_Port associated with a channel and the other associated with a control unit, over a Fibre Channel Fabric.

FC-FS defines all of the functions required to transfer information from one N_Port to another. FC-FS consists of related functions FC-0, FC-1, and FC-2. The physical interface (FC-0) consists of transmission media, transmitters, receivers, and associated interfaces. FC-1 specifies the transmission protocol. The signaling protocol, FC-2, provides the rules and mechanisms needed to transfer information from one N_Port to another.

11.1.1 FICON channel I/O operations

Figure 11-2 shows the transfer of I/O operations (zSeries channel commands and data) from the channel to the FICON-capable control unit. Each I/O operation is for a different device (A,B,C). Each I/O operation is transferred to the FICON channel adapter card, which then manages the I/O operation out to the control unit via the addressed FICON destination port if in a switched point-to-point configuration.

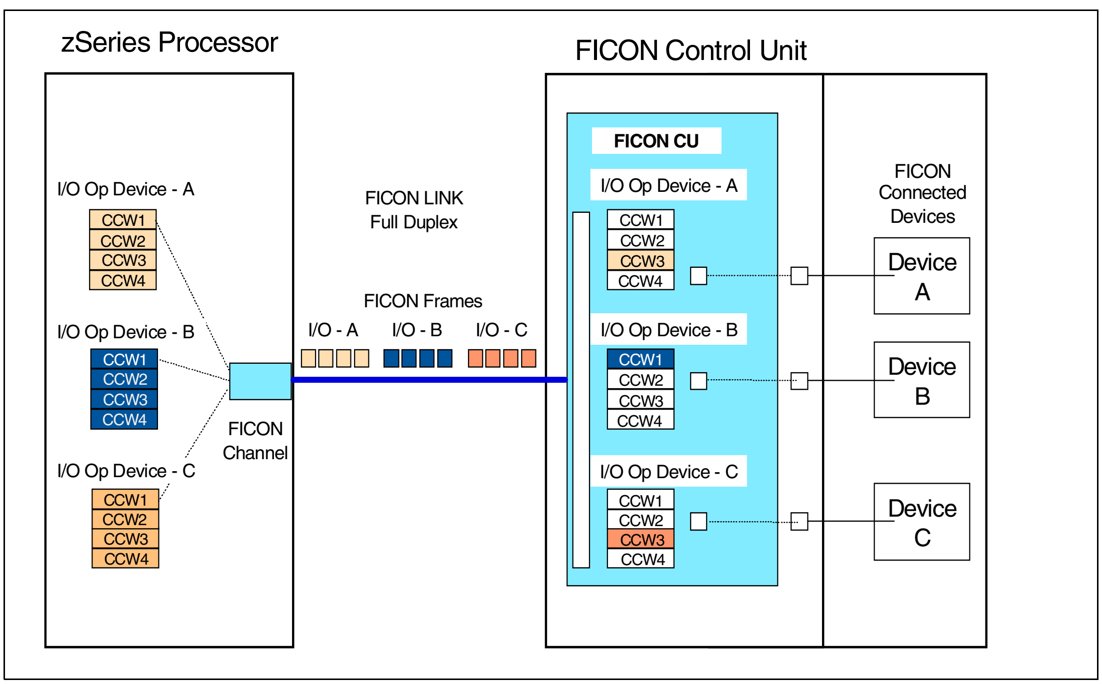

Figure 11-2 FICON channel I/O operation

For most cases, as the individual commands are being successfully executed from the FICON channel and the FICON control unit, there is no need to report back to the FICON channel. There is only a need to communicate with the channel when the operation does one of the following:

- A disconnect command chaining condition occurs
- The operation gets to the end of the CCW chain
- The operation terminates in an error
- A CU-detected modifying condition occurs (CU reports status-modifier)

The method of not communicating back to the channel for successful completion of individual commands in the channel command chain, up to the last command, saves both channel turnaround times and frame bandwidth on the FICON link.

11.1.2 CCW and data prefetch and pipelining

FICON (FC-SB-2) architecture provides the protocol for CCW and data prefetching and pipelining, which eliminates the interlocked interface communication that exists with parallel and ESCON channels.

The protocol interlock reduction has the following benefits:

- reduced number of interlocked handshakes
- prefetched CCWs and data
- CCW synchronization
- enhanced error recovery

Review of ESCON channel operation

An ESCON channel program operation requires a Channel End/ Device End (CE/DE) to be presented after execution of each CCW. FICON channels, by using CCW pipelining, can send groups of CCWs before requiring status (CE/DE). CCW operation (command and data transfer) on an ESCON channel is shown in Figure 11-3.

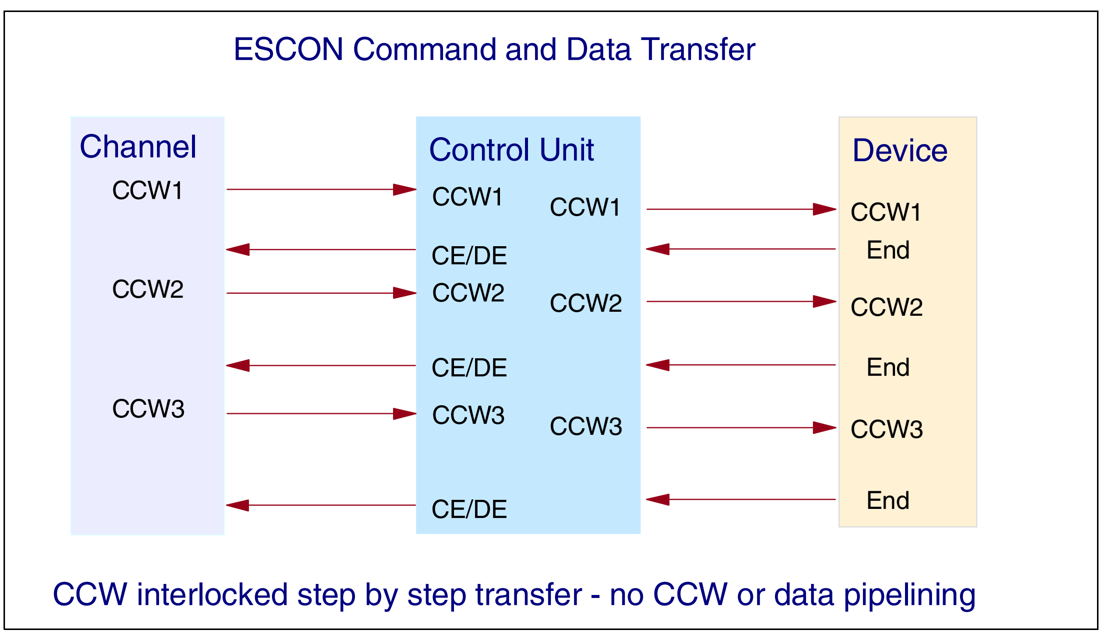

Figure 11-3 ESCON command and data transfer

As shown in the diagram, the ESCON channel transfers the CCW to the control unit and waits for Channel End/Device End to be presented by the control unit after execution of the CCW by the device (CCW interlock). After receiving CE/DE for the previous CCW, the channel transfers the next CCW to the control unit for execution.

On a FICON channel, all CCWs may be transferred to the control unit without waiting for CE/DE after each I/O operation. The device presents a DE to the control unit after each CCW execution, as before. If the last CCW of the CCW chain has been executed by the device, the Control Unit will present CE/DE to the channel. This feature of the Fibre Channel architecture is known as pipelining, or prefetching of CCW commands and data, and allows the FICON channel to operate at optimum efficiency.

However, prefetching may cause problems for self-modifying channel programs and for recovery routines which restart a failed read CCW from the point of failure. Self-modifying channel programs alter CCWs as a result of channel program execution. For example, a CCW in a channel program may read data into a buffer that is used by a CCW further along in the same CCW chain.

I/O Requester control

An I/O driver indicates that unlimited prefetch of CCWs and data can be used for its channel program by setting the IOSP bit on in the IOSB. This flag can be found in the IOSB + x ’F’, bit 1 (byte IOSOPT2=x’40’). EXCPVR users specify the setting of the prefetch control flag with the OPBEP flag in the IOB Extension.

I/O Supervisor control

Issuers of the SSCH instruction (the I/O Supervisor, IOS, in z/OS and OS/390, and standalone programs) enable CCW pipelining and prefetching by setting the prefetch control bit in the Operations Request Block (ORB), bit ORBP (word 1 bit 9). When ORBP is set to 1, unlimited prefetching is allowed for CCWs, IDAWs and their associated data. When ORBP is set to 0, no prefetching is allowed. Also, the synchronization control bit (ORBY, word 1 bit 7), described in 11.1.3, “Synchronization of read-write transition” on page 194, is ignored.

Figure 11-4 on page 193 shows the FICON channel operation when CCW and data pipelining is specified. It shows the FICON channel fetching and transferring CCWs and data to the control unit, without waiting for a status indicating the progress of the execution of the CCWs at the control unit and device. CCW and data pipelining allows the FICON channel to operate at maximum efficiency.

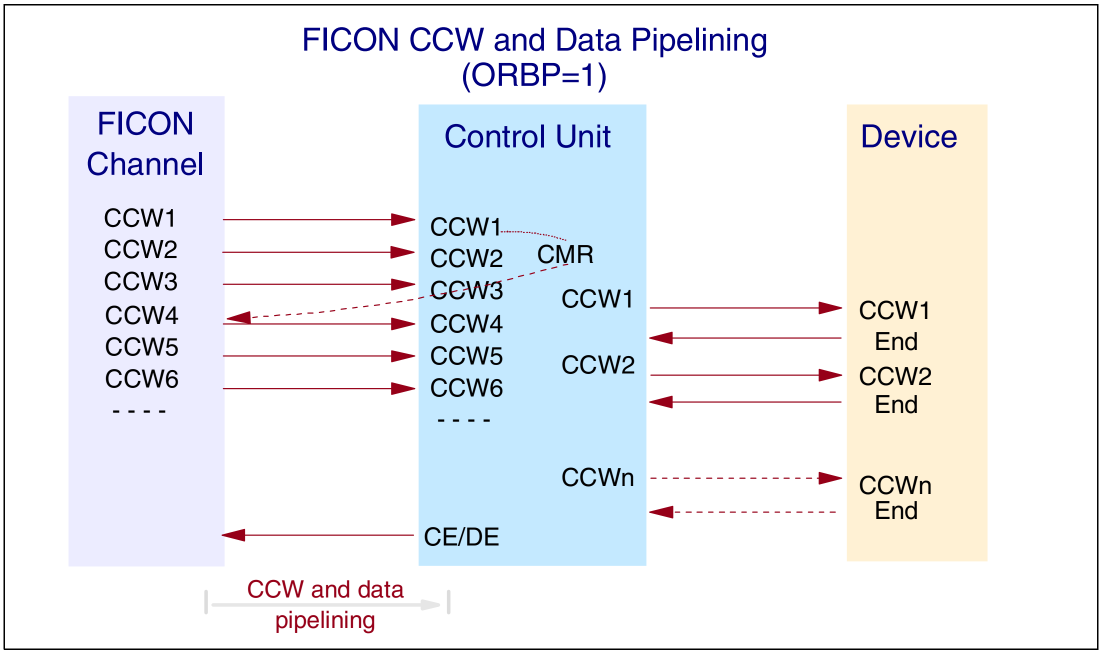

Figure 11-4 FICON CCW and data pipelining - ORBP=1

Figure 11-5 shows the consequences of preventing CCW and data pipelining in the FICON channel. If ORBP=0, the FICON channel must synchronize the execution of each CCW. The next CCW cannot be fetched and transferred to the control unit before status for the current CCW is received. Executing without pipelining means that the performance of the channel program is impacted.

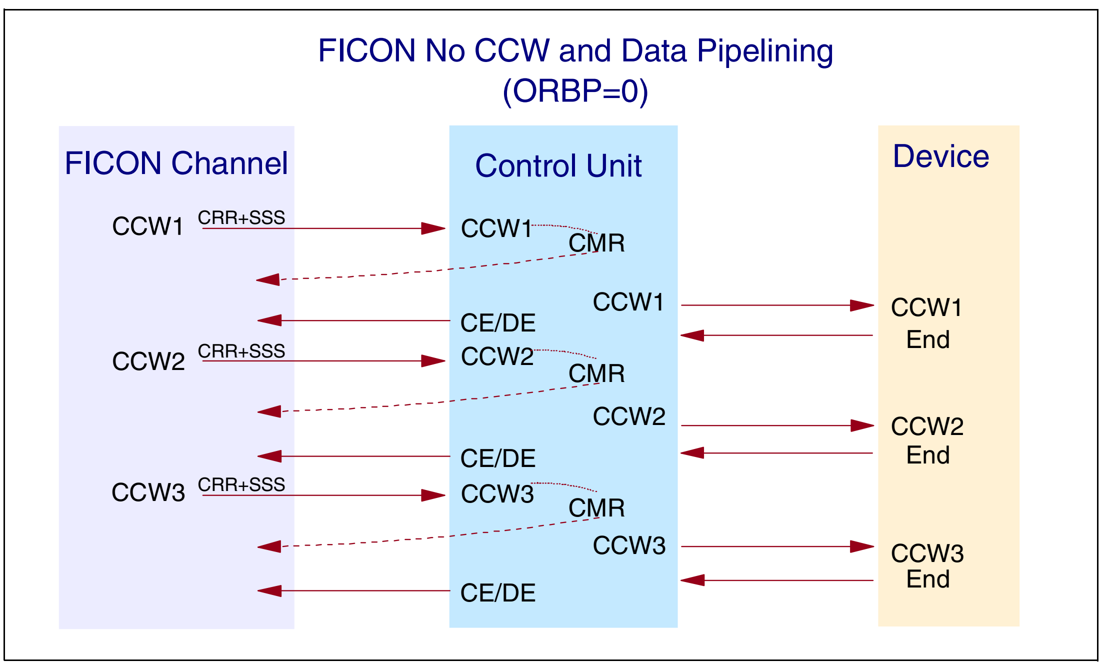

Figure 11-5 FICON No CCW and data pipelining - ORBP=0

11.1.3 Synchronization of read-write transition

To ensure data integrity, the FICON channel performs synchronization on read-to-write transitions in a channel program. That is, whenever the current command in execution in the FICON channel is an input operation (read) and the next CCW to be fetched describes an output operation (write), the FICON channel indicates to the control unit that status must be presented when the current (input/read) operation has completed execution at the device.

Overriding the synchronization that occurs on transition from read-type CCWs to write-type CCWs improves the performance of the I/O operation and allows maximum benefits to be gained from the CCW prefetching capabilities of the FICON channel. However, overriding the synchronization on read-to-write transitions should only be specified if the buffers used for reading are separate to those used for writing, or the read channel programs are separate from the write channel programs.

I/O Requester control

An I/O driver sets the IOSNORWS bit at byte x'2', bit 4 in the IOSB (IOSBFLC=x'08') to indicate that the channel should not synchronize on read-to-write transitions. The prefetching bit (IOSP) must also set.

An EXCP requester can also override read-write transition synchronization in the FICON channel by setting the IOBNORWS in the IOB extension.

With IOSNORWS/IOBNORWS=1 and IOSP/IOBEP=1, the I/O Supervisor (IOS) sets the override read-write transition synchronize control bit in the ORB when issuing the SSCH instruction for the channel program.

I/O Supervisor control

When explicitly indicated by the I/O requester, IOS overrides the FICON channel read-write transition synchronization by setting the synchronize control bit, ORBY (ORB word 1 bit 7), to 1.

When ORBY is set to 1 and ORBP (word 1 bit 9) is set to 1, synchronize control is not specified. That is, the FICON channel does not synchronize status at a read-write transition, and the benefits of CCW and data pipelining are realized. When ORBY is set to 0 and pipelining is indicated (ORBP=1), synchronize control is specified and the FICON channel must delay sending the output operation until the status at the end of execution of the input operation has been received at the channel.

The synchronize control bit is only meaningful when the device is configured on a FICON (FC or FCV) channel and the prefetch control bit (ORBP) is 1.

Figure 11-6 on page 195 shows the FICON channel operation when read-write transition synchronization is specified. That is, this diagram shows the normal FICON channel operation, and the I/O requester has not explicitly indicated that the synchronization can be overridden. In this example, the channel program consists of the following CCWs:

- 63 - Define Extent (transfers positioning data)
- 47 - Locate Record (transfers positioning data)
- 06 - Read Data
- 47 - Locate Record (transfers positioning data)
- and so on...

The FICON channel recognizes the transition from an input operation (Read Data CCW) to an output operation (Locate Record CCW), and sends CCW3 to the control unit with Synchronize Send Status (SSS) flag set. The FICON channel then suspends further fetching of CCWs until the status for CCW3 has been received.

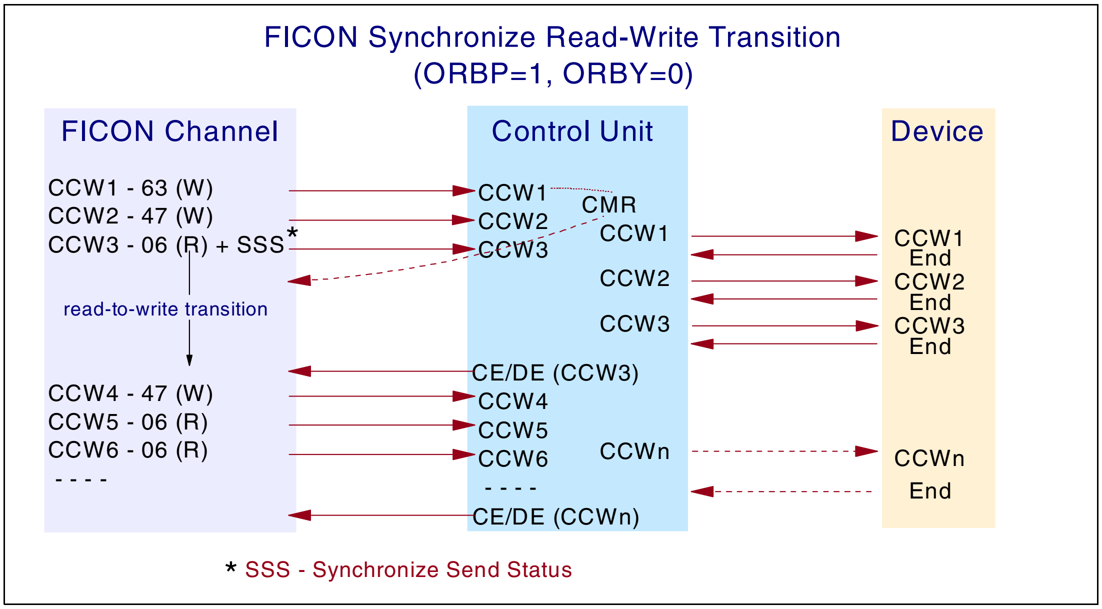

Figure 11-6 Read-write transition synchronization

Figure 11-7 shows the FICON channel operation when read-write transition synchronization is not specified. That is, the I/O requester has explicitly overridden synchronization. It shows that the full performance benefits of FICON pipelining can be realized without the FICON channel incurring the delay of waiting for synchronized status from the control unit before proceeding to fetch and transfer CCWs.

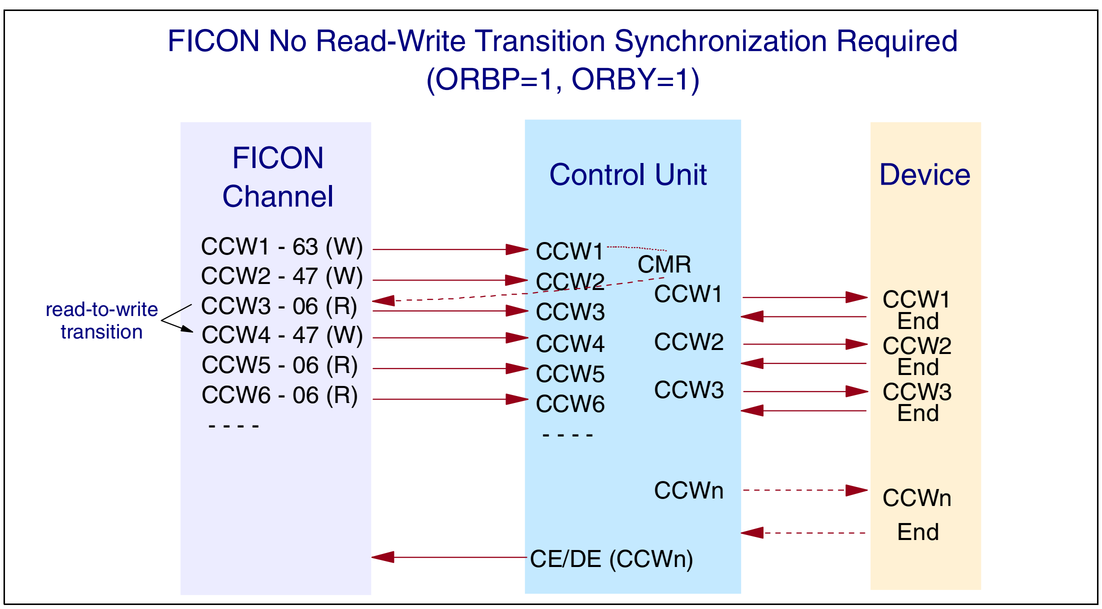

Figure 11-7 No read-write transition synchronization

11.1.4 PCI synchronization

The FICON channel performs synchronization when a CCW in the channel program has the PCI (Program Controlled Interrupt) flag set. When the FICON channel executes a command with the PCI and command-chain flags are set to 1, command synchronization is forced for the subsequent command. The channel subsystem temporarily suspends command chaining and does not fetch the next command-chained CCW until after normal ending status is received from the device.

The zSeries architecture provides the Modification Control bit that allows a program to request the FICON channel not to synchronize on the CCW following the PCI. When modification control is not specified, command synchronization is not required and the channel subsystem may transfer commands to the device without waiting for status.

Modification control provides the capability to optimize dynamically modified channel programs that use the PCI flag in the CCW to initiate channel program modification. The program may alter the channel program to allow it to execute in a different way, depending on the data already read. Modification control allows the program to delay the channel subsystem fetching and transfer of commands until after status is received for the command following the command with the PCI bit set. Examples of applications that use PCI are IEBCOPY and IEWFETCH.

On systems where FICON channels are supported, overriding the synchronization that occurs on PCI interrupts improves the performance of the I/O operation and allows maximum benefits to be gained from the prefetching capabilities of the FICON channel. Some applications use PCI interrupts to notify the program when buffers associated with a completed portion of the channel program can be freed or reused for other purposes. Programs that use PCI in this way do not want to incur the overheads of synchronization and can use modification control to override synchronization. However, overriding PCI synchronization should only be specified if the PCI interrupt is not used to modify the CCW chain following the CCW where the PCI is requested.

I/O Requester control

PCI synchronization can be requested by I/O drivers by setting the IOSXPCIS bit in the IOSB extension. EXCP users can request PCI synchronization by setting the IOBEPCIS bit in the IOB extension.

With IOXPCIS/IOBEPCIS set, modification control is specified and synchronization occurs on the CCW following the CCW with the PCI flag set.

I/O Supervisor control

To optimize performance of the FICON channel, the software default is no PCI synchronization. Unless the I/O requester specifically indicates PCI synchronization with the IOXPCIS/IOBEPCIS bit set to 1, IOS sets the modification control bit, ORBM (ORB word 1 bit 6), to 1. When ORBM is set to 1, modification control is not specified and no synchronization for a PCI is requested by the FICON channel. When ORBM is set to 0, modification control is specified, and the FICON channel requires status synchronization on the CCW following the CCW with the PCI flag set.

Modification control is only meaningful for a device configured on a FICON (FC or FCV) channel.

Figure 11-8 on page 197 shows the normal operation of the FICON channel when a CCW with a PCI flag is executed but the ORB does not specify modification control. In this example, the FICON channel fetches CCW12 which has the PCI flag on. ORBP=1 and ORBM=1 which means that modification control is not specified, that is, no PCI synchronization is required. The FICON channel sends CCW12 to the control unit with command response request (CRR) flag set. When CCW12 becomes current in the control unit, a command response (CMR) for CCW12 is sent to the FICON channel. When the FICON channel associates the CMR with CCW12 which has the PCI flag on, a PCI I/O interrupt is generated.

The PCI I/O interrupt is a signal to the I/O requester as to the progress of the execution of the channel program. The application may now re-use the buffers associated with the completed portion of the channel program. for example. Because PCI synchronization is not required and modification control is not specified, the full benefits of the FICON channel pipelining are realized.

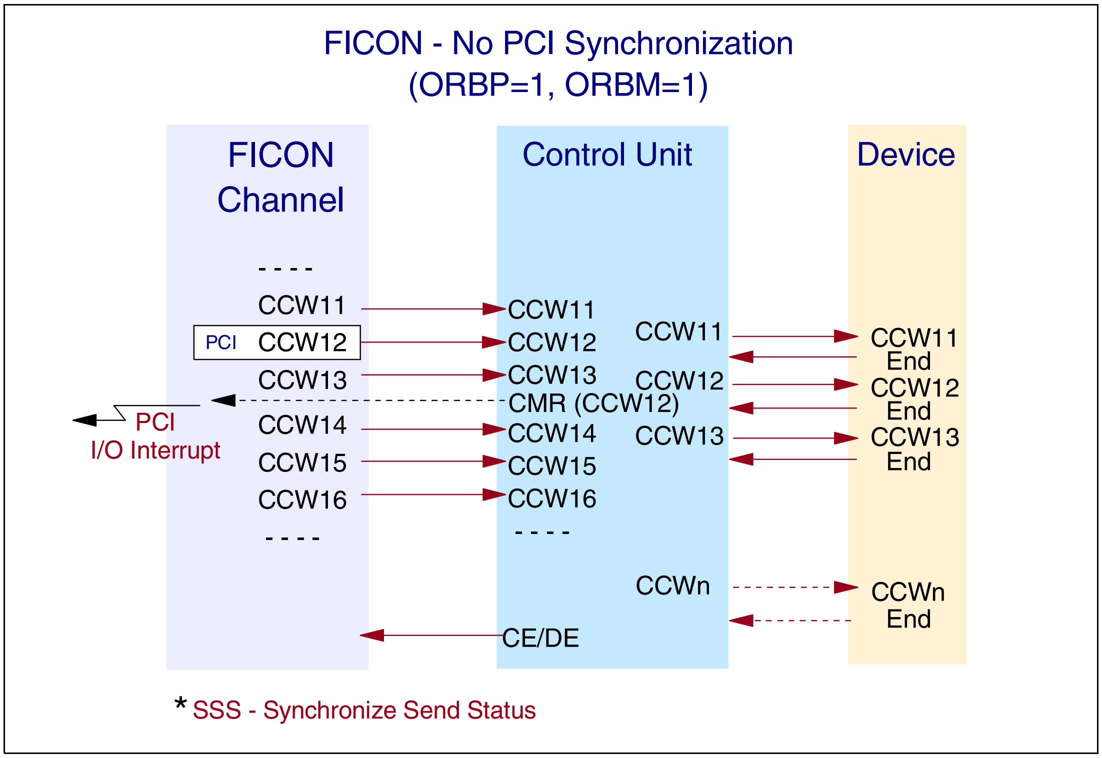

Figure 11-8 No PCI synchronization

Figure 11-9 on page 198 shows the FICON channel operation when PCI synchronization is required. ORBP=1 and ORBM=0 indicating modification control is specified. When the FICON channel fetches CCW12 with the PCI flag on, it sends CCW12 to the control unit with CRR flag on. The FICON channel then fetches CCW13 and sends it to the control unit with the Synchronize Send Status (SSS) flag set on. The FICON channel suspends fetching further CCWs until the status for CCW13 is received from the control unit.

In the control unit, when CCW12 becomes current, a CMR for CCW12 is sent to the FICON channel. The FICON channel recognizes that CCW12 has the PCI flag on and generates a PCI I/O interrupt. On receipt of the PCI interrupt, the authorized application may then modify any CCW from CCW14 (CCW12+8bytes) onwards.

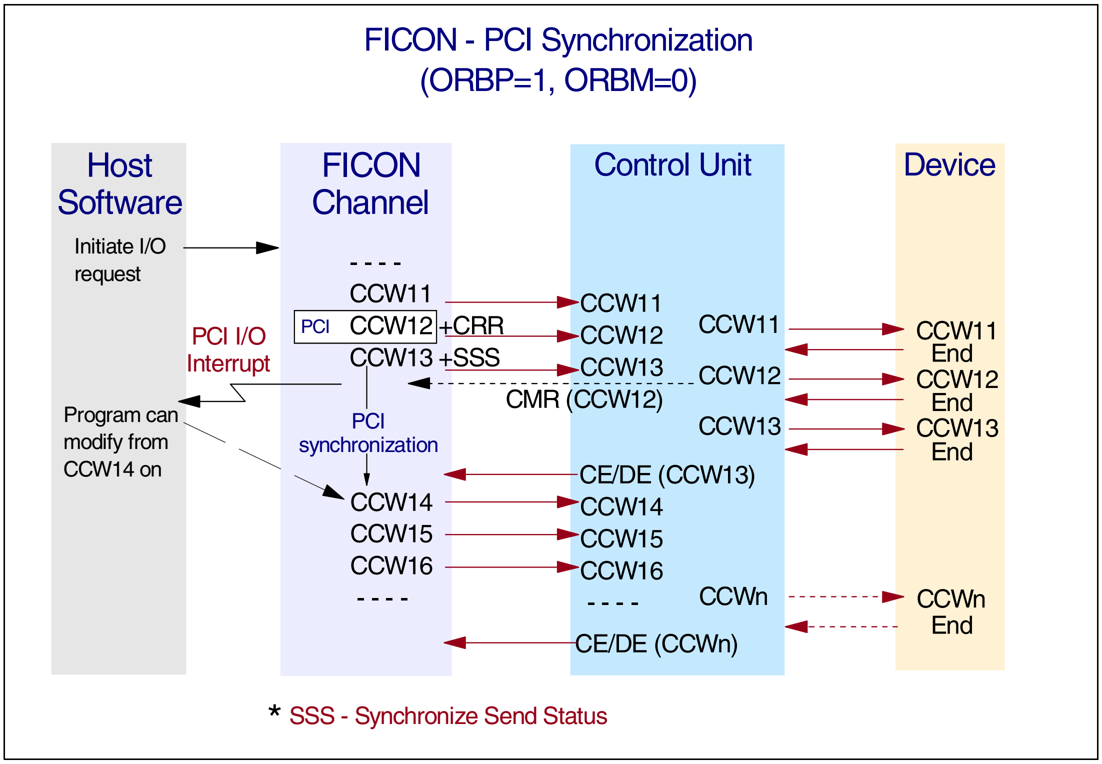

Figure 11-9 PCI synchronization

At the end of execution of CCW13, the control unit sends status to the FICON channel and synchronization is now complete. The FICON channel can now continue to fetch and send CCWs (that is, resume pipelining) to the control unit. Note that the I/O requester has no awareness of the point in time where the status for CCW13 is presented to the FICON channel. If the I/O requester intends modifying CCW14, the priority of the image, on an LPAR mode machine, and the dispatching priority of the application should be set to ensure that the requester receives control in a timely manner after the PCI interrupt.

11.1.5 Frame multiplexing

Fibre Channel architecture (FC-2) frames provide the protocol frame multiplexing, which allows a higher utilization of the fibre channel link bandwidth.

Frame multiplexing uses fibre channel's full duplex data transfer in each direction and provides:

- Multiplexing operations for different devices and control units.
- Transmitted frames are in groups (implementation dependent).
- Received frames may be multiplexed (switch and operation dependent).
- Frames from each system intermix at the destination port.
- Destination port busy signals to SAP are eliminated.

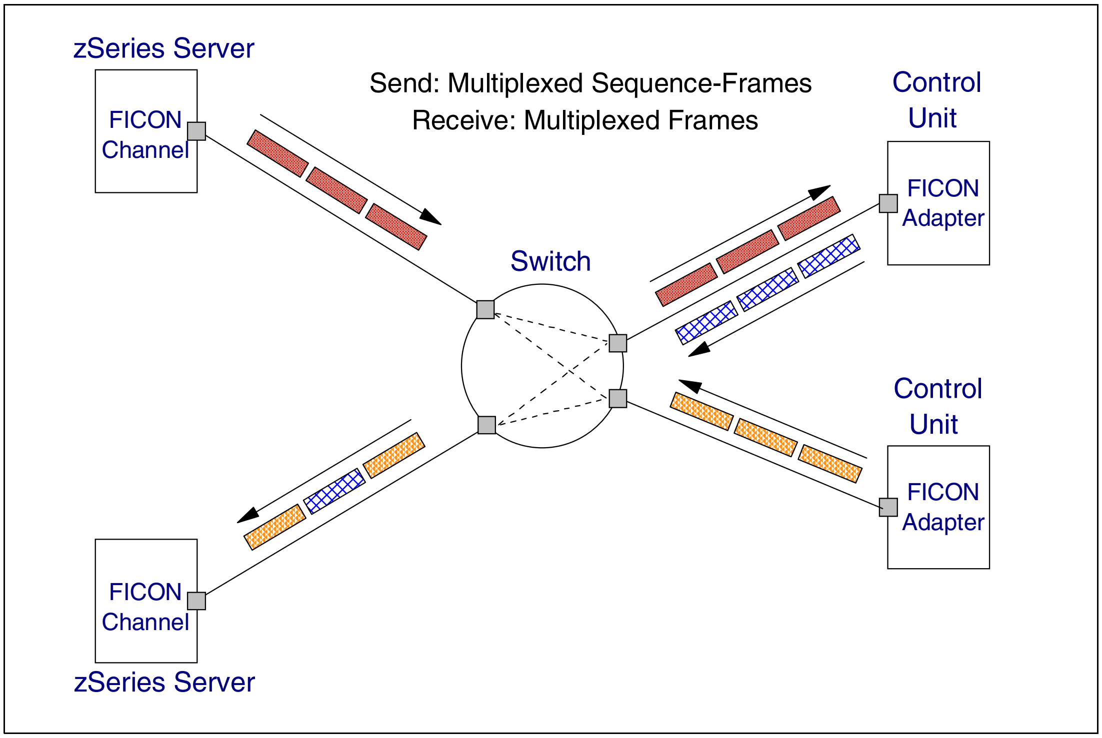

Figure 11-10 FICON frame multiplexing

Figure 11-10 shows a frame multiplexing example. FICON channels can send multiplexed sequence-frames, transmitting frames in groups via a switch to a control unit's FICON adapter. The received frames may be multiplexed by the switch (implementation dependent).

11.2 Comparison of FICON and ESCON I/O operations

This section compares the phases of an I/O operation over a FICON native (FC) channel with the same sequence on an ESCON channel. The following terms are used to describe the different phases with respect to the measurements available for determining the duration of an I/O operation and potential delays:

- I/O Supervisor Queue time (IOSQ), measured by the operating system

  The application I/O request may be queued in the operating system, if the I/O device, represented by the UCB, is already being used by another I/O request from the same operating system image (UCB busy). The I/O Supervisor (IOS) does not issue a Start Subchannel (SSCH) command to the Channel Subsystem until the current I/O operation to this device ends, thereby freeing the UCB for use by another I/O operation.

- Pending time (PEND), measured by the channel subsystem

  After IOS issues the Start Subchannel command, the Channel Subsystem may not be able to initiate the I/O operation if any path or device busy condition is encountered:

  – Channel busy, with another I/O operation from the same CEC

  – Switch port busy, with another I/O operation from another or the same CEC. This can only occur on an ESCON channel. The use of buffer credits on a FICON native (FC) channel eliminates switch port busy.

  – Control unit adapter busy, with another I/O operation from another or the same CEC

  – Device busy, with another I/O operation from another CEC

- Connect time, measured by the channel subsystem

  This is the time that the channel is connected to the control unit, transferring data for this I/O operation.
- Disconnect time

  The channel is not being used for this I/O operation, as the control unit is disconnected from the channel, waiting for access to the data or to reconnect. Disconnect time often does not exist when a cache hit occurs because data is transferred directly from cache without the need for access to the device.

It is also important to be aware of some of the new functions implemented by the IBM ESS 2105:

- Multiple Allegiance (MA)

  This function enables different operating system images to perform multiple concurrent I/O operations to the same logical volume, when no extent conflict exists. This can reduce the pending time, as device busy is not be presented to the channel.
- Parallel Access Volumes (PAV)

  This function allows more than one I/O operation from the same operating system image to be sent and to access the same logical volume at the same time. PAV provides multiple UCBs and device addresses. This can reduce the IOSQ time, by reducing device (UCB) busy conditions.

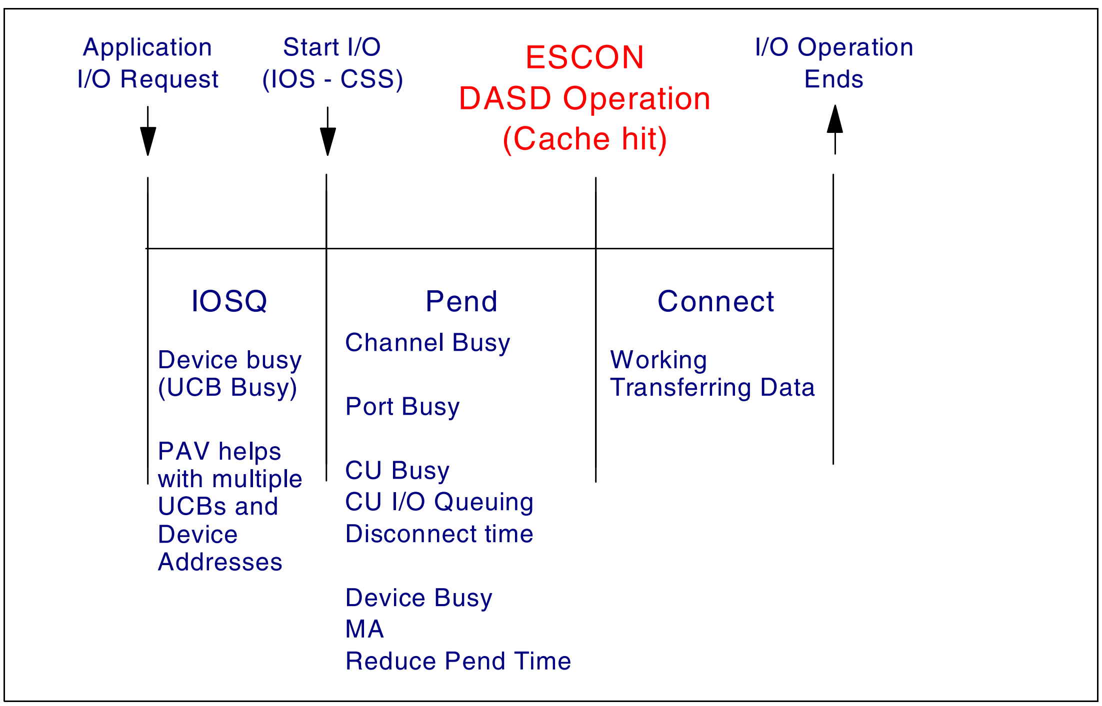

Figure 11-11 ESCON I/O operation sequence - cache hit

Figure 11-11 shows the components of an ESCON I/O operation when a cache hit occurs. In this case, there is no disconnect time and the I/O operation ends at the end of the connect time, after transferring the requested data.

The ESCON I/O operation may accumulate IOSQ time if the device (UCB) is already in use for another I/O request from this system. IOS only initiates one I/O operation at a time for a device with the Channel Subsystem. The new I/O operation cannot be started with the

Channel Subsystem until the I/O interrupt signalling completion of the current outstanding I/O operation has been processed by IOS. Parallel Access Volume (PAV) support, available on the IBM ESS 2105 subsystem, helps reduce IOSQ time and device busy conditions by allowing multiple I/O requests per UCB for access to the same logical volume.

Once the request has been accepted by the Channel Subsystem, it may accumulate PEND time if the Channel Subsystem is unable to start the request because of either channel busy, port busy, control unit (CU) busy, or device busy.

With the ESS 2105 subsystem, some control unit busy can be alleviated with I/O queuing by the control unit. In the case of a cache hit, the ESS 2105 control unit may queue an I/O request for conditions which in other subsystems would result in CU busy, such as destaging, extent conflict resolution, and so on. This control unit I/O queuing time is accumulated in DISCONNECT time, but reported later in PEND time.

With the ESS 2105 subsystem, some device busy can be alleviated through the Multiple Allegiance function which enables different operating system images to perform concurrent I/O operations at the same logical volume as long as no extent conflict exists. Note that device busy still occurs if the device is reserved by another operating system image.

When the I/O operation is accepted by the control unit, CONNECT time is accumulated as the channel transfers data to/from cache.

The I/O operation completes when the data transfer into cache is complete. No access to the physical volume is required before the end of the I/O operation is signalled in the case of a cache hit.

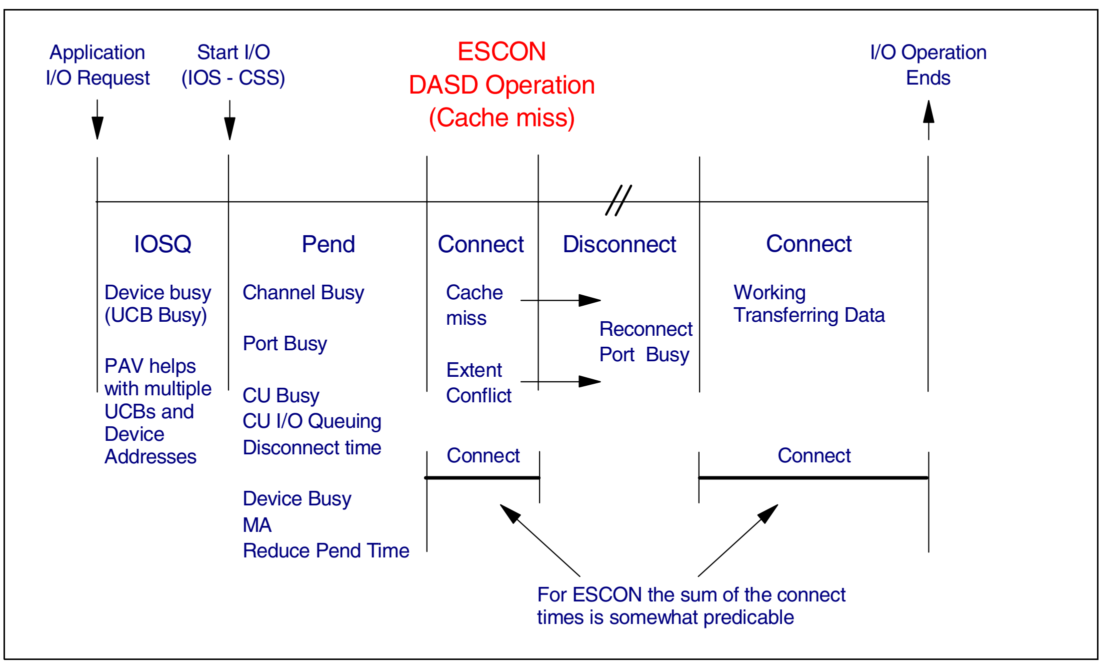

Figure 11-12 ESCON I/O operation sequence - cache miss

Figure 11-12 shows an ESCON I/O operation sequence when a cache miss occurs. In this case, CONNECT time is accumulated as the positioning CCWs are transferred to the control unit. For the ESS 2105 subsystem, this CONNECT time component also includes the extent conflict checking time.

DISCONNECT time is then accumulated as the physical DASD positioning operations are performed. Then the control unit must reconnect to the channel for the transfer of data. It is during the attempt to reconnect, that a port busy condition may occur.

Further CONNECT time is accumulated as data is transferred over the channel. For ESCON I/O operations, the total connect time component is somewhat predictable since the data transfer is directly related to the speed of the channel and the number of bytes transferred.

The I/O operation ends after the requested data has been transferred and the terminating interrupt has been presented by the channel.

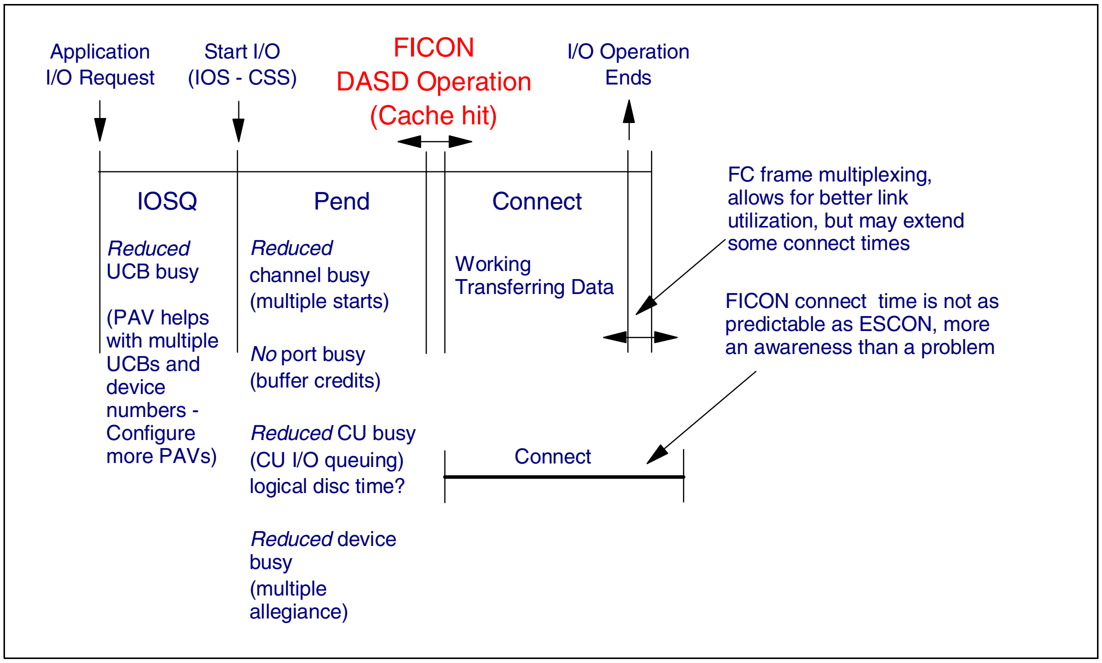

Figure 11-13 FICON I/O operation sequence - cache hit

Figure 11-13 shows a FICON I/O operation sequence when a cache hit occurs. As with an ESCON cache hit operation, no DISCONNECT time is accumulated. Note that some busy conditions can be reduced or eliminated when using FICON channels:

- More devices/UCBs can be configured (up to 16,384 devices per FICON channel), allowing a higher ESS 2105 PAV function exploitation, including dynamic PAV support in OS/390 R2.7 Workload Manager (WLM). This reduces the number of device busy and UCB busy conditions that will be accumulated in IOSQ time.
- Channel busy is reduced with FICON's capability of multiple starts to the same channel path, thereby reducing PEND time.
- Port busy does not exist on FICON switches. The FICON switch uses switch port buffer credits.
- Control unit busy conditions are reduced with CU I/O queueing in the ESS 2105 subsystem, also reducing PEND time.
- Device busy conditions are reduced by further exploitation of the ESS 2105 Multiple Allegiance (MA) function due to FICON's multiple concurrent I/O operations capability.

As Fibre Channel frame multiplexing is used by FICON links, some CONNECT times may be extended when comparing to CONNECT times in ESCON. As each FICON link may have multiple concurrent I/O operations, now a single I/O operation may take more time to transfer its data. So the FICON connect time is not as predictable as ESCON time, but this is more an awareness issue than a problem.

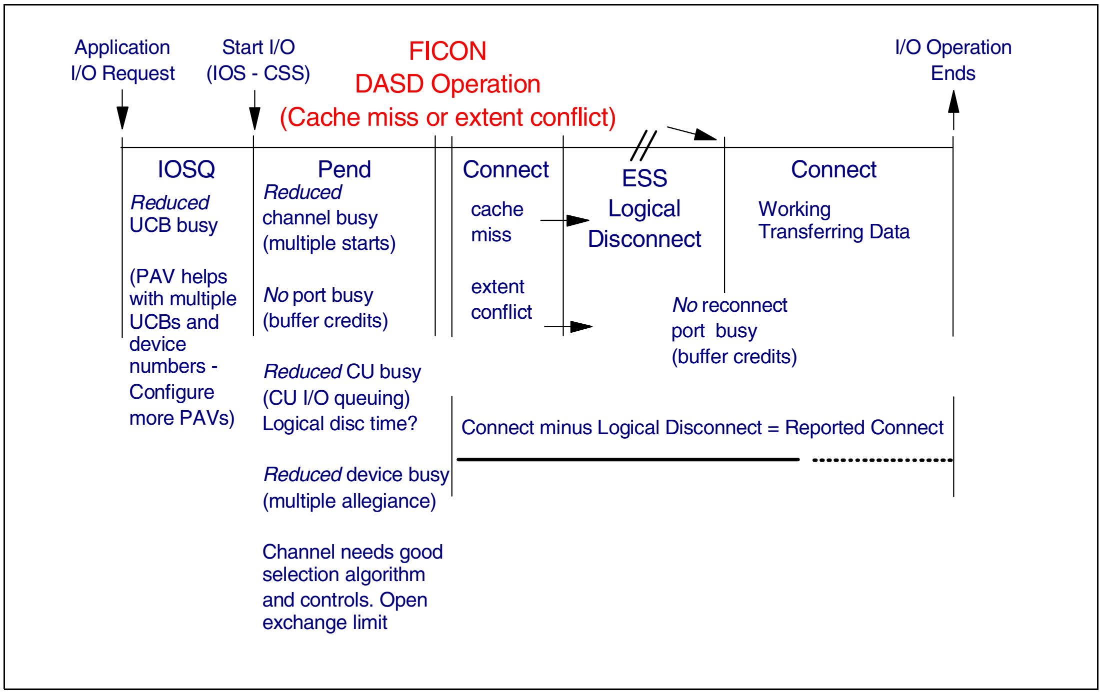

Figure 11-14 FICON I/O operation sequence - cache miss

Figure 11-14 shows a FICON I/O operation sequence when a cache miss occurs. In the ESCON cache miss operation, a DICONNECT time component is expected.

Having all the benefits about reducing busy conditions and times as shown in the previous cache hit example, a new condition takes place in this kind of I/O operation, removing another busy condition.

As the control unit FICON adapter can handle multiple concurrent I/O operations at a time, it will not disconnect from the channel when a cache miss occurs for a single I/O operation. So the control unit adapter remains connected to the channel, being able to transfer data from other I/O operations. This condition is called “logical disconnect”.

With no disconnect time, the port busy condition during ESCON channel reconnect time does not exist also, and this is another improvement over ESCON channels. Note that the channel subsystem reported connect times are not affected by logical disconnected times.The logical disconnect time is accumulated by the hardware as a component of CONNECT time, but the CONNECT time reported by the channel is calculated by excluding the logical disconnect time. The logical disconnect time is reported as part of DISC time.

11.3 FICON performance considerations

FICON channels provide many improvements over ESCON channels, reducing bottlenecks from the I/O path and allowing the maximum control unit I/O concurrency exploitation:

- IOSQ time (UCB busy) can be reduced by configuring more Alias device addresses, using Parallel Access Volumes (PAVs). This is possible because FICON channels can address up to 16,384 device (ESCON channels address up to 1,024).

- Pending time can also be reduced:
  - Channel busy conditions are reduced by FICON channel's multiple starts capability.
  - Port busy conditions are eliminated by FICON switches frame multiplexing capability.
  - Control unit busy conditions are reduced by FICON adapter's multiple starts capability.
  - Device busy conditions can also be reduced as FICON's multiple concurrent I/O operations capability can improve the Multiple Allegiance (MA) function exploitation.

FICON channels allow a higher I/O throughput, using fewer resources, but this does not mean that each I/O response time will be reduced (although this is expected on large block size transfers).

The key point is FICON's architecture capability to execute multiple concurrent I/O operations, which can be sustained by the FICON link bandwidth. Multiple systems can perform multiple I/O operations at a time from/to each control unit port, and the I/O performance is more related to the control unit capabilities.

Other performance related aspects to consider:

- The number of buffer credits (on processor channels, switch ports and control unit adapters) is a very important factor related to FICON link distances. Performance will be affected if required buffer credits are not provided on both ends of a FICON link (N_Port to N_Port, or N_Port to F_Port) for a given distance. To achieve the FICON link maximum distance of 100 km with no performance impact, both FICON link ports must have at least 64 buffer credits.
- Intermixing control unit types with different channel usage characteristics (like disk and tape) on the same FICON channel may interfere with the response time of some control units requiring the best possible response time (like disk control units), because tape control units normally transfer large data blocks. Therefore, response time sensitive control units should not be configured to use the same FICON channel being used by tape control units.

11.3.1 zSeries channel performance paradigms

Each zSeries channel type has its own performance paradigm as well as its own topology requirements and advantages.

Different zSeries channel types accessing the same CU can perform differently for the same operation with the same topology or distance for the new channel environment due to the operating characteristics of the channel type:

- Topology and data-traffic patterns
- Distances - characteristic impacts
  - Frame multiplexing
  - Number of outstanding frame requests allowed

Whenever a new zSeries host processor or new I/O channel type is introduced, there will always be performance comparisons made between the current channels and the new channels when they provide connectivity to the same type of CU and device.

This was the case going from:

- One type of parallel channel to another (selector to block)
- All the changes in parallel channels (DCI to streaming)
- Parallel to ESCON (3 MB - 4.5 MB to 17 MB data rate) and topology

- ESCON to EMIF support
- ESCON to FICON Bridge (FCV)
- ESCON and FICON Bridge (FCV) to FICON native (FC)

New zSeries channel types that provide connectivity to the same type of CU/device are always introduced to provide connectivity, addressing, topology, or performance benefits over the previous channels. Not every characteristic of the older channel will automatically be improved. But the net of all the new channel benefits provides significant improvements over the previous channel. In each case the new channel type provides connectivity and performance enhancements in a more complex, intermixed environment.

11.3.2 Parallel - ESCON - FICON comparisons

Parallel - Interlocked tag protocol selection sequences:

- Supports one I/O operation at a time
- Requires careful selection of intermixed CU types

ESCON - Interlocked frame protocol sequences:

- Supports one I/O operation at a time
- Requires careful selection of intermixed CU types

FICON Bridge (FCV) - Command/Data - multiplexed and less interlocked protocols:

- Multiplexes frames to up to 8 different control units
- Reduced command sequence requirement
- Supports multiple concurrent I/O operations
- Greater selection of intermixed CU types

FICON native (FC) - Command/Data - greater multiplexed and less interlocked protocols:

- Multiplexes frames to the same or different control units
- Reduced command sequence requirement
- Supports multiple concurrent I/O operations, even to a same logical control unit
- Greater selection of intermixed CU types

FICON native (FC), FICON Bridge (FCV) and ESCON (CNC) can coexist with the same control unit.

The zSeries FICON channel provides the zSeries tie-in to the evolving Storage Area Networks (SAN) environment.

11.3.3 S/390 ESCON and FICON operation

Today's ESCON ties up the channel for every I/O operation on the interface:

Link utilization = Channel utilization

FICON multiplexing allows a number of I/O operations to proceed concurrently, on the same channel.

Therefore, you need to understand the FICON performance paradigm in order to design an I/O configuration using the new paradigm rules in regards to the following:

- There is improved response time (pending and connect times for extended distances).
- You have the freedom to intermix different CU types with different data transfer and channel usage characteristics.
- Distances can be extended before a performance droop occurs.

FICON channel utilization is separate from FICON channel link utilization:

- New Channel Path Measurement data

  Channel utilization = number of sequences/maximum number of sequences.

  Link utilization = Number of bytes transferred per partition, both reads and writes.

11.3.4 zSeries ESCON Channels

With ESCON CNC channels:

- The operating distance between the channel and configured control units is increased from the parallel channel operating distance of 122 meters to 3 km for the ESCON channel (using 62.5 micron multi-mode fiber optic cabling).
- There is greater shared-system CU connectivity with the introduction of the ESCON director.
- There are shorter response times on longer records (as compared to parallel channels).
- There is a slight response time elongation on short records.
- EMIF was introduced with ESCON channels to allow for sharing of a channel between images on the same zSeries processor.
- A Port busy condition occurs when a zSeries channel attempts to access a CU/device via an ESCON director destination port address (destination link) at the time that it is already in use by another zSeries channel. This condition is managed by the zSeries channel that sees the Port Busy condition.
- ESCON channels support a control unit request to disconnect in the middle of an I/O operation. This frees up the channel to perform another I/O operation to the same or a different control unit on the same channel path.
- ESCON channel multi-path mode supports:
  - Dynamic Path Selection
  - Dynamic Path Reconnect (DASD RPS miss-avoidance)

11.3.5 zSeries FICON Bridge (FCV) channels

The FICON Bridge (FCV) channel provides:

- Increased I/O operation concurrency.
- Frame multiplexing to up to 8 different control units.
- MIF is also supported to allow for sharing of a FICON Bridge (FCV) channel between zSeries images on the same zSeries processor.
- Because it uses ESCON links to control units, a Port Busy condition still occurs when a zSeries channel attempts to access a CU/device via an ESCON director destination port address (destination link) at the time that it is already in use by another zSeries channel. This condition is managed by the zSeries channel that sees the Port Busy condition.
- Distance (un-repeated) of up to 10 km is supported (20 km with an RPQ).
- End-to-end distances using repeaters are up to 100 km, with no data droop effect.

- It uses the Fibre Channel FC-PH (FC-2) standard.

11.3.6 zSeries FICON native (FC) channels

The FICON native (FC) channel provides:

- Frame multiplexing to the same or different control units.
- Sharing of a FICON native (FC) channel between zSeries images on the same zSeries processor.
- A Port busy condition does not occur when a FICON channel attempts to access a CU/device via a FICON Director destination port address (destination link) at the time that it is already in use by another FICON channel. So destination port busy signals to the System Assist Processor (SAP) are eliminated.
- Distance (un-repeated) of up to 10 km is support (an RPQ is available).
- End-to-end distances using repeaters is up to 100 km, with no data droop effect.
- It uses the Fibre Channel FC-PH (FC-2) standard and the Fibre Channel FC-SB-2 (FC-4) protocol.

11.3.7 zSeries FICON channel benefits

FICON channel exploitation benefit is customer installation-dependent.

- Greater channel and link bandwidth per FICON channel, which allows for more control units to be connected via the same channel.
- Multiple concurrent I/O operations per FICON channel, which can be to different control units, to the same control unit and even to the same logical control unit.
- A larger number of device numbers (subchannels) are supported per FICON channel. Up to 1,024 devices are supported on an ESCON channel, and up to 16,384 devices for a FICON channel. This allows for more of today’s control units (with the larger number of devices per CU) to be accessed from the same channel.
- Greater fiber link un-repeated distances: 10 km for FICON channels versus 3 km for ESCON channels.
- Greater fiber link repeated distances up to 100 km.
- Performance droop is moved from 9 km for ESCON channels to 100 km for FICON channels.
- Intermixing of CU types with different channel usage characteristics on the same channel.

11.4 RMF reporting for FICON

This section describes the changes to RMF in support of FICON.

11.4.1 FICON channel support

RMF support for FICON channels (both FCV and FC) includes the reporting of five measurements:

- Bus utilization

  Percentage of bus cycles, the bus has been found busy for this channel in relation to the theoretical limit.

- Read bandwidth for an image in MB/sec

  Data transfer rates from the control unit to the channel for this individual logical partition.
- Total read bandwidth (for all images on the system) in MB/sec

  Data transfer rates from the control unit to the channel for the entire system.
- Write bandwidth for an image in MB/sec

  Data transfer rates from the channel to the control unit for this individual logical partition.
- Total write bandwidth (for all images on the system) in MBsec

  Data transfer rates from the channel to the control unit for the entire system.

Sample RMF information is shown below:

```
11:41:42  CHANNEL UTILIZATION(%)   READ(B/S)  WRITE(B/S)  MSG  MSG SEND RECV
ID NO  G  TYPE  S PART  TOT  BUS   PART  TOT  PART  TOT  RATE SIZE FAIL FAIL
5E     2  FC_S  Y  0.9  0.1  5.1    323  323     0    0
5F     2  FC_S  Y  1.2  0.1  5.1    970  970     0    0
60        FC_S    ---- ----
```

  – The values in the **ID** column represent the CHPIDs
  – The values in the **G** column show the data rate at which the FICON Express (for that particular CHPID), is operating.

    In this example, the FICON Express channels (CHPIDs 5E and 5F) are running at 2 Gbps. A number 1 in the G column would mean they are running at a data rate of 1 Gbps.

SMF record types 73, 74 and 79-12 have been changed. The record changes are documented in “SMF record changes for FICON” on page 211.

11.4.2 Device active only time

Device-active-only time is a architected field in the CMB. It represents the time between reporting of primary and secondary status, that is Channel End (CE) and Device End (DE).

A

Determine the EC level and IOCP release

This appendix provides the procedures needed to determine the EC level of your CPC, as well as the stand-alone IOCP release, using the Hardware Management Console or Support Element.

A.1 Determining the EC level of the CPC

The EC level of the zSeries or 9672 G5/G6 processor can be determined from the Hardware Management Console or Support Element using the following procedure:

1. Open the **Task List** from the Views area.
2. Open **Change Management Tasks** from the Task List Work Area.
3. Open **Groups** from the Views area.
4. Open the group that contains the CPC you are interested in.
5. Select the CPC.
6. Drag and drop the selected CPC object onto System Information or CPC EC Details in the Change Management tasks area.

A.2 Determining the stand-alone IOCP release

The stand-alone IOCP version and release can be determined from the Hardware Management Console or Support Element using the following procedures (begin with step 7 for the Support Element console):

1. Open the **Task List** from the Views area.
2. Open **CPC Recovery Tasks** from the Task List Work Area.
3. Open **Groups** from the Views area.
4. Open the group that contains the CPC you are interested in.
5. Select the CPC.
6. Drag and drop the selected CPC object onto Single Object Operations in the CPC Recovery tasks area.
7. Open the **Task Lis**t from the Views area.
8. Open **CPC Configuration** from the Task List Work Area.
9. Open **Groups** from the Views area.
10. Drag and drop the selected CPC object onto Input/Output (I/O) Configuration in the CPC Configuration tasks area. Continue with step 14.
11. Select **Customize** from the Monitor the System panel.
12. Select **Input/output (I/O) configuration**.
13. Select the **View** pull-down.
14. Select **Configuration program level**.

B

SMF record changes for FICON

This appendix introduces the changes in SMF records in support of FICON channel and FICON Director statistics.

APAR OW35586 introduces the following changes to SMF records in support of FICON.

SMF Type 73, the Channel Path Control Section, contains the information shown in Table 11-1.

Table 11-1 SMF type 73 Channel Path Control section

Offset dec (hex)	Name	Length	Format	Description	
4 (4)	SMF73CFL	1	Binary	Configuration change flags	
				VALUE	**MEANING**
				7	CPMF mode has changed
90 (5A)	SMF73CMI	1	Binary	CPMF mode	
				VALUE	**MEANING**
				0	CPMF not active
				1	Compatibility mode
				2	Extended mode
91 (5B)		1		Reserved	

SMF Type 73, the Channel Path Data Section, contains the information shown in Table 11-2.

Table 11-2 SMF type 73 Channel Path Data section

Offset dec (hex)	Name	Length	Format	Description	
22 (16)	SMF73CMG	1	Binary	CPMF channel measurement group	
23 (17)	SMF73FG5	1	Binary	CPMF validation flags	
				Bit	**Measurement Data**
				0	Maximum bus cycles
				1	Maximum channel work units
				2	Maximum write units
				3	Maximum read units
				4	Data unit size
				5 - 7	Reserved
24 (18)	SMF73CCM	48		CPMF channel measurement data (extended mode). See contents for measurement group 1 and measurement group 2 below.	

SMF Type 73, CPMF Channel Measurement Data (Measurement Group 1) contains the information shown in Table 11-3 on page 213.

Table 11-3 SMF type 73 Channel Measurement Data (Measurement Group 1)

Offset dec (hex)	Name	Length	Format	Description
0 (0)	SMF73TUT	4	s-float	Total channel path busy time (in units of 128 microseconds)
4 (4)	SMF73PUT	4	s-float	LPAR channel path busy time (in units of 128 microseconds)
8 (8)		40		Reserved

SMF Type 73, CPMF Channel Measurement Data (Measurement Group 2) contains the information shown in Table 11-4.

Table 11-4 SMF type 73 Channel Measurement Data (Measurement Group 2)

Offset dec (hex)	Name	Length	Format	Description
0 (0)	SMF73MBC	4	s-float	Maximum bus cycles per sec
4 (4)	SMF73MCU	4	s-float	Maximum channel work units per sec
8 (8)	SMF73MWU	4	s-float	Maximum write data units per sec
12 (C)	SMF73MRU	4	s-float	Maximum read data units per sec
16 (10)	SMF73US	4	s-float	Data unit size in bytes
20 (14)	SMF73TBC	4	s-float	Total bus cycles count
24 (18)	SMF73TUC	4	s-float	Total channel work units count
28 (1C)	SMF73PUC	4	s-float	LPAR channel work units count
32 (20)	SMF73TWU	4	s-float	Total write data units count
36 (24)	SMF73PWU	4	s-float	LPAR write data units count
40 (28)	SMF73TRU	4	s-float	Total read data units count
44 (2C)	SMF73PRU	4	s-float	LPAR read data units count

SMF Type 79-12, the Channel Path Control Section, contains the information shown in Table 11-5 on page 214.

Table 11-5 SMF type 79-12 Channel Path Control section

Offset dec (hex)	Name	Length	Format	Description	
4 (4)	R79CFLG1	1	Binary	Configuration change flags	
				VALUE	**MEANING**
				1	CPMF mode has changed
5 (5)	R79CCMI	1	Binary	CPMF mode	
				VALUE	**MEANING**
				0	CPMF not active
				1	Compatibility mode
				2	Extended mode
6 (6)		2		Reserved	

SMF Type 79-12, the Channel Path Data Section, contains the information shown in Table 11-6.

Table 11-6 SMF type 79-12 Channel Path Data section

Offset dec (hex)	Name	Length	Format	Description	
21 (15)	R79CCMG	1	Binary	CPMF channel measurement group	
22 (16)	R79CFG4	1	Binary	CPMF validation flags.	
				Bit	**Measurement Data**
				0	Maximum bus cycles
				1	Maximum channel work units
				2	Maximum write units
				3	Maximum read units
				4	Data unit size
				5 - 7	Reserved
23 (17)		1		Reserved	
24 (18)	R79CCM	48	EBCDIC	CPMF channel measurement data (extended mode). See contents for measurement group 1 and measurement group 2 following.	

SMF Type 79-12, CPMF Channel Measurement Data (Measurement Group 1) contains the information shown in Table 11-7 on page 215.

Table 11-7 SMF type 79-12 Channel Measurement Data (Measurement Group 1)

Offset dec (hex)	Name	Length	Format	Description
0 (0)	R79CTUT	4	s-float	Total channel path busy time (in units of 128 microseconds)
4 (4)	R79CPUT	4	s-float	LPAR channel path busy time (in units of 128 microseconds)
8 (8)		40		Reserved

SMF Type 79-12, CPMF Channel Measurement Data (Measurement Group 2) contains the information shown in Table 11-8.

Table 11-8 SMF type 79-12 Channel Measurement Data (Measurement Group 2)

Offset dec (hex)	Name	Length	Format	Description
0 (0)	R79CMBC	4	s-float	Maximum bus cycles per sec
4 (4)	R79CMCU	4	s-float	Maximum channel work units per sec
8 (8)	R79CMWU	4	s-float	Maximum write data units per sec
12 (C)	R79CMRU	4	s-float	Maximum read data units per sec
16 (10)	R79CUS	4	s-float	Data unit size in bytes
20 (14)	R79CTBC	4	s-float	Total bus cycles count
24 (18)	R79CTUC	4	s-float	Total channel work units count
28 (1C)	R79CPUC	4	s-float	LPAR channel work units count
32 (20)	R79CTWU	4	s-float	Total write data units count
36 (24)	R79CPWU	4	s-float	LPAR write data units count
40 (28)	R79CTRU	4	s-float	Total read data units count
44 (2C)	R79CPRU	4	s-float	LPAR read data units count

APAR OW52396 introduces the following changes to SMF 74 records (subtype 7) in support of FICON Director statistics.

For the Switch Data section Bit 2 of R747SPFL is used as shown in Table 11-9.

Table 11-9 SMF type 74 Switch Data section

Offset dec (hex)	Name	Length	Format	Description
3 (3)	R74SPFL	1	Binary	Switch processing flags **Bit** / **MEANING when set** 0 Status of switch has changed 1 Number of ports has changes 2 Switch is offline 3 - 7 Reserved

For the Port Data section Bit 3 of R747PTFL is used, and Bits 2, 3, 7 of R747PSFL are used, as shown in Table 11-10.

Table 11-10 SMF type 74 Port Data section

Offset dec (hex)	Name	Length	Format	Description
2 (2)	R74PTFL	1	Binary	Port type flags **Bit** / **MEANING when set** 0 Port type is single CU 1 Port type is multiple CU 2 Port type is CHPID 3 Port type is switch 4 - 7 Reserved
3 (3)	R74PSFL	1	Binary	Port type flags **Bit** / **MEANING when set** 0 Port type is not unique 1 ID is not unique or not known 2 Channel on caller’s system 3 Port installed 4 Port status changed 5 Port has been removed 6 Port has been activated 7 This entry does not contain measurement data

C

FICON Director configuration worksheet

This appendix contains a worksheet that will aid in documenting the lay out of your FICON Director. It can be applied as a tool to help understand how the ports are allocated for configuration and problem determination purposes.

FICON Director Configuration Worksheet

FICON Director Manufacturer: _______________ Type: _______ Model: _____ S/N ______________

HCD defined Switch ID ______ (Switch ID)
FICON Director Domain ID ______ (Switch @)

Cascaded Directors No ___ Yes ___
Corresponding cascaded Director Domain ID _______
Fabric name ______________________________

FICON Director F_Ports					Attached N_Ports / E_Ports (CU, CPC or ISL)				
Slot Number	Port Number	Port Address	Laser Type: LX / SX	Port Name	Node Type CU / CHNL	Machine Type	Model	Serial Number	ISL CU I/F CPC CHPID

D

HCD reference panels

This appendix introduces the HCD panels in support of cascaded FICON Directors. This support requires HCD release 9 plus PTFs.

The HCD - I/O configuration definition sequence is as follows:

1. Operating systems
   - EDTs
   - Esoteric
   - NIP Consoles
2. Switch
   - Switch ID (LSN), Switch address, Switch Device-number
   - Installed port range, optional ISL occupied ports
3. Processor
   - Type, Model, Mode
   - Support Level
   - Cascade support selection
4. Processor - LPARS
5. Processor Channels
   - FICON (FCV, FC, FCP)
   - Dedicated, Reconfigurable, Shared
   - Dynamic Switch, Entry Switch, Entry Port
6. Control Units
   - Connection Switch, Link Address (Switch Address + Port Address), Link Address Rules
7. I/O devices - defined to CUs and the OS (or OSs)
   - No change for FICON cascade switching

D.1 List of referenced HCD panels

Table D-1 lists the HCD I/O definition panels used to define the switch characteristics in support of cascaded FICON Directors.

Table D-1 I/O definition panels

HCD Panel Name	Figure / Page
HCD Version	Figure D-1 on page 221
Add Switch	Figure D-2 on page 221
Port List	Figure D-3 on page 222
Switch List (SW-defined only)	Figure D-4 on page 222
Switch List (SW-connected)	Figure D-5 on page 223
Add Processor	Figure D-6 on page 223
Available Support Level	Figure D-7 on page 224
Processor List	Figure D-8 on page 224
Partition List	Figure D-9 on page 225
Add Channel Path	Figure D-10 on page 225
Channel Path List	Figure D-11 on page 226
Add Control Unit	Figure D-12 on page 226
Select Processor / Control Unit	Figure D-13 on page 227
Control Unit CUADD	Figure D-14 on page 227
Control Unit List	Figure D-15 on page 228
Add Control Unit	Figure D-16 on page 228
Control Unit 2-byte Link Addresses	Figure D-17 on page 229
Control Unit unit-address	Figure D-18 on page 229
Control Unit List	Figure D-19 on page 230
Add CU / ISL Port Error-	Figure D-20 on page 230
Add Device	Figure D-21 on page 231
Device/Processor Definition	Figure D-22 on page 231
I/O Device List	Figure D-23 on page 232
Add Device	Figure D-24 on page 232
Add Device for Processor	Figure D-25 on page 233
I/O Device List	Figure D-26 on page 233
Control Unit Link Addresses	Figure D-27 on page 234

HCD - FICON Cascade Switch configuration support

```
                         OS/390 Release 9 HCD
Command ===> ________________________________________________________________

                          Hardware Configuration

Select one of the following.

__  1.  Define, modify, or view configuration data
    2.  Activate or process configuration data
    3.  Print or compare configuration data
    4.  Create or view graphical configuration report
    5.  Migrate configuration data
    6.  Maintain I/O definition files
    7.  Query supported hardware and installed UIMs
    8.  Getting started with this dialog
    9.  What's new in this release

For options 1 to 5, specify the name of the IODF to be used.

I/O definition file . . . 'SYS6.IODFAF.WORK'                  +


 F1=Help      F2=Split     F3=Exit      F4=Prompt     F9=Swap     F12=Cancel
F22=Command
```

FICON support of cascaded Directors requires HCD release 9 plus APARs OW48236 and OW54246

Figure D-1 HCD Version

HCD - FICON Cascade - Switch support

```
                             Add Switch


  Specify or revise the following values.

  Switch ID . . . . . . . . . 61 _ (00-FF)
  Switch type . . . . . . . . 2032_________  +
  Serial number . . . . . . . __________
  Description . . . . . . . . ________________________________
  Switch address  . . . . . . 61   (00-FF) for a FICON switch

  Specify the port range to be installed only if a larger range
  than the minimum is desired.

  Installed port range  . . . 04  -  43  +

  Specify either numbers of existing control unit and device, or
  numbers for new control unit and device to be added.

  Switch CU number(s) . . . . 0c61  ____  ____  ____  ____  +
  Switch device number(s) . . 0c61  ____  ____  ____  ____
  F1=Help     F2=Split    F3=Exit     F4=Prompt   F5=Reset    F9=Swap
  F12=Cancel
```

For FICON switches there is a need to define both the Switch.ID and the Switch.Address (switch.@). The HCD switch.address field is new with HCD FICON cascade switching support.

Actual port addresses specified on this panel are switch vendor - switch specific. There is no need to include the CUP port.

Figure D-2 Add Switch

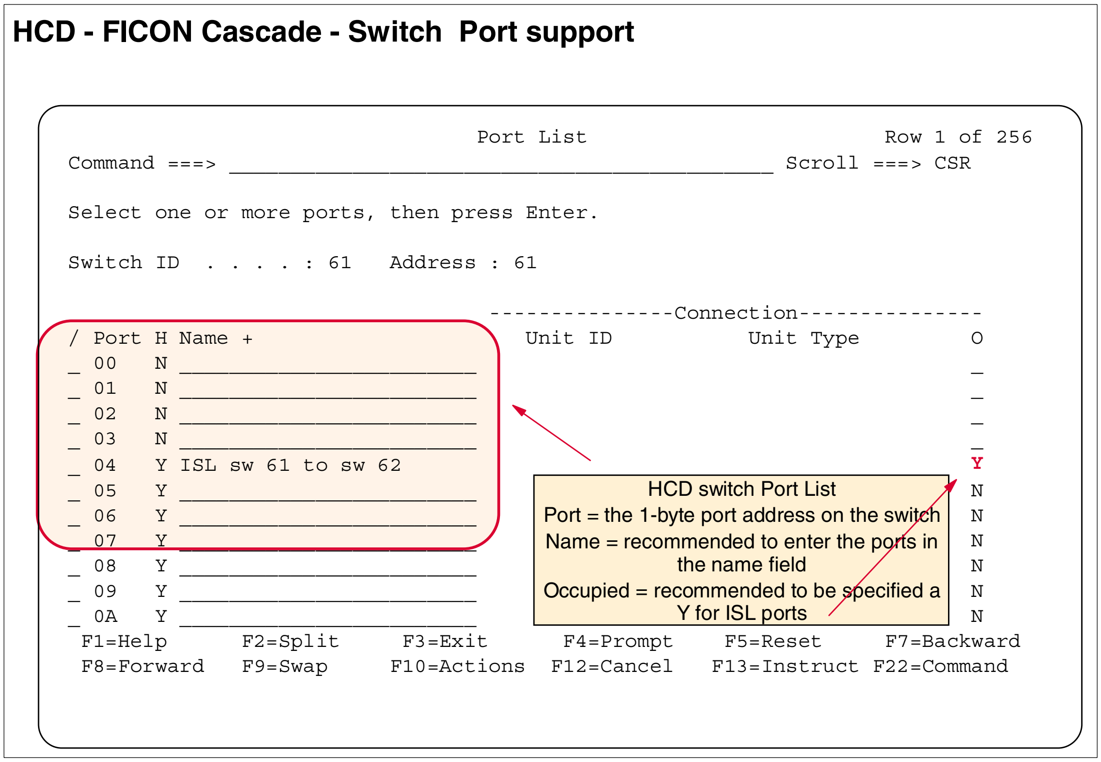

Figure D-3 Port List

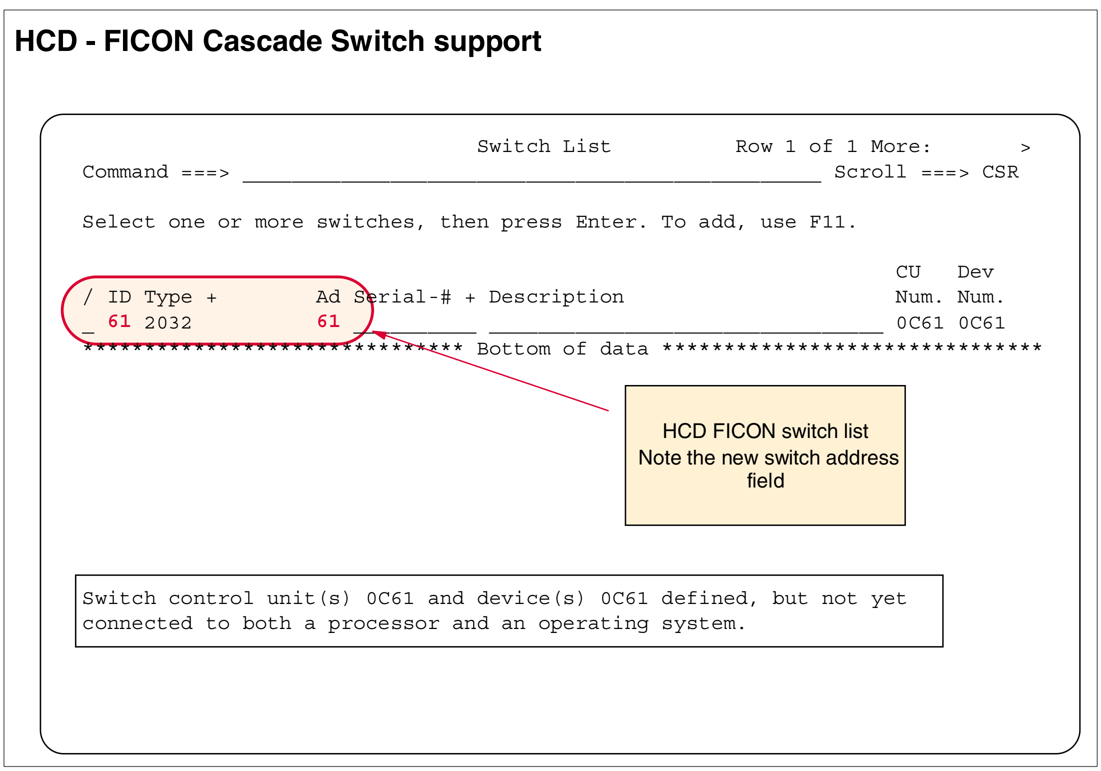

Figure D-4 Switch List (Switches only defined)

HCD - FICON Cascade Switch support

```
                                  Switch List           Row 1 of 4 More:        >
Command ===> _______________________________________________ Scroll ===> CSR

Select one or more switches, then press Enter. To add, use F11.

                                                                    CU   Dev
/ ID Type +          Ad Serial-# + Description                      Num. Num.
_ 61 2032            61 __________ ________________________________ 0C61 0C61
_ 62 2032            62 __________ ________________________________ 0C62 0C62
_ 63 2032            63 __________ ________________________________ 0C63 0C63
_ 64 2032            64 __________ ________________________________ 0C64 0C64
******************************* Bottom of data ********************************

 F1=Help       F2=Split      F3=Exit       F4=Prompt     F5=Reset      F7=Backward
 F8=Forward    F9=Swap      F10=Actions   F11=Add       F12=Cancel    F13=Instruct
F20=Right     F22=Command
```

HCD FICON switch list
Switches 61 to 64 defined
Note the new switch address field

Figure D-5 Switch List (Switches connected)

HCD - FICON Cascade Switch - Add Processor

```
                                Add Processor


 Specify or revise the following values.

 Processor ID . . . . . . . . . proc100_

 Processor type . . . . . . . . 2064____   +
 Processor model  . . . . . . . 116_____   +
 Configuration mode . . . . . . lpar    +

 Serial number  . . . . . . . . __________
 Description  . . . . . . . . . ________________________________

 Specify SNA address only if part of an S/390 microprocessor cluster:

 Network name . . . . . . . . . usibmsc_   +
 CPC name . . . . . . . . . . . proc100_   +


  F1=Help      F2=Split     F3=Exit      F4=Prompt    F5=Reset     F9=Swap
 F12=Cancel
```

No change to the processor definition (1st panel, changes on next panel)

Figure D-6 Add processor

HCD - FICON Cascade Switch - Add Processor - Support Level

```
                         Available Support Levels
                                                 Row 1
Command ===> ____________________________________________

Select one.

  Support Level
  Basic 2064 support, IQD, FCP, CF Duplex
#
  Basic 2064 support, IQD, FCP, CF Duplex, CAS
#
***************************** Bottom of data ********

 F1=Help        F2=Split       F3=Exit        F7=Back
 F9=Swap        F12=Cancel     F20=Right      F22=Comm

A support level selection is required.
```

Change to the processor support level panel for those processors that support FICON cascade switching (example: zSeries 900 and zSeries 800).
Select the line with the CAS feature included.

If you select cascade, and the actual processor does not support the FICON cascade switch function, you will be able to:
- Define CU using 2-byte link addresses for the processor
- Write IOCDSs for the processor

You will not be able to:
- Activate dynamic I/O reconfiguration
- POR using the 2-byte link address IOCDS

Figure D-7 Available Support Levels

HCD - FICON Cascade Switch - Processor List

```
                              Processor List        Row 1 of 1 More:       >
Command ===> _______________________________________________ Scroll ===> CSR

Select one or more processors, then press Enter. To add, use F11.

/ Proc. ID Type +   Model +  Mode+ Serial-# + Description
_ PROC100  2064     116      LPAR  __________ ________________________________
 ******************************* Bottom of data *******************************

 F1=Help      F2=Split     F3=Exit      F4=Prompt    F5=Reset     F7=Backward
 F8=Forward   F9=Swap      F10=Actions  F11=Add      F12=Cancel   F13=Instruct
F20=Right     F22=Command
```

No change to the processor list panel

Figure D-8 Processor List

HCD - FICON Cascade Switch - Processor - Partition List

```
                              Partition List
  Goto  Backup  Query  Help
----------------------------------------------------------------------
                                                            Row 1 of 3
Command ===> ________________________________________  Scroll ===> CSR

Select one or more partitions, then press Enter. To ad

Processor ID  . . . . : PROC100
Configuration mode  . : LPAR

/ Partition Name   Number Usage + Description
_ LP1              1      OS      ________________________________
_ LP2              2      OS      ________________________________
_ LP3              3      OS      ________________________________
**************************** Bottom of data ****************************



 F1=Help       F2=Split      F3=Exit       F4=Prompt     F5=Reset
 F7=Backward   F8=Forward    F9=Swap      F10=Actions   F11=Add
F12=Cancel    F13=Instruct  F22=Command
```

No change to the processor Partition definition or list panels

Figure D-9 Partition List

HCD - FICON Cascade Switch - Processor - Add Channel

```
                              Add Channel Path


Specify or revise the following values.

Processor ID . . . . : PROC100
Configuration mode : LPAR

Channel path ID  . . . . 84   +
Number of CHPIDs . . . . 1
Channel path type  . . . FC   +
Operation mode . . . . . SHR  +
Managed  . . . . . . . . No   (Yes or No)   I/O Cluster ________  +
Description  . . . . . . ________________________________

Specify the following values only if connected to a switch:

Dynamic entry switch ID  61  + (00 - FF)
Entry switch ID  . . . . 61  +
Entry port . . . . . . . 20  +
 F1=Help      F2=Split     F3=Exit      F4=Prompt    F5=Reset     F9=Swap
F12=Cancel
```

For FICON (FC) channels the entry switch.ID value is required and the dynamic switch.ID value must specify the same switch.

At this time, managed CHPIDs are not supported.

Figure D-10 Add Channel Path

HCD - FICON Cascade Switch - Processor - Channel Path List

```
                            Channel Path List        Row 1 of 4 More:       >
Command ===> _______________________________________________ Scroll ===> CSR

Select one or more channel paths, then press Enter. To add use F11.

Processor ID . . . : PROC100
Configuration mode : LPAR

                    DynEntry Entry +
/ CHPID Type+ Mode+ Switch + Sw Port Con Mngd Description
_ 84    FC    SHR   63       63 20       No   ________________________________
_ 86    FC    SHR   63       63 28       No   ________________________________
_ A2    FC    SHR   61       61 20       No   ________________________________
_ A8    FC    SHR   61       61 28       No   ________________________________
******************************* Bottom of data ********************************



 F1=Help      F2=Split     F3=Exit      F4=Prompt    F5=Reset     F7=Backward
 F8=Forward   F9=Swap     F10=Actions  F11=Add      F12=Cancel   F13=Instruct
F20=Right    F22=Command
```

For FICON (FC) channels the entry switch.ID value is required and the dynamic switch.ID value must specify the same switch.

Figure D-11   Channel Path List

HCD - FICON Cascade Switch - Add Control Unit - Connections

```
                              Add Control Unit


  Specify or revise the following values.

  Control unit number  . . . . 1000   +
  Control unit type  . . . . . 2105_________   +

  Serial number  . . . . . . . __________
  Description  . . . . . . . . ________________________________

  Connected to switches  . . . 63   63   61   61   __   __   __   __   +
  Ports  . . . . . . . . . . . 30   38   30   38   __   __   __   __   +

  If connected to a switch:

  Define more than eight ports . . 2   1.  Yes
                                       2.  No
  Propose CHPID/link addresses and
  unit addresses . . . . . . . . . 2   1.  Yes
                                       2.  No
   F1=Help     F2=Split    F3=Exit     F4=Prompt  F5=Reset    F9=Swap
  F12=Cancel
```

No change in the way this is specified for FICON (FC), it's the same as ESCON, and is the switch.ID and port addresses that the CU is physically connected to.

Figure D-12   Add Control Unit

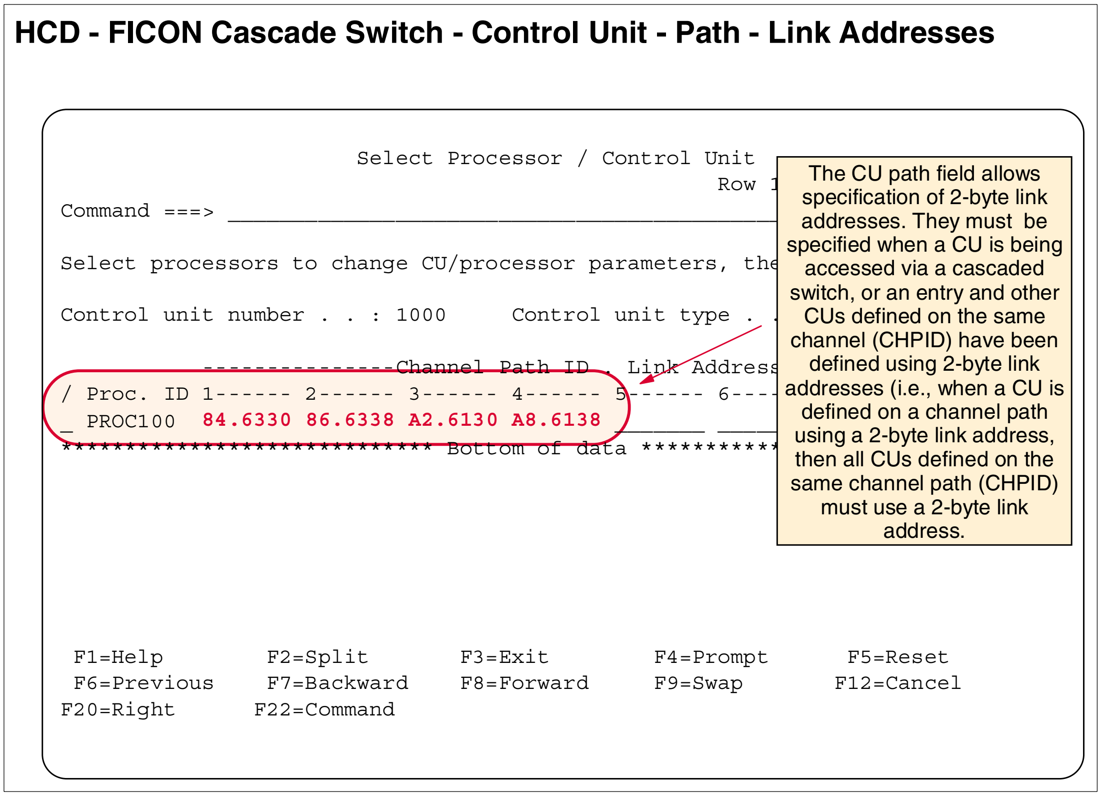

Figure D-13 Select Processor / CU

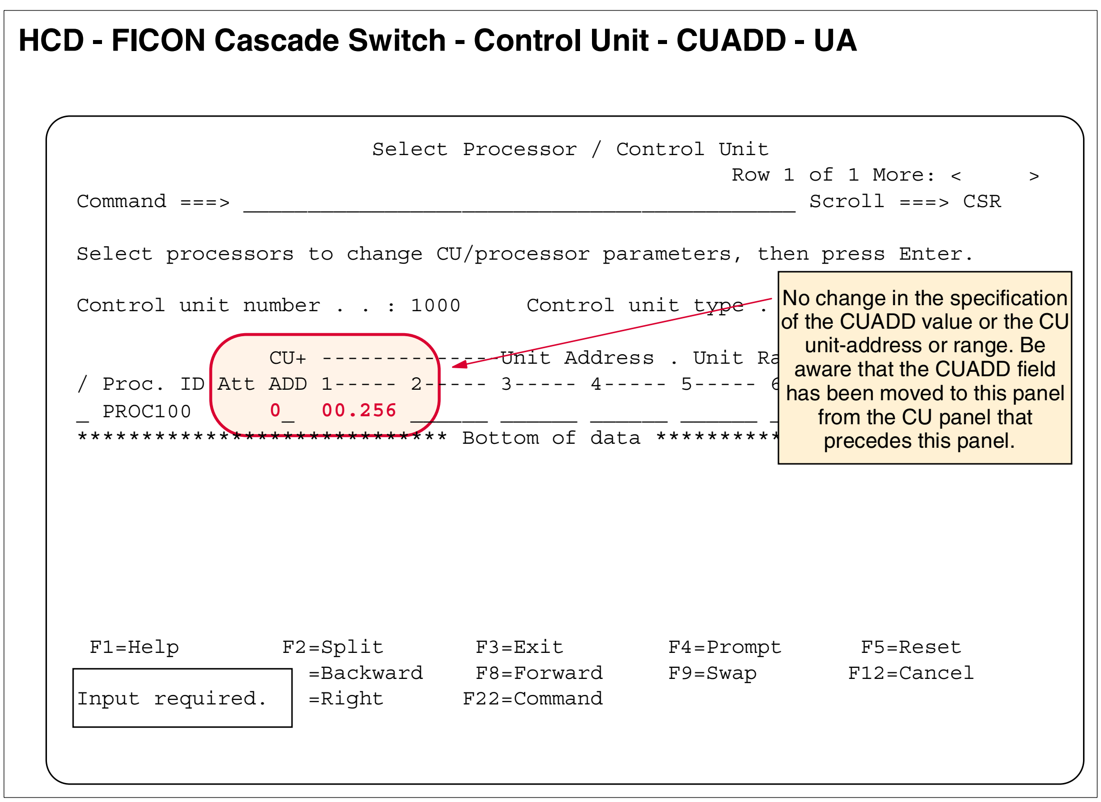

Figure D-14 Control Unit CUADD

HCD - FICON Cascade Switch - Control Unit List - #s 1000 - 1700

```
                              Control Unit List                          Row 1 of 8
Command ===> ___________________________________________ Scroll ===> CSR

Select one or more control units, then press Enter.  To add, use F11.

Processor ID . . . : PROC100            Channel path ID  . : 84

/ CU   Type +         #PR #MC Serial-# + Description
_ 1000 2105           1       __________ ________________
_ 1100 2105           1       __________ ________________
_ 1200 2105           1       __________ ________________
_ 1300 2105           1       __________ ________________
_ 1400 2105           1       __________ ________________________________
_ 1500 2105           1       __________ ________________________________
_ 1600 2105           1       __________ ________________________________
_ 1700 2105           1       __________ ________________________________
******************************* Bottom of data ********************************

 F1=Help      F2=Split     F3=Exit      F4=Prompt    F5=Reset     F7=Backward
 F8=Forward   F9=Swap     F10=Actions  F11=Add      F12=Cancel   F13=Instruct
F22=Command
```

No change to the Control Unit List panel

Figure D-15 Control Unit List

HCD - FICON Cascade Switch - Add Control Unit - Connections

```
                               Add Control Unit


  Specify or revise the following values.

  Control unit number  . . . . 9000  +
  Control unit type  . . . . . 2105_________  +

  Serial number  . . . . . . . __________
  Description  . . . . . . . . ________________________________

  Connected to switches  . . . 62   62   64   64   __   __   __
  Ports  . . . . . . . . . . . 30   38   30   38   __   __   __

  If connected to a switch:

  Define more than eight ports . . 2   1.  Yes
                                       2.  No
  Propose CHPID/link addresses and
  unit addresses . . . . . . . . . 2   1.  Yes
                                       2.  No
   F1=Help     F2=Split    F3=Exit     F4=Prompt  F5=Reset    F9=Swap
  F12=Cancel
```

No change in the way this is specified for FICON (FC), it's the same as ESCON, and is the switch.ID and port addresses that the CU is physically connected to. But see the ISL warning on a later foil.

Figure D-16 Add Control Unit

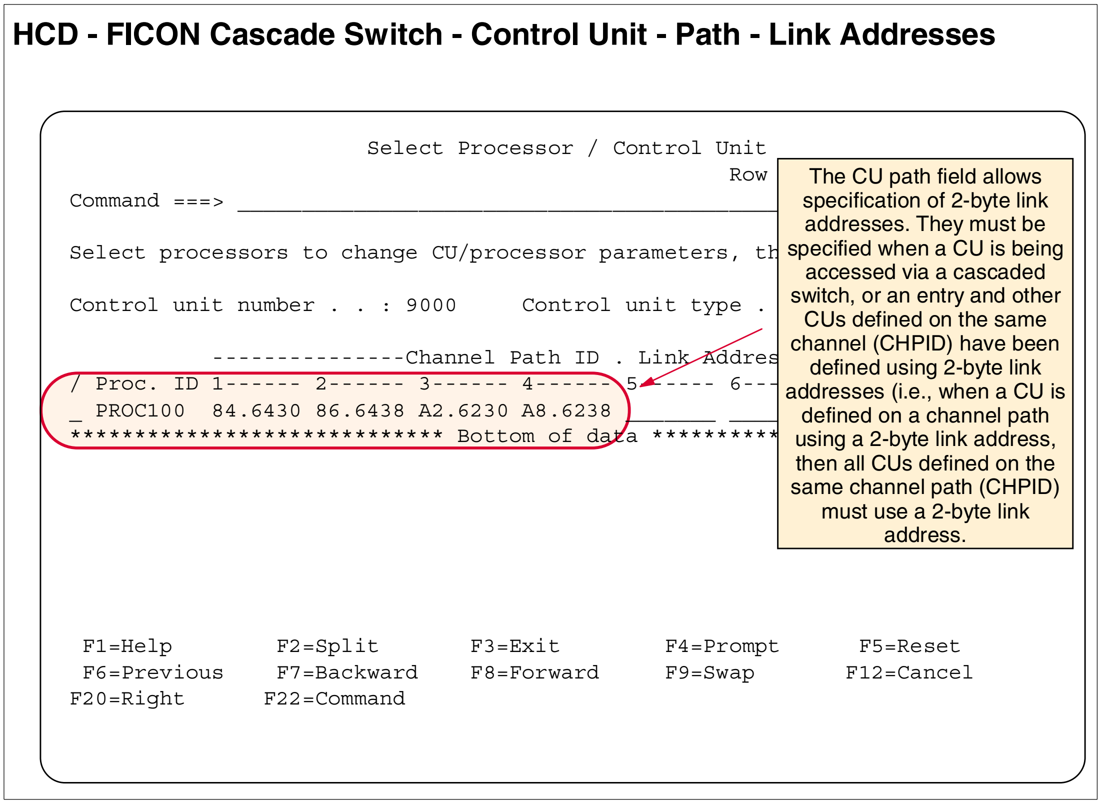

Figure D-17 CU 2-byte Link addresses

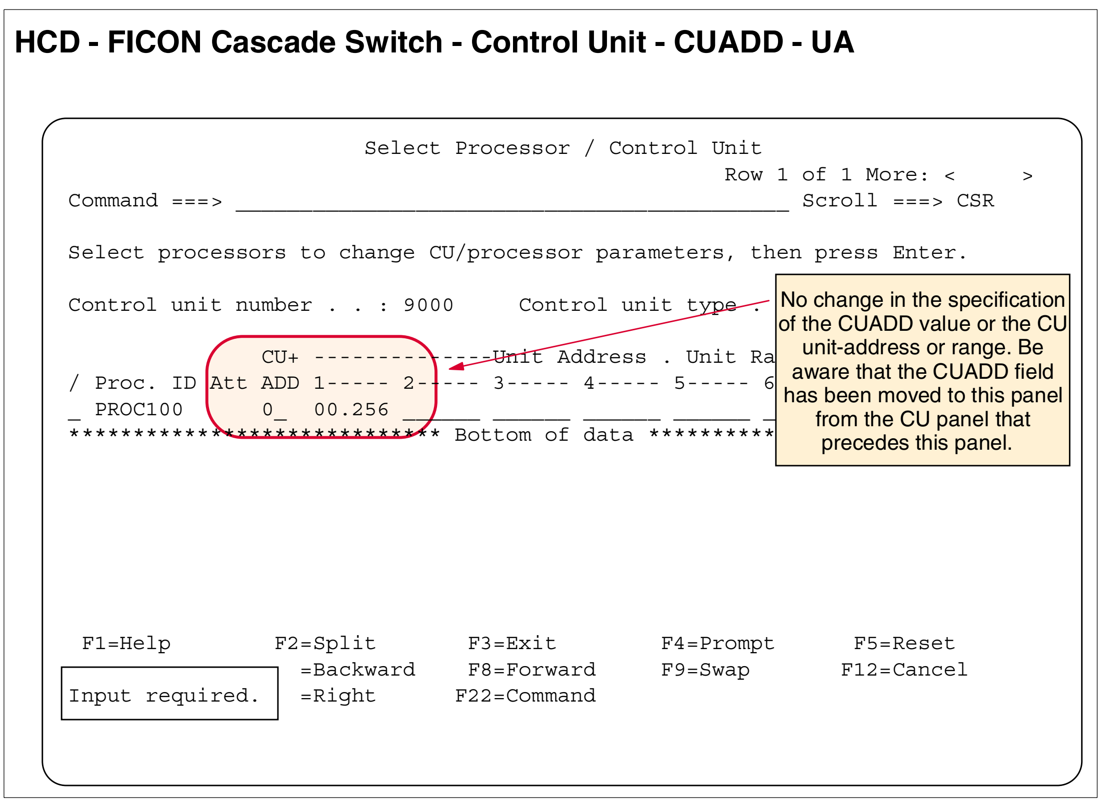

Figure D-18 CU unit-address

HCD - FICON Cascade Switch - Control Unit List - #s 100x - 900x

```
                          Control Unit List                      Row 2 of 16
Command ===> ___________________________________________ Scroll ===> CSR

Select one or more control units, then press Enter.  To add, use F11.

Processor ID . . . : PROC100           Channel path ID  . : 84

/ CU   Type +         #PR #MC Serial-# + Description
_ 1100 2105           1       __________ ________________
_ 1200 2105           1       __________ ________________
_ 1300 2105           1       __________ ________________
_ 1400 2105           1       __________ ________________
_ 1500 2105           1       __________ ________________________________
_ 1600 2105           1       __________ ________________________________
_ 1700 2105           1       __________ ________________________________
_ 9000 2105           1       __________ ________________________________
_ 9100 2105           1       __________ ________________________________
_ 9200 2105           1       __________ ________________________________
_ 9300 2105           1       __________ ________________________________
 F1=Help      F2=Split     F3=Exit      F4=Prompt    F5=Reset     F7=Backward
 F8=Forward   F9=Swap     F10=Actions  F11=Add      F12=Cancel   F13=Instruct
F22=Command
```

No change to the Control Unit List panel

Figure D-19   Control Unit List

HCD - FICON Cascade Switch - CU ADD to ISL Port in Error

```
                          Add Control Unit


   Specify or revise the following values.

   Control unit number  . . . . 0011  +
   Control unit type  . . . . . 2105         +

   Serial number  . . . . . . . __________
   Description  . . . . . . . . ________________________________

   Connected to switches  . . . 61  61  __  __  __  __
   Ports  . . . . . . . . . . . 04  05  __  __  __  __

   If connected to a switch:

   Define more than eight ports . . 2   1.  Yes
                                       2.  No
   Propose CHPID/link addresses and
   unit addresses . . . . . . . . . 2   1.  Yes

   Port 04 of switch 61 is flagged as occupied. If you want to connect
   this port, change the port to not occupied first.
```

For this configuration an ISL is connected to switch 61 port 04, and on the switch port specification panel this port was specified as "occupied". This provides definition protection in cases like the one shown on this pane,l where it is attempted to define a CU to the same switch port.

Figure D-20   Add CU / ISL Port Error

HCD - FICON Cascade Switch - Add Device - 100x (Base)

```
                          Add Device


Specify or revise the following values.

Device number  . . . . . . . . 1000  (0000 - FFFF)
Number of devices  . . . . . . 32__
Device type  . . . . . . . . . 3390b________  +

Serial number  . . . . . . . . __________
Description  . . . . . . . . . ________________________

Volume serial number . . . . . ______  (for DASD)

Connected to CUs . . 1000  ____  ____  ____  ____  ____  ____  ____  +


 F1=Help     F2=Split    F3=Exit     F4=Prompt   F5=Reset    F9=Swap
F12=Cancel
```

No change to the Add Device panel (3390b - Base devices being defined)

Figure D-21   Add Device

HCD - FICON Cascade Switch - Add Device - for Processor

```
                    Device / Processor Definition
                                                       Row 1 of 1
Command ===> _____________________________________ Scroll ===> CSR

Select processors to change device/processor definitions, then press
Enter.

Device number  . . : 1000           Number of devices  . : 32
Device type  . . . : 3390B

                                        Preferred Explicit Device
/ Processor ID   UA +  Time-Out  STADET CHPID +   Candidate List
_ PROC100        __    No        Yes    __        No
************************** Bottom of data ***************************





 F1=Help       F2=Split      F3=Exit       F4=Prompt     F5=Reset
 F6=Previous   F7=Backward   F8=Forward    F9=Swap      F12=Cancel
F22=Command
```

No change to the Devive/Processor Definition panel

Figure D-22   Device / Processor Definition

HCD - FICON Cascade Switch - I/O Device List - 100x

```
                              I/O Device List         Row 1 of 32 More:       >
Command ===> ____________________________________________ Scroll ===> CSR

Select one or more devices, then press Enter.  To add, use F11.

Control unit number  : 1000     Control unit type  . : 2105

  -------Device------- --#-- --------Control Unit Numbers + --------
/ Number Type +         PR OS 1--- 2--- 3--- 4--- 5--- 6--- 7--- 8--- Base
_ 1000   3390B          1     1000 ____ ____ ____ ____ ____ ____ ____
_ 1001   3390B          1     1000 ____ ____ ____ ____ ____
_ 1002   3390B          1     1000 ____ ____ ____ ____ ____
_ 1003   3390B          1     1000 ____ ____ ____ ____ ____
_ 1004   3390B          1     1000 ____ ____ ____ ____ ____
_ 1005   3390B          1     1000 ____ ____ ____ ____ ____
_ 1006   3390B          1     1000 ____ ____ ____ ____ ____
_ 1007   3390B          1     1000 ____ ____ ____ ____ ____ ____ ____
_ 1008   3390B          1     1000 ____ ____ ____ ____ ____ ____ ____
_ 1009   3390B          1     1000 ____ ____ ____ ____ ____ ____ ____
 F1=Help      F2=Split     F3=Exit      F4=Prompt    F5=Reset     F7=Backward
 F8=Forward   F9=Swap     F10=Actions  F11=Add      F12=Cancel   F13=Instruct
F20=Right    F22=Command
```

No change to the I/O Device List panel

Figure D-23 I/O Device List

HCD - FICON Cascade Switch - Add Device - 10Ax (Alias)

```
                                 Add Device


 Specify or revise the following values.

 Device number  . . . . . . . . 10a0  (0000 - FFFF)
 Number of devices  . . . . . . 96__
 Device type  . . . . . . . . . 3390a________  +

 Serial number  . . . . . . . . __________
 Description  . . . . . . . . . ________________________________

 Volume serial number . . . . . ______  (for DASD)

 Connected to CUs . . 1000  ____  ____  ____  ____  ____  ____  ____  +


  F1=Help     F2=Split    F3=Exit     F4=Prompt   F5=Reset    F9=Swap
 F12=Cancel
```

No change to the Add Device panel (3390a - Alias devices being defined)

Figure D-24 Add Device

HCD - FICON Cascade Switch - Add Device - for Processor

```
                     Device / Processor Definition
                                                      Row 1 of 1
Command ===> _____________________________________ Scroll ===> CSR

Select processors to change device/processor definitions, then press
Enter.

Device number  . . : 10A0          Number of devices  . : 96
Device type  . . . : 3390A

                                        Preferred Explicit Device
/ Processor ID   UA +  Time-Out  STADET CHPID +   Candidate List
_ PROC100        __    No        Yes    __        No
************************* Bottom of data **************************




 F1=Help       F2=Split      F3=Exit       F4=Prompt     F5=Reset
 F6=Previous   F7=Backward   F8=Forward    F9=Swap      F12=Cancel
F22=Command
```

No change to the Devive/Processor Definition panel

Figure D-25 Add Device for Processor

HCD - FICON Cascade Switch - I/O Device List - 100x and 10Ax

```
                             I/O Device List      Row 32 of 128 More:       >
Command ===> ___________________________________________ Scroll ===> CSR

Select one or more devices, then press Enter.  To add, use F11.

Control unit number  : 1000     Control unit type  . : 2105

  -------Device------- --#-- --------Control Unit Numbers + --------
/ Number Type +        PR OS 1--- 2--- 3--- 4--- 5--- 6--- 7--- 8--- Base
_ 101F   3390B         1     1000 ____ ____ ____ ____ ____ ____ ____
_ 10A0   3390A         1     1000 ____ ____ ____ ____ ____
_ 10A1   3390A         1     1000 ____ ____ ____ ____ ____
_ 10A2   3390A         1     1000 ____ ____ ____ ____ ____
_ 10A3   3390A         1     1000 ____ ____ ____ ____ ____
_ 10A4   3390A         1     1000 ____ ____ ____ ____ ____
_ 10A5   3390A         1     1000 ____ ____ ____ ____ ____
_ 10A6   3390A         1     1000 ____ ____ ____ ____ ____ ____ ____
_ 10A7   3390A         1     1000 ____ ____ ____ ____ ____ ____ ____
_ 10A8   3390A         1     1000 ____ ____ ____ ____ ____ ____ ____
 F1=Help       F2=Split      F3=Exit       F4=Prompt     F5=Reset      F7=Backward
 F8=Forward    F9=Swap      F10=Actions   F11=Add       F12=Cancel    F13=Instruct
F20=Right     F22=Command
```

No change to the I/O Device List panel

Figure D-26 I/O Device List

HCD - FICON Cascade Switch - Control Unit - Path - Link Addresses

```
                       Select Processor / Control Unit
                                                    Row
Command ===> _________________________________________

Select processors to change CU/processor parameters, t

Control unit number . . : 2000     Control unit type .

          ---------------Channel Path ID . Link Addres
/ Proc. ID 1------ 2------ 3------ 4------ 5------ 6--
_ PROC100  84.6331 86.6339 A2.6131 A8.6139 _______ ___
_ PROC200  84.6331 86.6339 A2.6131 A8.6139 _______ ___
_ PROC300  84.6331 86.6339 A2.6131 A8.6139 _______ ___
_ PROC400  84.6331 86.6339 A2.6131 A8.6139 _______ ___
_ PROC500  84.6331 86.6339 A2.6131 A8.6139 _______ ___
_ PROC600  84.6331 86.6339 A2.6131 A8.6139 _______ ___
**************************** Bottom of data *********


F1=Help       F2=Split      F3=Exit       F4=Prompt
F6=Previous   F7=Backward   F8=Forward    F9=Swap
F20=Right     F22=Command
```

The CU path field allows specification of 2-byte link addresses. They must be specified when a CU is being accessed via a cascaded switch, or an entry and other CUs defined on the same channel (CHPID) have been defined using 2-byte link addresses (i.e., when a CU is defined on a channel path using a 2-byte link address, then all CUs defined on the same channel path (CHPID) must use a 2-byte link address.

HCD supports the same definition/specification approach when a CU is being defined to be accessed from more than one processor.

Figure D-27 CU Link Addresses

E

Cascaded FICON Directors

This appendix depicts possible configuration options for cascaded FICON Directors, and shows the corresponding IOCP definitions for each example.

E.1 Examples of FICON support for cascaded Directors

In Figure E-1 there are two control units connected to the fabric. Notice that the 2-byte link addresses in this example are using the same 1-byte switch address plus a unique 1-byte port address.

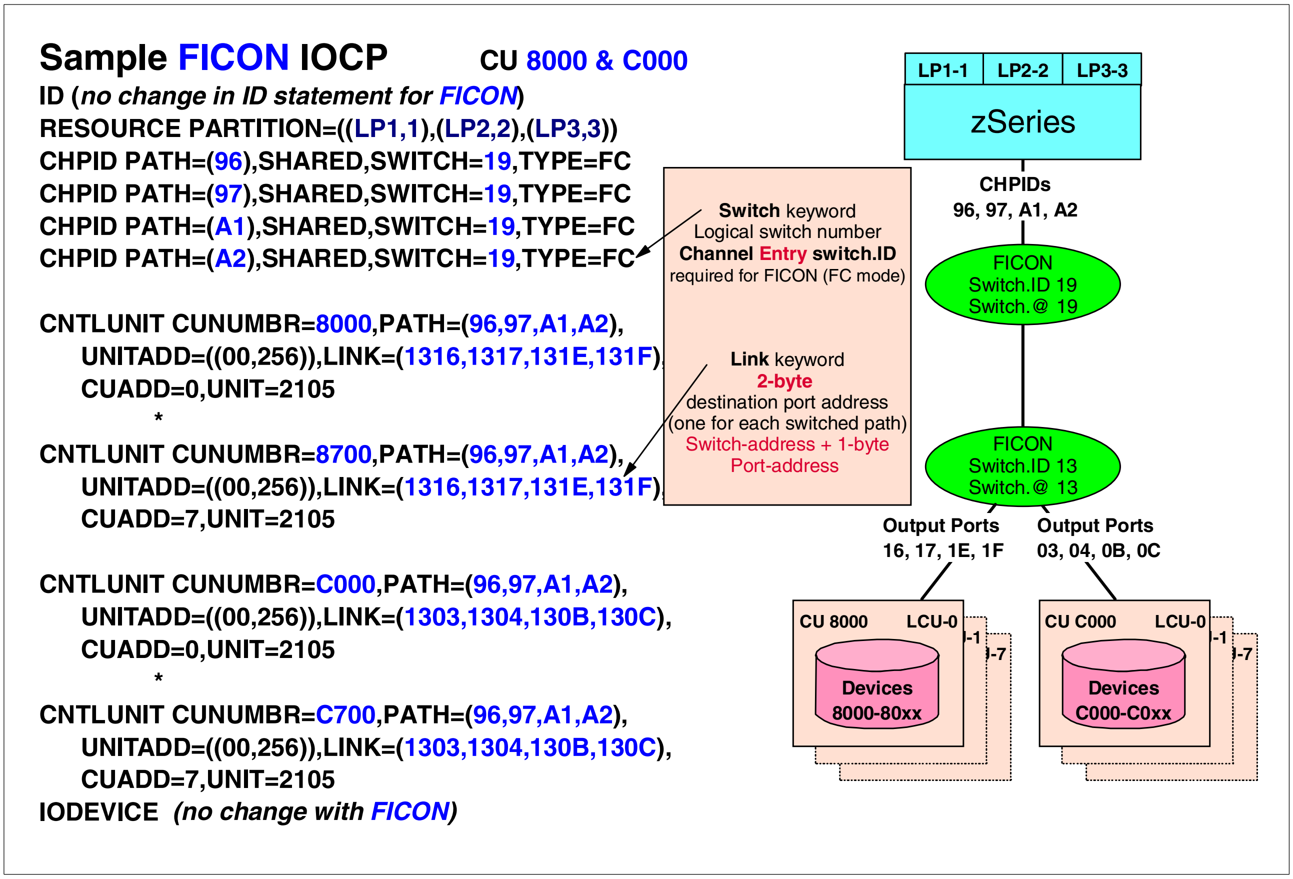

Figure E-1 Two switch cascaded configuration (one fabric, two control units)

Figure E-2 on page 237 shows two fabrics with a control unit attached to each. The same destination 1-byte port addresses can be used in the IOCP because different switches are involved, hence providing a unique 2-byte link address.

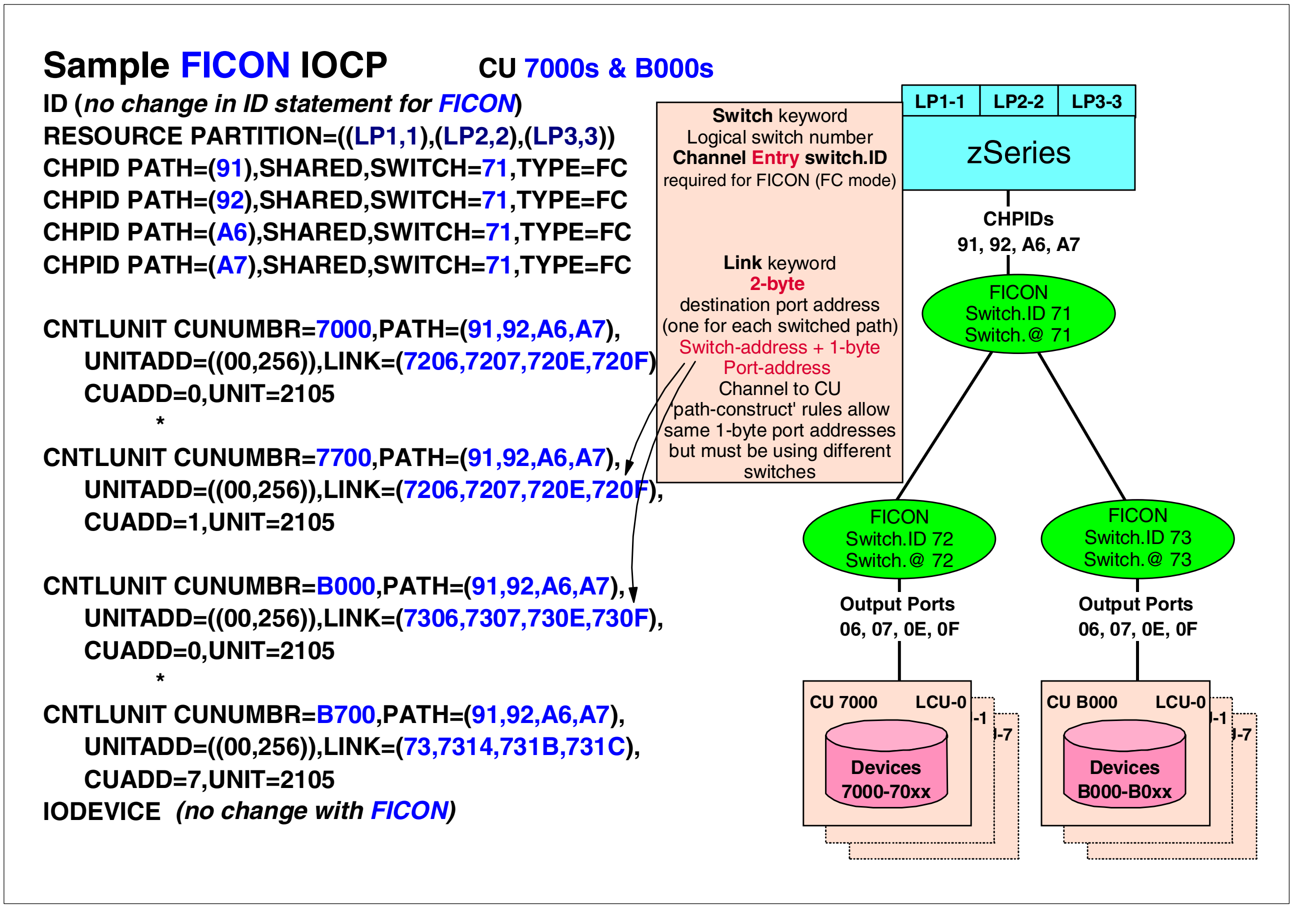

Figure E-2 Two switch cascaded configuration (two fabrics, one control unit each)

Figure E-3 on page 238 shows an intermixed configuration: a cascaded link to one control unit and a non-cascaded link to another control unit.

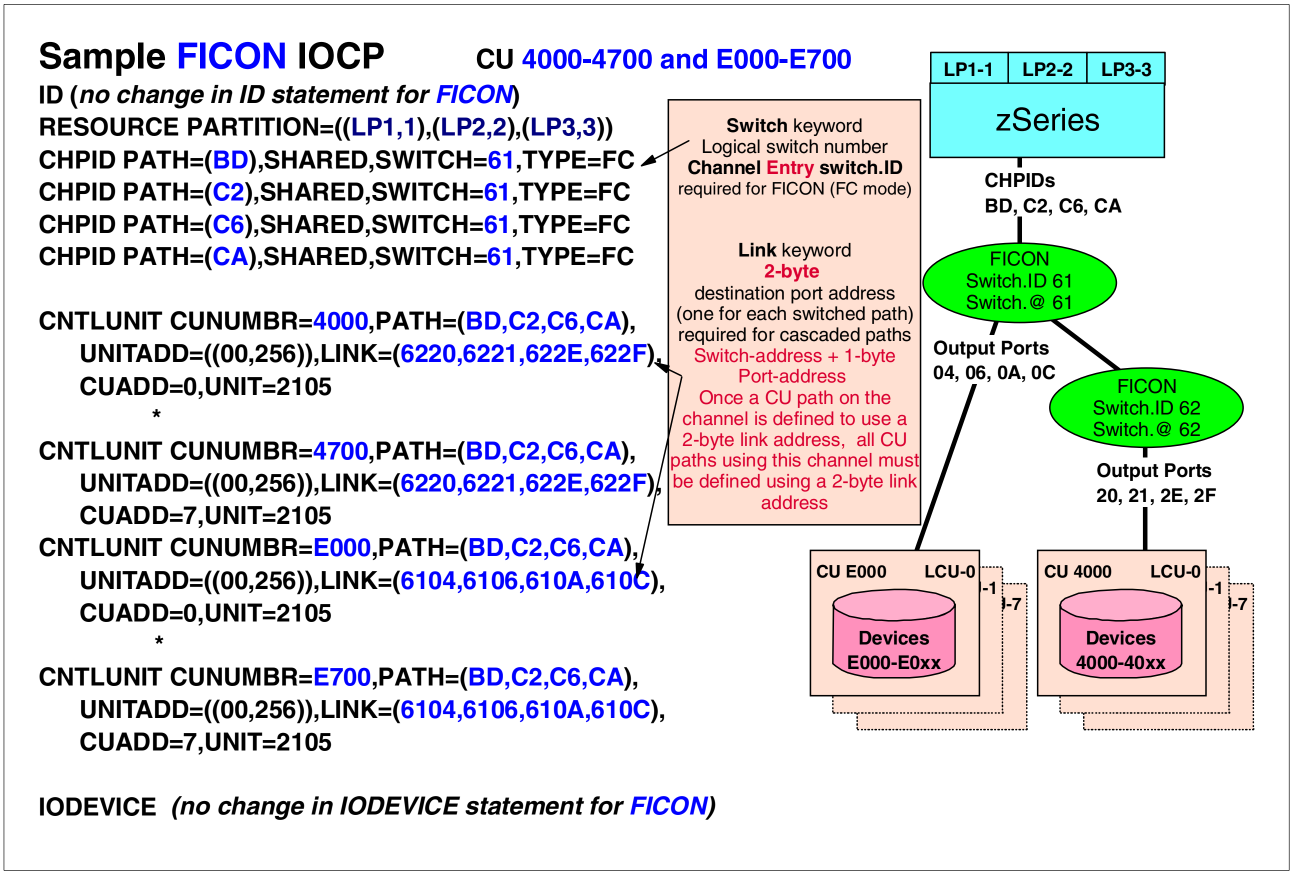

Figure E-3 Two-switch cascaded and one-switch non-cascaded

- In Figure E-3 CU 4000 is cascaded and one of its defined 2-byte link addresses is 6220 (1-byte switch address (62) plus 1-byte port address (20)).
- CU E000 is defined as being accessed from the same channel (CHPID). Therefore, it must also use 2-byte link addresses (6104).

  Intermixed definitions (1-byte and 2-byte link addresses) on the same channel path are not allowed

F

z/OS commands and utilities

This appendix contains useful z/OS and System Automation (I/O-Ops) commands that can be used to display the status of CHPIDs, control units, and devices. Also included are tools such as GTF trace and ICKDSF. A GTF trace is a tool that can be used for analyzing problems with I/O operations to attached devices. ICKDSF can generate a report that shows the state of the logical paths to a controller.

F.1 z/OS commands

A number of z/OS and OS/390 commands are available to display the status of CHPIDs, devices and their paths.

D M=CHP

The D M=CHP command displays the status and type of CHPIDs (Figure F-1).

```
D M=CHP
 IEE174I 15.12.46 DISPLAY M 630
 CHANNEL PATH STATUS
    0 1 2 3 4 5 6 7 8 9 A B C D E F
 0  . . . . . . . . + + + + + + + +
 1  + + - + + + + + + - + + + + + +
 2  + + + + . + + + + + + + + + - +
 3  + + + + + + + + + + + + + + + +
 4  + + + + - + + + + + + + + + + -
 5  + + + + + + + + + - + - + - + +
 6  + + . . . . . . . . . . . . . .
 7  . . . . . . . . . . . . . . . .
 / / / /
 E  . . . . . . . . . . . . + + + +
 F  . . . . . . . . . . . . + + + +
 *********************** SYMBOL EXPLANATIONS ***********************
 + ONLINE    @ PATH NOT VALIDATED   - OFFLINE    . DOES NOT EXIST
 * MANAGED AND ONLINE    # MANAGED AND OFFLINE
CHANNEL PATH TYPE STATUS
     0  1  2  3  4  5  6  7  8  9  A  B  C  D  E  F
 0  16 17 16 17 00 00 00 00 11 11 11 11 11 11 10 10
 1  11 11 11 10 11 11 11 10 10 11 05 05 05 05 05 09
 2  05 05 04 05 05 04 05 05 05 05 05 05 05 05 04 09
 3  05 05 05 05 05 05 05 05 05 05 05 09 05 05 04 05
 4  05 05 05 05 04 05 05 05 04 05 05 05 05 05 05 04
 5  05 09 05 04 05 05 05 05 05 04 1B 1B 1B 1B 1B 1B
 6  1B 1B 00 00 00 00 00 00 00 00 00 00 00 00 00 00
 / / / /
 E  00 00 00 00 00 00 00 00 00 00 00 00 24 24 24 24
 F  23 23 23 23 00 00 00 00 00 00 23 23 23 23 23 23
 *********************** SYMBOL EXPLANATIONS ***********************
 00  UNKNOWN                           UNDEF
 01  PARALLEL BLOCK MULTIPLEX          BLOCK
 02  PARALLEL BYTE MULTIPLEX           BYTE
 03  ESCON POINT TO POINT              CNC_P
 04  ESCON SWITCHED OR POINT TO POINT  CNC_?
 / / / /
 1A  FICON POINT TO POINT              FC
 1B  FICON SWITCHED                    FC_S
 1C  FICON TO ESCON BRIDGE             FCV
 1D  FICON INCOMPLETE                  FC_?
 / / / /
 25  FCP CHANNEL                       FCP
 NA  INFORMATION NOT AVAILABLE
```

Figure F-1 The D M=CHP command

The first part of the display shows the local status of the CHPIDs (online, and so on), while the second part of the display provides information about the type of every CHPID installed on the processor.

More detailed information and examples of each of these FICON CHPID states are provided in subsequent sections.

D M=CHP(cc)

The D M=CHP(cc) command displays the status of an individual CHPID.

Figure F-2 shows sample output of the D M=CHP(cc) command for a FICON channel in FICON native (FC) mode, connected to a FICON Director, type FC_S.

```
D M=CHP(5A)
IEE174I 15.46.17 DISPLAY M 642
CHPID 5A:  TYPE=1B, DESC=FICON SWITCHED, ONLINE
DEVICE STATUS FOR CHANNEL PATH 5A
    0  1  2  3  4  5  6  7  8  9  A  B  C  D  E  F
006 .  +  .  .  .  .  .  .  .  .  .  .  .  .  .  .
800 +  +  +  +  +  +  +  +  +  +  +  +  +  +  +  +
801 +  +  +  +  +  +  +  +  +  +  +  +  +  +  +  +
802 +  +  +  +  +  +  +  +  +  +  +  +  +  +  +  +
803 +  +  +  +  +  +  +  +  +  +  +  +  +  +  +  +
804 +  +  +  +  +  AL AL AL AL AL AL AL AL AL AL AL
805 AL AL AL AL AL AL AL AL AL AL AL AL AL AL AL AL
/ / / /
80F AL AL AL AL AL AL AL AL AL AL AL AL AL AL AL AL
SWITCH DEVICE NUMBER = NONE
ATTACHED ND = 006064.001.MCD.01.0000000119D3
************************ SYMBOL EXPLANATIONS ************************
+ ONLINE    @ PATH NOT VALIDATED   - OFFLINE    . DOES NOT EXIST
* PHYSICALLY ONLINE   $ PATH NOT OPERATIONAL
BX DEVICE IS BOXED           SN SUBCHANNEL NOT AVAILABLE
DN DEVICE NOT AVAILABLE      PE SUBCHANNEL IN PERMANENT ERROR
AL DEVICE IS AN ALIAS        UL DEVICE IS AN UNBOUND ALIAS
```

Figure F-2 The D M=CHP(cc) command

Note the reported description for CHPID 5A in the above display: FICON SWITCHED. The ATTACHED ND (node descriptor) can be used to verify that the CHPID is physically connected to the appropriate FICON Director. For example, CHPID 5A is connected to SW 61, which has the serial number 119D3.

D U,,,dddd,1

The Display Units command is useful for determining the z/OS status of a device. An example is shown in Figure F-3.

```
D U,,,8021,1
IEE457I 13.39.20 UNIT STATUS 557
UNIT TYPE STATUS        VOLSER     VOLSTATE
8021 3390 O             NW8021     PRIV/RSDNT
```

Figure F-3 The Display Units command

Note that there is no information in the output of the Display Units command to identify a device as FICON-attached.

D M=DEV(dddd)

Figure F-4 shows the output of the Display Matrix command for a device connected to FICON native (FC) channels:

```
D M=DEV(8021)
IEE174I 15.57.39 DISPLAY M 649
DEVICE 8021   STATUS=ONLINE
CHP                   5A   5C   5E   60   5B   5D   5F   61
DEST LINK ADDRESS     14   10   6214 6210 610C 6108 0C   08
ENTRY LINK ADDRESS    05   09   610D 6111 6205 6209 0D   11
PATH ONLINE           Y    Y    Y    Y    N    N    N    Y
CHP PHYSICALLY ONLINE Y    Y    Y    Y    N    N    Y    Y
PATH OPERATIONAL      Y    Y    Y    Y    N    N    Y    Y
DESTINATION CU LOGICAL ADDRESS = 00
CU ND      = 002105.000.IBM.13.000000022513
DEVICE NED = 002105.000.IBM.13.000000022513
PAV BASE AND ALIASES  4
```

Figure F-4 The Display Matrix

This display lists the CHPIDs defined for device number 8021. It also lists the destination link address for each CHPID, and the destination logical control unit, in this case CUADD, or CU image, 00. Once again there is nothing in this display to identify this device as FICON-attachable. The display would look the same for a device configured on ESCON switched point-to-point channels.

DS P,dddd

Another useful command for determining the status of paths to a device is the DFSMS DEVSERV PATHS command. Sample output is shown in Figure F-5.

```
-DS P,8021
 IEE459I 13.44.54 DEVSERV PATHS 583
 UNIT DTYPE  M CNT VOLSER  CHPID=PATH STATUS
      RTYPE   SSID CFW TC    DFW   PIN  DC-STATE CCA  DDC   ALT  CU-TYPE
 8021,33903 ,O,000,NW8021,5A=- 5C=- 5E=+ 60=- 5B=- 5D=- 5F=+ 61=+
      2105    8910  Y  YY.  YY.    N   SIMPLEX   21   21        2105
 ************************ SYMBOL DEFINITIONS ************************
 O = ONLINE                         + = PATH AVAILABLE
 - = LOGICALLY OFF, PHYSICALLY OFF
```

Figure F-5 The DFSMS DEVSERV PATHS command

This display is only available for disk and tape and is useful in reporting the real-time state of each path to the device. Once again, there is no information in the output of this display to identify the device as FICON-attached. This display would look the same for parallel, ESCON or FICON channels.

F.2 Systems Automation for zOS I/O-Ops

SA I/O-Operations supports FICON native (FC) channels and attached control units and devices. Not all SA I/O-Ops commands are described here, only those useful for problem determination in a FICON I/O error or configuration problem.

The following commands are available to display the status of CHPIDs and devices, and path routing for FICON attached devices:

Display Switch

Figure F-6 shows an example of the output of the SA I/O-Ops Display Switch command when the configuration includes FICON Directors.

```
 SDSF OPERLOG  DATE 07/31/2002     0 WTORS                     COLUMNS 52- 131
COMMAND INPUT ===> /F IHV,D S *                                SCROLL ===> 5
000091  IST891I USIBMSC.SC67M GENERATED FAILURE NOTIFICATION
000091  IST314I END
000098  IHVI001E NO SESSION WITH SC67IHV .  OPNDST FAILED. RC 10 01 X
000290  IHVR021I DISPLAY    COMMAND SUCCESSFUL. RC  0, REASON CODE 40000004
000090  IHVC999I ESCON MANAGER DISPLAY 635
000090  IHVC833I SWCH                                PORTS   SWCH
        STATUS
000090  IHVC834I DEVN LSN UNIQUE ID                INSTALLED STATUS
        CODE
000090  IHVC838I 001A AA  009032000IBM00000000010147    61    OPERATIONAL   00
000090  IHVC838I 001B AB  009032000IBM00000000010146    61    OPERATIONAL   00
000090  IHVC838I 001C AC  009032002IBM02000000010678    61    OPERATIONAL   00
000090  IHVC838I 001D AD  009032002IBM02000000010679    61    OPERATIONAL   00
000090  IHVC838I 001E AE  009032003IBM02000000020995    89    OPERATIONAL   00
000090  IHVC838I 001F AF  009032005IBM02000000040869    69    OPERATIONAL   00
000090  IHVC838I 0061 61  006064001MCD010000000119D3    25    OPERATIONAL   00
000090  IHVC838I 0062 62  006064001MCD010000000119D2    25    OPERATIONAL   00
000090  IHVO000I I/O-OPS IS READY TO PROCESS OPERATOR COMMANDS
```

Figure F-6 Display Switch command - 1

This display shows that the configuration includes two McDATA ED-6064 FICON Directors, each with 24 physical ports plus one logical port for the CUP feature. Also shown are a number of IBM 9032 ESCON Directors. The two McDATA FICON Directors are defined as device numbers 0061 and 0062, with Logical Switch Numbers (LSN) 60 and 61 respectively as recommended.

Information about an individual switch can be displayed with the SA I/O-Ops Display Switch dddd command, as shown in Figure F-7 on page 244.

```
 SDSF OPERLOG  DATE 07/31/2002     0 WTORS                    COLUMNS 42- 121
 COMMAND INPUT ===> /F IHV,D S 0061                           SCROLL ===> 5
TC29579 00000290  IHVA201I SWITCH 001B PORT CB STATE CHANGED
TC29579 00000290  IHVR021I DISPLAY    COMMAND SUCCESSFUL. RC  4, REASON CODE 500
TC29579 00000090  IHVC999I ESCON MANAGER DISPLAY 706
    706 00000090  IHVC001I DISPLAY    COMMAND SUCCESSFUL. RC  4, REASON CODE 500
    706 00000090  IHVC421I SWCH(S) DATA HAS BEEN CHANGED
    706 00000090  IHVC833I SWCH                                PORTS   SWCH
                  STATUS
    706 00000090  IHVC834I DEVN LSN UNIQUE ID                INSTALLED STATUS
                  CODE
    706 00000090  IHVC838I 0061 61  006064001MCD010000000119D3    25    OPERATIONAL
    706 00000090  IHVC835I                  PORT
    706 00000090  IHVC836I                 STATUS
    706 00000090  IHVC837I      PORT     H S C  P     PORT NAME
    706 00000090  IHVC839I       04                   Cascade_to_0062_PA04
    706 00000090  IHVC839I       05      O
    706 00000090  IHVC839I       06      O
    706 00000090  IHVC839I       07      O
    706 00000090  IHVC839I       08                   P801_CHP_5A
    //////////////////////////////////////
    706 00000090  IHVC839I       40      N
    706 00000090  IHVC839I       41      N
    706 00000090  IHVC839I       42      N
    706 00000090  IHVC839I       43      N
    706 00000090  IHVC839I       FE                   2032A-0061
TC29579 00000090  IHVO000I I/O-OPS IS READY TO PROCESS OPERATOR COMMANDS
```

Figure F-7 The Display Switch dddd command - 2

This display shows the status and port name of each port on the switch. The status reflects the real-time status of the port:

- O - offline
- L - loss of light
- B - blocked

Other status conditions may also be displayed, such as S (service), P (prohibited), and so on.

The port name is assigned and written by the systems programmer.

Note that there is no change to this display for a FICON Director from that of an ESCON Director.

Display CHPID

Figure F-8 shows the output of the I/O-Ops Display Channel command for a FICON native (FC) channel.

```
 SDSF OPERLOG  DATE 07/31/2002     0 WTORS                       COLUMNS 52- 131
 COMMAND INPUT ===> /F IHV,D C 5A                                SCROLL ===> 5
000091  IST314I END
000290  IHVR021I DISPLAY    COMMAND SUCCESSFUL. RC  0, REASON CODE 40000004
000090  IHVC999I ESCON MANAGER DISPLAY 050
000090  IHVC815I                               PORT
000090  IHVC816I       CHP     SWCH           STATUS
000090  IHVC817I CHP   TYPE    DEVN LSN PORT H S C  P  PORT NAME
000090  IHVC818I 5A    FC_S    0061 61   08            P801_CHP_5A
000090  IHVO000I I/O-OPS IS READY TO PROCESS OPERATOR COMMANDS
```

Figure F-8 Output of the Display Channel command

Information about CHPID 5A is displayed including its type, FC_S, the switch to which it is connected, device number 0061 and logical switch number 61, the channel's entry port, 08, and the status and name of the port.

Display Device

The Display Device command can be used to determine all the devices connected through a particular switch. Figure F-9 shows an example of the command used to determine the list of devices accessible through FICON Director device number 0061.

```
 SDSF OPERLOG  DATE 07/31/2002     0 WTORS                     COLUMNS 52- 131
 COMMAND INPUT ===> /F IHV,D D * 0061                          SCROLL ===> 5
000290  IHVR021I DISPLAY    COMMAND SUCCESSFUL. RC  4, REASON CODE 50000036
000090  IHVC999I ESCON MANAGER DISPLAY 190
000090  IHVC824I                              PORT
000090  IHVC825I          CHP   SWCH         STATUS
000090  IHVC826I DEVN CHP TYPE  DEVN LSN PORT H S C  P PORT NAME
000090  IHVC827I 0061 5A  FC_S  0061 61   08          P801_CHP_5A
000090  IHVC827I      5B  FC_S  0061 61   0C          P801_CHP_5B
000090  IHVC827I 0062 5B  FC_S  0061 61   0C          P801_CHP_5B
000090  IHVC827I 8000 5A  FC_S  0061 61   08          P801_CHP_5A
000090  IHVC827I      5B  FC_S  0061 61   0C          P801_CHP_5B
000090  IHVC827I      5C  FC_S  0061 61   10          P801_CHP_5C
000090  IHVC827I      5D  FC_S  0061 61   14          P801_CHP_5D
000090  IHVC827I 8001 5A  FC_S  0061 61   08          P801_CHP_5A
000090  IHVC827I      5B  FC_S  0061 61   0C          P801_CHP_5B
  F1=HELP      F2=SPLIT     F3=END       F4=RETURN    F5=IFIND     F6=BOOK
  F7=UP        F8=DOWN      F9=SWAP     F10=LEFT     F11=RIGHT    F12=RETRIEVE
```

Figure F-9 The Display Device command - 1

The Display Device command can also be used to display the routing for all paths to a particular device. Figure F-10 shows the output of the I/O-Ops Display Device command for a device connected to several FICON (FC) switched channels.

```
 SDSF OPERLOG  DATE 07/31/2002     0 WTORS                     COLUMNS 52- 131
 COMMAND INPUT ===> /F IHV,D D 8000 *                          SCROLL ===> 1
000290  IHVR021I DISPLAY    COMMAND SUCCESSFUL. RC  0, REASON CODE 40000004
000090  IHVC999I ESCON MANAGER DISPLAY 217
000090  IHVC824I                              PORT
000090  IHVC825I          CHP   SWCH         STATUS
000090  IHVC826I DEVN CHP TYPE  DEVN LSN PORT H S C  P PORT NAME
000090  IHVC827I 8000 5A  FC_S  0061 61   08          P801_CHP_5A
000090  IHVC82AI CNTL UNIT DATA:0061 61   08          P801_CHP_5A
000090  IHVC827I      5B  FC_S  0061 61   0C          P801_CHP_5B
000090  IHVC82AI CNTL UNIT DATA:0061 61   0C          P801_CHP_5B
000090  IHVC827I      5C  FC_S  0061 61   10          P801_CHP_5C
000090  IHVC82AI CNTL UNIT DATA:0061 61   10          P801_CHP_5C
000090  IHVC827I      5D  FC_S  0061 61   14          P801_CHP_5D
000090  IHVC82AI CNTL UNIT DATA:0061 61   14          P801_CHP_5D
000090  IHVC827I      5E  FC_S  0062 62   09
000090  IHVC82AI CNTL UNIT DATA:0062 62   0A    +
000090  IHVC827I      5F  FC_S  0062 62   0D
000090  IHVO000I I/O-OPS IS READY TO PROCESS OPERATOR COMMANDS
  F1=HELP      F2=SPLIT     F3=END       F4=RETURN    F5=IFIND     F6=BOOK
  F7=UP        F8=DOWN      F9=SWAP     F10=LEFT     F11=RIGHT    F12=RETRIEVE
```

Figure F-10 The Display Device command - 2

This display shows that device number 8000 has several paths defined:

- 5A - FICON switched point-to-point (connected to FICON Director 0061, LSN 61)
- 5B - FICON switched point-to-point (connected to FICON Director 0061, LSN 61))
- 5C - FICON switched point-to-point (connected to FICON Director 0061, LSN 61)
- 5D - FICON switched point-to-point (connected to FICON Director 0061, LSN 61)
- 5E - FICON cascaded Directors (connected to FICON Director 0062, LSN 62)
- 5F - FICON cascaded Directors (connected to FICON Director 0062, LSN 62)

F.3 GTF trace

GTF trace is a useful tool for analyzing problems with I/O operations to devices attached to FICON channels. More than in an ESCON or parallel environment, it is necessary to be aware that the CCW chain traced on a SSCH entry may not be the CCW chain that is sent on the interface. There are several events, such as the execution of a PCI, that need to be considered. These events are discussed in more detail below.

Channel programming changes in a FICON environment are under the control of bit settings in the ORB, which is traced by GTF on a SSCH. For a performance problem, it may be necessary to check the ORB settings of the following FICON-related controls:

- ORBP, prefetch control
- ORBY, read-to-write transition synchronization control
- ORBM, PCI synchronization control

Refer to 11.1.2, "CCW and data prefetch and pipelining" on page 191 for more information on the ORB bit settings.

CCW and data prefetch

Figure F-11 shows an example of the ORB with the prefetch bit set in a GTF trace SSCH entry.

In this scenario, SMF is writing to a dataset on device number CAEF, which is on an IBM ESS 2105 subsystem. The subsystem is connected by both ESCON (CNC) and FICON native (FC) CHPIDs.

Word 1 of the ORB=03C0D800. Bit 9, ORBP=1 indicating unlimited prefetch of data and CCWs is allowed. Incidentally, ORBY (bit 7) and ORBM (bit 6) are also set to one, which indicates that neither read-write transition synchronization nor PCI synchronization is required. This combination of ORB bit settings allows optimal operation of the FICON channel.

```
SSCH.... CAEF     ASCB.... 00F4CD00 CPUID... 0000     JOBN.... SMF
                   RST..... 1C6F9F68 VST..... 0F405F68 DSID.... 00000000
                   CC...... 00       SEEKA... 00000001 F400090B
                   GPMSK... 00       OPT..... 04       FMSK.... 10
                   DVRID... 03       IOSLVL.. 01       UCBLVL.. 01
                   UCBWGT.. 08       BASE.... CA05
                   ORB..... 02B474A8 03C0D800 1C6F9F68 00000000 00000000
                            00000000 00000000 00000000
               GMT-05/10/2001 17:53:20.623817  LOC-05/10/2001 13:53:20.623817

          CCW CHAIN         FORMAT 1          SSCH
                            DEV..... CAEF     ASCB.... 00F4CD00
                            CPU..... 0000     JOBN.... SMF
          0F405F68 63400010 1C6F9F00 00C01000 00000000 | .{...... |
                                     01F40009 01F40009 | .4...4.. |
          0F405F70 47400010 1C6F9F10 01000001 01F40009 | .....4.. |
                                     01F40009 0BB80000 | .4...... |
```

Figure F-11 GTF trace example (prefetch)

Read-to-write transition and PCI synchronization

Figure F-12 shows an example of an I/O request specifying modification control (PCI synchronization) and read-write transition synchronization. This I/O request is from SA

I/O-Ops, jobname IOOPSV2, to switch device number B550. ORBP, ORBY and ORBM are all set to zero in word 1 of the ORB.

```
SSCH.... B550     ASCB.... 00F4F800 CPUID... 0000     JOBN.... IOOPSV2
                  RST..... 00EC4000 VST..... 00082000 DSID.... 00000000
                  CC...... 00       SEEKA... 00000000 00000000
                  GPMSK... FF       OPT..... 40       FMSK.... 00
                  DVRID... 01       IOSLVL.. 01       UCBLVL.. 01
                  UCBWGT.. 00       BASE.... B550
                  ORB..... 00F36220 00808000 00EC4000 00000000 00000000
                           00000000 00000000 00000000
               GMT-05/08/2001 15:18:48.257113  LOC-05/08/2001 11:18:48.257113

         CCW CHAIN         FORMAT 1          SSCH
                           DEV..... B550     ASCB.... 00F4F800
                           CPU..... 0000     JOBN.... IOOPSV2
         00082000 0D400004 5D6814F8 0000017F          | ..."     |
         00082008 03000000 00000000
         00082010 08000000 00A13000
         00071000 06400004 5D6814FC
```

Figure F-12 GTF trace example (I/O request)

Device active only time

APAR OW37986 added device-active-only time to GTF I/O summary trace records. I/O summary trace records are produced when either option IOX or IOXP is specified.

F.4 ICKDSF logical paths report

When the number of available logical paths to the disk subsystem's logical control unit has been exhausted, the ICKDSF ANALYZE function can be used to generate a report showing the state of the logical paths (established or not established), and the channel images owning the established logical paths. Sample JCL for the job is shown below in Figure F-13. Note that the device against which the job is run can be any device on the logical control unit with "CU resources exceeded", but it must be varied offline first.

```
//U12345A JOB (999,POK),'LOG PATH ',MSGLEVEL=(1,1),
//      CLASS=A,MSGCLASS=T,NOTIFY=&SYSUID
//STEP1  EXEC PGM=ICKDSF
//SYSPRINT DD SYSOUT=*
//SYSIN DD *
    ANALYZE UNIT(6421) NODRIVE NOSCAN
/*
```

Figure F-13 Sample ICKDSF JCL for logical paths listing

Figure F-14 on page 248, Figure F-15 on page 249, Figure F-16 on page 251, and Figure F-17 on page 252 show extracts from the sample output of the ICKDSF job run to a device on an ESS subsystem configured with FICON native (FC) channels only.

```
ICK00700I DEVICE INFORMATION FOR 9800 IS CURRENTLY AS FOLLOWS:
          PHYSICAL DEVICE = 3390
          STORAGE CONTROLLER = 2105
          STORAGE CONTROL DESCRIPTOR = E8
          DEVICE DESCRIPTOR = 0A
          ADDITIONAL DEVICE INFORMATION = 4A000035
ICK04000I DEVICE IS IN SIMPLEX STATE
                                 PATH   STATUS
+-------------------+------+------+------+------+------+------+------+------+
| CHPID             |  47  |  EE  |  5B  |  84  |  51  |  E2  |  EF  |  95  |
+-------------------+------+------+------+------+------+------+------+------+
| AVAILABLE         | YES  | YES  | YES  | YES  | YES  | YES  | YES  | YES  |
+-------------------+------+------+------+------+------+------+------+------+
| ONLINE            | YES  | YES  | YES  | YES  | YES  | YES  | YES  | YES  |
+-------------------+------+------+------+------+------+------+------+------+
| SUBSYSTEM ID      | 0900 | 0900 | 0900 | 0900 | 0900 | 0900 | 0900 | 0900 |
+-------------------+------+------+------+------+------+------+------+------+
| DLSE              | YES  | YES  | YES  | YES  | YES  | YES  | YES  | YES  |
+-------------------+------+------+------+------+------+------+------+------+
| CLUSTER           |  0   |  0   |  0   |  0   |  0   |  0   |  0   |  0   |
+-------------------+------+------+------+------+------+------+------+------+
| STORAGE PATH 0    | A    | A    | A    | A    | A    | A    | A    | A    |
+-------------------+------+------+------+------+------+------+------+------+
| STORAGE PATH 1    | A    | A    | A    | A    | A    | A    | A    | A    |
+-------------------+------+------+------+------+------+------+------+------+
- = NOT APPLICABLE
STORAGE PATH :
        A = ATTACHED
        D = DISABLED
        F = DEVICE FENCED FROM STORAGE PATH
        C = CHANNEL FENCED FROM STORAGE PATH
```

Figure F-14 Sample ICKDSF logical path report - part 1

The first part of the ICKDSF logical path report, shown in Figure F-14, provides information about the device and the paths to the device.

LOGICAL PATH STATUS

LOGICAL PATH NUMBER	LOGICAL PATH TYPE	SYSTEM ADAPTER ID	HOST LINK ADDRESS	FENCED	HOST PATH GROUP ID CPU SERIAL #	CPU TYPE	CPU TIME STAMP
1	F/E	08	11260000		0000011511	2064	B5D571BB
2-8	F/L	08	11260000		0000011511	2064	B5D571BB
9	F/E	08	11280000		0000011511	2064	B5D571BB
10-16	F/L	08	11280000		0000011511	2064	B5D571BB
17	F/L	08	11320000				
/ / /							
35	F/L	08	11180000		0000010A74	2064	B5D57C72
36	F/L	08	11370000				
37	F/L	08	11180000		0000010A74	2064	B5D57C72
38	F/L	08	11370000		0000010A74	2064	B5D57C72
39	F/L	08	11010000		0000010A74	2064	B5D57C72
40	F/L	08	11370000		0000010A74	2064	B5D57C72
41	F/L	08	11010000		0000010A74	2064	B5D57C72
42	F/E	08	11010000		0000010A74	2064	B5D57C72
43-45	F/L	08	11240000		0000010A74	2064	B5D57C72
/ / /							
1025-1088	N/E	A4-A4					
1089-1152	N/E	A5-A5					
1153-1216	N/E	A0-A0					
1217-1280	N/E	A1-A1					
1281-2048	P	00					

```
LOGICAL PATH :
        P = PARALLEL
      N/E = NOT ESTABLISHED
      F/N = FICON - NOT ESTABLISHED
      F/E = FICON - ESTABLISHED
      F/L = FICON - ESTABLISHED TO ANOTHER LOGICAL SUBSYSTEM
```

Figure F-15 Sample ICKDSF logical path report - part 2

The extract from the report shown in Figure F-15 lists:

- Logical path by number (the FICON-capable ESS supports a maximum of 2048 logical paths for all fibre-channel in FC-SB2 mode (FICON) logical control units)
- State of the logical path (whether it is established or not)
- Host link address
- Host path group information for established logical paths

For example, logical paths 35 and 37 to 45 are established by the channel image on the zSeries processor with serial number 10A74. The operating system host path group ID information is 0000010A742064B5D57C72. The CPU serial # and CPU type portions of this host path group ID can be matched to the output of the D M=CPU command issued on the z/OS console.

The report is run for any device number on the required logical control unit. The paths with status F/E are those established for this specific logical control unit. Those paths with status F/L are established for some other logical control unit than that associated with the device for which the report was run. Therefore, if this logical control unit has a “control unit resources exceeded” condition, the logical paths of interest are those with status F/E. These should be matched with the owning operating systems (through the use of the D M=CPU command output) to determine who owns all the possible logical paths for this logical control unit.

Some other points to note in this report:

- Logical path number 17 has status F/L, which means the logical path is established but has no host path group ID information. In this case, the processor has been POR and/or logical partition activated (if the processor is in LPAR mode) and the FICON channel has established a logical path with the defined logical control unit on the ESS subsystem. However, the operating system IPL is not yet complete.
- The information in the column marked Host Link Address consists of:
  - The 24-bit Fibre Channel port address
  - The one-byte channel image ID

    The channel image ID of zero is used for an image on a processor in Basic mode, or for a channel that is not shared (defined as dedicated or reconfigurable) on a processor in LPAR mode.

```
        INTERFACE  INFORMATION
+--------+-----------+-------------+
|  TYPE  |  SYSTEM   |  PORT       |
|        |  ADAPTER  |  LINK       |
|        |  ID       |  ADDRESS    |
+--------+-----------+-------------+
|   F    |   08      |   000033    |
+--------+-----------+-------------+
|   E    |   04      |   N/A       |
+--------+-----------+-------------+
|   E    |   05      |   N/A       |
+--------+-----------+-------------+
|   E    |   00      |   N/A       |
+--------+-----------+-------------+
|   E    |   01      |   N/A       |
+--------+-----------+-------------+
|   F    |   88      |   000071    |
+--------+-----------+-------------+
|   E    |   84      |   N/A       |
+--------+-----------+-------------+
|   E    |   85      |   N/A       |
+--------+-----------+-------------+
|   E    |   80      |   N/A       |
+--------+-----------+-------------+
|   E    |   81      |   N/A       |
+--------+-----------+-------------+
|   F    |   28      |   000070    |
+--------+-----------+-------------+
|   E    |   24      |   N/A       |
+--------+-----------+-------------+
|   E    |   25      |   N/A       |
+--------+-----------+-------------+
|   E    |   20      |   N/A       |
+--------+-----------+-------------+
|   E    |   21      |   N/A       |
+--------+-----------+-------------+
|   F    |   A8      |   000A20    |
+--------+-----------+-------------+
|   E    |   A4      |   N/A       |
+--------+-----------+-------------+
|   E    |   A5      |   N/A       |
+--------+-----------+-------------+
|   E    |   A0      |   N/A       |
+--------+-----------+-------------+
|   E    |   A1      |   N/A       |
+--------+-----------+-------------+
N/A=NOT AVAILABLE OR NOT ASSIGNED
INTERFACE TYPE :
        E = ESCON
        F = FICON
        HOST INTERFACE INFORMATION
```

Figure F-16   Sample ICKDSF logical path report - part 3

This part of the logical path report provides information about each ESCON or fibre channel host adapter (FC 3021 or 3023) in FC-SB2 mode (FICON).

```
        HOST INTERFACE INFORMATION
+--------+-----------+-------------+---------+
|  TYPE  |  CHPID    |  HOST       | SYSTEM  |
|        |           |  LINK       | ADAPTER |
|        |           |  ADDRESS    | ID      |
+--------+-----------+-------------+---------+
|   F    |      47   |  10380000   |    28   |
+--------+-----------+-------------+---------+
|   F    |      EE   |  10650000   |    88   |
+--------+-----------+-------------+---------+
|   F    |      5B   |  11010000   |    08   |
+--------+-----------+-------------+---------+
|   F    |      84   |  21081300   |    A8   |
+--------+-----------+-------------+---------+
|   F    |      51   |  10010000   |    28   |
+--------+-----------+-------------+---------+
|   F    |      E2   |  10770000   |    88   |
+--------+-----------+-------------+---------+
|   F    |      EF   |  11370000   |    08   |
+--------+-----------+-------------+---------+
|   F    |      95   |  21091300   |    A8   |
+--------+-----------+-------------+---------+
- = NOT APPLICABLE
INTERFACE TYPE :
        F = FICON
```

Figure F-17   Sample ICKDSF logical path report - part 4

This part of the logical path report shows information about the interfaces from the system where the report was run to the logical control unit associated with the device for which the report was run.

Glossary

This glossary includes terms for the zSeries and System/390 (S/390) processors, ESCON and FICON channels, ESCON Director products, FICON Fibre Channel switches, and for the FICON environment.

A

active configuration. In an ESCON environment, the ESCON Director configuration determined by the status of the current set of connectivity attributes. Contrast with *saved configuration*.

allowed. In an ESCON Director, the attribute that, when set, establishes dynamic connectivity capability. Contrast with *prohibited*.

American National Standards Institute (ANSI). An organization consisting of producers, consumers, and general interest groups, that establishes the procedures by which accredited organizations create and maintain voluntary industry standards in the United States.

ANSI. See *American National Standards Institute*.

APAR. See *authorized program analysis report*.

authorized program analysis report (APAR). A report of a problem caused by a suspected defect in a current, unaltered release of a program.

B

basic mode. A S/390 or zSeries central processing mode that does not use logical partitioning. Contrast with *logically partitioned (LPAR) mode*.

blocked. In an ESCON and FICON Director, the attribute that, when set, removes the communication capability of a specific port. Contrast with *unblocked*.

byte. (1) In fibre channel, an eight-bit entity prior to encoding or after decoding, with its least significant bit denoted as bit 0, and most significant bit as bit 7. The most significant bit is shown on the left side in FC-FS unless otherwise shown. (2) In S/390 architecture or zSeries z/Architecture (and FICON), an eight-bit entity prior to encoding or after decoding, with its least significant bit denoted as bit 7, and most significant bit as bit 0. The most significant bit is shown on the left side in S/390 architecture and zSeries z/Architecture.

C

Cascade switches. The connecting of one Fibre Channel switch to another Fibre Channel switch, thereby creating a cascaded switch route between two N_Nodes connected to a fibre channel fabric.

CBY. Mnemonic for an ESCON channel attached to an IBM 9034 convertor. The 9034 converts from ESCON CBY signals to parallel channel interface (OEMI) communication operating in byte multiplex mode (Bus and Tag). Contrast with *CVC*.

chained. In an ESCON environment, pertaining to the physical attachment of two ESCON Directors (ESCDs) to each other.

channel. (1) A processor system element that controls one channel path, whose mode of operation depends on the type of hardware to which it is attached. In a channel subsystem, each channel controls an I/O interface between the channel control element and the logically attached control units. (2) In the ESA/390 or zSeries architecture (z/Architecture), the part of a channel subsystem that manages a single I/O interface between a channel subsystem and a set of controllers (control units).

channel path (CHP). A single interface between a central processor and one or more control units along which signals and data can be sent to perform I/O requests.

channel path identifier (CHPID). In a channel subsystem, a value assigned to each installed channel path of the system that uniquely identifies that path to the system.

channel subsystem (CSS). Relieves the processor of direct I/O communication tasks, and performs path management functions. Uses a collection of subchannels to direct a channel to control the flow of information between I/O devices and main storage.

channel-attached. (1) Pertaining to attachment of devices directly by data channels (I/O channels) to a computer. (2) Pertaining to devices attached to a controlling unit by cables rather than by telecommunication lines.

CHPID. Channel path identifier.

cladding. In an optical cable, the region of low refractive index surrounding the core. See also *core* and *optical fiber.*

CNC. Mnemonic for an ESCON channel used to communicate to an ESCON-capable device.

configuration matrix. In an ESCON environment or FICON, an array of connectivity attributes that appear as rows and columns on a display device and can be used to determine or change active and saved ESCON or FICON director configurations.

connected. In an ESCON Director, the attribute that, when set, establishes a dedicated connection between two ESCON ports. Contrast with *disconnected.*

connection. In an ESCON Director, an association established between two ports that provides a physical communication path between them.

connectivity attribute. In an ESCON and FICON Director, the characteristic that determines a particular element of a port's status. See *allowed, prohibited, blocked, unblocked, (connected and disconnected)*.

control unit. A hardware unit that controls the reading, writing, or displaying of data at one or more input/output units.

core. (1) In an optical cable, the central region of an optical fiber through which light is transmitted. (2) In an optical cable, the central region of an optical fiber that has an index of refraction greater than the surrounding cladding material. See also *cladding* and *optical fiber*.

coupler. In an ESCON environment, link hardware used to join optical fiber connectors of the same type. Contrast with *adapter*.

CTC. (1) Channel-to-channel. (2) Mnemonic for an ESCON channel attached to another ESCON channel, where one of the two ESCON channels is defined as an ESCON CTC channel and the other ESCON channel would be defined as a ESCON CNC channel (3) Mnemonic for a FICON channel supporting a CTC Control Unit function logically or physically connected to another FICON channel that also supports a CTC Control Unit function. FICON channels supporting the FICON CTC control unit function are defined as normal FICON native (FC) mode channels.

CVC. Mnemonic for an ESCON channel attached to an IBM 9034 convertor. The 9034 converts from ESCON CVC signals to parallel channel interface (OEMI) communication operating in block multiplex mode (Bus and Tag). Contrast with *CBY.*

D

DDM. See *disk drive module.*

dedicated connection. In an ESCON Director, a connection between two ports that is not affected by information contained in the transmission frames. This connection, which restricts those ports from communicating with any other port, can be established or removed only as a result of actions performed by a host control program or at the ESCD console. Contrast with *dynamic connection*.

Note: The two links having a dedicated connection appear as one continuous link.

default. Pertaining to an attribute, value, or option that is assumed when none is explicitly specified.

Dense Wavelength Division Multiplexing (DWDM). The concept of packing multiple signals tightly together in separate groups, and transmitting them simultaneously over a common carrier wave.

destination. Any point or location, such as a node, station, or a particular terminal, to which information is to be sent. An example is a Fibre Channel fabric F_Port; when attached to a fibre channel N_port, communication to the N_port via the F_port is said to be to the F_Port destination identifier (D_ID).

device. A mechanical, electrical, or electronic contrivance with a specific purpose.

device address. (1) In ESA/390 architecture and zSeries z/Architecture, the field of an ESCON device-level frame that selects a specific device on a control unit image. (2) In the FICON channel FC-SB-2 architecture, the device address field in an SB-2 header that is used to select a specific device on a control unit image.

device number. (1) In ESA/390 and zSeries z/Architecture, a four-hexadecimal character identifier (for example, 19A0) that you associate with a device to facilitate communication between the program and the host operator. (2) The device number that you associate with a subchannel that uniquely identifies an I/O device.

direct access storage device (DASD). A mass storage medium on which a computer stores data.

disconnected. In an ESCON Director, the attribute that, when set, removes a dedicated connection. Contrast with *connected*.

disk. A mass storage medium on which a computer stores data.

disk drive module (DDM). A disk storage medium that you use for any host data that is stored within a disk subsystem.

distribution panel. (1) In an ESCON and FICON environment, a panel that provides a central location for the attachment of trunk and jumper cables and can be mounted in a rack, wiring closet, or on a wall.

duplex. Pertaining to communication in which data or control information can be sent and received at the same time, from the same node. Contrast with *half duplex.*

duplex connector. In an ESCON environment, an optical fiber component that terminates both jumper cable fibers in one housing and provides physical keying for attachment to a duplex receptacle.

duplex receptacle. In an ESCON environment, a fixed or stationary optical fiber component that provides a keyed attachment method for a duplex connector.

dynamic connection. In an ESCON Director, a connection between two ports, established or removed by the ESCD and that, when active, appears as one continuous link. The duration of the connection depends on the protocol defined for the frames transmitted through the ports and on the state of the ports. Contrast with *dedicated connection.*

dynamic connectivity. In an ESCON Director, the capability that allows connections to be established and removed at any time.

Dynamic I/O Reconfiguration. A S/390 and z/Architecture function that allows I/O configuration changes to be made non-disruptively to the current operating I/O configuration.

E

ELS. See *Extended Link Services.*

EMIF. See *ESCON Multiple Image Facility.*

Enterprise System Connection (ESCON). (1) An ESA/390 computer peripheral interface. The I/O interface uses ESA/390 logical protocols over a serial interface that configures attached units to a communication fabric. (2) A set of IBM products and services that provide a dynamically connected environment within an enterprise.

Enterprise Systems Architecture/390 (ESA/390). An IBM architecture for mainframe computers and peripherals. Processors that follow this architecture include the S/390 Server family of processors.

ESA/390. See *Enterprise Systems Architecture/390*.

ESCD. Enterprise Systems Connection (ESCON) Director.

ESCD console. The ESCON Director display and keyboard device used to perform operator and service tasks at the ESCD.

ESCON. See *Enterprise System Connection.*

ESCON channel. A channel having an Enterprise Systems Connection channel-to-control-unit I/O interface that uses optical cables as a transmission medium. May operate in CBY, CNC, CTC or CVC mode. Contrast with *parallel channel.*

ESCON Director. An I/O interface switch that provides the interconnection capability of multiple ESCON interfaces (or FICON Bridge (FCV) mode - 9032-5) in a distributed-star topology.

ESCON Multiple Image Facility (EMIF). In the ESA/390 architecture and zSeries z/Architecture, a function that allows LPARs to share an ESCON and FICON channel path (and other channel types) by providing each LPAR with its own channel-subsystem image.

Extended Link Services (ELS). An Extended Link Service (command) request solicits a destination port (N_Port or F_Port) to perform a function or service. Each ELS request consists of an Link Service (LS) command; the N_Port ELS commands are defined in the FC-FS architecture.

F

FC. (1) (Fibre Channel), a short form when referring to something that is part of the fibre channel standard. (2) Also used by the IBM I/O definition process when defining a FICON channel (using IOCP of HCD) that will be used in FICON native mode (using the FC-SB-2 communication protocol).

FC-FS. Fibre Channel-Framing and Signalling, the term used to describe the FC-FS architecture.

FCS. See *fibre channel standard*.

fiber. See *optical fiber*.

fiber optic cable. See *optical cable.*

fiber optics. The branch of optical technology concerned with the transmission of radiant power through fibers made of transparent materials such as glass, fused silica, and plastic.

Note: Telecommunication applications of fiber optics use optical fibers. Either a single discrete fiber or a non-spatially aligned fiber bundle can be used for each information channel. Such fibers are often called “optical fibers” to differentiate them from fibers used in non-communication applications.

fibre channel standard. An ANSI standard for a computer peripheral interface. The I/O interface defines a protocol for communication over a serial interface that configures attached units to a communication fabric. The protocol has four layers. The lower of the four layers defines the physical media and interface, the upper of the four layers defines one or more Upper Layer Protocols (ULP)—for example, FCP for SCSI command protocols and FC-SB-2 for FICON protocol supported by ESA/390 and z/Architecture. Refer to ANSI X3.230.1999x.

FICON. (1) An ESA/390 and zSeries computer peripheral interface. The I/O interface uses ESA/390 and zSeries FICON protocols (FC-FS and FC-SB-2) over a Fibre Channel serial interface that configures attached units to a FICON supported Fibre Channel communication fabric. (2) An FC4 proposed standard that defines an effective mechanism for the export of the SBCCS-2 (FC-SB-2) command protocol via fibre channels.

FICON channel. A channel having a Fibre Channel connection (FICON) channel-to-control-unit I/O interface that uses optical cables as a transmission medium. May operate in either FC or FCV mode.

FICON Director. A Fibre Channel switch that supports the ESCON-like “control unit port” (CUP function) that is assigned a 24-bit FC port address to allow FC-SB-2 addressing of the CUP function to perform command and data transfer (in the FC world, it is a means of in-band management using a FC-4 ULP).

field replaceable unit (FRU). An assembly that is replaced in its entirety when any one of its required components fails.

FRU. See *field replaceable unit*.

G

Giga bit (Gbit). Usually used to refer to a data rate, the number of Giga bits being transferred in one second. One Giga bit is 1062.5 Mega bits.(*See Mega bit*)

H

half duplex. In data communication, pertaining to transmission in only one direction at a time. Contrast with *duplex.*

hard disk drive. (1) A storage media within a storage server used to maintain information that the storage server requires. (2) A mass storage medium for computers that is typically available as a fixed disk or a removable cartridge.

HCD. Hardware Configuration Dialog.

HDA. Head and disk assembly.

HDD. See *hard disk drive.*

head and disk assembly. The portion of an HDD associated with the medium and the read/write head.

I

ID. See *identifier.*

identifier. A unique name or address that identifies things such as programs, devices or systems.

initial program load (IPL). (1) The initialization procedure that causes an operating system to commence operation. (2) The process by which a configuration image is loaded into storage at the beginning of a work day, or after a system malfunction. (3) The process of loading system programs and preparing a system to run jobs.

input/output (I/O). (1) Pertaining to a device whose parts can perform an input process and an output process at the same time. (2) Pertaining to a functional unit or channel involved in an input process, output process, or both, concurrently or not, and to the data involved in such a process. (3) Pertaining to input, output, or both.

input/output configuration data set (IOCDS). The data set in the S/390 and zSeries processor (in the support element) that contains an I/O configuration definition built by the input/output configuration program (IOCP).

input/output configuration program (IOCP). A S/390 program that defines to a system the channels, I/O devices, paths to the I/O devices, and the addresses of the I/O devices.The output is normally written to a S/390 or zSeries IOCDS.

interface. (1) A shared boundary between two functional units, defined by functional characteristics, signal characteristics, or other characteristics as appropriate. The concept includes the specification of the connection of two devices having different functions. (2) Hardware, software, or both, that links systems, programs, or devices.

I/O. See *input/output*.

I/O configuration. The collection of channel paths, control units, and I/O devices that attaches to the processor. This may also include channel switches (for example, an ESCON Director).

IOCDS. See *Input/Output configuration data set.*

IOCP. See *Input/Output configuration control program.*

IODF. The data set that contains the S/390 or zSeries I/O configuration definition file produced during the defining of the S/390 or zSeries I/O configuration by HCD. Used as a source for IPL, IOCP and Dynamic I/O Reconfiguration.

IPL. See *initial program load*.

J

jumper cable. In an ESCON and FICON environment, an optical cable having two conductors that provides physical attachment between a channel and a distribution panel or an ESCON/FICON Director port or a control unit/device, or between an ESCON/FICON Director port and a distribution panel or a control unit/device, or between a control unit/device and a distribution panel. Contrast with *trunk cable.*

L

LAN. See *local area network*.

laser. A device that produces optical radiation using a population inversion to provide *light amplification by stimulated emission of radiation* and (generally) an optical resonant cavity to provide positive feedback. Laser radiation can be highly coherent temporally, or spatially, or both.

LCU. *See Logical Control Unit.*

LED. See *light emitting diode*.

licensed internal code (LIC). Microcode that IBM does not sell as part of a machine, but instead, licenses it to the customer. LIC is implemented in a part of storage that is not addressable by user programs. Some IBM products use it to implement functions as an alternate to hard-wire circuitry.

light-emitting diode (LED). A semiconductor chip that gives off visible or infrared light when activated. Contrast *Laser*.

link. (1) In an ESCON environment or FICON environment (fibre channel environment), the physical connection and transmission medium used between an optical transmitter and an optical receiver. A link consists of two conductors, one used for sending and the other for receiving, thereby providing a duplex communication path. (2) In an ESCON I/O interface, the physical connection and transmission medium used between a channel and a control unit, a channel and an ESCD, a control unit and an ESCD, or, at times, between two ESCDs. (3) In a FICON I/O interface, the physical connection and transmission medium used between a channel and a control unit, a channel and a FICON Director, a control unit and a fibre channel FICON Director, or, at times, between two fibre channels switches.

link address. (1) On an ESCON interface, the portion of a source or destination address in a frame that ESCON uses to route a frame through an ESCON director. ESCON associates the link address with a specific switch port that is on the ESCON director. See also *port address.* (2) On a FICON interface, the port address (1-byte link address), or domain and port address (2-byte link address) portion of a source (S_ID) or destination address (D_ID) in a fibre channel frame that the fibre channel switch uses to route a frame through a fibre channel switch or fibre channel switch fabric. See also *port address.*

local area network (LAN). A computer network located in a user's premises within a limited geographic area.

logical control unit (LCU). A separately addressable control unit function within a physical control unit. Usually a physical control unit that supports several LCUs. For ESCON, the maximum number of LCUs that can be in a control unit (and addressed from the same ESCON fiber link) is 16; they are addressed from x'0' to x'F'. For FICON architecture, the maximum number of LCUs that can be in a control unit (and addressed from the same FICON fibre link) is 256; they are addressed from x'00' to x'FF'. For both ESCON and FICON, the actual number supported, and the LCU address value, is both processor- and control unit implementation-dependent.

logical partition (LPAR). A set of functions that create a programming environment that is defined by the ESA/390 architecture or zSeries z/Architecture. ESA/390 architecture or zSeries z/Architecture uses the term LPAR when more than one logical partition is established on a processor. An LPAR is conceptually similar to a virtual machine environment except that the LPAR is a function of the processor. Also, LPAR does not depend on an operating system to create the virtual machine environment.

logical switch number (LSN). A two-digit number used by the I/O Configuration Program (IOCP) to identify a specific ESCON or FICON Director. (This number is separate from the director's "switch device number" and, for FICON, it is separate from the director's "FC switch address").

logically partitioned (LPAR) mode. A central processor mode, available on the Configuration frame when using the PR/SM facility, that allows an operator to allocate processor hardware resources among logical partitions. Contrast with *basic mode.*

LPAR. See *logical partition*.

M

megabyte (MB). (1) For processor storage, real and virtual storage, and channel volume, 2^{20} or 1 048 576 bytes. (2) For disk storage capacity and communications volumes, 1 000 000 bytes.

multi-mode optical fiber. A graded-index or step-index optical fiber that allows more than one bound mode to propagate. Contrast with *single-mode optical fiber.*

N

National Committee for Information Technology Standards. NCITS develops national standards and its technical experts participate on behalf of the United States in the international standards activities of ISO/IEC JTC 1, information technology.

NCITS. See *National Committee for Information Technology Standards.*

ND. See *node descriptor*.

NED. See *node-element descriptor.*

node descriptor. In an ESCON and FICON environment, a node descriptor (ND) is a 32-byte field that describes a node, channel, ESCON Director port or a FICON Director port, or a control unit.

node-element descriptor. In an ESCON and FICON environment, a node-element descriptor (NED) is a 32-byte field that describes a node element, such as a disk (DASD) device.

O

OEMI. See *original equipment manufacturers information.*

open system. A system whose characteristics comply with standards made available throughout the industry and that therefore can be connected to other systems complying with the same standards.

optical cable. A fiber, multiple fibers, or a fiber bundle in a structure built to meet optical, mechanical, and environmental specifications. See also *jumper cable*, *optical cable assembly*, and *trunk cable.*

optical cable assembly. An optical cable that is connector-terminated. Generally, an optical cable that has been connector-terminated by a manufacturer and is ready for installation. See also *jumper cable* and *optical cable*.

optical fiber. Any filament made of dialectic materials that guides light, regardless of its ability to send signals. See also *fiber optics* and *optical waveguide*.

optical fiber connector. A hardware component that transfers optical power between two optical fibers or bundles and is designed to be repeatedly connected and disconnected.

optical waveguide. (1) A structure capable of guiding optical power. (2) In optical communications, generally a fiber designed to transmit optical signals. See *optical fiber.*

original equipment manufacturer information (OEMI). A reference to an IBM guideline for a computer peripheral interface. More specifically, it refers to IBM S/360 and S/370 Channel to Control Unit Original Equipment Manufacturer Information. The interface uses ESA/390 logical protocols over an I/O interface that configures attached units in a multi-drop bus environment. This OEMI interface is also supported by the zSeries 900 processors.

P

parallel channel. A channel having a System/360 and System/370 channel-to-control-unit I/O interface that uses bus and tag cables as a transmission medium. Contrast with *ESCON channel*.

path. In a channel or communication network, any route between any two nodes. For ESCON and FICON this would be the route between the channel and the control unit/device, or sometimes from the operating system control block for the device and the device itself.

path group. The ESA/390 and zSeries architecture (z/Architecture) term for a set of channel paths that are defined to a controller as being associated with a single S/390 image. The channel paths are in a group state and are on-line to the host.

path-group identifier. The ESA/390 and zSeries architecture (z/Architecture) term for the identifier that uniquely identifies a given LPAR. The path-group identifier is used in communication between the system image program and a device. The identifier associates the path-group with one or more channel paths, thereby defining these paths to the control unit as being associated with the same system image.

PCICC. (IBM) PCI Cryptographic Coprocessor.

port. (1) An access point for data entry or exit. (2) A receptacle on a device to which a cable for another device is attached. (3) See also *duplex receptacle*.

port address. (1) In an ESCON Director, an address used to specify port connectivity parameters and to assign link addresses for attached channels and control units. See also *link address.* (2) In a FICON director or Fibre Channel switch, it is the middle 8 bits of the full 24-bit FC port address. This field is also referred to as the “area field” in the 24-bit FC port address. See also *link address.*

port card. In an ESCON and FICON environment, a field-replaceable hardware component that provides the optomechanical attachment method for jumper cables and performs specific device-dependent logic functions.

port name. In an ESCON or FICON Director, a user-defined symbolic name of 24 characters or less that identifies a particular port.

processor complex. A system configuration that consists of all the machines required for operation; for example, a processor unit, a processor controller, a system display, a service support display, and a power and coolant distribution unit.

program temporary fix (PTF). A temporary solution or bypass of a problem diagnosed by IBM in a current unaltered release of a program.

prohibited. In an ESCON or FICON Director, the attribute that, when set, removes dynamic connectivity capability. Contrast with *allowed.*

protocol. (1) A set of semantic and syntactic rules that determines the behavior of functional units in achieving communication. (2) In fibre channel, the meanings of and the sequencing rules for requests and responses used for managing the switch or switch fabric, transferring data, and synchronizing the states of fibre channel fabric components. (3) A specification for the format and relative timing of information exchanged between communicating parties.

PTF. See *program temporary fix*.

R

route. The path that an ESCON frame takes from a channel through an ESCD to a control unit/device.

S

saved configuration. In an ESCON or FICON Director environment, a stored set of connectivity attributes whose values determine a configuration that can be used to replace all or part of the ESCD's or FICON's active configuration. Contrast with *active configuration*.

service element (SE). A dedicated service processing unit used to service a S/390 machine (processor).

Small Computer System Interface (SCSI). (1) An ANSI standard for a logical interface to computer peripherals and for a computer peripheral interface. The interface uses an SCSI logical protocol over an I/O interface that configures attached targets and initiators in a multi-drop bus topology. (2) A standard hardware interface that enables a variety of peripheral devices to communicate with one another.

subchannel. A logical function of a channel subsystem associated with the management of a single device.

subsystem. (1) A secondary or subordinate system, or programming support, usually capable of operating independently of or asynchronously with a controlling system.

SWCH. In ESCON Manager, the mnemonic used to represent an ESCON Director.

switch. In ESCON Manager, synonym for ESCON Director.

T

trunk cable. In an ESCON and FICON environment, a cable consisting of multiple fiber pairs that do not directly attach to an active device. This cable usually exists between distribution panels (or sometimes between a set processor channels and a distribution panel) and can be located within, or external to, a building. Contrast with *jumper cable*.

U

unblocked. In an ESCON and FICON Director, the attribute that, when set, establishes communication capability for a specific port. Contrast with *blocked.*

unit address. The ESA/390 and zSeries term for the address associated with a device on a given controller. On ESCON and FICON interfaces, the unit address is the same as the device address. On OEMI interfaces, the unit address specifies a controller and device pair on the interface.

Z

z/Architecture. An IBM architecture for mainframe computers and peripherals. Processors that follow this architecture include the zSeries family of processors.

zSeries. A family of IBM mainframe servers that support high performance, availability, connectivity, security and integrity.

Related publications

The publications listed in this section are considered particularly suitable for a more detailed discussion of the topics covered in this redbook.

IBM Redbooks

For information on ordering these publications, see "How to get IBM Redbooks" on page 261.

- *FICON (FCV Mode) Planning Guide,* SG24-5445
- *Introduction to IBM S/390 FICON,* SG24-5176
- *IBM S/390 FICON Implementation Guide,* SG24-5169
- *IBM ESCON Director 9032-5 Presentation,* SG24-2005
- *IBM Fiber Saver (2029) Implementation Guide,* SG24-5608
- *Enterprise Systems Connection (ESCON) Implementation Guide,* SG24-4662

Other resources

These publications are also relevant as further information sources:

- *OS/390 RMF Performance Management Guide,* SC28-1951
- *Planning for the 9032 Model 3, 9033 Model 4, and 9032 Model 5,* SA22-7295
- *S/390 I/O Configuration Program User's Guide and ESCON Channel-to-Channel Reference*, GC38-0401
- *Fiber Optic Link Planning*, GA23-0367
- *Fiber Channel Connection for S/390 I/O Interface Physical Layer*, SA23-0395
- *S/390 (FICON) I/O Interface Physical Layer*, SA24-7172
- *IBM Cabling System Optical Fiber Planning and Installation*, GA27-3943
- *Planning for the 9032 Model 5 with FICON Converter Feature*, SA22-7415

Referenced Web sites

These Web sites are also relevant as further information sources:

- Fibre Channel standards

  `http://www.t11.org/`
- zSeries I/O connectivity

  `http://www.ibm.com/servers/eserver/zseries/connectivity/`

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G

H

I

FICON Native Implementation and Reference Guide

(0.5” spine)
0.475”<->0.873”
250 <-> 459 pages

FICON Native Implementation and Reference Guide

Architecture, terminology, and topology concepts

Planning, implemention, and migration guidance

Realistic examples and scenarios

This IBM Redbook covers the planning and implementation of FICON channels, operating in FICON native (FC) mode for the IBM zSeries and 9672 Generation 5 (G5) and Generation 6 (G6) processors. It discusses the FICON and Fibre Channel architectures, terminology, and supported topologies.

This book provides information about FICON native system setup, availability and recovery considerations, and migration recommendations. You will find examples of the z/OS and OS/390 definitions required to support FICON native control units, FICON Channel-to-Channel (FCTC), and FICON Directors (including cascading), as well as migration scenarios for control units using ESCON (CNC) channels or FICON Bridge (FCV) mode channels to FICON native (FC) mode channels.

This redbook is intended for system programmers, hardware planners, and system engineers who will plan and install FICON native (FC) products in a zSeries and 9672 Generation 5 (G5) and Generation 6 (G6) environment. A good background in systems planning, hardware and cabling infrastructure planning, and I/O definitions (HCD or IOCP) is assumed.

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