

INTERNATIONAL STANDARD

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First edition
2000-05

Information technology – Fibre Channel –

Part 131: Switch Fabric Requirements (FC-SW)



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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) together form a system for world-wide standardization as a whole. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other internal organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in this work.

In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1. Draft International Standards adopted by the joint technical committee are circulated to national bodies for approval before their acceptance as International Standards. They are approved in accordance with procedures requiring at least 75% approval by the national bodies voting.

International Standard ISO/IEC 14165-131 was prepared by Joint Technical Subcommittee ISO/IEC JTC 1, *Information Technology*, Subcommittee SC 25, *Interconnection of Information Technology Equipment*.

This part of ISO/IEC 14165 describes tools and algorithms for interconnection and initialization of Fibre Channel switches to create a multi-switch Fibre Channel Fabric.

ISO/IEC 14165 will consist of the following parts, under the general title *Information technology - Fibre Channel*

- Part 111: Physical and Signaling Interface (FC-PH)
- Part 112: Physical and Signaling Interface - Two (FC-PH-2)
- Part 122: Arbitrated Loop - 2 (FC-AL-2)
- Part 131: Switch Fabric Requirements (FC-SW)
- Part 141: Generic Fabric Requirements (FC-FG)
- Part 211: Mapping to HIPPI-FP (FC-FP)
- Part 222: Single-Byte Command Code Sets - 2 (FC-SB-2)
- Part 412: Generic Services -2 (FC-GS-2)

Annexes A through C are not integral part of ISO/IEC 14165-131, but are included for information only.

Introduction

This ISO/IEC standard for FC-SW specifies tools and algorithms for interconnection and initialization of Fibre Channel switches to create a multi-switch Fibre Channel Fabric. This Standard defines an E_Port ("Expansion Port") that operates in a manner similar to an N_Port and F_Port, as defined in ISO/IEC 14165-111, with additional functionality provided for interconnecting switches.

This standard describes the following:

- An overview of the Switched-based Fabric;
- The general behavior for all modes of the Switch Port;
- The services provided for use by the Switch Fabrics;
- Fabric Configuration process.

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Information Technology Fibre Channel

Part 131: Switch Fabric Requirements (FC-SW)

1 Scope

This ISO/IEC standard for FC-SW specifies tools and algorithms for interconnection and initialization of Fibre Channel switches to create a multi-switch Fibre Channel Fabric. This Standard defines an E_Port (“Expansion Port”) that operates in a manner similar to an N_Port and F_Port, as defined in ISO/IEC 14165-111, with additional functionality provided for interconnecting switches.

This Standard also defines how ports that are capable of being an E_Port, F_Port, and/or FL_Port may discover and self-configure for their appropriate operating mode. Once a port establishes that it is connected to another switch and is operating as an E_Port, an address assignment algorithm is executed to allocate port addresses throughout the Fabric.

This Standard does not define credit models and management between E_Ports for the various Classes of Service other than Class F. Broadcast and multicast services are not defined. E_Ports conforming to this Standard support Class F, and also Class 1, Class 2, and/or Class 3; support for other Classes of Service are not defined by this Standard. The method by which routing of frames is established and effected is not described.

2 Normative references

2.1 General Provisions

The following Standards contain provisions which, through reference in the text, constitute provisions of ISO/IEC 14165. At the time of publication, the editions indicated were valid. All Standards are subject to revision, and parties to agreements based on ISO/IEC 14165 are encouraged to investigate the possibility of applying the most recent editions of the Standards listed below. Members of IEC and ISO maintain registers of currently valid international standards.

2.2 Approved references

- [1] ISO/IEC 14165-111, *Information Technology - Fibre Channel Physical and Signaling Interface (FC-PH)*.
- [2] ISO/IEC 14165-112, *Information Technology - Fibre Channel - Physical and Signaling Interface-2 (FC-PH-2)*
- [3] ISO/IEC 14165-122, *Information Technology - Fibre Channel - Arbitrated Loop - 2 (FC-AL-2)*.
- [4] ISO/IEC 14165-412, *Information Technology - Fibre Channel - Generic Services - 2 (FC-GS-2)*.
- [5] ISO/IEC 14165-141, *Information Technology - Fibre Channel - Generic Fabric Requirements (FC-FG)*.

2.3 References under development

At the time of publication, the following referenced Standards were still under development. For information on the current status of the document, or regarding availability, contact the relevant Standards body or other organization as indicated.

- [6] ISO/IEC 14165-113, *Fibre Channel - Physical and Signaling Interface-3 (FC-PH-3)*

[7] ISO/IEC 14165-241, *Fibre Channel - Backbone (FC-BB)*

2.4 Other references

Profiles provided by the Fibre Channel Association (FCA) are available from the Fibre Channel Association (FCA), 12407 MoPac Expressway North 100-357, P. O. Box 9700, Austin, TX 78758-9700; (800) 272-4618 (phone); or via e-mail, FCA-Info@amcc.com.

[8] FCSI-101, *FCSI Common FC-PH Feature Sets Used in Multiple Profiles*, Rev 3.1

[9] *FCA N_Port to F_Port Interoperability Profile*, Rev 1.0

3 Definitions and conventions

3.1 Definitions

3.1.1

address assignment

a process whereby addresses are dispensed to Switches and Switch Ports.

3.1.2

address identifier

as defined in FC-PH (see reference [1]), an unsigned 24-bit address value used to uniquely identify the source (S_ID) and destination (D_ID) of Fibre Channel frames.

3.1.3

address Manager

a logical entity within a Switch which is responsible for address assignment.

3.1.4

area

as defined in FC-FG (see reference [5]), the second level in a three-level addressing hierarchy.

3.1.5

area Identifier

as defined in FC-FG (see reference [5]), bits 15 through 8 of an address identifier.

3.1.6

class F service

as defined in FC-FG (see reference [5]), a service which multiplexes frames at frame boundaries that is used for control and coordination of the internal behavior of the Fabric.

3.1.7

class N service

a generic reference to a Class 1, Class 2, or Class 3 service, as defined in FC-PH (see reference [1]).

3.1.8

domain

as defined in FC-FG (see reference [5]), the highest level in a three-level addressing hierarchy.

3.1.9

domain Address Manager

a Principal Switch which is responsible for address assignment to other Switches outside of its Domain.

3.1.10

domain Identifier

as defined in FC-FG (see reference [5]), bits 23 through 16 of an address identifier.

3.1.11**domain_ID_List**

a list in which each record contains a Domain_ID value and the Switch_Name of the Switch assigned the Domain_ID.

3.1.12**downstream Principal ISL**

from the point of view of the local Switch, the downstream Principal ISL is the Principal ISL to which frames may be sent from the Principal Switch to the destination Switch. All Principal ISLs on the Principal Switch are downstream Principal ISLs. A Switch that is not the Principal Switch may have zero or more downstream Principal ISLs.

3.1.13**E_Port**

as defined in FC-FG (see reference [5]), a Fabric "Expansion" Port which attaches to another E_Port to create an Inter-Switch Link.

3.1.14**E_Port Identifier**

an address identifier assigned to an E_Port.

3.1.15**E_Port_Name**

a Name_Identifier which identifies an E_Port for identification purposes. The format of the name is specified in FC-PH. Each E_Port shall provide a unique E_Port_Name within the Fabric.

3.1.16**Error_Detect_Timeout value**

a time constant defined in FC-PH. In this Standard, the recommended value of this time constant is 2 seconds.

3.1.17**F_Port**

as defined in FC-PH (see reference [1]). In this Standard, an F_Port is assumed to always refer to a port to which non-loop N_Ports are attached to a Fabric, and does not include FL_Ports.

3.1.18**Fabric**

As defined in FC-FG (see reference [5]), an entity which interconnects various Nx_Ports attached to it and is capable of routing frames using only the D_ID information in an FC-2 frame header.

3.1.19**Fabric Controller:**

1. as defined in FC-FG (see reference [5]), the logical entity responsible for operation of the Fabric. 2. the entity at the well-known address hex 'FF FF FD'.

3.1.20**Fabric Element**

1. As defined in FC-FG (see reference [5]), the smallest unit of a Fabric which meets the definition of a Fabric. From the point of view of an attached Nx_Port, a Fabric consisting of multiple Fabric Elements is indistinguishable from a Fabric consisting of a single Fabric Element.

3.1.21**Fabric F_Port**

the entity at the well-known address hex 'FF FF FE'. See reference [1].

3.1.22**FL_Port**

an L_Port which is able to perform the function of an F_Port, attached via a link to one or more NL_Ports in an Arbitrated Loop topology (see FC-AL). The AL_PA of an FL_Port is hex'00'. In this Standard, an FL_Port is assumed to always refer to a port to which NL_Ports are attached to a Fabric, and does not include F_Ports.

3.1.23

Fx_Port

a Switch Port capable of operating as an F_Port or FL_Port.

3.1.24

Fabric_Stability_Timeout value

a time constant used to detect inactivity during Fabric Configuration. The value of this time constant shall be 5 seconds.

3.1.25

Interject

as defined in FC-FG.

3.1.26

intermix

as defined in FC-FG.

3.1.27

Inter-Switch Link

a Link connecting the E_Port of one (local) Switch to the E_Port of another (remote) Switch.

3.1.28

Isolated

a condition in which it has been determined that no Class N traffic may be transmitted across an ISL.

3.1.29

L_Port

a port which contains Arbitrated Loop functions associated with the Arbitrated Loop topology.

3.1.30

Link

as defined in FC-PH.

3.1.31

local Switch

a Switch that can be reached without traversing any Inter-Switch Links.

3.1.32

loop Fabric Address

an address identifier used to address a loop for purposes of loop management.

3.1.33

N_Port

as defined in FC-PH (see reference [1]). In this Standard, an N_Port is assumed to always refer to a direct Fabric-attached port, and does not include NL_Ports.

3.1.34

N_Port Identifier

an address identifier assigned to an N_Port.

3.1.35

Name_Identifier

as defined in FC-PH (see reference [1]), a 64-bit identifier.

3.1.36

NL_Port

an L_Port which is able to perform the function of an N_Port, attached via a link to one or more NL_Ports and zero or more FL_Ports in an Arbitrated Loop topology. In this Standard, an NL_Port is assumed to always refer to a loop-attached port, and does not include N_Ports.

3.1.37**non-zero Domain_ID_List**

a Domain_ID_List which contains at least one record.

3.1.38**Nx_Port**

a Port operating as an N_Port or NL_Port.

3.1.39**path**

a route between a source and a destination.

3.1.40**path selection**

a process whereby a path between a source and one or more destinations is discovered.

3.1.41**port**

1. A generic reference to an N_Port, NL_Port, F_Port, FL_Port, or E_Port.

2. As defined in FC-FG (see reference [5]), the lowest level in a three-level addressing hierarchy.

3.1.42**Port Identifier**

as defined in FC-FG (see reference [5]), bits 7 through 0 of an address identifier.

3.1.43**port Mode**

a generic reference to E_Port, F_Port or FL_Port operation.

3.1.44**preferred Domain_ID**

a Domain_ID previously granted to a Switch by the Domain Address Manager.

3.1.45**principal ISL**

an Inter-Switch Link that is used to communicate with the Principal Switch.

3.1.46**principal Switch**

a Switch which has been selected to perform certain duties.

3.1.47**remote Switch**

a Switch that can be reached only by traversing one or more Inter-Switch Links.

3.1.48**Resource_Allocation_Timeout value**

a time constant defined in FC-PH. In this Standard, the recommended value of this time constant is 10 seconds.

3.1.49**router**

an entity within a Switch responsible for routing of Class 2 and Class 3 frames.

3.1.50**routing**

a process whereby the appropriate Switch Port(s) to deliver a Class 2 or Class 3 frame towards its destination is identified.

3.1.51

switch

1. A Fabric Element conforming to this Standard. 2. A member of the Fabric collective.

3.1.52

switch Construct

an entity within a Switch responsible for transporting frames between Switch Ports.

3.1.53

Switch_Name

a Name_Identifier which identifies a Switch for identification purposes. The format of the name is specified in FC-PH. Each Switch shall provide a unique Switch_Name within the Fabric.

3.1.54

switch Port

an E_Port, F_Port, or FL_Port.

3.1.55

Switch_Priority

a value used during Principal Switch selection to cause one Switch to be favored over another.

3.1.56

upstream Principal ISL

the upstream Principal ISL is the Principal ISL to which frames may be sent from the local Switch to the Principal Switch. A Switch that is not the Principal Switch always has exactly one upstream Principal ISL. The Principal Switch does not have an upstream Principal ISL.

3.1.57

zero Domain_ID_List

a Domain_ID_List which is empty.

3.2 Editorial conventions

In this Standard, a number of conditions, mechanisms, sequences, parameters, events, states, or similar terms that do not have their normal English meaning are printed with the following conventions:

- the first letter of each word in uppercase and the rest lowercase (e.g., Exchange, Class, etc.).
- a term consisting of multiple words, with the first letter of each word in uppercase and the rest lowercase, and each word separated from the other by an underscore (_) character. A word may consist of an acronym or abbreviation which would be printed in uppercase. (e.g., NL_Port, Transfer_Length, etc.).
- a term consisting of multiple words with all letters lowercase and each word separated from the other by a dash (-) character. A word may also consist of an acronym or abbreviation which would be printed in uppercase. (e.g., device-level, CUE-with-busy, etc.).

All terms and words not conforming to the conventions noted above have the normal technical English meanings.

Numbered items in this Standard do not represent any priority. Any priority is explicitly indicated.

In all of the figures, tables, and text of this Standard, the most significant bit of a binary quantity is the left side of the bit string. Exceptions to this convention are indicated in the appropriate sections.

The term “shall” is used to indicate a mandatory rule. If such a rule is not followed, the results are unpredictable unless indicated otherwise.

The fields or control bits which are not applicable shall be reset to zero.

If a field or a control bit in a frame is specified as not meaningful, the entity which receives the frame shall not check that field or control bit.

If a field or control bit is specified as reserved, it shall be filled with binary zeros by the source, and shall be ignored by the destination.

3.2.1 Binary notation

Binary notation may be used to represent some fields. Single bit fields are represented using the binary values 0 and 1. For multiple bit fields, the binary value is enclosed in single quotation marks followed by the letter b. For example, a four-byte Process_Associator field containing a binary value may be represented as '00000000 11111111 10011000 11111010'b.

3.2.2 Hexadecimal notation

Hexadecimal notation may be used to represent some fields. When this is done, the value is enclosed in single quotation marks and preceded by the word hex. For example, a four-byte Process_Associator field containing a binary value of '00000000 11111111 10011000 11111010'b is shown in hexadecimal format as hex'00 FF 98 FA'.

3.3 Abbreviations, acronyms, and symbols

Abbreviations and acronyms applicable to this International Standard are listed. Definitions of several of these items are included in 3.1. Abbreviations used that are not listed below are defined in FC-PH (see reference [1]).

3.3.1 Acronyms and abbreviations

Area_ID	Area Identifier
BLS	Basic Link Service
Domain_ID	Domain Identifier
E_D_TOV	Error_Detect_Timeout value
ELS	Extended Link Service
FAN	Fabric Address Notification Extended Link Service
FC-AL	Fibre Channel Arbitrated Loop
FC-AL-2	Fibre Channel Arbitrated Loop-2
FC-BB	Fibre Channel Backbone
FC-FG	Fibre Channel - Generic Fabric Requirements
FC-FLA	Fibre Channel - Fabric Loop Attachment
FC-GS-2	Fibre Channel - Generic Services-2
FC-PH	Fibre Channel Physical and Signaling Interface
FC-PH-2	Fibre Channel Physical and Signaling Interface-2
FC-PH-3	Fibre Channel Physical and Signaling Interface-3
F_S_TOV	Fabric_Stability_Timeout value
ISL	Inter-Switch Link
IU	Information Unit
LAN	Local Area Network
LFA	Loop Fabric Address
Port_ID	Port Identifier
R	Reserved
R_A_TOV	Resource_Allocation_Timeout value
SI	Sequence Initiative
SW_ACC	Switch Fabric Link Service Accept
SW_LS	Switch Fabric Link Service
SW_RJT	Switch Fabric Link Service Reject
ULP	Upper Level Protocol
WKA	Well-Known Address
WWN	World Wide Name

3.3.2 Symbol

Unless indicated otherwise, the following symbol has the listed meaning.

|| concatenation

4 Structure and Concepts

4.1 Fabric

A Fabric is a transport facility that provides switched interconnect between Nx_Ports. The general model of a Fibre Channel Fabric is defined in FC-FG, reference [5].

4.2 Switch

A Switch is the smallest entity that can function as a Switch-based Fibre Channel Fabric. Figure 1 illustrates the conceptual model of a Switch.

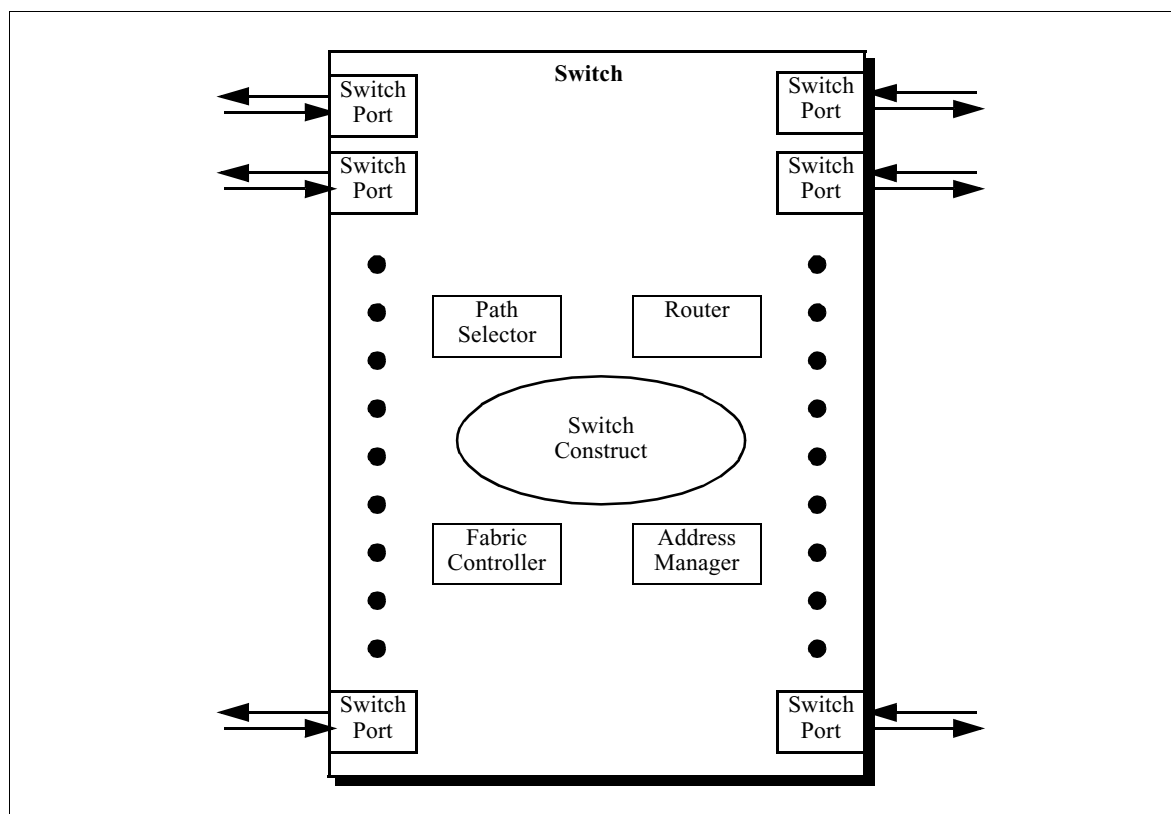


Figure 1 – Switch Model

A Switch is composed of the following major components:

- One or more Switch Ports;
- a Switch Construct, capable of either multiplexed frame switching or circuit switching, or both;
- an Address Manager;
- a Path Selector, which performs path selection;
- a Router;
- and a Fabric Controller.

A Switch Port may be either an E_Port, an F_Port, or an FL_Port. A Switch Port that is capable of assuming more than one of these roles is called a multi-function Switch Port. Once a Switch Port assumes a role, via the Switch Port Initialization Procedure, it shall remain in that role until an event occurs that causes re-initialization.

The Link joining a pair of E_Ports is called an Inter-Switch Link (ISL). E_Ports conforming to this Standard use FC-PH compliant media, coding and data rates to form an ISL.

ISLs carry frames originating from the Node Ports and those generated within the Fabric. The frames generated within the Fabric serve as control, management and support for the Fabric.

Switches may be joined freely or in a structured fashion to form a larger Fabric, as illustrated in Figure 2

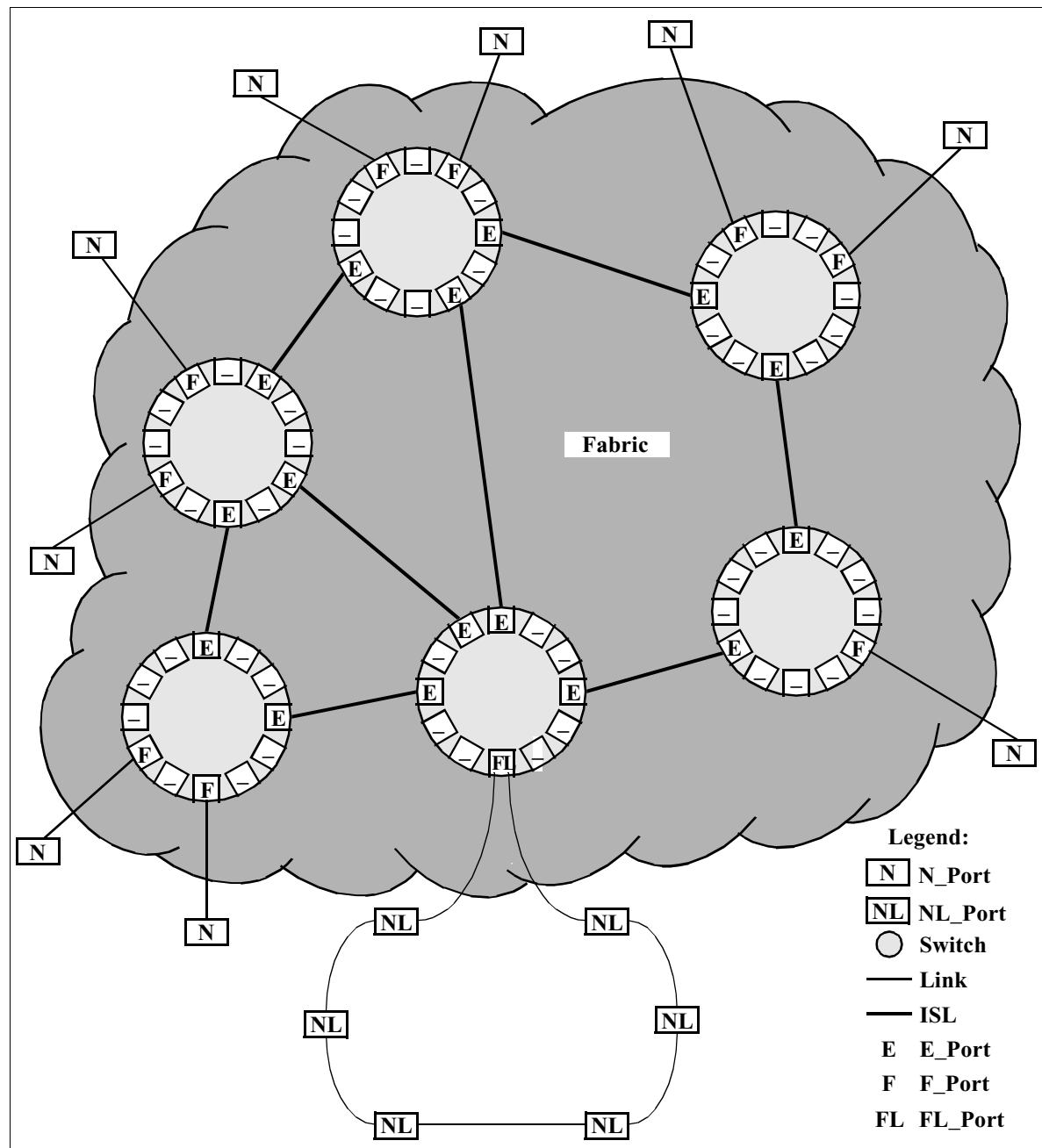


Figure 2 – Multiple Switch Fabric Example

The structure of the Switch Construct in the Switch, as seen in figure 1, is undefined and beyond the scope of this Standard. It may support either or both circuit switching and multiplexed frame switching. It may be non-blocking, allowing concurrent operation of all possible combinations or it may be blocking, restricting operations. The Switch Construct may also contain redundancy, as may be required for high availability configurations.

The Address Manager is responsible for the assignment of addresses within some portion of the Fabric. Within the Switch, the Address Manager is responsible for acquiring a Domain and Area for the Switch, and allocating Port_IDs within the Domain and Area.

The Path Selector is a logical entity that establishes frame routing paths.

The Router is a logical entity that performs the routing of Class 2 and Class 3 frames to their final destination.

The Fabric Controller is a logical entity that performs the management of the Switch. The Fabric Controller has the characteristics of an N_Port, though it may or may not be attached to the Fabric via a Link.

4.3 Switch Topologies

Switch topologies are defined in FC-FG, reference [5].

4.4 Switching characteristics

Path and circuit switching, and frame routing within a Switch may occur synchronously or asynchronously to the current word alignment of the outbound fibre.

Synchronous switching guarantees retention of the established word alignment on the outbound fibre of the Switch Port. Asynchronous switching does not guarantee retention of word alignment on the outbound fibre of the Switch Port.

A Switch may employ either synchronous or asynchronous switching or a combination of the two (e.g., a Switch may use synchronous switching for Class F, Class 2 and Class 3, and asynchronous switching for Class 1). However, a Switch shall never mix the two within a given Class of Service.

A switching event occurs every time a connectionless frame is transmitted and when a connection based service is established, suspended or terminated. Frame Intermixing and Interjecting also constitute switching events.

4.4.1 Synchronous switching

Synchronous switching associated with connectionless frame routing and connection oriented Dedicated Connections or virtual connection Services shall guarantee the word alignment on the outbound fibre.

Switches shall ensure that synchronous switching only occurs between frames. Switches should use synchronous switching in support of Class 2, Class 3 and Class F service.

4.4.2 Asynchronous switching

Asynchronous switching may be performed any time Fill Words are being transmitted. Bit alignment and word alignment may be lost when an asynchronous switching event occurs. A recovery time that allows the attached Port time to regain synchronization shall be inserted before frame transmission resumes for the outbound fibre. Fill Words shall be transmitted during this recovery time. If conditions arise warranting transmission of a Primitive Sequence, then this should take precedence over transmission of Fill Words.

If a Switch or Node Port recognizes that it is linked to a Switch which employ asynchronous switching, and a permissible word realignment event occurs, then the Port may discount any resulting errors, i.e. not log errors resulting from the realignment event.

4.5 Switch Ports

A Switch shall have three or more Switch Ports. A Switch equipped only with F_Ports or FL_Ports forms a non-expandable Fabric. To be part of an expandable Fabric, a Switch shall incorporate at least one Switch Port capable of E_Port operation.

A Switch Port supports one or more of the following Port Modes: E_Port, F_Port, FL_Port. A Switch Port that is capable of supporting more than one Port Mode attempts to configure itself first as an FL_Port (as defined in FC-AL), then as an E_Port (as defined in this Standard), and finally as an F_Port (as defined in FC-PH), depending on which of the three Port Modes are supported by the Switch Port.

The detailed procedure is described in 7.2.

4.5.1 F_Port

An F_Port is the point at which all frames originated by an N_Port enter the Fabric, and all frames destined for an N_Port exit the Fabric. An F_Port may also be the Fabric entry point for frames originated by an N_Port destined for an internal Fabric destination, such as the Fabric Controller. Similarly, an F_Port may also be the Fabric exit point for frames originated internal to the Fabric and destined for an N_Port. Frames shall not be communicated across a Link between an F_Port and anything other than an N_Port.

F_Ports are described in detail in 5.3.

4.5.2 FL_Port

An FL_Port is the point at which all frames originated by an NL_Port enter the Fabric, and all frames destined for an NL_Port exit the Fabric. An FL_Port may also be the Fabric entry point for frames originated by an NL_Port destined for an internal Fabric destination, such as the Fabric Controller. Similarly, an FL_Port may also be the Fabric exit point for frames originated internal to the Fabric and destined for an NL_Port. Frames shall not be communicated across a Link between an FL_Port and anything other than an NL_Port.

FL_Ports are described in detail in 5.4.

4.5.3 E_Port

An E_Port is the point at which frames pass between the Switches within the Fabric. Frames with a destination other than the local Switch or any N_Port or NL_Port attached to the local Switch exit the local Switch through an E_Port. Frames that enter a Switch via an E_Port are forwarded to a local destination, or are forwarded towards their ultimate destination via another E_Port. Frames shall not be communicated across a Link between an E_Port and anything other than an E_Port.

E_Ports are described in detail in 5.5.

4.6 Fabric Addressing

Switches use the address partitioning model described in FC-FG (Annex A), and as described below. The 24-bit address identifier is divided into three fields: Domain, Area, and Port, as shown in figure 3.

2	2	2	2	1	1	1	1	1	1	1	1	1											
3	2	1	0	9	8	7	6	5	4	3	2	1	0	9	8	7	6	5	4	3	2	1	0
Domain_ID								Area_ID								Port_ID							
Address Identifier																							

Figure 3 – Domain, Area, and Port Address Partitioning

A Domain is one or more Switches that have the same Domain_ID for all N_Ports and NL_Ports within or attached to those Switches, except for Well-Known Addresses. If there is more than one Switch in the Domain, any Switch within the Domain shall be directly connected via an ISL to at least one other Switch in the same Domain.

An Area_ID shall apply to either of the following:

- One or more N_Ports or E_Ports within and attached to a single Switch, except for Well-Known Addresses; or,
- an Arbitrated Loop of NL_Ports attached to a single FL_Port.

A single Arbitrated Loop shall have exactly one Area_ID.

A Port_ID shall apply to either of the following:

- a single N_Port or E_Port within a Domain/Area, except for Well-Known Addresses; or,
- the valid AL_PA of a single NL_Port or FL_Port on an Arbitrated Loop.

Address identifier values for this Standard are listed in table 1. Any value listed as Reserved is not meaningful within this Standard. Note also that some values defined below are different from the address allocations defined in Informative Annex A of FC-FG; these differences are noted in the table.

Table 1 – Address Identifier Values

Address Identifier (hex)			Description
Domain_ID	Area_ID	Port_ID	
00	00	00	Undefined (note 1)
00	00	AL_PA	E_Port: Reserved F_Port: Reserved FL_Port: Private Loop NL_Port (note 2)
00	00	non-AL_PA	Reserved
00	01 - FF	00 - FF	Reserved
01 - EF	00 - FF	00	E_Port: E_Port Identifier (note 4) F_Port: N_Port Identifier (note 4) FL_Port: Loop Fabric Address (note 3)
01 - EF	00 - FF	AL_PA	E_Port: E_Port Identifier (note 4) F_Port: N_Port Identifier (note 4) FL_Port: N_Port Identifier for Public Loop NL_Port (note 3)
01 - EF	00 - FF	non-AL_PA	E_Port: E_Port Identifier (note 4) F_Port: N_Port Identifier (note 4) FL_Port: Reserved
F0 - FE	00 - FF	00 - FF	Reserved
FF	00 - FA	00 - FF	Reserved
FF	FB	00 - FF	Reserved for Multicast Group_ID (note 5)
FF	FC	00	Reserved (note 5)
FF	FC	01 - EF	N_Port Identifier for Domain Controller (note 6)
FF	FC	F0 - FF	Reserved (note 5)
FF	FD - FE	00 - FF	Reserved (note 5)
FF	FF	00 - EF	Reserved (note 5)
FF	FF	F0 - FC	Well-Known Address (note 7)

Table 1 – Address Identifier Values

Address Identifier (hex)			Description
Domain_ID	Area_ID	Port_ID	
FF	FF	FD	N_Port Identifier for Fabric Controller (note 8)
FF	FF	FE	N_Port Identifier for Fabric F_Port
FF	FF	FF	Well-Known Address (note 7)
Notes: 1 This value is used by an N_Port requesting an address identifier during FLOGI. 2 See FC-AL for a definition of AL_PA and FC-FLA for a definition of Private Loop and FL_Port operation with Private Loop devices. In FC-FG, this range was reserved for other purposes. 3 See FC-FLA for the definition and use of Loop Fabric Address, and for a definition of Public Loop. 4 In FC-FG, the Area_ID range F0-FF was reserved for “Fabric Assisted Functions”, which were not defined in FC-FG. 5 In FC-FG, this range was reserved for other purposes. 6 A Domain Controller identifier may be used to address the Fabric Controller of a remote Switch that is not directly connected via an ISL to the originating Switch. The Port_ID field is set to the Domain_ID of the remote Switch. 7 The usage of Well-Known Addresses hex’FFFFFF0’ through hex’FFFFFFC’, and hex’FFFFFFF’, are not defined by this Standard. FC-PH defines or reserves these values for Well-Known Addresses. 8 This address identifier has special usage depending on the originator. If the originator is an attached external N_Port or NL_Port (attached via an F_Port or FL_Port) then the destination of a frame sent to hex’FFFFFFD’ is the Fabric Controller of the local Switch. If the originator is the Fabric Controller of the local Switch, then the destination of a frame sent to hex’FFFFFFD’ via an ISL is the Fabric Controller of the remote Switch at the other end of the ISL.			

4.7 Class F Service

Class F service is a connectionless service very similar to Class 2 that is used for internal control of the Fabric. Class F service as defined by this Standard differs in some ways from the definition in FC-FG. Class F service as used by this Standard is defined in 5.6.

4.8 Relationship Between this Standard and FC-FG

FC-FG defines the generic requirements for all Fabrics, independent of the specific type or topology. Many issues are appropriately left open for definition by later Fabric Standards specific to certain types and topologies.

In the process of defining the Switch Fabric, some items that were defined in FC-FG were found that required modification for use in this Standard.

In case where the items defined in this Standard conflict with those defined in FC-FG, the definitions of this Standard shall take precedence.

5 Switch Ports

5.1 General Model

Note that the models described below are defined for purposes of describing behavior. No implication is made as to whether the actual implementation of an element is in hardware or software. An element may be implemented on a per-Port basis, or may be a logical entity that is embodied in a single physical implementation shared by multiple ports.

A Switch Port may be able to operate in more than one mode, and configure itself to the appropriate mode during the initialization process (see 7.2). During initialization, the Switch Port can assume a mode for purposes of determining if that mode is appropriate. For example, a Switch Port operates in FL_Port mode to determine if it is attached to a loop of NL_Ports. If that is not successful, it then tries operating as an E_Port to see if another E_Port is attached. The Switch Port continues until it finds a mode in which to operate.

5.2 Model elements

Each Switch Port model described in this clause is made up of a set of elements. These elements are briefly defined below.

5.2.1 FC Transports

The FC-PH Transport includes all of the functionality described in FC-PH to construct and deconstruct a frame, to encode and decode the words that make up the frame, and to transmit and receive the frame on the physical media. The FC-AL Transport contains additional functionality to support the Arbitrated Loop protocols.

5.2.2 Switch Transport

The Switch Transport is an abstraction to show the “back end” of the Switch Port as it interacts with the Switch Construct and/or other Switch Ports within the Switch. The Switch Transport exists to move frames between the Switch Port and the rest of the Switch. No other implementation details are implied by this element.

5.2.3 Control Facilities

The Control Facilities are internal logical ports that receive and perform requests, and generate responses. Each Control Facility has associated with it an address identifier, and support for Classes of Service. The Control Facilities also manage the various Transport elements.

5.2.4 Link Services

The Link Services represent the various Link Services that are supported by the corresponding Control Facility.

5.3 F_Port Operation

An F_Port is the point at which an external N_Port is attached to the Fabric. It normally functions as a conduit to the Fabric for frames transmitted by the N_Port, and as a conduit from the Fabric for frames destined for the N_Port.

An F_Port shall support one or more of the following Classes of service: Class 1 service, Class 2 service, Class 3 service. An F_Port shall not intentionally transmit Class F frames on its outbound fibre.

NOTE – When a Class 1 Connection is ended, a Class F frame may be inadvertently transmitted by an F_Port. An N_Port that receives a Class F frame discards it, as required by FC-PH.

An F_Port shall not admit to the Fabric any Class F frames, any Primitive Sequences, or any Primitive Signals other than Idle, that the F_Port receives on its inbound fibre.

NOTE – Primitive Signals and Primitive Sequences are prohibited from entering the Fabric by FC-PH. For example, if an R_RDY was admitted to a Fabric, it could presumably propagate to another F_Port and be transmitted by that F_Port, disrupting credit on that Link.

5.3.1 Model

The model of an F_Port is shown in figure 4.

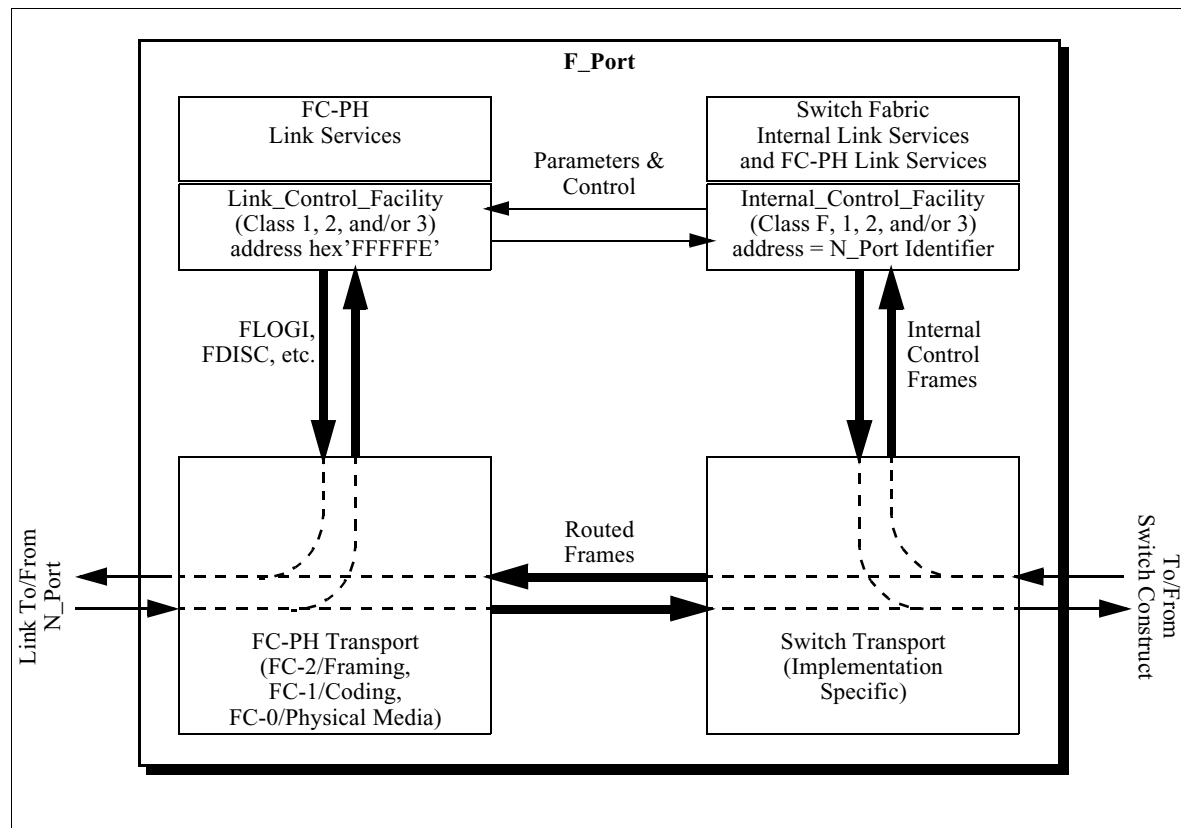


Figure 4 – F_Port Model

An F_Port contains an FC-PH Transport element through which passes all frames and Primitives transferred across the Link to and from the N_Port. Frames received from the N_Port are either directed to the Switch Transport element, or directed to the Link_Control_Facility. The Link_Control_Facility receives frames related to Link Services such as FLOGI, and transmits responses to those Link Service frames.

Frames received from the FC-PH Transport element that are destined for other ports are directed by the Switch Transport to the Switch Construct for further routing. Frames received from the Switch Construct by the Switch Transport are directed either to the FC-PH Transport for transmission to the N_Port, or to the Internal_Control_Facility. The Internal_Control_Facility receives frames related to Switch Fabric Internal Link Services, and transmits responses to those Internal Link Services frames. Information is passed between the Internal_Control_Facility and the Link_Control_Facility to effect the control and configuration of the Transport elements.

5.3.2 Link Behavior

The F_Port Link is used by Switches to transmit and receive frames with a single Node. A Link to an F_Port always connects to exactly one N_Port.

An F_Port Link follows the FC-0, FC-1, and FC-2 protocols defined for point-to-point Links as defined in FC-PH.

5.4 FL_Port Operation

An FL_Port is the point at which one or more external NL_Ports are attached to the Fabric. It normally functions as a conduit to the Fabric for frames transmitted by the attached NL_Ports, and as a conduit from the Fabric for frames destined for the attached NL_Ports.

An FL_Port shall support one or more of the following Classes of service: Class 1 service, Class 2 service, Class 3 service. An FL_Port shall not intentionally transmit Class F frames on its outbound fibre. An FL_Port shall not admit to the Fabric any Class F frames, any Primitive Sequences, or any Primitive Signals other than Idle, that the FL_Port receives on its inbound fibre.

An FL_Port that conforms to this Standard shall conform to the FL_Port requirements defined in FC-FLA.

5.4.1 Model

The model of an FL_Port is shown in figure 5.

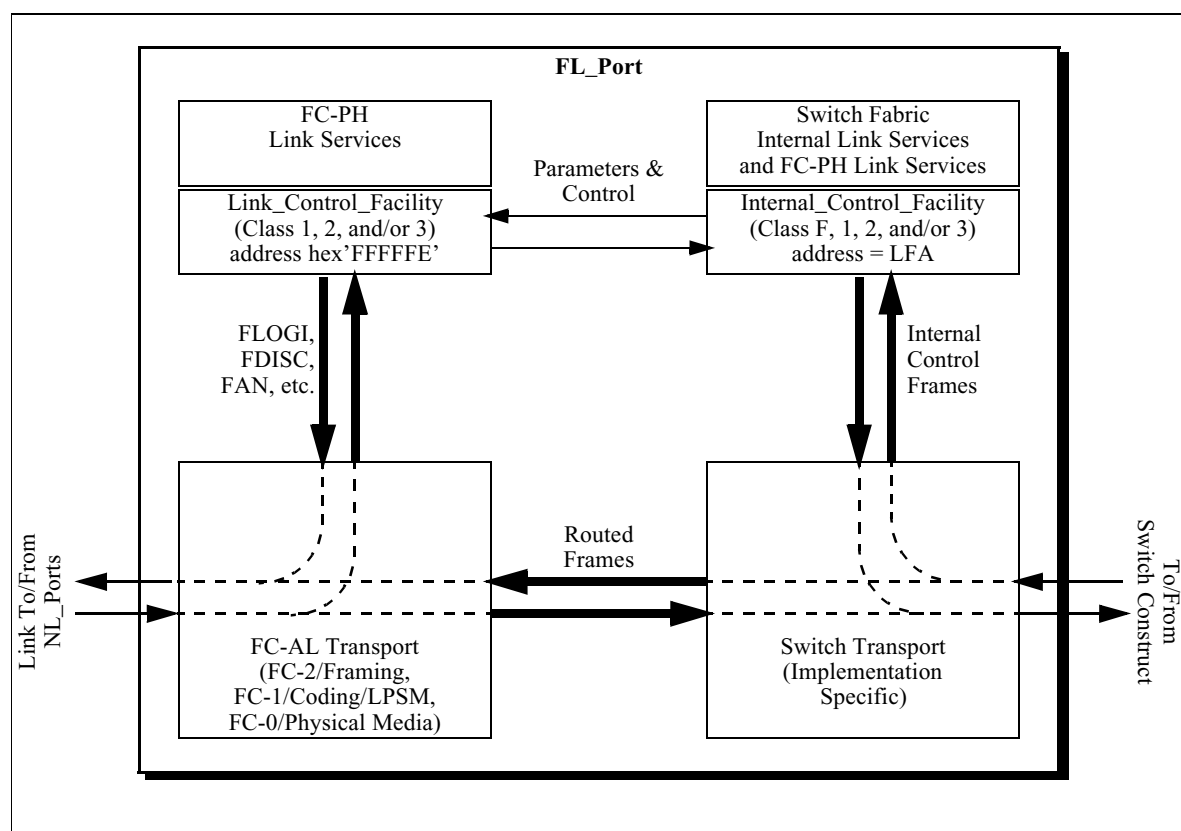


Figure 5 – FL_Port Model

An FL_Port contains an FC-AL Transport element through which passes all frames and Primitives transferred across the Link to and from the multiple NL_Ports. Frames received from the NL_Ports are either directed to the Switch Construct via the Switch Transport element, or directed to the Link_Control_Facility. The Link_Control_Facility receives frames related to Link Services such as FLOGI, and transmits responses to those Link Service frames. The Link_Control_Facility also transmits and receives Loop Initialization Sequences and transmits the FAN ELS.

Frames received from the FC-AL Transport element that are destined for other ports are directed by the Switch Transport to the Switch Construct for further routing. Frames received from the Switch Construct by the Switch Transport are directed either to the FC-AL Transport for transmission to the destination NL_Port, or to the Internal_Control_Facility. The Internal_Control_Facility receives frames related to Switch Fabric Internal Link Services and Loop management Extended Link Services (see FC-FLA), and transmits responses to those Link Services frames. Information is passed between the Internal_Control_Facility and the Link_Control_Facility to effect the control and configuration of the Transport elements.

5.4.2 Link Behavior

The FL_Port Link is used by Switches to transmit and receive frames with multiple Nodes. A Link to an FL_Port connects to one or more NL_Ports.

An FL_Port Link follows the FC-0, FC-1, and FC-2 protocols defined in FC-PH, with the additional Arbitrated Loop protocols defined in FC-AL.

5.5 E_Port Operation

An E_Port is the point at which a Switch is connected to another Switch to create a Fabric. It normally functions as a conduit between the Switches for frames destined for remote N_Ports and NL_Ports. An E_Port is also used to carry frames between Switches for purposes of configuring and maintaining the Fabric.

An E_Port shall support the Class F service. An E_Port shall also be capable of routing one or more of the following Classes of service: Class 1 service, Class 2 service, Class 3 service. An E_Port shall not admit to the Fabric any Primitive Sequences, or any Primitive Signals other than Idle, that the E_Port receives on its inbound fibre.

5.5.1 Model

The model of an E_Port is shown in figure 6.

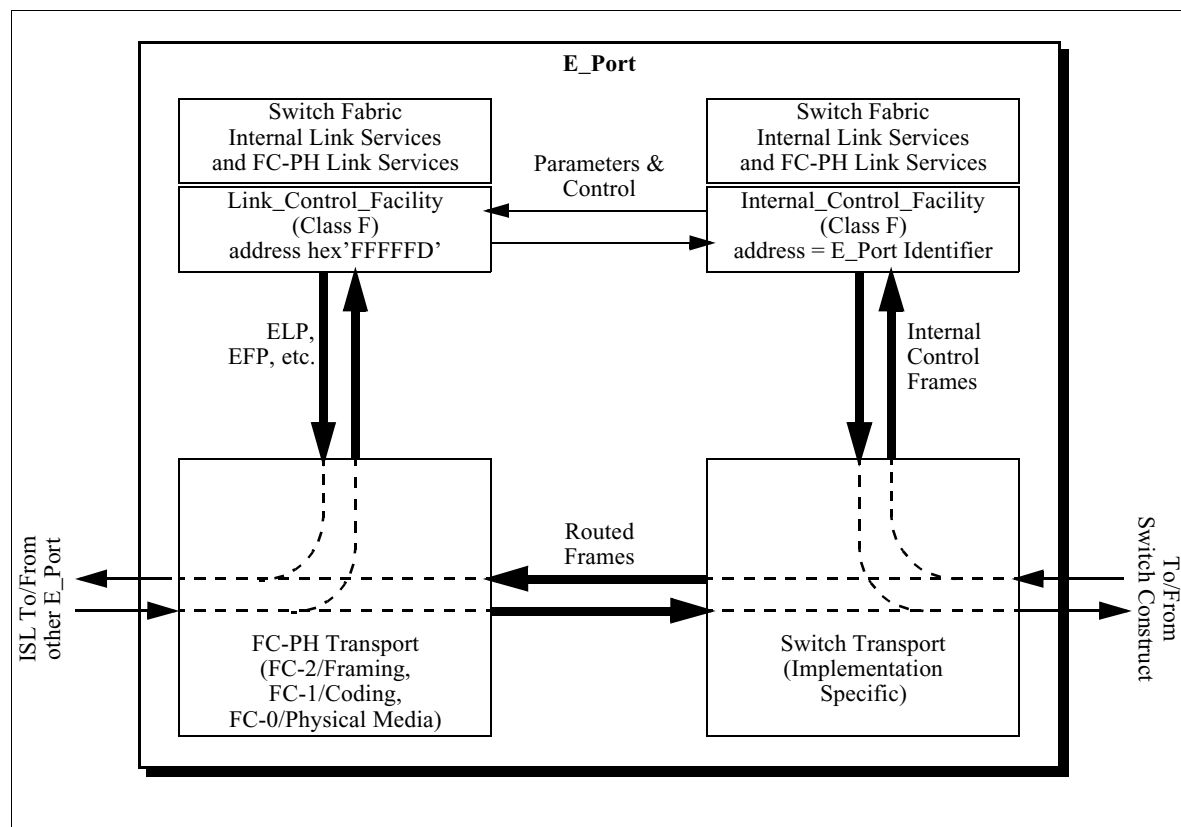


Figure 6 – E_Port Model

An E_Port contains an FC-PH Transport element through which passes all frames and Primitives transferred across the Link to and from the other E_Port. Frames received from the other E_Port are either directed to the Switch Construct via the Switch Transport element, or directed to the Link_Control_Facility. The Link_Control_Facility receives frames related to Switch Fabric Internal Link Services such as ELP, and transmits responses to those Link Service frames.

Frames received from the FC-PH Transport element that are destined for other ports are directed by the Switch Transport to the Switch Construct for further routing. Frames received from the Switch Construct by the Switch Transport are directed either to the FC-PH Transport for transmission to the other E_Port, or to the Internal_Control_Facility. The Internal_Control_Facility receives frames related to Switch Fabric Internal

Link Services, and transmits responses to those Internal Link Services frames. Information is passed between the Internal_Control_Facility and the Link_Control_Facility to effect the control and configuration of the Transport elements.

5.5.2 Inter-Switch Link Behavior

Inter-Switch Links (ISLs) are used by Switches to transmit and receive frames with other Switches. An ISL always connects exactly one E_Port on a Switch to exactly one E_Port on another Switch.

An ISL follows the FC-0, FC-1, and FC-2 protocols defined for point-to-point Links as defined in FC-PH, with the exception that Class F frames are allowed to transit the Link, as defined in FC-FG. The use of R_RDY shall be restricted to the management of buffer-to-buffer flow control of Class F frames on the ISL prior to the completion of the exchange of Link parameters (see 6.1.3 and 7.2); an alternate method of buffer-to-buffer flow control may be defined in that process. Flow control of Class N frames shall be managed by other means not defined in this Standard.

NOTE – It is expected that the various flow control models will be defined by a future standard.

For purposes of defining and maintaining the Fabric Configuration, an ISL may be designated as a Principal ISL. The Principal ISL is a path that is used during configuration and address assignment to route Class F configuration frames, and is therefore a known path between two Switches. If a Principal ISL is lost, there may be no other available paths between the two affected Switches, so as a result the Fabric Configuration is possibly broken and must be rebuilt (by issuing the BF SW_ILS, see 6.1.7). If a non-Principal ISL is lost, at least one other path is known to be available between the Switches (i.e., the Principal ISL), therefore the lost ISL can be resolved via a routing change.

A Switch discovers the Principal ISL(s) during the process of Principal Switch Selection (see 7.3) and Address Distribution (see 7.4). During this process, the Switch identifies two kinds of Principal ISL. The Principal ISL that leads towards the Principal Switch is called the upstream Principal ISL. All frames from the Switch to the Principal Switch are sent via the upstream Principal ISL. The Principal Switch has no upstream Principal ISL; all other Switches have exactly one upstream Principal ISL.

A Principal ISL that leads away from the Principal Switch is called the downstream Principal ISL. Any frame sent by the Switch to another Switch as a result of a frame received on the upstream Principal ISL is sent via the downstream Principal ISL that leads towards that Switch. The Principal Switch may have one or more downstream Principal ISLs; all other Switches may have zero or more downstream Principal ISLs.

Principal ISLs are further illustrated in figure 7.

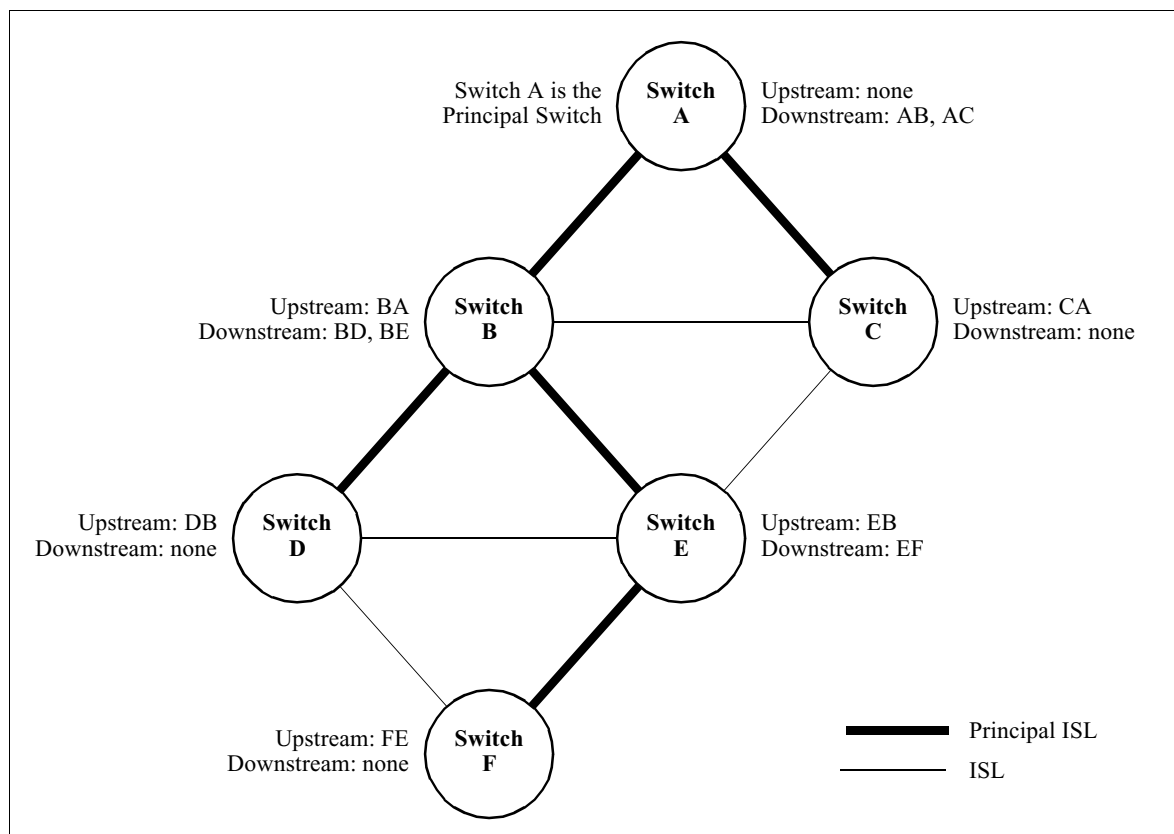


Figure 7 – Principal Inter-Switch Links

5.6 Class F Service

Class F Service is a connectionless service with notification of non-delivery between E_Ports, used for control, coordination, and configuration of the Fabric. Class F Service is defined by this Standard for use by Switches communicating across Inter-Switch Links. This definition of Class F for Inter-Switch Links supersedes the definitions of Class F for Inter-Element Links in FC-FG.

5.6.1 Class F Function

A Class F Service is requested by an E_Port on a frame by frame basis. The Fabric routes the frame to the destination E_Port. If the E_Port transmits consecutive frames to multiple destinations, the Fabric demultiplexes them to the requested destinations. Class F delimiters are used to indicate the requested service and to initiate and terminate one or more Sequences as described in FC-PH.

5.6.2 Class F Rules

To provide Class F Service, the transmitting and receiving E_Ports and the Fabric shall obey the following rules:

- Except for some Switch Fabric Internal Link Service protocols, an E_Port is required to have exchanged Link parameters (see 6.1.3 and 7.2) with the associated destination with which it intends to communicate (**Login**).
- The Fabric routes the frames without establishing a Dedicated Connection between communicating E_Ports. To obtain Class F service, the E_Port shall use Class F delimiters as defined in 5.6.3. (**Connectionless service**)
- An E_Port is allowed to send consecutive frames to one or more destinations. This enables an E_Port to demultiplex multiple Sequences to a single or multiple destinations concurrently. (**demultiplexing**)
- A given E_Port may receive consecutive frames from different sources. Each source is allowed to send consecutive frames for one or more Sequences. (**multiplexing**)