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X3T11/Project 958-D/Rev 3.5

FIBRE CHANNEL

FABRIC GENERIC REQUIREMENTS (FC-FG)

REV 3.5

working draft proposed
American National Standard
for Information Systems

August 7, 1996

Secretariat:
Information Technology Industry Council

ABSTRACT:
This standard describes the minimum requirements for a topology independent interconnecting Fabric to support the ANSI X3.230-1994, Fibre Channel – Physical and Signaling Interface (FC-PH).

NOTE:

This is a draft proposed American National Standard of Accredited Standards Committee X3. As such, this is not a completed standard. The X3T11 Technical Committee may modify this document as a result of comments received during public review and its approval as a standard.

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for Information Technology—

Fibre Channel —
Fabric Generic Requirements (FC-FG)

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Abstract

This standard describes the minimum requirements for a topology independent interconnecting Fabric to support the ANSI X3.230-1994, Fibre Channel – Physical and Signaling Interface (FC-PH).

American National Standard

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Foreword (This Foreword is not part of ANSI X3.289-199x.)

This document presents requirements for Fabrics supporting ANSI X3.230, the Fibre Channel Physical and Signaling Interface (FC-PH) standard, that are independent of specific Fabric topologies. ANSI X3.230, FC-PH, describes the point-to-point physical interface, transmission protocol, and signaling protocol of a high-performance serial link for support of the higher level protocols associated with HIPPI, IPI, SCSI, IP and others.

This standard was developed by Task Group X3T11 of Accredited Standards Committee X3 brginning in 1992. The standards approval process started in 1995. This standard includes an annex, which is informative, that is not considered part of the standard.

Requests for interpretation, suggestions for improvement or addenda, or defect reports are welcome. They should be sent to the X3 Secretariat, Information Technology Industry Council, 1250 Eye Street, NW, Suite 200, Washington, DC 20005.

This standard was processed and approved for submittal to ANSI by Accredited Standard Committee on Information Processing Systems, X3. Committee approval of the standard does not necessarily imply that all committee members voted for approval. At the time it approved this standard, the X3 Committee had the following members:

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NOTE: The developers of this standard have requested that holders of patents that may be required for the implementation of the standard, disclose such patents to the publisher. However neither the developers nor the publisher have undertaken a patent search in order to identify which if any patents may apply to this standard. No position is taken with respect to the validity of any claim or any patent rights that may have been disclosed. Details may be obtained from the publisher concerning any statement of patents and willingness to grant a license on a nondiscriminatory basis and with reasonable terms and conditions to applicants desiring to obtain such a license.

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Introduction

The Fibre Channel provides a general transport vehicle for Upper Level Protocols (ULPs) such as Intelligent Peripheral Interface (IPI) and Small Computer System Interface (SCSI) command sets, the High-Performance Parallel Interface (HIPPI) data framing, IP (Internet Protocol), ANSI/IEEE 802.2, and others. Proprietary and other command sets may also use and share the Fibre Channel, but such use is not defined as part of the Fibre Channel standard. Other usages such as local area network protocols and backbone configurations have been considered.

The Fibre Channel standard is organized in the following levels:

- FC-0 defines the physical portions of the Fibre Channel including the fiber, connectors, and optical and electrical parameters for a variety of data rates and physical media. Coax and twisted pair versions are defined for limited distance applications. FC-0 provides the point-to-point physical portion of the Fibre Channel. A variety of physical media is supported to address variations in cable plants.

- FC-1 defines the transmission protocol which includes the serial encoding, decoding, and error control.

- FC-2 defines the signaling protocol which includes the frame structure and byte sequences.

- FC-3 defines a set of services which are common across multiple ports of a node.

- FC-4 is the highest level in the Fibre Channel standards set. It defines the mapping between the lower levels of the Fibre Channel and the IPI and SCSI command sets, the HIPPI data framing, IP, and other Upper Level Protocols (ULPs).

Of these levels, FC-0, FC-1, and FC-2 are integrated into the ANSI X3.230, FC-PH document. The Fibre Channel protocol provides a range of implementation possibilities extending from minimum cost to maximum performance. The transmission medium is isolated from the control protocol so that each implementation may use a technology best suited to the environment of use.

This document, ANSI X3.289, FC-FG, describes the generic requirements placed on Fabrics which support the Fibre Channel standard.

Figure 1 shows the relationship of this American National Standard (the highlighted rectangle) with other Fibre Channel standards and draft proposed standards. ANSI X3.297, FC-PH-2 specifies enhanced functions added to ANSI X3.230, FC-PH. ANSI X3.289, FC-FG and FC-SW are related to Fabric requirements. ANSI X3.272, FC-AL specifies the arbitrated loop topology. ANSI X3.288, FC-GS is related to Generic Fibre Channel Services. FC-IG provides some implementation guidance. ANSI X3.271, FC-SB; ANSI X3.254, FC-FP; ANSI X3.287, FC-LE; FC-ATM; ANSI X3.291, IPI-3 Disk revision; ANSI X3.290, IPI-3 Tape revision and SCSI-FCP are FC-4 standards.

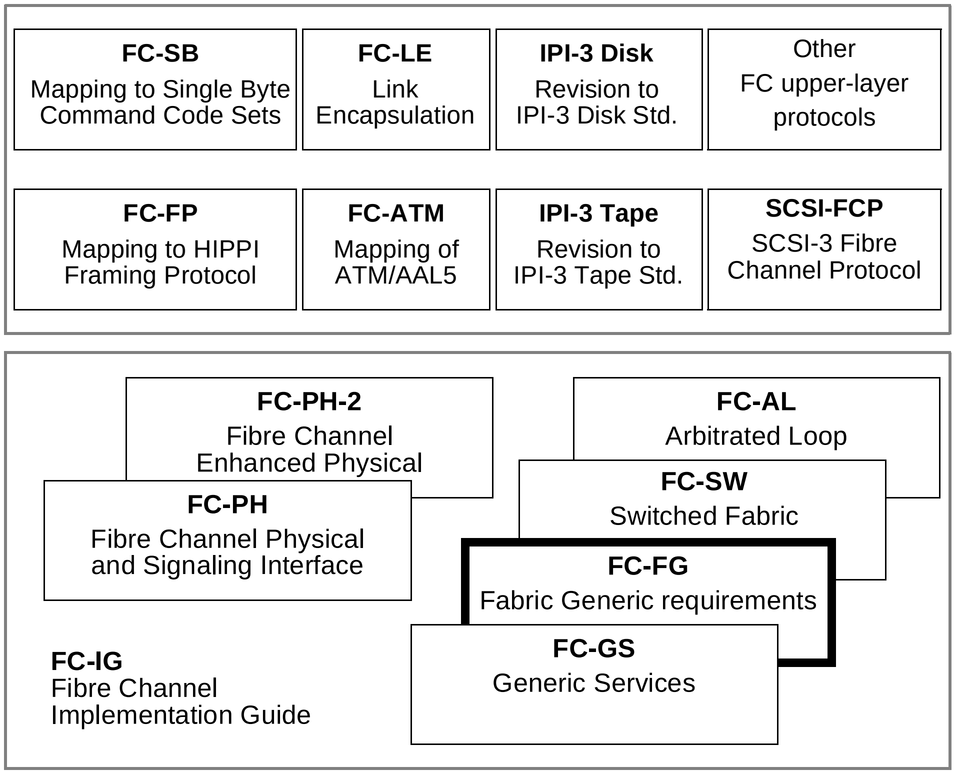

Figure 1 – Document relationship

draft proposed American National Standard for Information Technology—

Fibre Channel — Fabric Generic Requirements (FC-FG)

1 Scope and purpose

1.1 Scope

This standard describes generic requirements for a communications transport medium called the Fabric, an entity that provides switched interconnect between pairs of user attachment points. Fabrics may be implemented using one or more topologies and this document describes requirements that are generic across all topologies.

A companion document, ANSI X3.230, *Fibre Channel - Physical and Signaling Interface (FC-PH)*, describes the physical interface, transmission protocol, and signaling protocol of high-performance serial links which attach user nodes to the Fabric. The Fabric serves to extend these serial links between pairs of attachment points. ANSI X3.230, FC-PH also describes features and behaviors of the Fabric required by user nodes.

1.2 Purpose

The purpose of this standard is to promote the development and use of Fabrics compatible with the Fibre Channel standard.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed below.

Copies of the following documents can be obtained from ANSI: Approved ANSI standards, approved and draft international and regional standards (ISO, IEC, CEN/CENELEC, ITUT), and approved and draft foreign standards (including BSI, JIS, and DIN). For further information, contact ANSI Customer Service Department at 212-642-4900 (phone), 212-302-1286 (fax) or via the World Wide Web at http://www.ansi.org.

2.1 Approved references

ANSI X3.230-1994, *Fibre Channel–Physical and Signaling Interface (FC-PH)*.

ANSI X3.272-1996, *Fibre Channel--Arbitrated Loop (FC-AL).*

2.2 References under development

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

ANSI X3.288-199x, *Fibre Channel–Generic Services (FC-GS)*[1].

ANSI X3.297-199x, *Fibre Channel–Physical and Signaling Interface-2 (FC-PH-2)*[1].

3 Definitions and conventions

For the purpose of ANSI X3.289, FC-FG, the following definitions, conventions, abbreviations, and acronyms apply.

3.1 Definitions

3.1.1 address identifier: An address value used to identify source (S_ID) or destination (D_ID) of a frame.

3.1.2 alias address identifier (alias): One or more address identifiers which may be recognized by an N_Port in addition to its N_Port Identifier. An alias address identifier is Fabric unique and may be common to multiple N_Ports.

3.1.3 Arbitrated Loop topology: A configuration that allows multiple ports to be connected serially (see ANSI X3.272, FC-AL).

3.1.4 Area: The second hierarchical level in the three-level addressing hierarchy.

3.1.5 bandwidth: Maximum effective transfer rate for a given set of physical variants such as communication model, Payload size, Fibre speed, and overhead specified by FC-PH (see 4.7 and annex M of ANSI X3.230, FC-PH).

3.1.6 Broadcast: A simplified Multicast service in which all available destinations are implicitly registered (see 31.5 of ANSI X3.297, FC-PH-2).

3.1.7 Broadcast Alias_ID: The address of the logical entity within the Fabric that provides a Broadcast service.

3.1.8 circuit: A bidirectional path within the Fabric.

3.1.9 Class 1 service: A service which establishes a Dedicated Connection between communicating N_Ports.

3.1.10 Class 2 service: A service which multiplexes frames at frame boundaries to or from one or more N_Ports with acknowledgment provided.

3.1.11 Class 3 service: A service which multiplexes frames at frame boundaries to or from one or more N_Ports without acknowledgment.

3.1.12 Class 4 service: A service that establishes Virtual Connections to provide fractional bandwidth service between communicating N_Ports. The service multiplexes frames at frame boundaries to or from one or more N_Ports with acknowledgment provided.

3.1.13 Class F service: A service which multiplexes frames at frame boundaries that is used for control and coordination of the internal behavior of the Fabric.

3.1.14 Classes of service: Different types of services provided by the Fabric and used by the communicating N_Ports.

3.1.15 Connection Initiator: The source N_Port which initiates a Class 1 Connection with a destination N_Port through a connect-request and also receives a valid response from the destination N_Port to complete the Connection establishment.

3.1.16 Connection Recipient: The destination N_Port which receives a Class 1 connect-request from the Connection Initiator and accepts establishment of the Connection by transmitting a valid response.

3.1.17 Connectionless service: Communication between two N_Ports performed without a Dedicated Connection.

3.1.18 Dedicated Connection: A communicating circuit guaranteed and retained by the Fabric for two given N_Ports.

[1] For information about obtaining copies of this document or for more information on the current status of the document, contact the X3 Secretariat at http://www.x3.org or 202-626-5783.

3.1.19 destination F_Port: The F_Port which is directly connected through a link to a destination N_Port.

3.1.20 Destination_Identifier (D_ID): The address identifier used to indicate the targeted destination of the transmitted frame.

3.1.21 destination N_Port: The N_Port to which a frame is targeted.

3.1.22 disconnection: The process of removing a Dedicated Connection between two N_Ports.

3.1.23 Distributed_Fabric_Element (DFE): A Fabric Element with a 1-to-n tree-like topology.

3.1.24 Domain: The highest or most significant hierarchical level in the three-level addressing hierarchy.

3.1.25 E_Port: A Fabric Inter-Element Port used to establish Inter-Element Links (IEL).

3.1.26 Element Controller: A logical entity which is that portion of the Fabric Controller that manages a Fabric Element.

3.1.27 Element_Name: A Name_Identifier associated with a Fabric Element.

3.1.28 Exclusive Connection: A Class 1 Dedicated Connection without Intermix.

3.1.29 Extended Region: A section of two or more Sub-Fabrics with compatible service parameters forming an extended communication group.

3.1.30 F_Port: The Link_Control_Facility within the Fabric which attaches to an N_Port through a link. An F_Port is addressable by the N_Port attached to it, with a common well-known address identifier (hex 'FFFFFE').

3.1.31 F_Port Name: A Name_Identifier associated with an F_Port.

3.1.32 Fabric: The entity which interconnects various N_Ports attached to it and is capable of routing frames by using only the D_ID information in a FC-2 frame header.

3.1.33 Fabric Controller: The logical entity responsible for operation of the Fabric.

3.1.34 Fabric Element: A Fabric Element is the smallest unit of a Fabric which meets the definition of a Fabric. A Fabric may consist of one or more Fabric Elements, interconnected E_Port to E_Port in a cascaded fashion, each with its own Fabric controller. To the attached N_Ports, a Fabric consisting of multiple Fabric Elements is indistinguishable from a Fabric consisting of a single Fabric Element.

3.1.35 Fabric Name: A Name_Identifier associated with a Fabric.

3.1.36 Fabric_Port: A generic reference to an E_Port, F_Port, FL_Port, G_Port, or GL_Port.

3.1.37 FL_Port: An F_Port that contains Arbitrated Loop functions associated with Arbitrated Loop topology.

3.1.38 G_Port: A generic Fabric_Port that can function either as an E_Port or as an F_Port.

3.1.39 GL_Port: A generic Fabric_Port that can function either as an E_Port or as an FL_Port.

3.1.40 Identified N_Port: An N_Port which has been assigned an N_Port identifier by the initialization procedure.

3.1.41 Inter-Element Link (IEL): A link connecting the E_Port of one Fabric Element to the E_Port of another Fabric Element.

3.1.42 Interject: A service that interleaves Class F frames on an established Class 1 Connection within the Fabric.

3.1.43 Intermix: A service that interleaves Class 2 and Class 3 frames on an established Class 1 Connection.

3.1.44 L_Port: A generic reference to an FL_Port, a GL_Port, or an NL_Port.

3.1.45 link: Two unidirectional fibers transmitting in opposite directions and their associated transmitters and receivers.

3.1.46 Link_Control_Facility: A link hardware facility which attaches to an end of a link and manages transmission and reception of data. It is contained within each Port type.

3.1.47 local F_Port: The F_Port to which an N_Port is directly attached by a link (see remote F_Port).

3.1.48 Login: The generic name for a procedure that exchanges link level or end-to-end service parameters.

3.1.49 N_Port: A hardware entity which includes a Link_Control_Facility. It may act as an Originator, a Responder, or both.

3.1.50 N_Port Identifier: A Fabric unique address identifier by which an N_Port is uniquely known. The identifier may be assigned by the Fabric during the initialization procedure. The identifier may also be assigned by other procedures not defined in FC-PH. The identifier is used in the S_ID and D_ID fields of a frame.

3.1.51 Name_Identifier: A 64 bit identifier, with a 60 bit value preceded with a four bit Network_Address_Authority_Identifier, used to identify physical entities in Fibre Channel such as N_Port, Node, F_Port, or Fabric.

3.1.52 Network_Address_Authority (NAA): An organization such as CCITT or IEEE which administers network addresses.

3.1.53 Network_Address_Authority Identifier: A four bit identifier defined in FC-PH to indicate a Network_Address_Authority (NAA).

3.1.54 NL_Port: An N_Port that contains Arbitrated Loop functions associated with Arbitrated Loop topology.

3.1.55 Node: A collection of one or more N_Ports controlled by a level above FC-2.

3.1.56 Originator: The logical function associated with an N_Port responsible for originating an Exchange.

3.1.57 Payload: Contents of the Data Field of a frame, excluding Optional Headers and fill bytes, if present.

3.1.58 Port: A generic reference to an E_Port, F_Port, G_Port, N_Port or S_Port.

3.1.59 Port_Name: A Name_Identifier associated with a Port.

3.1.60 Region: A section of a Sub-Fabric with compatible service parameters in which all ports can communicate.

3.1.61 remote F_Port: The F_Port to which the other communicating N_Port is directly attached (see local F_Port).

3.1.62 Responder: The logical function in an N_Port responsible for supporting the Exchange initiated by the Originator in another N_Port.

3.1.63 S_Port: A Fabric internal service node that functions both as a Fabric_Port and as an N_Port.

3.1.64 source F_Port: The F_Port which is directly connected through a link to a source N_Port.

3.1.65 Source_Identifier (S_ID): The address identifier used to indicate the source Port of the transmitted frame.

3.1.66 source N_Port: The N_Port from which a frame is transmitted.

3.1.67 Sub-Fabric: The set of ports and services in a Fabric uniquely identified by one data rate and one Class of service.

3.1.68 Translator: An agent within a Fabric that performs conversions for data rate and Class of service.

3.1.69 Unidentified N_Port: An N_Port which has not yet had its N_Port identifier assigned by the initialization procedure.

3.1.70 Virtual Connection (VC): A unidirectional path between two communicating N_Ports that permits fractional bandwidth services to be used. Two Virtual Connections are required to form a Class 4 connection.

3.1.71 well-known addresses: A set of address identifiers defined in FC-PH to access global server functions such as a Directory server.

3.1.72 Zone: A non-exclusive administrative partition of a Region or an Extended Region.

3.2 Editorial conventions

In ANSI X3.289, FC-FG, a number of conditions, mechanisms, sequences, parameters, events, states, or similar terms are printed with the first letter of each word in uppercase and the rest lowercase (e.g., Fabric, Class). Any lowercase uses of these words have the normal technical English meanings.

Numbered items in ANSI X3.289, FC-FG do not represent any priority. Priority is explicitly indicated.

In case of any conflict between figure, table, and text, the text takes precedence. Exceptions to this convention are indicated in the appropriate sections.

In all of the figures, tables, and text of this document, the most significant bit of a binary quantity is shown on the left side. 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.

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.

3.3 Abbreviations and acronyms

Abbreviations and acronyms applicable to this standard are listed. Definitions of several of these items are included in 3.1”Definitions”.

ACC	Accept
ACK	Acknowledgment
alias	alias address identifier
Credit_CNT	Credit count
D_ID	Destination_identifier
E_D_TOV	Error Detect_Timeout value
E_Port	Fabric Expansion port
F_BSY	F_Port busy
F_Port	Fabric N_Port attachment port
F_RJT	F_Port reject
FL_Port	Fabric Loop Port
G_Port	Generic E_Port/F_Port
GL_Port	Generic Fabric/Loop Port
IEL	Inter-Element Link
IELOGI	Inter-Element Login
L_Port	Generic Loop Port
LA_RJT	Link Application Reject
N_Port	Node Port
NL_Port	Node Loop Port
OLS	Offline Primitive Sequence
P_RJT	N_Port reject
QoSF	Quality of Service Facilitator - Class 4
R_A_TOV	Resource_Allocation_Timeout value
RJT	generic F_RJT, P_RJT
S_ID	Source_Identifier
S_Port	Fabric service node
VC	Virtual Connection

4 Fabric concepts

4.1 Fabric and Fabric Elements

The Fabric is a transport medium that provides switched interconnect between multiple link attachment points called N_Ports. The extent of the Fabric is limited to those Ports that can be addressed by unique values of the 24-bit Port Identifier.

NOTE – In the Fibre Channel context, fabric written with a lower-case ‘f’ embraces the interconnect of any ports within the 24-bit address space; Fabric written with a capital ‘F’ describes topologies distinct from Point-to-point topology and Arbitrated Loop topology (see 4.8 of ANSI X3.230, FC-PH). This document describes the Fabric of FC-PH.

A Fabric may be composed of one or more Fabric Elements as illustrated in figure 2. The link attachment point between the Fabric Element and an N_Port is called the F_Port. The link attachment point between one Fabric Element and another Fabric Element is called the E_Port. The link between Fabric Elements is called an Inter-Element Link (IEL).

The Fabric has characteristics defined in terms of the transport services provided on a bidirectional link between the Link Control Facility within a node N_Port and the Link Control Facility within the Fabric F_Port. The Fabric provides transport services by routing frames between F_Ports.

Fabric transport services have been divided into multiple Classes of service. These Classes of service are distinguished primarily by whether or not a communication circuit is allocated and retained between the communicating N_Ports, and by the level of delivery integrity provided. Users of a Fabric discover the capabilities available within a particular Fabric through a Login procedure.

This document, ANSI X3.289, FC-FG, describes more features than any one Fabric or Fabric Element is required to implement. It is expected that Fabric Elements will be optimized for selected environments of use. ANSI X3.230, FC-PH, defines several implementations of the physical interface to the Fabric. It defines a single logical interface to the Fabric. Neither document intends to prescribe or limit the design of the internal workings of a Fabric.

4.1.1 Sub-Fabric

Within a Fabric, capabilities for multiple data rates and multiple Classes of service may coexist. This typically occurs where unlike Fabric Elements are connected by Inter-Element Links (see figure 3). Each possible combination of data rate and Class of service that is available within the Fabric defines a logically independent section of the Fabric called a Sub-Fabric.

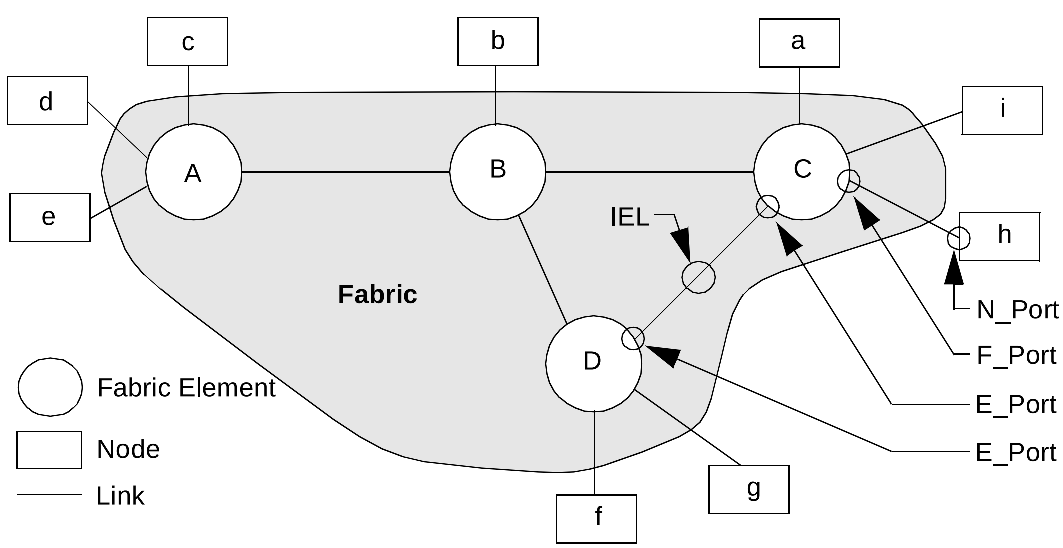

Figure 2 – Fabric model

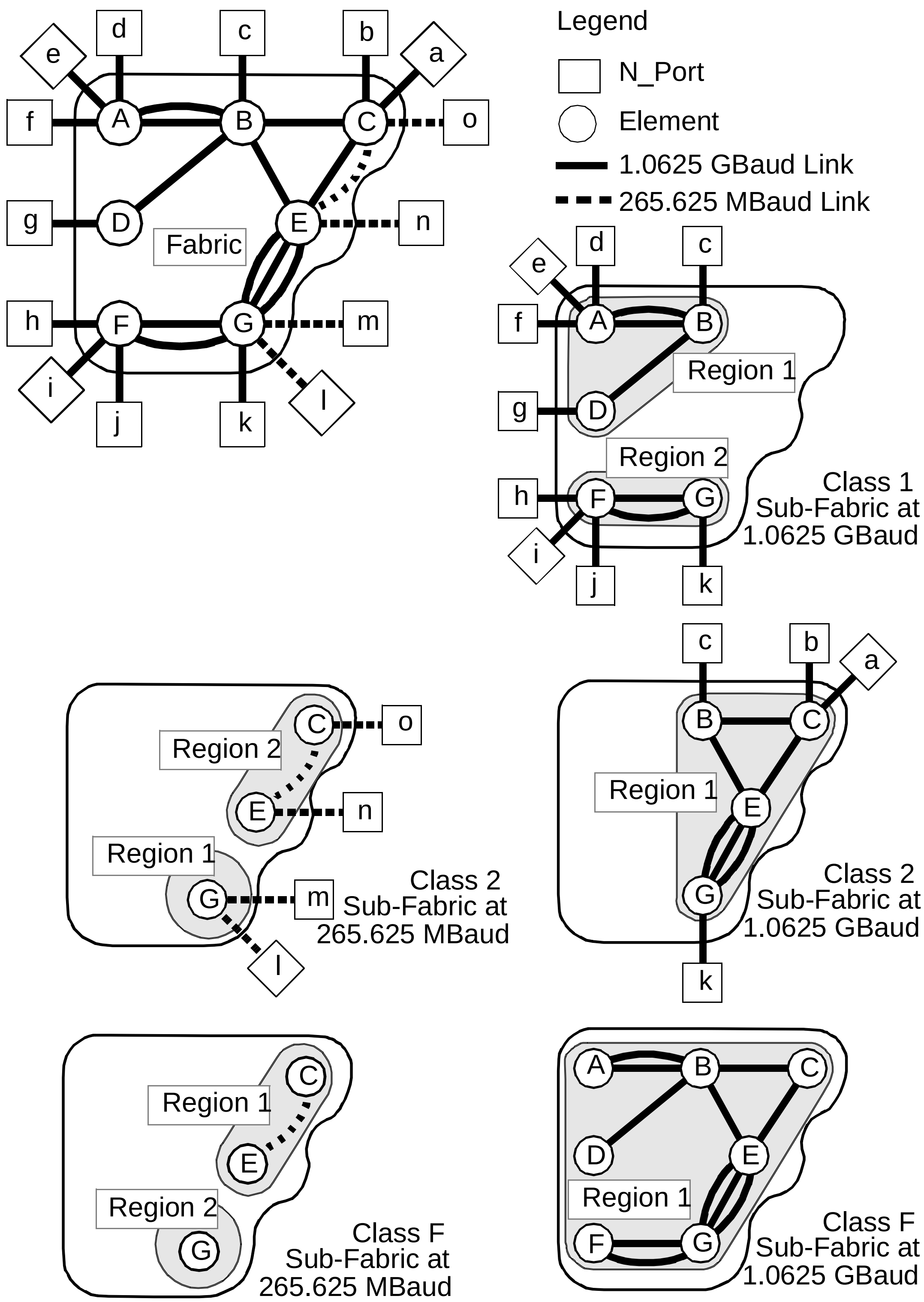

Figure 3 – Fabric with Sub-Fabric illustrations

4.1.2 Region

A Sub-Fabric may be divided into sections that have incompatible variations in service parameters which prevent ports in one section from communicating directly with ports in another section. Each section with compatible service parameters within a Sub-Fabric is a Region (see figures 3 and 4).

4.1.3 Translator

A Fabric may provide a service that permits Sub-Fabrics or Regions to communicate across data rate and Class of service boundaries. The logical entity providing this service is a Translator.

4.1.4 Extended Region

When a single Region in one Sub-Fabric provides access to more than one Region in a second Sub-Fabric, the Fabric may provide a Translator to transparently bridge the disjoint Regions in the second Sub-Fabric using links of the first Sub-Fabric. The bridged Regions of the second Sub-Fabric are said to form an Extended Region (see figure 4).

4.1.5 Zone

For many environments, it is not appropriate for certain Nodes to communicate with other Nodes. There may exist system and application boundaries that must be guarded. The Fabric may support subdividing Regions and Extended Regions into independent partitions for purely administrative purposes. These administered partitions are called Zones.

4.2 Typical Fabric topologies

There are no specific requirements for Fabric topology. Topologies favored by early implementors are illustrated in this clause.

There is also no requirement that a Fabric be implemented with a single, homogenous topology. It is anticipated, for example, that the Arbitrated Loop topology may attach to the Switch topology.

4.2.1 Switch topology

The Switch topology may consist of one or more Fabric Elements as shown in figure 5. Each Fabric Element is a Switch Element.

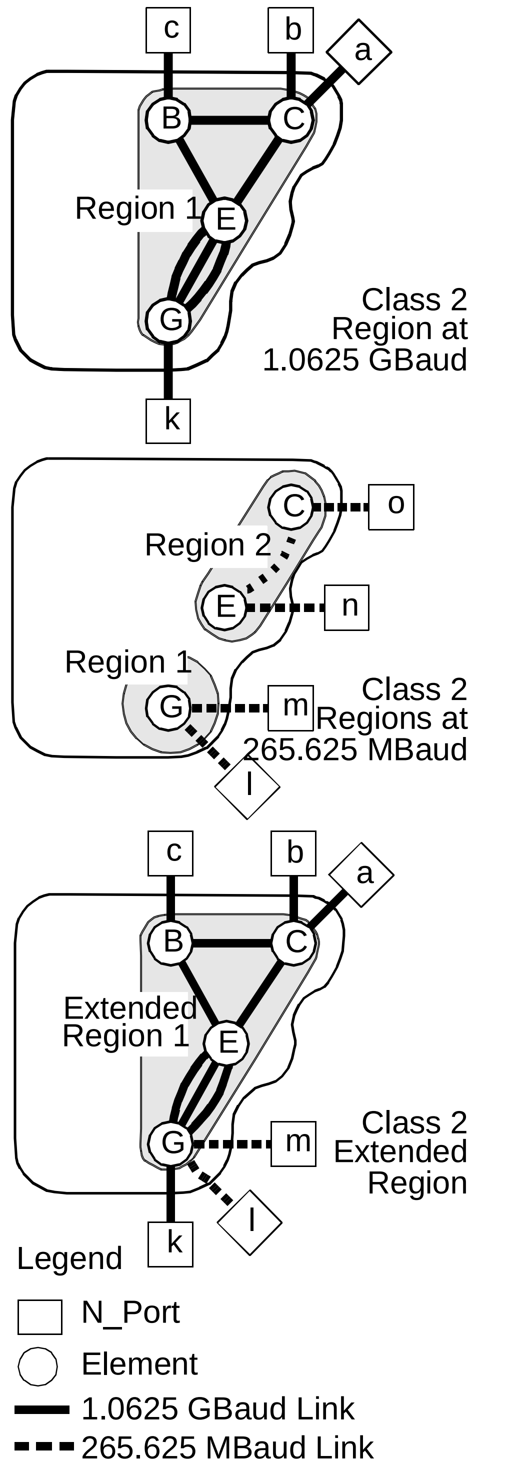

Figure 4 – Class 2 Sub-Fabrics and an extended region

A Switch topology provides connections between pairs of F_Ports, and thereby between pairs of N_Ports. The connections may be Cir-

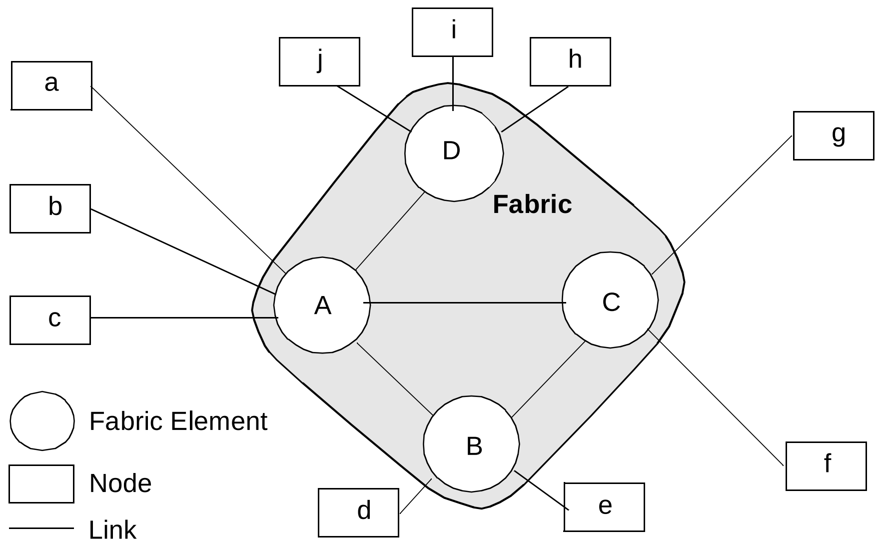

Figure 5 – Example of Switch topology

cuit Switched (Dedicated Connections), or Frame Switched (Connection-oriented and Connectionless services).

The Class of service required by the N_Port and provided by the Fabric is determined by the choice of frame delimiters (see 17.2.2 of ANSI X3.230, FC-PH and clause 18 of ANSI X3.297, FC-PH-2).

4.2.1.1 Dedicated Connections

A Switch Fabric provides the capability to interconnect the links that are attached to it. Multiple Dedicated Connections may exist simultaneously within the Fabric. The interconnection of F_Ports established by the Fabric does not affect the existing interconnection of any other F_Ports, nor does it affect the ability of the Fabric to remove those connections, nor does it affect the ability of any other F_Ports to handle connectionless operations. The maximum number of Dedicated Connections supported is equal to the integer value of one-half the number of attached N_Ports. Fabrics subject to blocking may support less than the maximum number of connections.

When a Dedicated Connection is established, F_Ports and their respective point-to-point links are interconnected within the Fabric, such that the links appear as one continuous link for the duration of the connection. When frames are received by one of the connected F_Ports, the frames are normally passed from one F_Port to the other or others, through the Fabric, for transmission. A Dedicated Connection is retained until a removal request is received

Class 1, Buffered Class 1, and Dedicated Simplex are services based on Dedicated Connections.

4.2.1.2 Connectionless service

Connectionless service is characterized by the absence of a Dedicated Connection. Frames are multiplexed, on frame boundaries, between an F_Port and any other F_Port and thereby between the N_Ports attached to them.

Consecutive frames received from an attached N_Port by a source F_Port may be directed to the same or different destination N_Ports. Likewise, frames received by a destination F_Port for its attached N_Port may be received from the same or different source N_Ports. The Fabric treats each frame individually without reference to the frame that precedes it or follows it through the Fabric. Once a frame has been delivered to the destination N_Port by the Fabric, the Fabric may have no memory of the routing taken through the Fabric by the frame. Subsequent frames delivered from the same source N_Port to the same destination N_Port may be routed differently through the Fabric. Some

Fabrics ensure that frames sent from a source N_Port to a destination N_Port arrive at the destination in the same order as sent by the source, and some do not.

With Connectionless service, congestion may occur within the Fabric. The Fabric manages this congestion through buffer-to-buffer flow control.

Class 2 and Class 3 are services based on Connectionless service.

4.2.1.3 Connection-oriented service

Connection-oriented service is a virtual connection service that is commonly implemented upon a Connectionless service. The Connection-oriented circuit may provide a fractional allocation of the resources available on the path between connected N_Ports.

Class 4 - Fractional is a Connection-oriented service.

4.2.2 Distributed Fabric Element topology (DFE)

The Distributed Fabric Element is a 1-to-n switch element that may be combined with like Distributed Fabric Elements to form a tree-like topology. An example of the topology is given as figure 6.

4.2.3 Other topologies

Additional Fabric topologies may be defined and implemented. It is not the intent of this document to restrict topologies and implementations to those previously defined.

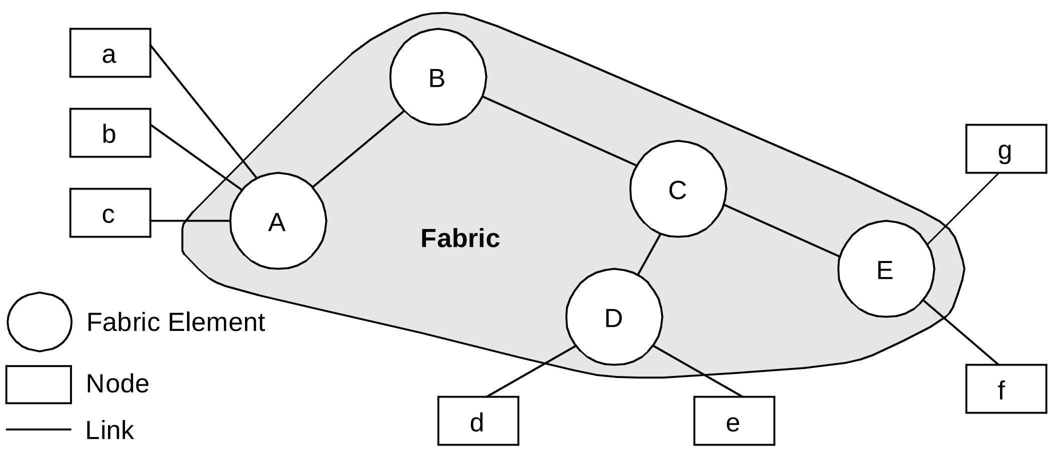

Figure 6 – Example of Distributed Fabric Element topology

4.3 Fabric frame

A Fabric frame is distinguished by a unique Start of Frame Delimiter, the Start_of_Frame Fabric (**SOFf**). It is used for communication within the Fabric itself. Fabric frames are not expected to appear outside of the Fabric, and if they do, they are discarded and ignored.

ANSI X3.230, FC-PH, requires that N_Ports shall transmit a minimum of six Primitive Signals following each frame, but that receivers need only see two primitive signals ahead of a frame. The difference of four Primitive Signals between the transmitted data stream and the received data stream provides the Fabric with reserved bandwidth that may be used for clock skew management and for the delivery of Fabric frames.

4.4 Fabric_Ports

Fabric_Ports may connect through a link to an N_Port or through a link to the Fabric_Port of another Fabric Element. Six possible configurations of a Fabric_Port are identified:

1. The Fabric_Port that connects through a link to an N_Port is an F_Port that behaves as prescribed in ANSI X3.230, FC-PH.

2. The Fabric_Port that connects through a link to another Fabric_Port is called an E_Port, an inter-element expansion port. Provision for one or more E_Ports is optional. An E_Port may use FC-PH compliant media, interface, and signaling protocols, or it may use other interconnect not specified by this document.

3. The Fabric may optionally provide a G_Port, a generic Fabric_Port, which is capable of behaving either as an E_Port or as an F_Port. The G_Port determines through Login at initialization whether it has been configured as an E_Port or as an F_Port and thereafter operates as required by the port configuration.

4. The Fabric_Port that may connect either to an N_Port or to an Arbitrated Loop is an FL_Port.

5. The Fabric_Port that may connect either to an N_Port, to an E_Port, or to an Arbitrated Loop is a GL_Port.

6. A logical node within the Fabric, capable of communicating either with other Fabric_Ports or with N_Ports is an S_Port.

4.5 Fabric Service Parameters

During Fabric Login, the F_Port delivers to its associated N_Port a single set of Service Parameters common to all the destinations accessible to that N_Port. Fabrics may or may not be homogeneous. They may be composed of Fabric Elements supporting different Classes of service, different media rates, different data field sizes, different transit delays, and so on. The Fabric has to determine a common set of Service Parameters available to the N_Port by methods described in the topology specific references.

Changes within the Fabric that affect Service Parameters may require that the N_Port re-Login. The Fabric initiates this process by issuing a Link Reset (see 16.4.4 of ANSI X3.230, FC-PH).

4.6 Fabric addressing

4.6.1 Address identifiers

Address identifiers are three bytes in length. The Frame Header contains two three-byte fields for address identifiers, the Destination Identification (D_ID) field and the Source Identification (S_ID) field.

Each N_Port has a Fabric unique identifier, the N_Port Identifier, by which it is known. An N_Port may have one or more alias address identifiers as well. The source and destination N_Port Identifiers and alias address identifiers are used to route frames within the Fabric.

The F_Port which is directly connected through a Link to an N_Port has the reserved address identifier 'FFFFFE'. This reserved address identifier is used primarily as the Destination Identifier (D_ID) for Fabric Login.

Certain other address identifiers have been designated well-known addresses (see table 33 of ANSI X3.230, FC-PH and table 33 of ANSI X3.297, FC-PH-2) as summarized in table 1.

Table 1 – Well-known Address Identifiers

Hex value	Description
FFFFF0 to FFFFF7	Reserved
FFFFF8	Alias Server
FFFFF9	Quality of Service Facilitator - Class 4 (QoSF)
FFFFFA	Management Server
FFFFFB	Time Server
FFFFFC	Directory Server
FFFFFD	Fabric Controller
FFFFFE	Fabric F_Port
FFFFFF	Broadcast Alias_ID

The Fabric may or may not provide address assignment. Where the Fabric does provide address assignment, the N_Ports take their address identifiers from the Fabric. The procedures for acquiring address identifiers are described in clause 23 of ANSI X3.230, FC-PH.

Where the Fabric does provide address assignment, the Fabric first assigns unique address identifiers to each of its F_Ports as part of the initialization procedure (see clause 7). The N_Ports attached to each of the F_Ports then inherit the address identifiers of their associated F_Ports. The F_Port entity is not separately addressable from the N_Ports except that the N_Port can address the F_Port to which it is linked using the reserved F_Port address.

4.6.2 Address space partitioning

All addresses not otherwise reserved or assigned are available for use as N_Port Identifiers or alias address identifiers. While partitioning of the unused address identifiers is not required by this document, it is encouraged as a framework for inter-operation and for anticipated Fibre Channel enhancements. Annex A of this standard describes the recommended address space partitioning.

Within the recommended address space partitioning is a hierarchical division of the address space reserved for Port Identifiers into logical or administrative entities described as Domain, Area, and Port. The suggestion is that, for addressing purposes, Ports are members of Areas, Areas are members of Domains, and Domains are partitions of the Fabric.

4.7 Fabric addressable service elements

The Fabric provides an address mapping between certain well-known addresses (see 4.6.1) and the service elements, or servers, that respond to those addresses. These Fabric addressable service elements have the appearance of Nodes attached to the Fabric, even though they may be an integral part of the Fabric, and are assigned N_Port Identifiers.

Servers appear as single entities to the external N_Ports, regardless of the actual implementation within the Fabric.

4.7.1 Broadcast Alias_ID

The Broadcast Alias_ID is the address of the logical entity within the Fabric that provides a Broadcast service (see 31.5 of ANSI X3.297, FC-PH-2). Class 3 frames delivered to the well-known address hex ‘FFFFFF’, the Broadcast Alias_ID, are replicated and delivered by the Fabric to all N_Ports able, at the time of delivery, to receive such frames.

4.7.2 Fabric F_Port/Login server

The F_Port is the Link_Control_Facility within the Fabric that attaches to an N_Port through a link. It is addressed by the well-known address identifier hex 'FFFFFE'.

The F_Port provides access to the Fabric for Fabric Login. The Login procedure is used by N_Ports and by other Fabric Elements to discover the operating characteristics associated with a Fabric or Fabric Element. The Login server is the logical entity within the Fabric that receives and responds to Fabric Login frames. The Login server also assigns, confirms or reassigns the N_Port Identifier of the N_Port that initiates the Login. All Fabrics provide a Login server function.

When the F_Port receives a Fabric Login (FLOGI) frame with a D_ID of hex 'FFFFFE' it routes the frame to the Fabric Login server. The Login server provides appropriate responses as described in clauses 21 and 23 of ANSI X3.230, FC-PH.

4.7.3 Fabric Controller

Every Fabric contains one or more Fabric Controllers. The Fabric Controller is the logical entity responsible for general operation of the Fabric. Fabric control may include such functions as:

– Execution of the Fabric initialization procedure (see clause 7).

– Parsing and routing of frames directed to well-known addresses.

– Setup and tear down of Dedicated Connections.

– General frame routing.

– Generation of F_BSY and F_RJT link responses.

In addition, the Fabric Controller responds to the Read Connection Status Link Service request Sequence as prescribed by 21.4.9 of ANSI X3.230, FC-PH.

Fabric control may be distributed among Fabric Elements, in which case, the logical entity controlling the Fabric Element is called the Element Controller.

The Fabric Controller has the well-known address identifier hex 'FFFFFD'.

4.7.4 Directory server

At a minimum, the Directory server maintains tables that correlate N_Port Name_Identifiers with N_Port address identifiers. These tables may be used by Nodes to discover one form of identification given knowledge of the other form of identification (see ANSI X3.288, FC-GS).

The Directory server may also provide Directory Services which catalog a much broader list of port characteristics.

The Directory server is optional. When provided, the Directory server has the well-known address identifier hex 'FFFFFC'.

4.7.5 Time server

The Time server is optional, and where provided gives the time values required to manage expiration timers (see clause 11 of ANSI X3.288, FC-GS).

The Time server has the well-known address identifier hex 'FFFFFB'.

4.7.6 Management server

The Management server is optional, and where provided is used to collect and report information on link usage, errors, link quality and the like.

The Management server has the well-known address identifier hex 'FFFFFA'.

4.7.7 Quality of Service Facilitator - Class 4 (QoSF)

The Quality of Service Facilitator (QoSF) is a function provided within Fabrics that offer Class 4 service (see clause 34 of ANSI X3.297, FC-PH-2).

The Quality of Service Facilitator has the well-known address identifier hex ‘FFFFF9’.

4.7.8 Alias Server

The Alias server is optional, and where provided may be used to issue Hunt Group Identifiers, Multicast Group Identifiers (see clause 32 of ANSI X3.297, FC-PH-2), and such other Identifiers as may be defined within the Fibre Channel document set (see figure 1).

The Alias server has the well-known address identifier hex ‘FFFFF8’.

5 Fabric entity requirements and characteristics

5.1 General requirements

The internal design and behavior of the Fabric is largely unspecified. Equivalent internal mechanisms and/or functions are allowed by ANSI X3.230, FC-PH, and this document, ANSI X3.289, FC-FG, so long as the Fabric and each Fabric_Port behaves according to the standards.

5.2 Link_Control response

If a frame is accepted by an F_Port and is found subsequently to be undeliverable to a destination N_Port, the Fabric is required in Class 1 and Class 2 service to issue an appropriate Busy (F_BSY) or Reject (F_RJT) response with a valid reason code. In Class 1 operation, the Fabric shall only issue the Busy or Reject for frames delimited by **SOFc1**.

5.3 Frame validity checking

The Fabric may or may not verify the validity of a frame as the frame passes through the Fabric. The Fabric is required only to parse those fields required for routing. If the Fabric does check frame validity within the meaning of clause 17 of ANSI X3.230, FC-PH, and if an error is detected within the frame, the frame may be forwarded with a modified **EOF** delimiter to indicate that an error has been detected.

The Fabric shall not do anything which will cause the indication of a transmission error in a received frame to be lost, nor do anything which permits part of a path of a frame through the Fabric to be unprotected by an error check. This maybe accomplished, among other ways, by passing the CRC contained in the frame from the source N_Port through to the destination N_Port unmodified, and by passing invalid transmission codes through to the destination N_Port.

5.4 Connection independence

The interconnection of F_Ports established by the Fabric shall not affect the existing interconnection of any other F_Ports, nor shall it affect the ability of the Fabric to remove those connections, nor shall it affect the ability of any other F_Ports to handle connectionless operations.

5.5 Class 1 bandwidth & frame jitter

FC-PH requires (see 17.1 of ANSI X3.230, FC-PH) that at an N_Port transmitter there shall be a minimum of six Primitive Signals (Idles and R_RDY) between frames and that a minimum of two primitive signals shall be guaranteed to precede the start (SOF) of each frame received by a destination N_Port. The surplus of Idles on N_Port transmit is provided to assist the Fabric in clock skew management and to provide a bandwidth allocation for Fabric frames (delimited by SOFf) and for Intermix.

At the destination F_Port, the Fabric may delay a Class 1 frame, by inserting an Intermix frame, no more than one maximum frame time. Once a frame is inserted, the Fabric shall wait before issuing a subsequent Intermix frame until the number of surplus Primitive Signals received from the source N_Port matches the size of the frame previously transmitted as Intermix.

5.6 Fabric Controller

The Fabric shall contain one or more Fabric controllers. The Fabric Controller is a logical entity at the well-known address hex 'FFFFFD'.

The Fabric Controller shall respond to the Read Connection Status Link Service request sequence as required by 21.4.9 of ANSI X3.230, FC-PH.

5.7 Login Server

The Fabric shall provide a Login Server function. The Login Server is a logical entity at the well-known address hex 'FFFFFE'. The Login Server provides appropriate responses to requests for Fabric Login originating at attached N_Ports (see clause 23 of ANSI X3.230, FC-PH), or NL_Ports (see ANSI X3.272, FC-AL).

5.8 Service Parameter extent

A Fabric may be composed of multiple Fabric Elements with different service characteristics (e.g., differing support for Class of Service, different data rates, etc.) During Fabric Login, the Fabric delivers to the source N_Port a single set of Service Parameters which expresses the most limiting characteristics of all destination F_Ports accessible by that source N_Port. The method used internally by the Fabric to discover a common set of Service Parameters is not defined by this document.

5.9 E_D_TOV, R_A_TOV enforcement

The Error_Detect_Timeout Value (E_D_TOV) and the Resource_Allocation_Timeout Value (R_A_TOV) are specified in clause 29 of ANSI X3.230, FC-PH. When an N_Port performs Fabric Login, the Common Service Parameters provided by the F_Port specify values for E_D_TOV and R_A_TOV. The value of R_A_TOV shall be greater than or equal to E_D_TOV plus twice the maximum time that a frame may be delayed within a Fabric and still be delivered. The Fabric shall guarantee that a frame received by the Fabric from a source N_Port shall be delivered to a destination N_Port within the R_A_TOV, or that the frame shall never be delivered.

The Fabric shall ensure delivery within the maximum delivery time by requiring each Fabric Element to time out frames stored in receive buffers within the Fabric. Individual Elements may use different timeout values. The maximum Fabric delivery time is the cumulative timeout value for elements along the path or paths joining the source and destination N_Ports.

When the Fabric encounters a Data frame requiring an F_BSY or F_RJT Link_Control frame response from the Fabric, the Fabric shall generate and transmit the F_BSY or F_RJT at a time not later than E_D_TOV after receipt of the Data frame. No Link_Control frame shall be returned in response to the Data frame, if the facility within the Fabric generating the F_BSY or F_RJT Link_Control frame is unable to transmit the Link_Control frame in time.

5.10 Non-duplication of frames

As the Fabric receives frames from a source N_Port, the Fabric shall do one of three things with those frames attempting (a) before (b) and (b) before (c):

a) Deliver one and only one copy of a frame to a destination N_Port within R_A_TOV.

b) Discard the frame and, where indicated by Class of service, provide an appropriate F_BSY or F_RJT response within E_D_TOV.

c) Discard the frame without notice.

5.11 Phase discontinuities

The Fabrics is permitted to switch the Fibre Channel serial bit stream and while switching the serial bit stream may produce a phase discontinuity (see 5.3 of ANSI X3.230, FC-PH). Such phase discontinuities shall not occur within a frame between the Start_of_Frame and End_of_Frame delimiters.

NOTE – Implementations producing such a phase discontinuity are discouraged.

6 Fabric_Port requirements and characteristics

6.1 General requirements

Fabric_Port is a generic name for F_Ports, FL_Ports, E_Ports, G_Ports, and GL_Ports. An F_Port is the Link_Control_Facility within a Fabric that attaches to an N_port. An E_Port is the Link_Control_Facility within a Fabric Element that attaches to another Fabric Element. A G_Port is capable of operating as either an E_Port or an F_Port depending on whether a Fabric_Port or an N_Port is discovered at the other end of the Link during Link initialization. FL_Ports and GL_Ports are F_Ports and G_Ports, respectively, capable of Loop attachment.

An F_Port is a source or destination point of the Fabric. An E_Port is an entry point to a Fabric Element or an exit point from a Fabric Element where two or more Fabric Elements are combined to create a Fabric. A Fabric may use one or more Fabric Elements to achieve its function.

The requirements for F_Port behavior are described throughout ANSI X3.230, FC-PH. In the event of a conflict between the requirements of this document and the requirements of ANSI X3.230, FC-PH, the FC-PH standard takes precedence.

An F_Port is not an N_Port addressable entity, separate from the N_Port to which it attaches. The Source_ID (S_ID) and Destination_ID (D_ID) fields within the frame header identify N_Ports. Certain features within the Fabric, such as the Fabric Controller, have been assigned well-known N_Port Identifiers.

F_Ports may, however, be addressed from within the Fabric by entities generating Fabric frames. A Fabric frame addressed to an N_Port Identifier shall be delivered to the F_Port associated with that N_Port.

An F_Port shall support one or more Classes of service. The services provided by an F_Port are discovered during Fabric Login.

6.2 Class 1 service - Dedicated Connection

A Class 1 Dedicated Connection normally guarantees simultaneous, bidirectional flow. However, ANSI X3.230, FC-PH allows an optional behavior, called Unidirectional Transmit, in which one data path provides full-bandwidth capability and the other data path is used only for the return of frame acknowledgments (ACKs).

A Dedicated Connection guarantees full-bandwidth transfers and delivery of frames at the destination F_Port in the order of receipt at the source F_Port. The Fabric guarantees, within the error rate, that all frames received from the source N_Port shall be delivered to the destination N_Port.

If two N_Ports are in a Class 1 Dedicated Connection, a Class 1 request from another source to either of the connected N_Ports is handled according to optional behaviors negotiated during Fabric Login (see for example “Camp-On”, clause 35 of ANSI X3.297, FC-PH-2 and “Stacked Connect Request”, clause 36 of ANSI X3.297, FC-PH-2).

If the Fabric is unable to establish a Dedicated Connection, it shall return a Busy or a Reject indication with a valid reason code.

The Fabric shall provide buffer-to-buffer flow control for frames delimited by the Start_of_Frame Connect Class 1 (**SOFc1**).

While a Dedicated Connection exists, the Fabric is not involved in buffer-to-buffer flow control. The Fabric may, however, utilize speed matching buffers and may interleave Fabric frames and/or intermixed Class 2 and Class 3 frames with the Class 1 data flow, so long as the Class 1 bandwidth requirement is not violated.

The entry and exit F_Ports, working in conjunction with the Fabric, are required to follow the procedures for establishing and removing Class 1 Dedicated Connections as presented in clause 27 of ANSI X3.230, FC-PH.

Primitive sequences transmitted from an N_Port to its associated F_Port shall remove an existing or pending Class 1 Dedicated Connection. The affected F_Port shall respond with the appropriate Primitive Sequence protocol. The Fabric shall notify the other F_Port participating in the Dedicated Connection to initiate the Link Reset Protocol with its respective N_Port.

If the Fabric is able to determine that a Dedicated Connection has been broken somewhere within the Fabric, the Fabric may initiate the Link Reset Protocol at the entry and exit F_Ports of the Dedicated Connection.

6.3 Buffered Class 1 service

Buffered Class 1 service is an extension of Class 1 service - Dedicated Connection (see 6.2) in which the flow of all frames is regulated by buffer-to-buffer credit rules (see clause 37 of ANSI X3.297, FC-PH-2). The purpose of such a connection is to allow ports with differing data rates to communicate in an otherwise Dedicated Connection like environment

Buffered Class 1 service is similar in all respects to Class 1 service - Dedicated Connection except that the usable bandwidth of the connection is limited to no more than the data rate of the slowest connected port.

6.4 Dedicated Simplex service

Dedicated Simplex service is a variation of Class 1 service - Dedicated Connection (see 6.2) in which the connection is established in one direction only (see clause 33 of ANSI X3.297, FC-PH-2).

A Dedicated Simplex connection guarantees full-bandwidth transfers and delivery of frames in one direction only. Frame delivery acknowledgments (ACKs) return to the Connection Initiator using the Connectionless service Class 2 (see 6.5).

In Dedicated Simplex service, it is possible for the outbound fiber of a port to have a dedicated path to one destination port at the same time as the inbound fiber has a dedicated path from another source port. In Dedicated Simplex service, the ports are required to support Intermix (see 6.8) so that the ACK response frames may share bandwidth with the Dedicated Simplex connections.

6.5 Class 2 service - Multiplex

Class 2 Multiplex is a Connectionless service that multiplexes frames at the frame boundary between a source F_Port and a destination F_Port of the Fabric. Some Fabrics ensure that frames sent from a source N_Port to a destination N_Port arrive at the destination N_Port in the same order as sent by the source, and some do not.

Class 2 service assures the sender of notification of frame delivery or failure to deliver frames so long as the frames remain error free in transit.

The F_Port participates in buffer-to-buffer flow control (see 26.5 of ANSI X3.230, FC-PH) and provides R_RDY primitive signalling for Class 2 frames (see 16.3.2 of ANSI X3.230, FC-PH).

6.6 Class 3 service - Datagram

Class 3 Datagram is a Connectionless service that multiplexes frames at the frame boundary between a source F_Port and a destination F_Port of the Fabric. Some Fabrics ensure that frames sent from a source N_Port to a destination N_Port arrive at the destination N_Port in the same order as sent by the source, and some do not.

Class 3 service provides best-effort delivery with no Busy or Reject indications.

The F_Port participates in buffer-to-buffer flow control (see 26.5 of ANSI X3.230, FC-PH) and provides R_RDY primitive signalling for Class 3 frames (see 16.3.2 of ANSI X3.230, FC-PH).

6.7 Class 4 service - Fractional

Class 4 service is a connection-oriented service that provides fractional allocation of the resources of the connection path between communicating N_Ports (see clause 34 of ANSI X3.297, FC-PH-2).

The Class 4 circuit is bidirectional with one Virtual Circuit (VC) operational in each direction. Each VC may have different Quality of Service (QoS) parameters. The QoS parameters include guaranteed bandwidth and latency.

An N_Port may have up to 254 coexistent Class 4 circuits with the same or different N_Ports.

The Virtual Circuit Identifier (VC_ID) is entered in the Class Specific Control Field (CS_CTL) of the frame header (see 18.2.4 of ANSI X3.297, FC-PH-2).

Class 4 operation is separated into two parts, circuit setup and circuit activation. During the setup process, QoS parameters for both VCs are negotiated between the circuit initiator N_Port, who requests QoS parameters, and the Fabric and the circuit recipient N_Port who guarantee a certain QoS.

Once a Class 4 circuit is setup, it may be activated and deactivated one or more times. Class 4 circuit activation is accomplished separately on each VC when either N_Port issues a frame delimited by the activate Class 4 Start_of_Frame delimiter (**SOFc4**). Class 4 circuits are deactivated by the End_of_Frame Disconnect_Terminate (**EOFdt**).

Class 4 circuit setup is removed by issuing a frame delimited by the End_of_Frame Remove_Terminate (**EOFrt**).

6.8 Intermix service

The requirements for Class 1 Intermix are given in 22.4 of ANSI X3.230, FC-PH.

6.9 Class F service - Fabric signaling

Class F service is a connectionless service used for control and coordination of the internal behavior of the Fabric. Class F service is defined in this specification for use by Fabric entities communicating across inter-element links (IEL). It is patterned after Class 2 service with the exceptions that the Start-of-Frame delimiter is the Start-of-Frame Fabric **(SOFf)** and most options are declined.

6.9.1 Class F Frame formats

Class F frames shall use a Fibre Channel compliant Frame Header (see clause 18 of ANSI X3.230, FC-PH) except when the Routing Control field indicates vendor unique. If the Routing Control field (Word 0, Bits 31-24) contains the value binary '1111', indicating vendor unique, then only Word 0 and Word 1 of the Frame Header are defined.

The Class F frame format is illustrated in figure 7. Class F frames shall be delimited by the Start_of_Frame Fabric **(SOFf)** and the End_of_Frame Normal **(EOFn)** and shall include the Cyclic Redundancy Check (CRC) defined by FC-PH. Class F frames shall not include the optional headers described in FC-PH.

6.9.2 Class F function

Class F service is a Connectionless service that multiplexes frames at the frame boundary between a Fabric source entity and a Fabric destination entity. Class F service assures the sender of notification of frame delivery or failure to deliver frames so long as the frames remain error free in transit.

Fabric frames move buffer to buffer and are regulated by R_RDY flow control using the same buffer-to-buffer credit mechanism prescribed for Class 2, Class 3 and Class 1/**SOFc1** frames.

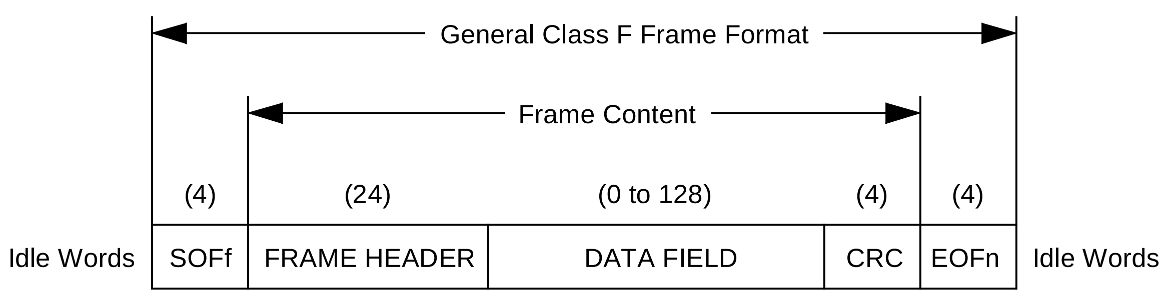

Figure 7 – The Class F frame format

6.9.3 Class F rules

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

a) Except for some Inter-Element Link Service Protocols, an E_Port supporting Class F service is required to have logged in with the associated Fabric Elements (IELOGI) and the E_Ports (IELOGI) with which it intends to communicate, either explicitly or implicitly. **(Login).**

b) The Fabric Element routes Class F frames through Connectionless Sub-Fabric, without establishing a Dedicated Connection between communicating E_Ports. To obtain Class F service from the Fabric Element, the E_Port shall use the Fabric frame **(SOFf)** delimiter. **(Connectionless service)**

c) 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)**

d) 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)**

e) A destination E_Port shall provide an acknowledgment to the source for each valid frame received. The destination E_Port shall use ACK_1 for the acknowledgment. If the Fabric Element is unable to deliver the ACK_1 frame, the Fabric Element shall return an F_BSY or F_RJT. **(Acknowledgment)**

f) The Sequence Initiator shall increment the SEQ_CNT field of each successive frame transmitted within a Sequence. However, the Fabric Elements may not guarantee delivery to the destination in the same order of transmission. **(non-sequential delivery)**

g) An E_Port may originate multiple Exchanges and initiate multiple Sequences with one or more E_Ports. The E_Port originating an Exchange shall assign an X_ID unique to the Originator called OX_ID and the Responder of the Exchange shall assign an X_ID unique to the responder called RX_ID. The value of OX_ID or RX_ID is unique to a given E_Port. The Sequence Initiator shall assign a SEQ_ID, for each Sequence it initiates, which is unique to the Sequence Initiator and the respective Sequence Recipient pair while the Sequence is Open. (concurrent Exchanges and Sequences)

h) Each E_Port exercises buffer-to-buffer flow control with the E_Port to which it is directly attached. End-to-end flow control is performed by communicating E_Ports. ACK_1 frames are used to perform end-to-end flow control and R_RDY is used for buffer-to-buffer flow control. **(dual flow control)**

i) If a Fabric Element is unable to deliver the frame to the destination E_Port, then the source is notified of each frame not delivered by an F_BSY or F_RJT frame from the Fabric Element with corresponding D_ID, S_ID, OX_ID, RX_ID, SEQ_ID, and SEQ_CNT. The source is also notified of valid frames busied or rejected by the destination E_Port by P_BSY or P_RJT. **(non-delivery)**

j) A busy or reject may be issued by an intermediate E_Port or the destination E_Port with a valid reason code. **(busy/reject)**

k) If a Class F frame is busied, the sender shall retransmit the busied frame up to the ability of the sender to retry, including zero. **(retransmit)**

l) The Credit established during the Login protocol by interchanging Service Parameters shall be honored. **(Credit)**

m) Effective transfer rate between any given E_Port pair is dependent upon the number of E_Ports a given E_Port is demultiplexing to and multiplexing from. **(bandwidth)**

n) Frames within a Sequence are tracked on a Sequence_Qualifier and SEQ_CNT basis. **(tracking)**

o) An E_Port shall be able to recognize **SOF** delimiters for all Classes of service, whether or not all Classes of service are supported by the Port. An E_Port shall accept frames for all service Classes. **(Invalid Class)**

p) An E_Port receiving a Vendor Unique Class F frame may discard the frame without notification. **(vendor unique)**

q) An E_Port shall support insertion of Class F frames onto an established Class 1 Dedicated Connection. However, this insertion shall not cause loss of any Class 1 frames. A Fabric Element may abort **(EOFa)** or discard an Intermixed Class 2 or Class 3 frame in progress if its transmission interferes. A Fabric Element shall not abort an Inserted Class F frame.

6.9.4 Class F delimiters

Class F frames shall begin with an **SOFf** delimiter. The Class F frame shall be terminated by an **EOFn** delimiter. The ACK_1 frame may be terminated by **EOFt**.

6.9.4.1 Class F frame size

The Data_Field size for Class F shall be set to 128 by Inter-Element Login; otherwise, the Login is rejected.

6.9.4.2 Class F flow control

Class F service uses both buffer-to-buffer and end-to-end flow controls. R_RDY is used for buffer-to-buffer flow control. R_RDY is transmitted by the E_Port, at one link end, to the E_Port, at the other link end, to indicate that a buffer is available for further frame reception by the first E_Port. This process operates in both directions on the link.

ACK_1 frames are used to perform end-to-end flow control. ACK_1 frames shall begin with an **SOFf** delimiter. The ACK_1 frame shall be terminated by an **EOFn** or **EOFt** delimiter.

All Class F frames shall follow both buffer-to-buffer and end-to-end flow control rules.

6.9.5 Link Control

Link Control frames delimited by **SOFf** and **EOFn** shall be used by Class F. The ACK_0 and ACK_N Link Control frame shall not be used for Class F service.

6.10 Fabric Login

The Fabric may support one or more of the Classes of service defined by Fibre Channel documents. The capability of the F_Port is initially discovered by a Login procedure.

Both implicit and explicit Login are defined by FC-PH, and where explicit Login is appropriate, it shall be initiated by the N_Port.

Each F_Port shall respond to explicit Login whether or not an implicit Login is in effect, and an explicit Login shall override an implicit Login until a Link Reset is executed.

In the case of a reply to a Class 1 Login, the F_Port shall set the End_Connection (E_C) bit in the Accept (ACC) Link Service reply Sequence in order to permit the N_Port to disconnect with the ACK response.

The Service Parameters provided by an F_Port to an N_Port shall be characteristic of the entire region of the Fabric accessible to that N_Port. In the event that the Service Parameters for the Fabric change due to reconfiguration, the Fabric shall Logout with affected N_Ports in order to notify the N_Ports of the change in Service Parameters.

7 Initialization and configuration control

7.1 Initialization

Initialization of the Fabric is required before frame transmission can be undertaken through the Fabric.

Fabric initialization includes:

a) Determination by the Fabric of the Fabric topology, i.e. the number and location of Fabric Elements and the connection between them.

b) The assignment by the Fabric of the N_Port Identifiers.

c) The determination of the operating characteristics of the attached N_Ports.

d) Initialization of the Fabric Credit_CNT.

The last three functions are accomplished using the Fabric Login procedure which may be implicit or explicit. Implicit Login is implementation dependent and is defined by the Fabric Manufacturer. Explicit Login is requested by the attached N_Port using the Login (FLOGI) Link_Data Application frame. The contents of this frame and of the Accept (ACC) and Reject (RJT) response frames are defined by ANSI X3.230, FC-PH.

The Fabric and the attached N_Ports shall be initialized at power on. The stages of Fabric initialization are Power On, Link Initialization Protocol, Link Attachment Protocol, Addressing and Configuration Determination, F_Port Activation, and N_Port Login with the Fabric.

7.1.1 Power On

The initialization or re-initialization process begins whenever a Fabric Element, individual F_Port, E_Port, or N_Port is powered on.

7.1.2 Link Initialization Protocol

The Link Initialization Protocol as defined in FC-PH assures that the link between an N_Port and an F_Port is operating properly and is ready to receive frames. If the N_Port or F_Port at the other end of the link is not powered on, the F_Port in the Fabric being initialized goes to the Wait for OLS state (OL3) and the Link Initialization Protocol is completed after the other port powers on.

The Link Initialization Protocol is also used to ensure that two Fibre Channel compliant E_Ports are operating properly and are ready to receive frames. If the two E_Ports are connected and either E_Port is not powered on, the E_Port in the Fabric being initialized goes to the Wait for OLS state (OL3) and the Link Initialization Protocol is completed after the other port powers on (see 16.5 and 16.6 of ANSI X3.230, FC-PH).

Following successful completion of the Link Initialization Protocol (both ends transmitting Idle), the port proceeds to the next stage.

7.1.3 Link Attachment Protocol

During the Link Attachment Protocol the F_port, E_Port, or G_Port will perform Inter-Element Login with whatever is attached at the other end of the link in order to determine if it is an N_Port or an E_Port (i.e. another Fabric Element). If a G_Port detects an N_Port at the other end of the link then the G_Port assumes the characteristics of an F_Port, or if it detects an E_Port at the other end of the link then the G_Port assumes the characteristics of an E_Port. If a G_Port detects an F_Port at the other end of the link then the connected ports are incompatible and no further communication is possible over the link.

If an F_Port detects an N_Port at the other end of the link then the link is taken offline (Online to Offline Protocol) pending completion of Fabric Initialization. If an F_Port detects an E_Port at the other end of the link then the connected ports are incompatible and no further communication is possible over the link.

If an E_Port detects an F_Port at the other end of the link then the connected ports are incompatible and no further communication is possible over the link. If an E_Port is detected at the other end of the link then the Inter-Element Login procedure results in the transfer of Service Parameters between the two E_Ports. If these parameters are compatible then the Initialization process proceeds to the next stage. If the parameters are not compatible no further communication is possible over the link.

FC-PH requires that the parameters presented to the N_Port during N_Port to Fabric Login represent the characteristics of the Fabric as a whole. In particular the frame size parameter shall represent the smallest maximum frame size acceptable to the entire Fabric. In some cases a Fabric may already be initialized when a new Fabric Element attempts to join. If the new Fabric Element is incompatible with the existing Fabric in any way which requires a total Fabric re-initialization, then the attempt for Inter-Element Login may be rejected and the new Fabric Element may not be allowed to join the Fabric. In some cases Fabric Elements may also reject attempts from other Fabric Elements to attach during primary initialization if the parameters of the other Fabric Element would restrict the performance or function of the Fabric Element which rejects the request. Fabric Element manufacturers may specify the range of Service Parameters which are acceptable for attachment of other Fabric Elements to their Fabric Elements.

7.1.4 Addressing and Configuration Determination

The Fabric next proceeds to Address and Configuration Determination. During this stage each Fabric Element determines its Element Identifier and the Port Identifiers of the ports within the element. These Identifiers may be hard-wired, remembered from a previous configuration, or determined through an algorithm which is not defined by this document. Each Fabric Element also performs a procedure to determine the

Fabric topology and configuration. The procedures for determination of the topology and configuration of the Fabric are topology dependent and defined by the topology specific documents.

This stage shall be completed before Fabric Login requests from N_Ports can be handled. Any Login (FLOGI) frames received by an F_Port prior to the completion of this stage receive LA_RJT (Unable to perform command request).

7.1.5 F_Port Activation

Once Addressing and Configuration Determination is complete the F_Ports attached to N_Ports are activated, the link is taken online, and the N_Port has initiative to originate a Login request to the Fabric.

7.1.6 N_Port Login with Fabric

There are a number of different implementation options available for both N_Ports and Fabrics. During initialization N_Ports use the Login procedure to discover whether or not they are connected to a Fabric or directly to another N_Port, and if connected to a Fabric, the characteristics of that Fabric. N_Port characteristics are transmitted to the Fabric in the Service Parameters fields of the Login frame. N_Port Login with the Fabric is initiated by the N_Port using any Class of service supported by the N_Port. If the Fabric does not support the Class of service selected by the N_Port it rejects the Login request and the N_Port may try again with another Class of service. If the Fabric rejects the N_Port's Login requests for all Classes of service supported by the N_Port, then the N_Port and Fabric are incompatible and no further communication is possible.

When Login is successful using any Class of service, the Service Parameter fields of the Login frame include the characteristics of the N_Port for all Classes of service supported. The Fabric associates these characteristics with the attached F_Port. The Fabric responds to the Login frame with an Accept frame (ACC) including the Service Parameters applicable to the Fabric and the three-byte N_Port Identifier which the Fabric has assigned to the N_Port as a result of the initialization procedure. There is no further negotiation of Service Parameters between the N_Port and the Fabric. Subsequent operation between the N_Port and the Fabric is restricted to those characteristics identified during Login as being in common.

At the completion of the initialization procedure the F_Port and the attached N_Port are ready to communicate with other F_Ports and N_Ports which have also been initialized.

7.2 Configuration Changes

Configuration changes may occur within the Fabric, or with N_Ports attached to the Fabric, after initialization has been completed. The configuration changes may require that some or all N_Ports be notified. The OLS Primitive Sequence shall be sent from the Fabric to all affected N_Ports to communicate that a configuration change has occurred. N_Ports receiving OLS from the Fabric shall perform Fabric Login after the Link Initialization Protocol is completed.

8 Fabric inter-operation

Communication between compatible Fabric Elements is accomplished with methods that are defined by the topology specific documents. Such intra-Fabric communication is accomplished within the frame definitions and protocols defined by the Fibre Channel standard for intra-Fabric communication and has no effect outside of the Fabric. Address assignment within a Fabric is determined by the Fabric.

Connection of incompatible Fabrics requires the use of a gateway. Exchange level communication between Fabrics and gateways takes place as defined by the ANSI X3.230, FC-PH standard.

Annex A
(Informative)

Address Space Partitioning

A.1 Address partitioning

In Fibre Channel, the Fabric is normally the entity that distributes address identifiers to the N_Ports and in general, the N_Ports do need to be aware of how the Fabric manages address identifier allocation. The purpose of address space partitioning is to encourage Fabric vendors to adopt similar strategies for address assignment so that interoperation between vendors is simplified. The proposed address space partitioning is summarized in table A.1.

In the partitioning table, the largest partition is reserved for Port Identifiers, meaning N_Port or E_Port Identifiers. The N_Port Identifiers may be native address identifiers or transparent N_Port aliases, that is, aliased ports that behave like N_Ports.

A.1.1 Port Identifier partition

The Port Identifier partition is further divided into a three-level logical hierarchy consisting of Domains, Areas, and Ports as illustrated in figure A.1.The number of bits assigned to the Domain, Area, and Port fields may vary from one implementation to another.

The range of the Domain_ID field as illustrated is limited on the low end to the value 1 and on the high end to the value hex 'EF' in order to provide encodings for other reserved fields.

A Domain is the highest logical construct in the hierarchy of Port Identifiers and may consist of a collection of Fabric Elements with matching service parameters, or matching transmission rates, or matching topology. Areas are the intermediate level logical construct and Ports are the lowest level logical construct in the hierarchy.

Native address identifiers and transparent aliases may be closely grouped into a contiguous range of values to minimize the resources required in a Fabric for routing.

A.1.2 Fabric-Assisted functions

The second largest partition is for Fabric-Assisted functions in which the Fabric is required to provide special handling identified by the Special_ID field.

A.1.3 Vendor Unique partitions

The Vendor Unique partitions allow Fabric suppliers to offer added value features.

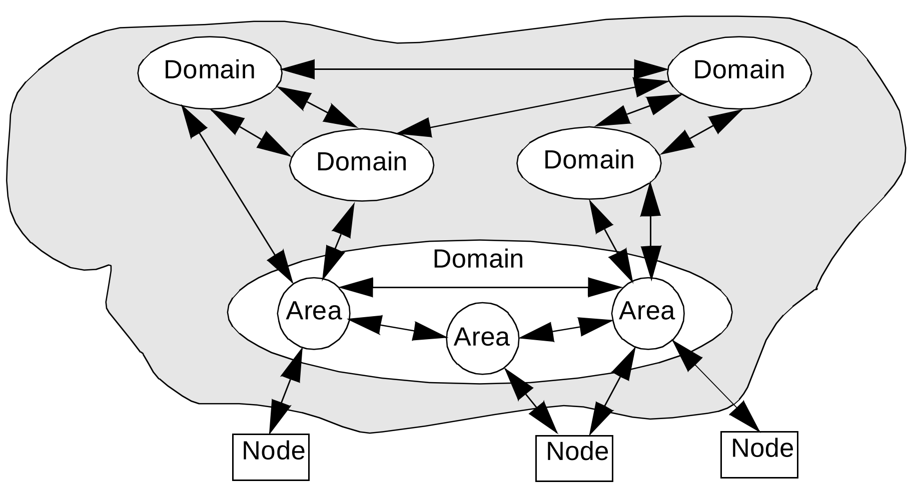

Figure A.1 – Fabric hierarchy

Table A.1 – Address Partitioning

	S_ID-D_ID		**Description**	
23 . .	**Bit**	**. . 0**		
00000000	00000000	00000000	Undefined	(1)
00000000	00000000	00000001	Reserved	(1)
00000000	00000000	0000001x	Reserved	(2)
00000000	00000000	000001xx	Reserved	(4)
00000000	00000000	00001xxx	Reserved	(8)
00000000	00000000	0001xxxx	Reserved	(16)
00000000	00000000	001xxxxx	Reserved	(32)
00000000	00000000	01xxxxxx	Reserved	(64)
00000000	00000000	1xxxxxxx	Reserved	(128)
00000000	00000001	xxxxxxxx	Reserved	(256)
00000000	0000001x	xxxxxxxx	Reserved	(512)
00000000	000001xx	xxxxxxxx	Reserved	(1 024)
00000000	00001xxx	xxxxxxxx	Reserved	(2 048)
00000000	0001xxxx	xxxxxxxx	Reserved	(4 096)
00000000	001xxxxx	xxxxxxxx	Reserved	(8 192)
00000000	01xxxxxx	xxxxxxxx	Reserved	(16 384)
00000000	1xxxxxxx	xxxxxxxx	Reserved	(32 768)
{Domain_ID}	{Area_ID}	{Port_ID}	Port Identifiers	(14 684 160)
{Domain_ID}	1111{ Special_ID }		FABRIC assisted functions	(987 944)
11110xxx	xxxxxxxx	xxxxxxxx	Reserved	(524 288)
111110xx	xxxxxxxx	xxxxxxxx	Reserved	(262 144)
1111110x	xxxxxxxx	xxxxxxxx	Reserved	(131 072)
11111110	xxxxxxxx	xxxxxxxx	Reserved	(65 536)
11111111	0xxxxxxx	xxxxxxxx	Reserved	(32 768)
11111111	10xxxxxx	xxxxxxxx	Reserved	(16 348)
11111111	110xxxxx	xxxxxxxx	Reserved	(8 192)
11111111	1110xxxx	xxxxxxxx	Reserved	(4 096)
11111111	11110xxx	xxxxxxxx	Reserved	(2 048)
11111111	1111100x	xxxxxxxx	Reserved	(512)
11111111	11111010	xxxxxxxx	Reserved	(256)
11111111	11111011	xxxxxxxx	Vendor Unique	(256)
11111111	11111100	00000000	Reserved	(1)
11111111	11111100	{Domain_ID}	Domain Controllers	(239)
11111111	11111100	1111xxxx	Vendor Unique	(16)
11111111	11111101	{Area_ID}	Area Controllers for ’This’ Area	(240)
11111111	11111101	1111xxxx	Vendor Unique	(16)
11111111	11111110	{Port_ID}	Port Controllers for ’This’ Area	(256)
11111111	11111111	0xxxxxxx	Vendor Unique	(128)
11111111	11111111	10xxxxxx	Reserved for FC-PH-n	(64)
11111111	11111111	110xxxxx	Reserved for FC-PH-n	(32)
11111111	11111111	1110xxxx	Reserved for FC-PH-n	(16)
11111111	11111111	11110xxx	Reserved for FC-PH	(8)
11111111	11111111	11111000	Alias Server	(1)
11111111	11111111	11111001	Quality of Service Facilitator	(1)
11111111	11111111	11111010	Management Server	(1)
11111111	11111111	11111011	Time Server	(1)
11111111	11111111	11111100	Directory Server	(1)
11111111	11111111	11111101	Fabric Controller	(1)
11111111	11111111	11111110	Fabric F_Port	(1)
11111111	11111111	11111111	Broadcast Alias_ID	(1)