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FIBRE CHANNEL

April 4, 2011

(FC-MI-3)

REV 1.03

INCITS working draft proposed
Technical Report

April 4, 2011

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American National Standard
for Information Technology

Fibre Channel — Methodologies for Interconnects - 3 (FC-MI-3)

Secretariat

Information Technology Industry Council

Approved (not yet approved)

American National Standards Institute, Inc.

Abstract

This technical report specifies common methodologies for both Arbitrated Loop and Switched environments. The goal of this technical report is to facilitate interoperability between devices whether they are connected in a loop or Fabric topology.

INCITS Technical Report Series

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Foreword (This Foreword is not part of Technical Report TR-XX-201x.)

The Fibre Channel Methodologies for Interconnects - 3 (FC-MI-3) Technical Report describes common methodologies for facilitating interoperability in both loop and Fabric environments.

This technical report was developed by Task Group T11 of Accredited Standards Committee INCITS during 2010-2011. The approval process started in 2011.

Requests for interpretation, suggestions for improvements or addenda, or defect reports are welcome. They should be sent to the INCITS Secretariat, Information Technology Industry Council, 1101 K Street NW Suite 610, Washington, DC 20005.

This technical report was processed and approved for submittal to ANSI by the InterNational Committee for Information Technology Standards (INCITS). Committee approval of the technical report does not necessarily imply that all committee members voted for approval.

At the time it approved this technical report, INCITS had the following members:

(to be filled in by INCITS)

Technical Committee T11 on Fibre Channel Interfaces, that reviewed this technical report, had the following members:

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Robert Nixon, Secretary

Company	Representative
tbd	

Task Group T11.3 on Fibre Channel Protocols, that developed and reviewed this technical report, had the following members:

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Introduction

FC-MI-3 is a technical report that assists implementors of Fibre Channel devices in achieving interoperability by selecting a preferred implementation among the many options allowed by Fibre Channel. Fibre Channel is defined by a number of related standards developed by INCITS Technical Committee T11. The Fibre Channel family of standards and technical reports describes physical layer requirements, FC_Port requirements, and switch requirements necessary to implement Fibre Channel communication systems.

See clause 1 for information about the scope of the technical report.

See clause 2 for references to the relevant Fibre Channel standards.

See clause 3 for definitions of terms, keywords, and editorial conventions used by this technical report.

See clause 4 for overall FC-MI-3 structure and concepts.

See clause 5 through Clause 8 for the specific interoperability requirements of this technical report.

See clause 9 for a cross-listing of clauses applicable to different conformance environments.

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1 Scope

This technical report is intended to document interoperability behavior for Fabric elements (i.e., E_Port, F_Port, FL_Port). The scope of this technical report is to include a wide range of issues such as link initialization, error detection, error recovery, Fabric operation, management capabilities, and zoning.

This technical report is intended to serve as an implementation guide, the primary objective of which is to maximize the likelihood of interoperability between conforming implementations. This technical report prohibits or requires some features that are in the referenced ANSI/INCITS standards.

A second objective of this technical report is to simplify implementations and their associated documentation, testing, and support requirements. As a result there may be some optional features of the referenced ANSI/INCITS standards that are not mutually exclusive, but are prohibited or required for the purpose of this simplification. Features that some but not all of the referenced ANSI/INCITS standards require for compliance may be optional in this technical report. Each specification of such an optional feature in this technical report identifies the referenced ANSI/INCITS standards for which the feature is required.

Internal characteristics of conformant implementations are not defined by this technical report. This technical report incorporates features from the standards and technical reports described in clause 2.

2 Normative References

2.1 Overview

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

For electronic copies of ANSI standards and INCITS Technical Reports listed here, visit ANSI's Electronic Standards Store (ESS) at:

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IETF Request for Comments (RFCs) may be obtained directly from the IETF web site (http://www.ietf.org/rfc.html).

2.2 Approved references

INCITS 332-1999, *Fibre Channel - Arbitrated Loop (FC-AL-2)*

INCITS 463-2010, *Fibre Channel - Generic Services - 6 (FC-GS-6)*

INCITS 461-2010, *Fibre Channel - Switch Fabric - 5 (FC-SW-5)*

INCITS xxx-201x, *Fibre Channel - Single-Byte Command Code Sets - 4 (FC-SB-4)*

INCITS TR-32-2003, *Management Information Base-FA (MIB-FA)*

RFC 3410, Introduction and Applicability Statements for Internet Standard Management Framework, December 2002

RFC 4044, Fibre Channel Management MIB, May 2005

RFC 4338, Transmission of IPv6, IPv4, and Address Resolution Protocol (ARP) Packets over Fibre Channel

2.3 References under development

At the time of publication, the following referenced standards and technical reports 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.

T11/Project 2118D, *Fibre Channel - Physical Interface - 5 (FC-PI-5)*

T11/Project 1861D, *Fibre Channel - Framing and Signaling Interface - 3 (FC-FS-3)*

T11/Project 2103D, *Fibre Channel - Link Services - 2 (FC-LS-2)*

T11/Project 1835D, *Fibre Channel - Security Protocols - 2 (FC-SP-2)*

T11/Project 1870DT, *Fibre Channel - Device Attach - 2 (FC-DA-2)*

3 Definitions and conventions

3.1 Overview

For FC-MI-3, the following definitions, conventions, abbreviations, acronyms, and symbols apply.

3.2 Definitions

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

3.2.2 AL_PA bit map: A bit map that shows which ports are present on an Arbitrated Loop. See FC-AL-2.

3.2.3 AL_PA position map: A map that shows port ordering on an Arbitrated Loop. See FC-AL-2.

3.2.4 Arbitrated Loop time out value (AL_Time): A time interval defined by FC-AL-2.

3.2.5 Application: An entity that makes requests of a Service.

3.2.6 Arbitrated Loop Physical Address (AL_PA): A one-byte address value. See FC-AL-2.

3.2.7 Area Identifier: The second or middle level of the three-level addressing hierarchy, found in bits 15 through 8 of an address identifier (see 3.2.1). See FC-SW-5.

3.2.8 B_Port: An Interconnect_Port used to connect bridge devices with E_Ports on a switch. The B_Port provides a subset of the E_Port functionality. See FC-SW-5.

3.2.9 Domain Identifier: The highest level of the three-level addressing hierarchy, found in bits 23 through 16 of an address identifier (see 3.2.1). See FC-SW-5.

3.2.10 E_Port: A Fabric Expansion port that attaches to another Interconnect_Port to create an Inter-Switch Link. See FC-SW-5.

3.2.11 Entry Switch: A role that a switch assumes with respect to a distributed service request. The switch that is attached to an Nx_Port making a service request assumes the role of an entry switch with respect to that request. See FC-SW-5.

3.2.12 Error_Detect_Timeout value (E_D_TOV): A time interval defined in FC-FS-3.

3.2.13 F_Port: In this technical report, an FC_Port within the Fabric that attaches to a non-loop PN_Port through a link, and does not include FL_Ports.

3.2.14 Fabric: A Fibre Channel frame transport infrastructure that includes switches and interconnects various Nx_Ports attached to it.

3.2.15 F_Port Controller: The entity at the well-known address FFFFFEh. See FC-SW-5.

3.2.16 Fabric Shortest Path First (FSPF): The link state protocol used for Path Selection. See FC-SW-5.

3.2.17 FC_Port: A port that is capable of transmitting and receiving Fibre Channel frames according to the FC-0, FC-1, FC-2P, FC-2M, FC-2V, and FC-3 levels of the Fibre Channel standards. See FC-FS-3.

3.2.18 FL_Port: An L_Port that 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 -2). The AL_PA of an FL_Port is 00h. In this technical report, 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.

3.2.19 Fx_Port: A Switch Port (see 3.2.49) capable of operating as an F_Port or FL_Port.

3.2.20 Gateway/Bridge: Any device that interfaces FC to some other interface (see FC-FS-3). The definition of such a device is outside the scope of this technical report.

3.2.21 Hub: For the purposes of this technical report, an interconnect element used with Arbitrated Loops.

3.2.22 Interconnect_Port: An E_Port or a B_Port.

3.2.23 Link Control Facility (LCF): A hardware facility that attaches to an end of a link and manages transmission and reception of data. See FC-FS-3.

3.2.24 Loop Fabric Address (LFA): An address identifier used to address an FL_Port (see FC-SW-5) for the purpose of loop management. See 6.4 and FC-LS-2.

3.2.25 L_Port: A port that contains Arbitrated Loop functions associated with the Arbitrated Loop topology. See FC-AL-2.

3.2.26 Managed Hub: A Hub (see 3.2.21) that provides either in-band or out-of-band management functions.

3.2.27 Name Server: A Server (see 3.2.45) that allows registration and reporting of various objects. See FC-GS-6.

3.2.28 N_Port: An Nx_Port communicating through a PN_Port that is not operating a Loop Port State Machine. See FC-FS-3 and FC-AL-2.

3.2.29 N_Port_ID: A topology unique address identifer of an Nx_Port.

3.2.30 NL_Port: An Nx_Port communicating through a PN_Port that is operating a Loop Port State Machine. See FC-FS-3 and FC-AL-2. In this technical report, an NL_Port is assumed to always refer to a loop-attached port including both Private NL_Ports and Public NL_Ports, and does not include N_Ports.

3.2.31 Node_Name: An identifier associated with a Fibre Channel node. See FC-FS-3.

3.2.32 Nx_Port: A port operating as an N_Port or NL_Port.

3.2.33 OLD-PORT: The state on a set of ports where two devices operate in a point-to-point mode utilizing FC-FS-3 protocols instead of FC-AL-2 protocols. See FC-AL-2 and FC-FS-3.

3.2.34 OPEN_INIT: A state in the LPSM as defined in FC-AL-2.

3.2.35 N_Port_Name: An Identifier associated with an FC_Port. See FC-FS-3.

3.2.36 Partial Response: A response from a Distributed Service that may not have a complete set of data. See FC-SW-5.

3.2.37 Platform: An association of one or more nodes for the purpose of discovery and management.

3.2.38 PN_Port: A Link Control Facility that supports only Nx_Ports. See FC-FS-3

3.2.39 Port: An N_Port, NL_Port, F_Port, FL_Port, B_Port, or E_Port, used in a context where the distinction between specific port types is clarified by other text or not significant.

3.2.40 Port Identifier: The lowest level of the three-level addressing hierarchy, found in bits 7 through 0 of an address identifier (see 3.2.1). See FC-SW-5.

3.2.41 Private NL_Port: An NL_Port that is observing the rules of private loop behavior. See FC-AL-2 and FC-DA-2.

3.2.42 Public NL_Port: An NL_Port that attempts a fabric login and may transfer frames through the FL_Port. A Public NL_Port observes the rules of public loop behavior and/or private loop behavior. See FC-AL-2 and FC-DA-2.

3.2.43 Receiver_Transmitter_Timeout value (R_T_TOV): A time interval defined in FC-FS-3.

3.2.44 Resource_Allocation_Timeout value (R_A_TOV): A time interval defined in FC-FS-3.

3.2.45 Server: An entity that accepts CT requests and provides CT responses. A Server is accessed via a Service (e.g., the Name Server is accessed using the Directory Service). See FC-GS-6.

3.2.46 Service: A service provided by a node, accessible via an N_Port that is addressed by a Well-Known Address (e.g., the Directory Service and the Alias Service). A Service provides access to one or more Servers. See FC-GS-6.

3.2.47 Speed Negotiation: A process that allows an FC_Port capable of multiple operating speeds and connected to another FC_Port that may or may not have the same capability to arrive at the optimum speed of operation. See FC-FS-3.

3.2.48 Switch: An element that makes up the switching portion of the Fabric. See FC-SW-5.

3.2.49 Switch Port: An E_Port, B_Port, F_Port, or FL_Port.

3.2.50 Symbolic Name: A user-defined name for an object, up to 255 characters in length. The Directory Service (see FC-GS-6) does not guarantee uniqueness of its value.

3.2.51 Well-Known Address (WKA): An address identifier defined to access a Service. See FC-FS-3.

3.2.52 Zone: A group of Zone Members. Members of a Zone are made aware of each other, but not made aware of Zone Members outside the Zone. See FC-GS-6 and FC-SW-5.

3.2.53 Zone Member: A device to be included in a Zone. See FC-GS-6 and FC-SW-5.

3.2.54 Zone Set: A set of Zones that are used in combination. See FC-GS-6 and FC-SW-5.

3.3 Editorial Conventions

In FC-MI-3, 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., Exchange, Class). Any lowercase uses of these words have the normal technical English meanings.

Lists sequenced by letters (e.g., a-red, b-blue, c-green) show no ordering relationship between the listed items. Numbered lists (e.g., 1-red, 2-blue, 3-green) show a ordering between the listed items.

The ISO/British convention of decimal number representation is used in this standard. Numbers may be separated by single spaces into groups of three digits counting from the decimal position, and a period is used as the decimal marker. A comparison of the ISO/British, ISO/French, and American conventions is shown in table 1.

Table 1 – ISO and American conventions

ISO/British	ISO/French	American
0.6	0,6	0.6
3.14159265	3,14159265	3.14159265
1 000	1 000	1,000
1 323 462.9	1 323 462,9	1,323,462.9

In case of any conflict between figure, table, and text, the text, then tables, and finally figures take 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.

When the value of the bit or field is not relevant, x or xx appears in place of a specific value.

Numbers that are not immediately followed by lower-case b or h are decimal values.

Numbers immediately followed by lower-case b (xxb) are binary values.

Numbers or upper case letters immediately followed by lower-case h (xxh) are hexadecimal values.

3.4 Abbreviations, acronyms and symbols

Abbreviations and acronyms applicable to this standard are listed. Definitions of several of these items are included in 3.2.

ACC Accept
AL_PA Arbitrated Loop Physical Address, see FC-AL-2
AL_PD Arbitrated Loop Destination Address, see FC-AL-2
AL_Time Arbitrated Loop Time out value, see FC-AL-2
CLS Close Primitive Signal, see FC-AL-2
CT Common Transport, see FC-GS-6
CT_IU Common Transport Information Unit, see FC-GS-6
D_ID Destination address identifier
E_D_TOV Error_Detect_Timeout value
EFP Exchange Fabric Parameters, see FC-SW-5

ELP Exchange Link Parameters, see FC-SW-5
ELS Extended Link Service, see FC-SW-5
FAN Fabric Address Notification Extended Link Service
FLOGI F_Port Login
FSPF Fabric Shortest Path First, see FC-SW-5
HBA Host Bus Adapter
IP Internet Protocol
ISL Inter-Switch Link, see FC-SW-5
IU Information Unit
LFA Loop Fabric Address
LIFA Loop Initialization Fabric Assigned, see FC-AL-2
LINIT Loop Initialization Request, see FC-LS-2
LIP Loop Initialization Primitive Sequence, see FC-AL-2
LIRR Link Incident Report Registration, see FC-LS-2
LISM Loop Initialization Select Master, see FC-AL-2
LS_ACC Link Service Accept
LSTS Loop Status, see FC-LS-2
LOGO Logout
LPSM Loop Port State Machine, see FC-AL-2
LP_TOV Loop Time out Value, see FC-AL-2
LS_RJT Link Service Reject
NPIV N_Port_ID Virtualization, see FC-LS-2
OPN Open Primitive Signal, see FC-AL-2
PLOGI N_Port Login
RLIR Registered Link-Incident Record
RLS Read Link Error Status Block
RNID Request Node Identification Data Extended Link Service
RSCN Registered State Change Notification
R_T_TOV Receiver_Transmitter_Timeout value
S_ID Source address identifier
SAN Storage Area Network
SNMP Simple Network Management Protocol, see RFC 3410
SW_ILS Switch Internal Link Service, see FC-SW-5
ULP Upper Level Protocol
WAN Wide Area Network
WKA Well-Known Address

3.5 Symbols

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

|| concatenation

3.6 Keywords

3.6.1 expected: A keyword used to describe the behavior of the hardware or software in the design models assumed by this technical report. Other hardware and software design models may also be implemented.

3.6.2 ignored: A keyword used to describe an unused bit, byte, word, field or code value. The contents or value of an ignored bit, byte, word, field or code value shall not be examined by the receiving device and may be set to any value by the transmitting device.

3.6.3 invalid: A keyword used to describe an illegal or unsupported bit, byte, word, field or code value. Receipt of an invalid bit, byte, word, field or code value shall be reported as an error.

3.6.4 mandatory: A keyword indicating an item that is required to be implemented as defined in this technical report.

3.6.5 may: A keyword that indicates flexibility of choice with no implied preference (equivalent to “may or may not”).

3.6.6 may not: A keyword that indicates flexibility of choice with no implied preference (equivalent to “may or may not”).

3.6.7 obsolete: A keyword indicating that an item was defined in prior Fibre Channel standards but has been removed from a subsequent Fibre Channel standard.

3.6.8 optional: A keyword that describes features that are not required to be implemented by the referenced standard. However, if any optional feature is implemented, then it shall be implemented as defined in the referenced standard.

3.6.9 reserved: A keyword referring to bits, bytes, words, fields and code values that are set aside for future standardization. A reserved bit, byte, word or field shall be set to zero, or in accordance with a future extension. Recipients are not required to check reserved bits, bytes, words or fields for zero values. In defined fields, receipt of reserved code values shall be reported as an error.

3.6.10 restricted: A keyword referring to bits, bytes, words, and fields that are set aside for use in other standards. A restricted bit, byte, word, or field shall be treated as a reserved bit, byte, word or field for the purposes of the requirements defined in this technical report.

3.6.11 shall: A keyword indicating a mandatory requirement. Designers are required to implement all such mandatory requirements to ensure interoperability with other products that conform to this technical report.

3.6.12 should: A keyword indicating flexibility of choice with a strongly preferred alternative; equivalent to the phrase “it is strongly recommended”.

3.7 Applicability and use of this Technical Report

This technical report specifies which features shall be used (i.e., required) and which features shall not be used (i.e., prohibited) by interoperating compliant Fibre Channel implementations. Use of some features is optional (i.e., allowed). The use of such functions is either negotiated in a fixed and standard manner or the availability of the functions for use shall be determined in a standard manner.

The relationship between use as specified in this technical report and support as implemented by a product is subtle. If this technical report specifies that a feature shall be used, then a compliant implementation shall support it. In some cases, this technical report is asymmetric: to ensure interoperability when an optional feature is used, this technical report requires support for the infrastructure required to use the feature without specifying that the feature be used to conform to this technical report.

The requirements of this technical report are a proper subset of the various relevant standards. This technical report prohibits use of many features and options in these standards. Use of prohibited features may prevent interoperability with Fibre Channel devices complying to this technical report. This technical report does not prohibit implementation of features, only their use. Functions that are mandatory in the appropriate base standard are assumed to be implemented. Implementations may

support features whose use is prohibited by this technical report and such prohibited features may be required for compliance with the relevant standards or other technical reports.

3.8 Feature Set table terms, definitions, and abbreviations

3.8.1 Overview

Features in this technical report are summarized in the form of Feature Set tables. These tables indicate whether the feature is Required, Prohibited, Invocable, or Allowed for compliance with this technical report; or whether a parameter is Required to be a particular value for compliance with this technical report. Features or parameters that are not listed do not affect interoperability.

In several tables within this technical report, there are references to notes associated with the table. These notes are normative and are mandatory requirements of this technical report.

3.8.2 Feature Set table terms and definitions

Terms and definitions are used to define usage of reference features or options provided by the applicable standards are described in table 2.

Table 2 – Feature Set table terms and definitions

Term	Definition
Prohibited	A feature that shall not be used between Fibre Channel devices compliant with this technical report. An implementation may use the feature to communicate with non-compliant implementations. This technical report does not prohibit the implementation of features, only their use between Fibre Channel devices compliant with this technical report. Use of a prohibited feature may prevent interoperability with Fibre Channel devices complying to this technical report.
Required	A feature or parameter value that shall be used between all Fibre Channel devices compliant with this technical report. Fibre Channel devices compliant with this technical report are required to implement the feature. An implementation may use the feature to communicate with non-compliant implementations. If a Fibre Channel device does not implement a required feature that device may not be interoperable with Fibre Channel devices complying to this technical report.
Allowed	A feature or parameter value that may be used between Fibre Channel devices compliant with this technical report. Fibre Channel devices compliant with this technical report are not required to implement the feature, but if they do, the feature shall be implemented as described in the applicable standard. The potential user of a feature may determine if the recipient supports that feature via a Required discovery process or a minimal response by the recipient.
Invocable	A feature or parameter that is required to be implemented by a device to which a request may be sent, but it is not required to be used by a requesting device.

3.8.3 Feature Set table abbreviations

Table 3 contains the key of table abbreviations used within this technical report.

Table 3 – Feature Set table key abbreviations

Key	Definition
P	Prohibited
R	Required
A	Allowed
I	Invocable
X	This parameter has no required value; any value is allowed.
-	This parameter is ignored or this feature is not applicable.

3.9 Feature testing compliance

While not a compliance vehicle in itself, this technical report should be used as the basis for compliance testing. As such, the relationship for the definitions of Prohibited, Required, Allowed, and Invocable (see 3.8) to compliance testing is described in table 4.

Table 4 – Feature testing compliance relationship to definitions

Term	Definition
Prohibited	A feature that is not allowed to be used in a compliant implementation. A compliance test shall only verify that the prohibited feature is not requested by a device. A compliance test shall not generate a request for the prohibited feature, since if it does so, the response is outside the scope of this technical report.
Required	A feature that is required to be implemented by a compliant device. A compliance test is allowed to verify that the feature is correctly requested, and responded to as specified in this technical report or other referenced standards and technical reports.
Allowed	If a device claims to implement the feature, the feature may be tested. If tested, the feature shall conform to the discovery mechanism and function as specified in this technical report and other referenced standards and technical reports. If a device claims to not implement a feature, the feature shall not be tested.
Invocable	A feature that is required to be implemented by a device to which a request may be directed, but it is not required to be used by a requesting device. A compliance test is allowed to verify that the request is correctly responded to as specified in this technical report or other referenced standards and technical reports.

3.10 Timing Constraints

All timings defined in this technical report are meant to limit the amount of time a device takes to accomplish a task. These timings shall be measured on an unloaded system. A heavily loaded

system may exhibit timings in excess of those specified. The term unloaded means that system activity is induced only in direct invocation of the feature under test.

4 Structure and Concepts

4.1 Interoperability Environment

This technical report defines an interoperability environment in which a compliant device adheres to certain sets of behavior (FC_Port Behavior) that allow for interoperability across a wide variety of topologies and management methods. This environment encompasses three areas:

a) Management Behavior: The set of behaviors required to create an interoperable management environment.

b) Loop Behavior: The set of behaviors required to create an interoperable Arbitrated Loop envirment.

c) Fabric Behavior: The set of behaviors required to create an interoperable Fabric environment.

FC_Port Behavior is defined as Loop Behavior, Fabric Behavior, and Management Behavior taken together.

All behaviors are interrelated (e.g., a Fabric may be required not only to meet Fabric Behavior but Loop and Management Behavior as well, or an adapter may be required to meet both Loop and Management Behavior). The level of behavior support in any particular device depends on the supported Management, Loop, FC_Port and Fabric functions.

A device may be non-compliant with this technical report, and still be compliant with the various referenced Fibre Channel Standards. However, devices not compliant with this technical report may not be interoperable.

5 Loop Behaviors

5.1 Loop Initialization

5.1.1 Power On Behavior

During power on, after the transmitter has been enabled and 200 microseconds of valid Fibre Channel signal at or above FC-PI minimum amplitude levels has been driven by the transmitter, an FL_Port that is not executing Speed Negotiation shall not disrupt the operation of the loop for more than 95 milliseconds and shall begin forwarding transmission words or begin initialization within 95 milliseconds.

NOTE 1 – The delay of 200 microseconds of enforcement of limits on disruption recognizes that many HBAs and devices by design disrupt during power-on, and that most hubs isolate an attached device or HBA until it has presented at least 200 microseconds of FC-PI-compliant signal. The expectation is that any disruption caused by a device or HBA at power-on is harmless until after it has presented 200 microseconds of valid signal, because until then it is isolated from the loop by its hub.

FC-FS-3 specifies the disruption of a loop that may result from attaching to it an FL_Port configured to execute Speed Negotiation. An FL_Port that is executing Speed Negotiation disrupts up to three times over a period not exceeding t_disrupt2. No period of disruption exceeds t_disrupt1. See FC-FS-3 for definitions and derivations of t_disrupt1 and t_disrupt2.

5.1.2 Loop Failure

An FL_Port shall not issue a LIP for loop failure based on loss of synchronization before the loss of synchronization exceeds R_T_TOV.

5.1.3 Initialization at Power-on

FL_Ports shall request only one loop initialization at power on, unless the FL_Port attempts to enter OLD-PORT state, after which only one additional loop initialization may be requested.

An FL_Port that is executing Speed Negotiation may disrupt the loop causing the loop to initialize more than once, however, having completed Speed Negotiation as evidenced by the FL_Port originating or passing through LISM frames, such an FL_Port is subject to the limits of this subclause.

5.1.4 FL_Port Time-out during Initialization

It may be necessary for an FL_Port to request loop initialization multiple times. An FC-AL-2 FL_Port may request initialization again using the following rules:

a) If loop initialization has not completed within 2 sec.;

b) The second time the device shall increase the initialization completion timeout to greater than 24 sec.;

c) The third and subsequent times the device shall increase the initialization completion timeout to greater than 128 sec.

FC-AL-2 FL_Ports shall follow the FC-AL-2 initialization timeout requirements. If there is an upper level timer running on the initialization process the upper level shall follow the rules above for FC-AL-2 FL_Ports.

5.1.5 LIP Generation

An FL_Port requesting loop initialization shall generate a minimum of 12 LIPs.

5.1.6 Response to LIP

An FL_Port shall recognize and forward 12 of the LIPs received within 5 milliseconds, unless it is already in OPEN_INIT and ignoring LIPs for AL_Time.

An FL_Port that is executing Speed Negotiation may issue continuous LIPs of type unrelated to the type it receives, however, having completed Speed Negotiation as evidenced by the FL_Port originating or passing through LISM frames, such an FL_Port is subject to the limits of this subclause.

5.1.7 Origination of LISM Frames

An FL_Port that has not received a higher priority LISM shall originate LISM frames with a maximum of 5 milliseconds. between LISM frames. FC-AL FL_Ports may source IDLEs for 15 milliseconds before they begin sourcing LISMs.

5.1.8 Forwarding of LISM frames

An FL_Port that has received a higher priority LISM than what it is currently transmitting shall forward the last LISM recognized, provided only higher priority LISMs are received, with a delay of no more than the maximum of either:

a) 25 milliseconds; or

b) 2 times the delay between received LISM frames.

Subsequent LISM frames shall be forwarded, provided only higher priority LISMs are received, with a delay of no more than the maximum of either:

a) 5 milliseconds; or

b) 2 times the delay between received LISM frames.

5.1.9 Address Selection

After any of the following, the FL_Port shall attempt to take address 00h during the LIFA phase:

a) A power cycle or equivalent reset of the FL_Port;

b) Receipt of any LIP; or

c) When the FL_Port transitions from Non-Participating to Participating.

5.1.10 Multi-port Initialization

In order to minimize disruptions, a multi-port FL_Port device has the following initialization requirements:

a) A LIP on one FL_Port shall not cause a LIP on any of the other FL_Ports; and

b) Initialization on one FL_Port shall not cause any other FL_Port to lose any frames, state, or otherwise impact traffic on its loop, except data being transferred between the initializing FL_Port to another FL_Port.

5.1.11 AL_PA Position Map Support

AL_PA position map support has the following rules:

a) AL_PA position map support shall be provided by all FC-AL-2 FL_Ports;

b) Devices that do not support the AL_PA position map may be present on the loop, therefore FL_Ports shall not rely on AL_PA position map support for functionality; and

c) If all devices on a loop support AL_PA position map, then AL_PA position map shall be used to determine what devices are available. Attempting to open devices that were not in the last AL_PA position map is prohibited.

5.1.12 Availability after LIP

For FL_Ports, the following shall apply after a LIP:

a) An FL_Port that has taken an address during a loop initialization shall be capable of processing all supported Fabric services upon completion of loop initialization; and

b) After an FL_Port has taken an address, unless it goes non-participating for any reason, it shall take an address in all subsequent loop initializations.

5.2 Post Initialization

5.2.1 LIP Generation

5.2.1.1 Proper LIP Generation

Once an FL_Port has initialized, an FL_Port should minimize the generation of LIPs. Situations where it is permitted, but not required for an FL_Port to generate a LIP are as follows:

a) Unable to win arbitration for greater than LP_TOV;

b) Loss of word sync for greater than R_T_TOV;

c) A loss of signal is detected;

d) A CLS in response to CLS has not been received within LP_TOV; or

e) An FL_Port receives an OPN that it sent to an NL_Port.

5.2.1.2 Improper LIP Generation

An FL_Port shall not generate a LIP in response to the following:

a) Link error counter overrun;

b) CRC error detection;

c) Reception of an unexpected frame;

d) Reception of a CLS in response to an OPN; and

e) No R_RDY or CLS received in response to an OPN.

5.2.2 FL_Port Unfair behavior and Transfer behavior

The FL_Port delivers frames by arbitrating for the loop, opening the destination NL_Port, transmitting the frames, and closing the loop. As allowed by FC-AL-2, the FL_Port may arbitrate unfairly (i.e., the FL_Port may enter the ARBITRATING state at any time without regard to access fairness).

Once the FL_Port has acquired control of the loop, it may retain that control to deliver frames to more than one destination NL_Port by using the TRANSFER state. When the FL_Port transmits and receives a CLS with a destination NL_Port, it may maintain control of the loop and open another destination NL_Port. The FL_Port should weigh this control against starvation of other ports on the loop. In the case of the FAN ELS, the FL_Port is required to deliver frames to all attached Public NL_Ports using the TRANSFER state with access set true.

NOTE 2 – One possible arbitration strategy is to retain control of the loop until an NL_Port arbitrates, then release the loop after completing the current loop tenancy.

5.2.3 Responses to OPN

If an FL_Port sends an OPN, and receives that same OPN, the NL_Port addressed by the OPN is no longer participating on the loop. The FL_Port shall perform an implicit logout of the NL_Port. The FL_Port may perform a Loop Initialization.

The reception of a CLS in response to an OPN is an indication that an NL_Port is busy. This is not an error condition, and shall not cause error recovery to occur. If the FL_Port is operating with an NL_Port with a Login BB_Credit of zero, the NL_Port may be busy, and the FL_Port shall forward the CLS, and retry the OPN. Because the busy condition is handled by the procedure in this subclause, the FL_Port shall not originate a LIP to clear this condition. The normal frame timeout limits shall be observed if the NL_Port is busy for sufficient time to cause a frame timeout to occur. If the busy condition persists for greater than LP_TOV, the FL_Port may originate a LIP to initialize the loop.

5.2.4 No response to OPN

The lack of any response to an OPN can indicate a number of failures (e.g., the OPN was corrupted on the loop, or the R_RDY or CLS from the device was corrupted). The proper response to this condition is for the originator of the OPN to originate a CLS and after the CLS is received by the originator, when the arbitration window is again available arbitrate and attempt to OPN this device. Because this error condition is cleared by this procedure, the originator of the OPN shall not originate a LIP to clear this condition.

6 Fx_Port Behaviors

6.1 Fx_Port Login responses

6.1.1 FLOGI ACC features and parameters for Fx_Ports

Table 5 lists features and parameters for FLOGI ACC with usage defined by this technical report.

Table 5 – FLOGI ACC features and parameters for Fx_Ports

Feature/Parameter	Fx_Port Responder
FLOGI ACC S_ID	
N_Port	FFFFFEh
NL_Port	FFFFFEh
FLOGI ACC D_ID	
N_Port	ddaaXX[a]
NL_Port	ddaa||AL_PA[b]
Class of service for FLOGI[c]	
Class 2	A
Class 3	R
Supported Classes of Service	
Class 2	A
Class 3	R

[a] The fabric shall assign the address identifier according to the rules in FC-LS-2. Multiple N_Ports may be assigned addresses with the same aa.

[b] The fabric shall build the assigned ID by using the requestor's Port_ID (AL_PA) for the low order byte (i.e., the AL_PA was received in the FLOGI request as the low order byte of the S_ID). The fabric shall assign the Domain_ID (dd) and Area_ID (aa) to a valid value (see FC-SW-5). The value of 'ddaa' shall be the same for all Public NL_Ports on a given loop. The fabric shall return the value of the low order byte of the S_ID of the FLOGI request in the low order byte of the D_ID.

[c] FLOGI ACC shall be returned in the same class of service in which the FLOGI was received, if that class of service is supported by the fabric. If the class of service of the request is not supported, an LS_RJT shall be returned in the class of service of the request.

6.1.2 Nx_Port PLOGI

Fabric services in a switch shall respond to PLOGIs as specified in FC-DA-2.

6.1.3 Fx_Port Common Service Parameters (FLOGI ACC)

Table 6 lists Fx_Port Common Service Parameters for FLOGI ACC with usage defined by this technical report. The parameters are valid for both Class 2 and Class 3 delivery service.

Table 6 – Fx_Port Common Service Parameters (FLOGI ACC) (Sheet 1 of 2)

Common Service Parameter	Fx_Port Responder
FC-LS-2	
FC-PH Version	2020h[a]
Buffer-to-Buffer Credit (minimum for FL_Port)	0[b]
Buffer-to-Buffer Credit (minimum for F_Port)	1
Common Features	
Valid Vendor Version Level	0
N_Port/F_Port	1
BB_Credit Management	X[c]
Buffer-to-Buffer Receive Data Field Size (minimum)	256 bytes
Clean Address bit	X[d]
Virtual Fabrics bit	X
Multiple N_Port_ID Assignment	X[g]
N_Port/F_Port	1
Name Server Session Started	X

[a] Although FC-LS-2 has obsoleted the version numbers, this field shall be set as specified.

[b] An FL_Port is required to support a value of zero or greater for this parameter.

[c] For FL_Ports operating in loop mode this value shall be one, for F_Ports this value shall be zero.

[d] The Clean Address bit functionality shall be supported.

[e] These shall be used as default values. A compliant implementation may change these values, but it is up to the implementor to ensure interoperability.

[f] These values may need to be modified when used in a WAN environment.

[g] The Multiple N_Port_ID Assignment bit shall be set as defined in FC-LS-2.

[h] For Fabrics that support RFC 4338, this bit shall be set to one.

[i] If the Payload bit is set to one in a FLOGI request an FC-MI-3 compliant device may respond with the payload bit set to one or reject the request. FC-DA-2 compliant devices do not set the Payload bit to one.

[j] If BB_Credit Recovery is supported, then BB_SC_N shall be set to 8. If BB_Credit Recovery is not supported, then BB_SC_N shall be set to zero.

Table 6 – Fx_Port Common Service Parameters (FLOGI ACC) (Sheet 2 of 2)

Common Service Parameter	Fx_Port Responder
E_D_TOV Resolution	0[e]
Broadcast supported by Fabric	X[h]
Query Data Buffer conditions	0
Security Bit (see FC-SP-2)	X
Clock Synchronization Primitive Capable	X
R_T_TOV Value	0
Dynamic Half Duplex Supported	X
Payload Bit	X[i]
BB_SC_N	X[j]
R_A_TOV	10 000 ms[e, f]
E_D_TOV	2 000 ms[e, f]

[a] Although FC-LS-2 has obsoleted the version numbers, this field shall be set as specified.

[b] An FL_Port is required to support a value of zero or greater for this parameter.

[c] For FL_Ports operating in loop mode this value shall be one, for F_Ports this value shall be zero.

[d] The Clean Address bit functionality shall be supported.

[e] These shall be used as default values. A compliant implementation may change these values, but it is up to the implementor to ensure interoperability.

[f] These values may need to be modified when used in a WAN environment.

[g] The Multiple N_Port_ID Assignment bit shall be set as defined in FC-LS-2.

[h] For Fabrics that support RFC 4338, this bit shall be set to one.

[i] If the Payload bit is set to one in a FLOGI request an FC-MI-3 compliant device may respond with the payload bit set to one or reject the request. FC-DA-2 compliant devices do not set the Payload bit to one.

[j] If BB_Credit Recovery is supported, then BB_SC_N shall be set to 8. If BB_Credit Recovery is not supported, then BB_SC_N shall be set to zero.

6.1.4 Fx_Port Class 2 Service Parameters (FLOGI ACC)

If Class 2 is supported, Table 7 lists Class 2 Service Parameters for FLOGI ACC response with usage defined by this technical report.

Table 7 – Class 2 Service Parameters (FLOGI ACC)

Class 2 Service Parameter	Value
Class validity	1
Service Options	
Sequential Delivery	1
Priority	X[a]
Preference	X[a]
DiffServ QoS	0
Initiator Control	
ACK_0 capable	-
ACK generation assistance	-
Clock synchronization capable	0
Recipient Control	
ACK_0 capable	-
X_ID interlock	-
Error Policy Supported	-
Categories per Sequence	-
Clock synchronization capable	A
Reserved - Fabric specific	0
Receive data field size (minimum)	-
Concurrent Sequences (minimum)	-
N_Port End-to-end Credit (minimum)	-
Open Sequences per Exchange (minimum)	-

[a] This bit shall only be set to one if the entire Fabric supports the feature.

6.1.5 Fx_Port Class 3 Service Parameters (FLOGI ACC)

Table 8 lists Class 3 Service Parameters for FLOGI ACC response with usage defined by this technical report.

Table 8 – Class 3 Service Parameters (FLOGI ACC)

Class 3 Service Parameter	Value
Class validity	1
Service Options	
Sequential Delivery	1
Priority/Preemption	X[a]
Preference	X[a]
DiffServ QoS	0
Initiator Control	
ACK_0 capable	-
ACK generation assistance	-
Clock synchronization capable	0
Recipient Control	
ACK_0 capable	-
X_ID interlock	-
Error Policy Supported	-
Categories per Sequence	-
Clock synchronization ELS capable	A
Reserved - Fabric specific	0
Receive data field size (minimum)	-
Concurrent Sequences (minimum)	-
N_Port End-to-end Credit	-
Open Sequences per Exchange (minimum)	-

[a] This bit shall only be set to one if the entire Fabric supports the feature.

6.2 Link Services

6.2.1 Basic Link Services

Fabric services in a switch shall support Basic Link Services as specified in FC-DA-2.

6.2.2 ELS requirements for well-known addresses

See FC-DA-2 for N_Port well-known address responder requirements.

If Zoning is active in the fabric, an ELS response from a well-known address shall only include data relating to Nx_Ports that are in the same Zone(s) as the requesting Nx_Port.

6.2.3 Extended Link Service replies

Table 9 specifies the support required by this technical report for Extended Link Service Replies. This table only applies to those supported Extended Link Service requests that have valid replies as indicated in FC-LS-2.

Table 9 – Extended Link Service Replies

Name	Abbr	OpCode	Originator Support	Responder Support
Accept	LS_ACC	-	-	R
Link Service Reject	LS_RJT	-	-	R

6.2.4 FC-4 specific behavior

6.2.4.1 FC-SB-4 Extended Link Services

Table 10 lists FC-4 specific Extended Link Services for FC-SB-4 usage as defined by this technical report.

Table 10 – FC-SB-4 Extended Link Service support (Sheet 1 of 2)

Name	Originated by Switch	Response by Switch
Link Incident Record Registration (LIRR)[a]	P	R
Query Security Attributes (QSA)	P	R
Read Link Error Status Block (RLS)	P	R
Registered Fabric Change Notification (RFCN)	R	-
Registered Link Incident Report (RLIR)[a]	R	-
Registered State Change Notification (RSCN)	R	R

[a] FC-SB-4 (type 18h) specific node-identification data and link incident record format shall be supported (see FC-SB-4).

Table 10 – FC-SB-4 Extended Link Service support (Sheet 2 of 2)

Name	Originated by Switch	Response by Switch
Request Node Identification Data (RNID)[a]	R	R
State Change Registration (SCR)	P	R
Process Login (PRLI)	P	-
Process Logout (PRLO)	P	-

[a] FC-SB-4 (type 18h) specific node-identification data and link incident record format shall be supported (see FC-SB-4).

6.3 FC-AL-2 features for FL_Ports

Table 11 lists Fibre Channel Arbitrated Loop features for FL_Ports with usage defined by this technical report. In table 11, the FL_Port Originator column refers to an FL_Port sending an FC-AL-2 feature to an NL_Port, and the FL_Port Responder column refers to an FL_Port receiving an FC-AL-2 feature from an NL_Port.

Table 11 – FC-AL-2 features for FL_Ports (Sheet 1 of 3)

Feature	FL_Port Originator	FL_Port Responder
Open Full Duplex	R	R
Open Half Duplex	P	R
Send frames from multiple S_IDs in a single Loop Tenancy	I	-
Receive frames to multiple D_IDs in a single Loop Tenancy	-	R
Unfairness	I	-
Transfer mode (use of TRANSFER loop state)	R[a]	-
Alternate BB_Credit model[b]	R	R

[a] Required uses of Transfer mode are described in 5.2.2.

[b] Alternate BB_Credit management is mandatory in FC-AL-2.

[c] FL_Ports shall interoperate with NL_Ports that support any Login_BB_Credit. A recipient of frames may login with Login_BB_Credit greater than zero, but the originator of frames is not required to take advantage of the non- zero Login_BB_Credit.

[d] NL_Ports may use Broadcast Replicate (OPNfr) or Selective Replicate (OPNyr) to communicate on a Local Loop. As required by FC-AL-2, the FL_Port shall not receive frames associated with OPNfr or OPNyr. Therefore, frames originated on a Local Loop by an NL_Port using OPNfr or OPNyr shall not propagate beyond the Local Loop.

[e] The only method allowed by this technical report for delivering broadcast from the FL_Port to the attached NL_Ports is via an OPNfr sent by the FL_Port. The FL_Port is not required to perform a discovery process to determine whether the attached NL_Ports are able to receive broadcast frames via OPNfr. Use of broadcast, and the number of frames that may be sent following OPNfr, are both specific to the ULP.

[f] An NL_Port with broadcast frames intended for Remote Ports shall open the FL_Port via OPNyx or OPNyy or be opened by the FL_Port via OPNyx, and send the frames to the FL_Port for forwarding by the fabric (see FC-AL-2). This causes broadcast frames to be delivered to the Local Loop.

[g] LPEfx allows resetting the bypass circuits of NL_Ports that have been bypassed and have lost their AL_PAs due to a LIP and therefore are not enabled using an addressed LPEyx.

[h] This LIP may be issued by an FL_Port to request an AL_PA if it is non-participating, or for any of the reasons listed in 5.2.1.1. The FL_Port response to a LIP is described in 5.1.6.

[i] This LIP may be issued by an FL_Port which detects a Link Failure (see FC-FS-3).

[j] An NL_Port or FL_Port may invoke this form of LIP to reset an NL_Port in a ULP-specific manner. An FL_Port shall respond to this form of LIP in the same manner as LIP(F7,AL_PS).

[k] An FL_Port that receives MRK shall attempt to forward the MRK. An FL_Port may remove a MRK if necessary for clock skew management (see FC-AL-2).

Table 11 – FC-AL-2 features for FL_Ports (Sheet 2 of 3)

Feature	FL_Port Originator	FL_Port Responder
Login_BB_Credit equal to 0[c]	I	R
Login_BB_Credit greater than 0[c]	A	A
Broadcast via Broadcast Replicate (OPNfr)		
Transmit to NL_Ports on the Local Loop[e, f]	A	-
Receive from NL_Ports on the Local Loop[d, f]	-	P
Broadcast via Selective Replicate (OPNyr)		
Transmit to NL_Ports on the Local Loop[e]	P	-
Receive from NL_Ports on the Local Loop[d]	-	P

[a] Required uses of Transfer mode are described in 5.2.2.

[b] Alternate BB_Credit management is mandatory in FC-AL-2.

[c] FL_Ports shall interoperate with NL_Ports that support any Login_BB_Credit. A recipient of frames may login with Login_BB_Credit greater than zero, but the originator of frames is not required to take advantage of the non- zero Login_BB_Credit.

[d] NL_Ports may use Broadcast Replicate (OPNfr) or Selective Replicate (OPNyr) to communicate on a Local Loop. As required by FC-AL-2, the FL_Port shall not receive frames associated with OPNfr or OPNyr. Therefore, frames originated on a Local Loop by an NL_Port using OPNfr or OPNyr shall not propagate beyond the Local Loop.

[e] The only method allowed by this technical report for delivering broadcast from the FL_Port to the attached NL_Ports is via an OPNfr sent by the FL_Port. The FL_Port is not required to perform a discovery process to determine whether the attached NL_Ports are able to receive broadcast frames via OPNfr. Use of broadcast, and the number of frames that may be sent following OPNfr, are both specific to the ULP.

[f] An NL_Port with broadcast frames intended for Remote Ports shall open the FL_Port via OPNyx or OPNyy or be opened by the FL_Port via OPNyx, and send the frames to the FL_Port for forwarding by the fabric (see FC-AL-2). This causes broadcast frames to be delivered to the Local Loop.

[g] LPEfx allows resetting the bypass circuits of NL_Ports that have been bypassed and have lost their AL_PAs due to a LIP and therefore are not enabled using an addressed LPEyx.

[h] This LIP may be issued by an FL_Port to request an AL_PA if it is non-participating, or for any of the reasons listed in 5.2.1.1. The FL_Port response to a LIP is described in 5.1.6.

[i] This LIP may be issued by an FL_Port which detects a Link Failure (see FC-FS-3).

[j] An NL_Port or FL_Port may invoke this form of LIP to reset an NL_Port in a ULP-specific manner. An FL_Port shall respond to this form of LIP in the same manner as LIP(F7,AL_PS).

[k] An FL_Port that receives MRK shall attempt to forward the MRK. An FL_Port may remove a MRK if necessary for clock skew management (see FC-AL-2).

Table 11 – FC-AL-2 features for FL_Ports (Sheet 3 of 3)

Feature	FL_Port Originator	FL_Port Responder
LPEyx, LPByx, or LPEfx[g]	I	P
LIP		
(F7, F7) and (F7, AL_PS) [initializing][h]	I	R
(F8, F7) and (F8, AL_PS) [loop failure][i]	I	R
(AL_PD, AL_PS) [selective hard reset][j]	I	R
MRK[k]	P	R

[a] Required uses of Transfer mode are described in 5.2.2.

[b] Alternate BB_Credit management is mandatory in FC-AL-2.

[c] FL_Ports shall interoperate with NL_Ports that support any Login_BB_Credit. A recipient of frames may login with Login_BB_Credit greater than zero, but the originator of frames is not required to take advantage of the non- zero Login_BB_Credit.

[d] NL_Ports may use Broadcast Replicate (OPNfr) or Selective Replicate (OPNyr) to communicate on a Local Loop. As required by FC-AL-2, the FL_Port shall not receive frames associated with OPNfr or OPNyr. Therefore, frames originated on a Local Loop by an NL_Port using OPNfr or OPNyr shall not propagate beyond the Local Loop.

[e] The only method allowed by this technical report for delivering broadcast from the FL_Port to the attached NL_Ports is via an OPNfr sent by the FL_Port. The FL_Port is not required to perform a discovery process to determine whether the attached NL_Ports are able to receive broadcast frames via OPNfr. Use of broadcast, and the number of frames that may be sent following OPNfr, are both specific to the ULP.

[f] An NL_Port with broadcast frames intended for Remote Ports shall open the FL_Port via OPNyx or OPNyy or be opened by the FL_Port via OPNyx, and send the frames to the FL_Port for forwarding by the fabric (see FC-AL-2). This causes broadcast frames to be delivered to the Local Loop.

[g] LPEfx allows resetting the bypass circuits of NL_Ports that have been bypassed and have lost their AL_PAs due to a LIP and therefore are not enabled using an addressed LPEyx.

[h] This LIP may be issued by an FL_Port to request an AL_PA if it is non-participating, or for any of the reasons listed in 5.2.1.1. The FL_Port response to a LIP is described in 5.1.6.

[i] This LIP may be issued by an FL_Port which detects a Link Failure (see FC-FS-3).

[j] An NL_Port or FL_Port may invoke this form of LIP to reset an NL_Port in a ULP-specific manner. An FL_Port shall respond to this form of LIP in the same manner as LIP(F7,AL_PS).

[k] An FL_Port that receives MRK shall attempt to forward the MRK. An FL_Port may remove a MRK if necessary for clock skew management (see FC-AL-2).

6.4 Loop Fabric Address

The Loop Fabric Address is used as the destination ID (D_ID) in the LINIT and LSTS ELS Request Sequences, and is used as the source ID (S_ID) in the Reply Sequences. No other Sequences shall be directed to a Loop Fabric Address. Devices compliant with FC-DA-2 are prohibited from sending LINIT to the Loop Fabric Address. As such, devices compliant with this technical report are only required to support LSTS sent to the Loop Fabric Address.

7 Fabric Behaviors

7.1 Overview

This clause defines the interoperability requirements for a Fabric. A Fabric consists of a Fabric containing a single Switch, or containing two or more Switches connected via E_Ports. The purpose of this clause is to define the minimum functionality that needs to be supported in order to deploy a Fabric.

This clause defines the following two aspects of Fabrics:

a) Required Switch-to-Switch (E_Port) behaviors. These are based primarily on functions defined in FC-SW-5; and

b) Required Fabric services provided to an attached Nx_Port. These are based primarily on functions defined in FC-GS-6.

7.2 Switch-to-Switch Requirements

7.2.1 Overview

Table 12 summarizes support requirements for features defined in FC-SW-5. A compliant device shall implement all features as specified in table 12. FC-SW-5 clauses that are descriptive in nature are not included in table 12.

Table 12 – FC-SW-5 Fabric Support Summary (Sheet 1 of 4)

Description	Support
Structure and Concepts	
Fabric Addressing	R
Switch Ports	
For specific Port Type support, see table 13.	
Class F Service	R
Switch Internal Link Services	
SW_ACC	R
Switch Reject (SW_RJT)	R
Exchange Link Parameters (ELP) (see 7.2.3)	R[a]
Exchange Fabric Parameters (EFP)	R[a, b]
Domain_ID Assigned (DIA)	R[a]
Request Domain_ID (RDI)	R[a]
Hello (HLO)	R[c]

[a] The ELP, EFP, RDI, DIA, and BF SW_ILS frames shall not be used except as part of the initialization and Principal Switch selection state machines as specified in FC-SW-5.

[b] The Multicast_ID_List fields of the EFP shall not be used.

[c] FSPF SW_ILS frames shall not be used except as part of the FSPF state machines as specified in FC-SW-5.

[d] Only the Switch Link Record (i.e., LSR Type 01h) is required in LSU and LSA SW_ILS frames.

[e] A Fabric is prohibited from autonomously generating a RCF, but an outside administrative function may request a switch to generate an RCF. Such an administrative function is outside the scope of this technical report.

[f] The ESC SW_ILS is allowed here for vendor specific reasons.

[g] The MR SW_ILS is required for Basic Zoning and allowed for Enhanced Zoning.

[h] Switches adhering to FC-SW-2 respond unpredictably if an Enhanced Zoning MR is received.

[i] The DRLIR SW_ILS is required for FC-SB-4 support and allowed in other environments.

[j] See 7.2.4 for details of Principal Switch Selection requirements.

[k] CEC SW_ILS support is required for B_Port only.

Table 12 – FC-SW-5 Fabric Support Summary (Sheet 2 of 4)

Description	Support
Link State Update (LSU)	R[d, c]
Link State Acknowledgement (LSA)	R[d, c]
Build Fabric (BF)	R[a]
Reconfigure Fabric (RCF)	A[e]
Inter-Switch Registered State Change Notifications (SW_RSCN)	R
Distributed Registered Link Incident Records (DRLIR)	R[i]
Merge Request (MR)[h]	R[g]
Acquire Change Authorization Request (ACA)	R
Release Change Authorization Request (RCA)	R
Stage Fabric Configuration Request (SFC)	R
Update Fabric Configuration Request (UFC)	R
Check E_Port Connectivity (CEC)	R[k]
Enhanced Acquire Change Authorization (EACA)	P
Enhanced Stage Fabric Configuration (ESFC)	P
Enhanced Update Fabric Configuration (EUFC)	P
Enhanced Release Change Authorization (ERCA)	P

[a] The ELP, EFP, RDI, DIA, and BF SW_ILS frames shall not be used except as part of the initialization and Principal Switch selection state machines as specified in FC-SW-5.

[b] The Multicast_ID_List fields of the EFP shall not be used.

[c] FSPF SW_ILS frames shall not be used except as part of the FSPF state machines as specified in FC-SW-5.

[d] Only the Switch Link Record (i.e., LSR Type 01h) is required in LSU and LSA SW_ILS frames.

[e] A Fabric is prohibited from autonomously generating a RCF, but an outside administrative function may request a switch to generate an RCF. Such an administrative function is outside the scope of this technical report.

[f] The ESC SW_ILS is allowed here for vendor specific reasons.

[g] The MR SW_ILS is required for Basic Zoning and allowed for Enhanced Zoning.

[h] Switches adhering to FC-SW-2 respond unpredictably if an Enhanced Zoning MR is received.

[i] The DRLIR SW_ILS is required for FC-SB-4 support and allowed in other environments.

[j] See 7.2.4 for details of Principal Switch Selection requirements.

[k] CEC SW_ILS support is required for B_Port only.

Table 12 – FC-SW-5 Fabric Support Summary (Sheet 3 of 4)

Description	Support
Transfer Commit Ownership (TCO)	P
Exchange Switch Capabilities (ESC)	A[f]
Exchange Switch Support (ESS)	I
Merge Request Resource Allocation (MRRA)	A
Switch Trace Route (STR)	A
Exchange Virtual Fabric Parameters (EVFP)	A
Fast Fabric Initialization for the Avionics Environment (FFI)	P
Fabric Configuration	
Switch Port Initialization	R
Principal Switch Selection	R[j]
Address Distribution	R
E_Port and Fabric Isolation	R
B_Port operation	A

[a] The ELP, EFP, RDI, DIA, and BF SW_ILS frames shall not be used except as part of the initialization and Principal Switch selection state machines as specified in FC-SW-5.

[b] The Multicast_ID_List fields of the EFP shall not be used.

[c] FSPF SW_ILS frames shall not be used except as part of the FSPF state machines as specified in FC-SW-5.

[d] Only the Switch Link Record (i.e., LSR Type 01h) is required in LSU and LSA SW_ILS frames.

[e] A Fabric is prohibited from autonomously generating a RCF, but an outside administrative function may request a switch to generate an RCF. Such an administrative function is outside the scope of this technical report.

[f] The ESC SW_ILS is allowed here for vendor specific reasons.

[g] The MR SW_ILS is required for Basic Zoning and allowed for Enhanced Zoning.

[h] Switches adhering to FC-SW-2 respond unpredictably if an Enhanced Zoning MR is received.

[i] The DRLIR SW_ILS is required for FC-SB-4 support and allowed in other environments.

[j] See 7.2.4 for details of Principal Switch Selection requirements.

[k] CEC SW_ILS support is required for B_Port only.

Table 12 – FC-SW-5 Fabric Support Summary (Sheet 4 of 4)

Description	Support
Routing Protocols	
Fabric Shortest Path First (FSPF)	R
Distributed Services (see 7.2.6)	
Switch Zone Exchange & Merge (see 7.2.7)	
Distributed Event Notification (see 7.2.8)	

[a] The ELP, EFP, RDI, DIA, and BF SW_ILS frames shall not be used except as part of the initialization and Principal Switch selection state machines as specified in FC-SW-5.

[b] The Multicast_ID_List fields of the EFP shall not be used.

[c] FSPF SW_ILS frames shall not be used except as part of the FSPF state machines as specified in FC-SW-5.

[d] Only the Switch Link Record (i.e., LSR Type 01h) is required in LSU and LSA SW_ILS frames.

[e] A Fabric is prohibited from autonomously generating a RCF, but an outside administrative function may request a switch to generate an RCF. Such an administrative function is outside the scope of this technical report.

[f] The ESC SW_ILS is allowed here for vendor specific reasons.

[g] The MR SW_ILS is required for Basic Zoning and allowed for Enhanced Zoning.

[h] Switches adhering to FC-SW-2 respond unpredictably if an Enhanced Zoning MR is received.

[i] The DRLIR SW_ILS is required for FC-SB-4 support and allowed in other environments.

[j] See 7.2.4 for details of Principal Switch Selection requirements.

[k] CEC SW_ILS support is required for B_Port only.

7.2.2 Switch Port Types

Switch Port Type usage is shown in table 13.

Table 13 – Switch Port Type Usage

Switch Port Type	Support
F_Port	A
FL_Port	A
E_Port	R
B_Port	A

Switch Ports have the following requirements:

a) A Switch may have a mix of different Switch Port types. Not all Switch Ports on a Switch are required to support the same Switch Port types;

b) A single Switch Port may support more than one Switch Port type. If a single Switch Port supports multiple Switch Port types, the Switch Port type shall be discovered as specified in FC-SW-5;

c) A Switch shall support E_Port functionality on at least one Switch Port; and

d) A Switch shall support at least one of F_Port, or FL_Port operation. A switch may support both F_Port and FL_Port.

7.2.3 Exchange Link Parameters (ELP)

The ELP SW_ILS as defined in FC-SW-5 shall be used with the parameters specified in table 14.

Table 14 – ELP SW_ILS Parameters (Sheet 1 of 2)

Item	Value
Revision	3
Flags	0[a]
BB_SC_N	0 or 8
R_A_TOV	10 000 milliseconds[c, d, e]
E_D_TOV	2 000 milliseconds[c, d, e]
Requestor Interconnect Port_Name	X
Requestor Switch_Name	X

[a] B_Port functionality is allowed, but its use is outside the scope of this technical report.

[b] Support of Class F for an E_Port is required as specified by FC-SW-5.

[c] This value shall be used in FLOGI ACC.

[d] These shall be used as default values. A compliant implementation may change these values, but it is up to the implementor to ensure interoperability.

[e] These values may need to be modified when used in a WAN environment.

Table 14 – ELP SW_ILS Parameters (Sheet 2 of 2)

Item		Value
Class F Params	Class Valid	1[b]
	X_ID Interlock	0
	Receive Data Field Size	2 112 bytes
	Concurrent Sequences	1
	End-to-End Credit	1
	Open Sequences per Exchange	1
Class 2 Params	Class Valid	X
	Sequential Delivery	1
	Receive Data Field Size	2 112 bytes
Class 3 Params	Class Valid	1
	Sequential Delivery	1
	Receive Data Field Size	2 112 bytes
ISL Flow Control Mode		2
Flow Control Parameter Length		20 bytes
Flow Control Parameters		(see table 15)

[a] B_Port functionality is allowed, but its use is outside the scope of this technical report.

[b] Support of Class F for an E_Port is required as specified by FC-SW-5.

[c] This value shall be used in FLOGI ACC.

[d] These shall be used as default values. A compliant implementation may change these values, but it is up to the implementor to ensure interoperability.

[e] These values may need to be modified when used in a WAN environment.

To ensure consistent support of Classes of Service over the entire Fabric, the ELP SW_ILS shall be accepted by the responding Switch only if the two Switches support the same Classes of Service, otherwise it shall be rejected with a SW_RJT Reason Code “Logical Error” and SW_RJT Reason Code Explanation “Class N Service Parameter error”, and the involved E_Ports shall isolate.

To ensure consistent timeout values over the entire Fabric, the ELP SW_ILS shall be accepted by the responding Switch only if the two Switches have the same value for R_A_TOV and the same value

for E_D_TOV, otherwise it shall be rejected with a SW_RJT Reason Code “Logical Error” and SW_RJT Reason Code Explanation “R_A_TOV or E_D_TOV mismatch”, and the involved E_Ports shall isolate.

Required values for the Flow Control Parameters field of the ELP are shown in table 15. These values only apply to the ISL Flow Control Mode value as specified in table 14. The parameter values and format for any other ISL Flow Control Modes are outside the scope of this technical report.

Table 15 – Flow Control Parameters

Item	Size (Bytes)	Value
BB_Credit	4	X[a]
Compatibility Parameter 1	4	2 112[b]
Compatibility Parameter 2	4	10 000[b]
Compatibility Parameter 3	4	2 000[b]
Compatibility Parameter 4	4	0[b]

[a] BB_Credit may be set to any value supported by the Originating E_Port. This BB_Credit value shall be used only after the ELP and LR have been completed. Before that, the BB_Credit shall be one as specified by FC-SW-5.

[b] These values are required for backward compatibility and interoperability reasons.

7.2.4 Principal Switch Selection

Each Switch in the Fabric shall support Principal Switch selection as specified in FC-SW-5 except as modified by the following requirements:

a) At a minimum, each Switch shall support origination of an EFP with a Principal Switch Priority of FFh. This implies that each Switch is required to participate in the Principal Switch selection process but is not required to be capable of becoming the Principal Switch; and

b) A Switch may support origination of an EFP with a Principal Switch Priority of 01h to FEh. Supporting a Principal Switch Priority of FEh means that the Switch is capable of becoming a Principal Switch.

7.2.5 Fabric Shortest Path First (FSPF)

Each Switch in the Fabric shall support FSPF as specified in FC-SW-5. The following requirements apply to FSPF implementation:

a) The LSR Type field in the Link State Header shall be set to 01h indicating Switch Link Record; and

b) The Link Type field in the Link Descriptor shall be set to 01h indicating Point-to-Point Link.

7.2.6 Distributed Services

7.2.6.1 Overview

Distributed services as defined in FC-SW-5 allow Switches in a Fabric to share information required for support of the CT based well-known services. Switch-to-Switch support requirements for these Services are defined in 7.2.6.

7.2.6.2 Distributed Name Server

7.2.6.2.1 Switch-to-Switch Name Server Requests

Switch-to-Switch Name Server requests shall be supported as shown in table 16, table 17, and table 18.

Table 16 – FC-SW-5 Defined Name Server Requests

Feature	Support
Get Entry based on Port Identifier (GE_ID)	I
Get Entry based on Port Name (GE_PN)	I
Get Entry based on Node Name (GE_NN)	I
Get Entries based on FC-4 TYPEs (GE_FT)	I
Get Entries based on Port Type (GE_PT)	I
Get Entries based on Zone Member (GE_ZM)	P
Get Entries based on Zone Name (GE_ZN)	P
Get Entries based on FC-4 Feature (GE_FF)	I
Get Entries based on Fabric Port_Name (GE_FPN)	P

Table 17 – FC-GS-6 Defined Name Server Requests (Sheet 1 of 2)

Feature	Support
Get All Next (GA_NXT)	I
Get Identifiers - Scope (GID_A)	P
Get Port Name (GPN_ID)	I
Get Node Name (GNN_ID)	I
Get Class of Service (GCS_ID)	I
Get FC-4 Types (GFT_ID)	I
Get Symbolic Port Name (GSPN_ID)	I
Get Port Type (GPT_ID)	I

Table 17 – FC-GS-6 Defined Name Server Requests (Sheet 2 of 2)

Feature	Support
Get Fabric Port Name (GFPN_ID)	I
Get Hard Address (GHA_ID)	P
Get FC-4 Features (GFF_ID)	I
Get Port Identifier (GID_PN)	I
Get Port Identifiers (GID_NN)	I
Get Port Names (GPN_NN)	I
Get Symbolic Node Name (GSNN_NN)	I
Get Port Identifiers (GID_FT)	I
Get Port Names (GPN_FT)	I
Get Node Names (GNN_FT)	I
Get Port Identifiers (GID_PT)	I
Get Port Identifiers - Fabric Port Name (GID_FPN)	I
Get Permanent Port Name - Port Identifier (GPPN_ID)	I
Get Port Identifiers (GID_FF)	I
Get Port_Identifier (GID_DP)	P
Register Node Name (RNN_ID)	P
Register Class of Service (RCS_ID)	P
Register FC-4 Types (RFT_ID)	P
Register Symbolic Port Name (RSPN_ID)	P
Register Hard Address (RHA_ID)	P
Register FC-4 Features (RFF_ID)	P
Register Symbolic Node Name (RSNN_NN)	I
Deregister All (DA_ID)	P

Table 18 – FC-GS-6 Common Requests

Feature	Support
Get More Information (GMI)	A
Server Session Begin (SSB)	P
Server Session End (SSE)	P
Asynchronous Notification (ASYNC)	P

The requests in table 16, table 17, and table 18 have the following requirements:

a) The requests specified in table 16 are defined in FC-SW-5 for the special purpose of Switch-to-Switch exchange of Name Server data. The response payload of these requests contains the Name Server Object defined in FC-SW-5. The Name Server Object shall be used as specified in 7.2.6.2.2;

b) The requests specified in table 17 and table 18 are defined in FC-GS-6 and allowed within FC-SW-5 for Switch-to-Switch Name Server requests. These requests and their responses shall be sent according to the rules defined in FC-SW-5; and

c) Switch-to-Switch Name Server requests shall be processed independent of zoning. All filtering of Name Server data to support zoning shall be done at the Entry Switch. GE_ZM and GE_ZN are exceptions to this requirement since they may be required to perform zoning operations on a responding Switch.

7.2.6.2.2 Name Server Object Usage

For all Name Server requests to get entry (i.e., GE_XXX), as defined in FC-SW-5, the Name Server Object used in the response shall be as follows:

a) If the responder has either a non-null Port Symbolic Name or a non-null Node Symbolic Name, and a null FC-4 Descriptor, and a null FC-4 Features, then the Name Server Entry Object with an Entry Object Format Indicator of 00h shall be used by the responder;

b) If the responder has a null Port Symbolic Name, a null Node Symbolic Name, a null FC-4 Descriptor, and a null FC-4 Features, then the Name Server Entry Object with an Entry Object Format Indicator of 01h shall be used by the responder;

c) If the responder has either a non-null Port Symbolic Name or a non-null Node Symbolic Name, and either a non-null FC-4 Descriptor or a non-null FC-4 Features, then the Name Server Entry Object with an Entry Object Format Indicator of 02h shall be used by the responder; and

d) If the responder has a null Port Symbolic Name and a null Node Symbolic Name and either a non-null FC-4 Descriptor or a non-null FC-4 Features, then the Name Server Entry Object with an Entry Object Format Indicator of 03h shall be used by the responder.

The rules for Name Server Object usage are summarized in table 19.

Table 19 – Name Server Object Usage Summary

	Null FC-4 Features and Null FC-4 Descriptor	**non-Null FC-4 Features and/or non-Null FC-4 Descriptor**
non-Null Symbolic Node_Name and/or non-Null Symbolic N_Port_Name	00h	02h
Null Symbolic Node_Name and Null Symbolic N_Port_Name	01h	03h

7.2.6.2.3 Distributed Name Server Response

The following rules shall apply to responses to Distributed Name Server requests:

a) A reject of a 1-to-1 switch request, as specified by FC-SW-5, shall result in a reject of the original Nx_Port request;

b) A reject of a 1-to-many or 1-to-all request, as specified by FC-SW-5, shall result in either:

   A) A reject of the original Nx_Port request; or

   B) A Partial Response to the original requesting Nx_Port. If a Partial Response is sent, the Partial Response bit in the CT Header shall be set to one;

c) The original request shall be rejected with a Reject CT_IU if there is no response to a 1-to-all request; and

d) A response shall be generated for an original request if there is an answer, even if it is a partial answer, to a 1-to-all request.

7.2.6.3 Distributed Management Server

Switch-to-Switch Management Server requests shall be supported as shown in table 20 and table 21.

Table 20 – FC-SW-5 Defined Management Server Requests

Feature	**Support**
Get Management Server Capabilities (GCAP)	R

Table 21 – FC-GS-6 Defined Management Server Requests (Sheet 1 of 2)

Feature	Support
Get Topology Information (GTIN)	P
Get Interconnect Element List (GIEL)[a]	P
Get Interconnect Element Type (GIET)[a]	P
Get Domain Identifier (GDID)[a]	P
Get Management Identifier (GMID)	I
Get Fabric Name (GFN)	P
Get Interconnect Element Logical Name (GIELN)	I
Get Interconnect Element Management Address List (GMAL)	I
Get Interconnect Element Information List (GIEIL)	I
Get Port List (GPL)	I
Get Port Type (GPT)	I
Get Physical Port Number (GPPN)	I
Get Attached Port Name List (GAPNL)	I
Get Port State (GPS)	I
Get Port Speed Capabilities (GPSC)	I
Get Attached Topology Information (GATIN)	P
Get Switch Enforcement Status (GSES)	A
Get Interconnect Element Attribute Group (GIEAG)	A
Get Port Attribute Group (GPAG)	A
Get Platform Node Name List (GPLNL)	I
Get Platform Type (GPLT)	I
Get Platform Management Address List (GPLML)	I
Get Platform Attribute Block (GPAB)	A
Get Platform Name - Node Name (GNPL)	I
Get Platform Name List (GPNL)	I

[a] This only applies to Interconnect Elements of type Switch.

[b] This is required to allow local data copies to be maintained on remote switches as specified in FC-SW-5.

Table 21 – FC-GS-6 Defined Management Server Requests (Sheet 2 of 2)

Feature	Support
Get Platform FCP Type (GPFCP)	I
Get Platform OS LUN Mappings (GPLI)	I
Get Node Identification Data - Node Name (GNID)	P
Register Interconnect Element Logical Name (RIELN)	R[b]
Register Platform (RPL)	R[b]
Register Platform Node Name (RPLN)	R[b]
Register Platform Type (RPLT)	R[b]
Register Platform Management Address (RPLM)	R[b]
Register Platform Attribute Block (RPAB)	R[b]
Register Platform FCP Type (RPFCP)	R[b]
Register Platform OS LUN Mappings (RPLI)	R[b]
Deregister Platform (DPL)	R[b]
Deregister Platform Node Name (DPLN)	R[b]
Deregister Platform Management Address (DPLM)	R[b]
Deregister Platform Management Address List (DPLML)	R[b]
Deregister Platform OS LUN Mappings (DPLI)	R[b]
Deregister Platform Attribute Block (DPAB)	R[b]
Deregister All Platform Information (DPALL)	R
FC Trace Route (FTR)	A
FC Ping (FPNG)	A

[a] This only applies to Interconnect Elements of type Switch.

[b] This is required to allow local data copies to be maintained on remote switches as specified in FC-SW-5.

7.2.7 Zoning

7.2.7.1 Minimum Zoning Configuration Rules

Zoning, as defined in FC-SW-5, shall be supported as shown in table 22. Administration of Zones may be vendor specific and is therefore outside the scope of this technical report.

Table 22 – Zoning Support

Item	Support
Zoning Management Support	
Basic Zoning Management	R
Enhanced Zoning Management	A[a]
Zoning Enforcement	
Soft Zoning Enforcement	R
Hard Zoning Enforcement	A
Broadcast Zoning Enforcement	A
Zoning Data Structures Support	
Active Zone Set	R
Zone Set Database	A
Zone Object Support	
Zone Set Object	A
Zone Object	R
Zone Alias Object	A
Zone Reference Object	A
Zone Attribute Object	A
Vendor Specific Object	P
Zone Member Types Support	
N_Port_Name	R
Domain_ID & Physical Port	P
N_Port_ID	A

[a] A switch that implements only Basic Zoning is not interoperable with a Fabric that is operating with Enhanced Zoning.

[b] Alias Name zone member type support is Prohibited in Basic Zoning.

Table 22 – Zoning Support

Item	Support
Alias Name	A[b]
Node_Name	A
F_Port_Name	A
Wildcard	A
Vendor Specific	P
Zone Attribute Types	
Protocol	A
Hard Zone	A
Broadcast Zone	A
IFR Zone	A
Vendor Specific	P

[a] A switch that implements only Basic Zoning is not interoperable with a Fabric that is operating with Enhanced Zoning.

[b] Alias Name zone member type support is Prohibited in Basic Zoning.

7.2.7.2 Zone Objects

For Zone Objects and Zone Members as defined in FC-SW-5, the following apply:

a) Protocol field of the Zone Object shall be set to zero; and

b) Flag field of the Zone Member shall be set to zero.

7.2.8 Distributed Event Notification

7.2.8.1 Switch-to-Switch Registered State Change Notifications (SW_RSCN)

A Fabric detected SW_RSCN shall be generated under the conditions specified in 7.3.5.4 with the exception that an SW_RSCN shall not be generated for Fabric reconfiguration that is detectable by each switch in the Fabric (i.e., Zone and FSPF database changes).

7.2.8.2 Distribute Registered Link Incident Records (DRLIR)

Each Switch in the Fabric shall support the DRLIR request as defined in FC-SW-5.

7.2.9 Additional Switch requirements

A Switch is required to support sequential delivery. Sequential delivery within a Switch has the following implications:

a) Frames between a single entry Switch Port and exit Switch Port pair of a Fabric shall be delivered at the exit Switch Port in the same order they were received on the entry Switch Port;

b) A Switch is not responsible for maintaining sequence or frame order relative to other sequences or frames if an Nx_Port retransmits a sequence or frame due to error recovery policy;

c) The method by which a Switch implements sequential delivery between its own ports is outside the scope of this technical report;

d) If there is more than one Switch in a Fabric, then sequential delivery shall be maintained by using the same path for frames between any pair of ports on the Fabric, on a per class basis;

e) Frames are only required to be delivered sequentially within a single class of service;

f) Class F frames sent on inter-switch links are not required to be delivered sequentially; and

g) In the case where a path disappears or is introduced into a Fabric, sequential delivery may be temporarily suspended.

NOTE 3 – An example of why sequential delivery may be suspended as described in (g) is a frame that has partially traversed a path to a destination may be rerouted due to a change in the routing table causing it to arrive later than a frame transmitted at later time to the same destination. It is for this reason that R_A_TOV is applied to frames in a Fabric. After R_A_TOV, any frames still traveling non-existent paths will have been delivered, or discarded.

7.3 Fabric Service Requirements

7.3.1 Overview

Table 23 specifies support requirements for features defined in FC-GS-6. A compliant device shall implement all features as specified in table 23. FC-GS-6 features that are not included in table 23 are Prohibited.

Table 23 – FC-GS-6 Fabric Support (Sheet 1 of 2)

Description	Support
Common Transport for Generic Services (CT)	R
Directory Service	
Name Server	R[a]
Management Service	
[a] For supported Name Server objects, see specific requests supported in table 24.	

Table 23 – FC-GS-6 Fabric Support (Sheet 2 of 2)

Description	Support
Fabric Configuration Server	R
Unzoned Name Server	R
Fabric Zone Server	R
[a] For supported Name Server objects, see specific requests supported in table 24.	

7.3.2 Name Server

7.3.2.1 Name Server Request Support

Nx_Port originated Name Server requests shall be supported by each switch element in a Fabric as shown in table 24 and table 25. All other requests are Prohibited.

Table 24 – Name Server Request Support (Sheet 1 of 2)

Feature	Support
Get All Next (GA_NXT)	R
Get Identifiers - Scope (GID_A)	P
Get Port Name (GPN_ID)	R
Get Node Name (GNN_ID)	R
Get Class of Service (GCS_ID)	R
Get FC-4 Types (GFT_ID)	R
Get Symbolic Port Name (GSPN_ID)	R
Get Port Type (GPT_ID)	R
Get IP address (GIPP_ID)	P
Get Fabric Port Name (GFPN_ID)	R
Get Hard Address (GHA_ID)	P
Get FC-4 Descriptors (GFD_ID)	A
Get FC-4 Features (GFF_ID)	R
Get Port Identifier (GID_PN)	R
Get Port Identifiers (GID_NN)	R
[a] A Fabric shall implicitly register the N_Port_Name and Node_Name of an Nx_Port based on FLOGI payload.	

Table 24 – Name Server Request Support (Sheet 2 of 2)

Feature	Support
Get Port Names (GPN_NN)	R
Get Symbolic Node Name (GSNN_NN)	R
Get Port Identifiers (GID_FT)	R
Get Port Names (GPN_FT)	R
Get Node Names (GNN_FT)	R
Get Port Identifiers (GID_PT)	R
Get Port Identifiers (GID_FF)	R
Get Port Identifiers - Fabric Port Name (GID_FPN)	R
Get Permanent Port Name - Port Identifier (GPPN_ID)	R
Get Port Identifier (Domain/Port) (GID_DP)	A
Register Class of Service (RCS_ID)	R
Register FC-4 Features (RFF_ID)	R
Register FC-4 Types (RFT_ID)	R
Register Hard Address (RHA_ID)	P
Register Node Name (RNN_ID)	P[a]
Register Symbolic Port Name (RSPN_ID)	R
Register Symbolic Node Name (RSNN_NN)	R
De-register All (DA_ID)	R

[a] A Fabric shall implicitly register the N_Port_Name and Node_Name of an Nx_Port based on FLOGI payload.

Table 25 – Common Request Support

Feature	Support
Get More Information (GMI)	R
Server Session Begin (SSB)	R
Server Session End (SSE)	R
Asynchronous Notification (ASYNC)	A

7.3.2.2 Name Server Object Registration

7.3.2.2.1 Required Name Server Object Registration

The following Name Server Objects shall be implicitly registered by the Switch:

a) Node_Name and N_Port_Name objects of an Nx_Port. This registration is performed based on the FLOGI or FDISC payload;

b) Class of service supported by an Nx_Port. This registration is performed based on the FLOGI or FDISC payload; and

c) FC_Port type of an Nx_Port based on results of Switch Port initialization. FC_Port type registration shall be performed as follows:

   A) If the Switch Port is operating as an FL_Port, then any attached Nx_Port shall be registered as an NL_Port in the Name Server; or

   B) If the Switch Port is operating as an F_Port, then the attached Nx_Port shall be registered as an N_Port in the Name Server.

7.3.2.2.2 Prohibited Name Server Object Registration

A Switch shall not perform implicit Name Server Object registration for the following:

a) Switch Ports (see 3.2.49); or

b) FC-4 Type based on registration of FC-4 Features or FC-4 Descriptors.

7.3.2.3 Name Server Object Removal

7.3.2.3.1 Full Removal

If any of the following is true, the Name Server shall remove the affected Port Identifier and all objects associated with the Port Identifier from the Name Server Database and send an SW_RSCN SW_ILS to all other switches in the fabric:

a) An PN_Port attached to an F_Port goes to the OFFLINE state or LINK FAILURE state;

b) An OPN sent from an FL_Port to an NL_Port returns to the FL_Port. This includes the OPN for sending a FAN after initialization;

c) An NL_Port is no longer present at the end of a loop initialization. This may be detected by using the AL_PA bit map, item b) in this subclause, or the AL_PA position map;

d) A DA_ID is received for the Nx_Port;

e) A LOGO ELS is sent to FFFFFEh and the fabric supports NPIV; or

   NOTE 4 – When a Fabric supporting NPIV receives a LOGO ELS to D_ID FFFFFEh from a source Port Identifier, it logs out the source Port Identifier from the Fabric. See FC-LS-2.

f) A LOGO ELS sent to D_ID FFFFFEh is accepted by the F_Port Controller.

NOTE 5 – A switch that does not supporting NPIV may not accept a LOGO ELS to D_ID FFFFFEh and thus does not removed the affected port identifier from the Name Server Database.

7.3.2.3.2 Partial Removal

When a FLOGI is received in which either the Port Name or Node Name is different than what is currently registered for the Port Identifier, all Name Server objects are removed and implicit registration as defined in 7.3.2.2.1 is performed. All objects associated with all other Port Identifiers assigned to the N_Port by the F_Port Controller are also removed.

When a FLOGI is received in which the Port Name and Node Name are the same as what is currently registered for the Port Identifier, the Port Identifier and its objects shall not be removed. All objects associated with all other Port Identifiers assigned to the N_Port by the F_Port Controller are removed.

7.3.2.4 Name Server Resource Utilization

The name server shall generate an explicit LOGO if it logs a Nx_Port out due to resource limitations.

7.3.3 Fabric Configuration Server

As specified in table 23, support of the Fabric Configuration Server is required. Nx_Port originated Fabric Configuration Server requests shall be supported as shown in table 26.

Table 26 – Fabric Configuration Server Request Support (Sheet 1 of 3)

Item	Support
Get Topology Information (GTIN)	P
Get Interconnect Element List (GIEL)	R
Get Interconnect Element Type (GIET)	R
Get Interconnect Element Domain Identifier (GDID)	R
Get Interconnect Element Management Identifier (GMID)	R
Get Interconnect Element Fabric Name (GFN)	R
Get Interconnect Element Logical Name (GIELN)	R
Get Interconnect Element Management Address List (GMAL)	R
Get Interconnect Element Information List (GIEIL)	R
Get Port List (GPL)	R
Get Port Type (GPT)	R
Get Physical Port Number (GPPN)	R
Get Attached Port Name List (GAPNL)	R

Table 26 – Fabric Configuration Server Request Support (Sheet 2 of 3)

Item	Support
Get Port State (GPS)	R
Get Port Speed Capabilities (GPSC)	R
Get Attached Topology Information (GATIN)	P
Get Switch Enforcement Status (GSES)	R
Get Interconnect Element Attribute Group (GEIAG)	A
Get Port Attribute Group (GPAG)	A
Get Platform Node Name List (GPLNL)	R
Get Platform Type (GPLT)	R
Get Platform Management Address List (GPLML)	R
Get Platform Attribute Block (GPAB)	R
Get Platform Name - Node Name (GNPL)	R
Get Platform Name List (GPNL)	R
Get Platform FCP Type (GPFCP)	R
Get Platform OS LUN Mappings (GPLI)	R
Get Node Identification Data - Node Name (GNID)	P
Register Interconnect Element Logical Name (RIELN)	R
Register Platform (RPL)	R
Register Platform Node Name (RPLN)	R
Register Platform Type (RPLT)	R
Register Platform Management Address (RPLM)	R
Register Platform Attribute Block (RPAB)	R
Register Platform FCP Type (RPFCP)	R
Register Platform OS LUN Mappings (RPLI)	R
Deregister Platform (DPL)	R
Deregister Platform Node Name (DPLN)	R
Deregister Platform Management Address (DPLM)	R
Deregister Platform Management Address List (DPLML)	R

Table 26 – Fabric Configuration Server Request Support (Sheet 3 of 3)

Item	Support
Deregister Platform OS LUN Mappings (DPLI)	R
Deregister Platform Attribute Block (DPAB)	R
Deregister All Platform Information (DPALL)	R
FC Trace Route (FTR)	A
FC Ping (FPNG)	A

7.3.4 Fabric Zone Server

As specified in table 23 support of the Fabric Zone Server is required. Nx_Port originated Fabric Zone Server Basic Zoning requests shall be supported as shown in table 27.

Table 27 – Fabric Zone Server Basic Zoning Request Support

Item	Support
Get Capabilities (GZC)	R
Get Enforcement State (GEST)	R
Get Zone Set List (GZSN)	A
Get Zone List (GZD)	A
Get Zone Member List (GZM)	A
Get Active Zone Set (GAZS)	R
Get Zone Set (GZS)	A
Add Zone Set (ADZS)	A[a]
Activate Zone Set Direct (AZSD)	R[a]
Activate Zone Set (AZS)	A
Deactivate Zone Set (DZS)	R
Add Zone Members (AZM)	A[a]
Add Zone (AZD)	A
Remove Zone Members (RZM)	A[a]
Remove Zone (RZD)	A
Remove Zone Set (RZS)	A

[a] Use of the Node_Name Zone Member Identifier type (04h) is prohibited.

If the Fabric Zone Server supports Enhanced Zoning, Nx_Port originated Fabric Zone Server Enhanced Zoning requests shall be supported as shown in table 28.

Table 28 – Fabric Zone Server Enhanced Zoning Request Support (Sheet 1 of 2)

Item	Support
Control Zoning Management Requests	
Get Fabric Enhanced Zoning Support (GFEZ)	R
Set Fabric Enhanced Zoning Support (SFEZ)	R
Zoning Session Requests	
Server Session Begin (SSB)	R
Server Session End (SSE)	R
Commit Zone Changes (CMIT)	R
Enhanced Zoning Requests	
Get Activation Results (GAR)	R
Get Zone Attribute Object Name (GZA)	R
Get Zone Attribute Block (GZAB)	R
Get Zone Set List - Enhanced (GZSE)	R
Get Zone List - Enhanced (GZDE)	R
Get Zone Member List - Enhanced (GZME)	R
Get Zone Attribute Object List (GZAL)	R
Get Alias List (GAL)	R
Get Alias Member List (GAM)	R
Set Zone Attribute Object Name (SZA)	R
Set Zone Attribute Block (SZAB)	R
Create Zone Set (CZS)	R
Create Zone (CZ)	R
Create Alias (CA)	R
Create Zone Attribute Object (CZA)	R
Add Zones (AZ)	R
Remove Zones (RZ)	R
Add Zone Members - Enhanced (AZME)	R

Table 28 – Fabric Zone Server Enhanced Zoning Request Support (Sheet 2 of 2)

Item	Support
Remove Zone Members - Enhanced (RZME)	R
Add Alias Members (AAM)	R
Remove Alias Members (RAM)	R
Delete Zone Set (DLZS)	R
Delete Zone (DLZ)	R
Delete Alias (DLA)	R
Delete Zone Attribute Object (DLZA)	R
Get Active Zone Set - Enhanced (GAZSE)	R
Activate Zone Set Direct - Enhanced (AZSDE)	R
Activate Zone Set - Enhanced (AZSE)	R
Deactivate Zone Set - Enhanced (DZSE)	R

7.3.5 Registered State Change Notification

7.3.5.1 Overview

RSCN as described in FC-LS-2 shall be supported with the exception of the RSCN Event Qualifier field. The RSCN Event Qualifier field may be supported.

The State Change Registration (SCR) Extended Link Service as described FC-LS-2 shall be supported by a Fabric Controller. In addition, the SCR request may be sent to either the Fabric Controller (FFFFFDh), or an Nx_Port as specified in FC-LS-2.

7.3.5.2 RSCN Generation Rules

The following rules shall apply to generation of RSCN:

a) An RSCN may be delayed in order to consolidate a number of state changes into one RSCN;

b) The Fabric element that detects an event shall transmit an RSCN or SW_RSCN in less than 2.1 seconds from the event it is reporting, and

c) A Fabric element shall not delay origination of an RSCN more than 2 seconds from the receipt of an SW_RSCN.

7.3.5.3 RSCN Delivery Rules

After any necessary Name Server updates have been made, an RSCN shall be sent to an Nx_Port if:

a) An event (see FC-LS-2) has occurred, including those in 7.3.5.4, requiring an RSCN to be sent;

b) The Nx_Port has logged in to the Fabric;

c) The Nx_Port has registered to receive RSCNs;

d) The Nx_Port has not gone offline since the last SCR;

e) The Nx_Port supports Class 2 or Class 3;

f) The registration function matches the RSCN type of either Fabric detected or Nx_Port detected;

g) The Nx_Port is not included in the group of ports identified by the RSCN affected Port_ID page (this is not applicable to format 3); and

h) One of the following:

   A) The RSCN is a Fabric Format;

   B) The Nx_Port is in any active Zone in common with any Nx_port identified by the RSCN affected Port_ID page;

   C) A change occurs in the membership of the Active Zone Set such that the Nx_Port is no longer in any Zone in common with the Nx_Port; or

   D) Zoning is not active.

If the Nx_Port supports Class 3, the RSCN shall be sent in Class 3, otherwise it shall be sent in Class 2.

The sender of the RSCN Request may coalesce several events into a single RSCN. A coalesced RSCN may be sent to an Nx_Port if all of the conditions defined in this subclause are met. The affected Port_ID page(s) that are included in the coalesced RSCN shall meet the conditions in g) and h) of this subclause.

7.3.5.4 Events Causing the Fabric Controller to Deliver RSCNs

An RSCN shall be sent to those Nx_Ports that have specified a registration function 1 or 3 (i.e., Fabric detected or Full) and that satisfy the conditions listed in 7.3.5.3 under the conditions stated in this subclause.

Only one affected Port ID page Address Format, determined by the source of the event, should be generated for each event.

In the following list, DD represents the Domain Identifier portion of the address identifier, AA indicates the Area Identifier portion of the address identifier, and PP indicates the Port Identifier portion of the address identifier.

a) Address Format 0 (port address format, DD||AA||PP):

   A) An Nx_Port that is currently not in the Name Server database logs in to the Fabric;

   B) An Nx_Port is implicitly logged out (e.g., goes to the OFFLINE state or the LINK FAILURE state);

C) An Nx_Port deregisters with the name server;

D) Name Server Registration information has changed;

E) An NL_Port does not accept an OPN from an FL_Port;

F) The Active Zone Set is changed such that an Nx_Port either becomes accessible or inaccessible; or

G) Any other situation that notifies the Fabric that an Nx_Port is no longer responding;

b) Address Format 1 (area address format, DD||AA||00h):

A) Failure of loop initialization; or

c) Address Format 2 (domain address format, DD||0000h):

A) The link state database has changed and the affected domain identifier has become accessible or inaccessible from the destination Nx_Port.

7.4 Domain Controller and Well-Known Addresses

7.4.1 Domain controller and well-known address support requirements for fabrics

This subclause specifies the requirements for fabric support of Domain Controller and Well-Known Addresses, and the N_Port characteristics of those addresses. All services provided by Domain Controller and Well-Known Addresses are either directly performed by a fabric element, or by some other entity known to the fabric as a whole. This technical report does not make a distinction, instead, it mandates that Nx_Ports have access to the addresses and services identified as required, and that this access be available through the Fx_Port.

Table 29 lists the Domain Controller and Well-Known Address requirements for fabrics with usage defined by this technical report.

Table 29 – Domain Controller and Well-Known Address support requirements for Fabrics

Domain Controller or Well-Known Address	Support Requirement
Well-Known Address FFFFFFh (i.e., Broadcast)	A[b]
Well-Known Address FFFFFEh (i.e., F_Port Controller)[a]	R
Well-Known Address FFFFFDh (i.e., Fabric Controller)	R
Well-Known Address FFFFFCh (i.e., Directory Server)	R
Well-Known Address FFFFFBh (i.e., Time Server)	P
Well-Known Address FFFFFAh (i.e., Management Server)	R

[a] This is the address to which an Nx_Port sends a FLOGI.

[b] Well-Known Address FFFFFFh (i.e., Broadcast) support is required if RFC 4338 is supported.

Table 29 – Domain Controller and Well-Known Address support requirements for Fabrics

Domain Controller or Well-Known Address	Support Requirement
Well-Known Address FFFFF7h (i.e., Security Key Distribution Server)	P
Well-Known Address FFFFF6h (i.e., Clock Synchronization Server)	P
Domain Controller Address, FFFCh || Domain ID	R

[a] This is the address to which an Nx_Port sends a FLOGI.

[b] Well-Known Address FFFFFFh (i.e., Broadcast) support is required if RFC 4338 is supported.

7.4.2 Domain Controller and well-known address usage

Table 30 lists the ELS requirements for Domain Controller and well-known addresses with usage defined by this technical report. In table 30, N_Port Originator refers to an Domain Controller or well-known address sending a request Sequence to an Nx_Port. Extended Link Services not listed in table 30 are Prohibited or are FC-4 specific.

Table 30 – ELS requirements for Domain Controller and well-known addresses (Sheet 1 of 3)

Feature	N_Port Originator
Well-known address FFFFFEh (F_Port Controller)	
FAN	R[a]
LOGO	I
RRQ	I
RPBC	R[b]

[a] Applicable to arbitrated loop only.

[b] If Query Data Buffer Conditions is set to one in an FLOGI request from an Nx_Port and the F_Port Controller accepts the FLOGI, the F_Port Controller shall initiate an RPBC ELS to determine buffer conditions constraining the Nx_Port before sending any ELS with a payload greater than 128 bytes.

[c] Required only if the Nx_Port has registered for this service.

Table 30 – ELS requirements for Domain Controller and well-known addresses (Sheet 2 of 3)

Feature	N_Port Originator
Well-known address FFFFFDh (Fabric Controller)	
LOGO	I
PLOGI	I
RNID	I
RRQ	I
RSCN	R[c]
RFCN	R[c]
Well-known address FFFFFCh (Directory Service)	
LOGO	I
PLOGI	A
PRLI	A
PRLO	A
RRQ	I
Well-known address FFFFFAh (Management Service)	
ECHO	A
LOGO	I
RLIR	R[c]
RRQ	I

[a] Applicable to arbitrated loop only.

[b] If Query Data Buffer Conditions is set to one in an FLOGI request from an Nx_Port and the F_Port Controller accepts the FLOGI, the F_Port Controller shall initiate an RPBC ELS to determine buffer conditions constraining the Nx_Port before sending any ELS with a payload greater than 128 bytes.

[c] Required only if the Nx_Port has registered for this service.

Table 30 – ELS requirements for Domain Controller and well-known addresses (Sheet 3 of 3)

Feature	N_Port Originator
Domain controller address, FFFCxxh	
LOGO	I
PLOGI	A
PRLI	A
PRLO	A
RPL	I
RRQ	I

[a] Applicable to arbitrated loop only.

[b] If Query Data Buffer Conditions is set to one in an FLOGI request from an Nx_Port and the F_Port Controller accepts the FLOGI, the F_Port Controller shall initiate an RPBC ELS to determine buffer conditions constraining the Nx_Port before sending any ELS with a payload greater than 128 bytes.

[c] Required only if the Nx_Port has registered for this service.

7.4.3 Domain controller and well-known address (WKA) ELS login and address assignment requirements

7.4.3.1 Overview

Address assignment is required before communicating with the Domain Controller and any WKA except the F_Port Controller WKA.

7.4.3.2 Broadcast WKA ELS login requirements

No ELS are sent to the Broadcast WKA, thus there are no ELS login requirements.

7.4.3.3 F_Port Controller WKA ELS address assignment requirements

Table 31 lists the ELS address assignment requirements for the F_Port Controller WKA with usage defined by this technical report.

Table 31 – F_Port Controller WKA (FFFFFEh) ELS address assignment requirements

ELS	Address assignment required[a]	Payload size may be greater than 128 bytes
ECHO	Yes	Yes
FDISC	Yes[b]	Yes (Extended login)
FLOGI	No	Yes (Extended login)
LOGO	No	No
RLS	Yes	No
RRQ	Yes	No

[a] Address assignment may be through FLOGI or FDISC.

[b] The PN_Port shall have at least one address identifier already assigned before performing FDISC for additional address identifier assignment.

7.4.3.4 Fabric Controller WKA ELS login requirements

Table 32 lists the ELS login requirements for the Fabric Controller WKA with usage defined by this technical report.

Table 32 – Fabric Controller WKA (FFFFFDh) ELS login requirements

ELS	PLOGI Required	Payload size may be greater than 128 bytes
ECHO	No[a]	Yes
LOGO	No[a]	No
PDISC	Yes	Yes (Extended login)
PLOGI	No[a]	Yes (Extended login)
QSA	No[a]	No
RRQ	No[a]	No
RSCN	No[a]	Yes
SCR	No[a]	No
RNID	No[a]	Yes

[a] FLOGI provides an implicit PLOGI for the purposes of these ELSs.

7.4.3.5 Directory Service WKA ELS login requirements

Table 33 lists the ELS login requirements for the Directory Service WKA with usage defined by this technical report.

Table 33 – Directory Service WKA (FFFFFCh) ELS login requirements

ELS	PLOGI Required	Payload size may be greater than 128 bytes
ECHO	No	Yes
LOGO	No	No
PDISC	Yes	Yes (Extended login)
PLOGI	No	Yes (Extended login)
RRQ	Yes	No

7.4.3.6 Management Service WKA ELS login requirements

Table 34 lists the ELS login requirements for the Management Service WKA with usage defined by this technical report.

Table 34 – Management Service WKA (FFFFFAh) ELS login requirements

ELS	PLOGI Required	Payload size may be greater than 128 bytes
ECHO	No	Yes
LIRR	Yes	No
LOGO	No	No
PDISC	Yes	Yes (Extended login)
PLOGI	No	Yes (Extended login)
RLIR	Yes	Yes
RRQ	Yes	No

7.4.3.7 Domain Controller ELS login requirements

Table 35 lists the ELS login requirements for the Domain Controller with usage defined by this technical report.

Table 35 – Domain Controller (FFFCxxh) ELS login requirements

ELS	PLOGI Required	Payload size may be greater than 128 bytes
ECHO	No	Yes
LOGO	No	No
PDISC	Yes	Yes (Extended login)
PLOGI	No	Yes (Extended login)
RLS	Yes	No
RRQ	Yes	No
RPL	Yes	Yes[a]
SBRP	Yes	No
RPSC	Yes	Yes

[a] This ELS has the capability to specify the maximum size in the request.

7.4.3.8 Loop Fabric Address WKA ELS login requirements

Table 36 lists the ELS login requirements for the Loop Fabric Address WKA with usage defined by this technical report.

Table 36 – Loop Fabric Address ELS login requirements

ELS	PLOGI Required	Payload size may be greater than 128 bytes
LSTS	No	Yes

8 Discovery and Management

8.1 Overview

Clause 8 outlines implementation guidelines for SAN Fibre Channel devices to support automated SAN discovery and management. These requirements are presented to ensure that FC devices are capable of being discovered and managed by a wide range of SAN applications.

8.2 Management of Interconnect Components

8.2.1 Overview

An Interconnect Component is one of a set of components that are used to interconnect Nx_Ports. A manageable Interconnect Component may be a:

a) Switch;

b) Managed Hub; or

c) Gateway/Bridge (see FC-FS-3).

8.2.2 Switch

Switch support for discovery and management is summarized in table 37.

Table 37 – Switch Support Summary

Item	Support
RSCN event reporting	R
RLIR event reporting	R[a]
Responds to SRL	P
Responds to LIRR	R
Name Server Requests	R[b]
Management Services	
Fabric Configuration Server	R
Unzoned Name Server	R
Fabric Zone Server	R

[a] RLIR event reporting is required for FC-SB-4 support and allowed in other environments.

[b] Name Server requests shall be supported as specified in table 24.

For discovery and management, switches and their proxy environments shall support SNMP management via one or more MIBs. The FC Management MIB (see RFC 4044) should be supported whenever possible, but legacy devices may support MIB-FA (see 2.2). MIB support and SNMP

support in general may be provided either directly by the device or via a proxy service. SNMP support may be provided via either out-of-band or in-band transport.

8.2.3 Managed Hub

For discovery and management, hubs and their proxy environments shall support SNMP management via one or more MIBs. The FC Management MIB (see RFC 4044) should be supported whenever possible, but legacy devices may support MIB-FA (see 2.2). MIB support and SNMP support in general may be provided either directly by the device or via a proxy service. SNMP support may be provided via either out-of-band or in-band transport.

An embedded NL_Port in a hub that acts as a management entity shall follow the rules specified in FC-DA-2.

8.2.4 Gateway/Bridge

For discovery and management, Gateway/Bridge devices (see FC-FS-3) and their proxy environments shall support SNMP management via one or more MIBs. The FC Management MIB (see RFC 4044) should be supported whenever possible, but legacy devices may support MIB-FA (see 2.2). MIB support and SNMP support in general may be provided either directly by the device or via a proxy service. SNMP support may be provided via either out-of-band or in-band transport.

In addition any end device node that is contained within or simulated by a Gateway/Bridge devices shall meet the requirements in FC-DA-2.

9 Conformance Environments

Since this technical report covers multiple interoperable environments, there exist certain environments that are not required to support all clauses within this technical report. Table 38 shows the common environments that are supported by this technical report and the clause of this technical report that the environment shall conform to.

Table 38 – Conformance Environments

Environment	Required Conformance Clause(s)
Public Arbitrated Loop (Fabric with at least one FL_Port)	5, 6, 7
Fabric without any FL_Ports	6, 7
Management Support for All Environments	8