



BSI Standards Publication

Information technology — Fibre channel

Part 246: Backbone — 6 (FC-BB-6)

National foreword

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**Information technology — Fibre
channel —**

**Part 246:
Backbone — 6 (FC-BB-6)**



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Contents

Page

Foreword	vi
Introduction	vii
1 Scope	1
2 Normative References	3
2.1 Overview.....	3
2.2 Approved references.....	4
2.3 References under development.....	4
2.4 ITU-T references.....	5
2.5 IETF references.....	5
2.6 IEEE references.....	5
3 Definitions and conventions	6
3.1 Common definitions.....	6
3.2 FC-BB_IP definitions.....	9
3.3 FC-BB_GFPT definitions.....	11
3.4 FC-BB_PW definitions.....	12
3.5 FC-BB_E definitions.....	13
3.6 Editorial conventions.....	16
3.7 List of commonly used acronyms and abbreviations.....	17
3.7.1 General.....	17
3.7.2 FC-BB_IP.....	17
3.7.3 FC-BB_GFPT.....	18
3.7.4 FC-BB_PW.....	18
3.7.5 FC-BB_E.....	18
3.8 Symbols.....	18
3.9 Keywords.....	18
4 FC-BB-6 Structure and Concepts	19
4.1 FC-BB-6 backbone mappings.....	19
4.2 FC-BB-6 reference models.....	20
4.2.1 FC-BB-6 reference models overview.....	20
4.2.2 FC-BB_IP reference model.....	21
4.2.3 FC-BB_GFPT reference model.....	22
4.2.4 FC-BB_PW reference model.....	23
4.2.5 FC-BB_E reference models.....	24
4.3 FC-BB-6 models overview.....	26
4.3.1 FC-BB_IP.....	26
4.3.2 FC-BB_GFPT.....	26
4.3.3 FC-BB_PW.....	27
4.3.4 FC-BB_E.....	27
4.4 FC-BB-6 requirements.....	27
4.4.1 Fibre Channel Class support.....	27
4.4.2 Payload transparency.....	28
4.4.3 Latency delay and timeout value.....	28
4.4.4 QoS and bandwidth.....	29
4.4.5 In-order delivery.....	29
4.4.6 Flow control.....	29
4.5 FC-BB-6 SW_ILS codes.....	30
5 FC-BB_IP Structure and Concepts	30
5.1 Applicability.....	30
5.2 FC-BB_IP overview.....	30
5.3 VE_Port functional model.....	31
5.3.1 FC-BB_IP interface protocol layers.....	31
5.3.2 E_Port/F_Port FC interface.....	32

5.3.3	FC Switching Element (SE) with FC routing	33
5.3.4	FC-BB_IP protocol interface	33
5.3.5	IP network interface	38
5.4	B_Access functional model	39
5.4.1	FC-BB_IP interface protocol layers	39
5.4.2	B_Port FC interface	39
5.4.3	FC-BB_IP protocol interface	39
5.4.4	IP Network Interface	45
5.5	FC-BB_IP network topologies	45
5.6	Mapping and message encapsulation using TCP/IP	46
5.6.1	Encapsulated frame structures	46
5.6.2	TCP/IP encapsulation	49
5.7	FC-BB_IP protocol procedures	49
5.7.1	Overview	49
5.7.2	Procedures for platform management	49
5.7.3	Procedures for connection management	52
5.7.4	Procedures for error detection recovery	53
5.7.5	FC-BB_IP system parameters	54
5.8	FC-BB_IP service considerations	55
5.8.1	Latency delay	55
5.8.2	Throughput	55
5.8.3	Reliability	56
5.8.4	Quality of Service (QoS)	57
5.8.5	Delivery order	57
5.8.6	IP multicast and broadcast	58
5.8.7	Security and authentication	58
6	Transparent FC-BB (FC-BB_GFPT and FC-BB_PW) Structure and Concepts	58
6.1	Applicability	58
6.2	FC-BB_GFPT overview	58
6.3	FC-BB_PW overview	59
6.4	Transparent FC-BB functional model	60
6.4.1	Transparent FC-BB initialization	60
6.4.2	Transparent FC-BB initialization state machine	61
6.4.3	Login Exchange Monitors	66
6.4.4	Port initialization parameter observation and modification	69
6.4.5	Handling of BB_SCs, BB_SCr, and R_RDY Primitive Signals and BB_Credit initialization	69
6.4.6	Transparent FC-BB Primitive Signals	71
6.4.7	Transparent FC-BB flow control	71
6.4.8	Adaptation of FC information for Transparent FC-BB	74
6.4.9	WAN Holdoff Timeout Value (WAN_HOLDOFF_TOV)	78
6.4.10	Transparent FC-BB frame compression encoding	78
7	FC-BB_E Structure and Concepts	79
7.1	Applicability	79
7.2	FC-BB_E overview	79
7.3	ENode functional model	84
7.4	VN2VN ENode functional model	86
7.5	FCF functional model	87
7.6	Controlling FCF functional model	90
7.7	FDF functional model	92
7.8	FCoE Virtual Links	94
7.9	VN_Port MAC addresses	98
7.10	FCoE frame format	98
7.11	FC-BB_E device initialization	100
7.11.1	FCoE Initialization Protocol (FIP) overview	100
7.11.2	FIP VLAN discovery protocol	101
7.11.3	FIP discovery protocol	105
7.11.4	FCoE Virtual Link instantiation protocol	110
7.11.5	FCoE Virtual Link maintenance protocol	112

7.11.6	Locally Unique N_Port_IDs	115
7.11.7	FIP frames.....	119
7.11.8	FIP operations	131
7.12	Timers and constants	143
7.13	FC-BB_E Link Error Status Block (LESB) definition.....	145
7.14	Link incidents definition	146
7.15	Distributed FCF operations.....	146
Annex A (informative)	FC-BB_GFPT Interoperability Guidelines.....	147
Annex B (informative)	FCoE and FIP Frame Examples.....	148
Annex C (informative)	Increasing FC-BB_E Robustness Using Access Control Lists.....	150
Annex D (informative)	FCoE Security Recommendations.....	160
Annex E (normative)	FCoE MIB Definition	166
Annex F (informative)	Locally Unique N_Port_ID	186
Annex G (informative)	Options for Handling FCoE and FIP Traffic	192

Foreword

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Introduction

FC-BB-6 defines mappings for transporting Fibre Channel over different network technologies. FC-BB-6 defines four distinct Fibre Channel mappings:

- a) FC over TCP/IP;
- b) FC over GFPT;
- c) FC over MPLS; and
- d) FC over Ethernet.

The FC over ATM and FC over SONET backbone mappings are not specified in FC-BB-6. As such, FC-BB-6 is not a complete replacement of FC-BB-3 (i.e., see FC-BB-3 for the specification of the FC over ATM and FC over SONET backbone mappings).

Information technology — Fibre channel —

Part 246: Backbone — 6 (FC-BB-6)

1 Scope

This standard consists of distinct Fibre Channel mappings resulting in the following models:

- FC-BB_IP (FC over TCP/IP backbone network)
- Transparent FC-BB consisting of:
 - FC-BB_GFPT (FC over SONET/SDH/OTN/PDH backbone network using GFPT adaptation)
 - FC-BB_PW (FC over MPLS network using PW adaptation)
- FC-BB_E (FC over Ethernet)

Figure 1, Figure 2, Figure 3, and Figure 4 illustrate the scope and the major components of the FC-BB-6 models and its relationship to the IETF, ITU-T, and IEEE standards. Table 1 shows the organization of this standard. FC-BB_IP, Transparent FC-BB, and FC-BB_E do not interoperate in any manner and are independent models.

Table 1 – FC-BB-6 organization

Model Type	Applicable Clauses and Annexes
FC-BB_IP, FC-BB_GFPT, FC-BB_PW, FC-BB_E	1, 2, 3, 4
FC-BB_IP	5
Transparent FC-BB	
FC-BB_GFPT	6, Annex A
FC-BB_PW	6
FC-BB_E	7, Annex B, Annex C, Annex D, Annex E, Annex Annex F: , Annex G

The scope and components of the FC-BB_IP model is shown in Figure 1.

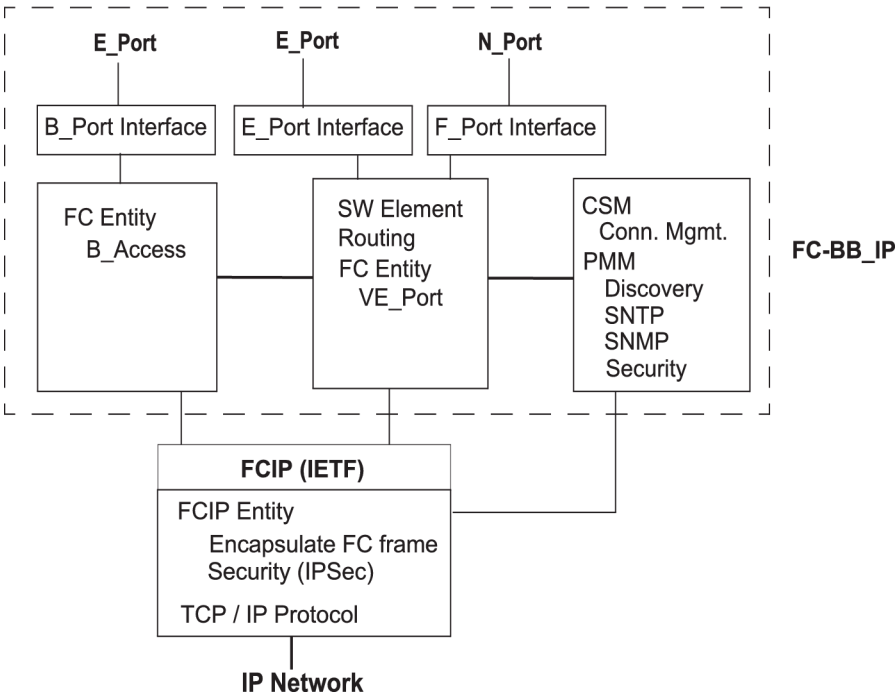


Figure 1 – Scope and components of FC-BB_IP model

The scope and components of the FC-BB_GFPT model is shown in Figure 2.

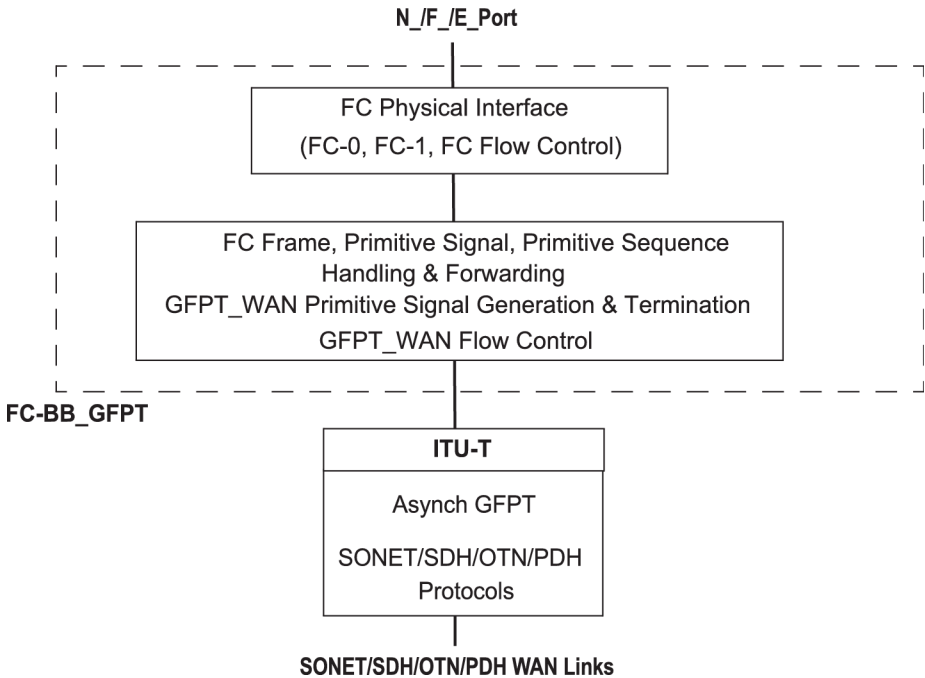


Figure 2 – Scope and components of FC-BB_GFPT model

The scope and components of the FC-BB_PW model is shown in Figure 3.

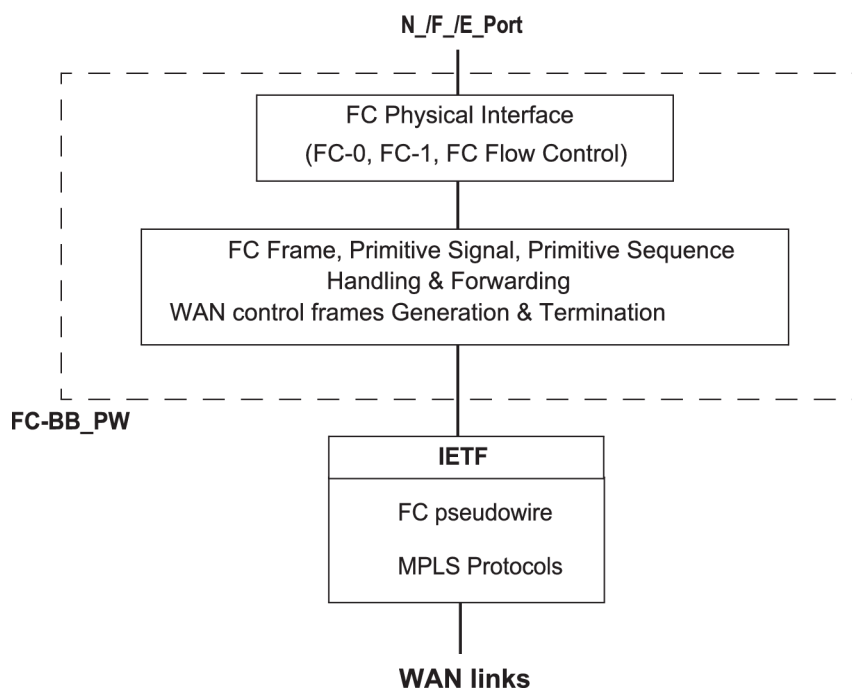


Figure 3 – Scope and components of FC-BB_PW model

The scope and components of the FC-BB_E model is shown in Figure 4.

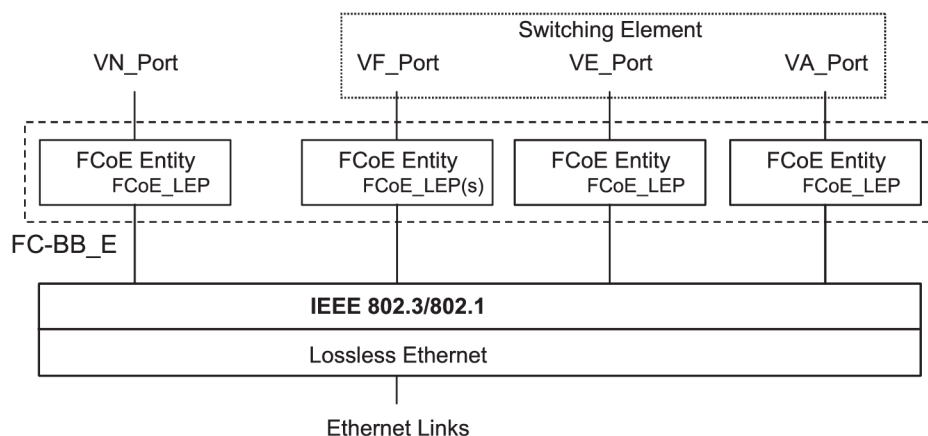


Figure 4 – Scope and components of FC-BB_E model

2 Normative References

2.1 Overview

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

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Additional availability contact information is provided below as needed.

2.2 Approved references

ANSI T1.105-2001, *Synchronous Optical Network (SONET) - Basic Description Including Multiplex Structures, Rates, and Formats*

ANSI INCITS 496-2012, *Fibre Channel - Security Protocols - 2 (FC-SP-2)*

ANSI INCITS 241-1994 (R1999), *Data Compression Method - Adaptive Coding with Sliding Window for Information Interchange*

2.3 References under development

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

For electronic copies of references under development by INCITS T11, see www.t11.org

T11/Project 2238-D, *Fibre Channel - Framing and Signaling - 4 (FC-FS-4)*

T11/Project 2220-D, *Fibre Channel - Switch Fabric - 6 (FC-SW-6)*

T11/Project 2237-D, *Fibre Channel - Link Services - 3 (FC-LS-3)*

2.4 ITU-T references

Copies of the following approved ITU-T standards may be obtained through the ITU-T Publications department at <http://www.itu.int>.

ITU-T Rec. G.707/Y.1322, (2007), *Network node interface for the synchronous digital hierarchy (SDH)*

ITU-T Rec. G.7041/Y.1303, (2005), *Generic Framing Procedure (GFP)*

ITU-T Rec. G.783, (2006), *Characteristics of synchronous digital hierarchy (SDH) equipment functional blocks*

ITU-T Rec. G.806, (2006), *Characteristics of transport equipment - Description methodology and generic functionality*

ITU-T Rec. G.702, (1988), *Digital Hierarchy Bit Rates*

2.5 IETF references

Copies of the following approved IETF standards may be obtained through the Internet Engineering Task Force (IETF) at www.ietf.org.

RFC 5905, *Network Time Protocol Version 4: Protocol and Algorithms Specification*, June 2010

RFC 3246, *An Expedited Forwarding PHB (Per-Hop Behavior)*, March 2002

RFC 3643, *Fibre Channel (FC) Frame Encapsulation*, December 2004

RFC 3821, *Fibre Channel Over TCP/IP (FCIP)*, July 2004

RFC 3822, *Finding Fibre Channel over TCP/IP (FCIP) Entities Using Service Location Protocol version 2 (SLPv2)*, July 2004

RFC 3031, *Multiprotocol Label Switching (MPLS) Architecture*, January 2001

RFC 3985, *Pseudowire Emulation Edge-to-Edge (PWE3) Architecture*, March 2005

RFC 4385, *Multiprotocol Pseudowire Emulation Edge-to-Edge (PWE3) Control Word for Use over an MPLS PSN*, February 2006

RFC 4447, *Pseudowire Setup and Maintenance Using the Label Distribution Protocol (LDP)*, April 2006

RFC 6307, *Encapsulation Methods for Transport of Fibre Channel frames Over MPLS Networks*, March 2012

2.6 IEEE references

Copies of the following approved IEEE standards may be obtained through the Institute of Electrical and Electronics Engineers (IEEE) at <http://standards.ieee.org>.

IEEE 802.3-2012: *IEEE Standard for Ethernet*

IEEE 802.1Q-2011: *Media Access Control (MAC) Bridges and*

Virtual Bridge Local Area Networks

IEEE 802.1Qbb-2011: *Media Access Control (MAC) Bridges and Virtual Bridged Local Area Network - Amendment 17: Priority-based Flow Control*

IEEE 802.1Qaz-2011: *Media Access Control (MAC) Bridges and Virtual Bridged Local Area Networks - Amendment 18: Enhanced Transmission Selection for Bandwidth Sharing Between Traffic Classes*

IEEE 1588-2008: *Precision Clock Synchronization Protocol for Networked Measurement and Control Systems*

IEEE 802.1AS-2011: *Timing and Synchronization for Time-Sensitive Applications in Bridged Local Area Networks*

3 Definitions and conventions

3.1 Common definitions

3.1.1

A_Port (see FC-SW-6)

combination of one PA_Port (see FC-SW-6) and one VA_Port operating together

3.1.2

B_Port

Bridge Port on a device that implements FC-BB_IP and connects to an E_Port on an FC switch

3.1.3

B_Port_Name (see FC-SW-6)

Name_Identifier (see 3.1.25) that identifies a B_Port (see 3.1.2) for identification purpose

3.1.4

codeword

sequence of bits of a code corresponding to a symbol

3.1.5

E_Port (see FC-SW-6)

Fabric expansion port that attaches to another E_Port to create an Inter-Switch Link

3.1.6

E_Port_Name

Name_Identifier (see 3.1.25) that identifies an E_Port (see 3.1.5)

3.1.7

ELP (see FC-SW-6)

Exchange Link Parameters SW_ILS

3.1.8

F_BSY (see FC-FS-4)

Fabric Busy

3.1.9

F_Port (see FC-SW-6)

combination of one PF_Port and one VF_Port operating together

3.1.10

F_Port_Name

Name_Identifier (see 3.1.25) that identifies an F_Port (see 3.1.9)

3.1.11

Fabric Initialization (see FC-SW-6)
process for configuring and building a Fabric

3.1.12

Fabric_Name
Name_Identifier (see 3.1.25) associated with a Fabric (see FC-SW-6)

3.1.13

FC-BB_E
protocol mapping defined by this standard in order to transport Fibre Channel over a Lossless Ethernet network

3.1.14

FC-BB_GFPT
equipment model defining gateway functionality for the interconnection of two non-Arbitrated Loop FC physical ports using 8B/10B encoding across a GFPT_WAN infrastructure (e.g., SONET, SDH, OTN, PDH)

3.1.15

FC-BB_IP
model defining equipment that interfaces with a Fibre Channel switched network on one side and an IP network on the other side

3.1.16

FC-BB_PW
equipment model defining gateway functionality for the interconnection of two non-Arbitrated Loop FC physical ports using 8B/10B encoding across a PSN (see 3.4.5)

3.1.17

FC_Port (see FC-FS-4)
port capable of transmitting and receiving Fibre Channel frames

3.1.18

Fibre Channel Backbone link
the Transport Trail (see 3.3.18) or equivalent network channel connection used for communications between two FC-BB-6 devices, encompassing FC-BB_IP and GFPT_WAN links, and in some cases made up of more than one physical or logical connection

3.1.19

FLOGI (see FC-LS-3)
Fabric Login ELS

3.1.20

Generic Framing Procedure (GFP) (see ITU-T Rec. G.7041/Y.1303)
procedure for adaptation of data (i.e., PDUs or 8B/10B encoded characters) to octet-synchronous (i.e., SONET, SDH, OTN) and bit-synchronous (i.e., PDH) Wide Area Network transport infrastructures

3.1.21

ISL (see FC-SW-6)
Inter-Switch Link

3.1.22

Keep Alive Timeout Value (K_A_TOV)
timer that is used by the Link Keep Alive (LKA) ELS (see FC-LS-3) as a trigger for issuing LKA

3.1.23

LS_ACC (see FC-LS-3)
Link Service Accept

3.1.24

LS_RJT (see FC-LS-3)
Link Service Reject

3.1.25

Name_Identifier (see FC-FS-4)
64-bit identifier, with a 60-bit value preceded with a 4-bit Network_Address_Authority Identifier, used to identify entities in Fibre Channel (e.g., N_Port, node, F_Port, or Fabric)

3.1.26

Node_Name (see FC-FS-4)
Name_Identifier (see 3.1.25) associated with a node

3.1.27

N_Port
device port that generates/terminates FC-4 traffic

3.1.28

N_Port_ID (see FC-FS-4)
topology unique address identifier of an Nx_Port

3.1.29

N_Port_Name
Name_Identifier (see 3.1.25) that identifies an N_Port (see 3.1.27)

3.1.30

Ordered Set (see FC-FS-4)

3.1.31

PLOGI (see FC-LS-3)
N_Port Login

3.1.32

P_BSY (see FC-FS-4)
N_Port Busy

3.1.33

Switch_Name
Name_Identifier (see 3.1.25) that uniquely identifies a Switch or a Bridge device

3.1.34

SW_ACC (see FC-SW-6)
Switch Fabric Internal Link Service Accept

3.1.35

SW_RJT (see FC-SW-6)
Switch Fabric Internal Link Service Reject

3.1.36

Transparent FC-BB
general model consisting of the FC-BB-GFPT (see 3.1.14) and the FC-BB_PW (see 3.1.16) models

3.1.37

WAN interface
interface that connects to a Wide Area Network, either physical (e.g., SONET) or logical (e.g., GFPT_WAN)

3.2 FC-BB_IP definitions

3.2.1

B_Access

component of the FC Entity (see 3.2.8) that interfaces with the FCIP_LEP (see 3.2.21) component of the FCIP Entity (see 3.2.15) on one side and the B_Port on the other side

3.2.2

B_Access_Name

Name_Identifier (see 3.1.25) of the B_Access portal

3.2.3

B_Access Virtual ISL

Virtual ISL (see 3.2.26) that connects two B_Access portals

3.2.4

Control and Service Module (CSM)

control component of the FC-BB_IP interface that mainly handles connection management and interfaces with the PMM (see 3.2.23)

3.2.5

encapsulated FC frame

SOF/EOF delimited FC frame prefixed with a 28-byte FC frame Encapsulation Header (see RFC 3643)

3.2.6

Encapsulated Frame Receiver Portal

TCP access point through which an encapsulated FC frame (see 3.2.5) is received from the IP network by an FCIP_DE (see 3.2.14)

3.2.7

Encapsulated Frame Transmitter Portal

TCP access point through which an encapsulated FC frame (see 3.2.5) is transmitted to the IP network by the FCIP_DE (see 3.2.14)

3.2.8

FC Entity

data forwarding component of the FC-BB_IP interface consisting of VE_Port(s) (see 3.2.24) and/or B_Access (see 3.2.1) portals

3.2.9

FC Entity Protocol Layer

protocol layer that lies between the Fibre Channel level FC-2 and the FCIP Entity Protocol Layer (see 3.2.16)

3.2.10

FC Receiver Portal

access point through which an FC frame and timestamp enters an FCIP_DE (see 3.2.14) from the VE_Port/B_Access (see 3.2.24 and 3.2.1)

3.2.11

FC Transmitter Portal

access point through which an FC frame and timestamp leaves an FCIP_DE (see 3.2.14) to the VE_Port/B_Access (see 3.2.24 and 3.2.1)

3.2.12

FC-BB_IP device

device defined by the FC-BB_IP model

3.2.13

FC-BB_IP interface

point that has interfaces to the FC switched network on one side and the IP network on the other side. It consists of a Switching Element, FC/FCIP Entity pair(s), the CSM, and the PMM

3.2.14

FCIP Data Engine (FCIP_DE)

data forwarding component of the FCIP Entity's (see 3.2.15) FCIP_LEP (see 3.2.21) that handles FC frame encapsulation, decapsulation, and transmission of encapsulated frames through a single TCP connection

3.2.15

FCIP Entity

data forwarding component of the FC-BB_IP interface consisting of the FCIP_LEP (see 3.2.21)

3.2.16

FCIP Entity Protocol Layer

protocol layer that lies between the FC Entity (see 3.2.8) layer and the TCP layer

3.2.17

FCIP frame

encapsulated FC frame (see 3.2.5)

3.2.18

FCIP Link

Virtual Link that connects an FCIP_LEP (see 3.2.21) in one FC-BB_IP device (see 3.2.12) with another

3.2.19

FCIP Link Acceptor

FC-BB_IP FCIP_LEP (see 3.2.21) that accepts an FCIP Link

3.2.20

FCIP Link Originator

FC-BB_IP FCIP_LEP (see 3.2.21) that originates an FCIP Link

3.2.21

FCIP Link Endpoint (FCIP_LEP)

component of an FCIP Entity (see 3.2.15) that contains one or more FCIP_DEs (see 3.2.14)

3.2.22

FCIP Transit Time (FTT)

total transit time of an encapsulated Fibre Channel frame in the IP network

3.2.23

Platform Management Module (PMM)

management component of the FC-BB_IP interface that handles time synchronization, discovery, and security, and interfaces with the CSM (see 3.2.4)

3.2.24

Virtual E_Port (VE_Port) (see FC-SW-6)

instance of the FC-2V sublevel of Fibre Channel that communicates with another VE_Port

3.2.25

VE_Port Virtual ISL

Virtual ISL (see 3.2.26) that connects two VE_Ports (see 3.2.24)

3.2.26

Virtual ISL

ISL that connects two VE_Ports (see 3.2.24) or two B_Access portals (see 3.2.1) across a non-FC link

3.3 FC-BB_GFPT definitions

3.3.1

ASFC_PAUSE

GFPT_WAN Primitive Signal used to pause flow on a GFPT_WAN link (see 6.4.4) and never transmitted to, or expected from, FC_Ports

3.3.2

ASFC_RESUME:

GFPT_WAN Primitive Signal used to resume flow on a GFPT_WAN link (see 6.4.4) and never transmitted to, or expected from, FC_Ports

3.3.3

GFP Server

Generic Framing Procedure (see 3.1.20) adaptation/de-adaptation engine

3.3.4

GFPT

(Asynchronous) Transparent Generic Framing Procedure (see 3.1.20)

3.3.5

GFPT_WAN interface

transport network-side interface, on an FC-BB_GFPT device, corresponding to one GFPT_WAN facility (see 3.3.7), and to one Transport Trail (see 3.3.18)

3.3.6

GFPT_WAN link:

Transport Trail (see 3.3.18) assigned to one GFPT_WAN facility (see 3.3.7)

3.3.7

GFPT_WAN facility

Transport Trail (see 3.3.18), GFP Server (see 3.3.3), FC-BB_GFPT devices, and their respective GFPT_WAN interfaces (see 3.3.5), corresponding to one interconnected FC_Port pair

3.3.8

inbound

sent from the FC-BB_GFPT device to the attached FC_Port

3.3.9

LEM (see 6.4.3)

Login Exchange Monitor

3.3.10

OTN (see ITU-T G.709/Y.1331)

term that refers to the rates and formats for Optical Transport Network

3.3.11

outbound

sent from the attached FC_Port to the FC-BB_GFPT device

3.3.12

PDH (see ITU-T G.702)

term that refers to the rates and formats for Plesiochronous Digital Hierarchy

3.3.13

PING

GFPT_WAN Primitive Signal used to initiate latency measurement on a GFPT_WAN link and never transmitted to, or expected from, FC_Ports

3.3.14

PING_ACK

GFPT_WAN Primitive Signal used to reply to a PING and complete round-trip latency measurement on a GFPT_WAN link and never transmitted to, or expected from, FC_Ports

3.3.15

RPSC ELS (see FC-LS-3)

Report Port Speed Capabilities ELS

3.3.16

SONET (see ANSI T1.105)

term that refers to the rates and formats for Synchronous Optical NETWORK

3.3.17

Synchronous Digital Hierarchy (SDH)

term that refers to the rates and formats specified in ITU-T G.707/Y.1322

3.3.18

Transport Trail

contiguously or virtually-concatenated signal group (see T1.105-2001) made up of one or more standardized SONET/SDH/OTN/PDH synchronous transport signals

3.3.19

WAN Primitive Signal

ASFC_PAUSE (see 3.3.1), ASFC_RESUME (see 3.3.2), PING (see 3.3.13), or PING_ACK (see 3.3.14) Primitive Signal

3.3.20

WAN_HOLDOFF_TOV

time-out value, specific to FC-BB_GFPT devices, which defines the period that elapses, following detection/indication of a GFPT_WAN link failure, before a GFPT_WAN Down condition is declared for the purposes of the state machine described in 6.4.2

3.4 FC-BB_PW definitions

3.4.1

Customer Edge (CE) (see RFC3985)

device where one end of a service originates and/or terminates

3.4.2

Multiprotocol Label Switching (MPLS)

data-carrying mechanism that belongs to the family of packet switched networks (see 3.4.5)

3.4.3

Provider Edge (PE)

device that provides PWE3 (see 3.4.4) to a CE (see 3.4.1)

3.4.4

Pseudowire Emulation Edge-to-Edge (PWE3)

mechanism that emulates the essential elements of an emulated service from one PE (see 3.4.3) to one or more PEs over a PSN (see 3.4.5)

3.4.5

Packet Switched Network (PSN)

network using IP or MPLS as the mechanism for packet forwarding

3.5 FC-BB_E definitions

3.5.1

Controlling FCF

Controlling Switch (see FC-SW-6) that supports Lossless Ethernet MACs (see 7.6)

3.5.2

Distributed FCF

set of FDFs associated with at least one Controlling FCF, that controls the operations of the set of FDFs

3.5.3

ENode (FCoE Node)

Fiber Channel node (see FC-FS-4) that is able to transmit FCoE frames using one or more ENode MACs

3.5.4

ENode MAC

Lossless Ethernet MAC coupled with an FCoE Controller in an ENode

3.5.5

ENode MAC address

assigned MAC address of an ENode MAC, used by the FCoE Controller of the ENode MAC for the FCoE Initialization Protocol (FIP)

3.5.6

FPMA (Fabric Provided MAC Address)

MAC address that is assigned by an FCF to a single ENode MAC and associated with a single VN_Port at that ENode MAC

3.5.7

FC-MAP (Mapped Address Prefix)

required value for the upper 24 bits of a MAC address assigned to a VN_Port in a Fabric Provided MAC Address

3.5.8

FCF (FCoE Forwarder)

Fibre Channel Switching Element (see FC-SW-6) that is able to forward FCoE frames across one or more FCF-MACs, and that optionally includes one or more Lossless Ethernet bridging elements and/or a Fibre Channel Fabric interface

3.5.9

FCF-MAC

Lossless Ethernet MAC coupled with an FCoE Controller in an FCF

3.5.10

FCF-MAC address

MAC address of an FCF-MAC

3.5.11

FCoE Controller

functional entity, coupled with a Lossless Ethernet MAC, instantiating and de-instantiating VE_Ports, VF_Ports, VN_Ports, VA_Ports, and/or FCoE_LEPs using the FCoE Initialization Protocol (FIP)

3.5.12

FCoE Entity

interface, containing one or more FCoE_LEPs, between a VN_Port, a VF_Port, or a VE_Port, and a Lossless Ethernet MAC

3.5.13

FCoE frame

Ethernet frame (see IEEE 802.3-2012) that contains an FCoE PDU (see 3.5.15)

3.5.14

FCoE_LEP (FCoE Link End-Point)

data forwarding component of an FCoE Entity that handles FC frame encapsulation/decapsulation, and transmission/reception of encapsulated frames through a single Virtual Link

3.5.15

FCoE PDU

PDU identified by the FCoE Ethernet Type that encapsulates a byte-encoded FC frame (see 7.10)

3.5.16

FDF (FCoE Data-Plane Forwarder)

FCDF (see FC-SW-6) that supports Lossless Ethernet MACs (see 7.7)

3.5.17

FDF-MAC

lossless Ethernet MAC coupled with an FCoE Controller in an FDF

3.5.18

FDF_Set

Switch_Names of the FDFs that are part of a Distributed FCF

3.5.19

FIP frame

Ethernet frame (see IEEE 802.3-2012) containing a FIP PDU

3.5.20

FIP PDU

PDU identified by the FIP Ethernet Type that encapsulates one or more FIP operations (see 7.11.7)

3.5.21

Lossless Ethernet bridging element

Ethernet bridging function operating across Lossless Ethernet MACs

3.5.22

Lossless Ethernet MAC

full duplex Ethernet MAC implementing extensions to avoid Ethernet frame loss due to congestion (e.g., the PAUSE mechanism (see IEEE 802.3-2012) or the Priority-based Flow Control mechanism (see IEEE 802.1Qbb))

3.5.23

Lossless Ethernet network

Ethernet network composed only of full duplex links, Lossless Ethernet MACs, and Lossless Ethernet bridging elements (see 4.4.4)

3.5.24

multi-node

VN_Port to VN_Port configuration supporting two or more VN2VN ENodes and in which the Locally Unique N_Port_ID protocol performs probing and claiming of an N_Port_ID

3.5.25

Multicast MAC address

MAC address associated with a group of logically related Ethernet stations on an Ethernet network and called a Multicast-Group Address in IEEE 802.3-2012

3.5.26**N_Port_ID P2P Beacon**

FIP N_Port_ID Beacon with the REC/P2P bit set to one

3.5.27**N_Port_ID P2P Claim Notification**

FIP N_Port_ID Claim Notification with the REC/P2P bit set to 1

3.5.28**N_Port_ID P2P Claim Response**

FIP N_Port_ID Claim Response with the REC/P2P bit set to 1

3.5.29**PE_Port (Physical E_Port)**

LCF (see FC-FS-4) within the Fabric that attaches to another PE_Port through a native FC link (see FC-SW-6)

3.5.30**PF_Port (Physical F_Port)**

LCF (see FC-FS-4) within the Fabric that attaches to a PN_Port through a native FC link (see FC-SW-6)

3.5.31**PN_Port (Physical N_Port)**

LCF (see FC-FS-4) that supports only VN_Ports (see FC-FS-4)

3.5.32**point-to-point**

VN_Port to VN_Port configuration supporting two VN2VN ENodes and in which the Locally Unique N_Port_ID protocol performs only the claiming of an N_Port_ID

3.5.33**Unicast MAC address**

MAC address associated with a particular Ethernet station on an Ethernet network and called an Individual Address in IEEE 802.3-2012

3.5.34**VA_Port (Virtual A_Port)**

instance of the FC-2V sublevel of Fibre Channel that communicates with another VA_Port

3.5.35**VA_Port/FCoE_LEP pair**

VA_Port and its associated FCoE_LEP

3.5.36**Vendor_ID**

8-byte ASCII string, the value of which shall be assigned by INCITS Technical Committee T10 (see <http://www.t10.org/lists/2vid.htm>), used to uniquely identify an organizational entity

3.5.37**VE_Port (Virtual E_Port)**

instance of the FC-2V sublevel of Fibre Channel that communicates with another VE_Port (see FC-SW-6)

3.5.38**VE_Port/FCoE_LEP pair**

VE_Port and its associated FCoE_LEP

3.5.39**VF_Port (Virtual F_Port)**

instance of the FC-2V sublevel of Fibre Channel that communicates with one or more VN_Ports (see FC-SW-6)

3.5.40

VF_Port/FCoE_LEP pair

VF_Port and one of its associated FCoE_LEPs

3.5.41

VN_Port/FCoE_LEP pair

VN_Port and its associated FCoE_LEP

3.5.42

Virtual Link

logical link connecting two FCoE_LEPs (see 7.8)

3.5.43

VN_Port (Virtual N_Port)

instance of the FC-2V sublevel of Fibre Channel that operates as an N_Port (see FC-FS-4)

3.5.44

VN2VN ENode

ENode supporting one or more VN2VN_Ports

3.5.45

VN2VN ENode MAC

ENode MAC that supports the Locally Unique N_Port_IDs protocol

3.5.46

VN2VN_Port

VN_Port dedicated to the instantiation of VN_Port to VN_Port Virtual Links

3.5.47

VN_Port MAC address

MAC address used by an ENode for a particular VN_Port

3.6 Editorial conventions

In FC-BB-6, 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, Sequence). 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 an ordering relationship between the listed items.

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 clauses.

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 clauses.

Data structures in this standard are displayed in Fibre Channel format (i.e., “big-endian”), while specifications originating in IEEE and IETF may display data structures in Ethernet format (i.e., “little-endian”).

If the value of the bit or field is not relevant, then x or xx appears in place of a specific value. If a field or a control bit in a frame is specified as not meaningful, then the entity that receives the frame shall not check that field or control bit.

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.

In figures, dashed components or bracketed components are optional.

3.7 List of commonly used acronyms and abbreviations

Abbreviations and acronyms applicable to this standard are listed. Definitions of several of these items are included in clause 3.

3.7.1 General

BB	Backbone
EBP	Exchange B_Access Parameters
ELP	Exchange Link Parameters
EOF	End of Frame
EOFni	End of Frame Invalid
ESC	Exchange Switch Capabilities
F_BSY	Fabric Busy
FCS	Frame Check Sequence
FC-FS-4	Fibre Channel - Framing and Signaling - 4
FC-LS-3	Fibre Channel - Link Services - 3
FC-SP-2	Fibre Channel - Security Protocols - 2
FC-SW-6	Fibre Channel - Switched Fabric - 6
FLOGI	Fabric Login
ISL	Inter-switch Link
ITU-T	International Telecomm. Union - Telecommunication Standardization Section
K_A_TOV	Keep Alive Timeout value
LKA	Link Keep Alive
LS_ACC	Link Service Accept reply frame
LS_RJT	Link Service Reject reply frame
LSB	least significant byte
MSB	most significant byte
P_BSY	N_Port Busy
PDU	Protocol Data Unit
PLOGI	N_Port Login
SOF	Start of Frame
SW_ACC	Switch Fabric Internal Link Service Accept
SW_ILS	Switch Fabric Internal Link Services
SW_RJT	Switch Fabric Internal Link Service Reject
VL	Virtual Link
WAN	Wide Area Network

3.7.2 FC-BB_IP

B_Access	B_Access Portals
CSM	Control and Service Module
FCIP	FC over TCP/IP
FCIP_DE	FCIP Data Engine
FCIP_LEP	FCIP Link Endpoint
IETF	IETF Internet Engineering Task Force (www.ietf.org)
PMM	Platform Management Module
RFC	Request For Comment
VE_Port	Virtual E_Port

3.7.3 FC-BB_GFPT

ASFC	Alternate Simple Flow Control
GFP	Generic Framing Procedure
GFPT	(Asynchronous) Transparent Generic Framing Procedure
GFPT_WAN	GFPT Wide Area Network
LEM	Login Exchange Monitor
OTN	Optical Transport Network
PDH	Plesiochronous Digital Hierarchy
SDH	Synchronous Digital Hierarchy
SONET	Synchronous Optical NETwork

3.7.4 FC-BB_PW

EF PHB	Expedited Forwarding Per-Hop Behavior
PE	Provider Edge
PW	pseudowire
MPLS/PW	Multiprotocol Label Switching pseudowire

3.7.5 FC-BB_E

ACE	Access Control Entry
ACL	Access Control List
D_A_TOV	Discovery Advertisement Timeout Value
ENode	FCoE Node
FC-MAP	FCoE Mapped Address Prefix
FCF	FCoE Forwarder
FCF-MAC	FCoE Forwarder Media Access Control
FCoE_LEP	FCoE Link Endpoint
FIP	FCoE Initialization Protocol
FPMA	Fabric Provided MAC Address
LAN	Local Area Network
MAC	Media Access Control
PFC	Priority-based Flow Control
PHY	Physical Layer
PTP	Precision Time Protocol
TLV	Type, Length, Value
VA_Port	Virtual A_Port
VE_Port	Virtual E_Port
VF_Port	Virtual F_Port
VLAN	Virtual Local Area Network
VN_Port	Virtual N_Port

3.8 Symbols

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

!= not equal

3.9 Keywords

3.9.1 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.

3.9.2 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.

3.9.3 mandatory: A keyword indicating an item that is required to be implemented as defined in this standard.

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

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

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

3.9.7 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 to this standard. Recipients should not check reserved bits, bytes, words or fields for zero values. Receipt of reserved code values in defined fields shall be reported as an error.

3.9.8 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 standard.

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

3.9.10 x or xx: The value of the bit or field is not relevant.

4 FC-BB-6 Structure and Concepts

4.1 FC-BB-6 backbone mappings

FC-BB-6 models (i.e., FC-BB_IP, FC-BB_GFPT, FC-BB_PW, and FC-BB_E), specified in this standard, define mappings for transporting Fibre Channel over different network technologies.

The FC-BB_IP model uses TCP connections over IP networks. The FC-BB_GFPT model makes use of the Asynchronous Transparent Generic Framing Procedure (GFPT) (see ITU-T Rec. G.7041/Y.1303). GFPT may be used for adaptation to different transport facilities including SONET, SDH, OTN and PDH. Details regarding the mapping of GFPT-adapted traffic to such transport facilities are elaborated in various ITU-T standards (see 2.4). The FC-BB_PW model uses PW connections over MPLS networks. The FC-BB_E model uses Lossless Ethernet links (i.e., full duplex Ethernet links extended to become lossless, see 4.4.4).

A second important distinction among the mappings discussed in this standard relates to supported architectures (i.e., network and/or link topologies) and the place of the defined devices within them. FC-BB_IP defines an FC Entity that consists of:

- a) one or more Virtual E_Port (VE_Port) virtual ISL(s) that interconnect the E_Ports of external FC switches and N_Ports of external end devices; or
- b) one or more B_Access virtual ISL(s) that interconnect the E_Ports of external FC switches.

The B_Access virtual ISL(s) are part Fabric bridge device with resident switch-facing interfaces called B_Ports. B_Ports have selected Fabric functions (see FC-SW-6). B_Ports are Fabric ports, and FC-BB_IP devices are components of an FC Fabric. FC-BB_IP also defines support for FC bridge devices with Fabric-facing B_Ports. However, FC-BB_IP also supports functional integration within an FC Switch. Thus FC-BB_IP devices may also have E_Ports and F_Ports.

FC-BB_GFPT and FC_BB_PW define a device that is not a component of a Fabric, and supports no Fabric functionality. Instead, it interconnects two Fibre Channel physical ports (i.e., attached FC_Ports), appearing architecturally as a wire to those ports.

FC-BB_E defines end devices (i.e., ENodes) and Fabric devices (i.e., FCFs and FDFs). ENodes are Fibre Channel nodes (see FC-FS-4) that are able to transport Fibre Channel frames over Lossless Ethernet. FCFs and FDFs are Fibre Channel Switching Elements (see FC-SW-6) that are able to transport Fibre Channel frames over Lossless Ethernet.

4.2 FC-BB-6 reference models

4.2.1 FC-BB-6 reference models overview

FC-BB-6 defines reference models corresponding to the FC-BB_IP, FC-BB_GFPT, FC-BB_PW, and FC-BB_E reference models.

The FC-BB_IP reference model supports the attachment of FC switches (i.e., E_Ports) via one or more B_Ports or E_Ports and the attachment of N_Ports via one or more F_Ports. The FC-BB_GFPT and FC-BB_PW reference models support the attachment of N_Ports, F_Ports, and E_Ports, and the following Fibre Channel port interconnections:

- a) N_Port to N_Port;
- b) N_Port to F_Port; and
- c) E_Port to E_Port.

The FC-BB_E reference model supports the operation of:

- a) VN_Ports (see FC-FS-4) in ENodes;
- b) VF_Ports and VE_Ports (see FC-SW-6) in FCFs;
- c) VF_Ports, VE_Ports, and VA_Ports (see FC-SW-6) in Controlling FCFs; and
- d) VF_Ports and VA_Ports (see FC-SW-6) in FDFs.

Table 2 summarizes the resident FC_Port types for the different FC-BB-6 reference models.

Table 2 – Reference models and resident FC_Port types

	Reference Model			
	FC-BB_IP	FC-BB_GFPT	FC-BB_PW	FC-BB_E ^a
Resident FC_Port Type(s)	B_Port, E_Port, F_Port	None (FC Physical Interface)	None (FC Physical Interface)	N_Port, E_Port, F_Port, A_Port
a) Resident FC_Ports are optional for FC-BB_E.				

4.2.2 FC-BB_IP reference model

In Figure 5, frames destined for a remote FC network enter a B_Port, an E_Port, or an F_Port, and are forwarded on the IP network to their destination.

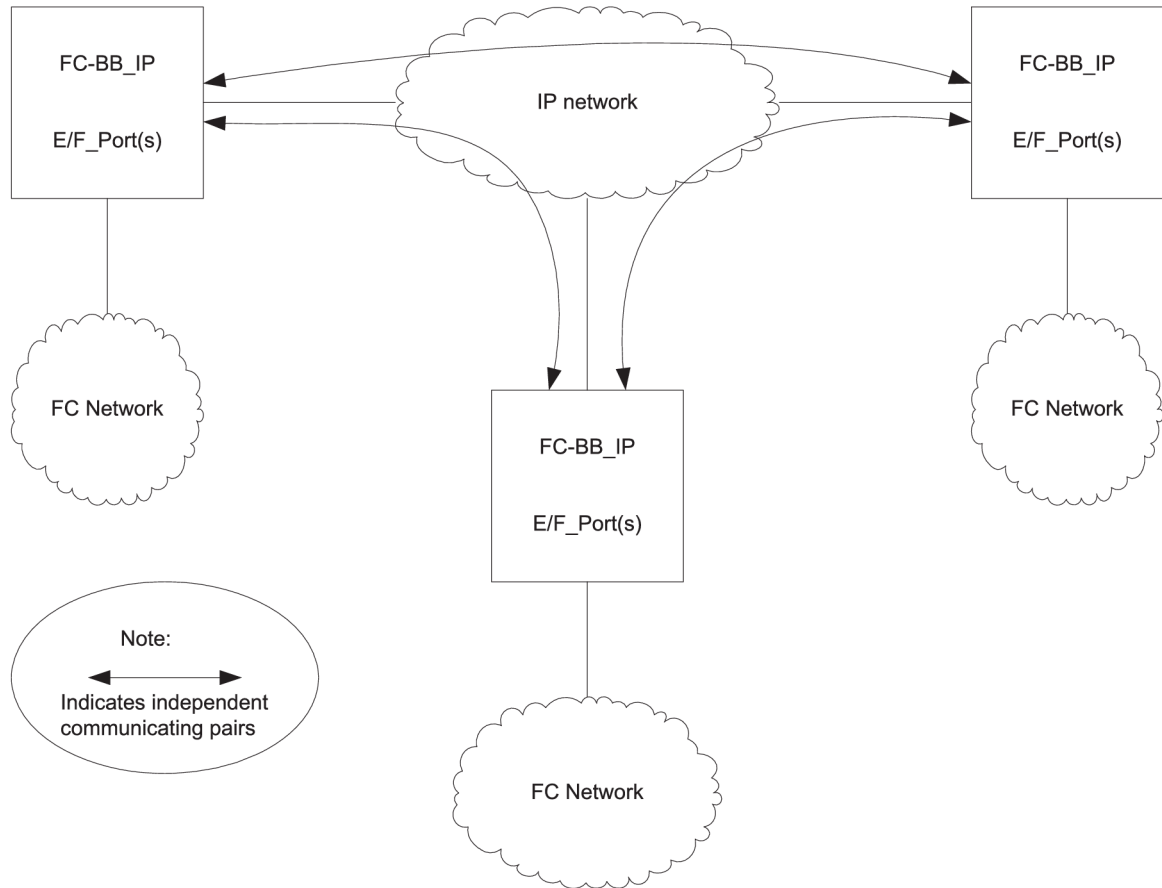


Figure 5 – FC-BB_IP reference model

4.2.3 FC-BB_GFPT reference model

In Figure 6, FC physical signals (i.e., relevant 8B/10B codewords) enter an FC physical port on an FC-BB_GFPT device, and are forwarded on the SONET/SDH/OTN/PDH network to their destination.

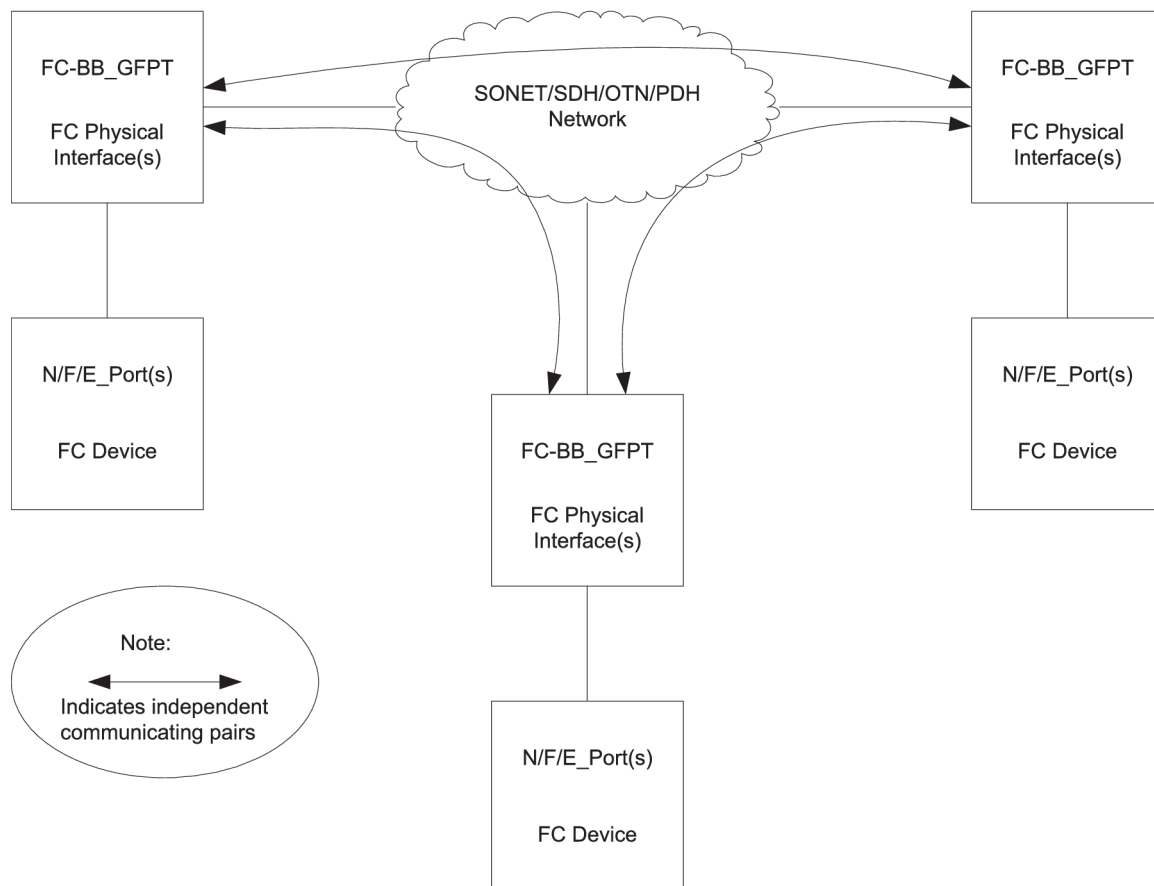


Figure 6 – FC-BB_GFPT reference model

4.2.4 FC-BB_PW reference model

In Figure 7, FC physical signals enter an FC physical port on an FC-BB_PW device, and are forwarded on the PSN network to their destination.

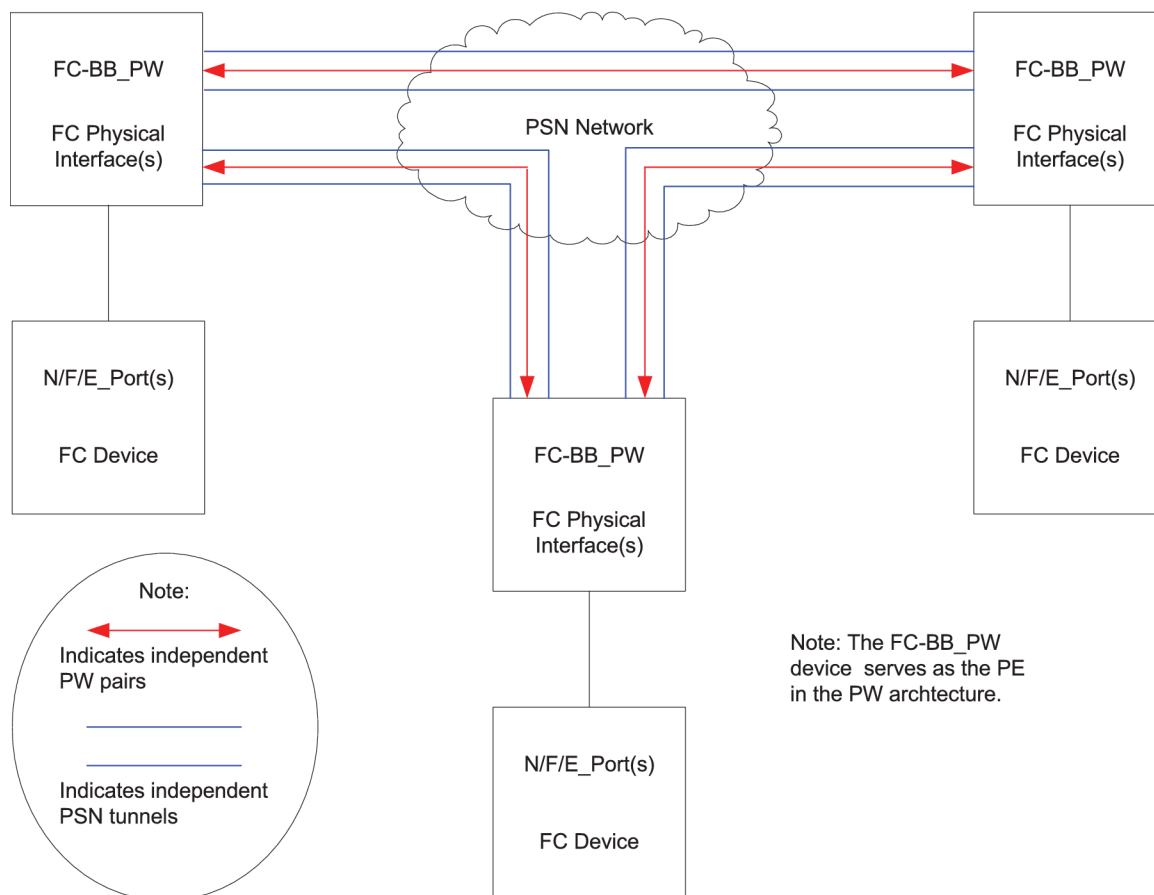


Figure 7 – FC-BB_PW reference model

4.2.5 FC-BB_E reference models

4.2.5.1 FC-BB_E VN_Port to VF_Port reference model

Figure 8 shows the VN_Port to VF_Port reference model. FCoE frames originated by a VN_Port are transported over the Lossless Ethernet network to the VF_Port the VN_Port is logged in with.

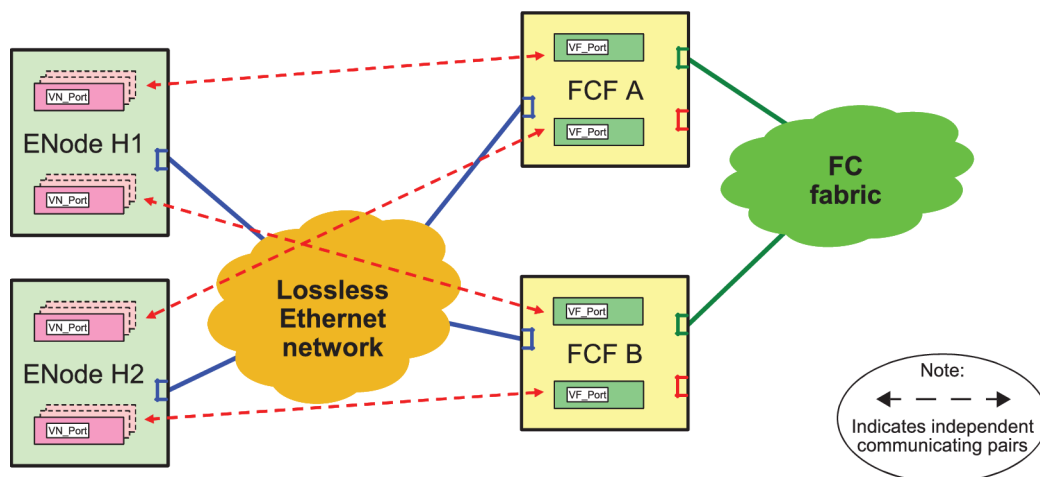


Figure 8 – FC-BB_E VN_Port to VF_Port reference model

4.2.5.2 FC-BB_E VE_Port to VE_Port reference model

Figure 9 shows the VE_Port to VE_Port reference model. FCoE frames originated by a VE_Port are transported over the Lossless Ethernet network to the VE_Port that the VE_Port is logically connected to.

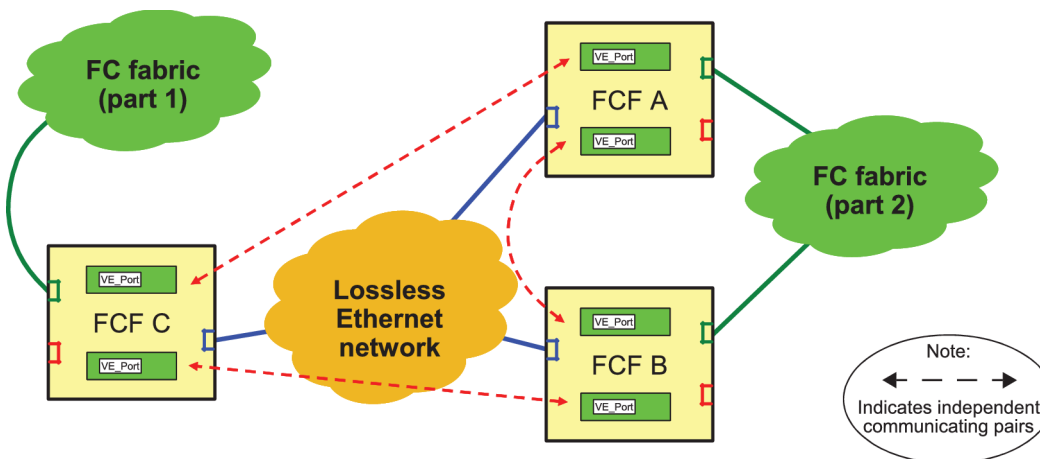


Figure 9 – FC-BB_E VE_Port to VE_Port reference model

4.2.5.3 FC-BB_E VN_Port to VN_Port reference model

Figure 10 shows the VN_Port to VN_Port reference model. FCoE frames originated by a VN_Port are transported over the Lossless Ethernet network to the VN_Port(s) with which the originating VN_Port is logged in with.

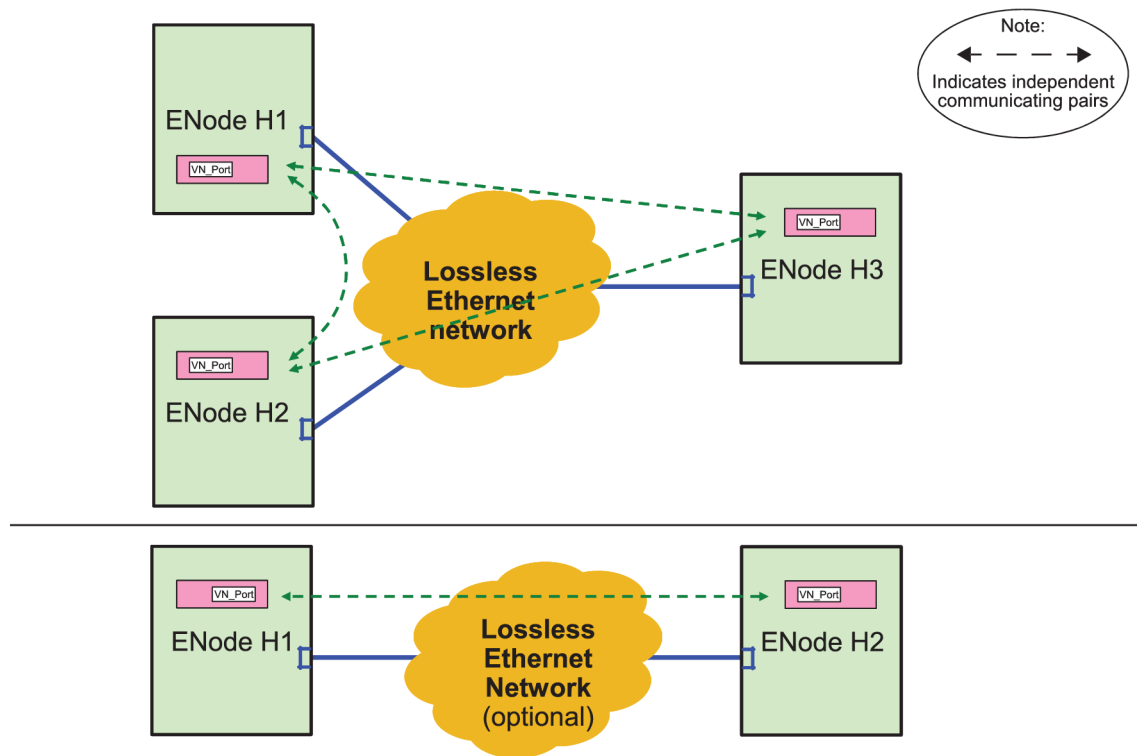


Figure 10 – FC-BB_E VN_Port to VN_Port reference model

4.2.5.4 FC-BB_E VA_Port to VA_Port reference model

Figure 11 shows the VA_Port to VA_Port reference model. FCoE frames originated by a VA_Port are transported over the Lossless Ethernet network to the VA_Port that the VA_Port is logically connected to.

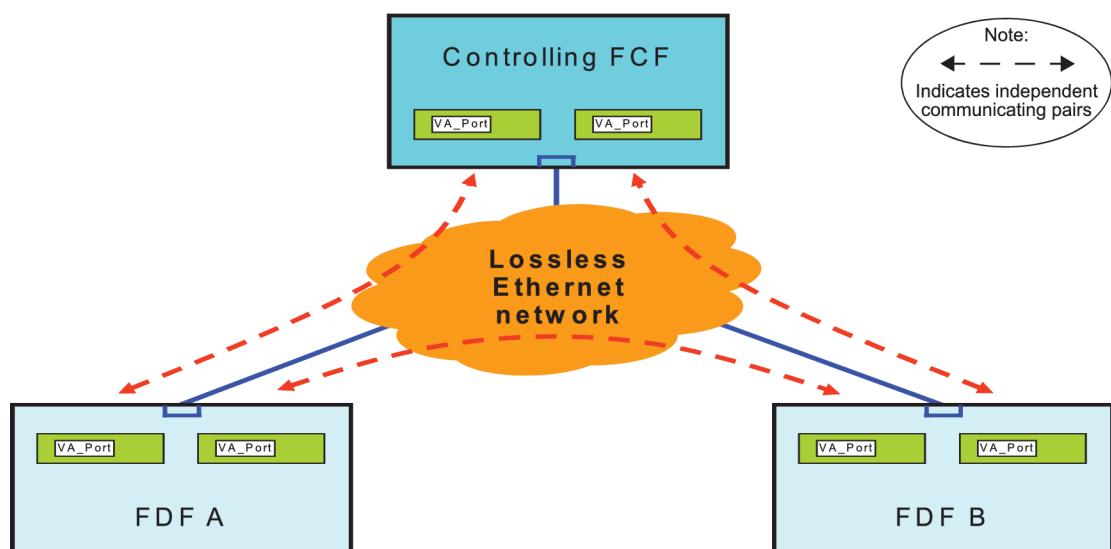


Figure 11 – FC-BB_E VA_Port to VA_Port reference model

4.3 FC-BB-6 models overview

4.3.1 FC-BB_IP

The FC-BB_IP model defines the means by which Fibre Channel networks interface with and connect across an IP network. FC-BB_IP makes use of the FCIP standard (see RFC 3821) to define the mapping and control required by the TCP/IP protocol and the FC frame encapsulation standard (see RFC 3643) to define the encapsulation. FC-BB_IP also defines the connection management, addressing, time synchronization, discovery, security, switching, routing, and error recovery required to support Fibre Channel over TCP/IP. FC-BB_IP is independent of the underlying physical technology that exists beneath the IP layer. In this sense, the IP network could use SONET, Gigabit Ethernet, or any other link-level technology below it.

FC-BB_IP encapsulates byte-encoded Class 2, 3, or F Fibre Channel frames into a suitable format (i.e., encapsulated FC frames) for carriage over the IP network. Subclause 5.6 describes encapsulated FC frames in detail. The TCP/IP protocol suite provides a reliable transport of frames over the IP network. TCP provides flow control and error recovery.

The FC-BB_IP protocol provides mechanisms to create VE_Port or B_Access connectivity over the IP network (see 5).

The FC-BB_IP device interfaces to attached FC_Ports are FC physical interfaces operating at standard rates. The FC-BB_IP devices may support automatic WAN link speed negotiation with the attached IP networks.

4.3.2 FC-BB_GFPT

The FC-BB_GFPT model defines the means by which FC physical links that carry 8B/10B encoded information may be extended over any WAN transport infrastructure for which GFP mapping is defined. The FC-BB_GFPT model is not applicable to FC physical links that use other encodings (e.g., 16GFC physical variants use 64B/66B encoding, and are not supported). With that restriction, FC-BB_GFPT supports the interconnection of arbitrary, legal, non-Arbitrated Loop FC_Port combinations, imposing no requirements, and making no suppositions regarding the topology, or even the presence of an FC Fabric. FC-BB_GFPT supports efficient transport of FC data over transport facilities of arbitrary bandwidths and potentially large distances. FC-BB_GFPT supports Class 2, 3, and F traffic.

FC-BB_GFPT supports the interconnection of arbitrary, legal, non-Arbitrated Loop FC_Port combinations, imposing no requirements, and making no suppositions regarding the topology, or even the presence of an FC Fabric. FC-BB_GFPT supports efficient transport of FC data over transport facilities of arbitrary bandwidths and potentially large distances. FC-BB_GFPT supports Class 2, 3, and F traffic.

FC-BB_GFPT devices do not generate FC frames and do not directly participate in port initialization or other Exchanges. FC-BB_GFPT devices are exempt from any requirements regarding FC_Port authentication (see FC-SP-2), and they do not impede or interfere with any such processes that may occur between the attached and interconnected FC_Ports. FC-BB_GFPT devices have no FC identity or visibility, and administratively they may be kept separate and distinct from FC Fabrics and ports.

FC_Ports are interconnected pair-wise over SONET/SDH/OTN/PDH networks, via FC-BB_GFPT devices, in a point-to-point fashion. Although multiple FC_Ports may interface with a single FC-BB_GFPT device, each opposing FC_Port pair is connected via a dedicated Transport Trail (e.g., a contiguously or virtually-concatenated group). Since trail and access section configurations may differ, FC-BB_GFPT devices have both physical interfaces to the transport network, and individual FC-BB_GFPT devices may have more than one such physical interface, as well as logical interfaces associated with individual circuits. Logical interfaces are referred to as GFPT_WAN interfaces. A GFPT_WAN interface corresponds to a specific Transport Trail, and always to a single attached FC_Port pair. Governance of the relationship of GFPT_WAN interfaces to physical SONET/SDH/OTN/PDH interfaces, and of any changes of such relationships (e.g., as may occur during network protection events), is specified in the appropriate ITU-T and ANSI-T1 standards (see clause 2), and is therefore outside the scope of this standard. Multiple GFPT_WAN links originating on one FC-BB_GFPT device may be terminated on different, and geographically disparate, FC-BB_GFPT devices. The routing and provisioning of network facilities underlying GFPT_WAN links is outside the scope of this standard.

The FC-BB_GFPT device interfaces to attached FC_Ports are FC physical interfaces operating at standard rates. The FC physical interfaces on FC-BB_GFPT devices may support link speed negotiation with the attached FC_Ports.

4.3.3 FC-BB_PW

The FC-BB_PW model defines the means by which FC physical links that carry 8B/10B encoded may be extended over a wide area MPLS network. The FC-BB_PW model is not applicable to FC physical links that use other encodings (e.g., 16GFC physical variants use 64B/66B encoding, and are not supported). FC-BB_PW is specified in conjunction with RFC 6307 to define the mapping and control required by the MPLS/PW protocol. According to this model the FC-BB_PW device serves as a PE network element in the PW architecture. FC-BB_PW is independent of the physical-level and link-level technologies that exist beneath the MPLS layer.

FC-BB_PW supports the interconnection of FC_Ports transporting Class 2, 3, and F traffic. FC-BB_PW encapsulates 8B/10B-encoded FC frames and a selected set of Primitive Signals and Primitive Sequences into PW PDUs for transport over the MPLS network. FC-BB_PW utilizes reliable transport of FC traffic over the MPLS network provided by the PW termination layer as specified in RFC 6307.

The FC-BB_PW entity does not generate FC frames and does not directly participate in port initialization or other Exchanges. The FC-BB_PW entity is exempt from any requirement regarding FC_Port authentication (see FC-SP-2), and it does not impede or interfere with any such processes that may occur between the attached and interconnected FC_Ports. The FC-BB_PW entity has no FC identity or visibility, and administratively it may be kept separate and distinct from FC Fabrics and ports.

4.3.4 FC-BB_E

The FC-BB_E model defines the means by which Fibre Channel frames are transported over a Lossless Ethernet network (see 4.4.4). Although a generic Ethernet network may lose frames due to congestion, a proper implementation of appropriate Ethernet extensions (e.g., the PAUSE mechanism defined in IEEE 802.3-2012) allows a full duplex Ethernet link to provide a lossless behavior similar to the one provided by the buffer-to-buffer mechanism (see FC-FS-4). The protocol mapping defined by FC-BB_E is referred to as Fibre Channel over Ethernet (FCoE) and requires the underlying Ethernet layer to be full duplex and lossless (i.e., to be composed only of full duplex links and to provide a lossless behavior when transporting FCoE frames).

FC-BB_E encapsulates byte-encoded Class 2, 3, or F Fibre Channel frames into a suitable format (i.e., FCoE frames) for transport over the Lossless Ethernet network. See 7.10.

The FC-BB_E protocol provides mechanisms to create VN_Port to VF_Port Virtual Links, VE_Port to VE_Port Virtual Links, VN_Port to VN_Port Virtual Links, and VA_Port to VA_Port Virtual Links.

4.4 FC-BB-6 requirements

4.4.1 Fibre Channel Class support

Class F shall be supported between FC-BB_IP, FC-BB_GFPT, and FC-BB_PW devices.

Class 2 and Class 3 may be supported between FC-BB_IP, FC-BB_GFPT, and FC-BB_PW devices.

Class 3 shall be supported between FC-BB_E devices. Class 2 and Class F may be supported between FC-BB_E devices.

NOTE 1 – A Lossless Ethernet network configuration that includes Lossless Ethernet bridges may not provide sufficient functionality to support all aspects of Class 2 service. FCFs and ENodes may indicate support for Class 2 service in the presence of Lossless Ethernet bridges, but such a configuration should be managed accordingly.

4.4.2 Payload transparency

4.4.2.1 FC-BB_IP

Arriving Class 2, 3, and F Fibre Channel frames from an FC network and destined to a remote FC network shall be encapsulated using the FC-BB_IP defined mechanisms and transmitted to the appropriate FC-BB_IP device.

Arriving encapsulated frames received from remote FC-BB_IP device shall be decapsulated and sent to an FC network.

Primitive Signals and Primitive Sequences shall not be transported between FC-BB_IP devices.

4.4.2.2 Transparent FC-BB (FC-BB_GFPT and FC-BB_PW)

FC frames inbound from one attached FC_Port shall be delivered to the remote FC_Port in native form (i.e., without further encapsulation) across the transport network according to the adaptation processes described in 6.4.8.1 for FC-BB_GFPT devices and 6.4.8.2 for FC-BB_PW devices. Frames received from remote Transparent FC-BB devices shall be forwarded to the attached FC_Port. Selected ELP, SW_ACC, FLOGI, PLOGI, and LS_ACC frames may be subject to inspection and/or minor modifications, in transiting one or the other Transparent FC-BB device, as described in 6.4.4.

Primitive Signals transmitted by an attached FC_Port are forwarded across the transport network for delivery to the remote FC_Port according to the rules described in clause 6. Primitive Signals are forwarded by an FC-BB_GFPT device in native form (i.e., without further encapsulation) according to the adaptation processes described in 6.4.8.1. Primitive Signals are forwarded by an FC-BB_PW device encapsulated within control frames as specified in RFC 6307.

Primitive Sequences transmitted by an attached FC_Port are forwarded across the transport network for delivery to the remote FC_Port according to the rules described in clause 6. Primitive Sequences are forwarded by an FC-BB_GFPT device in native form (i.e., without further encapsulation) according to the adaptation (including rate adaptation) processes described in 6.4.8.1. Primitive Sequences are forwarded by an FC-BB_PW device encapsulated within control frames as specified in RFC 6307.

4.4.2.3 FC-BB_E

Class 2, 3, and F Fibre Channel frames arriving from a VN_Port, a VF_Port, a VE_Port, or a VA_Port shall be encapsulated in FCoE frames and transmitted to the appropriate FC-BB_E device.

FCoE frames received from a remote FC-BB_E device shall be decapsulated and sent to the appropriate VN_Port, VF_Port, VE_Port, or VA_Port.

Primitive Signals and Primitive Sequences shall not be forwarded between FC-BB_E devices.

4.4.3 Latency delay and timeout value

FC-BB_IP shall ensure that the incoming encapsulated FC frames whose FCIP Transit Time (FTT) exceeds $1/2 E_D_TOV$ shall be discarded and not admitted into the FC network. Fibre Channel timeout values shall be administratively set to accommodate the FTT.

FC-BB_IP shall allow Class F encapsulated FC frames to be transmitted with a zero timestamp value.

Transparent FC-BB requires that the latency between two Transparent FC-BB devices be:

- a) no more than one-half of the E_D_TOV value of the attached devices for frames;
- b) no more than one-half of the R_T_TOV value of the attached devices for Primitive Sequences; and

- c) within the R_A_TOV values of the attached Fabric(s), if any.

The Lossless Ethernet bridges used to build a Lossless Ethernet network suitable for FC-BB_E usage should enforce a maximum bridge transit delay of 500 ms (see IEEE 802.1Q-2011).

4.4.4 QoS and bandwidth

FC-BB_IP recommends that some form of preferential QoS be used for the FCIP traffic in the IP network to minimize latency and packet drops although no particular form of QoS is recommended. See RFC 3821.

FC-BB_GFPT has no specific transport service requirements.

FC-BB_PW recommends that Primitive Sequences are carried with low latency and no loss over the MPLS network. In addition to these properties, FC data traffic should be provided with assurance of some amount of bandwidth, however no specific recommendation is made in this standard. The Differentiated Services EF PHB (see RFC 3246) is an example of a mechanism that may be used for FC-BB_PW traffic management.

FC-BB_E is intended to operate over an Ethernet network that does not discard frames in the presence of congestion. Such an Ethernet network is called Lossless Ethernet in this standard.

Lossless Ethernet may be implemented through the use of some Ethernet extensions. Suitable extensions include the PAUSE mechanism defined in IEEE 802.3-2012, or the Priority-based Flow Control (PFC) mechanism defined in IEEE 802.1Qbb, where FCoE frames shall use a lossless priority (see IEEE 802.1Qbb). The Precision Time Protocol (PTP) may be used to determine link latency (see IEEE 1588-2008 or IEEE 802.1AS).

4.4.5 In-order delivery

FC-BB_IP devices shall provide in-order delivery of frames within the scope of any TCP connection.

FC-BB_GFPT devices shall provide in-order delivery within each provisioned Transport Trail for all transmitted data (i.e., frames, Primitive Signals and Primitive Sequences), as discussed and with the exceptions detailed in clause 6.

FC-BB_PW devices shall provide in-order delivery within each provisioned PW for all transmitted data (i.e., frames, Primitive Signals and Primitive Sequences), as discussed and with the exceptions detailed in clause 6.

FC-BB_E devices shall be able to provide in-order delivery of FCoE frames on at least a per-Exchange basis within the Lossless Ethernet network.

4.4.6 Flow control

FC-BB_IP devices shall ensure that TCP flow control and error recovery acts in proper concert with the Fibre Channel BB_Credit flow control mechanism.

Flow control at E_Ports, F_Ports, VE_Ports, and B_Ports shall operate as defined in FC-SW-6.

The Alternate Simple Flow Control (ASFC) mechanism (see 6.4.4) shall be used between FC-BB_GFPT devices and between FC-BB_PW devices. Flow control on FC_Port-facing links is specified in clause 6.

Flow control at FC-BB_GFPT and FC-BB_PW physical interfaces to attached FC devices shall operate as defined in FC-SW-6 or FC-FS-4, as appropriate.

FC-BB_E devices rely on proper implementation of Ethernet extensions for flow control of FCoE frames. Ethernet extensions achieve the same level of service provided by the Fibre Channel buffer-to-buffer flow control (see FC-FS-4). Suitable extensions include the PAUSE mechanism defined in IEEE 802.3-2012, or the Priority-based Flow Control (PFC) mechanism defined in IEEE 802.1Qbb, where FCoE frames shall use a lossless priority (see IEEE 802.1Qbb). The Precision Time Protocol (PTP) may be used to determine link latency (see IEEE 1588-2008 or IEEE 802.1AS).

4.5 FC-BB-6 SW_ILS codes

Table 3 shows the SW_ILS codes allocated for FC-BB-6 use.

Table 3 – FC-BB-6 SW_ILS codes

Encoded Value (hex)	Description	Abbr.	Reference
28 03 00 00	Authentication Special Frame	ASF	5.7.2.3.2
28 01 00 00	Exchange B_Access Parameter	EBP	5.4.3.3.1

Table 4 shows the ELS codes allocated for FC-BB-6 use.

Table 4 – FC-BB-6 ELS codes

Encoded Value (hex)	Description	Abbr.	Reference
80 00 00 00	Link Keep Alive	LKA	FC-LS-3

5 FC-BB_IP Structure and Concepts

5.1 Applicability

Clause 4 specifies the FC-BB_IP reference model. This clause specifies the FC-BB_IP functional model.

5.2 FC-BB_IP overview

Figure 12 shows a network configuration consisting of three FC-BB_IP devices. FC-BB_IP is a Fibre Channel backbone transport protocol that tunnels encapsulated FC frames across the IP network. An FC-BB_IP device has interfaces to both the IP and the FC network. The FC network interface supports multiple E_Ports/F_Ports (see Figure 13) or multiple B_Ports (see Figure 17).

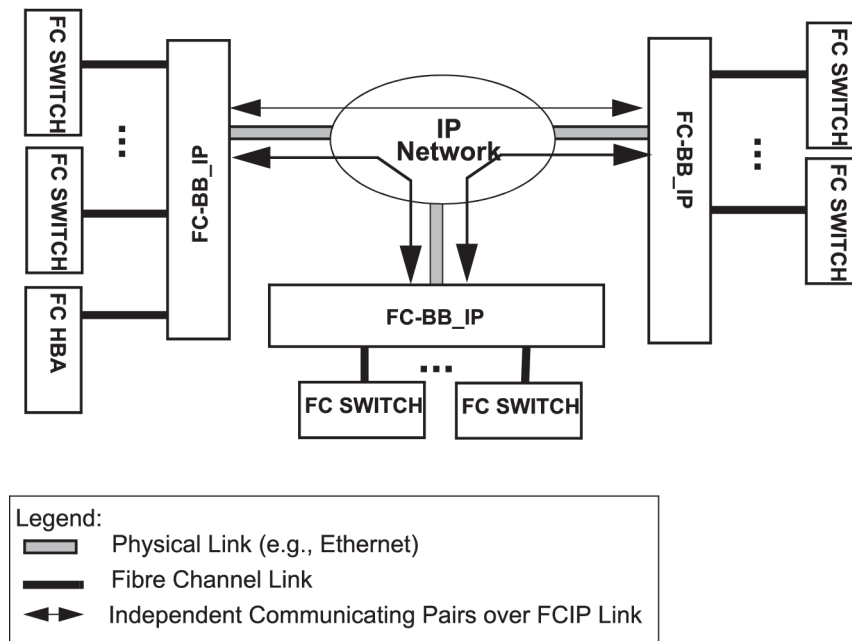


Figure 12 – FC-BB_IP network configuration

Only FC-BB_IP devices that support E_Ports or F_Ports require FC switching.

The FC-BB_IP protocol provides mechanisms to create VE_Port or B_Access connectivity over the IP network. The FC-BB_IP protocol communication occurs between pairs of FC-BB_IP devices over virtual constructs (i.e., FCIP Links) that are described in 5.3.4.2.4. Although the communication occurs between pairs of FC-BB_IP devices, a single FC-BB_IP device may communicate with more than one device at the same time (see Figure 20).

NOTE 2 – Although the current scheme allows an FC-BB_IP device to independently connect to more than one FC-BB_IP device, it does not specify a point-to-multipoint connection.

The FC-BB_IP protocol uses encapsulated FC frames created by prefixing a 28-byte FC Encapsulation Header to the incoming SOF/EOF delimited FC frame (see RFC 3643). FC-BB_IP devices are not required to interpret the data content of the FC frames other than capturing and recording their SOF/EOF identities in the encapsulated FC frame. As such, FC Sequences and Exchanges are not visible to the FC-BB_IP protocol. All encapsulated FC frames are transparently transported over the IP network.

FC-BB_IP devices also exchange SW_ILS control information using Class F FC frames (see Figure 15 and Figure 18). These FC frames are encapsulated and tunneled in the same way as the incoming FC frames.

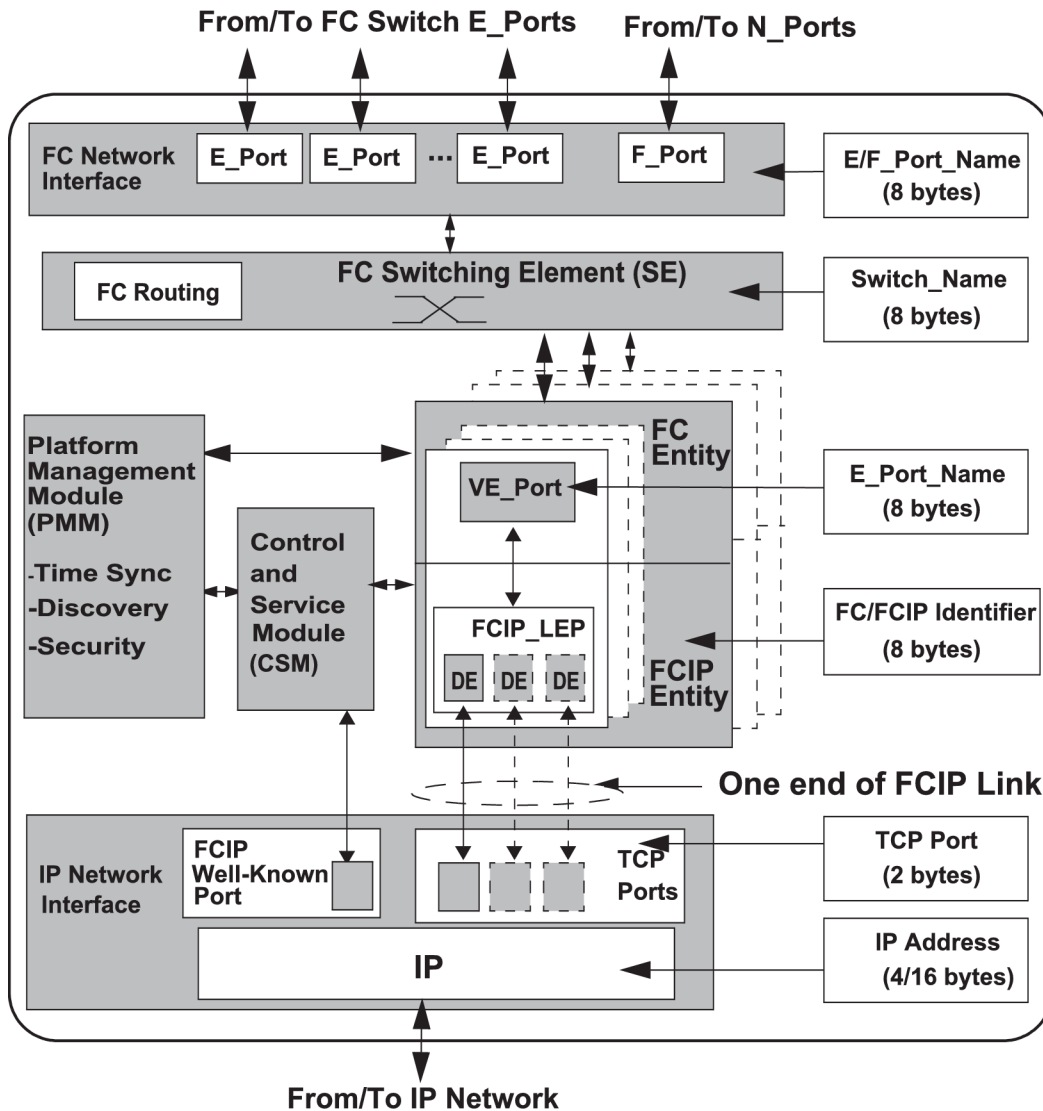
Encapsulated FC frames join the TCP byte stream in order (see Figure 21). TCP segments are created from TCP byte streams without any visibility or regard to encapsulated FC frame boundaries.

TCP flow control between two FC-BB_IP devices provides a reliable transport of encapsulated FC frames across the IP network. The only delivery order guarantee provided by TCP with respect to the FCIP protocol is the correctly ordered delivery of encapsulated FC frames within a single TCP connection. The FC Entity is expected to specify and handle all other FC frame delivery ordering requirements.

5.3 VE_Port functional model

5.3.1 FC-BB_IP interface protocol layers

Figure 13 shows the VE_Port functional model of an FC-BB_IP device that consists of the E_Port/F_Port FC interface, the FC-BB_IP interface, and the IP network interface.



Note: DE within each FCIP_LEP represents an FCIP_DE.

Figure 13 – FC-BB_IP VE_Port functional model

The protocol layers at these interfaces are:

- an E_Port/F_Port FC interface: FC-0, FC-1, and FC-2 levels;
- an FC Switching Element (SE) with FC routing;
- an FC-BB_IP protocol interface: FC Entity and FCIP Entity protocol layers; and
- an IP network interface: TCP and IP layers.

Figure 14 illustrates the protocol layers across these interfaces.

5.3.2 E_Port/F_Port FC interface

The FC-BB_IP FC interface supports one or more E_Ports or F_Ports thus requiring the support of the FC-0, FC-1, and FC-2 levels. The E_Ports in general connect to different external FC switches, but connectivity to the same FC switch is also allowed. The data emerging from the FC-2 level is fed into an FC Switching Element.

The initialization of any generic E_Port or F_Port is described in FC-SW-6. An E_Port indicates its support for the ELP/ESC parameters using the ELP/ESC SW_ILS that is capable of parameter negotiation. Since FC-BB-6 does not support Class 1, the Class 1 Port Parameter VAL bit in the ELP shall be set to 0 (i.e., invalid). An ELP received at an E_Port may be rejected using SW_RJT for many reasons (see FC-SW-6).

An E_Port/F_Port is uniquely identified by an 8-byte E_Port_Name/F_Port_Name.

5.3.3 FC Switching Element (SE) with FC routing

The FC Switching Element (SE) switches and routes the incoming FC frames from the E_Port or F_Port to the proper VE_Port (see FC-SW-6). Routing is accomplished with the support of the FSPF routing protocol. Similarly, the FC SE switches and routes the data arriving from a VE_Port to the proper E_Port or F_Port.

The SE is uniquely identified by an 8-byte Switch_Name.

5.3.4 FC-BB_IP protocol interface

5.3.4.1 Major components

The FC-BB_IP protocol has interfaces to the FC network on one side and the IP network on the other. In addition to the two network interfaces, it consists of the following major components:

- a) FC and FCIP Entities;
- b) Control and Service Module (CSM); and
- c) Platform Management Module (PMM).

FC routing occurs at a higher level than IP routing. FC/FCIP Entities themselves do not actively participate in FC frame routing. FC routing uses the FSPF protocol described in FC-SW-6. FSPF routes are mapped onto the FCIP Links interconnecting FC-BB_IP devices. An FC frame's FSPF route decides the selection of the VE_Port/FCIP_LEP pair within a selected FC/FCIP Entity pair if multiple pairs are in use. If multiple DEs within an FCIP_LEP are in use, then the selection of which FCIP_DE to use is described in 5.7.3.5.

5.3.4.2 FC and FCIP Entities

5.3.4.2.1 Function

The FC Entity is the principal interface point to the FC network on one side and, in combination with the FCIP Entity, to the IP network on the other side. The primary functions of the FC Entity are to support one or more VE_Ports and to communicate with the FCIP Entity. The FC Entity layer lies between the FC-2 FC level and the FCIP Entity layer as shown in Figure 14.

The FCIP Entity is the principal interface point to the IP network on one side, and in combination with the FC Entity, to the FC network on the other. The primary function of the FCIP Entity is formatting, encapsulating, and forwarding encapsulated FC frames across the IP network interface.

The FC/FCIP Entity pair interfaces with the CSM and the PMM through a vendor-specific mechanism.

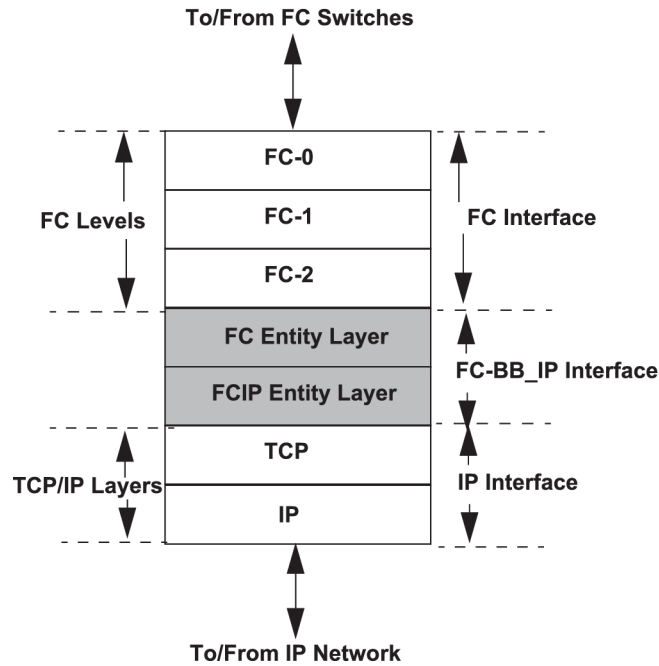


Figure 14 – FC-BB_IP Protocol Layers

5.3.4.2.2 FC Entity

The FC-BB_IP interface may support multiple instances of the FC/FCIP Entity pair. Each instance of the FC/FCIP Entity pair consists of one or more VE_Port/FCIP_LEP pairs. A VE_Port interfaces with the FCIP_LEP component of the FCIP Entity.

The VE_Port receives FC frames from the FC side and sends them to the FCIP_LEP for encapsulation and transmission on the IP network. The VE_Port may also exchange Class F control frames with the remote VE_Port via the FCIP_LEPs. There is a one-to-one relationship between a VE_Port and an FCIP_LEP. VE_Ports communicate via VE_Port Virtual ISLs (see 5.3.4.2.4).

NOTE 3 – The term Virtual ISL if used unqualified refers to both a VE_Port Virtual ISL and a B_Access Virtual ISL.

A VE_Port is uniquely identified by an 8-byte E_Port_Name.

Within an FC-BB_IP device, each FC/FCIP Entity pair instance is uniquely identified by an 8-byte identifier called the FC/FCIP identifier. The FC/FCIP identifier uses the Name_Identifier format.

Initialization at the FC-BB-6 protocol interface occurs between VE_Ports in a manner identical to standard E_Ports and is described in 5.3.4.3.

5.3.4.2.3 FCIP Entity

The FCIP_LEP is a component of the FCIP Entity that formats, encapsulates, and forwards encapsulated FC frames. Encapsulated FC frames are sent as TCP segments over the IP network.

The FCIP_LEP receives byte-encoded SOF/EOF delimited FC frames and a timestamp (see 5.3.4.5.2.2) from its VE_Port. The FCIP Data Engine (FCIP_DE) is the data forwarding component of the FCIP_LEP. The FCIP_DE handles all encapsulation and decapsulation, and transmission and reception of the encapsulated FC frames on the FCIP Link. The FCIP_LEP contains one or more FCIP_DEs, each corresponding to a TCP connection.

The FCIP_DE has four interface points (see RFC 3821):

- a) **FC Receiver Portal:** the access point through which a byte-encoded SOF/EOF delimited FC frame and timestamp enters an FCIP_DE from the VE_Port;
- b) **FC Transmitter Portal:** the access point through which a reconstituted byte-encoded SOF/EOF delimited FC frame and timestamp leaves an FCIP_DE to the VE_Port;
- c) **Encapsulated Frame Receiver Portal:** the TCP access point through which an encapsulated FC frame is received from the IP network by the FCIP_DE; and
- d) **Encapsulated Frame Transmitter Portal:** the TCP access point through which an encapsulated FC frame is transmitted to the IP network by the FCIP_DE.

5.3.4.2.4 VE_Port Virtual ISL and FCIP Link

The FC/FCIP Entity pair provides a data forwarding path between itself and a remote FC/FCIP Entity pair via virtual constructs. Two types of virtual constructs are defined:

- a) a VE_Port Virtual ISL is a logical construct that is created between two FC Entity VE_Ports for the explicit purpose of sending and receiving byte-encoded SOF/EOF delimited FC frames via the FCIP Entity. Conceptually, communication between two VE_Ports is similar to communication between E_Ports; and
- b) an FCIP Link is a logical construct that is created between two FCIP Entity LEPs for the explicit purpose of sending and receiving encapsulated FC frames and encapsulated FCIP control information. Conceptually, communication between two LEPs is similar to the communication between two instances of a TCP application.

There is a one-to-one mapping between a VE_Port Virtual ISL and an FCIP Link. Each FCIP Link consists of one or more TCP connections, all between the same two FC-BB_IP devices. Although more than one FCIP Link may be formed between a pair of FC-BB_IP devices, a typical configuration may only consist of a single FCIP Link. See Figure 20 for some examples of allowed network topologies.

The FCIP_LEP that originates an FCIP Link is defined as the FCIP Link Originator. The corresponding FCIP_LEP that accepts this link is defined as the FCIP Link Acceptor. An FCIP Link is fully characterized by its FCIP Link Originator and FCIP Link Acceptor identities. An FCIP Link Originator or FCIP Link Acceptor is fully identified by all of the following:

- a) an 8-byte Switch_Name;
- b) an 8-byte E_Port_Name; and
- c) an 8-byte FC/FCIP Entity identifier.

To uniquely identify an FCIP Link, all of the following are required:

- a) the 8-byte Switch_Name of the FCIP Link Originator;
- b) the 8-byte E_Port_Name of the FCIP Link Originator;
- c) the 8-byte FC/FCIP Entity identifier of the FCIP Link Originator; and
- d) the 8-byte Switch_Name of the FCIP Link Acceptor.

The FCIP Link Acceptor's 8-byte FC/FCIP Entity identifier and its E_Port_Name provide additional information about an FCIP Link but are not required to uniquely identify it.

5.3.4.3 VE_Port Virtual ISL exchanges

5.3.4.3.1 SW_ILS exchanges

VE_Ports exchange SW_ILSs on the VE_Port Virtual ISL. The SW_ILSs that occur on the VE_Port Virtual ISL are the standard E_Port SW_ILSs (e.g., ELP, ESC, EFP, etc.), and in addition the LKA ELS (see FC-LS-3). Figure 15 shows the scope of the VE_Port Virtual ISLs.

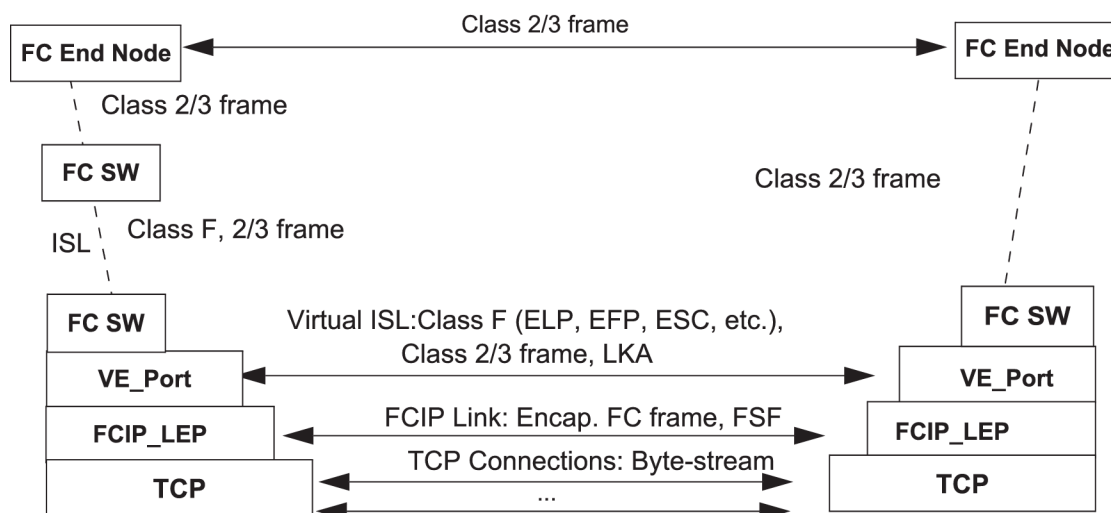


Figure 15 – Scope of VE_Port Virtual ISL

5.3.4.4 Control and Service Module (CSM)

The CSM is a control component of the FC-BB_IP interface that mainly deals with connection management. The CSM creates the FC/FCIP Entity pair during the Virtual ISL/FCIP Link setup. The CSM processes all requests for a link setup via the FCIP-registered TCP Port 3225 or optionally another TCP Port. The CSM processes requests to add additional TCP connections over the same FCIP Link. The CSM is also responsible for tearing down existing FCIP Links and TCP connections and deleting the FC/FCIP Entity pair.

NOTE 4 – Some aspects of the CSM functions are discussed only in RFC 3821.

5.3.4.5 Platform Management Module (PMM)

5.3.4.5.1 Function

The PMM is a management component of the FC-BB_IP interface that handles time synchronization, discovery, and security. The PMM is also the intended component for any miscellaneous housekeeping functions such as maintenance of event logs (see 5.8.3.5).

5.3.4.5.2 Time synchronization

5.3.4.5.2.1 FCIP Transit Time (FTT)

FCIP Transit Time (FTT) is defined as the total transit time of an encapsulated Fibre Channel frame in the IP network. The FCIP Transit Time is calculated by subtracting the timestamp value in the arriving encapsulated FC frame from the synchronized time in the FCIP Entity.

5.3.4.5.2.2 Building outgoing FC frame encapsulation headers

The FC Entity shall establish and maintain a synchronized time value in Simple Network Time Protocol (SNTP) Version 4 format (see RFC 2030) for use in computing the IP network transit times. The FC Entity shall use suitable internal clocks and one of the following mechanisms to establish and maintain the synchronized time value:

- a) Fibre Channel time services; or
- b) IP network SNTP server(s).

Each byte-encoded SOF/EOF delimited FC frame that the FC Entity delivers to the FCIP_DE through the FC receiver portal shall be accompanied by a timestamp value obtained from the synchronized time service. The FCIP_DE places the timestamp in the encapsulation header part of the encapsulated FC frame that carries the FC frame (see RFC 3643). If no synchronized timestamp value is available to accompany an entering Class 2 or Class 3 FC frame, then the frame should not be delivered to the FCIP_DE. However, FC-BB_IP shall allow any class F encapsulated FC frames to be transmitted with a zero timestamp value.

5.3.4.5.2.3 Checking IP network transit times in incoming FC frame encapsulation headers

Each byte-encoded SOF/EOF delimited FC frame delivered to the FC Entity through the FCIP_DE FC transmitter portal is to be accompanied by the timestamp value taken from the encapsulation header of the encapsulated FC frame. As noted in 5.3.4.5.2.2, the timestamp may be zero indicating that no valid timestamp was supplied by the sending FC Entity. Any frame other than a Class F frame whose timestamp is zero shall be discarded. A Class F frame whose timestamp is zero shall be processed as if it met all Fibre Channel timeout requirements.

If the timestamp is non-zero, then the FTT of the arriving encapsulated Fibre Channel frame shall be compared to $1/2 E_D_TOV$. If the FTT exceeds $1/2 E_D_TOV$, then the frame shall be discarded. Otherwise the frame shall be processed normally. Fibre Channel timeout values shall be administratively set to accommodate the FTT.

5.3.4.5.3 Discovery

Discovery of FC-BB_IP devices is handled in accordance with the procedures outlined in 5.7.2.2 and in RFC 3821 and RFC 3822.

5.3.4.5.4 Security

Security in FC-BB_IP is defined at two levels, FC and FCIP. The FC level is secured through FC-SP-2 mechanisms that are extended by FC-BB_IP. The FCIP level is secured through IPSec mechanisms (see RFC 3821). Figure 16 illustrates the scope of the two security mechanisms.

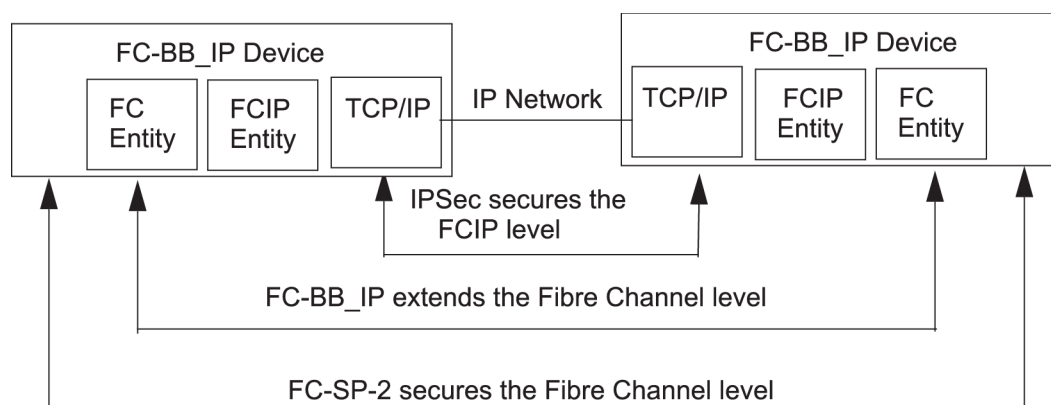


Figure 16 – Security layers

In most cases, the security requirements of an FC/FCIP Entity pair are satisfied outside the scope of this standard as follows:

- a) security for the FC Fabric is provided by the FC-SP-2 capabilities (e.g., switch-to-switch authentication, frame authentication and confidentiality); and
- b) security for the TCP connections used to transit the IP network is provided by the security features described in FCIP (e.g., IPSec packet authentication and confidentiality).

Depending on the security requirements of a given configuration, any or all of the security capabilities described in other standards may be enabled or disabled. However, it is important to note that the public IP network is subject to a large variety of security attacks, meaning that serious consideration should be given to enabling the full suite of security features described in RFC 3821 whenever the public IP network is to be used to transmit FCIP frames.

An FC/FCIP entity pair has a potential security vulnerability where interactions may not be fully secured by either the FC-SP-2 or FCIP security features. This vulnerability occurs if two or more TCP connections are aggregated in a single FCIP Link. The first TCP connection in an FCIP Link and its associated Virtual ISL may be authenticated using the FC-SP-2 mechanisms. However, no such authentication is defined for subsequent TCP connections, since to FC they all appear to be part of an already authenticated Virtual ISL.

To prevent attacking entities in the IP network from forging additional invalid TCP connections, the FC-BB_IP mechanism described in 5.7.2.3 extends the protection of FC-SP-2 authentication to subsequently-added TCP connections. The extension to FC-SP-2 authentication described in 5.7.2.3.2 is based on the exchange of Class F requests and responses between FC Entities. This mechanism works in concert with the FC-SP-2 Virtual ISL authentication mechanism, handling the Class F requests and responses over a previously authenticated TCP connection. In some configurations, this overhead may be unnecessary. However, in cases where Fabric entities are capable of being authenticated without having their behavior fully trusted, the extension to FC-SP-2 authentication should be used in combination with other FC-SP-2 and FCIP security mechanisms to assure trustworthy formation of FCIP Links and Virtual ISLs.

5.3.5 IP network interface

The FC-BB_IP VE_Port reference model supports one logical IP interface and allows sharing a 4-byte IPv4 or 16-byte IPv6 address in the following ways:

- a) a single IP address per FC-BB_IP device (i.e., a single IP address shared by all FC/FCIP Entity pairs);
- b) multiple IP addresses per FC-BB_IP device (i.e., a single IP address per FC/FCIP Entity pair);
- c) multiple IP addresses per FC/FCIP Entity pair (i.e., single IP address per VE_Port/FCIP_LEP pair); and
- d) multiple IP Addresses per FCIP Link (i.e., a single IP address per TCP Port).

Use of different IP address schemes at the two ends of an FCIP Link is not expected to cause inter-operability problems.

As shown in Figure 14, the IP network interface consists of the TCP and IP layers. The encapsulated FC frame emerging from the FCIP_DE interfaces with the TCP layer. The IP layer interfaces with the TCP layer above it and the IP network below it. The TCP layer supports multiple TCP connections, each corresponding to an FCIP_DE. Each TCP connection within an FCIP Link is assigned a unique local TCP Port Number. Either the FCIP well-known TCP Port 3225 or optionally another TCP Port is used for accepting connection requests. These ports interface with the CSM through a vendor-specific mechanism.

IP routing occurs inside the IP network. Within the IP network, the route taken by an encapsulated FC frame is determined by the normal routing procedures of the IP network.

5.4 B_Access functional model

5.4.1 FC-BB_IP interface protocol layers

Figure 17 shows the functional model of an FC-BB_IP device that consists of the B_Port FC interface, the FC-BB_IP protocol interface, and the IP network interface. Figure 14 shows the details of the protocol layers across these interfaces.

NOTE 5 – Because of the similarity between the E_Port and B_Port functional models this subclause only describes any unique definitions for the B_Access. Other definitions and descriptions from 5.3 apply equally well and remain unchanged.

5.4.2 B_Port FC interface

The FC-BB_IP FC network interface supports one or more B_Ports thus requiring the support of the FC-0, FC-1, and FC-2 levels. B_Ports in general connect to different external FC switches, but connectivity to the same FC switch is allowed.

B_Ports are uniquely identified by an 8-byte B_Port_Name.

5.4.3 FC-BB_IP protocol interface

5.4.3.1 Major components

The B_Port FC-BB_IP interface consists of all the components of the VE_Port functional model (see 5.3.4.1) except the FC Switching Element with FC routing.

5.4.3.2 FC and FCIP Entities

5.4.3.2.1 Function

The primary function of the FC Entity is to support one or more B_Access portals and to communicate with the FCIP Entity.

The function of the FCIP Entity is identical to its function in the VE_Port functional model described in 5.3.4.2.3.

The FC/FCIP Entity pair interfaces with the CSM and the PMM through a vendor-specific mechanism.

5.4.3.2.2 FC Entity

The FC-BB_IP interface may support multiple instances of the FC/FCIP Entity pairs. Each instance of the FC/FCIP Entity pair consists of one or more B_Access/FCIP_LEP pairs. A B_Access portal is a component of the FC Entity that interfaces with the FCIP_LEP component of the FCIP Entity. The B_Access portal receives FC frames from the B_Port and sends them to the FCIP_LEP for encapsulation and transmission on the IP network. The B_Access portal may also exchange Class F control frames with the remote B_Access portal via the LEPs. There is a one-to-one relationship between a B_Access portal and an FCIP_LEP. B_Access portals communicate via B_Access Virtual ISLs (see 5.4.3.2.4).

There is no switching and routing required in the case of the B_Port functional model. However, the forwarding of FC frames across the B_Access/FCIP_LEP pair is still required. If multiple DEs within an FCIP_LEP are in use, then the selection of which FCIP_DE to use is described in 5.7.3.5.

Initialization at the FC-BB-6 protocol interface occurs with EBP SW_ILS exchanges between B_Access portals in a manner identical to standard E_Ports and is described in 5.4.3.2.4. The B_Access initialization state machine is described in 5.4.3.3.1.1.

5.4.3.2.3 FCIP Entity

The FCIP_LEP receives byte-encoded SOF/EOF delimited FC frames and a timestamp from its B_Access portals. All other functions are identical to the functions of the FCIP Entity in the VE_Port functional model (see 5.3.4.2.3).

5.4.3.2.4 B_Access Virtual ISL and FCIP Links

A B_Access Virtual ISL is a logical construct that is created between two FC Entity B_Access portals for the explicit purpose of sending and receiving byte-encoded SOF/EOF delimited FC frames via the FCIP Entity. Conceptually, communication between two B_Access portals is similar to communication between two VE_Ports.

There is a one-to-one mapping between a B_Access Virtual ISL and an FCIP Link.

An FCIP Link Originator or FCIP Link Acceptor is fully identified by all of the following:

- a) an 8-byte Fabric_Name;
- b) an 8-byte B_Access_Name; and
- c) an 8-byte FC/FCIP Entity identifier.

To uniquely identify an FCIP Link, the following items are required:

- a) the 8-byte Fabric_Name of the FCIP Link Originator;
- b) the 8-byte B_Access_Name of the FCIP Link Originator;
- c) the 8-byte FC/FCIP Entity identifier of the FCIP Link Originator; and
- d) the 8-byte Fabric_Name of the FCIP Link Acceptor.

The FCIP Link Acceptor's 8-byte FC/FCIP Entity identifier and its B_Access_Name provide additional information about an FCIP Link but are not required to uniquely identify it.

The FC-BB_IP B_Access functional model is shown in Figure 17.