

INTERNATIONAL
STANDARD

ISO/IEC
14165-246

First edition
2019-12

Corrected version
2020-01

Information technology — Fibre channel —

Part 246: Backbone — 6 (FC-BB-6)



Reference number
ISO/IEC 14165-246:2019(E)

AVA Documents
Document Sharing Hub
© ISO/IEC 2019



COPYRIGHT PROTECTED DOCUMENT

© ISO/IEC 2019

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Foreword

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

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of document should be noted (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents) or the IEC list of patent declarations received (see <http://patents.iec.ch>).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by INCITS (as INCITS 509-2014) and drafted in accordance with its editorial rules. It was assigned to Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 25, *Interconnection of information technology equipment*, and adopted under the “fast-track procedure”.

This corrected version of ISO/IEC 14165-246:2019 incorporates the following corrections: throughout the document, formatting errors affecting the links have been corrected. This has also resulted in a different pagination of the document.

A list of all parts in the ISO/IEC 14165 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Contents	Page
Foreword	xiv
Introduction	xviii
1 Scope	1
2 Normative References	5
2.1 Overview	5
2.2 Approved references	5
2.3 References under development	6
2.4 ITU-T references	6
2.5 IETF references	6
2.6 IEEE references	7
3 Definitions and conventions	8
3.1 Common definitions	8
3.2 FC-BB_IP definitions	10
3.3 FC-BB_GFPT definitions	12
3.4 FC-BB_PW definitions	13
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	18
3.7.3 FC-BB_GFPT	18
3.7.4 FC-BB_PW	18
3.7.5 FC-BB_E	18
3.8 Symbols	19
3.9 Keywords	19
4 FC-BB-6 Structure and Concepts	20
4.1 FC-BB-6 backbone mappings	20
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	23
4.2.4 FC-BB_PW reference model	24
4.2.5 FC-BB_E reference models	25
4.2.5.1 FC-BB_E VN_Port to VF_Port reference model	25
4.2.5.2 FC-BB_E VE_Port to VE_Port reference model	25
4.2.5.3 FC-BB_E VN_Port to VN_Port reference model	26
4.2.5.4 FC-BB_E VA_Port to VA_Port reference model	27
4.3 FC-BB-6 models overview	27
4.3.1 FC-BB_IP	27
4.3.2 FC-BB_GFPT	28
4.3.3 FC-BB_PW	28
4.3.4 FC-BB_E	29
4.4 FC-BB-6 requirements	29
4.4.1 Fibre Channel Class support	29
4.4.2 Payload transparency	29
4.4.2.1 FC-BB_IP	29
4.4.2.2 Transparent FC-BB (FC-BB_GFPT and FC-BB_PW)	30

4.4.2.3 FC-BB_E	30
4.4.3 Latency delay and timeout value	30
4.4.4 QoS and bandwidth	31
4.4.5 In-order delivery	31
4.4.6 Flow control	31
4.5 FC-BB-6 SW_ILS codes	32
5 FC-BB_IP Structure and Concepts	33
5.1 Applicability	33
5.2 FC-BB_IP overview	33
5.3 VE_Port functional model	34
5.3.1 FC-BB_IP interface protocol layers	34
5.3.2 E_Port/F_Port FC interface	36
5.3.3 FC Switching Element (SE) with FC routing	36
5.3.4 FC-BB_IP protocol interface	36
5.3.4.1 Major components	36
5.3.4.2 FC and FCIP Entities	36
5.3.4.3 VE_Port Virtual ISL exchanges	39
5.3.4.4 Control and Service Module (CSM)	39
5.3.4.5 Platform Management Module (PMM)	39
5.3.5 IP network interface	42
5.4 B_Access functional model	42
5.4.1 FC-BB_IP interface protocol layers	42
5.4.2 B_Port FC interface	42
5.4.3 FC-BB_IP protocol interface	42
5.4.3.1 Major components	42
5.4.3.2 FC and FCIP Entities	43
5.4.3.3 B_Access Virtual ISL exchanges	45
5.4.3.4 B_Port Control and Service Module (CSM)	49
5.4.3.5 B_Port Platform Management Module (PMM)	49
5.4.4 IP Network Interface	49
5.5 FC-BB_IP network topologies	49
5.6 Mapping and message encapsulation using TCP/IP	51
5.6.1 Encapsulated frame structures	51
5.6.1.1 FC frame encapsulation structure	51
5.6.1.2 Encapsulated FCIP Special Frame (FSF) structure	52
5.6.2 TCP/IP encapsulation	53
5.7 FC-BB_IP protocol procedures	54
5.7.1 Overview	54
5.7.2 Procedures for platform management	54
5.7.2.1 Function	54
5.7.2.2 Procedures for discovery	54
5.7.2.3 Procedures for extending FC-SP-2 security	54
5.7.3 Procedures for connection management	56
5.7.3.1 Function	56
5.7.3.2 Procedures for link setup	57
5.7.3.3 Procedures for data transfer	57
5.7.3.4 Procedures for FCIP Link disconnection	58
5.7.3.5 Procedures for multiple connection management	58
5.7.4 Procedures for error detection recovery	58
5.7.4.1 Procedures for handling invalid FC frames	58
5.7.4.2 Procedures for error recovery	59
5.7.5 FC-BB_IP system parameters	59
5.7.5.1 FC timers	59

5.7.5.2	TCP timers	59
5.7.5.3	Maximum number of attempts to complete an encapsulated FC frame transmission	59
5.7.5.4	Maximum number of outstanding encapsulated FC frames	60
5.8	FC-BB_IP service considerations	60
5.8.1	Latency delay	60
5.8.2	Throughput	60
5.8.2.1	How timeouts affect throughput	60
5.8.2.2	How loss affects throughput	60
5.8.2.3	Other factors that affect throughput	60
5.8.3	Reliability	61
5.8.3.1	Loss of connectivity	61
5.8.3.2	Loss of synchronization	61
5.8.3.3	Loss or corruption of TCP segments	61
5.8.3.4	Loss or corruption of FC frames	61
5.8.3.5	FCIP error reporting	61
5.8.4	Quality of Service (QoS)	62
5.8.5	Delivery order	62
5.8.6	IP multicast and broadcast	62
5.8.7	Security and authentication	62
6	Transparent FC-BB (FC-BB_GFPT and FC-BB_PW) Structure and Concepts	64
6.1	Applicability	64
6.2	FC-BB_GFPT overview	64
6.3	FC-BB_PW overview	65
6.4	Transparent FC-BB functional model	66
6.4.1	Transparent FC-BB initialization	66
6.4.2	Transparent FC-BB initialization state machine	66
6.4.2.1	Initialization state machine keywords	66
6.4.2.2	Initialization state machine	66
6.4.3	Login Exchange Monitors	71
6.4.4	Port initialization parameter observation and modification	75
6.4.5	Handling of BB_SCs, BB_SCr, and R_RDY Primitive Signals and BB_Credit initialization	76
6.4.6	Transparent FC-BB Primitive Signals	77
6.4.7	Transparent FC-BB flow control	78
6.4.7.1	Overview	78
6.4.7.2	FC-BB_GFPT Alternate Simple Flow Control (ASFC)	78
6.4.7.3	FC-BB_PW Alternate Simple Flow Control (ASFC)	78
6.4.7.4	PING and PING_ACK signals	79
6.4.8	Adaptation of FC information for Transparent FC-BB	81
6.4.8.1	Adaptation of FC information for GFPT transport in FC-BB_GFPT	81
6.4.8.2	Adaptation of FC information for PW transport in FC-BB_PW	83
6.4.9	WAN Holdoff Timeout Value (WAN_HOLDOFF_TOV)	85
6.4.10	Transparent FC-BB frame compression encoding	85
6.4.10.1	FC-BB_GFPT FC frame compression	85
6.4.10.2	FC-BB_PW FC frame compression	86
6.4.10.3	LZS compression algorithm	86
7	FC-BB_E Structure and Concepts	87
7.1	Applicability	87
7.2	FC-BB_E overview	87
7.3	ENode functional model	93
7.4	VN2VN ENode functional model	94

7.5	FCF functional model	96
7.6	Controlling FCF functional model	99
7.7	FDF functional model	101
7.8	FCoE Virtual Links	103
7.9	VN_Port MAC addresses	108
7.10	FCoE frame format	108
7.11	FC-BB_E device initialization	109
7.11.1	FCoE Initialization Protocol (FIP) overview	109
7.11.2	FIP VLAN discovery protocol	110
7.11.2.1	Overview	110
7.11.2.2	ENode/FCF VLAN discovery	110
7.11.2.3	FCF/FCF VLAN discovery	112
7.11.2.4	VN2VN ENode VLAN discovery	112
7.11.2.5	ENode/FDF VLAN discovery	115
7.11.2.6	FDF/Controlling FCF VLAN discovery	115
7.11.3	FIP discovery protocol	115
7.11.3.1	Overview	115
7.11.3.2	ENode/FCF discovery	115
7.11.3.3	FCF/FCF discovery	118
7.11.3.4	FDF/Controlling FCF discovery	120
7.11.4	FCoE Virtual Link instantiation protocol	121
7.11.4.1	VN_Port to VF_Port Virtual Links	121
7.11.4.2	VE_Port to VE_Port Virtual Links	121
7.11.4.3	VN_Port to VN_Port Virtual Links	122
7.11.4.4	VA_Port to VA_Port Virtual Links	122
7.11.5	FCoE Virtual Link maintenance protocol	123
7.11.5.1	Virtual Link maintenance protocol overview	123
7.11.5.2	VN_Port to VF_Port Virtual Link maintenance protocol	123
7.11.5.3	VE_Port to VE_Port Virtual Link maintenance protocol	126
7.11.5.4	VN_Port to VN_Port Virtual Link and VN2VN Neighbor Set maintenance protocol	126
7.11.5.5	VA_Port to VA_Port Virtual Link maintenance protocol	127
7.11.6	Locally Unique N_Port_IDs	127
7.11.6.1	Overview	127
7.11.6.2	Multi-node operation	128
7.11.6.3	Point-to-point operation	130
7.11.6.4	Persistence of Locally Unique N_Port_IDs	131
7.11.7	FIP frames	132
7.11.7.1	FIP frame format	132
7.11.7.2	Encapsulated FIP operation	132
7.11.7.3	FIP descriptors	136
7.11.8	FIP operations	146
7.11.8.1	FIP operations overview	146
7.11.8.2	FIP Discovery Solicitation	150
7.11.8.3	FIP Discovery Advertisements	152
7.11.8.4	FIP Virtual Link Instantiation requests and replies	152
7.11.8.5	FIP Keep Alive	156
7.11.8.6	FIP Clear Virtual Links	156
7.11.8.7	FIP VLAN Request	157
7.11.8.8	FIP VLAN Notification	158
7.11.8.9	FIP VN2VN VLAN Notification	158
7.11.8.10	FIP Vendor Specific frames	158
7.11.8.11	N_Port_ID Probe Request	158
7.11.8.12	N_Port_ID Probe Reply	159

7.11.8.13 N_Port_ID Claim Notification	159
7.11.8.14 N_Port_ID Claim Response	159
7.11.8.15 N_Port_ID Beacon	160
7.12 Timers and constants	160
7.13 FC-BB_E Link Error Status Block (LESB) definition	162
7.14 Link incidents definition	163
7.15 Distributed FCF operations	164
Annex A: FC-BB_GFPT Interoperability Guidelines (Informative)	165
A.1 GFPT-specific interoperability guidelines	165
Annex B: FCoE and FIP Frame Examples (Informative)	166
B.1 Overview	166
Annex C: Increasing FC-BB_E Robustness Using Access Control Lists (Informative)	167
C.1 Overview	167
C.2 Access Control Lists	168
C.2.1 ACL overview	168
C.2.2 ACL nomenclature	169
C.3 Perimeter ACL construction	169
C.3.1 Perimeter ACL construction overview	169
C.3.2 FIP frame transmission	170
C.3.3 Prevention of the transmission of frames using an FCF-MAC address for the source address	170
C.3.4 Prevention of frames using FCoE Type or FCoE source addresses prior to successful completion of FIP FLOGI	170
C.3.5 Enabling traffic after successful completion of FIP FLOGI or FIP NPIV FDISC	170
C.3.6 Prevention of duplicate VN_Port MAC addresses	170
C.3.7 ACL summary	171
C.4 Security in depth	171
C.4.1 Overview	171
C.4.2 Bridge-to-bridge link receiving ENode frames destined to FCF(s)	172
C.4.3 Bridge-to-bridge link receiving FCF frames destined to ENode(s)	172
C.4.4 Bridge-to-bridge link receiving both FCF and ENode frames	173
C.4.5 Additional FCF protection	173
C.5 Prevention of FCoE related traffic	173
C.6 Automatic configuration of ACLs	174
C.7 Ethernet bridge learning considerations	174
C.8 VLAN considerations	175
C.9 Access Control Lists in a Locally Unique N_Port_ID configuration	175
C.9.1 Overview	175
C.9.2 Prevention of FCoE traffic	175
C.9.3 FCoE perimeter ACL	175
C.9.4 Graceful handling of network joins	176
Annex D: FCoE Security Recommendations (Informative)	178
D.1 Overview	178
D.2 Considerations	178
D.3 General deployment recommendations	178
D.4 Bridge recommendations	178
D.5 ENode and FCF recommendations	180
D.6 Additional threat isolation using FPMAs	182
Annex E: FCoE MIB Definition (Normative)	184
E.1 FCoE MIB definition	184

Annex F: Locally Unique N_Port_ID (Informative) 205

Annex G: Options for Handling FCoE and FIP Traffic (Informative) 211

Tables	Page
Table 1 – FC-BB-6 organization	1
Table 2 – Reference models and resident FC_Port types	21
Table 3 – FC-BB-6 SW_ILS codes	32
Table 4 – FC-BB-6 ELS codes	32
Table 5 – EBP request payload	46
Table 6 – EBP accept payload	46
Table 7 – EBP reject reason code explanation	47
Table 8 – TCP/IP Segment structure carrying encapsulated FC frame	51
Table 9 – Encapsulated FC frame structure	51
Table 10 – TCP/IP Segment structure carrying encapsulated FSF	52
Table 11 – Encapsulated FSF structure	52
Table 12 – ASF request payload	56
Table 13 – ASF accept response payload	56
Table 14 – Transparent FC-BB initialization state machine keywords	66
Table 15 – Login Exchange Monitor (LEM) state machine	74
Table 16 – Values of FC-BB_GFPT ASFC_PAUSE and ASFC_RESUME Primitive Signals.	78
Table 17 – FC-BB_PW ASFC_PAUSE and ASFC_RESUME control frame payload values.	79
Table 18 – FC-BB_GFPT PING and PING_ACK Primitive Signal values.	80
Table 19 – FC-BB_GFPT PING and PING_ACK CCC bit field values	80
Table 20 – FC-BB_PW PING and PING_ACK control frame payload values.	81
Table 21 – FC-BB_PW error indication control frame payload values	85
Table 22 – FCoE PDU format	108
Table 23 – FCoE SOF field	109
Table 24 – FCoE EOF field	109
Table 25 – FIP PDU format.	132
Table 26 – Encapsulated FIP operation format.	132
Table 27 – FIP Protocol Code and FIP Subcode field values	133
Table 28 – Fabric Provided bit and Server Provided bit setting	134
Table 29 – FIP descriptor type value ranges.	136
Table 30 – FIP descriptor types	137
Table 31 – FIP Priority descriptor format.	138
Table 32 – FIP MAC address descriptor format	138
Table 33 – FIP FC-MAP descriptor format	138
Table 34 – FIP Name_Identifier descriptor format	139
Table 35 – FIP Fabric descriptor format	139
Table 36 – FIP Max FCoE Size descriptor format.	139
Table 37 – FIP FLOGI descriptor format.	140
Table 38 – FIP NPIV FDISC descriptor format	140
Table 39 – FIP LOGO descriptor format	141
Table 40 – FIP ELP descriptor format.	141
Table 41 – FIP Vx_Port Identification descriptor format	141
Table 42 – FIP FKA_ADV_Period descriptor format.	142
Table 43 – FIP Vendor_ID descriptor format.	143
Table 44 – FIP VLAN descriptor format	143
Table 45 – FIP Vendor Specific descriptor format.	143
Table 46 – FIP VN2VN Attributes descriptor format	144
Table 47 – FIP Clear Virtual Links Reason Code descriptor format	144
Table 48 – FIP Clear Virtual Links Reason Codes	145
Table 49 – FIP Clear Virtual Links Reason Code Explanations	145
Table 50 – FIP Clear Virtual Links Reason Code descriptor examples	146
Table 51 – FIP operation descriptors and order	147
Table 52 – FIP Fabric login rejections.	154

Table 53 – FC-BB_E timers and constants 160

Table 54 – FC-BB_E Link Error Status Block format 162

Table 55 – FC-BB_E Link Incidents 164

Table B.1 – FCoE frame format example 166

Table B.2 – FIP frame format example 166

Table F.1 – FNV-1a Parameters 208

Table G.1 – Options for handling FCoE and FIP traffic 211

Figures	Page
Figure 1 – Scope and components of FC-BB_IP model	2
Figure 2 – Scope and components of FC-BB_GFPT model	3
Figure 3 – Scope and components of FC-BB_PW model	4
Figure 4 – Scope and components of FC-BB_E model	4
Figure 5 – FC-BB_IP reference model	22
Figure 6 – FC-BB_GFPT reference model	23
Figure 7 – FC-BB_PW reference model	24
Figure 8 – FC-BB_E VN_Port to VF_Port reference model	25
Figure 9 – FC-BB_E VE_Port to VE_Port reference model	25
Figure 10 – FC-BB_E VN_Port to VN_Port reference model	26
Figure 11 – FC-BB_E VA_Port to VA_Port reference model	27
Figure 12 – FC-BB_IP network configuration	33
Figure 13 – FC-BB_IP VE_Port functional model	35
Figure 14 – FC-BB_IP Protocol Layers	37
Figure 15 – Scope of VE_Port Virtual ISL	39
Figure 16 – Security layers	41
Figure 17 – FC-BB_IP B_Access functional model	44
Figure 18 – Scope of B_Access Virtual ISL	45
Figure 19 – B_Access initialization state machine	48
Figure 20 – FC-BB_IP network topologies	50
Figure 21 – TCP/IP encapsulation of an encapsulated FC frame	53
Figure 22 – FC-BB_GFPT protocol levels and layers	64
Figure 23 – FC-BB_PW protocol levels and layers	65
Figure 24 – Transparent FC-BB initialization state machine	67
Figure 25 – Example port initialization process	77
Figure 26 – FC-BB_PW error indication control frame format	79
Figure 27 – FC-BB_PW PING and PING_ACK control frame format	81
Figure 28 – FC-BB_PW error indication control frame format	85
Figure 29 – FC-BB_E mapping	87
Figure 30 – FC-BB_E protocol levels and layers	88
Figure 31 – FCoE VN_Port to VF_Port network configuration example	89
Figure 32 – FCoE VE_Port to VE_Port network configuration example	89
Figure 33 – FCoE multi-node VN_Port to VN_Port network configuration example	90
Figure 34 – FCoE mixed network configuration example	91
Figure 35 – FCoE point-to-point VN_Port to VN_Port network configuration example	91
Figure 36 – FCoE VA_Port to VA_Port network configuration example	92
Figure 37 – ENode functional model	93
Figure 38 – VN2VN ENode functional model	95
Figure 39 – FCF functional model	97
Figure 40 – Controlling FCF functional model	100
Figure 41 – FDF functional model	102
Figure 42 – VE_Port to VE_Port Virtual Links example	104
Figure 43 – VN_Port to VF_Port Virtual Links example	104
Figure 44 – VN_Port to VN_Port Virtual Links multi-node example	105
Figure 45 – VN_Port to VN_Port and VN_Port to VF_Port Virtual Links example	106
Figure 46 – VN_Port to VN_Port Virtual Link point-to-point example	107
Figure 47 – VA_Port to VA_Port Virtual Link example	107
Figure 48 – VLAN discovery processing example in an ENode MAC (informative)	111
Figure 49 – VLAN discovery processing in a VN2VN ENode MAC	114
Figure C.1 – Bridge port to ACE cross reference	168

Foreword (This foreword is not part of American National Standard INCITS 509-2014.)

This standard defines the functions and mappings for transporting Fibre Channel over various network technologies.

This standard was developed by Task Group T11.3 of Accredited Standards Organization INCITS during 2009-2013. The standards approval process started in 2012. This document includes annexes that are informative and are not considered part of the standard.

This standard includes seven annexes. Annex E is normative and is considered part of the standard. All of the other annexes are informative and are not considered part of the standard.

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 standard was processed and approved for submittal to ANSI by the International Committee for Information Technology Standards (INCITS). Committee approval of the standard does not necessarily imply that all committee members voted for its approval. At the time it approved this standard, INCITS had the following members:

Philip Wennblom, Chair
Jennifer Garner, Secretary

<i>Organization Represented</i>	<i>Name of Representative</i>
Adobe Systems Inc.	Scott Foshee
	Steve Zilles (Alt.)
AIM Global, Inc.	Steve Halliday
	Chuck Evanhoe (Alt.)
	Dan Kimball (Alt.)
Apple	Helene Workman
	Marc Braner (Alt.)
	David Singer (Alt.)
Distributed Management Task Force	John Crandall
	Jeff Hilland (Alt.)
	Lawrence Lamers (Alt.)
EMC Corporation	Gary Robinson
	Stephen Diamond (Alt.)
Farance, Inc.	Frank Farance
	Timothy Schoechle (Alt.)
Futurewei Technologies, Inc.	Yi Zhao
	Timothy Jeffries (Alt.)
	Wilbert Adams (Alt.)
GS1GO	Frank Sharkey
	Charles Biss (Alt.)
Hewlett-Packard Company	Karen Higginbottom
	Paul Jeran (Alt.)
IBM Corporation	Alexander Tarpinian
	Robert Weir (Alt.)
	Arnaud Le Hors (Alt.)
	Steve Holbrook (Alt.)
	Gerald Lane (Alt.)
IEEE	Jodi Haasz
	Terry deCourcelle (Alt.)
	Bob Labelle (Alt.)
	Tina Alston (Alt.)
Intel	Philip Wennblom
	Stephen Balogh (Alt.)
	Grace Wei (Alt.)
	Steven Balogh (Alt.)

<i>Organization Represented</i>	<i>Name of Representative</i>
Microsoft Corporation	Jim Hughes Dick Brackney (Alt.) John Calhoon (Alt.)
National Institute of Standards & Technology	Michael Hogan Sal Francomacaro (Alt.) Dan Benigni (Alt.) Fernando Podio (Alt.) Teresa Schwartzhoff (Alt.) Wo Chang (Alt.) Elaine Newton (Alt.)
Oracle Corporation	Donald R. Deutsch Jim Melton (Alt.) Michael Kavanaugh (Alt.) Toshihiro Suzuki (Alt.) Jeff Mischkinsky (Alt.) Tony DiCenzo (Alt.) Patrick Curran (Alt.)
Purdue University	Stephen Elliott Kevin O'Connor (Alt.)
Telecommunications Industry Association (TIA)	Herb Congdon, II Cheryl Blum (Alt.) Florence Otieno (Alt.)
US Department of Defense	Jerry Smith Dennis Devera (Alt.) Dave Brown (Alt.) Leonard Levine (Alt.) Matthew Young (Alt.) Thomas D'Agostino (Alt.)
US Department of Homeland Security	Peter Shebell Gregg Piermarini (Alt.) Juan Gonzalez (Alt.)
Technical Committee T11 on Fibre Channel Interfaces, which reviewed this standard, had the following members:	

Steve Wilson, Chair
 Claudio DeSanti, Vice-Chair
 Richard Johnson, Secretary

<i>Organization Represented</i>	<i>Name of Representative</i>
Agilent Technologies	Joachim Vobis Stephen Didde (Alt.) Steve Sekel (Alt.)
Amphenol Interconnect	Gregory McSorley Alex Persaud (Alt.) Michael Wingard (Alt.) Alex Persaud (Alt.)
Avago Technologies	Randy Clark David Cunningham (Alt.) Brian Misek (Alt.)
Broadcom Corporation	Pat Thaler
Brocade	Steven L. Wilson David Peterson (Alt.) Scott Kipp (Alt.) John Crandall (Alt.)
Cisco Systems	Claudio DeSanti Landon Noll (Alt.) Fabio Maino (Alt.) Joe Pelissier (Alt.)
CommScope	G. Mabud Choudhury Richard Case (Alt.) Paul Kolesar (Alt.) Joe Livingston (Alt.) Richard Baca (Alt.) Jack Jewell (Alt.)

<i>Organization Represented</i>	<i>Name of Representative</i>
Corning, Inc.	Doug Coleman Steven E. Swanson (Alt.)
Data Center Systems	Jack Edwards Kevin Ehringer (Alt.)
EMC Corporation.....	Gary S. Robinson David Black (Alt.) Erik Smith (Alt.) Louis Ricci (Alt.)
Emulex.....	Gautam Shiroom Hossein Hashemi (Alt.) David Baldwin (Alt.)
Finisar Corporation	Chris Yien Richard Johnson (Alt.)
Fujitsu America, Inc.	Sandy Wilson Eugene Owens (Alt.) Kun Katsumata (Alt.) Jim DeCaires (Alt.) Osamu Kimura (Alt.) Mark Malcolm (Alt.)
Hewlett Packard	Barry Maskas Krishna Babu Puttagunta (Alt.) Rupin Mohan (Alt.) Nadaraha Navaruparajah (Alt.) Siamack Ayandeh (Alt.)
IBM Corporation	Roger Hathorn Patty Driever (Alt.) Henry May (Alt.)
Intel Corporation	Mark Wunderlich
JDS Uniphase Corporation.....	Dave Lewis Jason Rusch (Alt.) Scott Baxter (Alt.) Paul Gentieu (Alt.)
LSI Corporation	Adam Healey John Lohmeyer (Alt.) Harvey Newman (Alt.)
Luxtera.....	Tom Palkert
Molex, Inc.	Jay Neer Mark Bugg (Alt.)
NetApp.....	Frederick Knight Denise Ridolfo (Alt.) Heather Lanigan (Alt.)
Oracle	Roger Dickerson Matt Gaffney (Alt.) Michael Roy (Alt.)
Panduit Corporation.....	Robert Elliott Jose Castro (Alt.) Steve Skiest (Alt.) Robert Reid (Alt.)
QLogic Corporation	Craig W. Carlson Skip Jones (Alt.) Alan Spalding (Alt.) Dean Wallace (Alt.) Ed McGlaughlin (Alt.)
TE Connectivity	Nathan Tracy Andrew Nowak (Alt.) Melissa Knox (Alt.)

Task Group T11.3 on Interconnection Schemes, which developed and reviewed this standard, has the following members:

Craig W. Carlson, Chair
 Lou Ricci, Vice-Chair
 Landon Curt Noll, Secretary

<i>Organization Represented</i>	<i>Name of Representative</i>
Broadcom.....	Pat Thaler
Brocade.....	David Peterson Steven L. Wilson (Alt.) John Crandall (Alt.)
Cisco Systems	Claudio DeSanti Landon Noll (Alt.) Fabio Maino (Alt.) Joe Pelissier (Alt.)
Dell.....	Joseph White Gaurav Chawla (Alt.) Manish Patil (Alt.) Jeff Young (Alt.)
EMC	Gary S. Robinson David Black (Alt.) Erik Smith (Alt.) Louis Ricci (Alt.)
Emulex	Gautam Shiroor David Baldwin (Alt.) Hossein Hashemi (Alt.)
Fujitsu	Sandy Wilson Eugene Owens (Alt.) Jim DeCaires (Alt.) Mark Malcolm (Alt.) Kun Katsumata (Alt.)
Hewlett Packard	Barry Maskas Krishna Babu Puttagunta (Alt.) Nadaraha Navaruparajah (Alt.) Rupin Mohan (Alt.) Siamack Ayandeh (Alt.)
IBM.....	Roger Hathorn Patty Driever (Alt.) Henry May (Alt.)
Intel	Mark Wunderlich
JDS Uniphase Corporation	Jason Rusch Scott Baxter (Alt.) Paul Gentieu (Alt.) George Bullis (Alt.)
LSI Corporation	John Lohmeyer Adam Healey (Alt.) Harvey Newman (Alt.)
NetApp	Frederick Knight Denise Ridolfo (Alt.)
Oracle	Roger Dickerson Matt Gaffney (Alt.) Ajoy Siddabathuni (Alt.) Hyon Kim (Alt.) Michael Roy (Alt.) Doug Meyers (Alt.)
QLogic.....	Craig W. Carlson Ed McGlaughlin (Alt.)

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).

Fibre Channel — 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 F, Annex G

INCITS 509-2014

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

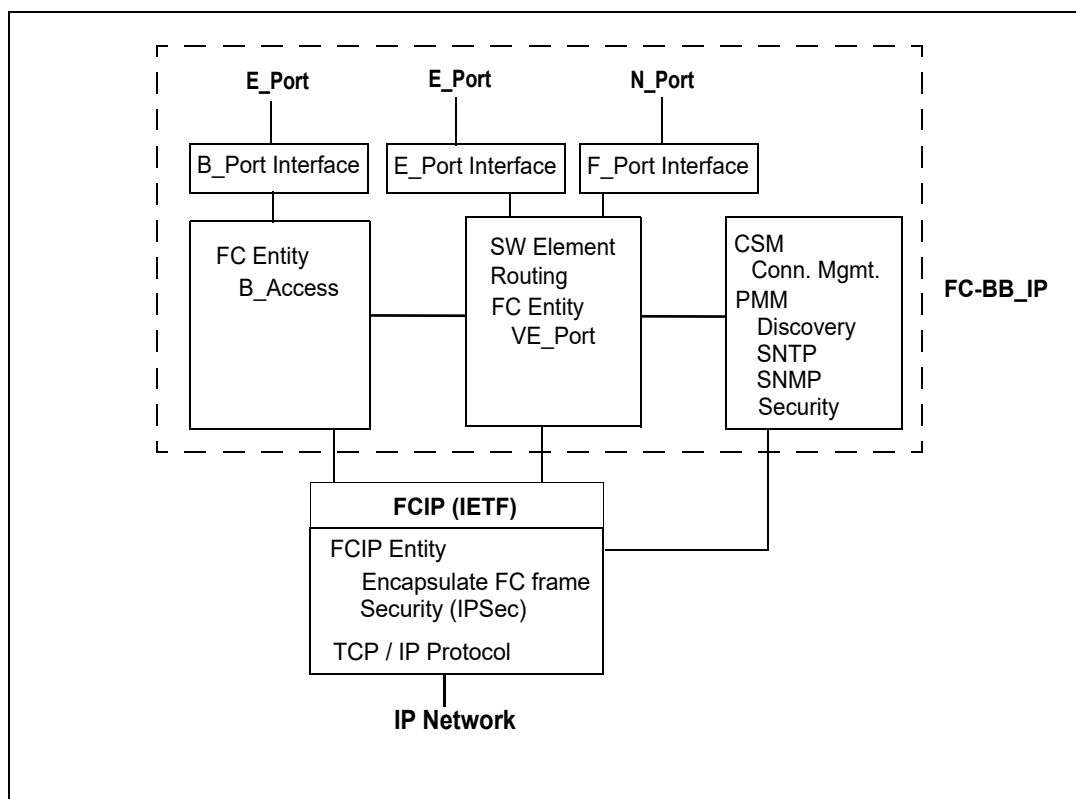


Figure 1 – Scope and components of FC-BB_IP model

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

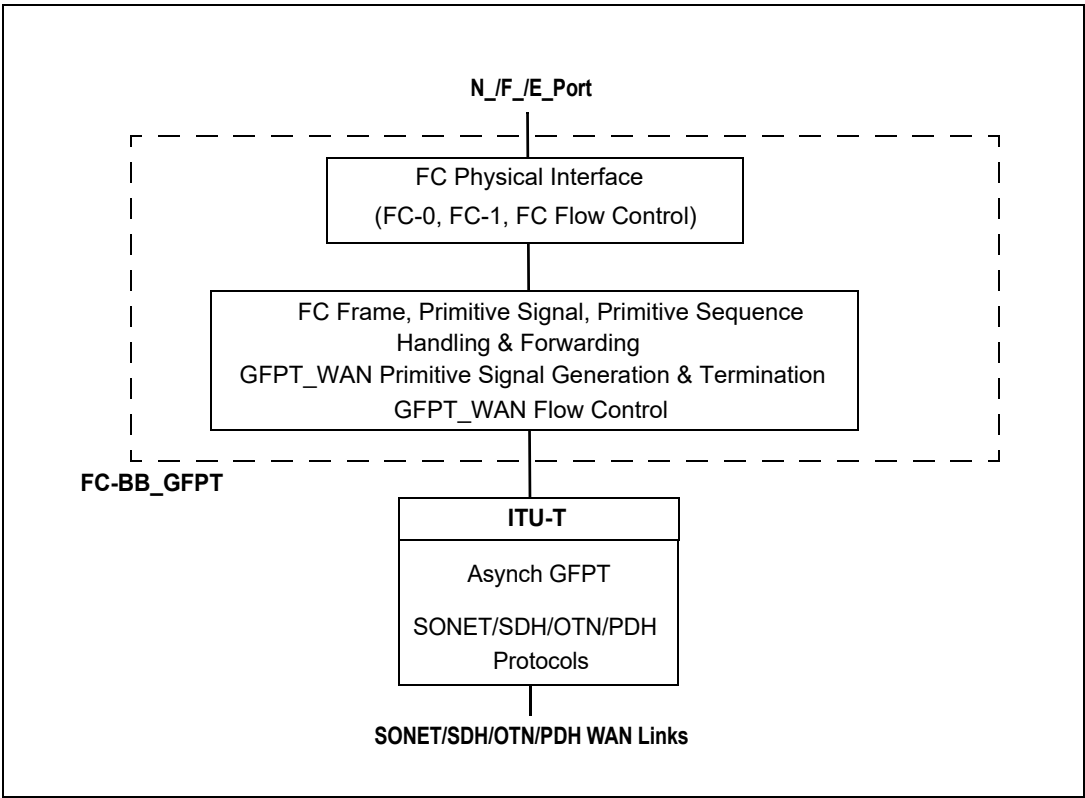


Figure 2 – Scope and components of FC-BB_GFPT model

INCITS 509-2014

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

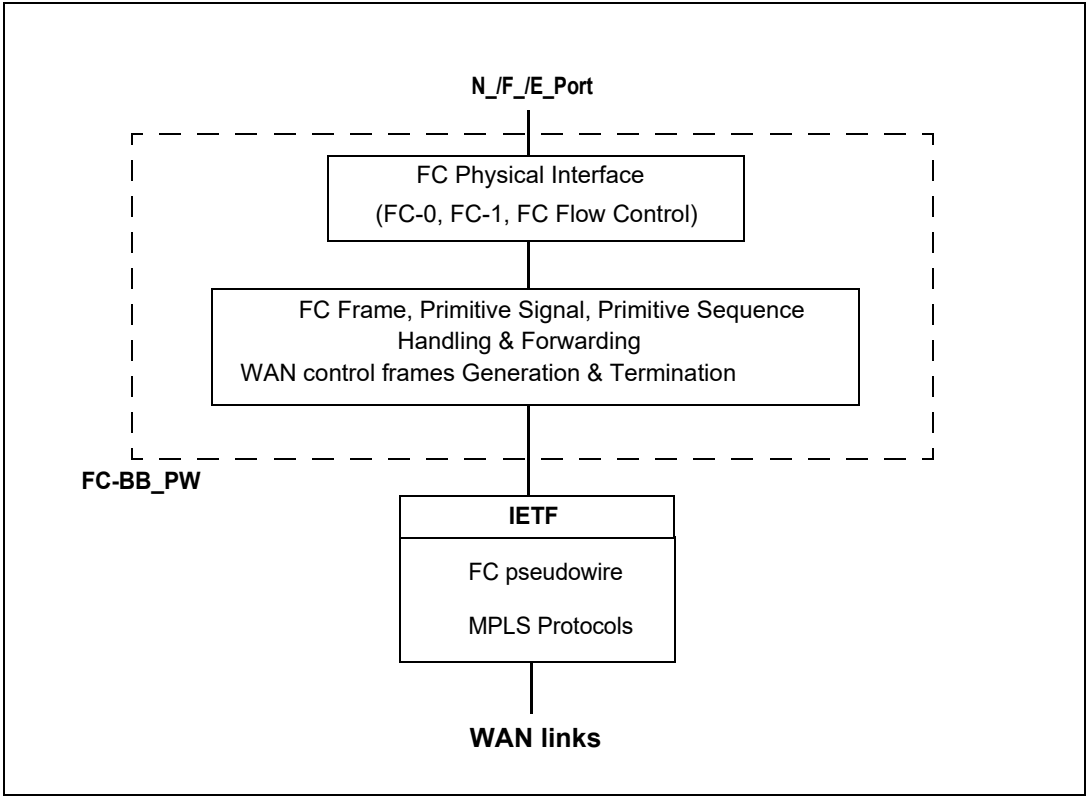


Figure 3 – Scope and components of FC-BB_PW model

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

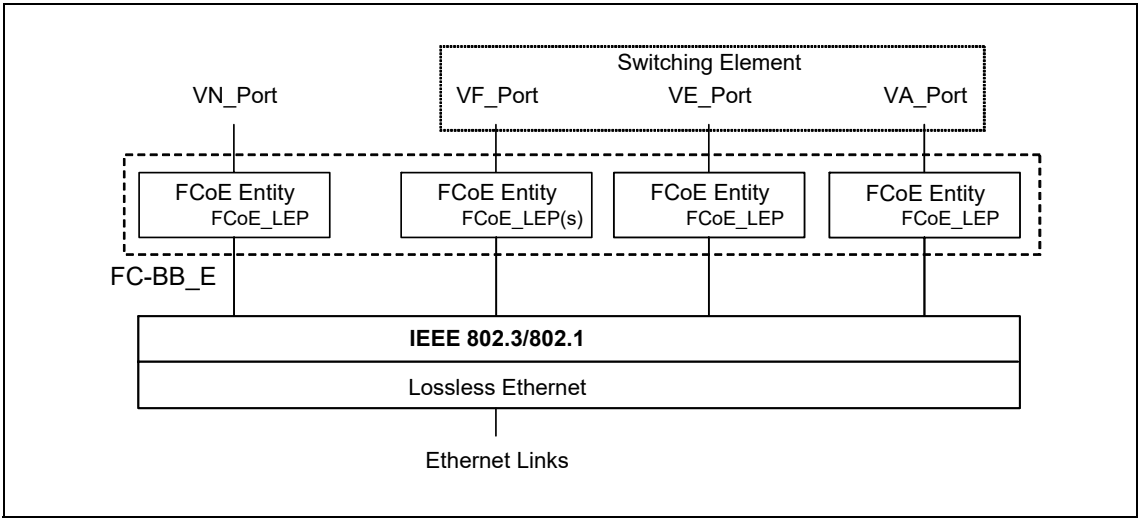


Figure 4 – Scope and components of FC-BB_E model

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.

For electronic copies of ANSI and INCITS standards, visit ANSI's Electronic Standards Store (ESS) at <http://www.ansi.org>. For printed versions of most standards listed here, contact Global Engineering Documents, 15 Inverness Way East, Englewood, CO; 80112-5704, (800) 854-7179.

Orders for ISO Standards and ISO publications should normally be addressed to the ISO member in your country. If that is impractical, ISO Standards and ISO publications may be ordered from ISO Central Secretariat (ISO/CS):

Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
E-mail: customerservice@iso.org
Post: ISO, 8, chemin de Blandonnet,
CP 401 - 1214 Vernier, Geneva - Switzerland

In order to avoid delivery errors, it is important that you accurately quote the standard's reference number given in the ISO catalogue. For standards published in several parts, you should specify the number(s) of the required part(s). If not, all parts of the standard will be provided.

Copies of the following documents may be obtained from ANSI, an ISO member organization:

- a) approved ANSI standards;
- b) approved and draft international and regional standards (ISO and IEC); and
- c) approved foreign standards (JIS and DIN).

For further information, contact the ANSI Customer Service Department:

Phone +1 212-642-4900
Fax: +1 212-302-1286
Web: <http://www.ansi.org>
E-mail: ansionline@ansi.org

or the InterNational Committee for Information Technology Standards (INCITS):

Phone 202-737-8888
Web: <http://www.incits.org>
E-mail: incits@itic.org

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)*

INCITS 509-2014

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*

INCITS 509-2014

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 N_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

INCITS 509-2014

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)

INCITS 509-2014

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_HOLD OFF_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

INCITS 509-2014

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

INCITS 509-2014

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

INCITS 509-2014

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.

INCITS 509-2014

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.

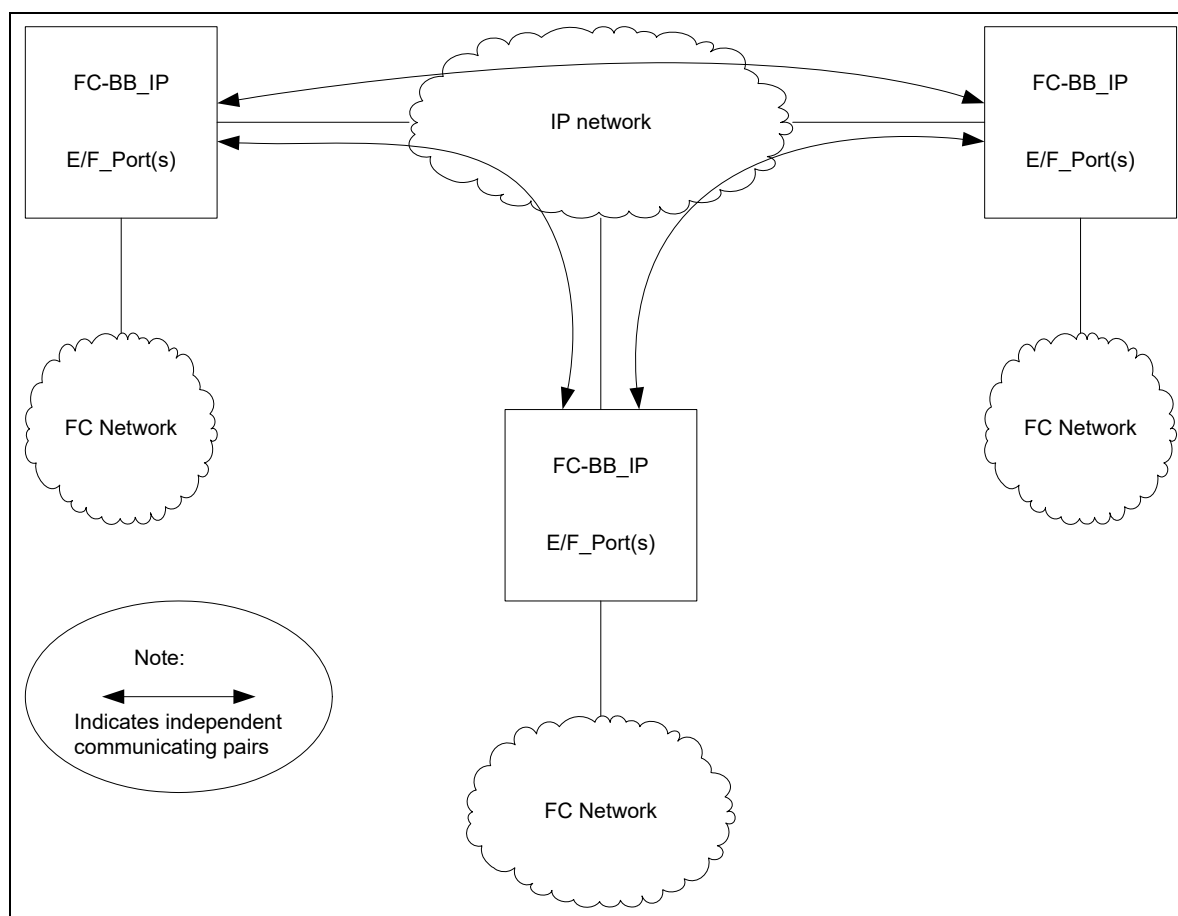


Figure 5 – FC-BB_IP reference model

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.

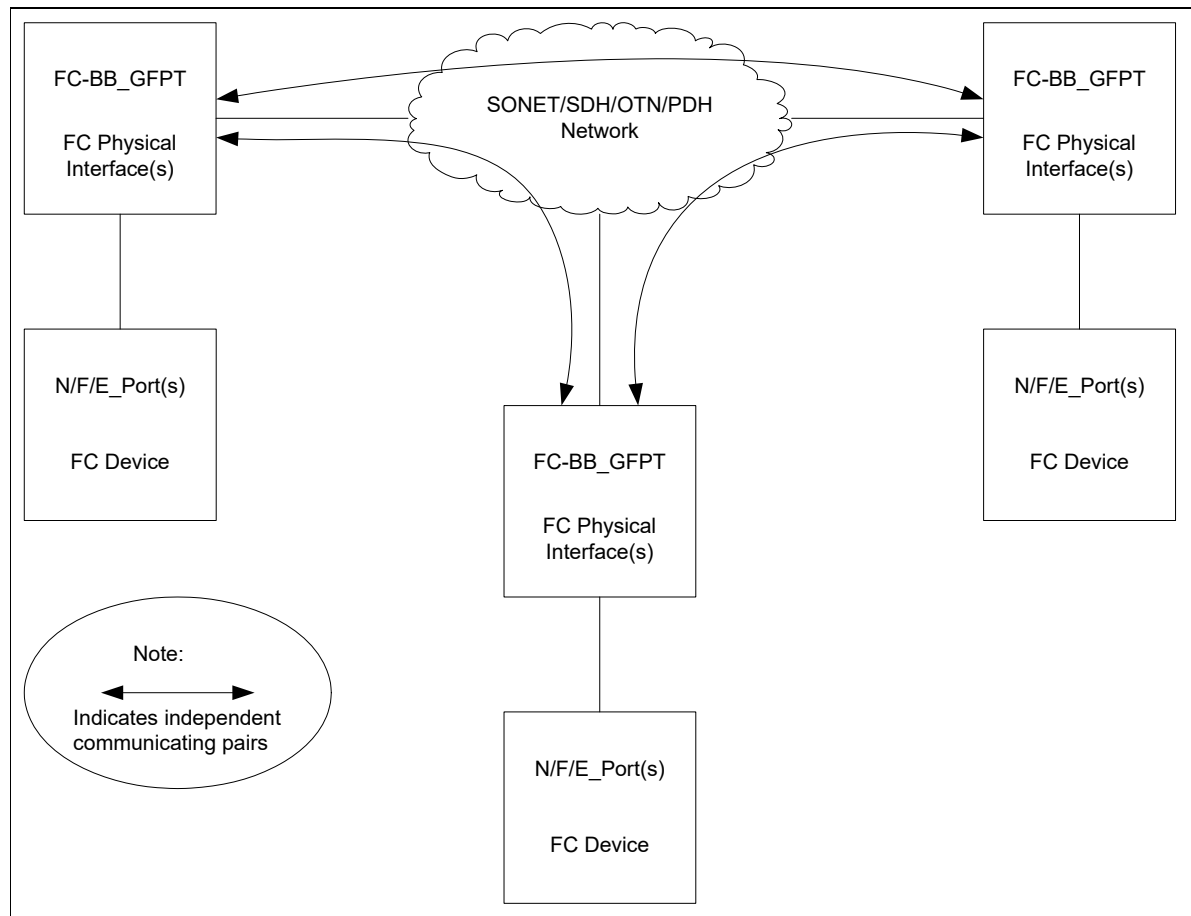


Figure 6 – FC-BB_GFPT reference model

INCITS 509-2014

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.

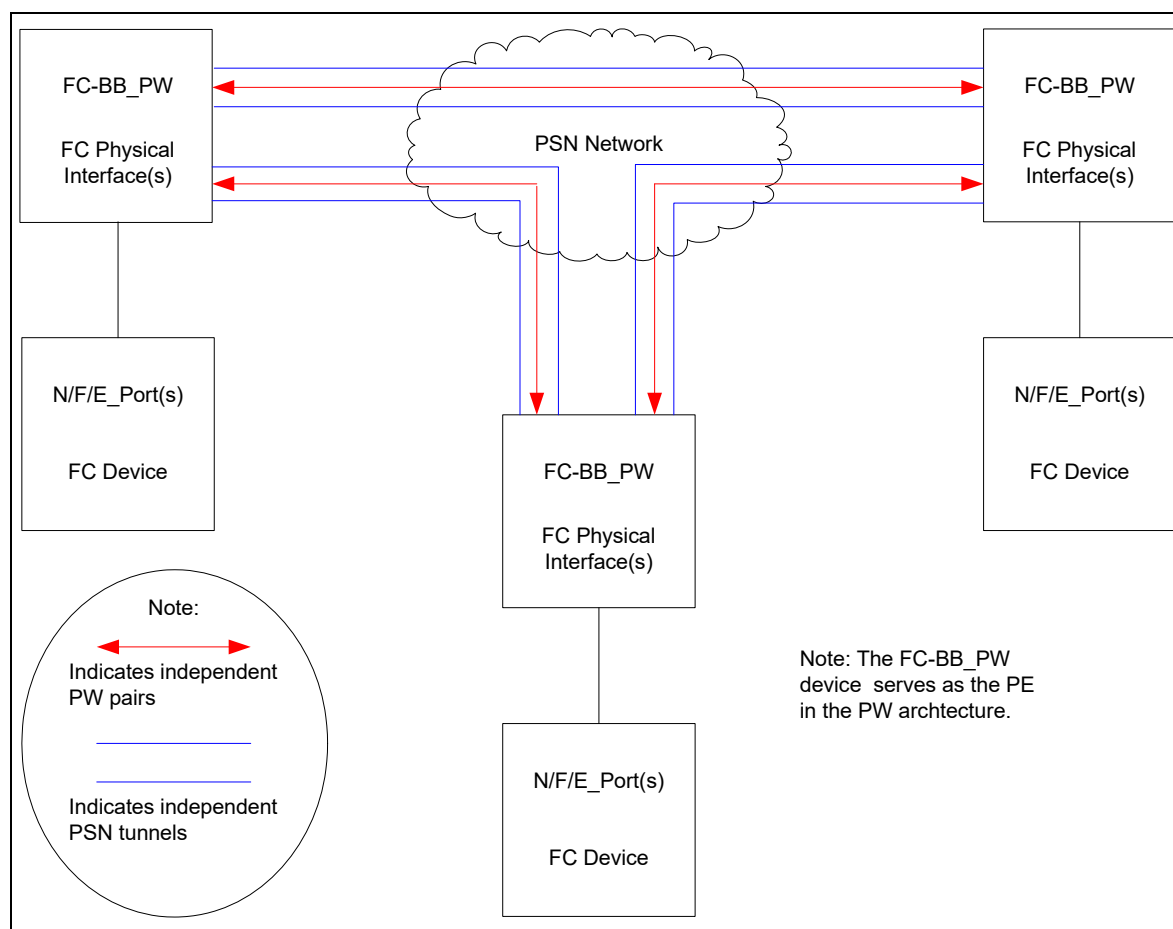


Figure 7 – FC-BB_PW reference model

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.

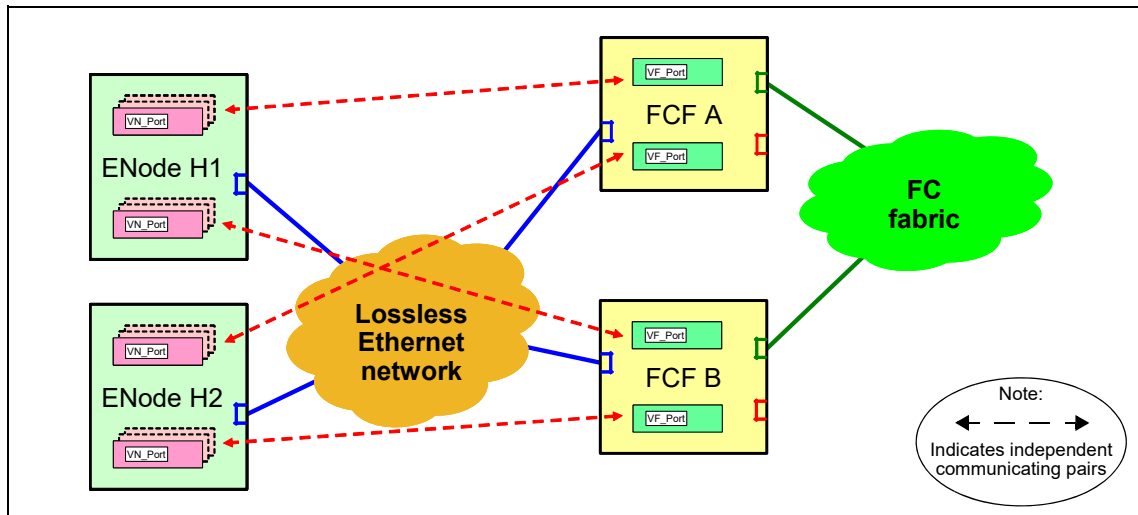


Figure 8 – FC-BB_E VN_Port to VF_Port reference model

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.

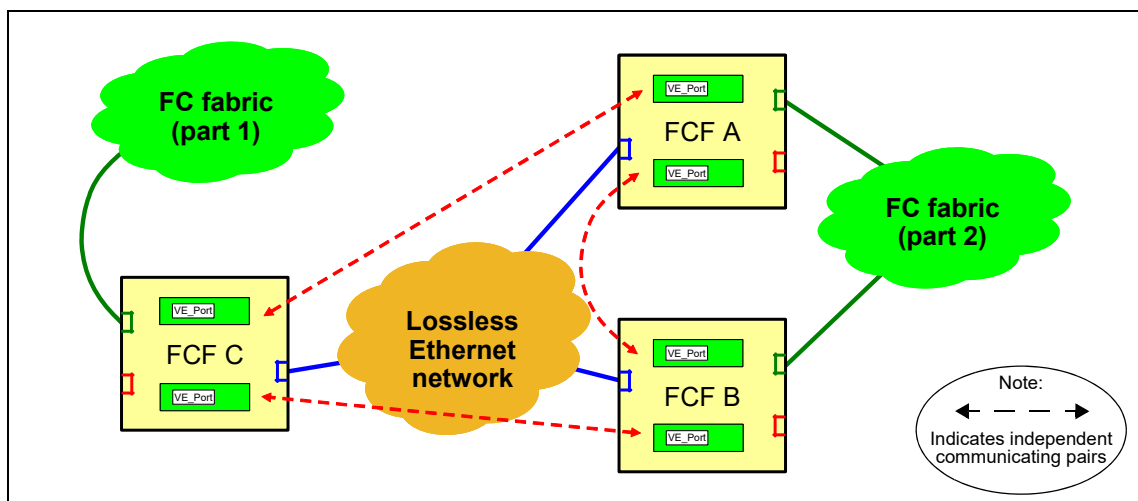


Figure 9 – FC-BB_E VE_Port to VE_Port reference model

INCITS 509-2014

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.

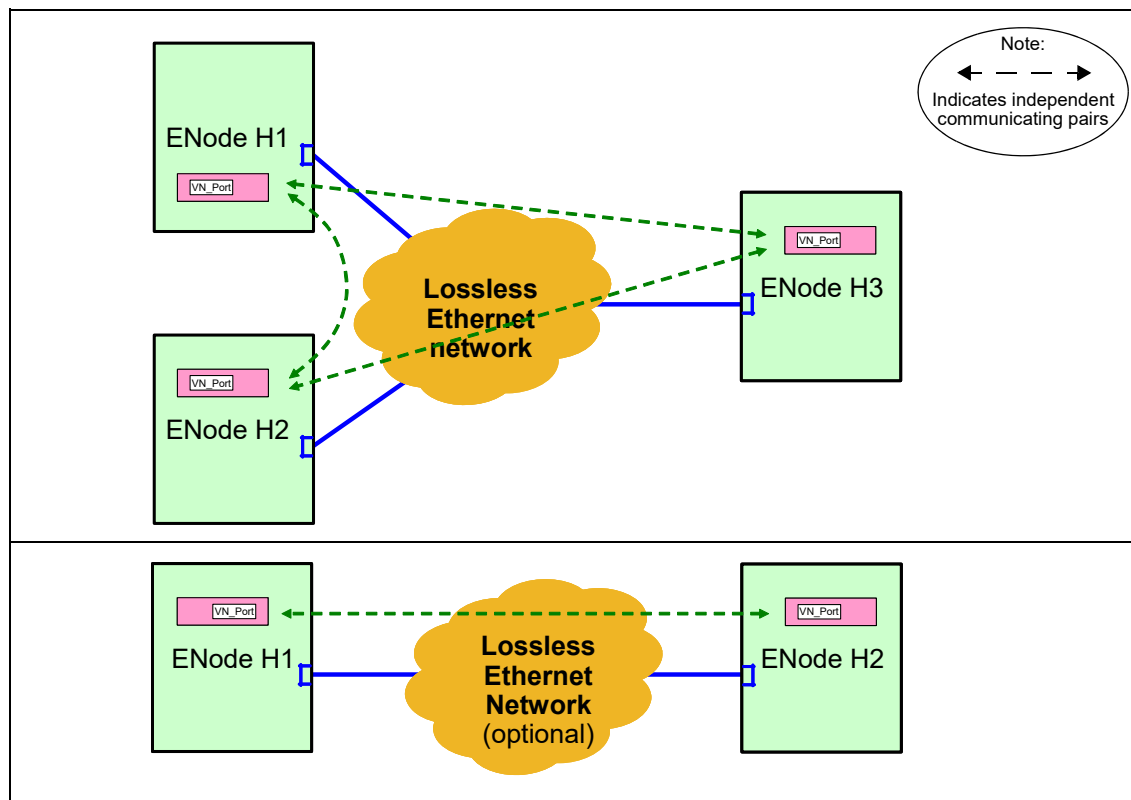


Figure 10 – FC-BB_E VN_Port to VN_Port reference model

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.

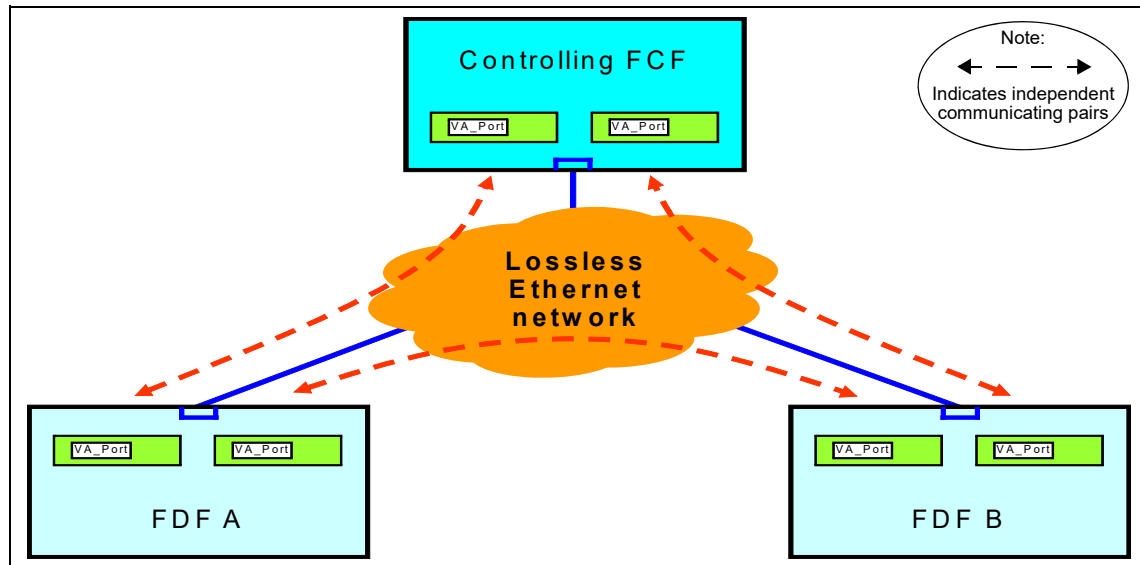


Figure 11 – FC-BB_E VA_Port to VA_Port reference model

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.

INCITS 509-2014

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.

INCITS 509-2014

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