



ISO/IEC 14165-133

Edition 1.0 2010-02

INTERNATIONAL STANDARD

**Information technology – Fibre channel –
Part 133: Fibre channel switch fabric-3 (FC-SW-3)**



THIS PUBLICATION IS COPYRIGHT PROTECTED
Copyright © 2010 ISO/IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester.

If you have any questions about ISO/IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

- Catalogue of IEC publications: www.iec.ch/searchpub

The IEC on-line Catalogue enables you to search by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, withdrawn and replaced publications.

- IEC Just Published: www.iec.ch/online_news/justpub

Stay up to date on all new IEC publications. Just Published details twice a month all new publications released. Available on-line and also by email.

- Electropedia: www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 20 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary online.

- Customer Service Centre: www.iec.ch/webstore/custserv

If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:

Email: csc@iec.ch
Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00



ISO/IEC 14165-133

Edition 1.0 2010-02

INTERNATIONAL STANDARD

**Information technology – Fibre channel –
Part 133: Fibre channel switch fabric-3 (FC-SW-3)**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

PRICE CODE **XD**

ICS 35.200

ISBN 2-8318-1076-7

Contents

FOREWORD	13
Introduction	15
1 Scope	16
2 Normative references	16
3 Terms and conventions.	17
3.1 Terms and definitions.	17
3.2 Abbreviations, acronyms, and symbols	25
3.3 Editorial conventions	26
3.4 State machine notation.	27
3.5 Definition of Compliance Terms	27
3.6 Keywords	28
4 Structure and Concepts	30
4.1 Overview	30
4.2 E_Port Operation	30
4.3 Fabric Operation.	30
4.4 Fabric Definition	31
4.5 Switch.	31
4.6 Switching characteristics	33
4.6.1 Switching overview	33
4.6.2 Synchronous switching	33
4.6.3 Asynchronous switching	33
4.7 Switch Ports and Bridge Ports	34
4.7.1 General Characteristics	34
4.7.2 F_Port	34
4.7.3 FL_Port	34
4.7.4 E_Port	34
4.7.4 B_Port	35
4.7.5 G_Ports and GL_Ports	35
4.8 Fabric Addressing	35
4.9 Class F Service	36
4.10 FSPF-Backbone Fabric	37
5 Switch Ports and Bridge Ports	38
5.1 Overview	38
5.2 Model elements	38
5.2.1 FC Transports	38
5.2.2 Switch Transport	38
5.2.3 Control Facilities	38
5.2.4 Link Services	39
5.3 F_Port Operation	39
5.4 FL_Port Operation	40
5.5 E_Port Operation	41
5.6 B_Port operation	43
5.7 Inter-Switch Link Behavior	44
5.8 Class F Service	45
5.8.1 Class F Function	45
5.8.2 Class F Rules	45

5.8.3 Class F Frame Format	47
5.8.4 Class F Flow Control	48
6 Internal Link Services	49
6.1 Switch Fabric Internal Link Services (SW_ILS)	49
6.1.1 SW_ILS overview	49
6.1.2 Switch Fabric Internal Link Service Accept (SW_ACC)	50
6.1.3 Switch Fabric Internal Link Service Reject (SW_RJT)	51
6.1.4 Exchange Link Parameters (ELP)	54
6.1.5 Exchange Fabric Parameters (EFP)	60
6.1.6 Domain Identifier Assigned (DIA)	64
6.1.7 Request Domain_ID (RDI)	65
6.1.8 Hello (HLO)	67
6.1.8.1 HLO overview.	67
6.1.8.2 FSPF Header Format.	69
6.1.9 Link State Update (LSU)	70
6.1.9.1 LSU overview.	70
6.1.9.2 Link-State Record (LSR) Format	71
6.1.9.3 Link State Header Format	72
6.1.9.4 Link Descriptor Format	74
6.1.9.5 Summary Descriptor Format	75
6.1.10 Link State Acknowledgement (LSA)	75
6.1.11 Build Fabric (BF)	76
6.1.12 Reconfigure Fabric (RCF)	77
6.1.13 Inter-Switch Registered State Change Notification (SW_RSCN)	78
6.1.14 Distribute Registered Link Incident Records (DRLIR)	81
6.1.15 Disconnect Class 1 Connection (DSCN)	82
6.1.16 Merge Request (MR)	83
6.1.16.1 MR overview	83
6.1.16.2 Merge Request Payload.	84
6.1.16.2.1 Merge Request Payload overview	84
6.1.16.2.2 Merge Request Payload in Basic Zoning	85
6.1.16.2.3 Merge Request Payload in Enhanced Zoning	86
6.1.16.3 Merge Request Reply	87
6.1.17 Acquire Change Authorization Request (ACA)	87
6.1.18 Release Change Authorization (RCA) Request.	89
6.1.19 Stage Fabric Configuration Update (SFC) Request	90
6.1.19.1 SFC overview	90
6.1.19.2 SFC in Basic Zoning	92
6.1.19.3 SFC in Enhanced Zoning	93
6.1.19.3.1 Overview	93
6.1.19.3.2 Operation Request 'Activate Zone Set Enhanced'	93
6.1.19.3.3 Operation Request 'Deactivate Zone Set Enhanced'	93
6.1.19.3.4 Operation Request 'Distribute Zone Set Database'	94
6.1.19.3.5 Operation Request 'Activate Zone Set by Name'	94
6.1.19.3.6 Operation Request 'Set Zoning Policies'	95
6.1.20 Update Fabric Configuration (UFC) Request.	95
6.1.21 Exchange Switch Capabilities	96
6.1.22 Exchange Switch Support (ESS)	99
6.1.22.1 ESS overview	99
6.1.22.2 ESS Request Payload.	99
6.1.22.3 Interconnect Element Information Object	100
6.1.22.4 Capability Object	100
6.1.22.5 Service Specific Capability Formats.	100

6.1.22.5.1 Directory Server Capability	100
6.1.22.5.2 Fabric Controller Capability	101
6.1.22.5.3 ESS Fabric Configuration Server Capability Object	102
6.1.22.5.4 ESS Enhanced Zone Server Capability Object	102
6.1.22.5.5 ESS-Vendor Specific Capability Object.	103
6.1.22.6 ESS Accept Payload	104
6.1.23 Merge Request Resource Allocation (MRRA)	104
7 Fabric Configuration	107
7.1 Fabric Configuration Summary.	107
7.2 Switch Port Initialization	107
7.2.1 Basic Operation	107
7.2.2 Exchange Switch Capabilities Processing.	116
7.3 Principal Switch Selection	117
7.4 Address Distribution	123
7.4.1 Address_Distribution overview	123
7.4.2 Domain_ID Distribution by the Principal Switch.	125
7.4.3 Domain_ID Requests by the Switches	127
7.5 E_Port and Fabric Isolation	130
7.6 B_Port Operation	131
7.6.1 Differences Between E_Ports and B_Ports	131
7.6.2 B_Port Internal Link Services	131
7.6.3 B_Port Initialization	132
7.6.4 Example B_Port Configuration	132
8 Fabric Shortest Path First (FSPF).	133
8.1 Overview	133
8.1.1 Basic Components.	133
8.1.2 Fabric connectivity.	133
8.1.3 Addressing.	133
8.1.4 Path Selection and Routing	134
8.1.5 Hierarchical Path Selection	134
8.1.6 FSPF Path Selection Summary.	134
8.2 FSPF Message Processing	134
8.2.1 Message transmission	134
8.2.2 Message Reception and Tests	135
8.3 Hello Protocol.	135
8.3.1 Basic Functions	135
8.3.2 Hello Message Transmission.	135
8.3.3 Hello Message Parameters	136
8.3.4 Hello Message Reception	136
8.4 The Topology Database.	137
8.5 Usage of LSR Fields	137
8.5.1 LSR Age	137
8.5.2 LSR Incarnation Number	138
8.5.3 LSR Instance Rules	138
8.5.4 LSR Checksum	139
8.5.5 Link Cost	141
8.6 Topology Database Synchronization	141
8.6.1 Synchronization overview	141
8.6.2 Neighborhood and Adjacency	142
8.6.3 Continuous Topology Database Synchronization	143
8.6.4 Reliable Flooding	144
8.6.4.1 Basic Operation.	144

8.6.4.2 The Flooding Procedure	144
8.6.4.3 Generating a New LSR	144
8.6.4.4 Transmitting an LSR	145
8.6.4.5 Receiving an LSR	145
8.7 Neighbor Finite State Machine (FSM)	146
8.8 FSPF-Backbone	149
8.8.1 FSPF-Backbone overview	149
8.8.2 Multiple Switch Connections	152
8.8.3 FSPF-Backbone Point-to-point Links.	154
8.8.4 FSPF-Backbone Routing Protocol.	154
9 Distributed Services	156
9.1 Basic Model	156
9.2 Distributed Services Framework	156
9.2.1 Goals and Characteristics of the Distributed Services Framework	156
9.2.2 Distributed Service Transport	156
9.2.2.1 Required FC-2 Parameters	156
9.2.2.2 FC-CT Header Usage	157
9.2.2.3 Frame Distribution	157
9.2.3 Common Characteristics	157
9.2.4 Zoning Considerations.	158
9.2.5 Work Categories	158
9.2.6 Frame Formats	159
9.2.7 FC-CT Command Restrictions.	159
9.3 Distributed Name Server	159
9.3.1 General Behavior.	159
9.3.2 FC-CT for Distributed Name Servers.	160
9.3.2.1 DNS Command Codes	160
9.3.2.2 FC-CT Header usage for DNS	164
9.3.3 Name Server Objects	164
9.3.4 FC-CT requests for DNS	167
9.3.4.1 Remove All	167
9.3.4.2 Get Entry based on Port Identifier	167
9.3.4.3 Get Entry based on Port_Name	168
9.3.4.4 Get Entries based on Node_Name	169
9.3.4.5 Get Entries based on IP address (Node)	169
9.3.4.6 Get Entries based on FC-4 TYPEs	170
9.3.4.7 Get Entries based on Port Type	171
9.3.4.8 Get Entries based on Zone Member	171
9.3.4.9 Get Entries based on Zone Name	172
9.3.4.10 Get Entries based on Port IP Address	173
9.3.4.11 Get Entries based on FC-4 Features	173
9.3.4.12 Get Entries based on Fabric Port_Name	174
9.4 Distributed Management Server.	175
9.4.1 General Behavior.	175
9.4.2 FC-CT Header	175
9.4.2.1 FC-CT Header Parameters.	175
9.4.2.2 FC-CT Header Rule for Fabric Internal Requests	175
9.4.3 Fabric Configuration Service	176
9.4.4 Unzoned Name Service.	178
9.4.5 Fabric Zone Service.	178
9.4.6 Fabric-Device Management Service	178
9.4.6.1 Operational Characteristics of the FDMI Server	178
9.4.6.2 Registration Scenarios	179

9.4.6.2.1 HBA Attached to a Single Switch	179
9.4.6.2.2 HBA Attached to Multiple Switches	179
9.4.6.2.3 Resolution of the Principal HBA Manager	179
9.4.6.3 FDMI Inter-Switch Messages	180
9.4.6.3.1 General Format	180
9.4.6.3.2 FC-CT Header	180
9.4.6.3.3 FDMI Header	180
9.4.6.3.4 Payload.	181
9.4.6.4 FDMI Inter-Switch Requests	181
9.4.6.5 FDMI Inter-Switch Responses	182
9.4.6.5.1 Reject Response	182
9.4.6.5.2 Accept Response	182
9.4.6.6 FDMI Inter-Switch Operations	182
9.4.6.6.1 Registration Notification (FRN) Operation	182
9.4.6.6.2 De-Register Notification (FDRN) Operation	182
9.4.6.6.3 Update Notification (FUN) Operation.	183
9.4.6.6.4 Update Forward (FUF) Operation	183
9.4.6.6.5 De-Register Forward (FDRF) Operation	183
9.4.6.6.6 Fetch	183
9.4.6.7 GS Client Initiated FDMI Requests	184
9.4.7 Other Fabric Internal Services	185
9.4.7.1 Fabric Internal Requests	185
9.4.7.2 Get Management Server Capabilities (GCAP) Operation	186
9.4.7.2.1 Overview	186
9.4.7.2.2 Capability Entry	186
9.4.7.2.3 Subtype Capability Bit Masks	187
10 Switch Zone Exchange and Merge	188
10.1 Overview	188
10.2 Joining Switches.	188
10.3 Enhanced Zoning Support Determination	188
10.4 Zoning Framework and Data Structures	189
10.4.1 Basic Zoning Framework.	189
10.4.2 Basic Zoning Data Structures	193
10.4.2.1 Zoning Object List	193
10.4.2.2 Zoning Object Format	193
10.4.2.3 Name Entry Format	194
10.4.2.4 Zone Member Format	195
10.4.3 Enhanced Zoning Framework	196
10.4.3.1 Introduction	196
10.4.3.2 Zone Set Database	196
10.4.3.3 Active Zone Set	198
10.4.4 Enhanced Zoning Data Structures.	199
10.4.4.1 Zoning Object List	199
10.4.4.2 Zoning Object Types	199
10.4.4.3 Zone Set Object	200
10.4.4.3.1 Zone Set Object in the Zone Set Database.	200
10.4.4.3.2 Zone Set Object in the Active Zone Set	201
10.4.4.4 Zone Reference Object	201
10.4.4.5 Zone Object in the Zone Set Database	202
10.4.4.6 Zone Object in the Active Zone Set	203
10.4.4.6.1 Overview	203
10.4.4.6.2 Zone Member Format.	204
10.4.4.7 Zone Alias Object	205

10.4.4.8 Zone Attribute Object	206
10.4.4.8.1 Overview	206
10.4.4.8.2 Zone Attribute Entry Format	207
10.5 Merge Zone	211
10.5.1 Example Merge Operation.	211
10.5.2 Merge Zone Rules	213
10.5.2.1 Merge Rules in Basic Zoning	213
10.5.2.2 Merge Rules in Enhanced Zoning.	214
10.6 Fabric Management Session Protocol	215
10.6.1 Fabric Management Session Protocol overview	215
10.6.2 Reserving Fabric Change Authorization	216
10.6.3 Staging the Fabric Configuration	216
10.6.4 Updating the Fabric Configuration	217
10.6.5 Releasing Fabric Change Authorization	217
10.6.6 Mapping of a GS Session to a Fabric Session	217
10.6.7 Fabric Behavior to Handle the CT SFEZ Request.	219
11 Distributed broadcast	220
11.1 Overview	220
11.2 Spanning tree	220
11.2.1 Overview	220
11.2.2 Spanning tree example	220
12 Timers and Constants.	222
12.1 General Timers and Constants	222
12.2 SW_ILS Time-Out Values	223
Annex A (informative) Examples of Switch Port Initialization	224
A.1 Overview	224
A.2 Example 1: two E/F/FL_Port-capable Switch Ports	224
A.3 Example 2: two E/F/FL_Port-capable Switch Ports and one Nx_Port	225
A.4 Example 3: one E/F/FL_Port-capable Port and one E/F_Port-capable Port	226
Annex B (informative) ELP Negotiation Example	227
B.1 Overview	227
B.2 ELP Exchange Protocol	227
B.2.1 General	227
B.2.2 ELP Exchange without Parameter Negotiation	227
B.2.3 ELP Exchange with Parameter Negotiation	228
B.3 Summary of Responses to ELP.	231
Annex C (informative) Fabric Device Management interface-Sample Flows	232
C.1 Overview	232
C.2 Sample Flows	232
C.2.1 HBA Registration - Single Switch	232
C.2.2 HBA Registration - Multiple Switches - Caches Updated	232
C.2.3 HBA Registration - Multiple Switches - Caches Not Updated	233
C.2.4 HBA De-Registration - Primary HBA Manager	235
C.2.5 HBA De-Registration - Non-Primary HBA Manager	236
Bibliography	237

Figures

Figure 1 State Machine Example.	27
Figure 2 Switch Model	31
Figure 3 Multiple Switch Fabric Example.	32
Figure 4 Domain, Area, and Port Address Partitioning	35
Figure 5 F_Port Model	39
Figure 6 FL_Port Model	41
Figure 7 E_Port Model	42
Figure 8 B_Port Model.	43
Figure 9 Principal Inter-Switch Links	45
Figure 10 Class F Frame Format.	47
Figure 11 Switch Port Mode Initialization State Machine.	108
Figure 12 Switch Port Mode Initialization State Machine - Continued	109
Figure 13 Example of Simultaneous ELP Processing- Parameters Acceptable to Both Switches . .	113
Figure 14 ESC Processing.	116
Figure 15 Principal Switch Selection State Machine	118
Figure 16 Example Propagation of BF and RCF SW_ILS requests	120
Figure 17 Address Distribution State Machines	124
Figure 18 RDI Request Processing by Principal Switch	126
Figure 19 RDI Request Processing by non-Principal Switch.	129
Figure 20 Example B_Port Configuration - Virtual ISL.	132
Figure 21 Neighbor Finite State Machine	149
Figure 22 FSPF-Backbone Architecture	150
Figure 23 Point-to-point FSPF-Backbone Links.	151
Figure 24 AR0 Consisting of Two ISW-0 Switching Devices.	151
Figure 25 Internal Service Supported By a BSW.	152
Figure 26 Dual BSW connectivity	153
Figure 27 Physically Contiguous FSPF-Backbone with dual BSWs (Allowed)	153
Figure 28 Physically Non-Contiguous FSPF-Backbone with dual BSWs (Disallowed)	154
Figure 29 FSPF-Backbone Routing Protocol overview.	155
Figure 30 Basic Zoning Framework.	190
Figure 31 Basic Zoning Hierarchy	192
Figure 32 Basic Zoning Object Structure.	192
Figure 33 Logical Structure of the Zone Set Database	197
Figure 34 Logical Structure of the Active Zone Set	198
Figure 35 Merge Operation Between Two Switches	211
Figure 36 Merge Operation Among Several Switches	213
Figure 37 Broadcast path selection example.	221
Annex Figure A.1 Initialization example 1	224
Annex Figure A.2 Initialization example 2	225
Annex Figure A.3 Initialization example 3	226
Annex Figure B.1 Reference ELP Configuration	227
Annex Figure B.2 A Successful and Complete ELP Exchange	228
Annex Figure B.3 An Unsuccessful but Complete ELP Exchange	228
Annex Figure B.4 A successful ELP Exchange Protocol Parameter Negotiation	229
Annex Figure B.5 An Unsuccessful ELP Exchange Protocol Parameter Negotiation	230
Annex Figure C.1 Registration of HBA Information - Single Switch.	232
Annex Figure C.2 Registration of HBA Information - Multiple Switches Caches Updated.	233
Annex Figure C.3 Registration of HBA Information - Multiple Switches Caches Not Updated	234
Annex Figure C.4 HBA De-Registration - Primary HBA Manager	235
Annex Figure C.5 HBA De-Registration - Non-Primary HBA Manager	236

Tables

Table 1 ISO and American Conventions	26
Table 2 Address Identifier Values	36
Table 3 SW_ILS Command Codes	49
Table 4 SW_RJT Payload	51
Table 5 SW_RJT Reason Codes	52
Table 6 SW_RJT Reason Code Explanation	53
Table 7 ELP Request Payload	55
Table 8 Interconnect_Port Class F Service Parameters	56
Table 9 Class 1 Interconnect_Port Parameters	57
Table 10 Class 2 Interconnect_Port Parameters	58
Table 11 Class 3 Interconnect_Port Parameters	58
Table 12 ISL Flow Control Mode Values	59
Table 13 Flow Control Parameters	59
Table 14 ELP Accept Payload	60
Table 15 EFP Request Payload	61
Table 16 Switch_Priority Field Values	62
Table 17 Domain_ID_List Record Format	62
Table 18 Record_Type Field Values	63
Table 19 Multicast_ID_List Record Format	63
Table 20 EFP Accept Payload	64
Table 21 DIA Request Payload	65
Table 22 DIA Accept Payload	65
Table 23 RDI Request Payload	66
Table 24 RDI Accept Payload	67
Table 25 HLO Request Payload	68
Table 26 FSPF Header	69
Table 27 FSPF Command Codes	69
Table 28 LSU Request Payload	70
Table 29 Flags Field Bit Map	71
Table 30 Link State Record - Link Descriptor Format	71
Table 31 Link State Record - Summary Descriptor Format	72
Table 32 Link State Header Format	72
Table 33 Link State Record Type Field Values	73
Table 34 Link Descriptor Format	74
Table 35 Link Type Values	74
Table 36 Summary Descriptor Format	75
Table 37 LSA Request Payload	76
Table 38 BF Request Payload	77
Table 39 BF Accept Payload	77
Table 40 RCF Request Payload	78
Table 41 RCF Accept Payload	78
Table 42 SW_RSCN Request Payload	79
Table 43 Device Entry Format	80
Table 44 SW_RSCN Accept Payload	81
Table 45 DRLIR Request Payload	81
Table 46 DRLIR Accept Payload	82
Table 47 DSCN Request Payload	82
Table 48 DSCN Reason Codes	83
Table 49 DSCN Accept Payload	83
Table 50 Merge Request Payload	84
Table 51 Protocol Version Values	84
Table 52 Basic Zoning Payload	85

Table 53 Enhanced Zoning Payload	86
Table 54 Merge Request Accept Payload	87
Table 55 ACA Request Payload	88
Table 56 Acquire Change Authorization Accept Payload	89
Table 57 RCA Request Payload	89
Table 58 Release Change Authorization Accept Payload	90
Table 59 SFC Request Payload	91
Table 60 Operation Request Value	91
Table 61 Stage Fabric Configuration Update Accept Payload.	92
Table 62 Payload for Operation Request Values 03 and 04	92
Table 63 Payload for Operation Request 'Activate Zone Set Enhanced'	93
Table 64 Payload for Operation Request 'Deactivate Zone Set Enhanced'	93
Table 65 Payload for Operation Request 'Distribute Zone Set Database'.	94
Table 66 Payload for Operation Request 'Activate Zone Set by Name'	94
Table 67 Payload for Operation Request 'Set Zoning Policies'	95
Table 68 Update Fabric Configuration Request Payload.	96
Table 69 Update Fabric Configuration Accept Payload.	96
Table 70 ESC Request Payload	97
Table 71 Protocol Descriptor Format.	97
Table 72 Protocol ID Values	98
Table 73 ESC Accept Payload.	98
Table 74 ESS Request Payload	99
Table 75 Capability Object Format	100
Table 76 Name Server Capability Flags	101
Table 77 Fabric Controller Capability Flags.	101
Table 78 Fabric Configuration Server Capability flags.	102
Table 79 Enhanced Zone Server Capability flags	102
Table 80 Vendor Specific Capability Object.	103
Table 81 ESS Accept Payload.	104
Table 82 MRRA Request Payload	105
Table 83 Vendor Specific Field	105
Table 84 MRRA Response Payload	106
Table 85 MRRA Response Values	106
Table 86 Fabric Configuration Summary	107
Table 87 Responses to ELP Request for Originating Interconnect_Port.	111
Table 88 Recommended BF and RCF Usage Summary.	117
Table 89 B_Port - ILS Support.	131
Table 90 Bridge Port Initialization Summary	132
Table 91 Path Selection (FSPF) Operation Summary.	134
Table 92 Checksum Byte Order Calculation	140
Table 93 Neighbor Finite State Machine	147
Table 94 FC-CT Command Codes for DNS	160
Table 95 Name Server Entry Object	164
Table 96 FC-4 Descriptor Format for Name Server Object	165
Table 97 Entry Object Format Indicator.	166
Table 98 Name Server Entry Object Description	166
Table 99 RA request payload	167
Table 100 RA Accept payload	167
Table 101 GE_ID request payload.	167
Table 102 GE_ID Accept payload	168
Table 103 GE_PN request payload	168
Table 104 GE_PN Accept payload	168
Table 105 GE_NN request payload	169
Table 106 GE_NN Accept payload	169

Table 107 GE_IP request payload	169
Table 108 GE_IP Accept payload	170
Table 109 GE_FT request payload	170
Table 110 GE_FT Accept payload	170
Table 111 GE_PT request payload	171
Table 112 GE_PT Accept payload	171
Table 113 GE_ZM request payload	171
Table 114 GE_ZM Accept payload	172
Table 115 GE_ZN request payload	172
Table 116 GE_ZN Accept payload	172
Table 117 GE_IPP request payload	173
Table 118 GE_IPP Accept payload	173
Table 119 GE_FF request payload	173
Table 120 GE_FF Accept payload	174
Table 121 GE_FPN request payload	174
Table 122 GE_FPN Accept payload	174
Table 123 Fabric Configuration Service Command Codes for dMS	176
Table 124 FDMI Inter-Switch Message	180
Table 125 FDMI Header	180
Table 126 Vendor Specified	181
Table 127 FDMI Fabric Internal Command Codes	181
Table 128 Reason Code Explanation	182
Table 129 Registered HBA/Port List	183
Table 130 HBA Entry	184
Table 131 Port Entry	184
Table 132 Fabric Device Management Interface CT Commands for the dMS	185
Table 133 Fabric Internal Management Server Operations	185
Table 134 GCAP Request Payload	186
Table 135 GCAP CT_ACC Payload	186
Table 136 Capability Entry	186
Table 137 Fabric Configuration Server (CT_Subtype 01h)	187
Table 138 Unzoned Name Server (CT_Subtype 02h)	187
Table 139 Zoning Object List	193
Table 140 Zoning Object	193
Table 141 Zoning Object Types	194
Table 142 Protocol Format	194
Table 143 Zone Member Format	195
Table 144 Zone Member Type and Identifier Formats	195
Table 145 Zoning Object List	199
Table 146 Zoning Object Types	199
Table 147 Zone Set Object Format in the Zone Set Database	200
Table 148 Zone Set Object Format in the Active Zone Set	201
Table 149 Zone Reference Object Format	201
Table 150 Zone Object Format in the Zone Set Database	202
Table 151 Zone Object Format in the Active Zone Set	203
Table 152 Zone Member Format	204
Table 153 Zone Member Type and Identifier Formats	204
Table 154 Zone Member Identifier Format - Vendor Specified	205
Table 155 Zone Alias Object Format	205
Table 156 Zone Attribute Object Format	206
Table 157 Zone Attribute Block Format	206
Table 158 Zone Attribute Entry Format	207
Table 159 Zone Attribute Types	207
Table 160 Protocol Attribute Value	208

Table 161 Vendor Specified Attribute Value	210
Table 162 Basic Zoning Merge Rules	214
Table 163 Enhanced Zoning Merge Rules	215
Table 164 Timers and Constants for FC-SW-3	222
Table 165 SW_ILS Time-Out Values.	223
Annex Table B.1 Responses to an ELP Request Initiator	231

INFORMATION TECHNOLOGY – FIBRE CHANNEL –

Part 133: Fibre Channel Switch Fabric-3 (FC-SW-3)

FOREWORD

- 1) ISO (International Organization for Standardization) and IEC (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. Their preparation is entrusted to technical committees; any ISO and IEC member body interested in the subject dealt with may participate in this preparatory work. International governmental and non-governmental organizations liaising with ISO and IEC also participate in this preparation.
- 2) In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.
- 3) The formal decisions or agreements of IEC and ISO on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC and ISO member bodies.
- 4) IEC, ISO and ISO/IEC publications have the form of recommendations for international use and are accepted by IEC and ISO member bodies in that sense. While all reasonable efforts are made to ensure that the technical content of IEC, ISO and ISO/IEC publications is accurate, IEC or ISO cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 5) In order to promote international uniformity, IEC and ISO member bodies undertake to apply IEC, ISO and ISO/IEC publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any ISO/IEC publication and the corresponding national or regional publication should be clearly indicated in the latter.
- 6) ISO and IEC provide no marking procedure to indicate their approval and cannot be rendered responsible for any equipment declared to be in conformity with an ISO/IEC publication.
- 7) All users should ensure that they have the latest edition of this publication.
- 8) No liability shall attach to IEC or ISO or its directors, employees, servants or agents including individual experts and members of their technical committees and IEC or ISO member bodies for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication of, use of, or reliance upon, this ISO/IEC publication or any other IEC, ISO or ISO/IEC publications.
- 9) Attention is drawn to the normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.

International Standard ISO/IEC 14165-133 was prepared by subcommittee 25: Interconnection of information technology equipment, of ISO/IEC joint technical committee 1: Information technology.

The list of all currently available parts of the ISO/IEC 14165 series, under the general title *Information technology – Fibre Channel*, can be found on the IEC web site.

This International Standard has been approved by vote of the member bodies and the voting results may be obtained from the address given on the second title page.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

Introduction

This International Standard describes the requirements for an interconnecting Fabric consisting of multiple Fabric Switch elements to support the ISO/IEC Fibre Channel - Framing and Signaling (FC-FS) and ISO/IEC Fibre Channel - Physical Interface (FC-PI) standards.

FC-SW-3 is one of the Fibre Channel family of standards. ISO/IEC FC-GS-4, is a standard related to Generic Fabric Services and is closely tied to FC-SW-3. ISO/IEC FC-BB-2 describes how Fabrics are extended over transports complementary to Fibre Channel. ANSI/INCITS FC-MI-2 and ANSI/INCITS FC-DA describe interoperability profiles that assists in the interoperability of Switches. ISO/IEC FC-AL-2 specifies the arbitrated loop topology. ISO/IEC FC-SP describes the Security requirements and protocols associated with Fibre Channel networks.

FC-SW-3 describes how switches communicate and interact with one another to form a Fabric of switches. Included are Fabric initialization and configuration, routing, server communication, event distribution and repository exchanges (e.g., zoning information).

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.

The International Electrotechnical Commission (IEC) and the International Organization for Standardization (ISO) draw attention to the fact that it is claimed that compliance with this document may involve the use of patents as indicated below.

ISO and IEC take no position concerning the evidence, validity and scope of the putative patent rights. The holders of the putative patent rights have assured IEC and ISO that they are willing to negotiate free licences or licences under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statements of the holders of the putative patent rights are registered with IEC and ISO.

Brocade Communications Systems Inc. has informed IEC and ISO that it has patent applications or granted patents as listed below.

6 765 919, 6 980 525 and 10/780 147

Information may be obtained from:
Brocade Communications Systems, Inc.
1745 Technology Drive
USA - San Jose, CA 95110

Cisco Systems Inc. has informed IEC and ISO that it has patent applications or granted patents.

Information may be obtained from:
Cisco Systems Inc.
170 West Tasman Drive
USA - San Jose, CA 95134

McData Corporation has informed IEC and ISO that it has patent applications or granted patents.

Information may be obtained from:
McData Corporation
11802 Ridge Parkway
USA - Broomfield, Colorado 80021

INFORMATION TECHNOLOGY

Fibre Channel —

Part 133: Fibre Channel Switch Fabric - 3 (FC-SW-3)

1 Scope

This part of ISO/IEC 14165-133 describes the operation and interaction of Fibre Channel Switches.

This part of ISO/IEC 14165-133 includes:

- a) E_Port Operation and Fabric Configuration;
- b) Path selection (FSPF and FSPF-Backbone);
- c) Bridge Port (B_Port) Operation;
- d) distributed server interaction and communication;
- e) exchange of information between Switches to support zoning;
- f) distribution of Event Notifications between Switches.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

The provisions of the referenced specifications other than ISO/IEC, IEC, ISO and ITU documents, as identified in this clause, are valid within the context of this International Standard. The reference to such a specification within this International Standard does not give it any further status within ISO or IEC. In particular, it does not give the referenced specification the status of an International Standard.

ISO/IEC 14165-122, *Information technology - Fibre channel - Part 122: Arbitrated loop-2 (FC-AL-2)*

ISO/IEC 14165-241, *Information technology - Fibre channel - Part 241: Backbone-2 (FC-BB-2)*

ISO/IEC 14165-251, *Information technology - Fibre channel - Part 251: Framing and signalling (FC-FS)*

ISO/IEC 14165-414, *Information technology - Fibre channel - Part 414: Generic services-4 (FC-GS-4)*

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

RFC 905, *ISO Transport Protocol Specification*, ISO DP 8073, April 1984.

RFC 1008, *Implementation Guide for the ISO Transport Protocol*, June 1987.

3 Terms and conventions

For the purposes of this standard, the following terms, definitions, conventions, abbreviations, acronyms, and symbols apply.

3.1 Terms and definitions

3.1.1

Active Zone Set

Active Zone Set is the Zone Set Definition currently in effect and enforced by the Fabric or other entity (e.g., the Name Server)

3.1.2

Address assignment

process whereby addresses are dispensed to Switches and Switch Ports

3.1.3

Address identifier

as defined in FC-FS, an unsigned 24-bit address value used to uniquely identify the source (S_ID) and destination (D_ID) of Fibre Channel frames

3.1.4

Address Manager

logical entity within a Switch that is responsible for address assignment

3.1.5

Adjacent Switch

remote Switch that does not require intermediate Switches in order to be reached

3.1.6

Adjacency

relationship between two Switches that have synchronized their topology databases

3.1.7

Adjacent

two Switches that have synchronized their databases are considered Adjacent

3.1.8

Area

second level in a three-level addressing hierarchy

3.1.9

Area Identifier

bits 15 through 8 of an address identifier

3.1.10

AR Number

unique number statically assigned to each autonomous region

3.1.11

AR0

special AR containing only the Switch backbone network, that in general may consist of point-to-point links and switching devices

3.1.12

AR0_SW

Switch inside AR0 and a component of the FSPF-Backbone layer

3.1.13

Autonomous Region

AR

encompasses one or more Fibre Channel Address Domains and consists of Switches all running a common routing protocol; an AR boundary is administratively defined

3.1.14

Border Switch

BSW

FC-SW-3 defined Switch that comprises the FSPF-Backbone network

3.1.15

Broadcast Address

FFFFFFh value in the D_ID field specifies that the frame be broadcast to all Nx_Ports

3.1.16

Broadcast Zone

zone with the Broadcast attribute specified

3.1.17

Broadcast Zoning Enforcement

zoning technique where the Fabric limits broadcast distribution among zone members using frame-by-frame filtering techniques

3.1.18

B_Port

Bridge Port is a Fabric inter-element port used to connect Bridge devices with E_Ports on a Switch; the B_Port provides a subset of the E_port functionality

3.1.19

Class F service

service that multiplexes frames at frame boundaries and is used for control and coordination of the internal behavior of the Fabric

3.1.20

Class N service

refers to any class of service other than Class F

3.1.21

Domain

highest level in a three-level addressing hierarchy

3.1.22

Domain Address Manager

Switch that is responsible for address assignment to other Switches outside of its Domain

3.1.23

Domain Identifier

bits 23 through 16 of an address identifier

3.1.24**Domain_ID_List**

list where each record contains a Domain_ID value and the Switch_Name of the Switch assigned the Domain_ID (see 6.1.5)

3.1.25**Downstream Principal ISL**

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

3.1.26**Distributed Service**

implementation of a Well-Known Service where certain components or functions of the service are distributed throughout the Fabric

3.1.27**Distributed Services Time-Out Value****D_S_TOV**

value that indicates the maximum time that a distributed service requestor waits for a response

3.1.28**Entry Switch**

role that a Switch assumes with respect to a distributed service request. The Switch that is attached to an Nx_Port making a service request assumes the role of an Entry Switch with respect to that request

3.1.29**E_Port**

Fabric "Expansion" Port that attaches to another Interconnect_Port to create an Inter-Switch Link

3.1.30**E_Port Index**

index value associated with an E_Port used by the Fabric Shortest Path First Protocol

3.1.31**Error_Detect_Timeout value****E_D_TOV**

time constant defined in FC-FS

3.1.32**F_Port**

as defined in FC-FS; in this standard an F_Port is assumed to always refer to a port to which non-loop N_Ports are attached to a Fabric, and does not include FL_Ports

3.1.33**Fabric**

as defined in FC-FS, an entity that interconnects various Nx_Ports attached to it, and is capable of routing frames using only the D_ID information in an FC-2 frame header

3.1.34**Fabric Controller**

logical entity responsible for operation of the Fabric identified by the well-known address FFFFFDh

3.1.35

Fabric Element

smallest unit of a Fabric that meets the definition of a Fabric; from the point of view of an attached Nx_Port, a Fabric consisting of multiple Fabric Elements is indistinguishable from a Fabric consisting of a single Fabric Element

3.1.36

Fabric F_Port

entity at the well-known address FFFFFFFEh (see FC-FS)

3.1.37

Flood

to cause information to be sent to all Switches within the Fabric

3.1.38

FL_Port

L_Port that is able to perform the function of an F_Port, attached via a link to one or more NL_Ports in an Arbitrated Loop topology (see FC-AL-2); the AL_PA of an FL_Port is 00h; in this standard, an FL_Port is assumed to always refer to a port to which NL_Ports are attached to a Fabric, and does not include F_Ports

3.1.39

Fx_Port

Switch Port capable of operating as an F_Port or FL_Port

3.1.40

Fabric Stability_Timeout value

F_S_TOV

time constant used to ensure that Fabric stability has been achieved during Fabric Configuration

3.1.41

Fabric Shortest Path First

FSPF

link state protocol used for Path Selection

3.1.42

Fibre Channel Address Domain

set of Domain_IDs associated with an AR

3.1.43

FSPF-Backbone Network

FC-SW-3 defined network backbone connecting different ARs via BSWs using point-to-point links and AR0_SW Switching devices

3.1.44

FSPF-Backbone Protocol

FC-SW-3 defined Switch routing and control protocol that runs over an FSPF-Backbone network

3.1.45

G_Port

generic Fabric Port that may function either as an E_Port, or as an F_Port

3.1.46**GL_Port**

generic Fabric Port that may function either as an E_Port, or as an Fx_Port

3.1.47**Hard Zone**

zone with the Hard Zone attribute specified

3.1.48**Hard Zoning Enforcement**

zoning technique in which the Fabric limits frame exchange by frame-by-frame filtering

3.1.49**Interconnect_Port**

generic reference to an E_Port or a B_Port

3.1.50**Intermix**

as defined in FC-FS

3.1.51**Inter-Switch Link****ISL**

Link directly connecting the E_Port of one Switch to the E_Port of another Switch

3.1.52**Isolated**

condition in which it has been determined that no Class N traffic may be transmitted across an ISL (see 7.5)

3.1.53**L_Port**

port that contains Arbitrated Loop functions associated with the Arbitrated Loop topology

3.1.54**Link**

as defined in FC-FS

3.1.55**Loop Fabric Address**

address identifier used to address an FL_Port for purposes of loop management (see FC-FLA)

3.1.56**N_Port**

as defined in FC-FS. In this Standard, an N_Port is assumed to always refer to a direct Fabric-attached port, and does not include NL_Ports

3.1.57**N_Port Identifier**

address identifier assigned to an N_Port

3.1.58**Name Identifier**

as defined in FC-FS, a 64-bit identifier

3.1.59

NL_Port

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

3.1.60

Non-zero Domain_ID_List

Domain_ID_List that contains at least one record (see 7.3)

3.1.61

Nx_Port

Port operating as an N_Port or NL_Port

3.1.62

Path

route through the Fabric between a source and a destination

3.1.63

Path Selection

process whereby paths are selected

3.1.64

Port

generic reference to an N_Port, NL_Port, F_Port, FL_Port, B_Port, or E_Port; the lowest level in a three-level addressing hierarchy

3.1.65

Point-to-Point Link

Fibre Channel link connecting two ports

3.1.66

Port Identifier

bits 7 through 0 of an address identifier

3.1.67

Port Index

three byte value used by FSPF to identify Switch ports

3.1.68

Port Mode

generic reference to E_Port, B_Port, F_Port or FL_Port operation

3.1.69

Preferred Domain_ID

Domain_ID previously granted to a Switch by the Domain Address Manager or through administrative means

3.1.70

Principal ISL

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

3.1.71**Principal Switch**

Switch that has been selected to perform certain Fabric Configuration duties

3.1.72**Reliable Flood**

flooding where all Switches are guaranteed to receive the flooded message

3.1.73**Remote Switch**

switch that may be reached via one or more ISLs; a remote Switch may be adjacent to the local Switch, or may be reached via one or more intermediate Switches

3.1.74**Resource_Allocation_Timeout value****R_A_TOV**

time constant defined in FC-FS

3.1.75**Router**

entity within a Switch responsible for the routing of connectionless frames

3.1.76**Routing**

process whereby the appropriate Switch Port(s) to deliver a connectionless frame towards its destination is identified

3.1.77**Soft Zoning Enforcement**

zoning technique in which the Fabric enforces membership through name server visibility

3.1.78**Switch**

a Fabric Element conforming to this Standard and a member of the Fabric collective

3.1.79**Switch Construct**

entity within a Switch responsible for transporting frames between Switch Ports

3.1.80**Switch_Name**

Name_Identifier (see FC-FS) that identifies a Switch or a Bridge device for identification purposes; each Switch and Bridge device provides a unique Switch_Name within the Fabric

3.1.81**Switch Port**

E_Port, F_Port, or FL_Port

3.1.82**Switch_Priority**

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

3.1.83

Upstream Principal ISL

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

3.1.84

Zero Domain_ID_List

Domain_ID_List that is empty (see 7.3)

3.1.85

Zone

group of Zone Members. Members of a Zone are made aware of each other, but not made aware of Zone Members outside the Zone

3.1.86

Zone Definition

parameters that define a Zone

3.1.87

Zone Member

specification of a device to be included in a Zone

3.1.88

Zone Member Definition

parameters that define a Zone Member including the Zone Member Type and Zone Member Information

3.1.89

Zone Name

name assigned to a Zone

3.1.90

Zone Set

set of Zones that are used in combination

3.1.91

Zone Set Database

database that contains the Zone Sets not enforced by the Fabric

3.1.92

Zone Set Name

name assigned to a Zone Set

3.1.93

Zone Set State

state of a Switch Zone Set (*Activated* or *Deactivated*)

3.1.94

Zoning Configuration

set of Zoning data including the Zone Set state, and Zone definitions

3.1.95**Zoning Database**

generic term used to indicate both the Active Zone Set and the Zone Set Database

3.2 Abbreviations, acronyms, and symbols

Abbreviations and acronyms applicable to this International Standard are listed below. Definitions of several of these items are included in 3.1. Abbreviations used that are not listed below are defined in FC-FS.

Area_ID	Area Identifier
AR	Autonomous Region
AR0	Autonomous Region 0
BSW	Border Switch
CT	Common Transport
Domain_ID	Domain Identifier
D_S_TOV	Distributed_Services_Timeout Value
E_D_TOV	Error_Detect_Timeout value
ELS	Extended Link Service
FAN	Fabric Address Notification Extended Link Service
FSM	Finite State Machine
FC-AL-2	Fibre Channel Arbitrated Loop-2
FC-BB-2	Fibre Channel Backbone-2
FC-DA	Fibre Channel- Device Attach
FC-FLA	Fibre Channel - Fabric Loop Attachment
FC-FS	Fibre Channel - Framing and Signaling
FC-GS-4	Fibre Channel - Generic Services-4
FC-MI-2	Fibre Channel - Methodologies for Interconnects-2
F_S_TOV	Fabric_Stability_Timeout value
FDMI	Fabric Device Management Interface
FSPF	Fabric Shortest Path First
ISL	Inter-Switch Link
IU	Information Unit
LFA	Loop Fabric Address
LSR	Link State Record
Port_ID	Port Identifier
R	Reserved
R_A_TOV	Resource_Allocation_Timeout value
RFC	Request For Comment
SM	State Machine
SW_ACC	Switch Fabric Link Service Accept
SW_ILS	Switch Internal Link Service
SWN	Switch Name
SWP	Switch Priority
SW_RJT	Switch Fabric Link Service Reject
WKA	Well-Known Address
WWN	World Wide Name
1xAL_TIME	One times the AL_TIME
1xF_S_TOV	One times the F_S_TOV
2xAL_TIME	Two times the AL_TIME
2xF_S_TOV	Two times the F_S_TOV
3xAL_TIME	Three times the AL_TIME
=	Is equal to

3.3 Editorial conventions

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

Lists sequenced by letters (e.g., a-red, b-blue, c-green) show no priority relationship between the listed items. Numbered lists (e.g., 1-red, 2-blue, 3-green) show a priority ordering 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 standard, the most significant bit of a binary quantity is shown on the left side. Exceptions to this convention are indicated in the appropriate clauses.

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

If a field or a control bit in a frame is specified as reserved, the entity that sends the frame shall set the field or control bit to zero, and the entity that receives the frame shall not check that field or control bit.

When the value of the bit or field is not relevant, 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, the entity that receives the frame shall not check that field or control bit.

Unless stated otherwise: 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; and numbers or upper case letters immediately followed by lower-case h (xxh) are hexadecimal values.

The ISO convention of numbering is used (i.e., the thousands and higher multiples are separated by a space and a comma is used as the decimal point.) A comparison of the American and ISO conventions are shown in table 1.

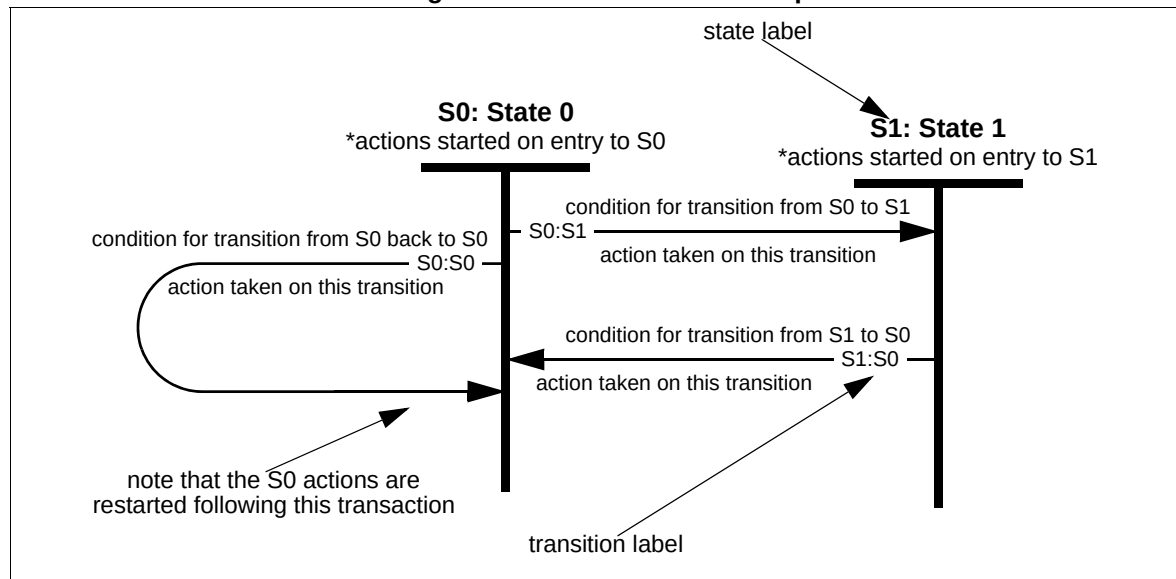
Table 1 – ISO and American Conventions

ISO	American
0,6	0.6
1 000	1,000
1 234 567,8	1,234,567.0

3.4 State machine notation

State machines in this standard should use the style shown in figure 1.

Figure 1 – State Machine Example



These state machines make three assumptions:

- Time elapses only within discrete states.
- State transitions are logically instantaneous, so the only actions taken during a transition are setting flags and variables and sending signals. These actions complete before the next state is entered.
- Every time a state is entered, the actions of that state are started. Note that this means that a transition that points back to the same state repeats the actions from the beginning. All the actions started upon entry complete before any tests are made to exit the state.

3.5 Definition of Compliance Terms

The usual definitions of the following terms do not apply in this standard and therefore they are defined below:

3.5.1

Prohibited

if a feature or parameter value is Prohibited, it means that it shall not be used between compliant implementations

3.5.2

Required

if a feature or parameter value is Required, it means that it shall be used between compliant implementations

3.5.3

Allowed

if a feature or parameter value is Allowed, it means that it may be used between compliant implementations

3.6 Keywords

3.6.1

expected

keyword used to describe the behavior of the hardware or software in the design models assumed by this standard. Other hardware and software design models may also be implemented

3.6.2

ignored

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

3.6.3

invalid

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

3.6.4

mandatory

keyword indicating an item that is required to be implemented as defined in this standard

3.6.5

may

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

3.6.6

may not

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

3.6.7

obsolete

keyword indicating that an item was defined in prior Fibre Channel standards but has been removed from this standard

3.6.8

optional

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.

3.6.9

reserved

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 are not required to check reserved bits, bytes, words or fields for zero values. Receipt of reserved code values in defined fields shall be reported as error.

3.6.10**restricted**

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

3.6.11**shall**

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

4 Structure and Concepts

4.1 Overview

This FC-SW-3 standard describes the operation and interaction of Fibre Channel Switches. This includes E_Port Operation and Fabric Operation.

4.2 E_Port Operation

E_Port operation specifies the tools and algorithms for interconnection and initialization of Fibre Channel Switches to create a multi-Switch Fabric. Fabric operation defines an E_Port ("Expansion Port") that operates in a manner similar to an N_Port and F_Port, as defined in FC-FS, with additional functionality provided for interconnecting Switches.

E_Port operation defines credit models and management between E_Ports for the various classes of service other than Class F. E_Ports conforming to this Standard support Class F, and one or more Class 1, Class 2, and/or Class 3; support for other classes of service are not defined by Fabric operation.

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

4.3 Fabric Operation

Fabric operation includes the following:

- a) Fabric Configuration- Describes how a Principal Switch is selected and describes the address assignment algorithm.
- b) Exchange Switch Capabilities - Allows Switches to exchange certain operational capabilities such as which path selection protocols are supported.
- c) B_Port - A simplified E_Port that allows Bridge type devices to participate in Fabric operation.
- d) Path selection - Path Selection is the process by which a Switch determines the best path from a source domain to a destination domain. These paths may then be used in any appropriate manner by the Switch to move frames to their destinations. This path selection process does not require nor preclude the use of static or dynamic load-balancing. The standard defines the Fabric Shortest Path First (FSPF) protocol and the FSPF-Backbone protocol. FSPF describes how Switches interact to establish path selection for an Intra-Region and the FSPF-Backbone protocol describes Inter-Region routing.
- e) Distributed Server communication - The Distributed Server model allows the Well-Known servers to be distributed among Switches that comprise the Fabric. Both the distributed Name Server and the distributed Management Server are described. In addition, the Inter-Switch FDMI protocol has been defined.
- f) Exchange of Zoning information - Defines how zoning information is communicated between Switches in the Fabric. Zoning information is exchanged between Switches when two Fabrics are merged, and when changes to zoning information are propagated between Switches.

- g) Distributed Event Notification - Defines how Registered State Change Notifications (RSCNs) and Distribute Registered Link Incident Records (DRLIR) are distributed between Switches in the Fabric.

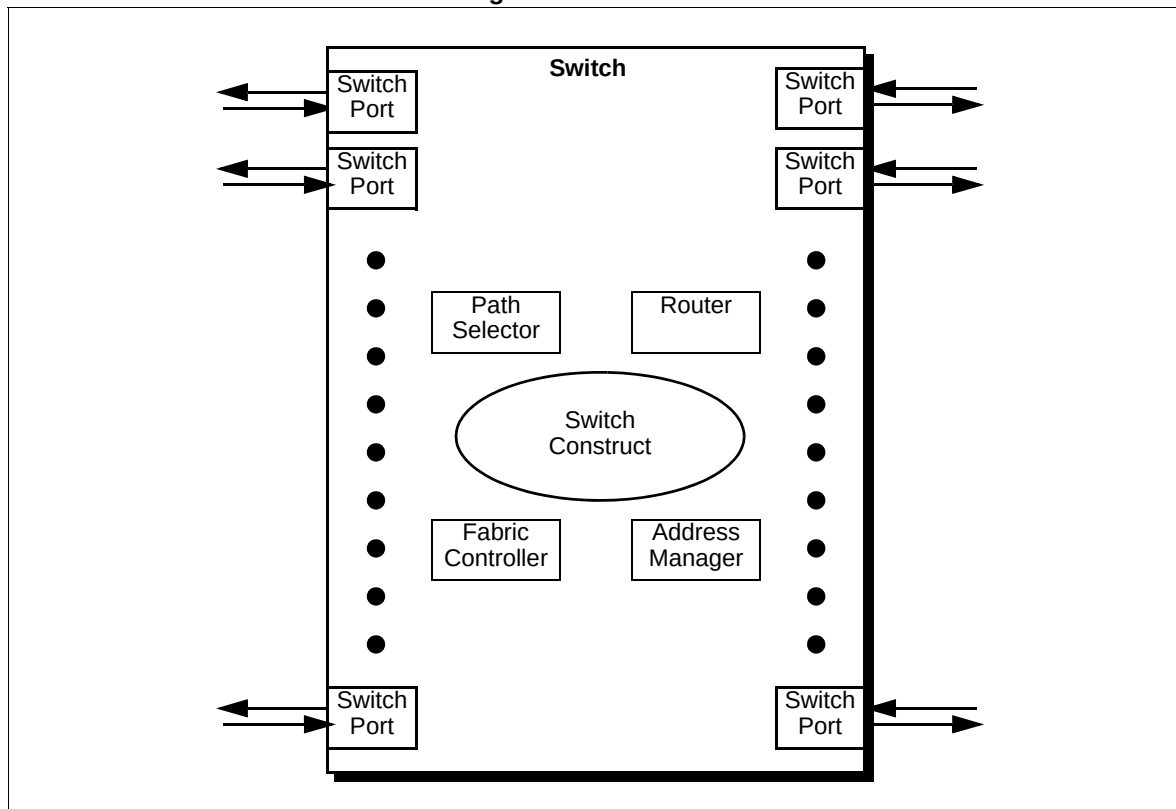
4.4 Fabric Definition

The Fabric serves as a transport that provides a switched interconnect between Nx_Ports.

4.5 Switch

A Switch is the smallest entity that may function as a Switch-based Fibre Channel Fabric. Figure 2 illustrates the conceptual model of a Switch.

Figure 2 – Switch Model



A Switch is composed of the following major components:

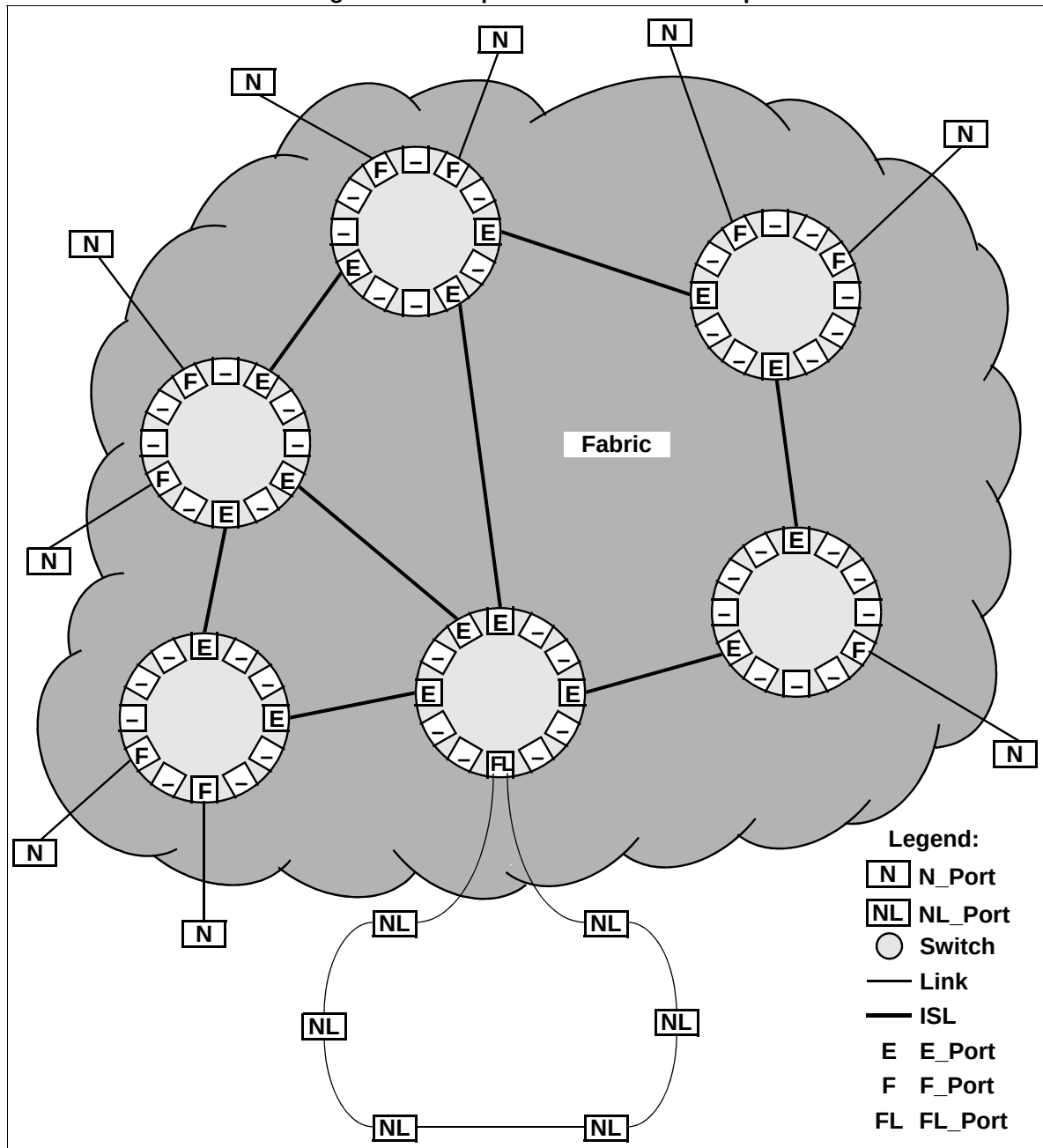
- a) Two or more Switch Ports;
- b) a Switch Construct, capable of either multiplexed frame switching or circuit switching, or both;
- c) an Address Manager;
- d) a Path Selector, which performs path selection;
- e) a Router;
- f) and a Fabric Controller.

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

The Link joining a pair of E_Ports is called an Inter-Switch Link (ISL). ISLs carry frames originating from Nx_Ports and those frames generated within the Fabric. The frames generated within the Fabric serve as control, management and support for the Fabric.

Switches may be joined freely or in a structured fashion to form a larger Fabric, as illustrated in figure 3.

Figure 3 – Multiple Switch Fabric Example



The structure of the Switch Construct in the Switch, as seen in figure 2, is undefined and beyond the scope of this Standard. It may support either or both circuit switching and multiplexed frame switching. It may be non-blocking, allowing concurrent operation of all possible combinations, or it may be blocking and restricting operations. The Switch Construct may also contain redundancy, as may be required for high availability configurations.

The Address Manager is responsible for the assignment of addresses within some portion of the Fabric. Within the Switch, the Address Manager is responsible for Domain_ID(s) for the Switch, and allocating Area_IDs and Port_IDs within the acquired Domain(s).

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

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

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

4.6 Switching characteristics

4.6.1 Switching overview

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

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

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

A switching event occurs every time a connectionless frame is transmitted and when a connection based service is established, suspended or terminated.

4.6.2 Synchronous switching

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

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

4.6.3 Asynchronous switching

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

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

4.7 Switch Ports and Bridge Ports

4.7.1 General Characteristics

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

A Switch Port supports one or more of the following Port Modes: E_Port, B_Port, F_Port, or FL_Port. Switch Ports that assume either the E_Port or B_Port mode are generally referred to as Interconnect_Ports. A Switch Port that is capable of supporting more than one Port Mode attempts to configure itself first as an FL_Port (as defined in FC-AL-2), then as an E_Port or a B_Port (as defined in this Standard), and finally as an F_Port (as defined in FC-FS), depending on which of the four Port Modes are supported by the Switch Port. A Bridge Port shall only support B_Port operation.

NOTE 1 The characteristics of a Bridge device are not described in this standard. See FC-BB-2 for a description of Bridge device characteristics.

The detailed procedure for Port Mode selection is described in 7.2.

4.7.2 F_Port

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

F_Ports are described in detail in 5.3.

4.7.3 FL_Port

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

FL_Ports are described in detail in 5.4.

4.7.4 E_Port

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

E_Ports are described in detail in 5.5.

4.7.4 B_Port

A Bridge Port (B_Port) is a port on a Bridge device. It normally functions as a conduit between the Switch and the Bridge for frames destined for or through a Bridge device. A B_Port is also used to carry frames between a Switch and the Bridge device for purposes of configuring the Bridge device.

4.7.5 G_Ports and GL_Ports

A G_Port is a Switch Port that is capable of either operating as an E_Port or F_Port. A G_Port determines through Port Initialization whether it operates as an E_Port or as an F_Port. A GL_Port is a G_Port that is also capable of operating as an FL_Port.

4.8 Fabric Addressing

Switches use the address partitioning model as described below. The 24-bit address identifier is divided into three fields: Domain, Area, and Port, as shown in figure 4.

Figure 4 – Domain, Area, and Port Address Partitioning

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

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

An Area_ID shall apply to either of the following:

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

A single Arbitrated Loop shall have exactly one Area_ID.

A Port_ID shall apply to either of the following:

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

Address identifier values for this Standard are listed in table 2. Any value listed as Reserved is not meaningful within this Standard.

Table 2 – Address Identifier Values

Address Identifier (hex)			Description
Domain_ID	Area_ID	Port_ID	
00	00	00	Undefined ^a
00	00	AL_PA	E_Port: Reserved F_Port: Reserved FL_Port: Private Loop NL_Port ^b and ^g
00	00	non-AL_PA	Reserved
00	01 - FF	00 - FF	Reserved
01 - EF	00 - FF	00	F_Port: N_Port Identifier FL_Port: Loop Fabric Address ^c
01 - EF	00 - FF	AL_PA	F_Port: N_Port Identifier FL_Port: N_Port Identifier for Public Loop NL_Port ^c
01 - EF	00 - FF	non-AL_PA	F_Port: N_Port Identifier FL_Port: Reserved
F0 - FE	00 - FF	00 - FF	Reserved
FF	00 - FA	00 - FF	Reserved
FF	FB	00 - FF	Reserved for Multicast Group_ID
FF	FC	00	Reserved
FF	FC	01 - EF	N_Port Identifier for Domain Controller ^d
FF	FC	F0 - FF	Reserved
FF	FD - FE	00 - FF	Reserved
FF	FF	00 - EF	Reserved
FF	FF	F0 - FC	Well-Known Address ^e
FF	FF	FD	N_Port Identifier for Fabric Controller ^f
FF	FF	FE	N_Port Identifier for Fabric F_Port
FF	FF	FF	Broadcast Address

^a This value is used by an N_Port requesting an address identifier during FLOGI.

^b See FC-AL-2 for a definition of AL_PA and FC-DA for a definition of Private Loop and FL_Port operation with Private Loop devices.

^c See FC-DA for the definition and use of Loop Fabric Address, and for a definition of Public Loop.

^d A Domain Controller Identifier may be used to address the Fabric Controller of a remote Switch that may or may not be connected via an ISL to the originating Switch. The Port_ID field is set to the Domain_ID of the remote Switch.

^e The usage of Well-Known Addresses FFFF0h through FFFFCh, are not defined by this Standard. FC-FS defines or reserves these values for Well-Known Addresses.

^f This address identifier has special usage depending on the originator. If the originator is an attached external N_Port or NL_Port (attached via an F_Port or FL_Port) then the destination of a frame sent to FFFF0h is the Fabric Controller of the local Switch. If the originator is the Fabric Controller of the local Switch, then the destination of a frame sent to FFFF0h via an ISL is the Fabric Controller of the remote Switch at the other end of the ISL.

^g This value is used by a public loop NL_Port requesting an address identifier during FLOGI.

4.9 Class F Service

Class F service is a connectionless service similar to Class 2 that is used for internal control of the Fabric. Class F service as used by this Standard is defined in 5.8.

4.10 FSPF-Backbone Fabric

The FSPF-Backbone Fabric consists of multiple Autonomous Regions (AR) that are interconnected by a backbone network. The FSPF-Backbone Fabric performs path selection using the FSPF-Backbone routing protocol. All ARs shall have unique Domain_IDs and be equipped with dynamic mechanisms to detect conflicting Domain_IDs. Assigning Domain_IDs within an AR does not necessarily have to be dynamic as in Principal Switch selection and Address assignment, as long as the links of the conflicting Domain_ID are isolated. The AR boundary is administratively defined, with each AR encompassing one or more Fibre Channel Address Domains.

The primary motivation in forming a 2-tier architecture is to allow the Switch Fabric to scale better. In general a layered routing architecture is known to incur shorter propagation delays compared to a flat network. This is particularly important for Fibre Channel networks with a large number of Switches.

5 Switch Ports and Bridge Ports

5.1 Overview

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

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

A Bridge device may contain one or more Bridge Ports (B_Ports).

Ports that operate in the E_Port or B_Port mode are generically referred to as Interconnect_Ports. A single Inter-Switch Link (ISL) connects two Interconnect_Ports together. Valid combinations of Interconnect_Ports are described below:

- a) E_Port to E_Port;
- b) E_Port to B_Port.

B_Port to B_port ISLs are not allowed.

5.2 Model elements

5.2.1 FC Transports

The FC-FS Transport includes all of the functionality described in FC-FS to construct and deconstruct a frame, to encode and decode the words that make up the frame, and to transmit and receive the frame on the physical media. The FC-AL-2 Transport contains additional functionality to support the Arbitrated Loop protocols.

5.2.2 Switch Transport

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

5.2.3 Control Facilities

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

5.2.4 Link Services

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

5.3 F_Port Operation

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

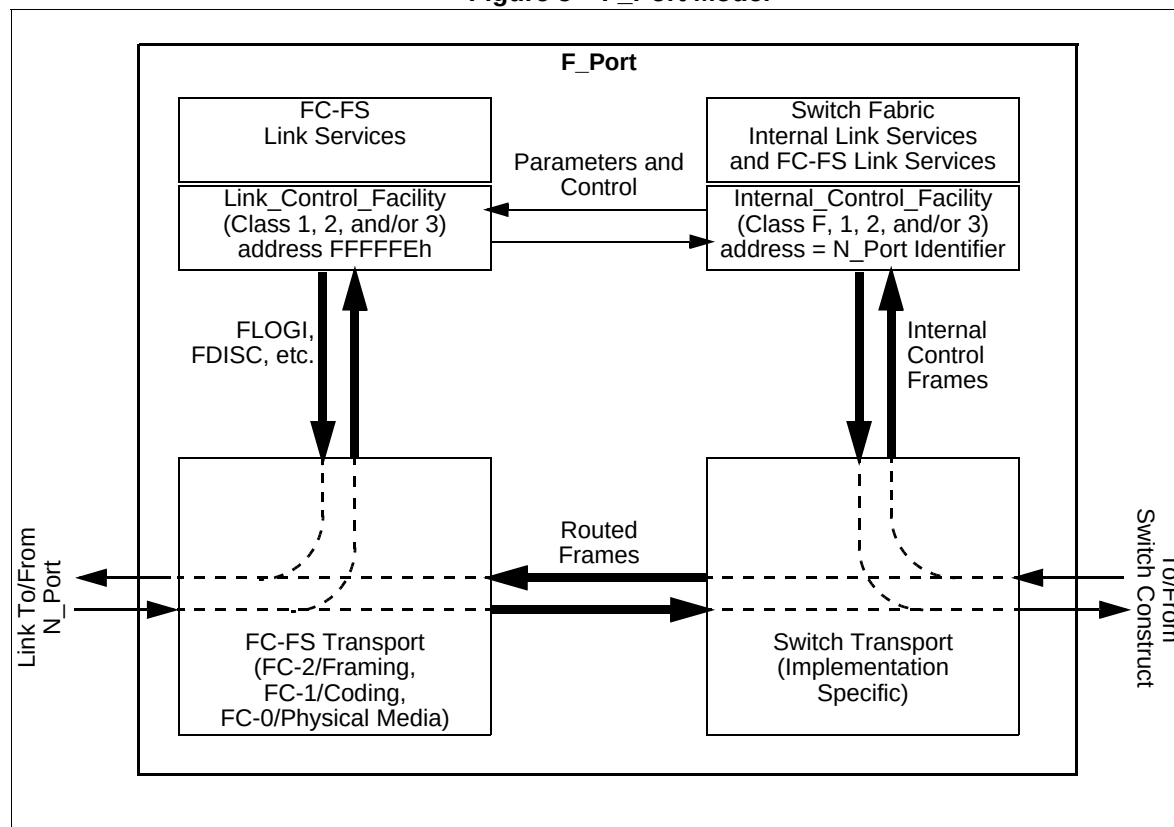
An F_Port shall support one or more of the following classes of service: Class 1 service, Class 2 service, Class 3 service. An F_Port shall not intentionally transmit Class F frames on its outbound fibre. An N_Port that receives a Class F frame shall discard it, as required by FC-FS.

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

NOTE 2 Primitive Signals and Primitive Sequences are prohibited from entering the Fabric by FC-FS. For example, if an R_RDY was admitted to a Fabric, it may propagate to another F_Port and be transmitted by that F_Port, disrupting credit on that Link.

The model of an F_Port is shown in figure 5.

Figure 5 – F_Port Model



An F_Port contains an FC-FS Transport element through which passes all frames and Primitives transferred across the Link to and from the N_Port. Frames received from the N_Port are either directed to

the Switch Construct via the Switch Transport element, or directed to the Link_Control_Facility. The Link_Control_Facility receives frames related to Link Services such as FLOGI, and transmits responses to those Link Service frames.

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

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

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

5.4 FL_Port Operation

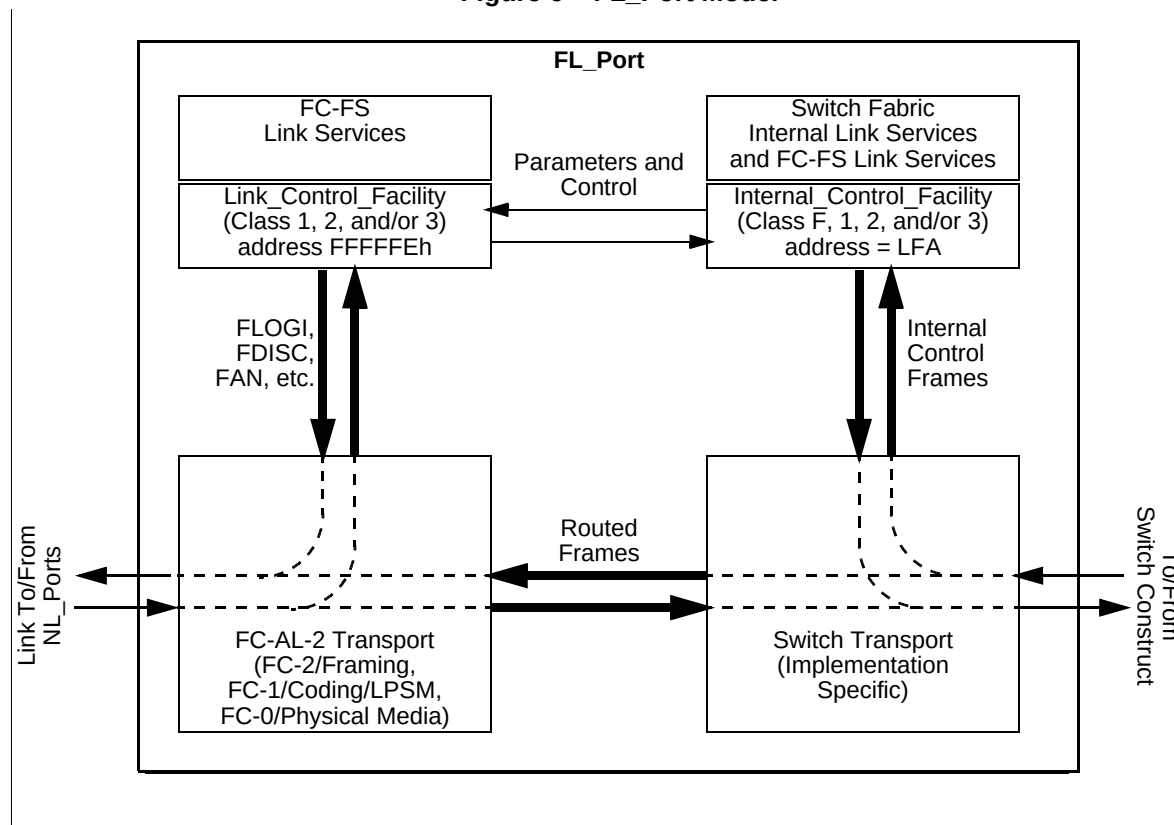
An FL_Port is the point at which one or more external NL_Ports are attached to the Fabric. It normally functions as a conduit to the Fabric for frames transmitted by the attached NL_Ports, and as a conduit from the Fabric for frames destined for the attached NL_Ports.

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

NOTE 3 It is recommended that an FL_Port that conforms to this Standard also conform to the FL_Port requirements defined in FC-DA.

The model of an FL_Port is shown in figure 6.

Figure 6 – FL_Port Model



An FL_Port contains an FC-AL-2 Transport element that passes all frames and Primitives transferred across the Link to and from the multiple NL_Ports. Frames received from the NL_Ports are either directed to the Switch Construct via the Switch Transport element, or directed to the Link_Control_Facility. The Link_Control_Facility receives frames related to Link Services such as FLOGI, and transmits responses to those Link Service frames. The Link_Control_Facility also transmits and receives Loop Initialization Sequences and transmits the FAN ELS.

Frames received from the FC-AL-2 Transport element that are destined for other ports are directed by the Switch Transport to the Switch Construct for further routing. Frames received from the Switch Construct by the Switch Transport are directed either to the FC-AL-2 Transport for transmission to the destination NL_Port, or to the Internal_Control_Facility. The Internal_Control_Facility receives frames related to Switch Fabric Internal Link Services and Loop management Extended Link Services (see FC-DA), and transmits responses to those Link Services frames. Information is passed between the Internal_Control_Facility and the Link_Control_Facility to effect the control and configuration of the Transport elements.

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

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

5.5 E_Port Operation

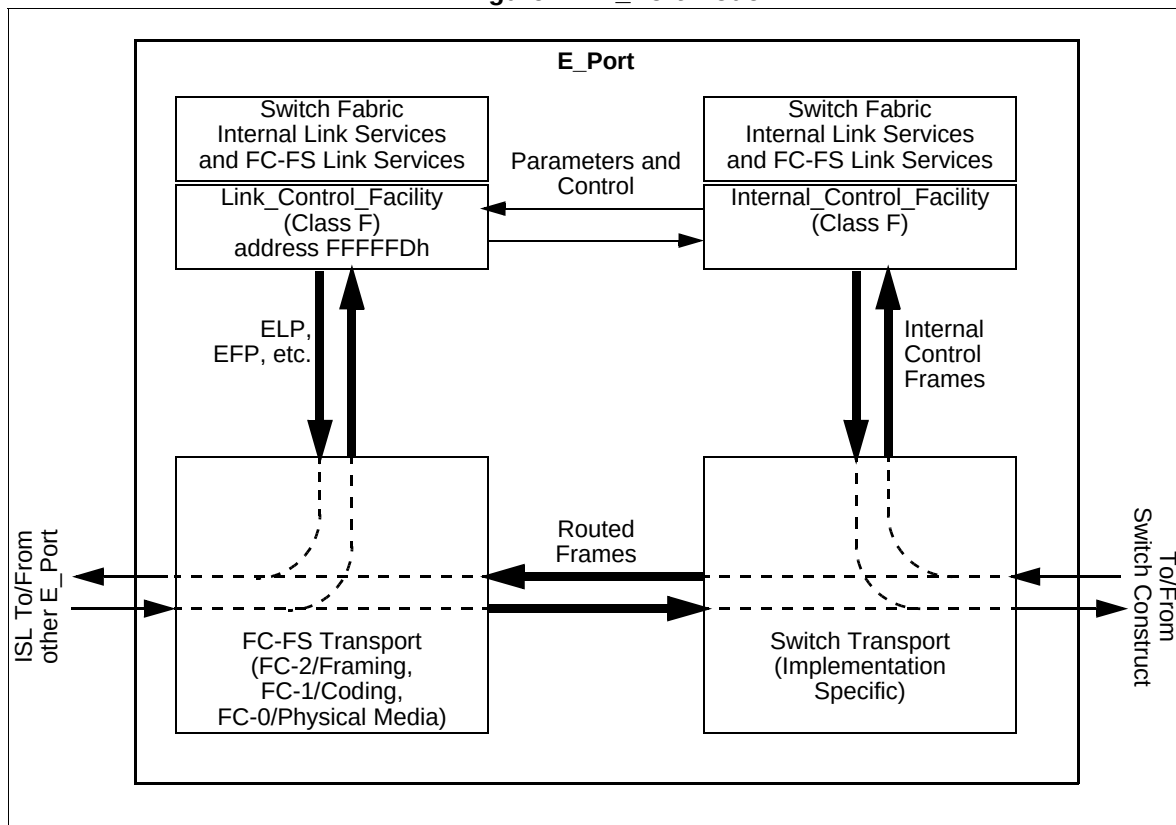
An E_Port is the point at which a Switch is connected to another Switch to create a multi-Switch Fabric. Also, an E_Port is the point at which a Switch is connected to a Bridge device. It normally functions as

a conduit between the Switches for frames destined for remote N_Ports and NL_Ports. An E_Port is also used to carry frames between Switches for purposes of configuring and maintaining the Fabric.

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

The model of an E_Port is shown in figure 7.

Figure 7 – E_Port Model



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

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

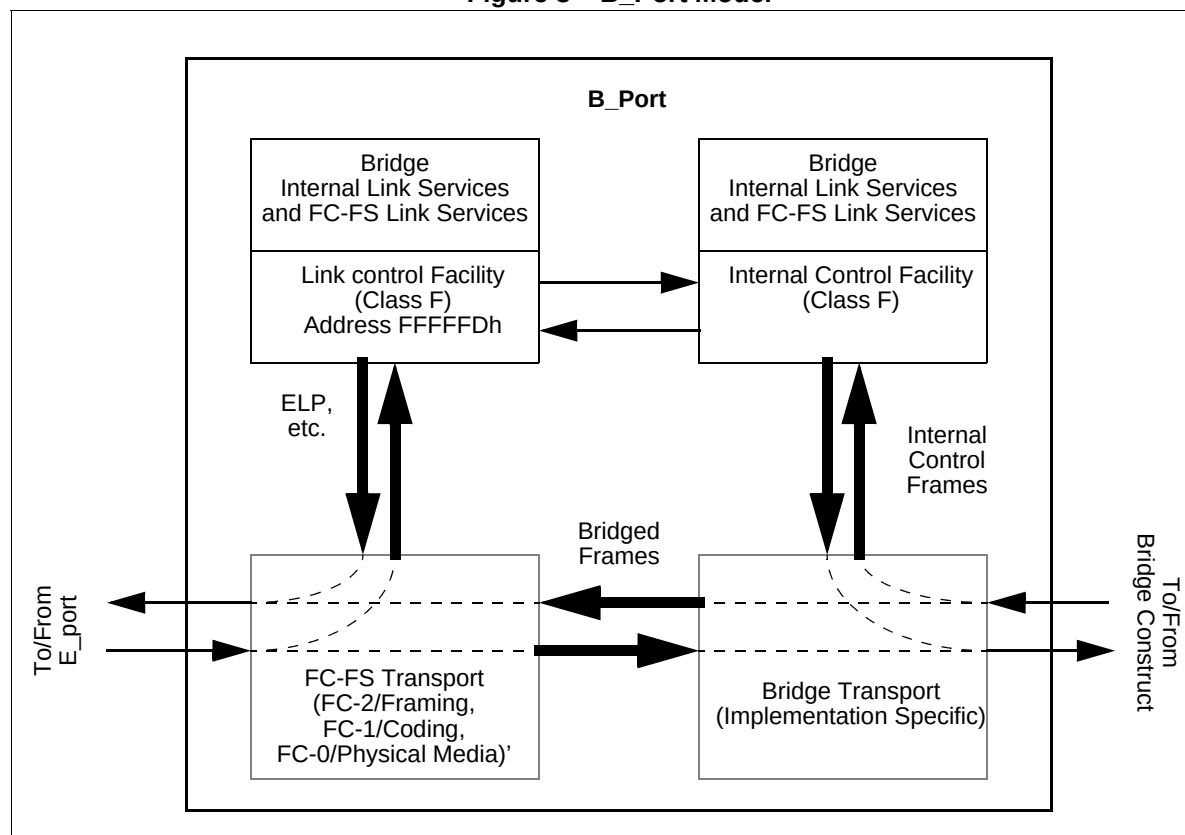
5.6 B_Port operation

A Bridge Port (B_Port) is a port that is used to connect a Switch to Bridge device. It normally functions as a conduit between the Switch and the Bridge for frames destined for or through a Bridge device. A B_Port is also used to carry frames between a Switch and the Bridge device for purposes of configuring the Bridge device.

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

The model of a B_Port is shown in figure 8.

Figure 8 – B_Port Model



A B_Port contains an FC-FS Transport element through which pass all frames and Primitives transferred across the Link to and from the E_Port. Frames received from the attached E_Port are either directed to the Bridge Construct via the Bridge Transport element, or directed to the Link_Control_Facility. The Link_Control_Facility receives frames related to Bridge Fabric Internal Link Services such as ELP, and transmits responses to those Link Service frames.

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

The Bridge Port utilizes Class F service as a connectionless service exchanging frames between E_ports and B_Ports. The definition of Class F function and Class F rules apply to both E_ports and B_Ports as defined in 5.8.

5.7 Inter-Switch Link Behavior

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

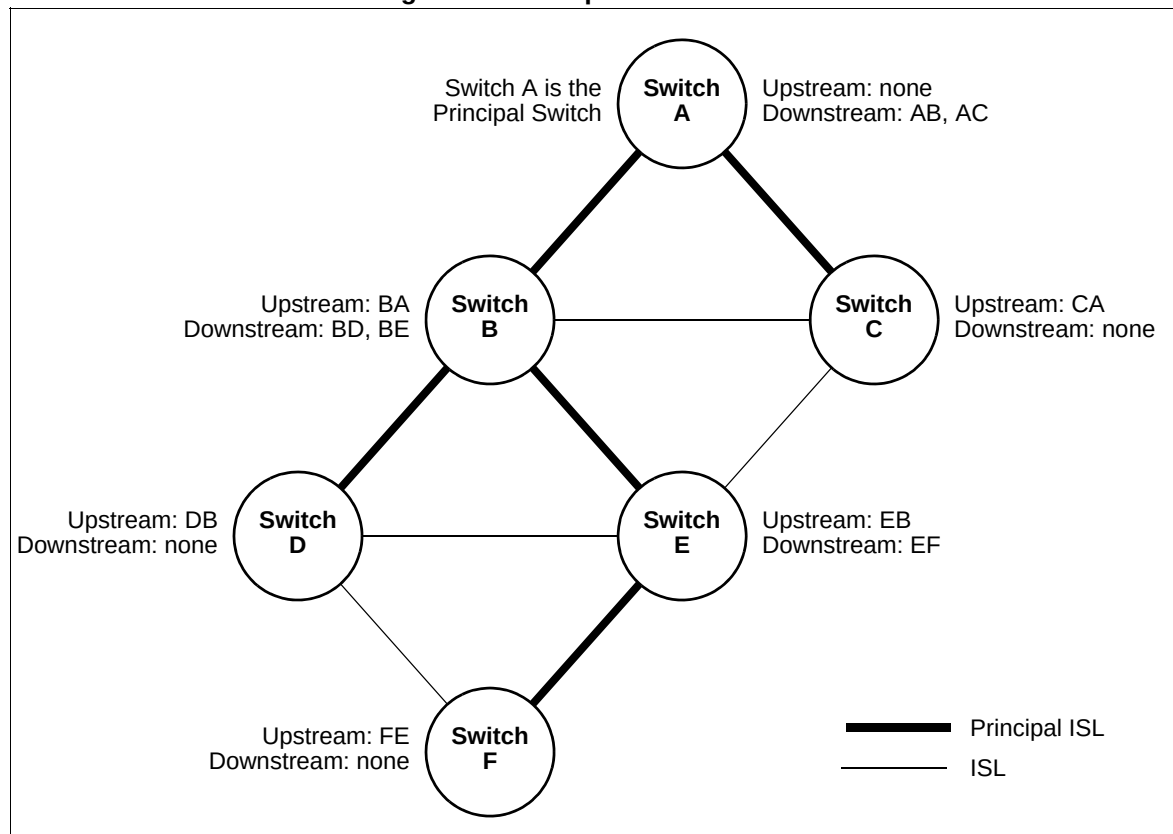
An ISL follows the FC-0, FC-1, and FC-2 protocols defined for point-to-point Links as defined in FC-FS, with the exception that Class F frames are allowed to transit the Link. R_RDY shall be used for the management of buffer-to-buffer flow control of Class F frames on the ISL prior to the completion of the exchange of Link parameters (see 6.1.4 and 7.2); an alternate method of buffer-to-buffer flow control may be defined in that process.

For purposes of defining and maintaining the Fabric Configuration, an ISL may be designated as a Principal ISL. The Principal ISL is a path that is used during configuration and address assignment to route Class F configuration frames, and is therefore a known path between two Switches. If a Principal ISL is lost, there may be no other available paths between the two affected Switches, so as a result the Fabric Configuration is possibly broken and shall be rebuilt (by issuing the BF SW_ILS, see 6.1.11). If a non-Principal ISL is lost, at least one other path is known to be available between the Switches (i.e., the Principal ISL), therefore the lost ISL may be resolved via a routing change.

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

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

Principal ISLs are further illustrated in figure 9.

Figure 9 – Principal Inter-Switch Links

5.8 Class F Service

5.8.1 Class F Function

Class F Service is a connectionless service with notification of non-delivery between Interconnect_Ports. Class F service is used for control, coordination, and configuration of the Fabric. Class F Service is defined by this Standard for use by Switches communicating across Inter-Switch Links.

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

5.8.2 Class F Rules

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

- Except for some Switch Fabric Internal Link Service protocols, an Interconnect_Port is required to have exchanged Link parameters (see 6.1.4 and 7.2) with the associated destination with which it intends to communicate (Login).
- The Fabric routes the frames without establishing a Dedicated Connection between communicating Interconnect_Ports. To obtain Class F service, the Interconnect_Port shall use Class F delimiters as defined in 5.8.3. (Connectionless service)

- c) An Interconnect_Port is allowed to send consecutive frames to one or more destinations. This enables an Interconnect_Port to demultiplex multiple Sequences to a single or multiple destinations concurrently (Demultiplexing).
- d) A given Interconnect_Port may receive consecutive frames from different sources. Each source is allowed to send consecutive frames for one or more Sequences. (multiplexing)
- e) An Interconnect_Port addressed by a Class F frame shall provide an acknowledgment to the source for each valid Data frame received. The destination Interconnect_Port shall use ACK_1 for the acknowledgment. If a Switch is unable to deliver the ACK_1 frame, the Switch shall return an F_BSY or F_RJT. (Acknowledgment)
- f) The Sequence Initiator shall increment the SEQ_CNT field of each successive frame transmitted within a Sequence. However, the Switches may not guarantee delivery to the destination in the same order of transmission. (Non-sequential delivery)
- g) Since the SOFf delimiter does not indicate whether a frame is the first frame of a Sequence, the starting SEQ_CNT of every Sequence shall be zero. (Sequence reassembly)
- h) An Interconnect_Port may originate multiple Exchanges and initiate multiple Sequences with one or more Interconnect_Ports. The Interconnect_Port originating an Exchange shall assign an X_ID unique to the Originator called OX_ID and the Responder of the Exchange shall assign an X_ID unique to the responder called RX_ID. The value of OX_ID or RX_ID is unique to a given Interconnect_Port. The Sequence Initiator shall assign a SEQ_ID, for each Sequence it initiates, that is unique to the Sequence Initiator and the respective Sequence Recipient pair while the Sequence is Open. (Concurrent Exchanges and Sequences)
- i) Each Interconnect_Port exercises buffer-to-buffer flow control with the Interconnect_Port to which it is directly attached. End-to-end flow control is performed by communicating Interconnect_Ports. ACK_1 frames are used to perform end-to-end flow control and R_RDY is used for buffer-to-buffer flow control. However, some other agreed upon methods outside the scope of this standard may be used for buffer-to-buffer flow control. (Dual flow control)
- j) If a Switch is unable to deliver the frame to the destination Interconnect_Port, then the source is notified of each frame not delivered by an F_BSY or F_RJT frame with corresponding D_ID, S_ID, OX_ID, RX_ID, SEQ_ID, and SEQ_CNT from the Switch. The source is also notified of valid frames busied or rejected by the destination Interconnect_Port by P_BSY or P_RJT. (Non-delivery)
- k) A busy or reject may be issued by an intermediate Interconnect_Port or the destination Interconnect_Port with a valid reason code. (Busy/reject)
- l) If a Class F Data frame is busied, the sender shall retransmit the busied frame up to the ability of the sender to retry, including zero. (Retransmit)
- m) The Credit established during the ELP protocol by interchanging Link Parameters shall be honored. Class F may share Credit with other classes of service. (Credit)
- n) Effective transfer rate between any given Interconnect_Port pair is dependent upon the number of Interconnect_Ports a given Interconnect_Port is multiplexing and demultiplexing. (Bandwidth)
- o) Frames within a Sequence are tracked on a Sequence_Qualifier and SEQ_CNT basis. (Tracking)

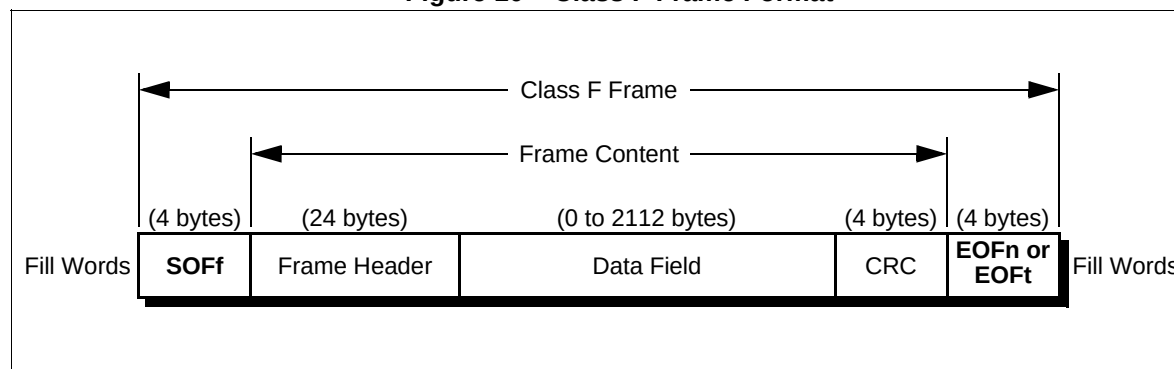
- p) An Interconnect_Port shall be able to recognize SOF delimiters for Class N service, whether or not all classes of service are supported by the Port. (Invalid Class)
- q) An Interconnect_Port addressed by a Vendor Specific Class F frame, shall send an LS_RJT if it does not understand the frame. A Vendor Specific Class F frame is indicated by an R_CTL field value of F0h. (Vendor specific)
- r) An Interconnect_Port shall support insertion of Class F frames onto an established Class 1 Dedicated Connection. However, this insertion shall not cause loss of any Class 1 frames. A Switch may abort (EOFa) or discard an Intermixed Class 2 or Class 3 frame in progress if its transmission of a Class F frame interferes. A Switch shall not abort an Inserted Class F frame. (Class F intermix)
- s) An Interconnect_Port shall use R_RDY and FC-FS buffer-to-buffer flow control with the Interconnect_Port to which it is directly attached, until after the exchange of Link parameters (see 6.1.4 and 7.2). The BB_Credit prior to the exchange of Link parameters shall be 1. An Interconnect Port may agree to use an alternate buffer-to-buffer credit model for Class F following the successful exchange of Link parameters. (Alternate credit models)
- t) A Class F frame shall be forwarded to its destination without checking by an intermediate entity. A Class F frame not destined for the receiving E_Port (or E_Port's domain) shall always be forwarded regardless of whether or not the receiving E_Port recognizes the frame. (Frame forwarding)

5.8.3 Class F Frame Format

Class F frames shall use the Frame_Header defined in FC-FS. The Class F frame format is shown in figure 10. The Start_of_Frame Fabric (SOFf) delimiter shall precede the frame content of all Class F frames. The Data Field size of all Class F frames shall be less than or equal to 256 bytes prior to the successful completion of Exchange Link Parameters (see 6.1.4; Exchange Link Parameters establishes the maximum receive frame size for Class F frames). All Class F frames shall include the CRC defined in FC-FS. The End_of_Frame Normal (EOFn) delimiter shall immediately follow the CRC of all normally completed Class F Data frames and all normally completed Class F Link_Control frames except the last frame of a Sequence. The End_of_Frame Terminate (EO Ft) delimiter shall immediately follow the CRC of all Class F Link_Control frames that indicate the last frame of a normally terminated Sequence. A Class F frame is preceded and followed by Primitive Signals as defined in FC-FS.

An Interconnect_Port or Switch may invalidate or discard without notification any incorrectly formed Class F frame, or any Class F frame with a code violation or CRC error.

Figure 10 – Class F Frame Format



5.8.4 Class F Flow Control

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

After the successful exchange of Link Parameters, an alternate method of buffer-to-buffer flow control may be established on an ISL (see 7.2). This alternate method of buffer-to-buffer flow control remains in effect until a Link Offline or Link Failure occurs, or a new set of Link Parameters is successfully exchanged between the Interconnect_Ports.

ACK_1 frames are used to perform end-to-end flow control. ACK_1 frames shall be formatted as described in 5.8.3. The ACK_0 Link Control frame shall not be used for Class F service.