BS ISO/IEC 14165-432:2022

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Information technology — Fibre channel

Part 432: Security Protocols — 2 (FC-SP-2)

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The UK participation in its preparation was entrusted to Technical Committee TCT/7, Telecommunications - Installation requirements.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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Published by BSI Standards Limited 2024

ISBN 978 0 539 05916 8

ICS 35.200

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 August 2024.

Amendments/corrigenda issued since publication

Date	Text affected

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ISO/IEC 14165-432

Edition 1.0 2022-03

INTERNATIONAL STANDARD

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Information technology – Fibre channel – Part 432: Security Protocols – 2 (FC-SP-2)

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ICS 35.200

ISBN 978-2-8322-1084-0

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INFORMATION TECHNOLOGY – FIBRE CHANNEL –

Part 432: Security Protocols - 2 (FC-SP-2)

FOREWORD

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The text of this International Standard is based on the following documents:

Draft	Report on Voting
JTC1-SC25/2999/CDV	JTC1-SC25/3029/RVC

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Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1, available at www.iec.ch/members_experts/refdocs and www.iso.org/directives

A list of all parts in the ISO/IEC 14165 series, published under the general title *Information technology – Fibre Channel*, can be found on the IEC and ISO websites.

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INTRODUCTION

This standard describes the protocols used to implement security in a Fibre Channel Fabric. This standard includes the definition of protocols to authenticate Fibre Channel entities, protocols to set up session keys, protocols to negotiate the parameters required to ensure frame-by-frame integrity and confidentiality, and protocols to establish and distribute policies across a Fibre Channel Fabric.

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INFORMATION TECHNOLOGY – FIBRE CHANNEL –

Part 432: Security Protocols - 2 (FC-SP-2)

1 Scope

This part of 14165 is one of the Fibre Channel family of standards. This standard describes the protocols used to implement security in a Fibre Channel Fabric. This standard includes the definition of protocols to authenticate Fibre Channel entities, protocols to set up session keys, protocols to negotiate the parameters required to ensure frame-by-frame integrity and confidentiality, and protocols to establish and distribute policies across a Fibre Channel Fabric.

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2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

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3 Terms, definitions, symbols, abbreviated terms, and conventions

3.1 Terms and definitions

For the purposes of this document the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org

- ISO Online browsing platform: available at http://www.iso.org/obp

3.1.1
Access Control
security service that prevents unauthorized use of a resource, including the prevention of use of a resource in an unauthorized manner

3.1.2
address identifier
address value used to identify source (S_ID) or destination (D_ID) of a frame

Note 1 to entry: See FC-FS-3.

3.1.3
Anti-replay
security service that prevents processing of duplicate frames

3.1.4
Ascending order
sorting order in which each entry is positioned in accord with the value of its key(s) to precede all entries with keys of greater value

3.1.5
Authentication
process that verifies an identity

3.1.6
Authentication Initiator
entity initiating an Authentication Transaction

3.1.7
Authentication Protocol
protocol to perform Authentication

3.1.8
Authentication Responder
responding entity in an Authentication Transaction

3.1.9
Authentication Transaction
instance of an Authentication Protocol

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3.1.10
Authorization
process that verifies that an entity is permitted to perform an action

3.1.11
Autonomous Switch
Switch that retains its own per Switch Policy Objects, all Fabric-wide Policy Objects, and all Node to Node (Zoning) information (see 4.8.1)

3.1.12
B_Port
Fabric inter-element port used to connect Bridge devices with E_Ports on a Switch

Note 1 to entry: The B_Port provides a subset of the E_port functionality.

Note 2 to entry: See FC-SW-5.

3.1.13
Bridge
device that encapsulates/de-encapsulates Fibre Channel frames within another protocol

Note 1 to entry: See FC-FS-2.

3.1.14
Certificate
data structure that cryptographically binds an identity to a public key

3.1.15
Certificate Revocation List
list of revoked Certificates issued by a specific CA

3.1.16
Certification Authority
organization or a function that creates, issues and manages Certificates

3.1.17
Child_SA
Security Association used to protect FC-2 frames or CT_IUs

Note 1 to entry: Its parent is an IKE_SA.

3.1.18
Client Switch
Switch that retains its per Switch Policy Objects, all Fabric-wide Policy Objects and the subset of the Node to Node (Zoning) information relevant for its operations (see 4.8.1)

3.1.19
Compliance Element
subset of the features defined in this standard

Note 1 to entry: See Annex A.

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3.1.20
Confidentiality
security service that protects data from unauthorized disclosure

3.1.21
Cryptographic Integrity
security service that ensures integrity by using cryptographic techniques

3.1.22
Data Origin Authentication
security service that verifies the identity of the claimed source of data

3.1.23
E_Port
Fabric “Expansion” Port that attaches to another Interconnect_Port to create an Inter-Switch Link

Note 1 to entry: See FC-SW-5.

3.1.24
Encryption
security mechanism used to transform data from an intelligible form (plaintext) into an unintelligible form (ciphertext), in order to provide confidentiality

Note 1 to entry: The inverse transformation process is called decryption.

3.1.25
entity
something that may communicate using a Fibre Channel topology and has an identity that distinguishes it for the purpose of applying the security features specified in this standard

3.1.26
Ephemeral key
nonce used as an intermediate key within a cryptographic protocol

3.1.27
ESP_Header
optional Header defined in FC-FS-3

3.1.28
Exchange
unit of protocol activity that transfers information between a specific Originator Nx_Port and specific Responder Nx_Port using one or more related non-concurrent Sequences that may flow in the same or opposite directions

Note 1 to entry: See FC-FS-3.

3.1.29
exchange (noun)
pair of related messages one of which is a response to the other one (used in clause 6)

3.1.30
Fabric
entity that interconnects Nx_Ports attached to it and is capable of routing frames by using the D_ID information in a FC-2 frame header

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Note 1 to entry: See FC-FS-3.

3.1.31
F_Port
Link Control Facility within the Fabric that attaches to an N_Port through a link

Note 1 to entry: An F_Port is addressable by the N_Port attached to it, with a common well-known address identifier (FFFFFEh).

Note 2 to entry: See FC-FS-3.

3.1.32
F_Port_Name
Name_Identifier associated with an F_Port

Note 1 to entry: See FC-FS-3.

3.1.33
FC-SP Compliance
set of Compliance Elements that are required to be implemented in order to claim compliance with this standard

Note 1 to entry: See 4.2.

3.1.34
FC-SP Zoning
variant of zoning defined in this standard (see 7.6)

3.1.35
Fx_Port
Switch port capable of operating as an F_Port or FL_Port

Note 1 to entry: See FC-FS-3.

3.1.36
IKE_SA
Security Association used to protect the messages used by the FC SA management protocol, in order to negotiate Child_SAs

3.1.37
Integrity
service that enables detection of modifications to data

3.1.38
Internet Key Exchange
security protocol used for the management of Security Associations in IP networks

Note 1 to entry: The FC SA Management protocol is based on version 2 of IKE, called IKEv2.

3.1.39
Key
value that controls the operation of a cryptographic algorithm

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3.1.40
Local Fx_Port
Fx_Port to which an Nx_Port is directly attached by a link or an Arbitrated Loop

Note 1 to entry: See FC-FS-3.

3.1.41
Log (noun)
one or more collections of information concerning events or conditions that have occurred and may be of interest to security administrator(s)

Note 1 to entry: The mechanism used to maintain a log or logs is vendor specific.

Note 2 to entry: A log may contain sensitive security information and should be appropriately protected.

3.1.42
Log (verb)
to insert information about a specific event or condition into a log

3.1.43
Name_Identifier
64-bit identifier, with a 60-bit value preceded by a 4-bit Network_Address_Authority Identifier, used to identify entities in Fibre Channel

Note 1 to entry: See FC-FS-3.

3.1.44
Node
collection of one or more Nx_Ports controlled by a level above FC-2

Note 1 to entry: See FC-FS-3.

3.1.45
Node_Name
Name_Identifier associated with a Node

Note 1 to entry: See FC-FS-3.

3.1.46
Nonce
unpredictable random value used only for a single instance or invocation of a cryptographic algorithm or protocol

3.1.47
N_Port
hardware entity that includes a Link Control Facility but not Arbitrated Loop functions associated with Arbitrated Loop topology, and has the ability to act as an Originator, a Responder, or both

Note 1 to entry: Well-known addresses are considered to be N_Ports.

Note 2 to entry: See FC-FS-3.

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3.1.48
N_Port_Name
Name_Identifier associated with an Nx_Port

Note 1 to entry: See FC-FS-3.

3.1.49
Nx_Port
port capable of operating as an N_Port or Public NL_Port, but not as a Private NL_Port

Note 1 to entry: See FC-FS-3.

3.1.50
Online Certificate Status Protocol
protocol for online verification of Certificate validity

Note 1 to entry: See RFC 2560.

3.1.51
Password
user generated value known to a limited group of entities

Note 1 to entry: Password based Security Protocols use an entity's knowledge of a password to establish security properties and privileges for that entity.

3.1.52
Perfect Forward Secrecy
security service that ensures that the compromise of a single key does not enable access to data protected by other keys

3.1.53
Printable ASCII characters
ASCII characters in the range 20h through 7Eh

3.1.54
Private Key
in asymmetric cryptography the element of a public-private key pair that shall be kept secret

3.1.55
Public Key
in asymmetric cryptography the element of a public-private key pair that may be made public

3.1.56
RADIUS Server
entity providing the security services defined in RFC 2865

3.1.57
Root Certificate
Certificate for a key that a Certification Authority uses to sign the Certificates that it issues

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3.1.58
Secret
value known to a limited group of entities and generated with sufficient randomness to be computationally intractable to guess

Note 1 to entry: Secret based Security Protocols use an entity's knowledge of a secret to establish security properties and privileges for that entity.

3.1.59
SA_Initiator
entity initiating an SA Management Transaction

3.1.60
SA Management Protocol
protocol to perform management of Security Associations

3.1.61
SA Management Transaction
instance of a SA Management Protocol

3.1.62
SA Proposal
Proposal
set of security parameters proposed to a peer in the process of negotiating an SA

3.1.63
SA_Responder
responding entity in an SA Management Transaction

3.1.64
Salt
random value associated with a password to increase the difficulty of cryptographic attacks

3.1.65
Security Association
uni-directional logical connection created by the SA Management protocol to provide security processing

Note 1 to entry: All traffic belonging to an SA has the same security processing applied to it.

3.1.66
Security Association Database
database maintaining Security Associations

3.1.67
Security Parameters Index
value used by a receiver to identify the SA to which an incoming frame, CT_IU or FC SA message belongs

3.1.68
security relationship
relationship based on shared state among two or more entities that allows the communication among them to be protected by one or more security services

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3.1.69
Server Switch
Switch that retains all Policy Objects and all Node to Node (Zoning) information (see 4.8.1)

3.1.70
Switch
member of the Fabric collective

Note 1 to entry: See FC-SW-5.

3.1.71
Switch_Name
Name_Identifier that identifies a Switch or a Bridge device for identification purposes

Note 1 to entry: See FC-SW-5.

3.1.72
T10 Vendor ID
character string that uniquely identifies a vendor (see 3.5).

3.1.73
well-known address
set of address identifiers defined to access Fabric and other functions (e.g., a name server)

Note 1 to entry: See FC-FS-3.

3.1.74
word
when used to indicate a size, 32 contiguous bits

3.2 Symbols and abbreviated terms

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

=	is equal to
#	number
||	concatenation symbol (e.g., A || B represents the concatenation of A and B)
ACA	Acquire Change Authorization SW_ILS (see FC-SW-5)
AES	Advanced Encryption Standard (see FIPS PUB 197)
CA	Certification Authority
CHAP	Challenge Handshake Authentication Protocol (see RFC 1994)
CRL	Certificate Revocation List
CT	Common Transport (see FC-GS-6)
CT_IU	Common Transport Information Unit (see FC-GS-6)
DH	Diffie-Hellman
DH-CHAP	Diffie-Hellman augmented CHAP
D_ID	Destination address identifier (see FC-FS-3)
ELS	Extended Link Service (see FC-LS-2)
HMAC	Keyed-Hashing for Message Authentication (see RFC 2104)
IANA	Internet Assigned Numbers Authority (see RFC 2434)
ICV	Integrity Check Value
IKEv2	Internet Key Exchange (IKEv2) Protocol (see RFC 5996)
IP	Internet Protocol (see RFC 791 and RFC 2460)

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ISO International Organization for Standardization
ITU International Telecommunication Union
LS_ACC Link Service Accept (see FC-LS-2)
LS_RJT Link Service Reject (see FC-LS-2)
MAC Message Authentication Code
MD5 Message Digest 5 (see RFC 1321)
mod The modulus function
OCSP Online Certificate Status Protocol
OID Object Identifier (see RFC 5280)
prf Pseudo Random Function
RADIUS Remote Authentication Dial In User Service (see RFC 2865)
RCA Remove Change Authorization SW_ILS (see FC-SW-5)
SA Security Association
SADB Security Association Database
SHA-1 Secure Hash Algorithm (see ANSI X9.30.2-1997)
SFC Stage Fabric Configuration SW_ILS (see FC-SW-5)
SPI Security Parameter Index
SSB Server Session Begin CT Request (see FC-GS-6)
SSE Server Session End CT Request (see FC-GS-6)
SW_ILS Switch Internal Link Service (see FC-SW-5)
SW_ACC Switch Fabric Link Service Accept (see FC-SW-5)
SW_RJT Switch Fabric Link Service Reject (see FC-SW-5)
S_ID Source address identifier (see FC-FS-3)
SRP Secure Remote Password (see RFC 2945)
T_ID Transaction Identifier
TCP Transmission Control Protocol (see RFC 793)
UDP User Datagram Protocol (see RFC 768)
UFC Update Fabric Configuration SW_ILS (see FC-SW-5)
UTC Universal Time Code

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.

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 is shown in table 1.

Table 1 – ISO and American conventions

ISO	American
0,6	0.6
1 000	1,000
1 323 462,9	1,323,462.9

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

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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.

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

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.

A numeric range is indicated by listing the two extremes separated by ".." (e.g., "1 .. 6" indicates the range from 1 to 6, including 1 and 6).

Optional parameters are enclosed in square brackets (e.g., [X] indicates that X is an optional parameter), except in the clause 7 policy enforcement definitions, where square brackets enclose restricted identifiers (e.g., [N(α)] indicates a restriction on access for the Switch with Node_Name α. See table 141 for additional examples).

The notation SK { ... } is used in clause 6 to indicate encrypted and integrity protected IKE Payloads (see 6.1.2).

3.4 Keywords

3.4.1 expected: A 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.

3.4.2 ignored: When speaking of a bit, byte, word, field, or code value, this keyword indicates that the object is unused. 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. When speaking of a protocol step or event, this keyword indicates that the recipient of the protocol step or event shall take no action.

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

3.4.4 Invocable: A keyword referring to a feature or parameter that is required to be implemented by an entity to which a request may be sent, but it is not required to be used by a requesting entity.

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

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

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

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

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

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3.4.10 prohibited: A keyword referring to a feature that shall not be used between entities compliant with this standard.

3.4.11 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 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.

3.4.12 restricted: A 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.

3.4.13 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.

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

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

3.5 T10 Vendor ID

A T10 Vendor ID shall be a string of one to eight characters that is recorded in an informal list of Vendor IDs maintained by INCITS Technical Committee T10 (see http://www.t10.org).

A field described as containing a T10 Vendor ID shall contain the first character of the T10 Vendor ID in the first byte of the field, and successive characters of the T10 Vendor ID in successive bytes of the field. Any bytes of the field not filled by characters of the T10 Vendor ID shall be filled with ASCII space characters (20h).

3.6 Sorting

3.6.1 Sorting alphabetic keys

An alphabetic key is an ordered series of bytes containing printable ASCII characters. Alphabetic keys are sorted by comparison of the values in their corresponding bytes (i.e., bytes at the same offset within the key):

a) one alphabetic key is equal to another alphabetic key if the two keys are the same length and each byte of the one is equal to the corresponding byte of the other; and

b) one alphabetic key is greater than another alphabetic key if:

   A) the first byte of the one alphabetic key in which the two keys differ is greater than the corresponding byte in the other alphabetic key; or

   B) there are no corresponding bytes of the two alphabetic keys that differ, but the one alphabetic key is longer than the other alphabetic key.

NOTE 1 – Unlike dictionary sorting, alphabetic key sorting compares the actual ASCII values of alphabetic characters of different case (i.e., a lower case character is not equal to its corresponding upper case character).

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3.6.2 Sorting numeric keys

A numeric key is an unsigned integer of arbitrary size. Numeric keys are sorted by numeric comparison of their values.

3.7 Terminate communication

This standard often uses language of the form “If the Authentication fails the entity shall terminate the communication.” This means that any further communication between the two involved entities is forbidden. More specifically, when an Authentication Transaction occurs in specific states of a state machine, the meaning is as follows:

a) When an Authentication Transaction is performed between E_Ports in state P17a (see 8.9.1) or in state P22 (see 8.9.3), terminate communication means going in state P16 (Invalid Attachment).

b) When an Authentication Transaction is performed between an E_Port and a B_Port in state P19 (see 8.9.2), terminate communication means going in state P16 (Invalid Attachment).

c) When an Authentication Transaction is performed between VE_Ports in state P24$^{(k)}$a (see 8.9.3), terminate communication means going in state P26$^{(k)}$ (Logical Isolation).

d) When an Authentication Transaction is performed between two Domain Controller addresses (see FC-SW-5), terminate communication means that no further communication occurs between the involved Domain Controller addresses.

e) When an Authentication Transaction is performed between an N_Port or a VN_Port and another N_Port or VN_Port, terminate communication means that no further communication occurs between the two entities.

f) When an Authentication Transaction is performed between an N_Port and an F_Port, terminate communication means that no further communication occurs between the involved FC_Ports (the situation is equivalent to a Fabric Logout).

g) When an Authentication Transaction is performed between a VN_Port and a VF_Port, terminate communication means that no further communication occurs between the involved Virtual FC_Ports (the situation is equivalent to a Fabric Logout in that particular Virtual Fabric).

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3.8 State machine notation

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

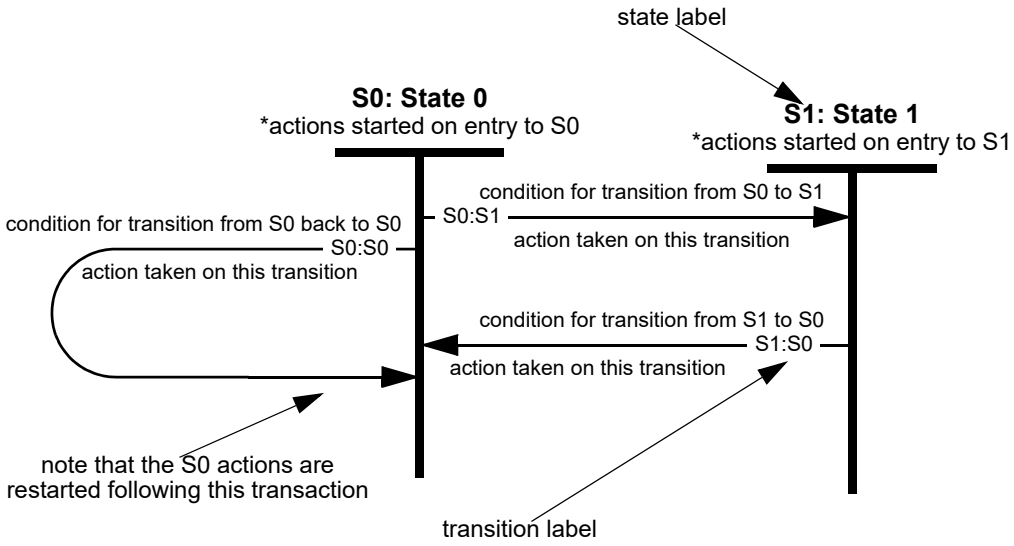

Figure 1 – State machine example

These state machines make three assumptions:

a) Time elapses only within discrete states.

b) 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.

c) Every time a state is entered, the actions of that state are started. 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.

3.9 Using numbers in hash functions and concatenation functions

When a numeric value is used as a bit string argument to a function (e.g., inputs to hash functions and concatenation functions), unless otherwise specified, the numeric value is represented as a bit string as follows:

a) if the numeric value used as a bit string argument to a function is determined by reference to a field with size determined by this standard, its bit string representation is the entire field that contained it; and

b) if the numeric value used as a bit string argument to a function is not determined by reference to a field with size determined by this standard and the numeric value is the output of a function or the result of an arithmetic computation, the bit string representation of the numeric value is the bit string that:

   A) has the same value when interpreted as a binary number; and

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B) has as many bits as the shortest bit string that is capable of representing all possible outputs of the function or computation.

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4 Structure and Concepts 4.1

Overview

The variety of environments in which Fibre Channel fabrics are deployed makes it difficult to rely on physical security. Storage subsystems may be accessed by different users over Fabrics that may span several sites. Security services are extremely important to prevent misconfigurations or access to data by non-authorized entities.

This standard defines mechanisms that may be used to protect against several classes of threats. These mechanisms include protocols to authenticate Fibre Channel entities, protocols to set up session keys, protocols to negotiate parameters to ensure frame-by-frame integrity and confidentiality, and protocols to define and distribute policies across a Fibre Channel Fabric.

The appropriate amount of security to deploy and the appropriate interfaces to protect are highly business and technology environment dependent. It is advisable that consumers of products based on this standard analyze their security needs, their business processes that require security technology, their flexibility requirements, and the range of available options to determine appropriate methods for mitigating identified risks for their particular environment. Risk mitigation is the core focus of any security technology deployment.

4.2 FC-SP-2 Compliance

To claim FC-SP-2 compliance, an implementation shall support the AUTH-A Compliance Element (see A.2.1). An FC-SP-2 compliant implementation may support additional Compliance Elements. Different combinations of Compliance Elements may be appropriate for different environments.

4.3 Fabric Security Architecture

The security architecture defined by this standard encompasses the following components:

a) Authentication Infrastructure (see 4.4);

b) Authentication (see 4.5);

c) Security Associations (see 4.6);

d) Cryptographic Integrity and Confidentiality (see 4.7); and

e) Authorization (see 4.8).

4.4 Authentication Infrastructure

The Fabric security architecture is defined for several authentication infrastructures. Secret-based, Certificate-based, password-based, and Pre-Shared Key based authentication infrastructures are accommodated. Specific authentication protocols that directly leverage these four authentication infrastructures are defined.

With a secret-based infrastructure, entities within the fabric environment that establish a security relationship share a common secret or centralize the secret administration in a RADIUS server (see Annex D). Entities may mutually authenticate with other entities by using the DH-CHAP protocol (see 5.4). Security Associations may be set up using the session key computed at the end of the DH-CHAP transaction. Frame integrity or confidentiality may be provided by using the ESP_Header (see FC-FS-3).

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With a Certificate-based infrastructure, entities within the fabric environment are certified by a trusted Certificate Authority. The resulting Certificates bind each entity to a public-private key pair that may be used to mutually authenticate with other certified entities via the FCAP protocol (see 5.5). Security Associations may be set up by using these entity Certificates and associated keys or by using the session key computed at the end of the FCAP transaction. Frame integrity or confidentiality may be provided by using the ESP_Header (see FC-FS-3).

With a password-based infrastructure, entities within the fabric environment that establish a security relationship have knowledge of the password-based credential material of other entities. Entities may use this credential material to mutually authenticate with other entities using the FCPAP protocol (see 5.6). Security Associations may be set up using the session key computed at the end of the FCPAP transaction. Frame integrity or confidentiality may be provided by using the ESP_Header (see FC-FS-3).

With a Pre-Shared Key based infrastructure, entities within the fabric environment that establish a security relationship have knowledge of the Pre-Shared Key based credential material of other entities. An example shared key infrastructure is shown in Annex B. Entities may use this credential material to mutually authenticate with other entities using the FCEAP protocol (see 5.7). Security Associations may be set up using the session key computed at the end of the FCEAP transaction. Frame integrity or confidentiality may be provided by using the ESP_Header (see FC-FS-3).

4.5 Authentication

Authentication Protocols are defined to allow entities to ensure the identity of the entities with which they are communicating. Two entities may negotiate whether authentication is required and which Authentication Protocol may be used. Authentication is defined for Switch to Switch, Node to Switch, and Node to Node. The defined Authentication Protocols are able to perform mutual authentication with optional shared key establishment. The shared key computed at the end of an Authentication Transaction may be used to establish Security Associations, as shown in figure 2.

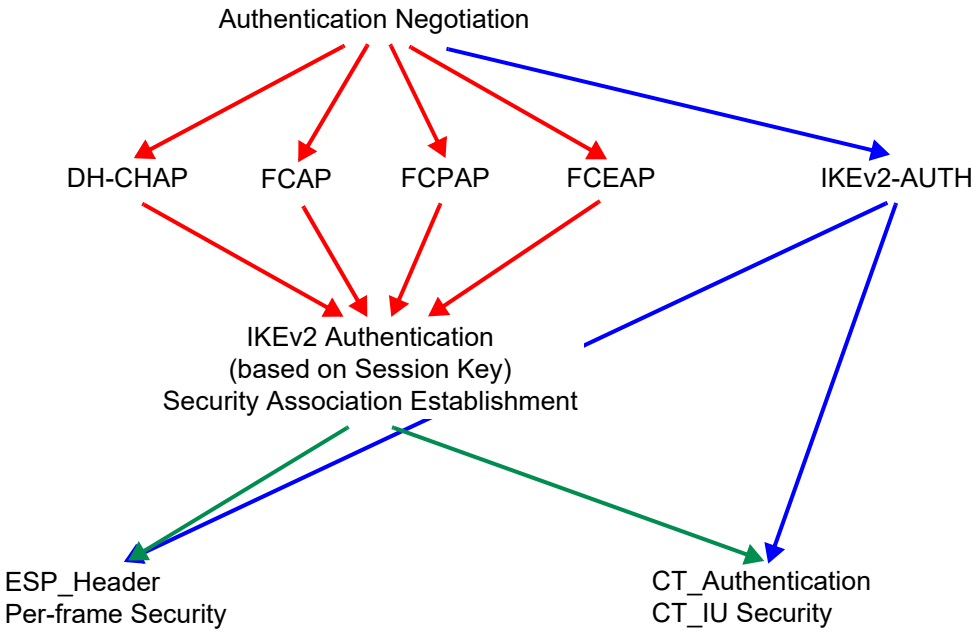

Figure 2 – Relationship between Authentication Protocols and Security Associations

The following Authentication Protocols are defined:

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a) Diffie-Hellman Challenge Handshake Authentication Protocol (DH-CHAP, see 5.4);

b) Fibre Channel Certificate Authentication Protocol (FCAP, see 5.5);

c) Fibre Channel Password Authentication Protocol (FCPAP, see 5.6);

d) Fibre Channel Extensible Authentication Protocol (FCEAP, see 5.7); and

e) The Security Association Management Protocol (IKEv2-AUTH, see 6.7.3).

NOTE 2 – Using the Security Association Management Protocol for both Authentication and Security Association management (see 6.7.3) usually has better security properties than concatenating the Security Association Management Protocol to another Authentication protocol. However concatenating the Security Association Management Protocol to another Authentication protocol (see 6.7.2) leverages the authentication infrastructure associated with that Authentication protocol and this may be easier to manage.

NOTE 3 – Some Authentication Protocols (e.g., DH-CHAP with a NULL DH algorithm) do not generate the session key needed to concatenate the Security Association Management Protocol to an Authentication protocol (see 5.4.6).

4.6 Security Associations

A subset of the IKEv2 protocol suitable for Fibre Channel (i.e., the Security Association Management protocol, see clause 6) is defined in order to establish Security Associations between entities. Traffic Selectors are defined to specify which type of traffic has to be protected by the Security Association, and what the characteristics of the protection are. Two mechanisms are available to protect specific classes of traffic: the ESP_Header is used to protect FC-2 frames, and CT_Authentication is used to protect Common Transport Information Units.

An entity protecting specific classes of traffic maintains an internal Security Association Database (SADB) that contains the currently active Security Associations and Traffic Selectors.

Each active Security Association is logically associated with an entry in the SADB. A Security Association entry includes the SA's SPI, a Sequence Number counter, and the parameters for the selected transforms (e.g., encryption algorithm, integrity algorithm, mode of operation of the algorithms, keys).

Each active Traffic Selector is logically associated with an entry in the SADB. Two types of Traffic Selector entries may be present:

a) Traffic Selector entries identifying FC-2 frames or CT_IUs to be bypassed or discarded; and

b) Traffic Selector entries identifying FC-2 frames or CT_IUs to be protected or verified. These entries point to the corresponding SA entry defining the parameters and the security processing to be performed.

4.7 Cryptographic Integrity and Confidentiality

4.7.1 Overview

Frame by frame cryptographic integrity and confidentiality, replay protection, and traffic origin authentication is achieved by using the ESP_Header optional header (see FC-FS-3). CT_Authentication (see FC-GS-6) may be leveraged to provide cryptographic integrity and confidentiality, replay protection, and traffic origin authentication to Common Transport Information Units.

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ESP_Header processing and CT_Authentication processing are independent, with two logically separated SADBs that apply to the respective levels (see 4.7.2 and 4.7.3).

NOTE 4 – It is then possible, although not recommended, to set up a set of Security Associations so that CT_Authentication protected CT_IUs are also protected with ESP_Header.

4.7.2 ESP_Header Processing

The ESP_Header is processed according to the model defined in RFC 2401. The ESP_Header processing is performed over selected frames according to a set of Traffic Selectors maintained in the SADB. Traffic Selectors are negotiated when Security Associations are established. Traffic Selectors may be Incoming Traffic Selectors, used to process incoming frames, or Outgoing Traffic Selectors, used to process outgoing frames. Each Traffic Selector has an action associated with it, that has to be applied to a frame that matches it. The action may be one of the following:

a) Bypass: the frame is passed unchanged;

b) Drop: the frame is discarded; or

c) Process: the frame is processed according to the SA pointed by the Traffic Selector.

Figure 3 shows an informative logical model of an entity capable of protecting selected subsets of Fibre Channel frames using the ESP_Header.

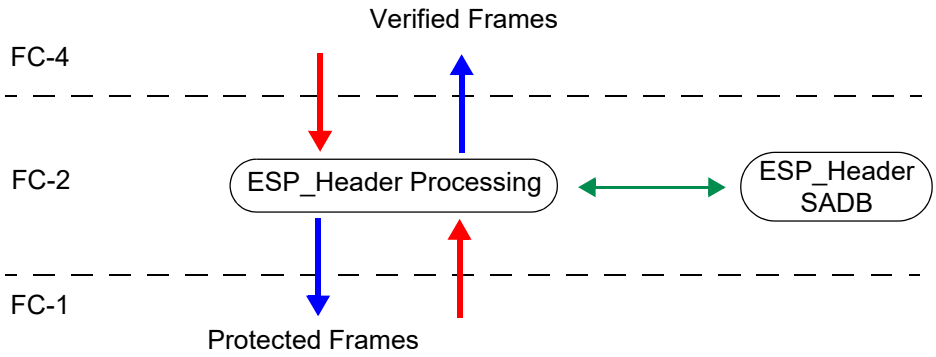

Figure 3 – Logical Model for Integrity and Confidentiality Protection with ESP_Header

When an outgoing frame is received by the ESP_Header Processing module, the SADB is checked to verify if the frame matches an Outgoing Traffic Selector. If there is no match, the frame is sent unchanged. If there is a match, the action associated with the matched Traffic Selector is applied to the frame. If the action is Process, the protecting security transforms defined by the SA pointed by the matched Traffic Selector are applied to the frame.

When an incoming frame not protected by the ESP_Header is received by the ESP_Header processing module, the SADB is checked to verify if the frame matches any of the existing Incoming Traffic Selectors. If there is a match and the action is Process, the frame is discarded. If there is a match and the action is Bypass or Drop, that action is applied to the frame. If there is no match, the frame is discarded.

This means that a frame not protected by the ESP_Header and not matching any Incoming Traffic Selector is discarded. It is possible to reverse this behavior by inserting in the SADB a last Incoming Traffic Selector associated with a Bypass action and that matches all frames. This guarantees a no-drop default behavior, however the security implications of this configuration should be carefully considered by a security administrator.

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When an incoming frame protected by the ESP_Header is received by the ESP_Header processing module, the SPI contained in the frame is used to locate the protecting SA in the SADB. The security transforms associated with the matched SA are applied to the frame and:

a) if all security transforms succeed and the frame matches at least one of the Traffic Selectors associated with the located SA, the processed frame is passed to the upper levels; or

b) if at least one security transform fails or the frame does not match the Traffic Selectors associated with the located SA, the incoming frame is discarded.

The ESP_Header SADB maintains for each established ESP_Header SA the following logical parameters:

a) the 4-byte SPI, mapped on the ESP_Header Security Parameter Index (SPI) field;

b) a 32-bit sequence number counter, mapped on the ESP_Header Sequence Number field;

NOTE 5 – 64-bit extended sequence numbers are not supported by this standard.

c) the security parameters for the negotiated Transforms (e.g., encryption algorithm, integrity algorithm, mode of operation of the algorithms, keys).

d) a sequence counter overflow flag, indicating whether overflow of the sequence number counter generates an auditable event or prevents processing of additional frames on the SA;

e) a 32-bit anti-replay window counter and bit-map, used to determine whether an incoming frame carrying an ESP_Header is a replay; and

f) the lifetime of the Security Association (i.e., a time interval after which the SA has to be replaced with a new SA or terminated).

4.7.3 CT_Authentication Processing

The CT_Authentication processing is performed over selected CT_IUs according to a set of Traffic Selectors maintained in the SADB (Security Associations Database). Traffic Selectors are negotiated when Security Associations are established. Traffic Selectors may be Incoming Traffic Selectors, used to process incoming CT_IUs, or Outgoing Traffic Selectors, used to process outgoing CT_IUs. Each Traffic Selector has an action associated with it, that has to be applied to a CT_IU that matches it. The action may be one of the following:

a) Bypass: the CT_IU is passed unchanged;

b) Drop: the CT_IU is discarded; or

c) Process: the CT_IU is processed according to the SA pointed by the Traffic Selector.

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Figure 4 shows an informative logical model of an entity capable of protecting selected subsets of Common Transport Information Units with CT_Authentication.

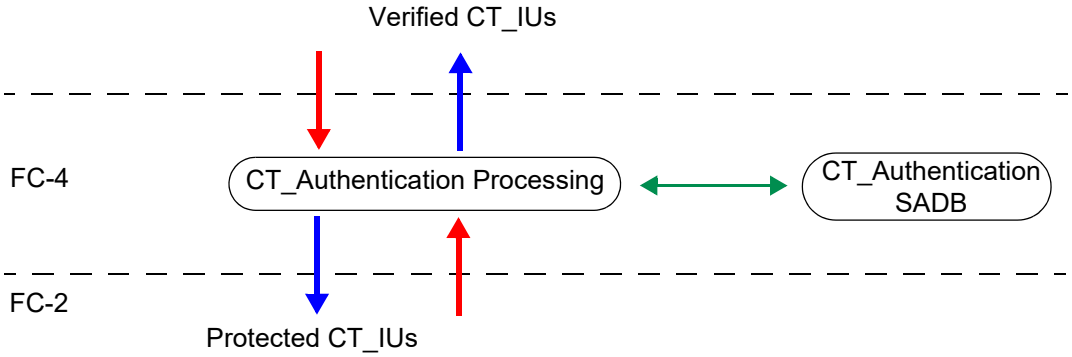

Figure 4 – Logical Model for Integrity and Confidentiality Protection with CT_Authentication

When an outgoing CT_IU is received by the CT_Authentication Processing module, the SADB is checked to verify if the CT_IU matches an Outgoing Traffic Selector. If there is no match, the CT_IU is sent unchanged. If there is a match, the action associated with the matched Traffic Selector is applied to the CT_IU. If the action is Process, the protecting security transforms defined by the SA pointed by the matched Traffic Selector are applied to the CT_IU.

When an incoming CT_IU not protected by CT_Authentication is received by the CT_Authentication processing module, the SADB is checked to verify if the CT_IU matches any of the existing Incoming Traffic Selectors. If there is a match and the action is Process, the CT_IU is discarded. If there is a match and the action is Bypass or Drop, that action is applied to the CT_IU. If there is no match, the CT_IU is discarded.

NOTE 6 – This means that a CT_IU not protected by CT_Authentication and not matching any Incoming Traffic Selector is discarded. It is possible to reverse this behavior by inserting in the SADB a last Incoming Traffic Selector associated with a Bypass action and that matches all CT_IUs. This guarantees a no-drop default behavior, however the security implications of this configuration should be carefully considered by a security administrator.

When an incoming CT_IU protected by CT_Authentication is received by the CT_Authentication processing module, the SAID contained in the CT_IU is used to locate the protecting SA in the SADB. The security transforms associated with the matched SA are applied to the CT_IU and:

a) if all security transforms succeed and the CT_IU matches at least one of the Traffic Selectors associated with the located SA, the processed CT_IU is passed to the upper levels; or

b) if at least one security transform fails or the CT_IU does not match the Traffic Selectors associated with the located SA, the incoming CT_IU is discarded.

The CT_Authentication SADB maintains for each established CT_Authentication SA the following logical parameters:

a) the 4-byte SPI, mapped on the CT_IU Authentication SAID field;

b) a 32-bit sequence number counter, mapped on the CT_IU Time Stamp field;

c) the security parameters for the negotiated Transforms (e.g., encryption algorithm, integrity algorithm, mode of operation of the algorithms, keys).

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d) a sequence counter overflow flag, indicating whether overflow of the sequence number counter generates an auditable event or prevent processing of additional CT_IUs on the SA;

e) a 32-bit anti-replay window counter and bit-map, used to determine whether an incoming CT_IU protected with CT_Authentication is a replay; and

f) the lifetime of the Security Association (i.e., a time interval after which the SA has to be replaced with a new SA or terminated).

4.8 Authorization (Access Control)

4.8.1 Policy Definition

Fabric policies provide basic authorization controls in the form of access control lists (ACLs). Two basic types of policies are defined:

a) policies that contain Fabric-wide data, distributed to every Switch of the Fabric; and

b) policies that contain per Switch data, sent to an individual Switch.

Fabric policies may be used to control which Switches are allowed in a Fabric and which Nodes are allowed to connect to a Fabric. Policies may be further used to specify topology restrictions within the Fabric environment (e.g., which Switches may connect to which other Switches or which Nodes may connect to which Switches).

Fabric policies also provide the mechanism for controlling management access to the Fabric and the ability to control authentication choices and to specify security attributes for Fabric entities (e.g., Nodes and Switches). Management access to the Fabric may be controlled for Common Transport or IP access.

A policy configuration is composed by a set of Policy Objects (see 7.1). Each Policy Object is summarized in a hash value. The enforcement of a policy configuration is performed with the definition of a Policy Summary Object (i.e., a Fabric-wide Object that consists of the names of all the Policy Objects along with their associated hashes). The Policy Summary Object allows an easy comparison of policy configurations.

Zoning policies (i.e., FC-SP Zoning) are defined to encode Node to Node restrictions in a form consistent with the Policy model (see 7.6).

Fabric policies and Zoning policies allow an asymmetric distribution of policy information in the Fabric with the definition of three types of Switches (see 7.1.4):

a) Server Switches: Switches that retain all Policy Objects and all Node to Node (Zoning) information;

b) Autonomous Switches: Switches that retain their own per Switch Policy Objects, all Fabric-wide Policy Objects, and all Node to Node (Zoning) information; and

c) Client Switches: Switches that retain their per Switch Policy Objects, all Fabric-wide Policy Objects and the subset of the Node to Node (Zoning) information relevant for their operations, which is pulled from a Server Switch when needed. In addition, they maintain the Zone Set Database Hash and the Active Zone Set Hash for the Fabric (see 7.6).

4.8.2 Policy Enforcement

Policy enforcement occurs whenever a connection is attempted, a management application attempts to access the Fabric, or a new policy configuration is activated (see 7.2). The appropriate Policy Objects are

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checked to determine whether the requested connection or access is to be allowed or denied. The Policy enforcement is performed locally by the entities involved in the connection or access attempt.

4.8.3 Policy Distribution

Distribution mechanisms are defined to ensure that policy information is distributed to the appropriate Switches in the Fabric (see 7.3).

4.8.4 Policy Check

When two Switches join they ensure that their enforced policy configurations are the same. They do this by exchanging their Policy Summary Objects. If the compared Policy Summary Objects are identical, then the join is allowed, otherwise the join is denied (see 7.4).

4.9 Name Format

This standard uses the name format shown in table 2 to identify entities (e.g., for Authentication or Fabric Policies).

Table 2 – Name Format

Item	Size (Bytes)
Name Tag	2
Name Length	2
Name Value	variable

Name Tag: Identifies the format of the name. Tag values are defined in 5.3.3 and 7.1.2.

Name Length: Indicates the total length in bytes of the Name Value.

Name Value: Contains the name value, according to the specified Name Tag.

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5 Authentication Protocols 5.1

Overview

Secure relationships are possible only between known entities. Authentication is the process by which an entity is able to verify the identity of another entity, thus providing the foundation for secure relationships.

Different Authentication Protocols may be used to validate an entity on the basis of different parameters, (e.g., digital Certificates, secrets, or passwords). Selection of allowed and preferred security protocols and parameters is a decision made by a security administrator.

Each entity is identified by a name. The purpose of an Authentication Protocol is to verify that a claimed name is associated with the claiming entity. The Authentication Protocols may be used to authenticate Nx_Ports, B_Ports, or Switches. When an Nx_Port authenticates with a Switch, the authentication is established to the whole Fabric because the Switch identity serves as a proxy for the Fabric of which the Switch is a member.

An Authentication Transaction occurs between an Authentication Initiator and an Authentication Responder. An Authentication Transaction (see figure 5) is identified by a unique Transaction Identifier. The Authentication Initiator starts the Authentication Transaction by sending the AUTH_Negotiate message (see 5.3.2) to the Authentication Responder. In the AUTH_Negotiate message, the Authentication Initiator shall specify the Transaction Identifier, and shall send its own name, together with the list of proposed Authentication Protocols and associated parameters that may be used in the transaction. The Authentication Responder shall choose from the proposed Authentication Protocols and associated parameters the ones to be used to perform the Authentication, and reply with an appropriate AUTH message (see 5.2.1).

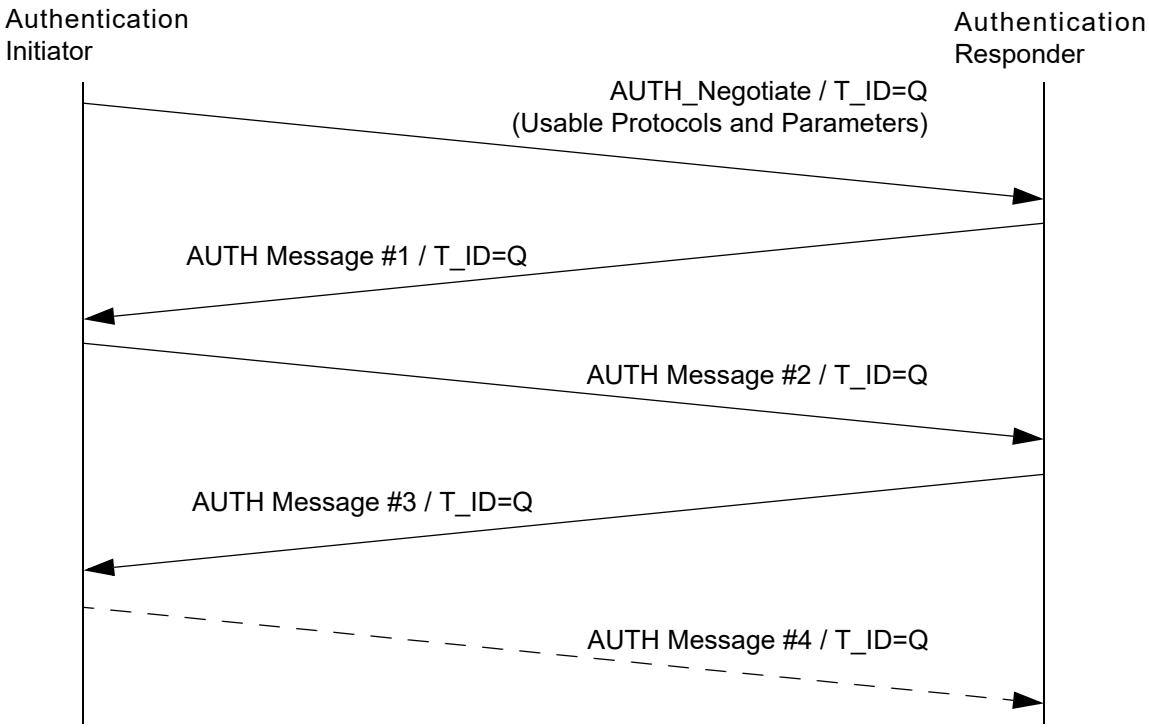

Figure 5 – A Generic Authentication Transaction

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The Authentication Protocols allow any Fibre Channel entity to act as an Authentication Initiator or as an Authentication Responder. A Fibre Channel entity may initiate an Authentication Transaction whenever needed. No more than one transaction of an Authentication Protocol shall be in progress between the same two entities at a time. If two communicating entities start an Authentication Transaction at the same time, a case by case rule (see 5.8.1 and 5.10.1) determines which transaction shall be aborted and which one shall be continued.

If a Fibre Channel entity is not acting as an Authentication Initiator or Authentication Responder and receives an AUTH_Negotiate message, it shall reply to that message as specified by the Authentication Protocol of its choosing, becoming the Authentication Responder.

If a Fibre Channel entity is acting as an Authentication Initiator and receives an AUTH_Negotiate message from the designated Authentication Responder, one of the two Authentication Transactions shall be aborted (see 5.8.1 and 5.10.1). The Fibre Channel entity that remains the Authentication Initiator shall reply to the received AUTH_Negotiate message with an appropriate AUTH_Reject message. The Fibre Channel entity that becomes the Authentication Responder shall reply to the received AUTH_Negotiate message and abort its own transaction upon receipt of the AUTH_Reject message.

Each Authentication Protocol specifies the conditions required for an Authentication Transaction to complete successfully. If an Authentication Transaction does not complete successfully, an Authentication failure shall occur and appropriate actions shall be taken (e.g., terminate the communication).

An AUTH message may receive a response with an error indication of:

a) AUTH_Reject message (see 5.3.7);

b) SW_RJT (see 5.8.3 and 5.9.3); or

c) LS_RJT (see 5.10.3).

Two error indications shall not be generated in response to one AUTH message. If a lower level error is detected (e.g., the AUTH_Negotiate ELS or SW_ILS is not supported) an appropriate LS_RJT or SW_RJT shall be generated. If the received message is correct for the lower level, but there are Authentication problems, then an appropriate AUTH_Reject message shall be generated.

5.2 Authentication Messages Structure

5.2.1 Overview

The Authentication Protocols may be used to authenticate Nx_Ports, B_Ports, or Switches. The Authentication messages are transmitted as SW_ILSs when the involved entities are Switches or B_Ports, and as ELSs when the involved entities include at least one Nx_Port. All Authentication messages share the same message structure, and are referred to as AUTH messages.

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5.2.2 SW_ILS Authentication Messages

When an AUTH message is transmitted between Switches (e.g., for E_Port to E_Port or Domain_Controller to Domain_Controller Authentication), it is transmitted as an SW_ILS and is referred to as an AUTH_ILS message (see table 3). The AUTH_ILS message is propagated by B_Ports.

Table 3 – AUTH_ILS Message Format

Item	Size (Bytes)
AUTH_ILS Code = 40h	1
AUTH_ILS Flags	1
AUTH Message Code	1
Protocol Version	1
Message Length	4
Transaction Identifier (T_ID)	4
Message Payload	variable

AUTH_ILS Flags: The AUTH_ILS flags are shown in table 4.

Table 4 – AUTH_ILS Flags

Bit	Description
7	Shall be set to 0
6	Concatenation Flag
5 .. 1	Reserved
0	Shall be set to 0

Concatenation Flag: Used to concatenate multiple AUTH transactions, a capability referred to as AUTH Concatenation. As an example of usage, AUTH Concatenation enables an SA Management Transaction to be concatenated to an Authentication Transaction (see 6.7.2). When the Concatenation Flag is set to one in AUTH_Negotiate, the Authentication Initiator requires AUTH Concatenation. If the Authentication Responder does not support AUTH Concatenation, an AUTH_Reject with Reason Code ‘Logical Error’ and Reason Code Explanation ‘AUTH Concatenation not Supported’ shall be returned (see 5.3.7). The Authentication Initiator may restart the Authentication Transaction without setting the Concatenation Flag, if appropriate. If the Authentication Responder supports AUTH Concatenation, the Concatenation Flag shall be set to one in all subsequent messages belonging to that transaction, otherwise an AUTH_Reject with Reason Code ‘Authentication Failure’ and Reason Code Explanation ‘Incorrect Authentication Protocol Message’ shall be returned (see 5.3.7).

See 5.2.4 for the definition of the other AUTH_ILS fields.

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When an AUTH message is transmitted between an E_Port and a B_Port, it is transmitted as an SW_ILS and is referred to as a B_AUTH_ILS message (see table 5). The B_AUTH_ILS message is terminated by B_Ports.

Table 5 – B_AUTH_ILS Message Format

Item	Size (Bytes)
B_AUTH_ILS Code = 41h	1
B_AUTH_ILS Flags	1
AUTH Message Code	1
Protocol Version	1
Message Length	4
Transaction Identifier (T_ID)	4
Message Payload	variable

B_AUTH_ILS Flags: The B_AUTH_ILS flags are equal to the AUTH_ILS flags, shown in table 4.

See 5.2.4 for the definition of the other B_AUTH_ILS fields.

5.2.3 ELS Authentication Messages

When an AUTH message is transmitted between an Nx_Port and an Fx_Port or between Nx_Ports, it is transmitted as an ELS, and is referred to as an AUTH_ELS message (see table 6).

Table 6 – AUTH_ELS Message Format

Item	Size (Bytes)
AUTH_ELS Code = 90h	1
AUTH_ELS Flags	1
AUTH Message Code	1
Protocol Version	1
Message Length	4
Transaction Identifier (T_ID)	4
Message Payload	variable

Flags: The AUTH_ELS flags are shown in table 7.

Table 7 – AUTH_ELS Flags

Bit	Description
7	1 = More Fragments Follow 0 = No More Fragments (see 5.10.4)
6	Concatenation Flag
5 .. 1	Reserved
0	Sequence Number (see 5.10.4)

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