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Edition 1.0 2019-10

INTERNATIONAL STANDARD

**Information technology – Small computer system interface (SCSI) –
Part 224: Fibre Channel Protocol for SCSI, fourth version (FCP-4)**



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INFORMATION TECHNOLOGY – SMALL COMPUTER SYSTEM INTERFACE (SCSI) – Part 224: Fibre Channel Protocol, fourth version (FCP-4)

FOREWORD

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The list of all currently available parts of the ISO/IEC 14776 series, under the general title *Information technology – Small computer system interface (SCSI)*, can be found on the IEC and ISO websites.

The text for this standard is based on the following document:

CDV	Report on voting
JTC1-SC25/2833/CDV	JTC1-SC25/2881/RVC

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2 except as indicated in 3.4.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

The Small Computer System Interface (SCSI) command set is widely used and applicable to a wide variety of device types. The transmission of SCSI command set information across Fibre Channel links allows the large body of SCSI application and driver software to be successfully used in the high performance Fibre Channel environment.

This standard describes the protocol for transmitting SCSI commands, data, and status using Fibre Channel FC-FS-3 Exchanges and Information Units. Fibre Channel is a high speed serial architecture that allows either optical or electrical connections. The topologies supported by Fibre Channel include point-to-point, fabric switched, and arbitrated loop. All Fibre Channel connections use the same standard frame format and standard hierarchy of transmission units to transmit the Information Units that carry SCSI information.

This standard is divided into the following clauses:

Clause 1 is the scope of this standard.

Clause 2 enumerates the normative references that apply to this standard.

Clause 3 describes the terms, definitions, abbreviations, and conventions used in this standard.

Clause 4 provides an overview of the protocol for transmitting SCSI information over Fibre Channel.

Clause 5 describes the FC-FS-3 frame header.

Clause 6 describes the Basic Link Services and Extended Link Services used by the protocol for transmitting SCSI information over Fibre Channel.

Clause 7 describes the Name Server objects defined for FCP-4.

Clause 8 describes the FCP FC-4 Link Service definitions for the protocol for transmitting SCSI information over Fibre Channel.

Clause 9 describes the Information Units used to transfer SCSI commands, data, and status across a Fibre Channel connection.

Clause 10 defines the SCSI mode pages used by the protocol for transmitting SCSI information over Fibre Channel.

Clause 11 defines the timers used for FCP-4 operation and recovery.

Clause 12 defines the link error detection and error recovery procedures for FCP-4.

This standard has the following annexes:

Annex A is a normative description of the relationship between the services defined by SAM-5 and the corresponding functions defined by this standard.

Annex B is an informative annex that provides examples of the protocol for transmitting SCSI information over FCP.

Annex C is an informative annex providing examples of the FCP-4 error recovery mechanisms.

Annex D is an informative annex describing techniques for discovering FCP device capabilities.

Annex E is an informative annex providing examples of the content of ELSs used during FCP-4 recovery operations.

This standard is part of ISO/IEC 14776 (all parts) developed to facilitate the use of the SCSI command sets for many different types of devices across many different types of physical interconnects. The architectural model for the family of standards is ISO/IEC 14776-415, *Information technology - Small computer system interface (SCSI) - Part 415: SCSI architecture model - 5 (SAM-5)*.

INFORMATION TECHNOLOGY – SMALL COMPUTER SYSTEM INTERFACE (SCSI) – Part 224: Fibre Channel Protocol, fourth version (FCP-4)

1 Scope

This part of ISO/IEC 14776 defines a fourth version of the SCSI Fibre Channel Protocol (FCP). This standard is a mapping protocol for applying the SCSI command set to Fibre Channel. This standard defines how the Fibre Channel services and the defined Information Units (IUs) are used to perform the services defined by the SCSI Architecture Model - 5 (SAM-5). This fourth version includes additions and clarifications to the third version (ISO/IEC 14776-223:2008), removes information that is now contained in other standards, and describes additional error recovery capabilities for the Fibre Channel Protocol.

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.

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

ISO/IEC 14776-415, *Information technology - Small computer system interface (SCSI) - Part 415: SCSI architecture model - 5 (SAM-5)*

ISO/IEC 14776-454, *Information technology - Small computer system interface (SCSI) - Part 454: SCSI Primary Commands - 4 (SPC-4)*

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

INCITS 470-2011, *Information Technology - Fibre Channel Framing and Signaling Interface - 3 (FC-FS-3)*

INCITS 477-2011, *Information Technology - Fibre Channel - Link Services - 2 (FC-LS-2)*

INCITS 540, *Information Technology - Fibre Channel - Non-Volatile Memory Express (FC-NVMe)*

INCITS 544, *Information technology - Fibre Channel - Single-Byte Command Code Sets Mapping Protocol - 6 (FC-SB-6)*

INCITS TR-49-2012, *INCITS Technical Report For Information Technology - Fibre Channel - Device Attach - 2 (FC-DA-2)*

SFF document SFF-8067, *40-pin SCA-2 Connector w/Bidirectional ESI*¹

1. SFF specifications are available from the SNIA SFF Technology Affiliate (see <http://www.snia.org/sff>).

3 Terms, definitions, abbreviations and conventions

3.1 Terms and definitions

3.1.1

acknowledged class

class of service that acknowledges transfers

Note 1 to entry: An example of an acknowledged class is class 2.

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

3.1.2

address identifier

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

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

3.1.3

application client

object that is the source of SCSI commands and task management function requests

Note 1 to entry: See SAM-5.

3.1.4

application client buffer offset

offset in bytes from the beginning of the application client's buffer (i.e., data-in or data-out) to the location for the transfer of the first byte of a data delivery service request

Note 1 to entry: See SAM-5.

3.1.5

command

request describing a unit of work to be performed by a device server

Note 1 to entry: See SAM-5.

3.1.6

command descriptor block

CDB

structure used to communicate a command from an application client to a device server

Note 1 to entry: See SAM-5.

3.1.7

command identifier

numerical identifier of a command

Note 1 to entry: See Annex A and SAM-5.

3.1.8

data buffer size

upper limit on the amount of data (i.e., data-in or data-out) to be transferred by the command

Note 1 to entry: See SAM-5.

3.1.9

Data frame

FC-4 Device_Data frame, FC-4 Video_Data frame, or Link_Data frame

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

3.1.10

data overlay

random buffer access capability where data is transmitted using the same application client buffer offset more than one time during the set of delivery actions performed by a single command

Note 1 to entry: See 6.3.3, 6.3.4, and 9.4.

3.1.11

Destination_Identifier

D_ID

address identifier used to indicate the destination of the transmitted frame

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

3.1.12

device server

object within the logical unit that processes SCSI commands and enforces the rules for task management

Note 1 to entry: See SAM-5.

3.1.13

discard

remove a frame or Sequence from the destination buffer without making use of the frame or Sequence and without notifying upper layers of the receipt of the frame or Sequence

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

3.1.14

Exchange

basic mechanism that transfers information consisting of one or more related non-concurrent Sequences that may flow in the same or opposite directions

Note 1 to entry: The Exchange is identified by an Originator Exchange_ID (OX_ID) and a Responder Exchange_ID (RX_ID).

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

3.1.15

FCP device

device containing one or more FCP_Ports operating as an initiator FCP_Port and/or a target FCP_Port

3.1.16

FCP Exchange

SCSI I/O operation for the Fibre Channel FC-2 layer

Note 1 to entry: The SCSI I/O operation for Fibre Channel is contained in a Fibre Channel Exchange.

Note 2 to entry: See FC-FS-3 and 4.1.

3.1.17

FCP I/O operation

SCSI I/O operation for the Fibre Channel FC-4 layer, as defined in this standard

3.1.18

FCP_Port

Nx_Port that supports the SCSI Fibre Channel Protocol

3.1.19

fully qualified Exchange identifier

FQXID

set of addresses and values used to uniquely identify an FCP I/O operation

Note 1 to entry: See 4.16.

3.1.20

image pair

originating and responding processes related by a Process Login operation

Note 1 to entry: For the Fibre Channel Protocol, the image pair is composed of one initiator FCP_Port and one target FCP_Port.

Note 2 to entry: See FC-LS-2.

3.1.21

I_T nexus loss

condition resulting from the events defined by SAM-5 in which the SCSI device performs the I_T nexus loss operations described in SAM-5, SPC-4, and this standard

3.1.22

I_T nexus loss notification

SCSI transport protocol specific event that results in an I_T nexus loss as described in SAM-5

3.1.23

Information Unit

IU

organized collection of data specified by the Fibre Channel Protocol to be transferred as a single Sequence by the Fibre Channel service interface (see FC-FS-3)

3.1.24

initiator FCP_Port

FCP_Port using the Fibre Channel Protocol to perform the SCSI initiator device functions defined by SAM-5

3.1.25

initiator port identifier

value by which a SCSI initiator port is referenced within a SCSI domain (see SAM-5)

Note 1 to entry: In this standard the address identifier of the initiator FCP_Port is an initiator port identifier.

3.1.26

initiator port name

name of a SCSI initiator port

Note 1 to entry: See SAM-5.

3.1.27

interconnect tenancy

period of time that an FCP device owns or may access a shared Fibre Channel link such as an FC-AL-2 loop

Note 1 to entry: See 10.2.1.

3.1.28

logical unit

externally addressable entity within a SCSI target device that implements a SCSI device model and contains a device server

Note 1 to entry: See SAM-5.

3.1.29

logical unit number

LUN

identifier for a logical unit

Note 1 to entry: See SAM-5.

3.1.30

loop initialization primitive

primitive used in Fibre Channel arbitrated loops to start loop initialization

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

3.1.31

management logical unit

logical unit that only performs management functions (e.g., device configuration and discovery of devices)

Note 1 to entry: See SAM-5.

3.1.32

Name_Identifier

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

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

3.1.33

Name Server

Fibre Channel service accessed through a well-known address identifier that uses the Common Transfer (CT) protocol as defined in FC-GS-6 to allow a client to determine the address identifier and properties of devices attached to a Fibre Channel switching fabric

Note 1 to entry: See FC-GS-6.

3.1.34

Node_Name

Name_Identifier associated with a Node

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

3.1.35

NL_Port

N_Port that contains arbitrated loop functions associated with the Fibre Channel arbitrated loop topology

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

3.1.36

N_Port

hardware entity that supports the FC-FS-3 FC-2 layer and may act as an Originator, a Responder, or both

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

3.1.37

N_Port Login

PLOGI

Fibre Channel Extended Link Service (ELS) that exchanges identification and operation parameters between an originating N_Port and a responding N_Port

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

3.1.38

N_Port_Name

Name_Identifier (see FC-FS-3) associated with an Nx_Port

3.1.39

Nx_Port

end device for Fibre Channel communication

Note 1 to entry: In this standard the term Nx_Port is used to specify behavior of either N_Ports or NL_Ports.

3.1.40

Originator

logical function associated with an N_Port responsible for originating an Exchange

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

3.1.41

Originator Exchange_ID

OX_ID

identifier assigned by an Originator to identify an Exchange

Note 1 to entry: See 3.1.48 and FC-FS-3.

3.1.42

private loop

arbitrated loop operating with no attached fabric loop ports

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

3.1.43

public loop

arbitrated loop operating with an attached fabric loop port

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

3.1.44

random buffer access

occurrence of device server data transfer requests that request data transfers to or from segments of the application client's buffer with an arbitrary offset and extent

Note 1 to entry: See SAM-5.

3.1.45

read operation

operation that uses the Data-In action, IU I3 (see 9.1)

3.1.46

request byte count

number of bytes to be moved by a data delivery service request

Note 1 to entry: See SAM-5.

3.1.47

Responder

logical function in an N_Port responsible for supporting the Exchange initiated by the Originator in another N_Port

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

3.1.48

Responder Exchange_ID

Responder Exchange Identifier

RX_ID

identifier assigned by a Responder to identify an Exchange and meaningful only to the Responder

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

3.1.49

SCSI device

device that contains one or more SCSI ports that are each connected to a service delivery subsystem and supports a SCSI application protocol

Note 1 to entry: See SAM-5.

3.1.50

SCSI I/O operation

operation defined by a command or a task management function

Note 1 to entry: See SAM-5.

3.1.51

SCSI initiator device

SCSI device (see 3.1.49) containing application clients (see 3.1.3) and SCSI initiator ports (see 3.1.52)

Note 1 to entry: SCSI Initiator devices originate device service and task management requests (see SAM-5) to be processed by a SCSI target device (see 3.1.53) and receive device service and task management responses from SCSI target devices.

Note 2 to entry: See SAM-5.

3.1.52

SCSI initiator port

SCSI initiator device (see SAM-5) object that acts as the connection between application clients and a service delivery subsystem through which requests and responses are routed

Note 1 to entry: See SAM-5.

3.1.53

SCSI target device

SCSI device (see 3.1.49) containing logical units (see 3.1.28) and SCSI target ports (see 3.1.54)

Note 1 to entry: SCSI target devices receive device service and task management requests (see SAM-5) for processing and send device service and task management responses to SCSI initiator devices.

Note 2 to entry: See SAM-5.

3.1.54

SCSI target port

SCSI target device (see SAM-5) object that acts as the connection between device servers and task managers and a service delivery subsystem through which requests and responses are routed

Note 1 to entry: See SAM-5.

3.1.55

sense data

data describing command completion information that a device server delivers to an application client in an FCP_RSP IU along with the status or as parameter data in response to a REQUEST SENSE command

Note 1 to entry: See SPC-4.

3.1.56

Sequence

set of one or more Data frames (see 3.1.9) with a common Sequence_ID (SEQ_ID), transmitted unidirectionally from one N_Port to another N_Port with a corresponding response, if applicable, transmitted in response to each Data frame

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

3.1.57

Sequence_ID

SEQ-ID

identifier used to identify a Sequence

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

3.1.58

Source_Identifier

S_ID

address identifier used to indicate the source port of the transmitted frame

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

3.1.59

status

single byte returned by the device server to the application client to indicate the completion and completion state of a command

Note 1 to entry: See SAM-5.

3.1.60

target FCP_Port

FCP_Port using the Fibre Channel Protocol to perform the SCSI target device functions defined by SAM-5

3.1.61

target port identifier

value by which a SCSI target port (see 3.1.54) is referenced within a SCSI domain (see SAM-5)

Note 1 to entry: In this standard the address identifier of the target FCP_Port is a target port identifier.

3.1.62

target port name

name of a SCSI target port

Note 1 to entry: See SAM-5.

3.1.63

task attribute

attribute of a command (see 3.1.5) that specifies the processing relationship of a command with regard to other commands in the task set

EXAMPLE - Examples of task attributes are SIMPLE, ORDERED, HEAD OF QUEUE, ACA.

Note 1 to entry: See SAM-5.

3.1.64**task management function**

peer-to-peer confirmed service provided by a task manager that may be invoked by an application client to affect the processing of one or more tasks

Note 1 to entry: See SAM-5.

3.1.65**task retry identifier**

identifier that is used to associate a command and the Link Services used to retry any of the command IUs

3.1.66**unacknowledged class**

class of service that does not acknowledge transfers

Note 1 to entry: An example of an unacknowledged class is class 3.

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

3.1.67**Worldwide_Name**

Name_Identifier that is worldwide unique, and represented by a 64-bit value

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

3.1.68**word**

string of four contiguous bytes occurring on boundaries that are zero modulo 4 from a specified reference

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

3.1.69**write operation**

operation that uses the Data-Out action, IU T6 (see 9.1)

3.2 Abbreviations

ABTS	Abort Sequence Basic Link Service (see FC-FS-3)
ABTS-LS	ABTS with the PARAMETER field bit 0 set to zero (i.e., Abort Exchange) (see FC-FS-3)
BA_ACC	Basic Link Service Accept (Basic_Accept) (see FC-FS-3)
BA_RJT	Basic Link Service Reject (Basic_Reject) (see FC-FS-3)
BLS	Basic Link Service (see FC-FS-3)
CDB	command descriptor block (see 3.1.6)
CRN	Command Reference Number (see 4.4 and 9.2.2.2)
D_ID	Destination_Identifier (see 3.1.11)
ELS	Extended Link Service (see FC-LS-2)
FC	Fibre Channel (see FC-FS-3)
FC-AL-2	Fibre Channel Arbitrated Loop-2 and Fibre Channel Arbitrated Loop-2/Amd1 (see clause 2)
FC-FS-3	Fibre Channel Framing and Signaling Interface - 3 (see clause 2)
FC-GS-6	Fibre Channel Generic Services - 6 (see clause 2)
FC-LS-2	Fibre Channel - Link Services - 2 (see clause 2)
FCP	Refers to this standard

FCP_ACC	FCP FC-4 Link Service Accept
FCP_LS	FCP FC-4 Link Service
FCP_RJT	FCP FC-4 Link Service Reject (see 8.4)
FCP-4	This standard
FC-4	Fibre Channel Layer 4 mapping layer (see FC-FS-3)
FLOGI	Fabric Login (see FC-LS-2)
FQXID	fully qualified Exchange identifier (see 3.1.19)
ID	identifier
IU	Information Unit (see 3.1.23)
LIFA	Loop Initialization Fabric Assigned (see FC-AL-2)
LIHA	Loop Initialization Hard Assigned (see FC-AL-2)
LIP	Loop Initialization Primitive (see FC-AL-2)
LIPA	Loop Initialization Previously Assigned (see FC-AL-2)
LISA	Loop Initialization Soft Assigned (see FC-AL-2)
LISM	Loop Initialization Select Master (see FC-AL-2)
LOGO	Logout (see FC-LS-2)
LS	Link Service
LS_ACC	Link Service Accept reply Sequence
LS_RJT	Link Service Reject reply Sequence
LUN	logical unit number
NA	Not Applicable
OX_ID	Originator Exchange Identifier (see 3.1.41)
PLOGI	N_Port Login (see FC-LS-2)
PRLI	Process Login (see 6.3 and FC-LS-2)
PRLO	Process Logout (see 6.4 and FC-LS-2)
REC	Read Exchange Concise (see 6.5 and FC-LS-2)
RRQ	Reinstate Recovery Qualifier (see 6.5 and FC-LS-2)
RX_ID	Responder Exchange_ID (see 3.1.48)
SAM-5	SCSI Architecture Model - 5 (see clause 2)
SCSI	Small Computer System Interface, any revision
S_ID	Source_Identifier (see 3.1.58)
SEQ_ID	Sequence_ID
SPC-4	SCSI Primary Commands - 4 (see clause 2)
SRR	Sequence Retransmission Request (see 8.2)
TPRLO	Third Party Process Logout (see FC-LS-2)
ULP	upper layer protocol (see FC-FS-3)

3.3 Keywords

3.3.1

invalid

keyword used to describe an illegal or unsupported bit, byte, word, field or code value

Note 1 to entry: Receipt of an invalid bit, byte, word, field or code value shall be reported as error.

3.3.2

mandatory

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

3.3.3

may

keyword that indicates flexibility of choice with no implied preference

Note 1 to entry: Equivalent to “may or may not”.

3.3.4

may not

keyword that indicates flexibility of choice with no implied preference

Note 1 to entry: Equivalent to “may or may not”.

3.3.5

obsolete

keyword indicating that an item was defined in a prior SCSI standard but has been removed from this standard

3.3.6

optional

keyword that describes features that are not required to be implemented by this standard

Note 1 to entry: If any optional feature defined by this standard is implemented, then it shall be implemented as defined in this standard.

3.3.7

reserved

keyword referring to bits, bytes, words, fields and code values that are set aside for future standardization

Note 1 to entry: A reserved bit, byte, word or field shall be set to zero, or in accordance with a future extension to this standard.

Note 2 to entry: Recipients are not required to check reserved bits, bytes, words or fields for zero values.

Note 3 to entry: Receipt of reserved code values in defined fields shall be reported as an error.

3.3.8

restricted

keyword referring to bits, bytes, words, and fields that are set aside for other identified standardization purposes

Note 1 to entry: A restricted bit, byte, word, or field shall be treated as a reserved bit, byte, word or field in the context where the restricted designation appears.

3.3.9

shall

keyword indicating a mandatory requirement

Note 1 to entry: Designers are required to implement all such mandatory requirements to ensure interoperability with other products that conform to this standard.

Note 2 to entry: This standard prescribes no specific response by a component if it receives information that violates a mandatory behavior.

3.3.10

should

keyword indicating flexibility of choice with a strongly preferred alternative

Note 1 to entry: Equivalent to the phrase “it is strongly recommended”.

3.4 Editorial conventions

Certain words and terms used in this standard have a specific meaning beyond the normal English meaning. These words and terms are defined either in clause 3 or in the text where they first appear.

Names of signals, address frames, primitives and primitive sequences, state machines, SCSI commands, SCSI statuses, SCSI sense keys, and SCSI additional sense codes are in all uppercase (e.g., REQUEST SENSE command).

Names of messages, requests, confirmations, indications, responses, event notifications, timers, SCSI diagnostic pages, SCSI mode pages, and SCSI log pages are in mixed case (e.g., Disconnect-Reconnect mode page).

Names of fields are in small uppercase (e.g., FCP_DL). Normal case is used when the contents of a field are being discussed. Fields containing only one bit are usually referred to as the NAME bit instead of the NAME field.

Normal case is used for words having the normal English meaning.

A binary number is represented in this standard by any sequence of digits consisting of only the Western-Arabic numerals 0 and 1 immediately followed by a lower-case b (e.g., 0101b). Underscores or spaces may be included between characters in binary number representations to increase readability or delineate field boundaries (e.g., 0 0101 1010b or 0_0101_1010b).

A hexadecimal number is represented in this standard by any sequence of digits consisting of only the Western-Arabic numerals 0 through 9 and/or the upper-case English letters A through F immediately followed by a lower-case h (e.g., FA23h). Underscores or spaces may be included between characters in hexadecimal number representations to increase readability or delineate field boundaries (e.g., B FD8C FA23h or B_FD8C_FA23h).

A decimal number is represented in this standard by any sequence of digits consisting of only the Arabic numerals 0 through 9 not immediately followed by a lower-case b or lower-case h (e.g., 25).

This standard uses the following conventions for representing decimal numbers:

- the decimal separator (i.e., separating the integer and fractional portions of the number) is a period;
- the thousands separator (i.e., separating groups of three digits in a portion of the number) is a space; and
- the thousands separator is used in both the integer portion and the fraction portion of a number.

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. Bit order and byte order are as specified in FC-FS-3.

Table 1 shows some examples of decimal numbers using various numbering conventions.

Table 1 - Numbering conventions

French	English	This standard
0,6	0.6	0.6
3,141 592 65	3.14159265	3.141 592 65
1 000	1,000	1 000
1 323 462,95	1,323,462.95	1 323 462.95

A decimal number represented in this standard with an overline over one or more digits following the decimal point is a number where the overlined digits are infinitely repeating (e.g., $666.\overline{6}$ means $666.666\ 666\dots$ or $666\ 2/3$, and $12.\overline{142\ 857}$ means $12.142\ 857\ 142\ 857\dots$ or $12\ 1/7$).

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

In the event of conflicting information the precedence for requirements defined in this standard is:

- 1) text;
- 2) tables; and
- 3) figures.

Notes do not constitute any requirements for implementers.

Notes are numbered consecutively throughout this standard.

4 General

4.1 Structure and concepts

Fibre Channel (FC) is logically a point-to-point serial data channel. The architecture has been designed so that it may be implemented with high performance hardware that requires little real-time software management. The Fibre Channel Physical layer (FC-2 layer) described by FC-FS-3 performs those functions required to transfer data from one Nx_Port to another. In this standard, Nx_Ports capable of supporting Fibre Channel Protocol transactions are collectively referred to as FCP_Ports. The FC-2 layer is a delivery service with information grouping and several defined classes of service.

A switching fabric allows communication among more than two FCP_Ports.

Fibre Channel Arbitrated Loop-2 (FC-AL-2) is an alternative multiple port topology that allows communication between two NL_Ports on an arbitrated loop.

An FC-4 mapping layer uses the services provided by FC-FS-3 to perform the functions defined by the FC-4. The protocol is described in terms of the stream of FC IUs and Exchanges generated by a pair of FCP_Ports that support the FC-4.

The detailed implementation that supports that stream is not defined by this standard. Originator and Responder FCP_Ports are assumed to have a common service interface, for use by all FC-4s, that is similar in characteristics to the service interface defined in FC-FS-3. The requirements for the service interface for SCSI are contained in SAM-5.

This standard defines four kinds of functional management:

- a) device management;
- b) task management;
- c) Process Login and Process Logout management; and
- d) link management.

The Fibre Channel Protocol device and task management protocols define the mapping of the SCSI functions (see SAM-5) to the Fibre Channel interface (see FC-FS-3). Link control is performed by standard FC-FS-3 protocols. The task management functions defined by SAM-5 are mapped as described in 4.9 of this standard. The I/O operation defined by SAM-5 is mapped into a Fibre Channel Exchange. A Fibre Channel Exchange carrying information for a SCSI I/O operation is an FCP Exchange. The request and response primitives of an I/O operation are mapped into Information Units (IUs) as shown in table 2.

Table 2 - SCSI and Fibre Channel Protocol functions

SCSI function	FCP equivalent
I/O operation	Exchange
Transport protocol service request and response	Sequence
Send SCSI Command request	Sending an unsolicited command IU (FCP_CMND)
SCSI Command Received indication	Receiving an unsolicited command IU (FCP_CMND)
Receive Data-Out request	Data descriptor IU (FCP_XFER_RDY)
Data-Out Received confirmation	Receipt of solicited data IU (FCP_DATA)
Send Data-In request	Sending solicited data IO (FCP_DATA)
Data-In Delivered confirmation	Dependent on class of service
Send Command Complete response	Sending a command status IU (FCP_RSP)
Command Complete Received confirmation	Receiving a command status IU (FCP_RSP)
Send Task Management request	Sending the FCP equivalent specified in 4.9.
Task Management Request Received indication	Receiving the FCP equivalent specified in 4.9.
Task Management Function Executed response	Sending the response specified in table 4, table 5, or table 6.
Received Task Management Function Executed response	Receiving the response specified in table 4, table 5, or table 6.

The number of Exchanges that may simultaneously be open between an initiator FCP_Port and a target FCP_Port is defined by the FC-FS-3 implementation. The architectural limit for this value is 65 535. The maximum number of active Sequences that may simultaneously be open between an initiator FCP_Port and a target FCP_Port is restricted by the allowable range of values of the Sequence ID to 256 (see FC-FS-3). To allow task management Exchanges to be originated, a certain number of extra Exchange IDs and at least one extra Sequence_ID should always be available.

4.2 FCP I/O operations

An application client begins an FCP I/O operation when it invokes a Send SCSI Command SCSI transport protocol service request or a Send Task Management Request SCSI transport protocol service request (see SAM-5).

The use of the FCP_CMND IU for Send Task Management Request SCSI transport protocol service requests is specified in 4.9.

The Send SCSI Command SCSI transport protocol service request conveys a single request from the application client to the FCP service delivery subsystem. Each request contains all the information necessary for the processing of one command, including the local storage address and characteristics of data to be transferred by the command. The Fibre Channel Protocol then performs the following actions using FC-FS-3 services to perform the command. The processing of the individual steps of the protocol is consistent with the SCSI architectural model as defined by SAM-5.

The initiator FCP_Port starts an Exchange by transmitting an unsolicited command IU containing the FCP_CMND IU payload, including some command controls, addressing information, and the command descriptor block (CDB). The initiator FCP_Port transmits the FCP_CMND IU payload to start the FCP I/O operation. The Exchange that is started is identified by its fully qualified Exchange identifier (EQ_ID).

during the remainder of the FCP I/O operation and is used only for the IUs associated with that FCP I/O operation. See 4.16.

If the device server has interpreted the command, has determined that a write operation is required, and is prepared to request the data delivery service, then it invokes the Receive Data-Out transport protocol service request and the target FCP_Port transmits a data descriptor IU containing the FCP_XFER_RDY IU payload to the initiator FCP_Port indicating which portion of the data is to be transferred. The initiator FCP_Port then transmits a solicited data IU to the target FCP_Port containing the FCP_DATA IU payload requested by the FCP_XFER_RDY IU. Data delivery requests containing FCP_XFER_RDY IU and returning FCP_DATA IU payloads continue until the data transfer requested by the command is complete. One FCP_DATA IU shall follow each FCP_XFER_RDY IU. If the initiator FCP_Port and target FCP_Port have negotiated to disable the initial FCP_XFER_RDY IU (see 6.3.3), then a first burst shall be transferred (see 10.2.10).

If the device server has interpreted the command and has determined that a read operation is required, then it invokes the Send Data-In transport protocol service request (see SAM-4) and the target FCP_Port transmits a solicited data IU containing the FCP_DATA IU payload to the initiator FCP_Port. Data deliveries containing FCP_DATA IU payloads continue until all data described by the command is transferred.

If the device server has interpreted the command and has determined that bidirectional transfer is required, then it selects the first FCP_DATA IU to be transferred. The IU may be either a Data-In or a Data-Out transfer. If the device server chooses to request a Data-Out transfer first, it invokes the Receive Data Out transport protocol service and the target FCP_Port transmits a data descriptor IU containing the FCP_XFER_RDY IU payload to the initiator FCP_Port to indicate which portion of the data is to be transferred. The initiator FCP_Port then transmits a solicited data IU containing the FCP_DATA IU payload requested by the FCP_XFER_RDY IU. If the device server chooses to transmit a Data-In transfer first, then it invokes the Send Data-In transport protocol service request (see SAM-4) and the target FCP_Port transmits a solicited data IU containing the FCP_DATA IU payload to the initiator FCP_Port. The device server then selects the next FCP_DATA IU to be transmitted and performs the appropriate procedure to transmit. Data deliveries continue until all data described by the command is transferred. This standard places no restrictions on the order that the device server performs Data-In and Data-Out transfer operations, except that only one Data-In or Data-Out transfer operation is allowed at a time in an Exchange. If the initiator FCP_Port and target FCP_Port have negotiated to disable the initial FCP_XFER_RDY IU (see 6.3.3), then a first burst shall be transferred (see 10.2.10).

After all the data has been transferred, the device server invokes the Send Command Complete transport protocol service response (see SAM-5) and the target FCP_Port transmits a command status IU containing the FCP_RSP IU payload. That payload contains the SCSI status and, if the SCSI status is CHECK CONDITION, the sense data describing the condition. The FCP_RSP IU indicates completion of the command. If no error recovery or confirmed completion is requested, then the FCP_RSP IU is the final Sequence of the Exchange, and the FCP I/O operation and the Exchange are terminated. If an FCP protocol error occurred during processing of the command, the FCP_RSP IU payload carries the FCP response information instead of the SCSI status and sense data.

When the command is completed, the initiator FCP_Port uses returned information to invoke the Command Complete Received transport protocol service confirmation to notify the application client. The returned status indicates whether or not the command was successful. The successful completion of the command indicates that the SCSI target device performed the requested operations with the transferred data and that the information was successfully transferred to or from the SCSI initiator device. Status other than successful completion indicates that either SCSI sense data or warnings about unexpected FCP behaviors are being provided. In this case, the sense data or warning is interpreted to determine whether the desired operation was successfully completed. The device server may request confirmed delivery of the FCP_RSP IU payload as described in 4.5.

The number of FCP I/O operations that may be active at one time depends on the queuing capabilities of the FCP device. If command queueing resources are unavailable in the logical unit when a command is received, then the device server returns TASK SET FULL status or BUSY status in the FCP_RSP IU as specified by SAM-5.

The Fibre Channel Protocol takes full advantage of the multiplexing and shared bandwidth capabilities provided by Fibre Channel classes of service. The protocol is designed to operate with Class 2 or Class

3 service and to provide options for reliable error detection and error recovery independent of the class of service.

The SCSI initiator port function may exist in any FCP_Port and the SCSI target port function may exist in any FCP_Port. For FCP I/O operations between a host and a peripheral subsystem, the host typically takes on the SCSI initiator port role and the peripheral subsystem typically takes on the SCSI target port role. For host to host communications, either one of the communicating pair may take on the SCSI initiator port role. For device to device communications, typically used to implement extended copy and other third-party operations, the SCSI initiator port role is adopted by the managing FCP device.

4.3 Bidirectional and unidirectional commands and FCP_RSP IU format

A device server that supports bidirectional commands should implement both unidirectional and bidirectional commands. Two FCP_RSP IU formats are defined. For commands that set both the RDDATA bit and WRDATA bit to one, the bidirectional FCP_RSP IU payload shall be used for presenting all status and error conditions. For commands that set either the RDDATA bit or WRDATA bit to one or both to zero, the unidirectional FCP_RSP IU payload shall be used for presenting all status and error conditions. The format of the FCP_RSP IU that is returned depends only on the state of the RDDATA bit and WRDATA bit.

If a device server that does not support bidirectional commands receives a command that requests read and write operations by setting both the RDDATA bit and WRDATA bit to one, then the device server may return CHECK CONDITION status with the sense key set to ILLEGAL REQUEST and an additional sense code of INVALID FIELD IN COMMAND INFORMATION UNIT.

4.4 Precise delivery of commands

In applications where SCSI communications between an application client and a device server are stateless, verification of the delivery and processing of commands may not be critical. Any changes in processing sequence caused by link failures or switch latencies may not be important and the recovery and retry mechanisms may be performed while other activities are continued by the application client and the device server.

To assure ordering of commands, an initiator FCP_Port transmits a single command and waits for GOOD status before transmitting the next command (i.e., commands are guaranteed to be processed in order).

This standard defines a second optional mechanism called precise delivery to assure ordering of commands. This may be used by any FCP device, but may be useful for devices performing ordered command queuing where device state is preserved from one command to the next. An application client may determine if a device server supports the precise delivery function by using the MODE SENSE command and MODE SELECT command to examine and set the EPDC bit in the Fibre Channel Logical Unit Control mode page to one (see 10.3).

If a SCSI command requires precise delivery and the device server has the EPDC bit set to one, then the application client provides the Command Reference Number (CRN) argument to the Send SCSI Command transport protocol service. The initiator FCP_Port then places the CRN value in the COMMAND REFERENCE NUMBER field in the FCP_CMND IU.

The CRN is a one byte unsigned integer that starts at the reset value of one and shall be incremented by one for each command requiring precise delivery for that device server. Separate increment counters are maintained for each I_T_L nexus (i.e., each initiator FCP_Port maintains a separate counter for each device server using precise delivery). After the number of precisely delivered commands causes the integer to increment to 255, the integer wraps back to a value of one. The value of zero is reserved and shall be used for those commands that do not require precise delivery and the COMMAND REFERENCE NUMBER field shall be set to zero for task management functions.

The following rules specify how the application client and device server use the CRN to determine that each command requiring precise delivery has been properly received and processed:

- a) see table 8 and table 9 for the actions that cause the CRN to be transmitted by the initiator FCP_Port to be set to one and the CRN expected by the device server to be set to one;

- b) the CRN shall be equal to one for the first FCP_CMND IU requiring precise delivery between the application client and device server and shall be incremented by one for each subsequent command requiring precise delivery;
- c) the CRN shall wrap from 255 to one (i.e., a value of zero in the COMMAND REFERENCE NUMBER field is not valid for an Exchange using precise delivery);
- d) the initiator FCP_Port shall not transmit the same CRN again until delivery of the first FCP_CMND IU transmitted with that CRN has been confirmed by receipt of:
 - A) an FCP_XFER_RDY IU;
 - B) the first Data frame of an FCP_DATA IU;
 - C) an FCP_RSP IU;
 - D) an ACK; or
 - E) a response to an REC ELS;
- e) the device server shall not accept a command with a nonzero CRN into the dormant or enabled state until after all commands with a previous CRN have been received by the device server. The commands shall be assumed to be received in the order of increasing CRN, and accounting for a wrap from 255 to one, the highest CRN last. The order of processing of the commands shall be managed by the normal task set management algorithms;
- f) the device server shall accept any valid command with a CRN of zero into the dormant or enabled state regardless of whether or not all commands with a nonzero CRN have been received. The processing order of the commands shall be managed by the normal task set management algorithms (see SAM-5); and
- g) task management functions shall have the FCP_CMND IU COMMAND REFERENCE NUMBER field set to zero and shall not be tested for precise delivery by the device server.

Any command may use a CRN of zero if precise delivery is not required for that command (e.g., commands such as INQUIRY, TEST UNIT READY, REPORT LUNS, MODE SENSE, and MODE SELECT that are used for booting and initialization may use a CRN of zero).

4.5 Confirmed completion of FCP I/O operations

Some device servers require an acknowledgment of successful delivery of FCP_RSP information. Such an acknowledgment is provided by the optional confirmed completion function. The CONFIRMED COMPLETION ALLOWED bits in the PRLI ELS request FCP Service Parameter page (see 6.3.3) and PRLI ELS accept FCP Service Parameter page (see 6.3.4) are used to negotiate the use of confirmed completion function.

If the CONFIRMED COMPLETION ALLOWED bit is set to one in the PRLI ELS accept FCP Service Parameter page, then the target FCP_Port may request the confirmed completion function by setting the FCP_CONF_REQ bit to one in the FCP_RSP IU. Upon receiving the request in the FCP_RSP IU, the initiator FCP_Port shall transmit an FCP_CONF IU to the target FCP_Port, indicating to the target FCP_Port that the FCP_RSP IU has been received by the initiator FCP_Port.

The confirmed completion function allows the retry of unsuccessful notifications of errors and confirms that the initiator FCP_Port and the target FCP_Port both agree upon the state of a state dependent device. Retry mechanisms for unsuccessful transmission of FCP_RSP IUs and FCP_CONF IUs are defined in this standard.

Target FCP_Ports shall not request confirmed completion for FCP_RSP IUs responding to task management requests.

If confirmed completion is not enabled, then the FCP_CONF IU shall not be requested by the FCP_RSP IU.

Confirmed completion may assist SCSI initiator devices and SCSI target devices in many environments. Examples include:

- a) the confirmed completion function may be used to confirm that an initiator FCP_Port has received an FCP_RSP IU reporting a SCSI CHECK CONDITION status, together with accompanying sense data. Upon receiving the FCP_CONF IU, the target FCP_Port may discard its copy of the sense data;
- b) the confirmed completion function may be used to confirm that a command has been completed and that the completion information has been successfully transferred to the initiator FCP_Port.

- That allows subsequent queued state dependent operations to be performed, since the FCP_CONF IU confirms that the FCP_RSP IU has been received by the initiator FCP_Port; and
- c) the confirmed completion function may be used to confirm that an initiator FCP_Port has received the FCP_RSP IU for target FCP_Ports that require state dependent synchronization with initiator FCP_Ports.

4.6 Retransmission of unsuccessfully transmitted IUs

Error detection and IU retransmission algorithms are defined in clause 12.

The Read Exchange Concise (REC) ELS may be used by the initiator FCP_Port to determine the state of an ongoing Exchange. See 6.5.

Support for the REC ELS by both the initiator FCP_Port and target FCP_Port is indicated by the REC SUPPORT bit in the PRLI ELS request FCP Service Parameter page (see 6.3.3) and the PRLI ELS accept FCP Service Parameter page (see 6.3.4).

If the target FCP_Port responds with the REC SUPPORT bit set to one and an error is identified by any of the detection mechanisms defined in clause 12, then the initiator FCP_Port may use the REC ELS to determine the nature of the error.

Target FCP_Ports that do not support the REC SUPPORT bit indicate they do not support the REC ELS by returning a Link Service Reject (LS_RJT) with a Reason Code of "Command not supported" in response to an REC ELS. See 8.4.

If the data retransmission capability is supported by both the initiator FCP_Port and target FCP_Port as indicated by the RETRY bit in the PRLI ELS request FCP Service Parameter page and PRLI ELS accept FCP Service Parameter page (see 6.3.3 and 6.3.4), then the initiator FCP_Port and target FCP_Port shall support the REC ELS and task retry identification (see 4.7).

If an error is identified by any of the mechanisms defined in clause 12, then the initiator FCP_Port may request retransmission using the Sequence Retransmission Request (SRR) FCP_LS request (see 8.2).

4.7 Task retry identification

Task retry identification provides an additional mechanism for relating commands that are being retried to the requests that are sensing the requirement for recovery (i.e., REC ELS request) and performing the recovery (i.e., SRR FCP_LS request).

For example, it is possible that initiator FCP_Ports may re-use OX_ID field values rapidly enough to create an ambiguous situation where the status being preserved in the target FCP_Port for possible retransmission and the new command being presented to the target FCP_Port may have the same OX_ID field values. When recovery of a transmission failure for the new command is attempted, the target FCP_Port instead indicates that the recovery is related to the previous command's status and the initiator FCP_Port is provided status for the completed command. That information is mistakenly interpreted as status for the failed command.

FCP_Ports that agree to perform recovery shall support task retry identification. If the initiator FCP_Port and target FCP_Port agree to support task retry identification, then a task retry identifier shall be provided in the PARAMETER field of each FCP_CMND IU frame. The Link Services associated with retransmission of IUs (i.e., REC ELS and SRR FCP_LS) each contain the same task retry identifier. If the initiator FCP_Port and target FCP_Port do not agree to support task retry identification, then the PARAMETER field shall be set to zero for the FCP_CMND IU frame, REC ELS frame, and SRR FCP_LS frame.

4.8 Discovery of FCP capabilities

A number of Fibre Channel Protocol capabilities require the knowledge and agreement of both the target FCP_Port and the initiator FCP_Port that such capabilities may or shall be used. Table 3 provides references to the discovery process for each of the Fibre Channel Protocol capabilities.

Table 3 - Discovery of FCP-4 capabilities

Capability	Discovery mechanism	Reference
Initiator FCP_Port	Process Login	6.3
Target FCP_Port	Process Login	6.3
Initiator FCP_Port accepts data overlay	Process Login	6.3.3
Target FCP_Port performs data overlay	Disconnect-Reconnect mode page EMDP bit	10.2.8
Initiator FCP_Port transmits FCP_CONF IU	Process Login	6.3
Target FCP_Port requests FCP_CONF IU	Process Login	6.3
Initiator FCP_Port transmits REC ELS request	None required, Process Login allowed	4.6 and 6.3
Target FCP_Port accepts REC ELS request	Process Login ^a	4.6 and 6.3
Initiator FCP_Port transmits SRR FCP_LS request	Process Login	6.3
Target FCP_Port accepts SRR FCP_LS request	Process Login	6.3
Initiator FCP_Port provides CRN	Fibre Channel Logical Unit Control mode page EPDC bit	4.4 and 10.3
Target FCP_Port accepts CRN	Fibre Channel Logical Unit Control mode page EPDC bit	4.4 and 10.3
Task Retry Identification	Process Login	6.3
a) If the target FCP_Port does not support the REC SUPPORT bit in the PRLI ELS, then the target FCP_Port may return an LS_RJT in response to an REC ELS (see 4.6).		

4.9 Task management functions

4.9.1 Task management functions overview

An application client requests a task management function (see SAM-5) to control explicitly the processing of one or more FCP I/O operations (see 9.2.2.5).

The task management function mappings are specified in table 4.

Table 4 - Task management functions, SAM-5 to FCP-4

SAM-4 task management function	FCP-4 implementation
ABORT TASK	ABTS-LS (see 4.9.2 and FC-FS-3)
ABORT TASK SET	FCP_CMND IU with TASK MANAGEMENT FLAGS field set to FCP_ABORT_TASK_SET
CLEAR TASK SET	FCP_CMND IU with TASK MANAGEMENT FLAGS field set to FCP_CLEAR_TASK_SET
CLEAR ACA	FCP_CMND IU with TASK MANAGEMENT FLAGS field set to FCP_CLEAR_ACA
I_T NEXUS RESET	Not supported (see SPC-4)
LOGICAL UNIT RESET	FCP_CMND IU with TASK MANAGEMENT FLAGS field set to FCP_LOGICAL_UNIT_RESET
QUERY TASK	REC ELS (see 4.9.2 and FC-LS-2)
QUERY TASK SET	FCP_CMND IU with TASK MANAGEMENT FLAGS field set to FCP_QUERY_TASK_SET
QUERY ASYNCHRONOUS EVENT	FCP_CMND IU with TASK MANAGEMENT FLAGS field set to FCP_QUERY_ASYNCHRONOUS_EVENT

Task management functions that use the FCP_CMND IU are transmitted as the first IU in a new Exchange. A task management function that uses the FCP_CMND IU ends with an FCP_RSP IU that indicates the completion status of the function. If the addressed logical unit is not supported or is not available (e.g., not connected or not configured), then the target FCP_Port:

- a) should end the Exchange with an FCP_RSP IU completion status of 09h (i.e., Task Management function incorrect logical unit number) (see table 29); or
- b) may end the Exchange with an FCP_RSP IU completion status of 00h (i.e., Task Management function complete) (see table 29).

The FCP_CDB field in an FCP_CMND IU that performs task management functions is ignored.

FC-FS-3 BLSs and FC-LS-2 ELSs are used to perform the ABORT TASK task management function, to perform the QUERY TASK task management function, to recover Exchange resources, and to re-establish other initial conditions.

Table 5 specifies the SCSI Service Response mappings for an initiator FCP_Port for FCP_CMND delivered task management functions.

Table 5 - SCSI Service Response mapping for FCP_CMND delivered task management functions

SCSI Service Response	Response to the FCP_CMND IU
FUNCTION_COMPLETE	FCP_RSP IU with the RSP_CODE field set to TMF_COMPLETE
FUNCTION_REJECTED	FCP_RSP IU with the RSP_CODE field set to TMF_REJECTED
INCORRECT LOGICAL UNIT NUMBER	FCP_RSP IU with the RSP_CODE field set to TMF_INCORRECT_LUN
SERVICE DELIVERY OR TARGET FAILURE	All other responses, including: a) timeout; and b) FCP_RSP IU with the RSP_CODE field set to TMF_FAILED.

4.9.2 ABORT TASK task management function

The ABORT TASK task management function causes the device server to abort the specified command, if it exists, using ABTS-LS (see FC-FS-3). An example ABTS frame format is shown in Annex E.

The ABORT TASK task management function may not immediately release all Exchange resources, since a Recovery_Qualifier may be established to allow for the management of information that may already have been delivered to the fabric.

In addition to recovering Exchange resources that may have been left unavailable while processing task management functions, ABTS-LS is used to recover Exchange resources left in an undefined state.

Table 6 specifies the SCSI Service Response mappings for an initiator FCP_Port for the ABORT TASK task management function.

Table 6 - SCSI Service Response mapping for ABORT TASK

SCSI Service Response	Response to the ABTS-LS
FUNCTION_COMPLETE	Either: a) BA_ACC; or b) BA_RJT with Reason Code set to 03h (i.e., Logical error) and Reason Code Explanation set to 03h (i.e., Invalid OX_ID-RX_ID combination).
FUNCTION_REJECTED	BA_RJT with Reason Code set to 01h (i.e., Invalid command code) or 09h (i.e., Unable to perform command request).
INCORRECT LOGICAL UNIT NUMBER	No responses map to this SCSI Service Response.
SERVICE DELIVERY OR TARGET FAILURE	All other responses, including timeout.

4.9.3 QUERY TASK task management function

The QUERY TASK task management function maps to the REC ELS. The REC ELS shall be transmitted in a new Exchange.

Table 7 specifies the SCSI Service Response mappings for an initiator FCP_Port for the QUERY TASK task management function.

Table 7 - SCSI Service Response mapping for QUERY TASK

SCSI Service Response	Response to the REC ELS
FUNCTION_COMPLETE	Either: a) LS_ACC with E_STAT (i.e., word 5) bit 29 (i.e., Completion) set to one (i.e., complete); or b) LS_RJT with Reason Code set to 03h (i.e., Logical error) or 09h (i.e., Unable to perform command request) and Reason Code Explanation set to 17h (i.e., Invalid OX_ID-RX_ID combination) or 15h (i.e., Invalid Originator S_ID).
FUNCTION_SUCCEEDED	LS_ACC with E_STAT (i.e., word 5) bit 29 (i.e., Completion) set to zero (i.e., open).
FUNCTION_REJECTED	LS_RJT with Reason Code set to: a) 01h (i.e., Invalid ELS command code); or b) 0Bh (i.e., Command not supported).
INCORRECT LOGICAL UNIT NUMBER	No responses map to this SCSI Service Response.
SERVICE DELIVERY OR TARGET FAILURE	All other responses, including: a) timeout; and b) LS_RJT with Reason Code set to 09h (i.e., Unable to perform command request) and Reason Code Explanation set to 15h (i.e., Invalid Originator S_ID).

4.10 Clearing effects of task management, FCP, FC-FS-3, FC-LS-2, and FC-AL-2 actions

Table 8 and table 9 summarize the clearing effects resulting from Fibre Channel link actions and SCSI operations, respectively. The clearing effects are applicable only to Sequences and Exchanges associated with Fibre Channel Protocol actions. Sequences and Exchanges associated with other actions follow rules specified in FC-FS-3 or other relevant protocol standards. Rows indicating a clearing effect for all initiator FCP_Ports have the specified clearing effect on all initiator FCP_Ports, regardless of the link that attaches the initiator FCP_Port to the target FCP_Port.

Table 8 - Clearing effects of link related actions

Clearing effect	FC link action						
	Target Power Cycle	Reset LIP(y,x) ^b	LOGO ELS ^e , PLOGI ELS	PRLI ELS ^d , PRLO ELS ^e	TPRLO ELS ^c	ABTS-LS	ABTS (Sequence)
PLOGI ELS parameters set to default values (see FC-LS-2)	Y	Y	N	N	N	N	N
For all logged-in initiator FCP_Ports	-	-	Y	N	N	N	N
Only for initiator FCP_Port associated with the action	-	-	-	-	-	-	-
Open FCP Exchanges terminated	Y	Y	N	N	Y	N	N
For all initiator FCP_Ports	-	-	Y	Y	-	N	N
Only for initiator FCP_Port associated with the action	-	-	-	-	-	Y	-
Only for FCP Exchange associated with ABTS	-	-	-	-	-	-	Y
FCP Sequence associated with ABTS terminated	-	-	-	-	-	-	Y
Login BB_Credit_CNT set to login value (see FC-FS-3)	Y	Y	N	N	N	N	N
For all Logged-In NL_Ports	-	-	Y	N	N	N	N
For transmitting NL_Port only	-	-	-	-	-	-	-
Hard address acquisition attempted by NL_Port	Y ^a	Y ^a	N	N	N	N	N
Process Login parameters cleared ^f	Y	Y	N	N	Y	N	N
For all logged-in initiator FCP_Ports	-	-	Y	Y	-	N	N
Only for FCP_Port associated with the action	-	-	-	-	-	-	-
CRN set to one	Y	Y	N	N	Y	N	N
For all initiator FCP_Ports	-	-	Y	Y	-	N	N
Only for initiator FCP_Port associated with the action	-	-	-	-	-	-	-
Key: "Y" indicates the clearing effect upon successful completion of the specified action. "N" indicates the clearing effect is not performed by the specified action. "-" indicates the clearing effect is not applicable. a) If the NL_Port has an AL_PA different than its hard address and the NL_Port experiences a power cycle or recognizes LIP(AL_PD,AL_PS), then the NL_Port shall relinquish its current AL_PA and attempt to acquire its hard address. b) This is also known as LIP(AL_PD,AL_PS). If the destination recognizes a selective hard reset LIP where the AL_PD matches the AL_PA of the receiving NL_Port, then the receiving NL_Port shall perform the behavior described in this column. c) For a TPRLO ELS, the actions listed shall be performed when the GLOBAL bit is set to one. If the GLOBAL bit is set to zero, then the actions listed under PRLI ELS/PRLO ELS shall be performed for the designated initiator FCP_Port. See FC-FS-3. d) The target FCP_Port shall clear the object only if ESTABLISH IMAGE PAIR is set to one and if the referenced image pair is FCP type. See 6.2. e) Logout and Process Logout may be either implicit or explicit. Implicit logout and Process Logout are specified in FC-FS-3. f) A target FCP_Port should transmit a PRLO ELS to all logged-in initiator FCP_Ports that are logged out as a result of processing a TPRLO ELS with the GLOBAL bit set to one. The PRLO ELS(s) may be transmitted before or after transmitting the LS_ACC for the TPRLO ELS.							

Table 9 - Clearing effects of initiator FCP_Port actions

Clearing effect	Initiator FCP_Port action		
	LOGICAL UNIT RESET ^b	CLEAR TASK SET ^b	ABORT TASK SET ^b
PLOGI ELS parameters set to default values (see FC-LS-2) For all logged-in initiator FCP_Ports Only for initiator FCP_Port associated with the action	N N	N N	N N
Open FCP Sequences Terminated For all initiator FCP_Ports with open FCP Sequences Only for initiator FCP_Port associated with the action Only for FCP Sequences associated with Aborted FCP Exchanges	Y ^a - -	Y ^a - -	N Y ^a -
Login BB_Credit_CNT set to login value (see FC-FS-3) For all Logged-In NL_Ports For transmitting NL_Port only	N N	N N	N N
Hard address acquisition attempted by NL_Port	N	N	N
Process Login parameters cleared For all logged-in initiator FCP_Ports Only for FCP_Port associated with the action	N N	N N	N N
CRN set to one For all initiator FCP_Port Only for initiator FCP_Port associated with the action	Y -	Y -	N Y
Key: "Y" indicates the clearing effect upon successful completion of the specified action. "N" indicates the clearing effect is not performed by the specified action. "-" indicates the clearing effect is not applicable. a) Exchanges are cleared internally within the target FCP_Port, but open FCP Sequences shall be individually aborted by the initiator FCP_Port using ABTS-LS. This has the effect of aborting the associated FCP Exchange. See 12.3. b) For multiple-logical unit SCSI target devices, CLEAR TASK SET, ABORT TASK SET, and LOGICAL UNIT RESET affect only the addressed logical unit.			

4.11 I_T nexus loss notification events

An FCP_Port shall deliver an I_T nexus loss notification (see SAM-5) as a consequence of the following events:

- transmitting or receiving a LOGO ELS (explicit or implicit);
- transmitting or receiving a PRLO ELS (explicit or implicit);
- receiving a TPRLO ELS;
- transmitting a TPRLO ELS with a Third Party Originator N_Port_ID (see FC-LS-2) that matches the N_Port_ID of the transmitting FCP_Port; or
- transmitting a TPRLO ELS with the GLOBAL bit set to one to a target FCP_Port that has an I_T nexus with the transmitting initiator FCP_Port.

4.12 Transport Reset notification events

If the AL_PD matches the AL_PA of the receiving NL_Port, then an NL_Port shall deliver a Transport Reset notification (see SAM-5) for a Reset LIP(y,x) (see FC-AL-2) FC link event.

4.13 Port Login/Logout

The N_Port Login (PLOGI) ELS is optionally used to establish the Fibre Channel operating parameters between any two Fibre Channel ports, including FCP_Ports. Implicit login functions are allowed.

If a target FCP_Port receives a PLOGI ELS request and it finds there are not enough login resources to complete the login, then the target FCP_Port shall respond to the PLOGI ELS with LS_RJT and Reason Code "Unable to perform command request" and Reason Code Explanation "Insufficient resources to support Login" as defined in FC-LS-2. By means outside the scope of this standard, the target FCP_Port may select another initiator FCP_Port and release some login resources by performing an explicit logout of the other initiator FCP_Port, thus freeing resources for a future PLOGI ELS.

4.14 Process Login and Process Logout

The Process Login (PRLI) ELS request is used to establish the FCP operating relationships between two FCP_Ports (see 6.3). The Process Logout (PRLO) ELS request is used to de-establish the FCP operating relationships between two FCP_Ports (see 6.4). Implicit Process Login and Process Logout parameters may be defined for FCP_Ports. Such definitions are outside the scope of this standard.

4.15 Link management

FC-FS-3 allows management protocols above the FC-FS-3 interface to perform link data functions. The standard primitive sequences, link management protocols, BLSs, and ELSs are used as required by FCP devices (see FC-FS-3 and FC-LS-2).

4.16 FCP addressing and Exchange identification

The address of each FCP_Port is defined by its address identifier as described in FC-FS-3.

Each FCP I/O operation is identified by the FCP I/O operation's fully qualified exchange identifier (FQXID). The FQXID is composed of the initiator port identifier, the target port identifier, the OX_ID field value, and the RX_ID field value. Other definitions of FQXID are outside the scope of this standard. The method used to identify FCP I/O operations internal to the application client and the device server is not defined by this standard.

Logical unit numbers are contained in the FCP_LUN field of FCP_CMD IUs. Subsequent identification of the FCP I/O operation and the Exchange that carries the protocol interactions for the FCP I/O operation uses the FQXID.

The target FCP_Port uses the OX_ID field value, and, if it has been assigned, the RX_ID field value to perform error recovery and task management functions. The task retry identifier is used as a supplemental command identifier if task retry identification is supported and enabled.

4.17 Use of Worldwide_Names

As specified in FC-FS-3, each Fibre Channel node shall have a Node_Name that is a Worldwide_Name and each Fibre Channel port shall have an N_Port_Name that is a Worldwide_Name. The Worldwide_Name shall be a unique name using one of the formats defined by FC-FS-3. See Annex A for a description of the mapping of FCP-4 terminology to SAM-5 terminology.

Each target FCP_Port and its associated logical units has knowledge of the N_Port_Name of each initiator FCP_Port through the Fibre Channel login process. As a result, the relationship between the address identifier of the initiator FCP_Port and a persistent reservation for a logical unit may be adjusted (see SPC-4) during those reconfiguration events that may change the address identifier of the initiator FCP_Port.

If a target FCP_Port receives a PRLI ELS or a PLOGI ELS from an initiator FCP_Port with a previously known N_Port_Name, but with a changed initiator port identifier, then the device server shall:

- a) assign the new initiator port identifier to the associated I_T nexus;
- b) maintain the existing registration on that I_T nexus; and
- c) set the reservation holder to the I_T nexus having the same N_Port_Name.

Each logical unit shall be able to present a Worldwide_Name through the INQUIRY command Device Identification VPD page (see SPC-4). For devices compliant with this standard and having a LUN 0, the Worldwide_Name of the logical unit having a LUN of 0 may be the same as the Node_Name of the SCSI target device. The Worldwide_Name for the FCP_Port shall be different from the Worldwide_Name for the node (i.e., the N_Port_Name shall be different than the Node_Name).

Each FCP device should include a SCSI device name in NAA IEEE Registered format (see SPC-4). If the FCP device includes a Platform Name (see FC-GS-6), then the Platform Name should be the same as the SCSI device name.

In the Device Identification VPD page, a device server in an FCP target device that implements a SCSI device name:

- a) shall report the SCSI device name in binary NAA format; and
- b) should report the SCSI device name in SCSI name string format (e.g., "naa." followed by 16 hexadecimal digits followed by 4 ASCII null characters).

5 FC-FS-3 frame header

5.1 FC-FS-3 frame header overview

The format of the standard FC-FS-3 header as used by the Fibre Channel Protocol is defined in table 10.

Table 10 - FCP frame header

Bits Word	31–24	23–16	15–08	07–00
0	R_CTL	D_ID		
1	CS_CTL	S_ID		
2	TYPE	F_CTL		
3	SEQ_ID	DF_CTL	SEQ_CNT	
4	OX_ID		RX_ID	
5	PARAMETER			

All fields in the FCP frame header use the standard FC-FS-3 definitions. The following explanations of the fields provide information about the use of those fields to implement FCP functionality.

5.2 FC-FS-3 frame header fields

5.2.1 R_CTL field

The R_CTL field is subdivided into a ROUTING field and an INFORMATION field (see FC-FS-3). The ROUTING field shall be set to 0h (i.e., Device_Data) and the INFORMATION field shall be set to the value specified in table 21 and table 22.

5.2.2 D_ID field

The value in the D_ID field is the D_ID of the frame. For FCP FC-4 Device_Data frames, the D_ID transmitted by the Exchange Originator is the address identifier of the target FCP_Port. The D_ID transmitted by the Exchange Responder is the address identifier of the initiator FCP_Port.

5.2.3 CS_CTL field

The values in the CS_CTL field are defined by FC-FS-3 for class specific control information and do not interact with the Fibre Channel Protocol.

5.2.4 S_ID field

The value in the S_ID field is the S_ID of the frame. For FCP FC-4 Device_Data frames, the S_ID transmitted by the Exchange Originator is the address identifier of the initiator FCP_Port. The S_ID transmitted by the Exchange Responder is the address identifier of the target FCP_Port.

5.2.5 TYPE field

The value in the TYPE field shall be 08h (i.e., Fibre Channel Protocol) (see FC-FS-3) for all frames of SCSI FCP Exchanges.

A TYPE field value of 08h is also used for Information Units specified in FC-NVMe and FC-SB-6.

5.2.6 F_CTL field

The bits in the F_CTL field manage the beginning and normal or abnormal termination of Sequences and Exchanges. The bits and definitions shall be as defined by FC-FS-3. See 5.2.12.

5.2.7 SEQ_ID field

The value in the SEQ_ID field identifies each Sequence between a particular Exchange Originator and Exchange Responder with a unique value as defined by FC-FS-3.

5.2.8 DF_CTL field

The bits in the DF_CTL field indicate any optional headers that may be present. The DF_CTL field shall be set to 00h (i.e., no optional headers) or 40h (i.e., Encapsulating Security Payload).

5.2.9 SEQ_CNT field

The value in the SEQ_CNT field indicates the frame order within the Sequence as defined by FC-FS-3.

5.2.10 OX_ID field

The value in the OX_ID field is the Originator Exchange Identifier and is one of the identifiers contained in the FQXID. The OX_ID field shall be assigned and shall have a value other than FFFFh.

5.2.11 RX_ID field

The value in the RX_ID field is the Responder Exchange Identifier and is one of the identifiers contained in the FQXID. The RX_ID field shall have the unassigned value of FFFFh until the Exchange Responder assigns a different value in its response to the Exchange Originator as specified in FC-FS-3. The Exchange Originator shall use the value assigned by the Exchange Responder for subsequent frames.

5.2.12 PARAMETER field

The PARAMETER field has two definitions for Device_Data frames with the TYPE field set to 08h (i.e., Fibre Channel Protocol).

For a frame with the R_CTL field set to 01h (i.e., solicited data) (i.e., an FCP_DATA IU) (see 9.1 and 9.4), the PARAMETER field shall contain a relative offset. The RELATIVE OFFSET PRESENT bit of the F_CTL field shall be set to one, indicating that the PARAMETER field value is a relative offset. The relative offset is the application client buffer offset as described by SAM-5. The relative offset shall have a value that is a multiple of 4 (i.e., each frame of each FCP_DATA IU shall begin on a word boundary).

For a frame with the R_CTL field set to 02h (i.e., unsolicited control) (i.e., an FCP_CMND IU) (see 9.1 and 9.2), the PARAMETER field value depends on whether task retry identification (see 4.7) is active. If the target FCP_Port and initiator FCP_Port have agreed upon performing task retry identification, then the PARAMETER field shall contain the task retry identifier. If the target FCP_Port and initiator FCP_Port have not agreed upon performing task retry identification, then the PARAMETER field shall be set to zero. In both cases, the RELATIVE OFFSET PRESENT bit of the F_CTL field shall be set to zero.

For a frame with the R_CTL field other than 01h and 02h, the RELATIVE OFFSET PRESENT bit of the F_CTL field shall be set to zero and the PARAMETER field shall contain a value of zero.

For FCP FC-4 Link Service frames, the PARAMETER field is specified in the description of the individual link services.

6 FCP link service definitions

6.1 Overview of link service requirements

The FCP link-level protocol includes the BLSs (see FC-FS-3) and ELSs defined by FC-LS-2. The protocol also includes the PRLI ELS and PRLO ELS specified in FC-LS-2, the PRLI FCP Service Parameter pages specified in 6.3, and the REC ELS with usage as defined in this standard.

Link-level protocols are used to configure the FC environment, including the establishment of configuration information and address information. FCP devices introduced into a configuration or modifications in the addressing or routing of the configuration may require the login and discovery procedures to be performed again. Annex D includes a model for the discovery procedure.

6.2 Overview of Process Login and Process Logout

Process Login allows for a process at one FCP_Port to be related to a corresponding process at another FCP_Port as an image pair. In addition, the PRLI ELS allows one or more FC-4 capabilities to be reported by the initiating FCP_Port to the recipient FCP_Port. The recipient FCP_Port indicates its acceptance or rejection of the capabilities in its response to the PRLI ELS request.

Since implicit login may be established by configuration conventions outside the scope of this standard, Process Login is optional except in the case where an initiator FCP_Port is not using implicit login and is operating in a point-to-point topology. In this case, the initiator FCP_Port shall always transmit an explicit PRLI ELS.

NOTE 1 - The requirement to transmit a PRLI ELS for an initiator FCP_Port that is not using implicit login and operating in a point-to-point topology is to remove a deadlock condition that occurs when the target FCP_Port N_Port_Name is larger than the initiator FCP_Port N_Port_Name. In this case the target FCP_Port PLOGI ELS request is processed, but the target FCP_Port is prohibited from transmitting a PRLI ELS. If the initiator FCP_Port does not transmit a PRLI ELS, then a deadlock occurs.

PRLI ELS requests shall only be initiated by devices having the initiator FCP_Port capability. Devices having only target FCP_Port capability shall not perform a PRLI ELS request.

An initiator FCP_Port shall have successfully completed Process Login with a target FCP_Port that establishes an image pair before any FCP IUs are exchanged. An image pair may also be established by an implicit Process Login performed by methods outside the scope of this standard. An image pair is removed by an implicit Process Logout or explicit PRLO ELS (see 6.4). If an image pair is not established by an initiator FCP_Port to a target FCP_Port, then the initiator FCP_Port and target FCP_Port shall not exchange any FCP IUs. Any FCP IUs received by a target FCP_Port from an Nx_Port that does not have an image pair with that target FCP_Port shall be discarded. In addition, a target FCP_Port that receives an FCP_CMND IU from an Nx_Port that has successfully completed PLOGI ELS, but does not have an image pair with that target FCP_Port, shall discard the FCP_CMND IU and respond with an explicit PRLO ELS (see 12.6). Reasons why the Nx_Port does not have an image pair with the target FCP_Port include:

- a) the Nx_Port has not established an image pair with that target FCP_Port;
- b) the target FCP_Port performed an implicit Process Logout of the Nx_Port; or
- c) the target FCP_Port processed a TPRLO ELS that effected the Nx_Port.

The creation of image pairs behind an FCP_Port has no effect on the Fibre Channel Protocol.

The FC-4 Service Parameter pages for the Fibre Channel Protocol are defined in 6.3.3 and 6.3.4.

Processing of a PRLI ELS or PRLO ELS request performs the clearing actions defined in 4.10.

Process Login has two actions that may be performed, selected by the ESTABLISH IMAGE PAIR bit (see 6.3.3):

- a) informative action - service parameter information is exchanged during the Process Login enabling subsequent negotiation for image pair establishment; or
- b) binding action - service parameter information is exchanged that establishes an image pair relationship between processes in the communicating Nx_Ports. The relationship does not allow any communication types or paths other than those established by the PRLI ELS.

6.3 PRLI ELS

6.3.1 Use of PRLI ELS by the Fibre Channel Protocol

The PRLI ELS request is transmitted from an Originator FCP_Port to a Responder FCP_Port to identify to the destination the capabilities that the Originator FCP_Port expects to use with the Responder FCP_Port and to determine the capabilities of the Responder (see FC-LS).

If the PRLI ELS is requesting an informative action by setting the ESTABLISH IMAGE PAIR bit to zero, then the PRLI ELS accept reports the capabilities of the Responder to the Originator.

If the PRLI ELS is requesting a binding action by setting the ESTABLISH IMAGE PAIR bit to one, then the PRLI ELS accept reports the capabilities of the Responder to the Originator and establishes an image pair. An image pair shall be established only if the FCP devices have complementary initiator FCP_Port and target FCP_Port capabilities. If both FCP devices have both initiator FCP_Port and target FCP_Port capabilities, then a single image pair allows both initiator FCP_Ports to access the complementary target FCP_Port capabilities of the other device in the pair. Some capabilities require support by both the Originator and Responder before they may be used (see 6.3.3). If the IMAGE PAIR ESTABLISHED bit is set to one in the PRLI ELS accept, then an image pair was successfully established. If the IMAGE PAIR ESTABLISHED bit is set to zero in the PRLI ELS accept, then an image pair was not successfully established.

An accept response code indicating other than REQUEST EXECUTED (see 6.3.4 and FC-LS-2) shall be provided if the PRLI ELS FCP Service Parameter page is incorrect or if a requested image pair is not established.

A Link Service Reject (LS_RJT) indicates that the PRLI ELS request is not supported or is incorrectly formatted.

The PRLI ELS common service parameters and accept response codes are defined in FC-LS. FC-4 service parameters for mappings other than the Fibre Channel Protocol are defined in other FC-4 standards.

6.3.2 New or repeated Process Login

After the completion of any new or repeated binding Process Login, all clearing actions specified in 4.10 shall be performed.

After the completion of any new or repeated informative Process Login, the state of the Originator and Responder remains unchanged.

FCP devices may have default Process Login information provided in a manner outside the scope of this standard. Such devices do not require the processing of a PRLI ELS to perform normal FCP I/O operations. If default Process Login information is sufficient for login (i.e., PLOGI ELS) to perform an implicit Process Login, then the PLOGI ELS shall perform the same clearing actions and establish the same Unit Attention condition that is normally performed and established by Process Login.

6.3.3 PRLI ELS request FCP Service Parameter page format

The FCP Service Parameter page for the PRLI ELS request is shown in table 11.

Table 11 - PRLI ELS request FCP Service Parameter page

Item	Word	Bit(s)
TYPE CODE (08h for this standard)	0	31–24
TYPE CODE EXTENSION	0	23–16
Obsolete	0	15
Obsolete	0	14
ESTABLISH IMAGE PAIR	0	13
Reserved	0	12–0
Obsolete	1	31–0
Obsolete	2	31–0
Service Parameters		
Reserved	3	31–12
ENHANCED DISCOVERY	3	11
REC SUPPORT	3	10
TASK RETRY IDENTIFICATION REQUESTED	3	9
RETRY	3	8
CONFIRMED COMPLETION ALLOWED	3	7
DATA OVERLAY ALLOWED	3	6
INITIATOR FUNCTION	3	5
TARGET FUNCTION	3	4
Obsolete	3	3
Obsolete	3	2
READ FCP_XFER_RDY DISABLED (shall be set to one)	3	1
WRITE FCP_XFER_RDY DISABLED	3	0

Word 0, Bits 31–24: TYPE CODE: The value of 08h in this byte indicates that this Service Parameter page is defined for the Fibre Channel Protocol (see FC-FS-3).

Word 0, Bit 13: ESTABLISH IMAGE PAIR: If the ESTABLISH IMAGE PAIR bit is set to zero, then the PRLI ELS only exchanges service parameters as defined in FC-LS-2. If the ESTABLISH IMAGE PAIR bit is set to one, then the PRLI ELS exchanges service parameters and attempts to establish an image pair as defined in FC-LS-2.

Word 3, Bit 11: ENHANCED DISCOVERY: If the ESTABLISH IMAGE PAIR bit is set to zero, then the ENHANCED DISCOVERY bit shall be ignored. If the ENHANCED DISCOVERY bit is set to one, then the Originator is requesting that an image pair be established only if the initiator FCP_Port has been authorized to access one or more logical units, not including management logical units (see SAM-5), that are addressed through the target FCP_Port. If the initiator FCP_Port is not authorized to access one or more logical units, not including management logical units, then the image pair shall not be established, the PRLI ELS

accept response code shall be set to THE EXCHANGE RECIPIENT HAS A PREDEFINED CONFIGURATION THAT PRECLUDES ESTABLISHING THIS IMAGE PAIR (i.e., 0101b), and the IMAGE PAIR ESTABLISHED bit shall be set to zero. If the ENHANCED DISCOVERY bit is set to zero by either the Originator or the Responder to the PRLI ELS, then accessibility of logical units shall not affect establishment of the image pair.

Word 3, Bit 10: REC SUPPORT: If the REC ELS supported (REC SUPPORT) bit is set to one, then the Originator is indicating that it supports the transmission of the REC ELS when it is acting as an initiator FCP_Port.

The capability of the initiator FCP_Port to retransmit unsuccessfully transmitted data is determined by the RETRY bit (i.e., a REC SUPPORT bit set to one does not indicate the initiator FCP_Port supports retransmission of data). If the REC SUPPORT bit is set to zero, then the Originator is providing no information about whether it supports transmission of the REC ELS.

Word 3, Bit 9: TASK RETRY IDENTIFICATION REQUESTED: If the TASK RETRY IDENTIFICATION REQUESTED bit is set to one, the Originator of the PRLI ELS requests that task retry identification (see 4.7) be used. If both the Originator of the PRLI ELS and the Responder to the PRLI ELS request that task retry identification be used, then it shall be used between the initiator FCP_Port and all logical units addressed through the target FCP_Port. The PARAMETER field for each FCP_CMND IU shall be set to a unique non-zero value. The PARAMETER field for any REC ELS request or SRR FCP_LS request for that command shall be set to the same value.

If the TASK RETRY IDENTIFICATION REQUESTED bit is set to zero by either the Originator or the Responder to the PRLI ELS, then task retry identification shall not be used. The PARAMETER fields for FCP_CMND IUs, for REC ELS requests, and for SRR FCP_LS requests shall be zero.

Word 3, Bit 8: RETRY: If the RETRY bit is set to one, then the Originator or Responder is indicating that its initiator FCP_Port functions support the capability of requesting a retransmission of unsuccessfully transmitted data or that its target FCP_Port functions support the capability of performing a requested retransmission. If the RETRY bit is set to zero, then the Originator or Responder is indicating that it does not support the capability of requesting or performing retransmissions of unsuccessfully transmitted data.

If the process has both initiator FCP_Port and target FCP_Port capabilities, then the RETRY bit shall apply to both. The SRR FCP_LS request may be both transmitted by and accepted by the process.

An initiator FCP_Port and target FCP_Port shall use the retransmission capability only if the RETRY bit is set to one in both the request payload and in the accept payload. If the RETRY bit is set to zero in either the request payload or the accept payload, then the SRR FCP_LS request shall not be transmitted by the initiator FCP_Port. If an SRR FCP_LS request is received by a target FCP_Port that has set the RETRY bit to zero, then the SRR FCP_LS request shall be rejected with an FCP_RJT.

If the image pair is allowed to use the retransmission capability, then overlay of data as defined for retransmission shall be allowed regardless of the state of the DATA OVERLAY ALLOWED bit.

Word 3, Bit 7: CONFIRMED COMPLETION ALLOWED: If the CONFIRMED COMPLETION ALLOWED bit is set to one, then the Originator's or Responder's initiator FCP_Port function has the capability of supporting confirmed completion. If the CONFIRMED COMPLETION ALLOWED bit is set to zero, then the initiator FCP_Port function does not have the capability of supporting confirmed completion. The CONFIRMED COMPLETION ALLOWED bit shall be zero for FCP devices having only target FCP_Port function. If the initiator FCP_Port function supports confirmed completion, then the target FCP_Port may request an FCP_CONF IU by setting the FCP_CONF_REQ bit to one as specified by 4.5. If the initiator FCP_Port function does not have the capability of supporting confirmed completion, then the target FCP_Port shall not set the FCP_CONF_REQ bit to one.

Word 3, Bit 6: DATA OVERLAY ALLOWED: If the DATA OVERLAY ALLOWED bit is set to one, then the Originator or Responder is indicating that its initiator FCP_Port function has the capability of supporting data overlay. If the DATA OVERLAY ALLOWED bit is set to zero, then the initiator FCP_Port function does not have the capability of performing data overlay. The DATA OVERLAY ALLOWED bit shall be zero for FCP devices having only target FCP_Port function. If the initiator FCP_Port function supports data overlay, then the target FCP_Port may perform random buffer access that performs a transfer to or from the same offset in the application client buffer more than once during processing of a command.