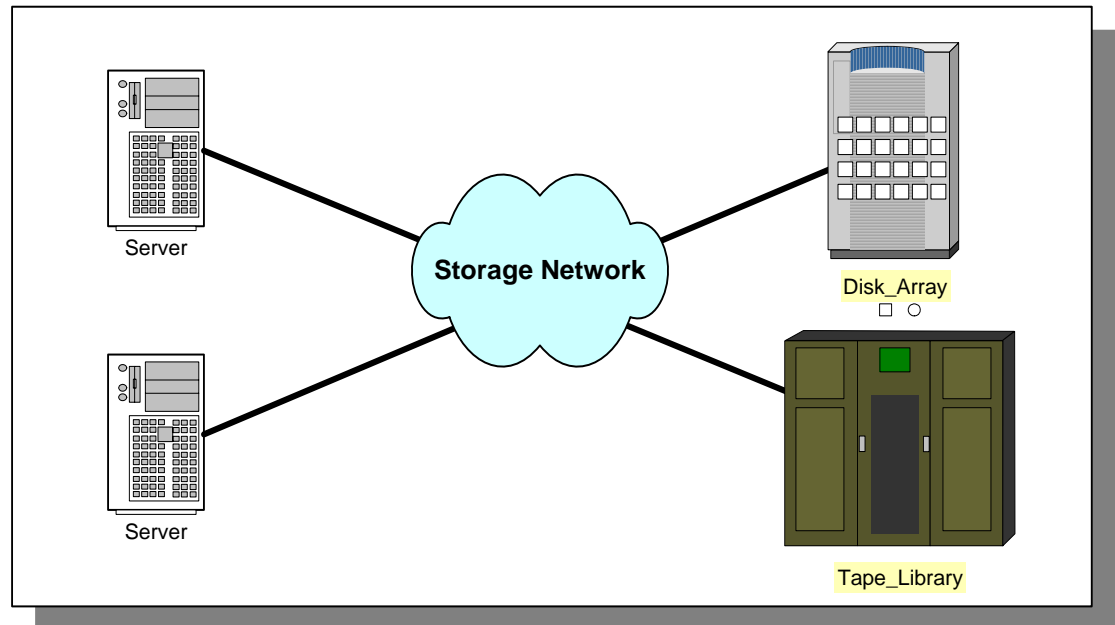# 6.   SAN Problem Sources

While SAN configurations can become very complex, a SAN can be simplified to three basic entities; the host system or systems, the network and the storage device or devices as shown in Figure 6. Whenever a problem occurs, it must be caused by one of these entities, or the interaction between entities.


Figure 6. Basic SAN Entities

Within each of these entities may exist sub-entities (and sub-sub-entities within them) that are the root cause of the problem. The following list shows a hierarchy that may be helpful in thinking about the potential cause of a problem.

1. Host System(s)

    - Application Software
    - Middleware (e.g., Volume Manager or Host RAID)
    - Operating System/File System
    - Host Bus Adapter (HBA) Driver
    - Host Bus Adapter (HBA)
    - Host Bus Adapter Firmware

2. Storage Network/Communications Infrastructure

    - Physical Links
    - Transceivers
    - Switches and Switch Firmware
    - Routers and Router Firmware
    - Bridges or Extenders and their Firmware

3. Storage Device(s)

- Interface Adapter
- Interface Adapter Driver/Firmware
- Storage Controller Firmware
- Storage Device (e.g., disk or tape)
- Storage Media

Sometimes a diagram, called a cause and effect diagram, or fishbone diagram is used to show the relationship between cause and effect as shown in Figure 7.
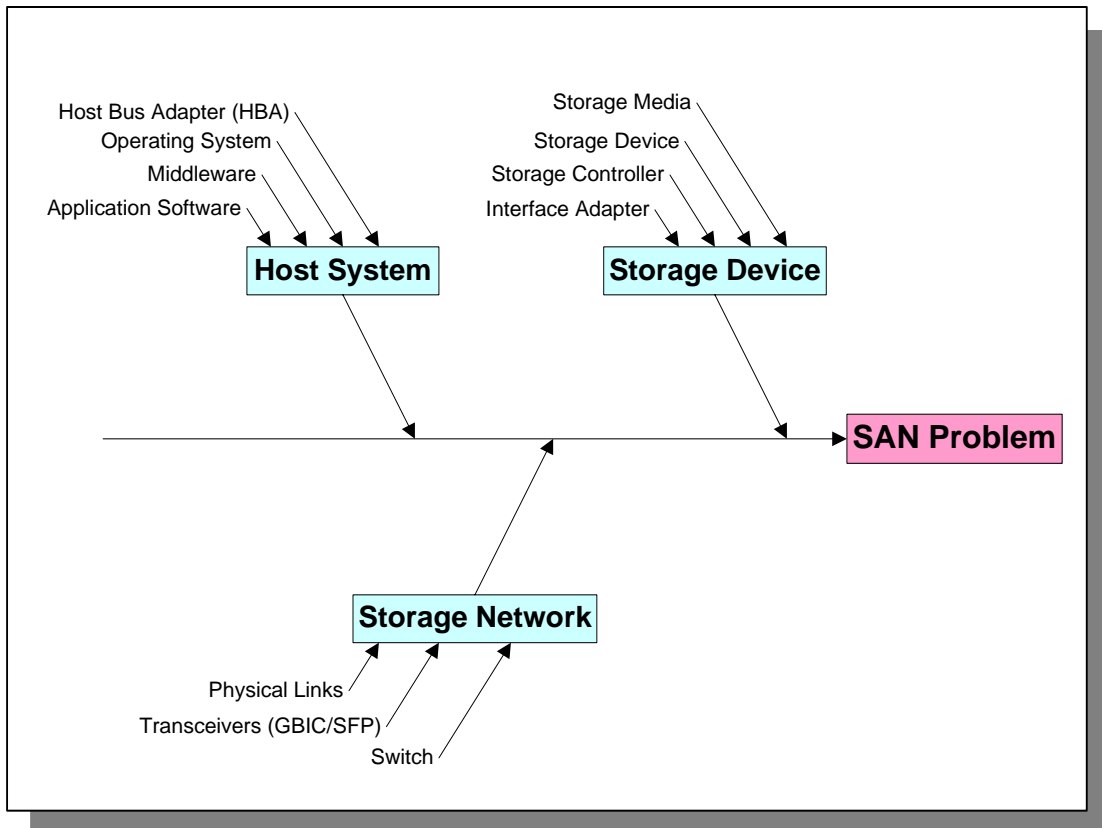

Figure 7. Cause and Effect Diagram

Each entity, in turn, has many sub-entities that could be the potential source of a problem. In turn, each of these has its own sub entities. For example, the Host Bus Adapter has hardware, firmware and driver software sub-entities (see Figure 8 on page 17). When a problem occurs, the cause of the problem must lie within one or more of these entities or their associated sub-entities.

As you might imagine, a complete fishbone-style diagram containing all of the possible root causes of SAN problems would be extremely complex and might identify thousands of potential problem causes. Because of this, it is probably impractical to attempt to put together a complete diagram, but even a simplified diagram such as the on shown in Figure 7 may help narrow the scope of the problem investigation.

This remainder of this chapter provides a set of checklists of potential problems that may be associated with each entity. The purpose of these checklists is not so much to provide a list of things to try when attempting to resolve a problem but to help provide ideas about some of the potential sources of problems.
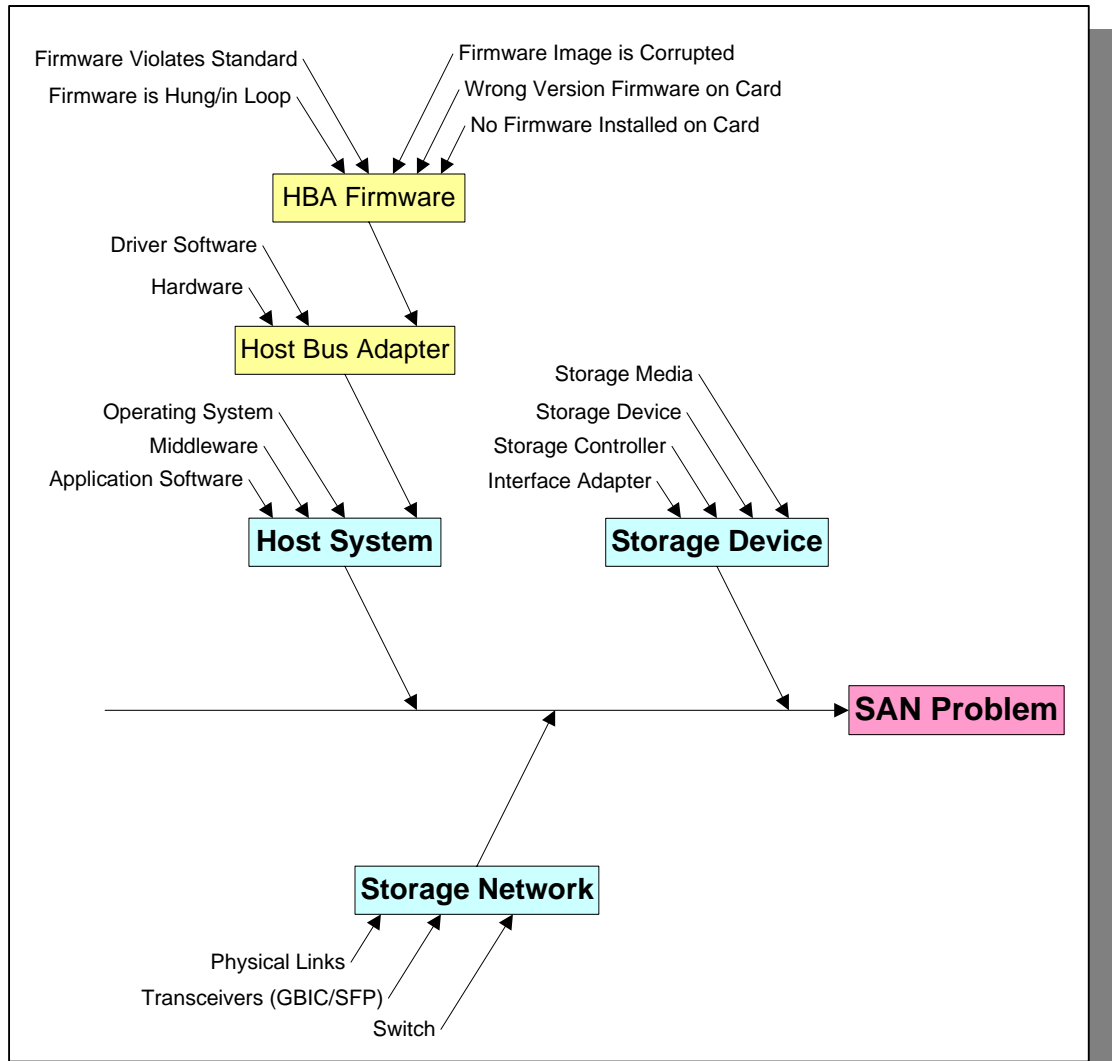
Figure 8. HBA Fishbone Diagram Expansion

6.1 Host Problems

- ❑ Storage device is not formatted
- ❑ Storage device is formatted for a different OS
- ❑ No signature written on storage device
- ❑ Storage device has not been mapped to a drive letter
- ❑ Storage device is not mounted to OS
- ❑ Storage device is not is system configuration file
- ❑ OS does not support devices being added after initialization
- ❑ Too many devices attached to system (e.g., no drive letters available)

6.1.1 Host Bus Adapter (HBA) Problems

- ❑ No HBA installed in System
- ❑ HBA is defective
- ❑ HBA is intermittent
- ❑ HBA is hung
- ❑ Driver for the HBA is not installed
- ❑ "Link Up" indicator not on (result of a problem, not the cause)
- ❑ Examing HBA error logs (result of a problem, not the cause)
- ❑ Wrong driver is installed (e.g., Qlogic 2000 versus QLogic 2200 or Windows NT versus 2000)
- ❑ Wrong version level of the HBA driver is installed
- ❑ Wrong version level of the HBA firmware is installed
- ❑ HBA port is administratively configured in wrong mode (loop vs. fabric)
- ❑ HBA port is administratively configured for the wrong speed (1g vs. 2g)
- ❑ Storage device is masked off at the HBA (not in HBA access control list)
- ❑ LUN is masked off at the HBA (HBA LUN Masking)
- ❑ Fabric Login failed — host cannot access the fabric
- ❑ HBA did discovery with the Name Server before registering for RSCNs and a device was added after discovery and before registration
- ❑ HBA did not do discovery for private devices on a local Arbitrated Loop
- ❑ Interoperability: HBA is incompatible with storage network
- ❑ Interoperability: HBA is incompatible with storage
- ❑ Two ports have the same Port_Name
- ❑ Two nodes have the same Node_Name
- ❑ HBA did not register for RSCNs and storage devices were added after the HBA initialized

- ❑ Security (port binding) is in effect and the HBA is connected to wrong port on the switch
- ❑ Security (port binding) is in effect and the HBA is not authorized to connect to this switch
- ❑ Security (authorization) is in effect and the HBA failed the authorization

6.2 Physical Link Problems

Each physical link consist of a transceiver (either fixed or pluggable such as a SFP or GBIC), the physical cable and a transceiver at the remote end. Link problems must be associated with one or the other of these entities.

6.2.1 Link Cable Problems

Cables can be the source of either solid or intermittent problems depending on the failure mechanism. Some possible causes of cable-related probems are:

❑ Cable: not installed

❑ Cable: not fully seated

❑ Cable: defective

❑ Electrical Cable: link is operating at a rate faster than supported by the cable

❑ Electrical Cable: cable has internal equalization and link is not operating at designed rate

❑ Electrical Cable: electrical cable too long for the link rate

❑ Electrical Cable: cable is miswired

❑ Electrical Cable: external interference is inducing errors in cable

❑ Electrical Cable: non-Fibre Channel cable used (e.g., RS-232 cable with DB-9 connectors)

❑ Optical Cable: wrong type of optical cable (i.e., multi-mode versus single mode)

❑ Optical Cable: multimode optical cable used with longwave GBIC/SFP

❑ Optical Cable: single-mode optical cable used with shortwave GBIC/SFP

❑ Optical Cable: mulitmode cable too long for the link rate

❑ Optical Cable: no crossover in optical cable

❑ Optical Cable: optical cable has broken fiber causing excessive signal loss

❑ Optical Cable: optical cable bend radius is exceeded

❑ Optical Cable: end of the fibre is damaged causing excessive signal loss

❑ Optical Cable: plug contaminated causing excessive signal loss

❑ Optical Cable: receptical contaminated causing excessive signal loss

6.2.2 Tranceiver, GBIC and SFP Problems

Pluggable GBICs and SFPs and non-removable tranceivers can be the source of either solid or intermittent problems depending on the failure mechanism. Some possible causes of tranceiver-related probems are:

❑ Tranceiver: transceiver, GBIC or SFP is defective

❑ Tranceiver: transceiver, GBIC or SFP is intermittent

❑ Tranceiver: optical transceiver, GBIC or SFP is operating outside of specifications

❑ GBIC/SFP: not fully seated

❑ GBIC/SFP: internal connector faulty

- ❑ GBIC/SFP: no power present at the GBIC/SFP

- ❑ GBIC/SFP: device does not supply the required power to GBIC/SFP (e.g., no 3.3v when needed)

- ❑ GBIC/SFP: wrong wavelength of GBIC/SFP (850 nm. shortwave versus 1300/1550 nm. longwave)

- ❑ GBIC/SFP: wrong wavelength of GBIC/SFP (1300 nm. Single Mode vs. 1550 nm. Single Mode)

- ❑ GBIC/SFP: wrong speed GBIC/SFP (e.g., 1 Gbit on a 2 Gbit link)

6.2.3 Link Initialization Problems

- ❑ Link failed to initialize successfully

- ❑ Link is in continual initialization

- ❑ Speed Negotiation: failed to complete successfully

- ❑ Speed Negotiation: Link is in continuous Speed Negotiation

- ❑ Administration: Two ends of the link are configured for different speeds

- ❑ Administration: Port is configured for wrong mode (Arbitrated Loop vs. Non-Loop)

- ❑ Ports are unable to determine correct mode (Arbitrated Loop vs. Non-Loop)

- ❑ Ports are in continuous mode determination (Arbitrated Loop vs. Non-Loop)

- ❑ Unexpected Ordered Set for the topology (e.g., Loop Ordered Set in a non-loop environment)

6.2.4 Link Protocol Problems

- ❑ Improper Primitive Signal separation (Primitive Signals must be preceded and followed by at least two Fill Words at the source)

- ❑ NOS Primitive Sequence too short (transmitted < 3 consecutive occurrences)

- ❑ OLS Primitive Sequence too short (transmitted < 3 consecutive occurrences)

- ❑ LR Primitive Sequence too short (transmitted < 3 consecutive occurrences)

- ❑ LRR Primitive Sequence too short (transmitted < 3 consecutive occurrences)

- ❑ Link-level protocol error — expected Ordered Set not received within R_T_TOV (e.g., LR --> LRR)

- ❑ Link-level protocol error — wrong Ordered Set received (e.g., LR receives OLS in response)

- ❑ Transmission error causes one Ordered Set to be converted to a different Ordered Set

6.3 Switch/Fabric Problems

- ❑ One or more switches not powered on
- ❑ One or more switches failed to complete power-on self test and initialization
- ❑ One or more switches defective or malfunctioning
- ❑ Wrong version of switch firmware
- ❑ One or more switches offline or disabled
- ❑ Switch port offline or disabled
- ❑ Switch port or firmware hung
- ❑ Zoning: System and storage not in the same zone
- ❑ Zoning: Wrong zoning configuration active at the switch
- ❑ Zoning: No zones defined and devices in the Default zone are not permitted to communicate
- ❑ Frame Delivery: Fabric failed to deliver frame (discarded)
- ❑ Frame Delivery: Fabric delivered multiple copies of the same frame
- ❑ Frame Delivery: Fabric corrupted frame (CRC error)
- ❑ Frame Delivery: Fabric altered/modified frame (without causing a CRC error)
- ❑ Frame Delivery: Fabric delivered frame to the wrong destination (misrouted)
- ❑ Frame Delivery: Fabric delivered frames out of order under static conditions
- ❑ Frame Delivery: Fabric delivered frames out of order during fabric reconfiguration
- ❑ Frame Delivery: Fabric took too long to deliver a frame (latency)
- ❑ FSPF routing database corrupted
- ❑ Incompatible: Arbitrated Loop device(s) connected to non-loop capable port
- ❑ Incompatible: Private Loop device(s) connected to switch that does not support private loop (translative loop mode) behavior
- ❑ Incompatible: Private Loop device(s) connected to port that is not in the translative loop mode (mode is supported by the switch)
- ❑ Incompatible: Multi-switch Fabric and one or more switches are incompatible
- ❑ Incompatible: Multi-switch Fabric and one or more switches are not configured in compatibility (interop) mode
- ❑ Incompatible: Multi-switch Fabric and ISL link flow control parameters are incompatible
- ❑ Incompatible: Multi-switch Fabric and E_D_TOV values are different
- ❑ Incompatible: Multi-switch Fabric and R_A_TOV values are different
- ❑ Incompatible: Multi-switch Fabric and Classes of Service supported are different
- ❑ Incompatible: Multi-switch Fabric and frame sizes supported are different
- ❑ Incompatible: Multi-switch Fabric and the zoning definitions are incompatible
- ❑ Incompatible: Multi-switch Fabric and Domain_ID is outside of allowed range

- ❑ Attempt to join two Fabrics having conflicting Domain_IDs

- ❑ Insistent Domain_IDs set and switch is unable to acquire the required Domain_ID

- ❑ Security (authorization) is in effect and the switch port failed the authorization

- ❑ Security (fabric binding) is in effect and the switch is not authorized to join the Fabric

- ❑ Security (switch binding) is in effect and the switch is not authorized to connect to a neighbor switch

6.4 Arbitrated Loop Problems

- ❑ Initialization: Loop failed to complete Loop Initialization and is hung

- ❑ Initialization: Failed to select a Loop Initialization Master (LIM)

- ❑ Initialization: Loop Initialization Master (LIM) failed to generate the correct initialization frame sequence

- ❑ Initialization: non-LIM port corrupted or dropped an initialization frame

- ❑ Initialization: non-LIM port created invalid or inappropriate initialization frame content

- ❑ Initialization: Loop is in continual initialization

- ❑ Initialization: NL_Port is causing excessive Loop Initializations

- ❑ Initialization: NL_Port was unable to acquire an AL_PA and is non-participating

- ❑ Initialization: NL_Port is unable to reacquire its AL_PA due to addressing conflict (two loops joined?)

- ❑ Initialziation: NL_Port acquires excessive number of AL_PAs causing other ports to become non-participating

- ❑ Initialization: One or more ports not operating at the same link rate (speed)

- ❑ Initialization: LIP occurred while loop circuit open — may cause loss of one or more frames

- ❑ Initialization: LIP(reset) issued causing Exchange(s) for other Initator(s) to be cleared

- ❑ Initialization: Initialization on one port of dual ported device affecting other port

- ❑ Initialization: LIP caused NL_Port to implicitly logout (PLOGI) other port(s)

- ❑ Initialization: LIP caused NL_Port to implicitly logout (PRLI) other port(s)

- ❑ Initialization: FL_Port did not send FAN following LIP and NL_Port is waiting for FAN before resuming operation

- ❑ Initialization: Initiator did not send ADISC or PDISC to private device following initialization and NL_Port is waiting before resuming operaiton

- ❑ Too many devices on the loop resulting in excessive delays and poor performance or timeouts

- ❑ Loop is to large physically resulting in excessive delays and poor performance or timeouts

- ❑ A time or bandwidth critical device such as tape is on a loop with other devices and unable to get the necessary bandwidth or timely access (performance, timeouts or job failures)

- ❑ Defective port on loop

- ❑ One or more ports are not powered on

- ❑ Defective cable/connector/backplane on loop

- ❑ Defective Port Bypass Circuit (PBC)

- ❑ No power to Port Bypass Circuit (PBC)

- ❑ Port Bypass Circuit faulty causing loop failure
- ❑ Port Bypass Circuit faulty causing device to be isolated
- ❑ Loop Port Bypass Primitive Sequence received causing device to be isolated
- ❑ Device detected internal error and activated Port Bypass Circuit
- ❑ NL_Port did not perform Fabric Login (FLOGI) and FL_Port does not support Private Loop Devices (no emulated private loop mode)
- ❑ Port is unable to win Arbitration
- ❑ Port is corrupting repeated transmission words
- ❑ OPN Ordered Set corrupted and no port opened
- ❑ OPN Ordered Set corrupted and wrong port opened
- ❑ CLS Ordered Set corrupted
- ❑ Fairness problem causing port starvation
- ❑ Unfair port is causing starvation of other ports
- ❑ Frame detected outside of loop circuit
- ❑ R_RDY detected outside of loop circuit (or after CLS transmitted)
- ❑ DHD detected outside of loop circuit (or after CLS transmitted)
- ❑ Two ports on the loop have the same Port_Name
- ❑ LIP error (too few consecutive LIPs)
- ❑ OPN Ordered set detected while loop circuit is already open
- ❑ ARB(F0) occurs when no loop circuit is open
- ❑ Invalid ARB(x) — x & y portions are incorrect/invalid
- ❑ Wrong AL_PA opened (D_ID does not match the opened port)
- ❑ Loop circuit remains open too long (maximum time is not specified by the standard)
- ❑ Loop circuit is opened, but no frame transmission occurs (this is not an error per se, but is suspicious)
- ❑ Continuous OPN/CLS cycles without frame transmission

6.5 Storage/Device Problems

- ❑ Storage is powered off
- ❑ Storage controller or device failed to complete power on and initialization
- ❑ Storage controller is offline or disabled
- ❑ Interface port is offline or disabled
- ❑ Storage controller firmware is hung
- ❑ Disk drive(s) are not installed
- ❑ Access Control: LUN Masking is preventing access by host port
- ❑ Access Control: Host port is not in storage Access Control List (ACL)
- ❑ Administration: Port is administratively configured in wrong mode (loop vs. fabric)
- ❑ Administration: Port is administratively configured for the wrong speed (1g vs. 2g)
- ❑ Storage is not registered with the Name Server
- ❑ Storage is not registered as supporting the FCP protocol in the Name Server
- ❑ Storage devices failed to register with the Name Server and probing is disabled at the switch
- ❑ Incompatibility: wrong firmware version in storage controller
- ❑ Security (port binding) is in effect and the storage is connected to wrong port on the switch
- ❑ Security (port binding) is in effect and the storage is not authorized to connect to this switch
- ❑ Security (authorization) is in effect and the storage failed authorization with the Fabric
- ❑ Security (authorization) is in effect and the storage failed authorization with the Host system

6.6 Fibre Channel Transport Problems

Errors can occur within the Fibre Channel transport at the frame, sequence or exchange levels. These errors may require a Fibre Channel analyzer in order to identify what is happening and the source of the problem.

Some of the potential causes of errors are listed in the following sections.

6.6.1 Invalid Frame Errors

❑ Transmission Error: invalid 8b/10b code

❑ Transmission Error: 8b/10b running disparity error

❑ Transmission Error: misplaced special character

❑ Transmission Error: CRC error

❑ Transmission Error: Loss-of-Synchronization during frame reception

❑ Transmission Error: Loss-of-Signal during frame reception

❑ Transmission Error: corrupted or missing Start-of-Frame (SOF)

❑ Transmission Error: corrupted or missing End-of-Frame (EOF)

❑ Frame terminates with EOFni (invalid frame)

❑ Frame terminates with EOFdti (invalid frame)

❑ Frame terminates with EOFa (aborted frame)

❑ SOF received during frame reception (prior to receiving EOF for previous frame)

❑ IDLE received during frame reception (prior to receiving EOF)

❑ Any Ordered Set received during frame reception (prior to receiving EOF)

❑ Frame is too short (must be 7 words or greater of frame content)

❑ Frame is too long (greater than receive buffer size)

❑ Frame is missing (dropped or discarded in route)

❑ 8b/10b running disparity is not negative at start of frame and K28.5 is not recognized

❑ Data words received outside of frame boundaries (not a frame error per se, but indicative of potential problem)

6.6.2 Class of Service Not Supported

❑ Class of service is not supported by fabric (e.g., Class-1)

❑ Class of service is not supported by recipient (e.g., Class-1)

6.6.3 Frame Header Errors

❑ Source and Destination IDs are the same

❑ Invalid R_CTL field value (unsupported or undefined value)

❑ Incorrect Destination_ID (D_ID) — frame was delivered to the wrong port

❑ Incorrect Source_ID (not the address assigned by the fabric)

❑ Unsupported Protocol Type (e.g., disk drives receives frame with IP over FC protocol, TYPE=05h)

- ❑ Invalid bit settings in the F_CTL field
- ❑ Invalid or unrecognized OX_ID value
- ❑ OX_ID set to FFFFh for other than Loop Initialization frames
- ❑ Invalid OX_ID/RX_ID combination
- ❑ Invalid DF_CTL field settings
- ❑ Invalid PARM field settings (e.g., Relative Offset is present and outside of allocated buffer space)
- ❑ Invalid PARM field settings (e.g., Relative Offset is present and is incorrect)
- ❑ Reserved bit set by the sender

6.6.4 Optional Headers

- ❑ DF_CTL indicates optional header is present, but it is not present in the Data field
- ❑ DF_CTL indicates optional header is present, but it is the wrong size
- ❑ DF_CTL indicates optional header is not present, but it is present in the Data field
- ❑ Unexpected optional header present (SCSI-FCP does not expect optional headers)
- ❑ Required Optional Header is not present (e.g., IP over FC requires the Network Optional Header)
- ❑ Information contained in an Optional Header is incorrect

6.6.5 Frame Delimiter Problems

- ❑ Class-2 Data Frame (R_CTL not equal to 'Cx'h) and EOF = EOFt
- ❑ Class-F Data Frame (R_CTL not equal to 'Cx'h) and EOF = EOFt
- ❑ Class-3 frame, F_CTL bit 19=1 (End_Sequence) and EOF does not equal EOFt
- ❑ Class-3 frame, F_CTL bit 19=0 (End_Sequence) and EOF does equal EOFt
- ❑ All frames within a Sequence do not use the same class of service
- ❑ EOF results in incorrect (positive) running disparity (wrong EOF used)

6.6.6 Flow Control Problems

- ❑ Port has insufficient BB_Credit to support the link distance (performance)
- ❑ Frame cannot be sent due to lack of credit (performance, timeout or frame drop)
- ❑ Inter-Switch Link (ISL) is blocked due to congestion or Head-of-Line blocking (performance and/or frame drop)
- ❑ No buffers are available at switch port because they have been allocated to another switch port (e.g., Extended Fabric feature)
- ❑ Frame is dropped because it was received when no receive buffer available

6.6.7 Inter-Frame Gap

- ❑ Frame not recognized due to insufficient inter-frame gap (too few words between consecutive frames - must be at least two)

6.6.8 Sequence Errors

- ❑ Frames received out-of-order (Sequence Count) when out-of-order is not supported by the recipient

- ❑ Non-initiation frame received when Sequence is not active and out-of-order is not supported by the recipient

- ❑ No Sequence initiation frame (SOFi) received

- ❑ No Sequence termination frame (EOFt) received

- ❑ Wrong SOF for current conditions

- ❑ Wrong EOF for current conditions (e.g., EOFt when should be EOFn)

- ❑ Duplicate Sequence_IDs from same sender at the same time

- ❑ Same Sequence_ID used for consecutive Sequences with same destination

- ❑ Sequence Count does not continuously increase across Streamed Sequence boundaries

- ❑ Missing frame(s) within sequence (see Invalid Frame Errors on page 27 for some possible causes)

- ❑ Sequence timeout (no frame received within E_D_TOV) while Sequence is open

- ❑ Too many Sequences attempted - no resources available at recipient

- ❑ Relative Offset in Parameter field is out-of-bounds or is incorrect/unexpected

- ❑ Unexpected Link Control frame received (e.g., none are expected in Class-3)

- ❑ Fill (Pad) bytes present in other than last frame of the sequence

- ❑ Class-1 or Class-2 frame fails to receive ACK, RJT or BSY Link Control frame within E_D_TOV

- ❑ Class-F frame fails to receive ACK_1, RJT or BSY Link Control frame within E_D_TOV

6.7 Exchange Errors

- ❑ Frame received outside of existing Exchange (OX_ID is unknown)

- ❑ Duplicate OX_IDs received from the same Originator

- ❑ Invalid OX_ID/RX_ID combination

- ❑ Data frame received while a port holds Sequence Initiative for the Exchange

- ❑ Streamed Sequences do not use the same Class-of-Service

- ❑ Out-of-order Sequences detected within an Exchange when out-of-order is not supported by the recipient

- ❑ Unsupported Exchange Error Policy

- ❑ Too many Exchanges attempted - no resources available at recipient

- ❑ Exchange aborted with ABTS

6.8 Session Errors

6.8.1 Fabric Login

- ❑ No FLOGI session in effect
- ❑ FLOGI received LS_RJT
- ❑ FLOGI timed out waiting for response
- ❑ FLOGI Service Parameters incorrect or incompatible
- ❑ Switch or switch port was reset or is offline or disabled
- ❑ Link failure occurred (NOS sent or received)
- ❑ Link was reinitialized (OLS sent or received)

6.8.2 N_Port Login

- ❑ No PLOGI session in effect
- ❑ PLOGI received LS_RJT
- ❑ PLOGI timed out waiting for response
- ❑ PLOGI Service Parameters are incorrect or incompatible
- ❑ Either N_Port was reset or is offline or disabled
- ❑ Other (wayward or malicious) host used LOGO to logout active session
- ❑ PLOGI issued while Exchanges pending for prior PLOGI session (PLOGI cause all Exchanges for previous session to be abnormally terminated)
- ❑ Device logged-out implicitly without notification to other N_Port
- ❑ SCSI Initiator receives PLOGI from another Initiator (not an error per se)
- ❑ SCSI Target device originates PLOGI
- ❑ Host issued LIP(reset) for loop device (either selective or reset all)
- ❑ Host issued Target Reset SCSI task management function

6.8.3 Process Login

- ❑ No Process Login (PRLI) session in effect
- ❑ PRLI received LS_RJT
- ❑ PRLI received LS_ACC, but the 'Accept Response Code' was not b'0001'
- ❑ PRLI timed out waiting for a response
- ❑ PRLI Service Parameters are incorrect or incompatible
- ❑ SCSI Initiator receives PRLI from another Initiator (not an error per se)
- ❑ Multiple Service Parameter Pages are present in PRLI but not supported
- ❑ PRLI issued while Exchanges are pending for prior PRLI session (PRLI cause all Exchanges for previous session to be abnormally terminated)
- ❑ Process Logout (PRLO) occurred
- ❑ Other (wayward or malicious) host used Third-Party Process Logout (TPRLO) to logout active session

- PLOGI session ended (causes PRLI session to end also)

- Either N_Port was reset or is offline or disabled

- PLOGI issued while Exchanges are pending for prior PLOGI session (PLOGI cause all Exchanges for previous session to be abnormally terminated)

- SCSI Target device originates PRLI

- Host issued LIP(reset) for loop device (either selective or reset all)

- Host issued Target Reset SCSI task management function

6.9 SCSI FCP Errors

The SCSI Fibre Channel Protocol (FCP) specifies the mapping of SCSI operations to Fibre Channel. Failure to follow the protocol mapping may result in problems.

6.9.1 FCP_CMND Information Unit

- ❑ FCP_CMND IU too short (< 32 bytes)
- ❑ FCP_CMND IU too long (> 32 bytes when a variable-length CDB is not present)
- ❑ FCP_CMND IU incorrect length for variable length CDB (size is not consistent with 32 bytes + Additional CDB Length)
- ❑ Reserved bits are not set to 0b by the sender
- ❑ More than one Task Management Flag bit is set
- ❑ Reserved Task Management Flag bit is set to 1b
- ❑ FCP_DL value is less than the transfer size specified by the CDB
- ❑ FCP_DL value is zero bytes for a read or write type command
- ❑ Task Codes field is set to a reserved value
- ❑ Invalid Logical Unit Number
- ❑ Logical Unit Number too large for device, OS or application
- ❑ The Read Data or Write Data Execution Management Code bits do not match the CDB type
- ❑ FCP_CMND IU received by an initiator
- ❑ Command Reference Number indicates a missing or out-of-order command
- ❑ The OX_ID field in the frame header contains a value already in use between this Initiator and Target and SCSI Linking is not active
- ❑ The RX_ID field in the frame header does not = FFFFh and SCSI Linking is not active
- ❑ The F_CTL field in the frame header is not as expected (s/b = 290000h or 090000h)
  - • FCP_CMND IU does not set the First_Sequence bit (F_CTL bit 21) in the frame header when SCSI Linking is not active
  - • FCP_CMND IU has the Last_Sequence bit (bit 20) set in the F_CTL field of the frame header
  - • FCP_CMND IU does not have the End_Sequence bit (bit 19) set in the F_CTL field of the frame header
  - • FCP_CMND IU does not transfer Sequence Initiative (F_CTL bit 16) and FCP_XFER_RDY was not disabled on write-type commands during Process Login (it would be rare to do this)

6.9.2 FCP_XFER_RDY Information Unit

- ❑ Target receives an FCP_XFER_RDY IU
- ❑ Initiator receives an FCP_XFER_RDY IU for a non-write type command

- ❑ Initiator receives an FCP_XFER_RDY IU for a command (Exchange) that is not active (OX_ID is unknown to the initiator)

- ❑ FCP_XFER_RDY IU is not 12 bytes long

- ❑ DATA_RO field is outside the bounds of the buffer allocated by the initiator (FCP_DL + BURST_LEN)

- ❑ DATA_RO is not on a word (4-byte) boundary

- ❑ BURST_LEN field is not a multiple of 4 and this is not the last FCP_XFER_RDY

- ❑ BURST_LEN field > Maximum Burst SIze specified in the Interface Disconnect/Reconnect Mode Page (page 02h)

- ❑ BURST_LEN field value = zero bytes

- ❑ BURST_LEN field value is > remaining amount of write data per the CDB

- ❑ The F_CTL field in the frame header is not as expected (s/b = 990000h)

  - • FCP_XFER_RDY IU does not transfer Sequence Initiative (F_CTL bit 16)

  - • FCP_XFER_RDY IU sets either First_Sequence or Last_Sequence (F_CTL bits 21 and 20)

  - • FCP_XFER_RDY IU does not set End_Sequence (F_CTL bit 19)

6.9.3 FCP_DATA Information Unit

- ❑ Target receives an FCP_DATA IU during a read type command

- ❑ Initiator receives an FCP_DATA IU during a write type command

- ❑ Target receives an FCP_DATA IU during a write type command and Sequence Initiative is not transferred

- ❑ Initiator receives an FCP_DATA IU during a read type command and Sequence Initiative is transferred

- ❑ FCP_DATA IU has the Last_Sequence bit set in the F_CTL field of the frame header

- ❑ FCP_DATA IU contains zero bytes of data

- ❑ The amount of data transferred by the resulting FCP_DATA IU does not match the BURST_LEN field in the FCP_XFER_RDY (too much or too little data in the data Sequence)

- ❑ Initiator or Target receives an FCP_DATA IU for a non-data transfer type command

- ❑ Initiator or Target receives an FCP_DATA IU for a command (Exchange) that is not active

- ❑ OX_ID/RX_ID combination is invalid or unknown

- ❑ The F_CTL field in the frame header is not as expected

  - • Should be = 800008h or 880008h when sent by a Target

  - • Should be = 000008h or 080008h when sent by an Initiator

6.9.4 FCP_RSP Information Unit

- ❑ Target receives an FCP_RSP IU

- ❑ Initiator receives an FCP_RSP IU for a command (Exchange) that is not active
- ❑ FCP_RSP IU is too short (less than 24 bytes - note some implementations fail to include the FCP_RESID, FCP_RSP_LEN and FCP_SNS_LEN fields)
- ❑ FCP_RSP IU is too long (greater than 24 + FCP_RSP_LEN + FSP_SNS_LEN padded to the next word boundary)
- ❑ The FCP_RSP IU RSP_CODE field is present and non-zero
- ❑ The RSP_CODE field contains a reserved value
- ❑ No FCP_RSP IU received before the command times out at the SCSI level
- ❑ OX_ID/RX_ID combination is invalid or unknown
- ❑ Fill bytes are indicated in the F_CTL field in the frame header (bits 1,0) when no sense information is present
- ❑ The number of Fill bytes indicated by the F_CTL field is inconsistent with the amount of Sense Information present
- ❑ Either the Initiator or Target did not indicate support for Confirmed Completion during Process Login and the FCP_CONF_REQ bit is set in the FCP_RSP
- ❑ The F_CTL field in the frame header is not as expected (should be 89000xh or 99000xh)
  - • The FCP_RSP IU does not transfer Sequence Initiative
  - • The FCP_RSP IU does not have the Last_Sequence bit set in the F_CTL field of the frame header when Linking is not active and FCP_CONF is not being requested.

6.9.5 FCP_CONF Information Unit

- ❑ Initiator receives an FCP_CONF IU
- ❑ The FCP_CONF IU frame payload is not = zero bytes
- ❑ Initiator or Target receives an FCP_CONF IU for a command (Exchange) that is not active
- ❑ The F_CTL field in the frame header is not as expected (should be 990000h)
  - • The FCP_RSP IU does not have the Last_Sequence bit set in the F_CTL field of the frame header

6.9.6 Unrecognized FCP Information Unit

- ❑ A frame has the TYPE field set to 08h does not have the R_CTL field set to 01h, 03h, 05h, 06h or 07h
- ❑ The Initiator does not support FCP_CONF and receives a frame with the TYPE field set to 08h and the R_CTL field is set to 03h

6.9.7 Other FCP Errors

- ❑ Either the Initiator or Target did not indicate support for Retry (Sequence Retransmission Request, SRR) during Process Login and an SRR FC-4 Link Service is received

6.10 SCSI Command Errors

- ❑ (tbd)

6.11 Data/Content Errors

There is nothing wrong at the Fibre Channel or SCSI level, but the data being read or written is incorrect. These errors typically represent product errors or failures.

- ❑ Data miscompare (data read does not match the data that was written)
- ❑ Incorrect data being returned (e.g., SCSI Enclosure Services is returning the wrong, or unexpected, data)
- ❑ others (tbd)

6.12 Timeout Problems

- ❑ Device or port is hung
- ❑ Because most Fibre Channel installations use Class-3 there is no explicit acknowledgement of frame delivery. Consequently, bad frames are simply discarded without notification and the operation times out.
- ❑ Excessive congestion can cause timeout problems
- ❑ Link extenders are in use resulting in excessive delays
- ❑ Fibre Channel traffic is sent through a non-Fibre Channel network and encounters excessive delay

6.13 Storage Network Design

Improper, or inappropriate design of the storage network can lead to problems. Some common design errors are listed below.

❑ Requirements: Requirements do not meet the actual need

❑ Requirements: Requirements do not match the technology capabilities

❑ Requirements: Requirements are incomplete

❑ Requirements: Requirements have changed and the design has not changed to meet the new requirements

❑ Design: the design does not meet the performance (bandwidth) requirements of the systems or storage devices

❑ Design: Design does not meet the availability (uptime) requirements

❑ Design: Design does not meet the serviceability requirements

❑ Design: Design does not meet the cost requirements

❑ Compenents chosen during the design do not meet the requirements (e.g., 1 Gbit chosen when 2 Gbit is required)

❑ Components chosen during the design are not interoperable

❑ Components do not meet their advertised specifications

6.14 Extended Link Service Errorrs

- ❑ ELS Request fails to receive expected Reply Sequence within 2 * R_A_TOV
- ❑ ELS Request receives LS_RJT response
- ❑ ELS Request is malformed or corrupted
- ❑ ELS Reply is malformed or corrupted
- ❑ ELS Request F_CTL field in frame header is not as expected (should be 290000h)
- ❑ ELS Reply F_CTL field in frame header is not as expected (should be 980000h or 990000h)