iSCSI and FCoE testing: What are the test Challenges Under the Hood of a 10 Gb iSCSI and a 10G FCOE Storage Array Product Certification?

Dr. M. K. Jibbe
Distinguished Engineer
Quality Czar for Development and Certifications of LSI Storage Products
Sr. Manager and Technical Lead of Test Architect
LSI Corporation (Engenio Storage Group)
Acronyms

- FCoE: Fibre Channel over Ethernet
- iSCSI: Internet Small Computer System Interface
- CNA: Converged Network Adapter
- PDU: Protocol Data Unit
- IPV6: Internet Protocol version 6
- IPV4: Internet Protocol version 4
- RAID: Redundant Array of Inexpensive Disks
- INCITS: InterNational Committee for Information Technology Standards
- IFR: Inter-Fabric Router
- SAN: Storage Area Network
- FCP: Fibre Channel Protocol
- FCIP: Fibre Channel over Internet Protocol
- IFCP: Internet Fibre Channel Protocol
- FIP: FCoE Initialization Protocol
- DCB: Data Center Bridging
- CHAP: Challenge Handshake Authentication Protocol
- R2T: Ready To Transmit
- RVM: Remote Volume Mirroring
- VE-Port: Virtual End Port
Abstract

The certification of a 10 Gb iSCSI and a 10 Gb FCoE RAID Storage System on the same network elicits a lot of challenges at the development level and the Test / Quality Assurance level. The challenges are due to the fact that both 10 Gb iSCSI and 10Gb FCOE are newly deployed host interfaces in the RAID Storage environment. As a result, development module test for both interfaces on the same network should be designed very carefully to establish test coverage beyond basic operations with a RAID Storage system, standard RAID testing, or an Ethernet plug fest. These module level tests must tackle the timing differences associated with a network being accessed by two different protocols with the following common and different characteristics:

- Device discovery for both protocols on the same network
- 10GB CNA which is common to both protocols
- 10 GB switch traffic control and congestion which is common for both interfaces
- Security mechanisms with different Operating systems,
- Operational parameters associated with I/O retries and recovery
- Management, Administration, and Integration with Storage products
- Design For Testability “DFT” mechanisms
- Debugging, Diagnostics, and problem Isolations
- IPV4 vs. IPV6

It should be noted that there is not much leverage between 1 Gbit and 10 Gbit operation due to differences in chip set and driver firmware.- may be somewhat true for IP level,

Again there are considerable differences between 10Gbit iSCSI and 10Gbit FCOE (Chipset, driver, and protocols). Common part is IP layer

There are specific features such as backup, snapshot, remote mirroring, and cluster application compatibility that must be supported by the RAID product and must be verified during the testing of the RAID controller host interface types. As with any inter connected usage, device operation, such as RAID Storage Subsystem, has direct dependency on proper operation of interfaces.
One should think about FCoE as placing the FC protocol on a new physical link
- New Lossless Ethernet links instead of physical FC links
- But it is still Fibre Channel

The protocol is being defined in the INCITS Fibre Channel (T11) technical committee

The new Lossless Ethernet links are being defined in the IEEE 802.1
Targeting Standards completion for 2H08
FCoE Fabrics

- FCoE fabrics must inter-operate seamlessly with FC Fabrics
- Existing FC services continue to operate in an FCoE environment
- FCoE supports all Fibre Channel advanced features (e.g. virtual fabrics, IFR, security, etc.)
- FCoE will not require changes to existing SAN management software

- FCoE is NOT a replacement for FCIP
  - FCIP is for inter-switch links beyond the Data Center
  - FCIP uses TCP/IP
FCoE Relation to ISO Layers

Operating System / Applications

SCSI Layer

FCP iSCSI FCP FCP FCP SRP/iSER

FCIP iFCP TCP TCP TCP

IP IP IP

Ethernet

FC 1, 2, 4, 8, 10 Gbps

TCP 1, 10 Gbps

IP 1, 10 Gbps

IP 10, 20 Gbps

FC 1, 2, 4, 8, 10 Gbps

iSCSI 1, 10 Gbps

TCP 10, 20 Gbps

IP 10, 20 Gbps

FCoE 10, 20 Gbps
FC Encapsulation Into Ethernet Frames
(2 FCoE Related Packet types)

Ethernet Header provides things needed for the physical network, including “Ethertype”

Ethertype “FCoE” (8906h)

FC Imbedded Frames: Same as in Physical FC
Protocol control information: Version, SOF, EOF, etc.

Frame Check Sequence (CRC)

FC-4
FC-3
FC-2
FC-1
FC-0

FC Levels (Unchanged)

IEEE 802.3 Layers

Ethernet Header provides things needed for the physical network, including “Ethertype”

Ethertype “FIP” (8914h)

Discovery and Login/Login/Logout Parameters
Protocol control information: Version, Op-codes, etc.

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What is iSCSI?

- Replaces shared bus with switched fabric
- Transparently encapsulates SCSI CDBs
- Unlimited target and initiator connectivity
What is iSCSI?

- **iSCSI: Internet Small Computer Systems Interface**
  - A TCP/IP based protocol for establishing and managing connections between IP-based storage devices, hosts, and clients.
  - TCP/IP used as a transport for SCSI protocol
  - Use: Native IP SANs

![ISCSI Protocol Diagram]

- iSCSI is a transport protocol for SCSI that operates on top of TCP through encapsulation of SCSI commands in a TCP/IP stream. Enables the transport of I/O Block data over IP Networks.
iSCSI Architectural Objects cont’d
How FCoE differs from iSCSI

1. FCoE layer replaces the TCP/IP layer used in iSCSI
2. FCoE requires the Data Center Bridging (DCB) Ethernet improvements to satisfy the requirements of different traffic classes on a single network without creating “traffic interference,” that is, without having one class of traffic starve another.
3. FCoE is not intrinsically routable using IP. However, FCoE routing can be performed using already established protocols such as FCIP.
## FCoE and iSCSI comparison

<table>
<thead>
<tr>
<th>Feature</th>
<th>FCoE</th>
<th>iSCSI</th>
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<tbody>
<tr>
<td>Enables existing FC infrastructure to interface directly with an Ethernet network</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Leverages existing FC management construct over Ethernet</td>
<td>X</td>
<td></td>
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<tr>
<td>Lossless Ethernet improves quality of service</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Leverages pervasive Ethernet skill set</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Support for 1GbE</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Native IP routing</td>
<td></td>
<td>X</td>
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</tbody>
</table>
Array Ethernet Port Configuration

Controller A
- 10/100 MB/s Ethernet
- Management Port
- iSCSI/FCOE Daughter Card
  - Port A
  - Port B
  - 10GB/s

Controller B
- 10/100 MB/s Ethernet
- Management Port
- iSCSI/FCOE Daughter Card
  - Port A
  - Port B
  - 10GB/s

SAS/SATA Disk Drives

iSCSI Portal Group A
- Management Port A
- iSCSI Port A

iSCSI Portal Group B
- Management Port B
- iSCSI Port A
Array Management Configuration
Single Path Topology

Array

Controller A
- iSCSI/FCoE Port A
- iSCSI/FCoE Port B

Controller B
- iSCSI/FCoE Port A
- iSCSI/FCoE Port B

Gigabit Ethernet Switch

Server

Laptop

Server

Workstation
Dual Path Topologies
Redundant Dual Path Topologies

Diagram of redundant dual path topologies involving controllers, arrays, servers, and gigabit Ethernet switches.
Primary and Secondary Paths
Test Parameters

Protocol Compliance / Interoperability
- Login
- Full Feature Phase
- Multi-Connection
- CHAP
- Error Recovery
- Negotiation limit

Controller Module Configuration
- Single-controller (Simplex)
- Dual-controller (Duplex)
- Single-power supplies (alternate CRU is fan-only)
- Dual-power supplies
- Fully loaded with internal drives (12 drives)
- Number of internal drives
- Internal drives are SAS, SATA, or FC
- 256MB cache
- 1GB cache
- # of Controllers with iSCSI host port modules

Array Configuration
- Non-expanded controller tray
- 1 expansion tray with SAS drives
- 1 expansion tray with SATA drives
- Max expansion trays (SAS / SATA/FC/Mix)
- Fully loaded expansion trays
- Partially loaded expansion trays
- Single-controller arrays with single-Card EXP trays
- Dual-controller arrays with dual-card EXP trays
- Expansion trays with single PWS and fan
- Expansion trays with dual power supplies

Host System Requirements
- Windows 2008 platforms – 10GB NIC and CNA variations
- Windows Server 2008 R2 & SP2 platforms - 10GB NIC and CNA
- Solaris 11 10GB NIC and CNA
- AIX 7.1 10GB NIC and CNA
- Redhat Linux 6.0- 1GB/2GB/4GB/8GB
- SuSE 11.1 10GB NIC and CNA
- Others

SAN Configuration
- Mix of iSCSI network speeds
- Heterogeneous Configs
  - O/S
  - Servers
  - Switch level
  - Speed
  - Model
- Arrays
  - Current
  - Legacy

Direct Configuration & Topologies
- Single host direct-connect
- Dual host direct-connect
- Single Path Topology
- Dual Path Topology
- Redundant Path Topology
- Primary & Secondary path
iSCSI and FCOE Test classes

<table>
<thead>
<tr>
<th>Test Classes</th>
<th>Count Of Test Cases</th>
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<tr>
<td>Interoperability</td>
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<tr>
<td>Compliance Tests</td>
<td>100</td>
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<tr>
<td>Component Tests</td>
<td>50</td>
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<tr>
<td>Module level Tests</td>
<td>50</td>
</tr>
<tr>
<td>Build Reliability Tests</td>
<td>30</td>
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<tr>
<td>Trunk Tests</td>
<td>350</td>
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<td>Functional Tests</td>
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<td>Latency Tests</td>
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<td>System tests</td>
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<td>Use cases</td>
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<td>Regression test</td>
<td>300</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>2785</strong></td>
</tr>
</tbody>
</table>

ISCSI and FCOE test classes vary in the area of interoperability, compliance, Module level testing, Reliability, and Use cases.
Interoperability Tests
PDU and Frame Encapsulations

iSCSI Encapsulation
1. Ethernet Header
2. Ethernet Trailer
3. IP Header
4. SOF FIELD
5. EOF FIELD
6. RESERVED FIELDS

FCoE Encapsulation
1. FCOE_TYPE FIELD
2. VERSION FIELD
3. SOF FIELD
4. FC Frame
5. EOF FIELD
6. RESERVED FIELDS

Encapsulated FIP Operation
1. FIP_OPERATION_CODE FIELD
2. FIP_SUBCODE FIELD
3. FIP_DESCRIPTOR LIST_LENGTH FIELD
4. FABRIC PROVIDED BIT FIELD
5. SERVER PROVIDED BIT FIELD
6. AVAILABLE_FOR LOGIN BIT FIELD
7. SOLICITED BIT FIELD
8. FCF BIT FIELD
9. FIP_DESCRIPTOR FIELD
10. FIP_PAD FIELD
11. RESERVED FIELDS

FIP Encapsulation
1. FIP_TYPE FIELD
2. VERSION FIELD
3. RESERVED FIELD

Reference: UNH IOP
ISCSI and FCOE Interoperability Discovery

**ISCSI: Discovery & Initialization Compliance**

1. Single CNA /NIC and single array
   a) Power On
   b) Enable/Disable
   c) Cable pull
   d) Disconnect / Reconnect target
   e) Remove / add resources
   f) Non iSCSI device on the network switch
2. Single Initiator and multiple targets (a, b, c, d, e, & f)
3. Multiple Initiators / Multiple Targets (a, b, c, d, e, & f)

**FCOE: FCF/FCF Discovery**

1. Periodic Transmission of Multicast Discovery Advertisements
2. Transmission of Unicast Discovery Solicitation
3. Transmission of Unicast Discovery Advertisement
4. Discarding Invalid Discovery Solicitations
5. Discarding Invalid Discovery Advertisements

**FCOE VE_Port to VE_Port Virtual Link Instantiation**

1. ELP Transmission.

Reference: UNH IOP
ISCSI and FCOE Interoperability
Discovery Cont’d

ALL-FCF-MAC Group Address Listening
1. FIP VLAN Request Frame Response
2. Discarding Multicast FIP VLAN Request Frames with Duplicate MAC Addresses
3. VLAN Configuration Change Response
4. FIP VLAN Request Frame Response
5. Discarding Multicast VLAN Request Frames with Duplicate MAC Addresses
6. VLAN Configuration Change Response
7. VN_Port VLAN Discovery Start
8. VN_Port VLAN Discovery Accept VLAN ID
9. VN_Port VLAN Discovery Change VLAN ID

ENode/FCF Discovery
1. DUT Transmits FIP Discovery Advertisements
2. DUT Receives FIP Discovery Advertisement
3. DUT Transmits FIP Discovery Solicitation
4. DUT Transmits FIP Discovery Solicitation upon Becoming Operational
5. DUT Transmits FIP Discovery Advertisement after Receiving FIP Discovery Solicitation
6. Max FCoE Size Descriptor in a FIP Discovery Solicitation
7. FIP Discovery Advertisement Pad Extension
8. DUT Discards Discovery Solicitation – DUT is ENode
9. DUT Discards Discovery Solicitation – DUT is VF_Port Capable FCF-MAC
10. DUT Discards Discovery Advertisement – Identical MAC Addresses

Reference: UNH IOP
ISCSI Login Conformance
Verify the usage / response of the following parameter during a target login

- Standard Login
- CmdSN
- Version Active
- T Bit
- ExpStatSN
- Negotiate Once
- Login Partial Response
- Status Detail
- Invalid PDU / Frame
- Parameter Names
- AuthMethod
- Header and Data Digest
- Header and Data Digest
- MaxConnections
- TargetAlias
- Marker Negotiation
- FirstBurstLength
- Full Feature Phase
- Conformance

FCOE
VN_Port to VF_Port Virtual Link Instantiation
1. Fabric Login Using FIP Frames
2. Indication of Addressing Mode in Fabric Login
3. Reception of FLOGI or NPIV FDISC by FCF
4. Explicit VN_Port to VF_Port Virtual Link De-Instantiation

Reference: UNH IOP
ISCSI and FCOE Parameters’ Verifications

iSCSI:
Basic I/O Completion (Read and Write)
Max Connections
Target Name
Initial R2T
Immediate Data
MaxRecvData
SegmentLength
MaxBurstLength
FirstBurstLength
DefaultTime2Wait
DefaultTime2Ratain
Connection Terminated
MaxOutstandingR2T
DataPDUInOrder
DataSequenceInOrder
HeaderDigests and DataDigests
CMDSN
DataSN
StatSN
R2TSN

Reference: UNH IOP

FCOE:
Basic I/O Completion (Read and Write)
Max Connections
Target Name
MaxRecvData SegmentLength
MaxBurstLength
FirstBurstLength
DefaultTime2Wait
Connection Terminated
MaxOutstanding
DataInOrder
DataSequenceInOrder
HeaderDigests and DataDigests
CMD Frame Count
Data Frame Count
Status Frame

Virtual Link Maintenance
1. Physical Layer Disconnect
2. Transmission of FIP Keep Alive
3. Transmission of Discovery Advertisement
4. Reception of a FIP Clear Virtual Links Frame
5. Transmission of FIP Clear Virtual Links Frame
6. Locally Modified FKA_ADV_PERIOD Value
7. Remotely Modified FKA_ADV_PERIOD Value

Reference: UNH IOP
GROUP 1: CHAP_A VERIFICATION
  CHAP_A VALID VALUE
  CHAP_A VALID VALUE IN LIST
  CHAP_A INVALID VALUE
  CHAP_A VALID VALUE NOT IN LIST
  CHAP_A OUT OF ORDER

GROUP 2: CHAP_I VERIFICATION
  CHAP_I VALID VALUE
  CHAP_I INVALID VALUE
  CHAP_I NO VALUE
  CHAP_I TOO BIG VALUE
  CHAP_I OUT OF ORDER
  CHAP_I REUSED ON SECOND CONNECTION
  CHAP_I DIFFERENT ON SECOND CONNECTION
  CHAP_I REFLECTED
  CHAP_I REFLECTED ON SECOND CONNECTION

GROUP 3: CHAP_C VERIFICATION
  CHAP_C REUSED
  CHAP_C BIG VALUE
  CHAP_C SMALL VALUE
  CHAP_C TOO BIG VALUE
  CHAP_C OUT OF ORDER
  CHAP_C RECEIVE REUSED
  CHAP_C REFLECTED
  CHAP_C REFLECTED ON SECOND CONNECTION
  CHAP_C NEW ON SECOND CONNECTION

GROUP 4: CHAP_N VERIFICATION
  CHAP_N INVALID
  CHAP_N
  CHAP_N SMALL
  CHAP_N TOO BIG
  CHAP_N OUT OF ORDER
  CHAP_N IDENTICAL
  CHAP_N REFLECT
  CHAP_N DIFFERENT NAME

GROUP 5: CHAP_R VERIFICATION
  CHAP_R INVALID VALUE
  CHAP_R TOO BIG
  CHAP_R TOO SMALL
  CHAP_R OUT OF ORDER

FCOE Chap Compliance where applicable

Reference: UNH IOP
Interoperability / Protocol Compliance Error Recovery
Conformance with 10 G CNA for iSCSI and FCoE

- Retry Advertent
- Retry After Digest Error
- Allegiance Reassignment
- R2T Snack Support
- Data Snack Support
- Status Snack Support
- Resegmentation SNACK Support
- Usage of Reject CMD PDU
- Termination of tasks
- Format Errors
- Header Digest Error
- Out of order DataSN
- Protocol Error
- Drop Immediate CMD
- Drop Non-Immediate CMD
- Drop Solicited Data-out
- Drop Data-In
- Drop Text Response, Request
- Drop NOP-In & Out
- Data Digest Error on non Immediate Data
- Data Digest Error on Immediate Data
- **Data Digest Error on Unsolicited Data** $F=0$
- **Data Digest Error on Unsolicited Data** $F=1$
- **Data Digest Error on solicited Data** $F=0$
- **Data Digest Error on solicited Data** $F=1$
- **Data Digest Error on Data-In** $F=0$
- **Data Digest Error on Data-In** $F=1$
- Data Digest Error on NOP-In
- **Data Digest Error on Immediate NOP-In**
- **Data Digest Error on NOP-Out**
- Data Digest Error on Immediate NOP-Out
- Data Digest Error on Text Request
- Data Digest Error on Immediate Test Request
- Data Digest Error on Text Response
- Connection Reinstatement

**FCOE is applicable in the bolded items**

Reference: UNH IOP
iSCSI and FCOE Latency Tests

Primary Site

Latency Emulator

Switch

Latency Emulator

Storage Array

Drive Trays

1000s of Miles

Latency Emulator

Secondary Site

Latency Emulator

Mirroring Over FCOE or iSCSI

Latency Emulator

Latency Emulator

Latency Emulator

Latency Emulator

Latency Emulator
RAID Functional Tests with 10 G CNA for iSCSI and FCoE

- Recognition of drive pulls/pushes, internal/expansion, FC/SAS/SATA
  - unassigned drives
  - assigned drives
  - GHS spare drives
  - GHS in-use drives
- Proper handling of drive failures, internal/expansion, FC/SAS/SATA
  - unassigned drives
  - assigned drives
  - GHS spare drives
  - GHS in-use drives
- Diagnostic reporting
  - host-side
  - drive-side
- Error Handling
  - Recovery guru spot-check
  - Recovery guru in-depth analysis of reports which previously were FC-centric
- Proper operation of, detection of, etc.
  - Fans
  - Power Supplies
  - Other managed components (interfaces, whatever)
- For dual back-end systems, back-end failure of a single FC/SATA/SAS channel
- Volume rebalancing
- I/O shipping
  - proper operation
  - rebalancing based on volume geometry
- Proper handling of iSCSI host-side link interruptions
  - P2P or Link failures, including LIPs, pathblock, ..
  - Host interface pulls/pushes during I/O
  - HBA pulls/pushes during I/O
  - Switch failures
- Spot-check volume/host mapping, esp. limitations
- Different host speeds on the various host ports
- Spot-check snapshot
- Spot-check volume copy
- LED proper behavior, including any new ready-to-remove indicators
- For dual back-end systems, back-end failure of a single FC/SATA/SAS channel
- Volume rebalancing
- I/O shipping
  - proper operation
  - rebalancing based on volume geometry
- Proper handling of iSCSI host-side link interruptions
  - P2P or Link failures, including LIPs, pathblock, ..
RAID System / Stress tests with 10G CNA for iSCSI and FCoE

- System/stress testing (all with media scan enabled)
- I/O with controller Reboot/failure/drive failure & iSCSI Switch Reboot/ Port Disable/Enable
  - vanilla
  - degraded volumes
  - during reconstruction
  - during copy-back
  - during CFW download
  - during volume configurations
  - with snapshots in play
  - with volume copy in play
  - with RVM in play
  - with short-run reconfiguration in play
  - Short/medium/long distances (Delay Simulator)
- Volume migration
- Tray migration
- Excessive reconfigurations
- Excessive stress tests
- Large configurations
- Host Management software
- Host Context Agent
- Support bundle limitations
iSCSI and FCoE Impacts on RAID Functionalities with 10 G Network!

- RAID Resource Discovery
- RAID Login
- RAID Configuration, Management, and SAN
- CMD Exchange
- Data Exchange
- Status Exchange
- Exception Handling
  - Time out
  - Failover
  - Recovery
- RAID Premium Features
- RAID Performance
- RAID Applications
Exception Handling Test Points with 10G CNA for both iSCSI and FCoE
Degraded Paths with 10G CNA for both iSCSI and FCoE
Surviving Paths with 10G CNA and 1G NIC
Design for Testability “DFT”

- Emulating multiple host
  - Hardware at the 10 G CNA level
  - Software with 1G NIC
- Emulate multiple login
  - Single / Multiple sessions
  - Single / Multiple connections
- Emulate soft reset and Hard reset
- Emulate flaky ports
- Emulate flaky cables
- Emulate components’ removal and reinsertion (Cable, Controller, Drive, etc)
- Unreadable sectors
- Injection of parity errors / ECC at different components
  - Cache
  - NIC and CNA
  - Memory
  - Others
- Inject syntax errors at the CMD, Data, and Status PDUs
Diagnostics requirements for an iSCSI Array

- State capture
- Debug Queue log
- Diagnostic bundle (Host interface)
- VKI_EDIT_OPTIONS
- Major Event Logs
- Statistics on port basis
- Statistic on a connection basis
- Statistic on a Session basis
IPV4 vs. IPV6

- Verify the controllers support both IPv4 and IPv6 protocols simultaneously.
- Verify IPv4 Changes
  - As a result of having multiple protocols, the IPv4 capabilities of each port may be enabled or disabled.
- Verify IPv6 Address Notation
  - The IPv6 address space is 128 bits or 16 bytes, and is represented by eight sixteen-bit hexadecimal blocks separated by colons.
- Verify IPv6 Address Configuration
- Verify Multiple Routable Addresses
- Verify IPv6 ICMP ECHO
- Verify IPv6 VLANs
- Verify Ethernet Priority for IPv6
- Verify IPv6 MTU Size
- Verify IPv6 Optional Header Extensions

Note: Those tests are CNA and NIC independent.
Testing Snapshot in an iSCSI Environment with 10G CNA for both iSCSI and FCoE

- Verify snapshot with Software and hardware initiators
- Verify management software control of Snapshot with different RAID levels
  - Creation Single / Multiple
  - Removal w/o deletion of base volume/ w/o I/Os / Mirror Change
- Verify volume states (Optimal, Degraded, reconstruct, etc) with snapshot
- Verify concurrent configuration with snapshot
- Verify component swap with snapshot
- Verify firmware download with snapshot
- Verify volume migration with snapshot
- Verify the functionality of the Sync / Async Cache command with snapshots.
- Verify NetBackup with Snapshot
- Verify Remote mirroring with Snapshot
Testing Remote Volume Mirroring in for both iSCSI and FCoE Environment

- Verify RVM with Software and hardware initiators
- Verify that activation and deactivation of RVM
  - Firmware download
  - Component swap
  - Different volume states and RAID levels
  - Minimum and Maximum configurations
  - Small, medium, and large I/Os (Raw / FS)
  - Synchronous and Asynchronous modes
  - GUI and CLI
  - Persistent reservation W/O Cluster
  - Failing and Unfailing components
Testing Cluster in an Environment with mixed 10G CNA for both iSCSI and FCoE

- Verify cluster installation with Software and hardware initiators across different O/Ses
- Verify Client and Agent management of a single and multi-node clusters
- Verify Component firmware and driver installations
- Verify Firmware and Host Software up / down grades
- Verify snapshot and RVM in a cluster environment
- Verify Components’ and Nodes’ failover (Failover driver functionality)
- Verify cluster W/O Persistent reservations
- Verify system reconfiguration in a Cluster environment
- Verify Resources migration between different arrays
- Verify volume states (Optimal, Degraded, reconstruct, etc)
- Verify components swap
## Defect Detections in Test Classes

### Test Classes

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<th>Defect detection</th>
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<td>Interoperability Tests</td>
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<td>Compliance Tests</td>
<td>2</td>
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<td>Component Tests</td>
<td>30</td>
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<tr>
<td>Module level Tests</td>
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<tr>
<td>Build Reliability Tests</td>
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<td>Trunk Tests</td>
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<td>Functional Tests</td>
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<td>Use cases</td>
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<td>Stress tests</td>
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<td>Regression test</td>
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<td><strong>Total</strong></td>
<td><strong>1000</strong></td>
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### Defect Detection % per Class

- Interoperability Tests: 3%
- Compliance Tests: 9%
- Component Tests: 0%
- Module level Tests: 12%
- Build Reliability Tests: 15%
- Trunk Tests: 15%
- Functional Tests: 15%
- System tests: 9%
- Use cases: 2%
- Stress tests: 2%
- Latency Tests: 2%
- Regression test: 3%
### Error Type Detection during iSCSI and FCOE RAID Certifications

<table>
<thead>
<tr>
<th>Error Type</th>
<th>Error Type %</th>
</tr>
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<tbody>
<tr>
<td>I/O Timeout</td>
<td>26</td>
</tr>
<tr>
<td>Failover driver</td>
<td>14</td>
</tr>
<tr>
<td>Data Integrity</td>
<td>8</td>
</tr>
<tr>
<td>Data access</td>
<td>12</td>
</tr>
<tr>
<td>Read Error</td>
<td>7</td>
</tr>
<tr>
<td>Write Error</td>
<td>10</td>
</tr>
<tr>
<td>Panic</td>
<td>8</td>
</tr>
<tr>
<td>Hang up</td>
<td>3</td>
</tr>
<tr>
<td>Dropped Frame/PDU</td>
<td>6</td>
</tr>
<tr>
<td>Data Overrun</td>
<td>3</td>
</tr>
<tr>
<td>CRC Errors</td>
<td>3</td>
</tr>
<tr>
<td>Silent Errors</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
Conclusions

- iSCSI and FCOE test Leverage is around 30%
- Majority of the error detection related to Network are common between the protocols
- Protocol Interoperability and Compliance testing were very successful
- Gray areas in both protocols led to additional exhaustive testing areas
  - Latency area
  - Stress with different I/O workloads
- Development and test teams have to verify the compatibility of 10 G iSCSI and 10G FCoE with the followings functionalities before releasing Host software and Controller firmware to a customer
  - Basic protocol handshake / compliance
    - RAID Resource Discovery with 10 G CNA for both iSCSI and FCoE
    - RAID Login with 10 G CNA for both iSCSI and FCoE
    - RAID Configuration, Management, and SAN
  - CMD Exchange over a 10 G Network
  - Data Exchange over a 10 G Network
  - Status Exchange over a 10 G Network
  - Exception Handling over a 10 G Network
    - Impact of Latency at different points of a SAN
    - Time out
    - Failover
    - Recovery
    - Connection and component loss
  - RAID Premium Features over a 10 G Network
  - RAID Performance over a 10 G Network
  - RAID Applications over a 10 G Network
- 10 G iSCSI and 10G FCoE can coexist on the same network

Please do not focus on just testing the protocols!