FCoE vs. iSCSI vs. iSER
A Great Storage Debate

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Today’s Presenters

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SNIA-At-A-Glance

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Agenda

- **A Brief Background**
  - FCoE – J Metz
  - iSCSI – Saqib Jang
  - iSER – Rob Davis

- **Compare and Contrast**

- **How do you decide?**
  - Scalability, in-house expertise, use case
J Metz

Fibre Channel over Ethernet - FCoE
In The Beginning...

- There were two philosophies
  - Deterministic Networks
  - Non-Deterministic Networks

- Similar, but not compatible
What’s the Problem?

- Ethernet is non-deterministic
  - Flow control is destination-based
  - Relies on TCP drop-retransmission / sliding window
- Fibre-Channel is deterministic
  - Flow control is source-based (B2B credits)
  - Services are fabric integrated (no loop concept)
Standards for Unified I/O with FCoE

- FCoE is fully defined in FC-BB-5 standard
- FCoE works alongside additional technologies to make I/O Consolidation a reality

FCoE

IEEE 802.1

DCB

T11

FC on Other Network Media

FC-BB-5

PE

PFC

ETS

DCBX

EVB

Port-Extender

Lossless Ethernet

Priority Grouping

Configuration Verification

Edge Virtual Bridge

802.1BR

802.1Qbb

802.1Qaz

802.1Qaz

802.1Qbg
Best of Both Worlds

- From a Fibre Channel standpoint it's still Fibre Channel
  - FC connectivity over an Ethernet cable
- From an Ethernet standpoint it's
  - Yet another ULP (Upper Layer Protocol) to be transported

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**FC-0 Physical Interface**
**FC-1 Encoding**
**FC-2 Framing & Flow Control**
**FC-3 Generic Services**
**FC-4 ULP Mapping**

**Ethernet Media Access Control**
**Ethernet Physical Layer**

**FCoE Logical End Point**
Fibre Channel Encapsulation

- From a Fibre Channel standpoint it's still Fibre Channel
  - FC connectivity over an Ethernet cable
- From an Ethernet standpoint it's
  - Yet another ULP (Upper Layer Protocol) to be transported

Normal Ethernet frame, ethertype = FCoE
Same as a physical FC frame
Control information: version, ordered sets (SOF, EOF)
Solving the Problem – Priority Flow Control

- **Lossless Ethernet**
  - Not only for FCoE traffic
- **PFC enables Flow Control on a Per-Priority basis**
  - Ability to have lossless *and* lossy priorities at the same time on the same wire
  - Allows FCoE to operate over a lossless priority independent of other priorities
- **Other traffic assigned to other CoS will continue to transmit and rely on upper layer protocols for retransmission**
History of Unified Fabrics
Using FCoE to Provide Consolidated I/O

- Traditional Data Centers had separation at the host
  - Separate Ethernet-based networks and Fibre Channel-based networks
  - Multiple cards per server
    - 2 HBAs
    - Average of 6 (or more!) NICs per server
    - High underutilization drives up unnecessary power, cooling, and asset costs
Access-Layer Convergence

- Consolidate I/O on 10G links
- Drastically reduced CapEx and OpEx
- Multiprotocol connectivity eased purchasing decisions for server refreshes
- Prepared Data Centers for VM mobility requirements
  - Any VM could connect to FC storage if necessary, not just the ones with HBAs pre-installed
History of Unified Fabrics
Using FCoE to Provide Consolidated I/O

- Multihop Convergence
  - Standardize on Ethernet assets
    - One physical infrastructure
  - Keeps best practices for both Ethernet and Fibre Channel
- Reduction of Additional Equipment
- Protected investment and future-proofed deployments
Advanced Design

- Dynamic FCoE – Clos networks
  - Use Ethernet Equal-Cost Multipathing (ECMP) to provide load-balanced traffic across entire topology
- Greater resiliency and robustness across core (spine)
- Dynamic configuration of Inter-Switch Links (ISLs)
Flexibility

- Can be used anywhere FC is used
  - Server-to-TOR
  - Server-to-Storage
  - Massive bandwidth ISLs
- Runs both SCSI and NVMe ULPs
- Zero-Copy transfers (same as RDMA)
- Flexible topology considerations (edge/core, edge/core/edge, Clos)
- End-to-End Qualification
Saqib Jang

iSCSI
What is iSCSI (Internet SCSI)?

- Mature and widely supported Ethernet block storage network protocol
  - Standardized by IETF: RFCs 3721, 3722, 4018, 4056, 7143, etc.
- Built-in support in mainstream server operating systems
  - Windows Server, Linux, and BSD (Initiator and Target)
  - Major Hypervisors: Hyper-V, Xen, and ESX
- iSCSI offload initiator/target adapters for performance-sensitive applications
  - Complementing servers using newer multi-core CPUs and target performance scalability
iSCSI Benefits for Enterprise Deployment

- Use of TCP/IP simplifies LAN/WAN deployment and operational requirements
- iSCSI software initiator is widely supported in-box capability
- Ethernet SAN protocol with built-in offload adapter “second source”
- Decoupling of server and storage SAN hardware upgrade cycles
iSCSI I/O Path

• iSCSI Software
  • Software-based Protocol Processing
• iSCSI Offload
  • Protocol Bypass
  • RDMA
iSCSI Target - 2 Intel Xeon CPU E5-2687W v4 12-core processors @ 3.00GHz (HT enabled), 128GB RAM and RHEL 7.2 operating system using 100GbE T6 iSCSI Offload

iSCSI Initiators - 1 Intel Xeon CPU E5-1620 v4 4-core processor @ 3.50GHz (HT enabled) and 16GB of RAM using 40GbE T5 iSCSI Offload
iSCSI Services

- **Management**
  - Mostly distributed (in clients and targets)
  - Ethernet, TCP/IP-based monitoring/troubleshooting tools

- **Servers/targets/network reusable**
  - Can concurrently other storage protocols: NFS, SMB, NVMe-oF
  - Object storage or scale-out filesystems
  - Compute traffic or hyper-converged infrastructure

- **Reliability**
  - iSCSI digest (CRC)
  - Ethernet CRC, TCP/IP checksums
iSCSI Services

- **Redundancy/Availability**
  - Protocol: Link aggregation (LACP) or iSCSI multi-pathing
  - Physical: Duplicate Ethernet networks (optional)

- **Zoning or isolation options**
  - Physically or logically separate networks
  - ACLs (access control lists), VLANs (virtual LAN), VPN (virtual private network)

- **Security**
  - IPSEC for encryption, CHAP or RADIUS for authentication
iSCSI Speeds and Feeds

Today
- 1G / 2.5G / 5G / 10G / 25G / 40G / 50G / 100G

Futures
- Coming in 2018: 200GbE (4x50) and 400GbE (8x50)
- In the plan: 800G, 1.6T, 3.2T (dates TBD)
- NVMe-oF: Ethernet network also supports NVMe
Rob Davis

iSER
iSER – iSCSI Extensions for RDMA

- Officially a standard in 2007 when IETF issued RFC-7145

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## iSER – iSCSI Extensions for RDMA

- Officially a standard in 2007 when IETF issued RFC-7145
- Features and characteristics are almost the same as iSCSI
  - Leverages management and tools (security, HA, discovery...)

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iSER – iSCSI Extensions for RDMA

- Officially a standard in 2007 when IETF issued RFC-7145
- Features and characteristics are almost the same as iSCSI
  - Management and tools (security, HA, discovery...)
- Major difference is performance
Performance Difference – iSCSI vs. iSER

- **IOPs**
  - ConnectX-4 100 GbE iSER: 3,974
  - ConnectX-4 100 GbE iSCSI: 1,500

- **Latency**
  - ConnectX-4 100 GbE iSER: 245.71 µs
  - ConnectX-4 100 GbE iSCSI: 615.07 µs

- **CPU Utilization**
  - ConnectX-4 100 GbE iSER: 25.59%
  - ConnectX-4 100 GbE iSCSI: 7.74%
Performance Difference – iSCSI vs. iSER

- 100GbE
- 25GbE

Bandwidth (Gbps) vs. Block size (Byte)

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Why Should We Care About Performance?

Because Faster Storage Needs a Faster Network!
Faster Storage Needs a Faster Network

![Graph showing SATA HDDs and bandwidth comparison]

- 24 SATA HDDs
- 100 SATA HDDs
- 250 SATA HDDs

Bandwidth (MB/s) comparison:
- 100GE
- 40GE
- 10GE
Faster Storage Needs a Faster Network

SATA HDDs

SATA SSDs

Sustained Bandwidth (MB/s)

2 SATA SSD
9 SATA SSD
24 SATA SSD

Bandwidth (MB/s) 100GE 40GE 10GE
Faster Storage Needs a Faster Network

- SATA HDDs
- SATA SSDs
- NVMe

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<th>1 NVMe</th>
<th>2 NVMe</th>
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Faster Storage Needs a Faster Network…and a Faster Protocol
Faster Storage Needs a Faster Network…and a Faster Protocol
Faster Storage Needs a Faster Network...and a Faster Protocol

![Storage Media vs. Networked Storage Diagram]

Networked Storage

Network

Storage Media

SSD

![Access Time (micro-sec) Chart]

Protocol and Network

Faster Wire Speeds

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Faster Network and Protocol

Networked Storage

Network

Storage Media

SSD

Protocol and Network

Access Time (micro-sec)

Faster Wire Speeds

More Efficient Protocol

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iSER and RDMA Protocols

- Any applications that uses SCSI and iSCSI can use iSER
- iSER uses RDMA to avoid unnecessary data copying on the target and initiator
- For Ethernet the RDMA can be RoCE or iWARP
What is RDMA
What is RDMA

Efficient Data Movement (RDMA)

Kernel Bypass  Protocol Offload

Application Buffer Network Buffer

Adapter based transport

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What is RDMA

Efficient Data Movement (RDMA)

Application Buffer Network Buffer
Kernel Bypass Protocol Offload

RoCE
IB Transport Protocol
UDP
IP
Ethernet Link Layer

iWARP
TCP
IP
Ethernet Link Layer

adapter based transport
Compare and Contrast…
Compare and Contrast

▸ FCoE
  + Maps FC frames over Ethernet
  + Enables FC on lossless Ethernet
  + Less infrastructure expense (cables, adapters and switches)
  - FC expertise required
Compare and Contrast

 iSER
  + Provides mapping of the iSCSI protocol on to iWARP/RoCE protocol suites
  + Provides lower latencies and higher bandwidth with lower CPU utilization
  + Leverages iSCSI management infrastructure
  - Requires newer adapters and switches that support RDMA
Compare and Contrast

- iSCSI
  + Ubiquitous, native support across major operating systems and hypervisors
  + Builds low-cost SAN across standard Ethernet & TCP/IP
  + Offload/TOE availability
  - Overhead (packetization, out-of-order delivery, etc.)
How do you decide?

- Do you want an isolated dedicated storage network?
- How big / complex is your environment?
- What is your inhouse expertise?
- Future scale?
- What are the applications/use cases?
More Webcasts

❖ Other Great Storage Debates
  ❖ Fibre Channel vs. iSCSI: https://www.brighttalk.com/webcast/663/297837
  ❖ File vs. Block vs. Object Storage: https://www.brighttalk.com/webcast/663/308609

❖ On-Demand “Everything You Wanted To Know About Storage But Were Too Proud To Ask” Series
  ❖ https://www.snia.org/forums/esf/knowledge/webcasts-topics

❖ SNIA resources on iSCSI
  ❖ Evolution of iSCSI: https://www.brighttalk.com/webcast/663/197361
  ❖ Comparing iSCSI and NVMe-oF blog: http://sniaesfblog.org/?p=647
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