Today’s Presenters

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TRENDFOCUS Introduction

- Established in 1993
- Over 80 clients globally
- Located in Silicon Valley
- Industry analysis for various technologies & segments:
  - HDD, SSD, NAND
  - PC, Gaming, Surveillance, Cloud, Hyperscale & Enterprise segments
- Quarterly short-term forecasts
- Annual long-term forecasts
- Periodic Installments - Major new product and earnings coverage
- Executive Briefs - Analyst commentary on market conditions
- FOCUS ON white papers
- Daily news links
- Special projects available to clients

Cloud, Hyperscale, & Enterprise Storage Service
Detailed SSD and HDD Device Adoption Trends by Traditional and Emerging Applications

Storage Interlinks
SSD and HDD Demand from Client Computing, Enterprise and Consumer Electronics

SDAS: HDD Information Service

NAND/SSD Information Service

Key Components:
- Rigid Disk
- Media/Substrate, Recording Head

August 11, 2020

May 2020
SAS Connected Storage Continues Strong Growth
SCSI was developed to connect peripheral devices - commonly disk, tape, and optical drives - to a host.

SAS was designed to address large topologies via an inexpensive interconnect system.

SCSI/SAS evolved to become the industry standard for desktop, server, and storage connectivity for decades.

NVM Express was specifically developed for NVM storage, optimized for performance and latency.

NVM Express addresses storage overhead and scalability (queues).
Serial Attached SCSI Overview

- SCSI-1 specification published in 1986; latest published is SAS-4
- Organization:
  - INCITS T10 (technical) and SCSI Trade Association (marketing)
- Command set and physical transport created for enterprise hard drives
  - Evolved to support SAS and SATA HDDs and SSDs
- 11 generations of SCSI/SAS technology
  - Transitioned from parallel to serial as cable lengths became impractical
- Specification includes SAS infrastructure (i.e. cables / connectors, expanders, controllers, end devices, etc.)
- Led by committee chairs/officers and board of directors (marketing)
- 50+ member companies over the years
Specifications/Enhancements Timeline

Physical Layer
- SAS-2
  - 6Gb/s link rate
  - Zoning
  - Managed cables
  - Power management
  - Cable management
- SAS-2.1
  - Transmitter training
  - Optical cables

SAS Protocol Layer
- SAS-3
  - 12Gb/s link rate
  - Decision Feedback Equalization (DFE)
  - Transmitter training
  - Crosstalk
- SPL-2
  - Persistent connections
  - Power primitives

SCSI Command Layer
- SAS-4
  - 22.5 Gbaud
  - 20-bit Forward Error Correction
  - 128b/130b encoding
  - Insertion loss specifications
  - Slimline connectors
- SPL-3
  - SAS packets
  - Fairness
  - Active PHY Transmitter Adjustment (APTA)
- SPL-4
  - Re-timers
  - Wide ports
  - Interleaving
  - Obsolete muxing

ZBC
- Support SMR
- Zoned blocks
- Zoned format

ZBC-2
- Multi Actuators
- Dynamic zones
- Sanitize rules

SBC / SPC
- SCSI evolutions for ZBC, etc.
- Rebuild assist for SSDs

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NVM Express Overview

NVMe™ specification published in 2011
- Latest published: NVMe 1.4, NVMe-oF™ 1.1, NVMe-MI™ 1.1

Organizations:
- NVM Express, Inc. technical work groups and marketing work group
- PCI-SIG for physical transport over PCI Express®

Command set created for non-volatile memory technologies

Led by 13 industry promoters and board of directors

Hundreds of member companies

Innovative

- Open collection of standards industry driven
- Full solution stack innovation
  - Interface – NVMe
  - Management – NVMe-MI
  - Fabric – NVMe-OF
- Value-add features delivered annually
- Robust ecosystem of open source software for management and performance (e.g. NVMe-CLI, spdk)
# NVM Express Technology Specification Roadmap

## NVMe Spec
- **NVMe 1.2.1 May’16**
  - Transport and protocol
  - RDMA binding
- **NVMe 1.3 May’17**
  - Sanitize
  - Streams
  - Virtualization
- **NVMe-oF 1.0 May’16**
  - Transport and protocol
  - RDMA binding
- **NVMe-MI 1.0 Nov’15**
  - Out-of-band management
  - Device discovery
  - Health & temp monitoring
  - Firmware Update

## NVMe-oF Spec
- **NVM-oF 1.1 Oct’19**
  - Enhanced Discovery
  - TCP Transport Binding
- **NVMe-MI 1.1 May’19**
  - Enclosure Management
  - In-band Mechanism
  - Storage Device Extension

## NVMe-MI Spec
- **NVMe 1.4 June’19**
  - IO Determinism (NVM Sets)
  - Persistent Event Log, Rebuild Assist
  - Persistent Memory Region (PMR)
  - Asymmetric Namespace Access (ANA)

## NVMe 2.0*
- NVMe Base Spec
  - Merged w/Fabrics
  - Namespace Types
  - Alternate Cmd Sets
- NVMe Transport Spec(s)
- NVMe Command Set Spec(s)

<table>
<thead>
<tr>
<th>Released NVMe specification</th>
<th>Planned release</th>
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*Note: NVMe 2.0 is planned for release in 2021.*
Performance at the Device Interface

Max Bandwidth (MB/s)

- **24G SAS** offers higher per-lane performance at ~2.4GB/s
- **Wide-port or MultiLink™ bandwidth** up to ~4.8GB/s
- **x1 PCIe** up to ~2GB/s
- **Typical SSD** requires 4x host resources

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Typical SSD requires 4x host resources
Performance Scalability

Scalable

- **Inside-the-box** scalability
  - High-perf & low latency
  - High IOPS/TB scales **usable capacity**
  - Taking advantage of gen over gen improvements for PCIe bandwidth
- **Outside-the-box** scalability with NVMe-oF
- **Processor** scalability
  - Queuing mechanism scales with cores, virtualization & containers
  - Streamlined protocol improves clock cycle to I/O efficiency

Max SSD Speed Seq (MB/s)
Scalability with SAS

- Up to 64K end devices
  - Dependent on memory for route tables
  - Deployments with up to 2K devices in practice
- Multiple hosts for high availability
- Dynamic scaling with zero downtime
- Active / passive and copper / optical cabling allow for both rack-level and data center-level reach
Flexibility - Form Factors for PCIe

Flexible

- Broad set of form factors to support range of solution design objectives
- Supports multiple media types to optimize data tiering on a common interface (TLC/QLC & SCM)
- Improve storage consolidation with higher capacity drives vs competing interfaces, e.g. E1.L
Flexibility with SAS

**Hot Tier**
- Performance (IOPS)
- SAS SSDs
- SAS HDDs
- SATA SSDs

**Warm Tier**
- Scalability
- Cascaded JBODs (with SAS expanders) of Nearline SAS HDDs

**Cold Tier**
- Large-scale, low power, low cost, high capacity ($/GB)
- Cascaded JBODs (with SAS expanders) of SATA SMR HDDs
Manageability and Serviceability

SAS / SCSI Enclosure Services

- Host Processor
  - Application
  - PCIe
- SCSI Controller
- BMC Processor
  - Power Supply control
  - Cooling fans
  - Temp Sensors
  - SMBus/I2C
- SAS Port
- SMBus/I2C
- SCSI Device (Logical Unit Number)

NVMe-MI

- Host Processor
  - Host Operating System
  - Application
  - NVMe Driver
  - PCIe Root Port
  - PCIe Root Port
  - PCIe Bus
- Management Controller (BMC)
  - BMC Operating System
  - Application
  - NVMe-MI Driver
  - PCIe Port
  - SMBus/I2C
  - PCIe Port
  - PCIe VDM
- PCIe Bus
  - SMBus/I2C
  - NVMe NVM Subsystem
And the WINNER is ...
CQ1 ‘20 End Market Splits
Hyperscale, Enterprise, Channel

SATA SSD: 5.623 Exabytes
- Enterprise: 33.9%
- Channel: 53.0%
- Tier-1 Hyperscale: 13.2%

SAS SSD: 3.352 Exabytes
- Enterprise: 90.8%
- Channel: 8.5%
- Tier-1 Hyperscale: 0.7%

PCIe SSD: 11.045 Exabytes
- Enterprise: 15.6%
- Tier-1 Hyperscale: 75.9%
- Channel: 8.4%

SAS/SATA HDD: 171.02 Exabytes
- Enterprise: 17.2%
- Tier-1 Hyperscale: 64.3%
- Channel: 18.6%

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Summary

- SAS is the tried and true enterprise storage technology for HDDs and SSDs
- Mature and proven for over three decades
- SAS-connected storage will be around for years to come

- NVMe technology was designed for NVM storage, focused on performance and low latency
- Available since 2011, the interface supports client, hyperscale and enterprise use cases
- Will be the storage interface for the future of computing
Summary - NVMe/PCIe The optimal interface for data center storage.

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**Innovative**
- **Open collection** of standards driven by 100+ members
- **Full solution stack innovation**
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NVMe/PCIe The optimal interface for data center storage.
Thank You!

For more information, go to:

www.scsita.org/
nvmexpress.org/
trendfocus.com/