SAS: Today’s Fast and Flexible Storage Fabric

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Abstract

- SAS is the backbone of nearly every enterprise storage deployment, rapidly evolving, adding new features and enhanced capabilities, and offering “no compromise” system performance. SAS not only excels as a device level interface, its versatility, reliability and scalability have made it the connectivity standard of choice for creating new enterprise storage architectures.

- This presentation covers the advantages of using SAS as a device interface and how its capabilities as a connectivity solution are changing the way data centers are being deployed. 12Gb/s SAS transfer rates, bandwidth aggregation, SAS fabrics (including switches) active connections, and multi-function connectors allow data center architects to create sustainable storage solutions that scale well into next-generation 24Gb/s SAS designs and beyond.
Today’s Takeaways

➤ Flexibility of SAS is Unparalleled
   - Media flexibility
   - Scalability
   - System architectures

➤ SAS Technology Addresses a Very Large, Growing Market

➤ SAS Continues to Evolve through Innovation
   - Performance
   - Features
SAS – Preserving the Past, Creating the Future

**Preserve Legacy SCSI**
- 25 years of SCSI middleware

**Future Architected**
- Protocol extends to new technologies
- Serial, switchable
- SFF connectors

**Customer Choice**
- 3.5” and 2.5” form factors
- Plug compatible
- Multi-protocol

**Usability**
- Dual-ported
- Point-to-point
- Cost equal to SCSI

**Performance**
- Wide ports
- Interconnect
- MultiLink SAS™
- Low overhead

**Scalable**
- 1000s of connections
SAS & SATA Span the Storage Spectrum

Direct Attach Storage
- Controllers/ROCs/HBAs
- Expanders
- SAS/SATA HDDs
- SAS/SATA SSDs

SAS Fabrics
- Expanders
- SAS switches
- Bridges
- Port multiplexers

External Storage
- Controllers/ROCs/HBAs
- Expanders
- SAS/SATA HDDs
- SAS/SATA SSDs
- SAS/SATA tape

Media
- SAS HDDs
- SAS SSDs
- Sata HDDs
- Sata SSDs
- Near-line SAS HDDs
- SMR HDDs

SAS is the Predominant Enterprise Drive Interface
Scalability in Server & Hyper-Converged Architectures

Simple DAS
- High Performance
- Inexpensive
- Modular

Extended DAS
- Pay-as-you-grow
- High Capacity
Scalability in External Storage Architectures

- Native High-Availability
- Modular
- Simplified, Robust Cabling
- Scales to 1000s of Devices
## Protocols Compared

<table>
<thead>
<tr>
<th></th>
<th>x1 24G SAS</th>
<th>x1 NVMe (Gen4)</th>
<th>x4 NVMe (Gen4)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Performance (Bandwidth)</strong></td>
<td>19.2 Gb/s</td>
<td>15.8 Gb/s</td>
<td>63.0 Gb/s</td>
</tr>
<tr>
<td><em><em>Performance (Read Latency</em>)</em>*</td>
<td>15.9us</td>
<td>15.7us</td>
<td>11.3us</td>
</tr>
<tr>
<td><strong>Scalability</strong></td>
<td>1000's of Devices</td>
<td>10's of Devices</td>
<td>10's of Devices</td>
</tr>
<tr>
<td><strong>Power</strong></td>
<td>9W</td>
<td>9W</td>
<td>25W</td>
</tr>
<tr>
<td><strong>Flexibility</strong></td>
<td>12G SAS HDD&amp;SSD, 6G SAS/SATA HDD&amp;SSD</td>
<td>NVMe Gen4 SSDs, NVMe Gen3 SSDs</td>
<td>NVMe Gen4 SSDs, NVMe Gen3 SSDs</td>
</tr>
<tr>
<td><strong>Manageability</strong></td>
<td>SES-2, SMP</td>
<td>To Be Developed</td>
<td>To Be Developed</td>
</tr>
<tr>
<td><strong>Availability</strong></td>
<td>Native Dual Port</td>
<td>Unproven</td>
<td>Unproven</td>
</tr>
<tr>
<td><strong>Channel Length</strong></td>
<td>19” FR4, 6m Cu Cable, 300m AOC</td>
<td>4” FR4, Cu Cable TBD</td>
<td>4” FR4, Cu Cable TBD</td>
</tr>
</tbody>
</table>

*Latency includes OS, driver, HBA (if required) and flight time, media access times not included
## Bandwidth by the Numbers

<table>
<thead>
<tr>
<th>No. of Links / Lanes</th>
<th>SATA</th>
<th>x1 PCIe</th>
<th>x1 SAS</th>
<th>x2 PCIe MultiLink SAS™</th>
<th>x4 PCIe MultiLink SAS™</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transfer Rate per Link/Lane</th>
<th>SATA</th>
<th>x1 PCIe</th>
<th>x1 SAS</th>
<th>x2 PCIe MultiLink SAS™</th>
<th>x4 PCIe MultiLink SAS™</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.6 GB/s</td>
<td>2.0 GB/s</td>
<td>2.4 GB/s</td>
<td>4.0 GB/s</td>
<td>8.0 GB/s</td>
</tr>
</tbody>
</table>

| Max Bandwidth | 0.6 GB/s | 2.0 GB/s | 2.4 GB/s | 4.0 GB/s | 4.8 GB/s | 8.0 GB/s | 9.6 GB/s |

SAS Supplies 20% More bandwidth Per Lane
4k Random Read Latency
QD1

Read Latencies Dominated by NAND Latencies (and will continue to increase)
95% of All Enterprise Shipments in 2019 Require SAS Infrastructure

Source: TRENDFOCUS, Jan 2016
SAS Technology Roadmap

- **First Plugfest** (leading edge)
- **First End-User Products** (approximately 12-18 months later)

- **3Gb/s SAS**
- **6Gb/s SAS**
- **12Gb/s SAS**
- **24Gb/s SAS**

Source: SCSI Trade Association – Aug 2015
Recent Innovations in SAS

- Storage Intelligence
- Persistent Connections
- Enhanced Power Control
- Shingled Magnetic Recording Support

Recent SAS Innovations - the Focus of the May SAS Plugfest
Storage Intelligence

Streams

- Provides hints to SSD about data sets that have similar expected lifetimes
- Reduces intermixing of data from different applications, thus reducing fragmentation during garbage collection
- Improves performance
- Reduces write amplification and improves endurance

Background Activity Control

- Provides hints to SSD to optimize timing of background activities (e.g., garbage collection)
- Provides more consistent performance during peak activity times
Why Shingled Magnetic Recording?

- Much higher track density
- Overall AD growth 25%/Y vs. 15%/Y
- 65% greater maximum capacity by 2020
The Need for Speed

Estimated 50B Connected Devices in 2020

DoD Drones Capable of Capturing 430 PB/Day

Surveillance Cameras Capture 859 PB/Day in 2017

400 Hours of Video Uploaded Per Minute, Nov. 2015

Source: HFS inc. October 2013
24Gb/s SAS Objectives

- Double the Effective Bandwidth of 12Gb/s SAS
- Backwards Compatibility
  - Support for two generations of backward compatibility
  - Leverage existing ecosystem (tools, test equipment)
- Preserve the Existing SAS Value Proposition
  - **Reliability** – Robust error handling
  - **Scalability** – Scalable to 1,000s of devices
  - **Flexibility** – SAS infrastructure supports SAS and SATA devices
  - **Serviceability** – Surprise add/remove media and cables
  - **Manageability** – Storage management built into the standard
- Align with a 2019 Platform Launch
Key Messages

- Flexibility of SAS is Unparalleled
  - Media flexibility
  - Scalability
  - System architectures

- SAS Technology Addresses a Very Large, Growing Market

- SAS Continues to Evolve
  - Performance
  - Features
The SNIA Education Committee thanks the following Individuals for their contributions to this Tutorial.

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