SAS – Storage Workhorse of the Data Center

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2018 Datacenter Storage Device Hierarchy
(Serviceable form factors)

- **Increasing Performance**
  - PCIe SSD U.2 (SFF-8639)
    - Break-through performance in a serviceable bay for latency sensitive applications
  - SAS SSD
    - Highest performance SSD in a standard SFF-8680 storage bay
  - SATA SSD
    - Lowest cost SSD in a standard SFF-8680 storage bay until SATA Express emerges

- **Increasing Cost (device & system)**

- **Decreasing Volume**
  - SATA and SAS HDD
    - Rotating media remains capacity workhorse @ 75%+ devices shipped

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Flash Memory Summit
PCle Performance Advantage Comes at a Cost

Standard SAS/SATA Storage Bay (server)

- SFF-8680 Connector
- 10 Watts
- SAS/SATA 1.2 GBs

U.2 PCle/SAS/SATA Storage Bay (server)

- SFF-8639 Connector
- 25 Watts
- PCIe 3.6 GBs
- SAS/SATA 1.2 GBs

24 Bays: Standard vs. U.2

<table>
<thead>
<tr>
<th></th>
<th>SFF-8680</th>
<th>SFF-8639</th>
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<tbody>
<tr>
<td>SerDes</td>
<td>24</td>
<td>120</td>
</tr>
<tr>
<td>Power (Watts)</td>
<td>240</td>
<td>600</td>
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U.2 Form Factor is Expensive to Scale
PCle Scalability Further Challenged “Beyond the Box”

Cost to Provision
Technical Complexity
Value Proposition
Latency, Simplicity

Scale

1 to 4 Devices
8 to 24 Devices
Greater than 24 Devices

PCle Sweet Spot – Small Number of Locally Attached Devices
Total Datacenter Storage Bay Population

PCle Highly Effective in Low-latency Cache and Storage Tier

SAS Remains Backbone of Scalable Storage
SAS SSD Remains Fastest Device in Standard Bay

PCle and SAS are complementary, will co-exist for the foreseeable future
SAS Spans the Storage Spectrum

Direct Attach Storage
- Controllers/ROCs/HBAs
- Expanders
- Storage Blades

External Storage
- NAS/SAN Heads
- Native SAS Connect
- Controllers/ROCs/HBAs
- Expanders

HDD/SSD
- SAS and SATA SSDs
- SAS and SATA HDDs

Scale to 1,000’s of Devices
Serviceable Infrastructure
Reliable Error Handling at Scale
Mature, robust ecosystem
SAS Roadmap – Continuing to Innovate

Key Innovations
- Atomic writes
- Command Priority
- Command Deadline
- 24GB/s (128b/130b, FEC)
- Storage Intelligence SBC-4
- High-density connectors & cables
- Passive Cu, Active Cu, Optical
- Standard cable management
- Multi-Link SAS

First End-User Products


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SCSI Trade Association
Datacenter SSD Market Opportunity

- **PCIe SSDs** – ideal for low-latency server and storage applications
- **SAS SSDs** – continues to be preferred in mainstream storage applications
- **Entry Level SSDs** – SATA continues to be volume leader in a bay until replaced by SATA Express; M.2 rules non-serviceable

Source: IDC and HGST Market Data
Current State of SAS SSDs

- 4TB max SAS SSD capacity available today
- Wide endurance range: 0.5 – 40 Drive Writes Per Day
- Aggregate sequential throughput = 25GB/s
- Aggregate random throughput = 5 Million IOPS
- Critical Enterprise Features - High Availability (dual porting)
  - End to End Data Path Protection

SAS SSDs build on the proven SAS interface to deliver benefits of Flash in Data Center applications
Summary

SAS continues to be the Storage workhorse in Data Centers due to proven scalability and robustness in the Enterprise.

PCle SSD
- Ideal for low-latency storage applications
- Limited and expensive scalability

SAS SSD
- Proven and robust interface
- Truly scalable, scales cost effectively