NVMe™ SSD Form Factor Challenges
Agenda

• A little bit of History
• Summary of potential NVMe™ SSD form factors
• System architectural challenges
  • Server platforms
  • Hyper-scale platforms
  • Client platforms

Presenters
– Bill Lynn          Dell/EMC
– Michael Krause     HPE
– Jonathan Hinkle    Lenovo
– Chris Petersen     Facebook
– Lee Prewitt        Microsoft
# History

## HDD’s

<table>
<thead>
<tr>
<th>Form Factor</th>
<th>Introduction</th>
<th>Present</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refrigerator</td>
<td>3.75MB</td>
<td></td>
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<tr>
<td>Washing Machine</td>
<td>92MB</td>
<td></td>
</tr>
<tr>
<td>5.25”</td>
<td>5MB</td>
<td></td>
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<tr>
<td>3.5”</td>
<td>10MB</td>
<td>12TB</td>
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<tr>
<td>2.5”</td>
<td>20MB</td>
<td>4TB</td>
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<tr>
<td>1.8”</td>
<td>21MB</td>
<td>250GB</td>
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<tr>
<td>1.3”</td>
<td>20MB</td>
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## SSD’s

<table>
<thead>
<tr>
<th>Form Factor</th>
<th>Introduction</th>
<th>Present</th>
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<tbody>
<tr>
<td>mSATA</td>
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<td>500GB</td>
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<tr>
<td>M.2</td>
<td></td>
<td>1TB</td>
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</table>
HDD / SSD Architecture

HDD Exploded View

SSD Exploded View
Potential NVMe SSD Form Factors

- SFF-TA-1006
- SFF-TA-1008
- SFF-TA-1007
- NGSFF
- AIC
- 2.5in U.2
- m.2
PCle CEM

Applicable market segments
- Towers (client / server), Data Center (server, storage, I/O)

Supported Component Types
- NIC, GPU, GPGPU, FPGA, DSP, ASIC, SSD, etc.

Supported Connectors
- CEM x1, x4, x8, x16 up to 32 GT/s
- 2x4 High Power Cable

CEM Benefits:
- CEM baseline, i.e., reference for multiple mechanical form factors throughout industry
- Forward / backward compatibility—1.0-5.0 provides consistent customer experience
- Four sizes to tailor I/O to meet solution-specific needs
- Scalable power—up to 75W (edge), 2x4 enables 300W (CEM 4.0) / 600W (CEM 5.0)
- Supports hybrid computing (processor + accelerators)
- Supports external cables (PCle, DP / HDMI, Ethernet, IB, FC, SAS / SATA, etc.)
U.2 2.5” SSD

Applicable market segments
- Primarily data center with some enthusiast desktop

Size
- 15 x 70 x 100.45 mm up to 25W

Supports SFF-8639 (PCIe x4)

U.2 Benefits:
- Adds PCIe support to high-volume 2.5” HDD form factor
- Supports PCIe up to 16 GT/s
- High-capacity / high-density NVM form factor
  - Up to 24 modules in 2U enclosure
  - Up to 14x18 mm packages per module
- Case for ESD protection and hot-plug support
PCIe M.2

Applicable market segments

- Embedded / T&M, Client, Data center (e.g., SSD carrier)
  - Connector and BGA solutions

Supported Connectors

- x1 / x2: Mid-mount, single-sided, double-sided

M.2 Benefits:

- Large, flexible mechanical form factor family
- Supports multiple protocols: PCIe/NVMe™, SATA, USB, etc.
- Supports 14 vendor-defined pins to customize solutions
- Forward / backward compatibility
- Low power (3.3V & 1.8V using 4 power pins)
- Supports external connectivity: cables, antennae, etc.
- Multiple M.2 can be provisioned on a carrier form factor
NGSFF

Applicable market segments
- ???

Size
- 30.5mm x 100mm supports up to 16W

Supported Connectors
- NGSFF connector, mechanically compatible with m.2 card edge

NGSFF Benefits:
- ???
SFF-TA-1006

Applicable market segments
- Data Center (optimized as scaled main storage in server and storage)

Size
- 31.5 mm x 111.5 mm x 5.75 or 7.55mm, supports up to 12W

Supports SFF-TA-1002 1C (PCIe x4)

SFF-TA-1006 Benefits:
- PCIe to 32 GT/s
- High-capacity / high-density NVMe™ form factor
  - Up to 36 modules across 1U rack space
  - Up to 12 14x18 mm packages per module
    - 432 packages / U
- Case & Case-less Options
**SFF-TA-1007**

**Applicable market segments**
- Data Center (1U optimized server and storage enclosure)

**Sizes**
- 9.5 x 38.4 x 318.75 mm supports up to 25W
- 18 x38.4 x 318.75 mm supports up to 40W
  - Adds heat sink to improve cooling at system density expense

**Supports SFF-TA-1002 2C (PCIe x4-x8)**

**SFF-TA-1007 Benefits:**
- PCIe to 32 GT/s
- High-capacity / high-density NVM form factor
  - 9.5 mm
    - Up to 32 modules
    - Up to 44 14x18 mm packages per module
    - 1408 packages / U
  - 18 mm
    - Up to 18 modules
    - Up to 44 14x18 mm packages per module
    - 704 packages / U
- Supports data-centric computation
  - Reduce packages to free up space for integrated accelerator
- Case for ESD protection, thermal management, & hot-plug
Applicable market segments
- Data Center (1U and 2U optimized server and storage enclosure)

Sizes
- 7.5 x 76 x 104.9 mm supports up to 25W
- 7.5 x 76 x 142.2 mm supports up to 35W
- 16.8 x 76 x 104.9 mm supports up to 70W
- 16.8 x 76 x 142.2 mm supports up to 70W

Supports SFF-TA-1002 1C, 2C, 4C (PCIe x4-x16)

SFF-TA-1008 Benefits:
- PCIe to 32 GT/s, 802.3 to 112 GT/s
- High-capacity / high-density NVM form factor
  - 7.5 mm
    - Up to 48 modules
    - 104.9 up to 24 14x18 mm packages per module (576 / U)
    - 142.2 up to 48 14x18 mm packages per module (960 / U)
  - 16.8 mm
    - Up to 24 modules
    - Up to 48 14x18 mm flash packages per module (960 / U)
- Supports data-centric computation
  - Reduce packages to free up space for integrated accelerator
- Case for ESD protection and hot-plug support
## Summary of Proposed Form Factors

<table>
<thead>
<tr>
<th>Form Factor</th>
<th>Width (mm)</th>
<th>Length (mm)</th>
<th>Thick (mm)</th>
<th>Front Slots</th>
<th>Power (Max)</th>
<th>Pkgs (14x18)</th>
<th>PCIe Lanes</th>
<th>Case</th>
<th>Standard</th>
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<tr>
<td>2.5” (Baseline)</td>
<td>70</td>
<td>100.45</td>
<td>15</td>
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<td>SFF- 8201</td>
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<td>EDSFF 3”-S-7.5</td>
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<td>104.9</td>
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<td>EDSFF 3”-L-7.5</td>
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<td>142.2</td>
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<td>35</td>
<td>40</td>
<td>4/8/16</td>
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<tr>
<td>EDSFF 3”-L-16.8</td>
<td>76</td>
<td>142.2</td>
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<td>70</td>
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<td>NGSFF</td>
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<td>EDSFF 1U-L-18</td>
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<td>40</td>
<td>44</td>
<td>4/8</td>
<td>Yes</td>
<td>SFF-TA-1007</td>
</tr>
</tbody>
</table>
Classical 2S Server Architecture

- Server is basically divided into thirds
- Front third used for storage and supporting infrastructure
- Need for balance
  - Cooling
  - Power
  - Storage performance
  - Memory performance
  - Networking performance
  - I/O capability
Server Architectural Issues
How do hyper-scalers use flash today?
Hyper-scale NVM Form Factor Characteristics

Important:
- Flexible
- High volume
- Low cost
- Power and thermal efficiency
- Hot swappable
- Serviceable

Less important:
- Backwards compatible
- Support for non-NVM media
- Maximum density

Call to Action: Consolidate to a small number (< 4) of form factors
Client Challenges

- Size, power, and cost are the biggest issues
- Many OEMs are planning on moving to NVMe™ on client platforms in the near future.
- Dependencies include:
  - Cost
  - Lowering the active idle power
Call to Action