Closing Summary & Future Directions

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Agenda

• NVMe in the Real World Today
• Continuous Innovation Underway in NVMe
• Looking Ahead and Resources to Learn More
Lenovo ThinkServer RD650 with Intel® SSD DC P3700 Series
Database TPC-H

Total database performance

<table>
<thead>
<tr>
<th>Legacy Server - HDD</th>
<th>ThinkServer RD 650 - SATA SSD</th>
<th>ThinkServer RD 650 - NVMe</th>
</tr>
</thead>
<tbody>
<tr>
<td>3560.2</td>
<td>9524.8</td>
<td>25062.1</td>
</tr>
</tbody>
</table>

New Server

Legacy Servers

4 to 1 server consolidation

For tests and configurations go to http://www.principledtechnologies.com/Lenovo/RD650_storage_performance_0415.pdf

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Dual 4K Video Editing in Real Time with NVMe™

Real time 4K editing made possible

Design & build richer content with larger data sets, textures and assets

NVMe SSD = ~2.5x (frames/sec) SATA SSD
NVMe SSD = ~8x (frames/sec) SATA HDD

Source: Intel
NVMe Driver Ecosystem is Strong

- NVMe drivers available on Windows*, Linux*, Solaris*, VMware*, UEFI
- Many are native / in-box drivers

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NVMe Available in a Variety of Form Factors

- NVMe products have been announced in form factors shown, depending on whether targeted for Data Center or Client

U.2 SSD
(formally SFF-8639)

PCIe add-in card (CEM)

M.2

BGA SSD
Robust Interop Program in Place

- The University of New Hampshire Interoperability Lab (UNH-IOL) has collaborated with NVMe to deliver a robust interop program

- Four plugfests have been held – populating robust NVMe Integrator’s List

More details at www.iol.unh.edu/services/testing/NVMe.
Data Center Use Cases for NVMe

**Cloud computing**
Better SLAs for CSPs, lower opx/capx, get developers to market faster, consumers services on demand

**Virtualization**
Lowering enterprise IT by increasing system utilization and improving virtual machine scalability

**HPC**
Eliminating bottlenecks in HPC workflows. NVMe keeps up with high bandwidth demands of HPC to speed up overall workflow times by an order of magnitude

**Database**
High performance and great QoS shine in traditional database

**Big data**
High bandwidth and low latency can provide business insights with real time analytics
Client Use Cases for NVMe

Gaming

Opens up the opportunity for unparalleled realism, with high quality textures and decreased load times.

Content Creation

NVMe creates opportunity for new workflows for content creation when working with large data sets.

Workstation

Opportunity to accelerate any WS workload with large data sets.
Caching from backend SAN in large organizations.

Client / Mobile

High performance is driving NVMe into client. Efficiency and features of NVMe lead to high battery life. Low latency and QoS delivers application responsiveness.

4K

High bandwidth is required for real time 4K editing.

High bandwidth is required for real time 4K editing.
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NVMe over Fabrics

- Scales NVMe across the Datacenter over Fabrics like Ethernet, Fibre Channel and InfiniBand™
- Encapsulates NVMe commands to leverage ~ 90% of NVMe
- Three separate prototypes have shown < 10 µs adder between local and remote NVMe
Enabling NVMe in Mobile Segments

NVM Express V1.0/V1.1

Data Center

- Optimized for NVM
- Low Latency
- Exploits Parallelism
- Efficient SW stack

Workstation / Server

NVM Express V1.2

PC

- Host memory buffer
- Replay Memory (RPMB)
- Power Enhancements

NVM Express V1.3

Tablet

- Boot Partitions for non-BIOS boot

Smart Phone

NVMe/PCIe

Data Center to Mobile

- M.2
- Emerging BGA
- L1.2 Sub-states

- Smaller BGA

- Smart Device / Bus Master
- No HBA

- Optimized for NVM
- Low Latency
- Exploits Parallelism
- Efficient SW stack
Enhancements for Mobile

- PCIe is a low power interface
- Smaller BGA coming for mobile
- NVMe defined “Boot Partitions” to enable non-BIOS boot
  - Read via MMIO registers
  - Write via enhanced firmware download commands
  - Protect/lock with RPMB

<table>
<thead>
<tr>
<th>Item</th>
<th>PCIe Gen3</th>
<th>PCIe Gen2</th>
<th>M-PHY Gear3</th>
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<tbody>
<tr>
<td>Line Speed [Gbps]</td>
<td>8</td>
<td>5</td>
<td>5.83</td>
</tr>
<tr>
<td>PHY overhead</td>
<td>128/130, 1[GB/s]</td>
<td>8/10, 500[MB/s]</td>
<td>8/10, 583[MB/s]</td>
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<tr>
<td>Active Power [mW]</td>
<td>60 (L0)</td>
<td>46 (L0)</td>
<td>58 (HS)</td>
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<tr>
<td>Standby Power [mW]</td>
<td>0.11 (L1.2)</td>
<td>0.11 (L1.2)</td>
<td>0.2 (Hibern8)</td>
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<tr>
<td>MB/ml (higher better)</td>
<td>14-18</td>
<td>8-12</td>
<td>8-12</td>
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Security – The NVMe and TCG Partnership

• NVMe is leveraging the security expertise of the Trusted Computing Group (TCG)

• TCG has developed a “family” of specifications to scale across the needs of NVMe in different Client and Enterprise solutions

• NVMe and TCG plan to continue collaborating on future security features for NVMe
Management Interface

- Enables pre-boot and out-of-band management during run-time
  - Power budgeting, inventory, health monitoring, firmware update, etc
- Standardization benefits include:
  - Reduces cost & broadens adoption
  - Common feature set
  - Industry ecosystem (including compliance testing)
Management Interface Roll-Out

• Basic Management Command published in February 2015
  • Standardized way to poll NVMe devices for basic health status over SMBus

• Full Management Specification will be published in ~ October 2015
  • Full specification has started ratification, includes in-band and out-of-band built on MCTP
  • The Basic Management command is an optional feature – and will not be enhanced

Take advantage of standardized enclosure management
Agenda

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See NVMe in Action at FMS

Visit our FMS Exhibitor Booth #702
Learn More at Intel Developer Forum

- IDF is August 18-20 at the Moscone Center in San Francisco
- Check out some of the great sessions on NVM Express

<table>
<thead>
<tr>
<th>Session ID</th>
<th>Session Title</th>
<th>Presenter(s)</th>
</tr>
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<tbody>
<tr>
<td>SSDS001</td>
<td>NVM Express™: The Data Center and Client Storage Transformation</td>
<td>Amber Huffman and Mike Shapiro</td>
</tr>
<tr>
<td>SSDS003</td>
<td>What You Need to Know to Win the Storage Transition – Preparing for NVM Express™ in the Data Center</td>
<td>Jonmichael Hands and Michael Hall</td>
</tr>
<tr>
<td>SSDC001</td>
<td>Tech Chat: Benchmarking Data Center Solid-State Drives – Insights Into Industry-Leading NVM Express* SSD Performance Metrics</td>
<td>Pallavi Pandit</td>
</tr>
<tr>
<td>SSDC003</td>
<td>Tech Chat: NVM Express* Features for High Availability and Storage Eco-System</td>
<td>Tahmid Rahman</td>
</tr>
</tbody>
</table>
More Demos at IDF

- The NVM Express Community at IDF shows off technology from 16 companies
  - Check out today’s NVMe PCIe SSD products
  - Preview tomorrow’s early prototypes from several IHVs of NVMe over Fabrics

<table>
<thead>
<tr>
<th>Company</th>
<th>Booth #</th>
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<td>Aperion Data Systems</td>
<td>873</td>
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<tr>
<td>EMC</td>
<td>887</td>
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<tr>
<td>HGST</td>
<td>886</td>
</tr>
<tr>
<td>Intel</td>
<td>871 &amp; 881</td>
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<td>JDSU</td>
<td>874</td>
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<td>Kazan Networks</td>
<td>880</td>
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<td>Keysight Technologies</td>
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<td>Microsoft</td>
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<td>PMC-Sierra</td>
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<td>QLogic Corporation</td>
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<td>Samsung Semiconductor</td>
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<td>Seagate Technology</td>
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<td>SK Hynix</td>
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<td>Storage Networking Industry Association (SNIA)</td>
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<tr>
<td>Super Micro Computer</td>
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<tr>
<td>Teledyne LeCroy</td>
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<td>Viking Technology</td>
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Keep Up to Date on the Latest

- NVMe Blog: http://www.nvmexpress.org/blog
- Twitter @NVMExpress: https://twitter.com/NVMexpress
- LinkedIn: https://www.linkedin.com/grp/home?gid=4307826
Summary

- NVMe is available today on PCI Express in Data Center and Client

- New features and innovation are coming, including:
  - NVMe over Fabrics
  - Mobile Enhancements
  - Management Interface
  - Security

Get involved – Join NVMe at http://nvmexpress.org/join-nvme/
SSD Give Away at the NVMe Booth!

- Giving away 7 SSDs
- Wed: 1:30, 4:30, 6:30
- Thursday: 12:30

Stop by booth #702 to enter drawing (must be present to win)
Thank You