Solid-State Drive (SSD) Optimizations in Enterprise Client IT, Server and Storage Environments

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Casey Cerretani, ZT Systems Engineering Director
Bob Weisickle, ZT Systems CTO

Session ID: SSD005
Agenda

- Session Overview
- Content Distribution Network Server
- Enterprise IT Client Deployments
- Q&A
Agenda

• **Session Overview**
• Content Distribution Network Server
• Enterprise IT Client Deployments
• Q&A
The Promise of SSD Technology

Enterprise Server/Client Optimizations
Unleash the Potential of SSDs
Agenda

• Session Overview

• **ZT Systems**
  - Content Distribution Network Server

• Enterprise IT Client Deployments

• Q&A
Moving into the Enterprise

Who would put tens of thousands of MLC SSDs into an enterprise application?

- ZT Systems worked with a leading provider of online content delivery to widely deploy Intel SSDs

Some key attributes that pointed to SSDs:

- The workload is read intensive
- Writes are well understood in Gb/Day
- Power consumption is a key cost driver
- Performance is always critical
- Enterprise level of endurance required
The Process

• **Endurance**
  - Required a 3-5 year service life and a 2-3 GB/Day Write workload
  - With proper over provisioning, models predicted a 5 year life
  - 6 months of audit testing correlated the models

• **Capacity**
  - TCO checked out when power and acquisition costs were considered

• **Performance**
  - 100% Random, 33% write, 67% read, 8 KB I/O size, 8KB I/O alignment

<table>
<thead>
<tr>
<th>Drive model</th>
<th>Configured user capacity, GB</th>
<th>IOPS per drive with Queue Depth = 32</th>
<th>IOPS per drive with Queue Depth = 1</th>
<th>IOPS / GB with Queue Depth = 32</th>
<th>IOPS / GB with Queue Depth = 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>80GB</td>
<td>68.4</td>
<td>2200</td>
<td>1450</td>
<td>32</td>
<td>21</td>
</tr>
<tr>
<td>80GB</td>
<td>64</td>
<td>3200</td>
<td>1700</td>
<td>50</td>
<td>27</td>
</tr>
<tr>
<td>160GB</td>
<td>128</td>
<td>4400</td>
<td>2100</td>
<td>34</td>
<td>16</td>
</tr>
</tbody>
</table>
Over-Provisioning the X25-M 160GB

By allocating spare area that will not be used for data, ZT was able to scale up endurance and performance.

Significant TCO and I/O Gains compared to enterprise spindle drives – varies based on workload and block size:

<table>
<thead>
<tr>
<th>Read/Write</th>
<th>Block Size</th>
<th>TCO Reduction</th>
<th>I/O Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>95/5</td>
<td>4K</td>
<td>$21K</td>
<td>23K</td>
</tr>
<tr>
<td>65/35</td>
<td>4K</td>
<td>$19K</td>
<td>13K</td>
</tr>
<tr>
<td>95/5</td>
<td>16K</td>
<td>$23K</td>
<td>11K</td>
</tr>
<tr>
<td>65/35</td>
<td>16K</td>
<td>$23K</td>
<td>7K</td>
</tr>
</tbody>
</table>

*Measured with 8KB transfer size with a 2:1 Read:Write mix*
## System Performance Gains

### 2U, 8x 80GB Intel SSD, Single 3470

**Key SSD Benefits:**
- Eases thermal and power loads with improved performance
- **2.25x** improvement in system SPECPower w/ Intel SSDs

<table>
<thead>
<tr>
<th>Performance</th>
<th>Power</th>
<th>Performance to Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target Load</td>
<td>Actual Load</td>
<td>ssj_ops</td>
</tr>
<tr>
<td>100%</td>
<td>99.9%</td>
<td>235,263</td>
</tr>
<tr>
<td>90%</td>
<td>90.4%</td>
<td>212,765</td>
</tr>
<tr>
<td>80%</td>
<td>79.5%</td>
<td>187,170</td>
</tr>
<tr>
<td>70%</td>
<td>70.1%</td>
<td>165,033</td>
</tr>
<tr>
<td>60%</td>
<td>59.2%</td>
<td>139,402</td>
</tr>
<tr>
<td>50%</td>
<td>49.4%</td>
<td>116,422</td>
</tr>
<tr>
<td>40%</td>
<td>39.7%</td>
<td>93,441</td>
</tr>
<tr>
<td>30%</td>
<td>29.9%</td>
<td>70,503</td>
</tr>
<tr>
<td>20%</td>
<td>19.7%</td>
<td>46,443</td>
</tr>
<tr>
<td>10%</td>
<td>10.0%</td>
<td>23,461</td>
</tr>
<tr>
<td>Active Idle</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

\[
\text{\Sigma ssj_ops / \Sigma power} = 1,119
\]

### 2U, 8x 10K SAS, Single 3470

<table>
<thead>
<tr>
<th>Performance</th>
<th>Power</th>
<th>Performance to Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target Load</td>
<td>Actual Load</td>
<td>ssj_ops</td>
</tr>
<tr>
<td>100%</td>
<td>99.4%</td>
<td>235,285</td>
</tr>
<tr>
<td>90%</td>
<td>89.9%</td>
<td>212,652</td>
</tr>
<tr>
<td>80%</td>
<td>79.9%</td>
<td>189,067</td>
</tr>
<tr>
<td>70%</td>
<td>70.2%</td>
<td>166,109</td>
</tr>
<tr>
<td>60%</td>
<td>60.6%</td>
<td>143,466</td>
</tr>
<tr>
<td>50%</td>
<td>49.9%</td>
<td>118,006</td>
</tr>
<tr>
<td>40%</td>
<td>40.1%</td>
<td>94,976</td>
</tr>
<tr>
<td>30%</td>
<td>29.9%</td>
<td>70,716</td>
</tr>
<tr>
<td>20%</td>
<td>20.4%</td>
<td>48,239</td>
</tr>
<tr>
<td>10%</td>
<td>9.8%</td>
<td>23,229</td>
</tr>
<tr>
<td>Active Idle</td>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

\[
\text{\Sigma ssj_ops / \Sigma power} = 498
\]

**Significant Performance/ Power Benefit**

on Intel X25-M SSDs vs 10k SAS HDD
Key Takeaways – ZT Deployment

• Understand the workload in detail
• Set clear expectations on cost, endurance and performance
• Analyze, model, test, and correlate
• Partner with the experts

SSDs Work in the Data Center for the Right Applications With Considerable SPECPower Gains over Enterprise SAS
## Product Offering from ZT

<table>
<thead>
<tr>
<th>ZT Enterprise Server SS-ZTA8450</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intel® Xeon® X3470 Processor</td>
</tr>
<tr>
<td>Intel® 3420 chipset server board</td>
</tr>
<tr>
<td>16GB DDR3 1333 ECC Unbuffered</td>
</tr>
<tr>
<td>2.5&quot; 4-8 x 80GB Intel X25-M MLC SSD</td>
</tr>
<tr>
<td>8 port SAS/ SATA HBA</td>
</tr>
<tr>
<td>Slim DVD-ROM</td>
</tr>
<tr>
<td>1U 400Watt Gold Level Power Supply</td>
</tr>
</tbody>
</table>
Agenda

- Session Overview
- Content Distribution Network Server
- **Intel® IT**
  - Enterprise IT Client Deployments
- Q&A
Intel® IT – Client Deployments

- Client Overview
- Technology Timeline
- SSD Benefits
- IT Analysis
- Next Steps
**Highly Mobile Workforce**

- 78,900 Intel employees
- 20% Extended Work Day From Home
- 12% Work 3-5 Full Days/Week at Home
- 6% Work 1-2 Full Days/Week at Home
- 6% Do Not Work From Home

**Mobile Business PCs Managed Standard**

- >90,000 client PCs
- >80% laptops
- >7,000 access points
- <24 month avg. laptop age

**PC Standards Initiatives**

- Employee Productivity, IT Efficiency
- Mobile Business PCs (since 1997)
- Wireless Computing (since 2002)
- 2-4yrs PC Refresh (since 2004)
- Intel® vPro Technology (since 2008)
- Solid State Drives (since 2009)
- Microsoft Windows7* (since 2010)

**Solid State Drives**

- 46 different notebook models
- 33% Microsoft Windows XP*
- 67% Microsoft Windows 7*
- 75%-80GB 25% -160GB
- > 36,000 deployed!

**Mandate: Maximize Productivity and Efficiency**
## Technology Timeline

<table>
<thead>
<tr>
<th>Year</th>
<th>Technology</th>
<th>Deployed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>Mobile Business PC adoption (80/20)</td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>HDD Shock Absorption</td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>Shock sensor technology</td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>SATA NB drives/HDD Failure analysis/SSD TCO</td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>Phase 1: Technology Evaluation/Sales Force Deployment/Gen1 SSD</td>
<td>1,500</td>
</tr>
<tr>
<td>2009</td>
<td>Phase 2: Department Funded upgrades, OEM adoption, PC Refresh</td>
<td>7,000</td>
</tr>
<tr>
<td>2010</td>
<td>Phase 3: PC Refresh and OS upgrade/Gen2 SSD</td>
<td>40,000</td>
</tr>
<tr>
<td>2011</td>
<td>100% Mobile Business PC with SSD</td>
<td>35,000</td>
</tr>
</tbody>
</table>

**SSDs are Solving Key Pain-points in Mobile Business PCs**
Benefits

• **Employee -- faster, better!**
  - Performance benefits are a slam dunk
    β Enabled WDE adoption, discounted IT overhead
  - Improved battery life
  - Cooler, quieter, smaller systems
  - Reduced failures/ interruptions
  - Improved mobility

• **IT -- reduced TCO!**
  - Order of magnitude decrease in drive failures
    β 5% ‡ 0.5%
  - Improved support
    β Faster turnaround on repairs, rebuilds, data restore

*Enterprise, IT and Employee ALL WIN!*
Intel® IT’s SSD Analysis
3 Categories

1. Total Cost Of Ownership
2. Performance
3. Support

Goal: Unleash the True Value of SSDs
## Intel® IT’s SSD Analysis

### 1. Total Cost of Ownership

<table>
<thead>
<tr>
<th>Topic</th>
<th>Analysis</th>
<th>Conclusion / Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failure Rate</td>
<td>Key to positive ROI. We are tracking and analyzing failures for 36,000 drives with 0-30 months of use.</td>
<td>Dramatic reduction over HDD rate. Trending toward specified rate.</td>
</tr>
<tr>
<td>Premature Wear Out</td>
<td>Need the drives to last for the life of the asset. We studied volume of write activity for a sample group, and performed stress tests.</td>
<td>Not a concern. Average write volume in our sample group was about ½ of spec. Drives stressed to 3x spec are still performing well.</td>
</tr>
<tr>
<td>Pricing / Capacity</td>
<td>Will 80GB meet capacity requirements 3 yrs from now? We analyzed current use and potential future needs.</td>
<td>Initially buying 80GB. Standardized on 160GB moving forward.</td>
</tr>
<tr>
<td>Drive Standardization</td>
<td>Common components reduce cost.</td>
<td>Pervasively available from the OEMs that we use, in multiple form-factors.</td>
</tr>
</tbody>
</table>

**Reduced TCO is real**
## Intel® IT’s SSD Analysis

### 2 Performance

<table>
<thead>
<tr>
<th>Topic</th>
<th>Analysis</th>
<th>Conclusion / Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benchmarks</td>
<td>Completed extensive internal testing and reviewed external results.</td>
<td>Performance increase with SSDs is obvious from test results and user feedback.</td>
</tr>
<tr>
<td>Encryption</td>
<td>Software-based whole disk encryption impacts performance.</td>
<td>SSDs, even if encrypted, provide a better mobile experience than HDDs. A fast processor is important and AES-NI is the right 1\textsuperscript{st} step</td>
</tr>
<tr>
<td>Performance Over Time / Trim</td>
<td>Without trim, write performance is reduced over time to some degree. We analyzed out-of-box performance vs. performance after 12-18 months of use.</td>
<td>Nice to have, but not a panacea. Deployed without trim support initially. Moving to native OS trim support. Use the Intel® SSD Toolbox to optimize manually.</td>
</tr>
<tr>
<td>Platform Capabilities</td>
<td>AHCI vs. IDE; SATA 1.5 Gb/s vs. 3 Gb/s impact performance.</td>
<td>Ensure systems support SATA 3 Gb/s and have AHCI mode enabled for best performance. SSDs still showcase benefit on SATA 1.5 Gb/s</td>
</tr>
<tr>
<td>Tuning</td>
<td>Defragmentation and SuperFetch are not necessary.</td>
<td>Disable if required.</td>
</tr>
</tbody>
</table>

**Performance benefits are obvious**
## Intel® IT’s SSD Analysis

### Support

<table>
<thead>
<tr>
<th>Topic</th>
<th>Analysis</th>
<th>Conclusion / Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Software</td>
<td>Tools used to optimize and protect HDDs may or may not provide benefits on SSDs.</td>
<td>Ensure software is SSD-aware. Modify, disable, or uninstall if not applicable.</td>
</tr>
<tr>
<td>Information Security</td>
<td>We need to wipe data prior to internal reuse of SSDs. Degaussing is not effective on SSDs.</td>
<td>Using traditional wipe tools for HDDs and SSDs. Investigating secure erase for SSDs. We use drive shredding for disposal - “No drive leaves Intel.”</td>
</tr>
<tr>
<td>Data Recovery</td>
<td>SSDs fail too. Data recovery tools/techniques are different for HDDs vs. SSDs.</td>
<td>Ecosystem is maturing. Reiterated importance of backups.</td>
</tr>
<tr>
<td>Firmware</td>
<td>Does the firmware need to be updated to the latest version?</td>
<td>We verify firmware version for retrofits, and align with new NBs. We will update firmware if required to address specific issues.</td>
</tr>
<tr>
<td>Battery Life</td>
<td>Device Initiated Power Management (DIPM) must be enabled to yield optimal power consumption.</td>
<td>Understand DIPM and under what conditions it is enabled; varies based on OS, storage driver and power scheme.</td>
</tr>
</tbody>
</table>

**Support changes need to be considered**
Intel® IT Next Steps

• Aggressively drive to 100% deployment
  – To solve key pain-points in Mobile Business PCs

• Improve encryption performance
  – Working with encryption providers to improve software-based encryption performance.
  – Drive-based encryption is on the horizon.

• Drive SSD deployment in desktops
  – Opportunity to significantly lower repair incidents.
  – Different value proposition than notebook PCs.
Session Summary

• Intel® SSDs have moved from lab projects to real world server deployments – giving end customers competitive advantages in the marketplace

• In Mobile Business PC deployments, Intel® SSDs yield significant cost benefits over time through lower failure rates/ service calls

• Intel® SSD can be inserted into any SATA port, but environmental optimizations should be considered in order to extract the most out of the technology

The #1 optimization is simply to plug it in...
Additional info on this topic:

- Attend or download these SSD-related sessions
  **Monday, Sept 13th**
  - SSDL001 - Intel® Solid-State Drive (Intel® SSD) Optimizations
  - STOS001 - Low Power and High Performance of Solid State Drives Applied to a 1U Storage Server
  **Tuesday, Sept 14th**
  - SSDS001 - Solid-State Drive (SSD) Endurance Verification
  - SSDS002 - Enterprise Solid-State Drive (SSD) Endurance
  - SSDS003 - Client Solid-State Drives (SSDs): Scalable Solutions
  - SSDS004 - Solid-State Drive (SSD) Impacts on the Run-Time Performance of A-List Games
  - SSDS005 - Solid-State Drive (SSD) Optimizations in Enterprise Client IT, Server and Storage Environments
  **Wednesday, Sept 15th**
  - SFTS014 - Intel® Solid-State Drive in High Performance Computing

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  - [www.ztsystems.com](http://www.ztsystems.com)
  - [www.intel.com/it](http://www.intel.com/it)
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