Flash SSDs in the Enterprise: Where, How and Why

Marius Tudor
Director, Business Development
BiTMICRO Networks, Inc.
Agenda

- Enterprise SSD Market Outlook
- Enterprise Storage Requirements
- Flash SSD Major Advantages
- Flash SSD and HDD Pricing
- Flash SSD Performance Class
- Enterprise Usage Models
  - Storage Performance Acceleration (Traditional)
  - Server and Blade Storage
  - Tiered Storage Environments
  - Flash SSD Technology Trends
SSD Outlook

- IDC (2008) SSD Market Projections

<table>
<thead>
<tr>
<th>Worldwide Enterprise SSD Analysis, 2007–2012</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<tr>
<td>----------------</td>
</tr>
<tr>
<td>Enterprise DRAM</td>
</tr>
<tr>
<td>Enterprise NAND High I/O</td>
</tr>
<tr>
<td>Enterprise NAND</td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
<tr>
<td>Revenue ($M)</td>
</tr>
<tr>
<td>ASP ($)</td>
</tr>
<tr>
<td>TB shipped</td>
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</tbody>
</table>

- Increase in SSD players
  - SSD OEMS: ~50 manufacturers
  - Enterprise Class SSD
    - Flash SSD: 7 manufacturers
    - RAM SSD: 7 manufacturers
Enterprise Storage Requirements

- 24/7 Reliability
- Capacity
- 99.999% Availability
- High Performance
- Low Power Consumption
Traditional SSD Application

- Storage performance acceleration
Flash SSDs in the Enterprise

- Server and Blade Storage
  - Typically lower storage capacity requirements
  - SAS and SATA interfaces
  - Server and storage blades for boot and cache
Flash SSDs in the Enterprise

- Performance vs. Power: Buzz vs. Fact
  - High Performance & Low Power typically is an Oxymoron
  - 1W Flash SSD beats a 12W consuming version, or does it?
  - Case in Point: SSD ‘Uno’ performs 600 IOPS and Flash SSD ‘Duo’ delivers 40k Random Write IOPS
  - Flash SSD ‘Uno’ is 5X Higher in Power consumption that Flash SSD ‘Duo’: .0016W/IOPS vs. .0003W/IOPS
  - Million $ Q: Which one is better in an Enterprise Storage environment?

Note: This is solely an example depicting critical factors to consider; ‘Uno’ and ‘Duo’ are generic names and not meant to represent any one SSD or other brand;
Flash SSDs in the Enterprise

$/ Gbyte is Dead: Long live…$/ IOPS
(...at least as far as Enterprise SSDs are concerned)

- Flash SSDs really are NV buffers between front RAM & slower HDDs, right?
- Flash SSDs differ greatly when it comes to Random IOPS
- A 40k IOPS Flash SSD can displace 4X the HDDs that a 10k IOPS contender can
- 20% premium for the 40k IOPS SSD derives better TCO
- Consider the lowest Denominator…Guess Who?
- Random Write IOPS

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**Tiered Storage Requirements**

- Migration toward tiered storage environments within datacenters
  - Combination of very-high performance, Flash SSD-based transaction-intense tier;
  - High performance HDD; and
  - “Bulk” storage capacity, low-cost HDD tier

<table>
<thead>
<tr>
<th>Applications</th>
<th>Tier 0</th>
<th>Tier 0</th>
<th>Tier 1</th>
<th>Tier 1 or 2</th>
<th>Tier 2 or 3</th>
<th>Tier 2 or 3</th>
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</thead>
<tbody>
<tr>
<td>Interface Speeds</td>
<td>4GFC</td>
<td>3Gb/s</td>
<td>4GFC</td>
<td>6Gb/s &amp; 3Gb/s</td>
<td>3Gb/s</td>
<td>3Gb/s</td>
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<tr>
<td>Capacities (GB)</td>
<td>640GB</td>
<td>160GB</td>
<td>146, 300 &amp; 450GB</td>
<td>250, 300, 500, 750GB and 1TB</td>
<td>160GB</td>
<td>250, 500, &amp; 750GB, 1TB</td>
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<tr>
<td>Access Times</td>
<td>30 - 100 μs</td>
<td>30 - 100 μs</td>
<td>5-8 ms</td>
<td>5-8 ms</td>
<td>30 - 100 μs</td>
<td>12 - 14 ms</td>
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<td>MTBF (hours)</td>
<td>2 million</td>
<td>2 million</td>
<td>1.6 million</td>
<td>1.6 million</td>
<td>2 million</td>
<td>1.2 million</td>
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<td>Form Factors</td>
<td>3.5”</td>
<td>2.5”</td>
<td>3.5”</td>
<td>2.5”/3.5”</td>
<td>2.5”</td>
<td>3.5”</td>
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<tr>
<td>Sustained Rates</td>
<td>Up to 230MB/s</td>
<td>Up to 230MB/s</td>
<td>170 MB/s</td>
<td>Up to 170 MB/s</td>
<td>Up to 100 MB/s</td>
<td>100 MB/s</td>
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<td>Dual Ports</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
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<tr>
<td>Vibration Tolerance</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
</tr>
</tbody>
</table>
Balancing Cost & Performance

- Tiered Storage Application #1 – Tier 0 Storage Subsystem
Tiered Storage Application #2 – Hybrid SSD and HDD Arrays

- Destage data that have become less critical over time
- Promote hotfiles onto high-performance storage
- Migrate production data for short term archival purposes
- Data Recall from archive

Options:

- FC SSD + FC HDD
  - 15000 RPM
  - 72GB

- 2.5" SAS SSD +
  - 2.5" SAS HDD
  - 15000 RPM
  - 36GB

- 2.5" SAS SSD +
  - 2.5" SAS HDD
  - 10000 RPM
  - 146GB

- SATA SSD + SATA HDD
  - 7200 RPM
  - 250GB

Legend:
- HDD
- SSD
Flash SSD Technology Trends

- Increased Parallelism of Flash Operations
  - Increase in number of flash buses
  - Increase in parallel flash access
    - Multi-page writes
    - Multi-block erase

- Migration from SLC and mixed SLC-MLC SSDs to MLC
  - Need to address reliability issues (next ➔)
Persistent Reliability concerns

- Dealing with Flash Block degradation:
  - Permanent vs. Recoverable NAND Flash Failures
  - Recoverable Failures
    - Program Disturb, Read Disturb, Over-Programming, Data Loss

- Wear-Leveling techniques: Dynamic & Static

- ECC: RS ECC vs. BCH, which is Best & Why?
  - Memory Scrubbing
  - SLC vs. MLC ECC: is increasing the ECC for MLC based SSDs to 20+ bits per block sufficient?
Flash SSD Technology Trends

- Flash SSD variants

### Flash SSD Variants

- **SLC-Based**
  - OLTP
  - Data Warehousing
  - ERP
  - Video Rendering
  - Email/Web Caching
  - Notebook (Road Warriors)

- **MLC-Based**
  - PC/Desktop
  - Video-on-Demand
  - Notebook (Business)
  - PC/Desktop
  - Notebook (Consumer)
  - Video Camcorders
  - Portable Devices

- **Mixed SLC/MLC**
Flash SSD Technology Trends

- Tiered NVM Architecture

- Mixed SLC/MLC SSD

- SLC

- MLC

- Write-Intensive

- Read-Intensive
Flash SSD Performance Trends

Year 2010
Max. **Sustained Transfer Rate** = 1.3 GB/s

6-8x HDDs’ est. of 200 MB/s
Max. **Random IOPS** = 250,000

500x HDDs’ est. of 500 IOPS
Concluding Thoughts

- Flash SSDs have crossed over from military/industrial applications to enterprise computing mainly because of realized benefits in performance, availability, reliability and precipitous decline in price points.
- Balance between cost and performance should still be considered when deploying Flash SSDs in enterprise computing to achieve lower TCO.
- Leverage on enterprise storage implementations and data classification strategies.
- There is a continuous effort by Flash SSD manufacturers to address cost and performance concerns in enterprise computing.
Thank You!

“There is nothing so powerful as an idea whose time has come.”
– Victor Hugo