Tutorial T1C
Testing/Performance/Endurance

Changing Dynamics of Flash Performance Benchmarks
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Mike Engbretson – Granite River Labs

August 10, 2010
**Agenda**

- Market Trend - update
- Changes in Performance Landscape
- Benchmarking Methods & Standards
- Challenges beyond just Performance
- Ways OakGate Technology and Granite River Labs can help
SSD Market Trend

Server Class
- SATA/SAS/FC/PCI-e
- Primarily SLC
- Leadership Read/Write Performance
- Acceptable Endurance for any Traffic Workload

Consumer Class
- SATA
- Primarily MLC
- Good Read Performance
- Limited Write Performance
- Limited Endurance but Acceptable for Client Applications

- SATA/SAS/PCI-e
- Primarily MLC/eMLC
- Good Read Performance
- Acceptable Write Performance
- Endurance dependent on Application
- Best Price/Performance
Performance Landscape

• 3rd / 4th Generation of Controllers
• Improved Performance (especially writes)
• Improved OTB versus Steady State Performance
• Refinements in Wear-leveling and Garbage Collection algorithms
• New FLASH (eMLC) that improves endurance
• Use of Data Compression to improve Write Performance and Write Amplification
• 4K IO Optimization – general trend to 4K Sectors
OTB versus Steady State

MLC FLASH – 2 hour pre-conditioning
2010          2011

- Higher Performance
- Quicker transition to Steady State

Monday, August 29, 11
Impact of Data Compression

- Need to understand the Entropy of the Real Data
4K IO Optimized

- IO Alignment Important
- Flash Technology Dependent
Benchmarking Methods

- Standards Based Performance/Endurance
  - SNIA – Solid State Storage Performance Test Specification Enterprise 1.0
  - JEDEC – JESD218A and JESD219
- User Defined Performance Measurement
  - Application Specific
  - Synthetic workloads
  - Captured Traffic workloads
- Functionality Validation
  - Conformance and Error Injection
Benchmarking Methods

- SNIA – SSS-PTS-Enterprise Ver. 1.0

- Transition from OTB State
- Reach Steady State
- Make Reliable/Repeatable Measurements
Benchmarking Methods

- SNIA – SSS-PTS-Enterprise Ver. 1.0
- Measurement Rounds
- Measurement Convergence

<table>
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<th>Blk Size</th>
<th>0/100</th>
<th>95/5</th>
<th>65/35</th>
<th>50/50</th>
<th>35/65</th>
<th>5/95</th>
<th>100/0</th>
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<td>1347</td>
<td>1166</td>
<td>839</td>
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<td>1819</td>
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Challenges beyond Performance

- Data Validation
  - Data Integrity Checking (including stale data and missed writes)
  - Data commit during power failure/recovery
- Endurance Prediction
  - Using SMART Attributes
  - JEDEC
- Latency
  - IO Latency Distribution
  - Understand impact on application
- Protocol/Command Robustness
  - Device Software Reliability
Latency Distribution
Example 1

- A few longer latency IO's but in general very good distribution
• Large groupings of long latency IO's
• Impact on Application Performance
• Impact on Raid Controller Performance
# Smart Attributes (Endurance Related)

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<thead>
<tr>
<th>ID</th>
<th>Attribute Name</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
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<td>177</td>
<td>1) Wear Range Delta</td>
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<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
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<td>2) Wear Leveling Count</td>
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<tr>
<td>231</td>
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<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
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<tr>
<td></td>
<td>2) Temperature (degC)</td>
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<td>232</td>
<td>Vendor Unique</td>
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<td>233</td>
<td>Media Wear-out Indicator</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>241</td>
<td>Lifetime Writes from HOST</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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Data Integrity/Power Fail Testing

- Why this is Important
  - Young and Maturing Technology (FLASH, Controllers, Super Caps)
  - New Software Algorithms
  - Data is not Stationary (wear-leveling)
- What should be tested
  - Super Cap or Equiv Hold up time – did all data get committed in time
  - Extended Data Checking (correct data and from correct location/time)
  - Extended Run periods to stress wear-leveling
  - Power off – data retention intervals
OakGate Technology/Granite River Labs

- Validation & Performance System
  - SNIA and Custom Performance Benchmarks
  - JEDEC Compliant Endurance test suite
  - User definable/customized Benchmarks and Validation test suites
  - Data Integrity/Power Fail Test Suite
  - Full API for fully vendor unique tests development

- Full set of Services
  - SATA/SAS physical layer compliance
  - SATA Interop Testing
  - SAS/SATA Device Benchmarking
  - Data Integrity and Power Cycle Testing
# SATA/SAS Compliance - Overview

What SATA Compliance & SAS Conformance DO address:

<table>
<thead>
<tr>
<th>Standard</th>
<th>Official Logo Program?</th>
<th>PHY</th>
<th>Digital</th>
<th>System Interop</th>
<th>Mechanical</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>SATA</td>
<td>Y – Administered by SATA-IO</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>“Building Blocks” cert program available for IC components DOS-based scripts used for System Interop tests</td>
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<tr>
<td>SAS</td>
<td>N – “Conformance” based on test methodologies developed by UNH</td>
<td>Y</td>
<td>Y</td>
<td>Not defined</td>
<td>Not defined</td>
<td>Receiver PHY jitter tolerance requirements defined but no conformance test spec RX/TX (return loss/impedance) test accepted practice includes “gating” out the connector</td>
</tr>
</tbody>
</table>
What SATA Compliance & SAS Conformance DO NOT address:

<table>
<thead>
<tr>
<th>Category</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHY Stress Testing</td>
<td>“How much input jitter can my receiver tolerate and still pass compliance?”</td>
</tr>
<tr>
<td>PVT Characterization</td>
<td>“How much margin does my product have in meeting spec under a range of PVT conditions and what are my points of failure?”</td>
</tr>
<tr>
<td>Extensive Interop &amp; System Validation</td>
<td>“Will my device/host interoperate with a wide range of products and system environments?”</td>
</tr>
<tr>
<td>Functional Stress Tests</td>
<td>“How well does my product handle a variety of real-world and corner case test conditions?”</td>
</tr>
<tr>
<td>Performance Benchmarking</td>
<td>“How does my product stack up against industry benchmarks and competitors’ products?”</td>
</tr>
</tbody>
</table>
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