Apples to Apples, Pears to Pears in SSS performance Benchmarking

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Abstract

SSS Performance Benchmarking Learning Objectives

- Get a good understanding of the various parameters that influence the performance characteristics of SSDs
- Get a full understanding of the proposed SNIA Performance Measurement Specification
- Provide step-by-step guidance on how to set up a test benchmark that enables comparison among the various SSS devices
Definition of SSS

SSS = Solid State Storage

Traditional hard disk drive

Solid state hard drive
The Performance Landscape

- Bandwidth Performance Specifications
  - Sustained Sequential Reads: Up to 250 MB/s
  - Sustained Sequential Write: Up to 70 MB/s
- Read and Write IOPS specifications (Iometer Queue Depth 32)
  - Random 4 KB Reads: Up to 35 K IOPS
  - Random 4 KB Writes: Up to 3 K IOPS

Like other high-performance, enterprise-class flash drives, the drive is being positioned as an alternative to traditional 15,000-rpm serial-attached SCSI (SAS) hard disk drives. The drive is said to process IOPS (input/output per second) more than 10 times faster than the fastest SAS hard drive, with a sequential read rate of 230 MB/sec. and a sequential write rate of 180 MB/sec.

Table 3: Sustained and Random Read/Write Performance

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burst Read</td>
<td>150 MBytes/sec</td>
</tr>
<tr>
<td>Burst Write</td>
<td>150 MBytes/sec</td>
</tr>
<tr>
<td>Sustained Read</td>
<td>Up to 15 MBytes/sec</td>
</tr>
<tr>
<td>Sustained Write</td>
<td>Up to 15 MBytes/sec</td>
</tr>
<tr>
<td>Random Read</td>
<td>6100 Input/Output Operations Per Second (IOPS)</td>
</tr>
<tr>
<td>Random Write</td>
<td>400 IOPS</td>
</tr>
<tr>
<td>Random 57% Read, 33% Write</td>
<td>1120 IOPS</td>
</tr>
</tbody>
</table>

4 One megabyte, or MByte, equals 1,048,576 bytes.
5 Random performance values are based on 4 KByte transfers.
Variables influencing Performance

Platform
- Test Hardware (CPU, interface, chipset, etc)
- Software (OS, drivers)

SSS Device Architecture
- Flash geometry, cache, flash management algorithm, etc

Workload
- Write history (Terabytes written, % spares)
- Random, sequential, read/write mix, etc
- Preconditioning (Random, sequential, transfer size, etc)
- Data content
- TRIM command
The 3 dimensions of SSS performance

SSS performance depends on
- Read/Write Mix
- Transfer Size
- Queue Depth (not shown)
Performance States

Performance States for Various SSDs

- N1 (MLC)
- N6 (SLC)
- JS (SLC)
- PSM (MLC)
- PS (PLC)

Normalized IOPS (IOPS/Max IOPS))

FOB
Transition
Steady State (desirable test range)

Time (Minutes)

Normalized IOPS (IOPS/Max IOPS))

0 0.2 0.4 0.6 0.8 1 1.2
0 50 100 150 200 250 300
Workload Dependency - 1

Step 1: HD Tune Pro Sequential Write Test

Step 2: IOMeter Random Write Test

Step 3: HD Tune Pro Sequential Write Test

SSD Mfg A
Workload dependency - 2

Step 1: HD Tune Pro Sequential Write Test

Step 2: IOMeter Random Write Test

Step 3: HD Tune Pro Sequential Write Test

SSD Mfg B
Dependency on data content
Dependency on data content
# Benchmark Suites

<table>
<thead>
<tr>
<th>Test Suite</th>
<th>Commercial/Client SSD</th>
<th>Enterprise SSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCMark</td>
<td>HDD Score, OS and application loading timing, user simulation (surfing web, windows media player, etc)</td>
<td>√</td>
</tr>
<tr>
<td>SysMark</td>
<td>System-level test. Measures performance based on average response time, gives score (0-250)</td>
<td></td>
</tr>
<tr>
<td>IOMeter</td>
<td>Sequential/Random performance, workload simulation</td>
<td>√</td>
</tr>
<tr>
<td>HD Tach/H2benchw</td>
<td>Performance stability, Sequential/Burst performance, Access Time</td>
<td>√</td>
</tr>
<tr>
<td>HD Tune</td>
<td>Performance stability, Sequential/Burst performance, Access Time</td>
<td></td>
</tr>
<tr>
<td>Everest</td>
<td>Random Access Time (Read/Write)</td>
<td>√</td>
</tr>
<tr>
<td>VDBench</td>
<td>Workload generator, performance on DAS and NAS</td>
<td>√</td>
</tr>
</tbody>
</table>

Type of preconditioning and order of benchmarks can influence results.
The Need for Industry Standardization!

- SNIA Technical Working Group (TWG) created in early 2009 to define SSS Performance Specifications for a suite of tests and test procedures to enable comparative testing and reporting of Solid State Storage (SSS) performance.

- Specification
- Agnostic – Does not favor any one technology
- Relevant – Meaningful to end users
- Repeatable – Easy comparison between devices
- Practical – Complete with reasonable time and effort
- Accessible – Open specification, 3rd party validation
Scope of SSS Performance Spec

- Setup and Methodology
  - Purge
  - Preconditioning
  - Test Parameters

- Workloads (synthetic)
  - Client – IOPS, Throughput, Latency
  - Enterprise – IOPS, Throughput, Latency

- Reporting
  - Show convergence to steady state
  - Show performance results during steady state

- Performance Test Platform in development by SSSI Tech Dev Group (2H10)
Status of SSS Performance Spec

- V0.x available for public review/comment
  - www.snia.....

- Your Feedback is crucial!
  - Do we test the right things? Do we need others?
  - Are the reports useful?
  - Are the procedures clear?
  - Does this truly give us apples-to-apples performance comparison?

- Performance Test Platform
  - Working in SSSI; please join us
Performance Benchmark Steps

1. Prepare the Device
   - Purge/Secure erase → put SSS back into “original” state

2. Precondition the Device
   - Write data 2x capacity → bring device to known state

3. Steady State Testing
   - Run Test Loop up until steady state is achieved
   - Performance stays within ± 10% margin in last 5 test loops

4. Test Report
   - Show convergence to steady state
   - Show 3D test results
Convergence to Steady State

Steady State reached if performance swing is within 10% margin

SSD A
Steady State

SSD B
Steady State

SSD C
(Steady State???)

SSD D
(Steady State???)

Normalized IOPS (IOPS/Max(IOPS))

0 0.2 0.4 0.6 0.8 1 1.2

0 50 100 150 200 250 300

Time (Minutes)
Indicates steady state performance
- Various Block Size
- Various Read/Write mixes
Other Standardization Initiatives

- **SSSI Group of SNIA**
  - Technical Work Group (TWG) → Performance Benchmark Spec
  - Tech Dev Group → Performance Test Platform

- **JEDEC 64.8**
  - Specification for SSD endurance measurement

- **SSDA**
  - Testing of reliability (power cycling, data retention, endurance, etc) and OS compatibility (Windows 7)
Summary

- SSS Performance is dependent on many variables
- Comparing vendors is not trivial \( \rightarrow \) industry standard required
- SNIA Performance Specs allows apples to apples comparison
  - Spec for review at [http://www.snia.org/forums/sssi](http://www.snia.org/forums/sssi)
  - Send your feedback to ssstwg@snia.org

- GET INVOLVED!!
Q&A / Feedback

Please send any questions or comments on this presentation to SNIA: tracksolidstate@snia.org

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