‘How fast is fast?’
Block IO performance on a RAM disk

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Why Measure Performance on a RAM Disk?

- High Performance Storage is moving to the memory channel
- New NVDIMM Block IO SSDs are being released
- RAM disk Performance shows how fast Storage may get:
  - Block IO SSD devices on the memory channel
  - In memory load / store memory mapping
Test Set Up

Hardware: PTS Reference Test Platform
- Intel S2600 COE Gen 3
- Dual Xeon 8 core, 3.2Ghz E5 2687W
- 32 GB (4GB x 8) DDR3 1600 ECC
- 16GB RAM Disk

Software:
- OS – CentOS 6.5
- Linux RAM Disk Block IO Driver 2.6.32-431.11.2.EL6.x86_64
- Test Software - Calypso CTS BE 1.9.216
### Year in Review 2014 - Summary Performance Comparison by Storage Class

<table>
<thead>
<tr>
<th>Storage Class</th>
<th>IOPS FOB PTS WSAT - T4Q32</th>
<th>IOPS Steady State PTS IOPS - T2Q16 / T4Q32</th>
<th>Bandwidth PTS Throughput - T1Q32</th>
<th>Response Time PTS Latency - T1Q1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Category</td>
<td>Device Type</td>
<td>Capacity</td>
<td>RND 4KiB 100% W</td>
</tr>
<tr>
<td>HDD &amp; SSHD</td>
<td>1</td>
<td>SSHD 7,200 RPM 2.5” SATA Hybrid</td>
<td>500 GB</td>
<td>134</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>SAS HDD 15,000 RPM 3.5” SAS HDD</td>
<td>80 GB</td>
<td>350</td>
</tr>
<tr>
<td>CLIENT SSDs</td>
<td>3</td>
<td>mSATA 1.8” MLC</td>
<td>128 GB</td>
<td>45,743</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>M.2 x2 M.2 x2 2280 MLC</td>
<td>512 GB</td>
<td>61,506</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>SATA Client 2.5” MLC</td>
<td>200 GB</td>
<td>54,788</td>
</tr>
<tr>
<td>ENTERPRISE SSDs</td>
<td>6</td>
<td>SATA 6Gb/s 2.5” eMLC</td>
<td>800 GB</td>
<td>57,422</td>
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<tr>
<td></td>
<td>7</td>
<td>SAS 12Gb/s 2.5” MLC</td>
<td>800 GB</td>
<td>97,950</td>
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<tr>
<td></td>
<td>8</td>
<td>SFF 8639 4 lane 2.5” MLC</td>
<td>700 GB</td>
<td>149,512</td>
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<td></td>
<td>9</td>
<td>PCIe 8 Lane Edge Card MLC</td>
<td>1400 GB</td>
<td>159,926</td>
</tr>
</tbody>
</table>

All measurements taken on the RTP 3.0 CTS 6.5 Reference Test Platform pursuant to the SNIA PTS-E 1.1.

NOTE: Thread and Queue settings for PTS IOPS are T2Q16 for HDD/SSHD & Client SSDs and T4Q32 for Enterprise SSDs.
4K IOPS: 3-4 Million; .01mS ART
SEQ TP 1024K: 75GB/s Read

THROUGHPUT - SEQ 1024KiB: Bandwidth v Average Response Times - RW0 / RW100

- Bandwidth Writes
- Bandwidth Reads
- Ave Response Time W
- Ave Response Time Reads

Bandwidth (MB/s)

Average Response Time [ms]

SAS 12Gb/s
- 448
- 973

PCIe 8 Ln
- 614
- 2,673

RAM Disk
- 51,218
- 0.31
- 0.21
4K W Latency T1Q1: 0.004mS ART

Latency Test: RND 4KRW0 T1Q1: Ave v Max Response Time

<table>
<thead>
<tr>
<th>Storage Type</th>
<th>Ave Response Time (mS)</th>
<th>Max Response Time (mS)</th>
<th>IOPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAS 12Gb/s</td>
<td>0.054</td>
<td>18,417</td>
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<tr>
<td>PCIe 8 Ln</td>
<td>0.014</td>
<td>70,444</td>
<td>241,657</td>
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<tr>
<td>RAM Disk</td>
<td>0.004</td>
<td>0.120</td>
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</table>

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Factors Affecting Performance

NAND Flash SSDs:

- Pre-conditioning & Active Range
- Steady State & Write History
- Workload & Access Patterns

RAM Disk:

- Demand Intensity / Outstanding IOs (Threads & Queues)
- Number of CPUs and CPU cores
- Number of Memory Channels & Parallelism
RAM Disk Scaling:
Add Threads, not Queues
IOPS & ‘QoS’ RTs at different OIO

P16 Confidence Level Plots Compare

Response Time (mSec)

IOPS

Demand Intensity - Total Outstanding IOs

T1Q1
T8Q1
T16Q4
Application Workload Comparison

Compare 3 devices:

- RAM Disk 16GB DDR3 4x 4GB
- PCIe x8 SSD 700GB MLC
- SAS 12G/s 800GB MLC

Apply Database OLTP Workload

- db OLTP = RND 8K 70:30 RW
- Run to Steady State
- Map drive by varying the OIO (Thread Count x Queue Depth combinations)
- Select highest IOPS & lowest RT at the optimal OIO combination
Application Workload – db OLTP

Confidence Level Plot Compare (CLPC)

- Select the ‘optimal’ IOPS/RT OIO for each of the three drives
- IOPS are shown as the blue bar

Quality of Service (QoS) = High Percentile Response Times (RTs)

- RT Quality of Service (QoS) tracks:
  - ART (average Response Time)
  - “Number of 9’s” percentile response times (3, 4 and 5 9’s)
  - Note: 5 9’s is 99,9999 our of 100,000 IOs
- RT Ceiling (red dotted line)
  - Maximum response time allowed by the application
  - RT goal for device & system optimization
db OLTP – SAS v PCIe v RAM Disk
2.1M IOPS, 5 9’s QoS 11.72mS
TAKE AWAYS

RAM Disk Block IO Performance is much higher than NAND Flash

NVDIMM RAM Block IO can approach the level of RAM Disk Block IO

RAM Disk Block IO Performance Depends on Settings

Applications can run much faster with RAM Disk and/or NVDIMM SSD

RAM Disk / NVDIMM SSD offer new Storage Tiering Opportunities
For more information, contact Calypso Systems, Inc.

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