An Examination of User Workloads
Real World Storage Workload Capture

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A. What Are Real World Storage Workloads & Why Do We Care?

B. What Do Real World Storage Workloads Look Like?

C. Case Study: Retail Store Web Portal 24 hour Capture

D. Take Aways

E. Q & A
What Are Real World Storage Workloads and Why Do We Care?
Real World Storage Workloads are Unique and are the:

IOs that occur when YOUR application is running

IO Streams that traverse YOUR Hardware/Software Stack

IO Streams that present to YOUR HDD/SSD/Array Storage
IO Streams are YOUR Data
Traversing the HW/SW Stack

Many Different IO Streams each with a Unique:
- Random or Sequential Access, Data Transfer Size
- Read/Write Mix, Entropy and
- Spatial & Temporal Locality of Reference

IO Streams Change at each level of SW Abstraction
- Fragmented, Coalesced, Appended due to
- Virtualization, Packetization, Encryption, Data Reduction
- Compression, Deduplication, Storage Tiering and more

Because IO Streams Change, it is important to Capture IOs as close to the storage as possible – ideally at the Block IO level
Why Do We Care?

**SSD Performance & Endurance Depends on it:**

- SSD Performance Depends on the Type of Workload
- Workloads Affect Endurance (Write Amplification)
- Storage Tiering Strategies are Based on Workload Assumptions
- Workloads Determine What Type of SSD is Best for Your Application
- Be Sure to Buy the Right Amount of Performance and Endurance!
What Do Real World Storage Workloads Look Like?
IO Streams Can Be Visualized As:

IO Stream Maps by Frequency over Time (IO Stream Map)

IO Stream Maps by Location over Time (LBA Hit Map)

A Tabular Distribution of IO Streams
Key IO Stream Metrics Include:

- IO Stream Map Frequency & Amount
- LBA Hit Maps – Spatial & Temporal Locality of Reference
- Specific Process ID for IO Streams
- IO Stream Sequentiality, Queue Depth, Response Times
- IOPS rate, Bandwidth, Access Patterns, Data Transfer Sizes
- Reads, Writes, Amount Written
- Compressibility Ratio
- Deduplication Ratio
Workload Visualization – Example #3 at TestMyWorkload.com
Case Study
Test Plan

- Create Workload Segments from IO Capture Data
- Test using the same OS and Software as Captured Data
- Apply Workloads to 3 Data Center SATA SSDs
- Compare Performance to Workload Segments
- Compare Performance to Workload Replay
Test Set Up

**Hardware Platform**
- Calypso IOProfiler – Real World Workload Tester
- OS: Hyper-V Server 2012 R2 (same as source capture)
- Test Software: RTP BE ver 1.9.184
- Motherboard: Intel SC2600COE, 32GB DDR3 ECC RAM
- CPUs: Dual Intel XEON Eight Core W2687v2 3.1Ghz
- HBA: 6Gb/s LSI 9212

**Software Platform**
- Test Software: IPF 1.05 FE ver 1.18.11
- OS: Windows 7 Pro
- Capture Tool: IPF Win Capture applets
SSD Sample Pool

SSD A - Data Center 2.5” SATA SSD – 960 GB
SSD B - Data Center 2.5” SATA SSD – 800 GB
SSD C - Data Center 2.5” SATA SSD – 960 GB
Replay - Throughput by Segments: Average MB/s Over Segment

Higher TP is Better

SSD A Avg TP
SSD B Avg TP
SSD C Avg TP

Cumulative Workload
SQL 2 AM Back-up
10 am - 4 pm Segments
6 pm to Close
SQL 24 hr

Throughput (MB/s)

185
57
67

213
36
36

460
312
356

187
51
57

Higher TP is Better
Replay - ART by Segments: Average Over Segment

Lower Response Times are Better
Replay - 5 9s Response Time by Segments: Average Over Segment

SSD A 99.999%
SSD B 99.999%
SSD C 99.999%

Lower Response Times are Better

Cumulative Workload: 15.60, 139.00, 112.50
SQL 2 AM Back-up: 18.50, 35.90, 24.00
10 am - 4 pm: 18.07, 183.58, 152.83
6 pm to Close: 30.80, 53.64, 54.38
SQL 24 hr: 17.28, 166.54, 138.66

Response Times (mSec)
Power Consumption by Segments - Average Over Segment

- SSD A Avg Power
- SSD B Avg Power
- SSD C Avg Power

<table>
<thead>
<tr>
<th>Segment</th>
<th>Cumulative Workload</th>
<th>SQL 2 AM Back-up</th>
<th>10 am - 4 pm</th>
<th>6 pm to Close</th>
<th>SQL 24 hr</th>
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</thead>
<tbody>
<tr>
<td>Power (mW)</td>
<td>3,163</td>
<td>2,990</td>
<td>3,003</td>
<td>2,832</td>
<td>3,064</td>
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<tr>
<td>Power (mW)</td>
<td>1,987</td>
<td>1,747</td>
<td>1,815</td>
<td>2,561</td>
<td>1,911</td>
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<tr>
<td>Cumulative Workload</td>
<td>1,400</td>
<td>1,328</td>
<td>1,605</td>
<td>1,357</td>
<td>1,911</td>
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Replay - Throughput by Segments: Average MB/s Over Segment

- **SSD A Avg TP**
- **SSD B Avg TP**
- **SSD C Avg TP**

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<td><strong>SSD A Avg TP</strong></td>
<td>185</td>
<td>519</td>
<td>213</td>
<td>460</td>
<td>187</td>
</tr>
<tr>
<td><strong>SSD B Avg TP</strong></td>
<td>57</td>
<td>436</td>
<td>36</td>
<td>312</td>
<td>51</td>
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<tr>
<td><strong>SSD C Avg TP</strong></td>
<td>67</td>
<td>466</td>
<td>36</td>
<td>356</td>
<td>57</td>
</tr>
</tbody>
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Higher TP is Better
Workload Segments - Net IO Streams Distribution % by Segments

Cumulative Workload
- RND 64K R: 30.30%
- SEQ 0.5K W: 27.80%
- RND 8K R: 16.30%
- SEQ 8K R: 13.70%
- RND 4K W: 6.40%
- SEQ 64K R: 5.50%

SQL 2 AM Back-up
- RND 64K R: 100.00%
- SEQ 0.5K W: 0%
- RND 8K R: 0%
- SEQ 8K R: 0%
- RND 4K W: 0%
- SEQ 64K R: 0%
- RND 8K W: 0%

10 am - 4 pm Segments
- RND 64K R: 22.60%
- SEQ 0.5K W: 34.30%
- RND 8K R: 14.40%
- SEQ 8K R: 15.50%
- RND 4K W: 7.40%
- SEQ 64K R: 5.80%

6 pm to Close
- RND 64K R: 52.10%
- SEQ 0.5K W: 26.50%
- RND 8K R: 16.80%
- SEQ 8K R: 14.20%
- RND 4K W: 5.60%
- SEQ 64K R: 4.40%

SQL 24 hr
- RND 64K R: 30.50%
- SEQ 0.5K W: 28.90%
- RND 8K R: 16.40%
- SEQ 8K R: 14.20%
- RND 4K W: 5.60%
- SEQ 64K R: 4.40%
Real World Workloads Are Changing Groups of IOs
SSD Performance Depends on the SSD Workload

IO Streams Change as they Traverse the SW Stack

Replay Storage Workloads are Changing Groups of IO Streams

Individual IO Streams Can Be Compared to Synthetic Benchmarks

IO Workloads Result In Specific Performance & Endurance

Each Real World IO Capture is Unique to its Time and System
Understand Your SSD Workloads

The Example #3 Workload in this Presentation Can Be Accessed as a Live Demo at TestMyWorkload.com

Try FREE Capture & Analysis of Your SSD Real World Storage Workloads Today!
For more information, contact Calypso Systems, Inc.

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