Achieving Consistent Low Latency with All-Flash Arrays

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E-Series Flash Architect
## Two worlds for Latency

<table>
<thead>
<tr>
<th></th>
<th>Dedicated Application Hardware</th>
<th>Shared Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average Latency</strong></td>
<td>&lt;0.5 ms</td>
<td>&lt;1 ms</td>
</tr>
<tr>
<td><strong>Latency Sensitivity</strong></td>
<td>Very Sensitive to spikes</td>
<td>Less sensitive to spikes</td>
</tr>
<tr>
<td><strong>Feature use</strong></td>
<td>Light</td>
<td>Heavy</td>
</tr>
<tr>
<td><strong>Key Metric</strong></td>
<td>$/IOP</td>
<td>$/GB Effective</td>
</tr>
</tbody>
</table>
IOP = 8K Block, 40/60 R/W, 80% Random
Single Application – Dedicated Hardware

IOP = 8K Block, 40/60 R/W, 80% Random
How do we keep latency low in All Flash Arrays?

<table>
<thead>
<tr>
<th>Function</th>
<th>Size</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erase</td>
<td>256 KB</td>
<td>2 ms</td>
</tr>
<tr>
<td>Write</td>
<td>4 KB</td>
<td>200 usec</td>
</tr>
<tr>
<td>Read</td>
<td>4 KB</td>
<td>50 usec</td>
</tr>
</tbody>
</table>

We want to keep read and write to near flash speeds.
Latency in the storage system
What gets in the way of low latency?

1. Conflict with Flash media operations
   - Read/write waiting for a 2 ms erase
2. Complexity of Storage Management Features
   - Layers of indirection & mapping
   - Multiple media accesses
What gets in the way of low latency?

1. Media access conflicts
2. Storage System Features
   - Replication
   - Resiliency
   - Efficiency
What gets in the way of low latency?

1. Media access conflicts
2. Storage System Features
   - Replication
   - Resiliency
   - Efficiency
Handling Media Access Conflicts

Within Device
1. Flash lanes and flash controllers
2. CPU / RAM
3. Over provisioning flash capacity
Handling Media Access Conflicts

SSD & Storage System Together
1. Sequential write patterns
2. Access other devices
3. SCSI Stream commands
What gets in the way of low latency?

1. Media access conflicts
2. Storage System Features
   - Replication
   - Resiliency
   - Efficiency

Storage System
- Storage Management
- SSD
Handling Latency from Storage System features

• Replication
  – Snapshots
  – Clones

• Latency mitigation
  – Built into architecture
  – Hardware Assist
    • More cores
    • More DRAM
  – Higher performing SSD
Handling Latency from Storage System features

- **Resiliency**
  - Erasure codes / RAID
  - Replication

- **Latency mitigation**
  - Hardware Assist
    - More cores
    - Specialized HW
  - NV Mirror
  - Higher performing SSD
  - RAID Level choice
  - Full stripe writes
Handling Latency from Storage System features

• Efficiency
  – Thin provisioning
  – Compression
  – De-duplication

• Latency mitigation
  – Built into architecture
  – IHardware Assist
    • More cores
    • More RAM
    • Specialized HW
  – Higher performance SSD
  – Fewer IO to SSD from efficiency
NetApp EF-Series Latency Optimization

Storage System Features

- SANtricity OS
- Custom drivers
- Streamlined IO Path
- Direct mapped
- Mirrored NVRAM
- Hardware assist for erasure coding

Resiliency

Media Access Conflicts

SSD Selection & Qualification
- Over provisioning
- Flash lanes / device
- CPU/RAM

Top 5 SPC-1 Price-Performance
#1 SPC-1 LRT
All Flash FAS Latency Optimization

- Data ONTAP OS
- Features Built into the Architecture
- Cores & DRAM, Mirrored NVRAM
- Flash Optimized Read IO Path
- Efficient Sequential Write Streams

Storage System Features
- Replication
- Resiliency
- Efficiency

Media Access Conflicts
- SSD Selection & Qualification
  - Less Over provisioning
  - Flash lanes / device
  - CPU/RAM

Top 5 SPC-1 Performance
Summary

- Multiple approaches to developing an architecture for low latency
- No single feature is key for low latency
- Look for features and performance to fit your application needs

- NetApp Booth #511