Delivering Predictable Storage Performance in a Virtualized Environment

Vincent LaPaglia
Pivot3
Pivot3
PCIe Flash Storage

Vincent LaPaglia
Sr. Storage Engineer
Pivot3 Delivers Smarter Infrastructure

→ Proven Innovation
  • Software Defined Storage
  • Quality of Service
  • Flash array architecture

→ 30 Patents Awarded
→ Over 16,000 systems in 53 countries
→ Extensive technology partnerships
Major Innovations and Patents

- **2005**: Software-Defined Storage
- **2011**: Hyperconverged Infrastructure
- **2012**: Quality of Service
- **2016**: PCIe All-Flash Arrays

**Software-Defined Storage**

**Hyperconverged Infrastructure**

**Quality of Service**

**PCIe All-Flash Arrays**

**Innovation Timeline**

**Patents**

- **30** Patents
- **10** Pending
Business Innovation Puts Pressure on IT

**PERFORMANCE**
- Meeting application requirements
- Increasing user expectations

**AVAILABILITY**
- Always on/high availability
- Meeting service levels

**COMPLEXITY**
- Infrastructure sprawl
- Time to deploy

**ECONOMICS**
- Acquisition costs
- Operation costs
Challenges with Server Virtualization Deployment

• Meeting IOPS & especially low latency performance needs
• Mitigating blender effect: multiple VMs with unique characteristics
  • Variable block size ingestion
  • Unique IOPS and latency requirements
• Unpredictable performance due to I/O contention from heterogeneous workloads and higher VM densities
• Time and effort spent dealing with performance issues
VDI Stresses Storage

VDI is a demanding workload
- Bursty, massive load sometimes, quiet others
- Varies by the hour, day and month
- Demands random write-heavy I/O
- Inconsistent performance impacts user experience

Cost and complexity impacts project ROI
- Storage is expensive
- More disk drives increases maintenance expense
  - Excess capacity consumes more rack space
  - Higher power and cooling expenses
  - Higher maintenance costs
- Separate storage infrastructure for VDI increases costs
“I/O Blender” Alters Performance Reality

VMware vSphere
aka
“The Randomizer”

Virtual Machines
• 64K Random Read/Write

Exchange
• 64K Sequential Read/Write

SQL Server
• 8K Random Read/Write

SharePoint
• 8K Random Read/Write
• 64K Sequential Writes
Understanding the Storage Challenge

- VMs share storage resources
- Creates contention
- VMs have unique storage requirements
  - IOPS
  - Throughput
  - Latency
  - Capacity
  - Availability

- 15,000 IOPS
- 4 TB
- 5 ms Latency
Considerations for meeting your storage goals

- Architecture matters
- Not all data is equal
- Priorities drive performance
The Next Wave of Flash Arrays Are Here

First All-Flash Arrays

- Single Critical App
- Want flash performance for a limited set of applications

Next All-Flash Arrays

- Want flash performance for broader mixed workloads

KEY CONSIDERATIONS

- Optimized for flash?
- Designed for lowest latency?
- Prioritize application workloads?
- Ensure service levels are met?
- VM-level Performance Management?
Pivot3 Flash Storage Solutions

- Multi-tier Architecture
- Flash-First Datapath
- Patented Quality of Service
- All inclusive features

→ Ultra-low Latency Performance
  • PCIe flash acceleration
→ Prioritize What Matters Most
  • Patented Quality of Service
→ Management Simplified
  • Granular policy-based management
Multi-tier Flash Architecture Advantages

Conventional Arrays

- All IO traverses controller
- Bottlenecks exist

Pivot3 PCIe Flash Arrays

- Multi-tier architecture for efficient performance
- Priority-driven data placement

Advantages:

- Ultra-Low Latency
  - all writes / reads
- Lowest Latency
  - read cache
- High Capacity
  - reads

Features:

- SSD
- HDD
- Disk Controller
- SP1
- SP2
- PCIe Flash
- RAM
Prioritize What Matters Most With Pivot3 QoS

- **Target**
  - Preconfigured policies
  - Manage min/max performance

- **Prioritize**
  - Prioritize resources
  - Meet application SLAs

- **Place**
  - Real-time data placement
  - Efficient flash utilization
# Prioritize Performance With Service Levels

## All-Flash Arrays
- Rated @ 450,000 IOPS

<table>
<thead>
<tr>
<th>Min Performance Level</th>
<th>QoS Policy</th>
<th>Min Performance Level</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mission Critical</strong></td>
<td></td>
<td><strong>Mission Critical</strong></td>
</tr>
<tr>
<td>125K IOPS 1000 MB/s 1 ms max</td>
<td>1</td>
<td>100K IOPS 750 MB/s 5 ms max</td>
</tr>
<tr>
<td><strong>Business Critical</strong></td>
<td></td>
<td><strong>Business Critical</strong></td>
</tr>
<tr>
<td>75K IOPS 500 MB/s 3 ms max</td>
<td>2</td>
<td>50K IOPS 375 MB/s 10 ms max</td>
</tr>
<tr>
<td><strong>Business Critical</strong></td>
<td></td>
<td><strong>Business Critical</strong></td>
</tr>
<tr>
<td>50K IOPS 250 MB/s 10 ms max</td>
<td>3</td>
<td>20K IOPS 150 MB/s 25 ms max</td>
</tr>
<tr>
<td><strong>Non-Critical</strong></td>
<td></td>
<td><strong>Non-Critical</strong></td>
</tr>
<tr>
<td>25K IOPS 100 MB/s 20 ms max</td>
<td>4</td>
<td>10K IOPS 75 MB/s 50 ms max</td>
</tr>
<tr>
<td><strong>Non-Critical</strong></td>
<td></td>
<td><strong>Non-Critical</strong></td>
</tr>
<tr>
<td>10K IOPS 50 MB/s 40 ms max</td>
<td>5</td>
<td>2K IOPS 38 MB/s 100 ms max</td>
</tr>
</tbody>
</table>

## Hybrid Flash Arrays
- Rated @ 250,000 IOPS

<table>
<thead>
<tr>
<th>Min Performance Level</th>
<th>QoS Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Business Critical</strong></td>
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<tr>
<td>100K IOPS 750 MB/s 5 ms max</td>
<td>1</td>
</tr>
<tr>
<td><strong>Business Critical</strong></td>
<td></td>
</tr>
<tr>
<td>50K IOPS 375 MB/s 10 ms max</td>
<td>2</td>
</tr>
<tr>
<td><strong>Business Critical</strong></td>
<td></td>
</tr>
<tr>
<td>20K IOPS 150 MB/s 25 ms max</td>
<td>3</td>
</tr>
<tr>
<td><strong>Non-Critical</strong></td>
<td></td>
</tr>
<tr>
<td>10K IOPS 75 MB/s 50 ms max</td>
<td>4</td>
</tr>
<tr>
<td><strong>Non-Critical</strong></td>
<td></td>
</tr>
<tr>
<td>2K IOPS 38 MB/s 100 ms max</td>
<td>5</td>
</tr>
</tbody>
</table>
Meet Application Performance Service Levels

Storage Without QoS

- All data treated the same
- Inconsistent performance
- Impacts business operations

Pivot3’s Patented Quality of Service

- Align performance with business needs
- Meet Application service levels
- Mission Critical performance is always guaranteed
Consolidated Virtualization

- QoS allows consolidation of dissimilar workloads
  - VDI
  - Database
  - Virtual servers
  - Business decision apps
- Eliminates the “I/O blender” effect of mixed workloads
QoS Optimizes Each Workload’s Datapath

Prioritized Active Cache
• Protected Read/Write Area
  • All writes occur in PCIe flash
  • Writes are mirrored for HA
  • QoS determines destage to disk
• Prioritized Read Cache
  • Determines if and when and where
  • Data is cached to RAM and/or PCIe flash

<table>
<thead>
<tr>
<th>Policy</th>
<th>Caching Priority</th>
<th>Read Threshold*</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC: Policy 1</td>
<td>Most Aggressive</td>
<td>1 I/O hit</td>
</tr>
<tr>
<td>BC: Policy 2</td>
<td>Aggressive</td>
<td>4 I/O hits</td>
</tr>
<tr>
<td>BC: Policy 3</td>
<td>Less Aggressive</td>
<td>16 I/O hits</td>
</tr>
<tr>
<td>NC: Policies 4 &amp; 5</td>
<td>None</td>
<td>Data is never cached</td>
</tr>
</tbody>
</table>

*Per 1 MB Page
Benefits of Pivot3 Data Reduction Technologies

- **IO Reduction for Performance**
  - 2.5X acceleration*
  - 50% lower latency
  - Reduced IO vs. PCIe Flash IO

- **IO Consolidation for Endurance**
  - 4X SSD life extension
  - 7:1 consolidation ratio** from PCIe Flash writes to SSD writes

- **Data Reduction for Capacity**
  - 2:1 data reduction ratio***
  - 50% average capacity reduction
  - No performance impact

* 2.5X acceleration based on v3.5 software benchmarks; ** 7:1 consolidation ratio based on Pivot3 customer measured metrics; *** 2:1 capacity reduction based on Pivot3 customer measured metrics
Storage QoS Per VM

- VMware VVol integration with Pivot3 QoS
  - Natively surfaces Pivot3 performance QoS and service levels in vCenter
  - Tied to VM-level granularity = manage storage SLAs per VM
- Simplify Management
  - Gives administrators granular control over Pivot3 storage management tasks (provisioning, snap, rep, clone, QoS, performance, etc.) per VM
  - Integrates VM level performance QoS/SLAs with Pivot3 performance QoS/SLAs
Managing Performance at a VM-level

Storage Silo Consolidation

Host multiple VM Storage QoS policies on a single storage array; no separate silos

Predictable VM Performance

Per VM Storage QoS policies enable granular assignment of storage performance

Simple Policy Management

Pre-defined Storage QoS Policies applied to the VM removes management complexity
Storage QoS Takes VVOLs to the Next Level

Pre-vSphere 6 VVOLs
- Storage Pool Consolidation
- VM Workload Management
- VM Aware Storage
- I/O Blender Effect
  - VMotion Needed

vSphere 6 VVOL Integration
- Storage Pool Consolidation
- VM Workload Management
- VM Aware Storage
- I/O Blender Effect
  - VMotion Needed

Pivot3 QoS + VVOL
- Storage Pool Consolidation
- VM Workload Management
- VM Aware Storage
- No I/O Blender Effect
  - No VMotion Required
Pivot3 VVol Architecture

**Pivot3 VVol Features:**
- QoS mapped to Storage Policy
- Software Defined Performance
- On-the-Fly QoS Change
- Automated VVol Provisioning
- Thin Snapshot / Clone
- Equivalent Performance

**VVOL Addressing:**
- **VASA** = VASA Provider 2.0
- **PE** = Protocol Endpoint
- **Admin LUN**
- **Subsidiary LUN**

**Pivot3 N5**
- Datastore Containers map to the Storage Pools on the N5
- ESX Servers connect to Protocol Endpoints via iSCSI

**vCenter**
- VASA Providers Registered with vCenter
- VVols assigned to Pivot3 QoS policy

**ESX Servers**
- Datastore Containers A
  - Container-A
  - Container-B
  - VASA
  - PE
  - VASA
  - PE

**Pivot3 N5**
- Pool-A
  - Pool-B
  - SP-A
  - SP-B
  - Pool-A
  - Pool-B
Simple, Actionable Performance Information

Performance Info at a Glance

- Proactive monitoring
- Real-time performance information
- Performance by workload type and tier

Actionable Performance Statistics

- Granular performance information
  - Volume, tier, service level, system wide
  - By IOPS, TP, latency
  - Up to one year, and exportable
Simple to Manage Data Protection

- Snapshots
- Space efficient
- Scheduled
- Replication for DR
- Scheduled
- Asynchronous
- Between Different N5 Models
- VSS Provider for Microsoft
- Clones
Pivot3 Flash Storage Use Cases

- Virtualize Critical Apps
- Server Virtualization
- VDI
- Deploy alongside other workloads
- Database
- Meet Mission Critical App SLAs
Server Virtualization: Confidently Virtualize Critical Applications

- **Considerations**
  - Meet mission critical application SLAs
  - Ease of management

- **Why Pivot3?**
  - Quickly apply QoS directly to VMs
  - Ensure mission critical VMs meet SLAs
  - Manage storage entirely within VMware vCenter

2-3x LOWER LATENCY AND PERFORMANCE WITH PCIE FLASH
40% MORE VM WORKLOADS WITH PIVOT3 QOS
VDI: Deploy Alongside Other Workloads

- **Considerations**
  - High volume logins (boot storms)
  - Meet mission critical VM SLAs

- **Why Pivot3?**
  - Ultra-low latency cache for disk images
  - Consolidating multiple workloads with QoS
  - Ensure boot storms don’t impact other apps

6X FASTER BOOT TIMES
LA Metro

77% REDUCTION IN VDI RECOMPOSE PROCESS
C&S Companies
Database: Meet Critical Application SLAs

- **Considerations**
  - Meeting low latency database requirements
  - Meet end-user experience expectations

- **Why Pivot3?**
  - Low-latency PCIe flash performance
  - Mission critical apps get resource priority in both sunny day and degraded mode operation

- **INCREASE IN MONTHLY TRANSACTIONS**
  - Bridgepay: 500%

- **LOWER READ LATENCY**
  - Kolcraft: 157%
Pivot3 N5 PCI-e Flash Arrays

• All-Flash and Hybrid
• Multi-tier Flash
• All-inclusive Feature Set
  • Quality of Service
  • Data Reduction Technologies
  • Data Protection
  • Deep VMware Integration
  • Online Scalability
## Technical Specifications

<table>
<thead>
<tr>
<th>Item</th>
<th>N5-200</th>
<th>N5-300</th>
<th>N5-500</th>
<th>N5-1000</th>
<th>N5-1500</th>
<th>N5-3000</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Array Type</strong></td>
<td>Hybrid</td>
<td>Hybrid</td>
<td>Hybrid</td>
<td>Hybrid</td>
<td>All-Flash</td>
<td>All-Flash</td>
</tr>
<tr>
<td><strong>PCIe Flash Capacity</strong></td>
<td>2.0 TB flash (base)</td>
<td>2.6 TB flash (base)</td>
<td>5.2 TB flash (base)</td>
<td>10.4 TB flash (base)</td>
<td>2.6 TB flash</td>
<td>2.6 TB flash</td>
</tr>
<tr>
<td></td>
<td>7.2 TB flash (max)</td>
<td>7.8 TB flash (max)</td>
<td>10.4 TB flash (max)</td>
<td>15.6 TB flash (max)</td>
<td></td>
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<tr>
<td><strong>SSD Flash Capacity</strong></td>
<td></td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>15.0 TB raw (base)</td>
<td>30.0 TB raw (base)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>60.0 TB raw (max)</td>
<td>60.0 TB raw (max)</td>
</tr>
<tr>
<td><strong>HDD Capacity</strong></td>
<td>32.0 TB raw (base)</td>
<td>64.0 TB raw (base)</td>
<td>64.0 TB raw (base)</td>
<td>64.0 TB raw (base)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>128 TB raw (max)</td>
<td>256 TB raw (max)</td>
<td>256 TB raw (max)</td>
<td>256 TB raw (max)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Performance Rating</strong></td>
<td>150,000 IOPS * 2.0 GB/sec **</td>
<td>200,000 IOPS * 2.4 GB/sec **</td>
<td>225,000 IOPS * 2.7 GB/sec **</td>
<td>250,000 IOPS * 3.0 GB/sec **</td>
<td>450,000 IOPS * 6.0 GB/sec **</td>
<td>450,000 IOPS * 6.0 GB/sec **</td>
</tr>
<tr>
<td><strong>PCIe Flash Scalability</strong></td>
<td>5.2 TB flash Perf Pack</td>
<td>5.2 TB flash Perf Pack</td>
<td>5.2 TB flash Perf Pack</td>
<td>5.2 TB flash Perf Pack</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SSD Flash Scalability</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>15.0 TB SSD Shelf</td>
<td>15.0 TB SSD Shelf</td>
</tr>
<tr>
<td><strong>HDD Scalability</strong></td>
<td>32 TB Shelf HDD</td>
<td>32/48/64 TB HDD Shelf</td>
<td>32/48/64 TB HDD Shelf</td>
<td>32/48/64 TB HDD Shelf</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>RAM</strong></td>
<td>96GB</td>
<td>192GB</td>
<td>192GB</td>
<td>192GB</td>
<td>96GB</td>
<td>96GB</td>
</tr>
<tr>
<td><strong>CPU</strong></td>
<td>4x 6-core Intel Xeon E5645 2.4GHz (2x CPU per storage processor), 24x physical cores / 48 cores with hyper-threading</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Storage Processors</strong></td>
<td>Dual Active/Active Storage Processors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Network Interfaces</strong></td>
<td>Data: (4) 1/10GbE SFP+ or (4) 1/10GBT RJ45, iSCSI / Management: (4) 1GbE RJ45, http, https</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>All-Inclusive Feature-set</strong></td>
<td>Quality of Service</td>
<td>Service Levels</td>
<td>Dynamic Data Path</td>
<td>Prioritized Active Cache</td>
<td>Data Reduction</td>
<td>Data Protection (Snapshot and Replication)</td>
</tr>
<tr>
<td><strong>VMware Integration</strong></td>
<td>VAAI - vCenter Plug-in - MPIO ALUA - Virtual Volumes - Horizon View Proven Storage – vSphere Virtual Volumes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hardware Availability</strong></td>
<td>Redundant storage processors</td>
<td>Redundant fans</td>
<td>Redundant, hot swap power supplies</td>
<td>Redundant network connections</td>
<td>Dual port SAS SSD drives</td>
<td>RAID, hot swap SSD drives</td>
</tr>
</tbody>
</table>

* 4K random reads; ** 256K sequential reads
Services and Support

Professional Services

• Design, configure and implement
  • Advanced architectural design
  • Business continuity planning & implementation
  • Application deployment
  • VDI implementation
  • Hardware and software upgrades

• System analysis
  • Performance optimization
  • Best practices for success

• Training and certification
  • Live remote or onsite
  • Online

Technical Support

• Support Offerings
  • 7 day x 24 hour phone | onsite/same day parts
  • 7 day x 24 hour phone | NBD parts
  • 5 day x 9 hour phone | NBD Parts

• Proactive Monitoring
  • Actionable alerts and notifications
  • Integrated phone-home telemetry

• Expertise to complement your IT team
  • Storage
  • Virtualization
Thank You