IDF15
INTEL DEVELOPER FORUM

Next Generation Storage Architecture: Microsoft* Storage Spaces Direct and Intel® SSD Data Center Family for NVM Express™

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Spencer Shepler – Principal Architect, Microsoft

SFTS015

intel
experience
what's inside™

Agenda

- Current Trends and Impact to Storage
- Intel and Microsoft* Joint Collaboration
- What is Microsoft Storage Spaces Direct?
- The Need For NVM Express™
- Methodology and Performance Results
- Details of Demo in NVM Express Community
- Summary and Next Steps/Q&A

Current Trends and Impact to Storage

Current Trends and Impact to Storage

- Rise of content rich and content driven enterprise
- Hyper-scale public cloud
- SDS is evolving
- Non Volatile Memory

Moore's Law and Intel's Innovation Engine is Key!

Intel and Microsoft* Joint Collaboration

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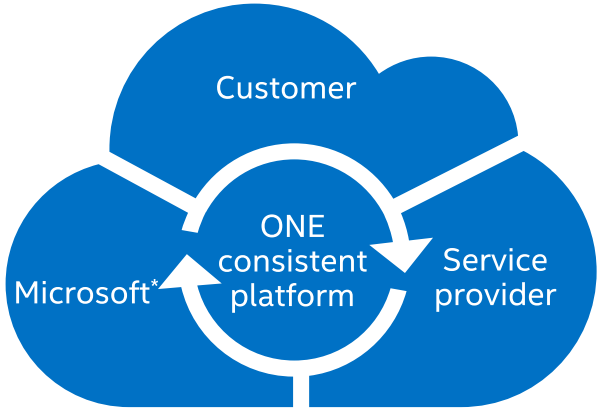
Intel and Microsoft* are Collaborating on a Storage Solution

- Joint design of a reference architecture
  - Integrated solution that is performance optimized with the latest Intel hardware and Microsoft* software
  - Cost optimized to meet broad market demands
  - Feature rich to compete in the market

Customer Choices



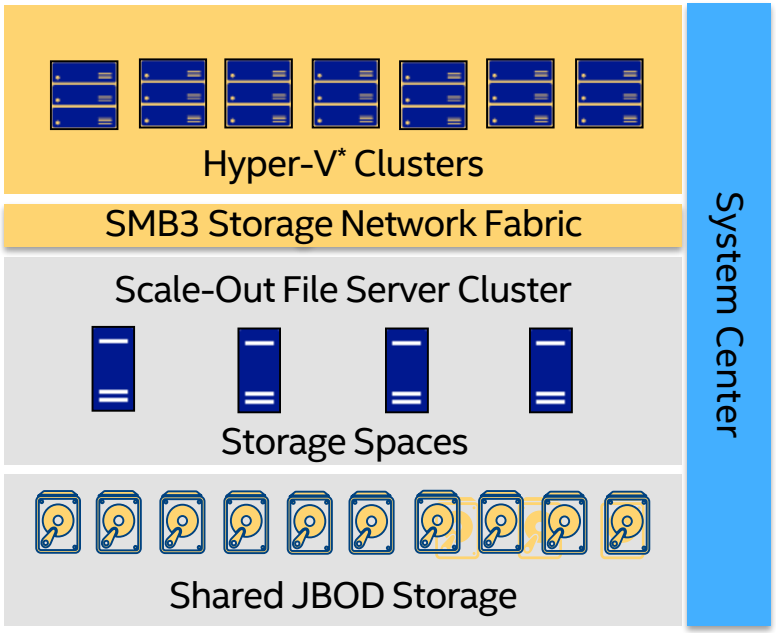
Private cloud with traditional storage	Private cloud with Microsoft SDS	Hybrid cloud Storage	Public cloud Storage
SAN and NAS storage	Microsoft Azure* Stack Storage	StorSimple* with Azure storage	Azure storage

What is Microsoft* Storage Spaces Direct?

Windows® Server* 2012 R2 Software Defined Storage Recap

Primary application data storage

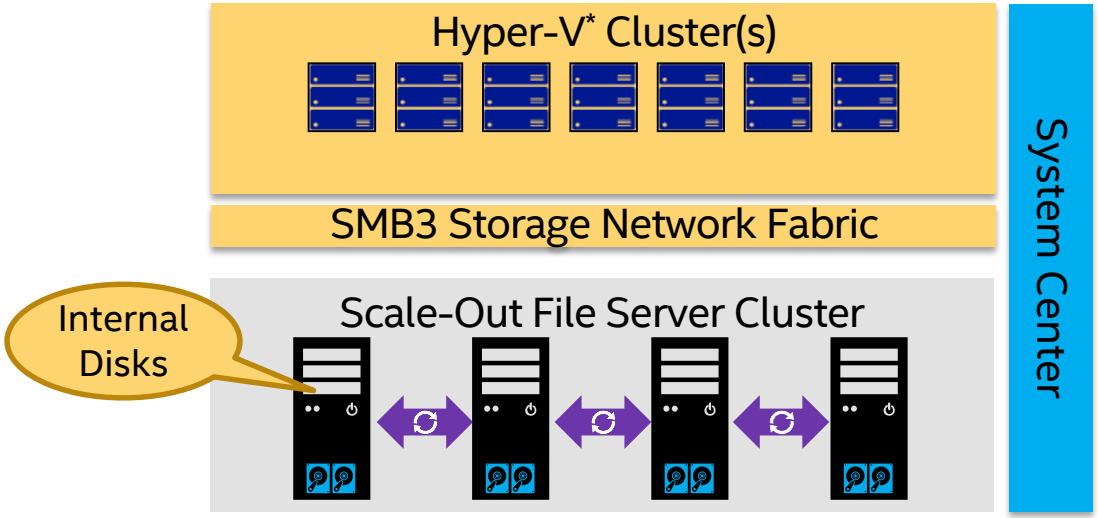
- Cost effective with standard volume hardware
- Continuously available
- Scale-out and elasticity
- Reliability
- Unified management



Introducing Microsoft* Storage Spaces Direct

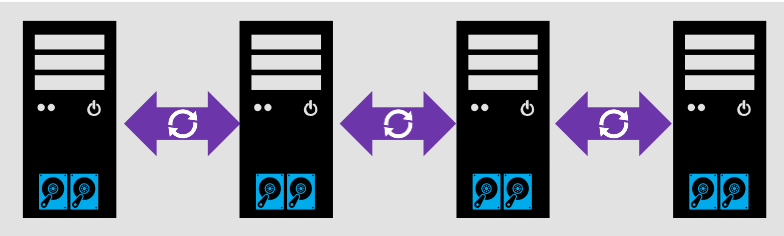
What is Storage Spaces Direct?

- Private cloud storage
- Servers with local storage
- Highly available and scalable
- Enabling new scenarios
- Evolution of Storage Spaces



Why Microsoft* Storage Spaces Direct?

- Embrace new disk device types
  - Lower cost flash storage with SATA* SSDs
  - Better flash performance with NVM Express™ SSDs
- Simple deployment
  - Network fabric instead of SAS fabric
  - External enclosures not needed
- Seamless expansion
  - Add more nodes
  - Storage rebalancing
  - Increase scalability

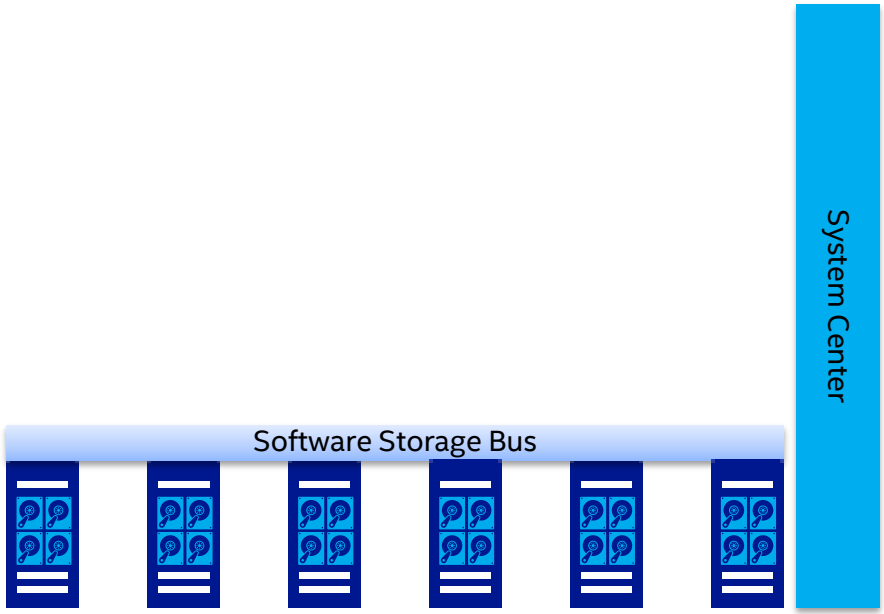


Under the Hood

- Servers with local disks
  - SATA*, NVM Express™, SAS

Under the Hood

- Software Storage Bus
  - Spans entire cluster, Leverages SMB3/SMBDirect
- Servers with local disks
  - SATA*, NVM Express™, SAS



Under the Hood

- Storage Spaces
  - Scalable pool with all disk devices
  - Resilient virtual disk
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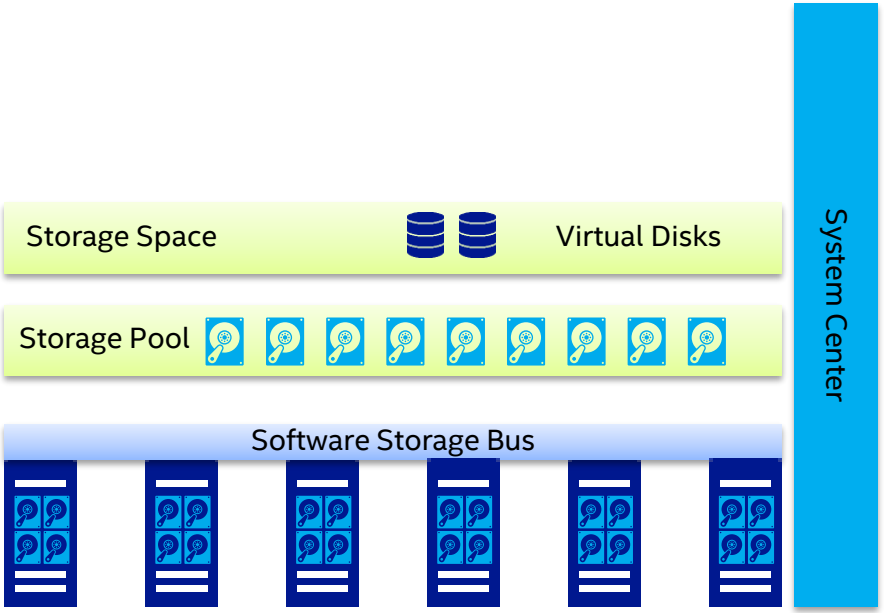

Under the Hood

- File System (CSVFS with ReFS)
  - ReFS is the primary Cluster-wide file system
  - Fast VHDX creation, expansion and checkpoints
- Storage Spaces
  - Scalable pool with all disk devices
  - Resilient virtual disk
- Software Storage Bus
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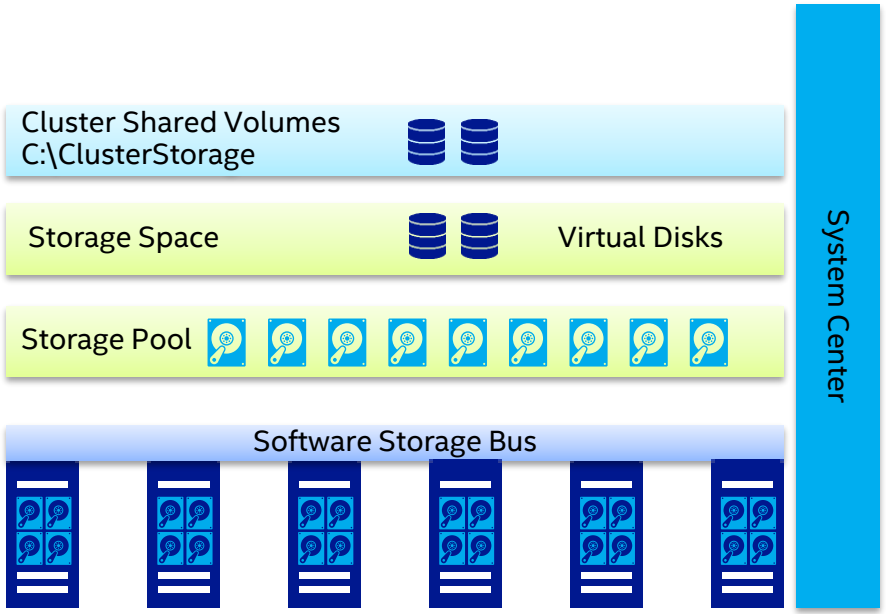

Under the Hood

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  - Remote data Access using Scale-out File Server
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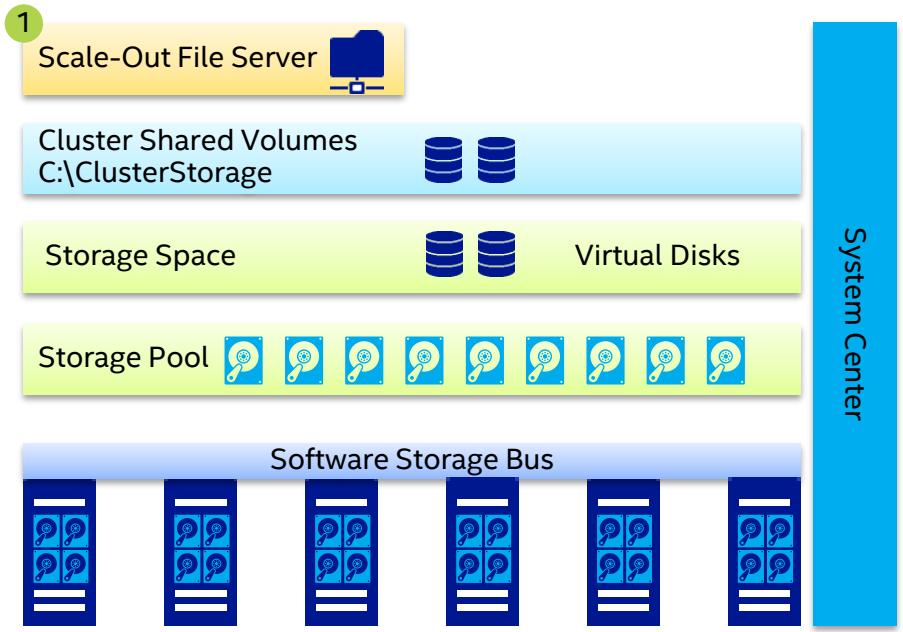

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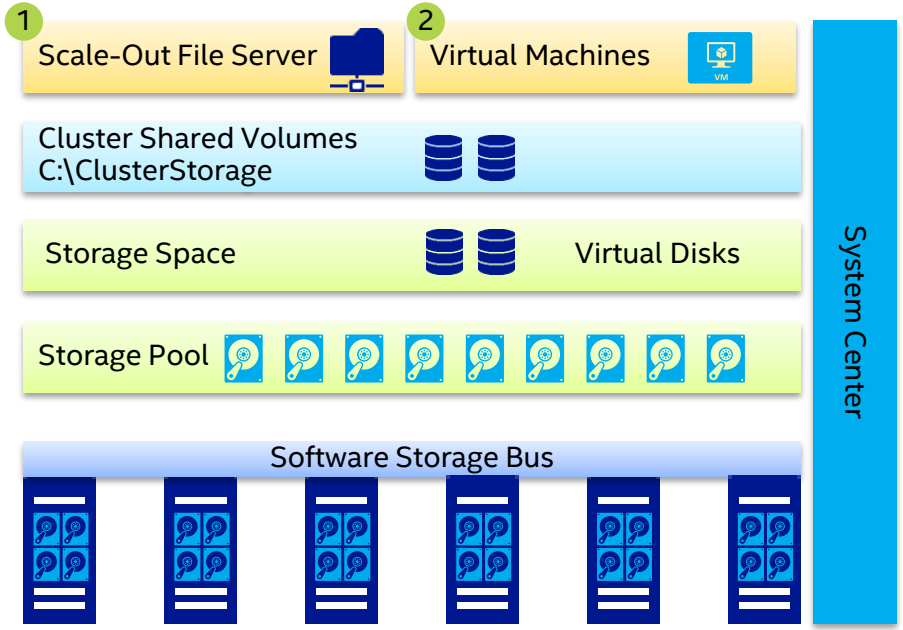
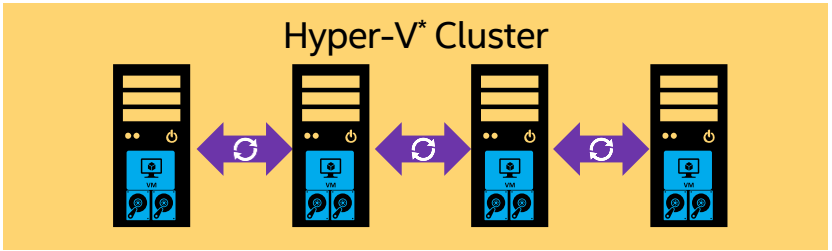


Microsoft* Storage Spaces Direct – Deployment Choice

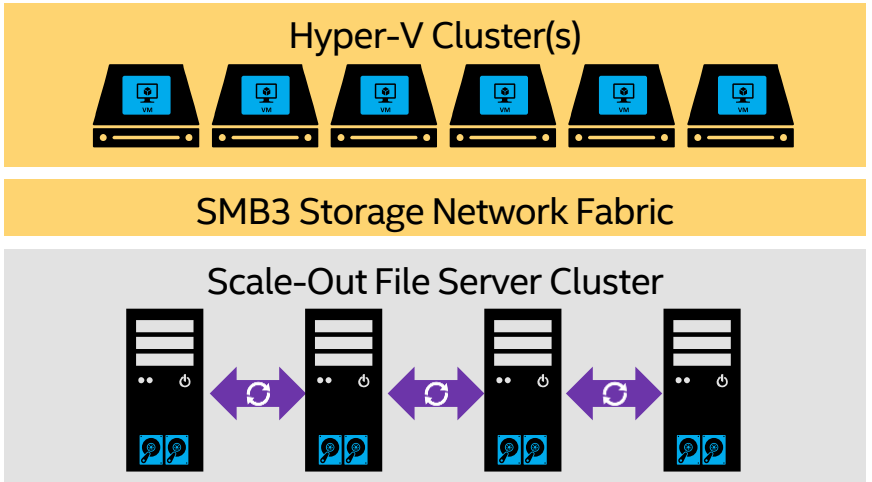
Hyper-converged

- Compute and Storage resources together
- Compute and Storage scale and are managed together
- Typically small to medium sized scale-out deployments



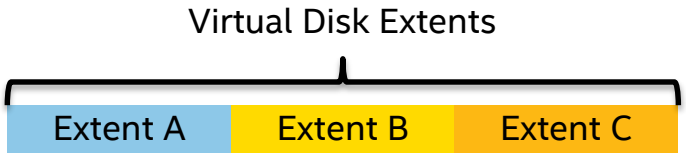
Converged (Disaggregated)

- Compute and Storage resources separate
- Compute and Storage scale and are managed independently
- Typically larger scale-out deployments



Microsoft* Storage Spaces Direct – Data Placement

- Virtual Disks
  - Virtual disks consists of extents
  - Extents are 1GB, so a 100GB virtual disks has 100 extents



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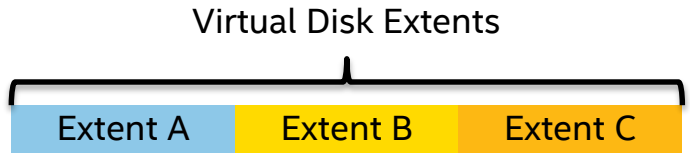

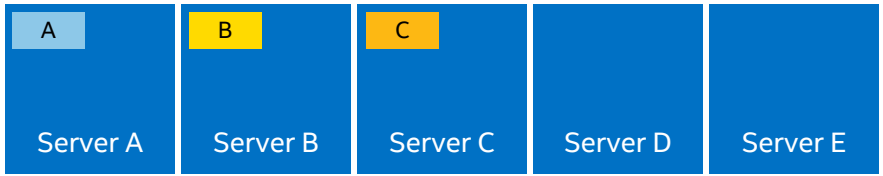

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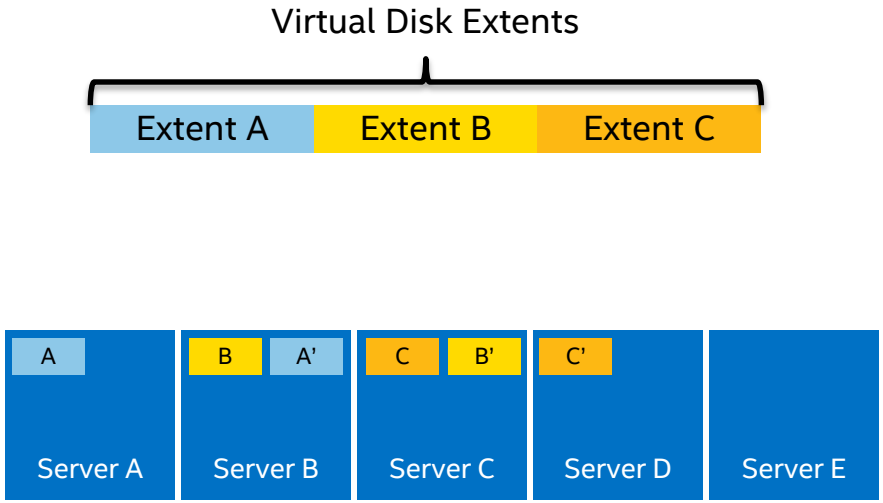

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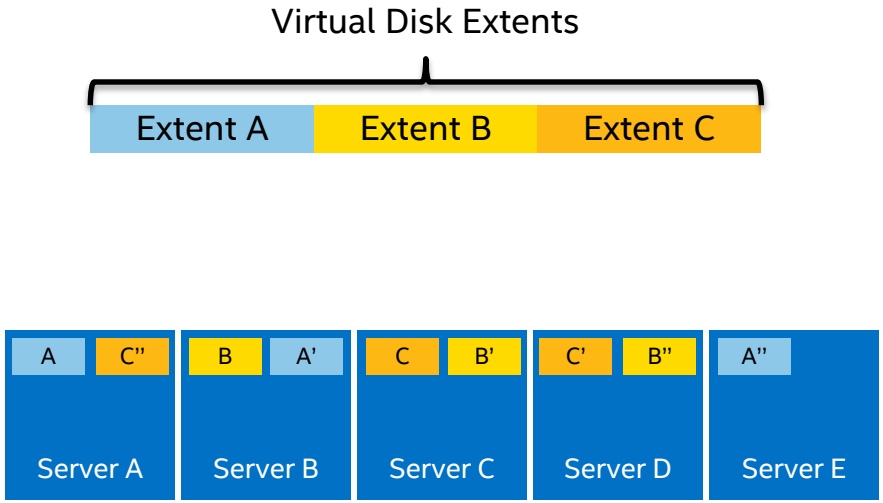
  - A 3rd copy of an extent is placed on yet another server



Microsoft* Storage Spaces Direct – Scalability

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  - Scaling to large pools

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  - Utilizes SMB3 and SMB Direct
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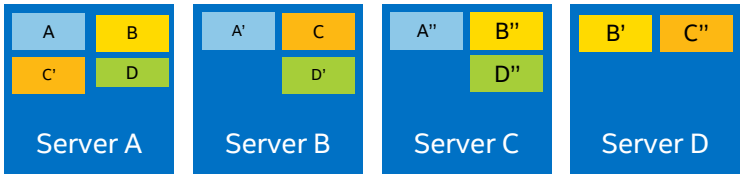

3-way mirror

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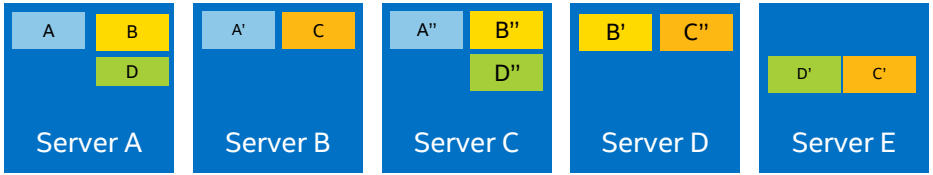
- Simple expansion
  - Add node(s) and expand pool
  - Rebalance for capacity
  - Min – 4 servers, Max - 12 servers
  - Maximum of 240 disk devices in a single pool



3-way mirror

ReFS – Data Integrity

- Metadata Checksums
  - Checksums protect all filesystem metadata
- User Data Checksums
  - Optional checksums protect file data
- Checksum Verification
  - Occurs on every read of checksum-protected data
  - During periodic background scrubbing

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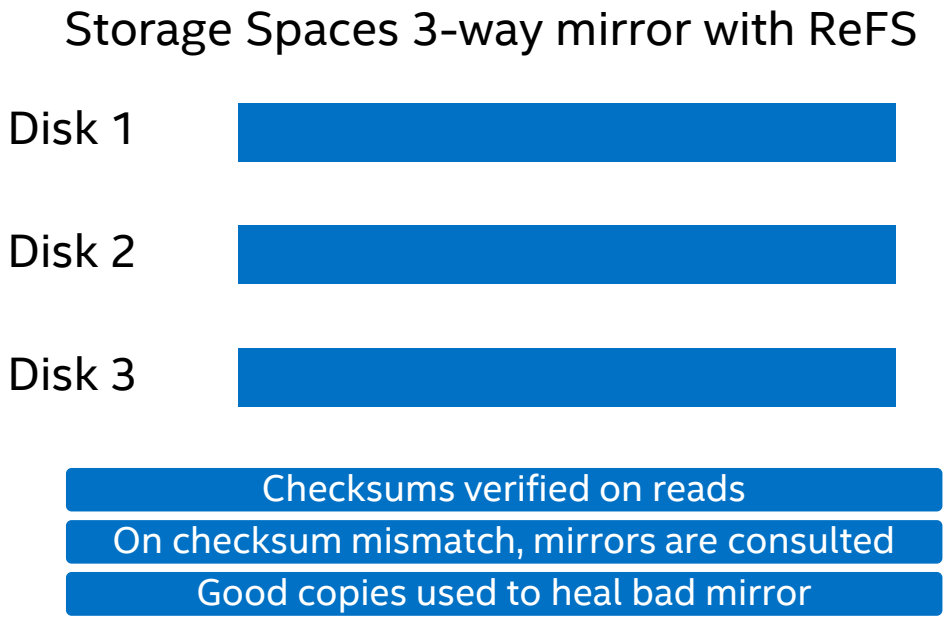

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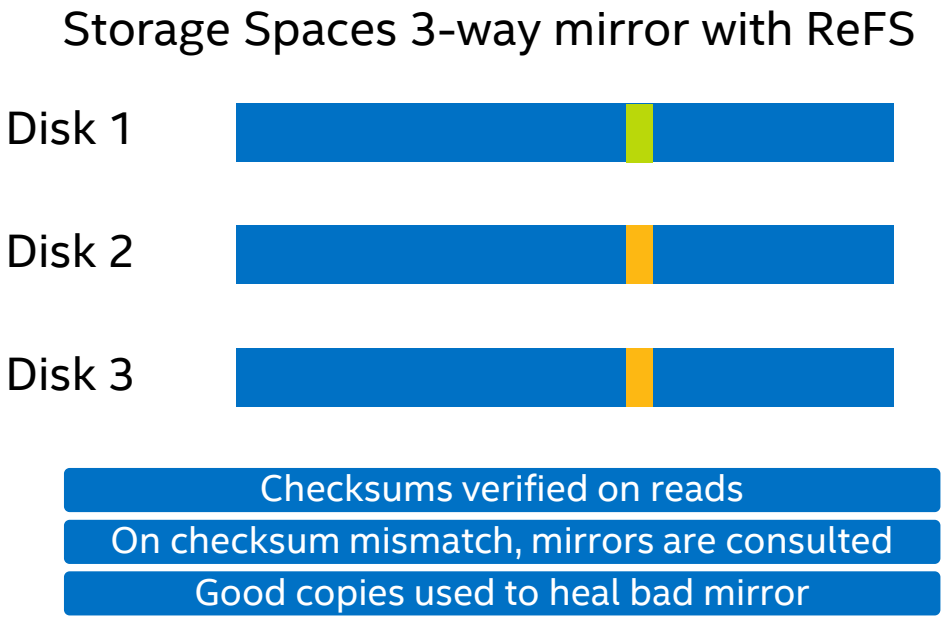

ReFS – Resiliency and Availability

ReFS – Resiliency and Availability

- Availability
  - Designed to stay online
  - Keep data accessible when all else fails
- Online Repair
  - Repairs performed without taking the volume offline
  - No downtime due to repair operations!
- On-Volume Backups of Critical Metadata
  - Automatically maintain backup of critical metadata
  - Online repair consults backup if checksum-based repair fails
  - Provides additional protection for volume-critical metadata

ReFS – Speed and Efficiency

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ReFS – Speed and Efficiency

- Efficient VM checkpoints and backup
  - Checkpoints cleaned up without physical data copies
  - Data migrated as a ReFS metadata operation
    - Significant reduction of I/O to disk
    - Almost instantaneous
    - Minimal impact to workloads

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- Efficient VM checkpoints and backup
  - Checkpoints cleaned up without physical data copies
  - Data migrated as a ReFS metadata operation
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    - Almost instantaneous
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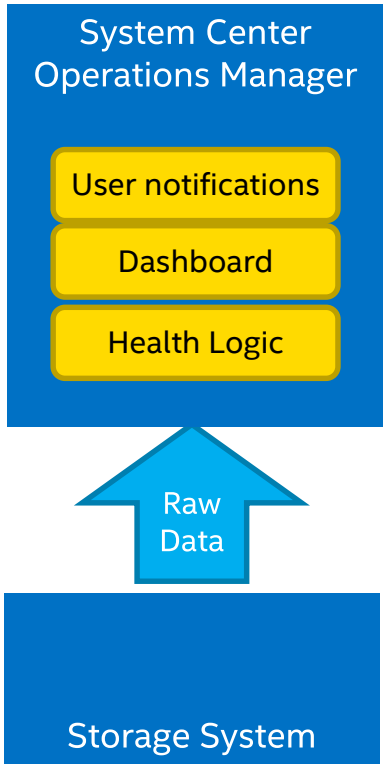
- Accelerated Fixed VHD(X) Creation
  - VHD(X) zeroed as a metadata operation
  - No impact to workloads
  - Decreased VM deployment time
  - Also applicable to dynamic VHD(X) expansion

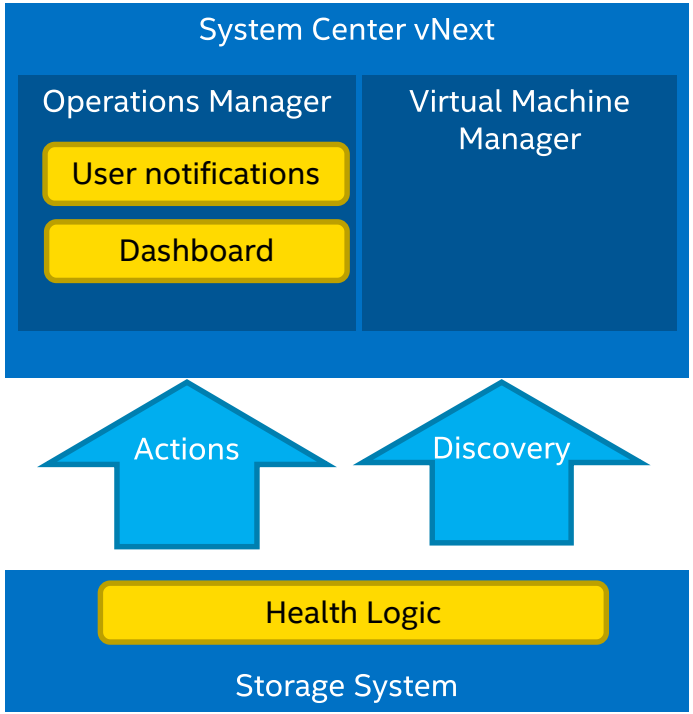
Traditional SCOM Storage Monitoring

- System Center Operations Manager determines health
  - Collect health indicators, state computation and rollup
  - Management pack (MP) tightly coupled to the topology, version and storage technology
- Requires highly knowledgeable MP authors
  - Storage subsystem model replicated by MP author
    - Complex health model
    - Need to handle different subsystems, topologies, versions, etc.
- Difficult to represent system health accurately
  - Monitoring likely to be incomplete, erroneous and noisy
  - Unable to determine actual impact on pools/shares
- No easy extensibility
  - Everything encoded in management packs
  - Write new/updated monitoring for each new variant



SCOM Storage Monitoring Reimagined

- Storage subsystem determines health
  - Focus on relevant objects
    - Storage subsystem, volumes and file shares
    - Automatic remediation when possible
- Actionable alerts
  - Alert specifies urgency
  - Alert specifies remediation action
  - Alerts automatically resolve when issue is addressed
  - Easy to determine affected objects
- Extensibility
  - Consumable through PowerShell and 3rd parties
  - SMAPI

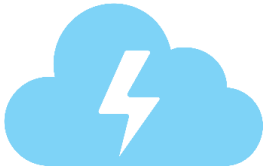


The Need For NVM Express™

Your Stuff Works Better with Intel® SSDs with NVM Express™

Virtualization

NVM Express™ SSDs lower enterprise IT TCO by enabling increased Virtual Machine scalability and optimizing platform utilization

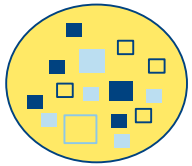


Private Cloud

Software Defined Infrastructure or hyper-convergence is made affordable with high performance SSDs

Database

Consistent, low latency, high bandwidth performance of NVM Express shines in traditional relational databases



Big Data

Analytics and NoSQL databases fully utilize NVM Express performance to provide near real time results

HPC

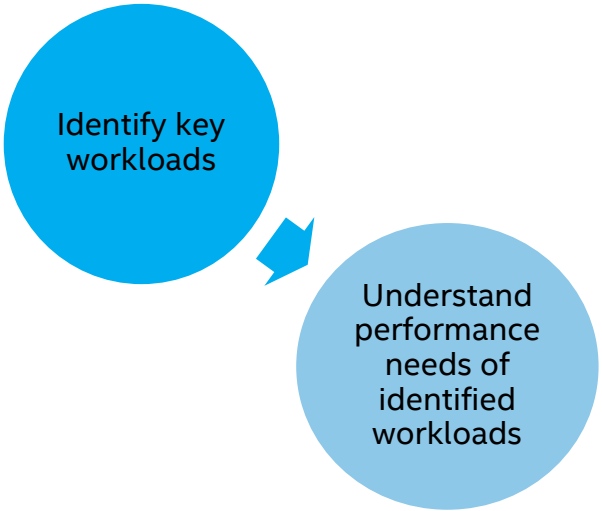
NVM Express keeps up with high bandwidth demands of HPC designed to speed up overall workflow times

Methodology and Performance Results

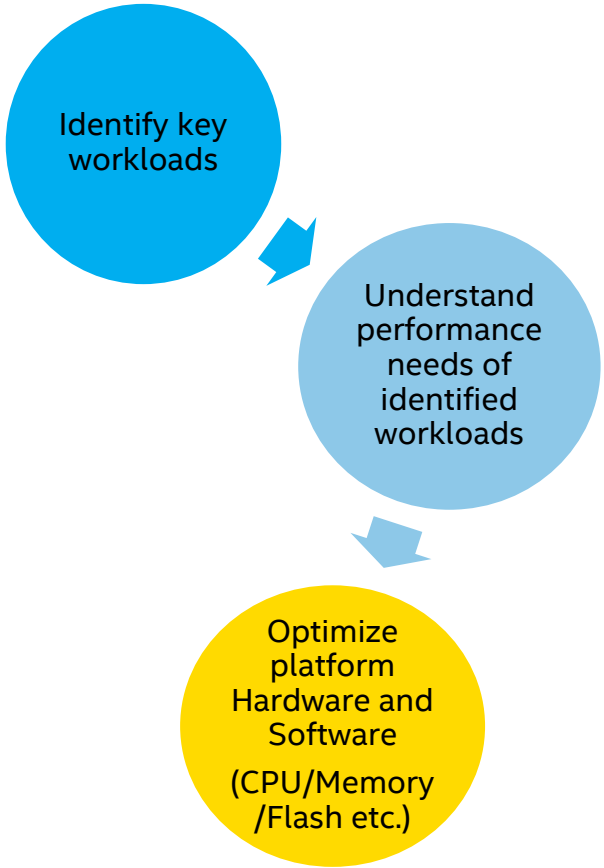
Methodology

Methodology

Methodology



Methodology



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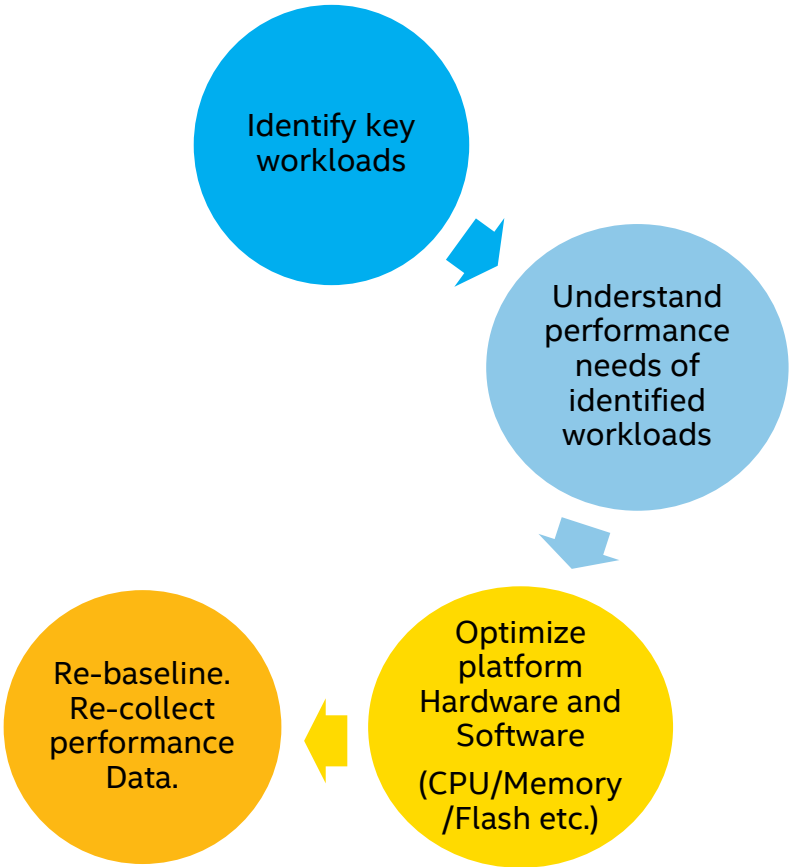

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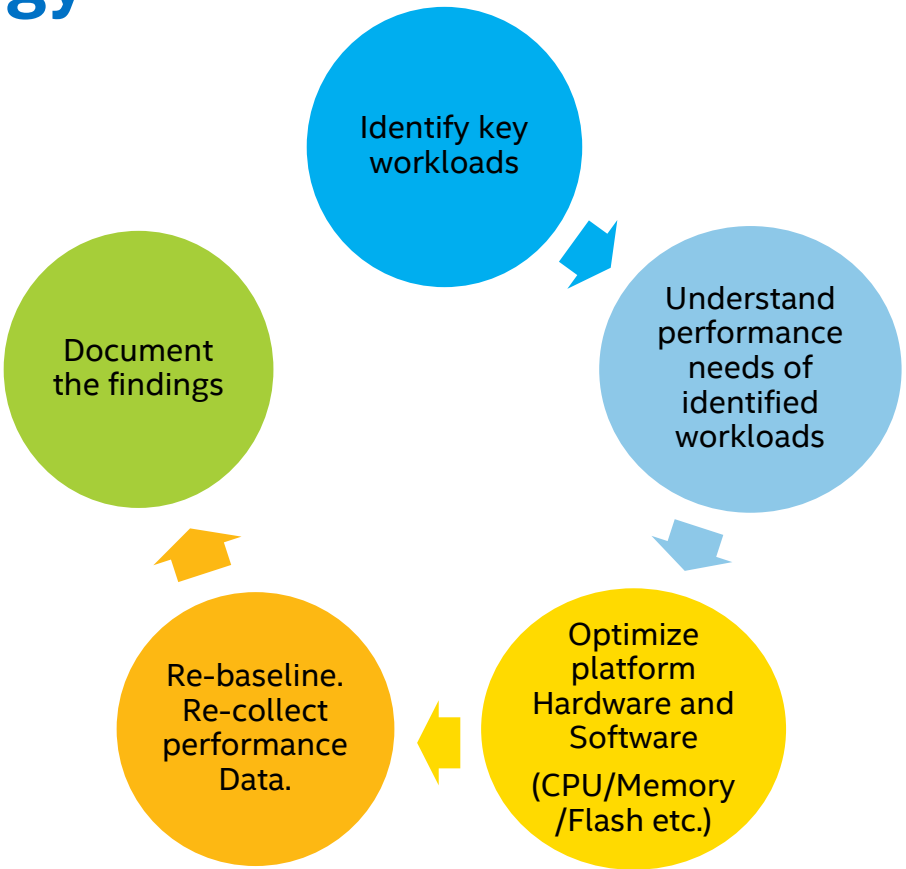

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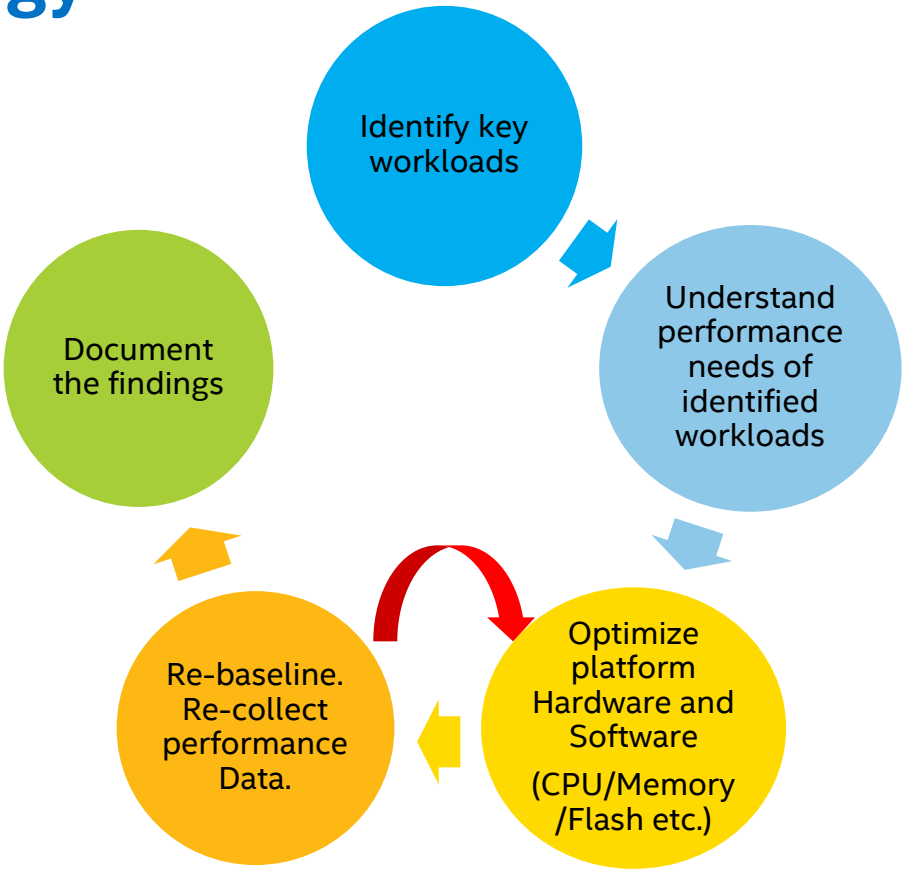

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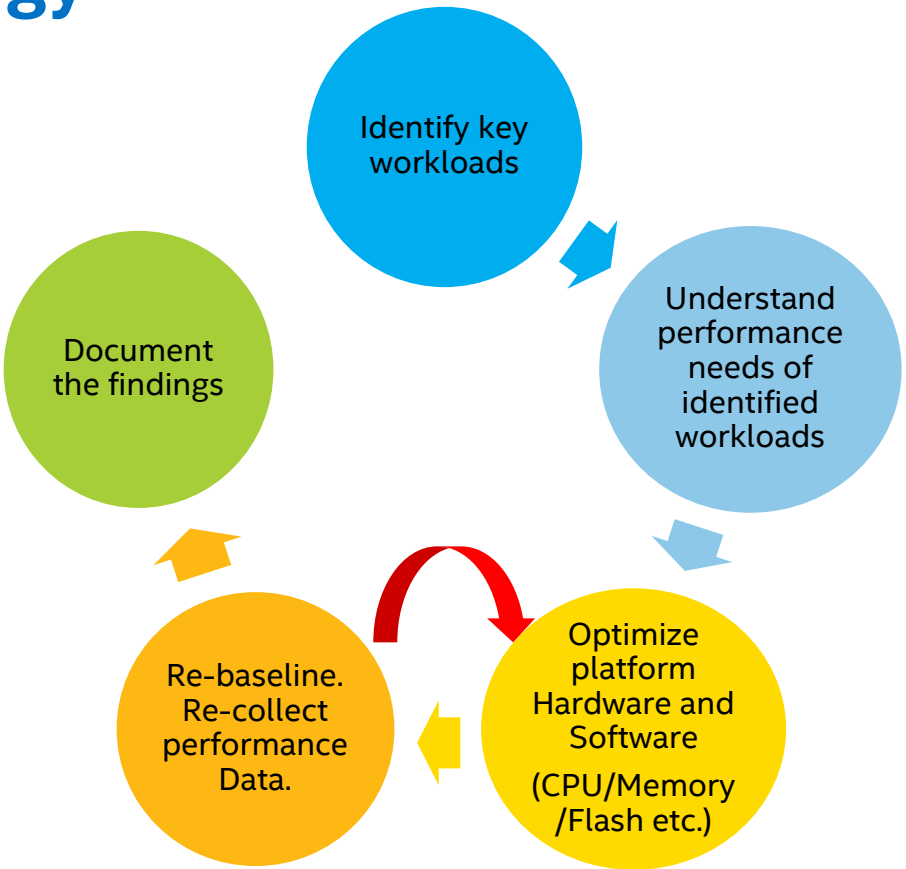

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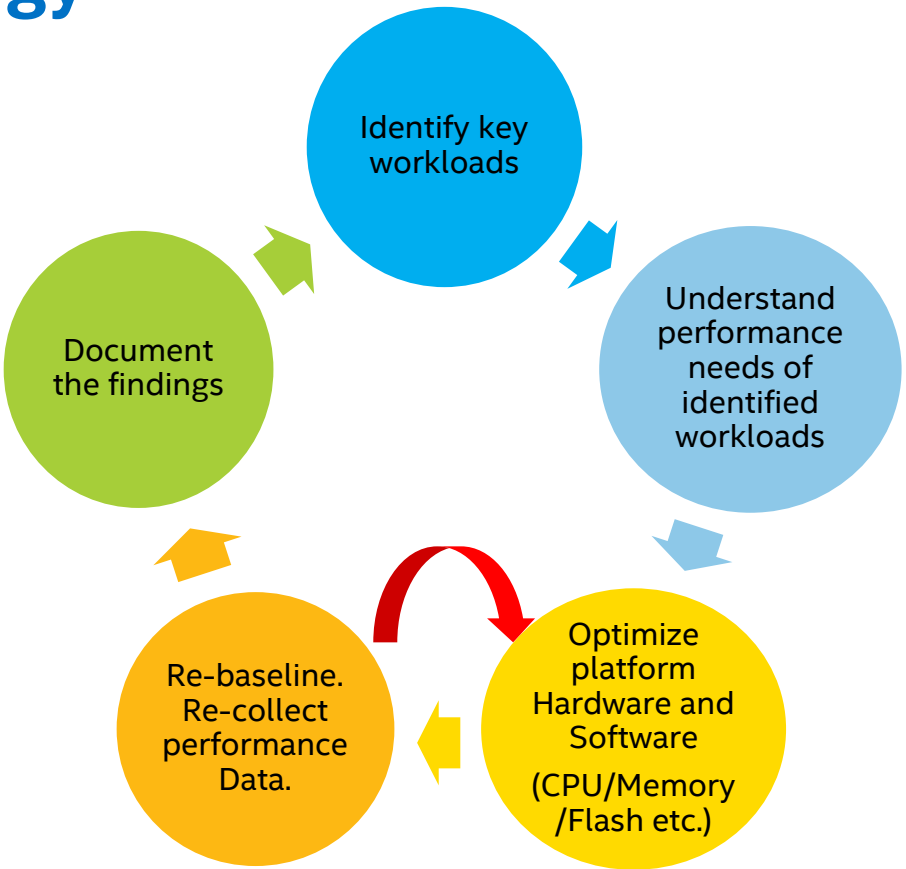
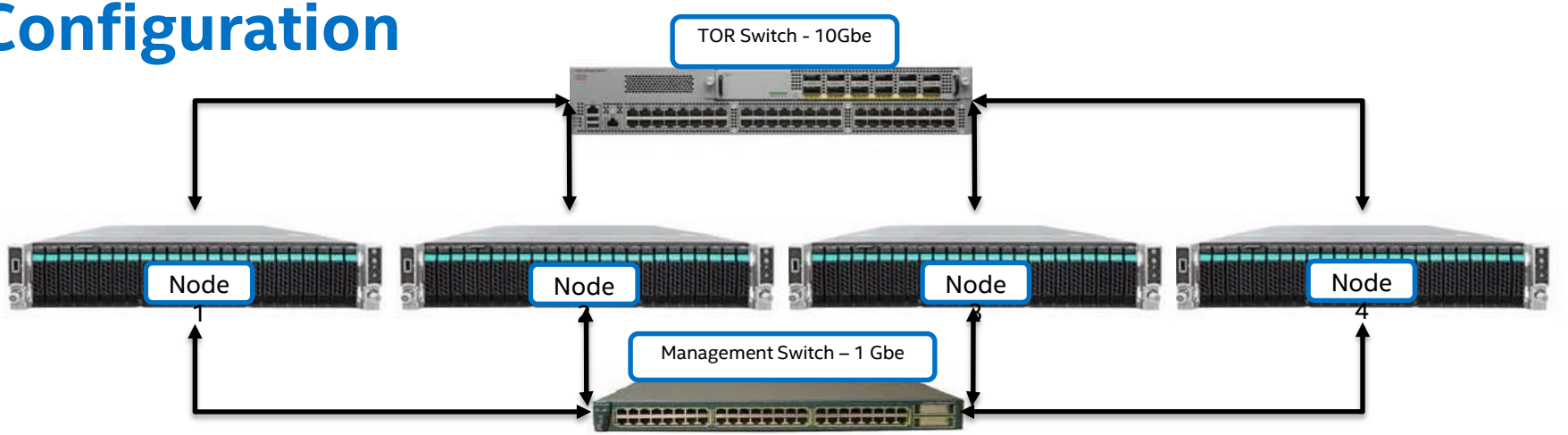


Configuration



Hardware Configuration

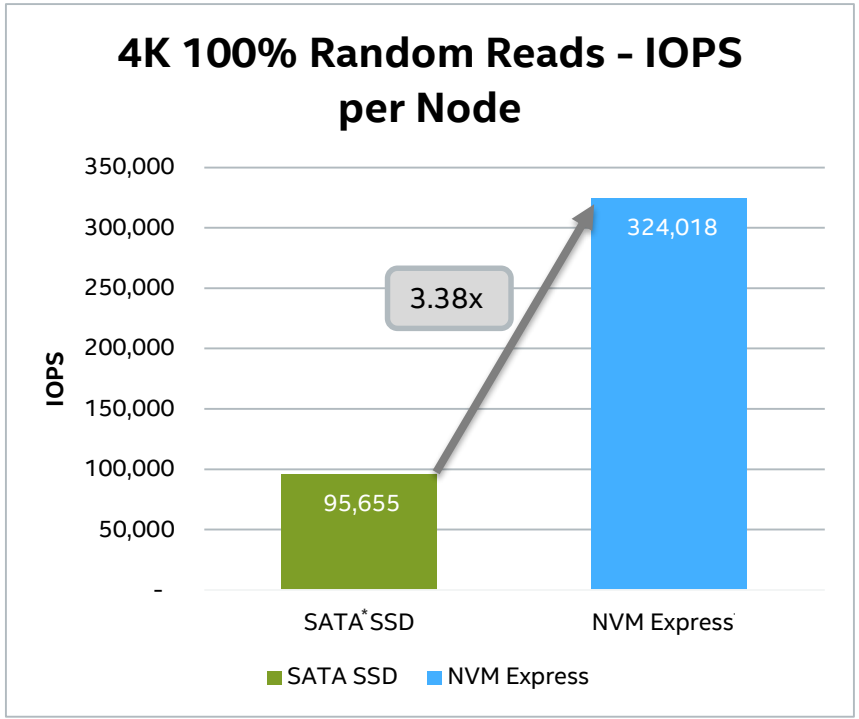
- Intel® Xeon® processor E5-2699 v3 based Server 2U 24x2.5" [R2224WTTYS-IDD]
- 2x10Gbe Chelsio* T520-CR Ethernet Adapter
- Cache:
  - NVM Express™ Config-1x Intel® SSD DC P3700 – 2TB
  - SATA* Config – 2xIntel SSD S3700 – 800GB
- Storage: 5x1TB Seagate* Constellation 2
- TOR Switch-Cisco* Nexus N9K-C93128TX- 10Gbe

Software Configuration

- Windows® Server* 2016 Technical Preview 3†
- Diskspd Version 2.0.15 running on 4x10GB files per share per node
- Storage Spaces Direct with 3-Way mirrored configuration

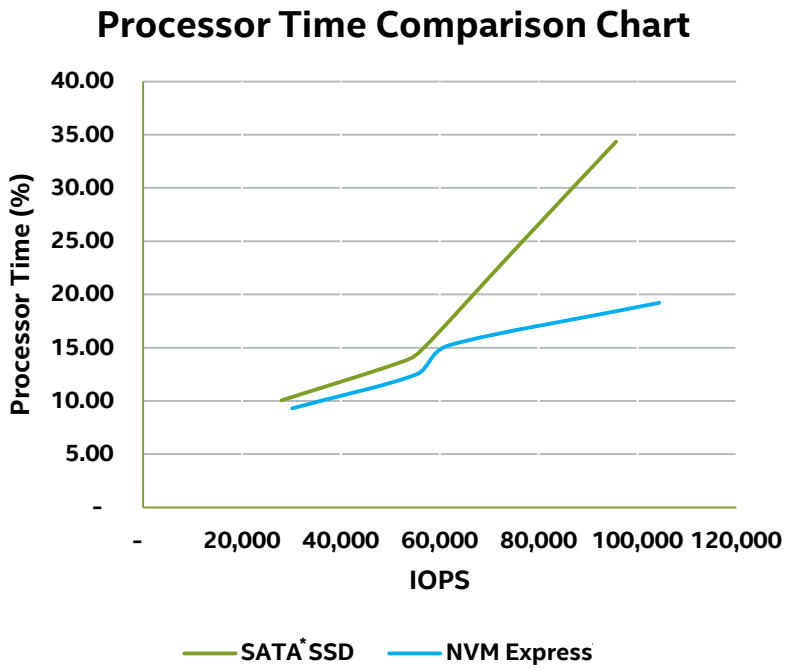
† This technology demonstration uses pre-release software; features and functionality may differ in the final release.

Results –SATA SSD Vs NVM Express™ Max Performance (IOPS, Latency)



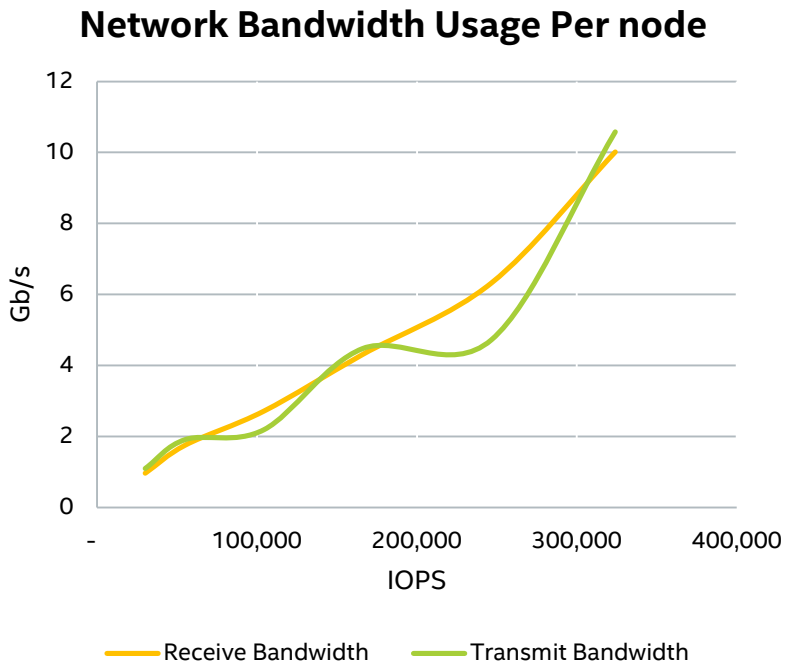
- NVM Express™ Configuration
  - Performance Boost of 3.38x per node
  - Each node delivers similar IOPs (3 Way Mirrored Configuration)
  - Cumulatively 4 nodes deliver 1.25M IOPS!

Per Node Average Processor Time



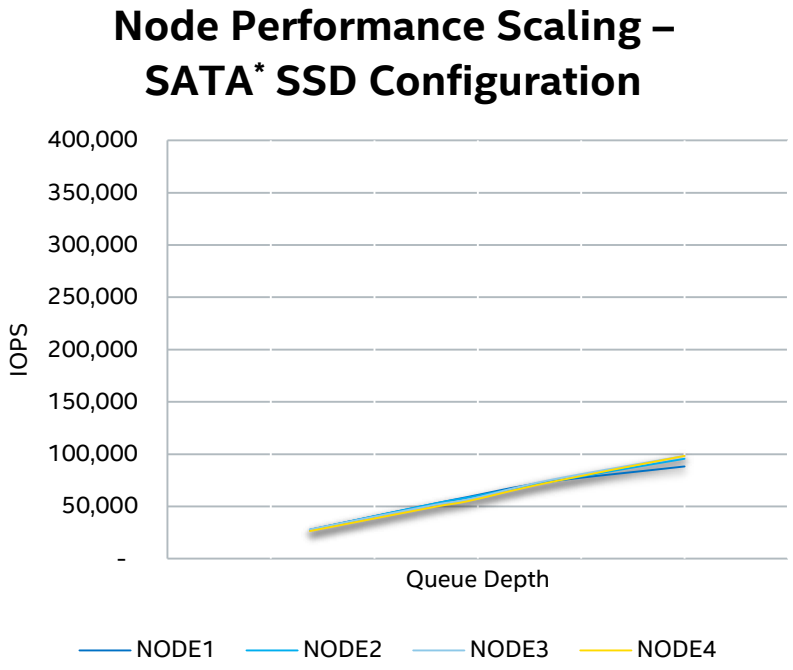
- NVM Express™ Configuration
  - Consumes less CPU resources at the same IOPs (10%-40%)
  - Reflective of reduced stack execution using NVM Express
  - Compute given back to VMs\user

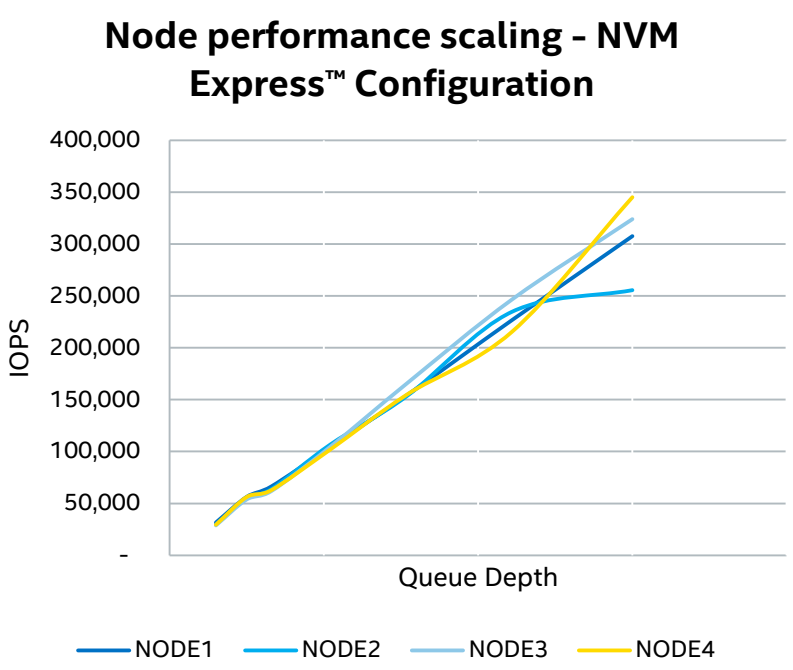
Per Node Network Utilization



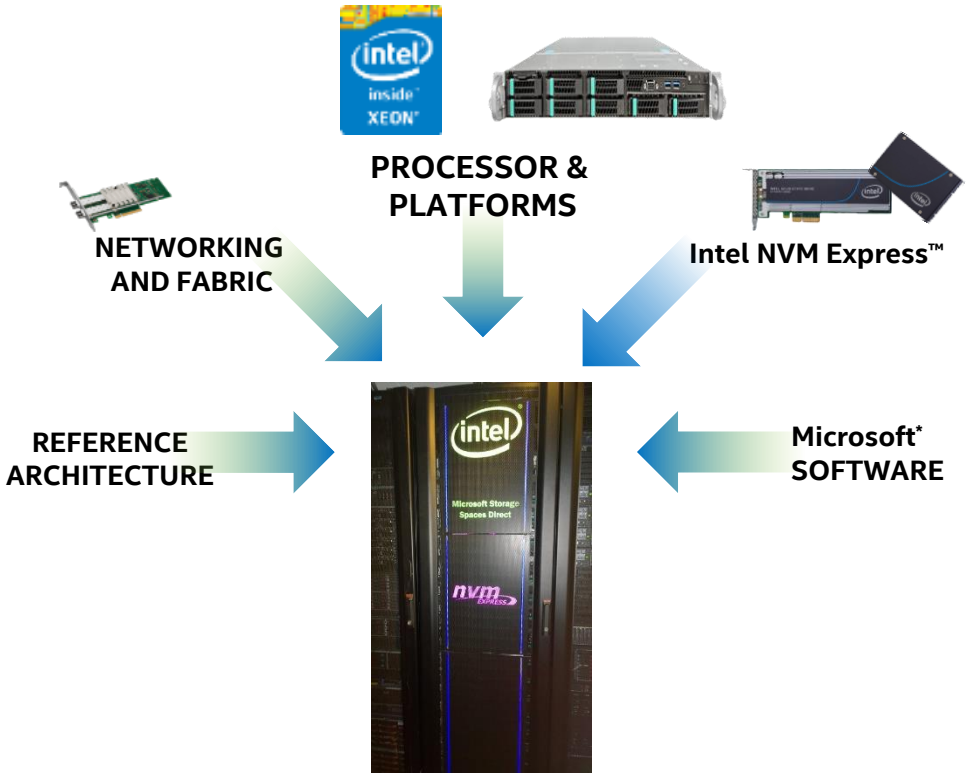
- NVM Express™ Configuration
  - Network Utilization scales with performance
  - No network bottleneck perceived as we scale IOPS
  - We continue to optimize for greater efficiencies

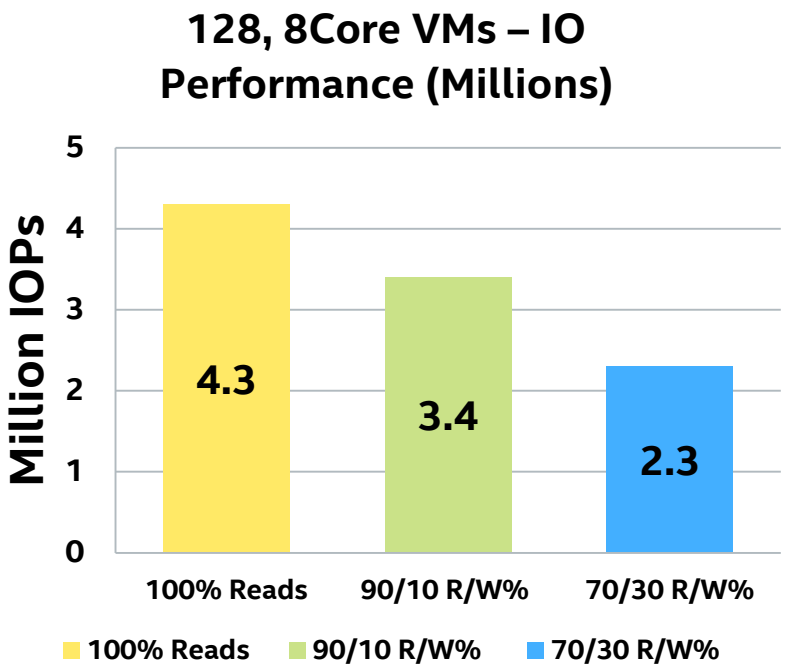
Per Node Performance Scaling





Intel® and Microsoft* Storage Spaces Direct Hyper-Converged Demo





Summary and Next Steps

Summary and Next Steps

- Our optimized NVM Express™ configurations show great results!
  - Greater than 3X performance boost compared to SATA* (similar capacity)
  - Lower CPU time for the same IO rate compared to SATA
- Critical inflection points are impacting storage now more than EVER!
- Non Volatile Memory is MAINSTREAM
- CLOUD usage will continue to drive efficiencies in storage technologies

Additional Sources of Information

- A PDF of this presentation is available from our Technical Session Catalog: www.intel.com/idfsessionsSF. This URL is also printed on the top of Session Agenda Pages in the Pocket Guide.

- More web based information:

http://www.microsoft.com/en-ca/server-cloud/solutions/storage.aspx

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Rev. 4/14/15

Backup

4 Node Configuration Details

- Hardware Configuration:
  - Intel® Xeon® processor E5-2699 v3 based Server 2U 24x2.5" [R2224WTTYS-IDD]
  - 16GB Micron* DIMMs
  - 2x10Gbe Chelsio* Ethernet Adapter
  - Cache:
    - 1xIntel® SSD DC P3700 – 2TB
    - 2xIntel SSD S3700 – 800GB
  - Storage: 1TB Seagate* Constellation 2 ST91000640NS
  - Boot: SSD DC 3710 - 200GB
  - Cisco* Nexus Switch N9K-C93128TX
  - Cisco Catalyst Switch – 3548G – 1Gb
  - 1U Intel Xeon Utility Server

4 Node Configuration Details Continued

- Software Configuration
  - Windows® Server* 2016 Technical Preview 3†
  - Hyper Converged 4 node Configuration
  - Diskspd Version 2.0.15 running on 4x10GB files per share per node
  - Spaces Direct - 3-Way mirrored configuration

† This technology demonstration uses pre-release software; features and functionality may differ in the final release.

Intel and Microsoft* Storage Demo Configuration

- Hyper-Converged using Storage Spaces Direct
- 16 Intel® Server Systems S2600WT
  - Intel Server System R2224WTTYS-IDD (2U)
  - Dual Intel® Xeon® processor E5-2699 v3 Processors
  - 128GB Memory (16GB DDR4-2133 1.2V DR x4 RDIMM)
- Total Raw Capacity for Hyper-V* Cluster: **51.2 TB**
- Data network
  - Chelsio* 10GbE RDMA Card (CHELT520CRG1P10)
- Top of Rack Switch- Cisco* Nexus Switch N9K-C93128TX
- Per Server
  - 4 - Intel® SSD DC P3700 Series (800 GB, 2.5” SFF)
  - 2U NVM Express™ e kit for Wildcat Pass A2U8X25PCIDSPP
  - Boot Drive: Intel SSD DC S3710 Series (200 GB, 2.5” SFF)

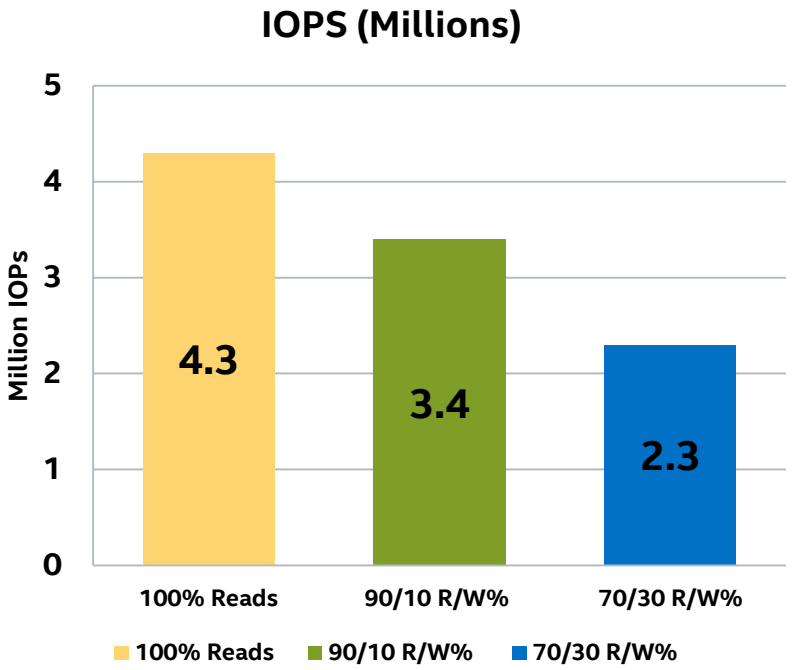
Intel and Microsoft* Storage Demo Results

Spaces Configuration

- Storage Spaces Direct
- Single Storage Pool: 51.2 TB Formatted
- 3-way Mirrored Virtual Disks
- Allocated to Virtual Disks: 44.3 TB
- Free for Rebuild: 6.8 TB
- 16 Virtual Disks for Workload
  - 919 GB each, Total 14.7 TB

Load Generators

- 8 Virtual Machines per Server (128 Total)
  - 8 Virtual Cores, 7.5 GB Memory per VM
  - Equivalent to Azure* A4 sizing
- DISKSPD for load generation
  - 8 threads per DISKSPD instance
  - Queue Depth of 20 per thread

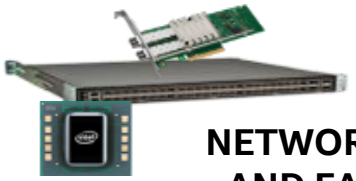


What are Intel's Storage Assets?

Intel® QuickAssist Technology

Intel® Storage Acceleration Library (ISA-L)

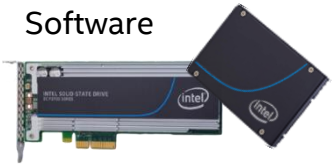
PROCESSOR PLATFORMS



NETWORKING AND FABRIC

SSD'S AND NVM

Intel® Cache Acceleration Software



REFERENCE ARCHITECTURES

Intel® Architecture Storage Solutions

SOFTWARE ECOSYSTEM

Intel® SSD DC P3700 Series

Intel SSD DC P3600 Series

Intel SSD DC P3500 Series

Capacity

Intel® SSD DC P3700 Series	Intel SSD DC P3600 Series	Intel SSD DC P3500 Series
400 GB	400 GB	400 GB
800 GB	800 GB	1.2TB
1.6TB	1.2TB	2TB
2TB	1.6TB	
	2TB	

Endurance

Intel® SSD DC P3700 Series	Intel SSD DC P3600 Series	Intel SSD DC P3500 Series
10 DWPD	3 DWPD	0.3 DWPD
High Endurance Technology	Mixed use	Read Intensive

Performance

	Intel® SSD DC P3700 Series	Intel SSD DC P3600 Series	Intel SSD DC P3500 Series
Random 4k Read	450k IOPS	450k IOPS	450k IOPS
Random 4k Write	175k IOPS	56k IOPS	35k IOPS
Random 4k 70/30 R/W	265k IOPS	160k IOPS	85k IOPS
Sequential Read	2800 MB/s	2600 MB/s	2500 MB/s
Sequential Write	2000 MB/s	1700 MB/s	1700 MB/s

Sequential latency of 20µs

Tests document performance of components on a particular test, in specific systems. Differences in hardware, software, or configuration will affect actual performance. Consult other sources of information to evaluate performance as you consider your purchase. For more complete information about performance and benchmark results, visit www.intel.com/benchmarks. Configurations: Intel® Core™ i7-3770K CPU @ 3.50GHz, 8GB of system memory, Windows® Server 2012, IOMeter*. Random performance is collected with 4 workers each with 32 QD

Recommendations

- Buy as much NVM Express™ storage as your working set
- Build your configuration for worst-case N/W and storage limits
  - Test with basic disk workloads to gauge sizing (Small IO–> IOPS, Large IO -> Bandwidth
  - N/W - To account for optimal cross-node traffic
- Different Resiliency themes will deliver different results
- Leverage new Microsoft* Storage Spaces Direct features for optimal results
  - Monitoring
  - ReFS