LATEST INTEL TECHNOLOGIES POWER NEW PERFORMANCE LEVELS ON VMWARE VSAN

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Enabling you to make the best technology decisions

EXECUTIVE OVERVIEW

The Intel® Xeon® Scalable platform is designed to support today's enterprise application needs; specifically workloads requiring high I/O combined with intensive processor and memory access found in virtualized data centers. However, improving the processing performance without also improving the storage would lead to an unbalanced system, one unable to achieve optimal performance.

One trend that has been enabled by increasing processing capabilities is the emergence of Hyperconverged systems that utilize server platforms together with internal storage hardware and software defined storage to deliver an integrated platform for virtual applications. While many organizations have evaluated Hyperconverged appliances, some found that the performance of first generation systems was not suitable for their most demanding workloads.

Working with Intel, Evaluator Group tested several next generation Hyperconverged configurations based on VMware vSAN and Intel technologies, including a new class of storage media known as Optane™ for enhanced performance levels. The systems used during testing utilized VMware vSAN 6.7 along with Intel's new scalable system architecture including Intel Optane and 3D NAND NVMe storage.

In this paper we show both the performance and price / performance benefits achievable by using next generation Hyperconverged systems based on Intel Xeon Scalable processor systems with Intel Optane and 3D NAND Flash storage, running VMware ESXi and vSAN software to provide the Hyperconverged environment. For comparisons, the results are compared with Intel's previous generation of CPU and storage media, utilizing the same benchmarks.

KEY INSIGHTS

Findings

Evaluator Group utilized the latest Intel® Xeon® Scalable processor systems and Intel® Optane™ technology SSDs, together with VMware ESXi and vSAN to construct a hyperconverged cluster. Testing utilized multiple virtual server workloads, with results showing dramatic performance and price / performance increases compared to the previous generation of hyperconverged systems.

Intel Xeon systems and NVMe storage provided the following benefits vs. the previous generation systems and storage:

- 13x performance vs. previous generation system for IOmark-VM workloads
- 10x lower price vs. previous generation system for IOmark-VM workloads
- Up to 3x more virtual desktops per cluster
- Record IOmark-VM of $216 / VM

Take-away

Intel Xeon processors with Optane and 3D NAND SSDs increased VM density with better performance and efficiency for tested workloads, including virtual desktop and virtual server applications.

EVALUATION OVERVIEW

Evaluator Group analyzed Intel based Hyperconverged systems running two different workloads, including virtual server applications (VM) and virtual desktops (VDI) workloads. The test scenarios were designed to recreate typical application workloads seen in enterprise environments.

Virtual Server Workload Results

The IOmark-VM benchmark was chosen to measure the storage performance of typical systems running virtual machine workloads. This benchmark has published results for earlier generations of Hyperconverged appliances, including previous results for Intel hardware together with VMware vSAN storage.

Note: ***Comparisons to previous Evaluator Group testing of Intel based Hyperconverged system performance in 2016 is available.[1] Benchmark results for Configuration utilizing Intel Optane with Intel NVMe solid-state media (Configuration 'C' as noted below) are available at IOmark.org.[2]***

Test Configurations and Results

The metrics captured included performance and price / performance for each configuration. Performance was measured using the IOmark-VM benchmark, with validated performance results noted below. Each of the configurations was tested using VMware ESXi and vSAN in a 4-node cluster configuration running the IOmark-VM benchmark. Each of the three configurations was tested as a storage system, achieving IOmark-VM validation.

Additional details along with pricing for all configurations is provided in Appendix A and subsequent Appendices.

- Configuration 'A' (P4600 + P4500 - no Deduplication)
  - Storage: Media: 1 x Intel DC P4600 (1.6 TB) + 4 x Intel DC P4500 (3 @ 4 + 1 @ 2 TB)
  - Performance: 704 IOmark-VM
  - Price / Performance: $322.76 / IOmark-VM
- Configuration 'B' (Optane + P4500 - with Deduplication)
  - Storage: Media: 2 x Intel Optane DC P4800x (375 GB) + 4 x Intel DC P4500 (2 TB)
  - Performance: 800 IOmark-VM
  - Price / Performance: $269.12 / IOmark-VM
- Configuration 'C' (Optane + P4500 - no Deduplication)
  - Storage: Media: 2 x Intel Optane DC P4800x (375 GB) + 5 x Intel DC P4500 (4 TB)
  - Performance: 1,152 IOmark-VM (**13x** vs. previous worst case, **2.9x** vs. previous best)
  - Price / Performance: $216.23 / IOmark-VM (**10x** vs. previous worst, **3.1x** vs. previous best)

Evaluator Group comments: Improvement in performance or price / performance of 50% from one generation to the next is considered as good. The results achieved with Intel's new generation of processors and NVMe storage media show 3x performance and price / performance, which is a significant achievement .

The results for all three configurations are reported as IOmark-VM, denoting each configuration supported the required storage performance and capacity necessary to run the reported workload.

1 "Evaluating Server-Based Storage Performance", Evaluator Group 2016: www.evaluatorgroup.com/document/evaluating-server-based-storage-performance-enterprise-workloads/

2 IOmark.org: http://www.iomark.org/sites/default/files/IOmark-VM_report_Intel-vSAN_181011a.pdf

Performance Comparison

Shown below in Figure 1 are the performance results for three tests previously reported on the left, along with three new results to the right. See Appendix B for details on the previous and new configurations details.

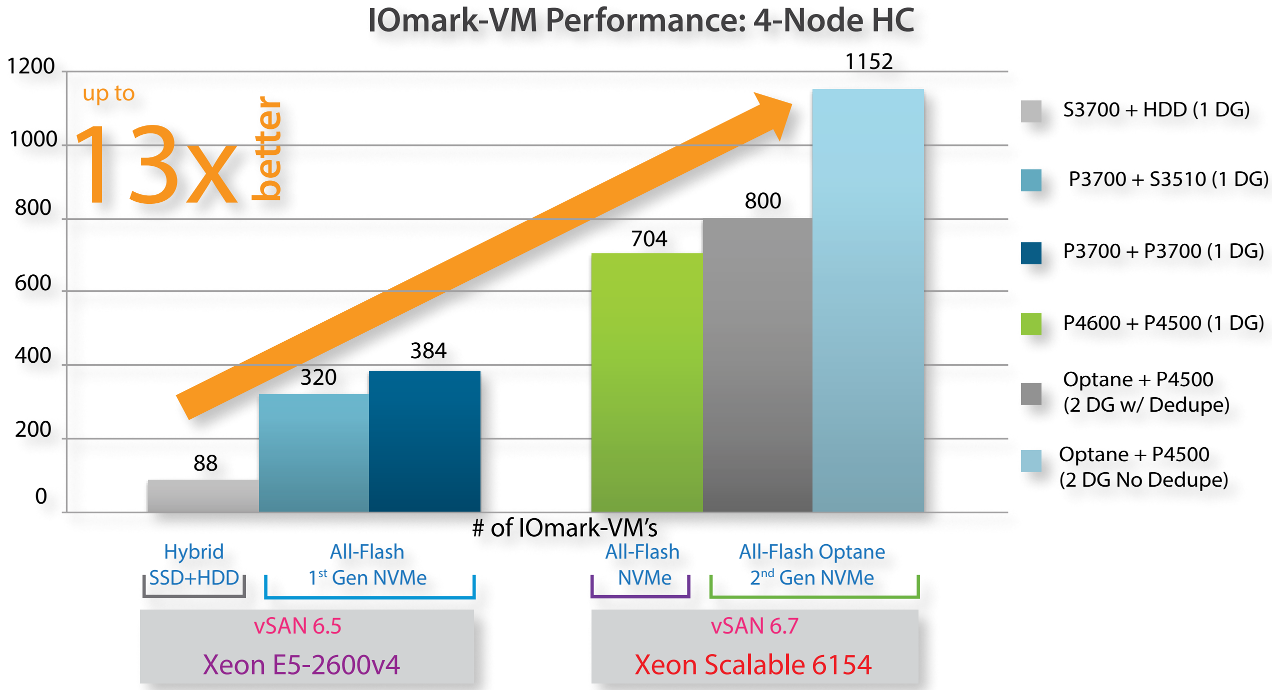


Figure 1: Performance Comparison of Intel Hyperconverged Systems

As shown above, the first three data points on the left (88, 320 and 384) are based on previous generation Intel servers utilizing NVMe devices and VMware vSAN 6.2. All testing was completed in 2018 with all patches at the time of testing in August 2018. The three data points on the right are based on the latest generation Intel Xeon processor systems, together with new Intel NVMe devices and the latest version of VMware vSAN 6.7, with all patches applied at the time of testing.

It is clear that the results obtained with the Xeon Scalable systems together with Intel Optane and 3D NAND storage media and vSAN 6.7 provide significant performance improvements compared to the prior generation systems and solid-state storage media.

Efficiency Comparison

While performance results are interesting, improving VM density and lowering the cost of infrastructure are often the most important considerations for IT environments. The price / performance results measured show compelling value obtained by moving to new Intel Xeon Scalable systems and VMware vSAN 6.7.

As shown below in Figure 2, the cost per VM is significantly lower by using higher performing systems and storage. These results clearly show that the lowest cost on a per VM basis is obtained by using new Intel Optane and 3D NAND storage together with Intel Xeon Scalable processors and VMware vSAN 6.7.

Older systems without sufficient storage performance leads to VMs that are starved for I/O throughput, wasting the precious processor and memory resources of these systems. As a result, it was common for IT administrators to over-provision storage capacity, in order to achieve the required performance.

With new Intel Optane and 3D NAND media, IT architects are able to choose storage media for performance and capacity independently, enabling systems that exactly meet both the capacity and performance requirements.

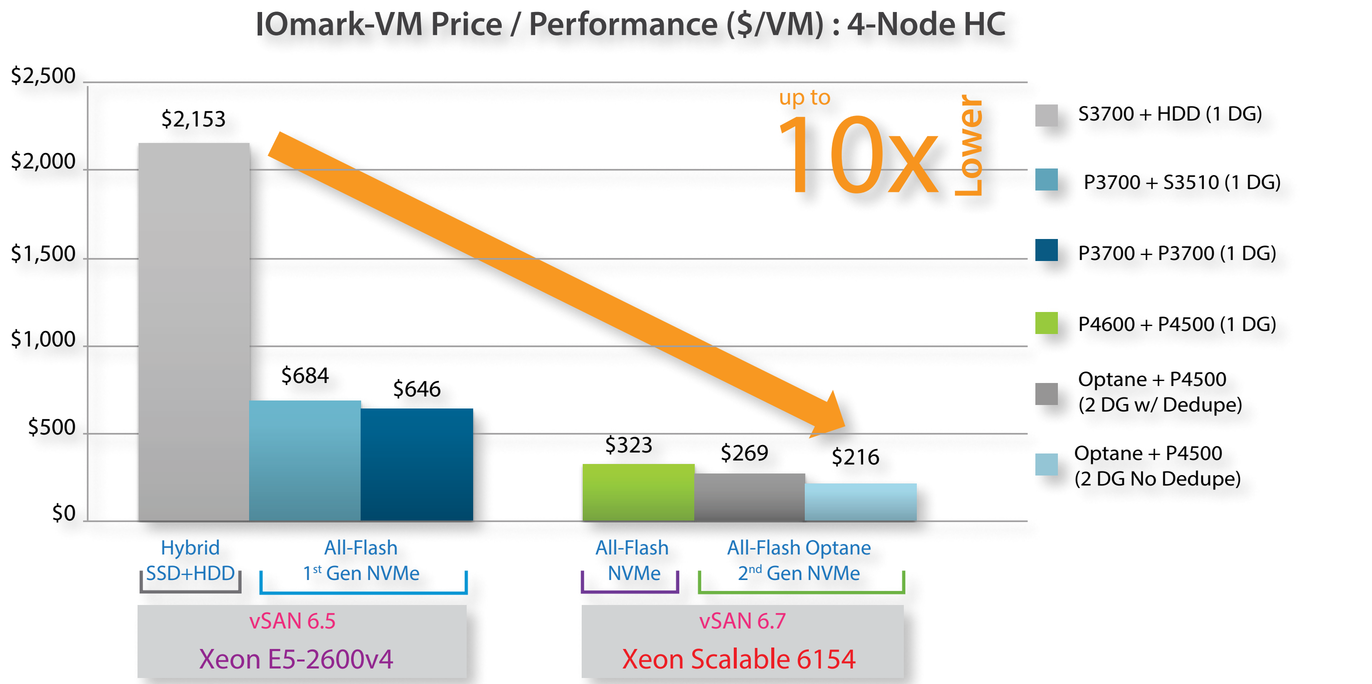


Figure 2: Price / Performance Comparison of Intel Hyperconverged Systems

Storage Capacity Comparison

Storage capacity requirements vary significantly between companies, workloads and for other reasons. In Hyperconverged environments excess storage capacity can be wasteful, since that capacity is not easily shared with other compute systems. Therefore, optimally configured Hyperconverged systems will have sufficient storage capacity for the workloads being run on them without excessive capacity.

Hyperconverged systems utilize scale out architecture, enabling the ability to add performance and capacity in granular increments, simply by adding additional nodes, with minimal downtime. This allows companies to match systems to requirements, without the need to overprovision in advance.

The usable capacity of the tested systems includes RAID overhead and capacity gains from the use of deduplication and compression. For IOmark-VM, the data is approximately 2.5:1 reducible. The capacity factors used for each configuration are listed in the configuration details section of Appendix A.

Comparison to Previous Generation

Comparing the new Intel Xeon Scalable processor systems using Optane and 3D NAND flash storage to earlier test results, there are several important results.

- Performance levels increased dramatically when using higher speed storage media, up to 13X
- Effeciency measured by $ / VM also improved with newer systems and storage media, up to 10X

Virtual Desktop Workload Results

A virtual desktop or VDI workload was created using the IOmark-VDI benchmark to measure storage performance. This benchmark has published results for earlier generations of Hyperconverged appliances, however no previous vSAN systems have reported their IOmark-VDI results. Therefore comparisons between the tested Intel Xeon Scalable processor systems with vSAN and previous IOmark-VDI results have several differences between their configurations, as shown on the following page.

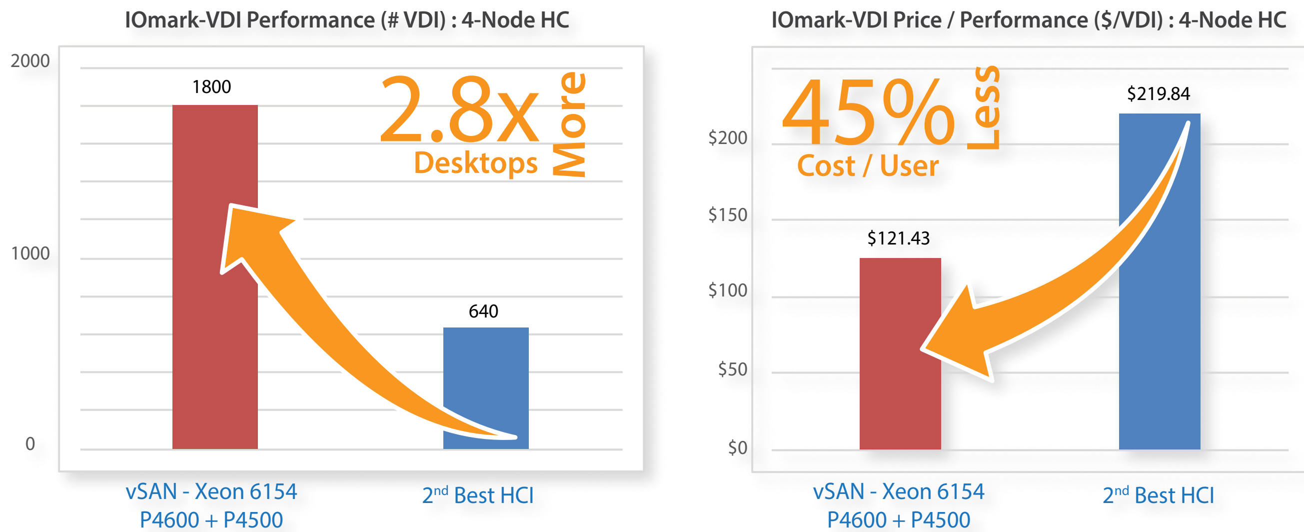
Test Configurations and Results

The primary limitation of the tested system was determined to be the CPU and memory available. This was based upon recommendations from the two primary VDI brokers, VMware View and Citrix XenDesktop. Each VDI desktop was allocated the following resources:

- VDI HW configuration (vSAN Storage with Intel P4600 + P4500 - with Deduplication)
  - 36 CPU cores, 1.0 TB DRAM and 16 TB of usable capacity per node
  - 2 vCPU's, 2 GB RAM and 35 GB storage capacity per VDI instance
  - 12.5 : 1 CPU over-provisioning and no DRAM over-provisioning
- Performance: 1,800 IOmark-VDI
- Price / Performance: $121.43 / IOmark-VDI

Comparison to Previous Results

Shown below in Figures 3 and 4 are the performance and price / performance results respectively for the latest Intel Xeon with vSAN results vs. the previous best VDI Hyperconverged results. See Appendix B for details on configurations tested.



Figures 3 and 4: VDI Performance and Price / Performance

From these results it is clear that the results obtained with the new Xeon Scalable processor systems together with Intel 2nd generation NVMe storage media and vSAN 6.7 provide significant performance and price / performance improvements compared to the prior generation systems.

Key improvements vs. previous generations HCI include:

- Intel Xeon Scalable processor, enabling 512 VDI users per system with 2vCPU and 2-3 GB RAM per VDI
  - More cores, higher clock speed, 50% more DRAM and increased bandwidth vs. previous systems
- vSAN 6.7 enhancements, enabling greater performance using NVMe media vs. prior systems
  - 3X more desktops compared to 2nd best HCI systems, as shown above

SUMMARY

Evaluator Group analysis found that the new Intel Xeon Scalable system architecture, combined with next generation solid-state storage technologies with Intel Optane technology and 3D NAND NVMe storage devices are able to deliver better performance and more importantly price / performance for a variety of common workloads running on Hyperconverged systems using vSAN.

Virtual server workloads are the most common applications run as on-premise private and hybrid cloud, as well as by cloud service providers. These demanding workloads require balanced system performance in order to achieve high system utilization while still meeting application performance requirements. These workloads were found to have between 3x - 13x the performance of previous generation systems, with price / performance levels between 3x - 10x lower than previous generation systems as measured by IOmark-VM benchmark.

Virtual desktop or VDI workloads were also found to benefit, primarily from the increased processor and memory capabilities, but also from the improvements of vSAN 6.7 which enabled the use of new Intel high capacity NVMe devices while delivering 2x more performance versus prior generation NVMe devices with vSAN 6.5.

Taken together, each technology enhancement adds to the overall system capabilities, making Hyperconverged systems based upon Intel server and storage hardware combined with Hyperconverged infrastructure using VMware ESXi and vSAN able to deliver significantly better performance, but more importantly lower total cost when measured by the application results.

A common perception is that new technologies are expensive; however, the reality is that using these technologies can provide significant price / performance advantages due to the high performance relative to their price. Testing using IOmark-VM and IOmark-VDI clearly show that the highest performing configurations also provide the greatest efficiency, delivering the lowest cost per virtual server and virtual desktop.

When compared to first generation Hyperconverged systems using hybrid storage, the price / performance benefits of the Intel Xeon Scalable processor systems together with Intel Optane and 3D NAND NVMe storage are nearly an order of magnitude better. Even compared to most all-flash Hyperconverged systems, the new Intel based systems with vSAN deliver approximately 2x better performance and price / performance levels compared to recent all-flash Hyperconverged.

The IOmark-VM performance for the four-node cluster surpasses most all-flash storage systems tested to date, making it possible to run even the most I/O intensive applications using the latest Intel processors and server-based storage technology.

Final Observations

Storage performance has traditionally been a significant limitation for Hyperconverged system performance, leading applications to waste system resources while simultaneously being starved for I/O. Intel's new system and storage technologies, combined with VMware vSAN's enhancements enable enterprises to meet their application I/O needs, resulting in better performance while lowering IT costs.

IT organizations looking to improve their VM density, improve performance or lower the cost of running virtual workloads should utilize Intel's next generation Optane and 3D NAND media in order to leverage the full benefits of new Intel processors and HCI software such as VMware vSAN.

Evaluator Group

Appendix A – IOmark-VM Pricing

Provided in Table 1 is a summary of the three configurations tested, along with their respective costs, performance and the price / performance results. Data from this table is used in Figures previously listed.

Table 1 : Test Configuration and Pricing Details

Intel Storage / Node						
	Broadwell	Broadwell	Broadwell	Skylake	Skylake	Skylake
	S3700 + HDD	P3700 + S3510	P3700 + P3700	P4600 + P4500	Optane + P4500	Optane + P4500
Seagate Const. 1 TB HDD	4					
Intel S3700 (400 GB)	1					
Intel DC S3510-1600		6				
Intel DC P3700-800		1	1			
Intel DC P3700-1600			3			
Intel DC P4500-2000				1	4	
Intel DC P4500-4000				3		5
Intel DC P4600-1600				1		
Intel DC P4800x-400					2	2
Raw Capacity / Node	4,000	9,600	4,800	14,000	8,000	20,000
IOmark-VM-HC Required Raw / Node	1,375	3,750	4,500	8,250	5,188	13,500
RAID Level Used	R-10	R-5 + R-10	R-5 + R-10	R-5 + R-10	R-5 + R-10	R-5 + R-10
Dedup - Compression	No	No	No	No	**Yes**	No
Storage Overhead Factor	2.0	1.5	1.5	1.5	0.8	1.5
Usable Capacity / Node (GB)	2,000	6,400	3,200	9,333	10,667	13,333
VMmark Tiles / Node	2.75	10	12	22	25	36
IOmark-VM's / Node	22	80	96	176	200	288
IOmark-VM's / Cluster	88	320	384	704	800	1,152

Intel Test Configuration Pricing						
	S3700 + HDD	P3700 + S3510	P3700 + P3700	P4600 + P4500	Optane + P4500	Optane + P4500
Seagate Const. 1 TB HDD	$ 847.96	$ -	$ -	$ -	$ -	$ -
Intel S3700 (800 GB)	$ 568.81	$ -	$ -	$ -	$ -	$ -
Intel DC S3510-1600	$ -	$ 5,819.94	$ -	$ -	$ -	$ -
Intel DC P3700-800	$ -	$ 2,019.99	$ 2,019.99	$ -	$ -	$ -
Intel DC P3700-1600	$ -	$ -	$ 12,113.97	$ -	$ -	$ -
Intel DC P4500-2000	$ -	$ -	$ -	$ 1,456.00	$ 5,824.00	$ -
Intel DC P4500-4000	$ -	$ -	$ -	$ 7,902.00	$ -	$ 13,170.00
Intel DC P4600-1600	$ -	$ -	$ -	$ 1,569.99	$ -	$ -
Intel DC P4800x-400	$ -	$ -	$ -	$ -	$ 2,511.98	$ 2,511.98
1 Node Storage Media Total	$ 1,416.77	$ 7,839.93	$ 14,133.96	$ 10,927.99	$ 8,335.98	$ 15,681.98
4 Node Storage Media Total	$ 5,667.08	$ 31,359.72	$ 56,535.84	$ 43,711.96	$ 33,343.92	$ 62,727.92
4 Nodes (Server Only)	$ 61,416.00	$ 61,416.00	$ 61,416.00	$ 56,840.00	$ 56,840.00	$ 56,840.00
4 Node VMware (ESXi + vSAN)	$ 59,920.00	$ 59,920.00	$ 59,920.00	$ 59,920.00	$ 59,920.00	$ 59,920.00
3 Year Ent Support (HW + SW)	$ 61,567.20	$ 61,567.20	$ 61,567.20	$ 60,194.40	$ 60,194.40	$ 60,194.40
3 Year Media Maint. (5%)	$ 850.06	$ 4,703.96	$ 8,480.38	$ 6,556.79	$ 5,001.59	$ 9,409.19
Total 4 Nodes (HW, SW, Media, Mnt.)	$ 189,420.34	$ 218,966.88	$ 247,919.42	$ 227,223.15	$ 215,299.91	$ 249,091.51

Intel Price / Performance - Price / Cap.						
	S3700 + HDD	P3700 + S3510	P3700 + P3700	P4600 + P4500	Optane + P4500	Optane + P4500
IOmark-VM's / Cluster	88	320	384	704	800	1,152
$ / VM (HW, SW, Media, Mnt.)	$ 2,152.50	$ 684.27	$ 645.62	$ 322.76	$ 269.12	$ 216.23

Appendix B - IOmark-VM Details

For the server virtualization or VM workloads, the IOmark-VM application workload was utilized. Results for Configuration 'C' with Optane and P4500 media is published on IOmark.org website. Other configurations followed recommendations and review but were not published as certified results. However, the comparisons are valid as all testing was performed to the same standards, using the same test infrastructure and methods.

Configuration for Xeon Scalable System Tests

Performance and price / performance information for Xeon Scalable systems with Optane were previously provided on page 2 and shown in Figures 1 and 2. The hardware and software details are provided in Appendix D. The only change between configurations were the storage media noted below.

- Configuration 'A' (P4600 + P4500 - no Deduplication
  - Storage: Media: 1 x Intel DC P4600x + 3 x Intel DC P4500
  - Performance: 704 IOmark-VM ; Price / Performance: $322.76 / IOmark-VM
- Configuration 'B' (Optane + P4500 - with Deduplication)
  - Storage: Media: 2 x Intel Optane DC P4800x + 4 x Intel DC P4500
  - Performance: 800 IOmark-VM ; Price / Performance: $269.12 / IOmark-VM
- Configuration 'C' (Optane + P4500 - no Deduplication)
  - Storage: Media: 2 x Intel Optane DC P4800x + 4 x Intel DC P4500
  - Performance: 1,152 IOmark-VM ; Price / Performance: $216.23 / IOmark-VM

Configurations for Broadwell Systems - Previously Reported

The results provided below are updates to testing performed in 2016. These configurations utilized the same storage media and E5-2600v4 processors as those systems referenced in Footnote 1 on page #2. Three specific configurations were retested, utilizing all current software patches, including those for processor vulnerabilities to speculative instructions. Pricing is current as of the time of original publication, except where components were substituted, in which case current pricing is used. The configurations re-tested are as follows:

- Configuration #1 (1 SSD + 4 HDDs)
  - Storage: Media: 1 x DC S3700 + 4 x Seagate 1 TB 10K HDD
  - Performance: 88 IOmark-VM ; Price / Performance: $2,152.50 / IOmark-VM
- Configuration #2 (1 NVMe + 6 SSDs)
  - Storage: Media: 1 x DC P3700 + 6 S3510
  - Performance: 320 IOmark-VM ; Price / Performance: $684.27 / IOmark-VM
- Configuration #3 (1 Intel P3700 NVMe cache + 3 Intel P3700 NVMe capacity)
  - Storage: Media: 1 Intel DC P3700 + 3 Intel DC P3700
  - Performance: 384 IOmark-VM ; Price / Performance: $645.62 / IOmark-VM

Pricing Data

Prices can change and although data was accurate at the time of publication, the prices may not be accurate currently. Prices for prior generation (Broadwell) systems and storage media was accurate at the time of initial publication in 2016 and those prices have not been updated. Pricing for current generation equipment (Skylake / Xeon Scalable) are accurate at the time of publication. Pricing was gathered for individual components and then combined in order to provide prices for each configuration as detailed in Appendix A of this report.

Price data gathered included list prices for all Intel components including systems, CPU's and storage media as well as for VMware software. All pricing data was verified as accurate on the date of publication. Additional details available upon request.

Appendix C - IOmark-VDI Details

For the virtual desktop or VDI workloads, the IOmark-VDI application workload was utilized. None of the tested configurations were submitted for audit and certification, thus none of the results were published as certified IOmark-VDI or IOmark-VDI-HC results. However, all testing was performed to the same standards, using the same test infrastructure and methods by Evaluator Group, thereby enabling comparisons to other Evaluator Group reported IOmark-VDI results.

Server Configuration

The configuration consisted of a cluster of 4 physical server nodes running VMware ESXi 6.7 with vSAN 6.7. The Hyperconverged systems used for testing included the following CPU, memory and network configuration. The configuration utilized deduplication and compression features of vSAN, providing effective capacity of 35 GB per VDI instance with only a 2:1 reduction rate, higher deduplication rates would provide more capacity.

- Memory: 1.0 TB of memory
- Storage Media: 1@ Intel P4600 cache and 4 @ Intel P4500 capacity devices per node
- Total cost for 4 server nodes with HW, SW, Media and maintenance was $218,574.75
- Total number of VDI instances supported on 4 node cluster was 1,800 “Standard” VDI users
- Cost per IOmark-VDI-HC is ($218,574.75 / 1,800) = $121.43 for a “Standard” VDI instance

Comparison to Previously Reported Results

As with IOmark-VM results, the IOmark-VDI results obtained were compared to previously reported IOmark-VDI results available on iomark.org website. The previous best reported results for IOmark-VDI-HC Hyperconverged instances running the “Standard” workload is as follows:

- Total cost for 4 server nodes with HW, SW, Media and maintenance was $140,700.00
- Total number of VDI instances supported on 4 node cluster was 640
- Cost per IOmark-VDI-HC instance is ($140,700.00 / 640) = $219.84

Note: Published results are available on iomark.org for a Hyperconverged system showing 1,020 IOmark-VDI-HC users running an “Office” workload. However, “Standard” and “Office” workloads are not directly comparable, hence the comparison to the 640 “Standard” VDI users was used.

Appendix D - Hardware Details

Xeon Scalable Configurations

Server Configurations

The configuration consisted of a cluster of 4 physical server nodes running VMware ESXi 6.7 with vSAN 6.7 and vCenter 6.7. All Spectre and Meltdown patches were applied to the CPU microcode, Hypervisor and Guest OS. The Hyperconverged systems used for testing included the following CPU, memory and network configuration. The storage media utilized changed for each configuration as noted.

- Each Node in the 4 node cluster consisted of an Intel Xeon Scalable system platform
  - Intel Server System R2208WFTZS, with 8 U.2 NVMe accessible slots
  - CPU: 2 x Intel Xeon Gold 6154 CPU (24 cores @ 2.7 Ghz w/ hyper threading)
  - Memory: Tested with 256 GB DRAM, priced for comparison at 384 GB DRAM
  - NIC : Tested with onboard 10 GbE X722 10 GbaseT

Hyperconverged Software

- VMware ESXi 6.7 (Build 8169922)
- VMware vSAN 6.7 (included in ESXi build)
- VMware vCenter 6.7 (Build 9232942)

Broadwell Configurations

Server Configurations

The configuration consisted of a cluster of 4 physical server nodes running VMware ESXi 6.0 with vSAN 6.2 and vCenter 6.0. All Spectre and Meltdown patches were applied to the CPU microcode, Hypervisor and Guest OS. The Hyperconverged systems used for testing included the following CPU, memory and network configuration. The storage media utilized changed for each configuration as noted.

- Each Node in the 4 node cluster consisted of an Intel Xeon Scalable system platform
  - Intel Server System R2600 WTT, with 8 U.2 NVMe accessible slots
  - CPU: 2 x Intel E5-2699v4 CPU (22 cores @ 2.2 Ghz w/ hyper threading)
  - Memory: Tested with 256 GB DRAM, priced for comparison at 384 GB DRAM
  - NIC : Tested with 10 GbE LOM 10 GbE X-540 AT2

Hyperconverged Software

- VMware ESXi 6.0-201803001 (Build 7967664 with Spectre & Meltdown patches)
- VMware vSAN 6.2 (included in ESXi build)
- VMware vCenter 6.0 update 3f (Build 8874691 with Spectre & Meltdown patches)

About Evaluator Group

Evaluator Group Inc. is dedicated to helping IT professionals and vendors create and implement strategies that make the most of the value of their storage and digital information. Evaluator Group services deliver in-depth, unbiased analysis on storage architectures, infrastructures and management for IT professionals. Since 1997 Evaluator Group has provided services for thousands of end users and vendor professionals through product and market evaluations, competitive analysis and education. www.evaluatorgroup.com Follow us on Twitter @evaluator_group

* This document was developed with Intel funding. Although the document may utilize publicly available material from various vendors, it does not necessarily reflect the positions of such vendors on the issues addressed in this document.

Note: Benchmark results include the use of software patches and firmware updates intended to address exploits referred to as “Spectre” and “Meltdown”. All testing was performed in July and August 2018 with the most recent patches applied to all software and hardware as of August 2018.