



# Adding Intel® Optane™ SSDs to VMware vSAN\* Data Storage Increases Performance While Reducing Cost

Agile storage systems rapidly enhance analysis and insight from stored data

This solution brief describes how to solve business challenges through investment in innovative technologies.

If you are responsible for...

- **Business strategy:** You will better understand how a storage solution featuring Intel® Optane™ SSDs will enable you to successfully meet your business outcomes.
- **Technology decisions:** You will learn how a storage solution featuring Intel® Optane™ SSDs works to deliver IT and business value.



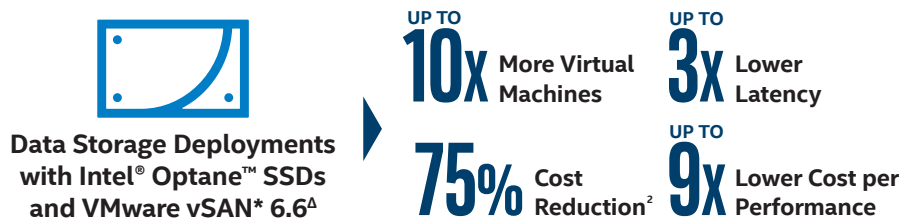
## Executive Summary

Enterprises continue to make collecting and mining data a central part of their competitive strategy. However, many organizations are discovering that their legacy storage architecture lacks the ability to scale with the surge in data their business generates. With an estimated 80 percent of workloads running on cloud architecture by 2024, the need for faster interfaces will become apparent as SATA and magnetic disks are unable to keep up with end user requirements.<sup>1</sup>

Today, companies are already benefiting from innovation taking place in software-defined infrastructure, software-defined storage, and solid state drives (SSDs) that use the speedy PCIe\* interface. The next step in this evolution is the enhancement of the caching layer with Intel® Optane™ SSDs. A solution built around Intel® Optane™ SSDs using VMware vSAN\* software can allow end users to better manage their storage resources while optimizing performance. Adding Intel® Optane™ SSDs to the cache tier running on Intel® Xeon® Scalable processors can deliver up to 10x performance improvements and up to 9x cost per performance improvements, as well as a paradigm shift in cache capacity.<sup>Δ</sup> Intel® Optane™ SSDs using 3D XPoint™ technology enable cache capacity to be at 2.5 to 4 percent instead of 10 percent.<sup>Δ</sup> These capabilities help produce accurate business insights while reducing time and effort.

Companies appreciate easy scalability and the ability to effortlessly add storage capacity. Intel Xeon Scalable processor platforms offer more NVMe\* slots than ever before, as well as hot swapability and LED management in the latest version of vSAN 6.6. With the exponential increase in NVMe capacities and costs trending down as much as 50 to 75 percent in four to six years,<sup>2</sup> there has never been a better time to optimize and future-proof storage solutions.

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**Figure 1.** Adding Intel® Optane™ SSDs with Intel® Xeon® Scalable Processors to vSAN\* 6.6 data storage enables businesses to handle the influx of data they need to rapidly deliver actionable business intelligence.

<sup>Δ</sup> Benchmark results were obtained prior to implementation of recent software patches and firmware updates intended to address exploits referred to as "Spectre" and "Meltdown." Implementation of these updates may make these results inapplicable to your device or system. For complete information on performance test results and system configurations, see [Appendix A on page 5](#).

### Solution Benefits

A VMware vSAN\* SSD storage solution powered by Intel® Xeon® Scalable processors with Intel® Optane™ technology can help companies optimize their storage solutions in order to gain fast access to large data sets by:

- Achieving low latency
- Increasing performance and doing more per server
- Reducing processor-request bottlenecks
- Reduced caching tier requirements through the use of Intel® Optane™ technology
- Reducing the transaction cost of latency-sensitive workloads

### Business Challenge: Make Data Mining Faster, Productive, and Economical

With increased pressure to reduce the cost and time needed to run data analytics and deliver accurate and actionable business intelligence, organizations are seeking new ways to optimize and future-proof their data storage technology. In the past, the choice between placing data on inexpensive but extremely slow hard disk drives or in extremely fast but expensive DRAM left businesses with a difficult dilemma. What companies need is a solution to handle large data sets that offers high performance, high density, and low cost.

### Use Case: Optimizing Storage and Cache

Storage solutions using Intel® Optane™ SSDs and Intel® 3D NAND SSDs provide high performance, high density, and low cost. As illustrated in Figure 2, fast storage and cache are two of the most common uses of SSDs today. Intel® Optane™ SSDs help provide the level of accelerated performance, low latency, and high endurance needed for the most demanding cache applications and services. These gains in performance enable companies to do more per server, break storage bottlenecks, and lower transaction costs of latency-sensitive workloads.

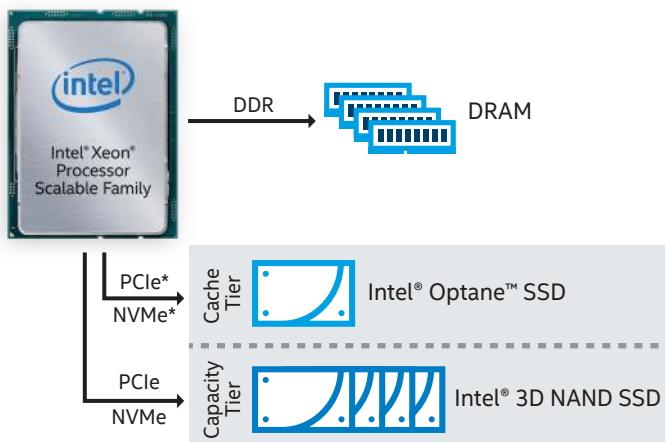
### Solution Value: High Performance, Low Cost, Actionable Intelligence

Enterprise applications such as operational databases, storage caches, log files, and similar high-performance or mission-critical applications require an elevated degree of responsiveness. Typically, mixed workload requests are 70 percent reads and 30 percent writes. Figure 3 compares the performance of a NAND-based Intel® SSD DC P3700 Series with an Intel® Optane™ SSD DC P4800X Series.

The Intel® Optane™ SSD DC P4800X Series performance at Queue Depth One (QD1) is up to 15 times faster than a NAND-based Intel® SSD DC P3700 Series for 70/30 mixed workloads.<sup>Δ</sup> The Intel® Optane™ SSD DC P4800X Series achieves maximum throughput at QD12, while most NAND-based SSDs require QDs of 100 or more to saturate performance.<sup>Δ</sup> Typical enterprise workload applications are mixed reads and writes, with QDs between 8 and 12.

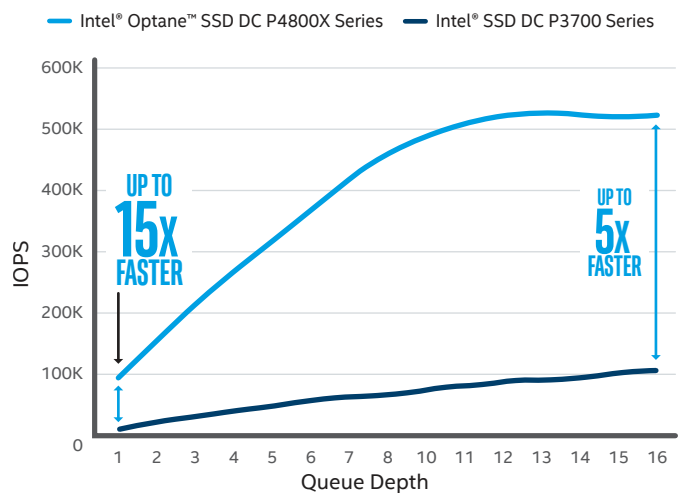
<sup>Δ</sup> Benchmark results were obtained prior to implementation of recent software patches and firmware updates intended to address exploits referred to as "Spectre" and "Meltdown." Implementation of these updates may make these results inapplicable to your device or system. For complete information on performance test results and system configurations, see [Appendix A on page 5](#).

### Fast Cache and High Capacity with Intel® Optane™ SSDs and Intel® 3D NAND SSDs



**Figure 2.** Organizations can gain multiple benefits by deploying Intel® Optane™ SSDs and Intel® 3D NAND SSDs in their data storage solutions.

### Performance at Low-Queue Depth<sup>Δ</sup> 4K Workload, 70/30 Reads and Writes



**Figure 3.** Intel® Optane™ SSDs provide breakthrough performance.

Figure 4 shows average read response time for NAND and Intel® Optane™ SSDs under varying 4 KB random write pressure. As write pressure increases, so does NAND read latency. However, the Intel® Optane™ SSD maintains a consistent response time of less than 20µs. As write pressure increases, so does the average latency delta between NAND-based SSDs and Intel® Optane™ SSDs.<sup>Δ</sup>

VMware vSAN\* delivers another component in helping organizations reduce costs and speed up how they search their data—data that can empower executives to make accurate decisions affecting their entire business. By running vSAN on two Intel® Optane™ SSDs DC P4800X Series in the cache tier running on Intel® Xeon® Scalable processors and eight Intel® SSD DC P4500 Series in the capacity tier, businesses can increase performance with up to 10 times more virtual machines, lower latency by up to three times, and reduce cost per performance by up to nine times.<sup>Δ</sup>

Businesses can also achieve the following results:<sup>Δ</sup>

- **Run 89 percent more transactions while reducing cost by 44 percent** by choosing Intel® Optane™ SSDs over the Intel® SSD DC P4600 Series or other NAND-based SSDs.
- **Produce up to 10x more transactions per second** by replacing one Intel® SSD DC P3700 Series with an Intel® Optane™ SSD DC P4800X Series while using two Intel® Xeon® processor E5 family-based servers for the same service.
- **Deliver up to 10x better responsiveness and achieve up to 4x more input/output operations per second** by replacing one NAND PCIe\* SSD with an Intel® Optane™ SSD and adding 16 2-TB Intel® SSD DC P3520 Series SSDs for object storage while using two Intel Xeon processor E5 family-based servers running an all-flash array.

- **Offer a 2x lower price/performance ratio** by running vSAN on two Intel® Optane™ SSDs DC P4800X Series in the cache tier and eight Intel® SSD DC P4500 Series in the capacity tier.
- **Gain nearly 2x better performance** of vSAN on database results running a workload similar to TPC-C\*.

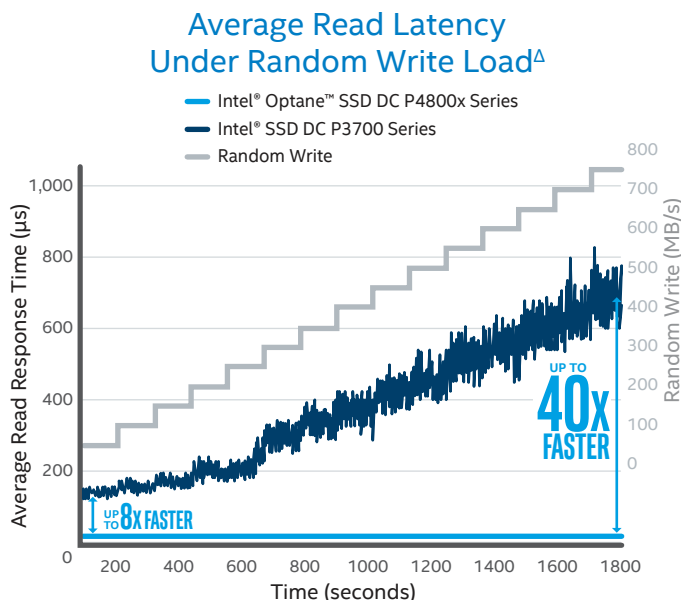
### Solution Architecture: Non-Volatile Memory Express\* (NVMe\*)

Using NVMe with PCIe enables significant benefits to both cache and capacity, while the insertion of the Intel® Optane™ SSDs in the caching tier reduces the size of the cache. Previously, caching SSDs had to account for 10 percent of the capacity tier. For example, on a 16 TB capacity tier, the cache needed to be a 1.6 TB SSD. With an Intel® Optane™ SSD solution, only a 375 GB Intel® Optane™ SSD is required to handle a 16 TB capacity tier.

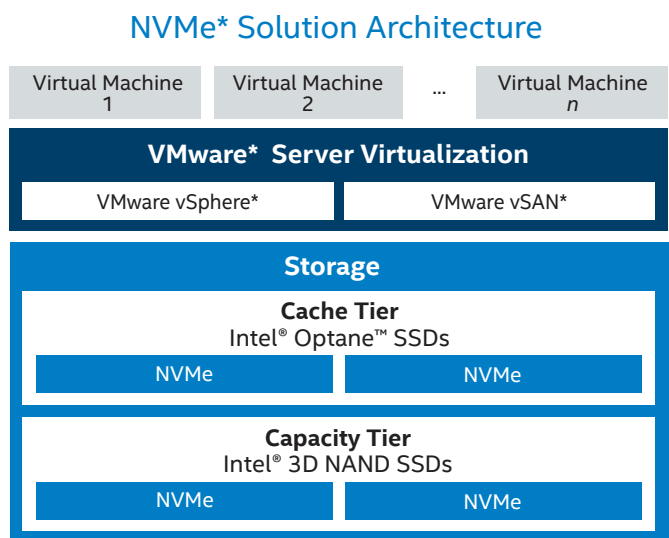
Intel® 3D NAND Technology surpasses the capacity restrictions that occur in traditional 2D NAND technology, accelerating Moore’s Law into three dimensions. By layering cells in 3D, the capacity is increased without significantly increasing the size of the chip.

Figure 5 depicts the various tiers in the solution architecture. The Intel® 3D NAND SSD capacity tier, at the bottom of the figure, serves all read requests. The Intel® SSD DC P4500 Series is optimized for read-intensive workloads and designed to maximize CPU utilization. Moving up from the capacity tier, the cache tier absorbs the write pressure, reducing the need to continually return to the capacity tier until all the writes are completed. This enables the capacity tier to require lower

<sup>Δ</sup> Benchmark results were obtained prior to implementation of recent software patches and firmware updates intended to address exploits referred to as “Spectre” and “Meltdown.” Implementation of these updates may make these results inapplicable to your device or system. For complete information on performance test results and system configurations, see [Appendix A on page 5](#).



**Figure 4.** Intel® Optane™ SSDs deliver consistently amazing response times under load.



**Figure 5.** Intel® Optane™ technology helps optimize and future-proof data storage resources.

endurance-rated SSDs, since the cache tier handles the large volume of write requests. This benefit also helps lower costs, because lower-endurance-rated SSDs are less expensive than those rated as high endurance. Data is de-staged or drained from write cache to the capacity tier only when needed, extending the life of the capacity tier. Deduplication and compression occurs in the de-staging process. The Intel® Optane™ SSD DC P4800X Series provides low latency and ultra-high endurance, which benefit the cache tier's transactional workloads. The next two levels in the solution architecture represent VMware's server virtualization and virtual machines.

## Conclusion

Small improvements in legacy storage systems are unlikely to keep up with the inundation of data that organizations are storing and searching through to arrive at new insights that are needed to increase sales and profits and help achieve additional goals. Innovation in software-defined data centers enables companies to improve how they manage and pool their data. This helps simplify and accelerate the way they produce business value from customer data and other information. Intel® hardware coupled with VMware software demonstrates how these innovations are coming to fruition. The combination of Intel® Optane™ SSDs, Intel® 3D NAND SSDs, VMware software, and standard Intel Xeon Scalable processor-based servers helps lower costs while increasing performance, which makes all-flash data storage a viable alternative that optimizes, modernizes, and future-proofs data storage solutions.

Find the solution that is right for your organization. Contact your Intel representative or visit [intel.com/vmware](https://www.intel.com/vmware).

## Spotlight on VMware

More than 500,000 customers around the world trust VMware to accelerate their digital transformation through a software-defined approach to business and IT. VMware pioneered virtualization as well as cloud and business mobility. VMware's proven solutions enable their customers to run, manage, connect, and secure applications across clouds and devices in a common operating environment, offering them freedom, control, and a low total cost of ownership.

## Learn More

You may also find the following resources useful:

- VMware vSAN software  
[vmware.com/products/vsan](https://www.vmware.com/products/vsan)
- Intel® Optane™ Technology  
[intel.com/optane](https://www.intel.com/optane)
- VMware on VMware, videos, and more  
[vmware.com/company/vmware-on-vmware](https://www.vmware.com/company/vmware-on-vmware)
- Intel® Optane™ SSD DC P4800X Series  
[intel.com/content/www/us/en/products/memory-storage/solid-state-drives/data-center-ssds/optane-dc-p4800x-series](https://www.intel.com/content/www/us/en/products/memory-storage/solid-state-drives/data-center-ssds/optane-dc-p4800x-series)

## Appendix A

For individual performance claims used in the paper, see the following:

- Adding Intel Optane SSDs running on Intel® Xeon® Scalable processors to the cache tier can deliver 10x performance improvements and 9x cost per performance improvements:** Evaluator Group, "Latest Intel Technologies Power New Performance Levels on VMware vSAN," 2017. [evaluatorgroup.com/document/intel-next-generation-technology-powering-new-performance-levels](http://evaluatorgroup.com/document/intel-next-generation-technology-powering-new-performance-levels)
- Intel Optane SSDs enable cache capacity to be at 2.5 to 4 percent instead of 10 percent using all NAND technology:** Evaluator Group, "Latest Intel Technologies Power New Performance Levels on VMware vSAN," 2017. [evaluatorgroup.com/document/intel-next-generation-technology-powering-new-performance-levels](http://evaluatorgroup.com/document/intel-next-generation-technology-powering-new-performance-levels)
- The Intel Optane SSD DC P4800X Series performance at QD1 is 15 times faster than a NAND-based Intel SSD DC P3700 Series for 70/30 mixed workloads. The Intel Optane SSD DC P4800X Series achieves maximum throughput at QD12, while most NAND-based SSDs require QDs of 100 or more to saturate performance:** Common configuration: Intel 2U PCSD Server ("Wildcat Pass"), OS CentOS\* 7.2, kernel 3.10.0-327.el7.x86\_64, CPU 2x Intel® Xeon® processor E5-2699 v4 @ 2.20 GHz (22 cores), RAM 396 GB DDR @ 2133 MHz. Configuration: Intel® Optane™ SSD DC P4800X Series 375 GB and Intel® SSD DC P3700 Series 1600 GB. Performance: Measured under 4K 70–30 workload at Queue Depth 1–16 using fio-2.15. Tests document performance of components on a particular test, in specific systems. Differences in hardware, software, or configuration will affect actual performance.
- As write pressure increases, so does the average latency delta between NAND-based SSDs and Intel Optane SSDs:** Responsiveness defined as average read latency measured at Queue Depth 1 (QD1) during 4k random write workload. Measured using fio-2.15. Common configuration: Intel 2U PCSD Server ("Wildcat Pass"), OS CentOS\* 7.2, kernel 3.10.0-327.el7.x86\_64, CPU 2x Intel® Xeon® processor E5-2699 v4 @ 2.20 GHz (22 cores), RAM 396 GB DDR @ 2133 MHz. Configuration: Intel® Optane™ SSD DC P4800X Series 375 GB and Intel® SSD DC P3700 Series 1600 GB. Latency: Average read latency measured at QD1 during 4K random write operations using fio-2.15. Tests document performance of components on a particular test, in specific systems. Differences in hardware, software, or configuration will affect actual performance.
- By running VMware on two Intel Optane SSDs DC P4800X Series running on Intel® Xeon® Scalable processors in the cache tier and eight Intel® SSDs DC P4500 Series in the capacity tier, businesses can increase performance with 10 times more virtual machines, lower latency by three times, and reduce cost per performance by nine times:** Evaluator Group, "Latest Intel Technologies Power New Performance Levels on VMware vSAN," 2017. [evaluatorgroup.com/document/intel-next-generation-technology-powering-new-performance-levels](http://evaluatorgroup.com/document/intel-next-generation-technology-powering-new-performance-levels)
- Run 89 percent more transactions while reducing cost by 44 percent:** Evaluator Group, "Latest Intel Technologies Power New Performance Levels on VMware vSAN," 2017. [evaluatorgroup.com/document/intel-next-generation-technology-powering-new-performance-levels](http://evaluatorgroup.com/document/intel-next-generation-technology-powering-new-performance-levels)
- Produce up to 10x more transactions per second:** System configuration: Server Intel® Server System R2208WT2YS, 2x Intel® Xeon® processor E5 2699 v4, 384 GB DDR4 DRAM, boot drive 1x Intel® SSD S3710 Series (400 GB), database drives- 1x Intel® SSD DC P3700 Series (400 GB) and 1x Intel® Optane™ SSD DC P4800X Series (140 GB prototype), CentOS\* 7.2, MySQL\* Server 5.7.14, Sysbench 0.5 configured for 70/30 read/write OLTP transaction split using a 100 GB database. Cost per transaction determined by total MSRP for each configuration divided by the transactions per second. Tests document performance of components on a particular test, in specific systems. Differences in hardware, software, or configuration will affect actual performance.
- Deliver up to 10x better responsiveness:** Evaluator Group, "Latest Intel Technologies Power New Performance Levels on VMware vSAN," 2017. [evaluatorgroup.com/document/intel-next-generation-technology-powering-new-performance-levels](http://evaluatorgroup.com/document/intel-next-generation-technology-powering-new-performance-levels)
- Achieve up to 4x more input/output operations per second:** Evaluator Group, "Latest Intel Technologies Power New Performance Levels on VMware vSAN," 2017. [evaluatorgroup.com/document/intel-next-generation-technology-powering-new-performance-levels](http://evaluatorgroup.com/document/intel-next-generation-technology-powering-new-performance-levels)
- Offer a 2x lower price/performance ratio:** Evaluator Group, "Latest Intel Technologies Power New Performance Levels on VMware vSAN," 2017. [evaluatorgroup.com/document/intel-next-generation-technology-powering-new-performance-levels](http://evaluatorgroup.com/document/intel-next-generation-technology-powering-new-performance-levels)
- Gain nearly 2x better performance:** Evaluator Group, "Latest Intel Technologies Power New Performance Levels on VMware vSAN," 2017. [evaluatorgroup.com/document/intel-next-generation-technology-powering-new-performance-levels](http://evaluatorgroup.com/document/intel-next-generation-technology-powering-new-performance-levels)

<sup>4</sup> 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. Benchmark results were obtained prior to implementation of recent software patches and firmware updates intended to address exploits referred to as "Spectre" and "Meltdown." Implementation of these updates may make these results inapplicable to your device or system.

**Solution Provided By:**



<sup>1</sup> Intel solution brief, "Simplifying Access to Software-Defined Storage (SDS) Solutions and Private Cloud." [intel.com/content/www/us/en/technology-provider/cloud-computing/accelerate-path-to-private-cloud](https://www.intel.com/content/www/us/en/technology-provider/cloud-computing/accelerate-path-to-private-cloud).

<sup>2</sup> Network World, "The future of storage: Pure Storage CEO Charlie Giancarlo shares his predictions," 2017. [networkworld.com/article/3238830/storage/the-future-of-storage-pure-storage-ceo-charlie-giancarlo-shares-his-predictions](https://www.networkworld.com/article/3238830/storage/the-future-of-storage-pure-storage-ceo-charlie-giancarlo-shares-his-predictions).

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