

## Intel Optane Technology Transforms Memory and Storage Capabilities

**Intel Optane technology establishes new memory and storage tiers to optimize infrastructure performance, capacity, and total cost of ownership.**

### A multi-tier approach

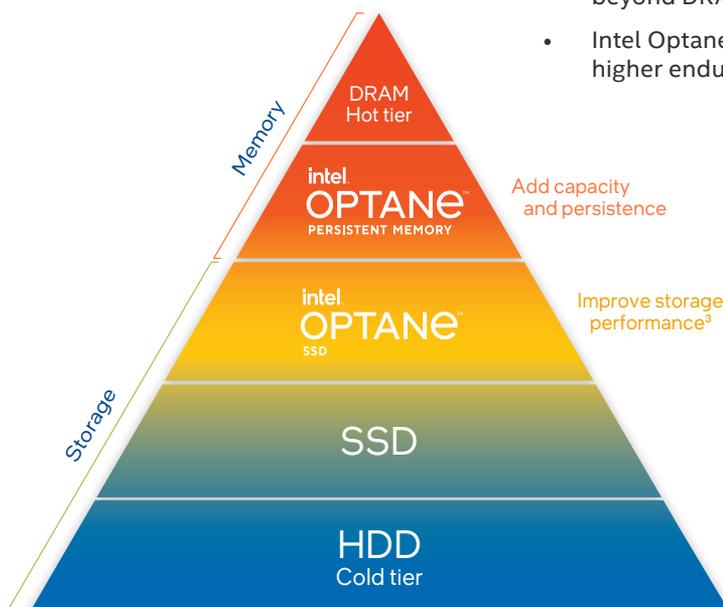
Bridge the gap between memory and storage. Add Intel Optane persistent memory (PMem) to DRAM to increase memory capacity and reduce costs for similar performance.<sup>1,2</sup> Add Intel Optane Solid State Drives (SSDs) to traditional flash storage to improve storage, reduce latency, and improve endurance.<sup>3,4,5</sup>

The challenge for IT organizations is that memory and storage solutions have historically been limited by capacity, performance, or cost. For example, traditional DRAM is great for in-memory processing of data at high speeds, but it's volatile, expensive, and limited in capacity and scalability. Flash storage, such as SSDs, offers greater capacity and a lower cost relative to DRAM, but it can't offer the same levels of performance. Hard-disk drives (HDDs) can provide massive storage at low prices, but spinning disks bring well-understood total-cost-of-ownership (TCO) issues around reliability, physical space requirements, cooling, and much more. These memory and storage limitations result in data center architecture gaps when trying to balance capacity, performance, and cost considerations.

### A flexible approach to memory and storage

The memory-storage landscape has evolved with innovative solutions. Companies across many industries have embraced Intel Optane technology to bridge the cost, performance, and capacity gap between DRAM and flash. Intel Optane technology is available in two forms:

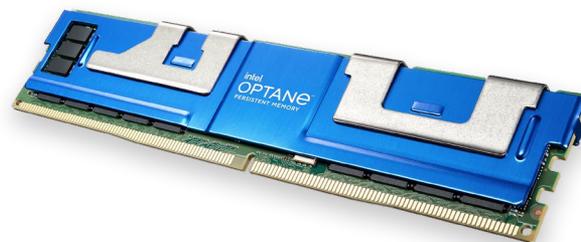
- Intel Optane PMem in a DIMM form factor increases memory capacity beyond DRAM limits at a lower cost.<sup>1,2</sup>
- Intel Optane SSDs increase performance, reduce latency, and deliver much higher endurance than flash drives.<sup>3,4,5</sup>



**Figure 1.** Intel Optane technology enables new memory and storage tiers

## Intel Optane PMem

Intel Optane PMem 200 series creates another tier of system memory and occupies DRAM slots. When paired with 3rd Generation Intel® Xeon® Scalable processors, Intel Optane PMem 200 series supports up to 6 TB of total memory per socket with consistent low latency for easy access to larger datasets. Intel Optane PMem is available in 128 GB, 256 GB, and 512 GB modules, and it is installed in proportion to DRAM, ranging from 1:1 to 1:8 ratios. Different usage models are available to meet different needs.



**Figure 2.** Intel Optane PMem coexists on the memory bus with DRAM

### Memory Mode: Transparent volatile memory capacity

In Memory Mode, Intel Optane PMem delivers large memory capacity that is transparent to the operating system and applications, with performance close to that of DRAM. There is no need to modify applications to use Intel Optane PMem in Memory Mode—it just works.

Intel Optane PMem makes a higher capacity of memory available at a lower price than traditional DRAM.<sup>1,2</sup> Larger memory capacities enable companies to process increasingly large datasets in memory, or to support more virtual machines (VMs) per server.<sup>6</sup>

### App Direct Mode: Non-volatile memory capacity

In App Direct Mode, Intel Optane PMem enables applications to bypass the operating system and kernel and access persistent memory directly. This consistently reduces latency for faster insights from data. This capability also provides higher capacity for in-memory databases such as SAP HANA.<sup>7</sup> Customers are finding value in Intel Optane PMem in a wide variety of workloads including artificial intelligence (AI), analytics, cloud infrastructure, virtualized infrastructure, and more.<sup>8</sup>

In App Direct Mode, data structures can also be made persistent even though they live in memory, which can help reduce reboot times and enables multi-terabyte capacity for large datasets without having to go from a 2-socket server to a more expensive 4-socket server.

### App Direct Mode: High-performance block storage

The specialized deployment method of App Direct Mode, known as Storage over App Direct Mode, provides high-performance block storage to applications that need it, avoiding the latency of moving data to and from the input/output (I/O) bus. This deployment method makes Intel Optane PMem address space accessible through standard file APIs. This allows existing applications to access the App Direct region of Intel Optane PMem modules without any modifications to the existing applications or the file systems that expect block storage devices.

## Intel Optane SSDs

Intel Optane SSDs are ideal for accelerating access to hot data with a combination of low latency, high quality of service (QoS), fast throughput, and high endurance at 100 drive writes per day (DWPD). Intel Optane SSDs provide the ability to accelerate, cache, or tier data, while consolidating the storage footprint to reduce infrastructure costs.

Unlike other SSD technologies, Intel Optane SSDs can read and write simultaneously without performance degradation.<sup>5</sup> Companies can optimize their storage investments by deploying a small number of Intel Optane SSDs for efficient acceleration, caching, or tiering in front of large flash SSD capacity storage.

In contrast to traditional flash-based SSDs, Intel Optane SSDs aren't limited to a "sweet spot" for peak performance. Intel Optane technology provides high random read/write performance, along with consistent, low latency that is ideal for demanding database applications that require frequent, high-speed caching, logging, or journaling. Businesses can take advantage of this benefit by deploying Intel Optane SSDs to accelerate caching, as an alternative to using large quantities of costly, limited-capacity DRAM. With this strategy, organizations can deploy a high-speed, high-endurance tier of Intel Optane SSDs for caching, and they can use NAND flash-based SSDs as capacity storage.



**Figure 3.** The Intel Optane SSD P5800X is the fastest data center SSD in the world<sup>9</sup>

Intel Optane SSDs also offer high endurance and QoS, which makes them a good fit for write-intensive uses, such as online transaction processing (OLTP), high-performance computing (HPC), and data caching and logging.

In particular, Intel Optane SSDs provide consistent, high performance under load, reaching peak performance at low queue depths (QDs), where nearly all real-world applications operate. In comparison, traditional storage drives often reach optimum performance levels only at higher QDs—beyond the usable range of most applications. Peak performance at higher QDs looks impressive with the artificial test workloads used for marketing materials, but it does not accurately reflect real-world drive performance. As a result, Intel Optane SSDs offer enhanced performance for applications in real-world use cases, compared to NAND flash-based SSDs.

**Table 1.** Comparison of Intel Optane memory and storage



Interface	Memory channel	PCIe 4.0 bus
Capacity	Up to 512 GB per DIMM	Up to 1.5 TB per SSD
Intel platform	3rd Generation Intel Xeon Scalable processors	Any
Function	Persistent memory (App Direct Mode) Volatile memory (Memory Mode)	Persistent storage
Form factor	DDR4 DRAM DIMM	U.2, M.2, and AIC
Operating system	Windows, Linux, and VMware ESXi	Any

## Conclusion

Intel Optane technology modernizes memory and storage infrastructure, unlocking new business value through more affordable, faster access to larger datasets. Organizations running analytics, AI, content delivery, and real-time processing can optimize system performance, capacity, and cost by deploying Intel Optane PMem and Intel Optane SSDs. This multi-tier memory and storage approach is game-changing. You can add Intel Optane PMem to DRAM to increase memory capacity while reducing costs, and you can add Intel Optane SSDs to traditional flash to accelerate performance and reduce latency.

Learn more at:

[intel.com/optane](https://intel.com/optane)



<sup>1</sup> Higher capacity: Intel® Optane™ PMem modules come in 128 GB, 256 GB and 512 GB capacities, vastly larger than DRAM modules that typically range from 16 GB to 64 GB, though larger DRAM capacities exist. For more details, see the frequently asked questions section at: Intel. "Memory Optimized for Data-Centric Workloads." [intel.com/content/www/us/en/architecture-and-technology/optane-dc-persistent-memory.html](https://www.intel.com/content/www/us/en/architecture-and-technology/optane-dc-persistent-memory.html).

<sup>2</sup> Lower costs per VM by up to 25 percent while delivering the same performance. Source: Claim 3 at: Intel. "Intel® Optane™ Persistent Memory 200 Series – performance index." <https://edc.intel.com/content/www/us/en/products/performance/benchmarks/intel-optane-persistent-memory-200-series/>.

<sup>3</sup> Improve storage: up to 9x higher throughput than fastest NAND drives. Source: Claim 7 at: Intel. "Intel Optane SSD P5800X Series – Performance Index." <https://edc.intel.com/content/www/us/en/products/performance/benchmarks/intel-optane-ssd-p5800x-series/>.

<sup>4</sup> Reduce latency: up to 23x lower latency at 530K input/output operations per second (IOPS) than NAND drives. Source: Claim 5 at: Intel. "Intel Optane SSD P5800X Series – Performance Index." <https://edc.intel.com/content/www/us/en/products/performance/benchmarks/intel-optane-ssd-p5800x-series/>.

<sup>5</sup> Higher endurance: up to 20x more total terabytes written. Source: Claim 4 at: Intel. "Intel Optane SSD P4800X Series – Performance Index." <https://edc.intel.com/content/www/us/en/products/performance/benchmarks/optane-ssd-dc-p4800x-series/>.

<sup>6</sup> Intel. "Increase VM Density with Intel Optane Persistent Memory." [intel.ca/content/www/ca/en/architecture-and-technology/optane-persistent-memory-vm-density-demo.html](https://www.intel.com/content/www/us/en/architecture-and-technology/optane-persistent-memory-vm-density-demo.html).

<sup>7</sup> Double the database capacity for similar price and performance. Source: Intel. "Intel Optane Persistent Memory and SAP HANA Platform Configuration." February 2021. [intel.com/content/dam/www/public/us/en/documents/technical-specifications/sap-hana-and-intel-optane-configuration-guide.pdf](https://www.intel.com/content/dam/www/public/us/en/documents/technical-specifications/sap-hana-and-intel-optane-configuration-guide.pdf).

<sup>8</sup> See customer stories at: [intel.com/content/www/us/en/customer-spotlight/overview.html](https://www.intel.com/content/www/us/en/customer-spotlight/overview.html) | [intel.com/content/www/us/en/customer-spotlight/overview.html](https://www.intel.com/content/www/us/en/customer-spotlight/overview.html).

<sup>9</sup> Source: Claim 14 at: Intel. "Intel Optane SSD P5800X Series – Performance Index." <https://edc.intel.com/content/www/us/en/products/performance/benchmarks/intel-optane-ssd-p5800x-series/>.

Performance varies by use, configuration and other factors. Learn more at [www.intel.com/PerformanceIndex](https://www.intel.com/PerformanceIndex).

Performance results are based on testing as of dates shown in configurations and may not reflect all publicly available updates. No product or component can be absolutely secure.

Your costs and results may vary.

Intel technologies may require enabled hardware, software or service activation.

© Intel Corporation. Intel, the Intel logo, and other Intel marks are trademarks of Intel Corporation or its subsidiaries. Other names and brands may be claimed as the property of others.

Printed in USA

0322/SSAL/PRW/PDF

Please Recycle 350428-001US