TECHNOLOGY BRIEF

Data Center Memory and Storage Hierarchy
Intel® Optane™ Technology

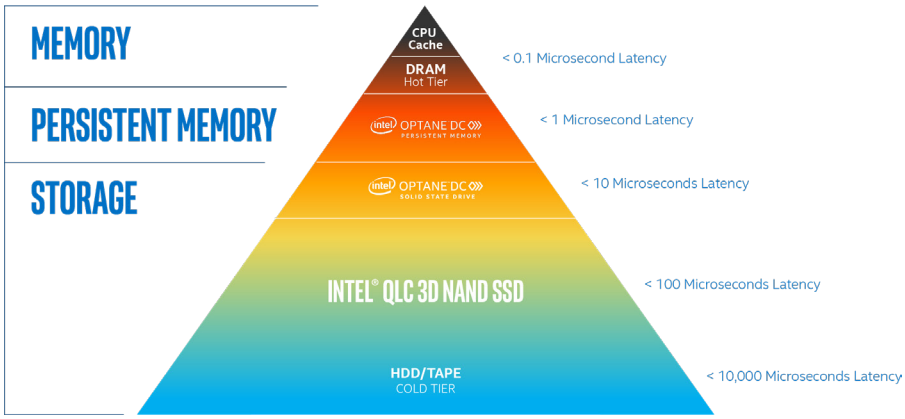
# Intel® Optane™ Technology

**Establishing new tiers in the memory and storage hierarchy, this innovative technology provides persistent memory, volatile memory, and persistent storage in multiple form factors.**

The challenge for storage architects 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 expensive and limited in capacity and scalability. NAND-based storage, such as traditional solid state drives (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 New Approach to Memory and Storage

Intel is pioneering a new approach for data center architectures that closes the gap between traditional memory and storage. The keystone to this approach is Intel® Optane™ technology. Intel Optane technology is not based on NAND; it's a whole new technology built on a unique architecture that allows memory cells to be individually addressed in a dense, transistor-less, stackable design.




*Intel® Optane™ technology fills memory and performance gaps in the data center*

### Memory and Storage Flexibility

One of the many benefits offered by the innovative architecture of Intel Optane memory media is that it can be deployed in a variety of form factors that can connect to either the memory channel or the storage bus to provide a range of memory and storage solutions for storage designers.

## Intel Optane Technology as Memory

**Intel Optane DC persistent memory in App Direct Mode** delivers Intel Optane technology as persistent memory modules, which plug into standard DIMM slots on the memory channel. Unlike traditional DRAM, Intel Optane DC persistent memory offers two important features to revolutionize memory and storage: persistence, which means data is retained even in the event of a power loss or restart, and high density—up to 512 GB per DIMM, which is double the maximum density of current DRAM DIMMs.

Applications that have been optimized for Intel Optane DC persistent memory avoid the significant software overhead of input/output (I/O) operations and instead benefit from much faster low-latency memory-access operations. This advantage enables organizations to transform their systems and services to deliver new advancements across a wide range of data center use cases, including improved analytics with in-memory databases, high-performance in-memory computing, artificial intelligence (AI), high-capacity virtual machines (VMs) and containers, and content delivery networks (CDNs).

Intel Optane DC persistent memory also significantly reduces in-memory database restart times because the database does not have to be reloaded into volatile memory after a shutdown. And with Intel Optane DC persistent memory, organizations can more affordably scale system memory capacity to unprecedented levels because the cost per gigabyte of memory is lower with Intel Optane DC persistent memory modules, compared to traditional DRAM DIMMs.

**Intel Optane DC persistent memory in Memory Mode** enables applications to make use of Intel Optane DC persistent memory as expanded volatile system memory. Memory Mode offers the advantage of additional system memory capacity (module sizes up to 512 GB), without needing to rewrite software.

## Intel Optane Technology as Storage

**Intel Optane DC SSDs** enable an entirely new storage tier between Intel Optane DC persistent memory and NAND SSDs that brings data closer to the processor for fast caching or fast storage of hot and warm data.

In contrast to traditional NAND-based SSDs, Intel Optane DC 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 DC SSDs to accelerate caching, as an alternative to using large quantities of costly, limited-capacity DRAM. With this strategy, organizations can deploy Intel Optane DC SSDs for caching, and high-capacity Intel® QLC NAND-based SSDs as affordable capacity storage.

Intel Optane DC SSDs also offer high endurance and quality of service, 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 DC SSDs provide consistent, high performance under load, reaching peak performance at lower queue depths, where nearly all real-world applications operate. In comparison, traditional NAND storage drives often reach optimum performance levels only at higher queue depths—beyond the usable range of most applications. Peak performance at higher queue depths does not accurately reflect real-world drive performance. As a result, Intel Optane DC SSDs offer enhanced performance for applications, compared to NAND-based SSDs.

*Comparison of memory and storage: Intel® Optane™ DC Persistent Memory DIMMs and Intel® Optane™ DC SSDs*

| | Intel® Optane™ DC Persistent Memory  | Intel® Optane™ DC SSD   |
|---|---|---|
| Interface | Memory Channel | PCIe* Bus |
| Capacity | Up to 512 GB per DIMM | Up to 1.5 TB per SSD, |
| Intel Platform | 2nd Generation Intel® Xeon® Scalable | Any |
| Function | Persistent Memory (App Direct Mode)<br>Volatile Memory (Memory Mode) | Persistent Storage<br>Volatile Memory (with Intel® Memory Drive Technology |
| Form Factor | DDR4 DRAM DIMM | U.2, M.2, AIC |
| Operating System | Windows*, Linux*, VMware ESXi* | Any |

Intel technologies may require enabled hardware, specific software, or services activation. Check with your system manufacturer or retailer.

Cost reduction scenarios described are intended as examples of how a given Intel-based product, in the specified circumstances and configurations, may affect future costs and provide cost savings. Circumstances will vary. Intel does not guarantee any costs or cost reduction.

Intel technologies' features and benefits depend on system configuration and may require enabled hardware, software, or service activation. Performance varies depending on system configuration. No product or component can be absolutely secure. Check with your system manufacturer or retailer, or learn more at intel.com.