

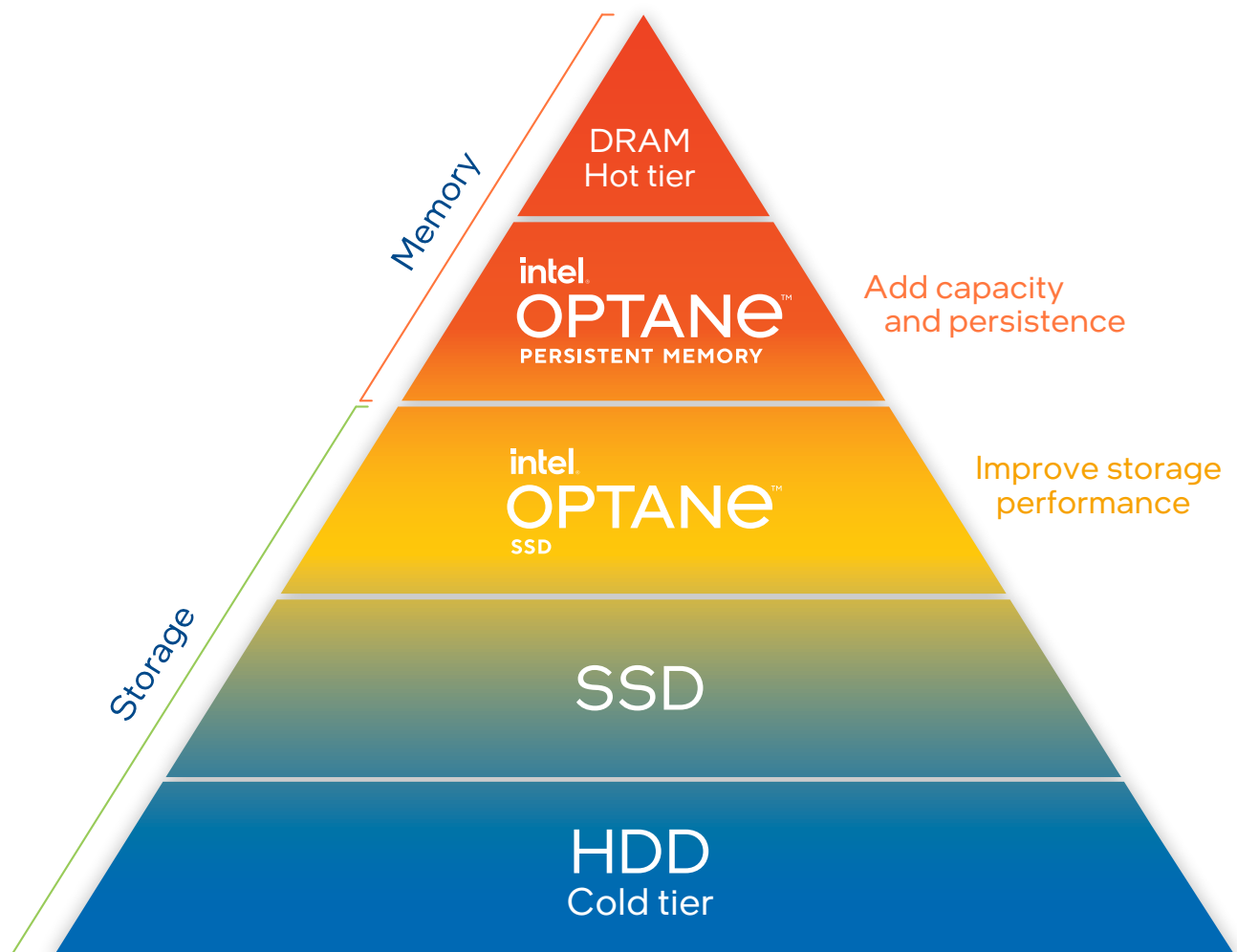
# Intel® Optane™ Technology FAQ

This document answers some frequently asked questions (FAQs) from IT administrators, business decision makers (BDMs), and system and storage architects about Intel Optane technology and data center products.

## Intel Optane technology

### What is Intel Optane technology?

- Intel Optane technology is a unique combination of memory media, controllers, interface hardware, and software intellectual property (IP). It is available in a variety of form factors that can attach either on the Intel® Xeon® processor-based memory channel or on a standard PCIe bus via NVM Express (NVMe).
- Intel Optane technology bridges the gap between fast-but-expensive DRAM and more affordable, but slower/higher latency, storage.



### How long has Intel Optane technology been in use?

Intel Optane technology was first released in storage products in 2017. Today, Intel Optane technology has a well-established ecosystem that includes leading software vendors. For example, SAP has optimized the SAP HANA database platform to make use of Intel Optane persistent memory (PMem), and VMware has optimized VMware vSAN and VMware vSphere for Intel Optane technology.

### What Intel Optane products are available?

- Intel Optane technology is available in a DIMM form factor as Intel Optane PMem, which attaches to the memory channel on supported systems built with 2nd or 3rd Gen Intel Xeon Scalable processors. In addition, NVMe Intel Optane Solid State Drives (SSDs) are available in U.2, M.2, and add-in card (AIC) form factors, and they can be attached to a PCIe bus for use as fast storage or cache with consistent, low latency.
- For a complete list of Intel Optane products and their statuses, see the [product specifications](#).

### What's the difference between Intel Optane PMem and Intel Optane SSDs?

- The underlying architecture of Intel Optane memory media gives it the flexibility to be used in different form factors, each with its own set of hardware controllers, interconnects, and software IP.
- Both Intel Optane PMem and Intel Optane SSDs are targeted for use as memory offload and very fast storage.
- Intel Optane PMem is attached directly to Intel Xeon Scalable processors via DDR-T/DDR-T2, and it can be used as a memory augmentation or for memory displacement in a software-transparent way by using two-level memory (2LM) caching support with Intel Xeon Scalable processors, or with software support in volatile App Direct mode.
- Intel Optane PMem directly attached to Intel Xeon Scalable processors can also be used as fast storage with software support in non-volatile App Direct mode, using the media as persistent memory or storage over App Direct.
- Intel Optane SSDs are attached via the common NVMe-over-PCIe protocol and are used as fast storage or fast memory offload.

#### Intel Optane SSD P5800X

- NVMe-over-PCIe bus
- U.2, M.2, AIC
- Up to 3.2 TB per SSD
- Persistent storage



#### Intel Optane PMem 200 Series

- Memory channel (DDR-T, DDR-T2)
- DIMM
- Up to 512 GB per module, 6 TB maximum memory
- Modes for volatile and persistent memory



### Is Intel Optane technology being discontinued?

Development of future products is being discontinued, but existing Intel Optane PMem and Intel Optane SSD products will continue to be supported and warranted through their full lifetimes.

## Intel Optane SSDs

### How are Intel Optane SSDs different from NAND SSDs?

The primary technology underlying Intel Optane technology products is inherently different from NAND. Intel Optane technology is transistor-less and byte-addressable, not block-addressable. Unlike NAND media, Intel Optane technology is also write-in-place media, meaning it does not need to be erased before being rewritten. As a result, Intel Optane products do not have garbage collection and spare block requirements like NAND devices. Intel Optane products are faster than NAND, with consistent low latency and high endurance, and they can read and write simultaneously at similar speeds.

### Do Intel Optane SSDs replace NAND SSDs?

Intel Optane SSDs are fully interchangeable with NAND SSDs, and they are functionally compatible and fully compliant with the NVMe specification. Both can be used simultaneously as part of a tiered capacity/performance hierarchy for storage in the data center. Intel Optane SSDs can be used as cache or to provide a faster tier of storage for write-intensive and latency-sensitive data operations.

### For what use cases would I want to choose Intel Optane SSDs?

- Intel Optane SSDs are ideal for hot or warm data that needs to be accessed often and quickly, either for tiering or for caching.
- Intel Optane SSDs excel at handling write-intensive storage operations, especially with small data transfers, like write-ahead logs, metadata, and caching, that can quickly wear out lower-endurance NAND SSDs.

## Intel Optane PMem

### How does Intel Optane PMem compare to DRAM?

Intel Optane PMem is available in much larger capacities than DRAM, at a lower cost-per-gigabyte. It is typically deployed in a volatile usage model, similar to DRAM, but can also be deployed with persistence so that data is retained in memory across a power cycle.

### Does Intel Optane PMem completely replace DRAM?

No, Intel Optane PMem requires a certain amount of DRAM to be installed alongside it. The proportions can vary depending on your performance, capacity, and cost requirements. Typically a small amount of DRAM is installed with a large amount of Intel Optane PMem in a 1:4 ratio.

### Does Intel Optane PMem support hardware encryption?

Yes, Intel Optane PMem supports industry-standard AES-256 encryption.

### Do I need to write code to run my application on Intel Optane PMem?

- No code changes are needed when using Intel Optane PMem in Memory mode with Intel Xeon Scalable processors. Intel Optane PMem provides cost benefits if substituted for more expensive DRAM.
- Intel Optane PMem can be configured to support persistent memory and to optimize performance with byte-addressable memory tiering. The configuration of Intel Optane in App Direct mode requires application-specific code.

### What's the difference between Memory mode and App Direct mode in Intel Optane PMem?

- Intel Optane PMem in Memory mode can be deployed without custom code changes to your applications. In this usage, Intel Optane PMem behaves like DRAM from the perspective of applications, although under the hood, the DRAM is acting as a fast cache for Intel Optane PMem capacity memory.
- Intel Optane PMem in App Direct mode enables persistence and lets you choose which data to store in DRAM and which to store in Intel Optane PMem. App Direct mode requires code changes to your applications to enable this functionality.
- Another use for App Direct mode is not for persistence, but to aggregate the DRAM and Intel Optane PMem capacity for a large, tiered memory bank. Open source software like Linux kernel memory tiering and Persistent Memory Development Kit (PMDK), in addition to commercial software like MemVerge Standard Edition, make use of this mode.

### What is memory tiering?

As with storage tiering, memory tiering describes the ability to deploy a range of memory options from lower latency/higher bandwidth/lower capacity to higher latency/lower bandwidth/higher capacity. Typically, the tiers of memory are referred to as near memory and far memory, with Intel Optane memory media being the far memory, and DRAM the near memory.

### Is memory tiering possible with Intel Optane PMem?

Yes, Intel Optane PMem was the first memory-tiering technology available on the market. You can make use of memory tiers by combining DRAM and Intel Optane PMem in App Direct mode or in Memory mode.

### What's the future of memory tiering?

The future of near and far memory tiering will utilize memory devices attached via Compute Express Link (CXL) to expand memory capacity and bandwidth, optimize for total cost of ownership (TCO), and share memory between compute devices. As a leading industry partner in the CXL Consortium, Intel is committed to supporting CXL as an industry-standard solution for providing additional memory-tiering options in the data center.

## Intel Optane technology and CXL

### What is CXL?

In 2019, Intel helped form the CXL Consortium with the goal of creating a standard to enable next-generation memory capabilities that address challenges associated with interconnecting processors, memory, and accelerators. The consortium's response is CXL, a technology designed to provide efficient resource sharing between CPUs and input/output (I/O) devices via a high-speed interconnect, optimized for high bandwidth and low latency.

### What are CXL technology-attached memory devices?

CXL memory devices are typically referred to as type 2 or CXL.mem devices. They have a PCIe Gen5 electrical interface and support the CXL protocol. They can be a CXL controller and board that allows for memory DIMMs to be added or an Enterprise and Data Center SSD Form Factor (EDSFF) with integrated memory.

### Does Intel support CXL?

Yes. Intel is a CXL Consortium board member and has contributed to each new release of the CXL specification. The Intel Xeon processor and field-programmable gate array (FPGA) product lines will support the CXL standard. To accelerate the maturation of the ecosystem, Intel is working with leading technology companies to test engineering samples of CXL 2.0 memory devices.

### Is Intel Optane PMem compatible with CXL?

There are no plans to develop further Intel Optane solutions based on the CXL standards. However, Intel Optane solutions are proven and readily available for data center deployments while CXL-based products are being developed.

### Does CXL replace Intel Optane PMem?

- CXL is a next-generation memory solution that extends the memory-tiering capabilities provided by Intel Optane PMem. However, it is not yet known how the pricing and performance characteristics of such devices will compare to Intel Optane PMem.
- The transition from Intel Optane PMem to CXL can be gradual, as server systems using Intel Optane technology can coexist in the data center with newer server systems that will support CXL.
- Much of the software ecosystem created for Intel Optane PMem will be functionally compatible with CXL memory devices. This software ecosystem will serve as a starting point to accelerate the maturity of software to support CXL-attached memory devices.

## What is the recommended roadmap to CXL?

- Upgrade your current servers to make use of Intel Optane PMem where possible to cost-effectively increase memory capacity.
- When replacing or adding servers, choose servers with Intel Optane PMem.
- For optimum performance, make use of software solutions such as SAP HANA that are optimized to use Intel Optane PMem in App Direct mode.
- Use Intel Optane PMem as a vehicle for pathfinding and as a proof of concept for moving architecture and software toward CXL-based memory tiering. Several memory-tiering software choices like Linux kernel memory tiering, PMDK, and MemVerge software are compatible with both Intel Optane technology and CXL memory tiering.
- As servers and devices that support CXL become available and mature, you can evaluate when to begin acquiring CXL systems to run alongside your fleet of Intel Optane PMem–equipped servers.

## Learn more about Intel Optane technology

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



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Your costs and results may vary.

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