Solution Brief

Data Centers | Tiered Memory

Reduce Memory Costs While Maintaining High Performance of Microsoft SQL Running on VMware vSphere and vSAN

Tiered memory with Intel® Optane™ persistent memory (PMem) reduces memory costs by up to 49%[1] while retaining similar OLTP performance and power consumption

Solution Benefits

Using Intel® Optane™ PMem with Microsoft SQL databases deployed on VMware vSphere and vSAN provides the following:

- **Reduced memory costs.** IT departments can use savings to spend on digital transformation and other innovations.[1]
- **Improved cost efficiency.** Increase memory capacity for a lower $/GB compared to DRAM.[1]
- **Same impressive performance.** Due to the technology of Intel Optane PMem, SQL performance is comparable to DRAM-only configurations at similar power consumption.[1]

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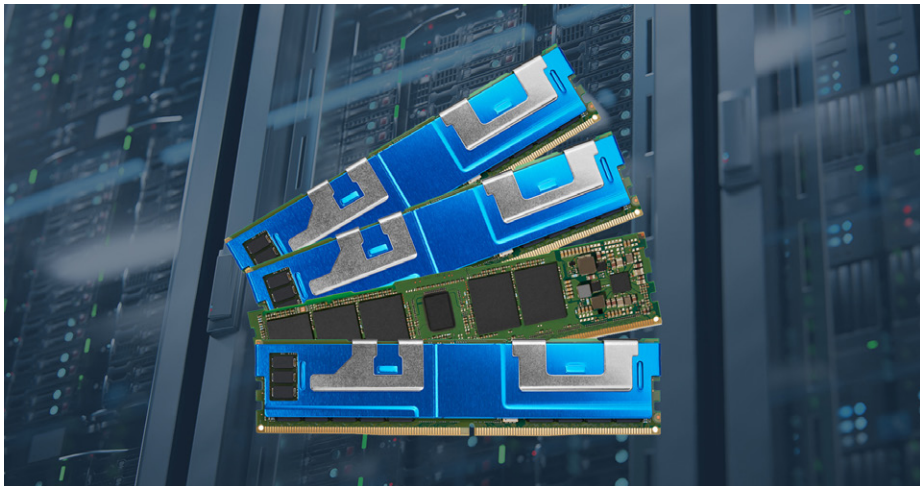
Executive Summary

E-commerce is built on online transactional processing (OLTP) and is essential to an increasingly digital-first world. OLTP applications require well-designed database solutions, such as Microsoft SQL, to store and process OLTP data. Performance of the database scales first and foremost with the amount of memory available and is critical to maintaining a consistent experience.

Benchmark tests reveal that deploying tiered memory with Intel® Optane™ persistent memory (PMem) supports the high-performance requirements of OLTP database servers while reducing memory costs by up to 49%.[1] In other words, Intel Optane PMem can be used to increase memory capacity for a lower $/GB compared to an all-DRAM system. Intel Optane PMem provides nearly the same user experience as DRAM-only configurations in terms of new operations per minute (NOPM) and with negligible impact to power consumption.[1] Tiered memory configurations are transparent to applications and require no software changes or modifications.

In summary, tiered memory with Intel Optane PMem reduces memory costs in virtualized SQL deployments and increases memory capacities, without sacrificing customer experience and impacting service-level agreements (SLAs).



Intel® Optane™ PMem presents the opportunity to reduce memory costs substantially, providing relief for increasingly constrained budgets.

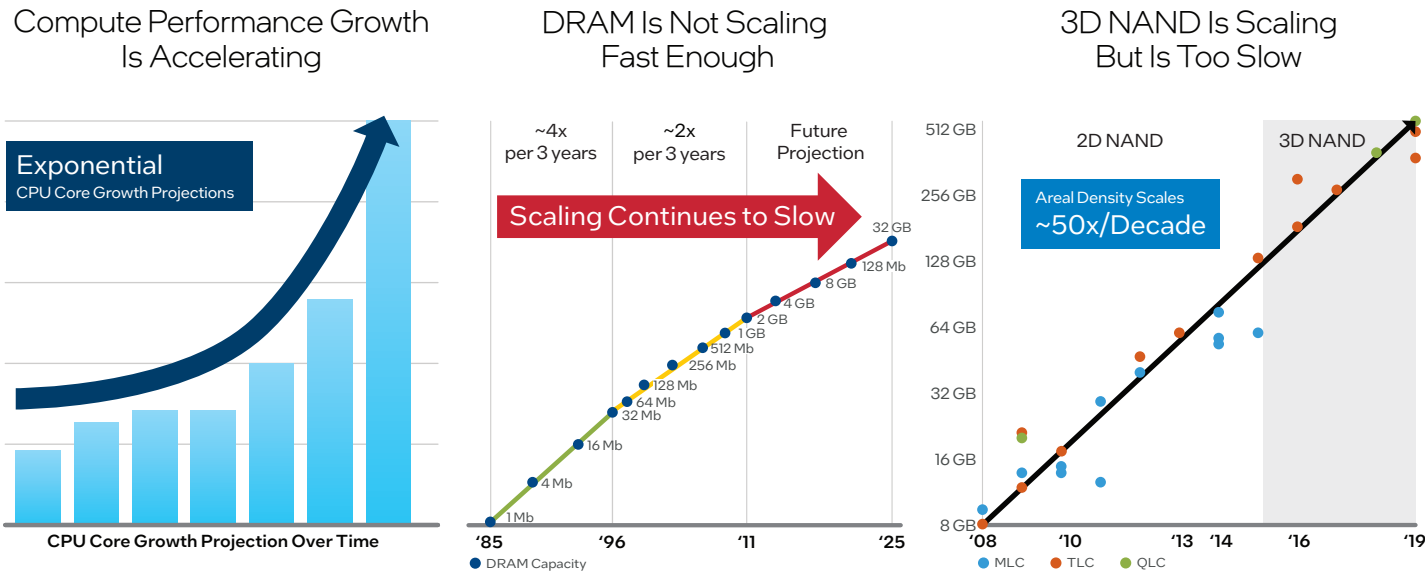


Figure 1. DRAM density is not increasing fast enough to handle today's OLTP growth, and 3D NAND latency is too high to meet performance needs.[3]

Business Challenge: OLTP Scaling Is Limited by DRAM Cost and Low Density

Online transactional processing (OLTP) for e-commerce is an important driver for strong database market growth between now and 2028. Enterprises spent USD 38.6 billion on database management systems (DBMS) in 2022—that number is expected to grow to USD 124.9 billion by 2028.[2]

As enterprises, telecommunications providers and cloud service providers struggle to scale their OLTP systems, a dilemma arises: adding more compute power is relatively easy, but DRAM density is not scaling fast enough to keep up with global data growth (see left-hand and middle portions of Figure 1).[3] 3D NAND density has increased much faster (see right-hand portion of Figure 1),[3] but accessing data from the storage subsystem can incur unacceptable latencies. Therefore, organizations must buy more DRAM as datasets grow in order to meet service-level agreements (SLAs).

The cost of DRAM at scale has increased faster than many IT budgets can accommodate, forcing IT departments to make difficult decisions. The issue is compounded by concerns about supply shortages, price increases, shipping delays and logistical issues. What if it were possible to scale memory without increasing hardware costs? Intel has the answer: Intel® Optane™ persistent memory (PMem).

OLTP and Virtualized Microsoft SQL

OLTP applications on Microsoft SQL are ideally suited for financial transactions, online retail and transportation bookings. OLTP use cases involve fast, effective querying across vast amounts of data where consumers expect real-time responsiveness. Businesses with e-commerce websites and data center IT management are seeking cost-effective solutions to address consumer expectations, comply with 24/7 SLAs, allow for scale and stay within budgets.

Hosting SQL databases on VMware vSphere and vSAN is a great way to optimize resource utilization and consolidate licensing costs. Adding Intel Optane PMem can help reduce costs even more, while maintaining high performance.[4]

> "Internal industry surveys commissioned by VMware over the years consistently show that approximately 75% of VMware customers have at least one Microsoft SQL Server database deployed and approximately 40% of VMware customers have at least one Oracle database deployed."[5]
>
> **— Todd Muirhead**
> Performance Engineer, VMware

Solution Value: Spend 49% Less on System Memory with Excellent User Experience[6]

Intel Optane PMem is a unique type of media with characteristics of both memory and storage, which in its standard configuration does not require any software application changes and is transparent to end users.

With tiered memory, a small amount of DRAM serves as a cache for the hottest data and the main system memory consists of cost-effective Intel Optane PMem. In virtualized Microsoft SQL deployments, a 2 TB tiered memory configuration can significantly reduce memory expenditures:

- Spend up to 49% less on memory compared to a DRAM-only configuration.
- Memory savings translate to a 26% cost reduction of the total system compared to the DRAM-only configuration, freeing up funds for additional scale investment.

As shown in Figure 2, we observed only a 5% difference in performance for tiered memory compared to DRAM only. In addition, the power consumption remained similar to the DRAM-only configuration (see Figure 3).

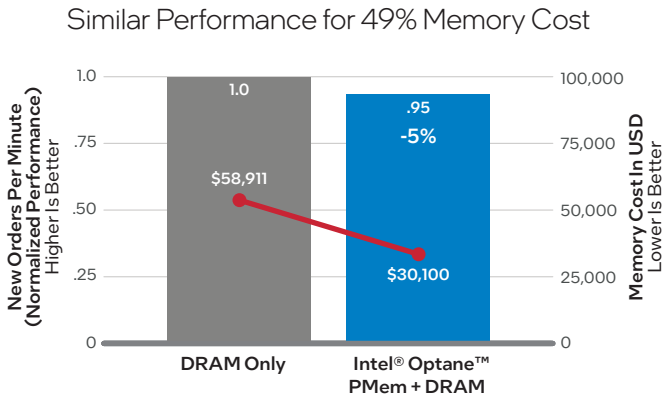


Figure 2. Intel® Optane™ PMem reduces memory cost by up to 49% while staying within five percentage points of DRAM-only performance.[6]

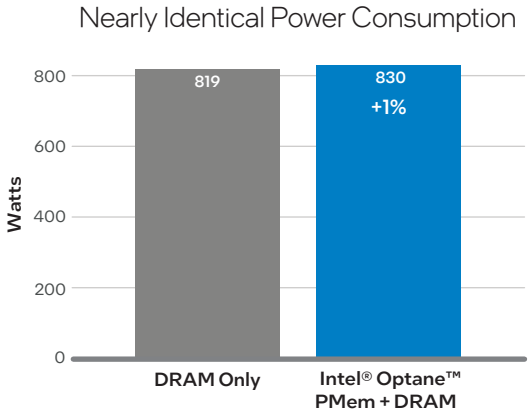


Figure 3. Power consumption remains similar between Intel® Optane™ PMem and the DRAM-only configuration, allowing organizations to take advantage of tiered memory without concerns about increased power costs.[6]

Solution Architecture: Tiered Memory for Virtualized SQL Deployments

A typical virtualized Microsoft SQL Server 2019 deployment is based on SQL running inside VMs on VMware vSphere. The system uses Intel Optane technology for both tiered memory and vSAN storage, specifically Intel Optane PMem for tiered memory and Intel Optane SSDs as the vSAN write buffer (see Figure 4).

As mentioned previously, DRAM acts as a memory cache and is not seen by SQL or the OS as part of system memory. As a rule of thumb, Intel recommends a DRAM-to-PMem ratio of 1:4. For example, a 2 TB OLTP system would use 512 GB of DRAM and 2,048 GB of Intel Optane PMem.

An Intel Optane PMem module has the same form factor as a DRAM DIMM and plugs into the same physical DIMM connectors on the memory bus. For most systems, on each memory channel, the DRAM DIMMs would be plugged into the first DIMM slot (slot 0), and the Intel Optane PMem DIMMs into the second slot (slot 1). The Intel Optane PMem best practices guide offers additional detailed information.

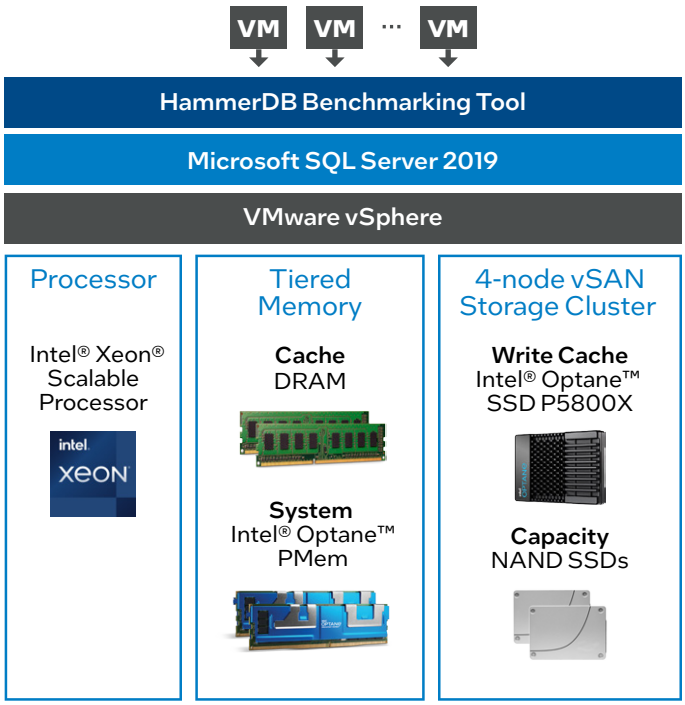


Figure 4. Intel® Optane™ PMem comprises main system memory (essentially a capacity tier), while a small amount of DRAM serves as a memory cache tier. For VMware vSAN, Intel Optane SSDs serve as a dedicated write buffer (cache).[6]

Conclusion

Microsoft SQL databases deployed on VMware vSphere and vSAN using Intel Optane PMem offer savings of up to 49%[6] compared to DRAM-only configurations. OLTP use cases, such as e-commerce applications, benefit from reduced memory costs with minimal impact to performance and power consumption. Intel Optane PMem paves the way for more cost-efficient tiered memory systems, providing customers — for the first time — with a choice in how they scale memory.

Learn More

You may also find the following resources useful:

- Tiered Memory Can Boost VM Memory Capacity and Lower TCO Solution Brief
- 3rd Generation Intel® Xeon® Scalable processors web page

For more details, contact your Intel representative or visit the website **Intel® Optane™ technology for data centers**.

Solution Provided By:

vmware® intel®

[1] Testing by Intel as of November 2022. Intel Optane PMem pricing and DRAM pricing referenced in cost calculations is provided for guidance and planning purposes only and does not constitute a final offer. Pricing guidance is subject to change and may revise up or down based on market dynamics. Please contact your original equipment manufacturer (OEM)/distributor for actual pricing.

Four hosts identically configured except for memory. **Common configuration:** 2x Intel® Xeon® Platinum 8358 processor (32 cores, 2.6 GHz); storage: 2x Intel® Optane™ SSD P5800X 400 GB for write cache, 6x Solidigm P5510 3.84 TB for capacity; Intel® Hyper-Threading Technology = ON, Intel® Turbo Boost Technology = ON; microcode = 0x0d000311; BIOS = SE5C620.86B.01.1.0004; network: 1x Intel® Ethernet E810-C 100 GbE for vSAN traffic (Intel® E810-CQDA2), 1x 10 GbE for management network. Software: VMware ESXi 7.0 U3 Build 18644231, Microsoft Windows Server 2019 Datacenter, Microsoft SQL Server 2019, HammerDB 4.2 TPROC-C, BIOS settings: Power–Performance.

DRAM-only configuration: 2 TB (32x 64 GB, 3,200 MHz), (baseline new orders per minute [NOPM], 819 watts power usage). Memory cost: $1,843.48 x 32 = $58,911.36; total system cost: $109,130.63; memory percentage of system cost: 54%. DRAM-only pricing as available on https://www.dell.com/en-us/buy/email/index/6388666?ac=90e65b80-7799-4942-93d2-5f8f4844b7c8 as of February 13, 2023.

DRAM + Intel® Optane™ persistent memory (PMem) configuration: 512 GB DRAM (16x 32 GB, 3,200 MHz) and 2,048 GB Intel Optane PMem (16x 128 GB, 3,200 MHz), (–5% NOPM, 830 watts power usage). Memory cost: DRAM cost = $907.56 x 16 = $14,520.96; Intel Optane PMem cost = $973.72 x 16 = $15,579.52; total memory cost = $30,100.48; total system cost: $80,079.58; memory percentage of system cost: 37.5%. DRAM + Intel Optane PMem pricing as available on https://www.dell.com/en-us/buy/email/index/6388660?ac=b50919df-2bda-4378-bf6d-c5d33f2ffe45 as of February 13, 2023.

[2] Business Research Insights, November 2022, "Enterprise Database Management System (DBMS) Market Size, Share, Growth, and Industry Analysis by Type."

[3] Source for left section of Figure 1: Intel. Results may vary.

Source for middle section of Figure 1: 3D NAND Technology – Implications for Enterprise Storage Applications by J. Yoon (IBM), 2015 Flash Memory Summit.

Source for right section of Figure 1: IEEE, February 2020, "3D NAND Technology Achievements and Future Scaling Perspectives."

[4] See endnote 1.

[5] VMware Core Metrics Survey 2019 (N=600).

[6] See endnote 1.