Solution Brief

Data Center | Tiered Memory

Reduce Memory Costs and Keep High Performance of Oracle Databases Running on VMware ESXi and vSAN

Create tiered memory by displacing DRAM with Intel® Optane™ persistent memory (PMem) to reduce memory costs by up to 54%[1] while retaining similar OLTP performance and power consumption

Solution Benefits

Using Intel® Optane™ persistent memory (PMem) with Oracle databases deployed on VMware ESXi and vSAN provides the following benefits:

- **Cost efficiency.** Increase memory capacity for a lower $/GB compared to DRAM.[1]
- **Free up budget.** As IT budgets stagnate, Intel Optane PMem helps reduce memory costs so IT departments can purchase more memory or use additional savings to spend on digital transformation and other innovations.
- **Same impressive performance.** Due to the unique nature of Intel Optane PMem, Oracle performance is comparable to DRAM-only configurations, with a similar power consumption as well.[1]

Executive Summary

Faced with flat IT budgets, system architects are always looking for ways to reduce hardware costs. On the other hand, providing a great user experience when performing real-time online transaction processing (OLTP) is also important for business success. Using DRAM is perhaps the best example of this conundrum. Keeping data in memory is crucial for fast Oracle queries, but as datasets grow, adding DRAM modules can be prohibitively expensive.

Intel® Optane™ persistent memory (PMem) is an effective solution to the DRAM problem. This unique technology acts as volatile memory in Memory Mode—with no software modification required—to implement tiered memory. In benchmark tests, Intel demonstrated that configurations running Oracle on VMware ESXi and vSAN, using Intel Optane PMem, provided nearly the same user experience as measured by new operations per minute, but also cut memory costs by up to 54%.[1]

Using Intel Optane PMem to displace costly DRAM in virtualized Oracle deployments on VMware ESXi and vSAN enables system architects to have the best of both worlds: lower costs while still meeting service-level agreements (SLAs) and satisfying end-user performance expectations.

Intel® Optane™ PMem presents the opportunity to reduce memory costs substantially, freeing up budget for whatever else is needed, such as more VMs and licenses, hardware accelerators or talent acquisition.

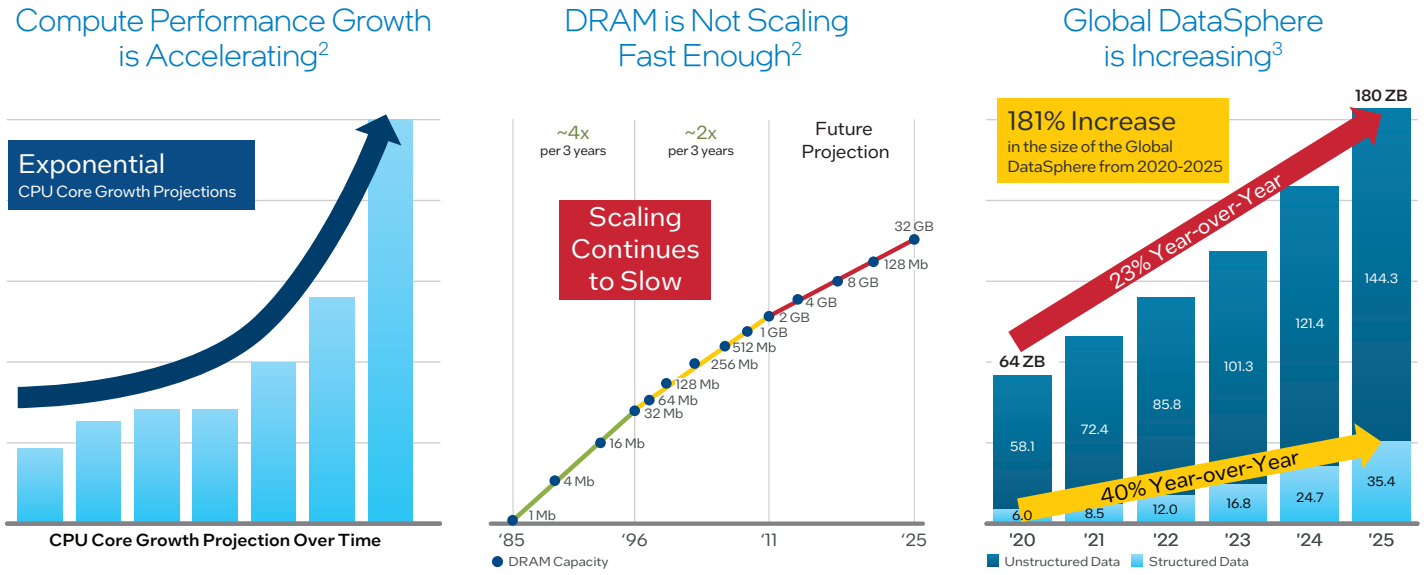

Figure 1. DRAM density is not increasing fast enough to handle today's data growth, which presents a cost barrier to scaling OLTP systems.

Business Challenge: DRAM Cost and Low Density Hinders OLTP Scaling

In response to the explosion of global data (see right-hand portion of Figure 1), online transaction processing (OLTP) is becoming more important than ever across nearly every industry. The Global DataSphere is expected to expand by 181% between 2020 and 2025.[3] Likewise, structured data, which accounts for the majority of data stored in databases like Oracle, has a compound annual growth rate of 40%.[4] As a result, database market growth is predicted to be strong between now and 2026. The general database management system (DBMS) market was valued at USD 63.1 billion in 2020 and is expected to reach USD 125.6 billion by 2026.[5]

As enterprises, cloud service providers and telecommunications providers struggle to keep their OLTP systems up to date, 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). Without enough system memory, data must be accessed from the storage subsystem, which can incur unacceptable latencies. Therefore, organizations are forced to buy more DRAM modules as datasets grow in order to meet service-level agreements (SLAs).

The problem is that DRAM modules are expensive, and IT budgets have historically remained relatively flat. The issue is compounded by concerns about shortages, price increases, shipping delays and logistical issues.[6]

What if there was a way to keep pace with OLTP data growth without increasing hardware costs? Intel has the answer: Intel® Optane™ persistent memory (PMem).

OLTP and Virtualized Oracle

Online transaction processing (OLTP) applications for which Oracle is ideally suited include financial transactions, online retail and transportation bookings. All of these use cases involve fast, effective querying and vast amounts of data. And in every case, end customers fully expect a real-time experience, while the data centers hosting the databases seek cost-effective solutions.

Hosting Oracle databases on VMware ESXi and vSAN is a great way to optimize resource utilization and consolidate licensing costs. Adding PMem can help reduce costs even more, while maintaining high performance.[1]

Solution Value: Spend 54%[1] Less per GB for System Memory with Excellent User Experience

Intel Optane PMem is a unique type of media with characteristics of both memory and storage. Using Intel Optane PMem in Memory Mode does not require any software application changes and is transparent to end users. (Memory tiering, in Memory Mode, is managed at the CPU level.)

With tiered memory, a small amount of DRAM serves as a cache for the hottest data and the main system memory comprises affordable Intel Optane PMem. In virtualized Oracle deployments, this means that a 1 TB or 2 TB system memory capacity can cost just a fraction of what DRAM-only configurations would cost, while still providing an excellent user experience.

As shown in Figure 2, for the 1 TB test of Intel Optane PMem versus DRAM alone, we observed a less-than-0.1% difference in performance. In this scenario, the 40% CPU utilization indicates that we had a moderate load in the system. In the 2 TB comparison, the databases were consuming 75% of the CPU, performing almost twice the number of transactions than the 1 TB system. At this high system utilization level, we observed a less-than-5% difference in performance compared to DRAM only. In addition, for either the 1 TB or 2 TB system, the power consumption remained similar to DRAM-only as well (Figure 3).[1]

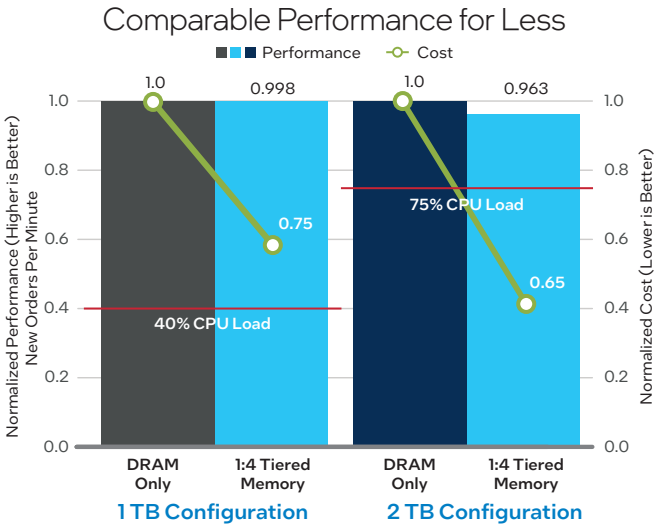

Figure 2. Intel® Optane™ PMem performance is within a few percentage points of DRAM-only performance, while providing the same memory capacity for 54% less cost.[1]

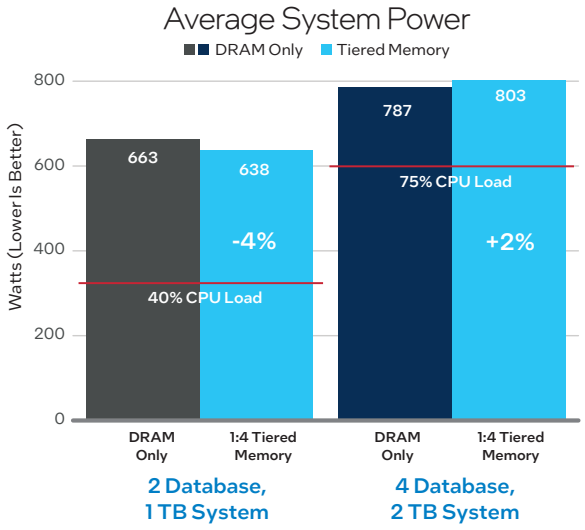

Figure 3. Power consumption remains similar between Intel® Optane™ PMem and DRAM for both the 1 TB and 2 TB systems, meaning organizations can take advantage of tiered memory without worrying about increased power costs.[1]

Solution Architecture: Tiered Memory for Virtualized Oracle Deployments

Figure 4 illustrates a virtualized Oracle 19c deployment that uses Intel Optane technology for both tiered memory and vSAN storage—Intel Optane PMem in Memory Mode for tiered memory and Intel Optane SSDs as the vSAN write buffer. Oracle runs inside the VMs on the VMware ESXi hypervisor.

As mentioned previously, the DRAM acts as a memory cache and is not seen by Oracle or the OS as part of system memory. As a rule of thumb, for databases like Oracle, Intel recommends a ratio of 1:4 for DRAM and Intel Optane PMem. For example, a 2 TB OLTP system would use 2,048 GB of Intel Optane PMem and a quarter of that amount—512 GB—of DRAM.

An Intel Optane PMem module looks very much like a DRAM DIMM and plugs into the same physical DIMM connectors on the same memory bus. For most systems, on each memory channel, plug the DRAM DIMMs into the first DIMM slot (slot 0), and the Optane PMem DIMMs in the second slot (slot 1). Refer to the Intel Optane PMem best practices guide for additional information.

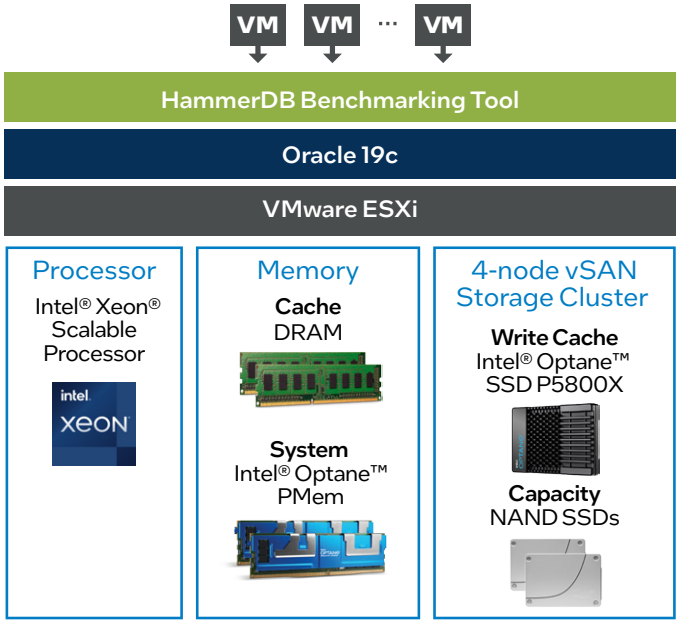

Figure 4. In Memory Mode, Intel® Optane™ PMem comprises main system memory (essentially a capacity tier), while a small amount of DRAM serves as a memory cache tier. For VMware vSAN, Intel Optane SSDs serve as a dedicated write buffer (cache).

Conclusion

Intel Optane PMem offers a singularly effortless way to cut costs for OLTP systems while enabling organizations to continue to meet SLAs. With savings up to 54%[1] compared to DRAM-only configurations, using Intel Optane PMem for virtualized Oracle deployments can free up IT budget for more VMs and licenses, new innovations, talent acquisition and more.

Learn More

You may also find the following resources useful:

- Tiered Memory Can Boost Virtual Machine Memory Capacity and Lower TCO
- 3rd Generation Intel® Xeon® Scalable processors

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 February 2022. Intel Optane PMem pricing and DRAM pricing referenced in total cost of ownership (TCO) calculations are 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. DRAM pricing as of February 2022. 4 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 SSD D7-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, Oracle Enterprise Linux 8.4, Oracle Database 19c, HammerDB 4.2 TPROC-C, BIOS settings: Power – Performance. **DRAM-only configurations:** 1 TB (32x 32 GB, 3200 MHz) and 2 TB (32x 64 GB, 3200 MHz).**DRAM + Intel® Optane™ persistent memory (PMem) configurations:** 1 TB system consists of 256 GB DRAM (16x 16 GB, 3200 MHz) and 1024 GB Intel Optane PMem (8x 128 GB, 3200 MHz). 2 TB system consists of 512 GB DRAM (16x 32 GB, 3200 MHz) and 2048 GB Intel Optane PMem (16x 128 GB, 3200 MHz).

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

[3] Source for middle section of Figure 1: https://flashmemorysummit.com/English/Collaterals/Proceedings/2018/20180809_NEWM-301A-1_Gervasi.pdf

[4] IDC, July 2021, #US47998321, "Worldwide Global DataSphere and Global StorageSphere Structured and Unstructured Data Forecast, 2021–2025," https://www.idc.com/getdoc.jsp?containerId=US47998321

[5] Datamation, February 2022, "Database Market for 2022," https://www.datamation.com/big-data/database-market/

[6] SWZD, "The 2022 State of IT," https://swzd.com/resources/state-of-it/