WHITE PAPER

DEFINING THE FUTURE OF IN-MEMORY DATABASE COMPUTING

INNOVATE TO THE NEXT >

Intel, SAP, and Accenture

deliver a solution for high-performance, high-capacity, low-cost memory that keeps pace with ever-increasing amounts of data

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WHITE PAPER

DEFINING THE FUTURE OF IN-MEMORY DATABASE COMPUTING

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SUMMARY BENEFITS OF SAP HANA® 2.3 ON INTEL® OPTANE™ DC PERSISTENT MEMORY

– Comparable latency with DRAM (direct random access memory); more capacity per dollar

- Greater capacity for in-memory databases at near-DRAM performance; memory support increase by 6X for online analytical processing (OLAP) and 3X for online transactional processing (OLTP)
- Data that is persistent remains available, even during power cycles
- 17X faster data loading at startup for enhanced business continuity
- Lower total cost of ownership (TCO)
- Data is more secure with AES-256 hardware-based encryption

AFTER YEARS OF DEVELOPMENT, THE NEXT-GENERATION OF MEMORY TECHNOLOGY HAS ARRIVED

Each year, data consumption and creation continues to grow by leaps and bounds. In fact, according to IDC, the sum of the world's data—the DataSphere—will grow from 33 zettabytes in 2018 to a mind-boggling 175ZB by 2025[1].

In today's data-centric world, it's clear that how data is stored is an increasingly important issue for businesses and a critical part of workload performance. For 30 years, systems have been built around the limitations of available technologies for data to reside, forcing businesses to choose between fast, volatile "main memory" or slow, permanent "storage." Businesses had to work applications around the large gap between these two options.

Despite ongoing innovation, data was sometimes unavailable when it was needed. As a result, systems were inefficient and lagging, and data insights could be slow.

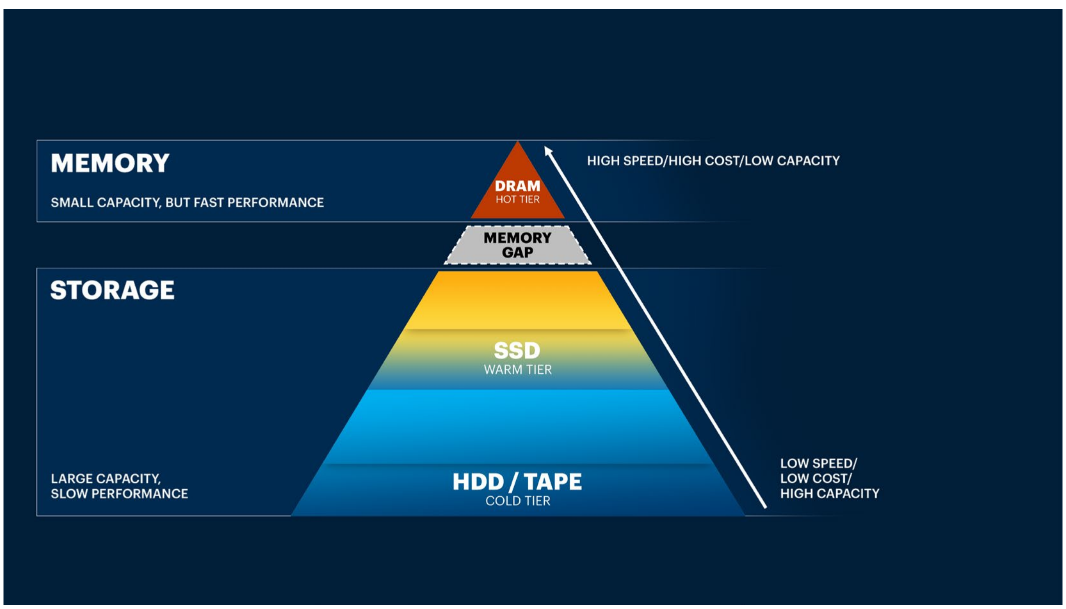

Figure 1. *Traditional storage pyramid*

[1] IDC white paper, sponsored by Seagate: "Data Age 2025: The Digitization of the World from Edge to Core," November 2018

For companies using the SAP HANA business data platform as their foundation for SAP and non-SAP applications, the rapid increase in database size creates a significant challenge because it:

- Drives up infrastructure costs—large-capacity systems with DRAM are expensive
- Hinders the migration of very large SAP environments into SAP HANA in-memory databases
- Forces enterprises to compromise by tiering their databases; which prevents the analytics engine from access to the full breadth and depth of data collected
- Restricts companies from keeping all working data sets in their SAP HANA in-memory database platform

To overcome today's memory/storage challenge, greater capacity must be delivered at a lower cost. This is the objective of Intel® Optane™ DC persistent memory. By combining the positive features of memory and storage, Intel Optane DC persistent memory creates a new flexible tier in the memory/storage hierarchy.

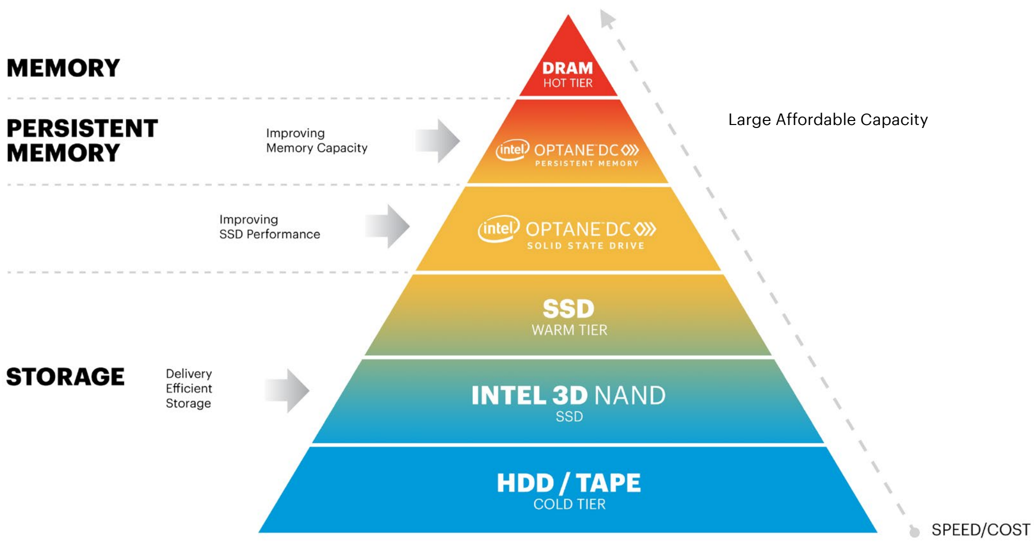

Figure 2. *Next-generation storage pyramid with persistent memory*

PARADIGM SHIFT

Intel Optane DC persistent memory bridges the gap between memory and storage—changing the historic data management paradigm. Until now, enterprises have used software and proprietary silicon solutions that hide the memory/storage gap, and they have grown accustomed to the pain points that accompany that gap (e.g., slow speeds and high costs). Today, those pain points are eased by Intel Optane DC persistent memory's new architecture, capacity, and cost-efficiency.

SOLUTION IN ACTION: EVONIK PROOF OF CONCEPT ILLUSTRATES REAL-WORLD PERFORMANCE AND TCO IMPROVEMENTS WITH INTEL OPTANE DC PERSISTENT MEMORY

Evonik strives to be a world-wide leader in producing sophisticated specialties chemicals for a variety of customer needs including 3D printing, tires, and sustainable farming. To understand the changing needs of its customers and the complex supply chain that supports them, Evonik relies heavily on real-time analytics and reporting. Evonik also depends on innovative technology to keep up with its infrastructure needs. To support real-time insights, Evonik's infrastructure needs include creating greater in-memory database capacity without sacrificing time or cost.

The organization wanted to reach the next level in total cost of ownership (TCO) efficiency. To reach this goal, Evonik worked with Accenture to implement servers using "2nd Generation Intel® Xeon® Scalable processors—Intel Optane DC persistent memory. Previously, Evonik's sole option for increasing memory capacity was limited to investing in larger servers. With Intel Optane DC persistent memory, Evonik can now invest in persistent memory modules. Doing so gives Evonik the flexibility to integrate data sets into its SAP HANA platform more efficiently. Whether data sets grow over time or by acquisition, Evonik is now well positioned to process far larger data sets faster as a result of the Optane DC persistent memory adoption.

In a recent proof of concept with Accenture, Intel, and SAP, Evonik found that with Intel Optane DC persistent memory, the company can save time during data table reloads after the server was restarted. Faster data loading at startup allows for shorter maintenance windows for SAP HANA patching or configuration changes. In a stable SAP HANA environment with a large memory footprint that supports both Intel Optane DC persistent memory and DRAM, Evonik can achieve a lower TCO. With less server downtime for its SAP HANA systems, there is also more time for productivity.

PoC objectives	Test approach	Findings
• Prove capacity increase by identifying ideal DRAM/Intel Optane DC persistent memory ratios. • Verify sizing and system requirements by focusing on the ratio between DRAM and Intel Optane DC persistent memory. • Perform tests with productive Suite on HANA and S/4HANA data from Evonik to simulate an analytics workload and custom queries to support business operations.	• Stage 1, Suite-on-HANA: Test environment provisioning and data/system exploration • Stage 2, Suite-on-HANA: Preliminary testing, dataset analysis • Stage 3, S/4 HANA: Agile test scenarios, test results analysis	• **System performance sustained** – HANA Cockpit reported sizeable queries resulted with comparable performance to typical DRAM workloads. • **Shorter system start-up time** – Test results confirmed system startup time (initial load of tables) was reduced after data was loaded and settled in Intel Optane DC persistent memory. • **Adoption with ease** – Near-flat learning curves and minimal training was required to adopt the Intel Optane DC persistent memory to provision the system for new installations and management of SAP HANA systems. • **Migration to be well planned** – Carefully analyzed the source system and developed a suitable migration approach for existing systems with significant database sizes. • **Stable system** – A stable system was established to support testing activities in a very short time. • **Ratio crucial for stable operation** – Proper sizing of the ratio between DRAM and Intel Optane DC persistent memory is the key for stable system operation.

Table 1: *Executive summary of Evonik proof of concept*[2]

[2] New configuration with a combination of DRAM and Intel® Optane™ DC persistent memory: Intel Lightning Ridge SDP with 4 x CXL QQ89 A0 processor (24 cores, 165W, 2.20 GHz). Total memory consists of 24 x 32GB DDR4* 2666 MHz and 24 x 128GB AEP ES2, and 1x Intel® SSD DC S3710 800GB, 3x Intel® SSD DC P4600 2.0TB, 3x Intel® SSD DC S4600 1.9TB TB capacity. BIOS version WW33'18. The operating system is SUSE* Linux* Enterprise Server 15 and uses SAP HANA 2.0 SPS 03 (a specific PTF Kernel from SUSE was applied) with a 1.3 TB dataset. Average start time for optimized tables preload (17x improvement).

INTEL OPTANE DC PERSISTENT MEMORY

A new approach to high-capacity memory technology from Intel

DRAM has supported main memory in servers for more than 30 years. However, DRAM is costly, and it is only available up to certain capacities—which limits some applications' ability to drive large memory footprints in DRAM.

To fill the gap between memory and storage, Intel Optane DC persistent memory offers much larger and more affordable capacity as compared to DRAM with performance latency near DRAM. The media, located inside the persistent memory chips, is significantly denser than typical DRAM cells, so much more data can be packed within a smaller space. This high density allows for much larger capacities—starting at 128GB and growing to 512GB—compared to the typical DRAM capacity of 64GB[3].

This new technology is persistent. Intel Optane DC persistent memory provides rapid recovery of applications because application data remains in memory even after a power failure. Intel Optane DC persistent memory is also anticipated to be less expensive than DRAM.

With Intel Optane DC persistent memory, a capacity of up to 4.5TB4[4] per socket can be reached vs. the previous generation platform's maximum 1.5TB capacity per socket[5]. This total memory capacity is a mix of Intel Optane DC persistent memory populated in conjunction with DRAM.

Intel Optane DC persistent memory fits into a regular DIMM slot, and it is only available on 2nd Generation Intel® Xeon® Scalable processors.

[3] 256GB DRAM are available, but it is more common for TCO reasons to populate 64GB DIMMs.
[4] SAP HANA recommends Intel Optane DC persistent memory 2-2-2 configurations. Maximum capacity is 4608GB per socket.
[5] Fully populated at 128GB DRAM, single socket capacity is 1.5TB. With Intel Optane DC persistent memory, at a 1:2 ratio of 256GB DRAM: 512GB DC persistent memory, 4.5TB can be achieved.

Intel Optane DC persistent memory modules at a glance

- Intel Optane DC persistent memory is a new flexible tier in the memory/storage hierarchy with the positive values of memory and storage.
- SAP HANA hardware of the future will most likely be based on Intel Optane DC persistent memory.
- With data persistence in memory, there is a 'nearly always on' experience... loading time is significantly reduced because the data is already loaded in memory and it doesn't have to be retrieved from storage.
- SAP HANA on Intel Optane DC persistent memory is a digital on-demand platform with faster data loading at startup, reduced from 50 minutes to 4[6] minutes— an order of magnitude faster.
- Intel Optane DC persistent memory is the way to support large datasets with scale to support analytics, AI & transactional processes.

Saving time and lowering latency with persistent data

This innovative new technology moves larger amounts of data closer to the CPU, so a larger set of data can be processed and analyzed in real-time without first being retrieved from storage. Intel Optane DC persistent memory is inherently persistent, so data remains intact even in the event of a power outage—enabling faster data loading at startup. Once an Intel Optane persistent memory cell captures data, it remains within the cell until altered or removed, even after a power cycle.

In addition, software developers can use this persistent memory as a working data space, as opposed to moving data back and forth in blocks using traditional storage—a time-saving benefit. Because Intel Optane DC persistent memory is byte-addressable, it enables the CPU to address data at the byte level, not the block level, which lowers latency.

Testing has demonstrated that DRAM latency is slightly lower than Intel Optane DC persistent memory and data that needs the lowest latency should be accessed by DRAM. Intel's persistent memory also demonstrated greater density and affordability.

[6] Results have been estimated based on tests conducted on pre-production systems, and provided to you for informational purposes. Any differences in your system hardware, softwareor configuration may affect your actual performance. Software and workloads used in performance tests may have been optimized for performance only on Intel microprocessors.Performance tests, such as SYSmark* and MobileMark*, are measured using specific computer systems, components, software, operations and functions. Any change to any of those factors may cause the results to vary. You should consult other information and performance tests to assist you in fully evaluating your contemplated purchases, including the performance of that product when combined with other products. For more information go to intel.com/benchmarks.

SAP HANA® simulated workload for SAP® BW edition for SAP HANA Standard Application Benchmark Version 2 as of 30 May 2018. Baseline configuration with traditional DRAM: Lenovo ThinkSystem SR950* server with 8 x Intel® Xeon® Platinum 8176M processors (28 cores, 165 watt, 2.1 GHz). Total memory consists of 48 x 16 GB TruDDR4* 2,666 MHz RDIMMS and 5 x ThinkSystem* 2.5" PM1633a 3.84 TB capacity SAS 12 Gb hot-swap solid-state drives (SSDs) for SAP HANA storage. The operating system is SUSE* Linux* Enterprise Server 12 SP3 and uses SAP HANA 2.0 SPS 03 with a 6 TB dataset. Average start time for all data finished after table preload for 10 iterations: 50 minutes.

Multiple operational modes

Knowing that today's enterprises have a wide range of requirements, Intel designed the Intel Optane DC persistent memory with a choice of operational modes.

- **Memory Mode**—In this mode, an application views Intel Optane DC persistent memory as main memory. The larger capacity translates directly to a greater virtual machine, container, and application density. Data is volatile while in Memory Mode. This mode makes Intel Optane DC persistent memory easy to adopt with no changes or modifications to the application required.
- **App Direct Mode**—With optimizations in the operating system and applications, users can take advantage of memory persistence in App Direct Mode. In this mode, applications view Intel Optane DC persistent memory and DRAM capacity as two separate pools—one persistent and one volatile. To boost performance, developers can configure their applications to optimize where data sets are placed.
  - ISVs must write applications to exist/operate in App Direct Mode.
  - SAP HANA is the first major database platform to be optimized with App Direct Mode.

Security

With persistent memory, data resides at rest within the module, which is a capability not available with DRAM. To ensure the security of data at rest, Intel Optane DC persistent memory applies 256-bit AES-XTP hardware encryption to all data stored in the persistent memory tier.

Two encryption keys are used in Intel Optane DC persistent memory. In Memory Mode, when the system powers down, the encryption key is lost. Upon start up, a new encryption key is generated. In App Direct Mode, persistent media is encrypted using a key on the module. The encryption key is stored in a security metadata region on the module, only accessible by the memory controller. Upon power loss, the module is locked, and a passphrase is needed to unwrap the key.

Cryptographic erase adds another level of security to the Intel Optane DC persistent memory. Even though data remains persistent within the originating system, cryptographic erase ensures the data is scrambled and irretrievable when moved to any other system. This erase function writes zeros across the data blocks, ensuring any old data is no longer accessible—unlike HDDs/SDDs where old data sometimes still lingers and is retrievable.

Security feature	Value
Full device data encryption	256b-AES-XTP encryption engine encrypts all user (host) data stored on Intel Optane DC persistent memory.
Internal key generation and wrapping	Internal digital random number generator (DRNG) and key management functions provide robust security and protection of internal key material.
Secure erase	Cryptographic erase removes the entire persistent memory region (used in App Direct Mode).
Runtime firmware protection	Mandatory access control for firmware assets protects the controller from firmware-based attacks.
Secure boot	Controller firmware is fully authenticated at boot by a read-only memory (ROMed) based root of trust.
Secure firmware update	Controller will only load authentic firmware signed by Intel's CSS (firmware rollback prevention).
Security interface	ATA security-based security commands manage security functions.
Firmware measurement and reporting	Digest of Intel Optane DC persistent memory firmware is calculated during boot and written to a host-visible measurement register.

Table 2: *Intel Optane DC persistent memory controller security features at a glance*

TESTED IN REAL-WORLD SAP ENVIRONMENTS

Up until now, enterprises have built systems to work around the memory/storage gap, and they have grown accustomed to the pain points that accompany that gap (e.g., slower speeds, slower data insights, higher costs, and/or sometimes the inability to move to new technology).

Recognizing the potential of this new technology, Accenture partnered with Intel and SAP to introduce Intel Optane DC persistent memory to its customers—wanting to highlight the value of this enterprise-ready technology. The Accenture team then began the next phase of development, which included a year-long collaboration to:

- Test and validate the performance and capabilities of the product through lab testing
- Prove the architecture by completing client beta tests

As one of the first systems integrators with comprehensive understanding of how to use and manage this disruptive new technology, Accenture is in the unique position of helping enterprise customers capitalize on it. Today, Accenture is actively working with its broad ecosystem of partners—enabling them to unlock the value of a multi-tiered memory environment that includes Intel Optane DC persistent memory.

PUTTING INTEL OPTANE DC PERSISTENT MEMORY TO WORK

Moving beyond the primary workloads of SAP HANA, Intel Optane DC persistent memory is well suited to handle a variety of other workloads, including:

- **Storage** – Remote direct memory access (RDMA) replication
- **Infrastructure** – Virtual machines, containers, application density
- **Databases** – In-memory databases, large/persistent caching
- **Artificial Intelligence** – Automated smart business processes including real-time analytics, machine learning, and deep learning
- **Communications** – Content Delivery Networks (CDN)
- **Transactions** – High volume transactional operations

Regardless of the workload, Intel Optane DC persistent memory is a revolutionary technology, delivering exceptional benefits enterprise-wide.

Time Savings	Greater Capacity	Enhaced Reliability	Lower TCO
Smoother data migration Based on a proof of concept (POC) performed at Evonik, SAP HANA running on Intel Optane DC persistent memory enables smoother data migration with low business impact and low system downtime. An additional benefit is a medium learning curve for data migrations; migration of existing SAP HANA databases requires reconfigurations and partitioning to realize the full potential of Intel Optane DC persistent memory. **Faster data loading at startup** Rebooting an SAP HANA large instance without Intel Optane DC persistent memory can take ~25 to 50 minutes to complete[7]. With Intel Optane DC persistent memory, the reboot is much quicker—as little as 4 minutes (less time is required for memory checks because the data is already prepopulated). **Faster analytics** Running reports based on old data can take hours, but reports run significantly faster when larger datasets are in Intel Optane DC persistent memory.	By offering greater capacity (up to 50TB or more in a scale-out configuration)[8], Intel Optane DC persistent memory enables enterprises to consolidate data and avoid investing in more servers to handle SAP HANA large instances for S/4HANA. Using the option to toggle the ratio between volatile and non-volatile memory, enterprises can achieve scale for their virtual machines.	During POCs, Intel Optane DC persistent memory with DRAM created a stable environment that experienced no unwanted system shutdowns.	Moving to large in-memory DRAM footprints can be costly, which has made the move to SAP HANA financially challenging for some companies. Intel Optane DC persistent memory delivers significant cost saving by reducing infrastructure cost and associated operating expenses.

[7] The restart time for each SAP HANA system will be different, based on the number of nodes, size of the database, underlying storage performance, network performance, etc.
[8] Maximum capacity in a scale-up configuration is 24TB (3TB x 8 sockets); 50TB capacity is based on an example configuration in various cloud service providers.

Learn More
Contact your Accenture Intel Optane DC persistent memory expert today to find out how you can deliver faster business insights and lower TCO.

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