The SAP HANA® platform altered the database landscape by providing an in-memory database-management system. While main memory is fast and provides SAP HANA a performance advantage, it is also volatile and doesn’t retain its contents during a server reboot, scheduled downtime, or power outage. When a server reboots, all SAP HANA data must be reloaded from storage, which can be time consuming. Intel is changing the game for in-memory databases with Intel® Optane™ DC persistent memory, a higher density, non-volatile memory technology that retains its contents like traditional solid state drives (SSDs) and spinning disks, yet provides speeds that are similar to main memory.

SAP HANA is the first major database platform to support Intel Optane DC persistent memory, which gives it the ability to expand beyond the density limitations of traditional memory while benefitting from the non-volatile capabilities of persistent memory. Combined with the power of SAP HANA 2.0 SPS 03 or a later version, Intel and SAP are ushering in a new generation of non-volatile in-memory technologies that promise to revolutionize the intelligent business.

This paper provides an overview of the benefits of combining servers equipped with Intel Optane DC persistent memory with SAP HANA, and it then provides a high-level overview of the physical server requirements and steps to configure Intel Optane DC persistent memory for use with SAP HANA.

Application Performance: A Key Driver for Success

Application performance is a requirement for succeeding in today’s business climate. Organizations rely on sophisticated applications, analytics, and database-management systems to provide a positive customer experience and to increase employee productivity. Customers demand constant availability and instantaneous responses, whereas employees rely on fast application performance from corporate databases and applications like enterprise resource planning (ERP) tools to get their jobs done as efficiently as possible.

Intel continually pushes the performance envelope with each new generation of Intel® Xeon® processor, system memory, and Intel® SSDs. As a result, Intel Optane DC persistent memory, a completely new class of memory, promises not only to continue the tradition of pushing the performance envelope, but to revolutionize application performance and capabilities.
Intel Optane DC Persistent Memory: A Revolution for Enterprise Computing

Enterprises with large data-storage requirements often use a tiered memory and storage architecture, or heat map, for different types of data and workloads. These tiers include:

- **“Hot tier” DRAM-based memory**: Among the main memory and storage tiers, DRAM-based main memory typically is the fastest memory available, but it is also the costliest, and it provides relatively low density when compared with other storage technologies. Data in DRAM does not persist when the server is rebooted or powered off. For in-memory database-management systems, such as SAP HANA, enterprises use DRAM to provide the fastest speeds possible. But DRAM capacities have not scaled as quickly as other storage technologies, such as flash-based SSDs and spinning disks, which limits the size of in-memory databases and the amount of memory available per processor. Access speed is measured in nanoseconds.

- **“Warm tier” flash-based storage**: Based on NAND memory, flash-based storage is less costly, but much slower than DRAM. Unlike DRAM, flash-based storage retains data when it is turned off, or when the device that contains the flash-based storage restarts. Data in this tier is frequently accessed, but not as often as hot-tier data. Examples of warm data include the financial data that drives monthly or quarterly reports. Access speed is measured in microseconds.

- **“Cold tier” spinning disk–based storage**: Based on hard disk drives (HDDs), this storage tier is the lowest cost storage, but it is slow compared to flash-based storage and DRAM. Spinning disk–based storage is most often used for archival data or big data that is infrequently accessed. For example, long-term data storage from Internet of Things (IoT) devices stored on Apache Hadoop* clusters often uses cold-tier storage. Access speed is measured in milliseconds.

Intel Optane DC persistent memory changes the data-storage landscape because it lets enterprises keep more data in the hot tier. Persistent memory provides near-DDR4 DRAM performance in the same dual in-line memory module (DIMM) slot as DRAM. It is also byte-addressable, just like DDR4 DRAM, but it provides the same persistence as flash- and disk-based block storage. This persistence means that data is retained across server reboots and power outages. In addition, while DRAM has traditionally been limited in size when compared to flash- and disk-based storage, persistent memory allows larger memory configurations at a cost that can drive down platform total cost of ownership (TCO).

**Persistent Memory Can Revolutionize Application Capabilities and Speed**

As data volumes grow and the need for fast analytics capabilities continues to increase, so does the need for larger memory capacities for in-memory databases. But with the size limitations of DRAM, enterprises have been unable to easily scale up their in-memory database deployments. The alternative has been scaling out using clustering and shared storage, but scale-out solutions can increase management complexity, introduce a performance penalty, and increase TCO.

Enterprises are also embracing new technologies such as artificial intelligence (AI) and machine learning. These technologies often require fast access to large datasets. Additionally, processing high-velocity data generated by technologies such as IoT places increased demands on in-memory database capacity.

Persistent memory brings new opportunities to in-memory databases and the applications that rely on them by providing higher memory density over DRAM. By keeping more data in memory, database-management systems and applications like SAP HANA, SAP S/4HANA®, and SAP® BW/4HANA benefit from the following:

- With greater memory densities, more data can move to the hot tier
- Drives new opportunities for memory-based applications like SAP HANA, SAP S/4HANA®, and SAP® BW/4HANA

**Figure 1.** Intel® Optane™ DC persistent memory provides new opportunities to expand the performance capabilities of in-memory databases by providing near-DDR4 DRAM speeds with the same persistence as flash- and disk-based storage.
• **No paging data from memory to disk:** Application code and data are maintained within persistent memory, which reduces the latency of transferring data from CPU cache to memory to disk. No context switching, interrupts, or kernel-code executions are required.

• **Data proximity to the CPU:** Persistent memory keeps data close to the CPU. Instead of requiring data to move across a peripheral bus from disk to memory, and then finally to the CPU, the data takes a much shorter route to move from persistent memory to the CPU. This proximity to the CPU improves the speed at which data can be accessed.

• **File-system support:** Persistent memory supports existing journaled file systems such as ext4* and XFS*. This feature provides the ability to store applications and data on persistent memory instead of slower flash-, spinning disk-, or storage area network (SAN)-based storage.

Intel Optane DC persistent memory also can provide 3 TB of persistent, byte-addressable storage capacity per socket. In a four-socket system, persistent memory can deliver up to 12 TB, whereas an eight-socket system can deliver 24 TB of byte-addressable storage that runs at near DRAM speeds. See Table 1 for socket- and memory-slot details. Persistent memory also provides higher endurance than enterprise-class SSDs, which reduces the risk of data loss from storage failures.

### SAP HANA 2.0 SPS 03 or Later Versions’ Support for Intel Optane DC Persistent Memory

Intel and SAP have collaborated to bring Intel Optane DC persistent memory support to the SAP HANA platform. By providing more memory for SAP HANA, enterprises can keep older data, typically stored in the warm data tier, in the hot data tier, which can help reduce data management complexity and TCO. In addition, the non-volatile nature and higher memory densities of Intel Optane DC persistent memory enable better business continuity solutions and provide a platform for emerging memory-intensive technologies.

**Higher Memory Densities Help Lower Total Cost of Ownership**

SAP HANA and application suites such as SAP S/4HANA and SAP BW/4HANA are ideal platforms for addressing the needs of the data-driven enterprise. However, organizations have experienced constraints due to DRAM’s stagnant memory density and higher cost; multiple SAP HANA nodes and complex data tiering strategies are often required to address the growing data needs. Intel Optane DC persistent memory addresses these issues by providing increased density, up to 24 TB of storage per server, which increases the memory scalability of SAP HANA, SAP S/4HANA, and SAP BW/4HANA.

Higher memory densities also enable more efficient use of hardware through system consolidation. Enterprises can scale up instead of scaling out to run larger transactional and analytics systems in the same physical hardware space, which reduces the data center hardware footprint of SAP HANA and lowers power and cooling costs. For example, Intel IT tested scaling up versus scaling out. The scale-up system provided 52 percent more memory capacity and 2.4 times better performance than the scale-out system.1,2

With more memory available, organizations can also dramatically simplify their SAP HANA deployment architecture by consolidating smaller DRAM-only SAP HANA nodes onto fewer nodes configured with DRAM and Intel Optane DC persistent memory. Organizations can also upgrade servers that support Intel Optane DC persistent memory with higher capacity memory modules as database sizes grow. With the ability to store more data in the hot and warm tiers, enterprises can simplify SAP HANA, SAP S/4HANA, and SAP BW/4HANA data-tier management, which helps lower management and infrastructure costs.

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**Figure 2.** Intel® Optane™ DC persistent memory improves performance and quality of service by eliminating data paging between DRAM and SSDs
Organizations can also combine transactional and analytical workloads onto single SAP HANA nodes, further reducing deployment complexity. With Intel Optane DC persistent memory, organizations can realize a 39 percent cost savings per database terabyte. Larger memory configurations also let enterprises run memory-intensive workloads, such as predictive analytics, in less time, which leads to greater operational efficiencies.

**More Memory Provides Efficient Business Continuity Solutions**

A robust business continuity solution is key to any business’s survival. With hardware solutions that make use of the expanded memory densities of Intel Optane DC persistent memory, enterprises can create more efficient and cost-effective business continuity solutions.

The larger memory capacity of Intel Optane DC persistent memory expands the architectural options available to enterprises that rely on SAP HANA for critical business needs. Smaller DRAM-based SAP HANA nodes at a primary site can replicate data to a larger, offsite node that contains Intel Optane DC persistent memory and DRAM. The offsite node can also be used for multiple purposes, such as quality assurance (QA) and development. In the event of a primary site failure, the larger node can take over the demands of the primary-site SAP HANA nodes until the primary site is restored.

SAP HANA deployments that use Intel Optane DC persistent memory no longer require data to be loaded from slower storage systems when the node is restarted, dramatically lowering data load times at startup and enabling a quicker return to operations. Faster loading times reduce recovery time, which can cost enterprises more than $100,000 for every hour of downtime. For example, Intel and SAP engineers demonstrated how a server, equipped with DRAM only and the SAP HANA 2.0 SPS 03 platform with 6 terabytes of data, required 50 minutes to start, including data loading. By contrast, a server equipped with a combination of Intel Optane DC persistent memory and DRAM reduced the start time of the SAP HANA 2.0 SPS 03 platform by 12.5x to only 4 minutes.

**Increased Memory Capacity Enables Emerging Technologies**

Larger datasets and the higher velocity data being driven by new technologies place additional strains on the traditional data-deployment model. DRAM’s lower memory density limits the amount of data SAP HANA and applications such as SAP S/4HANA and SAP BW/4HANA have available to them in the hot tier. As a result, more data must be stored in the slower warm and cold tiers.

The increased memory density and near-DRAM speed of Intel Optane DC persistent memory means SAP HANA can store more data in the hot tier, making low-latency access to greater amounts of data a reality for use cases such as artificial intelligence and machine learning. Larger data models and faster response times help lower the time required for training AI, which can help lower the time to value of AI deployments. Larger memory architectures are also ideal for capturing and processing high-velocity data, such as the data generated by large IoT deployments. Higher capacity also means more data can be maintained in memory to meet legal and compliance requirements while driving more robust real-time analytics across larger datasets.

**SAP HANA Scale-Out and Disaster Recovery Capabilities**

For organizations that require scale-out capabilities, SAP HANA 2.0 SPS 03 provides native extension-node support for the scale-out capabilities of SAP HANA extension nodes. SAP HANA extensions nodes, combined with the additional capacity of Intel Optane DC persistent memory, can provide seamless integration of analytical and transactional platform architectures. Hot-tier data within extension nodes is stored in persistent memory modules (Intel Optane DC PMMs) and DRAM. More data can be stored in persistent memory and accessed at near-DRAM speeds, which translates into less disk swapping and increased performance.

Up to eight times the amount of hot-tier SAP HANA data can be held in warm-data SAP HANA instances configured with Intel Optane DC PMMs and DRAM. Additionally, extension nodes can support an 8-to-1 ratio of persistent memory to DRAM, such as pairing 512 GB Intel Optane DC PMMs with 64 GB DRAM DIMMs. Note that persistent memory on a failed host is not accessible by a standby host. The SAP HANA services on the standby host must read data from disk into the host’s own persistent memory.

SAP HANA backup, recovery, and system replication function exactly the same with Intel Optane DC persistent memory. Backup and recovery operations work transparently with persistent memory in that backups save all persistence volume data without accessing persistent memory. Data can then be restored to the persistence volume. SAP systems engineers might consider deploying servers equipped Intel Optane DC persistent memory as replicated backup or disaster recovery nodes.

System replication also works transparently with Intel Optane DC persistent memory, and it can be used in a mixed environment with systems configured with or without persistent memory.

**Intel Optane DC Persistent Memory Configuration Considerations for SAP HANA**

This section discusses the following persistent memory configuration steps:

- Platform support and operating modes for persistent memory
- Hardware sizing for SAP HANA 2.0 SPS 03+
- DRAM-to–persistent memory ratios
- Memory-slot configuration and Intel Optane DC PMM placement
BIOS configuration
- Operating system support and configuration
- Enabling persistent memory support in SAP HANA

Platform Support and Operating Modes for Persistent Memory
Intel Optane DC persistent memory is supported on servers equipped with 2nd Generation Intel Xeon Gold processors and Intel Xeon Platinum processors. Two primary modes are supported: App Direct Mode, including Block over App Direct, and Memory Mode. App Direct Mode is the only mode that is currently supported by SAP HANA 2.0 SPS 03. In App Direct Mode, Intel Optane DC persistent memory modules appear as byte-addressable memory resources that are controlled by SAP HANA 2.0 SPS 03. In this mode, the persistent memory space is controlled directly by SAP HANA.

Hardware Sizing for SAP HANA 2.0 SPS 03+
Sizing for an SAP HANA deployment can be accomplished using a fixed core-to-memory ratio based on workload type, or by doing a self-assessment using the SAP HANA Tailored Datacenter Integration (TDI) approach and tools such as SAP® Quick Sizer.

The web-based SAP Quick Sizer tool can be used for greenfield sizing and for current production systems. The SAP Quick Sizer tool makes sizing recommendations based on the types of workloads that will be running on SAP HANA. Memory, CPU, disk input/output (I/O), network loads, and business requirements all play a part in determining the optimal configuration for SAP HANA.

Because DRAM is used in addition to Intel Optane DC persistent memory, the SAP Quick Sizer tool will take into consideration what data should be stored in DRAM and what data should be stored in Intel Optane DC persistent memory when making recommendations. Note that SAP HANA uses persistent memory for all data that resides in the column data store.

For more information about the SAP Quick Sizer tool, please see sap.com/about/benchmark/sizing.quick-sizer.html#quick-sizer.

DRAM–to–Persistent Memory Ratios
Intel Optane DC PMMs must be installed with DRAM DIMMs in the same system. Intel Optane DC PMMs will not function without any DRAM DIMMs installed.

In two-, four-, and eight-socket configurations, each socket contains two integrated memory controllers (IMCs). Each memory controller is connected to three double data rate (DDR) memory channels that are then connected to two physical DIMM/persistent memory slots. In this configuration, a maximum of 12 memory slots per CPU socket can be configured with a combination of Intel Optane DC PMMs and DRAM DIMMs. Table 1 lists the maximum number of memory slots available in various CPU socket configurations.

Table 1. Maximum number of memory slots available in common CPU socket configurations

<table>
<thead>
<tr>
<th>Number of CPU sockets</th>
<th>Maximum number of memory slots</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td>12</td>
</tr>
<tr>
<td>Two</td>
<td>24</td>
</tr>
<tr>
<td>Four</td>
<td>48</td>
</tr>
<tr>
<td>Eight</td>
<td>96</td>
</tr>
</tbody>
</table>

SAP HANA 2.0 SPS 03 currently supports various capacity ratios between Intel Optane DC PMMs and DIMMs. Ratio examples include:

- **1:1 ratio:** A single 128 GB Intel Optane DC PMM is matched with a single 128 GB DDR4 DIMM, or a 256 GB Intel Optane DC PMM is matched with a single 256 GB DRAM DIMM
- **2:1 ratio:** A 256 GB Intel Optane DC PMM is matched with a 128 GB DRAM DIMM, or a 128 GB Intel Optane DC PMM is matched with a 64 GB DDR4 DIMM
- **4:1 ratio:** A 512 GB Intel Optane DC PMM is matched with a 128 GB DDR4 DIMM, or a 256 GB Intel Optane DC PMM is matched with a 64 GB DRAM DIMM

Different-sized Intel Optane DC PMMs and DIMMs can be used together as long as supported ratios are maintained.
## Table 2. DRAM and Intel® Optane™ DC persistent memory allocations for 2nd Generation Intel® Xeon® Scalable processors

<table>
<thead>
<tr>
<th>Memory Configuration (System, PMEM + DRAM)</th>
<th>CPU Type</th>
<th>Capacity (GB) with # of CPUs</th>
<th>DDR/Intel® Optane™ DC Persistent Memory Ratio:1:X</th>
</tr>
</thead>
<tbody>
<tr>
<td>2DPC 128 GB Intel Optane DC persistent memory + 32 GB DRAM</td>
<td>BASE</td>
<td>960 1,920 3,840 5,760 7,680</td>
<td>4</td>
</tr>
<tr>
<td>2DPC 128 GB Intel Optane DC persistent memory + 64 GB DRAM</td>
<td>M</td>
<td>1,152 2,304 4,608 6,912 9,216</td>
<td>2</td>
</tr>
<tr>
<td>2DPC 128 GB Intel Optane DC persistent memory + 128 GB DRAM</td>
<td>M</td>
<td>1,536 3,072 6,144 9,216 12,228</td>
<td>1</td>
</tr>
<tr>
<td>2DPC 256 GB Intel Optane DC persistent memory + 64 GB DRAM</td>
<td>M</td>
<td>1,920 3,840 7,680 11,520 15,360</td>
<td>4</td>
</tr>
<tr>
<td>2DPC 128 GB Intel Optane DC persistent memory + 256 GB DRAM</td>
<td>L</td>
<td>2,304 4,608 9,216 13,824 18,432</td>
<td>0.5</td>
</tr>
<tr>
<td>2DPC 256 GB Intel Optane DC persistent memory + 128 GB DRAM</td>
<td>L</td>
<td>2,304 4,608 9,216 13,824 18,432</td>
<td>2</td>
</tr>
<tr>
<td>2DPC 256 GB Intel Optane DC persistent memory + 256 GB DRAM</td>
<td>L</td>
<td>3,072 6,144 12,288 18,432 24,576</td>
<td>1</td>
</tr>
<tr>
<td>2DPC 512 GB Intel Optane DC persistent memory + 128 GB DRAM</td>
<td>L</td>
<td>3,840 7,680 15,360 23,040</td>
<td>4</td>
</tr>
<tr>
<td>2DPC 512 GB Intel Optane DC persistent memory + 256 GB DRAM</td>
<td>L</td>
<td>4,608 9,216 18,432</td>
<td>2</td>
</tr>
</tbody>
</table>

### Memory-Slot Configuration and Intel Optane DC PMM Placement

While servers configured with Intel Optane DC persistent memory accept a number of different memory configurations, SAP HANA 2.0 SPS 03 only supports a 2-2-2 memory configuration per CPU socket.

In a 2-2-2 configuration, each of the IMC’s three DDR channels connect to two physical memory slots. To achieve the highest memory bandwidth possible, each DDR channel can contain a maximum of one Intel Optane DC PMM and one DRAM DIMM. The maximum number of Intel Optane DC PMMs and DRAM DIMMs is six per CPU socket. Each IMC requires a minimum of one DRAM DIMM, whereas Intel Optane DC PMMs can be placed in any slot.

### 2-2-2 Memory configuration

![Diagram of 2-2-2 Memory configuration]

Figure 3. SAP HANA® 2.0 SPS 03 and later versions support a 2-2-2 memory configuration per CPU socket.
For testing purposes, servers should be configured with the same capacity DDR4 DIMMs and Intel Optane DC PMMs in all 12 slots. Intel Optane DC PMMs should be placed in the slots closest to the CPU. If only six of the 12 memory slots per socket will be used, the best practice is to populate the slots of IMC 0 before IMC 1.

**BIOS Configuration**

Intel Optane DC persistent memory is enabled through BIOS settings. Because each server vendors’ BIOS layout is different, this section discusses general BIOS settings and pre-boot UEFI command-line utilities. To configure servers from a specific OEM, refer to the OEM’s server documentation for persistent memory-specific information.

Enabling Intel Optane DC PMM support in the BIOS generally follows these steps:

1. During the server boot process, enter the BIOS by pressing the key that activates the server’s BIOS settings.
2. Navigate to the BIOS option that correlates to the Intel Optane DC persistent memory configuration.
3. Select the option that enables persistent memory in read/write mode.
4. Save the changes and exit the BIOS.

Once Intel Optane DC persistent memory is enabled in the BIOS, you can use the UEFI shell or operating system tools for further configuration.

### Operating System Support and Configuration

The following operating systems support Intel Optane DC persistent memory and SAP HANA 2.0 SPS 03:

- SUSE Linux Enterprise Server (SLES) 15
- SUSE Linux Enterprise Server (SLES) 12 SPS4
- Red Hat Linux Enterprise Server (RHEL) 7

Once Intel Optane DC persistent memory is enabled in the server BIOS, it is then managed using either a UEFI pre-boot shell or from a supported operating system using the Intel Optane DC PMM command-line interface (CLI). Both the UEFI and operating system persistent memory CLIs provide similar management capabilities, including persistent memory discovery, provisioning, maintenance, and monitoring. The following sections describe the discovery process only. For more information on configuring Intel Optane DC persistent memory on Linux, please see [https://software.intel.com/en-us/articles/quick-start-guide-configure-intel-optane-dc-persistent-memory-on-linux](https://software.intel.com/en-us/articles/quick-start-guide-configure-intel-optane-dc-persistent-memory-on-linux).

### Discovery

Prior to provisioning Intel Optane DC persistent memory, you can use the Intel Optane DC PMM commands shown in Table 3 from either the UEFI shell or the Linux version of the Intel Optane DC PMM shell to display the Intel Optane DC PMMs and DRAM DIMMs installed on the system and to view information about the individual Intel Optane DC PMMs and DIMMs.

#### Table 3. Intel® Optane™ DC PMM discovery commands provide information specific to the physical persistent memory and DRAM configuration

<table>
<thead>
<tr>
<th>Intel Optane DC PMM Discovery Command</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>show -topology</td>
<td>Displays both the Intel Optane DC PMMs and DRAM DIMMs installed in the system</td>
</tr>
<tr>
<td>show -dim</td>
<td>Displays the Intel Optane DC PMMs installed in the system</td>
</tr>
<tr>
<td>show -a -dim</td>
<td>Displays detailed information about the Intel Optane DC PMMs</td>
</tr>
<tr>
<td>show -memoryresources</td>
<td>Displays how the Intel Optane DC PMM capacity is provisioned for the App Direct Mode and Memory Mode</td>
</tr>
</tbody>
</table>
Enabling Persistent Memory Support in SAP HANA

Once you have configured the Intel Optane DC PMMs, you must enable persistent memory support in SAP HANA using the following steps:7

1. **Create an ext4 or XFS file system on the persistent memory device:** Once you've created a namespace with mode “fsdax,” the namespace is assigned a device name by the operating system, usually /dev/pmemX, where X denotes the type of persistent memory device. Use either command-line or graphical user interface (GUI) tools to create an ext4 or XFS file system on the /dev/pmemX device.

   Example: mount -t xfs -o dax /dev/pmem0 /hana/pmem/SID/pmem1
   mount -t xfs -o dax /dev/pmem2 /hana/pmem/SID/pmem3

   If you are installing SAP HANA after configuring persistent memory, the SAP HANA installer will automatically configure persistent memory if it is able to identify a DAX-enabled file system and you confirm that you have persistent memory enabled. If you are reconfiguring an existing SAP HANA installation, continue to step 3.

2. **Mount the file system:** The file system must be mounted as a Direct Access (DAX) file system using the “-o dax” option at the command line, or the “dax” option in /etc/fstab.

   Example for an eight-socket server:
   ```ini
   [global.ini]
   [persistence]
   basepath_persistent_memory_volumes=/hana/pmem/SID/pmem0;/hana/pmem/SID/pmem1
   ```

3. **Set the SAP HANA base path:** The directory that SAP HANA uses as its base path must point to the journal ext4 or XFS file system created in the previous steps. The base path location is defined as a configuration parameter in the persistence section of the SAP HANA global.ini file. This section can contain multiple locations separated by semicolons. Changes to this parameter require a restart of SAP HANA services.

   Example for an eight-socket server:
   ```ini
   [global.ini]
   [persistence]
   basepath_persistent_memory_volumes=/hana/pmem/SID/pmem0;/hana/pmem/SID/pmem1
   ```

4. **Restart SAP HANA:** Once the previous steps are complete, restart SAP HANA.

   At startup, SAP HANA tests for a DAX-enabled file system at the location defined in the base path. Once SAP HANA verifies that the file system is DAX-enabled, all tables will use persistent memory by default. This default behavior can be overridden if necessary. Savepoints ensure that the contents of data in persistent memory are consistent with the persistence and data log volumes.

**Intel and SAP: The Next Generation of In-Memory Database Performance**

Intel Optane DC persistent memory changes the landscape of data storage by blurring the line between RAM and persistent storage. SAP HANA 2.0 SPS 03 takes advantage of the capabilities of Intel Optane DC persistent memory by natively supporting memory persistence while benefitting from greater memory capacities.

This paper can help you gain an understanding of the configuration steps needed to configure a server running Intel Optane DC persistent memory and SAP HANA 2.0 SPS 03. As more persistent memory–compliant server systems become available from leading OEMs, this overview can help you configure proof-of-concept systems that demonstrate the value of Intel Optane DC persistent memory and SAP HANA 2.0 SPS 03 for your customers. For more information, visit intel.com/sap or sap.com/persistent-memory, or contact field engagement engineering.
1 Pricing guidance as of March 15, 2019. Scale-up configuration: eight-node SAP HANA® 2 landscape. Per-node: 8-socket 2nd Generation Intel® Xeon® Platinum 8276M processors. Memory capacity per socket: 6 x 128 GB DDR4 2,133 MHz and 6 x 128 GB Intel® Optane™ DC persistent memory. Cost per terabyte on the scale-up system is $24,682.

Scale-out configuration: 21-node SAP HANA 2 landscape. Per-node: 4-socket 2nd Generation Intel Xeon Platinum 8276 processor. Memory capacity per socket: 12 x 64 GB DDR4 2,133 MHz. Cost per terabyte on the scale-out system is $44,991.

2 Performance results are based on testing as of March 12, 2019 and may not reflect the publicly available security updates. Baseline: three-node SAP HANA® 2 scale-out configuration (per node): 4 x Intel® Xeon® processor E7-8880 v3 (2.3 GHz, 150 W, 18 cores), CPU sockets: 4; RAM capacity: 64 x 32 GB DIMM. RAM model: DDR4 2,133 Mbps; storage: GPFS®, approximately 21.8 TB of formatted local storage per node, SAN storage for backup space only; network: redundant 10 gigabit Ethernet (GbE) network for storage and access, redundant 10G network for node-to-node; OS: SUSE* 12 SP2; SAP HANA: 2.0.035, GPFS: 4.2.3.10. Average time of 50 individual test queries executed 30–50 times each, for a total of approximately 25,000 steps: 2.81 seconds.

New configuration, one-node SAP HANA 2 scale-up configuration: CPU: 4 x 2nd Generation Intel Xeon Platinum 8260 processor (2.2 GHz, 165 W, 24 cores), CPU sockets: 4; RAM capacity: 24 x 64 GB DIMM. RAM model: DDR4 2,133 Mbps; Intel® Optane™ DC persistent memory: 24 x 128 GB PMM; storage: XFS*; 21 TB network: redundant 10 GbE network; OS: SUSE 15, SAP HANA: 2.0.035, Intel BIC: WW06. Average time of 50 individual test queries executed 30–50 times each, for a total of approximately 25,000 steps: 1.13 seconds.

Based on Intel testing as of March 1, 2019: base configuration: 10 systems with 4S Intel® Xeon® processor E7-8884 v4. 768 GB (12 x 64 GB) memory. Compared to: 5 systems with 4S Intel Xeon Platinum 8280L (28 cores), 2,304 GB (6 x 256 GB Intel® Optane™ DC persistent memory + 6 x 128 GB DRAM, 2-2-2, App Direct Mode). Base system included $35,590 on CPU, $33,994 on memory, $94,000 on storage, $7,603 on RDOM, and $0 on software, for a total of $101,189 (or $1,011,891 for 10 systems), $67,459 per TB of storage. Comparison configuration included $71,624 on CPU, $123,163 on memory, $54,000 on storage, $7,603 on RDOM, and $0 on software, for a total of $256,390 (or $1,281,950 for 10 systems; $42,732 per TB storage).


SAP HANA® simulated workload for SAP® BW edition for SAP HANA Standard Application Benchmark Version 2 as of 30 May 2016. Baseline configuration with traditional DRAM: Lenovo ThinkSystem SR650* 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 SSDs for SAP HANA storage. The operating system is SUSE® Linux® Enterprise Server (SLES®) 12 SP3 and uses SAP HANA 2.0 SPS 03 with a 6 TB dataset. Start time: 50 minutes.

New configuration with a combination of DRAM and Intel® Optane™ DC persistent memory: Lenovo ThinkSystem SR650 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 48 x 128 GB Intel Optane DC persistent memory modules (PMMs), and 5 x ThinkSystem 2.5” PM1633a 3.84 TB capacity SAS 12 Gb hot swap SSDs for SAP HANA storage. The operating system is SLES 12 SP3 and uses SAP HANA 2.0 SPS 03 with a 6 TB dataset. Start time: 4 minutes.

As of publication date, Red Hat support for Intel® Optane™ DC persistent memory is only available for SAP HANA®. See https://access.redhat.com/articles/3830541 for details.

2 More SAP HANA® persistent memory configuration information can be found at help.sap.com/viewer/6b94445c94ae495c83a19646e7c3fd56/2.0.03/en-US/1f61b13e096d4e89e82d678debf117e.html

No product or system can be completely secure.

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