Bringing the Memory Revolution to Your Intelligent Enterprise

Intel® Xeon® Scalable Processors and the SAP HANA® 2 Platform

Tim Allen, Intel Global SAP Alliance Manager
April 2019
The Next-Generation Platform for Digital Transformation
Decades of Intel and SAP Collaboration

Intel® Xeon® processors are tuned for SAP® workloads.

Intel and SAP have worked together on the SAP HANA® platform since 2009.

Intel Xeon processors are the reference architecture for the SAP HANA platform.¹

Intel Xeon Scalable processors and the Intel Xeon processor E7 v4 family are certified by SAP for the SAP HANA 2 platform.

¹ HP, INTEL, SAP, SUSE, AND VMWARE. “VIRTUALIZING ENTERPRISE SAP® SOFTWARE DEPLOYMENTS.” JUNE 2011. SUSE.COM/DOCUMENTATION/2012/VMWAREENTERPRISESAPSOFTWAREDEPLOYMENTS.PDF.

Performance results are based on testing as of the date set forth in the configurations and may not reflect all publicly available security updates. See configuration disclosure for details. No product or component can be absolutely secure.
Years of Innovative SAP HANA®
Performance Optimizations

2009

Intel® Microarchitecture
Codename Nehalem

Nehalem
45 nm
New Micro-architecture

Intel® Xeon® Processor E7

2019

SAP HANA on IBM Power*
GA Aug. 2015

Intel® Microarchitecture
Codename Sandy Bridge

Westmere
32 nm
New Processor Technology

Intel Xeon Processor E7 v2

Intel® Microarchitecture
Codename Haswell

Ivy Bridge
22 nm
New Processor Technology

Intel Xeon Processor E7 v3

Intel® Microarchitecture
Codename Skylake

Haswell
22 nm
New Micro-architecture

Intel Xeon Processor E7 v4

New Processor Technology

Intel Xeon Platinum Processor

New Processor Technology

Intel® Xeon® Platinum Processor

Cascade Lake
14 nm
New Processor Technology

BRIKLAND PLATFORM IS IVY BRIDGE® X, HASWELL® X, AND BROADWELL® X
PERFORMANCE RESULTS ARE BASED ON TESTING AS OF THE DATE SETFORTH IN THE CONFIGURATIONS AND MAY NOT REFLECT PUBLICLY AVAILABLE SECURITY UPDATES. SEE CONFIGURATION DISCLOSURE FOR DETAILS. NO PRODUCT OR COMPONENT CAN BE ABSOLUTELY SECURE.
Drive Innovation with Intel® Technologies and the SAP HANA® 2 Platform

Internet of Things (IoT) analytics at the edge, manufacturing, oil, and gas verticals

Intel® Optane™ DC persistent memory

Machine and deep learning tools and platforms, blockchain
Intel® Xeon® processors FOR the SAP HANA® platform
Intel® Xeon® Scalable Processors and SAP HANA® 2.0 SPS 03

- Designed for Intel® Optane™ DC persistent memory
- New data integration and federation sources
- Advanced data and privacy protection capabilities
- Many data types supported
- Broad analytical intelligence capabilities
- The ability to enable a new class of application security
Matching Memory to Your SAP HANA® Analytics Needs

PERFORMANCE

Up to 3 TB/CPU Memory
- Intel Xeon Processor E7-8890 v4
- Up to 3 TB/CPU Memory
- Intel Xeon Processor E7-8894 v4
- Up to 1.5 TB/CPU Memory
- Intel Xeon Platinum Processor 8180
- Up to 4.5 TB/CPU Memory
- 2nd Gen Intel Xeon Platinum Processor 8280

Note: The Intel Xeon Processor E7-8890 v4 and Intel Xeon Processor E7-8894 v4 are certified for up to 1 TB CPU of memory on SAP HANA 2, Service Pack 1, 2, 3. See Legal Notices and Disclaimers.

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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.
Intel® Xeon® Processor Advantage for SAP

HANA® Choice

12 OEMs, 1,300+ appliances/tailored data center integrations (TDIs), and no vendor lock-in

Proven
Track Record

• Top open, industry-standard ecosystem choice
• 9+ years of co-innovation with SAP HANA
• Long-term alignment
• Thousands of customers

Performance

All SAP® BW/4HANA world records are on Intel Xeon Platinum processors and Intel Xeon Scalable processors

Designed for 99.999% uptime

Up To 53% Better TCO

Compared to IBM Power*-based solutions

Scalability

Scale up
up to 48 TB

Scale out
up to 564 TB

4,5,6,7,8 See Legal Notices and Disclaimers. Performance results are based on testing as of the date set forth in the configurations and may not reflect all publicly available security updates. See configuration disclosure for details. No product or component can be absolutely secure.

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Performance results are based on testing as of June 2016 and September 2018 and may not reflect all publicly available security updates. See configuration disclosure for details. No product can be absolutely secure.
On-Premises, in the Cloud, and at the Edge

### On Premises

12 OEMs and 1,300+ certified appliances[^4]

- Bull
- Cisco
- Dell
- Fujitsu
- Hewlett Packard Enterprise
- Hitachi
- Huawei
- Inspur
- Lenovo
- NEC
- Supermicro
- VCE

### In the Cloud

Cloud offerings: PaaS, IaaS, SaaS, hybrid cloud, and managed private cloud on-premises

- SAP Cloud Platform
- Alibaba Cloud
- Amazon Web Services
- CenturyLink
- Google Cloud Platform
- IBM Bluemix™
- T-Systems
- Virtustream

### At The Edge

- Intel® IoT Platform
- SAP HANA® Cloud Platform

### Operating Systems

- SUSE
- Red Hat
- VMware

### System Integrators

- Accenture
- Deloitte
- Capgemini
- EY

[^4]: Offering server hardware choice for SAP HANA® on Intel® Xeon® processor-based solutions used by 12 OEMs versus SAP HANA on IBM Power Systems® used by only IBM. SAP.COM/COMPANY/SUPPORT/PRODUCTS/HANAHARDWARE/EN.MANUFACTURERS.HTML Performance results are based on testing as of the date set forth in the configurations and may not reflect all publicly available security updates. See configuration disclosure for details. No product or component can be absolutely secure.
SAP HANA® Tailored Customer Sizing
Flexibility for better total cost of ownership (TCO)

Tailored Datacenter Integration (TDI) for customer workload–driven SAP HANA system sizing.

Allows for:
• An optimal number of cores and memory
• Use of existing hardware
• A choice of OEMs

Latest advancement for SAP HANA in tailored customer sizing

Performance results are based on testing as of the date set forth in the configurations and may not reflect publicly available security updates. See configuration disclosure for details. No product or component can be absolutely secure.
SAP HANA® Tailored Customer Sizing v5
Self-certify your system using the SAP® Quick Sizer online tool

Easily translate business requirements into technical requirements

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Intel® Optane™ DC persistent memory SUSE support

• Persistent Memory Support:
  • SLES 15 or 12 sps4 & SAP HANA 2.3+
  • BIOS = App Direct Mode Only
  • Filesystem details:
    • DAX enabled XFS or ext4 filesystems
    • Enable journaling
    • ‘mount /dev/pmem’
Big Memory for Your Biggest Data Challenges

Intel® Optane™ DC persistent memory for the SAP HANA® platform
Today’s Data Management Challenges

The need for real-time insights, complex predictions from broad and diverse datasets, and getting more from your enterprise resource planning (ERP)

- **Dramatic increase in data volumes**
- **Data volume and IT cost management**
- **New demands on data**
- **Decreased time to value**

Performance results are based on testing as of the date set forth in the configurations and may not reflect all publicly available security updates. See configuration disclosure for details.

No product or component can be absolutely secure.
New Era of Data Center Technology

Data-Centric infrastructure

Move Faster
INTEL® SILICON PHOTONICS
INTEL® OMNI-PATH FABRIC
INTEL® ETHERNET ADAPTERS

Store More

Process Everything

Software and System-Level Optimized

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An Innovative, New Type of Memory

Extract more value from larger datasets than previously possible with Intel® Optane™ DC persistent memory

- Performance close to DRAM
- Low total cost of ownership (TCO)
- Data persistency
- DIMM Form factor
- Available in much larger capacities than DRAM
- Large DIMM SIZES
  - 128 GB, 256 GB, 512 GB

Performance results are based on testing as of the date set forth in the configurations and may not reflect all publicly available security updates. See configuration disclosure for details. No product or component can be absolutely secure.
Re-architecting the Memory/Storage Hierarchy

**Memory**

**Persistent Memory**

**Storage**

- **DRAM**
  - HOT TIER
- **HDD/TAPE**
  - COLD TIER
- **SSD**
  - WARM TIER
- **Intel® 3D Nand SSD**

Improving memory capacity

Delivering efficient storage

Improving SSD performance

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Traditional SAP HANA® Data Tiering Deployment

**DRAM**
- Fast performance, but costly, and with limited densities

**NAND SSDs**
- Affordable, but slower performance than DRAM

*Performance results are based on testing as of the date set forth in the configurations and may not reflect all publicly available security updates. See configuration disclosure for details. No product or component can be absolutely secure.*
**Intel® Optane™ DC Technology**

**Revolutionizes SAP HANA® Data Tiering**

*Intel Optane DC persistent memory*, combined with DRAM, expands the capacity of the “hot” data tier.  
*Intel Optane DC SSDs* increase performance for the “warm” data tier over NAND-based SSDs.  

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9,10 See [Legal Notices and Disclaimers](#) for details.
Intel® Xeon® Platinum Processors: 
The 2nd generation platform for digital transformation

Up to 3X
More capacity for online transaction processing (OLTP) workloads with Intel® Optane™ DC persistent memory compared to the Intel® Xeon® Platinum processor running SAP HANA® 2.0 SPS 03

Up to 6X
Greater system memory for online analytical processing (OLAP) workloads with Intel Optane DC persistent memory compared to the Intel Xeon Platinum processor

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11, 12 For configuration details, see legal notices and disclaimers.
SAP HANA® Appliance

OLTP maximum memory/socket certification\(^{13}\)

**Int e l Xeo n P l at inum pro c essor s del iver bal an ced memo ry“CP U rat io**

- Ivy Bridge\(\text{E X}\), Haswell\(\text{E X}\), and Broadwell\(\text{E X}\).

\(^{13}\) SAP. “Find Certified Appliances.” September 2018. SAP.com/IDM/OE/214-10/08/08/HANAHardware/NE/NAPPLIANCES.html.

**IN T EL X E ON PLAT I NUM PRO C E SSORS DEL I V E R A BAL A N C ED M E M ORY:CPU RATIO**

<table>
<thead>
<tr>
<th>Processor Type</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
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<tbody>
<tr>
<td>Intel® Xeon® Processor E7 v2</td>
<td>0.75</td>
<td>1.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intel Xeon Processor E7 v3</td>
<td>0.75</td>
<td>1.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intel Xeon Processor E7 v4</td>
<td>1</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intel Xeon Platinum Processor</td>
<td>1.5</td>
<td>1.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2nd Gen Intel Xeon Platinum Processor(^{**})</td>
<td>4.5</td>
<td>4.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:** 4.6 TB per socket allocation is not supported by SAP HANA on 8 socket configurations. SAP HANA supports up to 24 TB of memory on 8 socket configurations. Performance results are based on testing as of the date set forth in the configurations and may not reflect publicly available security updates. See configuration disclosure for details. No product or component can be absolutely secure.

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**Supported by the SAP HANA platform**

**Intel® platform**
Overcome SAP HANA® Data Management Barriers

With Intel® Optane™ DC persistent memory

Lower Platform TCO for SAP HANA
Consolidation of SAP HANA nodes can enable total cost of ownership (TCO) reductions

Build Better Business-Continuity Solutions
Deploy robust backup systems, disaster recovery & decrease database load on restart time

Increase Memory Capacity
Combine transactional and analytical workloads to support advanced use cases for both hot and warm data

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Lower Platform TCO

Intel® Optane™ DC persistent memory for the SAP HANA® platform
Consolidate Multiple Scale-up SAP HANA® Multitenant Transactional systems

SAP® ERC Central Component (ECC)
5 Servers, 15 TB DRAM
$67,459 Cost/TB

SAP® Supply Chain Management (SCM)
5 Servers, 15 TB DRAM
$67,459 Cost/TB

ECC + SCM in SAP HANA Multitenant Database
15 TB DRAM
30 TB Intel® Optane™ DC persistent memory
$42,732 Cost/TB

OLTP Consolidation
Scale-up to scale-up
With SAP HANA tenant databases
• Lower Cost
• Faster Startup Time
**Deliver More For Less with Intel® Optane™ DC Persistent Memory + SAP HANA®**

### More Capacity

| 3 TB DRAM + 6 TB Intel Optane DC persistent memory | = 9 TB TOTAL |

#### Go faster

**MINIMIZE DOWNTIME**

<table>
<thead>
<tr>
<th><strong>CPU</strong></th>
<th><strong>Memory</strong></th>
<th><strong>Restart time</strong></th>
<th><strong>Faster restart</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU: 4 Intel Xeon Platinum 8280M processor&lt;br&gt;MEMORY: 48 x 128 GB DDR4</td>
<td>24 x 256 GB Intel Optane DC persistent memory for 9 TB system</td>
<td>20 mins</td>
<td>13X</td>
</tr>
</tbody>
</table>

#### SAVE MORE

**Cost/DB Terabyte**

<table>
<thead>
<tr>
<th><strong>~$62,495 USD</strong></th>
<th><strong>~$38,357 USD</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU: 4 Intel Xeon Platinum 8280L processor&lt;br&gt;MEMORY: 2 x 128 GB DDR4 + 24 x 256 GB Intel Optane DC persistent memory for 9 TB system</td>
<td>CPU: 4 Intel Xeon Platinum 8280M processor&lt;br&gt;MEMORY: 48 x 128 GB DDR4</td>
</tr>
</tbody>
</table>

### Pricing Guidance

Pricing guidance as of March 1, 2019. Intel does not guarantee any costs or cost reduction. You should consult other information and performance tests to assist you in your purchase decision.

### Performance Results

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### Cost Savings

<table>
<thead>
<tr>
<th><strong>Cost Savings</strong></th>
<th><strong>39%</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>~$62,495 USD</td>
<td>~$38,357 USD</td>
</tr>
</tbody>
</table>

14, 15 For details, see [Legal Notices and Disclaimers](https://intel.com/notice).
“DELIVER MORE FOR LESS” CONFIG SUMMARY

1. **13x faster restart** time and **39% less cost** configs:

<table>
<thead>
<tr>
<th></th>
<th>Baseline Config (DRAM)</th>
<th>AD 2-2-2 Config</th>
</tr>
</thead>
<tbody>
<tr>
<td>System</td>
<td>Lightning Ridge (4S)</td>
<td>Lightning Ridge (4S)</td>
</tr>
<tr>
<td>CPU</td>
<td>Intel® Xeon® 8280M</td>
<td>Intel® Xeon® 8280L</td>
</tr>
<tr>
<td>CPUs per node</td>
<td>4-socket @ 28 core / socket</td>
<td>4-socket @ 28 core / socket</td>
</tr>
<tr>
<td>Memory</td>
<td>6TB 48x 128GB DDR4 @ 2666 MT/s</td>
<td>9TB 24x 256GB Intel® Optane™ DC PMEM</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24x 128GB DDR4 @ 2666 MT/s</td>
</tr>
<tr>
<td>Network</td>
<td>10 GbE Intel X520 NIC</td>
<td>10 GbE Intel X520 NIC</td>
</tr>
<tr>
<td>Storage</td>
<td>60x Intel SSD DC S4600 SATA 480GB TB</td>
<td>90x Intel SSD DC S4600 SATA 480GB TB</td>
</tr>
<tr>
<td>BIOS</td>
<td>WW48’18</td>
<td>WW48’18</td>
</tr>
<tr>
<td>OS or VM version</td>
<td>SUSE 15</td>
<td>SUSE 15</td>
</tr>
<tr>
<td>WL Version</td>
<td>Intel IT workload</td>
<td>Intel IT workload</td>
</tr>
<tr>
<td>SAP HANA* database size</td>
<td>3TB</td>
<td>6TB</td>
</tr>
<tr>
<td>Security mitigations</td>
<td>Variants 1,2,3 enabled</td>
<td>Variants 1,2,3 enabled</td>
</tr>
<tr>
<td>Date costs projected</td>
<td>March 1, 2019</td>
<td>March 1, 2019</td>
</tr>
</tbody>
</table>

1. **~39% less cost** pricing details:

Pricing Guidance as of March 1, 2019. Intel does not guarantee any costs or cost reduction. You should consult other information and performance tests to assist you in your purchase decision.
Business Continuity

Intel® Optane™ DC persistent memory for the SAP HANA® platform
SAP HANA®—Utilization of Intel® Optane™ DC Persistent Memory

- Main moves to Intel Optane DC persistent memory
  - Loading of tables into memory at startup becomes obsolete\(^{15}\)
  - Lower TCO, larger capacity

- No changes to persistence

Volatile data structure remains in DRAM

*SAP HANA® is the first major RDBMS to support App Direct Mode BIOS mode.*

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\(^{15}\) When operating with persistence enabled.
Minimize SAP HANA® 2.0 SPS 03
Database System Downtime
Faster starts help ensure business continuity and service-level agreements

4-
minute

average SAP HANA 2.0 SPS 3.0 index server start time using Intel® Optane™
Memory—a 12.5x decrease compared to DRAM alone.\(^{16}\)

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\(^{16}\) Based on testing as of May 30, 2018. 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.

New configuration with a combination of DRAM and Intel® Optane™ DC persistent memory: 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 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 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: 4 minutes (12.5x improvement).
Business Continuity Solutions: Replication

Data no longer needs to be loaded from slower storage when an SAP HANA® data load on startup, dramatically reducing startup times.\(^{16}\)

Multiple smaller SAP HANA nodes can replicate their data to a larger backup SAP HANA node, simplifying disaster recovery.

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Increased memory capacity

Intel® Optane™ DC persistent memory for the SAP HANA® platform
Increased Memory Capacity: Enable New Technology Use Cases with Extension Nodes

- Extension Nodes is a new alternative to Dynamic Tiering in SAP HANA 2.3
- New HANA instance for Warm data: Move more data from the hot data tier to the warm data tier
- Increase scale-up capabilities for larger SAP HANA
- Better utilize new technologies such as artificial intelligence (AI), machine learning (ML), and advanced analytics

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No product or component can be absolutely secure.
Example OLTP Configurations for SAP HANA® 2 SPS

2-socket system: DRAM vs. Intel® Optane™ DC persistent memory DIMM

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Example OLTP configurations for SAP HANA® 2 SPS 04

4-socket system: DRAM vs. Intel® Optane™ DC persistent memory DIMM

- **Total:** 6,144 GB
- **DRAM:** 3,072 GB
- **Persistent Memory:** 12,288 GB
- **Total:** 15,360 GB

Performance results are based on testing as of the date stated in the configurations and may not reflect all publicly available security updates. See configuration disclosure for details.

No product or component can be absolutely secure.
Largest OLTP configurations for SAP HANA® 2 SPS 03

4-socket system: DRAM vs. Intel® Optane™ DC persistent memory DIMM

- **DRAM**: 6,144 GB
- **Persistent Memory**: 12,288 GB
- **Total**: 18,432 GB

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I want to create this as its own section, hopefully we’ll have more than the Intel IT Use Case in here. Need better slide/section title. These are POCs.

Current Use Cases
“Intel® Optane™ DC persistent memory provides the performance we need today for real-time analytics of business opportunities, and the capacity we need for data growth in our Supply Chain platform based on SAP HANA.” Aziz Safa, Intel VP and Chief Data Officer
Server Consolidation in an SAP HANA® Landscape

<table>
<thead>
<tr>
<th>Scale OUT</th>
<th>Scale UP</th>
</tr>
</thead>
<tbody>
<tr>
<td>21 servers with 4-socket Intel® Xeon® Platinum processor</td>
<td>8 servers with 8-socket Intel Xeon Platinum processor</td>
</tr>
<tr>
<td>3 TB DRAM DIMMs</td>
<td>6 TB DRAM + 6 TB Intel® Optane™ DC persistent memory</td>
</tr>
<tr>
<td>48 * 64 GB DDR DIMMS for 3 TB system</td>
<td>48 * 128 GB DDR = 6 TB DDR and 48 * 128 GB PMEM = 6 TB PMEM</td>
</tr>
<tr>
<td>$$ Investment</td>
<td>$$ Investment</td>
</tr>
</tbody>
</table>

Same investment but 30% more memory capacity, providing significant headroom for future data growth.

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Faster Performance, Lower Run Costs
Evonik Tests Proof-of-Concept with Intel® Optane™ DC Persistent Memory and SAP HANA®

Evonik uses SAP HANA for real-time analytics and reporting to better understand customers and complex supply chains.

Challenges
- Keeping up with exploding volume of data
- Heterogenous business landscape with multiple ERP systems
- Handling data migrations and integrations from mergers and acquisitions

Business benefits
- Fast data load at startup and shorter maintenance windows for SAP HANA
- Lower TCO from reduced infrastructure memory costs and consolidation
- Adoption with ease: near-flat learning curves and minimal training
- Increased productivity from faster query times

Solution
- 1.3 TB SAP HANA database with Intel Optane DC persistent memory:
  - 17X Faster data load at startup: From 27 minutes to 1:35
  - 1.6X Faster system response times
  - 30% Reduction of run costs

1. See Legal Notices and Disclaimers.
Performance results are based on testing of the date set and configuration and may not reflect all publicly available security updates, soft configuration changes, or other software factors.
No product or component can be absolutely secure.
Learn More

Solutions powered by Intel and SAP: intel.com/sap

Intel® Optane™ DC persistent memory:
sap.com/persistent-memory and software.intel.com/pmem

The SAP HANA® platform: saphana.com and blogs.saphana.com
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2 SAP Certification 2017003, performed January 2017 by Lenovo. Configuration: Lenovo System x3850 X6*, 4 x Intel® Xeon® processor E7-8894 v4 (2.40 GHz; 24 cores, 48 threads per processor; 64 KB L1 cache and 256 KB L2 cache per core; 60 MB L3 cache per processor), 2,048 GB memory, running SUSE Linux Enterprise Server 11*, SAP HANA® 1.0, and SAP NetWeaver® 7.50. (4,273 query execs/hour)

Source: sap.com/documents/2017/02/f2732a32-a77c-0010-82c7-eda71af511fa.html.

3 SAP Certification 2016070, performed December 2016 by Lenovo. Configuration: Lenovo System x3850 X6*, 4 x Intel® Xeon® processor E7-8890 v4 (2.20 GHz; 24 cores, 48 threads per processor; 64 KB L1 cache and 256 KB L2 cache per core; 60 MB L3 cache per processor), 1,024 GB memory, running SUSE Linux Enterprise Server 12*, SAP HANA® 1.0, and SAP NetWeaver® 7.50. (2,332 query execs/hour)

Source: sap.com/documents/2016/12/948a328a-9d7c-0010-82c7-eda71af511fa.html#.

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Configuration: Lenovo ThinkSystem SR950, four processors/112 cores/224 threads, Intel Xeon Platinum 8180 processor, 2.50 GHz, 64 KB L1 cache and 1,024 KB L2 cache per core, 38.5 MB L3 cache per processor, 3,072 GB main memory, running SUSE* Linux* Enterprise Server 12, SAP NetWeaver® 7.50, SAP HANA 2.0.

Source: SAP certification number 2018040, sap.com/dmc/benchmark/2018/Cert18040.pdf. Score: Number of initial records: 5,200,000,000; phase 1: data load phase = 28,715 (runtime of last dataset in seconds); phase 2: query throughput phase = 4,970 (query executions per hour/records selected); phase 3: query runtime phase = 156 (total runtime of complex query phase in seconds).

World records for SAP HANA performance on Intel processor–based systems include benchmarks conducted on HPE ProLiant DL560 Gen10 TDI* (1.3B initial records), Lenovo ThinkSystem SR950* (1.3B initial records and 2.6B initial records), and Dell EMC PowerEdge R940 (2B initial records). For details and other world records, see: intel.com/content/www/us/en/benchmarks/server/xeon-scalable/xeon-platinum-world-record.html and sap.com/dmc/exp/2018-benchmark-directory/#/bwh.

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7 Intel. “The Intel Xeon Platinum Processor Is Put to the Test and Comes Out Shining.” Intel IT Peer Network blog. July 2017. https://itpeernetwork.intel.com/intel-xeon-platinum-processor-put-to-test/. “SAP has certified the SAP HANA 2 platform for OLAP workloads to support up to 3 TB of memory per 4-socket system on the Intel Xeon processor Scalable family. The certification is for a 4-socket configuration or for 6 TB in an 8-socket configuration. … Now, scale-out implementations for very large SAP BW workloads can support up to 94 6 TB nodes for a total of 564 TB—without the need for a storage area network (SAN), resulting in a lower TCO for large scale-out implementations.”

8 “Up to 56 percent lower TCO (three-year) savings on the Intel® Xeon® Platinum 8180 processor versus IBM POWER9®” claim based on pricing of a comparable four-processor rack server using an Intel® Xeon® Platinum 8180 processor (28 cores) compared to a four-processor IBM Power System E950® using IBM POWER9® (3.15 GHz, 12 cores) as of February 2019. Based on Intel internal TCO tool comparing the two above-referenced options running an internal business warehouse database.

Estimated power: IBM Power System E950*/IBM POWER9*: Intel estimate for four IBM POWER9 processors (3.15 GHz) with four chips, 12 cores/chip, and 1.5TB memory at 2,067 watts max power. Intel estimate for 4 x Intel Xeon Platinum 8180 processor with 1.5TB memory, 2 x 146 G 15K SAS drives at 1,275 watts max power.

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8 (continued) Calculations include analysis based on performance, power, cooling, electricity rates, operating system, and annual support/license costs on Red Hat* Enterprise Linux* for IBM POWER*, Premium, and Red Hat* Enterprise Linux* server, Premium, at redhat.com/apps/store/server/ and https://www-01.ibm.com/common/ssi/ShowDoc.wss?docURL=/common/ssi/rep_ca/8/877/ENUSZP17-0418/index.html&request_locale=en, vSphere Enterprise Plus initial license cost at vmware.com/products/vsphere.html, plus estimated server costs. Assumptions include 42U racks, $0.11 per kWh, cooling costs 2 x average server power consumption costs, Alinean* assumptions of $30 per server networking costs, average real estate cost per year from VMware* planning tool at $310 per sq. foot * 10 sq. feet per rack divided by the number of servers per rack, 60 percent CPU utilization, and PUE of 2.0.


10 Based on Intel testing as of July 24, 2018: average read latency measured at queue depth 1 during 4K random-write workload. Measured using FIO 3.1*. Common configuration: 2U Intel® Server System, operating system: CentOS 7.5*, kernel 4.17.6-1.el7.x86_64, CPU: 2 x Intel® Xeon® Gold 6154 processor (3.0 GHz, 18 cores), RAM: 256 GB DDR4 at 2,666 MHz. Configuration: 375 GB Intel® Optane™ SSD DC P4800X and 1.6 TB Intel® SSD DC P4600. Latency: Average read latency measured at queue-depth 1 during 4K random-write operations using FIO 3.1. Intel Microcode: 0x2000043; system BIOS: 00.01.0013; Intel® Management Engine (ME) firmware: 04.00.04.294; Baseboard Management Controller (BMC) firmware: 1.43.91f76955; FRUSDR*: 1.43. SSDs tested were commercially available at time of test.
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11 Up to 3x greater system memory supported versus recently available solutions (representing the currently installed data center base). For online transaction processing (OLTP) workloads, SAP has certified its SAP HANA® 2 platform to support up to 18 TB of memory per system for a 4-socket configuration (or 36 TB for an 8-socket configuration) using the 2nd Generation Intel® Xeon® processor Scalable family installed with Intel® Optane™ DC persistent memory. Systems using the previous-generation Intel Xeon processor Scalable family (representing the typical data center installed base infrastructure) could only support 6 TB in a 4-socket configuration (or 12 TB in an 8-socket configuration). For comparative purposes, SAP certifies support for up to 6 TB of memory for the current Intel Xeon processor Scalable family in a 4-socket configuration, so upcoming Intel Xeon processor Scalable family–based systems are certified to support up to 50 percent greater system memory than the generation they replace.

12 Up to 6× greater system memory supported versus recently available solutions (representing the currently installed data center base). For online analytical processing (OLAP) workloads, SAP has certified its SAP HANA® 2 platform to support up to 18 TB of memory per system for a 4-socket configuration (or 36 TB for an 8-socket configuration) using the 2nd Generation Intel® Xeon® processor Scalable family installed with Intel® Optane™ DC persistent memory. Systems using the previous-generation Intel Xeon processor Scalable family (representing the typical data center installed base infrastructure) could only support 3 TB for a 4-socket configuration (or 6 TB for an 8-socket configuration). For comparative purposes, SAP certifies support for up to 3 TB of memory for the current Intel Xeon processor Scalable family in a 4-socket configuration, so upcoming Intel Xeon processor Scalable family–based systems are certified to support up to 50 percent greater system memory than the generation they replace.

Up to 3x greater system memory supported versus available solutions from four years ago (representing the currently installed data center base). For online transaction processing (OLTP) workloads, SAP has certified its SAP HANA® 2 platform to support up to 6 TB of memory per system for the Intel® Xeon® processor Scalable family for a 4-socket configuration (or 12 TB for an 8-socket configuration). Systems available four years ago (representing the typical data center installed base infrastructure) could only support 2 TB in a 4-socket configuration (or 4 TB in an 8-socket configuration), respectively.
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14 Based on testing as of July 29, 2018. Results have been estimated based on tests conducted on pre-production systems running OAP with 2.6 TB scale factor on I/O-intensive queries, and provided to you for informational purposes.

15 When operating with persistency enabled.

16 Based on testing as of May 30, 2018. 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.

New configuration with a combination of DRAM and Intel® Optane™ DC persistent memory: 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 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 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: 4 minutes.

17 Intel® Optane™ technology input/output operations per second (IOPS). Intel-tested as of November 30, 2018: 4K 70/30 read/write performance at low queue depth. Measured using FIO 3.1*. Common configuration: Intel® 2U Server System, CentOS 7.5*, kernel 4.17.6-1.el7.x86_64, 2 x Intel® Xeon® 6154 Gold processor at 3.0 GHz (18 cores), 256 GB DDR4 RAM at 2,666 MHz. Comparison configuration: 375 GB Intel Optane SSD DC P4800X compared to 1.6 TB Intel® SSD DC P4600. Intel® Microcode: 0x2000043; system BIOS: 00.01.0013; Intel® Management Engine (Intel® ME) firmware: 04.00.04.294; baseboard management controller (BMC) firmware: 1.43.91f76955; FRUSDR*: 1.43. The benchmark results may need to be revised as additional testing is conducted.
18 Intel® Optane™ technology QoS. Common configuration: 2U Intel® PCSD server, CentOS 7.2*, kernel 3.10.0-327.el7.x86_64, 2 x Intel® Xeon® processor E5-2699 v4 at 2.20 GHz (22 cores), 396 GB DDR RAM at 2,133 MHz. Comparison configuration: 375 GB Intel Optane SSD DC P4800X and 1,600 GB Intel® SSD DC P3700. QoS: Measured 99 percent QoS under 4K 70–30 workload at queue depth 1 using FIO 2.15*.

19 Intel® Optane™ technology response time under load tested as of July 2018. Response time refers to average read latency measured at queue depth 1 during random write workload. Measured using FIO 2.15*. Common configuration: 2U Intel® Server System, CentOS 7.5*, kernel 4.17.6-1.el7.x86_64, 2 x Intel® Xeon® Gold 6154 processor at 3.00 GHz (18 cores), 256 GB DDR RAM at 2,666 MHz. Comparison configuration: 375 GB Intel Optane SSD DC P4800X and 1.6 TB Intel® SSD DC P4600. Latency: Average read latency measured at queue depth 1 during 4K random write operations using FIO 2.15*. System BIOS: 00.01.0013; Intel® Management Engine (Intel® ME) firmware: 04.00.04.294; baseboard management controller (BMC) firmware: 1.43.91f76955; FRUSDR: 1.43.

20 Intel® Optane™ technology endurance. Comparing 750 GB Intel Optane SSD DC P4800X specifications to 1,600 GB Intel® SSD DC P4600 specifications. Total bytes written (TBW) calculated by multiplying specified or projected data writes per day (DWPD) by the specified or projected warranty duration and 365 days per year. For full Intel Optane SSD DC P4800X endurance specifications, see intel.com/content/www/us/en/products/memory-storage/solid-state-drives/data-center-ssds/optane-dc-p4800x-series/p4800x-750gb-2-5-inch.html.
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“Intel® Solution Benefits” Configuration Summary

1-3. Up to 53 percent lower TCO (three-year) savings on the Intel® Xeon® Platinum 8280 processor versus IBM POWER9* claim based on pricing of a four-processor server using an Intel® Xeon® Platinum 8280 processor (2.7GHz, 28 cores) compared to a four-processor IBM Power System E950* using IBM POWER9* (3.15 GHz, 12 cores) as of February 2019. Based on Intel internal estimated TCO costs comparing the two above-referenced solution options configured to run a 768GB internal business warehouse database.

**Estimated power:** IBM Power System E950*/IBM POWER9*: Intel estimate for four IBM POWER9 processors (3.15 GHz) with four chips, 12 cores/chip, and 1.5TB DDR4 memory at 2,152 watts max power. Intel estimate for 4 x Intel Xeon Platinum 8280 processor with 1.5TB DDR4 memory, 2 x 146 G 15K SAS drives at 1,260 watts max power.

**Estimated Intel system pricing:** Four-chip Intel® Xeon® Platinum 8280 processor–based platform Intel price of $86,651 with 4 x Intel® Xeon® Platinum 8280 processor, 1.5TB DDR4 memory, two hard-disk drives (HDDs) as of December 2018.


Calculations also include analysis based on power, cooling, electricity rates, operating system, and annual support/license costs on Red Hat* Enterprise Linux* for IBM POWER*, Premium, and Red Hat* Enterprise Linux* server, Premium, at redhat.com/apps/store/server/ and https://www-01.ibm.com/common/ssi/ShowDoc.wss?docURL=/common/ssi/rep_ca/8/877/ENUSZP17-0418/index.html&requestlocale=en, vSphere Enterprise Plus initial license cost at https://www.vmware.com/products/vsphere.html, plus estimated server costs. Assumptions include 42U racks, $0.10 per kWh, cooling costs 2 x average server power consumption costs, annual server maintenance costs of $2,399 per server per year, Alinean* assumptions of $15 per server networking costs, average real estate cost per year from VMware* planning tool at $310 per sq. foot * 10 sq. feet per rack divided by the number of servers per rack, 60 percent CPU utilization, and PUE of 2.0. Example based on one four-chip IBM Power System E950* solution at a total cost of $262,790 [acquisition=237.4K, infrastructure and utility=11.0K, OS & software=7.2K, maintenance=7.2K] vs. one four-chip Intel® Xeon® Platinum 8280 processor–based platform at a total cost of $121,271 [acquisition=86.7K, infrastructure and utility=5.6K, OS & software=13.4K].

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### DRAM and Intel® Optane™ DC Persistent Memory Allocations for 2nd Gen Intel® Xeon® Processors

#### Memory Configuration (System, PMEM + DRAM)

<table>
<thead>
<tr>
<th>Configuration</th>
<th>CPU Type</th>
<th>Capacity (GB) per CPU</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</td>
<td>1,920</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</td>
<td>2,304</td>
<td>2</td>
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<tr>
<td>2DPC 128 GB Intel Optane DC persistent memory + 128 GB DRAM</td>
<td>M</td>
<td>1,536</td>
<td>3,072</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</td>
<td>3,840</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</td>
<td>4,608</td>
<td>0.5</td>
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<tr>
<td>2DPC 256 GB Intel Optane DC persistent memory + 128 GB DRAM</td>
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<td>2,304</td>
<td>4,608</td>
<td>2</td>
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<tr>
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<td>6,144</td>
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<td>4,608</td>
<td>9,216</td>
<td>2</td>
</tr>
</tbody>
</table>

**Performance results are based on testing as of the date set forth in the configurations and may not reflect all publicly available security updates. See configuration disclosure for details. No product or component can be absolutely secure.**

**Configurations Not Supported**
“Deliver More For Less” Config Summary

1. **13x faster restart** time and **39% less cost** configs:

<table>
<thead>
<tr>
<th></th>
<th>Baseline Config (DRAM)</th>
<th>AD 2-2-2 Config</th>
</tr>
</thead>
<tbody>
<tr>
<td>System</td>
<td>Lightning Ridge (4S)</td>
<td>Lightning Ridge (4S)</td>
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<tr>
<td>CPU</td>
<td>Intel® Xeon® 8280M</td>
<td>Intel® Xeon® 8280L</td>
</tr>
<tr>
<td>CPUs per node</td>
<td>4-socket @ 28 core / socket</td>
<td>4-socket @ 28 core / socket</td>
</tr>
<tr>
<td>Memory</td>
<td>6TB 48x 128GB DDR4 @ 2666 MT/s</td>
<td>9TB 24x 256GB Intel® Optane™ DC PMEM 24x 128GB DDR4 @ 2666 MT/s</td>
</tr>
<tr>
<td>Network</td>
<td>10 GbE Intel X520 NIC</td>
<td>10 GbE Intel X520 NIC</td>
</tr>
<tr>
<td>Storage</td>
<td>60x Intel SSD DC S4600 SATA 480GB TB</td>
<td>90x Intel SSD DC S4600 SATA 480GB TB</td>
</tr>
<tr>
<td>BIOS</td>
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<td>WW48’18</td>
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<td>OS or VM version</td>
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<tr>
<td>WL Version</td>
<td>Intel IT workload</td>
<td>Intel IT workload</td>
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<tr>
<td>SAP HANA* database size</td>
<td>3TB</td>
<td>6TB</td>
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<tr>
<td>Security mitigations</td>
<td>Variants 1,2,3 enabled</td>
<td>Variants 1,2,3 enabled</td>
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<tr>
<td>Date costs projected</td>
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</tbody>
</table>

1. **~39% less cost** pricing details:

Pricing Guidance as of March 1, 2019. Intel does not guarantee any costs or cost reduction. You should consult other information and performance tests to assist you in your purchase decision.
Attributes of Memory and Storage in an SSD

Reliable, low-latency performance that outperforms NAND SSDs

Excellent performance

Predictably fast service

Responsive under load

High endurance

Up to 6x faster

Queue-depth 1, 4K 70/30 read/write input/output operations per second (IOPS)\textsuperscript{17}

Up to 63x faster

response time\textsuperscript{19}

Up to 60x Better

With 99% quality of service (QoS)\textsuperscript{18}

Up to 20x more

total terabytes written\textsuperscript{20}

Performance results are based on testing as of the date set forth in the configurations and may not reflect all publicly available security updates. See configuration disclosure for details.

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\textsuperscript{17,18,19,20} See Legal Notices and Disclaimers for details.