DRAM TECHNOLOGY SCALING PROBLEM

RATE OF GROWTH IN DRAM DENSITY IS SLOWING

Density

- 16Gb
- 8Gb
- 4Gb
- 2Gb
- 1Gb
- 512Mb
- 256Mb
- 128Mb
- 64Mb
- 16Mb
- 4Mb
- 1Mb

1980 1985 1995 2000 2005 2010 2015 2020

△ Density (Mb)

PHASE 3:
Density increase ~2X/4years

PHASE 2:
Density increase ~2X/2years

PHASE 1:
Density increase ~4X/3years
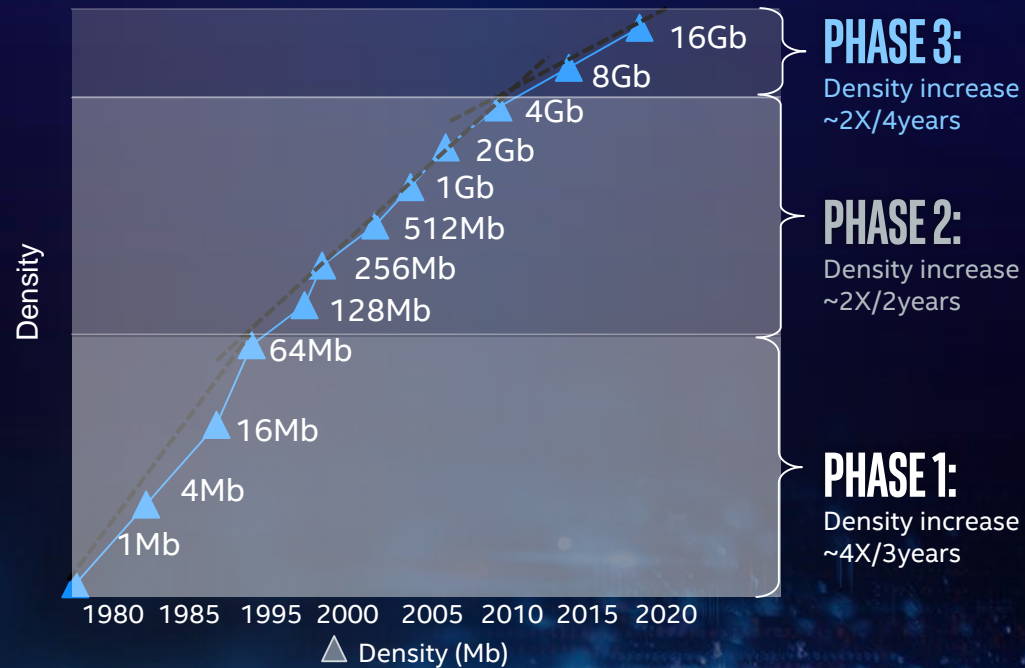
GAP BETWEEN DATA & MEMORY CAPACITY IS INCREASING
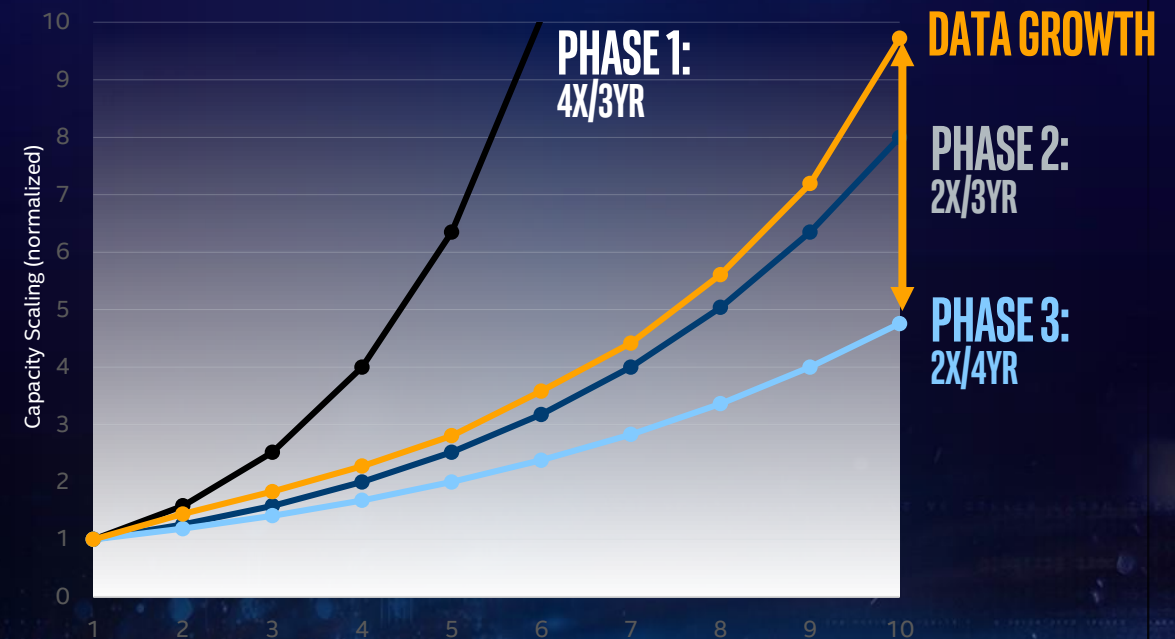
Capacity Scaling (normalized)

10 9 8 7 6 5 4 3 2 1 0

1 2 3 4 5 6 7 8 9 10

PHASE 1: 4X/3YR

DATA GROWTH

PHASE 2: 2X/3YR

PHASE 3: 2X/4YR

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RE-ARCHITECTING THE MEMORY / STORAGE HIERARCHY

MEMORY

DRAM
HOT TIER

PERSISTENT MEMORY

IMPROVING
MEMORY CAPACITY →

intel OPTANE ⟫⟫
PERSISTENT MEMORY

STORAGE

IMPROVING
SSD PERFORMANCE →

intel OPTANE ⟫⟫
SSD

DELIVERING
EFFICIENT STORAGE →

INTEL® 3D NAND SSD

HDD / TAPE
COLD TIER

intel

intel® OPTANE »»
PERSISTENT MEMORY

intel® XEON® PLATINUM inside™

BIG & AFFORDABLE MEMORY

DDR4 PIN COMPATIBLE

DIRECT LOAD/STORE ACCESS

HIGH PERFORMANCE STORAGE

128, 256, 512GB

2 MODES OF OPERATIONS:
APP DIRECT & MEMORY MODE

HARDWARE ENCRYPTION

HIGH RELIABILITY
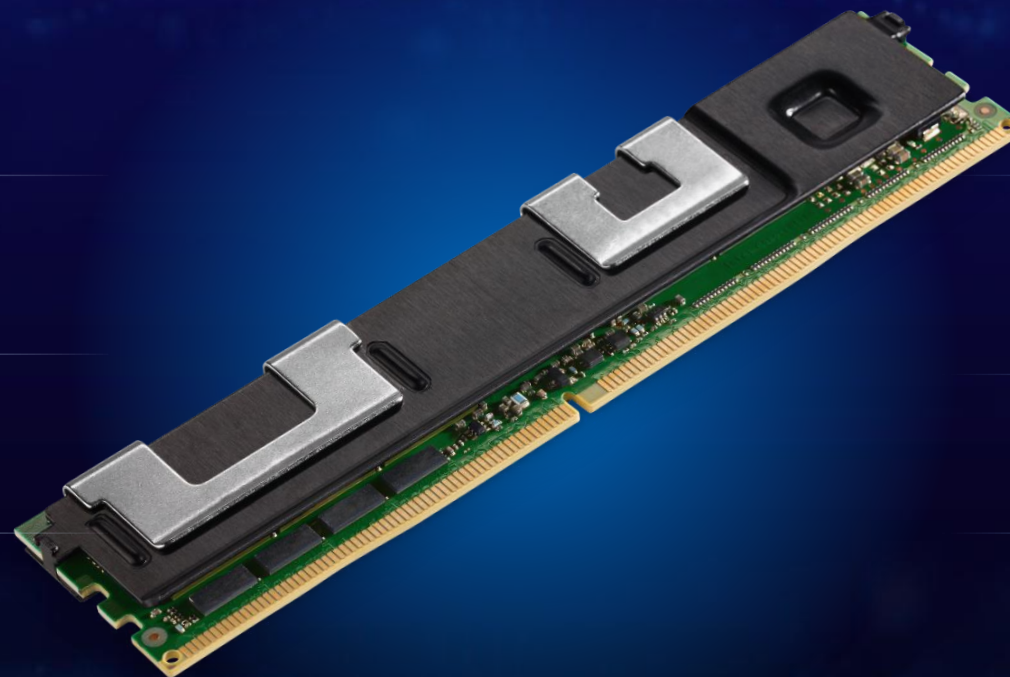
Launched on April 2nd, 2019
Available from all major OEMs

intel®

DELIVERING REAL CUSTOMER VALUE WITH INTEL® OPTANE™ PERSISTENT MEMORY

SAVE MORE

CP	30% SAVING VS IBM POWER (SAP HANA)
BT	20% COST SAVINGS (VMWARE)
Kingsoft Cloud KSCLOUD	1.3X TCO BENEFITS (REDIS)
NTT	BETTER TCO (POSTGRESQL)
平安云	48% TCO SAVINGS (REDIS)

DO MORE

PayPal	10X LATENCY IMPROVEMENT (AEROSPIKE)
SK telecom	2X MORE VMS (5G MEC)
快手 KUAISHOU TECHNOLOGY	IMPROVED EASE OF ADOPTION AND MANAGEMENT
DUKE ENERGY®	DATABASE CONSOLIDATION (HADOOP, MYSQL)
SOUTHWEST GAS	2X DB FOOTPRINT (SAP HANA)

GO FASTER

網易 NetEase www·163·com	40% FASTER PERF (REDIS)
AsiaInfo 亚信科技	~68% LOWER LATENCY (CUSTOM BILLING)
UC San Diego	~17X MORE PERF (MONGODB, MYSQL)
phoenixNAP GLOBAL IT SERVICES	3X FASTER (AI ON VMWARE)
Montefiore	7X FASTER QUERIES (ALLEGROGRAPH)

(intel)

A GROWING ECOSYSTEM FOR intel® OPTANE™ >>>
PERSISTENT MEMORY

SOFTWARE

Apache CASSANDRA
APACHE Spark™
Microsoft
◢EROSPIKE
NetApp®
AsiaInfo

CLOUDERA
TRANSWARP 星环科技
M MEMCACHED
MemVerge
SAP
SAS
SUSE
MySQL®
redis
ORACLE®
redhat.
ubuntu®

FORMULUS BLACK™
宝信软件 BAOSIGHT
GIGASPACES innovate with confidence

CSPS & COSPS

vmware®

Qwilt

kx

Alibaba Group 阿里巴巴集团
Microsoft Azure
IBM Cloud
海鑫科金 HISIGN TECHNOLOGY

平安云
Tencent Cloud
SK telecom
Bai 百度
packet
BONC 东方国信

快手 KUAISHOU TECHNOLOGY
人大金仓 Kingbase

OEMS & SIS

Kingsoft Cloud KSCLOUD
中国航信 TravelSky

QINGCLOUD
CDW
DELLEMC
ORACLE®
Hewlett Packard Enterprise
ZTE
scalar

accenture
inspur
CISCO
Lenovo
Capgemini
SUPERMICRO

intel®
Atos
PENGUIN COMPUTING
FUJITSU
Inventec
QCT
H3C
World Wide Technology

INTEL® OPTANE™ PERSISTENT MEMORY OEM READINESS

ASUS	CISCO	DELL	FUJITSU	GIGABYTE	H3C	Hewlett Packard Enterprise
ESC 8000 and 4000 series RS720, 700, 540, 520, and 500 series, Z11 series server	UCS B-series, C-series and HyperFlex HX-series servers	PowerEdge R640, R740, R740xd, R840, R940, R940xa, MX740c, and MX840c	CELSIUS, PRIMEQUEST, and PRIMERGY	Rack, Tower, HPC and HCI servers	Uniservers	ProLiant DL360, DL380, DL560, DL580, SY480, SY660, Superdome Flex

HUAWEI	inspur	intel	JABIL	Lenovo	ORACLE	QCT
FusionServer Pro	NF5280M5, NF5180M5, NF5288M5, NF5466M5, NF8260M5, NF8480M5, TS860M5, i24, i48	Server Family S2600BPR (Buchanan Pass), Server Family S2600WPR (Wolf Pass)	CI-1000 Series CI-2100 Series CI-2400 Series	ThinkSystem servers	Exadata X8M	QuantaPlex QuantaGrid

(intel)

AEROSPIKE & INTEL: BETTER TOGETHER

AEROSPIKE DATA PLATFORM:

➕ **INTEL HARDWARE ARCHITECTURE:**

➡️ **REAL-TIME, EXTREME SCALE APPLICATIONS**

AEROSPIKE DATA PLATFORM:	INTEL HARDWARE ARCHITECTURE:	REAL-TIME, EXTREME SCALE APPLICATIONS
▪ Edge database ▪ Transaction database ▪ Core database ▪ Query database ▪ Spark, Kafka, JMS integrations	▪ 2nd Gen Intel® Xeon® Platinum 8280 processor ▪ Intel® Optane™ Persistent Memory ▪ Intel® Ethernet 800 Series with Application Device Queues (ADQ)	▪ Digital payments ▪ Fraud detection ▪ Recommendation engines ▪ Customer 360 ▪ IoT ▪ AI and ML

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AEROSPIKE & INTEL: BETTER TOGETHER

Intel XEON PLATINUM inside

intel OPTANE >>>
PERSISTENT MEMORY

intel Ethernet 800 Series with ADQ

+

AEROSPIKE

Next Generation, NoSQL Data Platform

2000% FASTER
10TB/SEC DATA INGESTED

"Aerospike running on Intel Optane Persistent Memory DIMMs is 2000% FASTER[1] than anything else out there."
THERESA MELVIN: *Chief Architect of AI-Driven Big Data Solutions, HPE Labs*

75% IMPROVEMENT

in transaction volumes[2] running on Intel Ethernet 800 Series NICs with Application Device Queues (ADQ).

135X REDUCTION

in restart time[3] running on 2nd Gen Intel Xeon Platinum 8280L + Intel Optane Persistent Memory.

BENEFITS OF AEROSPIKE & INTEL

INCREMENTAL SAVING

- STORING INDEXES AND DATA IN INTEL OPTANE PERSISTENT MEMORY IS MUCH LOWER COST THAN IN DRAM

- HIGHER CAPACITY THAN DRAM FURTHER REDUCES SERVER COUNT AND COST

- FAR LESS OPERATIONAL COSTS WITH FASTER RESTART TIMES
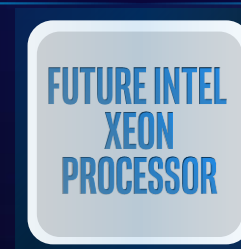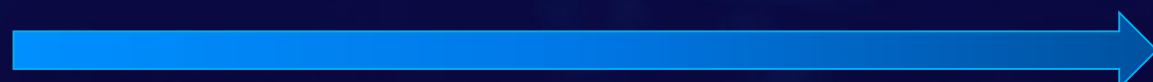
BREAKTHROUGH SCALABILITY

V 4.5

DRAM

Intel® Optane™ PMem
Primary Index

Data

Storage

V 4.8 +

DRAM

Intel® Optane™ PMem
Primary Index

Data

Storage

PERSISTENT MEMORY 4X MORE SCALABLE THAN DRAM[1]

STORAGE
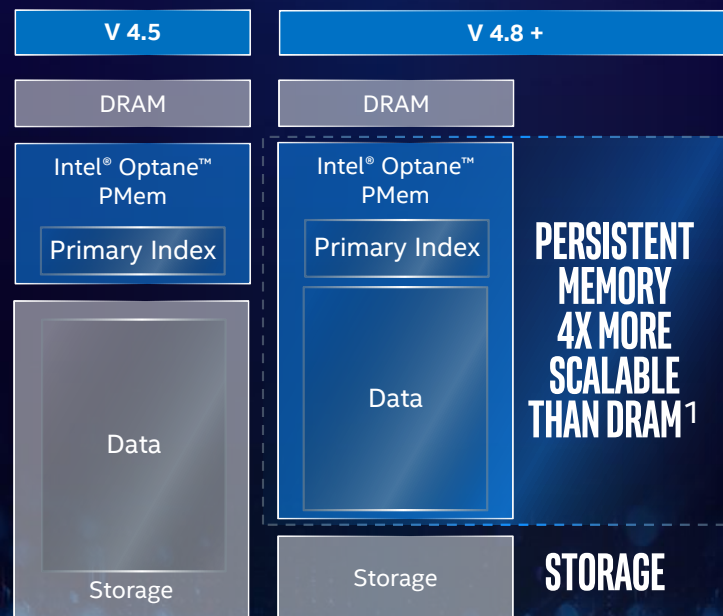
OVERCOMING BARRIERS

✓ **DRAM-LIKE PERFORMANCE**
BUILD FASTER REAL-TIME SOLUTIONS

✓ **UNMATCHED RELIABILITY**
MINIMIZE DOWNTIME WHILE ELIMINATING DATA LOSS

✓ **EXTREME SCALE**
EXPAND SCALE WHILE MAINTAINING PERFORMANCE

✓ **LOW TCO**
REDUCE COMPLEXITY AND COST

[1] The up to 4X increase in memory per server is based on a typical, two-socket server configured with 24 x 64 GB DRAM DIMMs (= 1.5 TB of memory) versus the same server configured with 12 x 512 GB Intel® Optane™ persistent memory modules (= 6.0 TB of memory).

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A STRONG MEMORY FUTURE

TODAY

FUTURE

Intel XEON PLATINUM inside™

Intel OPTANE ››› PERSISTENT MEMORY

2ND GEN INTEL XEON SCALABLE (CASCADE LAKE)	COOPER LAKE / ICE LAKE	SAPPHIRE RAPIDS	FUTURE INTEL XEON PROCESSOR
APACHE PASS	BARLOW PASS	3RD GEN INTEL PERSISTENT MEMORY	4TH GEN INTEL PERSISTENT MEMORY

RESULTS

SOLUTIONS
www.intel.com/optanepersistentmemory CV

PRODUCT
https://www.intel.com/content/www/us/en/products/memory-storage/optane-dc-persistent-memory.html

CUSTOMERS
https://www.intel.com/content/www/us/en/customer-spotlight/overview.html
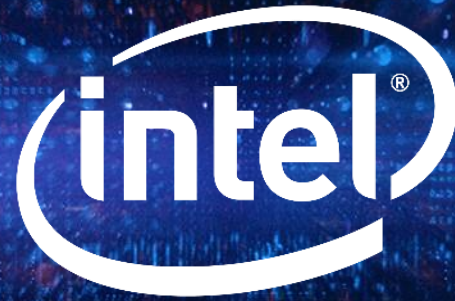
APPENDICES

APPENDIX C – OPTANE PMEM PERFORMANCE

Performance results are based on testing as of dates shown in configuration and may not reflect all publicly available security updates. No product or component can be absolutely secure. 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 complete information visit http://www.intel.com/benchmarks.

Intel® Optane™ persistent memory pricing & DRAM pricing as of September 17, 2019. Pricing referenced in TCO calculations is provided for guidance and planning purposes only and does not constitute a final offer. Pricing guidance is subject to change and may revise up or down based on market dynamics. Please contact your OEM/distributor for actual pricing.

Virtualized SQL

Performance results are based on testing as of Feb. 1, 2019 and may not reflect all publicly available security updates.
Baseline configuration (DRAM): 2x 2nd Gen Intel® Xeon® Platinum 8276 @ 28 cores/socket. Memory: 768 GB (24x32 GB DDR4@2666 MHz). Network: Intel® X520 SR2 (10 Gbps).
Storage: 8x Samsung* PM963M.2 960 GB, 4x Intel® SSDs S3600 (1.92 TB). BIOS: WW02'19. OS/VM: Windows Server 2019. WL Version: OLTP Cloud Benchmark (internal private customer confidential workload). Dataset/instance or workload size: 1.1 TB. Security mitigations: variants 1,2,3 enabled. Performance of 22 SQL VM instances.
New config (PMem): 2x 2nd Gen Intel® Xeon® Platinum 8276 @ 28 cores/socket. Memory: 1 TB (8x128 GB Intel® Optane™ DC persistent memory in Memory Mode + 12x 16 GB DDR4@2666 MHz). Network: Intel® X520 SR2 (10 Gbps). Storage: 8x Samsung* PM963M.2 960 GB, 4x Intel® SSDs S3600 (1.92 TB). BIOS: WW02'19. OS/VM: Windows Server 2019. WL Version: OLTP Cloud Benchmark (internal private customer confidential workload). Dataset/instance or workload size: 1.5 TB. Security mitigations: variants 1,2,3 enabled. Performance of 30 SQL VM instances.

VMware vSAN

Intel internal testing as of March 31, 2019. Base configuration: four nodes, 2 x Intel® Xeon® Gold 6230 processor, Intel® Server Board S2600WFT, total memory: 384 GB, 12 slots/32 GB/2,666 megatransfers per second (MT/s) DDR4 RDIMM, Intel® Hyper-Threading Technology (Intel® HT Technology) enabled, Intel® Turbo Boost Technology enabled, Intel® Volume Management Device (Intel® VMD) enabled, storage (boot): 1 x 960 GB Intel® SSD 3520 M.2 SATA, storage (cache): 2 x 375 GB Intel® Optane™ SSD DC P4800X PCIe* with NVM Express* (NVMe*), storage (capacity): 6 x 2 TB Intel SSD DC P4510 PCIe with NVMe; network devices: 1 x 25Gb Intel® Ethernet Converged Network Adapter XX710-DA2, network speed: 10 GbE, OS/software: VMware vSphere 6.7.0*, build 10764712. Benchmark: VMware VMmark* for Incremental Memory, performance of 95 VMs. VMware VMmark® is a product of VMware, Inc.

PMem configuration: four nodes, 2 x Intel Xeon Gold 6252 processor, Intel Server Board S2600WFT, total memory: 512 GB Intel® Optane™ DC persistent memory, 4 slots/128 GB/2,666 MT/s and 128 GB 8 slots/16 GB/2,666 MT/s DDR4 RDIMM, Intel HT enabled, Intel Turbo Boost Technology enabled, Intel VMD enabled, storage (boot): 1 x 960 GB Intel SSD 3520 M.2 SATA, storage (cache): 2 x 375 GB Intel Optane SSD DC P4800X PCIe with NVMe, storage (capacity): 6 x 2 TB Intel SSD DC P4510 PCIe with NVMe; network devices: 1 x 25Gb Intel Ethernet Converged Network Adapter XX710-DA2, network speed: 25 GbE, OS/software: vSphere 6.7.0, build 10764712. Benchmark: VMware VMmark* for Incremental Memory, performance of 152 VMs. VMware VMmark® is a product of VMware, Inc.

APPENDIX C – OPTANE PMEM PERFORMANCE

Performance results are based on testing as of dates shown in configuration and may not reflect all publicly available security updates. No product or component can be absolutely secure. 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 complete information visit http://www.intel.com/benchmarks.

Intel® Optane™ persistent memory pricing & DRAM pricing as of September 17, 2019. Pricing referenced in TCO calculations is provided for guidance and planning purposes only and does not constitute a final offer. Pricing guidance is subject to change and may revise up or down based on market dynamics. Please contact your OEM/distributor for actual pricing.

Spark

Tested by Intel on February 24th 2019. Common testing details: 2x 2nd Gen Intel Xeon Platinum 8280M processor, 8xHDD ST1000NX0313, BIOS: SE5C620.86B.0D.01.0134.100420181737, OS: Fedora release 29, kernel: 4.20.6-200.fc29.x86_64, 1-replica uncompressed & plain encoded data on Hadoop, Spark: 1 * Driver (5GB) + 2 * Executor (62 cores, 74GB), spark.sql.oap.rowgroup.size=1MB, Oracle JDK 1.8.0_161 , 3TB data scale, 9 I/O intensive queries, 9 threads. Memory config of baseline: 24x32GB DDR4. Memory config of system with Intel Optane Persistent memory: 8x128GB PMem in App Direct Mode + 12x16GB DDR4.

SAP HANA

2.4x better runtime performance: Performance results are based on testing by Intel® IT as of March 12, 2019. Baseline: three-node (1-master + 2-slave) 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; microcode: 0x400001c; RAM capacity: 64 x 32 GB DIMM, RAM model: DDR4 2133 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: 2.00.035, 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 master 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; microcode: 0x400001c, RAM capacity: 24 x 64 GB DIMM, RAM model: DDR4 2133 Mbps; Intel® Optane™ DC persistent memory: 24 x 126 GB PMM; storage: XFS*, 21 TB; network: redundant 10 GbE network; OS: SUSE 15, SAP HANA: 2.00.035, Intel BKC: WW06. Average time of 50 individual test queries executed 30–50 times each, for a total of approximately 25,000 steps: 1.13 seconds.

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