MEMORY TECHNOLOGY SCALING

RATE OF GROWTH IN DRAM DENSITY IS SLOWING

- **Phase 1:** Density increase ~4X/3 years
- **Phase 2:** Density increase ~2X/2 years
- **Phase 3:** Density increase ~2X/4 years

GAP BETWEEN DATA AND MEMORY CAPACITY IS INCREASING

- **Phase 1:** Density increase 4X/3 years
- **Phase 2:** Density increase 2X/3 years
- **Phase 3:** Density increase 2X/4 years

Source: Data Age 2025, sponsored by Seagate with data from IDC Global DataSphere, Nov 2018
Source: "3D NAND Technology – Implications for Enterprise Storage Applications" by J.Yoon (IBM), 2015 Flash Memory Summit & Yole Développement
# A Strong Memory & Storage Future

## Today

<table>
<thead>
<tr>
<th>Processor</th>
<th>Memory Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apache Pass</td>
<td>Intel® SSD DC P4800X (COLDSTREAM)</td>
</tr>
<tr>
<td>Barlow Pass</td>
<td>ALDER STREAM</td>
</tr>
</tbody>
</table>

## Future

<table>
<thead>
<tr>
<th>Processor</th>
<th>Memory Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>3rd Gen DC Persistent Memory</td>
<td>4th Gen DC Persistent Memory</td>
</tr>
<tr>
<td>Sapphire Rapids</td>
<td>Future Intel Xeon Processor</td>
</tr>
<tr>
<td>Next Generation</td>
<td>Next Generation</td>
</tr>
</tbody>
</table>

For each processor above, Intel® Optane™ DC Persistent Memory will be supported on select SKUs.
INTEL® OPTANE™ TECHNOLOGY IN THE DATA CENTER

**DATABASE**

- **EFFICIENT IN-MEMORY DATABASES**
  - SAP: 2.4X **PERF GAIN VS. 3-YEAR OLD SERVERS**
- **MORE VIRTUALIZED DATABASES INSTANCES**
  - Microsoft SQL Server: 36% **MORE VMS AT SIMILAR COST**

**AI/ANALYTICS**

- **FASTER ANALYTICS INSIGHTS**
  - Apache Spark: 8X **FASTER QUERIES VS. DRAM+HDD**
- **INCREASED ANALYTICS THROUGHPUT**
  - BAOSIGHT: 37% **MORE TRANSACTIONS PER SECOND**

**VIRTUALIZED INFRASTRUCTURE/STORAGE**

- **DENSER HYPER-CONVERGED INFRASTRUCTURE**
  - VMware VSAN: 60% **MORE VMS PER NODE**
- **DENSER HYPER-CONVERGED INFRASTRUCTURE**
  - Microsoft Azure Stack HCI: 36% **MORE VMS AT SIMILAR COST**
NEXT GEN CONTENT DELIVERY NETWORKS:
LIVE LINEAR CONTENT AT THE EDGE

SAME QUALITY OF SERVICE, SCALE CONTENT AT A REDUCED COST AND TCO
“With next generation Intel® Xeon® Scalable processor and Intel® Optane™ DC Persistent Memory
Qwilt doubled the amount of content it can store in our edge caches per node“

Mr. Mark Fisher
Vice President, Marketing and Business Development, Qwilt
A Solution Level Approach to Data-Centric Architecture
GROWING GLOBAL ECOSYSTEM FOR SOFTWARE

CSPS & CSPS

OEMS & SIS
Growing Global Ecosystem for TravelSky, the world’s third-largest Global Distributions System (GDS) provider, focuses on providing all stakeholders in aviation industry with first-class service. After two rounds of serious evaluation, we chose Intel® Optane™ DC Persistent Memory to upgrade our Fare system, one of our critical applications. I believe this innovative technology will bring us more memory bandwidth, less latency and higher computing capacity while significantly reducing TCO.

Mr. Wen Gong
Vice GM, Data Centre Operations, TravelSky
Using Intel Optane Technology

TACC
INTEL® OPTANE™ DC PERSISTENT MEMORY MOMENTUM

200 PROOFS-OF-CONCEPTS IN PROCESS WITH A TOTAL PIPELINE OF >500 OPPORTUNITIES
SUMMARY

TRANSFORMATIONAL DATA CENTRIC STRATEGY

MULTIPLE GENERATIONS WITH NEW CAPABILITIES UNDER DEVELOPMENT

DRIVING BROAD ECOSYSTEM INNOVATION TO FUEL CUSTOMERS DATA NEEDS
NOTICES AND DISCLAIMERS

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Intel® Optane™ DC 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.

SAP
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: 54 x 32 GB DIMM, RAM model: DDR4 2133 Mbps; network for storage and access, redundant 10 Gigabit Ethernet (GigE) network for network-to-node-to-node; OS: SUSE 12 SP2, SAP HANA: 2.00.035, GFS: 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.

Virtualized SQL


Spark

Baosight
Tested by Intel and Baosight on January 8, 2019. Shanghai Baosight xInsight* v2.0 (self-defined workload): OS: CentOS* 7.5 Kernel 3.10.0-877.1.3.el7.x86_64. Testing by Intel and Baosight completed on Jan 8, 2019. Security Mitigations for Variants 1,2,3 and L1TF in place. BASELINE: 2nd Gen Intel® Xeon® Platinum processor 8260L, 2.3 GHz, 24 cores, turbo, and HT on, BIOS 1.0180, 768GB total memory, 32 Slots / 32GB / 2666 MT/s / DDR4 LRDIMM, 1 x 480GB / Intel® SSD Data Center (Intel® SSD DC S4500 + 2 x 1TB / Intel® SSD DC P4500). NEW: 2nd Gen Intel® Xeon® Platinum processor 8260L, 2.3 GHz, 24 cores, turbo, and HT on, BIOS 1.0180, 192GB total memory, 12 slots / 16GB / 2666 MT/s / BDR4 LRDIMM and 1024GB DCPMM, 8 slots 128 GB / 2666 MT/s Intel® Optane™ DC persistent memory, 1 x 480GB / Intel® SSD DC S4500 + 2 x 1TB / Intel® SSD DC P4500.
Performance Configs & Disclaimers

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.

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VMware vSAN:

DCPMM 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 M2 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 vMark™ for Incremental Memory, performance of 152 VMs. VMware vMark™ is a product of VMware, Inc.

Azure Stack HCI:
Intel internal testing as of February 15, 2019. Common testing details: Vmfleet Test Each VM with 1 Core,8 GB Memory, 40 GB VHDX. Test setup: Threads=2 , Buffer Size= 4KiB, Pattern: Random, Duration = 300 Seconds, Queue Depth=16, 30% write.

Baseline configuration: 2 x Intel® Xeon® Gold 5218 processor, Intel® Server Board S2600WFT, 256 GB total memory (8 x 32 GB, 2,666 megatransfers per second [MT/s]), Intel® Hyper-Threading Technology (Intel® HT Technology) enabled, Intel® Turbo Boost Technology enabled, storage (boot): 1 x 480 GB Intel SSD DC 3520 U.2 SATA, storage tier: 4 x 1.6 TB Intel SSD DC P4610 PCIe® NVMe Express* (NVMe*), 1 x 25 gigabits per second (Gbps) Chelsio® network adapter, 10 GbE, Windows Server 2019 Datacenter edition* build 17763. Performance of 41 VMs per node.