TAPPING DATA VALUE, REAL TIME
MOUNTAINS OF UNDERUTILIZED DATA

CHALLENGE
SHIFTING DATA FROM BURDEN TO ASSET TO VALUE

POTENTIAL
BUSINESS OPPORTUNITY AND SOCIOLOGICAL ADVANCEMENTS
THE INTEL® OPTANE™ DC
PERSISTENT MEMORY OPPORTUNITY

Source: Amalgamation of analyst data and Intel internal analysis

<table>
<thead>
<tr>
<th>Year</th>
<th>Server DRAM TAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>$8.2B</td>
</tr>
<tr>
<td>2017</td>
<td>$17.3B</td>
</tr>
<tr>
<td>2022</td>
<td>$28B</td>
</tr>
</tbody>
</table>
“MIND THE GAPS”

MEMORY

DRAM
HOT TIER

STORAGE

3D NAND SSD
WARM TIER

HDD / TAPE
COLD TIER
NEW PERSISTENT MEMORY TIER

MEMORY

PERSISTENT MEMORY

STORAGE

DRAM HOT TIER

APPLICATION

USER SPACE

KERNEL SPACE

DDR

XEON PLATINUM inside

FILE SYSTEM

STORAGE DRIVER

3D NAND SSD WARM TIER

HDD / TAPE COLD TIER

OPTANE DC Persistent Memory

FILE SYSTEM

PCle/ SATA

SAS / SATA

FILE SYSTEM

STORAGE DRIVER
Big and Affordable Memory

High Performance Storage

Direct Load/Store Access

Native Persistence

128, 256, 512GB

DDR4 Pin Compatible

Hardware Encryption

High Reliability

NOW SHIPPING FOR REVENUE TO SELECT CUSTOMERS
MORE THAN A MEMORY INNOVATION – SYSTEM LEVEL BREAKTHROUGH

SOFTWARE/WORKLOAD
Persistent Memory Programming Model, libraries, Operating Systems, Workload Enablement

DRIVERS
Hardware Support

OPERATING SYSTEM/VIRTUALIZATION
Functional Updates and Optimizations

PLATFORM INTEGRATION
Firmware/BIOS, motherboard design updates

INTEL® OPTANE™ DC PERSISTENT MEMORY
Memory media, media management, module design

INTEL® XEON® SCALABLE PROCESSOR
CPU Architecture, Memory controller design for PM

#IntelDCISummit
https://builders.intel.com/persistent-memory-developer-challenge

#IntelDCISummit
Performance results are based on testing as of August 02, 2018 and may not reflect all publicly available security updates. Results have been estimated based on tests conducted on pre-production systems running OAP with 2.6TB scale factor on IO intensive queries, and provided to you for informational purposes. Software and workloads used in performance tests may have been optimized for performance only on Intel microprocessors. Performance tests, such as SYSmark and MobileMark, are measured using specific computer systems, components, software, operations and functions. Any change to any of those factors may cause the results to vary. You should consult other information and performance tests to assist you in fully evaluating your contemplated purchases, including the performance of that product when combined with other products. For more information go to www.intel.com/benchmarks.
FAST RESTART WITH PERSISTENCE

Performance results are based on testing as of July 31, 2018 and may not reflect all publicly available security updates. No product can be absolutely secure. Results have been estimated based on tests conducted on pre-production systems running Aerospike noSQL, and provided to you for informational purposes. Software and workloads used in performance tests may have been optimized for performance only on Intel microprocessors. Performance tests, such as SYSmark and MobileMark, are measured using specific computer systems, components, software, operations and functions. Any change to any of those factors may cause the results to vary. You should consult other information and performance tests to assist you in fully evaluating your contemplated purchases, including the performance of that product when combined with other products. For more information go to www.intel.com/benchmarks.
DATA REPLICATION WITH PERSISTENT MEMORY

TRADITIONAL REPPLICATION

Ethernet

 USING PERSISTENT MEMORY

Using Persistent Memory

14X Lower latency

Performance results are based on testing as of Aug 01, 2018 and may not reflect all publicly available security updates. No product can be absolutely secure.

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

Ethernet

Traditional Replication

Latency (µS) (lower is better)

NAND NVMe SSD

Intel® Optane™ DC persistent memory

Replication Latency (µS) (lower is better)
DATA REPLICATION WITH PERSISTENT MEMORY

TRADITIONAL REPLICATION

Ethernet

Using Persistent Memory

Ethernet

14X Improvement in IOPs

Thousands of IOPS
(higher is better)

NAND NVMe SSD

Intel® Optane™ DC persistent memory

Performance results are based on testing as of Aug 01, 2018 and may not reflect all publicly available security updates. No product can be absolutely secure. Results have been estimated based on tests conducted on pre-production systems with DRBD and RDMA, and provided to you for informational purposes. Software and workloads used in performance tests may have been optimized for performance only on Intel microprocessors. Performance tests, such as SYSmark and MobileMark, are measured using specific computer systems, components, software, operations and functions. Any change to any of those factors may cause the results to vary. You should consult other information and performance tests to assist you in fully evaluating your contemplated purchases, including the performance of that product when combined with other products. For more information go to www.intel.com/benchmarks.
REARCHITECTING THE MEMORY/STORAGE HIERARCHY

MEMORY

PERSISTENT MEMORY

STORAGE

IMPROVING SSD PERFORMANCE

DELIVERING EFFICIENT STORAGE

DRAM HOT TIER

intel OPTANE DC PERSISTENT MEMORY

intel OPTANE DC SOLID STATE DRIVE

INTEL® QLC 3D NAND SSD

HDD / TAPE COLD TIER

intel QLC 3D NAND SSD
REARCHITECTING THE MEMORY/STORAGE HIERARCHY

MEMORY

PERSISTENT MEMORY

STORAGE

DRAM
HOT TIER

INTEL® QLC 3D NAND SSD

HDD / TAPE
COLD TIER

TODAY AT FLASH MEMORY SUMMIT:

Intel® Optane™ SSD DC P4800X
Up To 60 DWPD

INTEL® SSD D5-P4320 AT TENCENT

"Tencent started deployment of Intel® SSD D5-P4320 series in our Content Delivery Network, which enabled us to dramatically improve scalability and customer service. We are looking forward to broad adoption of these 16Tb Intel® QLC SSDs. This enabled Tencent to...

"...increase customer served per system by 10x..."

"...increase the quality of service by 300%..."

INTEL® QLC SSD

Today at Flash Memory Summit:

- Improving SSD performance
- Delivering efficient storage
- Persistent Memory
- Memory

#IntelDCISummit
SUMMITING THE DATA-CENTRIC MOUNTAIN

- Semiconductor innovation
- Advanced silicon manufacturing
- Processor architecture
- Platform and system integration expertise
- Software development
- Data center knowledge
- Global ecosystem building
FIRST TO DELIVER BIG, PERSISTENT, AFFORDABLE MEMORY

CATALYST FOR INTEL® XEON® SCALABLE PLATFORM GROWTH
Q&A
Statements in this presentation that refer to business outlook, future plans and expectations are forward-looking statements that involve a number of risks and uncertainties. Words such as "anticipates," "expects," "intends," "goals," "plans," "believes," "seeks," "estimates," "continues," "may," "will," "would," "should," "could," and variations of such words and similar expressions are intended to identify such forward-looking statements. Statements that refer to or are based on projections, uncertain events or assumptions also identify forward-looking statements. Such statements are based on management's current expectations, unless an earlier date is indicated, and involve many risks and uncertainties that could cause actual results to differ materially from those expressed or implied in these forward-looking statements. Important factors that could cause actual results to differ materially from the company's expectations are set forth in Intel's earnings release dated July 26, 2018, which is included as an exhibit to Intel's Form 8-K furnished to the SEC on such date. Additional information regarding these and other factors that could affect Intel's results is included in Intel's SEC filings, including the company's most recent reports on Forms 10-K and 10-Q. Copies of Intel's Form 10-K, 10-Q and 8-K reports may be obtained by visiting our Investor Relations website at www.intc.com or the SEC's website at www.sec.gov.

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