Memory & Storage Moment
Enable Unprecedented Storage Value with Intel® Optane™ SSD P5800X

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Vice President and General Manager
Intel Data Center Optane Storage Division
Intel® Optane™ SSDs
The Storage Landscape has Changed

- **Latency**: reduce transaction costs for latency-sensitive workloads...
  - Alibaba Cloud

- **IOPS**: “Test queries... they’re almost instantaneous.”
  - itx

- **QoS**: met Telefónica’s stringent SLA requirements.
  - Telefónica

- **Endurance**: “far exceeds endurance requirements of 48 PBW”
  - Baidu

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**Customer Benefits**
- **Latency**: reduce transaction costs for latency-sensitive workloads...
- **IOPS**: “Test queries... they’re almost instantaneous.”
- **QoS**: met Telefónica’s stringent SLA requirements.
- **Endurance**: “far exceeds endurance requirements of 48 PBW”

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**Customer Wins**

>40%

Fortune 500 company adoption

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5 Source Intel – Internal sales data as of November 2020.
As NAND densities continue to increase, the need for storage acceleration grows.

IOPS/TB for Working Data
70/30 Read/Write Random

Results have been estimated or simulated using internal Intel analysis or architecture simulation or modeling and provided to you for informational purposes. Any differences in your system hardware, software or configuration may affect your actual performance. All information provided here is subject to change without notice. Contact your Intel representative to obtain the latest Intel product information.
Workloads are **Becoming More Intense**

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**Workload Intensity Increasing**

**Accelerating Compute Demand**

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**Legacy Storage is a** **Performance Bottleneck**

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1. Source for “Compute Demand Accelerating” Intel Market Intelligence Group - DRAM Market Monitor Q1-20” by Yole Development
Introducing
Intel® Optane™
SSD P5800X

The World’s Fastest Data Center SSD\(^1\)

\(^1\)Source – Intel. As compared to generally available PCIe Gen4 x4 Enterprise and Data Center industry SSDs.
Intel® Optane™ SSD P5800X

What’s New

Next-gen Intel Optane Media

PCle 4.0

- Sequential Read: up to 7.2GB/s
- Sequential Write: up to 6.2GB/s
- Random 4k Read (IOPS): up to 1.5M
- Random 4k Write (IOPS): up to 1.5M
- Random 4k 70/30 (IOPS): up to 1.8M
- QoS (4KRR, QD=1, 99%): <6us
- QoS (4KRR, RW, Mixed QD=1, 99.999%): <25us

4.6M 512B RR IOPS

100 DWPD

The World’s Fastest Data Center SSD

Improvements vs Intel Optane SSD DC P4800X (PCle gen 3)

- 3x Greater Random 4k Mixed R/W IOPS
- 40% Better QoS (4K Random Read, QD=1, 99%)
- 3x Higher Seq 4K-128K Bandwidth (R/W)
- 67% Higher endurance (Drive Writes Per Day)

Source - Intel. See Appendix A for workloads and configurations. Results may vary.

1 Source - Intel. See Appendix A for workloads and configurations. Results may vary.
2 Source - Intel. Latency measured using Intel® Storage Performance Developer Kit (Intel SPDK) and FIO 3.3 (with fio_plugin) based on random 4Kb transfer size with total queue depth of 1 (QD=1, workers/jobs=1) workload.
3 Source - Intel. As compared to generally available PCIe Gen4 x4 (4 lanes) Enterprise and Data Center industry SSDs. Results may vary.

400/800GB 1.60/3.20TB in U.2 form factor
Low Latency Under Heavy Write Workloads

Aerospike Certification Tool (ACT)
Maximize TPS below 1ms Latency, ACT v6.1

Zero Failures
for Intel Optane SSD P5800X at 1ms SLA

Meet SLAs with 2 Million TPS

Application: Minimize response times to accelerate time to insight

Financial Services
- Fraud-detection
- Analytics
- Compliance
- Market modeling, etc.

Real-time Bidding
- Ad requests
- Bid requests
- Bidding
- Ad delivery

Intel® SSD D7-P5600
Intel® Optane™ SSD P5800X

2,000K
480K

Faster Actionable Insights

TPS

1 Source – Intel. See Appendix B for workloads and configurations. See https://www.aerospike.com/act-for-ssds/ for Aerospike ACT information. Results may vary.
Outstanding QoS for Predictable Performance

Read Quality of Service (QoS) at 1GB/s Write\(^1\) (lower is better)

![Graph showing read latency and I/O](image)

Application: Differentiate storage-based services

<table>
<thead>
<tr>
<th>Service level</th>
<th>Target response time (latency)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entry</td>
<td></td>
</tr>
<tr>
<td>Basic</td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td></td>
</tr>
<tr>
<td>Better</td>
<td></td>
</tr>
<tr>
<td>Best</td>
<td></td>
</tr>
</tbody>
</table>

Offer **Premium** QoS Tiers

- up to **66x Better** QoS at 5.9s Latency

1 Source – Intel. See Appendix C for workloads and configurations. Results may vary.
Leading IOPS Performance Across Workloads

KIOPS\(^1\) across random mixed 4KB workload

3.7x Higher at 70R/30W

Application: Use a write buffer to balance high-speed network and storage performance

<table>
<thead>
<tr>
<th># SSDS to saturate 100 GbE network to 90%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intel® Optane™ SSD P5800X (400GB)</td>
</tr>
<tr>
<td>Intel SSD D7-P5600 (3,200GB)</td>
</tr>
<tr>
<td>------------------------------------------</td>
</tr>
<tr>
<td>100% Random Read</td>
</tr>
<tr>
<td>2 SSDs</td>
</tr>
<tr>
<td>4 SSDs</td>
</tr>
<tr>
<td>800GB</td>
</tr>
<tr>
<td>12,800GB</td>
</tr>
<tr>
<td>100% Random Write</td>
</tr>
<tr>
<td>3 SSDs</td>
</tr>
<tr>
<td>13 SSDs</td>
</tr>
<tr>
<td>1,200GB</td>
</tr>
<tr>
<td>41,600GB</td>
</tr>
<tr>
<td>70/30 Mixed Read/Write</td>
</tr>
<tr>
<td>3 SSDs</td>
</tr>
<tr>
<td>7 SSDs</td>
</tr>
<tr>
<td>1,200GB</td>
</tr>
<tr>
<td>22,400GB</td>
</tr>
</tbody>
</table>

1 Source - Intel. See Appendix D for workloads and configurations. Results may vary.
2 Source - Intel. Saturation calculations based on spec sheet data. See Appendix A for workloads and configurations. Results may vary.

Up to 2M IOPS for Mixed WLs\(^1\) — 16-35x More Efficient Saturation\(^2\)
High Endurance Storage is Cost Effective

Endurance Rating\(^1\) (higher is better)

<table>
<thead>
<tr>
<th>Drive</th>
<th>Drive Writes Per Day (DWPD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intel® Optane™ SSD P5800X(^1)</td>
<td>100</td>
</tr>
<tr>
<td>Intel Optane SSD DC P4800X(^1)</td>
<td>60</td>
</tr>
<tr>
<td>Intel® SSD D7-P5600(^1)</td>
<td>3</td>
</tr>
<tr>
<td>Intel® SSD D5-P4320(^1)</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Application: Protect low-endurance NAND capacity drives

Use Optane SSD for small block writes
Data ingest in 4K (small) blocks
Data de-staged in 1M (large) blocks
Fewer Replacements

Directing writes to high endurance Intel Optane SSDs can extend the life\(^2\) of capacity SSDs up to 20x

67% Higher vs Previous Gen

Reduce SSD Capacity Storage Costs

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1 Source - Intel. See Appendix A for workloads and configurations. Results may vary.

A Growing Ecosystem for Intel® Optane™ Technology

Kernel optimizations¹ make async I/O 66% more efficient using Intel® Optane™ SSD P5800X

Excelero improvement²: 2.5x B/W improvement moving data to QLC capacity vs previous gen Intel® Optane™ SSD DC P4800X

VAST 20% faster writes³: Intel Optane SSD P5800X vs P4800X (both on PCIe gen3)

Nutanix announced the launch of first-of-its-kind joint innovation lab in collaboration with Intel⁴

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¹ Source – Jens Axboe [https://twitter.com/axboe/status/1296904865508139009](https://twitter.com/axboe/status/1296904865508139009) and [https://twitter.com/axboe/status/1296905986498883004](https://twitter.com/axboe/status/1296905986498883004)

² Source – Excelero, as tested December 2020. Intel does not control or audit third-party data. You should consult other sources to evaluate accuracy.

³ Source – VAST Data. All tests performed on PCIe Gen3 servers. Intel Optane SSD P5800X is Gen4 but compatible with Gen3 PCIe platforms. Intel does not control or audit third-party data. You should consult other sources to evaluate accuracy.

## Storage Optimization for Modern Data Centers

### Linux
- **within kernel**
  - io_uring
    - *(Tech Session 2 – Developer Insights - Optimizing Software for the Next Gen Intel® Optane™ SSD P5800X, Tech Session 9 – Software Insights for SPDK and io_uring Storage Stack Optimization)*
- **separate stack**
  - Storage Performance Developer Kit
    - *(Tech Session 9 – Software Insights for SPDK and io_uring Storage Stack Optimization)*

### Windows
- NVMe optimization

### VMWare
- NVMe optimization
  - *(Tech Session 6 – Customer Storage Innovations to Break Through Barriers)*

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### Media Aware Storage Framework
- *(Tech Session 1 - IO Storage Optimizations for New Media)*

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**Remove SW Bottlenecks**

**Media Aware**
Real-world Value from the **World’s Fastest Data Center SSD**

<table>
<thead>
<tr>
<th>Lower Latency&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Consistent QOS&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Greater IOPS&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Higher Endurance&lt;sup&gt;2&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Get Actionable Insights Faster</td>
<td>Monetize Service Level Agreements</td>
<td>Better Saturate High-Speed Networks</td>
<td>Extend life of NAND SSDs</td>
</tr>
</tbody>
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**INTEL® OPTANE™ SSD P5800X**

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<sup>1</sup> Source – Intel. As compared to generally available PCIe Gen4 x4 (4 lanes) Enterprise and Data Center industry SSDs. Results may vary.

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Performance varies by use, configuration, and other factors. Learn more at [www.intel.com/PerformanceIndex](http://www.intel.com/PerformanceIndex).

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

Your costs and results may vary.

Intel does not control or audit third-party data. You should consult other sources to evaluate accuracy.

Results have been estimated or simulated.

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Appendix A – Intel® Optane™ SSD P5800X Specifications

Source – Intel

Date tested – November 13, 2020

Workload – FIO rev 3.5, based on random 512B transfer size with total queue depth of 64 (QD=8, workers/jobs=8) workload, 4KB transfer size with total queue depth of 32 (QD=4, workers/jobs=8) workload, 8KB transfer size with total queue depth of 16 (QD=4, workers/jobs=4) workload in most case, except where specified.

System configuration

Endurance Rating
100 Drive Writes per day for 5 years (JESD219 workload). Up to 584 Petabytes Written (PBW).

Performance varies by use, configuration and other factors. Intel Optane SSD P5800X Series is optimized for 4K aligned workloads. If the customer workload has a significant percentage of non 4K aligned I/O or sub 4K accesses, real performance data can vary. Contact your Intel representative for more information. Learn more at www.Intel.com/PerformanceIndex.
Appendix B – Aerospike Certification Test 6.1 (ACT) Results

Source – Intel

Date tested – November 13, 2020

Workload – Aerospike ACT Failure Rate @ 300K TPS

System configuration: Server System Configuration - Intel Server System Pre-production Whitely, 2x CPU, 256GB installed 16GB X DDR4 @ 2933MHz. Operating System: CentOS Linux release 8.2.2004 (Core), kernel 5.9.6-1.el8.elrepo.x86_64, ACT Version 6.1 - Aerospike Certification Tool is an open source tool that allows 66/33 read write mix. It is a database simulation tool and qualifies the get requests of different sizes for a drive to pass under 1 millisecond of read requests. No more than 5% can fail at 1 millisecond. Configuration 1 uses 2x Intel® SSD D7-P5600 6.4TB, Configuration 2 uses 1x Intel® Optane™ SSD P5800X 1.6TB.

Performance varies by use, configuration and other factors. Learn more at www.Intel.com/PerformanceIndex.
Appendix C – Outstanding QoS for Predictable Performance

Source – Intel

Date tested – November 18, 2020

Workload – Read Quality of Service (QoS) at 1GB/s Write

Common configuration: Server System Configuration - Intel Server System Pre-production Whitely, 2x CPU, BIOS: SE5C620.86B.02.01.0009.092820190230, RAM Capacity: 256GB(8x32G) DDR4@3200MT/s, PCIe Attach: CPU (not PCH lane attach), Chipset: Intel C610 chipset, Switch/ReTimer Model/Vendor: Intel G4SAC switch (PCIe Gen4), OS: CentOS 7.5, 5.8.3-1.el7.elrepo.x86_64, FIO version: 3.22 with io_uring; NVMe Driver: Inbox, C-states: Disabled, Hyper Threading: Disabled, CPU Governor (through OS): Performance Mode. EIST (Speed Step), Intel Turbo Mode, and P-states = Disabled; IRQ Balancing Services (OS) = Off; SMP Affinity, set in the OS; QD1 utilizes I/O Polling Mode with ioengine=pvsync2/hpri. Configuration 1 uses 1x Intel® SSD D7-P5600 6.4TB, Configuration 2 uses 1x Intel® Optane™ SSD P5800X 1.6TB.

Performance varies by use, configuration and other factors. Learn more at www.Intel.com/PerformanceIndex.
Appendix D – Leading IOPS Performance Across Workloads

Source – Intel
Date tested – October 10, 2020
Workload – KIOPS across random mixed 4KB workload

Common configuration: Server System Configuration - Intel Server System Pre-production Whitely, 2x CPU, BIOS: SE5C620.86B.02.01.0009.092820190230, RAM Capacity: 256GB(8x32G) DDR4@3200MT/s, PCIe Attach: CPU (not PCH lane attach), Chipset: Intel C610 chipset, Switch/ReTimer Model/Vendor: Intel G4SAC switch (PCIe Gen4), OS: CentOS 7.5, 5.8.3-1.el7.elrepo.x86_64, FIO version: 3.22 with io_uring; NVMe Driver: Inbox, C-states: Disabled, Hyper Threading: Disabled, CPU Governor (through OS): Performance Mode, EIST (Speed Step), Intel Turbo Mode, and P-states = Disabled; IRQ Balancing Services (OS) = Off; SMP Affinity, set in the OS; QD1 utilizes I/O Polling Mode with ioengine=pvsync2/hipri. Configuration 1 uses 1x Intel® SSD D7-P5600 6.4TB, Configuration 2 uses 1x Intel® Optane™ SSD P5800X 1.6TB.

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