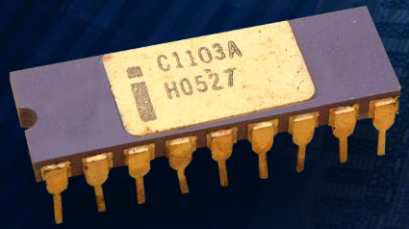
NEW INTEL ARCHITECTURE AND TECHNOLOGIES FOR HPC AND CLOUD

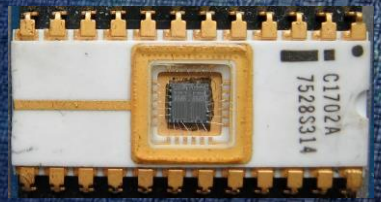
Nikolay Mester, Development Director, HPC/Cloud vertical

COMPUTER ARCHITECTURE

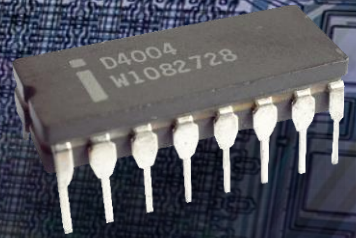
CELEBRATING 50 YEARS OF INDUSTRY INNOVATION



1970
Intel 1103 - *First DRAM Chip*



1971
Intel 1702A - *First EPROM Chip*



1971
Intel 4004 - *First Microprocessor*

TECHNOLOGIES

INTEL® XEON® SCALABLE PLATFORM

The foundation of Data Center Innovation: Agile & Trusted Infrastructure

PERFORMANCE

Pervasive through compute, storage, and network

SECURITY

Pervasive data security with near zero performance overhead

AGILITY

Rapid service delivery

DELIVERS 1.65X AVERAGE PERFORMANCE BOOST OVER PRIOR GENERATION[1]

[1] Up to 1.65x Geomean based on Normalized Generational Performance going from Intel® Xeon® processor E5-26xx v4 to Intel® Xeon® Scalable processor (estimated based on Intel internal testing of OLTP Brokerage, SAP SD 2-Tier, HammerDB, Server-side Java, SPEC*int_rate_base2006, SPEC*fp_rate_base2006, Server Virtualization, STREAM* triad, LAMMPS, DPDK L3 Packet Forwarding, Black-Scholes, Intel Distribution for LINPACK

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 http://www.intel.com/performance. Intel does not control or audit the design or implementation of third party benchmark data or Web sites referenced in this document. Intel encourages all of its customers to visit the referenced Web sites or others where similar performance benchmark data are reported and confirm whether the referenced benchmark data are accurate and reflect performance of systems available for purchase.

A GLIMPSE INSIDE THE INTEL® XEON® SCALABLE PLATFORM

Workload optimized frameworks & telemetry
(e.g. Caffe*, Intel® DAAL, Intel® MKL, DPDK, SNAP*, SPDK)

PERFORMANCE

SECURITY

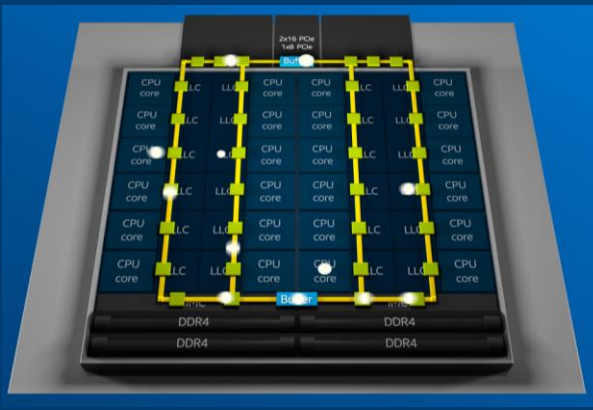
AGILITY

ADVANCING VIRTUALLY EVERY ASPECT: BRAND NEW CORE, CACHE, ON-DIE INTERCONNECTS, MEMORY CONTROLLER & MORE

Intel® Advanced Vector Extensions 512 (Intel® AVX-512)
Intel® Volume Management Device (Intel® VMD)
Intel® Data Analytics Acceleration Library (Intel® DAAL)
Intel® Math Kernel Library (Intel® MKL)
Storage Performance Development Kit (SPDK)
Data Plane Development Kit (DPDK)
Intel® Resource Director Technology (Intel® RDT)

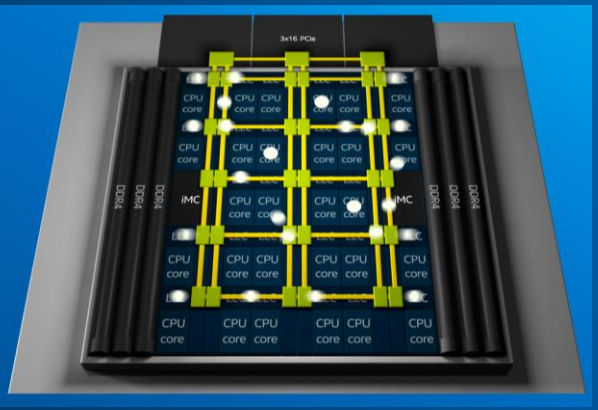
BREAKTHROUGH CPU DESIGN: INTEL® MESH ARCHITECTURE

Ring Architecture



2009-2017+

Mesh Architecture



New in 2017

- ✓ **Maximizes performance**
- ✓ **Enables consistent, low latencies**
- ✓ **Optimized for data** sharing and memory access between all CPU cores/threads for ideal memory bandwidth and capacity
- ✓ **Data flows scale efficiently** for 2, 4 & 8+ socket configurations
  - ✓ Designed for modern virtualized and hybrid cloud implementations

DESIGNED FOR NEXT-GENERATION DATA CENTERS

DELIVERING PERFORMANCE BEYOND BENCHMARKS

CLOUD	Baidu 百度 SEARCH	HUAWEI FUSIONSPHERE	KINGSOFT MYSQL CLOUD SERVICE	Neusoft ACLOME	Tencent 腾讯 CLOUD
	1.74X click-through-rate[1]	1.62X enterprise cloud applications[2]	1.63X OLTP database[3]	1.5X cloud monitoring[4]	1.72X video stitching[5]
AI & ANALYTICS	IBM DB2	IHS Markit ANALYTICS RISK ENGINE	LAMMPS	SAP HANA	sas
	1.47X in-memory analytics[6]	1.68X enterprise risk management[7]	1.72X molecular dynamics[8]	1.59X database transactions[9]	2X business analytics[10]
NETWORK	AsiaInfo VERIS	eBrisk EBLIVE	ERICSSON MEDIAFIRST	sandvine VIRTUAL SERIES	Telefónica VIRTUAL BNG
	2.21X business support system[11]	1.9X HEVC video encoding[12]	1.5X video transcoding[13]	1.64X packet inspection[14]	1.67X routing[15]

1. Baidu Search Click-Through-Rate (CTR) : OS: CentOS Linux release 7.3.1611. Testing by Intel June 2017. 2S Intel® Xeon® processor E5-2699 v4 vs 2S Intel® Xeon® Platinum processor 8180.
2. Huawei FusionSphere virtualized cloud Platform: OS: RHEL 7.2. Testing by Intel May 2017. 2S Intel® Xeon® processor E5-2699 v4 vs 2S Intel® Xeon® Platinum processor 8180.
3. Kingsoft Cloud Image Processing and MySQL Cloud Service: OS: CentOS 7.3.1611. Testing by Intel May 2017. 2S Intel® Xeon® processor E5-2699 v4 vs 2S Intel® Xeon® Platinum processor 8180.
4. Neusoft SaCa Aclome: SaCa Aclome workload (for general performance) and compressing/decompressing workload (for QAT). OS: CentOS 7.3.1611. Testing by Intel and Neusoft May 2017. 2S Intel® Xeon® processor E5-2699 v4 vs 2S Intel® Xeon® Platinum processor 8180.
5. Tencent Business Analytics: Video Stitching workload. OS: CentOS 7.3.1611 Linux kernel 4.9.8. Testing by Intel April 2017. 2S Intel® Xeon® processor E5-2699 v4 vs 2S Intel® Xeon® Platinum processor 8180.
6. IBM DB2: DB2 v11.1.1.1. The IBM Big Data Insights Internal Heavy Multiuser Workload (BDInsights) is a multi-user data warehousing workload based on a retail environment. Testing by Intel and IBM April/May 2017. 4S Intel® Xeon® processor E7-8890 v4 vs 4S Intel® Xeon® Platinum processor 8180.
7. IHS Markit Analytics Risk Engine: internal synthetic portfolio. OS: Windows server 2016. Testing by Intel and IHS Markit May 2017. 2S Intel® Xeon® processor E5-2699 v4 vs 2S Intel® Xeon® Platinum processor 8168.
8. LAMMPS: Testing by Intel June 2017. 2S Intel® Xeon® processor E5-2697 v4 vs 2S Intel® Xeon® Platinum processor 8168.
9. SAP HANA: 1-Node, 4S Intel® Xeon® Processor E7-8890 v4 on Grantley-EX-based platform with 1024 GB Total Memory on SLES12SP1 vs. estimates based on SAP internal testing on 1-Node, 4S Intel® Xeon® Scalable family.
10. SAS Business Analytics: SAS 9.4 m4 application running the 30 session SAS Mixed Analytics workload. OS: CentOS 7.2 kernel 3.10.0. ntel and SAS May 2017. 2S Intel® Xeon® E5-2699 v4 vs 2S Intel® Xeon® Platinum processor 8180.
11. AsiaInfo Telco BSS: AsiaInfo Telco BSS workload. OS: RHEL 7.3. Testing by Intel & AsiaInfo May 2017. 4S Intel® Xeon® processor E7-8890 v4 vs 4S Intel® Xeon® Platinum processor 8180.
12. eBrisk: OS: Windows Server 2012 R2 Standard Build 9600. Test clips: https://media.xiph.org/video/derf/ . Testing by Intel May 2017. 2S Intel® Xeon® processor E5-2699 v4 vs 2S Intel® Xeon® Platinum processor 8180.
13. Ericsson MediaFirst Video Processing UHD HEVC transcoding workload. OS: CentOS Linux* 7.2 kernel 3.10.0. Testing by Ericsson in May 2017. 2S Intel® Xeon® processor E5-2699 v4 vs 2S Intel® Xeon® Platinum processor 8168.
14. Sandvine Virtual Series OS: CentOS Linux release 7.3.1611 Kernal: Linux 3.10.0-514.6.2.el7.x86_64 Hypervisor: qemu-kvm-1.5.3-126.el7_3.3.x86_64 VNF sizing: 3vCPU (6 pCPU threads), 128 GB RAM Testing by Sandvine, June 2017. 2S Intel® Xeon® processor E5-2699 v3 vs 2S Intel® Xeon® Gold processor 6150.
15. Telefonica: Testing by Telefonica. 2S Intel® Xeon® processor E5-2600 v4 vs 2S Intel® Xeon® Platinum processor 8168.

INTEL® XEON® SCALABLE PROCESSORS

THE FOUNDATION FOR AGILE, SECURE, WORKLOAD-OPTIMIZED HYBRID CLOUD

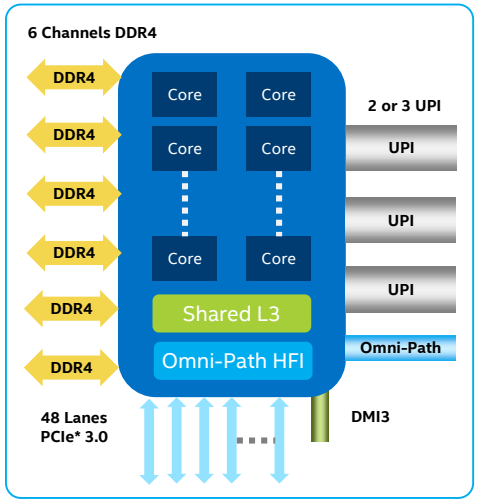
BEST	GREAT	GOOD	ENTRY
intel XEON PLATINUM inside™	intel XEON GOLD inside™	intel XEON SILVER inside™	intel XEON BRONZE inside™
UP TO 28 CORES	UP TO 22 CORES	SCALABLE PERFORMANCE AT LOW POWER STANDARD RAS	SCALABLE PERFORMANCE HARDWARE-ENHANCED SECURITY STANDARD RAS
UP TO 2, 4 & 8 SOCKET SUPPORT WITH UP TO 3 UPI LINKS	2 & 4 SOCKET SUPPORT	MODERATE TASKS	LIGHT TASKS
DDR4 2666 MHZ WITH UP TO 1.5 TB TOPLINE MEMORY CHANNEL BANDWIDTH	UP TO 3 UPI LINKS	INTEL® TURBO BOOST TECHNOLOGY AND INTEL® HYPER-THREADING TECHNOLOGY FOR MODERATE WORKLOADS	ENTRY PERFORMANCE, PRICE SENSITIVE FOR LIGHT WORKLOADS
HIGHEST ACCELERATOR THROUGHPUT	ADVANCED RELIABILITY, AVAILABILITY AND SERVICEABILITY		
MAINSTREAM		EFFICIENT	ENTRY

INTEL® XEON® SCALABLE PROCESSOR

Re-architected from the Ground Up

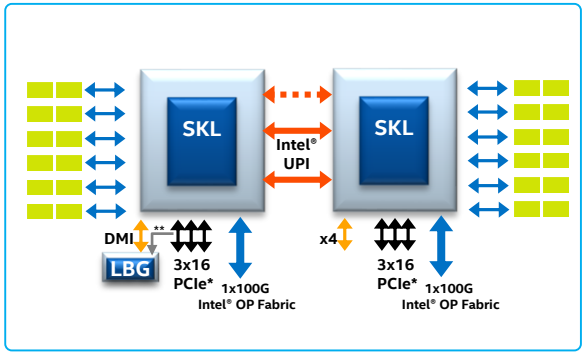
- Skylake core microarchitecture, with data center specific enhancements
- Intel® AVX-512 with 32 DP flops per core
- Data center optimized cache hierarchy – 1MB L2 per core, non-inclusive L3
- New mesh interconnect architecture
- Enhanced memory subsystem
- Modular IO with integrated devices
- New Intel® Ultra Path Interconnect (Intel® UPI)
- Intel® Speed Shift Technology
- Security & Virtualization enhancements (MBE, PPK, MPX)
- Optional Integrated Intel® Omni-Path Fabric (Intel® OPA)

Features	Intel® Xeon® Processor E5-2600 v4	Intel® Xeon® Scalable Processor
Cores Per Socket	Up to 22	Up to 28
Threads Per Socket	Up to 44 threads	Up to 56 threads
Last-level Cache (LLC)	Up to 55 MB	Up to 38.5 MB (non-inclusive)
QPI/UPI Speed (GT/s)	2x QPI channels @ 9.6 GT/s	Up to 3x UPI @ 10.4 GT/s
PCIe* Lanes/ Controllers/Speed(GT/s)	40 / 10 / PCIe* 3.0 (2.5, 5, 8 GT/s)	48 / 12 / PCIe 3.0 (2.5, 5, 8 GT/s)
Memory Population	4 channels of up to 3 RDIMMs, LRDIMMs, or 3DS LRDIMMs	6 channels of up to 2 RDIMMs, LRDIMMs, or 3DS LRDIMMs
Max Memory Speed	Up to 2400	Up to 2666
TDP (W)	55W-145W	70W-205W



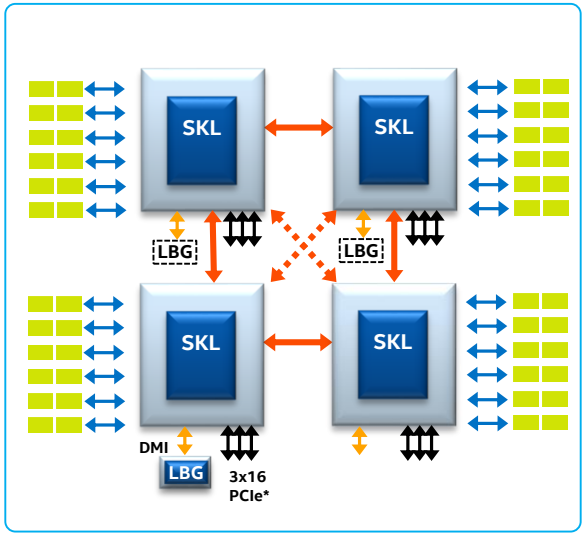
PLATFORM TOPOLOGIES

2S Configurations



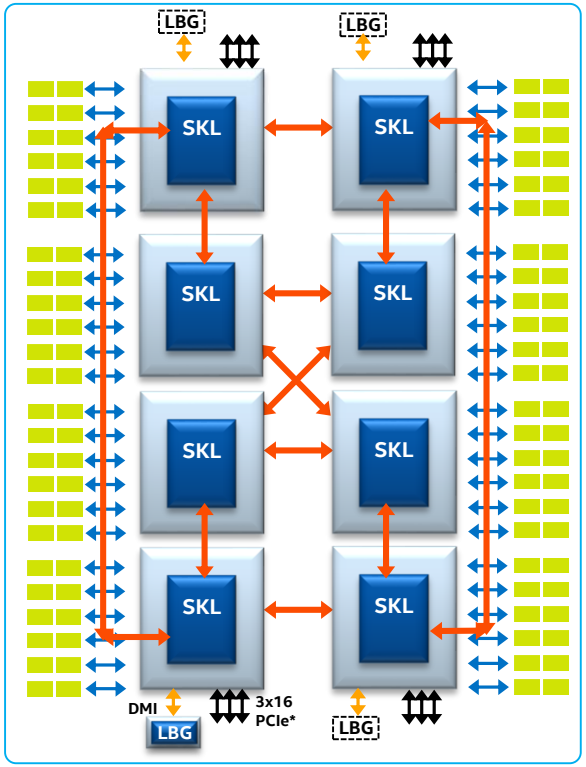
(2S-2UPI & 2S-3UPI shown)

4S Configurations



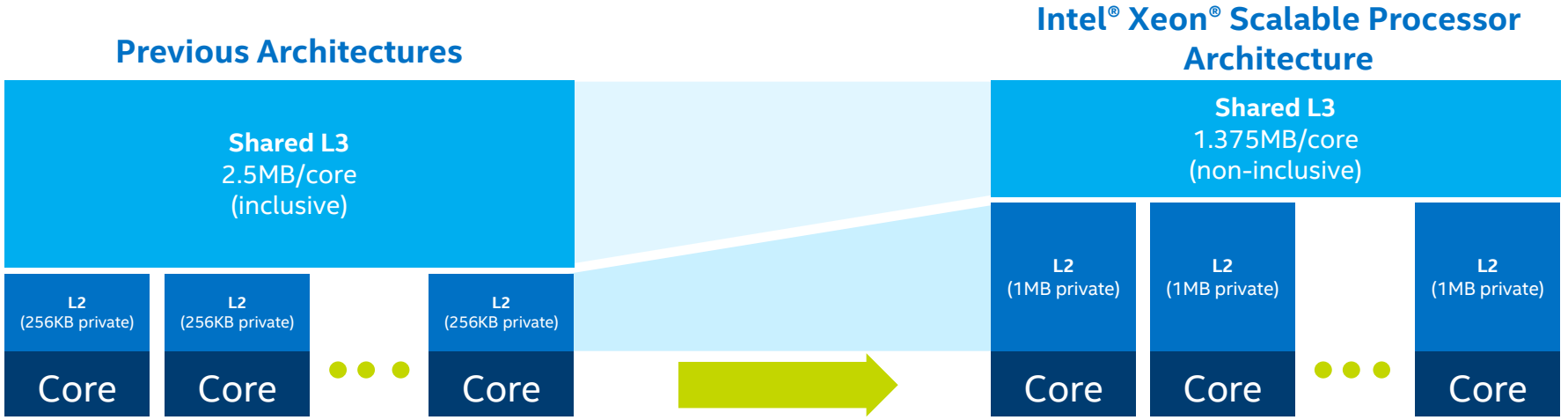
(4S-2UPI & 4S-3UPI shown)

8S Configuration



INTEL® XEON® SCALABLE PROCESSOR SUPPORTS CONFIGURATIONS RANGING FROM 2S-2UPI TO 8S

RE-ARCHITECTED L2 & L3 CACHE HIERARCHY



- On-chip cache balance shifted from shared-distributed (prior architectures) to private-local (Skylake architecture):
  - Shared-distributed ➔ shared-distributed L3 is primary cache
  - Private-local ➔ private L2 becomes primary cache with shared L3 used as overflow cache
- Shared L3 changed from inclusive to non-inclusive:
  - Inclusive (prior architectures) ➔ L3 has copies of all lines in L2
  - Non-inclusive (Skylake architecture) ➔ lines in L2 ***may not*** exist in L3

SKYLAKE-SP CACHE HIERARCHY ARCHITECTED SPECIFICALLY FOR DATA CENTER USE CASE

INTEL® ADVANCED VECTOR EXTENSIONS-512 (AVX-512)

End Customer Value: Workload-optimized performance, throughput increases, and H/W-enhanced security improvements for familiar analytics, HPC, video transcode, cryptography, and compression software.

Problems Solved:

1. Achieve more work per cycle (doubles width of data registers)

2. Minimize latency & overhead (doubles the number of registers) with ultra-wide (512-bit) vector processing capabilities (that that 2x FMA processing engines are available on Intel® Xeon® Platinum and Intel® Xeon® Gold Processors)

VALUE PILLARS

PERFORMANCE

SECURITY

SEGMENTS

Cloud Service Providers

Comms Service Providers

Enterprise

PROOF POINTS

Up to 2X FLOPS/clock cycle[1]

Up to 4X greater throughput[2]

Accelerates performance for your most demanding computational tasks

* FLOPs = Floating Point Operations

1 Peak performance vs. Intel® AVX2. As measured by Intel® Xeon® Processor Scalable Family with Intel® AVX-512 compared to an Intel® Xeon® E5 v4 with Intel® AVX2

2 Vectorized floating-point throughput. As measured by Intel® Xeon® Processor Scalable Family with Intel® AVX-512 compared to an Intel® Xeon® E5 v4 with Intel® AVX2

INTEL® ADVANCED VECTOR EXTENSIONS-512 (AVX-512)

- 512-bit wide vectors
- 32 operand registers
- 8 64b mask registers
- Embedded broadcast
- Embedded rounding

Microarchitecture	Instruction Set	SP FLOPs / cycle	DP FLOPs / cycle
Skylake	Intel® AVX-512 & FMA	64	32
Haswell / Broadwell	Intel AVX2 & FMA	32	16
Sandybridge	Intel AVX (256b)	16	8
Nehalem	SSE (128b)	8	4

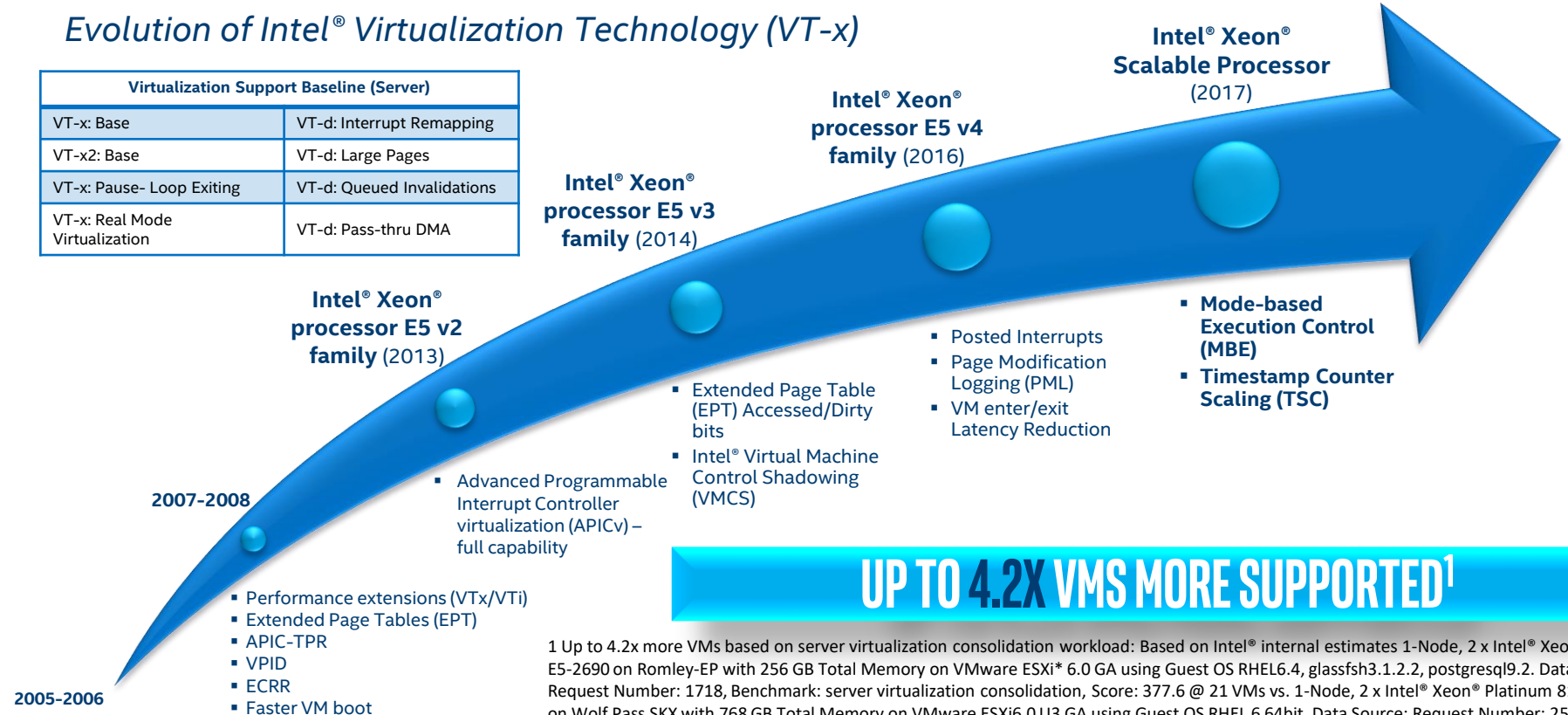
Intel AVX-512 Instruction Types	
AVX-512-F	AVX-512 Foundation Instructions
AVX-512-VL	Vector Length Orthogonality : ability to operate on sub-512 vector sizes
AVX-512-BW	512-bit Byte/Word support
AVX-512-DQ	Additional D/Q/SP/DP instructions (converts, transcendental support, etc.)
AVX-512-CD	Conflict Detect : used in vectorizing loops with potential address conflicts

POWERFUL INSTRUCTION SET FOR DATA-PARALLEL COMPUTATION

ENHANCED HARDWARE-BASED VIRTUALIZATION

Evolution of Intel® Virtualization Technology (VT-x)

Virtualization Support Baseline (Server)	
VT-x: Base	VT-d: Interrupt Remapping
VT-x2: Base	VT-d: Large Pages
VT-x: Pause- Loop Exiting	VT-d: Queued Invalidations
VT-x: Real Mode Virtualization	VT-d: Pass-thru DMA



UP TO 4.2X VMS MORE SUPPORTED[1]

1 Up to 4.2x more VMs based on server virtualization consolidation workload: Based on Intel® internal estimates 1-Node, 2 x Intel® Xeon® Processor E5-2690 on Romley-EP with 256 GB Total Memory on VMware ESXi* 6.0 GA using Guest OS RHEL6.4, glassfsh3.1.2.2, postgresql9.2. Data Source: Request Number: 1718, Benchmark: server virtualization consolidation, Score: 377.6 @ 21 VMs vs. 1-Node, 2 x Intel® Xeon® Platinum 8180 Processor on Wolf Pass SKX with 768 GB Total Memory on VMware ESXi6.0 U3 GA using Guest OS RHEL 6 64bit. Data Source: Request Number: 2563, Benchmark: server virtualization consolidation, Score: 1580 @ 90 VMs. Higher is better.

SNEAK PEEK INTO THE FUTURE

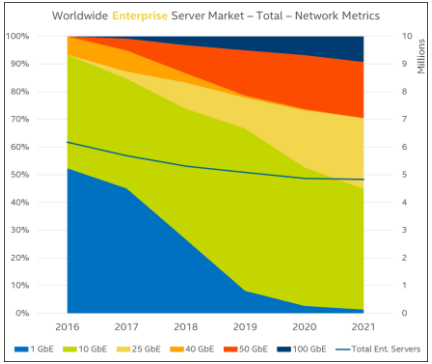
CONNECTIVITY

Integrated and discrete Intel® Ethernet

INTEGRATED INTEL® ETHERNET CONNECTION X722

Low-cost solution for up to four ports of 10GbE Ethernet

- 51% of server ports will be 10GbE in 2017[1]
- Less board space, lower power: ~50% power consumption saving [2]



Source: Dell'Oro Jan.'17 Preliminary Forecast

Proven "It Just Works" 10GbE Ethernet solution

- Based on Intel® Ethernet Converged Network Adapter XL710 (Fortville) architecture
- Upstream / In-box drivers
- Validated with and inherently aligned with the Intel® Xeon® Scalable platform
- External PHYs in production today support 1GbE and 10GbE 10GBASE-T
- Multiple Intel PHY OCP Mezzanine cards for flexible configuration options

Intel Ethernet Network Connection OCP X527-DA2

Intel Ethernet Network Connection OCP X527-DA4

Advanced features to enable Software Defined Infrastructure (SDI)

- Network Virtualization Offloads (VXLAN, NVGRE, GENEVE, NSH, etc.)
- iWARP RDMA for low latency, high throughput data transmission at lower CPU utilization
- Intel® Ethernet Flow Director traffic steering for increased efficiency
- Enhanced Data Plane Development Kit (DPDK) for advanced packet forwarding and high efficient packet processing

Intel Ethernet Network Connection OCP X547-T2

1. Dell'Oro, "Worldwide Server Market Total Network Metrics" January 2017
2. Intel estimates in comparison to Intel® Ethernet Controller XL710 LOM design

COMPLEMENTARY DISCRETE INTEL® ETHERNET SOLUTIONS

For Flexible Intel® Xeon® Scalable Platform Configurations

Integrated Intel® Ethernet targets at mainstream requirements for 10GbE and 1GbE

Intel® Ethernet Converged Network Adapter XXV710/XL710
Provides a performance upgrade to dual ports of 25GbE or 40GbE

Intel® Ethernet Converged Network Adapter X550
Offers dual-port 10GBASE-T in addition to SFP+/QSFP+ LOM designs or just adds more 10GBASE-T ports

Intel® Ethernet Server Adapter I350 Offers up to four ports of 1GbE when additional 1GbE ports are needed or backward compatibility to 100MbE is required

FABRIC

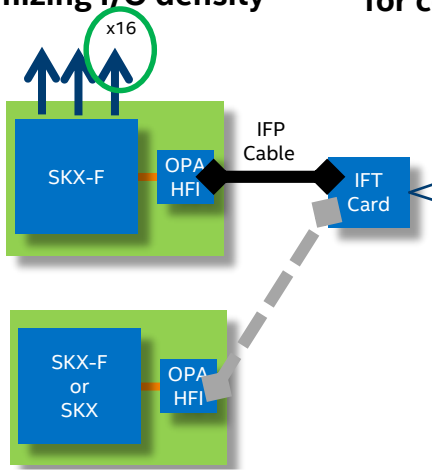
Integrated and discrete Intel® Omni-Path Architecture

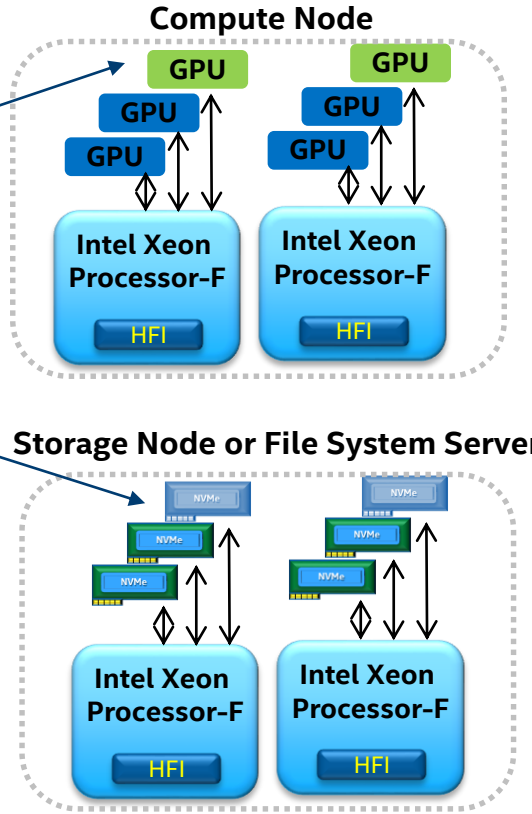
INTEGRATED INTEL® OMNI-PATH ARCHITECTURE

Platform Benefits - Maximized I/O Density per Node

Up to TWO additional PCIe x16 slots are available for maximizing I/O density[1]

Significantly more I/O capacity for compute or storage nodes[1]





SKUS WITH INTEGRATED INTEL® OMNI-PATH ARCHITECTURE FABRIC

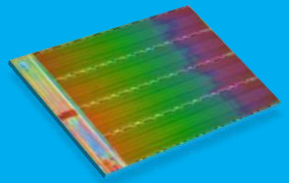
Class	SKU	Cores	Base Non-AVX Speed (GHz)	TDP (W)
Platinum	8176F	28	2.1	173
Platinum	8160F	24	2.1	160
Gold	6148F	20	2.4	160
Gold	6142F	16	2.6	160
Gold	6138F	20	2.0	135
Gold	6130F	16	2.1	135
Gold	6126F	12	2.6	105

[1] For illustrative purposes only. Assumes each CPU socket is configured with all 48 PCIe lanes routed to three x16 slots, or 96 total lanes for a 2S Purley platform. PCIe slot count and PCIe device support will vary by OEM platform, so check with your OEM for more details.

STORAGE

Intel® Volume Management Device (Intel® VMD)
Intel® Solid State drives (Intel® SSDs)

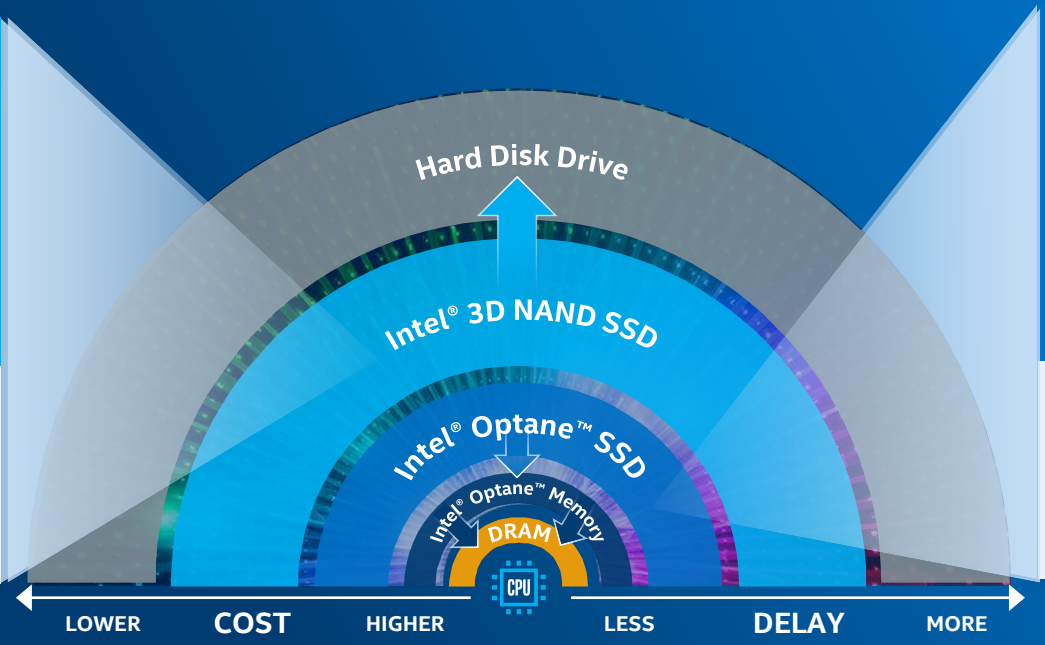
INTEL IS A LEADER IN TWO TECHNOLOGIES

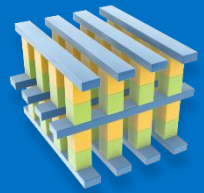


INTEL® 3D NAND TECHNOLOGY

LOWER COST AND HIGHER DENSITY

Bulk storage





INTEL® OPTANE™ TECHNOLOGY

HIGHER PERFORMANCE

Working storage and memory

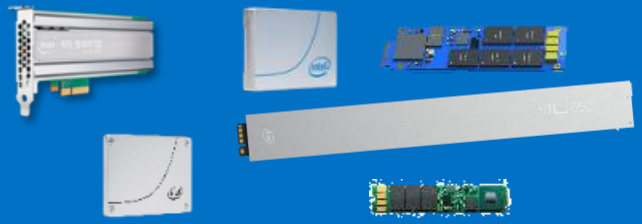
A BROAD PORTFOLIO OF DATA CENTER STORAGE SOLUTIONS

CACHING AND FAST STORAGE

- Intel® Optane™ SSD DC P4800X
- Intel® SSD DC P46X0 Series

MAINSTREAM STORAGE

- Intel® SSD DC P45X0 Series
- Intel® SSD DC P45X1 Series

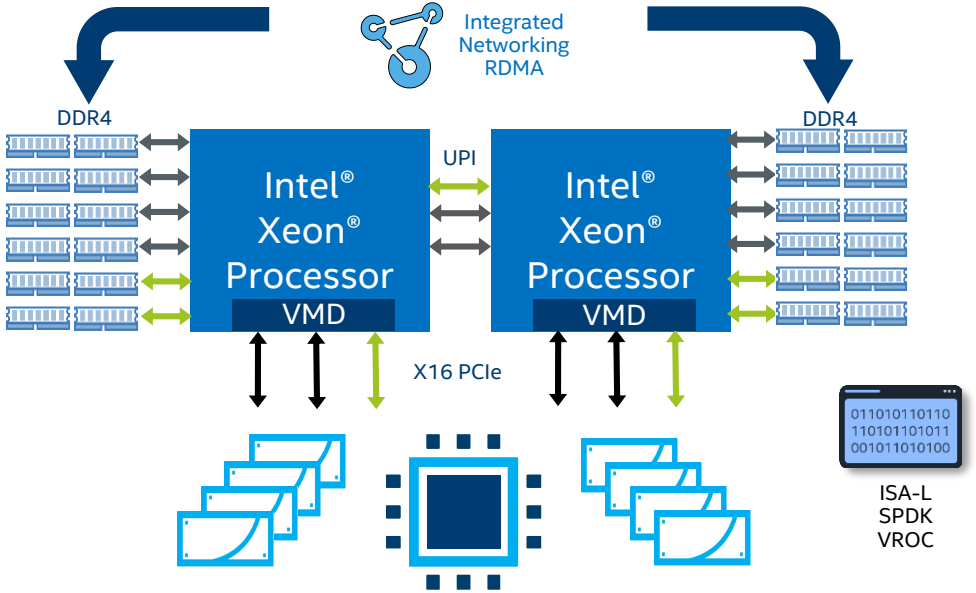


DATA THROUGHPUT IS KEY

PCIe Lanes
48 / processor

Memory Bandwidth
6 channels

UPI Bandwidth
3 UPI buses



Platform to drive storage transformation

INTEL STORAGE SOFTWARE

Intel® Intelligent Storage Acceleration Library (Intel® ISA-L)

storage-domain algorithms optimized from the silicon up

OS agnostic, forward- and backward-compatible: across entire Intel processor line, Atom® to Xeon®

Enhances Performance for data integrity (CRC), security/encryption, data protection (EC/RAID), and compression

Storage Performance Development Kit (SPDK)

drivers and libraries to optimize NVM Express* (NVMe) and NVMe over Fabrics (NVMe-oF)

Software Ingredients for Next-Gen Media

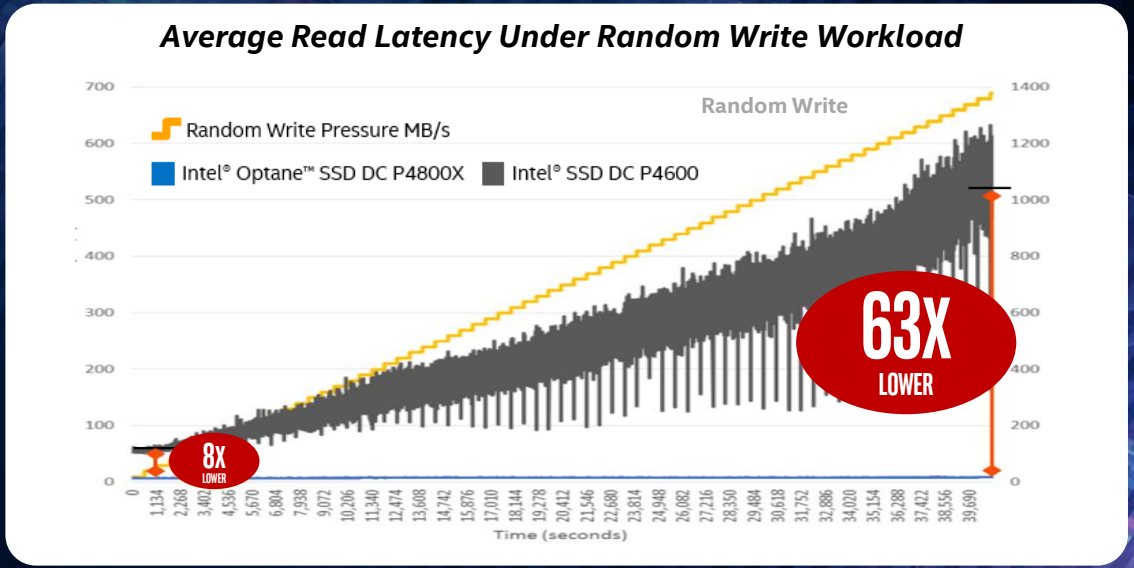
lockless, efficient components that scale to millions of IOs per second per core

User-space Polled-Mode Architecture

open source, BSD licensed for commercial or open source projects

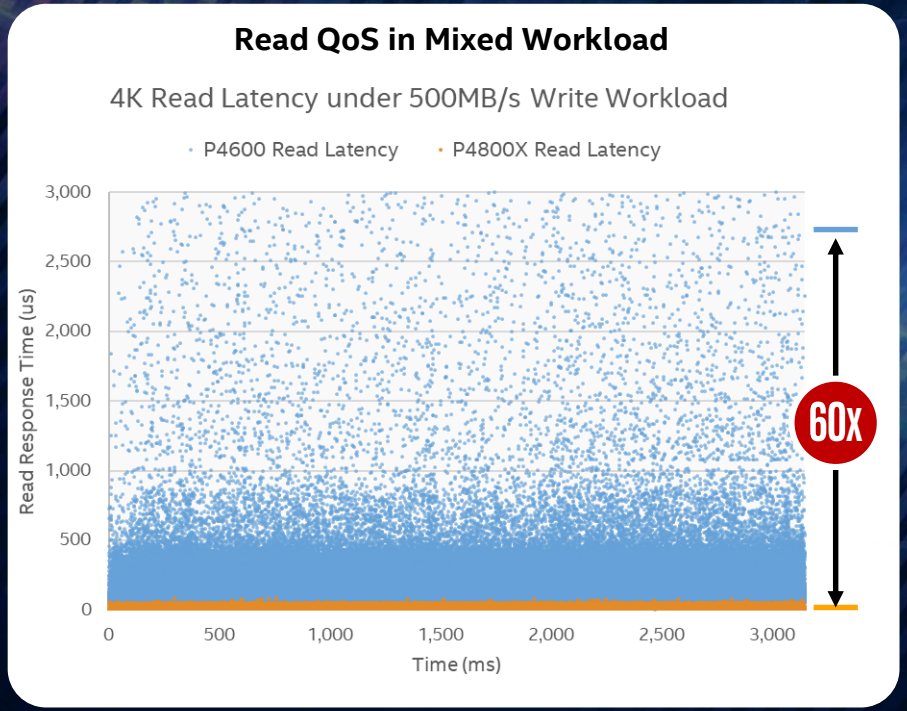
LOWER AND MORE CONSISTENT LATENCY

The Lowest Latency Non-Volatile Memory Technology in the Industry



Source – Intel-tested: Average read latency measured at queue depth 1 during 4k random write workload. Measured using FIO 2.15. Common Configuration - Intel 2U Server System, OS CentOS 7.5, kernel 4.17.6-1.el7.x86_64, CPU 2 x Intel® Xeon® 6154 Gold @ 3.0GHz (18 cores), RAM 256GB DDR @ 2666MHz. Configuration – Intel® Optane™ SSD DC P4800X 375GB and Intel® SSD DC P4600 1.6TB. Latency – Average read latency measured at QD1 during 4K Random Write operations using fio-2.15. System BIOS: 00.01.0013; ME Firmware: 04.00.04.294; BMC Firmware: 1.43.91f76955; FRUSDR: 1.43. The benchmark results may need to be revised as additional testing is conducted. Performance results are based on testing as of July 2018 and may not reflect all publicly available security updates. See configuration disclosure for details. No product can be absolutely secure

PREDICTABLY FAST SERVICE



intel XEON inside + intel OPTANE DC SOLID STATE DRIVE

up to

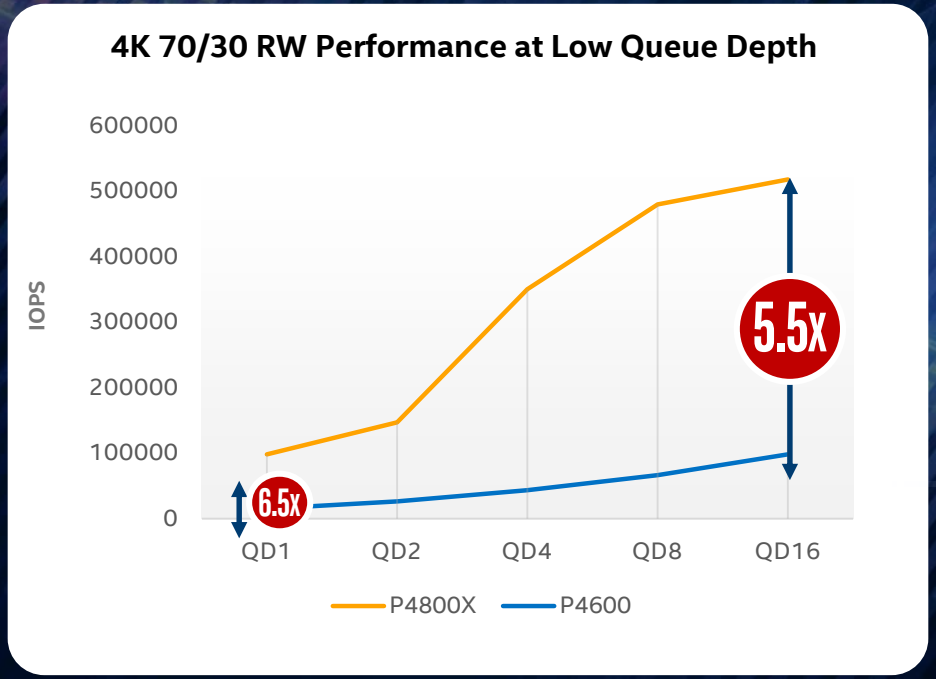
60X BETTER

at 99% QoS†

Ideal for Critical Applications with Aggressive Latency Requirements

† Source – Intel-tested: 4K Read Latency under 500MB/s write workload. Measured using FIO 2.15. Common Configuration - Intel 2U Server System, OS CentOS 7.5, kernel 4.17.6-1.el7.x86_64, CPU 2 x Intel® Xeon® 6154 Gold @ 3.0GHz (18 cores), RAM 256GB DDR @ 2666MHz. Configuration – Intel® Optane™ SSD DC P4800X 375GB and Intel® SSD DC P4600 1.6TB. Latency – Average read latency measured at QD1 during 4K Random Write operations using fio-2.15. System BIOS: 00.01.0013; ME Firmware: 04.00.04.294; BMC Firmware: 1.43.91f76955; FRUSDR: 1.43. The benchmark results may need to be revised as additional testing is conducted. Performance results are based on testing as of July 2018 and may not reflect all publicly available security updates. See configuration disclosure for details. No product can be absolutely secure.

BREAKTHROUGH PERFORMANCE



intel XEON inside + intel OPTANE DC SOLID STATE DRIVE

5-8x FASTER

at Low Queue Depths[1]

Vast Majority of Applications
Generate Low QD
storage workloads

1 Source – Intel-tested: 4K 70/30 RW Performance at Low Queue Depth. Test and System Configuration: CPU: Xeon Skylake Gold 6140 FC-LGA14B 2.3GHz 24.75MB 140W 18 cores CD8067303405200 , CPU Sockets: 2, RAM Capacity: 32G, RAM Model: DDR4, RAM Stuffing: NA, DIMM Slots Populated: 2 slots, PCIe* Attach: CPU (not PCH lane attach), Chipset: Intel C620 chipset BIOS: SE5C620.86B.00.01.0013.030920180427 , Switch/ReTimer Model/Vendor: Cable - Oculink 800mm straight SFF-8611 to right angle SFF-8611 Intel AXXCBL800CVCR, OS: CentOS 7.5, Kernel: 4.14.50(LTS), FIO version: 3.5; NVMe* Driver: Inbox, C-states: Disabled, Hyper Threading: Disabled, CPU Governor (through OS): Performance Mode. EIST (Speed Step), Intel Turbo Mode=Disabled, and P-states = Enabled. The benchmark results may need to be revised as additional testing is conducted. Performance results are based on testing as of July 2018 and may not reflect all publicly available security updates. See configuration disclosure for details. No product can be absolutely secure. Tests document performance of components on a particular test, in specific systems. Differences in hardware, software, or configuration will affect actual performance.
* Other names and brands may be claimed as the property of others .

HIGH ENDURANCE

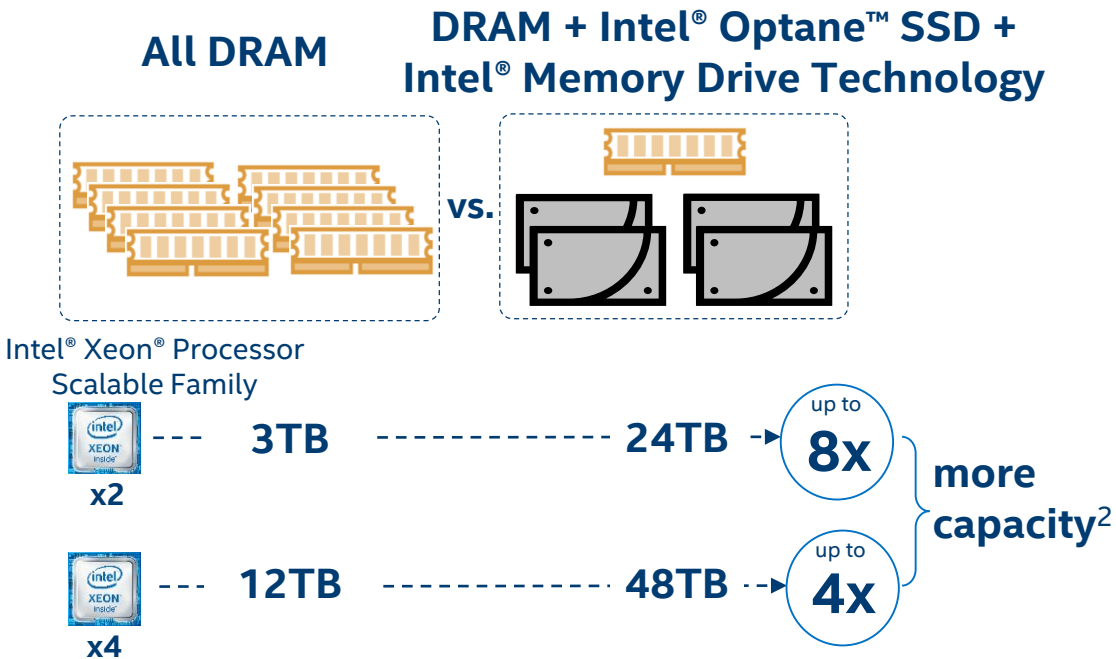
Intel® Optane™ Technology Endurance Significantly Improves the Number of Write Cycles It Can Endure, Making It More Durable

Drive Writes Per Day (DWPD)

Intel® Optane™ SSD DC P4800X Up To	60 DWPD[1]
Intel® SSD DC P4600 (3D NAND)	3.0 DWPD[2]

1.Source – Intel: Endurance ratings available at https://www.intel.com/content/www/us/en/solid-state-drives/optane-ssd-dc-p4800x-brief.html
2.Source – Intel Endurance ratings available at https://www.intel.com/content/www/us/en/solid-state-drives/ssd-dc-p4600-brief.html

MASSIVELY SCALABLE, FASTER[3] MEMORY POOLS



- Increase memory pool up to **8x**[1]
- Displace DRAM up to **10:1** in select workloads[2]
- **Higher platform** memory & PCIe **bandwidth** with Intel® Scalable Family of Processors[3]
- Accelerate applications and gain new insights from **larger working sets**

1. Source – Intel.
2. Xeon E5v5 All-DRAM memory configuration hardware limited up to 3TB (assumes 24 DIMM x 128GB). Intel® Memory Drive Technology software supports in 2 socket configuration up to 24TB addressable space, while DRAM as a cache is only 3TB. Attainable capacity depends on server configuration. Please consult your server manufacturer.
3. Comparing the new Intel® Xeon® Scalable Family of processors memory and PCIe bandwidth to Intel® Xeon E5v4 Processor Family memory and PCIe bandwidth

Tests document performance of components on a particular test, in specific systems. Differences in hardware, software, or configuration will affect actual performance.

intel OPTANE™ DC PERSISTENT MEMORY

intel XEON® PLATINUM inside™

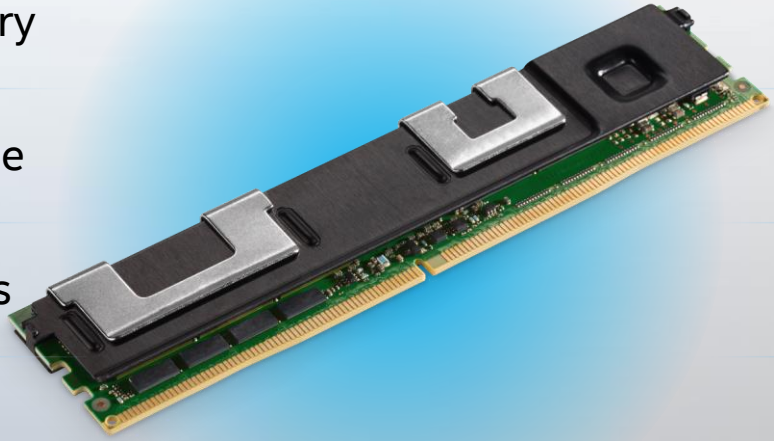
Big and Affordable Memory

128, 256, 512GB

High Performance Storage

DDR4 Pin Compatible

Direct Load/Store Access



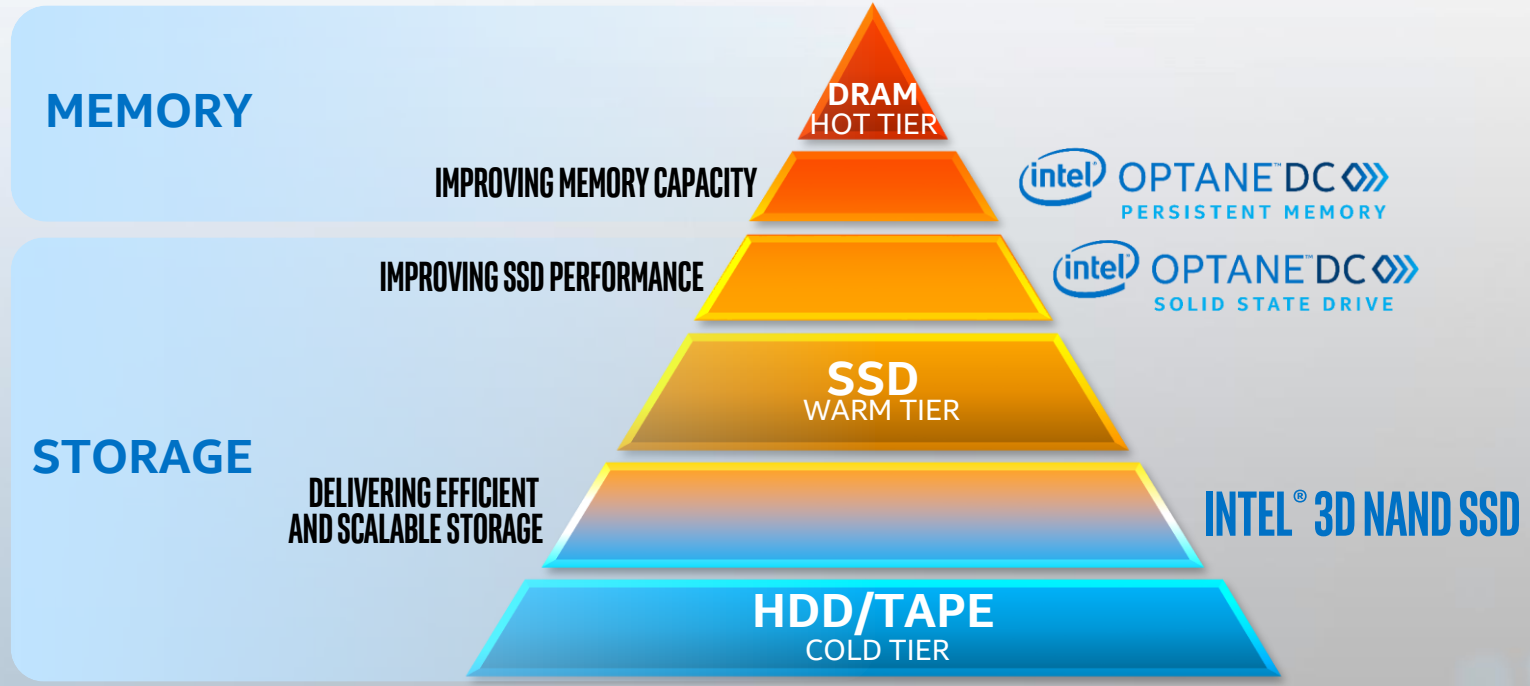
Hardware Encryption

Native Persistence

High Reliability

NOW SHIPPING SAMPLES
BROAD DEVELOPER ENGAGEMENT

INTEL INNOVATIONS ADDRESS THE GAPS



TWO MEMORY MEDIA TECHNOLOGIES
TWO PRODUCT FAMILIES

WORKING DATA

Intel® Optane™ Technology

CAPACITY DATA

Intel® QLC 3D NAND Technology

EDSFF "RULER". INTEL IS LEADING A REVOLUTIONARY FORM FACTOR.

1 A group of **15 companies** working together[1]

2 Goal to **maximize storage efficiency** by defining revolutionary industry standard form factors

3 Broad, dynamic range of solutions that **scales with new interface speeds**

A HEALTHY ECOSYSTEM

ODM/OEM solutions

intel, AIC, Celestica, Inventec, inspur, QCT, SUPERMICRO

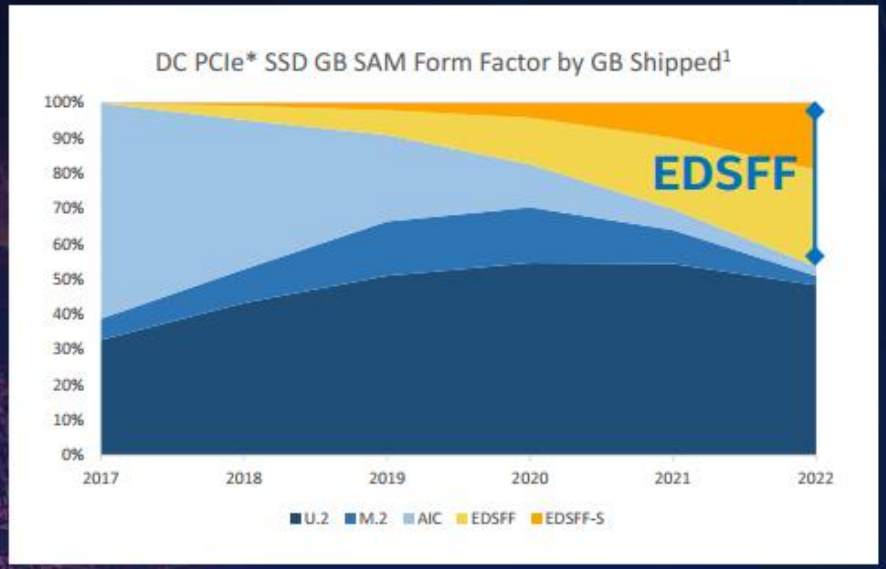
SSD Suppliers

intel, Micron, TOSHIBA, Western Digital.

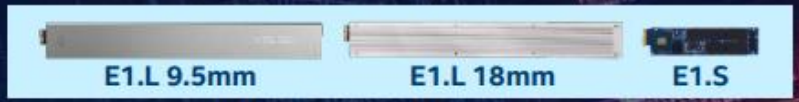
[1] List of EDSFF members provided at https://edsffspec.org/

* Other names and brands may be claimed as the property of others

EDSFF. INTEL IS BUILDING THE MOST ROBUST "RULER" PORTFOLIO.



EDSFF 45% of Data Center Serviceable Available Market (SAM) by 2022[1]



Capacity Scaling.

- Up to 32 E1.L 9.5mm drives per 1U[2]
- Up to 48 E1.S drives per 1U[2]

Thermal Efficiency.

- Up to 2x less airflow needed per E1.L 9.5mm SSD vs. U.2 15mm[3]
- Up to 3x less airflow needed per E1.S SSD vs. U.2 7mm[3]

Enhanced Serviceability.

- Fully front serviceable with integrated pull latch
- Integrated, programmable LEDs
- Remote, drive specific power cycling

Future Ready.

- x4, x8, x16 support, ready for PCIe* 4.0 and 5.0[4]

[1] Source: Intel NSG Market Forecast, Q2'18

[2] Source – EDSFF form factor specifications shown at edsffspec.org

[3] Source – Intel. Results have been estimated or simulated using internal analysis or architecture simulation or modeling, and provided for informational purposes. Comparing airflow required to maintain equivalent temperature of a 4TB U.2 15mm Intel® SSD DC P4500 to a 4TB "Ruler" form factor for Intel® SSD DC P4500. Simulation involves three drives for each form factor in a sheet metal representation of a server, 12.5mm pitch for "Ruler" form factor, 1000m elevation, limiting SSD on case temp of 70C or thermal throttling performance, whichever comes first. 5C guard band. Results used as a proxy for airflow anticipated on EDSFF spec compliant "Ruler" form factor Intel® SSD P4510.

[4] EDSFF Future Ready - https://edsffspec.org/edsff-resources/

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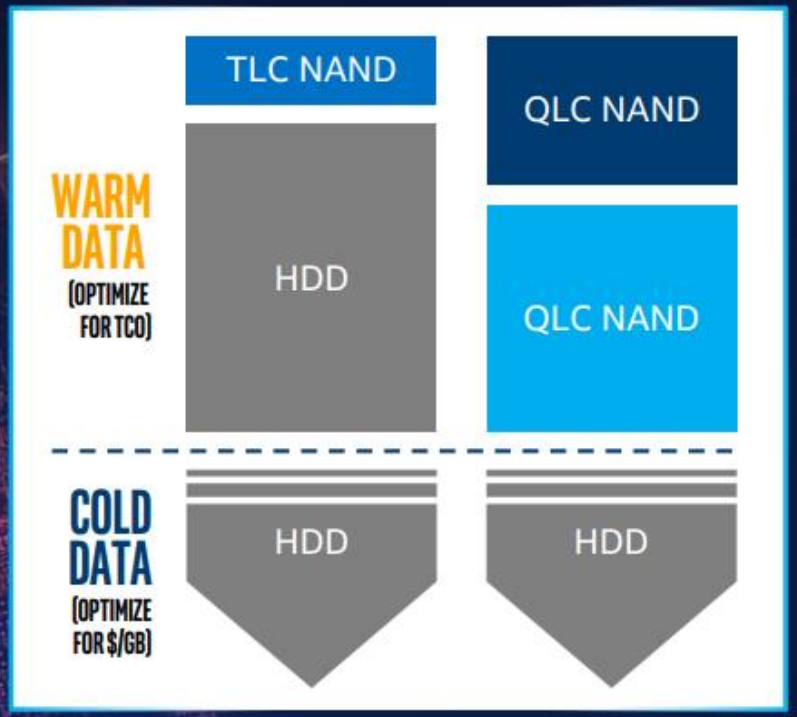
INTEL® QLC TECHNOLOGY. ACCELERATING HDD DISPLACEMENT IN WARM STORAGE.

Today with QLC



Broad QLC Portfolio

[1] All information provided here is subject to change without notice. Contact your Intel representative to obtain the latest Intel product specifications and roadmaps.

FLEXIBILITY. THE KEY TO FUTURE STORAGE & MEMORY ARCHITECTURE.

COMPUTE POWER		Intel® Xeon® Scalable Processors
FLEXIBLE MEMORY		Intel® Optane™ DC Persistent Memory
TEMP, TIER, CACHE		Intel® Optane™ SSD DC P4800X
CONVERGED & UNIFIED		Intel® Ethernet Network Adapter
REMOTE STORAGE		Intel® QLC 3D NAND SSD

Thanks!

nikolay.mester@intel.com