White Paper

Service Providers

Building the 5G Wireless Core

Discover how the new 3rd Generation Intel® Xeon® Scalable processor family helps meet the performance and security challenges of the 5G core. Features include built-in acceleration, improved input/output, and a range of security technologies.

Authors

Bryan Butters
Product Manager,
Intel Network Platforms Group

Rory Browne
Solution Architect,
Intel Network Platforms Group

Table of Contents

Executive summary

With mobile data traffic expected to grow by 4.5x over the next five years[1], communications service providers (CoSPs) need flexible and performant servers for the 5G core. At the same time, with the core becoming increasingly distributed, encryption and security are more important than ever.

3rd Generation Intel® Xeon® Scalable processors deliver the performance the 5G wireless core needs, backed with processor technologies that can be used to help secure the core. New instructions accelerate common encryption protocols including internet protocol security (IPsec) and Transport Layer Security (TLS). Intel® Software Guard Extensions (Intel® SGX) provide a security-enabled enclave to protect data, code, and keys.

In this paper, we share data that shows the performance improvements in the latest generation processor for workloads including 5G user plane function (UPF), IPsec forwarding, and Advanced Encryption Standard (AES). We also outline the improvements in input/output (I/O) and memory, and profile the new N SKUs designed especially for network workloads. The advancements in the latest processor generation deliver a strong architecture for the 5G core, with built-in security and an attractive total cost of ownership (TCO).

Building the 5G wireless core

Videos, music, apps: the traffic load on the mobile network has never been greater, and it's still growing. From 2021 through 2026, Ericsson estimates mobile data traffic will grow by 4.5x to reach 226 exabytes worldwide per month.[2]

To deliver 5G services effectively, CoSPs need highly performant servers for the wireless core. 3rd Generation Intel Xeon Scalable processors are optimized for network workloads. The processors come with 8–40 cores, and N SKUs are engineered specifically for the needs of modern network workloads. They're targeted for low latency, high throughput, and deterministic performance. N SKUs offer our best performance per watt. These processors offer higher base frequency for greater throughput for virtual network functions (VNFs) and cloud-native network functions (CNFs), with lower power consumption for dense or constrained physical deployments.

The architecture of 5G brings new security requirements. The UPF can be more widely distributed, including to untrusted customer sites. Backhaul to the core is encrypted using IPsec. TLS protects connections from third parties, such as automotive companies, that connect to the service-based architecture (SBA) to integrate with their services. As before, the network stores and processes sensitive customer data that must be protected.

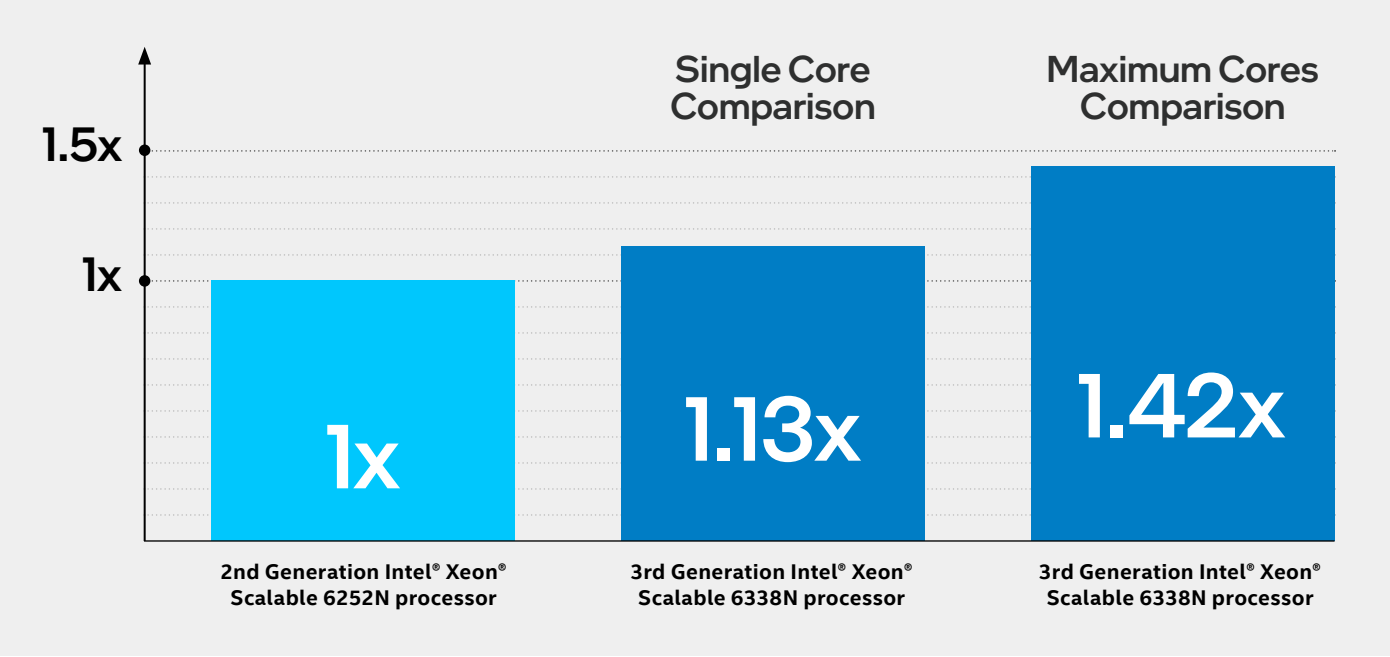

Figure 1. The 3rd Generation Intel® Xeon® Scalable processor accelerates the 5G User Plane Function by up to 13 percent per core, and up to 42 percent per processor when using the maximum cores[5]*.

With the 3rd Generation Intel Xeon Scalable processor family, CoSPs can use Intel SGX to isolate data and code in security-enabled memory enclaves.

Pervasive performance for the 5G core

With a combination of higher per-core performance and more cores, the 3rd Generation Intel Xeon Scalable processor family delivers significantly improved performance.

The latest processor family offers 20 percent higher instructions per clock (IPC) compared to the previous generation[3]. Processors are available with 8–40 cores, with network optimized processors offering 20–36 cores.

We put the new processor to the test to see how it performs on network workloads. 3rd Generation Intel Xeon Scalable Processors deliver on average up to 62% more performance on a range of broadly deployed network and 5G workloads over the prior generation[4]*.

For the 5G UPF, we measured a single core gain of 13 percent, and a generation-to-generation gain of 42 percent when using the maximum cores (see figure 1)[5]*. (We compared a 2nd Generation Intel® Xeon® Scalable processor with 22 cores with a comparable 3rd Generation Intel Xeon Scalable processor with 30 cores).

Accelerating encryption

In 5G, the user plane function will increasingly be deployed on customer premises and at other edge locations. IPsec will be needed to help protect traffic.

We compared the performance of the 3rd Generation Intel Xeon Scalable processor with the previous generation for Vector Path Processing (VPP) IPsec forwarding. Our test approximates an IPsec security gateway using software optimized for Intel® Advanced Encryption Standard New Instructions (Intel® AES-NI). We used a 128-bit key with Galois/Counter Mode (GCM). GCM is an AES mode that allows parallel processing, and there's a new instruction to support GCM in the 3rd generation processor.

We saw a single core performance increase of up to 88 percent over the previous generation processor; the system-wide gain was up to 95 percent[6]*.

One of the reasons for the significant performance increase is the introduction of new instructions in the processor that can be used to accelerate cryptography. They are:

- **VPMADD52** – fused multiply add of 52-bit precision integer values for public key cryptography, useful for Secure Sockets Layer (SSL) front end web server connections (NGINX, HA-Proxy, WordPress).
- **Vector AES and Vector Carry-less Multiply Instructions**, used for AES and AES-GCM to encrypt data transfers, databases, and cloud storage.
- **Galois Field New Instructions (GFNI)**, used for 5G encryption and integrity, error correction, and bit matrix multiplications. These instructions can also be used in the ZUC stream cipher for LTE.
- **Secure Hash Algorithm New Instructions (SHA-NI)**, used to accelerate SSL, TLS, IPsec, and data deduplication.

Using these instructions, you can improve security while reducing compute cycles (see Figure 3).

You can use the built-in crypto-accelerators to virtually eliminate the performance impact of full data encryption and dramatically increase the performance of encryption-intensive workloads.

*See backup for workloads and configurations. Results may vary.

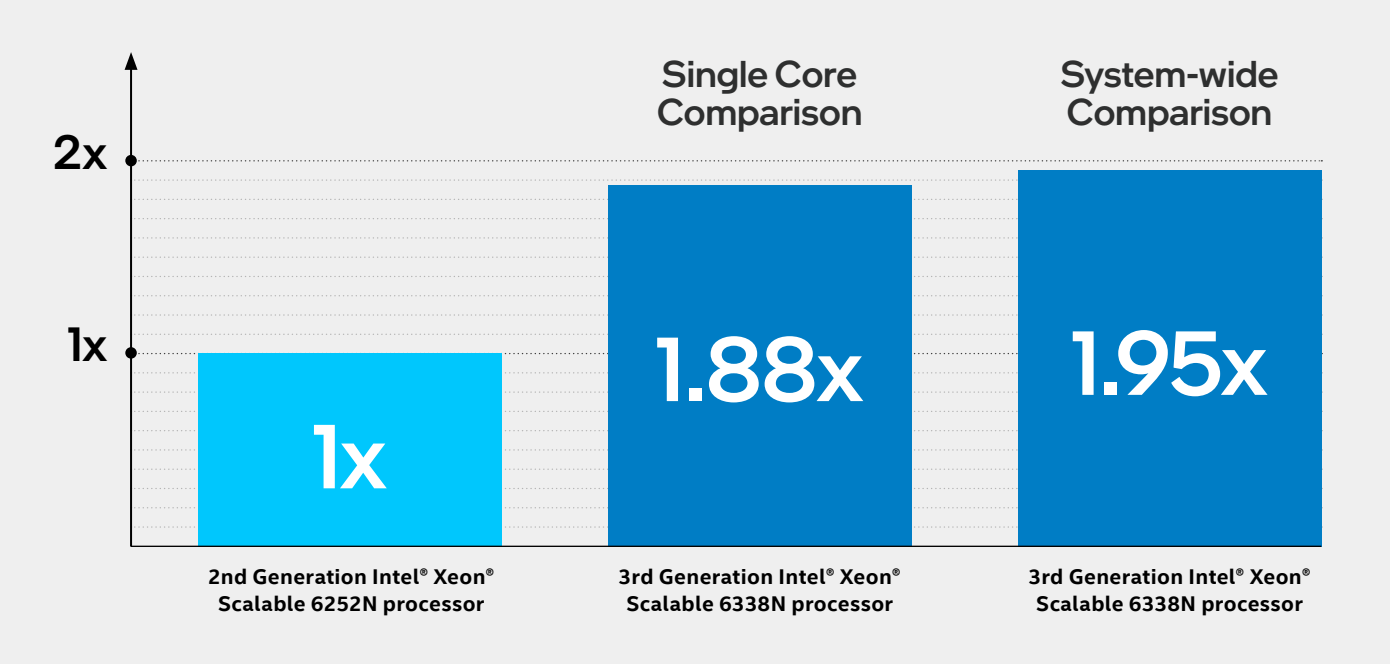

Figure 2. The 3rd Generation Intel® Xeon® Scalable processor accelerates Vector Path Processing (VPP) Internet Protocol security (IPsec) forwarding by up to 88 percent per core, and up to 95 percent per system[6]*.

Improved input/output (I/O)

The other reason that the VPP IPsec data shows a huge generation-to-generation improvement is that the 3rd Generation Intel Xeon Scalable processor introduces Peripheral Component Interconnect Express (PCIe) 4 support. PCIe 4 makes it easier to take full advantage of the improved performance and number of cores.

Elliptic Curve Diffie-Hellman Ephemeral (ECDHE) x25519	4.12x
RSA Sign 2048	5.63x
ECDHE p256	2.73x
ECDSA Sign p256	1.9x
Advanced Encryption Standard (AES) Counter Mode (AES-CTR)	3.84x
AES Cipher-based Message Authentication Code (AES-CMAC)	3.78x
AES-XTS (for encrypting sector-based storage data)	3.9x
AES Galois/Counter Mode (AES-GCM)	3.34x
Cyclic Redundancy Check (CRC)	2.3x
ZUC	1.5x

Previous generation processors supported PCIe 3. In the latest generation, there are 64 lanes available (compared to 48 previously), and those lanes offer double the bandwidth of PCIe 3. The combination of more lanes, and those lanes being faster, enables each server to handle more user plane traffic.

On a two socket system, there are 128 lanes supporting 1.6Tb/s of Ethernet I/O.

New security-enabled enclaves

The 5G service-based architecture uses public key cryptography. Using Intel SGX, you can store the private key in a security-enabled memory enclave, isolated from other software.

Intel SGX shrinks the attack surface. It helps to protect data and code from malware attacks, even if the operating system, drivers, BIOS, or hypervisor have been compromised. Intel SGX helps to prevent attacks such as memory bus snooping, memory tampering, and cold boot attacks against memory contents. The security-enabled enclave can be up to 1TB for a two-socket server.

SGX can be used in a vertically integrated model where the 5G core function stores private TLS keys in the enclave. Alternatively, the TLS function can be offloaded to a horizontal Kubernetes service mesh that handles all encryption transparently to the application.

Figure 3. 3rd Generation Intel® Xeon® Scalable processors have new instructions for built-in acceleration of security workloads essential to the 5G mobile network. These include Advanced Encryption Standard (AES) for Internet Protocol security (IPsec), and Elliptic Curve Diffie-Hellman Ephemeral (ECDHE) and RSA for Secure Sockets Layer (SSL)[7]*.

*See backup for workloads and configurations. Results may vary.

Built-in acceleration

Intel® Xeon® Scalable processors feature built-in acceleration with Intel® Advanced Vector Extensions 512 (Intel® AVX-512). With 512-bit wide vectors, Single Instruction Multiple Data (SIMD) instructions can process more packets at the same time.

3rd Generation Intel® Xeon® Scalable Processors are the only data center CPUs with built-in artificial intelligence (AI) acceleration, supported by end-to-end data science tools, and a vast ecosystem of smart solutions. Intel® Deep Learning Boost (Intel® DL Boost) enables you to run complex AI workloads on the same hardware as your existing workloads. It can be used for user-facing AI applications, or for AI-based self-healing and resource optimization applications in the network.

Improved memory performance

With the improved memory performance of the 3rd Generation Intel Xeon Scalable processor family, it's easier to maintain state for a subscriber in network functions. The server has eight channels of DDR memory per CPU instead of six, with previous generations for storing state and faster access to that memory. The new generation increases memory bandwidth by 1.60x and memory capacity by 2.66x compared to the 2nd Generation processor (see Figure 4).

As a result, it is possible to simultaneously handle more user equipment (UE) on the same processor than it was in the previous generation.

In addition, the latest processor generation introduces support for the new Intel® Optane™ Persistent Memory 200 Series[8]. Persistent memory keeps data at the CPU, in affordable huge capacities. It can be used in capacities of up to 512GB per DIMM, for a total of up to 6TB per socket of total system memory (DDR plus persistent memory). With the processor's improved memory interface, persistent memory can be used on eight memory channels with a faster speed of 3200 Mega Transfers per second (MT/s).

Persistent memory is useful for network workloads where there is an in-memory database. In the 5G wireless core, that includes the Network Repository Function (NRF), Network Exposure Function (NEF), Unified Data Management (UDM), and Charging Function (CHF).

Network-optimized processors

With the N SKUs, Intel offers processors that are specifically designed for network workloads, including 5G UPF. These processors enable low latency, high throughput, and deterministic performance. They have an extended supply life.

N SKU processors have a higher base frequency and lower thermal design power (TDP). N SKUs offer up to 1.9x more performance than the prior generation on network workloads[9].

N SKUs are available from 20 through 36 latest-generation cores, with a power consumption range of 135W to 225W. Compared to the standard SKUs, N SKUs have lower DDR4 speeds and a slightly lower uncore frequency (1.4GHz, as opposed to 1.6GHz).

With the 3rd Generation Intel Xeon Scalable processor family, Intel is introducing a new single socket N SKU with 36 cores. The 3rd Generation Intel® Xeon® Scalable 8351N processor has a flat non-uniform memory access (NUMA) architecture, with all the cores sharing the same NUMA pool. Network workloads can use any number of cores without the performance deterioration that arises when workloads have to straddle NUMA pools on other architectures. The flat NUMA architecture improves determinism per core, and helps to ensure that performance scales effectively with increased core counts.

A flexible foundation

The latest processor generation benefits from decades of innovation for the most common workload requirements, supported by close associations and deep integrations with the world's software leaders and solution providers.

	2nd Generation Intel® Xeon® Scalable processor	3rd Generation Intel® Xeon® Scalable processor	Increase
Memory bandwidth (in Mega Transfers per Second, MT/s)	6 channels 2666 MT/s	8 channels 3200 MT/s	**1.60x**
Memory capacity (two socket configuration)	6 channels 128GB DDR4	8 channels 256GB DDR4	**2.66x**

Figure 4. The 3rd Generation Intel® Xeon® Scalable processor family offers 1.60x the memory bandwidth and 2.66x the memory capacity of the previous 2nd generation.

The 3rd Generation Intel Xeon Scalable processor family is complemented by a portfolio of Intel® solutions that help you to optimize processor performance. Intel® Ethernet 800 Series Network Adapters enable up to 100GbE, helping you to optimize throughput in the wireless core. Intel® Dynamic Device Personalization (DDP) technology can be used to load balance subscriber traffic on the network adapter, without having to use processor cores. This adds a significant performance boost on user plane workloads like UPF.

With the 3rd Generation Intel Xeon Scalable processor, CoSPs can use a consistent platform from edge to core. It delivers the flexibility you need as you build today's 5G network, and prepare for unknown future demand.

Learn More

- **3rd Generation Intel® Xeon® Scalable processors**

[1] Ericsson Mobility Report, November 2020

[2] See endnote 1.

[3] 20% IPC improvement: 3rd Gen Intel® Xeon® Scalable processor: 1-node, 2x 28-core 3rd Gen Intel® Xeon® Scalable processor, Wilson City platform, 512GB (16 slots / 32GB / 3200) total DDR4 memory, HT on, ucode=x270, RHEL 8.0, Kernel Version4.18.0-80.el8.x86_64. Test by Intel on 3/30/2021. 2nd Gen Intel® Xeon® Scalable processor: 1-node, 2x 28-core 2nd Gen Intel® Xeon® Scalable processor, Neon City platform, 384GB (12 slots / 32GB / 2933) total DDR4 memory, HT on, ucode=x2f00, RHEL 8.0, Kernel Version 4.18.0-80.el8.x86_64. Test by Intel on 3/30/2021. SPECrate2017_int_base (est). Tests at equal frequency, equal uncore frequency, equal compiler.

[4] Performance varies by use, configuration and other factors. See [91] at www.intel.com/3gen-xeon-config

[5] 1.42x 5G User Plane Function: 1-node, 2(1 socket used)x Intel® Xeon® Gold 6338N on Whitley Coyote Pass 2U with 128 GB (8 slots/ 16GB/ 2667) total DDR4 memory, ucode 0x261, HT on, Turbo off, Ubuntu 18.04.5 LTS , 4.15.0-134-generic , 1x Intel® Ethernet Controller 810 (Columbiaville), FlexCore 5G UPF, Jan 2021 MD5 checksum: c4ad7f8422298ceb69d01e67419ff1c1, GCC 7.5.0, 5G UPF228 Gbps / 294 Gbps. Test by Intel on 3/16/2021. 1-node, 2(1 socket used)x Intel® Xeon® Gold 6252N on SuperMicro X11DPG-QT with 96 GB (6 slots/ 16GB/ 2934) total DDR4 memory, ucode 0x5003003 , HT on, Turbo off, Ubuntu 18.04.5 LTS, 4.15.0-132-generic, 1x Intel® Ethernet Controller 810 (Columbiaville), FlexCore 5G UPF, Jan 2021 MD5 checksum: c4ad7f8422298ceb69d01e67419ff1c1, GCC 7.5.0, 5G UPF161 Gbps / 213 Gbps. Test by Intel on 2/12/2021.

[6] 1.94x Vector Packet Processing - IP Security 1420B: 1-node, 2(1 socket used)x Intel® Xeon® Gold 6338N on Intel Whitley with 128 GB (8 slots/ 16GB/ 2667) total DDR4 memory, ucode 0x261, HT on, Turbo off, Ubuntu 20.04 LTS (Focal Fossa), 5.4.0-40-generic, 1x Intel® 240G SSD, 1x Intel® Ethernet Controller E810-2CQDA2 (Chapman Beach), v21.01-release, Gcc 9.3.0, VPP IPSEC(24c24t) test by Intel on 3/17/2021. 1-node, 2(1 socket used)x Intel Intel® Xeon® 6252N on SuperMicro X11DPG-QT with 96 GB (6 slots/ 16GB/ 2933) total DDR4 memory, ucode 0x5002f01, HT off, Turbo off, Ubuntu 20.04 LTS (Focal Fossa), 5.4.0-40-generic, 1x Intel® 240G SSD, 1x Intel® Ethernet Controller E810-CQDA2 (Tacoma Rapids), v21.01-release, Gcc 9.3.0, VPP IPSEC(18c18t). Test by Intel on 2/2/2021.

[7] 3.34x higher IPSec AES-GCM performance,3.78x higher IPSec AES-CMAC performance,3.84x higher IPSec AES-CTR performance,1.5x higher IPSec ZUC performance: 8380: 1-node, 2x Intel® Xeon® Platinum 8380 CPU on M50CYP2SB2U with 512 GB (16 slots/ 32GB/ 3200) total DDR4 memory, ucode 0x8d055260, HT On, Turbo Off, Ubuntu 20.04.2 LTS, 5.4.0-66-generic, 1x Intel® 1.8TB SSD OS Drive, intel-ipsec-mb v0.55, gcc 9.3.0, Glibc 2.31. Test by Intel on 3/17/2021. 8280M: 1-node, 2x Intel® Xeon® Platinum 8280M CPU on S2600WFT with 384 GB (12 slots/ 32GB/ 2933) total DDR4 memory, ucode 0x4003003, HT On, Turbo Off , Ubuntu 20.04.2 LTS, 5.4.0-66-generic, 1x Intel® 1.8TB SSD OS Drive, intel-ipsec-mb v0.55, gcc 9.3.0, Glibc 2.31. Test by Intel on 3/8/2021.

3.9x higher ISA-L AES-XTS performance, 2.30x higher ISA-L CRC performance: ISA-L: ISA-L: New: 1-node, 2x Intel® Xeon® Platinum 8380 Processor, 40 cores HT On Turbo OFF Total Memory 512 GB (16 slots/ 32GB/ 3200 MHz), Data integrity (CRC64), Data encryption (AES-XTS 128 Expanded Key), BIOS: SE5C6200.86B.3021.D40.2103160200 (ucode: 0x8d05a260), Ubuntu 20.04.2, 5.4.0-67-generic, gcc 9.3.0 compiler, yasm 1.3.0, nasm 2.14.02, isal 2.30, isal_crypto 2.23, OpenSSL 1.1.1.i, zlib 1.2.11, Test by Intel as of 03/19/2021. Baseline: 1-node, 2x Intel® Xeon® Platinum 8280 Processor, 28 cores HT On Turbo OFF Total Memory 384 GB (12 slots/ 32GB/ 2933 MHz), BIOS: SE5C620.86B.02.01.0013.121520200651 (ucode:0x4003003), Ubuntu 20.04.2, 5.4.0-67-generic,, gcc 9.3.0 compiler, yasm 1.3.0, nasm 2.14.02, isal 2.30, isal_crypto 2.23, OpenSSL 1.1.1.i, zlib 1.2.11 Test by Intel as of 2/9/2021. Gen on gen comparison based on cycle/Byte performance measured on single core.

5.63x higher OpenSSL RSA Sign 2048 performance,1.90x higher OpenSSL ECDSA Sign p256 performance,4.12x higher OpenSSL ECDHE x25519 performance,2.73x higher OpenSSL ECDHE p256 performance, 8280M:1-node, 2x Intel® Xeon® Platinum 8280M CPU on S2600WFT with 384 GB (12 slots/ 32GB/ 2933) total DDR4 memory, ucode 0x5003003, HT On, Turbo Off, Ubuntu 20.04.1 LTS, 5.4.0-65-generic, 1x INTEL_SSDSC2KG01 , OpenSSL 1.1.1j, GCC 9.3.0. Test by Intel on 3/5/2021. 8380: 1-node, 2x Intel® Xeon® Platinum 8380 CPU on M50CYP2SB2U with 512 GB (16 slots/ 32GB/ 3200) total DDR4 memory, ucode 0xd000270, HT On, Turbo Off, Ubuntu 20.04.1 LTS, 5.4.0-65-generic, 1x INTEL_SSDSC2KG01, OpenSSL 1.1.1j, GCC 9.3.0, QAT Engine v0.6.4. Test by Intel on 3/24/2021. 8380: 1-node, 2x Intel® Xeon® Platinum 8380 CPU on M50CYP2SB2U with 512 GB (16 slots/ 32GB/ 3200) total DDR4 memory, ucode 0xd000270, HT On, Turbo Off, Ubuntu 20.04.1 LTS, 5.4.0-65-generic, 1x INTEL_SSDSC2KG01, OpenSSL 1.1.1j, GCC 9.3.0, QAT Engine v0.6.5. Test by Intel on 3/24/2021.

[8] Intel® Optane™ persistent memory (PMem) does not work with Intel® Software Guard Extensions (Intel® SGX).

[9] Performance varies by use, configuration and other factors. See [91] at www.intel.com/3gen-xeon-config

Intel® Advanced Vector Extensions (Intel® AVX) provides higher throughput to certain processor operations. Due to varying processor power characteristics, utilizing Intel® AVX instructions may cause, a) some parts to operate at less than the rated frequency and, b) some parts with Intel® Turbo Boost Technology 2.0 to not achieve any or maximum turbo frequencies. Performance varies depending on hardware, software, and system configuration, and you can learn more at http://www.intel.com/go/turbo.

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

Intel may change availability of products and support at any time without notice. Please contact your Intel account rep for additional information.

Performance varies by use, configuration and other factors. Learn more at www.Intel.com/PerformanceIndex.

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

Your costs and results may vary.

Intel technologies may require enabled hardware, software or service activation.

0621/FP/CAT/PDF ♻ Please Recycle 347022-001EN