# 엔터프라이즈 클라우드의 도전 과제와 클라우드 컴퓨팅을 위한 인텔의 혁신

나승주 상무

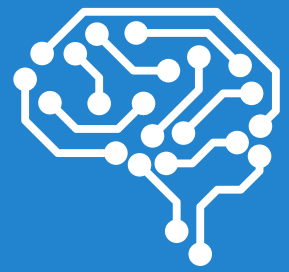
인텔 코리아, 한국 데이터센터 영업 총괄

intel®

# 주요 산업 동향

5G Network Transformation

HPC/Artificial Intelligence

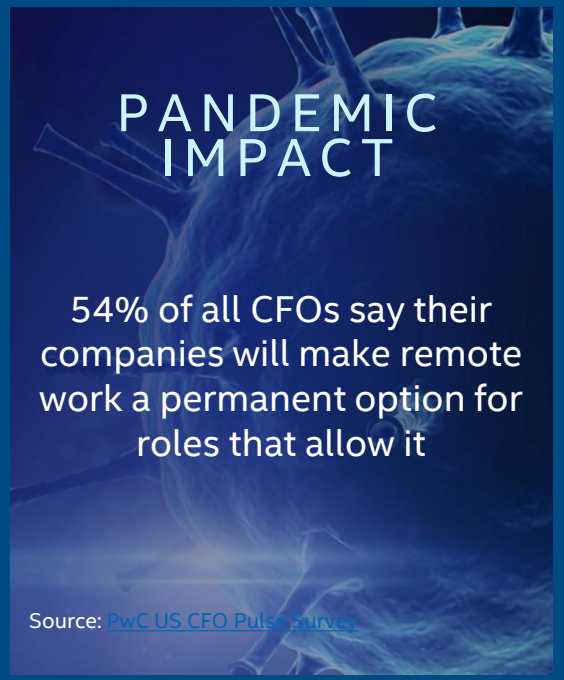


Intelligent Edge

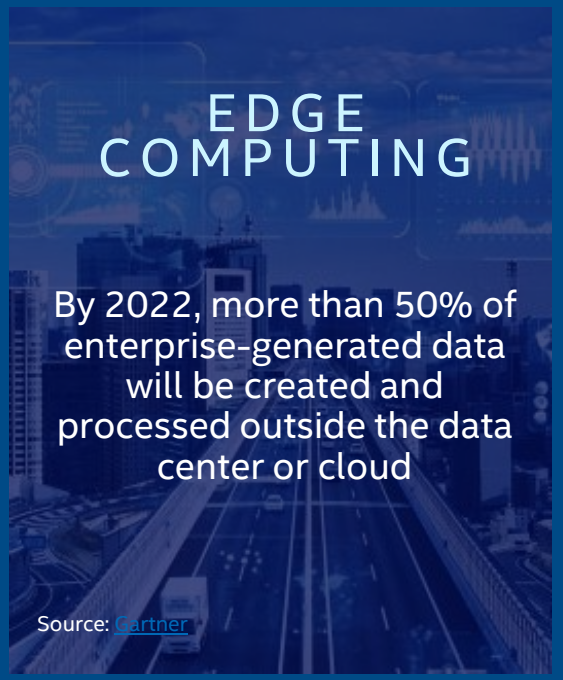
**Cloudification of Everything**

# 클라우드 컴퓨팅 동향 및 성장 동인

Business resiliency is being redefined by changes of today and uncertainties of tomorrow.






"Cloud" is fundamental to how companies run and drive operations in the digital economy

# 엔터프라이즈 클라우드의 도전 과제


BUSINESS RESILIENCE

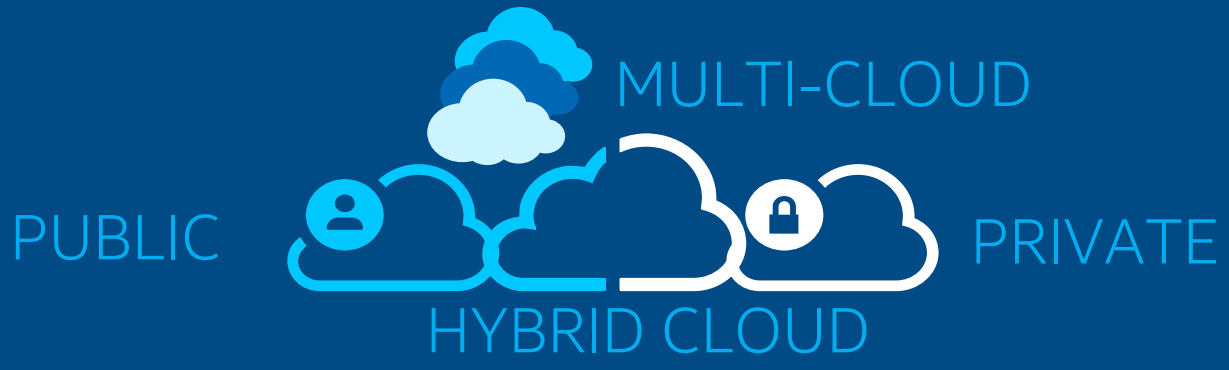
COST OPTIMIZATION

WORKLOAD STRATEGY

CLOUD MIGRATION

SECURITY

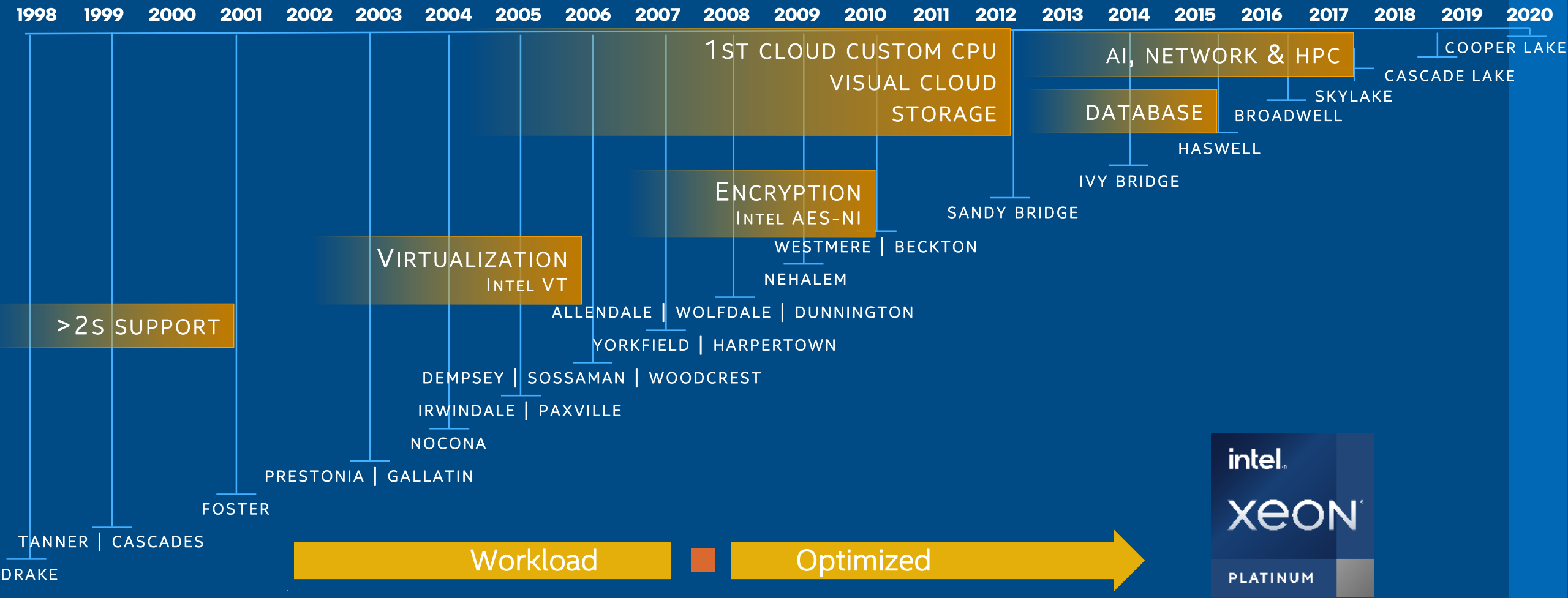
# 클라우드 컴퓨팅을 위한 인텔의 혁신




| Move **Faster** | Store **More** | Process **Everything** |
| --- | --- | --- |
| Intel® Ethernet | intel. OPTANE PERSISTENT MEMORY<br>intel. OPTANE SSD | intel. XEON PLATINUM<br>intel. ATOM<br>intel. AGILEX<br>intel. eASIC |
| Intel® Silicon Photonics | | |
| Intel® Tofino | | Xe<br>intel. MOVIDIUS |

Software & System Level **Optimized**

# 22년 동안의 프로세서 혁신



# THE CLOUD IS POWERED BY INTEL

## Thousands of Cloud Providers

DigitalOcean
EQUINIX
rackspace HOSTING
ByteDance 字节跳动
Flipkart
phoenixNAP GLOBAL IT SERVICES
QINGCLOUD 青云
UCLOUD
JD Cloud & AI
Kingsoft Cloud KSCLOUD
IONOS CLOUD
OVH Innovation is Freedom
Telefónica
swisscom

**aws**

22 REGIONS
70 AVAILABILITY ZONES
254 COUNTRIES/TERRITORIES

**Microsoft Azure**

58 REGIONS
67 AVAILABILITY ZONES
140 COUNTRIES

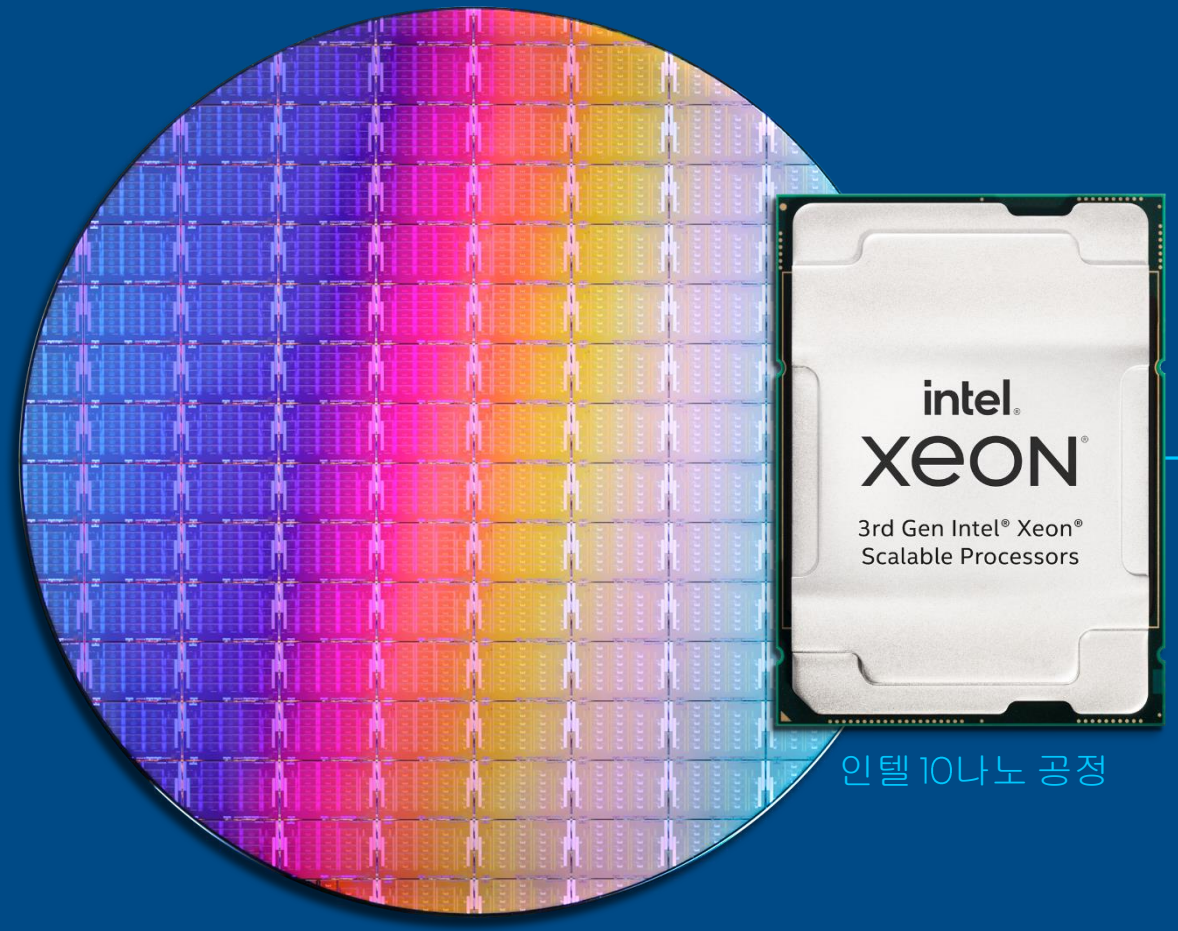
**Google Cloud**

24 REGIONS
73 AVAILABILITY ZONES
200+ COUNTRIES

Note: Representative, not a comprehensive list.
AWS, Microsoft Azure, and Google Cloud instance details as of November 2020 – see slide notes for link to find latest instance details

# 3세대 인텔® 제온® 스케일러블 프로세서

## Performance made flexible




인텔 10나노 공정

**최고 40 코어**
소켓당

**20% IPC 향상**
28 core, ISO Freq, ISO compiler

**평균 1.46배 성능 향상**
정수, 부동소수, Stream Triad, LINPACK의 기하평균
8380 vs. 8280

**1.74배 AI 추론 증가**
8380 vs. 8280 BERT

**평균 2.65배 성능 향상**
vs. 5년 전 시스템
8380 vs. E5-2699v4

Performance varies by use, configuration and other factors. Configurations see appendix [1,3,5,56]

# 3세대 인텔® 제온® 스케일러블 프로세서

## Performance made flexible

AI 및 보안 솔루션을 내장한
유일한 x86 데이터 센터 프로세서


1S-2S 시스템용

### 첨단 보안 솔루션

- 인텔 Software Guard Extensions
- 인텔 암호화 가속 기능
- 인텔 Total Memory Encryption
- 인텔 Platform Firmware Resilience

### 확장성, 유연성, 고객맞춤

- 인텔 딥 러닝 부스트
- 인텔 스피드 셀렉트 기술
- 인텔 AVX-512
- 최적화된 소프트웨어

### 차세대 인텔® 제온® 스케일러블 **플랫폼**

| 최대 6TB | 최대 8CH | 최대 2.6X | 최대 64 |
|---|---|---|---|
| 시스템 메모리 용량 (소켓 별) DRAM + PMEM | DDR4-3200 2 DPC (소켓 별) | 2세대 제온 스케일러블 프로세서 대비 메모리 용량 증가 | 레인 PCI Express 4 (소켓 별) |

### 획기적인 데이터 **성능**

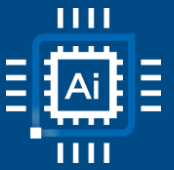
- 인텔 옵테인 퍼시스턴트 메모리 200 시리즈
- 인텔 옵테인 SSD P5800X 시리즈
- 인텔 SSD D 시리즈

### 더 빠르고, 유연하며, 데이터 **확장 가능**

- 인텔 이더넷 800 시리즈 네트워크 어댑터
- 인텔 애질렉스 FPGA 솔루션
- 인텔 셀렉트 솔루션

# 까다롭고 다양한 워크로드를 위한 유연한 성능

## 인텔리전트 엣지에서 클라우드까지 탁월한 성능 향상


### 클라우드

최고
**1.5배**

지연에 민감한 워크로드에서 성능 개선

### 5G

최고
**1.62배**

네트워크/통신 워크로드 성능 개선

### IoT

최고
**1.56배**

이미지 분류 추론 성능 개선

### 고성능 컴퓨팅 (HPC)

최고
**1.57배**

중요한 백신 연구에 더 빠른 모델링

### AI

최고
**1.74배**

언어 처리 추론 성능 개선

Performance varies by use, configuration and other factors. Configurations see appendix [5,7,17,19,52]

# Performance Made Flexible for Cloud & Enterprise

3세대 인텔® 제온® 스케일러블 프로세서

**50%** 이상

**성능 개선**

데이터베이스, 전자상거래,
웹 서버 애플리케이션 등
지연에 민감한 워크로드

진정한 하이브리드 및
멀티 클라우드의 기반

일관된 성능

원활한 가상머신
마이그레이션

세계적인 규모

주의: 워크로드 및 구성에 대한 정보는 웹사이트(https://www.intel.com/3gen-xeon-config)의 [81, 97, 98]을 참조합니다. 결과는 다를 수 있습니다.

# 내장된 **암호화 가속기**를 통한 개선된 암호화 처리

암호화 알고리즘의 연산 비용을 줄이기 위해 관련 업계를 이끌고 있으며 , 획기적인 성능으로 더 많은 데이터를 보다 안전하게 보호해 줍니다.

## 공개키 암호화

이전 세대 대비

**5.6X**

단일 스레드 공개키 암호화를 위한 OpenSSL RSA Sign 2048

## 대칭키 암호화

이전 세대 대비

**3.3X**

단일 스레드 대칭키 암호화를 위한 AES-GCM

워크로드 및 구성에 대한 정보는 웹사이트(https://www.intel.com/3gen-xeon-config)의 [70,71]을 참조합니다. 결과는 다를 수 있습니다.

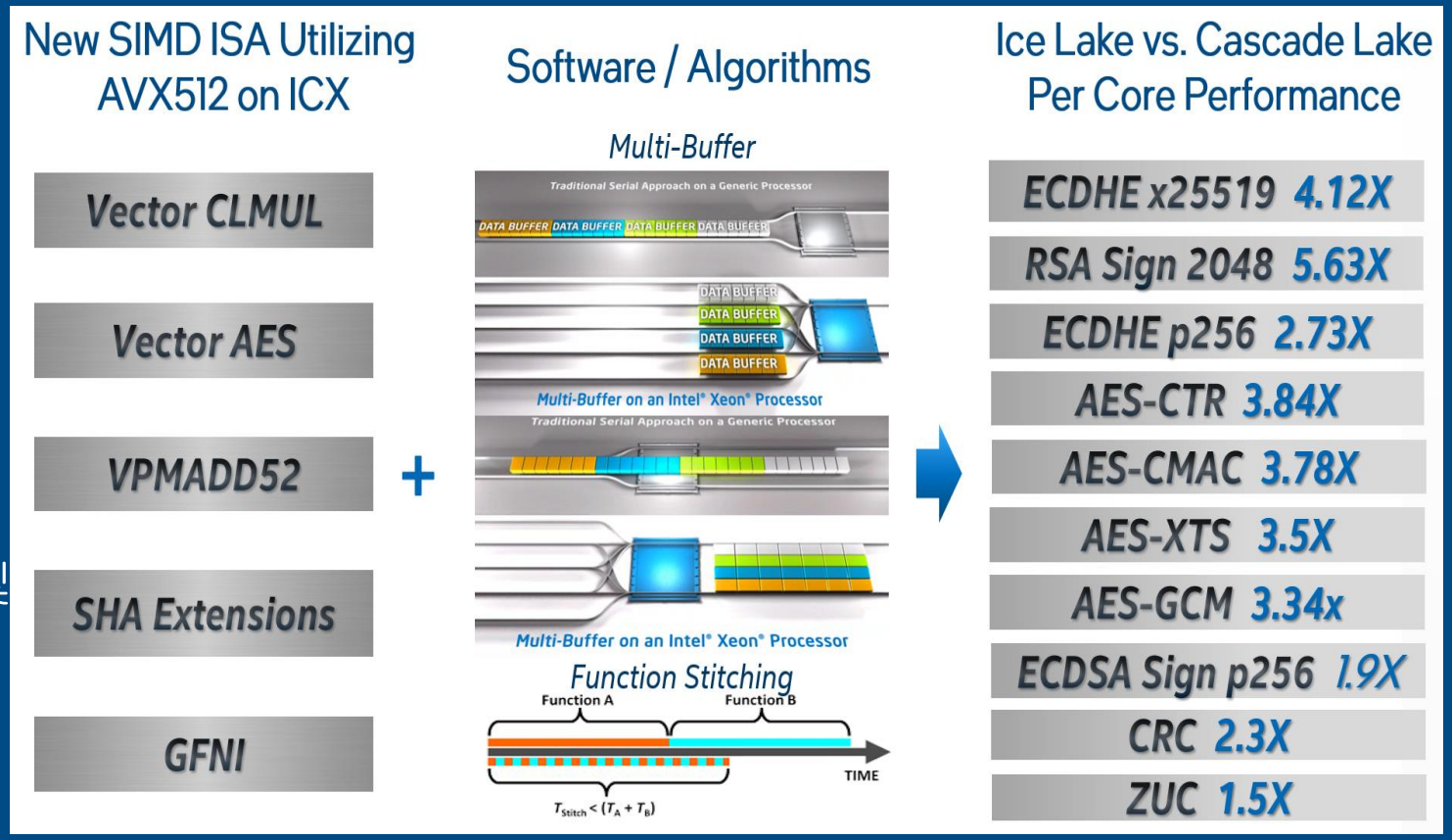
# 새로운 암호화 가속 명령어 추가

암호화

- Big-Number Arithmetic (AVX-512 Integer IFMA)
- Vector AES and Vector Carry-less Multiply Instructions
- Galois Field New Instructions (GFNI)
- SHA-NI

Compression/Decompression 및 특수 SIMD

- Bit Algebra
- VBMI – Vector Bit Manipulation Instruction

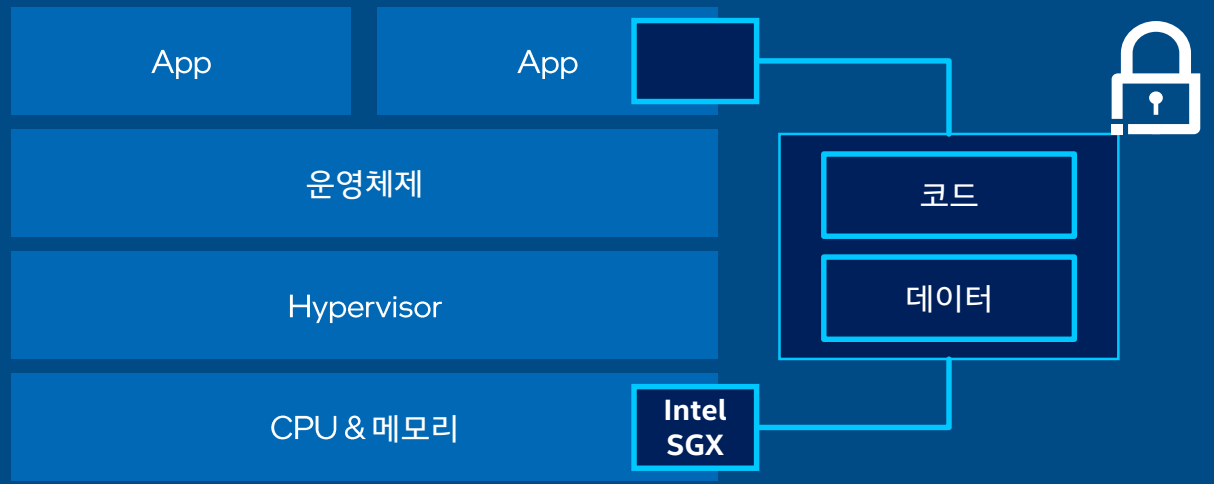



Performance varies by use, configuration and other factors. Configurations see appendix [20,21,24]

# 인텔 SGX (Software Guard Extensions)

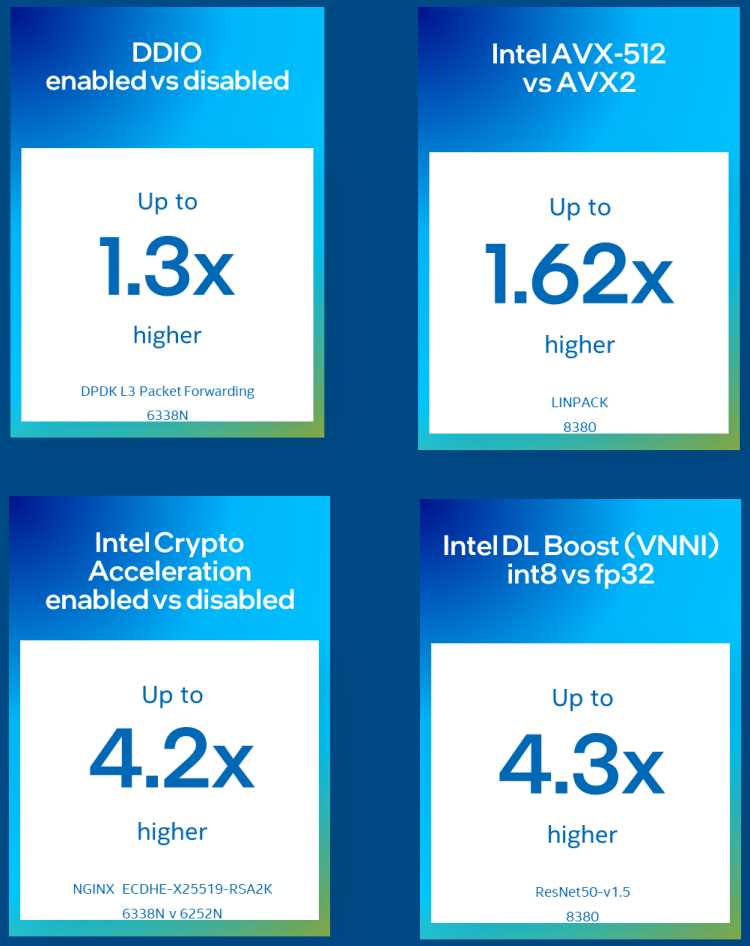
성능 저하 없이 **민감한 데이터 영역의 개인 정보 보호** 가능

메인스트림 워크로드를 위한 **더 크고 보안이 강화된** 엔클레이브 제공(최대 1TB 메모리 공간)



# 인텔 클라우드 장점

## Performance Gains with Acceleration




- **AI-ready**: Intel® DL Boost, Intel® Arria FPGAs, optimized frameworks
- **In-Memory Computing**: Intel® Optane™ DC Persistent Memory
- **HPC**: Intel® AVX-512, fabric, software
- **Networking**: Intel® Ethernet, Intel® QuickAssist, Intel® DDIO
- **Storage**: Intel® QuickAssist, Intel® Optane™ Solid State Drives, Intel® VMD
- **Security**: Crypto Acceleration, Intel® SGX, Intel® TXT

See backup for workloads and configurations. Results may vary.

# 인텔 소프트웨어 장점

**Powerful scale from a technology you can trust**

Dealing with vast volumes of raw, unstructured data across your business – data center to edge to cloud – takes compute that stands the test of time. Connectivity, bandwidth, and power are finite resources that must be expertly balanced with cost of ownership. Data and network security are nonnegotiable.

**68%** IMPROVED HPC FSI PERFORMANCE

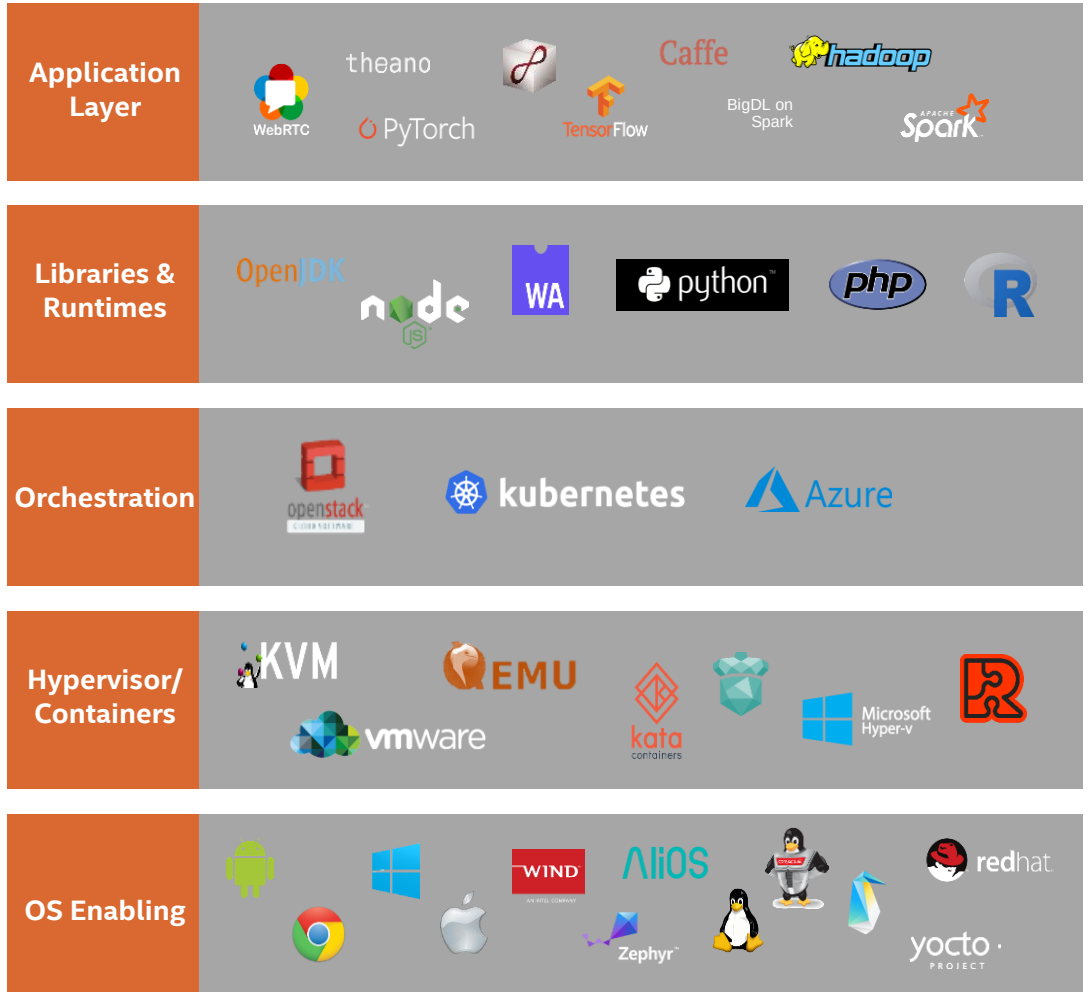
**30x** IMPROVEMED AI INFERENCE PERFORMANCE

**7.8x** IMPROVED STORAGE COMPRESSION

**5x** IMPROVEMED AUTOMATIC SPEECH RECOGNITION THROUPHPUT

**2.5x** IMPROVED CLOUD-NATIVE CONTAINER OPENSSL PERFORMANCE

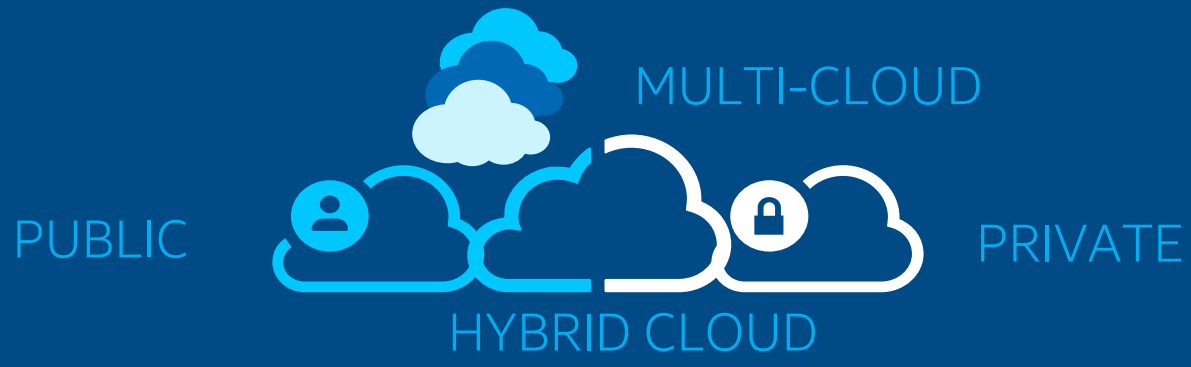
**~3x** IMPROVED RENDERING THROUGHPUT




See backup for workloads and configurations. Results may vary.

# 요약

## 클라우드 컴퓨팅을 위한 인텔의 혁신




| Move **Faster** | Store **More** | Process **Everything** |
| --- | --- | --- |
| Intel® Ethernet | intel. OPTANE PERSISTENT MEMORY<br>intel. OPTANE SSD | intel. XEON PLATINUM<br>intel. ATOM<br>intel. AGILEX<br>intel. eASIC<br>Xe<br>intel. MOVIDIUS |
| Intel® Silicon Photonics | | |
| Intel® Tofino | | |

Software & System Level **Optimized**


intel


intel
The Power of Cloud.
Taken Further.
Business resiliency – and new opportunity – demand agility. The future of your digital business is powered by Intel.
Move Faster
Store More
Process Everything

# NOTICES AND DISCLAIMERS

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

# CONFIGURATION DETAILS FOR INTEL CLOUD ADVANTAGE

- *1.52X NAMD- Baseline: Intel® Xeon® Platinum 8268 processor configuration: Intel "Wolf Pass" platform with 2-socket Intel® Xeon® Platinum 8268 processors (2.9GHz, 24C), 12x16GB DDR4-2933, 1 SSD, BIOS: SE5C620.86B.02.01.0008.031920191559; Microcode: 0x500001c, Red Hat Enterprise Linux* 7.7, kernel 3.10.0-1062.1.1. NAMD v2.13: Geomean (2 workloads: Apoa1, STMV), AVX2_256 build, Intel® Compiler 2019u4, Intel MPI 2019u4, BIOS: HT ON, Turbo ON, SNC OFF, 2 threads per core. Test by Intel as of 11/1/2019, w/AVX-512: Intel® Xeon® Platinum 8268 processor configuration: Intel "Wolf Pass" platform with 2-socket Intel® Xeon® Platinum 8268 processors (2.9GHz, 24C), 12x16GB DDR4-2933, 1 SSD, BIOS: SE5C620.86B.02.01.0008.031920191559; Microcode: 0x500001c, Red Hat Enterprise Linux* 7.7, kernel 3.10.0-1062.1.1. NAMD v2.13: Geomean (2 workloads: Apoa1, STMV), AVX-512 build, Intel® Compiler 2019u4, Intel MPI 2019u4, BIOS: HT ON, Turbo ON, SNC OFF, 2 threads per core. Test by Intel as of 11/1/2019.*
- *1.68X FSI Kernels- Baseline: Intel® Xeon® Platinum 8268 processor configuration: Intel "Wolf Pass" platform with 2-socket Intel® Xeon® Platinum 8268 processors (2.9GHz, 24C), 12x16GB DDR4-2933, 1 SSD, BIOS: SE5C620.86B.02.01.0008.031920191559; Microcode: 0x500001c, Red Hat Enterprise Linux* 7.7, kernel 3.10.0-1062.1.1. FSI Kernels v2.0: Geomean (3 workloads: Binomial Options, Black Scholes, Monte Carlo), AVX2_256 build, Intel® Compiler 2019u5, Intel® Math Kernel Library (Intel® MKL) 2019u5, BIOS: Binomial (HT ON, Turbo ON, SNC OFF, 2 threads/core), Black Scholes (HT OFF, Turbo ON, SNC OFF, 1 threads/core), Monte Carlo (HT ON, Turbo ON, SNC OFF, 2 threads/core). Test by Intel as of 11/1/2019, w/AVX-512: Intel® Xeon® Platinum 8268 processor configuration: Intel "Wolf Pass" platform with 2-socket Intel® Xeon® Platinum 8268 processors (2.9GHz, 24C), 12x16GB DDR4-2933, 1 SSD, BIOS: SE5C620.86B.02.01.0008.031920191559; Microcode: 0x500001c, Red Hat Enterprise Linux* 7.7, kernel 3.10.0-1062.1.1. FSI Kernels v2.0: Geomean (3 workloads: Binomial Options, Black Scholes, Monte Carlo), AVX-512 build, Intel® Compiler 2019u5, Intel® Math Kernel Library (Intel® MKL) 2019u5, BIOS: BIOS: Binomial (HT ON, Turbo ON, SNC OFF, 2 threads/core), Black Scholes (HT OFF, Turbo ON, SNC OFF, 1 threads/core), Monte Carlo (HT ON, Turbo ON, SNC OFF, 2 threads/core). Test by Intel as of 11/1/2019*
- *2.77X AIXPRT Image Classification Resnet-50v1 (INT8 vs FP32)- Baseline: Intel® Xeon® Platinum 8268 processor configuration: Test by Intel as of 11/8/2019. 1-node, 2x Intel® Xeon® Platinum 8268 Processor, HT On Turbo ON, 12x32GB DDR4-2933, BIOS: SE5C620.86B.02.01.0008.031920191559 (ucode:0x5000021), Ubuntu 19.04, kernel: 5.3.0-rc3-custom, Resnet50V1/AIXPRT 1.0 ( OpenVINO 2019 R3), BS=4, Datatype: FP32, w/VNNI enabled: Intel® Xeon® Platinum 8268 processor configuration: Test by Intel as of 11/8/2019. 1-node, 2x Intel® Xeon® Platinum 8268 Processor, HT On Turbo ON, 12x32GB DDR4-2933, BIOS: SE5C620.86B.02.01.0008.031920191559 (ucode:0x5000021), Ubuntu 19.04, kernel: 5.3.0-rc3-custom, Resnet50V1/AIXPRT 1.0 ( OpenVINO 2019 R3), BS=4, Batch4_int8_12instances, Datatype: INT8.*
- *3.49X AIXPRT Object Detection SSD-Mobile Netv1 (INT8 vs FP32)- Baseline: Intel® Xeon® Platinum 8268 processor configuration: Test by Intel as of 11/8/2019. 1-node, 2x Intel® Xeon® Platinum 8268 Processor, HT On Turbo ON, 12x32GB DDR4-2933, BIOS: SE5C620.86B.02.01.0008.031920191559 (ucode:0x5000021), Ubuntu 19.04, kernel: 5.3.0-rc3-custom, SSD-Mobilenetv1 /AIXPRT 1.0 ( OpenVINO 2019 R3), GCC 8.3, BS=4, Datatype: FP32, w/VNNI enabled: Intel® Xeon® Platinum 8268 processor configuration: Test by Intel as of 11/8/2019. 1-node, 2x Intel® Xeon® Platinum 8268 Processor, HT On Turbo ON, 12x32GB 2933 MHz), BIOS: SE5C620.86B.02.01.0008.031920191559 (ucode:0x5000021), Ubuntu 19.04, kernel: 5.3.0-rc3-custom, SSD-Mobilenetv1 /AIXPRT 1.0 ( OpenVINO 2019 R3), GCC 8.3, Batch4_int8_12instances, Datatype: INT8.*
- *4.3x improvement in security (key exchanges per second): Intel CLX 6252N Processor: Intel Corporation S2600WFD, Intel(R) Xeon(R) Gold 6252N CPU, 2.30GHz, run on 18C/36T w/Boost OFF, 12x32GB DDR4-2933, BIOS: SE5C620.86B.0X.02.0040.060420190144, Microcode: 0x5000026, Ubuntu 19.04, 5.0.0-23-generic, GCC 8.3 compiler, NIC XXV710-DA2 Ethernet Controller, NGINX 1.14.2, OpenSSL 1.1.0k, QATEngine v0.5.41, QAT Driver L05000007 Test by Intel 11/05/19.*
- *7.8X Storage Compression ISA-L -Intel Xeon 8268 Processor: Dell PowerEdge R640 with 2-socket Intel Xeon 8268 processors (2.9GHz, 24C), run on 1C/1T w/Turbo OFF, 12x32GB DDR4-2933, 1 SSD, BIOS: R06, Microcode: 0x4000029, Ubuntu 19.04, kernel: 5.3.7-050307-generic, GCC 8.3.0 compiler, Zlib 1.2.11. Test by Intel as of 10/29/2019*

# CONFIGURATION DETAILS FOR INTEL SOFTWARE ADVANTAGE

- 1.68X FSI Kernels- Baseline: Intel® Xeon® Platinum 8268 processor configuration: Intel "Wolf Pass" platform with 2-socket Intel® Xeon® Platinum 8268 processors (2.9GHz, 24C), 12x16GB DDR4-2933, 1 SSD, BIOS: SE5C620.86B.02.01.0008.031920191559; Microcode: 0x500001c, Red Hat Enterprise Linux* 7.7, kernel 3.10.0-1062.1.1. FSI Kernels v2.0: Geomean (3 workloads: Binomial Options, Black Scholes, Monte Carlo), AVX2_256 build, Intel® Compiler 2019u5, Intel® Math Kernel Library (Intel® MKL) 2019u5, BIOS: Binomial (HT ON, Turbo ON, SNC OFF, 2 threads/core), Black Scholes (HT OFF, Turbo ON, SNC OFF, 1 threads/core), Monte Carlo (HT ON, Turbo ON, SNC OFF, 2 threads/core). Test by Intel as of 11/1/2019, w/AVX-512: Intel® Xeon® Platinum 8268 processor configuration: Intel "Wolf Pass" platform with 2-socket Intel® Xeon® Platinum 8268 processors (2.9GHz, 24C), 12x16GB DDR4-2933, 1 SSD, BIOS: SE5C620.86B.02.01.0008.031920191559; Microcode: 0x500001c, Red Hat Enterprise Linux* 7.7, kernel 3.10.0-1062.1.1. FSI Kernels v2.0: Geomean (3 workloads: Binomial Options, Black Scholes, Monte Carlo), AVX-512 build, Intel® Compiler 2019u5, Intel® Math Kernel Library (Intel® MKL) 2019u5, BIOS: BIOS: Binomial (HT ON, Turbo ON, SNC OFF, 2 threads/core), Black Scholes (HT OFF, Turbo ON, SNC OFF, 1 threads/core), Monte Carlo (HT ON, Turbo ON, SNC OFF, 2 threads/core). Test by Intel as of 11/1/2019
- 7.8X Storage Compression ISA-L -Intel Xeon 8268 Processor: Dell PowerEdge R640 with 2-socket Intel Xeon 8268 processors (2.9GHz, 24C), run on 1C/1T w/Turbo OFF, 12x32GB DDR4-2933, 1 SSD, BIOS: R06, Microcode: 0x4000029, Ubuntu 19.04, kernel: 5.3.7-050307-generic, GCC 8.3.0 compiler, Zlib 1.2.11. Test by Intel as of 10/29/2019
- 30x boost in deep learning inference w/ DLBoost & SW optimizations, 6X better throughput/$ on Xeon vs GPU. Link to Roblox published blog for details.
- 5X automatic speech recognition improvement with Intel's Math Kernel Library, optimized Intel compiler improved perf 11X. Link to Intel published case study for details.
- 3X improvement in rendering throughput and reduced solution costs using Intel Optane DC persistent memory. Link to Intel published solution brief for details.
- 2.5X performance in OpenSSL with RedHat and Intel for Cloud-native containers and up to 2X improved performance RN50. Link to Intel published reference implementation for details.

# DETAILS FOR CLOUD SUCCESS STORIES

- 30x boost in deep learning inference w/ DLBoost & SW optimizations, 6X better throughput/$ on Xeon vs GPU. Link to Roblox published blog for details.
- 30% increase in performance w/ Intel MPI Library & AVX-512 for weather forecasting application on GCP C2 instances (ClimaCell and GCP). Link to Intel published case study for details.
- 50% performance boost or faster batch processing (IRSAP) with Lenovo ThinkAgile HX solution delivers and Xeon Scalable processors over IRSAP's legacy infrastructure. Link to Intel published customer story for details.
- 5X improvement in automatic speech recognition with optimized Intel's Math Kernel Library, Intel compiler improved perf 11X (Qihoo360). Link to Intel published case study for details.
- Using Intel Optane DC persistent memory for the cache reduced latency by 80% and accelerated indexing by 3x (phoenixNAP). Link to Intel published case study for details.
- Realized 30% lower TCO for Redis service w/ Optane. DLBoost enabling & optimization for key AI/Media WLs including OpenVINO integration into online AI WLs (Kaishou). Link to Intel published customer story for details.

# CONFIGURATION DETAILS FOR INTEL HARDWARE ADVANTAGE

**42% price/performance -** Configuration details updated on March 30, 2020, to reflect the latest SPEC guidelines.**36% More Estimated Performance and 42% More Estimated Performance/Dollar: Geomean of SPECrate®2017_int_base(est), SPECrate®2017_fp_base(est), STREAM Triad, and Intel® Distribution for LINPACK Across Ten New 2-socket 2nd Gen Intel® Xeon® Gold Processors Vs. First Generation**. 2nd Gen Intel® Xeon® Gold R processors: 1-node, 2x 2nd Gen Intel Xeon Gold processor (62xxR/$$) on Intel Reference platform with 384GB (12 slots / 32 GB / 62xx@2933,52xx@2666) total memory, ucode 0x500002c, HT on for all except off for STREAM (GB/s), LINPACK (GFLOPS/s), Turbo on, with Ubuntu19.10, 5.3.0-24-generic, 6258R/$3950: SPECrate®2017_int_base(est)=323, SPECrate®2017_fp_base(est)=262, STREAM=224, LINPACK =3305; 6248R/$2700: SPECrate®2017_int_base(est)=299, SPECrate®2017_fp_base(est)=248, STREAM=224, LINPACK =3010; 6246R/$3286: SPECrate®2017_int_base(est)=238, SPECrate®2017_fp_base(est)=217, STREAM=225, LINPACK =2394; 6242R/$2529: SPECrate®2017_int_base(est)=265, SPECrate®2017_fp_base(est)=231, STREAM=227, LINPACK =2698; 6240R/$2200: SPECrate®2017_int_base(est)=268, SPECrate®2017_fp_base(est)=228, STREAM=223, LINPACK=2438; 6238R/$2612: SPECrate®2017_int_base(est)=287, SPECrate®2017_fp_base(est)=240, STREAM=222, LINPACK =2545; 6230R/$1894: SPECrate®2017_int_base(est)=266, SPECrate®2017_fp_base(est)=227, STREAM=222, LINPACK =2219; 6226R/$1300: SPECrate®2017_int_base(est)=208, SPECrate®2017_fp_base(est)=192, STREAM=200, LINPACK =2073; 5220R/$1555: SPECrate®2017_int_base(est)=257, SPECrate®2017_fp_base(est)=220, STREAM=210, LINPACK =1610; 5218R/$1273: SPECrate®2017_int_base(est)=210, SPECrate®2017_fp_base(est)=188, STREAM=199, LINPACK =1290, test by Intel on 12/25/2019. First Gen Intel® Xeon® Gold processor: 1-node, 2x Intel Xeon Gold processor (61xx/$$) on Intel Reference platform with 384GB (12 slots / 32 GB / 61xx@2666,51xx@2400) total memory, ucode 0x500002c, HT on for all except off for STREAM (GB/s), LINPACK (GFLOPS/s), Turbo on, with Ubuntu19.10, 5.3.0-24-generic, 6152/$3655: SPECrate®2017_int_base(est)=224, SPECrate®2017_fp_base(est)=198, STREAM=200, LINPACK =1988; 6148/$3072: SPECrate®2017_int_base(est)=225, SPECrate®2017_fp_base(est)=198, STREAM=197, LINPACK =2162; 6146/$3286: SPECrate®2017_int_base(est)=161, SPECrate®2017_fp_base(est)=175, STREAM=185, LINPACK =1896; 6142/$2946: SPECrate®2017_int_base(est)=193, SPECrate®2017_fp_base(est)=176, STREAM=185, LINPACK =1895; 6140/$2445: SPECrate®2017_int_base(est)=202, SPECrate®2017_fp_base(est)=183, STREAM=188, LINPACK =1877; 6138/$2612: SPECrate®2017_int_base(est)=189, SPECrate®2017_fp_base(est)=195, STREAM=189, LINPACK =1976; 6130/$1894: SPECrate®2017_int_base(est)=172, SPECrate®2017_fp_base(est)=165, STREAM=185, LINPACK =1645; 6126(proj)/$1776: SPECrate®2017_int_base(est)=141, SPECrate®2017_fp_base(est)=157, STREAM=170, LINPACK =1605; 5120(proj)/$1555: SPECrate®2017_int_base(est)=148, SPECrate®2017_fp_base(est)=148, STREAM=159, LINPACK =924, 5118/$1273: SPECrate®2017_int_base(est)=134, SPECrate®2017_fp_base(est)=132, STREAM=149, LINPACK =818, test by Intel on 2/18/2020. Your costs and results may vary.

**87% more VDI & TCO** - 36% more VMs per node & 30% lower estimated cost per VM configurations. **Config1-DDR4 (Similar Cost) Config2-Intel Optane DC persistent memory (Similar Cost)** Test by Intel Intel Test date 01/31/2019 01/31/2019 Platform Confidential – Refer to M. Strassmaier if a need to know exists Confidential – Refer to M. Strassmaier if a need to know exists # Nodes 1 1 # Sockets 2 2 CPU Cascade Lake B0 8272L Cascade Lake B0 8272L Cores/socket, Threads/socket 26/52 26/52 HT ON ON Turbo ON ON BKC version – E.g. ww47 WW42 WW42 Intel Optane DC persistent memory FW version 5253 5253 System DDR Mem Config: slots/cap/run-speed 24 slots/32 GB/2666 12 slots/16 GB /2666 System DCPMM Config: slots/cap/run-speed 8 slots/128 GB/ 2666 Total Memory/Node (DDR, DCPMM) 768 GB, 0 192 GB, 1 TB Storage – boot 1x Samsung PM963 M.2 960 GB 1x Samsung PM963 M.2 960 GB Storage – application drives 7 x Samsung PM963 M.2 960 GB, 4x Intel SSDs S4600 (1.92 TB 7x Samsung PM963 M.2 960 GB, 4x Intel SSDs S4600 (1.92 TB)NIC 1xIntel X520 SR2 (10Gb) 1x Intel X520 SR2 (10 Gb) PCH LBG QS/PRQ – T – B2 LBG QS/PRQ – T – B2 Other HW (Accelerator) OS Windows Server 2019 RS5-17763 Windows Server 2019 RS5-17763 Kernel Workload & version OLTP Cloud Benchmark OLTP Cloud Benchmark Compiler Libraries Other SW (Frameworks, Topologies…)

14x AI Inference - Up to 14X AI Performance Improvement with Intel® DL Boost compared to Intel® Xeon® Platinum 8180 Processor (July 2017). Tested by Intel as of 2/20/2019. 2 socket Intel® Xeon® Platinum 8280 Processor, 28 cores HT On Turbo ON Total Memory 384GB (12 slots/ 32GB/ 2933 MHz), BIOS: SE5C620.86B.0D.01.0271.120720180605 (ucode: 0x200004d), Ubuntu 18.04.1 LTS, kernel4.15.0-45-generic, SSD 1x sda INTEL SSDSC2BA80 SSD 745.2GB, nvme1n1 INTEL SSDPE2KX040T7 SSD 3.7TB, Deep Learning Framework: Intel® Optimization for Caffe version: 1.1.3 (commit hash: 7010334f159da247db3fe3a9d96a3116ca06b09a) , ICC version 18.0.1, MKL DNN version: v0.17 (commit hash: 830a10059a018cd2634d94195140cf2d8790a75a, model: https://github.com/intel/caffe/blob/master/models/intel_optimized_models/int8/resnet50_int8_full_conv.prototxt, BS=64, DummyData, 4 instance/2 socket, Datatype: INT8 vs Tested by Intel as of July 11th 2017: 2S Intel® Xeon® Platinum 8180 CPU @ 2.50GHz (28 cores), HT disabled, turbo disabled, scaling governor set to "performance" via intel_pstate driver, 384GB DDR4-2666 ECC RAM. CentOS Linux release 7.3.1611 (Core), Linux kernel 3.10.0-514.10.2.el7.x86_64. SSD: Intel® SSD DC S3700 Series (800GB, 2.5in SATA 6Gb/s, 25nm, MLC).Performance measured with: Environment variables: KMP_AFFINITY='granularity=fine, compact', OMP_NUM_THREADS=56, CPU Freq set with cpupower frequency-set -d 2.5G -u 3.8G -g performance. Caffe: (http://github.com/intel/caffe/), revision f96b759f71b2281835f690af267158b82b150b5c. Inference measured with "caffe time --forward_only" command, training measured with "caffe time" command. For "ConvNet" topologies, dummy dataset was used. For other topologies, data was stored on local storage and cached in memory before training. Topology specs from https://github.com/intel/caffe/tree/master/models/intel_optimized_models (ResNet-50),. Intel C++ compiler ver. 17.0.2 20170213, Intel MKL small libraries version 2018.0.20170425. Caffe run with "numactl -l". 6 x 512GB Optane persistent memory (3,072 GB) + 6 x 256GB DDR4 DRAM (1,536 GB) = 4,608 GB total memory per socket5 Baseline: 1-node, 1x Intel® Xeon® 8280L 28C @ 2.7GHz processor on Intel reference platform (Neon City) with Single PMem module config (6x32GB DRAM; 1x{128GB,256GB,512GB} Intel Optane PMem 100 Series module at 15W) ucode Rev: 04002F00 running Fedora 29 kernel 5.1.18-200.fc29.x86_64,and MLC ver 3.8 with App-Direct. Source: 2020ww18_CPX_BPS_DI. Tested by Intel, on 27 Apr 2020. New configuration: 1-node, 1x Intel® Xeon® pre-production 3rd Gen Intel® Xeon® Scalable processor with 28C @ 2.9GHz processor on Intel reference platform (Cooper City) with Single PMem module config (6x32GB DRAM; 1x{128GB,256GB,512GB} Intel Optane PMem 200 Series module at 15W), ucode pre-production running Fedora 29 kernel 5.1.18-200.fc29.x86_64,and MLC ver 3.8 with App-Direct. Source: 2020ww18_CPX_BPS_BG. Tested by Intel, on 31 Mar 2020.

**68% performance gain** - *FSI Kernels*- Baseline: Intel® Xeon® Platinum 8268 processor configuration: Intel "Wolf Pass" platform with 2-socket Intel® Xeon® Platinum 8268 processors (2.9GHz, 24C), 12x16GB DDR4-2933, 1 SSD, BIOS: SE5C620.86B.02.01.0008.031920191559; Microcode: 0x500001c, Red Hat Enterprise Linux* 7.7, kernel 3.10.0-1062.1.1. FSI Kernels v2.0: Geomean (3 workloads: Binomial Options, Black Scholes, Monte Carlo), AVX2_256 build, Intel® Compiler 2019u5, Intel® Math Kernel Library (Intel® MKL) 2019u5, BIOS: Binomial (HT ON, Turbo ON, SNC OFF, 2 threads/core), Black Scholes (HT OFF, Turbo ON, SNC OFF, 1 threads/core), Monte Carlo (HT ON, Turbo ON, SNC OFF, 2 threads/core). Test by Intel as of 11/1/2019, w/AVX-512: Intel® Xeon® Platinum 8268 processor configuration: Intel "Wolf Pass" platform with 2-socket Intel® Xeon® Platinum 8268 processors (2.9GHz, 24C), 12x16GB DDR4-2933, 1 SSD, BIOS: SE5C620.86B.02.01.0008.031920191559; Microcode: 0x500001c, Red Hat Enterprise Linux* 7.7, kernel 3.10.0-1062.1.1. FSI Kernels v2.0: Geomean (3 workloads: Binomial Options, Black Scholes, Monte Carlo), AVX-512 build, Intel® Compiler 2019u5, Intel® Math Kernel Library (Intel® MKL) 2019u5, BIOS: BIOS: Binomial (HT ON, Turbo ON, SNC OFF, 2 threads/core), Black Scholes (HT OFF, Turbo ON, SNC OFF, 1 threads/core), Monte Carlo (HT ON, Turbo ON, SNC OFF, 2 threads/core). Test by Intel as of 11/1/2019

SAP HANA Source - SAP Certified and Support SAP HANA® Hardware Directory: https://www.sap.com/dmc/exp/2014-09-02-hana-hardware/enEN/iaas.html

**4.3x QuickAssist** – HiBench claim of 4.3X: 1+4-node, 2x Intel® Xeon® processor E5-2697 v2 on S2600JF with 128 GB (8 slots / 16GB / 1866 ) total memory, ucode 0x42d on CentOS-7.6.1810, 4.20.0-1.el7.x86_64, 1x 180GB SATA3 SSD, 3 x Seagate ST4000NM0033 (4TB), 1x Intel I350, HiBench v7.1 / bigdata, Mllib, OpenJDK-1.8.0_191, python-2.7.5, Apache Hadoop-2.9.1, Apache Spark-2.2.2, , HT on, Turbo on, result: SparkKmeans=119.5M, HadoopKmeans=49.6M, SparkSort=121.4M, HadoopSort=103M, SparkTerasort=107.4M, HadoopTerasort=109M, test by Intel on 1/23/2019. 1+4-node, 2x Intel® Xeon® Gold 6248 processor on S2600WF with 768 GB (384 GB used) (12 slots* / 64 GB / 2400 (384GB used)) total memory, ucode 0x400000A on CentOS-7.6.1810, 4.20.0-1.el7.x86_64, Intel SSD DC S3710, 6 x Seagate ST2000NX0253 (2TB), 1x Intel X722, HiBench v7.1 / bigdata, Mllib, OpenJDK-1.8.0_191, python-2.7.5, Apache Hadoop-2.9.1, Apache Spark-2.2.2, HT on, Turbo on, result: SparkKmeans=1235.8M, HadoopKmeans=92.8M, SparkSort=518.4M, HadoopSort=363.5M, SparkTerasort=589.3M, HadoopTerasort=457.3M, test by Intel on 1/23/2019. **Type** Intel® Xeon® E5-2697 v2 processor Intel® Xeon® Gold 6248 processor Intel® Xeon® E5-2697 v2 processor Intel® Xeon® Gold 6248 processor SparkKmeans 240,981,849,494 2015 195119,593,969 1,235,804,356 10.33 SparkSort 307,960,500,694 2535 594 121,483,432 518,452,021 4.27 SparkTerasort 600,000,000,000 5586 1018 107,411,385 589,390,962 5.49 Spark Geomean 6.23 HadoopKmeans240,981,849,4944854259649,646,034 92,828,139 1.87 HadoopSort 307,960,500,694 2990 847 103,002,660 363,589,729 3.53 HadoopTerasort 600,000,000,000 5504 1312 109,011,627 57,317,073 4.20 Hadoop Geomean 3.03
Overall Geomean 4.34

7.8X Storage Compression ISA-L -Intel Xeon 8268 Processor: Dell PowerEdge R640 with 2-socket Intel Xeon 8268 processors (2.9GHz, 24C), run on 1C/1T w/Turbo OFF, 12x32GB DDR4-2933, 1 SSD, BIOS: R06, Microcode: 0x4000029, Ubuntu 19.04, kernel: 5.3.7-050307-generic, GCC 8.3.0 compiler, Zlib 1.2.11. Test by Intel as of 10/29/2019

**225x faster CPU access** - Intel® Optane persistent memory idle read latency of 340 nanoseconds. Intel® SSD DC P4610 Series TLC NAND solid state drive idle read latency of 77 microseconds
Source: Principled Technologies Report: "Reap the full potential of workload mobility within the cloud and datacenter by using consistent processor architecture." https://www.principledtechnologies.com/intel/Migration-in-mixed-CPU-environment-0419-v2.pdf