SOLUTIONS BRIEF:
Transformation of Modern Healthcare

Healthcare & The Intel® Xeon® Scalable Processor

Intel is committed to bringing the best of our manufacturing, design and partner networks to enable our customers to create the next generation of dynamic, interoperable, and secure health technology. With our new Intel® Xeon® Scalable processors, patients, medical staff and researchers benefit from faster insights and enhanced data privacy.

ABSTRACT: Healthcare is complex, dynamic, and filled with professionals in all disciplines who feel a personal calling to care for patients. Modern healthcare requires technology that provides:

- **Connected and interoperable environment**
- **Cross-system interactions for broad, actionable insights**
- **Seamless and secure communications at the individual, team, and institutional levels**

Benefits of Upgrading to the Intel® Xeon® Scalable Processor

The new Intel® Xeon® Scalable processors pack performance, security and agility within a new scalable architecture, optimized for a wide variety of workloads. New features such as Intel® Mesh Architecture, 50% more memory channels, powerful cores, and 48 I/O PCIe gen 3.0 lanes allow for improved performance. In healthcare, applications for the Intel® Xeon® Scalable processor span edge to cloud, from precision imaging machines (CT Scanner/MRI), to medical workstations and the datacenter that powers the cloud. Modernizing your systems can result in the following benefits:

PERFORMANCE

Gain hospital efficiency through increased asset performance.

- Faster processing power and the Intel® AVX-512 feature in imaging machines and workstations accelerates image scanning, expanding machine availability and patient capacity.
- Datacenters powered by the Intel® Xeon® Scalable processor are workload optimized for software-defined infrastructure and virtualization, capable of **4.28x more virtual machines than 4 year old generations.**

AGILITY

Scalable configurations for a multi-cloud world

- At the edge, more powerful workstations paired with imaging scanners can be extended to perform multiple tasks, reducing the complexity and need for add-ons devices.
- 2,4, and 8 socket configurations with 48 I/O lanes of PCIe* Gen3 per socket, give flexibility for discrete options such as Intel® FPGAs, Intel® Optane™ SSDs, and graphics cards.

SECURITY

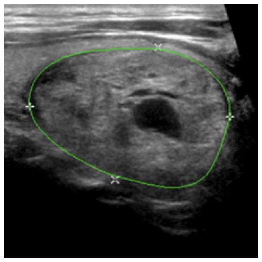
Guard against system vulnerabilities with hardware-enhanced security features

- Intel® Key Protection Technology (KPT) with Integrated Intel® QuickAssist Technology and Intel® Platform Trust Technology (Intel® PTT): delivers hardware-enhanced platform security by providing efficient key and data protection, at rest, in use and in flight.

MEDICAL IMAGING DEVICES AND ARTIFICIAL INTELLIGENCE

Intel® IoT Performance Systems in healthcare combine a responsive patient and clinician user experience, with high throughput of raw data transport and storage. At the edge, CT Scanners and MRIs paired with high-performance workstations benefit from fast processing and integrated high-bandwidth networking, allowing for quick diagnosis. Upcoming Deep Learning Inference Appliances can unlock Artificial Intelligence, enabling inference algorithm acceleration to detect organ trauma in ultrasounds, chest CT scans and MRI quality assessments.

Proof of concepts in Deep Learning Analytics are ongoing with healthcare institutions such as the University of California San Francisco (UCSF), Center for Digital Health Innovation (CDHI), aimed at helping clinicians make better treatment decisions, predict patient outcomes, and respond more nimbly in acute situations.



WITH INTEL® XEON® SCALABLE PROCESSORS, HOSPITALS CAN:

Reduce patient risk and dosage exposure, with fast image processing

- Powerful cores, 50% more memory channels, and the Intel® AVX-512 feature allow for fast image processing and less radiation exposure time to patients.

Expedite diagnosis and improve time to treatment

- Integrated 4x10Gb Ethernet with iWARP RDMA ensures a high-bandwidth network connection for inter-system data transfers, thus speeding the process of diagnosis.

Unlock Artificial Intelligence

- Leverage your existing Intel® infrastructure to start Deep Learning inference and training, through Intel® Data Analytics Acceleration Library (Intel® DAAL), Intel® Math Kernel Library (Intel® MKL), frameworks (TensorFlow, Caffe, Theano, etc.) optimized for Intel® Architecture.

GENOMICS AND LIFE SCIENCES RESEARCH

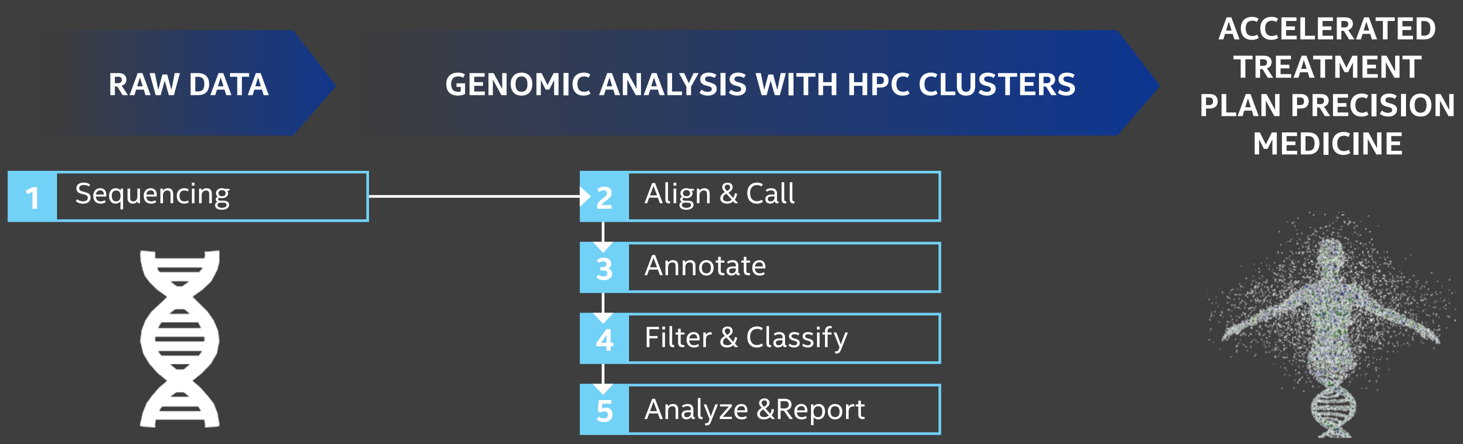
Beyond day-to-day patient treatment, workstations and modernized data centers with the Intel® Xeon® Scalable processor continue to drive better insights in the field of medical research.

MAKE QUICKER AND MORE INTELLIGENT MEDICAL DECISIONS

- **More powerful cores** and the new Intel® Mesh Architecture allow for faster results in compute intensive modeling.
- **Accelerate workloads;** storage options such as Intel® Optane™ and 3D NAND solid state drives along with discrete Intel® FPGAs can speed machine learning for identification of anomalies in images
- **Software optimizations** on Intel® Architecture that accelerate research.
    1. The Genomics Kernel Library (GKL) is a collection of common, compute-intensive kernels used in genomic analysis tools. Optimized on Intel® Architecture, GKL provides up to 2.7x and 2x speedup for compression and decompression of genomics data respectively, and accelerated implementation of Pair HMM kernel on Intel® FPGAs.
    2. GenomicsDB is an efficient and scalable data store for Genomic variants, providing an increase in scalability for joint genotyping in Genome Analysis Tool Kit (GATK), as benchmarked by the Broad Institute.

ACCELERATED GENOMIC ANALYTICS PROCESS USING HIGH-PERFORMANCE CLUSTERS

EXAMPLE: *Genomic analytics requires a high-performance compute cluster to work through genetic sequencing, alignment, annotation, classification, and reporting.*

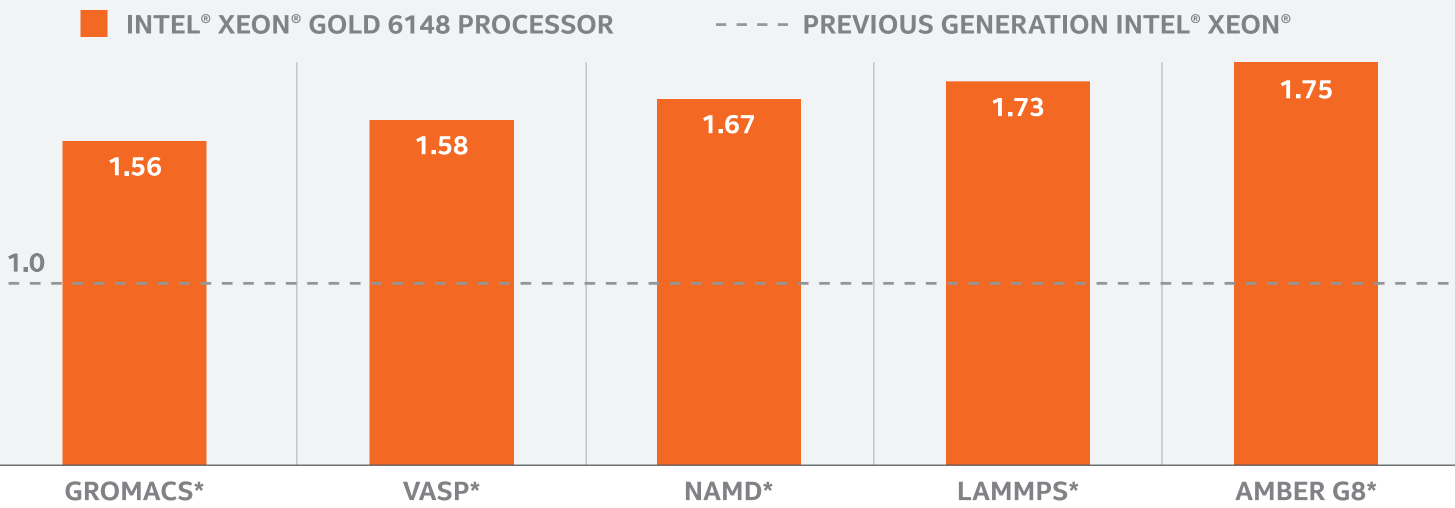


HELP REDUCE THE TIME IT TAKES TO GET FROM RAW SEQUENCING DATA TO A TREATMENT PLAN

The Genome Analysis Tool Kit (GATK), developed at the Broad Institute, standardizes genomic research through step-by-step recommendations for pre-processing and variant discovery analysis. Benchmarking the GATK best practices pipeline with an Intel® Xeon® Scalable processor resulted in up to 1.32x performance over the previous generation for a multi-sample analysis. Faster performance reduces the cost of research, while speeding valuable insights to drive new treatments.

Other life sciences research workloads show improvements from 1.56x to 1.75x increase over the previous generation in various molecular dynamics and scientific modeling, typically used for research.

WORKLOAD IMPROVEMENTS OVER THE PREVIOUS GENERATION



Better performance means faster insights and the ability to treat patients. With Intel® Xeon® Scalable processors, healthcare professionals can accelerate their research capabilities to better serve patients today and develop treatments for the future.

Modernize Your Healthcare Systems

Meeting today's healthcare needs means preparing for tomorrow. The Intel® Xeon® Scalable platform provides expanded performance and capability for better utilization of medical equipment, reduced patient exposure and powerful insights in medical research. For more information on how Intel® Xeon® Scalable processors can assist in the transformation of modern healthcare go to: intel.com/healthcare or contact your Intel® Account Sales Representative.

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https://www.ucsf.edu/news/2017/01/405536/ucsf-intel-join-forces-develop-deep-learning-analytics-health-care

https://www.intel.com/content/www/us/en/healthcare-it/solutions/documents/accelerating-genomics-data-gkl-white-paper.html

1.32x claim based on multi-sample WES analysis with Xeon E5v4 Broadwell, 22 cores, 256 GB memory, 2 socket, 6 CPU family, Model 79, Intel® Xeon® CPU E5-2699 v4@2.20 GHz, OS version RHEL 7.2 vs Intel® Xeon® Platinum 8180M CPU @ 2.2 GHz, OS version RHEL 7.2, 28 cores, 384 GB memory, 2 socket, 6 CPU family, Model 85

VASP CONFIGURATION: The Vienna Ab initio Simulation Package (VASP) is a computer program for atomic scale materials modeling and performs electronic structure calculations and quantum-mechanical molecular dynamics from first principles. VASP provides scientists with fast and precise calculation of materials properties covering wide range of MD methods from DFT, DFT-HF to Random-Phase approximation (GW, ACDFT). Beta VASP, a release candidate for v6.0. Developer branch provided as "Package" included with download: https://github.com/vasp-dev/vasp-knl. AVX512: Intel® Compiler 17.0.1.132, Intel® MPI 2017u1, ELPA 2016.05.004. Optimization Flags: "-O3 -xCORE-AVX512". AVX2: Intel® Compiler 17.0.1.132, Intel® MPI 2017u1, ELPA 2016.05.004. Optimization Flags: "-O3 -xCORE-AVX2". E5-2697 v4: 2S Intel® Xeon® processor E5-2697 v4 2.3 GHz , 18 Cores/Socket, 36 Cores, 72 Threads, HT on, turbo off, BIOS 86B0271.R00, 128GB total memory, 2400 MT/s DDR4 RDIMM, Red Hat Enterprise Linux* 7.2 kernel 3.10.0-327. Gold 6148: Dual Socket Intel® Xeon® processor Gold 6148 2.4 GHz , 20 Cores/Socket, 40 Cores, 80 Threads, HT on, turbo off, BIOS 86B.01.00.0412, 192GB total memory, 2666 MT/s / DDR4 RDIMM, Red Hat Enterprise Linux* 7.2 kernel 3.10.0-327.

NAMD: NAMD, recipient of a 2002 Gordon Bell Award, is a parallel molecular dynamics code designed for high-performance simulation of large biomolecular systems. Based on Charm++ parallel objects, NAMD scales to hundreds of cores for typical simulations and beyond 200,000 cores for the largest simulations. Version 2.12 Dec2016. Workloads: apoa1(92K atoms), stmv(1M atoms). Compiled with –DNAMD_KNL* define. Tests performed on March 2017. E5-2697 v4: 2S Intel® Xeon® processor E5-2697 v4, 2.3GHz, 36 cores, turbo and HT on, BIOS 86B0271.R00, 8x16GB 2400MHz DDR4, Red Hat Enterprise Linux* 7.2 kernel 3.10.0-327. Compiler option "-xCORE-AVX2". Gold 6148: 2S Intel® Xeon® Gold 6148 processor, 2.4GHz, 40 cores, turbo on, HT on, BIOS 86B.01.00.0412.R00, 12x16GB 2666MHz DDR, Red Hat Enterprise Linux* 7.2 kernel 3.10.0-327. Compiler option "-xCORE-AVX512".

LAMMPS: LAMMPS is a classical molecular dynamics code, and an acronym for Large-scale Atomic/Molecular Massively Parallel Simulator. It is used to simulate the movement of atoms to develop better therapeutics, improve alternative energy devices, develop new materials, and more. E5-2697 v4: 2S Intel® Xeon® processor E5-2697 v4, 2.3GHz, 36 cores, Intel® Turbo Boost Technology and Intel® Hyperthreading Technology on, BIOS 86B0271.R00, 8x16GB 2400MHz DDR4, Red Hat Enterprise Linux* 7.2 kernel 3.10.0-327. Gold 6148: 2S Intel® Xeon® Gold 6148 processor, 2.4GHz, 40 cores, Intel® Turbo Boost Technology and Intel® Hyperthreading Technology on, BIOS 86B.01.00.0412.R00, 12x16GB 2666MHz DDR4, Red Hat Enterprise Linux* 7.2 kernel 3.10.0-327.

GROMACS is a versatile package to perform classical Molecular Dynamics simulations. Heavily optimized for most modern platforms and provides extremely high performance. GROMACS AVX2 CONFIGURATION: Version 2016.3: ftp://ftp.gromacs.org/pub/gromacs/gromacs-2016.3.tar.gz , Intel® Compiler 17.0.1.132, Intel® MPI 2017u1. Optimization Flags: "-O3 -xCORE-AVX2". Cmake options: "-DGMX_FFT_LIBRARY=mkl -DGMX_SIMD=AVX2_256". GROMACS AVX512 CONFIGURATION: Version 2016.3: ftp://ftp.gromacs.org/pub/gromacs/gromacs-2016.3.tar.gz , Intel® Compiler 17.0.1.132, Intel® MPI 2017u1. Optimization Flags: "-O3 -xCORE-AVX512". Cmake options: "-DGMX_FFT_LIBRARY=mkl -DGMX_SIMD=AVX_512". E5-2697 V4: GROMACS AVX2 binary, Dual Socket Intel® Xeon® processor E5-2697 v4 2.3 GHz, 18 Cores/Socket, 36 Cores, 72 Threads (HT on, Turbo on), DDR4 128GB, 2400 MHz, Red Hat 7.2. Gold 6148: GROMACS AVX512 binary, Dual Socket Intel® Xeon® processor Gold 6148 2.4 GHz , 20 Cores/Socket, 40 Cores, 80 Threads (HT on, Turbo on), DDR4 192GB, 2666 MT/s DDR4 RDIMMs, Red Hat 7.2.

Amber* is a suite of programs for classical molecular dynamics and statistical analysis. The main MD program is PMEMD (Particle Mesh Ewald Molecular Dynamics) employs two separate algorithms for implicit- and explicit-solvent dynamics. Here performance for explicit solvent (PME) is presented. Amber: Version 16 with all patches applied at December, 2016. Workloads: PME Cellulose NVE(408K atoms), PME stmv(1M atoms), GB Nucleosome (25K), GB Rubisco (75K). No cut-off was used for GB workloads. Compiled with -mic2_spdp –intelmpi - openmp, –DMIC2 * defined. Tests performed on March 2017. E5-2697 v4: Executed with 36 MPI, 2 OpenMP. 2S Intel® Xeon® processor E5-2697 v4, 2.3GHz, 36 cores, turbo and HT on, BIOS 86B0271.R00, 8x16GB 2400MHz DDR4, Red Hat Enterprise Linux* 7.2 kernel 3.10.0-327. Gold 6148: Executed with 40 MPI and 2 OpenMP. 2S Intel® Xeon® Gold 6148 processor, 2.4GHz, 40 cores, turbo on, HT on, BIOS 86B.01.00.0412.R00, 12x16GB 2666MHz DDR, Red Hat Enterprise Linux* 7.2 kernel 3.10.0-327.

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 complete information visit www.intel.com/benchmarks.

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