Update from Intel® : Insights into Intel® innovations for HPC and AI

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9th MultiCore Workshop. September 26th, 2019
National Center for Atmospheric Research, Boulder, CO

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Tests document performance of components on a particular test, in specific systems. Differences in hardware, software, or configuration will affect actual performance. Consult other sources of information to evaluate performance as you consider your purchase. For more complete information about performance and benchmark results, visit www.intel.com/benchmarks.

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Intel® Advanced Vector Extensions (Intel® AVX)* provides higher throughput to certain processor operations. Due to varying processor power characteristics, utilizing 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.

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Agenda

- Introduction: Moore's Law, is it really ending?
- Overview of the latest generation of Intel® Xeon® Processor and roadmap
- Overview of coming technologies: oneAPI, DAOS, CXL, …
- Performance study of Intel® Xeon® Scalable Processor using mainstream HPC and ESM workloads
- Examples of HPC-AI convergence use cases from our customers

Acknowledgments

- Chris Allison, Nitya Hariharan, Nalini Kumar, Victor Lee, Andrea Luiselli, Johann Lombardi, Vikram Saletore, Stephen Van Doren

Moore's Law: 1965

"With unit cost falling as the number of components per circuit rises, by 1975 economics may dictate squeezing as many as 65000 components on a single silicon chip"

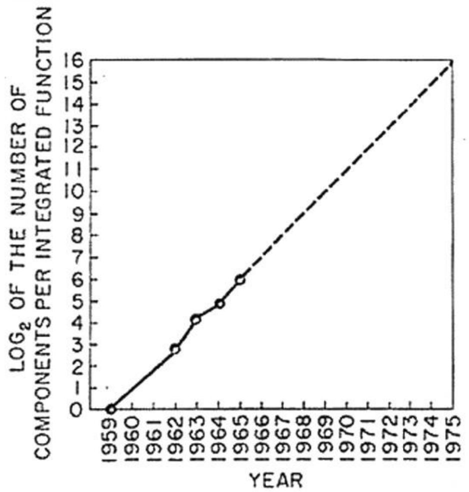


Fig. 2 Number of components per integrated function for minimum cost per component extrapolated vs time.

Cramming More Components onto Integrated Circuits
Gordon E. Moore,
Electronics, Vol 38, Number 8, April 19, 1965

Is Moore's Law ending?

"Everything that can be invented has been invented"

Charles H. Duell
US Patent Commissioner **1899**

"Moore's Law won't work at feature sizes less than a quarter of a micron"

Erich Bloch
Head of IBM Research, later Chairman of NSF **1988**

"There is nothing new to be discovered in physics now"

Lord Kelvin **1900**

The End of Moore's Law?

The current economic boom is likely due to increases in computing speed and decreases in price. Now there are some good reasons to think that the party may be ending.

2000

by **Charles C. Mann** May 1, 2000

"The End of History"

Francis Fukuyama **1989**

Moore's Law Is Dead. Now What?

Shrinking transistors have powered 50 years of advances in computing—but now other ways must be found to make computers more capable.

2016

by **Tom Simonite** May 13, 2016

Moore Sees 'Moore's Law' Dead in a Decade

By Mark Hachman on September 18, 2007 at 5:12 pm | 1 Comment **2007**

In a "fireside chat" with NPR "Tech Nation's" Moira Gunn, Intel co-founder and chairman emeritus Gordon Moore said he sees his famous law expiring in 10 to 15 years.

SCI-TECH

Moore's Law limit hit by 2014?

The high cost of semiconductor manufacturing equipment is making continued chipmaking advancements too expensive, threatening Moore's Law, according to iSuppli.

BY BROOKE CROTHERS | JUNE 16, 2009 12:48 PM PDT **2009**

NEWS

Death of Moore's Law Will Cause Economic Crisis

By John E Dunn
Techworld.com | MAR 21, 2011 11:28 AM PST **2011**

1,901 views | Apr 29, 2010, 01:37pm

Life After Moore's Law

F By Bill Dally **2010**

Intel's View

Jim Keller, SVP**,** General Manager, Silicon Engineering Group, Intel
UC Berkeley EECS Colloquium, September 18th, 2019.

Short summary: **Moore's Law will keep proceeding. There is a path to get *50x gate density.***

Link to a talk: https://eecs.berkeley.edu/research/colloquium/190918

The 2nd generation of Intel® Xeon® Scalable Processor and Overview of Next-Generation Data Center Products

INCREASING THE PACE OF INNOVATION

2014	2015	2016	2017	2018	2019	2020	2021	2022

- INTEL® XEON® PROCESSOR E5 V3 — HASWELL
- INTEL® XEON® PROCESSOR E5 V4 — BROADWELL
- INTEL® XEON® SCALABLE PROCESSOR — SKYLAKE
- 2ND GEN INTEL® XEON® SCALABLE PROCESSOR — CASCADE LAKE
- COOPER LAKE & ICE LAKE
- SAPPHIRE RAPIDS
- NEXT GEN

DRIVING LEADERSHIP WORKLOAD PERFORMANCE

5 TO 7 QUARTER CADENCE — MOVING TO — 4 TO 5 QUARTER CADENCE

AVAILABLE TODAY

2ND GENERATION INTEL® XEON® SCALABLE PROCESSOR

intel® XEON® PLATINUM inside™

2X
AVERAGE PERFORMANCE IMPROVEMENT[1]
COMPARED TO INTEL® XEON® PLATINUM 8180 PROCESSOR

UP TO 30X
AI PERFORMANCE WITH INTEL® DL BOOST[2]
COMPARED TO INTEL® XEON® PLATINUM 8180 PROCESSORS (JULY 2017)

UP TO 5.8X
BETTER PERFORMANCE THAN AMD EPYC* 7601[3]
COMPARED TO INTEL® XEON® PLATINUM 9282 PROCESSOR RUNNING LINPACK

HIGHEST DDR4
NATIVE BANDWIDTH OF ANY INTEL® XEON® PLATFORM

HIGHEST FLOPS
PER 2S SYSTEM WITH INTEL® ARCHITECTURE

HIGHEST DENSITY
INTEL® XEON® SCALABLE PROCESSOR CORES IN A 2S SYSTEM

Performance results are based on testing as of dates shown in configuration and may not reflect all publicly available security updates, see details on slide 44.
For more complete information about performance and benchmark results, visit www.intel.com/benchmarks..

INTEL® XEON®: ONWARDS AND UPWARDS

THE ONLY DATACENTER CPU OPTIMIZED FOR CONVERGENCE

INTEL® ADVANCED VECTOR EXTENSIONS 512

INTEL® DEEP LEARNING BOOST (INTEL® DL BOOST)

INTEL® OPTANE™ DC PERSISTENT MEMORY

2019	2020	2021
CASCADE LAKE 14NM NEW AI ACCELERATION (VNNI) NEW MEMORY STORAGE HIERARCHY	**COOPER LAKE** 14NM NEXT GEN INTEL DL BOOST (BFLOAT16) **ICE LAKE** 10NM SHIPPING 1H'20, SAMPLES SHIPPING NOW	**SAPPHIRE RAPIDS** NEXT GENERATION TECHNOLOGIES

ACCELERATING CONVERGENCE

LEADERSHIP PERFORMANCE FOR DATA LEVEL PARALLEL HPC & AI WORKLOADS

Xe

7NM PROCESS TECHNOLOGY

EMIB (2D) AND FOVEROS (3D) TECHNOLOGY

POWERING AURORA

DELIVERED IN 2021

intel

ACCELERATING INNOVATIONS FOR CONVERGENCE

INTEL® XEON® SCALABLE PROCESSOR +
MULTIPLE X^{E} ARCHITECTURE BASED GP-GPU IN EACH NODE

>10 PETABYTES MEMORY

>230 PETABYTES STORAGE (DAOS), BW >25TB/S

INTEL ONE API

MULTI OS
BETTER ISOLATION USING LIGHT WEIGHT KERNELS

UNIFIED CONTROL SYSTEM
SCALABLE, COHERENT COMPREHENSIVE SYSTEM VIEW

GEOPM
APPLICATION AWARE HOLISTIC POWER MANAGEMENT

PMIX
PROCESS MANAGEMENT WITH “INSTANT ON”

FOCUSED INVESTMENTS TO ACCELERATE HPC & AI

ADVANCED ARCHITECTURES

SCALAR | VECTOR | MATRIX | SPATIAL

+ Quantum & Neuromorphic

COMPUTE ARCHITECTURES FOR ALL YOUR WORKLOADS

MANUFACTURING EXCELLENCE

PROCESS

FPGA — 10 NM in 2019

10th Gen Intel® Core™ Processor — 10 NM in 2019

PACKAGING

EMIB + "FOVEROS"

ADVANCED PACKAGING FOR HETEROGENEOUS INTEGRATION

INTELLIGENT INTERCONNECT

OPEN STANDARDS

CXL Compute Express Link

ADVANCED HIGH PERFORMANT FABRICS

INTERCONNECT BEYOND "I/O"

SIMPLIFIED PROGRAMMING

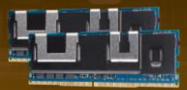
OPEN STANDARDS

oneAPI Services and Tools

UNIFIED SINGLE SOFTWARE ABSTRACTION AND DOMAIN-SPECIFIC LIBRARIES

TRANSFORMING MEMORY & STORAGE

OPEN STANDARDS



DAOS

RE-ARCHITECTING THE MEMORY HIERARCHY AND FILE SYSTEMS

BUILT-IN SECURITY

SECURITY AT ALL LEVELS: CORE, SOC, BOARD, PLATFORM, & SOFTWARE

UNIQUELY POSITIONED TO IMPLEMENT SECURITY TECHNOLOGIES AT EVERY LEVEL

GROWING THE ECOSYSTEM AND ADVANCING HPC & AI THROUGH OPEN STANDARDS

INTEL® OPTANE™ DC PERSISTENT MEMORY

CHANGING THE MEMORY AND STORAGE PARADIGM

nextgenio
FUJITSU
epcc

ECMWF

10X HIGHER BANDWIDTH

INTO RESULTS DATABASE
VS. CONVENTIONAL STORAGE SYSTEMS

ACCELERATING GLOBAL WEATHER FORECASTING ... WITH FEWER I/O NODES

ARCTUR
BSC
OpenFOAM

2X SPEED UP

VS. CONVENTIONAL STORAGE SYSTEMS
REDUCING SIGNIFICANT WRITE OVERHEAD INTO FILE SYSTEM

REDUCING OPENFOAM RUNTIME BY 50%

CASTEP

2X HIGHER THROUGHPUT

ON SAME NUMBER OF NODES
VS. DDR BASED SYSTEMS

ACCELERATING MATERIAL SCIENCE RESEARCH ACROSS MULTIPLE DOMAINS

Performance results based on testing by EPCC. See slide 45 for system configuration details as provided by EPCC.

The NEXTGenIO project is funded by the European Union's Horizon 2020 Research and Innovation program under Grant Agreement no. 671951

Generational performance study of Intel® Xeon® Processor using HPC and ESM workloads

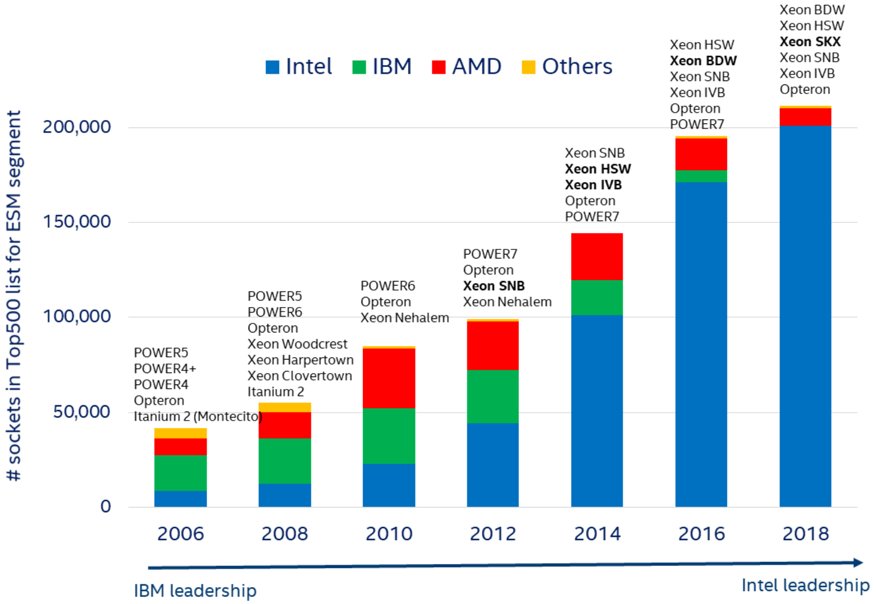
NWP and ESM HPC centers in Top500

From TOP500 List - June 2018

Rank	Site	System	Cores	Rmax (TFlop/s)	Rpeak (TFlop/s)	Power (kW)
20	United Kingdom Meteorological Office United Kingdom	Cray XC40, Xeon E5-2695v4 18C 2.1GHz, Aries interconnect Cray Inc.	241,920	7,038.9	8,128.5	
25	Japan Meteorological Agency Japan	Cray XC50, Xeon Platinum 8160 24C 2.1GHz, Aries interconnect Cray Inc./Hitachi	135,792	5,730.5	9,125.2	1,354
26	Japan Meteorological Agency Japan	Cray XC50, Xeon Platinum 8160 24C 2.1GHz, Aries interconnect Cray Inc./Hitachi	135,792	5,730.5	9,125.2	1,354
31	National Center for Atmospheric Research (NCAR) United States	**Cheyenne** - SGI ICE XA, Xeon E5-2697v4 18C 2.3GHz, Infiniband EDR HPE	144,900	4,788.2	5,332.3	1,727
36	ECMWF United Kingdom	Cray XC40, Xeon E5-2695v4 18C 2.1GHz, Aries interconnect Cray Inc.	126,468	3,944.7	4,249.3	1,897
37	ECMWF United Kingdom	Cray XC40, Xeon E5-2695v4 18C 2.1GHz, Aries interconnect Cray Inc.	126,468	3,944.7	4,249.3	1,897

www.top500.org

Arch of ESM HPC centers in 2006-2018

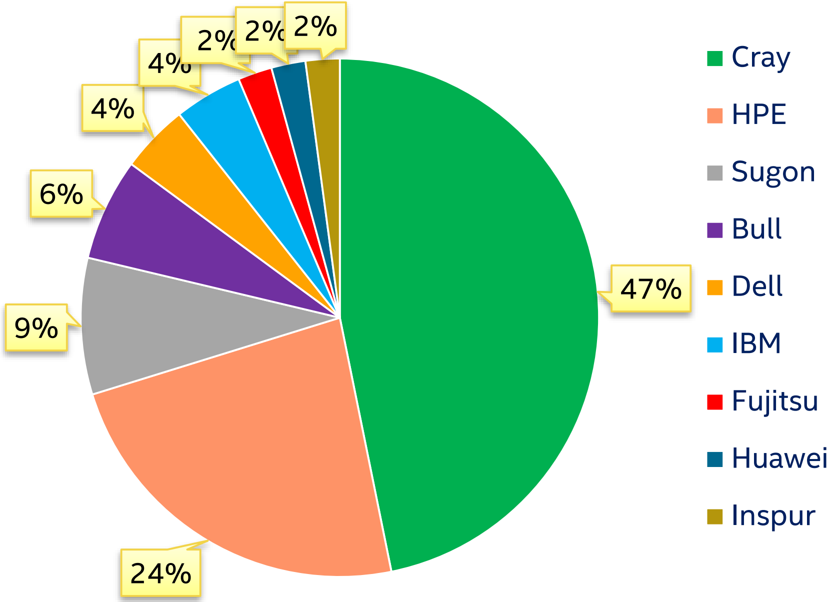


Data represents an architecture view of supercomputing centers from Top500 which are 100% dedicated to weather/climate.

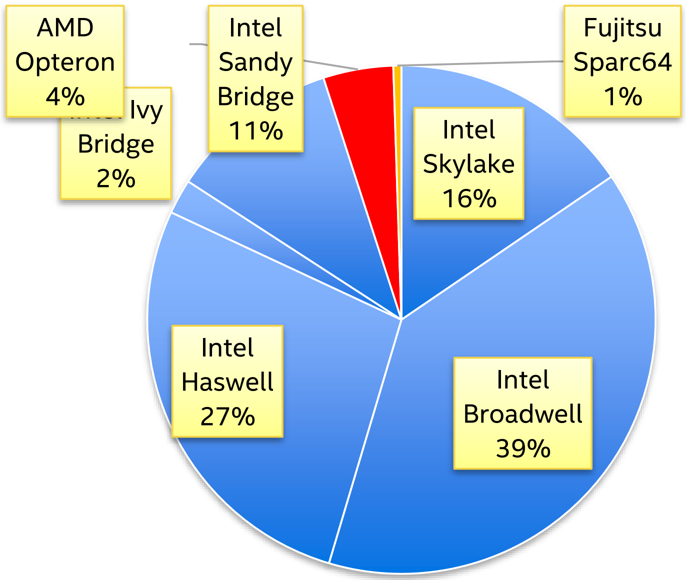
NWP and ESM HPC centers in Top500

Data source: www.top500.org

Distribution by OEM

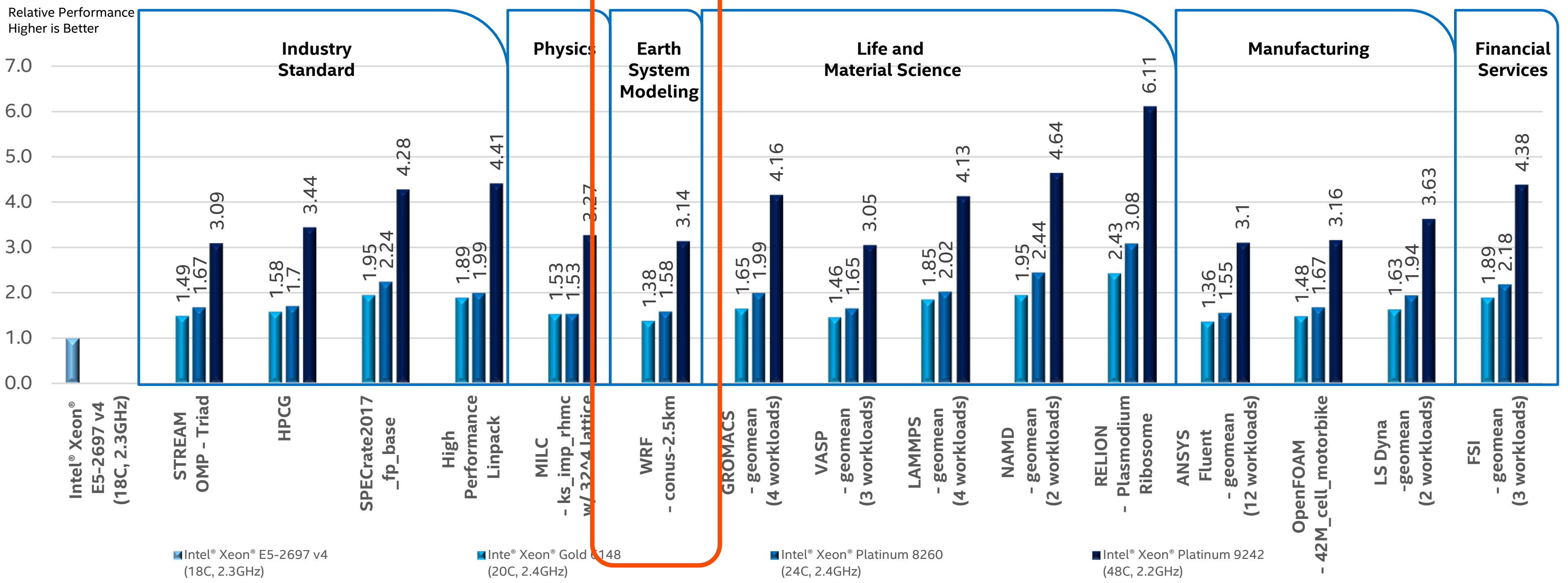


Distribution by arch



- **Cray** covers almost a half of NWP/ESM HPC in Top500
- **95%** of NWP/ESM HPC runs on Intel architecture

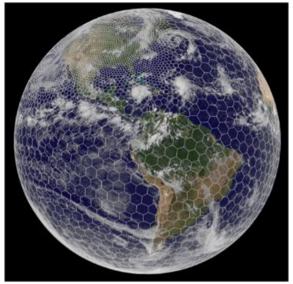
Intel® Xeon® Scalable Generational HPC Performance

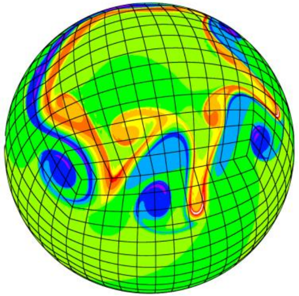


Geometric mean of group of workloads, actual individual workload performance may vary. Refer to appropriate application slide for individual workload performance. OpenFOAM Disclaimer: This offering is not approved or endorsed by OpenCFD Limited, producer and distributor of the OpenFOAM software via www.openfoam.com, and owner of the OPENFOAM® and OpenCFD® trademark.

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. Configuration: Refer to Detailed Workload Configuration Slides in this presentation. Performance results are based on testing as of March 11, 2019 and may not reflect all publicly available security updates. See configuration disclosures for details. No product or component can be absolutely secure.

Selected suite of NWP/ESM workloads

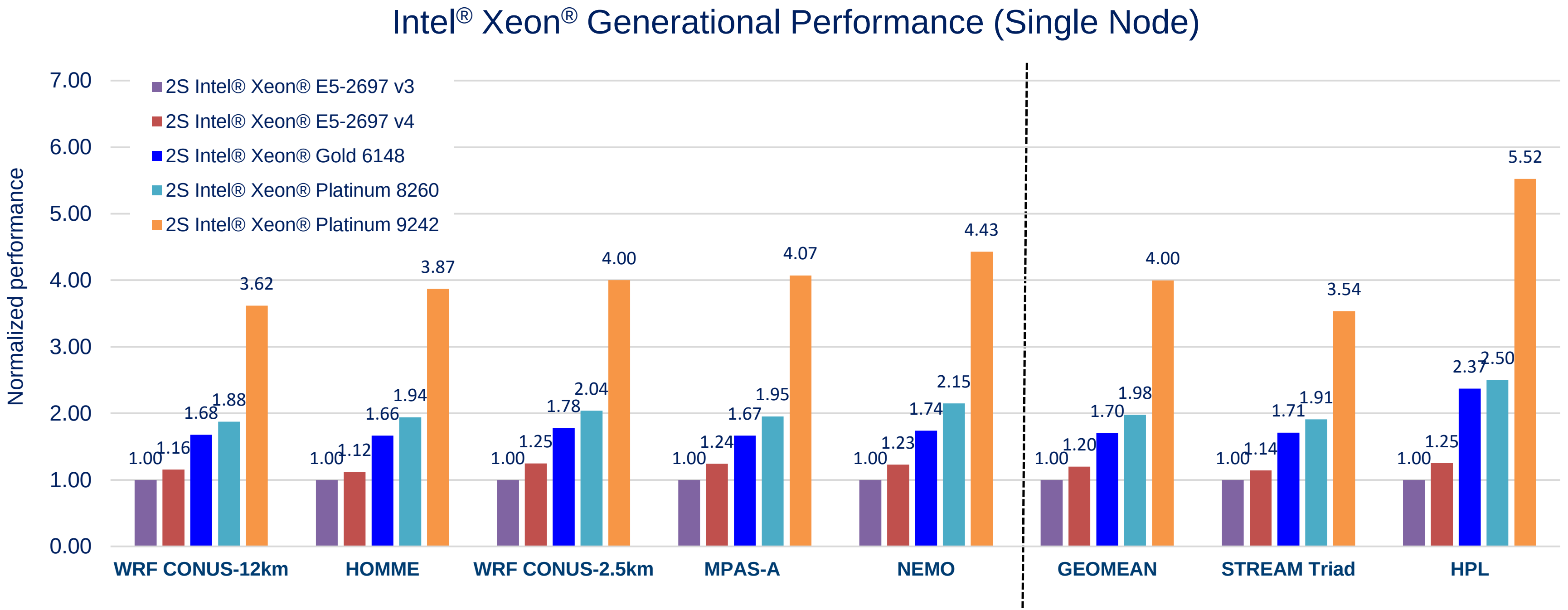




WRF **MPAS-A** **NEMO** **HOMME**

Application	Version	Dataset	Compiler/MPI	Run
WRF	3.9.1.1	CONUS-12km, CONUS-2.5km	Intel 2018 update 3	Out-of-the-box
MPAS-A	6.1	120km_L56, dycore+physics	Intel 2018 update 3	Out-of-the-box
NEMO	4.0	ORCA2_ICE_PISCES	Intel 2018 update 3	Out-of-the-box
HOMME	dungeon28	WACCM, NE=8	Intel 2018 update 3	Out-of-the-box

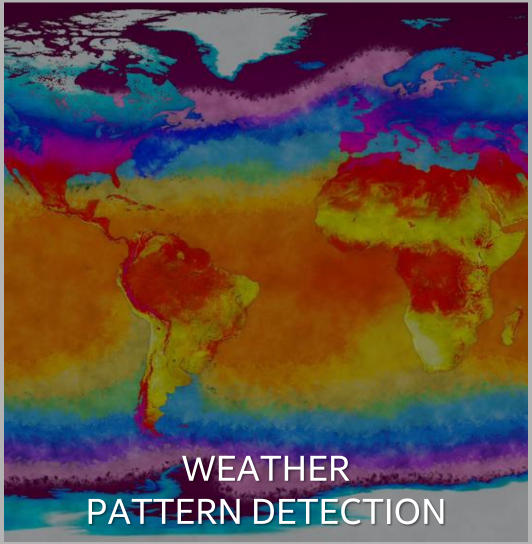
SUMMARY: Single Node Performance



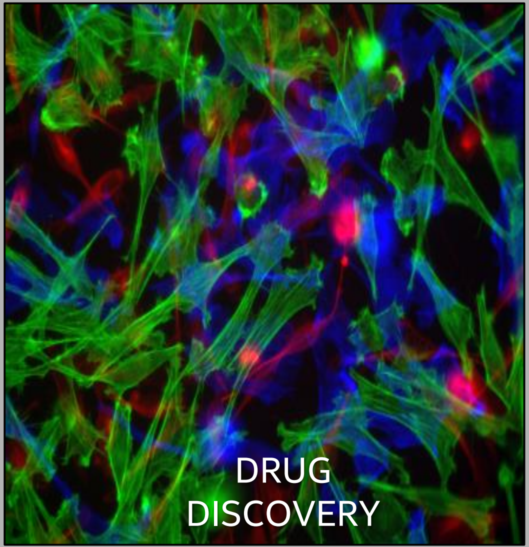
Performance results are based on testing as of January 30, 2019 to April 30, 2019 and may not reflect all publicly available security updates. See configuration disclosure for details. No product can be absolutely secure. Software and workloads used in performance tests may have been optimized for performance 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. 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. Refer to Configuration: HPC Workloads – WRF CONUS-12km, WRF CONUS-2.5km, MPAS-A, NEMO, HOMME, STREAM Triad, HPL . *Other names and brands may be claimed as the property of others.

HPC-AI Convergence: Examples of HPC-AI Use Cases from Our Customers

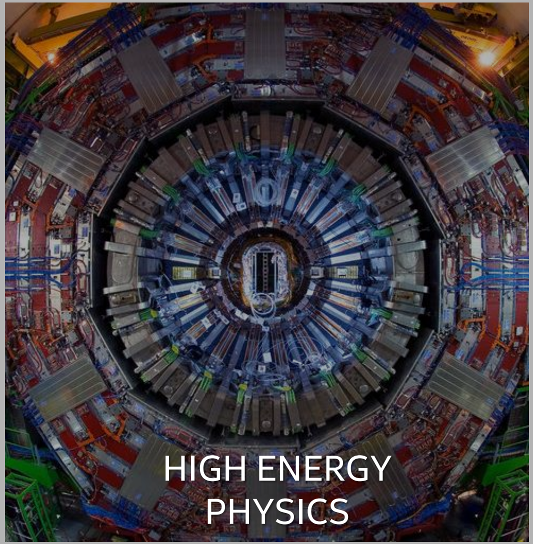
HPC-AI Use Cases with Collaborations



AI INTEGRATED IN HPC WORKFLOWS



AI ACCELERATING HPC SIMULATIONS



AI REPLACING HPC SIMULATIONS

DisCo - Unsupervised Detection of Spatiotemporal Structures

Joint collaboration of Intel, LBNL/NERSC, UC Davis

First distributed-memory implementation of local causal state reconstruction:

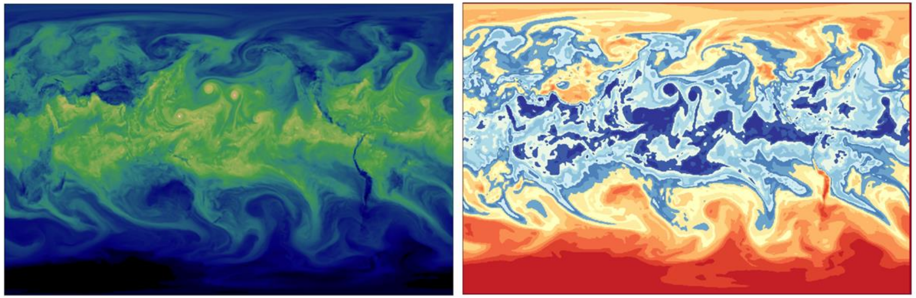
- Outperforms state-of-art methods for complex fluid flows
- Unprecedented data processing capability (**89.5TB** lightcone data in **6.6 minutes** on 1024 nodes)

Distributed implementations of K-Means and DBSCAN for high-dimensional data:

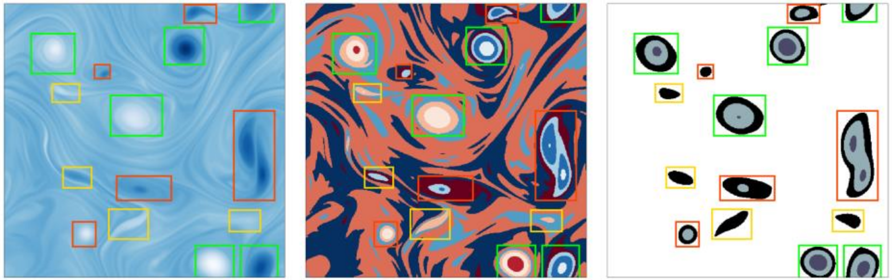
- Using standard scikit-learn like Python APIs in Intel® DAAL and daal4py

Achieved high performance while maintaining developer productivity:

- **30x** 1-node speedup, **91%** weak and **64%** strong scaling efficiency up to 1024 Intel® Haswell nodes



(f) Water vapor field of CAM5.1 climate model simulation (g) Climate local causal state field



(a) Turbulence vorticity field (b) Turbulence state field, fine structure (c) Turbulence state field, coarse structure

https://www.groundai.com/project/towards-unsupervised-segmentation-of-extreme-weather-events/1

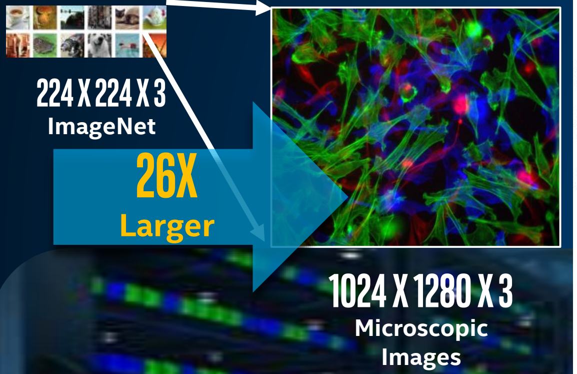
HPC ←→ AI: IMAGE ANALYSIS FOR DRUG DISCOVERY

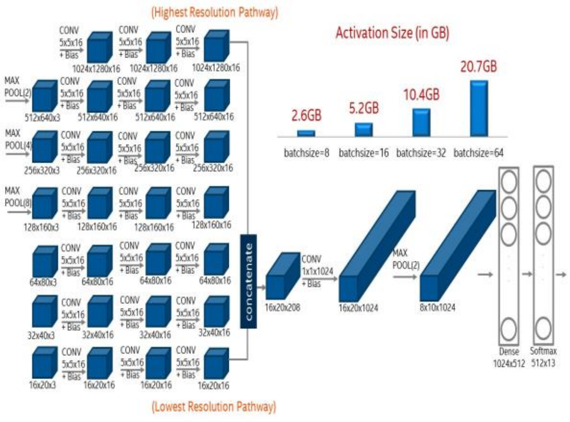
NOVARTIS

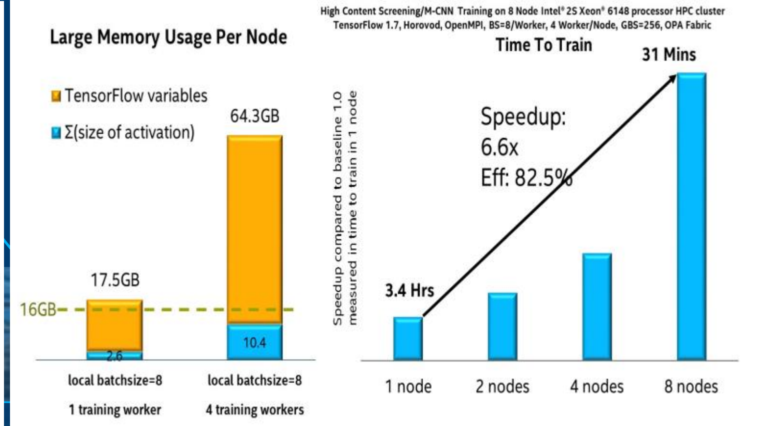
Joint Intel & Novartis collaboration

RESULTS

Processing 1024x1280 large image dataset, reducing the training time to 31 minutes to >99% accuracy on 2S Intel® Xeon® processor based cluster.







Customer: Novartis Inst. of Biomedical Research (Switzerland) is one of the largest pharmaceutical companies in the world

Challenge: High content screening of cellular phenotypes is a fundamental tool supporting early stage drug discovery. While analyzing whole microscopic images are desirable, these images are 26X larger than benchmark dataset such as ImageNet*-1K. As a result, the high computational workload with high memory requirement would be prohibitive for deep learning model training

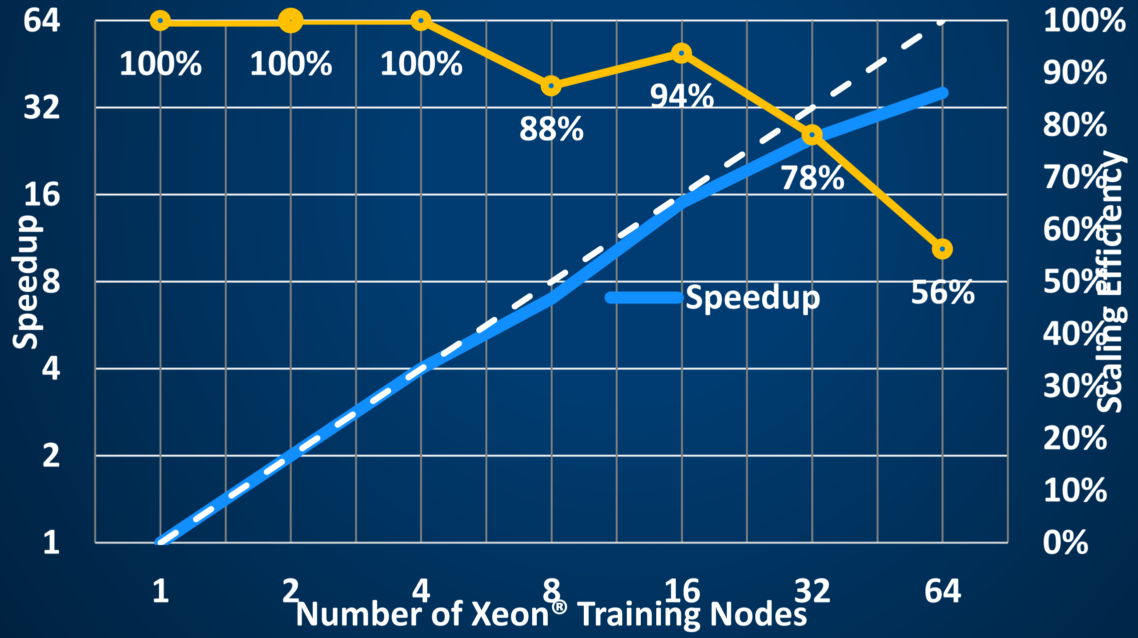
Solution: Intel and Novartis teams were able to scale and train the model with 32 TensorFlow* workers in 31 minutes.

http://aidc.gallery.video/detail/video/5790618241001/deep-learning-based-classification-of-high-content-cellular-images-on-intel-architecture?autoStart=true&q=Datta

HPC ← → AI: IMAGE ANALYSIS FOR DRUG DISCOVERY

Published at International Supercomputing Conference 19 (ISC19), Frankfurt. Available from Springer

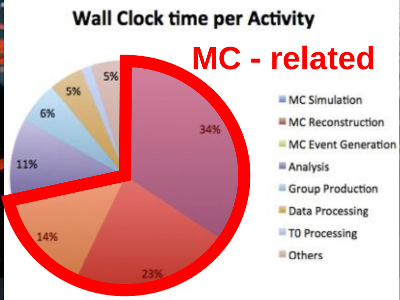
High Content Screening Training with 313K Images on 64-Node Intel® 2S Xeon® Scalable processor 6148, TensorFlow*, "horovod*", OpenMPI*, Batch Size=32/Node, Intel® Omni-Path™ Fabric



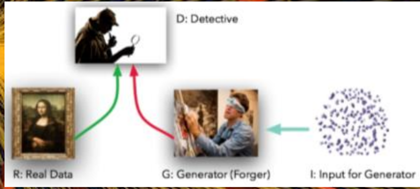
HPC ←→ AI: DIS/REPLACING MONTE CARLO SIM.

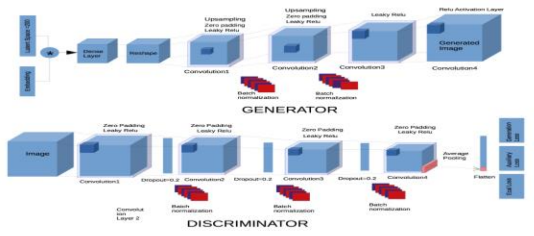
CERN HIGH ENERGY PHYSICS

JOINT COLLABORATION WITH INTEL AND SURFSARA



WLCG Wall Clock time for the ATLAS experiment





3D-Generative Adversarial Networks(GANs)

RESULT

94% scaling efficiency up to 128 nodes, with a significant reduction in training time per epoch for 3D-GANs & >2500X Inference

Time to create an electron shower		
Method	Machine	Time/Shower (msec)
Full Simulation (geant4)	2S Intel® Xeon® Platinum 8180	17000
3D GAN (batch size 128)	**2S Intel® Xeon® Platinum 8180**	**7**

Inference Perf: >2500X

Customer: CERN, the European Organization for Nuclear Research, which operates the Large Hadron Collider (LHC), the world's largest and most powerful particle accelerator

Challenge: CERN currently uses Monte Carlo simulations for complex physics and geometry modeling, which is a heavy computational load that consumes up to >50% of the Worldwide LHC Computing Grid power for electron shower simulations.

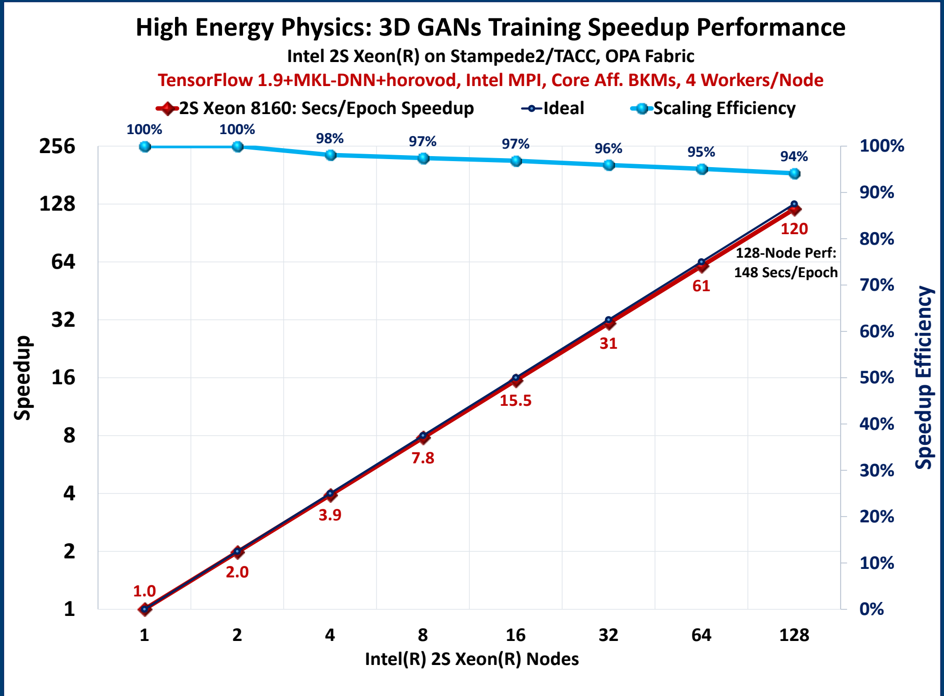
Solution: Distributed training using 128 nodes of the TACC Stampede 2 cluster (Intel® Xeon® Platinum 8160 processor, Intel® OPA) and a **3D Generative Adversarial Network (3D GAN)**. Performance was first optimized on a single node then scaled using TensorFlow* optimized with Intel® MKL-DNN, using 4 workers/node and an optimized number of convolutional filters.

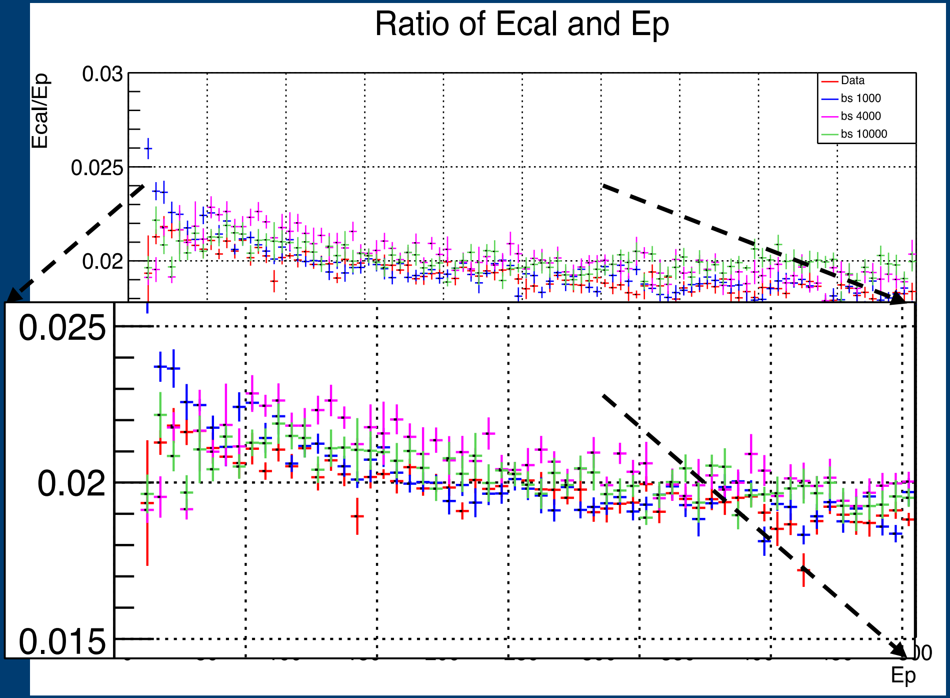
https://www.rdmag.com/article/2018/11/imagining-unthinkable-simulations-without-classical-monte-carlo

Multi-Node Training Performance & Accuracy (2018)

Distributed training using data parallelism

94% Scaling efficiency up to 128 nodes





Inference time

2018

Baseline (TF 1.9)

Time to create an Electron shower			
Method	**Platform**	**Time/Shower (msecs)**	**Speedup**
Classical Monte Carlo (Geant4)	2S Intel® Xeon® Platinum 8180	17000	**1.0**
3D GAN (BS=128) 1-Stream	2S Intel® Xeon® Platinum 8180	7	**2500**

*measured on 10000 showers

2019

Further optimization (TF 1.13, MKL-DNN, 3D-Conv)

Time to create an Electron shower			
Method	**Platform**	**Time/Shower (msecs)**	**Speedup**
Classical Monte Carlo (Geant4)	2S Intel® Xeon® Platinum 8180	**17000**	**1.0**
3D GAN (BS=128) 1-Stream	2S Intel® Xeon® Platinum 8160	**1.25**	**13600**
3D GAN (BS=128) 2-Stream	2S Intel® Xeon® Platinum 8160	**0.93**	**18279**
3D GAN (BS=128) 4-Stream	2S Intel® Xeon® Platinum 8160	**0.85**	**20000**

oneAPI: Single Programming Model to Deliver Cross-Architecture Performance

INTEL DATA-CENTRIC HARDWARE: HIGH PERFORMANCE, FLEXIBLE OPTIONS

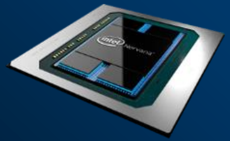
General Purpose CPU

GPU

Intel® Processor Graphics & Future Products

FPGA

Domain Optimized Accelerator



Intel Neural Network Processor

GENERAL PURPOSE

Provide optimal performance over the widest variety of workloads

HARDWARE

WORKLOAD OPTIMIZED

Deliver highest performance per $/Watt/U/Rack for critical applications

Optimization Notice

REVOLUTIONIZING PROGRAMMABILITY

INTEL'S ONE API

One API Tools

Optimized Applications

Optimized Middleware / Frameworks

One API Languages & Libraries

CPU	GPU	AI	FPGA
SCALAR	VECTOR	MATRIX	SPATIAL

DATA PARALLEL C++

Based on C++ and uses C / C++ constructs

Incorporates SYCL* for data parallelism & heterogeneous programming

Language extensions driven through an open community project

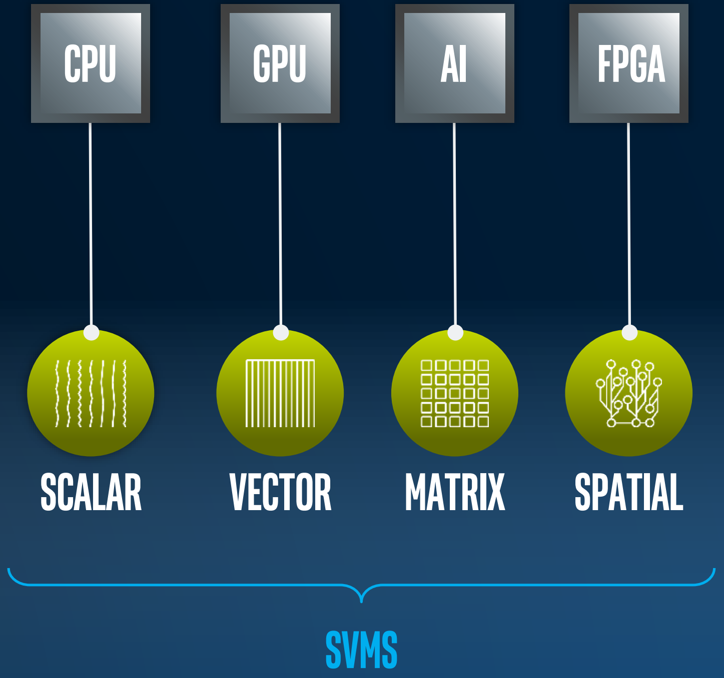
First available – Q4 2019

* from the Khronos Group

OPEN & INDUSTRY STANDARDS, UNCOMPROMISED PERFORMANCE, INTEROPERABLE

DIVERSE WORKLOADS REQUIRE DIVERSE ARCHITECTURES

The future is a **diverse** mix of scalar, vector, matrix, and spatial **architectures** deployed in CPU, GPU, AI, FPGA and other accelerators



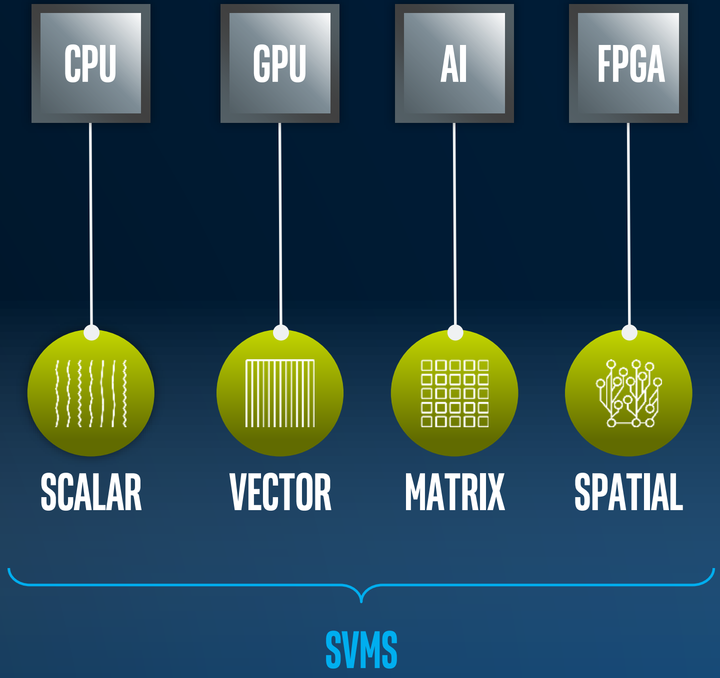
PROGRAMMING CHALLENGE

Diverse set of data-centric hardware

No common programming language or APIs

Inconsistent tool support across platforms

Each platform requires unique software investment



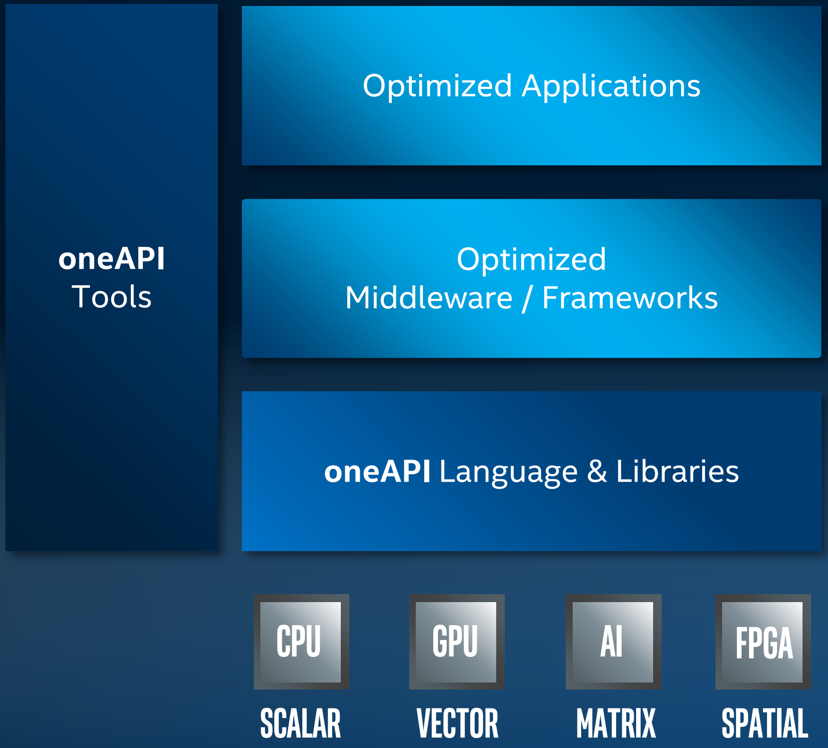
INTEL'S ONEAPI CORE CONCEPT

Project oneAPI delivers a unified programming model to simplify development across diverse architectures

Common developer experience across Scalar, Vector, Matrix and Spatial architectures (CPU, GPU, AI and FPGA)

Uncompromised native high-level language performance

Based on industry standards and open specifications



Optimization Notice

ONEAPI FOR CROSS-ARCHITECTURE PERFORMANCE

Optimized Applications

Optimized Middleware & Frameworks

oneAPI Product

Direct Programming

Data Parallel C++

API-Based Programming

Libraries

Analysis & Debug Tools

CPU – SCALAR

GPU – VECTOR

AI – MATRIX

FPGA – SPATIAL

Some capabilities may differ per architecture.

DATA PARALLEL C++

STANDARDS-BASED, CROSS-ARCHITECTURE LANGUAGE

Language to deliver uncompromised parallel programming productivity and performance across CPUs and accelerators

Based on C++ with language enhancements being driven through community project

Open, cross-industry alternative to single architecture proprietary language

There will still be a need to tune for each architecture.

ADVANCED ANALYSIS & DEBUG TOOLS

Productive performance analysis across SVMS architectures

Intel® VTune™ Profiler

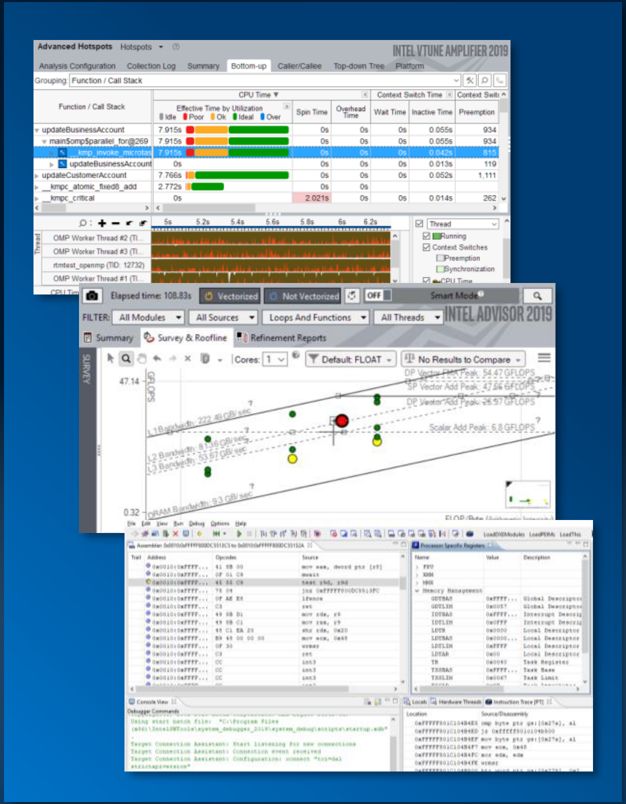
Profiler to analyze CPU and accelerator performance of compute, threading, memory, storage, and more

Intel® Advisor

Design assistant to provide advice on threading, and vectorization

Debugger

Application debugger for fast code debug on CPUs and accelerators



SUMMARY

Diverse workloads for data-centric computing are driving the need for diverse compute architectures including **CPUs, GPUs, FPGAs, and AI** accelerators

OneAPI unifies and simplifies programming of Intel CPUs and accelerators, delivering developer productivity and **full native language performance**

OneAPI is based on industry standards and **open** specifications to encourage ecosystem collaboration and innovation

More disclosures are coming in Q4

NOVEMBER 17-18, 2019 | DENVER, COLORADO

Join us for this robust training program connecting the HPC + AI community with Intel® architecture and software experts during Intel® HPC Developer Conference 2019. Speakers will share research and real results, plus provide training to instill the confidence and knowledge to use Intel's developer tools when you leave.

Event Overview | Why Attend | Agenda

Intel® HPC Developer Conference

Connect with HPC + AI Experts. Accelerate Your Innovations.

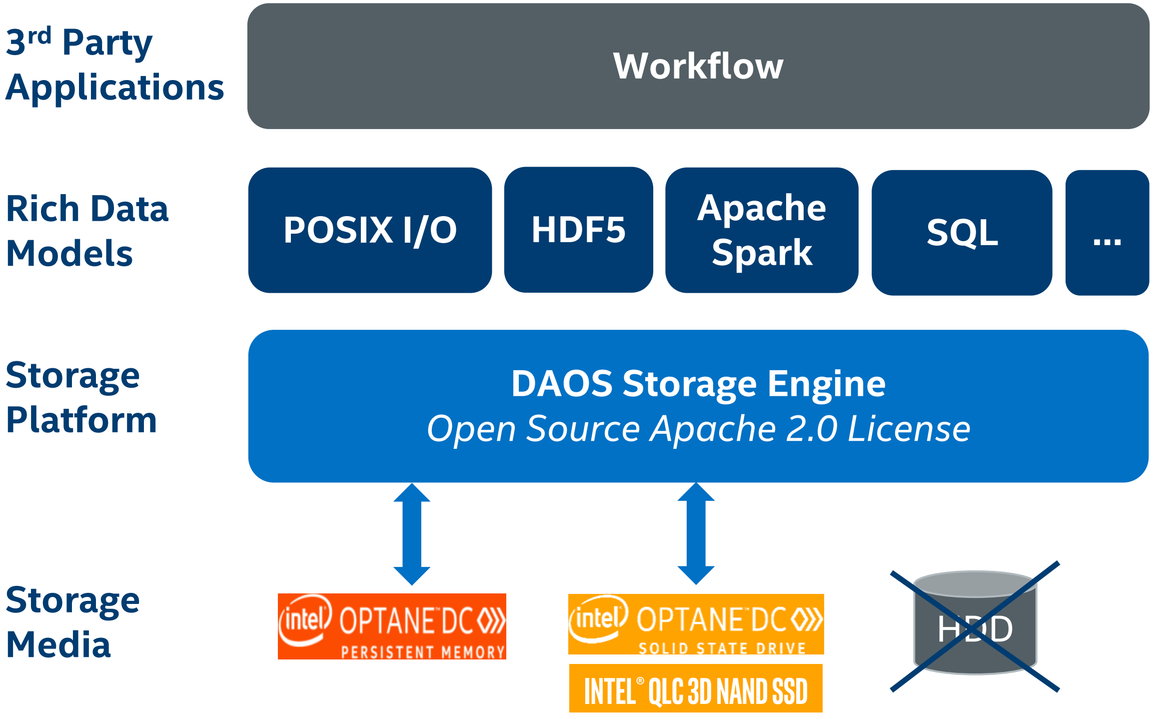
The Intel® HPC Developer Conference is the premier technical training event connecting the HPC + AI community with Intel and industry experts during Supercomputing 2019. Prepare to learn from academic & industry experts and kick start your SC19 experience **November 17–18, 2019**.

Register now

https://www.intel.com/content/www/us/en/events/hpcdevcon/overview.html

Thank you

DAOS: Distributed Asynchronous Object Storage



DAOS is the scale-out software-defined storage platform for HPC, Big Data, and AI convergence.

- High **throughput/IOPS @arbitrary** alignment/size
- **Low-latency I/O**
- Data access time **orders of magnitude faster** (µs vs ms)
- **Primary storage** on Aurora exascale supercomputer at Argonne National Labs, with a capacity of 230PB and bandwidth >25TB/s.

To learn more about DAOS

ISC demonstration

- Live DAOS demo at the Intel Booth
  - IOR + Spark workloads

  - https://youtu.be/5RJbHwtHos0

- DAOS solution brief
  - https://www.intel.com/content/www/us/en/high-performance-computing/

Source code on GitHub:

- https://github.com/daos-stack/daos

DAOS public roadmap:

- https://wiki.hpdd.intel.com/display/DC/Roadmap

Admin Guide:

- http://daos.io/doc

Community mailing list on Groups.io:

- daos@daos.groups.io

Support:

- https://jira.hpdd.intel.com

Footnotes and configuration details

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

1 - 2x Average Performance Improvement compared with Intel® Xeon® Platinum 8180 processor. Geomean of est SPECrate2017_int_base, est SPECrate2017_fp_base, Stream Triad, Intel Distribution of Linpack, server side Java. Platinum 92xx vs Platinum 8180: 1-node, 2x Intel® Xeon® Platinum 9282 cpu on Walker Pass with 768 GB (24x 32GB 2933) total memory, ucode 0x400000A on RHEL7.6, 3.10.0-957.el7.x86_65, IC19u1, AVX512, HT on all (off Stream, Linpack), Turbo on all (off Stream, Linpack), result: est int throughput=635, est fp throughput=526, Stream Triad=407, Linpack=6411, server side java=332913, test by Intel on 2/16/2019. vs. 1-node, 2x Intel® Xeon® Platinum 8180 cpu on Wolf Pass with 384 GB (12 X 32GB 2666) total memory, ucode 0x200004D on RHEL7.6, 3.10.0-957.el7.x86_65, IC19u1, AVX512, HT on all (off Stream, Linpack), Turbo on all (off Stream, Linpack), result: est int throughput=307, est fp throughput=251, Stream Triad=204, Linpack=3238, server side java=165724, test by Intel on 1/29/2019.

2 - Up to 30X AI performance with Intel® DL Boost compared to Intel® Xeon® Platinum 8180 processor (July 2017). Tested by Intel as of 2/26/2019. Platform: Dragon rock 2 socket Intel® Xeon® Platinum 9282(56 cores per socket), HT ON, turbo ON, Total Memory 768 GB (24 slots/ 32 GB/ 2933 MHz), BIOS:SE5C620.86B.0D.01.0241.112020180249, Centos 7 Kernel 3.10.0-957.5.1.el7.x86_64, Deep Learning Framework: Intel® Optimization for Caffe version: https://github.com/intel/caffe d554cbf1, ICC 2019.2.187, 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, No datalayer DummyData:3x224x224, 56 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“.

3 – Up to 5.8X better performance than AMD EPYC 7601 compared to Intel® Xeon® Platinum 9282 processor running LINKPACK. AMD EPYC 7601: Supermicro AS-2023US-TR4 with 2 AMD EPYC 7601 (2.2GHz, 32 core) processors, SMT OFF, Turbo ON, BIOS ver 1.1a, 4/26/2018, microcode: 0x8001227, 16x32GB DDR4-2666, 1 SSD, Ubuntu 18.04.1 LTS (4.17.0-041700-generic Retpoline), High Performance Linpack v2.2, compiled with Intel(R) Parallel Studio XE 2018 for Linux, Intel MPI version 18.0.0.128, AMD BLIS ver 0.4.0, Benchmark Config: Nb=232, N=168960, P=4, Q=4, Score =1095GFs, tested by Intel as of July 31, 2018. vs. 1-node, 2x Intel® Xeon® Platinum 9282 cpu on Walker Pass with 768 GB (24x 32GB 2933) total memory, ucode 0x400000A on RHEL7.6, 3.10.0-957.el7.x86_65, IC19u1, AVX512, HT off, Turbo on, score=6411, test by Intel on 2/16/2019. 1-node, 2x Intel® Xeon® Platinum 8280M cpu on Wolf Pass with 384 GB (12 X 32GB 2933) total memory, ucode 0x400000A on RHEL7.6, 3.10.0-957.el7.x86_65, IC19u1, AVX512, HT off Linpack, Turbo on, score=3462, test by Intel on 1/30/2019.

Footnotes and configuration details

System Configuration details as provided by EPCC for performance results on slide 15
34 DP nodes with Cascade Lake 8260M CPUs (A0 stepping), Fujitsu mainboard
96 GByte DDR4 DRAM per socket (6x16 GByte DIMMs, 2666 speed grade), plus 1.5 TByte Intel Optane DC Persistent Memory (6x256 GByte DIMMs, QS)
Dual-Rail Omni-Path networks (2 OPA NICS per node) connected via 2 48-port OPA switches
Two additional Storage server nodes running Lustre

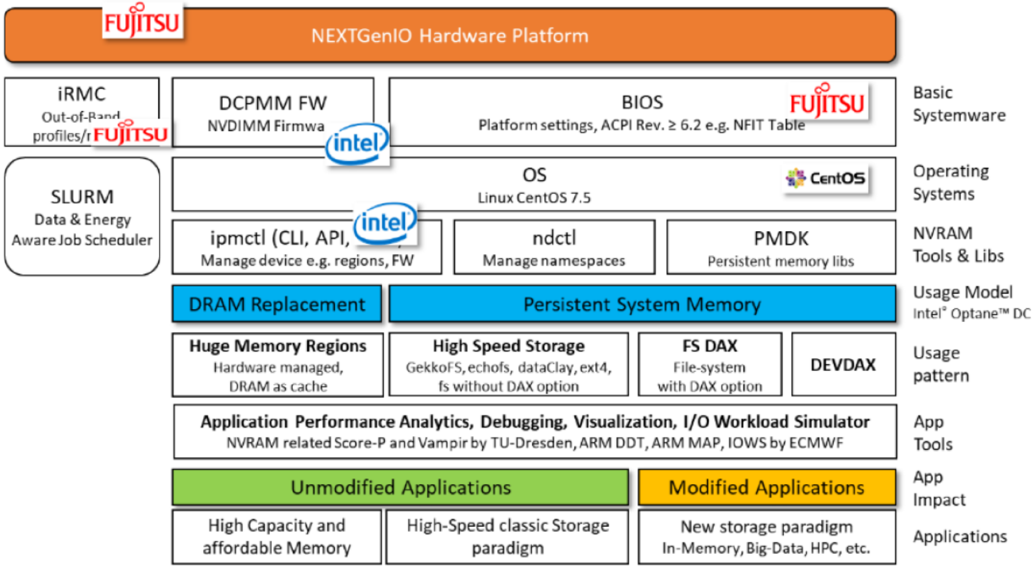


Figure 16: NEXTGenIO Solution Stack

Footnotes and configuration details

WRF CONUS-12km (higher is better):

2S Intel® Xeon® E5-2697 v3 Processor: 1-node Intel reference platform, 2x Intel® Xeon® E5-2697 v3 processor (2.6GHz, 14C), 8x16GB DDR4-2133, HT on (1 thread/core), Turbo on, 1 SSD SATA, BIOS: SE5C610.86B.01.01.0028.121720182203, Microcode: 0x3e, Oracle Linux Server release 7.6 (compatible with RHEL 7.6) on a 7.5 kernel using ksplice for security fixes, Kernel: 3.10.0-957.5.1.el7.crt1.x86_64. WRF version 3.9.1.1, Workload: CONUS-12km, compiled with AVX512, Intel® Parallel Studio XE 2018 Update 3 and Intel MPI 2018 Update 3, Relative performance=1.00, tested by Intel on 04/29/2019.

2S Intel® Xeon® E5-2697 v4 Processor: 1-node Intel reference platform, 2x Intel® Xeon® E5-2697 v4 processor (2.3GHz, 18C), 8x16GB DDR4-2400, HT on (1 thread/core), Turbo on, 1 SSD SATA, BIOS: SE5C610.86B.01.01.0028.121720182203, Microcode: 0xb000030, Oracle Linux Server release 7.6 (compatible with RHEL 7.6) on a 7.5 kernel using ksplice for security fixes, Kernel: 3.10.0-957.5.1.el7.crt1.x86_64. Workload: CONUS-12km, compiled with AVX512, Intel® Parallel Studio XE 2018 Update 3 and Intel MPI 2018 Update 3, Relative performance=1.16, tested by Intel on 04/29/2019.

2S Intel® Xeon® Gold 6148 processor: 1-node Intel reference platform, 2x Intel® Xeon® Gold 6148 processor (2.4GHz, 20 cores per socket), 12*16GB DDR4-2666, HT on (1 thread/core), Turbo on, 1 SSD SATA, BIOS: SE5C620.86B.00.01.0016.020120190930, Microcode ver 0x2000050, Oracle Linux Server release 7.6 (compatible with RHEL 7.6) on a 7.5 kernel using ksplice for security fixes, Kernel: 3.10.0-957.5.1.el7.crt1.x86_64. Workload: CONUS-12km, compiled with AVX512, Intel® Parallel Studio XE 2018 Update 3 and Intel MPI 2018 Update 3, Relative performance=1.68, tested by Intel on 04/29/2019.

2S Intel® Xeon® Platinum 8260 Processor: 1-node Intel reference platform, 2x Intel® Xeon® 8260 Intel processors (2.4GHz, 24C), 12x16GB DDR4-2933, HT on (1 thread/core), Turbo on, 1 SSD SATA, BIOS: SE5C620.86B.02.01.0008.031920191559, Microcode: 0x400001c, Oracle Linux Server release 7.6 (compatible with RHEL 7.6) on a 7.5 kernel using ksplice for security fixes, Kernel: 3.10.0-957.5.1.el7.crt1.x86_64. Workload: CONUS-12km, compiled with AVX512, Intel® Parallel Studio XE 2018 Update 3 and Intel MPI 2018 Update 3, Relative performance=1.88, tested by Intel on 04/29/2019.

2S Intel® Xeon® Platinum 9242 Processor: 1-node Intel reference platform, 2x Intel® Xeon® 9242 processors (2.2GHz, 48C), 24x16GB DDR4-2933, HT on (1 thread/core), Turbo on, 1 SSD SATA, BIOS: SE5C620.86B.0D.01.0456.033120191654, Microcode: 0x4000021, Oracle Linux Server release 7.6 (compatible with RHEL 7.6) on a 7.5 kernel using ksplice for security fixes, Kernel: 3.10.0-957.5.1.el7.crt1.x86_64. Workload: CONUS-12km, compiled with AVX512, Intel® Parallel Studio XE 2018 Update 3 and Intel MPI 2018 Update 3, Relative performance=3.62, tested by Intel on 04/29/2019.

Footnotes and configuration details

WRF CONUS-2.5km (higher is better):

2S Intel® Xeon® E5-2697 v3 Processor: 1-node Intel reference platform, 2x Intel® Xeon® E5-2697 v3 processor (2.6GHz, 14C), 8x16GB DDR4-2133, HT on (1 thread/core), Turbo on, 1 SSD SATA, BIOS: SE5C610.86B.01.01.0028.121720182203, Microcode: 0x3e, Oracle Linux Server release 7.6 (compatible with RHEL 7.6) on a 7.5 kernel using ksplice for security fixes, Kernel: 3.10.0-957.5.1.el7.crt1.x86_64. WRF version 3.9.1.1, Workload: CONUS-2.5km, compiled with AVX512, Intel® Parallel Studio XE 2018 Update 3 and Intel MPI 2018 Update 3, Relative performance=1.00, tested by Intel on 04/30/2019.

2S Intel® Xeon® E5-2697 v4 Processor: 1-node Intel reference platform, 2x Intel® Xeon® E5-2697 v4 processor (2.3GHz, 18C), 8x16GB DDR4-2400, HT on (1 thread/core), Turbo on, 1 SSD SATA, BIOS: SE5C610.86B.01.01.0028.121720182203, Microcode: 0xb000030, Oracle Linux Server release 7.6 (compatible with RHEL 7.6) on a 7.5 kernel using ksplice for security fixes, Kernel: 3.10.0-957.5.1.el7.crt1.x86_64. Workload: CONUS-2.5km, compiled with AVX512, Intel® Parallel Studio XE 2018 Update 3 and Intel MPI 2018 Update 3, Relative performance=1.25, tested by Intel on 04/30/2019.

2S Intel® Xeon® Gold 6148 processor: 1-node Intel reference platform, 2x Intel® Xeon® Gold 6148 processor (2.4GHz, 20 cores per socket), 12*16GB DDR4-2666, HT on (1 thread/core), Turbo on, 1 SSD SATA, BIOS: SE5C620.86B.00.01.0016.020120190930, Microcode ver 0x2000050, Oracle Linux Server release 7.6 (compatible with RHEL 7.6) on a 7.5 kernel using ksplice for security fixes, Kernel: 3.10.0-957.5.1.el7.crt1.x86_64. Workload: CONUS-2.5km, compiled with AVX512, Intel® Parallel Studio XE 2018 Update 3 and Intel MPI 2018 Update 3, Relative performance=1.78, tested by Intel on 04/30/2019.

2S Intel® Xeon® Platinum 8260 Processor: 1-node Intel reference platform, 2x Intel® Xeon® 8260 Intel processors (2.4GHz, 24C), 12x16GB DDR4-2933, HT on (1 thread/core), Turbo on, 1 SSD SATA, BIOS: SE5C620.86B.02.01.0008.031920191559, Microcode: 0x400001c, Oracle Linux Server release 7.6 (compatible with RHEL 7.6) on a 7.5 kernel using ksplice for security fixes, Kernel: 3.10.0-957.5.1.el7.crt1.x86_64. Workload: CONUS-2.5km, compiled with AVX512, Intel® Parallel Studio XE 2018 Update 3 and Intel MPI 2018 Update 3, Relative performance=2.04, tested by Intel on 04/30/2019.

2S Intel® Xeon® Platinum 9242 Processor: 1-node Intel reference platform, 2x Intel® Xeon® 9242 processors (2.2GHz, 48C), 24x16GB DDR4-2933, HT on (1 thread/core), Turbo on, 1 SSD SATA, BIOS: SE5C620.86B.0D.01.0456.033120191654, Microcode: 0x4000021, Oracle Linux Server release 7.6 (compatible with RHEL 7.6) on a 7.5 kernel using ksplice for security fixes, Kernel: 3.10.0-957.5.1.el7.crt1.x86_64. Workload: CONUS-2.5km, compiled with AVX512, Intel® Parallel Studio XE 2018 Update 3 and Intel MPI 2018 Update 3, Relative performance=4.00, tested by Intel on 04/30/2019.

Footnotes and configuration details

MPAS-A (higher is better):

2S Intel® Xeon® E5-2697 v3 Processor: 1-node Intel reference platform, 2x Intel® Xeon® E5-2697 v3 processor (2.6GHz, 14C), 8x16GB DDR4-2133, HT on (1 thread/core), Turbo on, 1 SSD SATA, BIOS: SE5C610.86B.01.01.0028.121720182203, Microcode: 0x3e, Oracle Linux Server release 7.6 (compatible with RHEL 7.6) on a 7.5 kernel using ksplice for security fixes, Kernel: 3.10.0-957.5.1.el7.crt1.x86_64. MPAS-A version 6.1, Workload: 120km_L56, compiled with AVX512, Intel® Parallel Studio XE 2018 Update 3 and Intel MPI 2018 Update 3, Relative performance=1.00, tested by Intel on 04/26/2019.

2S Intel® Xeon® E5-2697 v4 Processor: 1-node Intel reference platform, 2x Intel® Xeon® E5-2697 v4 processor (2.3GHz, 18C), 8x16GB DDR4-2400, HT on (1 thread/core), Turbo on, 1 SSD SATA, BIOS: SE5C610.86B.01.01.0028.121720182203, Microcode: 0xb000030, Oracle Linux Server release 7.6 (compatible with RHEL 7.6) on a 7.5 kernel using ksplice for security fixes, Kernel: 3.10.0-957.5.1.el7.crt1.x86_64. MPAS-A version 6.1, Workload: 120km_L56, compiled with AVX512, Intel® Parallel Studio XE 2018 Update 3 and Intel MPI 2018 Update 3, Relative performance=1.24, tested by Intel on 04/26/2019.

2S Intel® Xeon® Gold 6148 processor: 1-node Intel reference platform, 2x Intel® Xeon® Gold 6148 processor (2.4GHz, 20 cores per socket), 12*16GB DDR4-2666, HT on (1 thread/core), Turbo on, 1 SSD SATA, BIOS: SE5C620.86B.00.01.0016.020120190930, Microcode ver 0x2000050, Oracle Linux Server release 7.6 (compatible with RHEL 7.6) on a 7.5 kernel using ksplice for security fixes, Kernel: 3.10.0-957.5.1.el7.crt1.x86_64. MPAS-A version 6.1, Workload: 120km_L56, compiled with AVX512, Intel® Parallel Studio XE 2018 Update 3 and Intel MPI 2018 Update 3, Relative performance=1.67, tested by Intel on 04/26/2019.

2S Intel® Xeon® Platinum 8260 Processor: 1-node Intel reference platform, 2x Intel® Xeon® 8260 Intel processors (2.4GHz, 24C), 12x16GB DDR4-2933, HT on (1 thread/core), Turbo on, 1 SSD SATA, BIOS: SE5C620.86B.02.01.0008.031920191559, Microcode: 0x400001c, Oracle Linux Server release 7.6 (compatible with RHEL 7.6) on a 7.5 kernel using ksplice for security fixes, Kernel: 3.10.0-957.5.1.el7.crt1.x86_64. MPAS-A version 6.1, Workload: 120km_L56, compiled with AVX512, Intel® Parallel Studio XE 2018 Update 3 and Intel MPI 2018 Update 3, Relative performance=1.95, tested by Intel on 04/26/2019.

2S Intel® Xeon® Platinum 9242 Processor: 1-node Intel reference platform, 2x Intel® Xeon® 9242 processors (2.2GHz, 48C), 24x16GB DDR4-2933, HT on (1 thread/core), Turbo on, 1 SSD SATA, BIOS: SE5C620.86B.0D.01.0456.033120191654, Microcode: 0x4000021, Oracle Linux Server release 7.6 (compatible with RHEL 7.6) on a 7.5 kernel using ksplice for security fixes, Kernel: 3.10.0-957.5.1.el7.crt1.x86_64. MPAS-A version 6.1, Workload: 120km_L56, compiled with AVX512, Intel® Parallel Studio XE 2018 Update 3 and Intel MPI 2018 Update 3, Relative performance=4.07, tested by Intel on 04/26/2019.

Footnotes and configuration details

NEMO (higher is better):

2S Intel® Xeon® E5-2697 v3 Processor: 1-node Intel reference platform, 2x Intel® Xeon® E5-2697 v3 processor (2.6GHz, 14C), 8x16GB DDR4-2133, HT on (1 thread/core), Turbo on, 1 SSD SATA, BIOS: SE5C610.86B.01.01.0028.121720182203, Microcode: 0x3e, Oracle Linux Server release 7.6 (compatible with RHEL 7.6) on a 7.5 kernel using ksplice for security fixes, Kernel: 3.10.0-957.5.1.el7.crt1.x86_64. NEMO version 4.0, Workload: ORCA2_ICE_PISCES, compiled with AVX512, Intel® Parallel Studio XE 2018 Update 3 and Intel MPI 2018 Update 3, Relative performance=1.00, tested by Intel on 04/25/2019.

2S Intel® Xeon® E5-2697 v4 Processor: 1-node Intel reference platform, 2x Intel® Xeon® E5-2697 v4 processor (2.3GHz, 18C), 8x16GB DDR4-2400, HT on (1 thread/core), Turbo on, 1 SSD SATA, BIOS: SE5C610.86B.01.01.0028.121720182203, Microcode: 0xb000030, Oracle Linux Server release 7.6 (compatible with RHEL 7.6) on a 7.5 kernel using ksplice for security fixes, Kernel: 3.10.0-957.5.1.el7.crt1.x86_64. NEMO version 4.0, Workload: ORCA2_ICE_PISCES, compiled with AVX512, Intel® Parallel Studio XE 2018 Update 3 and Intel MPI 2018 Update 3, Relative performance=1.23, tested by Intel on 04/25/2019.

2S Intel® Xeon® Gold 6148 processor: 1-node Intel reference platform, 2x Intel® Xeon® Gold 6148 processor (2.4GHz, 20 cores per socket), 12*16GB DDR4-2666, HT on (1 thread/core), Turbo on, 1 SSD SATA, BIOS: SE5C620.86B.00.01.0016.020120190930, Microcode ver 0x2000050, Oracle Linux Server release 7.6 (compatible with RHEL 7.6) on a 7.5 kernel using ksplice for security fixes, Kernel: 3.10.0-957.5.1.el7.crt1.x86_64. NEMO version 4.0, Workload: ORCA2_ICE_PISCES, compiled with AVX512, Intel® Parallel Studio XE 2018 Update 3 and Intel MPI 2018 Update 3, Relative performance=1.74, tested by Intel on 04/25/2019.

2S Intel® Xeon® Platinum 8260 Processor: 1-node Intel reference platform, 2x Intel® Xeon® 8260 Intel processors (2.4GHz, 24C), 12x16GB DDR4-2933, HT on (1 thread/core), Turbo on, 1 SSD SATA, BIOS: SE5C620.86B.02.01.0008.031920191559, Microcode: 0x400001c, Oracle Linux Server release 7.6 (compatible with RHEL 7.6) on a 7.5 kernel using ksplice for security fixes, Kernel: 3.10.0-957.5.1.el7.crt1.x86_64. NEMO version 4.0, Workload: ORCA2_ICE_PISCES, compiled with AVX512, Intel® Parallel Studio XE 2018 Update 3 and Intel MPI 2018 Update 3, Relative performance=2.15, tested by Intel on 04/25/2019.

2S Intel® Xeon® Platinum 9242 Processor: 1-node Intel reference platform, 2x Intel® Xeon® 9242 processors (2.2GHz, 48C), 24x16GB DDR4-2933, HT on (1 thread/core), Turbo on 1, SSD SATA, BIOS: SE5C620.86B.0D.01.0456.033120191654, Microcode: 0x4000021, Oracle Linux Server release 7.6 (compatible with RHEL 7.6) on a 7.5 kernel using ksplice for security fixes, Kernel: 3.10.0-957.5.1.el7.crt1.x86_64. NEMO version 4.0, Workload: ORCA2_ICE_PISCES, compiled with AVX512, Intel® Parallel Studio XE 2018 Update 3 and Intel MPI 2018 Update 3, Relative performance=4.43, tested by Intel on 04/25/2019.

Footnotes and configuration details

HOMME (higher is better):

2S Intel® Xeon® E5-2697 v3 Processor: 1-node Intel reference platform, 2x Intel® Xeon® E5-2697 v3 processor (2.6GHz, 14C), 8x16GB DDR4-2133, HT on (1 thread/core), Turbo on, 1 SSD SATA, BIOS: SE5C610.86B.01.01.0028.121720182203, Microcode: 0x3e, Oracle Linux Server release 7.6 (compatible with RHEL 7.6) on a 7.5 kernel using ksplice for security fixes, Kernel: 3.10.0-957.5.1.el7.crt1.x86_64. HOMME version dungeon28ps://github.com/homme-dycore, WACCM benchmark, Intel Parallel Studio XE 2018 Update 3, Intel MPI 2018u3, Relative performance=1.00, tested by Intel on 04/29/2019.

2S Intel® Xeon® E5-2697 v4 Processor: 1-node Intel reference platform, 2x Intel® Xeon® E5-2697 v4 processor (2.3GHz, 18C), 8x16GB DDR4-2400, HT on (1 thread/core), Turbo on, 1 SSD SATA, BIOS: SE5C610.86B.01.01.0028.121720182203, Microcode: 0xb000030, Oracle Linux Server release 7.6 (compatible with RHEL 7.6) on a 7.5 kernel using ksplice for security fixes, Kernel: 3.10.0-957.5.1.el7.crt1.x86_64. HOMME version dungeon28ps://github.com/homme-dycore, WACCM benchmark, Intel Parallel Studio XE 2018 Update 3, Intel MPI 2018u3, Relative performance=1.12, tested by Intel on 04/29/2019.

2S Intel® Xeon® Gold 6148 processor: 1-node Intel reference platform, 2x Intel® Xeon® Gold 6148 processor (2.4GHz, 20 cores per socket), 12*16GB DDR4-2666, HT on (1 thread/core), Turbo on, 1 SSD SATA, BIOS: SE5C620.86B.00.01.0016.020120190930, Microcode ver 0x2000050, Oracle Linux Server release 7.6 (compatible with RHEL 7.6) on a 7.5 kernel using ksplice for security fixes, Kernel: 3.10.0-957.5.1.el7.crt1.x86_64. HOMME version dungeon28ps://github.com/homme-dycore, WACCM benchmark, Intel Parallel Studio XE 2018 Update 3, Intel MPI 2018u3, Relative performance=1.66, tested by Intel on 04/29/2019.

2S Intel® Xeon® Platinum 8260 Processor: 1-node Intel reference platform, 2x Intel® Xeon® 8260 Intel processors (2.4GHz, 24C), 12x16GB DDR4-2933, HT on (1 thread/core), Turbo on, 1 SSD SATA, BIOS: SE5C620.86B.02.01.0008.031920191559, Microcode: 0x400001c, Oracle Linux Server release 7.6 (compatible with RHEL 7.6) on a 7.5 kernel using ksplice for security fixes, Kernel: 3.10.0-957.5.1.el7.crt1.x86_64. HOMME version dungeon28ps://github.com/homme-dycore, WACCM benchmark, Intel Parallel Studio XE 2018 Update 3, Intel MPI 2018u3, Relative performance=1.94, tested by Intel on 04/29/2019.

2S Intel® Xeon® Platinum 9242 Processor: 1-node Intel reference platform, 2x Intel® Xeon® 9242 processors (2.2GHz, 48C), 24x16GB DDR4-2933, HT on (1 thread/core), Turbo on, 1 SSD SATA, BIOS: SE5C620.86B.0D.01.0456.033120191654, Microcode: 0x4000021, Oracle Linux Server release 7.6 (compatible with RHEL 7.6) on a 7.5 kernel using ksplice for security fixes, Kernel: 3.10.0-957.5.1.el7.crt1.x86_64. HOMME version dungeon28ps://github.com/homme-dycore, WACCM benchmark, Intel Parallel Studio XE 2018 Update 3, Intel MPI 2018u3, Relative performance=3.87, tested by Intel on 04/29/2019.

Footnotes and configuration details

STREAM Triad (higher is better):

2S Intel® Xeon® E5-2697 v3 Processor: 1-node Intel reference platform, 2x Intel® Xeon® E5-2697 v3 processor (2.6GHz, 14C), 8x16GB DDR4-2133, HT on (1 thread/core), Turbo on, 1 SSD SATA, BIOS: SE5C610.86B.01.01.0028.121720182203, Microcode: 0x3e, Oracle Linux Server release 7.6 (compatible with RHEL 7.6) on a 7.5 kernel using ksplice for security fixes, Kernel: 3.10.0-957.5.1.el7.crt1.x86_64. Benchmark software: STREAM , Compiler: Intel® Compiler IC19, Optimized libraries: AVX512, Relative performance=1.00, tested by Intel on 02/06/2019.

2S Intel® Xeon® E5-2697 v4 Processor: 1-node Intel reference platform, 2x Intel® Xeon® E5-2697 v4 processor (2.3GHz, 18C), 8x16GB DDR4-2400, HT on (1 thread/core), Turbo on, 1 SSD SATA, BIOS: SE5C610.86B.01.01.0028.121720182203, Microcode: 0xb000030, Oracle Linux Server release 7.6 (compatible with RHEL 7.6) on a 7.5 kernel using ksplice for security fixes, Kernel: 3.10.0-957.5.1.el7.crt1.x86_64. Benchmark software: STREAM , Compiler: Intel® Compiler IC19, Optimized libraries: AVX512, Relative performance=1.14, tested by Intel on 02/06/2019.

2S Intel® Xeon® Gold 6148 processor: 1-node Intel reference platform, 2x Intel® Xeon® Gold 6148 processor (2.4GHz, 20 cores per socket), 12*16GB DDR4-2666, HT on (1 thread/core), Turbo on, 1 SSD SATA, BIOS: SE5C620.86B.00.01.0016.020120190930, Microcode ver 0x2000050, Oracle Linux Server release 7.6 (compatible with RHEL 7.6) on a 7.5 kernel using ksplice for security fixes, Kernel: 3.10.0-957.5.1.el7.crt1.x86_64. Benchmark software: STREAM , Compiler: Intel® Compiler IC19, Optimized libraries: AVX512, Relative performance=1.71, tested by Intel on 02/06/2019.

2S Intel® Xeon® Platinum 8260 Processor: 1-node Intel reference platform, 2x Intel® Xeon® 8260 Intel processors (2.4GHz, 24C), 12x16GB DDR4-2933, HT on (1 thread/core), Turbo on, 1 SSD SATA, BIOS: SE5C620.86B.02.01.0008.031920191559, Microcode: 0x400001c, Oracle Linux Server release 7.6 (compatible with RHEL 7.6) on a 7.5 kernel using ksplice for security fixes, Kernel: 3.10.0-957.5.1.el7.crt1.x86_64. Benchmark software: STREAM , Compiler: Intel® Compiler IC19, Optimized libraries: AVX512, Relative performance=1.89, tested by Intel on 03/03/2019.

2S Intel® Xeon® Platinum 9242 Processor: 1-node Intel reference platform, 2x Intel® Xeon® 9242 processors (2.2GHz, 48C), 24x16GB DDR4-2933, 1 SSD SATA, BIOS: SE5C620.86B.0D.01.0456.033120191654, Microcode: 0x4000021, Oracle Linux Server release 7.6 (compatible with RHEL 7.6) on a 7.5 kernel using ksplice for security fixes, Kernel: 3.10.0-957.5.1.el7.crt1.x86_64. Benchmark software: STREAM , Compiler: Intel® Compiler IC19, Optimized libraries: AVX512, Relative performance=3.59, tested by Intel on 02/26/2019.

Footnotes and configuration details

HPL (higher is better):

2S Intel® Xeon® E5-2697 v3 Processor: 1-node Intel reference platform, 2x Intel® Xeon® E5-2697 v3 processor (2.6GHz, 14C), 8x16GB DDR4-2133, HT on (1 thread/core), Turbo on, 1 SSD SATA, BIOS: SE5C610.86B.01.01.0028.121720182203, Microcode: 0x3e, Oracle Linux Server release 7.6 (compatible with RHEL 7.6) on a 7.5 kernel using ksplice for security fixes, Kernel: 3.10.0-957.5.1.el7.crt1.x86_64. High Performance Linpack v2.1, compiled with Intel(R) Parallel Studio XE 2019 for Linux, Intel MPI and MKL Version 19.0.1.144, Relative performance=1.00, tested by Intel on 01/30/2019.

2S Intel® Xeon® E5-2697 v4 Processor: 1-node Intel reference platform, 2x Intel® Xeon® E5-2697 v4 processor (2.3GHz, 18C), 8x16GB DDR4-2400, HT on (1 thread/core), Turbo on, 1 SSD SATA, BIOS: SE5C610.86B.01.01.0028.121720182203, Microcode: 0xb000030, Oracle Linux Server release 7.6 (compatible with RHEL 7.6) on a 7.5 kernel using ksplice for security fixes, Kernel: 3.10.0-957.5.1.el7.crt1.x86_64. High Performance Linpack v2.1, compiled with Intel(R) Parallel Studio XE 2019 for Linux, Intel MPI and MKL Version 19.0.1.144, Relative performance=1.25, tested by Intel on 01/30/2019.

2S Intel® Xeon® Gold 6148 processor: 1-node Intel reference platform, 2x Intel® Xeon® Gold 6148 processor (2.4GHz, 20 cores per socket), 12*16GB DDR4-2666, HT on (1 thread/core), Turbo on, 1 SSD SATA, BIOS: SE5C620.86B.00.01.0016.020120190930, Microcode ver 0x2000050, Oracle Linux Server release 7.6 (compatible with RHEL 7.6) on a 7.5 kernel using ksplice for security fixes, Kernel: 3.10.0-957.5.1.el7.crt1.x86_64. High Performance Linpack v2.1, compiled with Intel(R) Parallel Studio XE 2018 for Linux, Intel MPI and MKL Version 19.0.1.144, Relative performance=2.37, tested by Intel on 02/06/2019.

2S Intel® Xeon® Platinum 8260 Processor: 1-node Intel reference platform, 2x Intel® Xeon® 8260 Intel processors (2.4GHz, 24C), 12x16GB DDR4-2933, HT on (1 thread/core), Turbo on, 1 SSD SATA, BIOS: SE5C620.86B.02.01.0008.031920191559, Microcode: 0x400001c, Oracle Linux Server release 7.6 (compatible with RHEL 7.6) on a 7.5 kernel using ksplice for security fixes, Kernel: 3.10.0-957.5.1.el7.crt1.x86_64. High Performance Linpack v2.1, compiled with Intel(R) Parallel Studio XE 2019 for Linux, Intel MPI and MKL Version 19.0.1.144, Relative performance=2.75, tested by Intel on 03/07/2019.

2S Intel® Xeon® Platinum 9242 Processor: 1-node Intel reference platform, 2x Intel® Xeon® 9242 processors (2.2GHz, 48C), 24x16GB DDR4-2933, HT on (1 thread/core), Turbo on, 1 SSD SATA, BIOS: SE5C620.86B.0D.01.0456.033120191654, Microcode: 0x4000021, Oracle Linux Server release 7.6 (compatible with RHEL 7.6) on a 7.5 kernel using ksplice for security fixes, Kernel: 3.10.0-957.5.1.el7.crt1.x86_64. High Performance Linpack v2.1, compiled with Intel(R) Parallel Studio XE 2019 for Linux, Intel MPI and MKL Version 19.0.1.144, Relative performance=5.52, tested by Intel on 03/05/2019.

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