OpenFOAM on Intel® Xeon® Scalable Processors

up to 51%
Higher OpenFOAM Performance
3rd Gen Intel® Xeon® Scalable Processor versus Prior Gen[1]

up to 34%
Competitive Advantage
2nd Gen Intel® Xeon® Platinum 9200 series versus AMD EPYC Milan Processor[2]

Addressing Computational Fluid-dynamics Challenges

Design engineers use computational fluid dynamics (CFD) software to simulate and analyze how products will perform as gas and liquid flow around them. These workloads involve complex, unstructured meshes with tens of millions of cells, and they demand high memory bandwidth for solvers to perform efficiently.

Intel's outstanding hardware, software, and ecosystem help manufacturers design better products faster and within budget. With increases in memory bandwidth, system memory, and instructions per clock (IPC), Intel® Xeon® Scalable processors deliver outstanding OpenFOAM performance compared to previous-generation processors.[1] For other applications, Intel® Xeon® Scalable processors can offer increased vectorization with AVX-512 and choice of core frequency with Intel® Speed Select Technology.

Key 3rd Generation Intel® Xeon® Scalable Processor Features

- 8 DDR4 memory channels, 3,200 MT/s
- Up to 20% higher instructions per clock versus prior generation[3]
- Built-in AI inference and training acceleration with Intel® Deep Learning Boost
- Built-in acceleration with Intel® AVX-512

Intel HPC Leadership

Intel's unmatched portfolio and broad ecosystem help users:

- Handle complex, diverse workloads and massive, sensitive datasets
- Achieve greater throughput with increased system utilization and availability
- Drive insight and discovery via accelerated computing

Built-in Acceleration

Only Intel® Xeon® processors support Intel® AVX-512 (512-bit register) instructions for **2x** the instructions completed per cycle versus Intel® AVX2 (256-bit register). While not directly related to OpenFOAM performance, this is a key differentiator on other key workloads.

Outstanding Performance

With eight DDR4 memory channels, up to 40 cores per socket, increased cache sizes, and up to **20%** increase in instructions per clock compared to the previous generation of processors,[3] 3rd Gen Intel® Xeon® Scalable processors deliver exceptional performance for a range of applications. The latest generation is configured to support up to 6 TB of system memory per processor with support for Intel® Optane™ persistent memory (PMem) 200 series. Built-in Intel® Speed Select Technology, plus a special SKU engineered for liquid cooled systems, provides unparalleled flexibility.

Unmatched Ecosystem

Intel has engaged for decades with a broad ecosystem of software engineers and organizations, ensuring that both open source and commercial applications perform better on Intel® architecture. As a result, users can reduce project timelines and reach insights faster—and developers can simplify their optimization efforts.

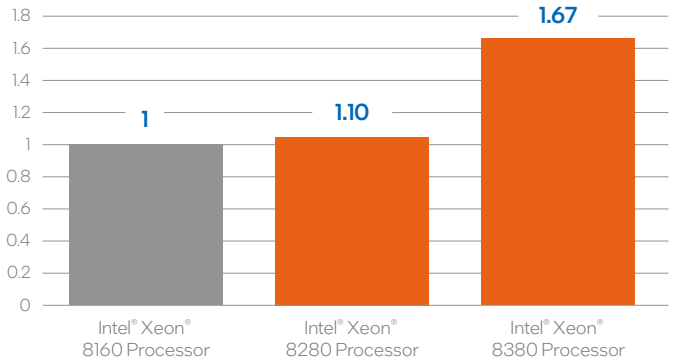
Choosing the Perfect Intel® Processor for OpenFOAM

OpenFOAM is distributed as open-source code by the OpenFOAM Foundation under the terms of the GNU General Public License. OpenFOAM is developed by multiple contributors led by Henry Weller, creator of OpenFOAM and Director of CFD Direct and The OpenFOAM Foundation. The current version can be downloaded at https://openfoam.org/download/. Downloads are available for Ubuntu Linux, other Linux distributions, and Windows or macOS versions of the software. Users can download and compile OpenFOAM from source code as well. In addition to the Foundation, there are several other companies writing for OpenFOAM.

OpenFOAM is highly memory bound, so memory bandwidth is a key consideration. Choosing a moderate core count and frequency SKU is ideal for product engineers running multiple types of workloads and applications on the same system as OpenFOAM. To reduce system footprint, some users choose lower core-count CPUs with higher frequencies. When performance is paramount, many users choose the higher core counts available with Intel® Xeon® Platinum 8300 processors or Intel® Xeon® Platinum AP processors, which also offer unapparelled memory bandwidth (12 channels, versus 8 channels from the closest competitor).

Figure 1. OpenFOAM Generational Results[7,8]

Comparative Ratio Versus Intel® Xeon® 8160 Processor[6]
Higher is better



Conclusion

Intel® architecture offers an outstanding combination of increased memory bandwidth and instructions per clock, in addition to software optimizations, resulting in optimized performance for OpenFOAM users. 3rd Gen Intel® Xeon® Scalable processors offer increased core counts over previous-generation processors, in addition to support for Intel® Optane™ PMem 200 series.

OpenFOAM is a very memory-bandwidth-sensitive code, and 3rd Gen Intel® Xeon® processors offer 33% more memory channels and 9% faster with DDR4 3,200 MT/S.[4] In addition, OpenFOAM is tuned by using Intel® tools to run on Intel® architecture and employ Intel® oneAPI math kernel library (MKL)—the fastest and most widely used math library for Intel-based systems—to simplify development and help ensure that new instruction-set[5] architectures (ISAs) just work.

Learn more

For more information about Intel® Xeon® Scalable processors for HPC, visit Intel.com/content/www/us/en/high-performance-computing/processors.html.

For details on Intel® software tools and libraries, visit intel.com/content/www/us/en/software/software-overview.html.

For more information about OpenFOAM, visit https://openfoam.org.

1. For workloads and configurations, see [108] at https://edc.intel.com/content/www/us/en/products/performance/benchmarks/3rd Results may vary.
2. Up to 34% Comparative advantage App name OpenFoam 4.2M cell motorbike test date 11/08/2021 AMD MILAN-7763 HPC (ww45'21)/OpenFOAM: App Version: v8; Data collected: 11/8/2021; Build notes: Tools: Intel® FORTRAN Compiler 2021.2, Intel® C Compiler 2021.2, Intel® MPI 2021.2; threads/core: 1; Turbo: used; Build knobs: -O3 -ip -march=core-avx2 Intel® Xeon® 9282 Processor (ww38'19)/OpenFOAM: App Version: v6.0; Data collected: 9/23/2019; Build notes: Intel® C/C++ Compiler 2019u3; Intel® MPI 2019u3; # threads/core = 1; BIOS Settings: HT=ON; Turbo=ON; SNC=Disabled AMD 7763 2S 64 cores Base freq 2.45 RAM 256GB, 16x16GB 3200MHz DDR4, SK Hynix HMA82GR7CJR8N-XN Hardrive 960GB Model: ATA Intel® SSDSC2KB96 (scsi) software BIOS Ver 2.1 Rev 5.22 BIOS settings HPC optimized BIOS settings: NPS4, Determinism Slider -Power, cTDP=280, PPL=280; HT=on TURBO=ON microcode0xa00111d OS CentOS Linux release 8.4.2105 Kernel 4.18.0-240.22.1.el8_3.crt2.x86_64 Intel® Xeon® 9282 Processor (ww38'19) 2S, 56cores CPU Base Frequency 2.6GHz. RAM 392 GB 24 x 16 GB 2933 DIMMs Micron 18ASF2G72PDZ-2G9E1 Hard Drive480 GB Micron_5100_MTFD Software BIOSSE5C620.86B.2X.01.0053 BIOS settings HT=On, Turbo=On, SNC=Disabled microcode 0x5000029 OSRHEL 7.7 Kernel 3.10.0-1062.1.1
3. Up to 20% IPC improvement: 3rd Gen Intel® Xeon® Scalable Processor: 1-node, 2x 28-core 3rd Gen Intel® Xeon® Scalable Processor, Intel® Reference Platform, 512GB (16 slots / 32GB / 3200) total DDR4 memory, HT on, ucode=x270, RHEL 8.0, Kernel Version4.18.0-80.el8.x86_64, test by Intel on 3/30/2021. 2nd Gen Intel® Xeon® Scalable Processor: 1-node, 2x 28-core 2nd Gen Intel® Xeon® Scalable Processor, Intel® Reference Platform, 384GB (12 slots / 32GB / 2933) total DDR4 memory, HT on, ucode=x2f00, RHEL 8.0, Kernel Version4.18.0-80.el8. x86_64, test by Intel on 3/30/2021. SPECrate2017_int_base (est). Tests at equal core frequency, equal uncore frequency, equal compiler.
4. 3rd Gen Intel® Xeon® Scalable Processors with Up to 8 channels DDR4 3200 MT/s vs 6 channels DDR4 2900MT/s on 2nd Gen Intel® Xeon® Scalable Processors.
5. #1 Math Library (fastest and most-used math library for Intel® processor-based systems) : See https://www.intel.com/content/www/us/en/developer/tools/oneapi/onemkl.html
6. Intel® Xeon® 8160 Processor (ww27,20) 2S, 48 cores CPU Base Frequency 4.2GHz, Max Frequency 7.4 GHz, RAM 192GB, 12x16GB 2666MHz DDR4, Micron 18ASF2G72PDZ, 2G6B1. BIOS SE5C620.86B.02.01.0008.031920191559. Operating System Base installation Oracle Linux Server 7.6, updated to, CentOS Linux 7.7.1908, (compatible with RHEL) Kernel 3.10.0-1127.13.1.el7.crt1.x86_64. Application / Workload Build Details Intel® SKX-8160 (ww27'20)/OpenFOAM: App Version: v7; Data collected: 7/20/2020; Build notes: Tools: Intel® FORTRAN Compiler 2019u5, Intel® C Compiler 2019u5, Intel® MPI 2019u7; threads/core: 1; Turbo: ON; Build knobs: -O3 -ip -xCORE-AVX512
7. 2nd Gen Intel® Xeon® 8280 Processor (ww27'20)/OpenFOAM: App Version: v7; Data collected: 7/20/2020; Build notes: Tools: Intel® FORTRAN Compiler 2019u5, Intel® C Compiler 2019u5, Intel® MPI 2019u7; threads/core: 1; Turbo: ON; Build knobs: -O3 -ip -xCORE-AVX512 2nd Gen Intel® Xeon® 8280 Processor; Config Date: 7/13/2020; Platform: ; CPU Details: ; # CPU Sockets: 2; # CPU Cores: 28; CPU Base Frequency: 2.7 GHz; CPU Max Frequency: 4.0 GHz; CPU Base TDP: 205 W; RAM: 192GB, 12x16GB 2933MHz DDR4, Hynix, HMA82GR7CJR8N WM; Hard Drive: 800GB ATA INTEL® SSDSC2BA80 (, scsi; Cluster File System: OPA based Lustre; BIOS: SE5C620.86B.02.01.0011.032620200659; BIOS Settings: HT=on TURBO=ON, SNC=disabled; Microcode: 0x500002c; Intel® Management: 04.01.04.339; BMC: 2.42; Security Vulnerabilities And Mitigations: itlb_multihit, : Processor vulnerable, l1tf: Not affected, mds, : Not affected, meltdown: Not affected, spec_store_bypass, : Mitigation: Speculative Store Bypass, disabled via prctl and seccomp, spectre_v1: Mitigation: Load fences,, usercopy swapgs, barriers and __user pointer sanitization, spectre_v2: Mitigation: Enhanced IBRS, IBPB, tsx_async_abort, : Mitigation: Clear CPU buffers; SMT, vulnerable; Operating System: Base installation Oracle Linux Server 7.6, updated, to CentOS Linux 7.7.1908, (compatible with RHEL; Kernel: 3.10.0-1127.13.1.el7.crt1.x86_64; OFED stack: OPA 10.10.2.0.44, Lustre 2.10.8, default; Ethernet Switch: Extreme Networks Black Diamond X8 core, Extreme, Networks X670 G2 48T top of rack; Fabric Switch: Intel® OPA Edge Switch 100 Series 48 Port; Host Bus Adapter: 100Gbps Intel® OPA 1 port, PCIe x16.
8. Intel® Xeon® Platinum 8380 Processor; Config Date: 12/5/2021; Platform: Coyote Pass; CPU Details: 2 CPUs per node; Stepping: 6; 40c @ 2.3Ghz; # CPU Sockets: 2; # CPU Cores: 40; CPU Base Frequency: 2.3 GHz; CPU Max Frequency: 3.4 GHz; CPU Base TDP: 270 W; RAM: 256GB 16*16GB 3200MT/s DDR4, Hynix HMA82GR7CJR8N-XN; Hard Drive: SSDSC2KG96 960GB; Cluster File System: HDR based Lustre; BIOS: SE5C6200.86B.0020.P23.2103261309; BIOS Settings: HT=on TURBO=ON; Microcode: 0xd000270; Intel® Management Engine: 04.04.04.053; BMC: 2.78; Security Vulnerabilities And Mitigations: itlb_multihit: Not affected; l1tf: Not affected; mds: Not affected; meltdown: Not affected; spec_store_bypass: Mitigation: Speculative Store Bypass disabled via prctl and seccomp; spectre_v1: Mitigation: usercopy/swapgsbarriers and __user pointer sanitization; spectre_v2: Mitigation: Enhanced IBRS, IBPB: conditional, RSB filling; srbds: Not affected; tsx_async_abort: Not affected; Operating System: CentOS Linux release 8.4.2105; Kernel: 4.18.0-240.22.1.el8_3.crt6.x86_64; OFED stack: Mellanox mlnx-5.1-2.5.8.0-default; Ethernet Switch: Extreme Networks Black Diamond X8 core, Extreme Networks X670-G2-48T top of rack; Fabric Switch: Mellanox MQM8790-HS2F HDR InfiniBand; Host Bus Adapter: 200Gbps Mellanox HDR MCX654105A-HCAT
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