Application Brief

Ansys® LS-DYNA® and Ansys® Mechanical®
4th Gen Intel® Xeon® Scalable Processors
Intel® Xeon® CPU Max Series

Optimizing Speed and Total Cost of Ownership for Ansys® LS-DYNA® and Ansys Mechanical™

Ansys workloads increase performance and cost efficiency from advances across compute, memory and I/O in 4th Gen Intel® Xeon® Scalable processors, with optimizations using Intel Software Development Tools. In-package high-bandwidth memory further accelerates memory-intensive workloads on the Intel Xeon CPU Max Series.

The most advanced high-performance computing (HPC) clusters in the world remain bound by economic and practical requirements to do more with less. The larger data sets that enable more sophisticated simulations require higher levels of computational resources. Completing simulations more quickly enables lower development cost and faster time to market for new products as well as the ability to run more iterations of those simulations for higher quality results.

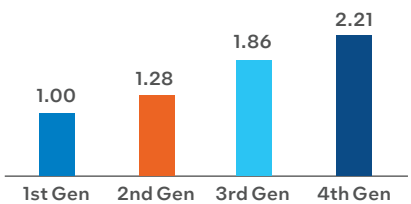
Ansys invests substantially in taking the best advantage possible of available hardware resources to deliver that performance. At the same time, HPC deployments as a whole must respond to cost considerations and environmental imperatives by maximizing performance per watt on the path to reducing energy consumption in the data center.

4th Gen Intel® Xeon® Scalable processors deliver relative performance improvements on Ansys® LS-DYNA® of up to 2.21x compared to the 1st Gen Intel Xeon Scalable processor from about five years earlier.[1] Likewise, the CPU provides up to 43% higher direct solver performance on Ansys Mechanical™, compared to its immediate predecessor.[2]

Intel hardware and software advantage with Ansys

Ongoing collaboration between Ansys and Intel over many years continues to push the envelope for optimizations that enable Ansys software to fully utilize the performance and energy potential of Intel platforms. In particular, Ansys uses Intel Software Development Tools and libraries to deliver out-of-the-box benefits from deploying software such as Ansys LS-DYNA and Ansys Mechanical on Intel architecture.

Gen-to-Gen LS-DYNA Relative Performance[1]
(Higher is Better)



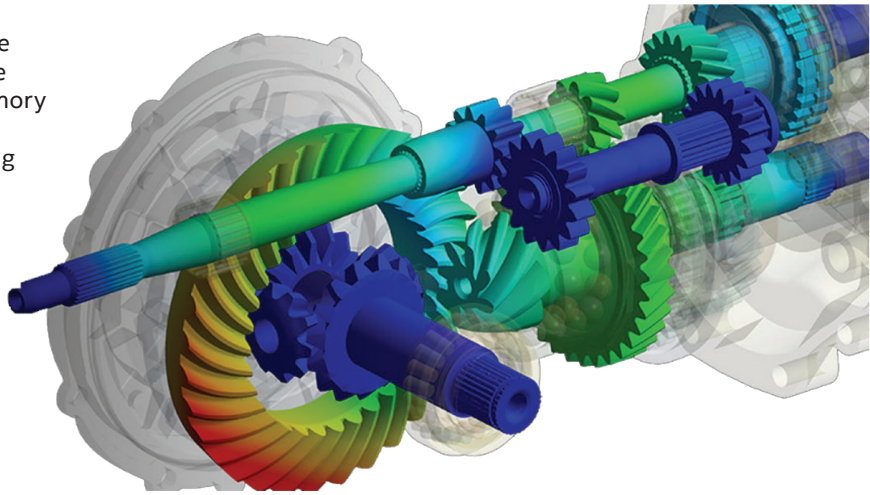
Intel® Xeon® Scalable Processors

Ansys Mechanical

UP TO
43%

Higher direct solver performance:[2]
4th Gen Intel Xeon Scalable processor vs predecessor platform

Optimized code helps capture the full performance and energy-efficiency benefits of 4th Gen Intel Xeon Scalable processors and the Intel Xeon CPU Max Series, which are delivered by balanced platforms across processing, memory and I/O resources. This application brief presents how those optimizations directly benefit end customers, using test results based on Ansys standard benchmarks. The combination of hardware and software building blocks substantially improves HPC simulation performance measured in terms of wall-clock time and the number of jobs that can be completed per day. Those speed-oriented metrics also correspond to completing a given simulation using fewer cluster resources, which reduces energy consumption, costs and carbon footprint.



Introducing Ansys LS-DYNA and Ansys Mechanical

Ansys LS-DYNA is explicit simulation software that is used to model the behavior of materials subjected to various types of load and physical stress. For example, the application is used in engineering tasks associated with simulating materials stresses, explosions, industrial processes or splashes. Phenomena studied may range from extremely short — milliseconds for a high-velocity impact — to sustained periods over months or years for wear and tolerance creep on industrial equipment.

Ansys Mechanical is finite element analysis (FEA) software that is used in structural engineering to model large assemblies, complex materials and mechanical systems that may exhibit both linear and nonlinear behavior. It incorporates a range of analysis tools and advanced solver options, including linear dynamics, nonlinearities, thermal analysis, materials, composites and hydrodynamics. Mechanical is built to be readily customizable, including with robust scripting capabilities for additional physics as well as automation of repetitive tasks.

Harnessing Intel processor breadth to drive up performance

Architects can tailor hardware to specific workload needs using the unmatched range of Intel platforms, including 4th Gen Intel Xeon Scalable processors and the Intel Xeon CPU Max Series, as shown in Figure 1. 4th Gen Intel Xeon Scalable processors provide optimized resources for all Ansys applications and particularly for compute-bound workloads. The Intel Xeon CPU Max Series provides high performance for memory-bandwidth-bound workloads, with 64 GB of in-package high-bandwidth memory (HBM). The two types of processors are socket-compatible, enabling systems to be tailored to individual implementations without code changes, in most deployments.

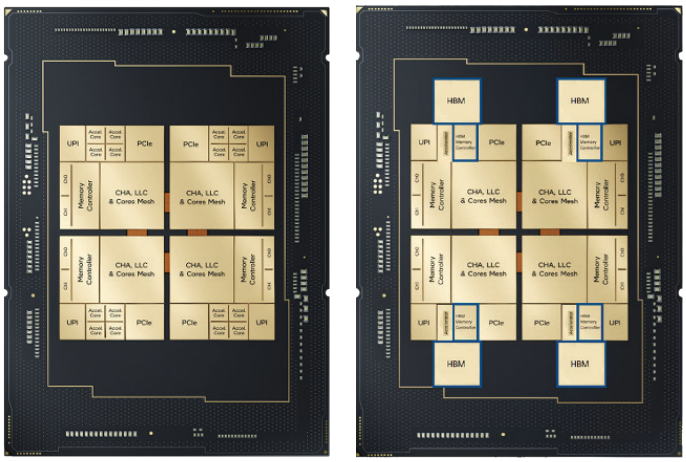


Figure 1. 4th Gen Intel® Xeon® Scalable processor and Intel Xeon CPU Max Series with High-Bandwidth Memory (HBM).

The performance of both LS-DYNA and Mechanical tend to be compute-bound, although performance may be bound by memory bandwidth and other reasons, including dataset size and the solver used. In addition, mixed workloads are common in production settings, where various software may run on the same hardware, either at the same time or separately. In particular, some of these workloads — such as those based on Ansys Fluent® or Ansys CFX — may be memory-bound.

4th Gen Intel Xeon Scalable processor

4th Gen Intel Xeon Scalable processors feature a new architecture that delivers significantly higher performance across workloads compared to the previous generation, with the industry's largest set of built-in hardware accelerators. The processors are available with a wide range of core counts and feature sets to match the needs of various implementations. With scalability up to 60 cores per socket and up to eight sockets per system, Intel Xeon Platinum 8400 processors provide breakthrough HPC cluster performance, including LS-DYNA and Mechanical workloads.

The extreme core count (XCC) SKUs within this processor generation each include 36-60 cores across four separate dies in a single package, which are interconnected using Intel's embedded multi-die interconnect bridge (EMIB) technology. Each of the dies has all the components of an independent multicore CPU, including integrated northbridge and interfaces for memory and I/O. The memory and I/O controlled by any die can be accessed transparently by resources on any of the other three dies through the EMIB bridges, helping reduce platform latency. The medium core count (MCC) SKUs each have 8-32 cores and use a monolithic (one-die) architecture to reduce that latency further.

To help ensure a balanced platform, the execution subsystem is complemented by advances in memory and I/O, as illustrated in Figure 2. The memory subsystem provides up to eight DDR5 channels per processor socket, operating at up to 4800 MT/s, for 1.5x the memory bandwidth and speed compared to the previous-generation platform. 4th Gen Intel Xeon Scalable processors I/O resources include up to 80 lanes of PCIe 5.0 per socket, with significant bandwidth increases compared to PCIe 4.0 and back-compatibility. The platform also supports Compute Express Link (CXL) 1.1 for high-speed fabric interconnect.

Intel Xeon Processors Max Series

The Intel Xeon CPU Max Series builds on a similar architecture to 4th Gen Intel Xeon Scalable processors, providing the only x86-based platform on the market with in-package HBM. That feature accelerates performance for memory-bound workloads, including many HPC applications, deep learning and analytics. Up to 56 cores per socket share 64 GB of HBM — more than 1 GB per core, which is enough memory to hold most common HPC workloads, complemented by up to 112.5 MB of shared last-level cache. Platform enhancements to help maximize the performance of the HBM subsystem include the following:

- Refactored hardware prefetching algorithms
- Enhanced uncore frequency scaling
- Direct-to-core response on all local memory requests
- Enhanced snoop filter for cross-socket coherency

Optimized Ansys software performance on Intel architecture

Ansys and Intel have collaborated for many years on code optimizations that deliver high throughput and efficiency. That joint enablement reaches new heights with LS-DYNA and Mechanical on the current generation of Intel Xeon processors, and the combination transparently delivers performance and efficiency benefits to joint customers.

The engineering relationship between Ansys and Intel extends to early enablement of LS-DYNA, Mechanical and other Ansys applications for each generation of Intel architecture. The two companies worked to ensure that the software can realize the full benefit of the hardware platforms.

Accelerating performance using Intel Software Development Tools

Co-engineering by Ansys and Intel improved performance by leveraging capabilities of Intel Software Development Tools, including the following:

- **Intel oneAPI Math Kernel Library (oneMKL)** is a set of enhanced math routines used extensively in scientific and technical computing. Core functions, including BLAS, LAPACK and sparse solvers, help Ansys software speed up algorithms and compute for high performance. Ansys Mechanical uses oneMKL routines within its own custom sparse solvers and ensures that the latest hardware and instruction set innovations are optimized in Ansys Mechanical. Intel MKL is leveraged in the Ansys Mechanical direct SP solver, ensuring that Xeon performance leverages the latest instruction set improvements.
- **Intel oneAPI DPC++/C++ Compiler** generates binaries highly optimized for Intel architecture, directly enabling unique hardware capabilities and acceleration into software products. Processor-specific optimizations, such as applying instruction sets supported in individual hardware platforms, help fine-tune results to keep the software up-to-date and relevant to new architectures. Ansys updates their development to the latest compilers on a regular basis. Each compiler transition is done with performance in mind, along with improved code quality and numerical precision.
- **Intel VTune™ Profiler** is a performance analysis tool that optimizes application and system performance as well as system configuration. It helps identify hotspots and hardware and memory issues and provides tuning guidance. Ansys code developers use Intel VTune Profiler to tune performance by drilling down on hotspots to improve code scalability and eliminate performance bottlenecks.

More instructions per clock with Intel AVX-512

Ansys software makes extensive use of Intel Advanced Vector Extensions 512 (Intel AVX-512) instructions to process more data per clock cycle. Intel AVX-512 instructions enable 32 double-precision and 64 single-precision floating point operations per clock cycle within 512-bit vectors, as well as eight 64-bit and sixteen 32-bit integers. Uniquely within the industry, Intel architecture implements two fused multiply-add (FMA) units per core. This innovation increases capacity for FMA operations, which combine addition and multiplication to reduce the number of steps in computations for higher throughput.

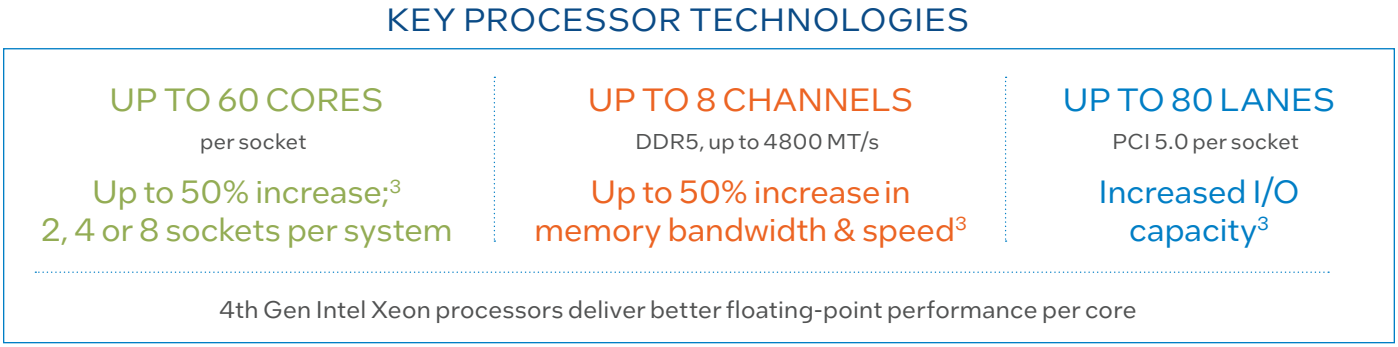


Figure 2. Processing, memory and I/O advances for a balanced hardware platform.

The future of AI-accelerated HPC

Intel and Ansys are involved in a long-term engineering collaboration to advance the state of the art in AI-accelerated HPC, including potential enablement of Ansys binaries for Intel AMX. This work explores the use of AI/machine learning for topology optimization in engineering design. It uses Parametric Surface Fitting Network (ParSeNet), a trainable deep network, to produce more robust and repeatable surface parametrizations than with purely geometric approaches. Another area of joint inquiry by Ansys and Intel is using Composable Machine Learning Simulator (CoMLSim), an HPC+AI solution, to potentially accelerate PDE solvers. This research shows how a vital ecosystem enables the next generation of HPC capability and performance, aided by AI.

Performance results on representative workloads

Testing by Intel confirms that 4th Gen Intel Xeon processors deliver significant performance advantages on Ansys software compared to both predecessor and competitor platforms.

Ansys LS-DYNA

Performance results for LS DYNA illustrate the performance benefits of 4th Gen Intel Xeon Scalable processors across multiple dimensions compared to predecessors and competitors. Figure 3 shows that the platform outperforms 1st Gen Intel Xeon Scalable processors by more than 2x on clusters up to eight nodes.

Figure 4 shows the benefit of vectorization enhancements from Streaming SIMD Extensions SSE2 to Intel Advanced Vector Extensions 2 (Intel AVX 2) to Intel AVX-512. In addition, it shows that the performance benefit of Intel AVX-512 relative to earlier vectorization instruction sets is more pronounced in the latest hardware platform. 4th Gen Intel Xeon Scalable processors provide a 1.32x speedup from Intel AVX-512 technology relative to SSE2 technology on the same hardware.

Ansys Mechanical

Performance testing for Ansys Mechanical, illustrated in Figure 5, shows a performance benefit of up to 43% from 4th Gen Intel Xeon Scalable processors compared to the predecessor platform. To varying degrees, speedup is seen across all of the direct solver workloads tested on 64 cores.

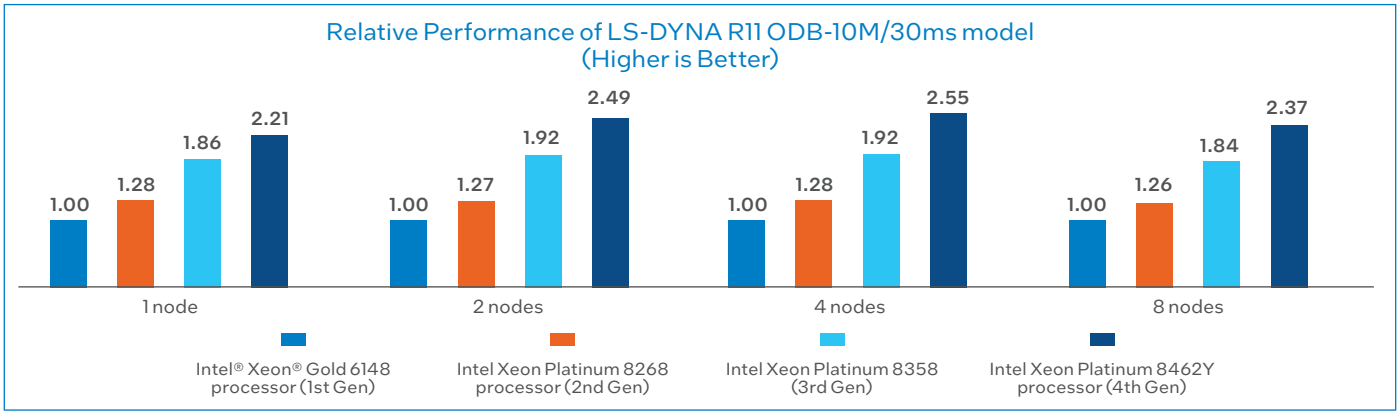


Figure 3. Ansys LS-DYNA performance on 4th Gen Intel® Xeon® Scalable processors versus predecessors and competing platforms.[1]

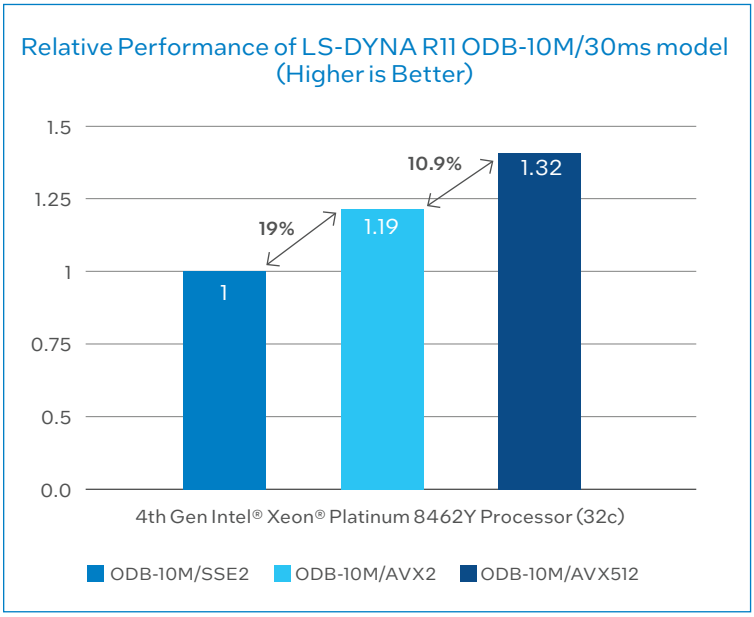


Figure 4. Benefits of enhanced vectorization on Ansys LS-DYNA performance.[1]

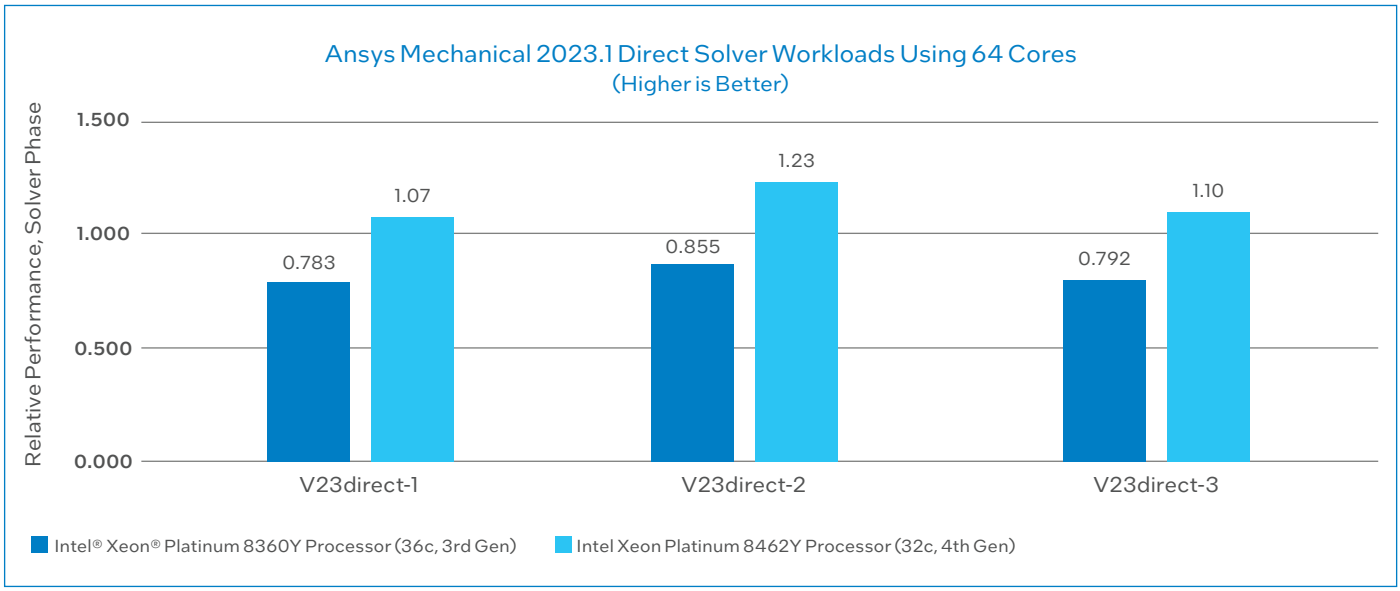


Figure 5. Ansys Mechanical performance on Intel® Xeon® processors versus competing platform.[2]

Conclusion

Co-engineering by Ansys and Intel delivers joint performance and value advantages to customers. Ansys LS-DYNA and Ansys Mechanical provide greater performance on 4th Gen Intel Xeon processors than predecessor and competitor platforms. In addition to these compute-bound workloads, the Intel Xeon CPU Max Series provides HBM within the processor package to further accelerate memory-bound and mixed workloads. Together, these platforms position HPC practitioners to meet the next generation of scientific and technical computing challenges.

Learn More:

Ansys® LS-DYNA®

Ansys® Mechanical™

4th Gen Intel® Xeon® Scalable processors

Intel® Xeon® CPU Max Series

Intel + Ansys Better Together

Solution provided by:

intel + Ansys

[1] **Ansys LS-Dyna Configurations**
Intel Xeon Gold 6148 processor: Test by Intel as of 05/08/23. Per node, 2x Intel Xeon Gold 6148 processors, Intel Hyper-Threading Technology enabled, Intel Turbo Boost Technology enabled, 192 GB DDR4-2666, BIOS SE5C620.86B.02.01.0008.031920191559, microcode 0x2000065, Rocky Linux 8.7, Kernel 4.18, LS-DYNA R11.

Intel Xeon Platinum 8268 processor: Test by Intel as of 05/08/23. Per node, 2x Intel Xeon 8268 processors, Intel Hyper-Threading Technology enabled, Intel Turbo Boost Technology enabled, 192 GB DDR4-2934, BIOS SE5C620.86B.02.01.0012.070720200218, microcode, 0x5002f01, Rocky Linux 8.7, Kernel 4.18, LS-DYNA R11.

Intel Xeon Platinum 8358 processor: Test by Intel as of 05/08/23. Per node, 2x Intel Xeon Platinum 8358 processors, Intel Hyper-Threading Technology enabled, Intel Turbo Boost Technology enabled, 256 GB DDR4-3200, BIOS SE5C6200.86B.0020.P23.2103261309, microcode, 0xd000270, Rocky Linux 8.7, Kernel 4.18, LS-DYNA R11.

Intel Xeon Platinum 8462Y processor: Test by Intel as of 05/05/23. Per node, 2x Intel Xeon Platinum 8462Y processors, Intel Hyper-Threading Technology enabled, Intel Turbo Boost Technology enabled, 1024 GB DDR5-4800, BIOS 1.1, microcode 0x2b000161, Red Hat Enterprise Linux 8.7, Kernel 4.18, LS-DYNA R11.

[2] **Ansys Mechanical Configurations**
Intel Xeon Platinum 8360Y processor: Test by Intel as of 05/08/23. 1-node, 2x Intel Xeon 8360Y processor, Intel Hyper-Threading Technology enabled, Intel Turbo Boost Technology enabled, 256GB DDR4-3200, BIOS SE5C620.86B.01.01.0003.2104260124, microcode, 0xd000280, Rocky Linux 8.7, Kernel 4.18, Ansys Mechanical 2022 R2.

Intel Xeon Platinum 8462Y processor: Test by Intel as of 05/05/23. 1-node, 2x Intel Xeon Platinum 8462Y processors, Intel Hyper-Threading Technology enabled, Intel Turbo Boost Technology enabled, 1024 GB DDR5-4800, BIOS 1.1, microcode 0x2b000161, Red Hat Enterprise Linux 8.7, Kernel 4.18, Ansys Mechanical 2022 R2.

[3] Compared to 2S 3rd Gen Intel Xeon Scalable processor.

Performance results are based on testing as of dates shown in configurations and may not reflect all publicly available updates. See configuration disclosure for configuration details.

No product or component can be absolutely secure.

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

Your costs and results may vary.

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

You may not use or facilitate the use of this document in connection with any infringement or other legal analysis concerning Intel products described herein. You agree to grant Intel a nonexclusive, royalty-free license to any patent claim thereafter drafted which includes subject matter disclosed herein.

The products described may contain design defects or errors known as errata which may cause the product to deviate from published specifications. Current characterized errata are available on request.

0723/JW/MESH/353913-001US