Application Brief

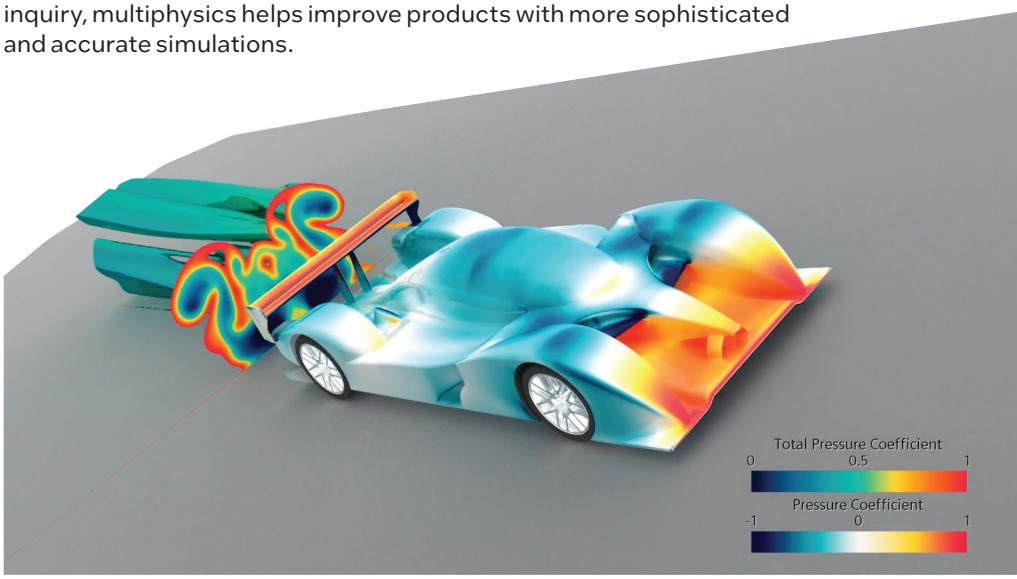
Simcenter™ STAR-CCM+™
Intel® Xeon® processors

Driving Up Performance and Scalability for Simulation and CFD

Simulations based on Siemens Simcenter™ STAR-CCM+™ software run faster and scale more efficiently on 5th Gen Intel® Xeon® processors than on predecessor CPUs. These advances help engineering-driven companies build better products and bring them to market faster, at lower cost.

The drive to out-innovate the competition often means out-engineering them. Iterative product improvement must be fast and well-informed, while minimizing time and cost requirements. Engineering simulation enables teams to predict the real-world effects of industrial-design changes, comparing multiple scenarios to guide product development. Using computer models to compare hypothetical outcomes can be far more efficient and comprehensive than physical experimentation, testing more scenarios under broader sets of operating conditions.

Making simulation models more comprehensive is central to driving up their value. Rather than considering systems in terms of isolated physics domains such as aerodynamics and heat transfer, a multiphysics approach improves fidelity with the real world by coupling those physical phenomena together. Multiphysics simulations reveal the interactions among physics domains, reducing the approximation needed to interpret results. Encompassing various fields of inquiry, multiphysics helps improve products with more sophisticated and accurate simulations.



Improved simulation and design pipelines with Simcenter STAR-CCM+

Simcenter STAR-CCM+ is a multiphysics software application used to simulate a comprehensive set of physical models, coupled together for holistic study. Physical models include computational fluid dynamics (CFD), electromagnetics, heat transfer and many others. This approach makes simulations more realistic and frees industrial engineering teams from having to implement, learn and connect multiple tools.

All aspects of multiphysics simulations are managed in a single integrated environment, using the Simcenter STAR-CCM+ user interface, with code-free automation to increase the efficiency of running complex simulations. Automated meshing and pre-processing help streamline simulation preparation, cut delivery time to market and let engineers focus on core design tasks. An easily accessible API enables interaction with other simulation tools to help preserve existing workflows.

This brief reports performance results based on Simcenter STAR-CCM+ version 2306/18.04.008_01, using various Intel processors as described below. It measures cell iterations per node and per second (higher is better), reported as the geomean of the following benchmarks, which are provided by Siemens:

- AeroSUV_Steady_Segregated_106M_V17_04_007_v2.sim
- civil.sim
- HlMach10AoA10Sou_AutoCFL_2000Iter_6M.sim
- LeMans_100M_Segregated_8.06.007.np_6144.sim
- lemans_poly_17m.amg.sim
- reactor.sim

Optimized performance and scaling with Intel® Xeon® processors

Intel Xeon processors offer a continuing roadmap of CPU innovation that helps drive successively better results on enterprise workloads in general and Simcenter STAR-CCM+ simulations specifically. While increased memory bandwidth is particularly valuable to Simcenter STAR-CCM+ performance, the software benefits from balanced roadmap improvements across the platform, in execution resources, memory and the I/O subsystem.

Simcenter STAR-CCM+ simulations communicate among parallel servers and virtual machines using Intel® Message Passing Interface (Intel® MPI), an enterprise-grade multi-fabric library based on the open source MPICH project. Recent collaboration between Intel and Google tuned and boosted Intel® Ethernet performance of the PSM3 and TCP providers provided by OpenFabrics Interfaces (OFI). That team identified Simcenter STAR-CCM+ as a test case to demonstrate the performance benefits of its Intel MPI optimization work. To quantify performance and scalability across different processors, the testing in this brief uses the following processors in its systems under test:

- **Intel® Xeon® Platinum 8480+ processor** (56 cores per socket @ 2.00 GHz, 105 MB cache) is a 4th Gen Xeon CPU with high per-core performance, eight channels of system memory and support up to DDR5-4800. The I/O subsystem includes up to 80 lanes of PCIe 5.0 and up to four Intel® Ultra Path Interconnect (Intel® UPI) links operating at 16 GT/s between processors.
- **Intel® Xeon® CPU Max 9480 processor** (56 cores per socket @ 1.90 GHz, 112.5 MB cache, 64 GB HBM2E) builds on the microarchitecture of the 4th Gen Intel Xeon CPUs with the addition of 64 GB of high-bandwidth in-package memory (HBM) per socket (128 GB in the two-processor system under test). This innovation targets memory-bandwidth-bound workloads, helping keep hot data available to execution resources with minimal latency. The Intel Xeon CPU Max Series provides flexible configuration of its HBM, with two modes that are tested separately for this brief:
  - **HBM-only mode** utilizes the processor's HBM — more than a gigabyte per core — as high-bandwidth system memory; in this mode, HBM is the only system memory in use by the CPU.
  - **Cache mode** implements the HBM as a high-speed processor cache, which can be advantageous in cases where data sets are too large to fit entirely in the HBM.
- **Intel® Xeon® Platinum 8592+ processor** (64 cores per socket @ 1.90 GHz, 320 MB cache) is a 5th Gen Intel Xeon CPU built on a common hardware platform with the other two processors in this study, with significant improvements. It provides a massive cache compared to predecessors, as well as support for DDR5-5600 memory, increased Intel UPI speed of 20 GT/s and improvements in the PCIe subsystem.

Relative performance and scaling-efficiency testing

To benchmark performance and scaling efficiency across multiple hardware configurations, Intel performance engineers compared multiple generations of Intel processors, the results of which are reported in Figures 1 and 2. For a complete picture of the benefits available from 5th Gen Intel Xeon processors, the comparison includes testing on various cluster sizes up to 16 nodes, including both HBM-only mode and Cache mode on the Intel Xeon CPU Max Series. Detailed results are listed in Appendix A, and the analytical processes to generate Figures 1 and 2 from those results are outlined in Appendix B.

As shown in Figure 1, the 5th Gen Xeon outperforms the 4th Gen at all cluster sizes, and the relative performance benefit grows with more nodes. Similarly, the relative performance of the 5th Gen Xeon compared to the Xeon CPU Max increases with the number of nodes and outperforms both HBM-only mode and Cache mode at larger cluster sizes. Note that from one to four nodes, HBM-only mode outperforms 5th Gen Xeon; because Simcenter STAR-CCM+ is memory-bandwidth-bound, the HBM bandwidth is sufficient to provide that higher performance.

As the node count increases, the large, high-speed memory supported by 5th Gen Xeon processors becomes more significant, outperforming HBM-only mode, which is limited to 64 GB per socket. The massive cache of the 5th Gen Xeon CPU enables it to outperform the Xeon CPU Max in Cache mode, even with one node, and that performance differential increases with larger clusters.

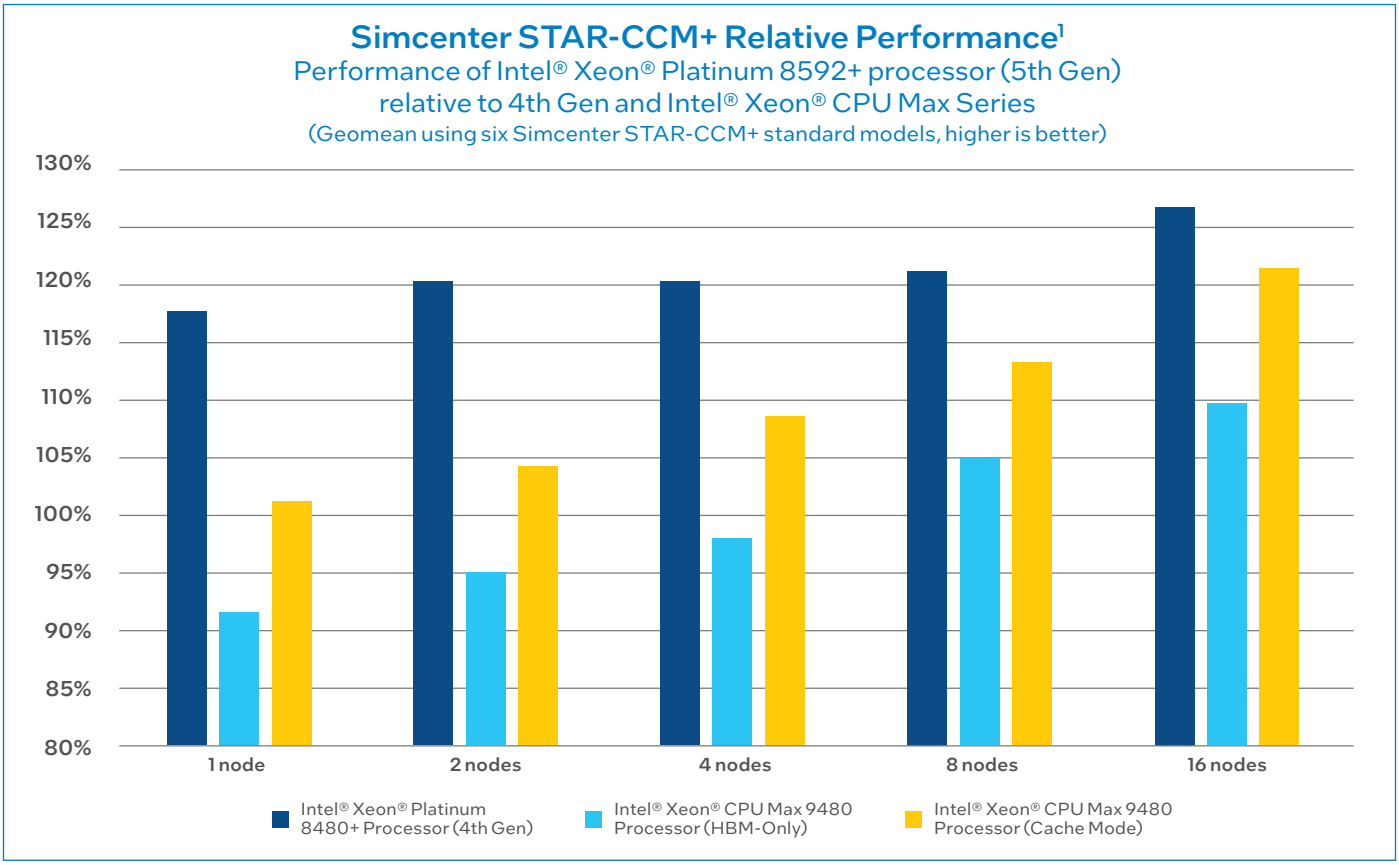


Figure 1. Relative Simcenter STAR-CCM+ performance across processor generations and cluster sizes.

5th Gen Intel Xeon processors scale better than the other systems under test, as shown in Figure 2. Here, the 5th Gen Xeon exhibits nearly linear scaling up to 16 nodes, primarily because of improvements in the PCIe subsystem and caching. Again, the 4th Gen and 5th Gen Xeon CPUs steadily gain performance relative to the Xeon CPU Max Series as node counts increase.

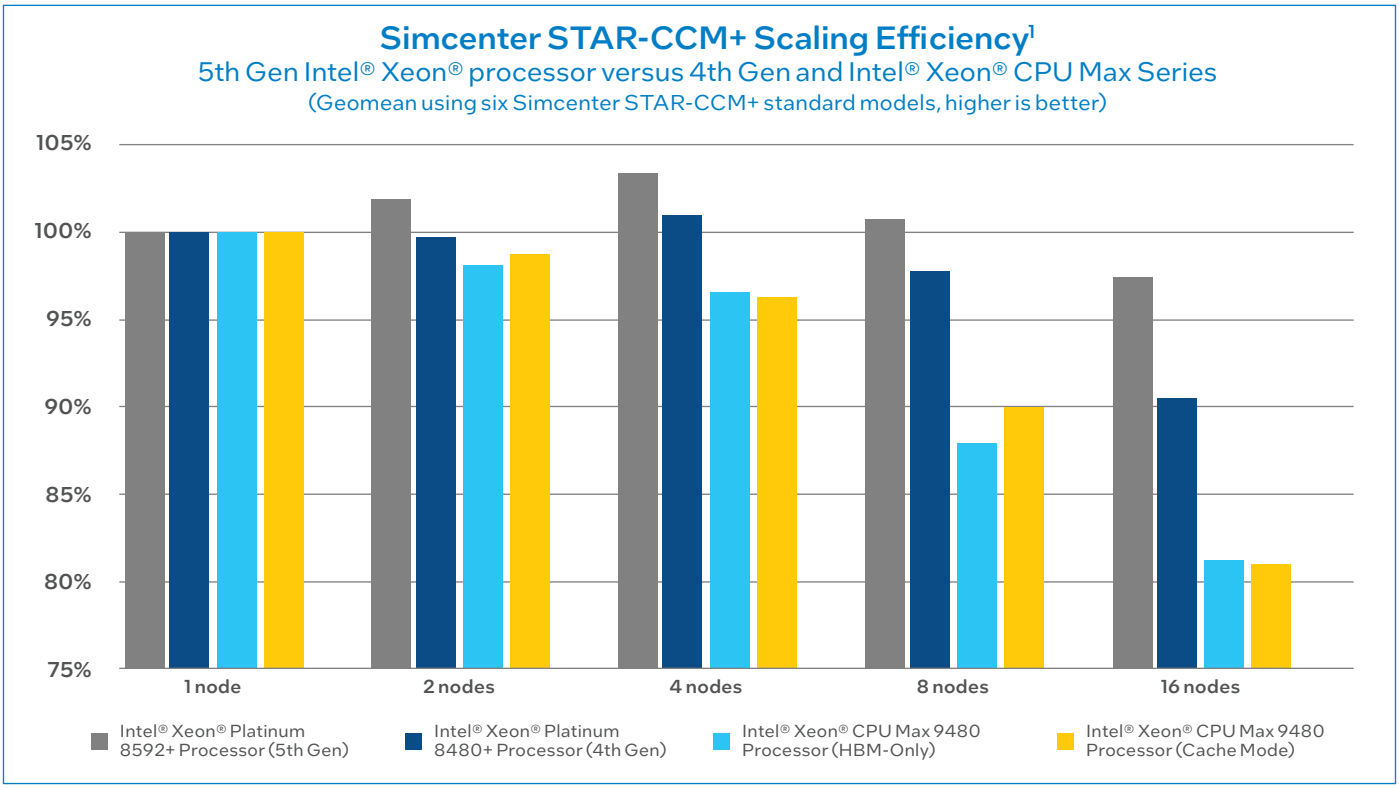


Figure 2. Relative Simcenter STAR-CCM+ scaling efficiency across processor generations and cluster sizes.

Conclusion

5th Gen Intel Xeon processors show marked benefits in Simcenter STAR-CCM+ performance and scaling efficiency over earlier processors, particularly with larger cluster sizes. The CPU's improvements in cache, PCIe and memory showcase Simcenter STAR-CCM+ multiphysics engineering simulation capabilities. The combination enables product teams to run more comprehensive simulations in less time, to help bring higher-quality products to market with faster time to revenue, helping build a lasting competitive advantage.

Learn More:

Simcenter™ STAR-CCM+™ CFD software
5th Gen Intel® Xeon® processors
Intel® Xeon® CPU Max Series

Appendix A: Detailed performance data

This appendix shows the detailed performance data for this application brief.

- **Simcenter STAR-CCM+ version:** 2306/18.04.008_01
- **Performance metrics:** cell iterations per node and second (higher is better)

Table A.1. Raw performance results: AeroSUV_Steady_Segregated_106M_V17_04_007_v2.sim

# nodes	Intel® Xeon® Platinum 8592+ Processor (5th Gen)	Intel® Xeon® Platinum 8480+ Processor (4th Gen)	Intel® Xeon® CPU Max 9480 Processor (HBM-Only)	Intel® Xeon® CPU Max 9480 Processor (Cache Mode)
1	22,138,500	18,984,340	24,178,117	21,004,132
2	22,508,788	19,208,835	26,071,071	23,590,529
4	22,363,616	19,147,917	24,932,969	22,734,667
8	22,151,249	18,287,619	20,033,607	21,147,272
16	21,915,919	17,288,923	20,690,266	18,985,827

Table A.2. Raw performance results: civil.sim

# nodes	Intel® Xeon® Platinum 8592+ Processor (5th Gen)	Intel® Xeon® Platinum 8480+ Processor (4th Gen)	Intel® Xeon® CPU Max 9480 Processor (HBM-Only)	Intel® Xeon® CPU Max 9480 Processor (Cache Mode)
1	12,002,004	10,045,370	13,792,131	12,287,640
2	12,049,406	9,862,358	13,472,576	11,899,103
4	12,121,955	10,220,703	13,622,113	12,055,637
8	11,981,377	9,899,333	12,363,237	11,045,867
16	11,277,414	9,230,156	10,953,536	9,799,751

Table A.3. Raw performance results: HlMach10AoA10Sou_AutoCFL_2000Iter_6M.sim

# nodes	Intel® Xeon® Platinum 8592+ Processor (5th Gen)	Intel® Xeon® Platinum 8480+ Processor (4th Gen)	Intel® Xeon® CPU Max 9480 Processor (HBM-Only)	Intel® Xeon® CPU Max 9480 Processor (Cache Mode)
1	5,828,400	5,060,012	6,531,409	5,871,945
2	5,899,112	5,021,470	6,377,029	5,683,294
4	6,190,587	5,094,925	6,318,772	5,498,996
8	5,972,927	4,802,212	5,746,725	4,833,873
16	5,744,412	4,471,937	5,397,903	4,704,671

Table A.4. Raw performance results: LeMans_100M_Segregated_8.06.007.np_6144.sim

# nodes	Intel® Xeon® Platinum 8592+ Processor (5th Gen)	Intel® Xeon® Platinum 8480+ Processor (4th Gen)	Intel® Xeon® CPU Max 9480 Processor (HBM-Only)	Intel® Xeon® CPU Max 9480 Processor (Cache Mode)
1	21,729,581	19,007,199	25,099,748	22,774,212
2	22,402,471	18,890,042	24,648,344	22,407,177
4	23,135,806	19,267,443	24,482,339	22,732,671
8	22,073,463	19,275,095	23,938,039	22,922,562
16	24,917,463	18,900,720	23,370,409	20,811,966

Table A.5. Raw performance results: lemans_poly_17m.amg.sim

# nodes	Intel® Xeon® Platinum 8592+ Processor (5th Gen)	Intel® Xeon® Platinum 8480+ Processor (4th Gen)	Intel® Xeon® CPU Max 9480 Processor (HBM-Only)	Intel® Xeon® CPU Max 9480 Processor (Cache Mode)
1	13,668,168	11,641,675	14,386,018	13,367,188
2	14,029,194	11,457,265	13,799,872	12,913,956
4	14,345,417	11,493,526	13,293,718	12,069,858
8	13,549,082	11,663,553	12,449,608	11,200,149
16	12,858,689	10,394,167	11,550,542	10,509,660

Table A.6. Raw performance results: reactor.sim

# nodes	Intel® Xeon® Platinum 8592+ Processor (5th Gen)	Intel® Xeon® Platinum 8480+ Processor (4th Gen)	Intel® Xeon® CPU Max 9480 Processor (HBM-Only)	Intel® Xeon® CPU Max 9480 Processor (Cache Mode)
1	14,616,678	11,778,339	14,419,028	13,514,720
2	14,907,483	11,935,866	13,321,379	12,508,849
4	14,655,166	12,112,228	13,189,473	12,004,774
8	14,801,369	11,220,538	12,367,491	11,443,678
16	12,647,709	9,831,053	9,887,263	9,275,522

Table A.7. Combined performance results: geometric mean performance for six benchmarks, across Tables A.1 - A.6

# nodes	Intel® Xeon® Platinum 8592+ Processor (5th Gen)	Intel® Xeon® Platinum 8480+ Processor (4th Gen)	Intel® Xeon® CPU Max 9480 Processor (HBM-Only)	Intel® Xeon® CPU Max 9480 Processor (Cache Mode)
1	13,738,108	11,661,518	14,988,832	13,566,702
2	13,989,630	11,616,628	14,714,313	13,394,278
4	14,189,677	11,781,672	14,478,703	13,061,051
8	13,836,590	11,398,322	13,181,746	12,212,381
16	13,386,114	10,549,295	12,180,030	11,004,466

Appendix B: Performance analysis

This appendix shows the analytical steps to generate the charts in this brief from the performance data given in Appendix A.

Analysis underlying Figure 1

Tables A.1 – A.6 show the raw performance figures for each of the six benchmark cases. Table A.7 shows the combined performance of the benchmark suite, based on the geomean of the six benchmarks for each processor at each node count. Table B.1 shows the geomean performance of the Intel Xeon Platinum 8592+ from Table A.7 relative to other processors. (That is, relative to the first performance column of Table A.7.) Table B.1 is visualized in Figure 1.

Table B.1. Geomean of Intel Xeon Platinum 8592+ processor performance relative to others, across all six benchmarks.

# nodes	Intel® Xeon® Platinum 8592+ processor (5th Gen)	Intel® Xeon® Platinum 8480+ Processor (4th Gen)	Intel® Xeon® CPU Max 9480 Processor (HBM-Only)	Intel® Xeon® CPU Max 9480 Processor (Cache Mode)
1	100%	118%	92%	101%
2	100%	120%	95%	104%
4	100%	120%	98%	109%
8	100%	121%	105%	113%
16	100%	127%	110%	122%

Analysis underlying Figure 2

To represent Simcenter STAR-CCM+ scaling efficiency as shown in Figure 2, results are expressed relative to single-node results. For example, from the combined geomean results in Table A.7, generate the relative results given in Table B.2. That is, Table B.2 shows the performance results relative to the first performance row from Table A.7.

Table B.2. Geomean of relative performance versus single-node results, across all six benchmarks.

# nodes	Intel® Xeon® Platinum 8592+ Processor (5th Gen)	Intel® Xeon® Platinum 8480+ Processor (4th Gen)	Intel® Xeon® CPU Max 9480 Processor (HBM-Only)	Intel® Xeon® CPU Max 9480 Processor (Cache Mode)
1	100%	100%	100%	100%
2	102%	100%	98%	99%
4	103%	101%	97%	96%
8	101%	98%	88%	90%
16	97%	90%	81%	81%

[1] 8480: Test by Intel as of 2023-08-17. 1-node, 2x Intel® Xeon® Platinum 8480+ processors (Family 6 Model 143 Stepping 6), 112 cores, HT On, Turbo On, NUMA configuration SNC4, Total Memory 512 GB (16x32GB 4800MT/s, Dual-Rank), BIOS SE5C7411.86B.9525.D26.2305160804, Microcode 0x2b0001b0; Rocky Linux release 8.8 (Green Obsidian), kernel: 4.18.0-477.21.1.el8_8.x86_64; Mellanox OFED 23.07-0.5.0.0, single rail Mellanox HDR200.

9480 HBM only: Test by Intel as of 2023-09-11. 1-node, 2x Intel® Xeon® CPU Max 9480 processors (Family 6 Model 143 Stepping 6), 112 cores, HT On, Turbo On, NUMA configuration SNC4, Total Memory 128 GB (HBM2e at 3200 MHz), BIOS SE5C7411.86B.9525.D26.2305160804, Microcode 0x2c0001d1; Rocky Linux release 8.8 (Green Obsidian), kernel: 4.18.0-477.21.1.el8_8.x86_64; Mellanox OFED 23.07-0.5.0.0, single rail Mellanox HDR200.

SPR HBM cache mode: Test by Intel as of 2023-08-17. 1-node, 2x Intel® Xeon® CPU Max 9480 processors (Family 6 Model 143 Stepping 6), 112 cores, HT On, Turbo On, NUMA configuration SNC4, Total Memory 5280834 MB, Micron MTC20F2085S1RC48BA1 DDR5 @ 4800 GT/s; BIOS SE5C7411.86B.9525.D26.2305160804, Microcode 0x2c0001d1; Rocky Linux release 8.8 (Green Obsidian), kernel: 4.18.0-477.21.1.el8_8.x86_64; Mellanox OFED 23.07-0.5.0.0, single rail Mellanox HDR200.

8592+: Test by Intel as of 2023-12-03 1-node, 2x Intel® Xeon® Platinum 8592+ processors (Family 6 Model 207 Stepping 2), 128 cores, HT On, Turbo On, NUMA configuration SNC2, Total Memory 512 GB (16x32GB 5600MT/s, Dual-Rank), BIOS SE5C7411.86B.9533.D01.2310110651, Microcode 0x21000170; SUSE Linux Enterprise Server 15 SP4, kernel: 5.14.21-150400.24.97-default, single rail Mellanox HDR200.

Performance varies by use, configuration and other factors. Learn more at https://www.intel.com/PerformanceIndex.

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

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