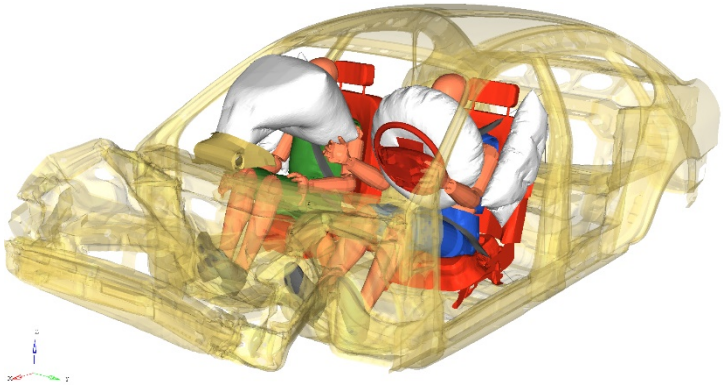
FINITE ELEMENT ANALYSIS

Altair Radioss™ Performance with AMD EPYC™ 7003 Series Processors

MARCH 2021

AMD EPYC™ 7003 Processors

Built on the x86 architecture innovations of the record setting EPYC 7002 processors[1], AMD EPYC™ 7003 Series Processors are the new standard for the modern data center. With high frequencies, high core counts, high memory bandwidth and capacity, and up to 32MB of L3 cache per core, AMD EPYC 7003 processors enable exceptional HPC performance across multiple industry verticals.



Balance is critical when driving HPC performance. 3rd Gen EPYC CPUs achieve that balance by pushing performance in several areas. Along with the high memory bandwidth achieved with 8 channels DDR4-3200 memory, EPYC 7003 CPUs also synchronize the data fabric clock to match the memory clock speeds, further improving both memory bandwidth and latency. And support for up to 4TB of memory per socket enhances the ability to efficiently utilize very large datasets.

Data access is further enhanced with extra-large caches, reaching up to 256MB per CPU. All of this helps enable the ability to efficiently utilize up to 64 cores per CPU. 128-160 lanes of PCIe® Gen4 offered by EPYC 7003 Series CPUs pushes the ability to efficiently access high-speed network interface cards, high-speed storage, and multiple accelerators.

EPYC 7003 Series processors raise the bar once more for workload performance, helping to drive faster time to results, and to provide more and better data for delivering better decisions and better outcomes. Time is the new metric for efficiency.

AMD EPYC 7003 FOR HPC

3rd Generation EPYC Processors help HPC workloads scale across on-premise clusters and bring HPC-level performance to the cloud for time-sensitive projects.

Check with your cloud provider about their AMD EPYC CPU-based cloud instances and ask them about helping to secure your workload in the cloud with encrypted memory.

"ZEN 3" CORE & SECURITY

Support for up to:

- 64 physical cores, 128 threads
- 256MB of L3 cache per CPU
- 32 MB of L3 cache per core
- 4 TB of DDR4-3200 memory
- 128-160 PCIe® Gen 4 lanes

Infinity Guard security[2]

- Secure Boot
- Encrypted memory with SEV-SME

SCALE OUT AND SCALE UP

Scaling is critical to HPC applications. AMD EPYC 7003 processors provide high bandwidth between nodes with support for PCIe Gen 4 enabled network devices and accelerators.

Within a node, take advantage of up to 64 cores, 8 memory channels of DDR4-3200, and up to 256 MB of L3 cache – per-CPU.

Altair Radioss

Altair Radioss benchmarks provide hardware performance data measured using sets of benchmark problems selected to represent typical usage.

EPYC 7003 Series Architecture Quick Look

The AMD EPYC 7003 Series Processor retains the proven Multi-Chip Module (MCM) Chiplet Architecture of prior successful AMD EPYC server-class processors while making further improvements. One of the most important upgrades is the new "Zen 3" core. The "Zen 3" core is manufactured using a 7nm process and designed to provide a significant performance improvement over prior generation "Zen 2" cores. Similar to EPYC 7002 Series processors, each core supports Simultaneous Multi-Threading (SMT), allowing up to 2 threads per core. In a typical 2-socket system with 64-core processors, EPYC 7003 Series processors offer up to 128 physical cores per 2-socket system and up to 256 threads per system.

The L3 cache was also improved in the Gen 3 EPYC processors. EPYC 7003 Series CPUs took the same total L3 cache as the prior generation (up to 256MB/CPU) and created significantly more cache sharing between cores. The EPYC Gen 3 processors now offer a unified 32MB of L3 cache per compute die. Up to 8 cores per compute die can now share 32MB of unified L3 cache with this generation of processors.

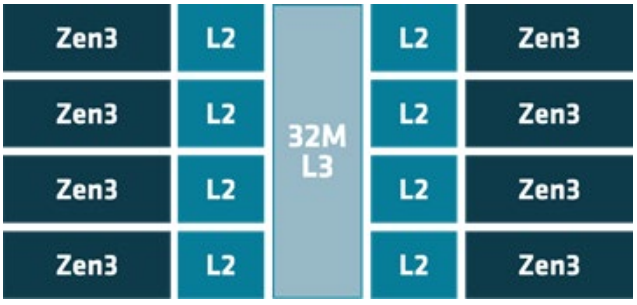


Figure 1 AMD EPYC 7003 Processor L3 Cache layout

The new L3 Cache design can increase the cache hit to miss ratio over the previous design. Improved cache sharing also allows larger blocks to fit directly into the cache whereas previously it would fall into the main memory. Improvements made in the cache fetching and eviction policies manage data more efficiently. All these benefits result in an uplift on HPC workloads in addition to the core and memory improvements.

EPYC 7003 Series CPU Options and Recommendations by Segment

AMD EPYC 7003 Series CPUs offer 19 different CPU configurations. Below is a table of each CPU with a summary of their features. For driving up per-core performance, pay special attention the 7xF3 series of processors, which offer the highest cache and frequencies at their respective core-counts of the 7003 series processors.

Model	# CCDs	Cores / Threads	Base Freq (GHz)	Max Boost [3]Freq (Up to GHz)	Default TDP (W)	cTDP (W)	L3 Cache (MB)	NPS	2P/1P
7763	8	64 / 128	2.45	3.50	280W	225-280W	256	1,2,4	2P/1P
7713	8	64 / 128	2.00	3.675	225W	225-240W	256	1,2,4	2P/1P
7713P								1,2,4	1P
7663	8	56 / 112	2.0	3.5	240W	225-240W	256	1,2,4	2P/1P
7643	8	48 / 96	2.3	3.6	225W	225-240W	256	1,2,4	2P/1P
75F3	8	32 / 64	2.95	4.0	280W	225-280W	256	1,2,4	2P/1P
7543	8	32 / 64	2.8	3.7	225W	225-240W	256	1,2,4	2P/1P
7543P								1,2,4	1P
7513	4	32 / 64	2.6	3.65	200W	165-200W	128	1,2,4	2P/1P
74F3	8	24 / 48	3.2	4.0	240W	225-240W	256	1,2,4	2P/1P
7453	4	28 / 56	2.75	3.45	225W	225-240W	64	1,2,4	2P/1P
7443	4	24 / 48	2.85	4.0	200W	165-200W	128	1,2,4	2P/1P
7443P								1,2,4	1P
7413	4	24 / 48	2.65	3.6	180W	165-200W	128	1,2,4	2P/1P
73F3	8	16/ 32	3.5	4.0	240W	225-240W	256	1,2,4	2P/1P
7343	4	16 / 32	3.2	3.9	190W	165-200W	128	1,2,4	2P/1P
7313	4	16 / 32	3.0	3.7	155W	155-180W	128	1,2,4	2P/1P
7313P								1,2,4	1P
72F3	8	8 / 16	3.7	4.1	180W	165-200W	256	1,2,4	2P/1P

Table 1 AMD EPYC 7003 SKU Options

HPC applications come in a wide range of unique characteristics. There is no one-size fits all CPU for the HPC market. The recommendations below are general and you are encouraged to talk to your AMD sales representative for more detailed guidance and CPU suggestions based on your unique environment and needs.

Listed in the table below are a few examples of different HPC market segments, a general sense of the characteristics and sensitivities of applications per segment, and specific AMD EPYC 7003 Series processor recommendations per segment.

Segment	Sensitivity	Example Applications	Recommended Models	Comments
FEA Explicit	Frequency & Cache	LS-DYNA, Radioss, Abaqus, VPS	75F3 | 7543 74F3 | 73F3	Look for CPUs with high frequencies, and large caches. Mid core-counts help increase performance per core to help maximize software investment.
FEA Implicit		Mechanical, Abaqus Standard, OptiStruct		
Molecular Dynamics	Core Count & Frequency	GROMACS, LAMMPS	7763 | 7713 7663 | 7643 75F3 | 7543	Look for CPUs with high core-counts and frequency. These applications scale very well with cores.
Weather	Memory BW & Cache	WRF, IFS	7763 | 7713 7663 | 7643 75F3 | 7543 74F3	Look for CPUs with 256 MB of cache. Large caches help relieve the potential memory bandwidth bottleneck if using high core counts. Look for mid core-count CPUs for per-core licensed codes.
CFD		Fluent, AcuSolve		
Oil & Gas		Reveal, Echos, SAVA		
EDA	Frequency & Cache	VCS, RedHawk	73F3 | 72F3	This market segment is dominated by low core-counts to drive up the frequency and cache per core, helping maximize software investment.

Table 2 Segment Examples

Altair Radioss

Altair Radioss is a leading structural analysis solver for highly non-linear problems under dynamic loadings. Radioss has established itself as a leader and an industry standard for automotive crash, drop and impact analysis, terminal ballistics, blast and explosion effects, and high velocity impacts. With a sophisticated customer base that values performance, reliability, safety, and innovation, the Radioss team is committed to supporting the most up-to-date, advanced computing architectures and integrating new technologies to improve performance, scalability, and usability. Radioss leads the industry in unlocking state-of-the-art computing hardware's potential for powering complex simulation software applications and environments. AMD and Altair have an ongoing technological partnership and AMD EPYC is fully supported on Radioss.

Test Methodology

This document focuses on performance and scaling of the EPYC 7003 Series Processors as well as competitiveness with Intel Xeon Gold 6258R processor.

Testing was performed on dual-socket EPYC™ 74F3, EPYC™ 7543, and EPYC™ 75F3-based systems. The compute nodes were each populated with 1 DIMM per channel of 64-GB, dual-rank, DDR4-3200 DIMMs from Micron®, for a total of 1TB of memory per node. A Mellanox® ConnectX-6 200 Gb/s HDR InfiniBand adapter, utilizing EPYC processors' support for PCIe Gen 4, is also populated on each EPYC processor-based system.

Testing was also run on dual-socket Intel® Xeon® Gold 6258R-based platforms. The 6258R was selected because it offers the highest frequency of the highest core-count (28c) in the Intel Xeon Gold family of processors. The Intel platforms were populated with 1 DIMM per channel of 64-GB, dual-rank, DDR4-2933 DIMMS (768GB total memory), matching the maximum memory speed supported for this processor.

Radioss uses a standard set of automotive crash simulation models to measure performance. These models are specifically created to reflect real-world workloads to give a standard basis of comparison across various computer systems and architectures. The single node tests in this document are using the neon and T10M models. Scalability tests were conducted with the T10M model.

Every benchmark was run a minimum of 3 iterations, with the average of the performance results used in this brief. Results of each benchmark were also confirmed to have <1% variability between all runs.

System Configuration

AMD System Configuration			
CPUs	2 x AMD EPYC 74F3	2 x AMD EPYC 7543	2 x AMD EPYC 75F3
Frequency: Base | Boost[3]	3.2 GHz | 4 GHz (up to)	2.8 GHz | 3.7 GHz (up to)	2.95 GHz | 4 GHz (up to)
Cores	24 cores/socket (48c/node)	32 cores/socket (64c/node)	
L3 Cache	256 MB		
Memory	1TB (16x) Dual-Rank DDR4-3200 64GB DIMMs, 1DPC		
NIC	Mellanox ConnectX-6 HDR 200Gb InfiniBand x16 (OFED-4.5-1.0.1)		
Storage: OS | Data	1 x 256 GB SATA | 1 x 1 TB NVMe		
BIOS and Settings	SMT=off, X2APIC=on, IOMMU=off, APBDIS=1, Fixed SOC P-state=0, Determinism=power, NPS=4,DF C-states=off, PIO,EPIO, TSME=off, PCIe 10 bit tag=on		
OS Settings	clear caches before every run, NUMA balancing 0, randomize_va_space 0, cc6 disabled, Governor=Performance		

Table 3 AMD System Configuration

Intel System Configuration	
CPUs	2 x Intel Xeon Gold 6258R
Frequency: Base | Turbo	2.7 GHz | 4.0 GHz
Cores	28 cores per socket (56 per node)
L3 Cache	38.5 MB
Memory	768 GB (12x) Dual-Rank DDR4-2933 64GB DIMMs, 1DPC
NIC	Mellanox ConnectX-6 HDR 200Gb InfiniBand x16 (OFED-4.5-1.0.1)
Storage: OS | Data	1 x 256 GB SATA | 1 x 1 TB NVMe
BIOS and Settings	3.3a: Power Management=Extreme Performance, Hyper-threading=Off, SNC=On, ADDDC=Off
OS Settings	clear caches before every run, NUMA balancing 0, randomize_va_space 0

Table 4 Intel System Configuration

Software	
Solver Version	Altair Radioss 2021
MPI	Intel MPI 2019
OS	RHEL 8.3

Table 5 Software

Altair Radioss Single-Node Performance

Single-node performance testing was performed on AMD EPYC 74F3, AMD EPYC 7543, and AMD EPYC 75F3 based systems and Intel Xeon Gold 6258R based systems.

Radioss performance is affected by many aspects of the CPU. Radioss specifically scales very well with frequency, cores, memory bandwidth, and cache size. The chart below shows the Gen 3 AMD EPYC processors performing exceptionally well in comparison with the Intel Xeon Gold 6258R processors.

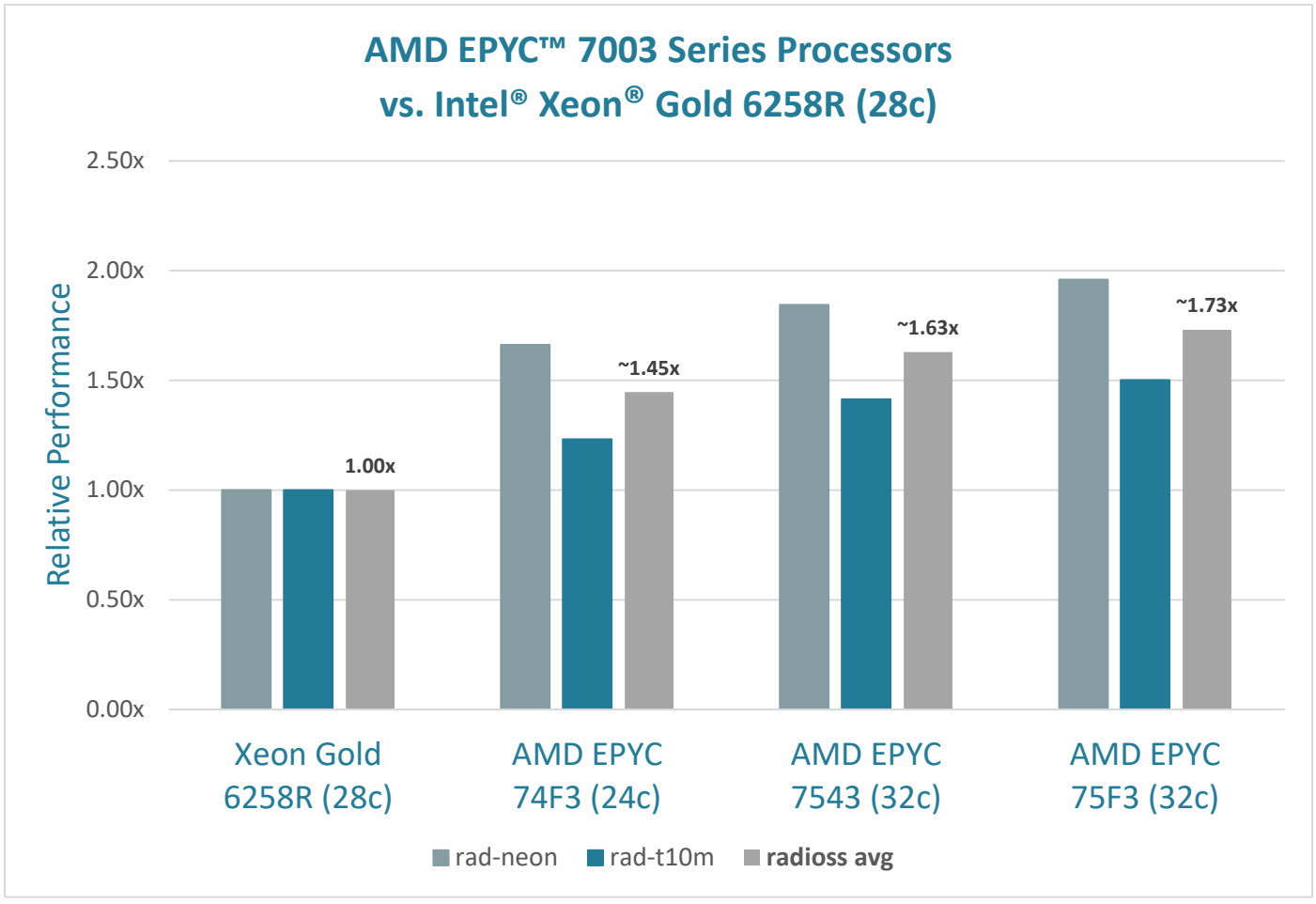


Figure 2 Altair Radioss Single Node Performance

All AMD EPYC processors that were tested outperformed the Intel Xeon Gold 6258R baseline in all benchmarks. A balance of high core and high base frequency yields best results:

- The most performant processor tested is the 32-core AMD EPYC 75F3, with a base frequency of 2.95GHz; it outperforms the Intel baseline system in all benchmarks by an average uplift of around 1.73x.
- The 24-core AMD EPYC 74F3, with a higher base frequency of 3.2GHz, has an average uplift of around 1.45x.

Altair Radioss Performance Per Core

Understanding workload performance at the core level allows one to have a better handle on the potential TCO of a hardware purchase:

- *Lower License Costs*: Many software vendors consider core count when computing licensing costs. Understanding how performance relates to core counts helps to correctly size how many license instances to buy.
- *Precise Installation Sizing*: Core-level performance makes it easier to fine-tune decision-making when "sizing" the application footprint of your hardware purchase.

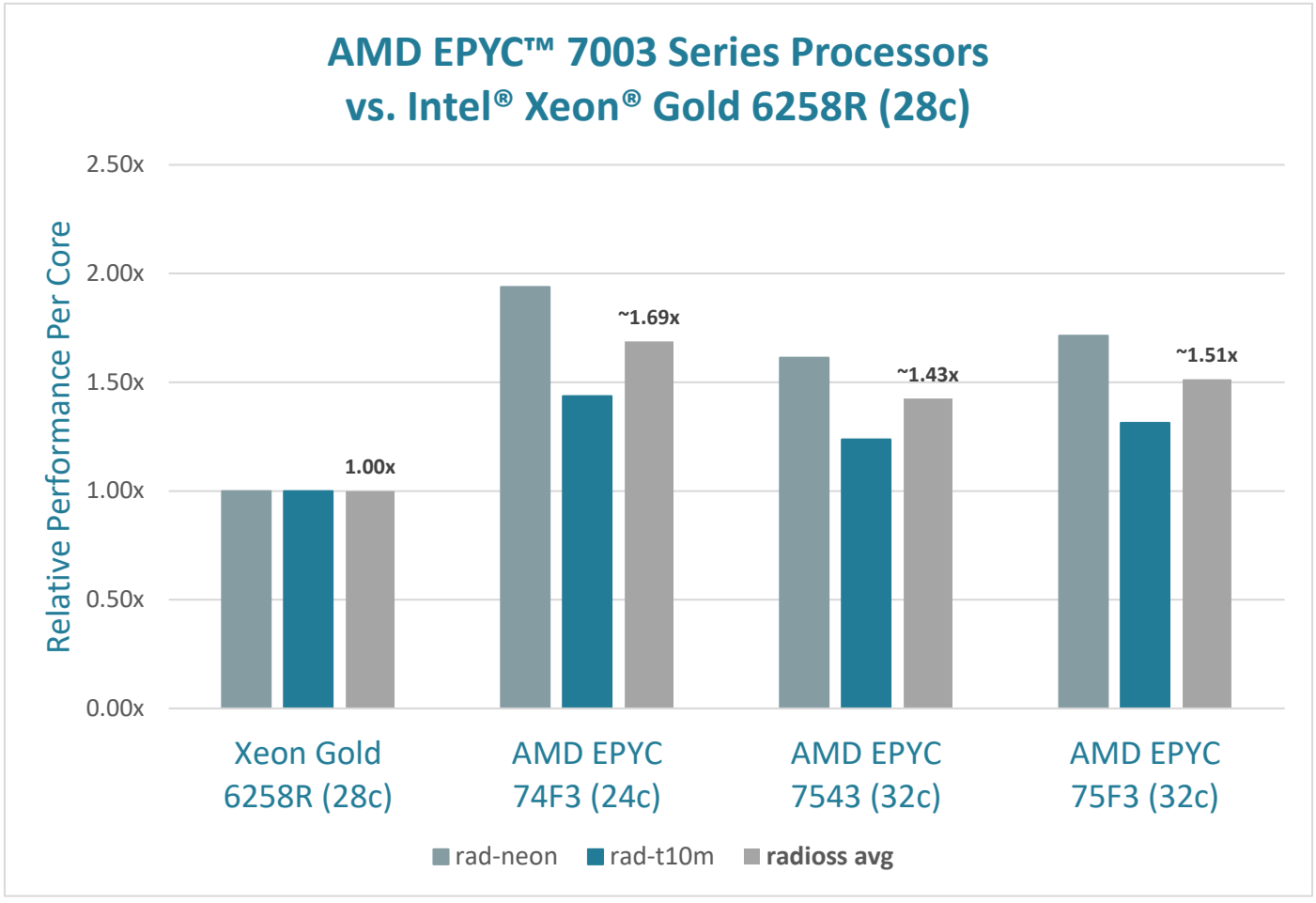


Figure 3 Altair Radioss Per-Core Performance

Altair Radioss Multi-Node Scaling

Radioss scales exceptionally well on AMD EPYC 7003 series processors. The chart below shows the scaling of the AMD EPYC 75F3 CPU in two-socket platforms vs. linear scaling running the T10M benchmark. At 32-cores per processor, each node has 64 physical cores for a total of 256 cores at 4 nodes.

FEA Explicit workloads generally do not scale linearly; however, Radioss exhibits very good scaling. At 2 nodes (128 cores), the speedup is ~1.99, and at 4 nodes (256 cores), the speedup stays very high at ~3.86.

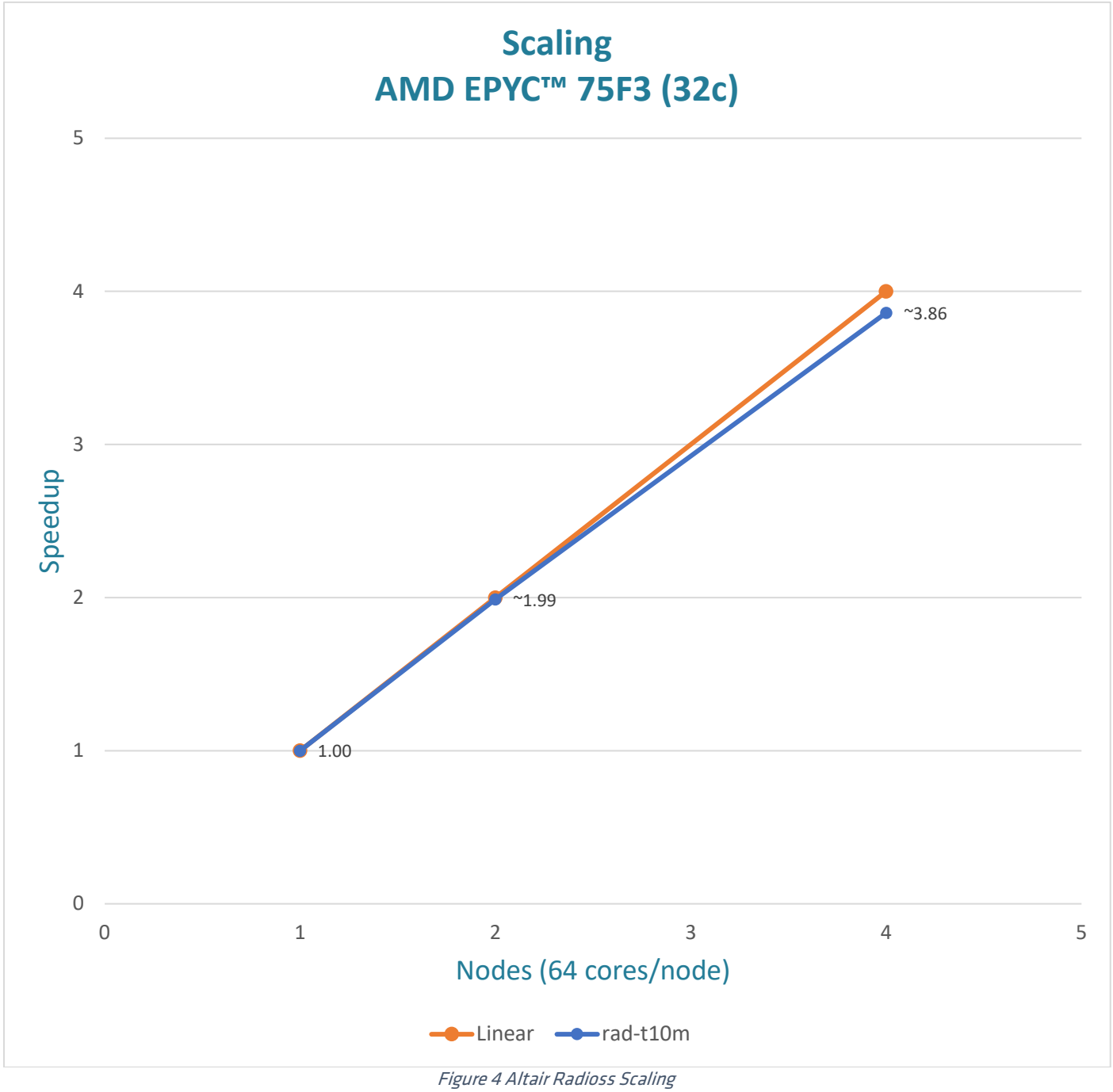


Figure 4 Altair Radioss Scaling

Conclusion

Competitive comparison results from multiple Radioss benchmarks were shown running on dual-socket AMD EPYC 7003 series processor-based systems and on dual-socket Intel Xeon 6258R based systems.

On a per node level the AMD EPYC 75F3 processor outperforms the Intel 6258R by an average of up to 1.73x. The AMD EPYC 7543 processor outperforms the Intel 6258R by an average of up to 1.63x. The AMD EPYC 74F3 outperforms the Intel Xeon 6258R by an average of up to 1.45x.

The per core performance advantage delivered by AMD EPYC 74F3 series processors is also an average of up to 1.69x higher compared to the Intel Xeon 6258R.

With the launch of the new AMD EPYC 7003 series, you can be confident you are getting excellent performance and the best solution on the market for Radioss.

RELATED LINKS

- Altair*
- Altair Radioss*
- AMD EPYC™ Processors
- AMD EPYC Technical Briefs and Tuning Guides

*Links to third party sites are provided for convenience and unless explicitly stated, AMD is not responsible for the contents of such linked sites and no endorsement is implied.

FOOTNOTES

1. *For a complete list of world records see http://amd.com/worldrecords. EPYC-22*
2. *AMD Infinity Guard features vary by EPYC™ Processor generations. Infinity Guard security features must be enabled by server OEMs and/or Cloud Service Providers to operate. Check with your OEM or provider to confirm support of these features. Learn more about Infinity Guard at https://www.amd.com/en/technologies/infinity-guard . GD-183*
3. *For AMD EPYC processors is the maximum frequency achievable by any single core on the processor under normal operating conditions for server systems. EPYC-18*