

# AMD 3D V-CACHE™ TECHNOLOGY EXTENDS ANSYS® FLUENT® PERFORMANCE LEADERSHIP<sup>1</sup>

## COMPUTATIONAL FLUID DYNAMICS

3rd Gen AMD EPYC™ processors with AMD 3D V-Cache technology demonstrate industry-leading performance with Ansys® Fluent®.

March 2022

## AMD EPYC™ 7003 PROCESSORS WITH AMD 3D V-CACHE TECHNOLOGY

AMD EPYC™ 7003 Series Processors with AMD 3D V-Cache™ technology extend the family of 3rd Gen AMD EPYC processors by introducing die stacking technology that enables denser, more efficient chiplet integration. AMD 3D Chiplet architecture stacks L3 cache tiles vertically to provide 768MB of L3 cache per socket (with up to 96MB of L3 cache per CCD), while still providing socket compatibility with existing AMD EPYC 7003 Series Processors. Applications that take advantage of AMD 3D V-Cache can see significant performance gain and lower overall Total Cost of Ownership (TCO) when running select technical computing workloads.<sup>2</sup>

3rd Gen AMD EPYC™ processors with AMD 3D V-Cache technology continue the x86 architecture innovations and carry on the tradition of balanced performance defined by the record-setting 2nd Gen and 3rd Gen AMD EPYC processors.<sup>3</sup> The high frequencies, high core-counts, high memory bandwidth and capacity, and 768MB of L3 cache found in 3rd Gen AMD EPYC processors with AMD 3D V-Cache technology unleash exceptional technical computing performance and are the new standard for the modern datacenter for technical computing workloads.

3rd Gen AMD EPYC processors support 8 channels (up to 4TB) of DDR4-3200 memory to handle very large datasets. Synchronizing the data fabric clock to match the memory clock speeds further improves both memory bandwidth and latency. The extra-large 768MB cache found in AMD EPYC 7003 Series Processors with AMD 3D V-Cache technology offers up to 96MB of L3 cache per core, to help efficiently utilize up to 64 cores per CPU. The large L3 caches enable unprecedented performance and scalability on many key workloads. The 128 (1P) to 160 (2P) lanes of PCIe® Gen4 offered by 3rd Gen AMD EPYC processors facilitate efficiently accessing high-speed network interface cards, high-speed storage, and multiple accelerators.

3rd Gen AMD EPYC 7003 Series Processors empower faster time-to-value by delivering performance and scalability, while also helping keep your data secure. AMD Infinity Guard helps your organization take control of security and decrease risks to your most important assets – your data.<sup>4</sup>

### AMD EPYC 7003 FOR TECHNICAL COMPUTING

3rd Gen AMD EPYC Processors with AMD 3D V-Cache technology help technical computing workloads scale across on-premise clusters and bring HPC-level performance to the datacenter for time-sensitive projects.

### “ZEN 3” CORE & SECURITY FEATURES

Support for up to:

- 64 physical cores, 128 threads
- 768MB of L3 cache per CPU
- Up to 96MB of L3 cache/core
- Up to 4 TB DDR4-3200 RAM
- 128 1P, up to 160 2P PCIe® Gen 4 lanes

Infinity Guard security features<sup>4</sup>

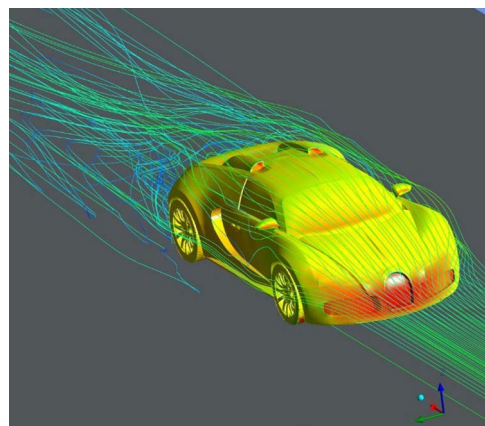
- Secure Boot
- Encrypted memory with SME

### ANSYS®

Ansys® offers a broad portfolio of engineering simulation software that helps customer solve complex design challenges, rapidly innovate and easily validate design ideas, and predict the performance of future products.

### ANSYS FLUENT®

Collaboration between AMD and Ansys offers high performance and scalability for Computational Fluid Dynamics (CFD) workloads. Customers across many industries can benefit from the technical partnership between AMD and Ansys.<sup>5</sup>



## EPYC 7003 SERIES ARCHITECTURE QUICK LOOK

3rd Gen AMD EPYC processors retain and improve on the proven Multi-Chip Module (MCM) chiplet architecture of previous AMD EPYC processor generations. The “Zen 3” core is one of the most important upgrades; it is manufactured using a 7nm process and designed to provide a significant instructions per cycle (IPC) uplift over prior-generation “Zen 2” cores. Each 3rd Gen AMD EPYC CPU core supports Simultaneous Multi-Threading (SMT), which allows up to 2 threads per core. Thus, a typical 2-socket system with two 3rd Gen AMD EPYC 64-core processors offers up to 128 physical cores per system and up to 256 threads per system.

AMD EPYC 7003 Series Processors with AMD 3D V-Cache technology introduce an improved L3 cache of 768MB/socket and up to 96MB per core that significantly increases cache sharing between the cores to a unified 96MB of L3 cache per compute die compared to standard AMD EPYC 76003 Series Processors. This means that up to 8 cores per compute die can share 96MB of unified L3 cache.

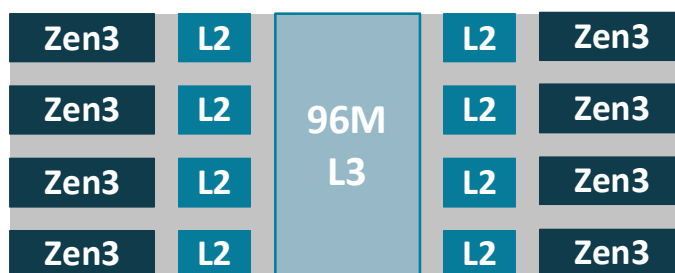


Figure 1: AMD EPYC 7003 Series Processor L3 cache layout with AMD 3D V-Cache technology

This extra-large L3 cache design can improve the cache hit-to-miss ratio over the standard design. Improved cache sharing also allows larger blocks to fit directly into the cache, instead of falling into the main memory. Further, improved cache fetching and eviction policies manage data more efficiently. The larger and more efficient cache found in AMD EPYC 7003 Series Processors with AMD 3D V-Cache technology enables a performance uplift on technical workloads compared to standard AMD EPYC 7003 Series Processors.

## AMD 3D V-CACHE TECHNOLOGY

Some AMD EPYC 7003 Series Processors debut AMD 3D V-Cache die stacking technology that enables denser, more efficient chiplet integration. AMD 3D Chiplet architecture stacks L3 cache tiles vertically to provide up to 96MB of L3 cache per CCD (and up to 768MB L3 cache per socket) while still providing socket compatibility with all AMD EPYC 7003 Series Processor model-based platforms.

AMD EPYC 7003 Series Processors with AMD 3D V-Cache technology employ industry-leading logic stacking based on a copper-to-copper hybrid bonding “bumpless” chip-on-wafer process. This process enables over 200X the interconnect densities of current 2D technologies (and over 15X the interconnect densities of other 3D technologies using solder bumps)<sup>6,7</sup>, which translates to lower latency, enhanced bandwidth, and robust power and thermal efficiencies.

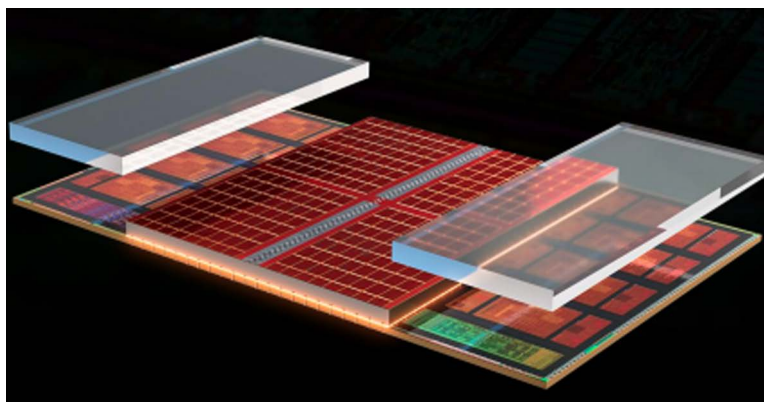


Figure 2: Central L3 tiles vertically stacked on the central L3 portion of the base CCX

## EPYC 7003 SERIES CPU OPTIONS AND RECOMMENDATIONS BY SEGMENT

AMD EPYC 7003 Series Processors with AMD 3D V-Cache technology come in 4 different CPU configurations. Table 1 lists the key features of each available EPYC 7003 Series Processor model.

Technical computing applications have a wide range of unique characteristics, and no single CPU can offer a “one-size fits” solution. Table 2 provides a few examples of different technical computing market segments, a general sense of the characteristics and sensitivities of applications per segment, and specific AMD EPYC 7003 Series Processor recommendations per segment. This list is not exhaustive. Please contact your AMD sales representative for more detailed guidance and CPU suggestions based on your unique environment and needs.

MODEL	# CCDS	CORES/ THREADS	BASE FREQ (GHZ)	MAX BOOST FREQ <sup>8</sup> (UP TO GHZ)	DEFAULT TDP (W)	CTDP (W)	L3 CACHE (MB)	NPS	2P/1P
7773X	8	64 / 128	2.20	3.50	280	225-280	768	1,2,4	2P/1P
7573X	8	32/ 64	2.80	3.60	280	225-280	768	1,2,4	2P/1P
7473X	8	24 / 48	2.80	3.70	240	225-280	768	1,2,4	2P/1P
7373X	8	16 / 32	3.05	3.80	240	225-280	768	1,2,4	2P/1P
7763	8	64/128	2.45	3.50	280	225-280	256	1,2,4	2P/1P
7713	8	64/128	2.00	3.675	225	225-240	256	1,2,4	2P/1P
7713P	8	64/128	2.00	3.675	225	225-240	256	1,2,4	1P
7663	8	56/112	2.00	3.50	240	225-240	256	1,2,4	2P/1P
7643	8	48/96	2.30	3.60	225	225-240	256	1,2,4	2P/1P
75F3	8	32/64	2.95	4.00	280	225-280	256	1,2,4	2P/1P
7543	8	32/64	2.80	3.70	225	225-240	256	1,2,4	2P/1P
7543P	8	32/64	2.80	3.70	225	225-240	256	1,2,4	1P
7513	4	32/64	2.60	3.65	200	165-200	128	1,2,4	2P/1P
74F3	8	24/48	3.20	4.00	240	225-240	256	1,2,4	2P/1P
7453	4	28/56	2.75	3.45	225	225-240	64	1,2,4	2P/1P
7443	4	24/48	2.85	4.00	200	165-200	128	1,2,4	2P/1P
7443P	4	24/48	2.85	4.00	200	165-200	128	1,2,4	1P
7413	4	24/48	2.65	3.60	180	165-200	128	1,2,4	2P/1P
73F3	8	16/32	3.50	4.00	240	225-240	256	1,2,4	2P/1P
7343	4	16/32	3.20	3.90	190	165-200	128	1,2,4	2P/1P
7313	4	16/32	3.00	3.70	155	155-180	128	1,2,4	2P/1P
7313P	4	16/32	3.00	3.70	155	155-180	128	1,2,4	1P
72F3	8	8/16	3.70	4.10	180	165-200	256	1,2,4	2P/1P

Table 1: AMD EPYC 7003 SKU options

SEGMENT	SENSITIVITY	EXAMPLE APPLICATIONS	RECOMMENDED MODELS	COMMENTS
FEA Explicit	Frequency & Cache	LS-DYNA®	7573X   7773X 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®		
CFD	Memory BW & Cache	Fluent® CFX®	7773X 7573X 75F3   7543 74F3	Look for CPUs with 768MB 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.
EDA	Frequency & Cache	RedHawk®	7373X 7473X 7573X 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

## ANSYS® FLUENT®

Ansys Fluent is a general-purpose computational fluid dynamics (CFD) and multi-physics tool that empowers you to go further and faster as you optimize your product's performance. AMD and Ansys have continued their technological partnership to deliver exceptional performance for customers.<sup>5</sup>

Fluent contains the broad physical modeling capabilities needed to model flow, turbulence, heat transfer, and reactions for industrial applications—ranging from air flow over an aircraft wing to combustion in a furnace, from bubble columns to oil platforms, from blood flow to semiconductor manufacturing, and from clean room design to wastewater treatment plants. Fluent covers a broad reach, including special models with capabilities to model in-cylinder combustion, aero-acoustics, turbo machinery, and multiphase systems.

## ANSYS FLUENT TEST METHODOLOGY

This document focuses on performance of 3rd Gen AMD EPYC 7003 processors with AMD 3D V-Cache technology, including a comparison with the Intel® Xeon® Platinum 8362.

The Fluent solver calculates the performance metrics of the Ansys Fluent benchmarks and reports them as “Core Solver Rating.” This metric follows best practices for comparing performance between different platforms and is the basis for all data and charts in this brief. Each benchmark shown in Figure 3 was run a minimum of 3 times, and an average was then calculated for presentation in this brief. The results of each benchmark were also confirmed to have <1% variability between all runs. Please see [Ansys Benchmarks Overview](#)\* for more information about the benchmark suite.

Testing was performed on systems configured as shown in Tables 3-5.

## SYSTEM CONFIGURATION

AMD SYSTEM CONFIGURATION			
CPU	2x 7763	2x 7573X	2x 7773X
Frequency: Base   Boost <sup>8</sup>	2.45 GHz   3.50 GHz	2.8 GHz   3.6 GHz	2.2 GHz   3.5 GHz
Cores	64 cores per socket (128 cores per node)	32 cores per socket (64 cores per node)	64 cores per socket (128 cores per node)
Thermal Design Power	280W		
L3 Cache	256MB	768MB	
Memory	1TB (16x) Dual-Rank DDR4-3200 64GB DIMMs, 1DPC		
Network Interface Card	Mellanox ConnectX-6 HDR 200Gb InfiniBand x16 (OFED-5.2-2.2.0)		
Storage: OS   Data	1 x 256GB SATA   1 x 1 TB NVMe		
BIOS and Settings	AGESA 1008C, 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		

Table 3: AMD system configuration

INTEL SYSTEM CONFIGURATION	
CPU	2x Intel Xeon Platinum 8362
Frequency: Base   Boost <sup>8</sup>	2.80 GHz   3.60 GHz
Cores	32 cores per socket (64 cores per node)
Thermal Design Power	265W
L3 Cache	48MB
Memory	1TB (16x) Dual-Rank DDR4-3200 64GB DIMMs, 1DPC
Network Interface Card	Mellanox ConnectX-6 HDR 200Gb InfiniBand x16 (OFED-5.2-2.2.0)
Storage: OS   Data	1 x 256GB SATA   1 x 1 TB NVMe
BIOS and Settings	Version 1.1, 3.3a: Power Technology=Custom, Power Performance Tuning=BIOS Control EPB, ENERGY_PERF_BIAS_CFG Mode=Maximum Performance, Package C State=C0/C1 Stat, Hyper-Threading (ALL)=Disabled, SNC (Sub NUMA)=Enable SNC2, Memory Frequency=3200
OS Settings	Clear caches before every run, NUMA balancing 0, randomize_va_space 0

Table 4: Intel system configuration

SOFTWARE	
Solver Version	Ansys Fluent 2022 R1
MPI	Intel MPI 2019
OS	Red Hat® Enterprise Linux® 8.3

Table 5: Software

## ANSYS FLUENT SINGLE-NODE PERFORMANCE

Single-node performance tests ran on a dual-socket system powered by two 32-core AMD EPYC 7573X processors ([Table 3](#)) versus a dual-socket system powered by two 32-core Intel Xeon Platinum 8362 processors ([Table 4](#)). Figure 3 shows that the system powered by the 2 x 32 core AMD EPYC 7573X processors outperforms the system powered by 2 x 32-core Intel Xeon 8362 processors by an average of 23% with a maximum uplift of ~68% on fluent-pump2.

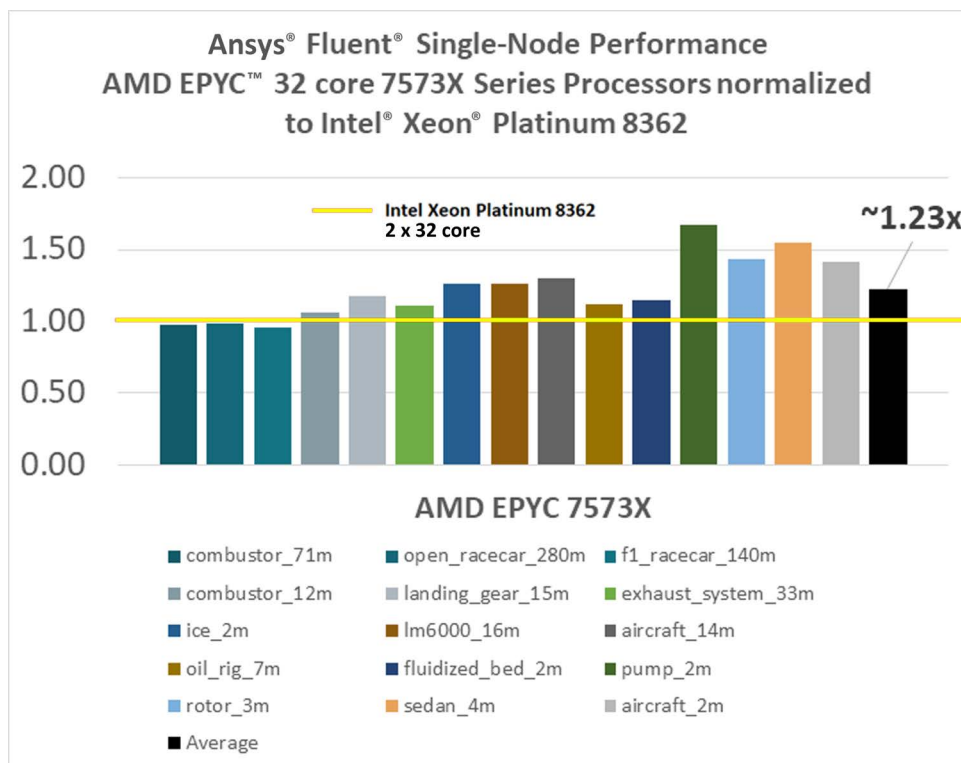


Figure 3: Average Ansys Fluent single-node 2P performance, normalized to the Intel Xeon Platinum 8362 system

## ANSYS FLUENT MULTI-NODE PERFORMANCE

The significant single-node performance advantage of AMD EPYC 7003 Series Processors with AMD 3D V-Cache technology becomes even more pronounced when these are deployed against realistic workloads in a multi-node technical computing context. Adding more computational nodes to a technical computing cluster reduces the portion of the dataset being processed by each node. Enough reduction allows each portion of the dataset to fit entirely within the L3 cache in each compute node, which causes a sudden performance boost called either *superlinear scaling*. This behavior is not unusual for processors, but the industry-leading 768MB size of the L3 cache in AMD EPYC 7003 Series Processors with AMD 3D V-Cache technology (3x the 256MB of the EPYC 7003 series L3 cache, and 16x that of the Intel Xeon Platinum L3 cache) makes superlinear scaling even more pronounced.<sup>9</sup>

Larger cache sizes mean that production-size workloads can be computed completely within a processor's cache using fewer computational nodes. Figure 4 shows scaling for 5 benchmarks in the Ansys Fluent suite on 64-core AMD EPYC 7763 processors at 2, 4, and 8 compute nodes, with results normalized to normalized to each benchmark's single-node performance. Figure 5 shows the same for benchmarks running on 64-core AMD EPYC 7773X compute nodes up to 16 nodes.

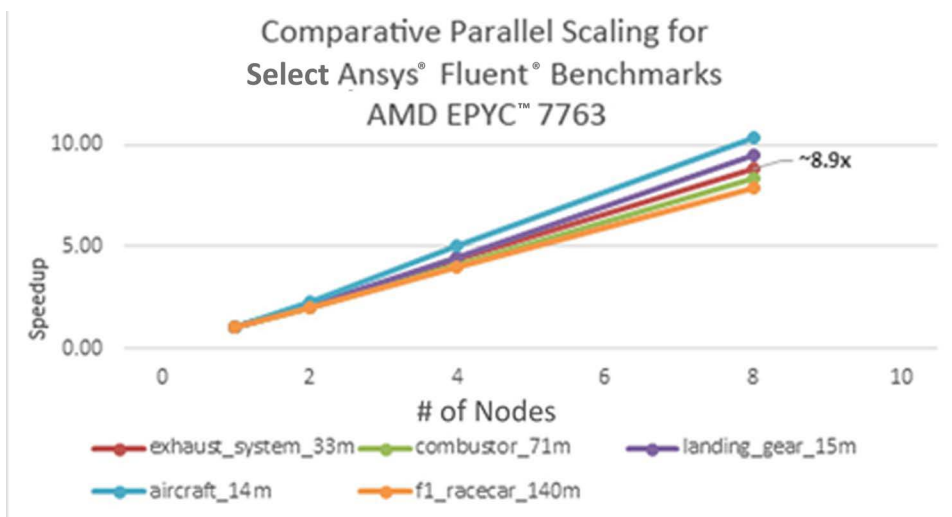


Figure 4: Ansys Fluent multi-node speedups relative to single node performance

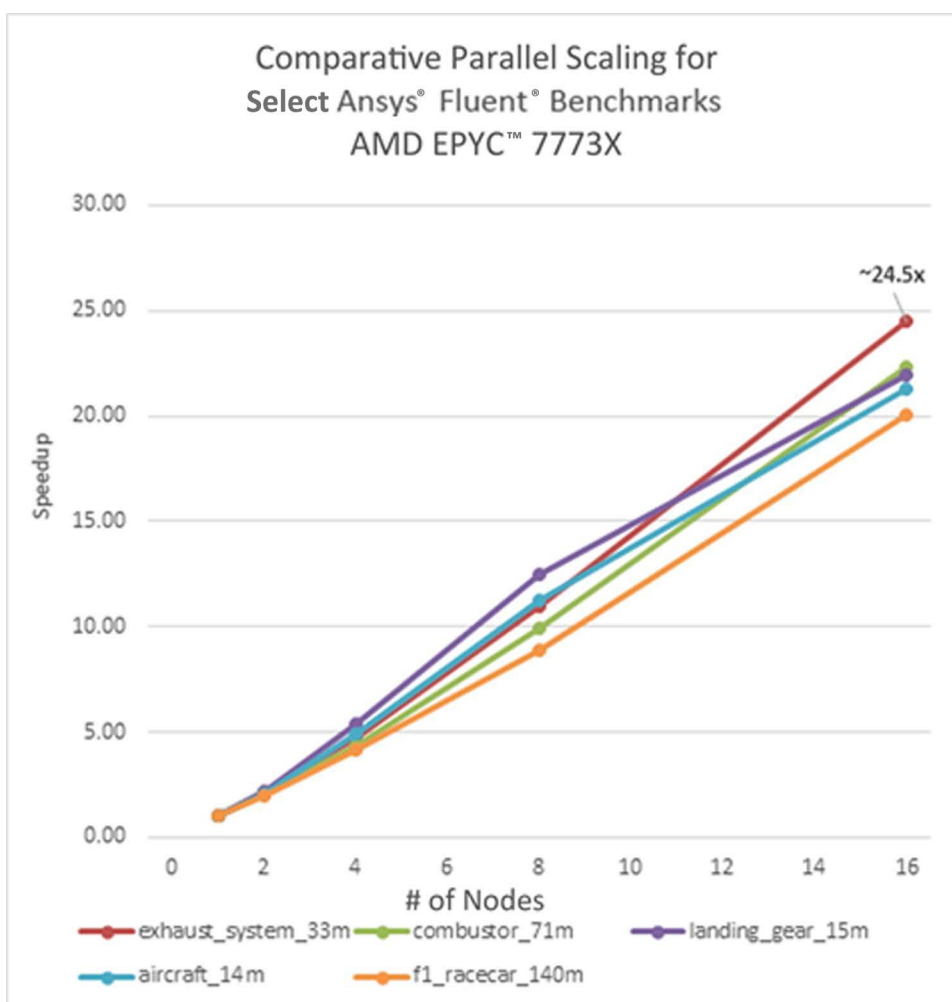


Figure 5: Ansys Fluent multi-node speedups relative to single node performance



Ideal scaling at 16 nodes would boost performance by 16x compared to a single node. The 768MB L3 cache found in AMD EPYC 7003 Series Processors with AMD 3D V-Cache technology results in an even higher performance uplift. For example, consider the 'exhaust\_system\_33m' benchmark:

- **AMD EPYC 7763 nodes:** The exhaust\_system\_33m benchmark on the baseline system exhibits superlinear speedups of up to ~8.9x at 8 nodes, which means that users have almost an extra node worth of available computing power available.
- **AMD EPYC 7773X nodes:** This same benchmark on the AMD EPYC 7773X system exhibits much higher superlinear speedups of up to ~24.5x at 16 compute nodes, which is more than eight extra nodes worth of available computing power.

## CONCLUSION

All AMD EPYC 7003 Series Processors are optimized to support a wide variety of applications and configurations. The industry-leading L3 data cache found in AMD EPYC 7003 Series Processors with AMD 3D V-Cache technology delivers exceptional speedups on technical and CFD workloads:

- The 32-core AMD EPYC 7573X boosted performance by approximately 1.23x using the same number of cores as the Intel system.
- On multi-node tests, the 64 core AMD EPYC 7773X processor exhibited exceptional superlinear scaling of approximately 24.5x speedup at 16 compute nodes.

Being able to do the same amount of work with far fewer compute nodes due to the increasing compute density and larger L3 cache offers significant cost and footprint advantages when planning datacenters. AMD EPYC 7003 Series Processors with AMD 3D V-Cache technology deliver innovative AMD 3D V-Cache technology that positively impacts both performance on technical computing workloads as well as your organization's bottom line, whether you are scaling-out to higher node counts or driving more density into your clusters.



## REFERENCES

1. See <https://www.amd.com/system/files/documents/ansys-fluent-performance-amd-epyc7003-series-processors.pdf>.
2. “Technical Computing” or “Technical Computing Workloads” as defined by AMD can include: electronic design automation, computational fluid dynamics, finite element analysis, seismic tomography, weather forecasting, quantum mechanics, climate research, molecular modeling, or similar workloads. GD-204
3. For a complete list of world records, see <http://amd.com/worldrecords>. EPYC-22
4. 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
5. Please see <https://www.ansys.com/products/fluids/ansys-fluent> for additional information.
6. Based on calculated areal density and based on bump pitch between AMD hybrid bond AMD 3D V-Cache stacked technology compared to AMD 2D chiplet technology and Intel 3D stacked micro-bump technology. EPYC-026
7. Based on AMD internal simulations and published Intel data on “Foveros” technology specifications. EPYC-027
8. For AMD EPYC processors, the boost frequency is the maximum frequency achievable by any single core on the processor under normal operating conditions for server systems. EPYC-18
9. AMD defines “linear scaling” as an equal and proportionate application performance uplift relative to single node performance; that is, when scaling out to 2 nodes results in 2x the performance of a single node, scaling out to 4 nodes results in 4x the performance of a single node, and so forth. “Super-linear” scaling is when the performance uplift achieved by adding one or more node(s) is greater than linear. AMD allows a +/- of 2% margin of error when claiming linear or super linear scaling. GD-205

## ACKNOWLEDGEMENTS

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### RELATED LINKS

- [Ansys\\*](#)
- [Ansys Fluent\\*](#)
- [Ansys HPC\\*](#)
- [High Performance Computing \(HPC\) Tuning Guide for AMD EPYC™ 7003 Series Processors](#)
- [AMD EPYC™ Processors](#)
- [AMD EPYC Technical Briefs and Tuning Guides](#)

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