OPENFOAM® AND AMD 3D V-CACHE™ TECHNOLOGY
COMPUTATIONAL FLUID DYNAMICS

Powered by 4th Gen AMD EPYC™ Processors with AMD 3D V-Cache™ technology

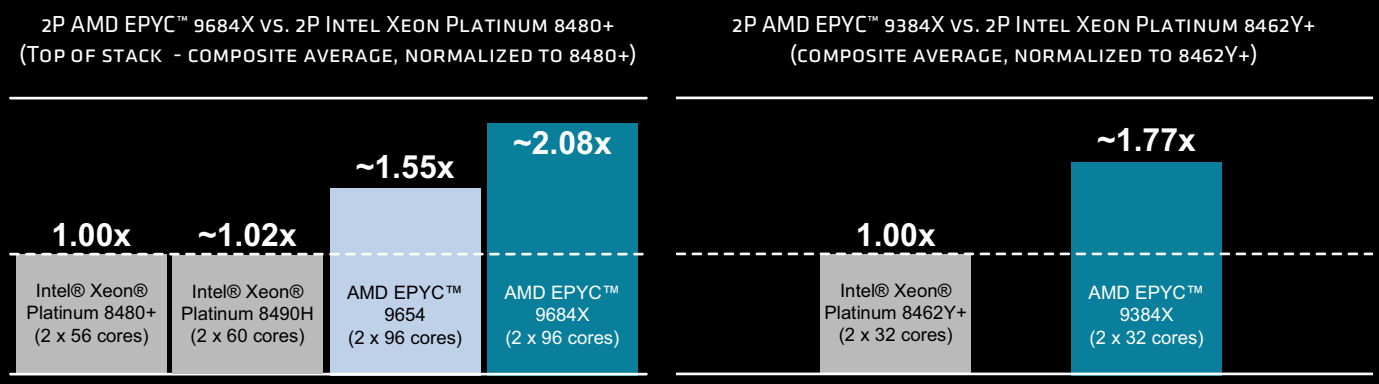
June 2023

AT A GLANCE

2P systems powered by 96-core 4th Gen AMD EPYC™ processors with AMD 3D V-Cache™ technology demonstrate outstanding top of stack and per-core performance uplifts on OpenFOAM®.

PERFORMANCE HIGHLIGHTS

A 2P 96-core 4th Gen AMD EPYC 9684X system with AMD 3D V-Cache technology demonstrates a composite average ~2.08x uplift on OpenFOAM workloads vs. a 2P Intel® Xeon® Platinum 8480+ system. A 2P 32-core AMD EPYC 9384X system outperforms a 2P 32-core Intel Xeon Platinum 8462Y+ system by ~1.77x.



KEY TAKEAWAYS

Comparing 2P servers - one powered by AMD EPYC 9684X (96-core) processors compared to a 2P server powered by a Intel Xeon Platinum 8480+ (56-core) or 8490H (60-core) processors delivered a composite average OpenFOAM competitive performance uplift of ~2.08x and ~2.05x (~2.21 and ~2.22x maximum on 100x40x40 mesh test case), respectively. Similarly, on a core-to-core basis, a 2P server powered by 32-core AMD EPYC 9384X processors showed a ~1.77x uplift (~1.86x maximum on 100x40x40 mesh test case) compared to a 2P server powered by 32-core Intel Xeon Platinum 8462Y+ processors. 4th Gen AMD EPYC 9004X processors with AMD 3D V-Cache technology are available in 1P and 2P configurations and feature:

- Up to 1,152MB L3 cache vs. 384MB in standard 4th Gen AMD EPYC processors.
- Up to 4 links of Gen 3 Infinity Fabric™ at up to 32 Gbps.
- 12 memory channels that support up to 6TB of DDR5-4800 memory.
- Support for PCIe® Gen 5 at up to 32 Gbps.
- AVX-512 instruction support for enhanced HPC and ML performance.
- AMD Infinity Guard technology to defend your data.[2]

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SCALABILITY

The significant single-node performance advantage of AMD EPYC 9004 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 a larger portion of the dataset to fit entirely within the L3 cache in each compute node, and in some cases fit entirely within the L3 cache, which causes a sudden performance boost called *superlinear scaling*. This behavior is not unusual for processors, but the industry-leading 1152MB size of the L3 cache in AMD EPYC 9684X Series Processors with AMD 3D V-Cache technology (3x the 384MB of the standard EPYC 9654 L3 cache) show excellent scalability, including superlinear scaling.[5] AMD testing on an 8-node cluster shows the AMD EPYC 9684X delivering up to ~13 nodes worth of performance on OpenFOAM.

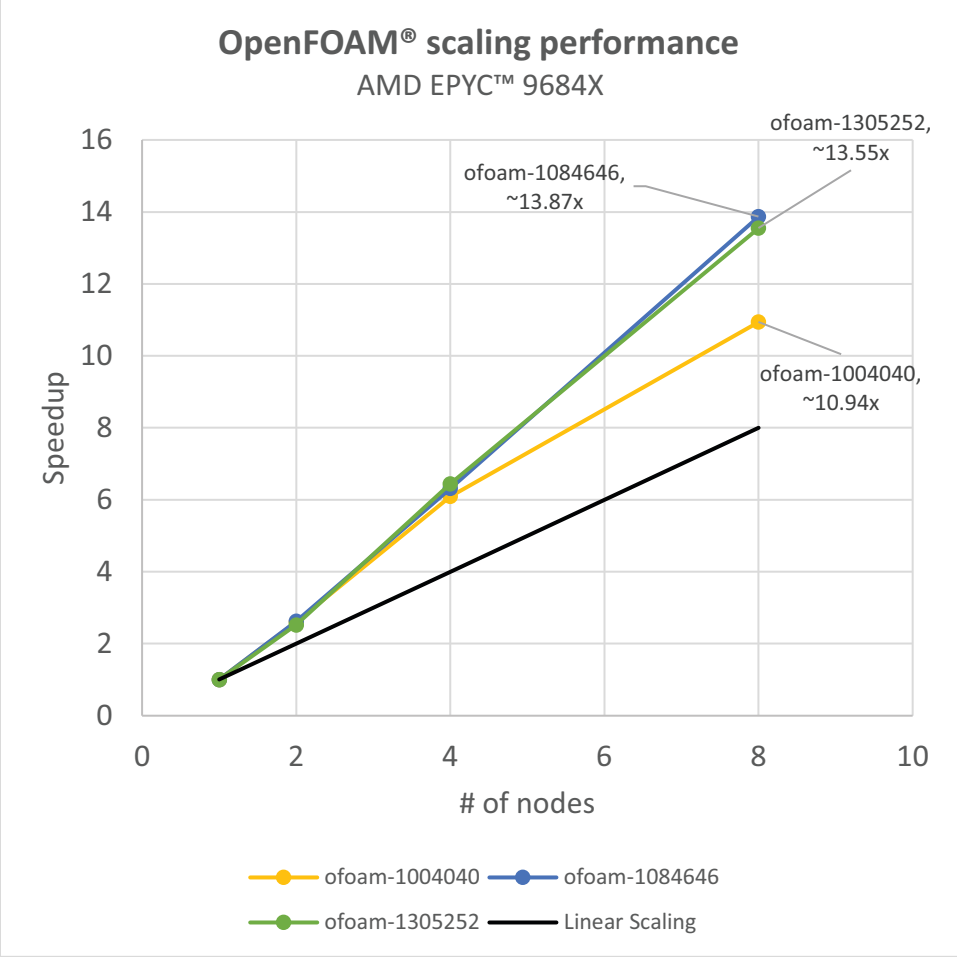

Figure 1: OpenFOAM 8-node scaling performance with AMD EPYC 9864X processors with AMD 3D V-Cache technology

AMD 3D V-CACHE™ TECHNOLOGY

Some AMD EPYC 9004 Series Processors include AMD 3D V-Cache™ die stacking technology that enables more efficient chiplet integration. AMD 3D Chiplet architecture stacks L3 cache tiles vertically to provide up to 96MB of L3 cache per die (and up to 1152 MB L3 Cache per socket) while still providing socket compatibility with standard AMD EPYC™ 9004 Series Processor models.

AMD EPYC 9004 Series Processors with AMD 3D V-Cache technology employ industry-leading logic stacking based on copper-to-copper hybrid bonding "bumpless" chip-on-wafer process to enable over 200X the interconnect densities of current 2D technologies (and over 15X the interconnect densities of other 3D technologies using solder bumps),[3,4] which translates to lower latency, higher bandwidth, and greater power and thermal efficiencies.

SYSTEM CONFIGURATION

AMD SYSTEM CONFIGURATION			
CPUs	2 x AMD EPYC 9384X	2x AMD EPYC 9654	2 x AMD EPYC 9684X
Frequency: Base | Boost[6]	3.10 GHz | 3.90 GHz (up to)	2.40 GHz | 3.55 GHz (up to)	2.55 GHz | 3.70 GHz (up to)
Cores	32 cores/socket (64 threads)	96 cores/socket (192 threads)	96 cores/socket (192 threads)
L3 Cache	768 MB per CPU	384 MB per CPU	1152 MB per CPU
Memory	1.5 TB (24x) Dual-Rank DDR5 4800 64 GB DIMMs 1 DPC		
NIC	25 Gb Ethernet CCX512-A ConnectX-5 (fw 16.35.2000)		
InfiniBand	200 Gb HDR ConnectX-6 VPI (fw 20.35.2000)		
Storage: OS | Data	Samsung MZQL21T9HCJR-00A07 1.92 TB		
BIOS Version	1007D		
BIOS Settings	SMT=OFF; NPS=4; Determinism=Power		
OS	RHEL 8.7 (kernel 4.18.0-425.3.1.el8.x86_64)		
OS Settings	amd_iommu=ON; iommu=pt; mitigations=off; clear caches; NUMA balancing=0; THP=on; CPU governor=Performance; C2 states=disabled		

Table 1: AMD system configurations

INTEL SYSTEM CONFIGURATION			
CPUs	2x Intel Xeon Platinum 8462Y+	2x Intel Xeon Platinum 8480+	2x Intel Xeon Platinum 8490H
Frequency: Base | Boost	2.40 GHz | 4.10 GHz (up to)	2.00 GHz | 3.80 GHz (up to)	1.90 GHz | 3.50 GHz (up to)
Cores	32 cores per socket (64 threads)	56 cores per socket (112 threads)	60 cores per socket (120 threads)
L3 Cache	60 MB per CPU	105 MB per CPU	112.5 MB per CPU
Memory	1.0 TB (16x) Dual-Rank DDR5 4800 64 GB DIMMs 2 DPC		
NIC	25 Gb Ethernet CCX512-A ConnectX-5 (fw 16.35.2000)		
InfiniBand	200 Gb HDR ConnectX-6 VPI (fw 20.35.2000)		
Storage: OS | Data	Samsung MZQL21T9HCJR-00A07 1.92 TB		
BIOS Version	ESE110Q-1.10		
BIOS Settings	Hyperthreading=Off, Profile = Maximum Performance		
OS	RHEL 8.7 (kernel 4.18.0-425.3.1.el8.x86_64)		
OS Settings	processor.max_cstate=1; intel_idle.max_cstate=0; iommu=pt mitigations=off; clear caches; NUMA Balancing=0; randomize_va_space 0; THP=ON; CPU Governor=Performance		

Table 2: Intel system configurations

TEST METHODOLOGY

OpenFOAM® provides a standard set of benchmarks that evaluate the performance of different platforms running OpenFOAM applications. These benchmark cases represent typical usage and cover a range of sizes. The uplift is calculated as the ratio of the systems under test (*sut*) to the reference systems (*ref*). In this Performance Brief, the Intel Xeon Platinum 8490H, 8480+ and 8462Y+ processors are the *ref* systems, and 4th Gen AMD EPYC processors are the *sut*. The 4th Generation AMD EPYC processors tested include both standard AMD EPYC 9004 and AMD EPYC 9004X models with AMD 3D V-Cache technology. The total amount of variability between individual runs was <1%. The results presented in this Performance Brief are the OpenFOAM® motorbike 130x52x52, motorbike 108x46x46, and motorbike 100x40x40 benchmarks. The systems tested were configured as shown in Tables 1 and 2, above.

FOR ADDITIONAL INFORMATION

Please see the following additional resources for more information about 4th Gen AMD EPYC features, architecture, and available models:

- AMD EPYC™ 9004 Series Processors
- AMD EPYC™ Tuning Guides
- AMD EPYC™ Products

REFERENCES

1. "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
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. 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
4. Based on AMD internal simulations and published Intel data on "Foveros" technology specifications. EPYC-027
5. 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
6. Maximum boost 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

AUTHORS

Alvaro Fernandez and Ashok Manikonda contributed to this Performance Brief.

RELATED LINKS

- OpenFOAM*
- AMD EPYC Processors
- AMD EPYC Technical Briefs

**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.*

AMD EPYC 9004 FOR CFD

4th Gen AMD EPYC CPUs deliver excellent per-core performance by taking advantage of fast CPU frequencies, low latency memory, and a unified cache structure. Design engineers can use AMD EPYC processors to perform complex computational fluid design tasks with ground-breaking high-performance computing and robust security features to deliver excellent results..

"ZEN 4" CORE & SECURITY FEATURES

Support for up to:

- 96 physical cores, 192 threads
- 1152 MB of L3 cache per CPU
- 96 MB of L3 cache per CCD
- 6 TB of DDR5-4800 memory
- Up to 128 1P, up to 160 2P PCIe® Gen 5 lanes

Infinity Guard security features[2]

- Secure Boot
- Encrypted memory with SME

OPENFOAM®

OpenFOAM® is free, open source CFD software. Its user base includes commercial and academic organizations.