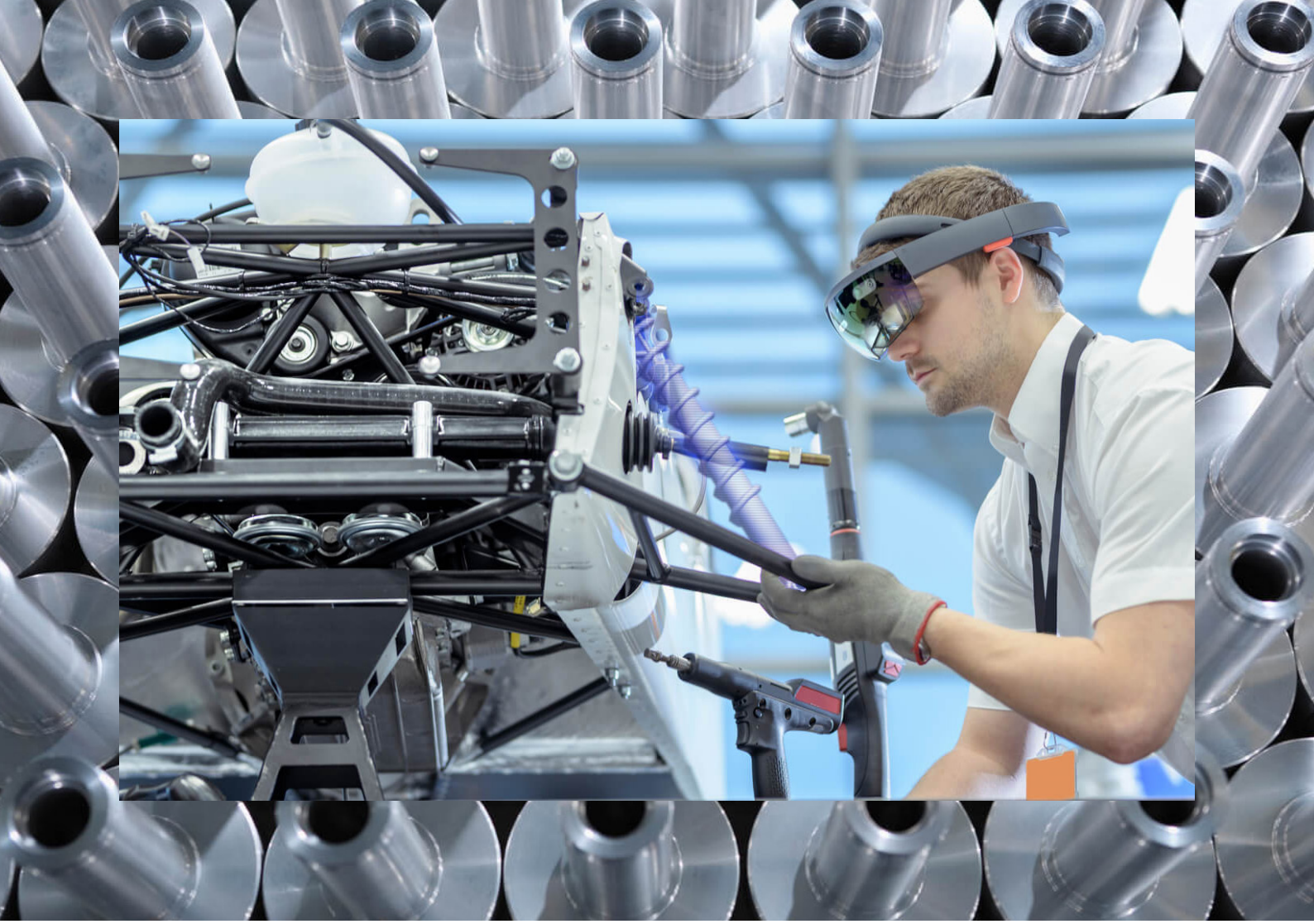

A new standard in CAE solutions for manufacturing

Enhancing product development using HPE systems powered by AMD EPYC processors with AMD 3D V-Cache technology

Business white paper

Hewlett Packard Enterprise | AMD

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Manufacturers need to deliver ever more complex products, get to market faster, and continuously innovate and improve product quality—all with limited resources.

Multiphysics design optimization studies are extremely challenging.

Meeting manufacturing challenges with CAE

As manufacturers of all sizes struggle with cost and competitive pressures, and as products become smarter, more complex, and highly customized, the use of computer-aided engineering (CAE) is growing. Figure 1 shows how a CAE solution addresses a manufacturer's business challenges and customer requirements.

Using CAE, engineers can design and test ideas for new products without having to physically build many expensive prototypes. This helps manufacturers lower costs, enhance productivity, improve quality, and reduce time to market by primarily focusing on designs with the best potential for market success. CAE also helps drive innovation and enhance collaboration throughout the supply chain while mitigating risks and costs associated with potential product failure and associated litigation.

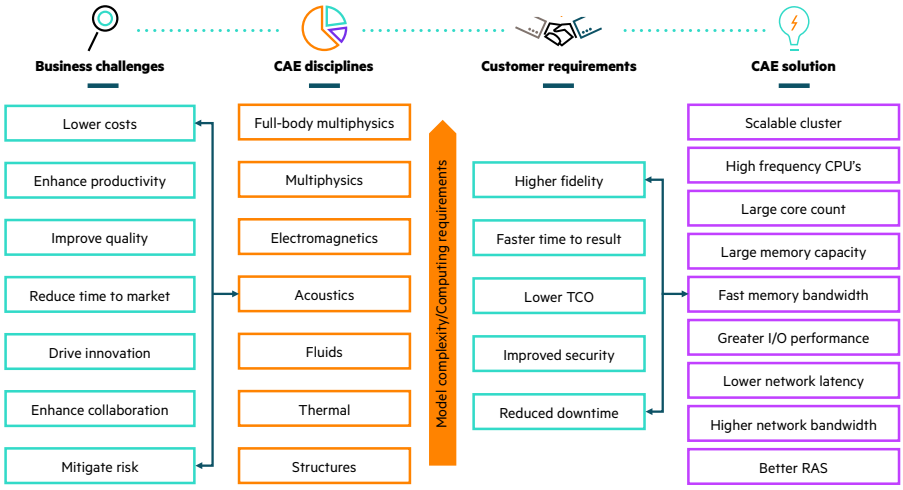

Figure 1. Manufacturing business challenges and requirements addressed with CAE

Of the CAE disciplines, multiphysics is among the most demanding because it combines several CAE applications such as structural analysis, fluid mechanics, mechanical dynamics, and electromagnetics. These comprehensive, high-fidelity simulations can help accurately predict how complex products behave in real-world environments. Iterative design exploration studies are also being extensively used to simulate, design, and optimize complex systems. Multiphysics design optimization studies need very detailed geometric models and large meshes over thousands of operating scenarios. This puts enormous stress on the high-performance computing (HPC) infrastructure required to power CAE workloads.

Customer requirements for HPC solutions

AMD's high frequency, high core count processors with large memory and cache are needed.

HPE is the market leader in HPC systems with a 33.4% market share.[1]

Manufacturers of all sizes need a highly reliable, secure HPC environment that scales and performs at extremely high levels to deliver fast time to results on large, complex simulation models. The solution should also foster collaboration throughout the supply chain and reduce complexity and total cost of ownership (TCO), including capital and operational (facilities, labor, and CAE software license) costs.

As high-resolution models become larger and more complex, memory and available cache have emerged as important requirements for data centers running CAE applications. Simulation models increasingly consist of millions of elements or cells, and the more of a model that can fit in CPU memory and cache, the faster a simulation can be performed. In addition, the use of digital twins—virtual representations of physical objects that mimic their real-world counterparts—is expected to double in the next five years.[2] Similarly, artificial intelligence (AI) and machine learning techniques are expected to triple in applications ranging from manufacturing processes to product quality to predictive maintenance. All of these requirements are driving the need for increased simulation capacity.

[1] "HPC Market Update During SC21," Hyperion Research, November 2021.

[2] "2021 Survey Report: Technology Convergence for a Smarter, More Connected World: Market Trends to 2026," Altair Engineering Inc.

To meet these evolving requirements, manufacturers need:

- High-frequency processors delivering high per-core throughput and high core count processors to complete more jobs faster to maximize their investment in expensive ISV applications
- Large memory capacity, high memory bandwidth, and high ratios of cache per core to further improve compute performance
- High I/O performance to improve storage performance
- Low network latency and high network bandwidth to ensure better scaling
- Reliability, availability, and serviceability (RAS) to minimize downtime costs

Besides raw performance, energy efficiency is also an important consideration. As engineering IT data center managers running CAE simulations seek to reduce their carbon footprint for sustainability, they need servers that deliver maximum throughput per watt to minimize power and cooling requirements. They may also need denser more energy-efficient designs that deliver superior performance while minimizing cooling and data center space requirements.

As the market leader in HPC systems with a 33.4% market share,[3] Hewlett Packard Enterprise delivers one of the industry's most comprehensive CAE solutions across compute, interconnect, software, storage, and services delivered on-premises, hybrid, or as a service. By teaming up with AMD, HPE delivers exceptional performance, flexibility, and choice on a range of CAE applications as shown in Figure 2.

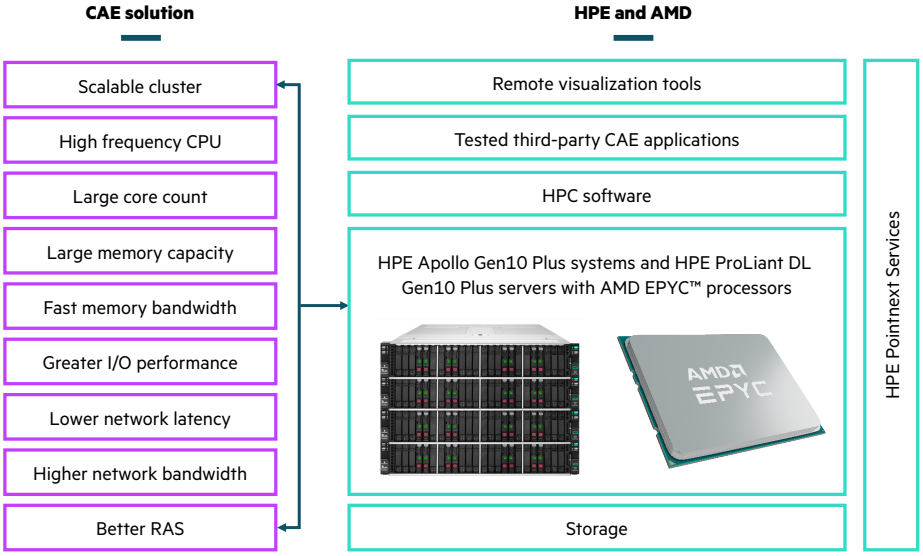

Figure 2. A high-level view of the HPE and AMD CAE solution

The HPE and AMD solution for CAE

HPE provides a complete end-to-end solution stack shown in Figure 2 that is flexible and customizable to meet manufacturing clients' business requirements. This stack provides a large portfolio of supported and tested third-party commercial and open-source CAE applications and a broad range of system software, server, and storage platforms, delivered with high-value services and remote visualization.

Remote visualization: Enhances security by keeping critical data within the data center; boosts productivity and collaboration with any time, any place / any location access to graphic-intensive models; helps lower costs by centralization, improving system manageability and helping optimize resources (software licenses, hardware, and so on) utilization; and promotes retention of highly skilled staff with better work-life balance and location flexibility.

[3] "HPC Market Update During SC21," Hyperion Research, November 2021.

HPE Apollo 2000 Gen10 Plus system with 4 x HPE ProLiant XL225n Gen10 Plus servers powered by AMD EPYC processors achieved ten world records on SPECpower_ssj2008, making it the most energy-efficient multinode server in the world.[4]

CAE applications: HPE and AMD have excellent relationships with independent software vendors (ISVs). HPE and AMD have computer scientists who help ISVs test and optimize their applications. Major CAE applications supported and tested include Altair Radioss®; Ansys® Fluent®, Ansys® Mechanical™, Ansys® LS-DYNA®, and Ansys® CFX®; MSC® Nastran®; Siemens® STAR-CCM+®; OpenFOAM®; Dassault Systèmes SIMULIA® Abaqus® FEA; and ESI® Virtual Performance Solutions® (VPS) to name just a few.

HPC architecture: AMD EPYC 7003 series processors with AMD 3D V-Cache™ technology offer industry performance leadership for many of the most challenging workloads in CAE. Designed for cache-sensitive workloads such as computational fluid dynamics (CFD) and impact analysis, AMD 3D V-Cache technology is available in four EPYC 7003 SKUs with triple the L3 cache compared to other EPYC 7003 SKUs.

HPC system software: HPE offers HPC customers a complete and modular software portfolio, which consists of HPE-developed software solutions, combined with best-of-breed solutions from business partners and open-source software providers. This portfolio is validated, integrated, and performance-enhanced by HPE, so manufacturers can select the right software mix for their CAE efforts—all from one source including operating system, cluster management, job schedulers and resource managers, HPC tools and libraries, and more.

Optimized numerical libraries: AMD Optimizing CPU Libraries (AOCL) are a set of numerical libraries optimized for the AMD EPYC processor family. They have a simple interface to take advantage of the latest hardware innovations to accelerate the development and performance of CAE applications.

Dense, HPC compute nodes: The HPE Apollo 2000 Gen10 Plus system shown in Figure 3 is a density-enhanced, multiserver with shared power and cooling resources that delivers high levels of efficiency and system scaling. The 2U chassis supports up to four HPE ProLiant XL225n Gen10 Plus servers each with up to two 2nd or 3rd generation AMD EPYC processors. The HPE Apollo 2000 Gen10 Plus system provides storage and compute flexibility, increased power capability, and support for the latest AMD EPYC processors.

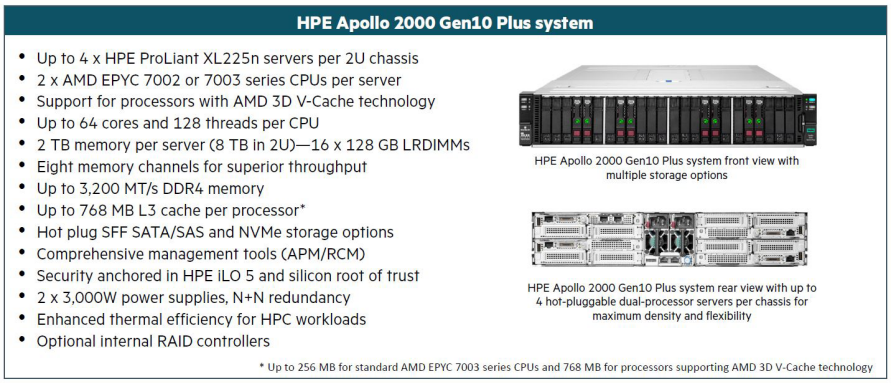

Figure 3. HPE Apollo 2000 Gen10 Plus system specifications

Manufacturers can also take advantage of optional HPE Apollo Platform Manager (APM), a rack-level power and system management solution for HPE Apollo servers providing an enhanced graphical interface for ease of system management.[5] An optional HPE Apollo 2000 Rack Consolidation Module kit allows HPE iLO aggregation at the chassis level that can be daisy-chained to connect to a top-of-rack (TOR) management switch.

HPE ProLiant servers: For CAE customers that prefer 1U, single-processor systems, the HPE ProLiant DL325 Gen10 Plus v2 server is an excellent solution. This server has modest power and cooling requirements and fits easily into most data center environments. For CAE workloads that require large amounts of memory, either HPE ProLiant DL365 Gen10 Plus or HPE ProLiant DL385 Gen10 Plus v2 server is a good choice.

[4] HPE ProLiant XL225n Gen10 Plus Achieves 10 Records on SPECpower_ssj 2008.

[5] HPE Apollo Platform Manager QuickSpecs.

HPE ProLiant servers

HPE ProLiant DL325 Gen10 Plus v2 server

- 1U/1P server
- Single AMD EPYC 7003 series processor
- 4 TB memory per server (16 x 256 GB LRDIMM)
- Multiple chassis options with up to 10 SFF / 4 LFF drives

HPE ProLiant DL325 Gen10 Plus v2 server front view

HPE ProLiant DL365 Gen10 Plus server

- 1U/2P server
- Single or dual AMD EPYC 7003 series processors
- 8 TB memory per server (32 x 256 GB LRDIMM)
- 8 SFF drives and optional SFF or NVMe drive bay options

HPE ProLiant DL365 Gen10 Plus server front view

HPE ProLiant DL385 Gen10 Plus v2 server

- 2U/2P server
- Single or dual AMD EPYC 7003 series processors
- 8 TB memory per server (32 x 256 GB LRDIMM)
- Multiple chassis options with up to 36 SFF drives

HPE ProLiant DL385 Gen10 Plus v2 server front view

Figure 4. HPE ProLiant servers for CAE workloads

The HPE ProLiant DL325 Gen10 Plus v2, HPE ProLiant DL365 Gen10 Plus, and HPE ProLiant DL385 Gen10 Plus v2 servers run the latest 3rd generation AMD EPYC processors and support for 3D V-Cache technology. For customers running AMD EPYC 7003 series processors, minimum operating system requirements apply. Supported Linux® operating environments include Red Hat® Enterprise Linux (RHEL) 8.3, SUSE Linux Enterprise Server (SLES) 12 SP5, and SLES 15 SP2.[6]

Only HPE offers industry-standard servers with firmware anchored into silicon with HPE iLO 5 and silicon root of trust. Tied into the silicon root of trust is the AMD Secure Processor, a dedicated security processor embedded in the AMD EPYC system on a chip (SoC). This, along with secure recovery and firmware runtime validation at startup, helps limit security breaches and system disruption if code is compromised.

Storage: Fast I/O is also critical for CAE applications to help ensure that file and network I/O do not become bottlenecks. HPE Apollo 2000 Gen10 Plus systems offer PCIe® 4.0, providing twice the throughput[7] of the previous generation PCIe 3.0. HPE offers a variety of high-performance PCIe options, including 200 Gbps HPE and HDR InfiniBand adapters,[8] multiport 100GbE adapters, and high-performance NVMe SSDs. Multiple storage options are available inside the chassis ranging from 0 to 24 (SFF) SAS/SATA. For data sets that are exceeding the storage capacity available inside the chassis, HPE offers two options for a shared external parallel file system depending on the customers' preference for parallel file systems:

- Cray ClusterStor E1000 Storage systems—An HPE storage product that embeds the open-source Lustre file system with full enterprise support for both hardware and software from HPE Pointnext Services
- HPE Parallel File System Storage—An HPE storage product that embeds the IBM Spectrum Scale file system with full enterprise support for both hardware and software from HPE Pointnext Services

Services: HPE offers a spectrum of services to meet manufacturing CAE requirements—from services such as application tuning to more integrated advisory service offerings such as project management, on-site consulting, technical account management, and solution architecture consulting.

[6] HPE ProLiant DL385 Gen10 Plus v2 server QuickSpecs.

[7] PCIe 4.0 delivers 16.0 GT/s, twice the transfer speed of PCIe 3.0.

[8] HPE and HDR InfiniBand adapters are based on standard Mellanox ConnectX-6 technology.

AMD EPYC 3rd Gen processors deliver exceptional performance and scalability for CAE workloads.

- World's first 7 nm x86 server CPU
- Highest available x86 server core count to help maximize parallelism
- World's first PCIe 4.0 capable x86 server CPU
- Eight memory channels per socket
- World's first x86 server processor with DDR4 3200 memory support[9]
- Large L3 cache (up to 768 MB per socket with 3D V-Cache)[10]

The "EPYC" advantage

Built on 7 nm technology, AMD EPYC processors bring together high core counts, large memory capacity, extreme memory bandwidth, large cache sizes, and massive I/O with the right ratios to enable exceptional HPC workload performance. For CAE workloads, this translates into excellent flexibility and the opportunity to optimize many CAE applications to deliver breakthrough performance. This helps manufacturers improve quality, innovation, and time to market.

When AMD EPYC 7002 series processors were introduced in August 2019, they were game changers, delivering industry-leading clock frequencies, latency, memory bandwidth, and cache per core.[11] The latest AMD EPYC 7003 series processors introduced in March 2021 extended this leadership even further, offering exceptional single core performance and new high-frequency parts ideal for CAE workloads, along with the addition of 3D V-Cache technology in select SKUs in March 2022. Both processor families deliver optimal performance enabling customers to select the processor that best meets their needs.

AMD EPYC 7003 series processors

AMD EPYC 7003 series processors offer several advantages over the previous generation.[12] Among these advantages are:

- A unified 8-core cache complex sharing a single 32 MB L3 cache per core complex die (CCD) providing up to twice the directly accessible L3 cache per core with low latency
- Up to a 19% improvement in instructions per clock (IPC) versus 2nd Gen
- A faster Infinity Fabric™, clocked at 1,600 MHz enabling synchronous transfers with the 3,200 MT/s DDR memory
- Advanced chip-level security enhancements (SME, SEV-ES, SEV-SNP)
- The availability of 7003 SKUs with AMD 3D V-Cache technology, tripling the L3 cache compared to standard 7003 CPUs. See details in the AMD EPYC 3D V-Cache technology section below.

AMD EPYC 7003 series processors are a drop-in upgrade, fully compatible with EPYC 7002 series systems.[13] Customers can deploy systems with either 7002 or 7003 series processors including 7003 series processors with 3D V-Cache technology depending on their needs.

AMD 3D V-Cache technology

The newest offering of the 3rd Gen AMD EPYC processor family feature AMD 3D V-Cache technology. This new technology extends the capabilities of the 7003 series for cache-sensitive workloads with an innovative 3D vertical cache that adds 64 MB of L3 cache per CCD, tripling the amount of L3 cache to 96 MB per CCD.

AMD EPYC 7003 series processors with AMD 3D V-Cache technology provide both density and energy efficiency leadership[14] with their unique solderless design.

- > 200x the interconnect density compared to on-package 2D chiplets[15]
- > 15x the interconnect density compared to micro bump 3D technology[16]
- > 3x the interconnect energy efficiency compared to 3D micro-bump[17]

The additional throughput that users can expect with 3D V-Cache technology varies depending on the workload. While additional cache may have only a modest impact on some workloads, for cache-intensive explicit FEA and CFD simulations, the results can be dramatic. Design engineers and data center managers can select the optimal AMD EPYC processor depending on their unique workloads and mix of tools.

[9] amd.com/en/processors/epyc-7002-series.

[10] amd.com/en/processors/epyc-7003-series.

[11] 2nd Gen AMD EPYC Processors Set New Standard for the Modern Datacenter with Record-Breaking Performance and Significant TCO Savings.

[12] AMD EPYC 7003 Series CPUs Set New Standard as Highest Performance Server Processor.

[13] For HPE Apollo 2000 Gen10 Plus systems, a BIOS update is required when upgrading to 7003 series processors. Also, minimum operating system requirements include RHEL 8.3, SLES 12 SP5, or SLES 15 SP2.

[14] All stated results are as of May 5, 2022. See spec.org for more information. All benchmarks referenced were conducted on 2P systems, so the core counts referenced are across both processors. Configurations as follows:

2P Intel® Xeon® Platinum 8380 (80C) scoring 489 SPECrate 2017_fp_base (489/80 = 6.11 score/core)—spec.org/cpu2017/results/res2021q2/cpu2017-20210521-26361.html

2P AMD EPYC 7763 (128C) scoring 663 SPECrate 2017_fp_base (663/128 = 5.18 score/core)—spec.org/cpu2017/results/res2021q4/cpu2017-20211121-30146.html

2P Intel Xeon Platinum 8362 (64C) scoring 465 SPECrate 2017_fp_base (465/64 = 7.27 score/core)—spec.org/cpu2017/results/res2021q3/cpu2017-20210802-28467.html

2P AMD EPYC 75F3 (64C) scoring 546 SPECrate 2017_fp_base (546/64 = 8.53 score/core)—spec.org/cpu2017/results/res2021q2/cpu2017-20210409-25543.html

2P Intel® Xeon® Gold 6342 (48C) scoring 395 SPECrate 2017_fp_base (395/48 = 8.23 score/core)—spec.org//cpu2017/results/res2022q2/cpu2017-20220327-31254.html

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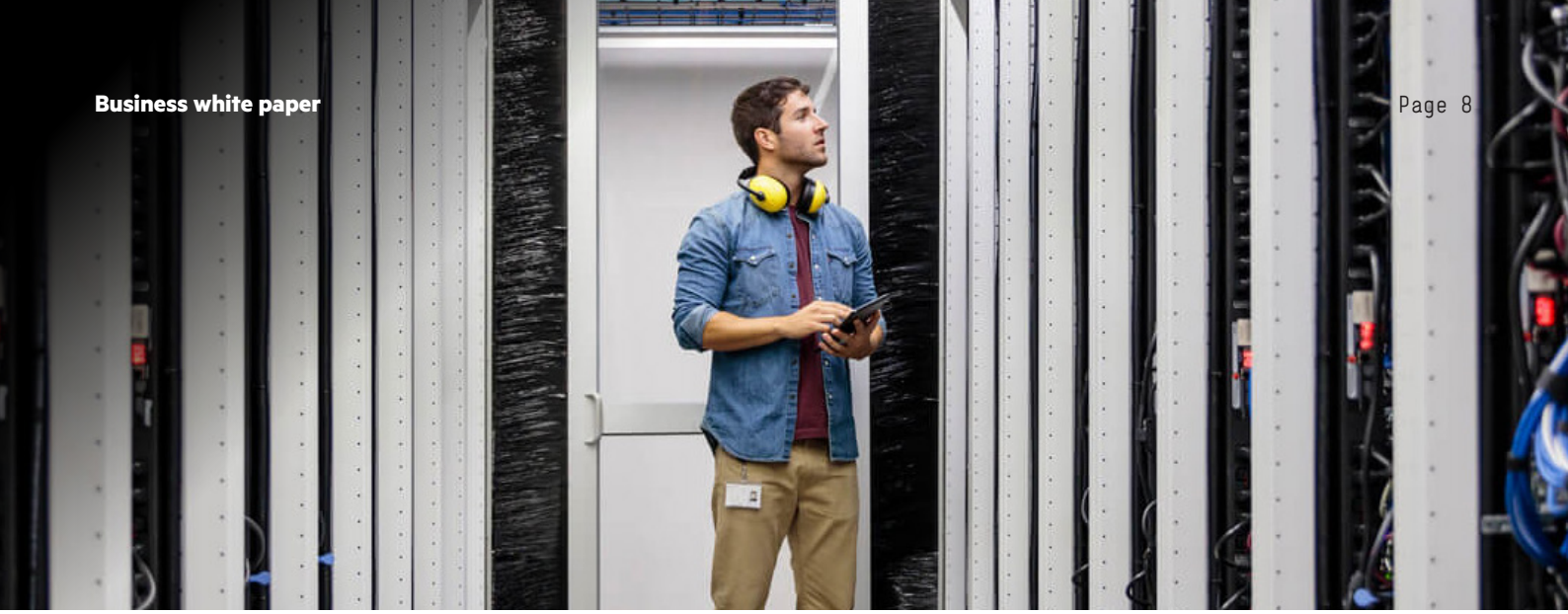
2P AMD EPYC 73F3 (16C) scoring 398 SPECrate 2017_fp_base (398/32 = 12.44 score per core)—spec.org/cpu2017/results/res2021q3/cpu2017-20210816-28714.html

[15, 16] EPYC-026: 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.

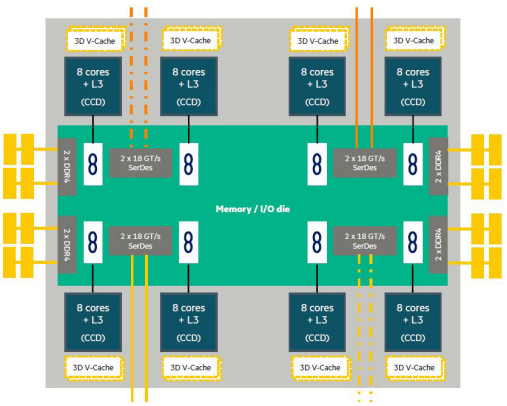
[17] EPYC-027: Based on AMD internal simulations and published Intel data on Foveros technology specifications.



An ideal architecture for CAE workloads

The unique architecture shown in Figure 5 is the key to the EPYC processor's throughput advantage. The 9-die EPYC 7003 SoC with 3D V-Cache features 8 per CCX and provides 8 cores and 96 MB of L3 cache per CCX.[18] This design places large amounts of L3 cache close to compute cores delivering optimal throughput. The advanced 7 nm process enables clock frequencies to scale up to 4.10 GHz with maximum boost helping maximize performance.[19]

While other processors share relatively small amounts of L3 cache across multiple cores, 3rd Gen AMD EPYC processors offer up to 768 MB of L3 cache on 3D V-Cache SKUs (up to 256 on standard 3rd Gen SKUs) and provide a direct path between each core and associated L3 cache to speed throughput and help reduce latency.[20] This combination of high L3 cache per core, direct channels to cache, multiple memory channels, and fast memory combines to deliver exceptional throughput.



- Industry-leading 7 nm technology
- Up to 64 cores / 128 threads
- Up to 19% boost in IPC vs. "Zen 2"*
- Up to 4.1 GHz boost clock speed**
- Up to 768 MB L3 cache***
- Up to 96 MB shared L3 cache per CCD
- Infinity Fabric—64 GB/s bidirectional bandwidth per link
- 8 DDR4 memory channels per socket
- Up to 3,200 MT/s DDR
- 128 PCIe 4.0 lanes per socket
- Configurable NUMA operation
- Embedded AMD Secure Processor

* MLN-003

** EPYC-18. Refers to the AMD EPYC 72F3 part. 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.

*** Up to 256 MB for standard AMD EPYC 7003 series CPUs and 768 MB for processors supporting AMD 3D V-Cache technology.

Figure 5. AMD EPYC high-level processor design

AMD EPYC processors are the choice of next-generation exascale supercomputers[21] with high core counts (up to 64 cores/processor) to improve scaling, throughput, and elapsed processing time. Yet, they are affordable, offering exceptional performance and fitting the budgets of small- or medium-sized CAE environments typically found among tier-1 and tier-2 suppliers.

For certain CAE applications, the high-frequency AMD EPYC 7xF3 processors will be of interest. These parts deliver leadership per-core performance while offering large amounts of L3 cache per core. In addition, the new 7x73X processors with AMD 3D V-Cache technology shown in Table 1 can help manufacturers improve performance, time to market, and reduce TCO for certain workloads. These processors offer choices for:

- Industry-leading per-core performance to optimize license efficiency for certain workloads.[22]
- Large L3 cache-per-core (up to 96 MB) for reduced analysis runtime
- 8 x DDR4 high-speed memory channels
- Dedicated L3 cache per CCD, enabling more concurrent analyses per server

[18, 20] CCX is a term used in AMD CPUs and stands for Core Complex. It refers to a group of up to four CPU cores in 7002 series processors or up to eight cores in 7003 series processors and their CPU caches (L1, L2, and L3). The number of cores per CCX varies by processor. In the case of other parts, CCXs contain two or more cores. amd.com/system/files/documents/high-performance-computing-tuning-guide-amd-epyc7003-series-processors.pdf.

[19] Max. boost for AMD EPYC processors is the maximum frequency achievable by any single core on the processor under normal operating conditions for server systems.

[21] AMD EPYC-based systems have been chosen as the basis of exascale supercomputers. Design wins include Frontier, a collaboration between the US Department of Energy (DOE), ORNL, and HPE. AMD EPYC processors will also power El Capitan, a collaboration between US DOE, LLNL, and HPE expected in early 2023.

[22] Highest per core performance claim based on 3rd generation EPYC 75F3/74F3/73F3 (32-/24-/16-cores) having the highest SPECrate®2017_fp_base score divided by total core count of all SPEC publications as of May 5, 2022.

Table 1. AMD EPYC 7003 series processors recommended for CAE workloads

EPYC model	Cores / threads	Base speed	Boost speed[23]	L3 cache	Power (Watts)	L3 cache per core[24]
AMD EPYC 7003 series						
7763	64/128	2.45 GHz	Up to 3.5 GHz	256 MB	280	4 MB
75F3	32/64	2.95 GHz	Up to 4.0 GHz	256 MB	280	8 MB
74F3	24/48	3.20 GHz	Up to 4.0 GHz	256 MB	240	10.7 MB
73F3	16/32	3.50 GHz	Up to 4.0 GHz	256 MB	240	16 MB
72F3	8/16	3.70 GHz	Up to 4.1 GHz	256 MB	180	32 MB
AMD EPYC 7003 series with 3D V-Cache technology						
7773X	64/128	2.20 GHz	Up to 3.5 GHz	768 MB	280	12 MB
7573X	32/64	2.80 GHz	Up to 3.6 GHz	768 MB	280	24 MB
7473X	24/48	2.80 GHz	Up to 3.7 GHz	768 MB	240	32 MB
7373X	16/32	3.05 GHz	Up to 3.8 GHz	768 MB	240	48 MB

For CAE workloads, processors in the 24–32 core range are often considered optimal to achieve a good balance of clock speed, per core throughput, and cache per core. Customers that are most concerned with overall throughput may be interested in the 64-core AMD EPYC 7763 or 7773X parts. Note that there is no 64-core part in the 3rd Generation Intel® Xeon® line, so for completeness, we compare the AMD EPYC 7763 with the 40-core Intel Xeon Platinum 8380, the processor with the highest core count among the latest 3rd generation Intel Xeon processors.[25]

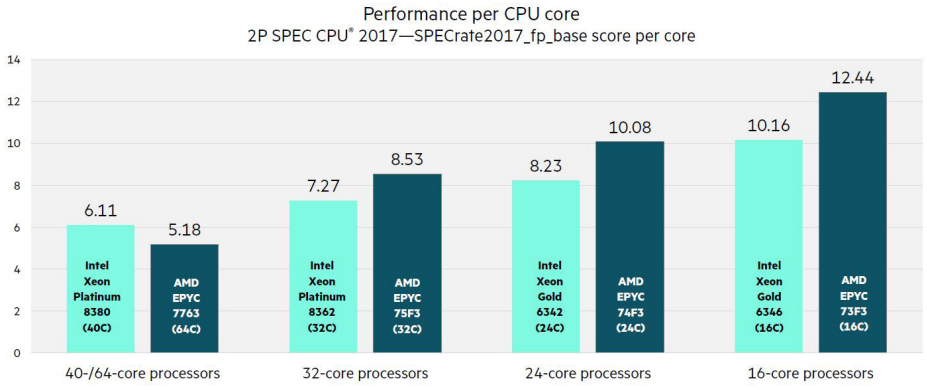


Figure 6. EPYC 7763 and 7xF3 series high-frequency parts vs. comparable CPU competitors

Figure 6 shows relative SPECrate2017_fp_base scores per core comparing selected AMD EPYC 7003 series processors to comparable competitive processors with similar core counts on dual-processor systems.[26] While the SPEC benchmarks are not necessarily indicative of CAE application performance, they provide an objective basis for comparison. AMD EPYC processors' exceptional performance is a result of high clock speeds, fast DDR4 memory supporting up to 3,200 MT/s, eight memory channels per processor, and ample amounts of L3 cache per core. The green bars in Figure 6 represent different AMD EPYC 7003 series processors with varying numbers of cores.

[23] EPYC-18: 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.

[24] L3 cache per core here is based on the cache being distributed evenly across all cores.

[25] In the Intel line, the 14 nm Cascade Lake AP Intel Xeon Platinum 9282 has 56 cores; however, this is an older processor announced in Q2 2019 and delivers a lower result on the SPECrate2017_fp_base benchmark both overall and on a per-core basis. The newer Ice Lake 10 nm 40-core Xeon Platinum 8380 is a more reasonable point of comparison because it was announced in Q2 2021 around the same time as the AMD EPYC 7763. The Intel Xeon Platinum 8380 could also be considered a competitor to the 32-core AMD EPYC 75F3.

[26] All stated results are as of May 5, 2022. See spec.org for more information. All benchmarks referenced were conducted on 2P systems, so the core counts referenced are across both processors. Configurations as follows:

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2P AMD EPYC 73F3 (16C) scoring 398 SPECrate 2017_fp_base (398/32 = 12.44 score per core)—spec.org/cpu2017/results/res2021q3/cpu2017-20210816-28714.html

Memory-intensive CAE workloads such as CFD and computational structural mechanics (CSM) may benefit from large amounts of physical memory and L3 cache per core. The AMD EPYC 7xF3 processors offer significantly more L3 cache (256 MB per socket) than competitive processors. For workloads that benefit from even larger amounts of L3 cache, AMD EPYC processors with AMD 3D V-Cache technology may deliver the best performance, offering 768 MB of L3 cache per socket.

Table 2 illustrates the unique advantages of AMD EPYC 7003 series processors over comparable competitive offerings across multiple points of comparison.

Table 2. AMD EPYC 7003 series processors provide superior clock speed, L3 cache, and cache per core

	Intel Xeon Platinum 8362[27]	AMD EPYC 75F3[28]	AMD EPYC 7573X[29]
# of cores	32	32	32
Total L3 cache	48 MB	256 MB	768 MB
L3 cache / core[30]	1.5 MB	8 MB	24 MB
Memory speed	3,200 MT/s	3,200 MT/s	3,200 MT/s
Memory channels	8	8	8
Base clock (GHz)	2.8 GHz	2.95 GHz	2.8 GHz
Boost clock (GHz)[31]	Up to 3.6 GHz[32]	Up to 3.6 GHz	Up to 3.8 GHz
Max. memory	6 TB[33]	4 TB	4 TB
PCIe lanes	64	128	128

When these results are plotted visually as illustrated in Figure 7A, the differences become apparent. The AMD EPYC 75F3 offers dramatically more L3 cache and cache per core as well as double the number of PCIe channels per socket.

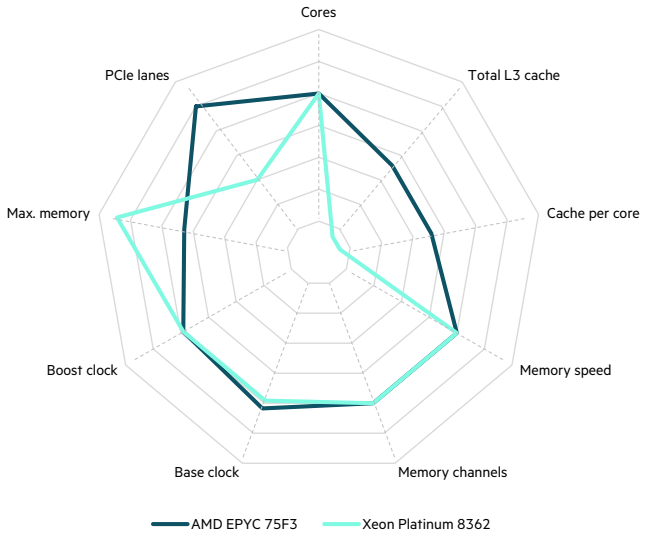

Figure 7A. Comparing AMD EPYC 75F3 to a comparable competitive processor

[27] intel.com/content/www/us/en/products/sku/217216/intel-xeon-platinum-8362-processor-48m-cache-2-80-ghz/specifications.html.

[28] amd.com/en/products/cpu/amd-epyc-75f3.

[29] amd.com/en/products/cpu/amd-epyc-7573x.

[30] L3 cache per core here is based on the cache being distributed evenly across all cores.

[31] 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.

[33] Maximum Turbo Frequency is the maximum single-core frequency at which the processor is capable of operating using Intel Turbo Boost Technology and, if present, Intel Turbo Boost Max Technology 3.0 and Intel Thermal Velocity Boost.

[33] See Intel Xeon Platinum 8362 processor specs at intel.com/content/www/us/en/products/sku/217216/intel-xeon-platinum-8362-processor-48m-cache-2-80-ghz/specifications.html. Note that 6 TB maximum memory assumes the use of Intel® Optane™ Persistent Memory. With DRAM, maximum memory capacity on the 8362 processor is 4 TB (same as the EPYC 75F3).

The differences between AMD and comparable competitive processors in terms of L3 cache and cache per core are even more dramatic when comparing the AMD EPYC 73F3X with AMD 3D V-Cache as illustrated in Figure 7B.

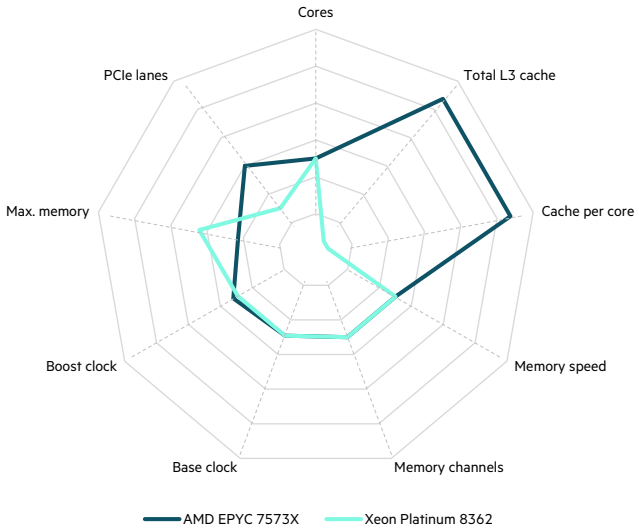

Figure 7B. Comparing AMD EPYC 7373X to a comparable competitive processor

HPE Apollo 2000 Gen10 Plus systems deliver sustained high performance across multiple cores.

CAE users can improve performance, solve very high-fidelity multiphysics problems, and reduce TCO with a smaller data center footprint.

AMD CPU-powered HPE servers—purpose built for CAE

CAE applications such as CFD and FEA have different computing requirements. CFD algorithm solutions are often memory bound and benefit from servers with large amounts of memory, multiple memory channels, and large amounts of L3 cache per core.

Implicit FEA involves computationally expensive sparse matrix inversion, which is typically limited by memory size and bandwidth. Explicit FEA problems, such as crash and transient non-linear analysis, need high processor performance—these workloads benefit from higher core counts and high-frequency processors with large amounts of cache.

Depending on the type of CAE problem, mixing and matching large core-count processors with high frequencies, very high cache per core, high memory bandwidth, and massive I/O are essential to solving CAE problems. The HPE servers with AMD EPYC processors deliver a broad range of unique choices for manufacturers to help optimize their high-fidelity CAE environments. High core-count EPYC processors can deliver high throughput per node for CAE applications that benefit from multicore parallelism. Lower-core count EPYC processors with high frequencies and high cache-per-core offer high performance per core, helping to efficiently utilize per-core software licenses.

Optional Direct Liquid Cooling

For customers with suitably equipped data centers, a new option for HPE Apollo 2000 Gen10 Plus systems is plug-and-play support for Direct Liquid Cooling (DLC). This DLC option allows customers increase power density and processing efficiency. These HPE DLC server racks connect directly to facility water supplies without the need for secondary plumbing. Options are available for CPU only or CPU plus memory cooling. While air cooling is fine for most applications using the latest AMD EPYC processors described in this document, for some HPE solutions with specific dense configurations including the AMD EPYC 7573X and 7773X with AMD 3D V-Cache CPU, HPE recommends their DLC option.

Power efficiency

For data center operators, power consumption and associated carbon emissions are increasingly important considerations—not just for environmental sustainability goals but to help reduce TCO as well. In September 2021, AMD announced an ambitious goal to deliver a **30x increase in energy efficiency** for AMD EPYC CPUs and AMD Instinct accelerators used to power AI training and high-performance computing applications by 2025.[34] AMD offers a Greenhouse Gas Emissions TCO estimation tool that can be used to estimate the potential savings and emission reductions with various AMD EPYC CPUs.[35] In addition to innovations in silicon, efficiency gains stem from the fact that CAE users can run more concurrent simulations per socket and get results faster, meaning that fewer nodes are required to deliver the same simulation throughput.

The HPE Apollo 2000 Gen10 Plus system with HPE ProLiant XL225n Gen10 Plus servers builds on the power efficiency of AMD EPYC 7003 series processors, delivering 18 world records in energy efficiency.[36] These dense multinode servers offer real space and power savings to data centers of any size. Taking energy efficiency to the maximum, the HPE ProLiant XL225n Gen10 Plus server has the highest result of 17,696 overall ssj_ops/watt for 4-node configurations on the SPECpower_ssj® 2008 benchmark.[37] With the HPE Apollo 2000 Gen10 Plus system, it is estimated that customers can see up to $15,000 in annual energy cost savings.[38]

Cloud deployment options with HPE GreenLake for HPC

Digital transformation is driving new data-intensive workloads and the need for real-time analytics at an unprecedented scale. This has increased demand for HPC and CAE in cloud environments. HPE GreenLake democratizes HPC by allowing companies of all sizes to access highly performant processing power and run simulation workloads. HPE is a leader in traditional HPC. Consumption-based solutions from HPE GreenLake are a natural next step. HPE GreenLake for HPC is a private cloud on-premises or colocation, turnkey solution, fully managed and operated by HPE. CAE-aaS is built on the foundation of HPE GreenLake for HPC and makes it easier and faster for customers to deploy converged CAE/AI workloads on high-performance clusters with predictable, transparent costs and continuous monitoring to enable capacity right-sizing plus the ability for capacity bursting on-site, on demand.

Industry-leading performance

While AMD EPYC 7003 series processors already offer industry-leading performance, for cache-sensitive applications, AMD 3D V-Cache technology can provide a decisive advantage.[39] In February 2022, HPE undertook a series of internal tests, evaluating the latest 32-core AMD EPYC 7573X processor with AMD 3D V-Cache against a similar 3rd Gen AMD EPYC 7543 processor without the extended cache.

As shown in Figure 8, the results are dramatic. For a CFD workload run using Ansys CFX, servers with AMD 3D V-Cache technology delivered a 38% performance improvement vs. an identical server configuration without the extended cache.[40] For FEA workloads, the Dassault Systèmes SIMULIA Abaqus/Standard™ benchmarks showed a 7% boost in performance and the Abaqus/Explicit™ suite of standard FEA benchmarks showed a 33% boost in performance.

These potential out-of-the-box performance uplifts are delivered with no application software changes. You simply upgrade your existing HPE Gen10 Plus servers with AMD EPYC 7003 series processors with AMD 3D V-Cache to receive the benefits of a larger L3 cache.[41]

In additional CAE benchmarks conducted by AMD, the same AMD EPYC 7573X processor with AMD 3D V-Cache technology demonstrated average performance uplifts of 37% over a competitive processor running Altair Radioss FEA explicit, 23% running Ansys Fluent, and 47% running Ansys LS-DYNA FEA explicit.[42]

[34] The energy-efficient AMD server processors can help reduce energy and greenhouse gas (GHG) emissions across a broad range of workloads toward sustainability.

[35] AMD EPYC Bare Metal and Greenhouse Gas Emissions TCO Estimation Tool.

[36] HPE Apollo 2000 Gen10 Plus System with HPE ProLiant XL225n Gen10 Plus Servers Achieves 18 World Records in Energy Efficiency!

[37] The latest industry standard SPECpower_ssj2008 results are detailed at SPECpower_ssj2008 Results. The results referenced are as of March 15, 2021. Details of the four-node HPE Apollo XL225n Gen10 Plus benchmark result are provided here: spec.org/power_ssj2008/results/res2021q1/power_ssj2008-20210223-01073.html.

[38] Annual energy cost and rack space calculated based on the performance envelope of a 42U rack populated with HPE ProLiant XL225 Gen10 Plus servers running at 100% utilization vs. the energy and rack space required by competitor products to achieve the same performance. Average price per kWh = $0.0693.

[39] AMD EPYC Processor World Records | AMD

[40] HPE internal testing—Ansys CFX suite of standard CFD benchmark testing was completed between February 16 and 20, 2022, using the HPE Apollo 2000 Gen10 Plus platform comparing the performance of up to four compute nodes of the AMD EPYC 7543 2.8 GHz 32C CPU with 256 MB of L3 cache and the AMD EPYC 7573X 2.8 GHz 32C CPU with 3D V-Cache technology. Results may vary based on factors including silicon version, hardware and software configuration, and driver versions.

[41] Updating to the latest BIOS is always recommended when updating processors.

[42] Results may vary. For details on each benchmark result, see AMD EPYC Family Claim Information, endnotes MLNX-017, MLNX-014, and MLNX-019.

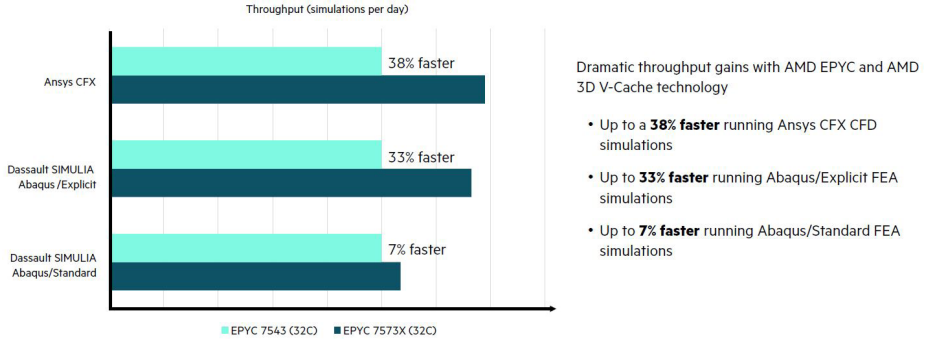

Figure 8. AMD EPYC with AMD 3D V-Cache technology significantly boosts simulation throughput

HPE continues to run a variety of internal benchmarks comparing EPYC 7003 series processors to comparable competitive CPUs using standard CAE applications on HPE servers. EPYC processors generally deliver superior performance for most of the application workloads benchmarked.[43]

Reduce data center footprint and TCO

Key metrics for CAE data center managers include job turnaround time, simulations per rack, and throughput per kilowatt-hour (kWh). Industry-standard benchmarks are helpful, but what matters more is how an organization's unique mix of HPC applications performs in the real world. The benchmarks described previously show that depending on their application, manufacturers can significantly increase throughput using the latest AMD EPYC 7003 series processors. This means that manufacturers can achieve the same performance with fewer compute nodes resulting in savings across multiple dimensions including infrastructure, power, cooling, and administrative costs. Analysis conducted by AMD suggests that manufacturers could achieve up to an estimated 51% TCO reduction over three years by upgrading to the latest AMD EPYC processors.[44]

Why HPE and AMD for CAE?

As the scale and scope of CAE continue to grow, manufacturers need reliable partners with deep HPC and manufacturing expertise. Together with AMD, HPE provides a comprehensive portfolio of high-performance systems and software, high-value services, and an outstanding ecosystem of performance-optimized CAE applications to help manufacturing customers reduce costs, improve quality, productivity, and time to market.

Worldwide, many manufacturing companies are already using these CAE solutions from HPE. As CAE becomes an even more integral part of the entire supply chain and product lifecycle, HPE Apollo 2000 Gen10 Plus systems powered by AMD EPYC processors can deliver excellent CAE application performance to help manufacturers solve their most complex problems, innovate faster, and improve productivity and profitability.

Using HPE servers with the latest AMD EPYC processors, manufacturers can:

- Accelerate the design process to meet time-to-market pressures
- Reduce runtimes to help maximize productivity
- Realize higher throughput to improve design quality
- Rightsize infrastructure investments to optimize TCO

As a market-leading CAE platform vendor, HPE delivers a unified compute and storage solution designed to simplify system and data management, reduce costs and complexity, and scale to deliver the exceptional performance needed for the next generation of CAE solutions in manufacturing.

[43] For a review of the HPE internal ISV standard benchmarks involving EPYC 7003 series processors, contact your HPE representative. These results are shared with a non-disclosure agreement (NDA).

[44] Based on a comparison of a 2P AMD EPYC 7573X-powered server running Ansys cfx-50 vs. a similarly configured 2P Intel Xeon Platinum 8362-based server to deliver 4,600 jobs per day. Detailed results and TCO calculations are provided in MLNXTCO-001 in the AMD EPYC Family Claim Information endnotes.

Learn more at

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