A new standard in CAE solutions for manufacturing

Accelerating product development and overall competitiveness using HPE systems powered by 4th Gen AMD EPYC processors

Hewlett Packard Enterprise | AMD

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

Design teams frequently run over thousands of simulated scenarios putting enormous stress on the high-performance computing (HPC) infrastructure.

Meeting manufacturing challenges with advanced simulation methods

As manufacturers of all sizes struggle with cost and competitive pressures, and as products become more complex and capable, advanced simulation methods using computer-aided engineering (CAE) tools has become essential to getting quality products to market faster.

Advanced simulation methods can help manufacturers better understand and test their products by providing detailed digital prototypes. By simulating the behavior of these prototypes before they go into production or into customers' hands, they can identify potential problems early in the process. This helps to reduce risk, save money and time, and ultimately improve product quality. Additionally, CAE tools can be used to quickly develop cost-effective designs that meet customer requirements considering factors such as materials selection, safety regulations, and overall cost.

CAE tools can also help drive innovation while mitigating risks and costs associated with potential product failures, such as warranty, recall costs, and potential litigation. Figure 1 shows how a CAE solution supporting multiple engineering disciplines can help address manufacturing business challenges and customer requirements.

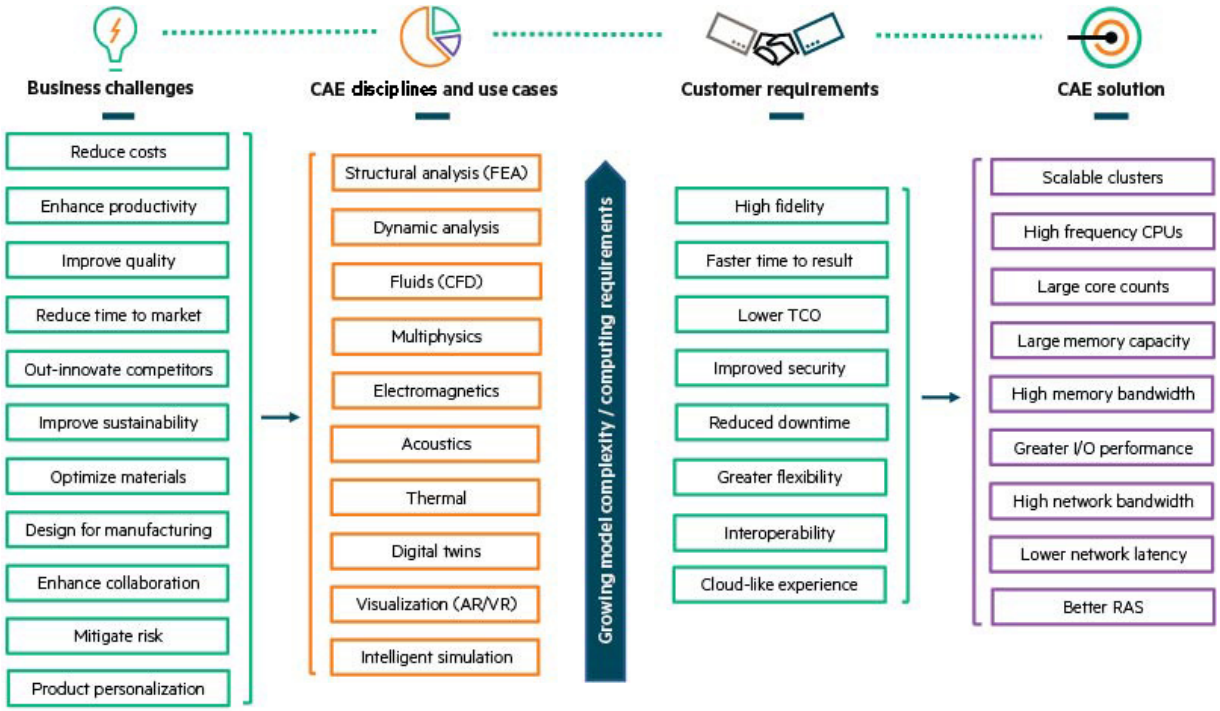

Figure 1. Manufacturing business challenges and requirements addressed with CAE

AMD high frequency, high core count processors with large memory and cache are ideal for CAE workloads, with industry-leading performance for key workloads.[1]

HPE is the market leader in HPC systems, with a 34.2% market share.[2]

Customer requirements for HPC solutions

CAE and advanced simulation are used across multiple industries from automotive manufacturing to aerospace to consumer products to industrial manufacturing. Engineers rely on CAE tool applications for applications that include testing for wind resistance/aerodynamics, assessing durability of materials, ensuring interoperability between parts and components, and optimizing product quality.

Manufacturers face a variety of product R&D challenges. They need a reliable, secure HPC environment that can help them:

- Achieve faster time to results for large simulations
- Support larger, more complex models
- Accommodate a wider variety of advanced simulation workloads
- Reduce complexity and TCO

As models grow in complexity, memory and available cache have emerged as essential requirements for the processors and servers that power CAE applications. Models are frequently comprised of millions of elements or cells. The more that a model is in CPU cache or memory, the faster a simulation can be performed. Engineering solvers typically perform calculations in parallel, exploiting modern multicore processor designs to maximize throughput and get results quickly. Depending on the application, processors with high core counts can help improve simulation throughput as long as they have large amounts of cache per core and fast memory subsystems.

Several factors are driving an increased need for advanced computer-based simulation. These include:

- **Materials optimization**—The use of more exotic materials and honeycombed structures to reduce weight and cost
- **Sustainability**—Demand for greener ecofriendly products, electric/hybrid vehicles, and higher levels of product and component recyclability and reuse
- **Compliance**—Adherence to various industry regulations related to product safety, emissions, and fuel-efficiency standards that vary by jurisdiction
- **Internet of Things (IoT)**—Smarter, more connected products incorporating a variety of sensors
- **Digital twins**—Virtual representations of physical objects that mimic their real-world counterparts

As examples, in electric and hybrid vehicles, manufacturers must allocate significant resources to simulating battery technologies to ensure optimal performance and safety. The proliferation of connected devices presents another challenge. As smart connected devices become a common feature in modern designs, engineers face new requirements related to spectrum management. They also need to worry more about electromagnetic compatibility (EMC) and electromagnetic interference (EMI).

[1] **SP5-009D:** SPECrate®2017_fp_base based on published scores from spec.org as of Jan 11, 2023. Configurations: 2P AMD EPYC™ 9654 (1480 SPECrate 2017_fp_base, 192 total cores, spec.org/cpu2017/results/res2022q4/cpu2017-20221024-32605.html) is 1.45x the performance of published 2P Intel® Xeon® Platinum 8490H (1020 SPECrate 2017_fp_base, 120 total cores, spec.org/cpu2017/results/res2023q1/cpu2017-20221206-33040.html). SPEC®, SPEC CPU®, and SPECrate® are registered trademarks of the Standard Performance Evaluation Corporation. See spec.org for more information. Based on AMD testing.

[2] "Hyperion Research HPC Market Update", Hyperion Research, page 10, November 2022

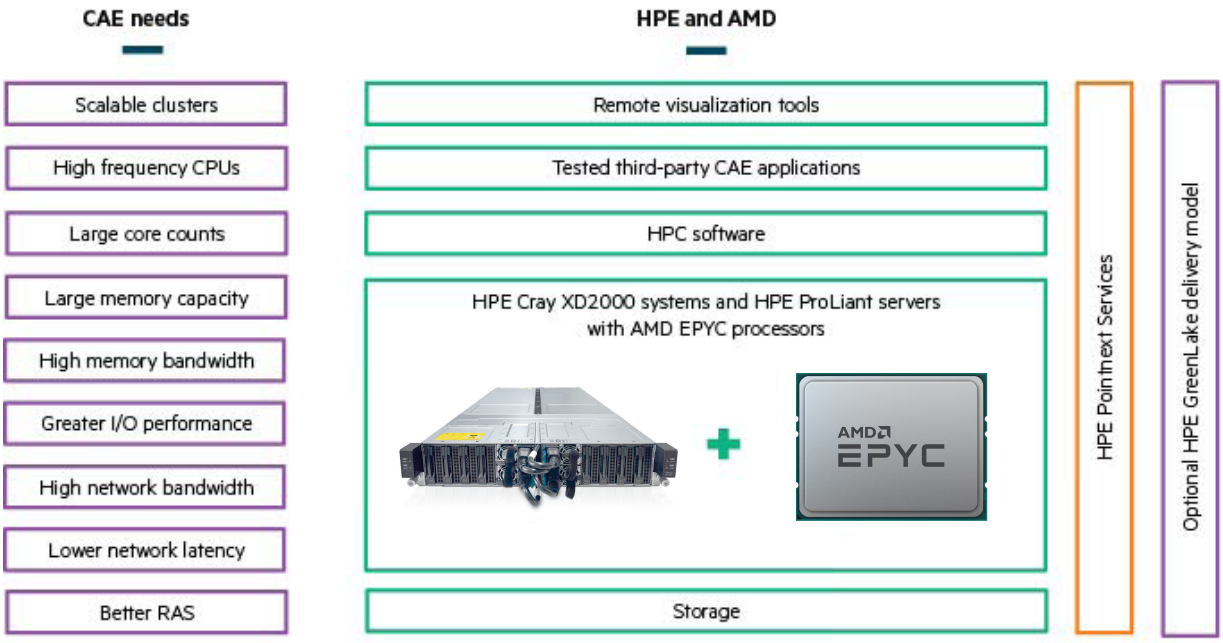

Figure 2. A high-level view of the HPE and AMD CAE solution

The use of digital twins is expected to double in the next five years. Similarly, artificial intelligence (AI) and machine learning techniques are expected to triple in applications ranging from manufacturing processes to product quality to predictive maintenance.[3] Autonomous vehicles and assistive driving technologies demand a dramatic increase in the amount of HPC infrastructure for applications such as model training.

Of the advanced simulation methods described in Figure 1, multiphysics is among the most demanding. Multiphysics combines several CAE disciplines, including structural analysis, fluid mechanics, mechanical dynamics, and electromagnetics. Engineers frequently use iterative design exploration techniques such as design of experiments (DOE) to explore the relationship between multiple design parameters to optimize complex systems.

To meet these evolving requirements, manufacturers are looking for servers with the following capabilities:

- High-frequency processors with high core counts to complete more simulations faster
- Large memory capacity, fast memory bandwidth, and high ratios of cache per core to maximize throughput
- High I/O performance for storage and network connections
- Low network latency and high network bandwidth to enable parallel simulations
- Reliability, availability, and serviceability (RAS) to maximize productivity and minimize downtime costs

Besides raw CPU performance, energy efficiency is also an important consideration for manufacturers. To reduce their carbon footprint and meet sustainability goals, data center managers need servers that deliver maximum throughput per watt to minimize power and cooling requirements. They may also need dense, energy-efficient designs that minimize cooling and data center space requirements.

As the market leader in HPC systems with a 34.2% market share, 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 a comprehensive solution that provides exceptional performance, flexibility, and choice across the full range of CAE applications. Components of the HPE and AMD CAE solution are shown in Figure 2.

[3] "2021 Survey Report: Technology Convergence for a Smarter, More Connected World: Market Trends to 2026," Altair Engineering Inc.

HPE has you covered with multiple deployment options for manufacturers, from on-premises infrastructure to colocation to private and hybrid clouds.

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 customers' business requirements. This stack provides an extensive portfolio of supported and tested third-party CAE application software. It also encompasses various system software, server, and storage platforms, delivered with high-value services and remote visualization tools.

The majority of large CAE teams choose to run their advanced engineering simulations in-house using on-premises infrastructure. Running in-house can be advantageous for several reasons. It is generally cost-efficient for organizations with sustained workloads that can keep their infrastructure highly utilized. It also ensures that sensitive intellectual property is protected and that organizations can manage costs through the lifecycle of the product.

For organizations that prefer colocation solutions, or hybrid cloud delivery models, HPE has you covered. The same powerful CAE solution can optionally be deployed on HPE GreenLake HPC for customers that prefer a managed service with a flexible cloud delivery model. These deployment options provide manufacturers with flexibility as their requirements evolve. Components of the HPE and AMD solution for CAE are described in the following:

Remote visualization: Enhances security by keeping critical data within the data center; boosts productivity and collaboration with any time, any place, or any location access to graphic-intensive models; helps lower costs by centralization, improving system manageability, and helping optimize software and hardware resource utilization; and promotes retention of highly skilled staff with better work-life balance and location flexibility. HPE offers a variety of remote visualization and virtual desktop infrastructure (VDI) solutions built using the latest 4th Gen AMD EPYC processors.[4] For CAE with demanding visualization requirements, NICE Desktop Cloud Visualization (DCV) provides efficient and optimized remote access to graphic-intensive 3D applications, including all the major CAE pre- and post-processing software.[5]

[4] "Elevate your virtual desktop experience with HPE ProLiant and AMD," HPE solution brief, 2022

[5] "NICE Software Desktop Cloud Visualization and EnginFrame," HPE QuickSpecs, 2021; DCV and EnginFrame are offered by NICE software, now part of Amazon Web Services

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

HPC architecture: 4th Gen AMD EPYC 9004 processors provide industry performance leadership for many of the most challenging workloads in CAE. For example, at the top of the 4th generation stacks, EPYC delivers up to 1.45x the throughput compared to the latest generation of alternative top-of-bin processors, helping manufacturers improve simulation throughput and engineering productivity.[6] They are also energy-efficient. An EPYC 9654, for example, provides up to 1.84x the throughput per watt compared to comparable high-end processors.[7]

HPC system software: HPE offers CAE customers a complete and modular software portfolio consisting 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 that manufacturers can select the right software mix for their CAE applications—all from one source, including OS, cluster management, job schedulers and resource managers, HPC tools and libraries, and more.

Optimized 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. These libraries can take advantage of hardware-level features such as AVX-512 instructions, available in the latest 4th Gen EPYC processors, to accelerate CAE applications that can use these extended instructions.

HPC compute nodes: HPE provides multiple high-performance server options to act as HPC compute nodes depending on customer requirements. For most commercial environments, either the HPE Cray XD2000 or HPE ProLiant servers are good choices as they fit easily into existing data center environments. Customers that prefer 3rd generation EPYC processors in dense data center environments or that have standardized on HPE iLO management may prefer HPE Apollo 2000 Gen10 Plus systems. Supercomputing facilities requiring the highest levels of performance in liquid-cooled configurations may be interested in the HPE Cray EX2500 and EX4000 supercomputers.

[6] **SP5-009D:** SPECrate®2017_fp_base based on published scores from spec.org as of Jan 11, 2023. Configurations: 2P AMD EPYC 9654 (1480 SPECrate 2017_fp_base, 192 total cores, spec.org/cpu2017/results/res2022q4/cpu2017-20221024-32605.html) is 1.45x the performance of published 2P Intel Xeon Platinum 8490H (1020 SPECrate 2017_fp_base, 120 total cores, spec.org/cpu2017/results/res2023q1/cpu2017-20221206-33040.html). SPEC®, SPEC CPU®, and SPECrate® are registered trademarks of the Standard Performance Evaluation Corporation. See spec.org for more information. Based on AMD testing.

[7] **SP5-011C:** SPECpower_ssj®2008 comparison based on published 2U, 2P Windows results as of Nov 10, 2022. Configurations: 2P AMD EPYC 9654 (30,602 overall ssj_ops/W, 2U, spec.org/power_ssj2008/results/res2022q4/power_ssj2008-20221204-01204.html) vs. 2P Intel Xeon Platinum 8480+ (16,653 overall ssj_ops/W, 2U, spec.org/power_ssj2008/results/res2023q1/power_ssj2008-20221207-01216.html). 2P AMD EPYC 7763 (23,505 overall ssj_ops/W, 2U, spec.org/power_ssj2008/results/res2021q2/power_ssj2008-20210324-01091.html) shown at 1.4x for reference. SPEC® and SPECpower_ssj® are registered trademarks of the Standard Performance Evaluation Corporation. See spec.org for more information. 30,602 ssj_ops/W / 16,653 ssj_ops/W = 1.84 energy efficiency improvement.

HPE servers and systems suitable for advanced simulation environments running CAE tools are shown in Table 1.

Table 1. HPC compute node options for advanced simulation environments

	HPE Apollo 2000 Gen10 Plus system	HPE ProLiant Gen 11	HPE Cray XD2000 system	HPE Cray EX2500/EX4000 supercomputers
Servers	HPE ProLiant XL220n Gen10 Plus server HPE ProLiant XL225n Gen10 Plus server HPE ProLiant XL290n Gen10 Plus server	HPE ProLiant DL325 Gen11 server HPE ProLiant DL365 Gen11 server HPE ProLiant DL385 Gen11 server	HPE Cray XD225v server HPE Cray XD295v server	HPE Cray EX425 blade HPE Cray EX235n blade HPE Cray EX346s blade
Processor technology	3rd Gen AMD EPYC	4th Gen AMD EPYC	4th Gen AMD EPYC	4th Gen AMD EPYC
Packaging	Dense, multiserver chassis	Standard 1/2U rackmount servers	Dense, multiserver chassis	Dense, multiserver chassis, blade-based architecture
Management	HPE iLO 5, DMTF Redfish, HPE Performance Cluster Manager	HPE iLO 5, DMTF Redfish, HPE Performance Cluster Manager	DMTF Redfish HPE Performance Cluster Manager	HPE Performance Cluster Manager
Interconnects	Ethernet, InfiniBand	Ethernet, InfiniBand	Ethernet, InfiniBand, HPE Slingshot	HPE Slingshot, dragonfly topology, optional InfiniBand, or Ethernet
Cooling options	Air cooling or Direct liquid cooling (DLC)	Air cooling only	Air cooling or DLC	Liquid cooling via cooling distribution units[8]
Ideal for	Dense HPC data center environments	Traditional air-cooled high-performance server building blocks	Dense HPC data center environments that require that latest high-performance processors	HPC centers that require the highest levels of supercomputing performance

The HPE Cray XD2000 system is a dense, multi-server platform that packs exceptional performance and workload flexibility into a small data center space while delivering the efficiencies of a shared infrastructure. Each HPE Cray XD2000 2U chassis supports up to four AMD EPYC CPU-powered HPE Cray XD225v 1U servers. Alternatively, each can support two half-width 2U 2P HPE Cray XD295v servers instead. Each of these servers can be serviced without impacting the operation of other servers in the same chassis, increasing server availability. The HPE Cray XD2000 delivers up to **4x the density** of a traditional rackmount 2U server in standard racks and provides rear-aisle serviceability access.[9]

[8] In the HPE Cray EX2500, parts of the system may be air-cooled in specific circumstances. See the HPE Cray EX Supercomputer QuickSpecs

[9] HPE Cray XD2000 QuickSpecs.

Density-optimized HPE Cray XD2000 chassis supporting up to 4x HPE Cray XD225v 1U server or 2x HPE Cray XD295v 2U servers

Figure 3. HPE data center rack with optional DLC

HPE Cray XD2000 system with 4th Gen AMD EPYC—HPE Cray XD225v (1U) and HPE Cray XD295v (2U) specifications

Processor	Up to two 4th Gen AMD EPYC processors—up to 96 cores / 192 threads per socket
OS support	Windows, Red Hat® Enterprise Linux® (RHEL), SLES, Ubuntu, HPE Cray OS, VMware®
Memory	12 channels DDR5 per CPU @4800 MT/s (up to 24 total DIMMs for 2P)
Nodes	1U/2P half-wide; up to 4 per chassis 2U/2P half-wide (GPU support); up to 2 per chassis
PCIe lanes	65 PCIe 5 lanes with 4-link XGMI + 6 bonus PCIe 3 lanes per CPU
Storage	Supports up to 2x NVMe SSDs per node (4 for 2U) and/or M.2 2280/22110
Expansion Slot	2x PCIe 5 x16 slot 1x PCIe 5 x16 MCIO slot 1x PCIe 5 x16 MCIO cable slot 1x PCIe 3 x4 M.2 Mezz
Power supply (hot plug)	CRPS PSU support 2400W 240V
Fans	4x 4056 fans per node
Cooling	Air-cooled or optional DLC

HPE Cray XD2000 systems offer a complete, scalable solution for HPC customers. They feature flexible power and cooling options, including DLC, delivering superior performance while reducing TCO. Up to 20 HPE Cray XD2000 chassis can be installed in either 42U or 48U HPE standard racks delivering up to 80 servers, and 160 x 4th Gen AMD EPYC processors per data center rack, subject to power and cooling considerations.

Customers that wish to maximize compute density can deploy the HPE Cray XD2000 with up to four 1U HPE Cray XD225v servers per chassis. For customers running GPU workloads, up to two HPE Cray XD295v servers can be installed in each chassis supporting the latest GPUs, including NVIDIA® T4, A30, or A100, or AMD Instinct™ MI series PCIe accelerators.

Manufacturers can also use HPE Performance Cluster Manager, a fully integrated system management solution offering all the functionality needed to manage HPE Cray XD2000 clustered servers.[10] HPE Performance Cluster Manager aggregates system management and remote management information from the standard DMTF Redfish API supported on the HPE Cray XD2000. The software also provides system setup, hardware monitoring and management, image management and updates, power management, and integrations with ISV and open-source software solutions.

HPE ProLiant servers: For CAE customers that prefer 1U, single-processor systems, the HPE ProLiant DL325 Gen11 server is an excellent solution. This server has modest power and cooling requirements and fits easily into most data center environments. For CAE workloads requiring large amounts of memory, the HPE ProLiant DL365 Gen11 or HPE ProLiant DL385 Gen11 servers are a good choice.

The HPE ProLiant DL325, DL365, and DL385 Gen11 servers pictured in Figure 4 run the latest 4th Generation AMD EPYC processors. For customers running these servers, minimum OS requirements apply. Supported operating environments include RHEL 9.0 or 8.6, SUSE Linux Enterprise Server (SLES) 15 SP4, and Windows Server 2019 or 2022.[11]

Only HPE offers industry-standard servers with firmware anchored into silicon with HPE iLO 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 our secure recovery and firmware runtime validation at startup, helps limit security breaches and system disruption if code is compromised.

Storage and networking: Fast I/O is also critical for CAE applications to ensure that file and network I/O do not become bottlenecks during simulation. HPE Cray XD2000 systems and HPE ProLiant Gen11 servers offer PCIe 5, providing twice the throughput of the previous generation PCIe 4.[12] HPE offers a variety of high-performance PCIe options, including 200 Gbps HDR and NDR InfiniBand adapters,[13] multiport 100GbE adapters, and high-performance NVMe SSDs. Customers deploying HPE Cray XD2000 systems can optionally use 200 Gbps HPE Slingshot Ethernet adapters for added network performance.

[10] HPE Performance Cluster Manager QuickSpecs

[11] HPE ProLiant DL385 Gen11 QuickSpecs

[12] PCIe 5 supports up to 32 GT/s. PCIe 4 supports up to 16 GT/s

[13] HPE InfiniBand adapters are based on standard Mellanox ConnectX-6 technology

HPE ProLiant servers

HPE ProLiant DL325 Gen11 server

- 1U 1P server
- Single 4th Gen AMD EPYC processor with up to 96 cores
- Up to 3 TB DDR5, CXL 1.1 supported
- Up to 4 LFF HDD/SSD; SAS/SATA or 10 SFF HDD/SSD; SAS/SATA/NVMe
- Up to 20 EDSFF E3.S; NVMe

HPE ProLiant DL325 Gen11 server front view

HPE ProLiant DL365 Gen11 server

- 1U 2P server
- Up to 2 x 4th Gen AMD EPYC processors with up to 96 cores
- Up to 6 TB DDR5, CXL 1.1 supported
- Up to 10 SFF HDD/SSD; SAS/SATA/NVMe; up to 20 EDSFF E3.S
- Up to 2 x16 PCIe 5 slots; up to 2 x8 OCP3.0 slots (upgradable to x16)

HPE ProLiant DL365 Gen11 server front view

HPE ProLiant DL385 Gen11 server

- 2U 2P server
- Up to 2 x 4th Gen AMD EPYC processors with up to 96 cores
- Up to 6 TB DDR5, CXL 1.1 supported
- Up to 12 LFF HDD/SSD; SAS/SATA; up to 24 SFF HDD/SSD; SAS/SATA/NVMe; up to 36 EDSFF E3.S; up to 48 SFF HDD/SDD
- Up to 8 PCIe 5 slots; up to 2 x8 OCP3.0 slots (upgradable to x16)

HPE ProLiant DL385 Gen11 server front view

Figure 4. HPE ProLiant servers for CAE workloads

Multiple storage options are available inside the chassis ranging from 0 to 24 (SFF) SAS/SATA. For data sets that exceed the storage capacity available inside the chassis, HPE offers two options for a shared external parallel file system depending on the customers' preference:

- Cray ClusterStor E1000 Storage Systems—An HPE storage product available in all-flash, disk, or hybrid configurations that embeds the open-source Lustre file system with full enterprise support for both hardware and software from Advisory and Professional Services

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

HPE GreenLake for High Performance Computing (HPC): Customers can also opt for a fully managed cloud-like delivery model based on the HPE GreenLake edge-to-cloud platform.

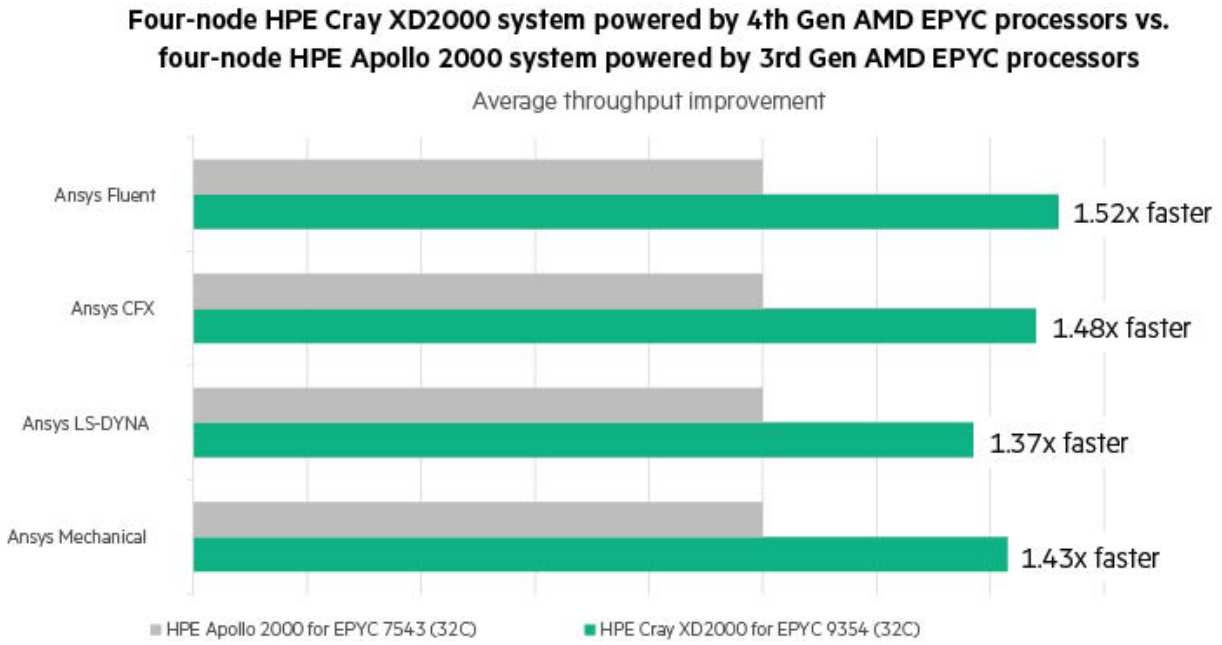

Figure 5. Comparing a four-node HPE Cray XD2000 system with 4th Gen EPYC processors to a four-node HPE Apollo 2000 system

A four-node HPE Cray XD2000 system powered by 4th Gen AMD EPYC processors delivered up to 1.52x the throughput of a similarly configured HPE Apollo 2000 system running a mix of standard Ansys Fluent workloads.

Industry-leading performance

HPE Cray XD2000 systems and HPE ProLiant Gen11 servers can provide a decisive competitive advantage for manufacturers. In January 2023, HPE undertook a comprehensive series of internal tests, evaluating the latest 32-core 4th Gen AMD EPYC 9354 processor against a similar 3rd Gen AMD EPYC 7543 processor. The tests were run on an HPE Cray XD2000 system comprised of four 2P clustered nodes (256 cores) and compared to a similar HPE Apollo 2000 system based on 3rd Gen EPYC technology with four nodes and 256 cores.[14]

Four different Ansys applications were tested (Ansys Fluent, Ansys CFX, Ansys LS-DYNA, and Ansys Mechanical), each involving multiple models.[15] The average performance improvement was calculated for each application across all the models run.

As shown in Figure 5, the results are dramatic. For the CFD workloads running Ansys Fluent, the latest HPE Cray XD2000 systems powered by 4th Gen AMD EPYC processors delivered a 1.52x performance improvement vs. the similarly configured HPE Apollo 2000 system. Similar improvements were observed for the other solvers as well.[16]

[14] HPE internal testing—The Ansys test were conducted from December 2022 through January 2023 comparing performance for an HPE Apollo 2000 Gen10 Plus platform with four 2P nodes to a similar HPE Cray XD2000 system. The HPE Apollo system had 8 x 3rd Gen AMD EPYC 9543 processors with a base clock of 2.8 GHz. The HPE Cray XD2000 system had 8 x 4th Gen AMD EPYC 9354 processors with a base clock of 3.25 GHz. Results may vary based on factors including silicon version, hardware and software configuration, and driver versions.

[15] The Ansys Fluent test involved 15 different models. The Ansys CFX test involved five different models. The Ansys LS-DYNA tests involved two models. The Ansys Mechanical test involved three models.

[16] Detailed results are available from HPE with a nondisclosure agreement (NDA).

AMD EPYC processors deliver exceptional performance and scalability for CAE workloads. For example:

- Up to 1.45x the floating-point throughput of alternative processors
- A faster Infinity Fabric™, delivering 2x the speed of the previous generation
- 50% more memory channels than any other x86-architecture CPU
- Greater I/O capacity than competing processors

The "EPYC" advantage

First introduced in June 2017, 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 performance for technical workloads. For CAE customers, this can translate into faster, more thorough simulations of larger, more complex models, helping deliver a significant competitive advantage.

4th Gen AMD EPYC processors offer several advantages over the previous generation. Examples of performance:

- Up to 96 cores per processor, delivering up to 1.45x the floating-point throughput of alternative processors[17]
- A faster Infinity Fabric, delivering 2x the speed of the previous generation[18]
- 12 memory channels—50% more than competing x86-based CPUs[19]
- Greater I/O capacity than competing processors[20]
- Advanced chip-level security feature enhancements (SME, SEV-ES, SEV-SNP)

The latest EPYC processors are also energy efficient, delivering, for example, approximately 1.8x the throughput per watt based on the SPECpower_ssj2008 benchmark compared to competing processors.[21] This means manufacturing customers can achieve dramatic performance and efficiency gains by carefully selecting processor technologies for their server infrastructure.

[17] **SP5-009D:** SPECrate 2017_fp_base based on published scores from spec.org as of Jan 11, 2023. Configurations: 2P AMD EPYC 9654 (1480 SPECrate 2017_fp_base, 192 total cores, spec.org/cpu2017/results/res2022q4/cpu2017-20221024-32605.html) is 1.45x the performance of published 2P Intel Xeon Platinum 8490H (1020 SPECrate 2017_fp_base, 120 total cores, spec.org/cpu2017/results/res2023q1/cpu2017-20221206-33040.html). SPEC®, SPEC CPU®, and SPECrate® are registered trademarks of the Standard Performance Evaluation Corporation. See spec.org for more information.

[18] "4th Gen AMD EPYC Processor Architecture," AMD, page 8.

[19] **EPYC-033A:** AMD EPYC 9004 CPUs support 12 memory channels. 3rd and 4th Gen Intel® Xeon® CPUs support 8 memory channels. 12 ÷ 8 = 1.5x the memory channels or 50% more memory channels per ark.intel.com/

[20] **EPYC-035A:** One AMD EPYC 9004 CPU supports 128 PCIe 5 lanes plus up to 8 PCIe 3 lanes. One 4th Gen Intel Xeon Scalable CPU supports up to 80 lanes of PCIe 5 per ark.intel.com/. EPYC 9004 series offers 128 ÷ 80 = 1.6x more PCIe 5 lanes.

[21] **SP5-011C:** SPECpower_ssj2008 comparison based on published 2U, 2P Windows results as of 11/10/2022. Configurations: 2P AMD EPYC 9654 (30,602 overall ssj_ops/W, 2U, spec.org/power_ssj2008/results/res2022q4/power_ssj2008-20221204-01204.html) vs. 2P Intel Xeon Platinum 8480+ (16,653 overall ssj_ops/W, 2U, spec.org/power_ssj2008/results/res2023q1/power_ssj2008-20221207-01216.html). 2P AMD EPYC 7763 (23,505 overall ssj_ops/W, 2U, spec.org/power_ssj2008/results/res2021q2/power_ssj2008-20210324-01091.html) shown at 1.4x for reference. SPEC® and SPECpower_ssj® are registered trademarks of the Standard Performance Evaluation Corporation. See spec.org for more information. 30,602 ssj_ops/W / 16,653 ssj_ops/W = 1.84 energy efficiency improvement.

An ideal architecture for CAE workloads

The unique architecture shown in Figure 4 is the key to the 4th Gen AMD EPYC processor's throughput advantage. The 13-die system-on-a-chip (SoC) features 1 I/O die and 12 core complex dies (CCDs). 32 MB of cache is shared across all cores on each CCD. The advanced 5 nm process enables clock frequencies to scale up to 4.40 GHz maximum boost for the AMD EPYC CPU shown in the following, delivering exceptional single-threaded performance for time-critical risk and pricing calculations.[22]

While other processors share relatively small amounts of L3 cache across multiple cores, 4th Gen AMD EPYC processors offer up to 384 MB of L3 cache per socket. Each core on a core complex (CCX) has a direct path to its associated L3 cache to speed throughput and help reduce latency.[23] This combination of high L3 cache per core, direct channels to cache, multiple memory channels, and fast memory combines to deliver exceptional throughput.

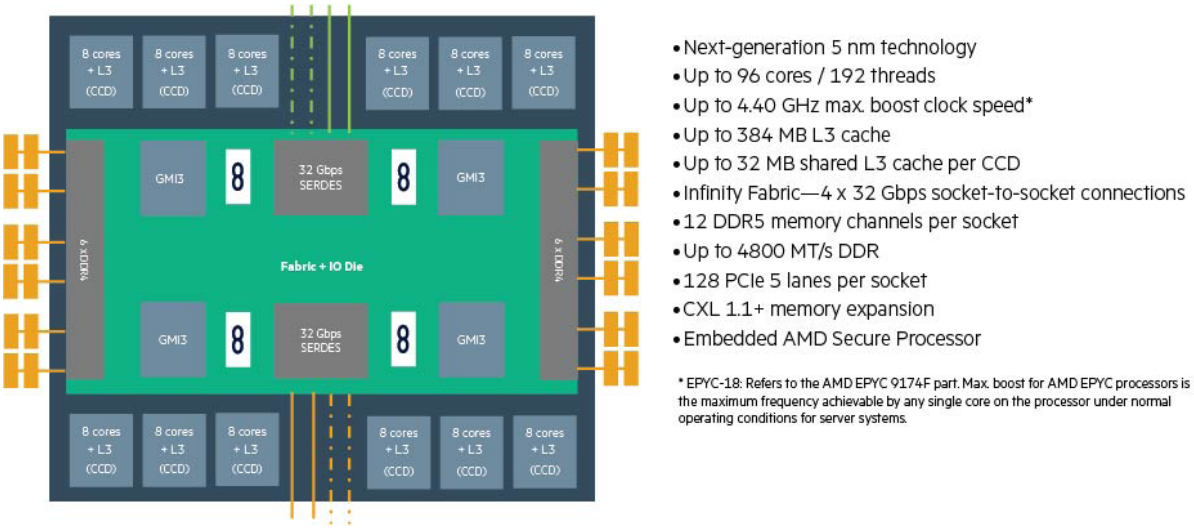

Figure 6. 4th Gen AMD EPYC 9174F high-level processor design

AMD EPYC processors are the choice of next-generation exascale supercomputers.[24] With high core counts (up to 96 cores/processor), the latest 4th Gen EPYC processors can help improve scaling and throughput and reduce simulation time. Despite their exceptional performance, they are affordable, fitting the budgets of small- or medium-sized CAE environments typically found among tier-1 and tier-2 suppliers.

For most CAE applications, either AMD EPYC 9354 or high-frequency 9374F processors with 32 cores will be of interest. Both parts deliver leadership per-core performance while offering large amounts of L3 cache per core. Combining high clock frequencies and large amounts of cache per core can help manufacturers improve performance, time to market, and reduce TCO by helping deliver better performance with a smaller data center footprint. 4th Gen AMD EPYC processors are an ideal choice for CAE workloads because they offer:

- Exceptional performance to optimize CAE tool license efficiency
- Large L3 cache-per-core ratios for reduced analysis runtime
- 12 x DDR5 high-speed memory channels for superior memory throughput
- Dedicated L3 cache per CCD, enabling more concurrent analyses per server

[22] Refers to the AMD EPYC 9174F 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 (EPYC-18).

[23] CCX is a term used in AMD CPUs and stands for Core Complex. It refers to a group of up to eight cores in 9004 series processors and their CPU caches (L1, L2, and L3). The number of cores per CCX varies by processor. See section 1.5 of the AMD EPYC 9004 Series Architecture Overview.

[24] 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 El Capitan, a collaboration between US DOE, LLNL, and HPE.

Table 2. AMD EPYC 9004 series processors recommended for CAE workloads

EPYC model	Cores / threads	Base clock	Max. boost clock[25]	All-core boost speed[26]	L3 cache	Power (watts)	Cooling	Workload type
4th Gen EPYC processors								
9654	96/192	2.40 GHz	Up to 3.7 GHz	3.55 GHz	384 MB	360	Liquid (DLC)	Throughput
9554	64/128	3.10 GHz	Up to 3.75 GHz	3.75 GHz	256 MB	360	Liquid (DLC)	Throughput
9454	48/96	2.75 GHz	3.8 GHz	3.65 GHz	256 MB	290	Air	Balanced
9354	32/64	3.25 GHz	3.8 GHz	3.75 GHz	256 MB	280	Air	Balanced
9474F	48/96	3.60 GHz	Up to 4.1 GHz	3.95 GHz	256 MB	360	Liquid (DLC)	Core performance
9374F	32/64	3.85 GHz	Up to 4.3 GHz	4.1 GHz	256 MB	320	Air	Core performance
9274F	24/48	4.05 GHz	Up to 4.30 GHz	4.1 GHz	256 MB	320	Air	Core performance
9174F	16/32	4.10 GHz	Up to 4.40 GHz	4.15 GHz	256 MB	320	Air	Core performance

A selection of the processor SKUs available for HPE Cray XD2000 systems and HPE ProLiant Gen 11 servers are shown in Table 2.[27] For CAE workloads, the highlighted processors in the 24 to 48 core range are often considered optimal to achieve a good balance of clock speed, per core throughput, and available cache. Customers can consult their HPE representative to discuss the best CPU profile depending on their workloads and goals. For customers considering an upgrade from previous generation AMD EPYC CPU-based systems, Figure 5 compares the relative throughput of 4th Gen high-frequency EPYC processors to 3rd Gen parts running the industry-standard SPEC CPU® SPECrate 2017_fp_base benchmark on servers from various manufacturers.[28] All results were run on dual-socket server configurations. In the case of the 32-core EPYC 9374F part, the latest processor technology delivers a 75% performance uplift compared to the previous-generation EPYC 73F3.[29]

[25] Maximum boost speed for EPYC processors is the maximum speed achievable by any core on the processor under normal operating conditions for server systems. (EPYC-18)

[26] All-core boost for EPYC processors is the average frequency of all processor cores running in performance mode while utilizing a low-activity workload. Actual achievable all-core boost will vary based on hardware, software, workloads, and other conditions. (EPYC-021)

[27] For a complete list of available processors, see the HPE Cray XD2000 QuickSpecs.

[28] SPEC and SPECrate are trademarks of the Standard Performance Evaluation Corporation. All rights reserved. SPECrate 2017_fp_base is a processor level benchmark, and these results are drawn from benchmarks conducted by multiple server manufacturers. All stated results are as of Feb 12, 2023, see spec.org for more information. Configurations are as follows:

96 core parts
- 2P AMD EPYC 9654 (192C) scoring 1400 SPECrate 2017_fp_base (1400/192 = 7.29 score/core)

64 core parts
- 2P AMD EPYC 7763 (128C) scoring 663 SPECrate 2017_fp_base (663/128 = 5.18 score/core)
- 2P AMD EPYC 9554 (128C) scoring 1190 SPECrate 2017_fp_base (1190/128 = 9.30 score/core)

32 core parts
- 2P AMD EPYC 75F3 (64C) scoring 546 SPECrate 2017_fp_base (546/64 = 8.53 score/core)
- 2P AMD EPYC 9374F (32C) scoring 956 SPECrate 2017_fp_base (956/64 = 14.94 score/core)

16 core parts
- 2P AMD EPYC 73F3 (16C) scoring 398 SPECrate 2017_fp_base (398/32 = 12.44 score per core)
- 2P AMD EPYC 9174F (16C) scoring 598 SPECrate 2017_fp_base (598/32 = 18.69 score per core)

[29] 2P AMD EPYC 75F3 (64C) scoring 546 SPECrate 2017_fp_base
2P AMD EPYC 9374F (32C) scoring 956 SPECrate 2017_fp_base. 956 / 546 = 1.75, a 75% throughput improvement.

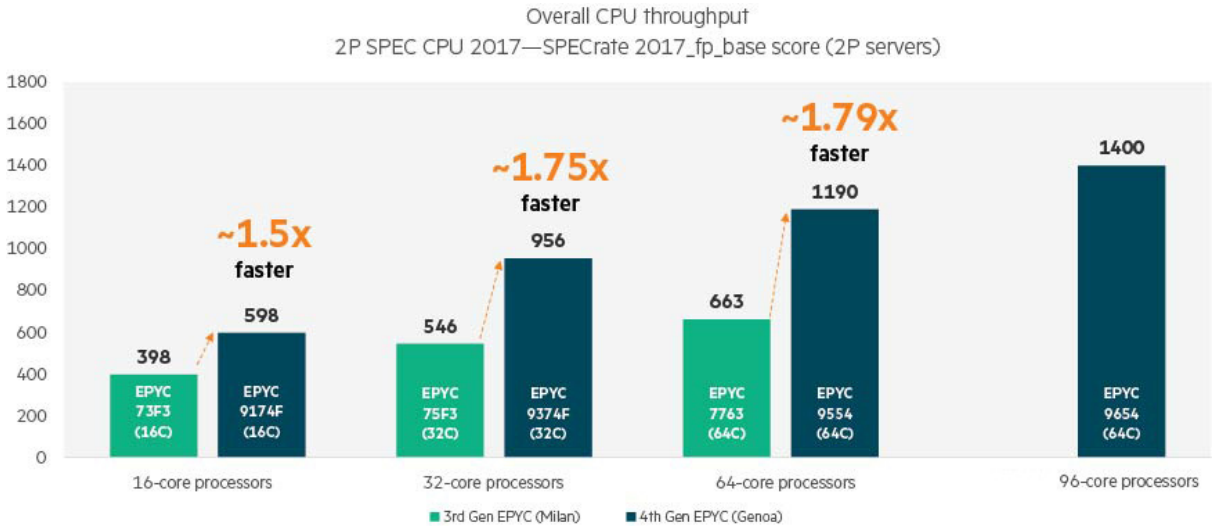

Figure 7. 4th Gen AMD EPYC throughput compared to the previous generation

The exceptional performance of 4th Gen EPYC processors results from high-clock speeds, fast DDR5 memory supporting up to 4800 MT/s, 12 memory channels per processor, and ample L3 cache. The taller bars in Figure 7 represent the latest 4th Gen AMD EPYC 9004 series processors with varying numbers of cores.[30]

Memory-intensive workloads such as CFD and computational structural mechanics (CSM) may benefit from large amounts of physical memory and L3 cache. The AMD EPYC 9354 and 9374F processors are good choices for these workloads since they offer a combination of large amounts of L3 cache and high clock-frequencies.

AMD CPU-powered HPE servers—ideal 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.

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, large amounts of L3 cache, high memory bandwidth, and massive I/O can help solve CAE problems more quickly. HPE servers with AMD EPYC processors deliver a broad range of unique choices for manufacturers to help optimize their CAE environments. High-core-count EPYC processors can deliver high throughput per node for CAE applications that benefit from multicore parallelism. Lower-core count processors with high frequencies and large L3 caches offer high performance per core, helping to utilize per-core software licenses efficiently.

Optional Direct Liquid Cooling

For customers with suitably equipped data centers, HPE Cray XD2000 systems offer plug-and-play support for Direct Liquid Cooling (DLC). The DLC option allows customers to increase power density and data center efficiency. HPE 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 specific dense configurations involving 360 watt processors, HPE may recommend the HPE Cray XD2000 system with the DLC option.[31]

[30] Note that there is no 3rd Gen EPYC part with 96 cores per socket.

[31] See the HPE Cray XD2000 QuickSpecs for details.

Advancing sustainability initiatives

For data center operators, power consumption and associated carbon emissions are increasingly essential considerations—not just for environmental sustainability goals but also to help reduce TCO. 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.[32] 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.[33] 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 fewer nodes are required to deliver the same simulation throughput.

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 infrastructure for simulation workloads. HPE is a leader in traditional HPC, and 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. CAEaaS 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 rightsizing plus the ability for capacity bursting on-site, on demand.

HPE can help find the optimal solution for CAE workloads

Customers run a wide variety of CAE workloads depending on their industry, mix of tools, and unique business requirements. HPE works closely with AMD and ISV partners to run a variety of internal benchmarks comparing systems based on 4th Gen EPYC processors to competitive CPUs using standard CAE applications. HPE can help customers find the optimal solution for their needs by sharing details of standard benchmarks we have run. We can also assist customers who wish to benchmark their own application workloads. For additional details on available benchmarks or to inquire about running your own benchmarks, contact your HPE representative.

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 manufacturers can significantly increase simulation throughput for various CAE workloads using HPE Cray XD2000 systems powered by 4th Gen AMD EPYC processors. This means that manufacturers can often achieve the same performance with fewer compute nodes resulting in savings across multiple dimensions, including infrastructure, power, cooling, and administrative costs.

[32] Includes high-performance CPU and GPU accelerators used for AI training and HPC in a 4-accelerator, CPU-hosted configuration. Goal calculations are based on performance scores as measured by standard performance metrics (HPC: LINPACK DGEMM kernel FLOPS with 4K matrix size. AI training: lower precision training-focused floating-point math DGEMM kernels such as FP16 or BF16 FLOPS operating on 4K matrices) divided by the rated power consumption of a representative accelerated compute node including the CPU host + memory and four GPU accelerators.

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

Conclusion: 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.

HPE GreenLake for HPC provides a cloud-like experience with a number of consumption and delivery options to suit the skillsets and bandwidth of IT organizations. These range from fully managed, pay-per-use* models to scalable solutions with self service capabilities.

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 Cray XD2000 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
- Rightsized 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.

Experience HPE GreenLake cloud services for HPC.

Take HPE GreenLake for a no-cost, no-obligation test drive. This guided, hands-on experience allows you to explore cloud services in a live production environment.

* May be subject to minimums or reserve capacity may apply

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