
4 WAYS AMD MODERNIZES DATA CENTER COMPUTING
AMD
together we advance_

Today's enterprise requires rapid advances in computing power and efficiency. Data agility—the ability to treat data as a living, breathing asset—is unlocking new opportunities with deeper insight. Digital transformation and advanced capabilities like machine learning and AI are beginning to drive a new productivity boom. But there are also new enterprise vulnerabilities, from economic uncertainty and new regulations to energy costs and supply-chain risk. Steady progress is challenging amid a storm of innovation and disruption. Data center leaders can take on these challenges with AMD.

As more organizations modernize their data centers, AMD is committed to producing a portfolio of processors and platforms that advance data center innovation. Our high-performance, adaptive and intelligent solutions are backed by long-term roadmaps for continuous advancement and optimization of your IT investment.

AMD EPYC™ processors lead a robust portfolio delivering extensive choice and outstanding value for your data center needs. AMD EPYC processors offer high performance—including the highest performance server CPU in the world.[SP5-013B] Our portfolio is optimized for workloads with a full stack of solutions to meet customer demands. And our ecosystem of technology partnerships accelerates time-to-value. AMD EPYC processors provide the power and efficiency to thrill us, move us and help us work smarter.

The AMD 'Zen' microprocessor architecture has been the consistent foundation across AMD EPYC processor generations and platforms, helping deliver easy data center upgrades and transformations, done at your own pace and on your own budget, whether on-premises, in the cloud or hybrid. AMD EPYC™ 9004 Series Processors are rising the bar yet again for workload performance, bringing you the next generation of server architecture and energy efficiency, today.

4 WAYS AMD MODERNIZES DATA CENTER COMPUTING:

1. Experience continued performance leaps
2. Open up a new world
3. Modernize efficiently while advancing data center sustainability
4. Target and manage a new set of business vulnerabilities

1

EXPERIENCE CONTINUED

PERFORMANCE LEAPS

AMD powers the modern data center with high-performance and adaptive solutions. The AMD portfolio of CPUs, GPUs, DPUs, FPGAs and Adaptive SOCs deliver high throughput for faster time to results, helping provide more and better business insights for decision making, driving better business outcomes and continued productivity improvements. It's a story of many platforms, all in one family.

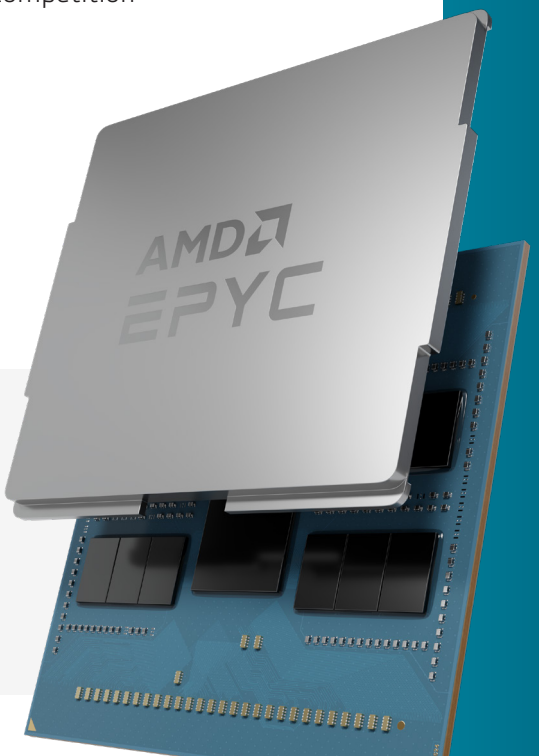
AMD has delivered on a multi-year AMD EPYC processor roadmap, delivering increasingly powerful performance, the way you need it. With AMD, you have the flexibility to optimize at the system level and scale horizontally or vertically to meet your business goals.

And now AMD is breaking even more new ground, launching the AMD EPYC 9004 Series of processors, and introducing several industry firsts:

- The only x86-compatible 5-nanometer server CPUs, with up to 96 cores
- Leading memory bandwidth through 12 channels of DDR5[EPYC-032A]
- Impressive IO with 128 lanes of PCIe® Gen 5: 1.6x more than our competition[EPYC-035A]

The results: gain 2.1x the integer and 2.2x the floating-point top-of-stack performance compared to our previous generation processors.[SP5-001C, SP5-002C]

Get ready for faster information, faster business decisions and faster action.



HIGHEST-PERFORMING

SERVER PROCESSOR

The latest generation of AMD EPYC™ processors feature the world's highest performing server processor[SP5-013B] and is optimized for a wide range of workloads spanning from the enterprise to the cloud.

POWERING THE MODERN DATA CENTER

AMD's portfolio of hardware and software platforms can power all of your data center needs

Server CPUs, GPU Accelerators, SmartNICs, DPUs, FPGAs and Adaptive SoCs

AMD EPYC
AMD INSTINCT
AMD PENSANDO
XILINX ALVEO
XILINX VERSAL

5,000+ Software Engineers, AMD CPU Tools and Compilers, Developer Toolkits and Libraries, ML-Based Design Optimization, Collaborative Design Environment, Unified AI Software and more

AMD ROCm
AMD ZenDNN
AMD VITIS
AMD VIVADO

AMD

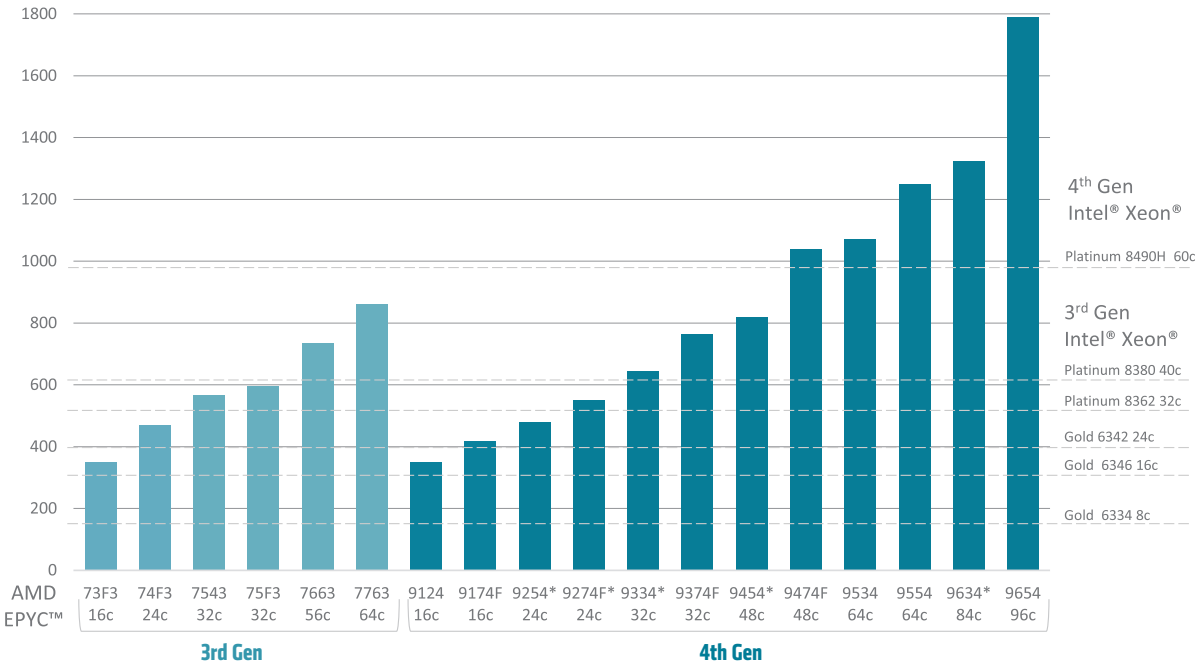
LEADERSHIP INTEGER PERFORMANCE

AMD EPYC™ 9004 processors deliver up to ~26% estimated average generational performance gains in mid-tier CPUs where most customers can benefit.[SP5-019]

Whether you're seeking virtualization, containerization, hybrid cloud or software-defined infrastructure opportunities, there is an AMD EPYC processor-powered solution to meet your needs—all thanks to our strong strategic technology partnerships with leading OEMs, Cloud Services Providers and leading-edge software vendors (ISVs). AMD EPYC processors are fully x86 compatible, enabling worry-free migration and seamlessly integrating into existing x86 infrastructures.

2P SPECRATE®2017_INT_BASE

INCREASINGLY POWERFUL DATA CENTER PERFORMANCE[SP5-023B]



*Estimates. See endnote SP5-023B for more details.

AMD EPYC™ ECOSYSTEM

AMD PARTNERS WITH LEADING ORGANIZATIONS ALL OVER THE WORLD TO DESIGN, INTEGRATE, DEPLOY AND OPTIMIZE DATA CENTER SOLUTIONS

ADVANTECH AIC ALTAIR anjuna Ansys
ASRock ASUS ATEME Atos BEAMR
Blackmagicdesign cadence CANONICAL casa systems
chaos V-Ray cisco CITRIX CLOUDERA CLOUDIAN
Couchbase DASSAULT SYSTEMES DATASTAX DELL Technologies
docker elastic ERICSSON Exasol
FOXCONN freeBSD FUJITSU GIGABYTE
hadoop Hewlett Packard Enterprise ingrasys Inventec iSIZE
JMA JUNIPER KEYSIGHT TECHNOLOGIES KIOXIA Lenovo
lightbits LIQID MariaDB MAVENIR Mentor
MICROCHIP Micron Microsoft mongoDB
msi MySQL NETSCOUT NOKIA NUTANIX
ORACLE Pivot3 PostgreSQL QCT Quobyte
Radisys Red Hat redislabs rescale
ROBIN SAMSUNG SAP sas SHEARWATER REVEAL
SIEMENS SingleStore SK hynix splunk> StorMagic
SUPERMICRO SUSE SYNOPSYS TigerGraph TRANSWARP
TYAN VELOCIX VERTICA vmware WEKA.io
Western Digital wiwynn

The cloud computing industry continues to show growing preference for AMD products.

- AWS offers various instances enabling optimizations for both cost and performance for general purpose and demanding workloads.
- Google Cloud N2D and C2D virtual machines (VMs) are enabling enhanced security offerings with 3rd Gen AMD EPYC processors.
- Microsoft Azure is the first public cloud provider to deploy AMD Instinct™ MI200 accelerators for large scale AI training.
- As part of the Oracle Cloud VMware® solution product offering, new Oracle Cloud Infrastructure E4 Dense instances leverage AMD EPYC processors to deliver ideal performance for hybrid cloud environments.

TBI

TBI shifted their CAD, BIM and other demanding 3D applications to a VDI environment on Microsoft Azure NVv4 Instances powered by AMD Radeon Instinct™ MI25 GPUs and AMD EPYC™ 7002 CPUs to gain **affordable yet impressive performance, improved managability and security, and flexibility** in how and where their engineers and site managers work.

> **"It was cheaper and it performed the same as before. All machines are running on the same versions, all CAD is the same build. And it's easier to keep up with technology in the cloud."**

FRANK WOLBERTUS
BIM Solution Specialist, TBI SSC-ICT

THE WORLD'S LARGEST HYPERSCALERS RUN ON AMD EPYC™ PROCESSORS

aws

Google Cloud

Microsoft Azure

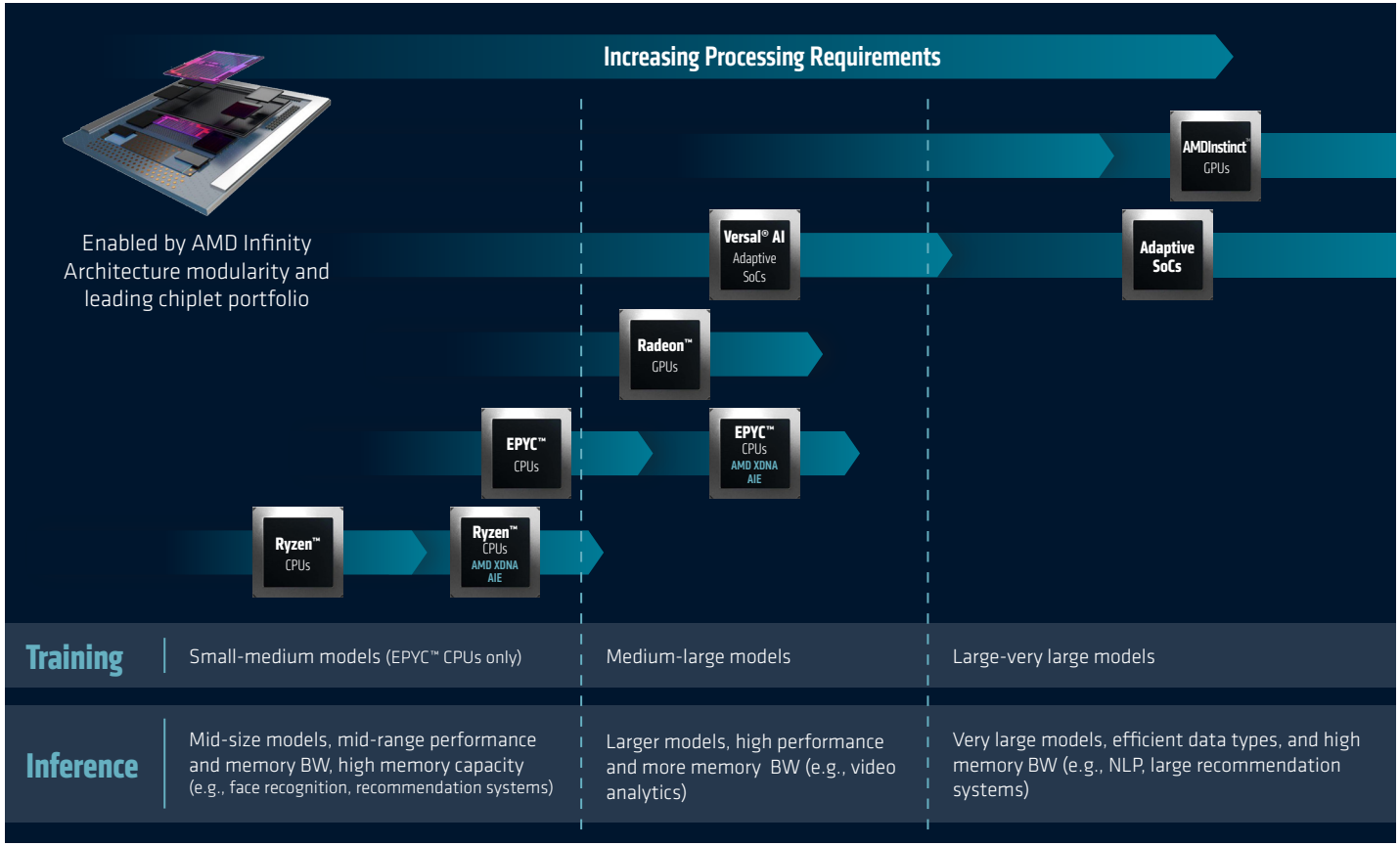
ORACLE CLOUD

AMD

The AMD data center portfolio is ideal in addressing specific HPC and AI applications across the cloud, edge and endpoint.

- The Frontier supercomputer, powered by AMD EPYC CPUs and AMD Instinct™ accelerators, holds the number one spot on the latest Top500 list. AMD also powers 75% of the top 20 systems on the Green500 list.[1]
- The HPC industry continues to show rapidly growing preference for AMD solutions, with a 38% year-over-year increase in the number of AMD technology powered systems on the Top500 list.[1]
- The AMD unified AI software stack represents a broad deployment of an AI engine across the entire AMD processor family. In fact, AMD EPYC CPU-powered servers are more often selected for AI Inference Datacenter and Training solutions posted on MLcommons.org than Intel® Xeon® Scalable CPU-based servers.[EPYC-037]

AMD EXPANDED PORTFOLIO FOR
AI APPLICATION COVERAGE



HPC

A 2P AMD EPYC 9654-powered server

OUTPERFORMS BY

45%

a 2P Intel® Xeon® Platinum 8490H-powered server on SPECrate®2017_fp_base for faster HPC performance in design simulations and research[SP5-097]

ADVANCING PERVASIVE AI

- Training and Inference across Cloud, Edge and Endpoint
- Leadership Roadmap with AMD Instinct™ Accelerators
- Broad Deployment of AI Engine across AMD
- AMD Unified AI Software Stack

2 OPEN UP A NEW WORLD

What if it felt like you were getting 28 hours of processing in a day? New capabilities in AI, HPC and analytics—and even virtualization and cloud—can drive your progress in a rapidly changing world. AMD EPYC processors are designed for solutions, not just specs so you can achieve deeper insights, faster HPC/AI/ML value or incredible animations and simulations.

AMD EPYC™ PROCESSORS POWER THE WORLD'S MOST IMPORTANT WORKLOADS

Generate new domains of value from leadership workload performance with a system-on-chip that's designed for solutions not just specs. Improvements such as 128 PCIe Gen5 lanes [EPYC-035A] for higher throughput help you gain deeper insights, improve the value of AI/ML, or create incredible animations and simulations. It's the opportunity to redefine your potential and set new, ambitious goals.

Built on AMD 'Zen3' and 'Zen4' microarchitecture-based cores and AMD Infinity Architecture, AMD EPYC 3rd and 4th Gen processors provide a full feature set across the stack with leadership I/O and 7nm or 5nm x86 CPU technology. They enable up to 32MB of L3 cache per core, 4-6-8 (3rd Gen) or 2-4-6-8-10-12 (4th Gen) memory channel interleaving to optimize performance in multiple DIMM configurations and synchronized clocks between fabric and memory—technologies that come together to drive leadership performance.

ENTERPRISE PERFORMANCE

90%

HIGHER GENERATIONAL TOP-OF-STACK PERFORMANCE

for Enterprises with Server-Side Java® Max Throughput instances for improved virtualization, SDS/HCI, Hadoop® and NoSQL instances[SP5-005C]

BUSINESS TRANSACTIONS

A 2P 96-core AMD EPYC 9654 powered server delivers

63%

BETTER MAX-JOPS PERFORMANCE

vs. a 2P 60-core Intel® Xeon® Platinum 8490H powered server on SPECjbb® 2015-MultiJVM workload, for more business transactions per second [SP5-012C]

DATABASE PERFORMANCE

~30%

HIGHER GENERATIONAL PERFORMANCE

with Oracle 19c DSS for more queries[SP5-030]

AMD

The capabilities and features of AMD EPYC processors pay off when it comes to performance for your workloads. AMD EPYC processors hold 300+ published world records and has earned them while meeting the strict SLA criteria included in all benchmark tests.

DATA MANAGEMENT

22 Structured Data & Analytics

30 Unstructured Data & Analytics

BUSINESS APPLICATIONS

8 ERP Business Apps

48 Java® Based Performance

18 Energy Efficiency

INFRASTRUCTURE/HCI/SDI

23 Cloud and Virtualization

15 Integer Performance

HPC/ENGINEERING/TECHNICAL

73 High Performance Computing Apps

53 Floating Point Performance

12 Floating Point Energy Efficiency

VIRTUALIZATION

2P 96-core AMD EPYC 9654 powered servers offer

2.8x THE SCORE

3.1x THE TILE (VM) CAPACITY

vs. 2P 40-core Intel® Xeon® Platinum 8380 powered servers for improved virtualization and consolidation[SP5-049A]

WEATHER FORECASTING

2P 96-core AMD EPYC 9654 powered servers deliver

UP TO

~150%

FASTER WEATHER FORECASTING

capabilities on WRF® - Conus 2.5km than 2P 40-core Intel® Xeon® Platinum 8380 powered servers[SP5-032]

COMPUTATIONAL FLUID DYNAMICS

2P 96-core AMD EPYC 9654 powered servers enable

UP TO

~1.5x

HIGHER ANSYS® FLUENT® PERFORMANCE

than 2P 40-core Intel® Xeon® Platinum 8380 powered servers for improved computational fluid dynamics[SP5-034A]

THE ERA OF EXASCALE IS HERE

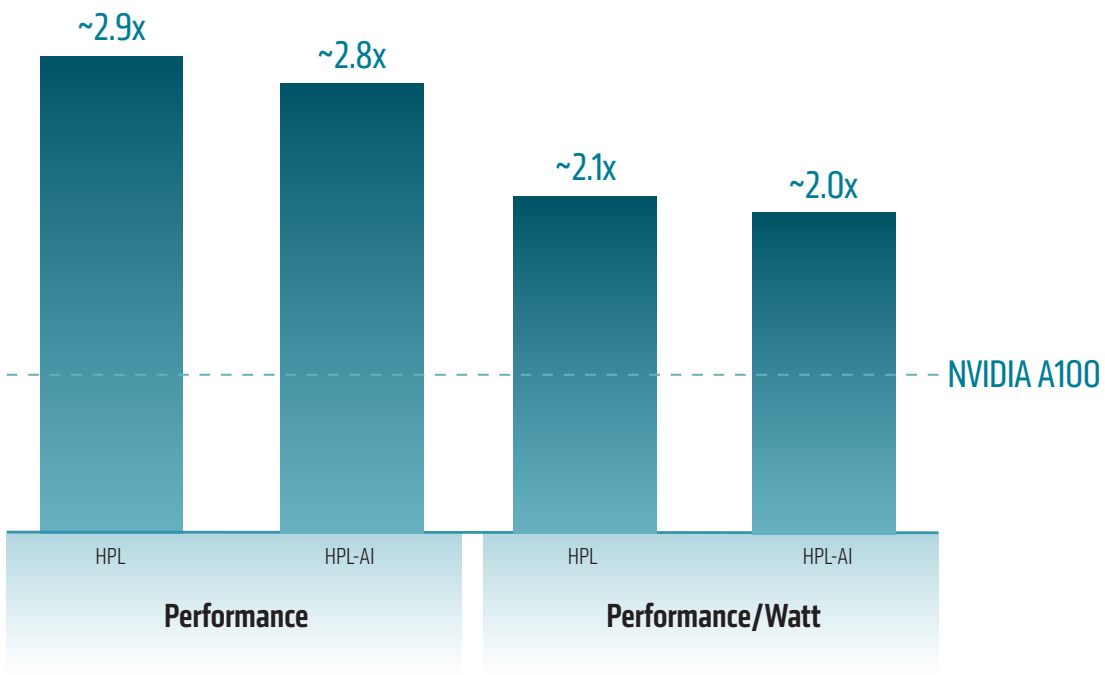
Immense computational power coupled with the fusion of HPC and AI is enabling researchers and scientists to tackle our most pressing challenges from climate change to vaccine research. With the **AMD Instinct™ MI200 accelerators and ROCm™ 5.0 software ecosystem**, innovators can tap the power of the world's most powerful HPC and AI data center GPUs to accelerate their time to science and discovery.[MI200-01] AMD Instinct accelerators are leading the exascale supercomputing era, powering the number one supercomputer on the Top500, 75% of the top 20 systems on the Green500 and the third fastest HPC/AI supercomputer.[1]

AMD Instinct MI250 series accelerators vs. Nvidia® A100 80GB SXM:

- HPL-AI benchmark - Up to ~2.88x the TFLOPS (4GPUs), and ~2.0x the performance/watt [MI200-81]
- HPL benchmark - Up to ~2.9x the TFLOPS (4GPUs), and ~2.1x the performance/watt [MI200-69A]
- HPL benchmark – Up to ~2.6x the TFLOPS (1GPU), and ~1.8x the performance/watt [MI200-69A]

LEADERSHIP PERFORMANCE AND EFFICIENCY

AMD INSTINCT™ MI250X VS. NVIDIA A100 (4 GPU) [MI200-069A, MI200-081]



IPGP | Université de Paris

The Institut de Physique du Globe de Paris deployed AMD EPYC processor-powered Lenovo ThinkSystem servers to increase performance for pioneering earth and planetary science research 5x versus its previous supercomputer, delivering 298 TLOPS peak CPU performance and up to 100x single-application speed boost.

> **"In terms of price, quality, and number of cores, Lenovo's offering, powered by AMD EPYC processors, was the best for our requirements."**

GENEVIÈVE MOGUILNY
Operations Manager, S-CAPAD, IPGP

AMD

3 MODERNIZE EFFICIENTLY WHILE ADDRESSING DATA CENTER SUSTAINABILITY GOALS

In addition to the performance demands on data centers, IT leaders consistently grapple with demands to modernize data center capabilities and manage efficiency—particularly when it comes to the budget for power and cooling. More recently, IT leaders are also called upon to help achieve sustainability goals. With AMD EPYC processors, tackling modernization, efficiency and sustainability are all possible.

With AMD EPYC processors, you can enable rapid digital transformations and performance gains while simultaneously delivering efficiency, often by deploying fewer servers to accomplish the same IT jobs. Lay the groundwork for rapid transformation and efficiency gains so you get more performance from the same or less data-center power, space or budget and its associated lower CO_2 generation. Gain benefits from advanced virtualization, hyperconverged infrastructure and containerization—whether on premises or in the cloud.

AMD HAS THE ADVANTAGE IN DATA CENTER MODERNIZATION MLNTCO-001, MLNTCO-002, MLNTCO-004

ESTIMATED BENEFITS OF AMD EPYC™ VS INTEL® XEON® PROCESSOR-BASED SERVERS IN THE DELIVERY OF 640 VIRTUAL MACHINES

AMD EPYC™	INTEL® XEON®	SUPPORT LICENSES/ SERVERS	POWER/COOLING COST SAVINGS	PER-CORE PERFORMANCE	ANNUAL COST SAVINGS
5 x 2P AMD EPYC™ 7763 64c	10 x 2P Intel® Xeon® Gold 6338 32c	Equivalent licenses and **50% fewer servers**	**32%**	Comparable	**17%**
20 x 2P AMD EPYC™ 7313 16c	20 x 2P Intel® Xeon® Gold 6346 16c	Equivalent servers and licenses	**19%**	**11% more performance**	**11%**
40 x1P AMD EPYC™ 7313P 16c	40x 2P Intel® Xeon® 4309Y 8c	Equivalent servers and **50% fewer licenses**	**15%**	**17% more performance**	**19%**

EFFICIENCY GAINS

GET

~24%

MORE INTEGER PERFORMANCE PER WATT

~52%

MORE FLOATING-POINT PERFORMANCE PER WATT

than the previous processor generation at the same core count (2x 64-core AMD EPYC 9534 vs. 2x 64-core AMD EPYC 7763) SP5-003A, SP5-004A

ENERGY EFFICIENCY

~89%

FEWER SERVERS USE LESS POWER AND LOWER RELATED EMISSIONS

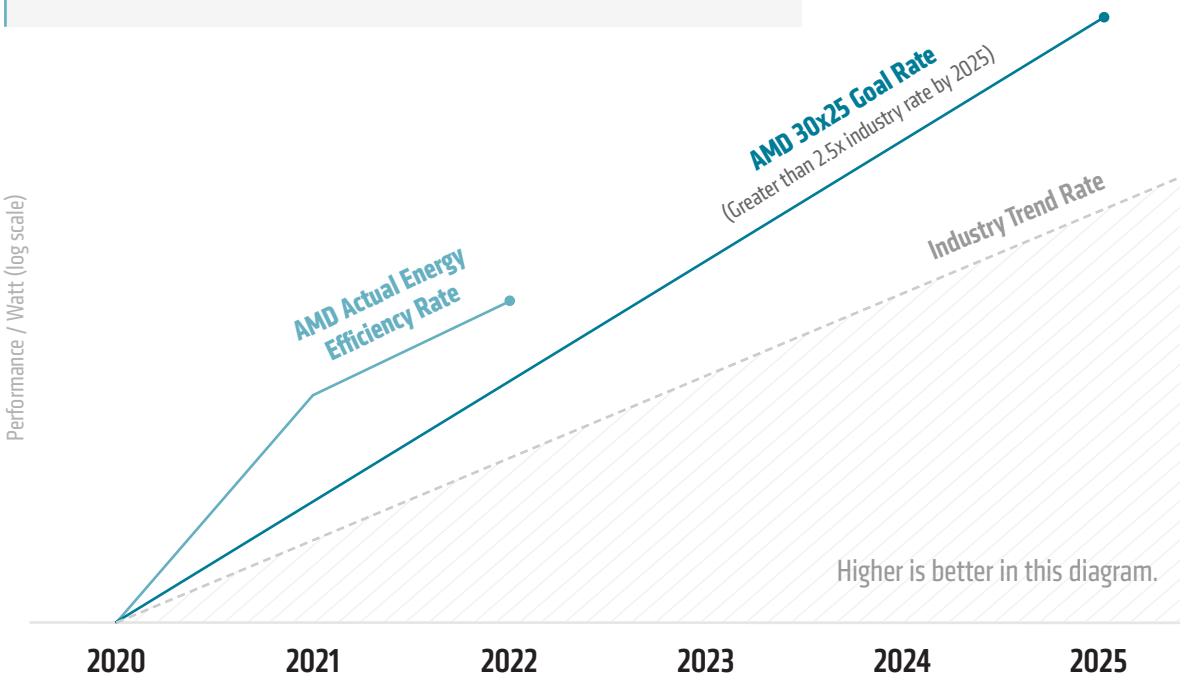
It takes just 8 new 2P 96-core AMD EPYC 9654 powered servers to deliver 1500 VMs with 1 core and 8GB of memory per VM compared to 47 four-year-old 2P 16-core Intel® Xeon® 6130 powered servers. The AMD EPYC processor-based solution uses an estimated 89% fewer servers, and 57% less power, saving ~516,633kWH of electricity over three years, resulting in the carbon sequestration equivalent of 94 acres of US forest annually SP5TCO-016

ADVANCING DATA CENTER SUSTAINABILITY

From 2020 through 2025, AMD plans to deliver a **30x increase in energy efficiency** for AMD processors and accelerators powering servers for the demanding workloads of HPC and AI. It's a goal that represents more than a **2.5x acceleration** of industry trends from 2015-2020 as measured by the worldwide energy consumption for these computing segments, and it equates to a **97% reduction in energy use per computation** (based on 2015-2020 industry trends in energy efficiency gains and data center energy consumption in 2025; see https://www.amd.com/en/corporate-responsibility/data-center-sustainability to learn more). In 2022 AMD is at **6.8x improvement** using an accelerated compute node powered by one 3rd Gen AMD EPYC CPU and four AMD Instinct MI250x GPUs.[2]

ACCELERATING DATA CENTER SUSTAINABILITY

30x AMD has set the goal of a 30x increase in energy efficiency for AMD processors and accelerators powering servers for HPC and AI-training (2020-2025)



DBS

DBS Bank Ltd. employed Dell PowerEdge servers powered by AMD EPYC processors to reduce its data center footprint to a quarter of the original size, consuming half the power and providing a 10x increase in room for growth.

> **"Our new quarter-sized data center is able to provide us with 40x efficiency."**

CHOON BOON TAN
Managing Director and Head of Cloud Engineering & Services, DBS Bank Ltd.

AMD

4 HELP TARGET AND MANAGE A NEW SET OF BUSINESS VULNERABILITIES

AMD enables organizations to better manage the myriad of vulnerabilities today, from cybercrime and privacy to compliance and business continuity. It starts with AMD Infinity Guard features built to help defend against internal and external threats and keep your data safe. These built-in IT security capabilities are fundamental to AMD EPYC processors—but these features also help mitigate a wider range of enterprise risks. Increased data-center efficiency can put less strain on energy sources with more capabilities and options at comparable energy and space profiles per node as well as help reduce the back-up power required for continuity in case of interruptions. Compliance and corporate responsibility are more straightforward with the confidence that AMD works with suppliers to advance human rights, drive environmental sustainability and support supply chain resilience.

MODERN SECURITY FEATURES

Data security is paramount in today's world. AMD continues to drive its leading Security by Design in x86 CPUs with its 4th Gen AMD EPYC processors, now with up to 1006 unique encryption keys, to help keep your data under your control. The AMD approach includes a set of modern security features and a silicon embedded security subsystem to help protect your data.

The AMD EPYC 9004 Series expands further on the AMD Infinity Guard security features, adding layers for both physical and virtual security.

AMD also enables **confidential computing with virtually no performance degradation**, addressing the special security concerns about migrating sensitive applications and data to the cloud. AMD EPYC processors offer **near-zero performance impact** running the STAC-A2 benchmark on AMD-based systems with AMD Secure Encrypted Virtualization (SEV) enabled.[3] In third-party testing, enabling AMD security features results in just a **1.7% difference** in online transaction processing (OLTP) performance.[4]

AMD Infinity Guard offers a state-of-the-art set of modern security features that help decrease potential attack surfaces as software is booted, executed and processes your critical data:[GD-183]

AMD SECURE PROCESSOR
A hardware root of trust which helps protect confidentiality and integrity of data with minor impact to system performance.

SECURE MEMORY ENCRYPTION
The industry's first full memory encryption, this innovative technology helps defend data against certain cold boot and even physical attacks.

SECURE ENCRYPTED VIRTUALIZATION
A set of technologies that help protect virtual machines with one of up to 509 (3rd Gen) or 1006 (4th Gen) unique encryption keys known only to the AMD Secure Processor, which is a subset of an AMD EPYC processor.

AMD SHADOW STACK
Hardware-enforced stack protection capabilities to help guard against malware attacks.

AMD EPYC ROADMAP EXECUTION

AMD has a long history of executing on its long-term processor roadmap, helping CIOs and data center leaders take the risk out of their planning and budgeting.

- AMD has extended data center product portfolio leadership with the complementary additions of Xilinx and Pensando Systems.[5]
- With a broad product portfolio, AMD is uniquely positioned to help customers develop and deploy applications with multiple forms of AI.[6]
- Despite global supply chain challenges, AMD has continued to meet its CPU portfolio release dates.

A RELIABLE—AND RESPONSIBLE—SUPPLY CHAIN

The social and environmental risks in the global semiconductor supply chain are persistent and real—which, in part, drives the AMD commitment to adhere to the highest standards. With the growing number of electronic devices being used globally comes the responsibility to help ensure that we are doing the right thing and conducting our business ethically. We are committed to delivering high-quality products and helping ensure that working conditions throughout our supply chain are safe, workers are treated with respect and dignity and the manufacturing processes of our products are environmentally responsible.[7]

- **100%** of AMD supplier manufacturing factories to have a Responsible Business Alliance (RBA) audit or equivalent by 2025.
- **100%** of AMD manufacturing suppliers have public emissions reduction goals by 2025.
- **80%** of AMD manufacturing suppliers source renewable energy by 2025.

AMD

See for yourself how AMD can help advance your data center with the performance, efficiency and scalability your business needs.

Discover more with AMD resources and interactive tools to customize your own configurations and calculate the benefits for your business.

- AMD EPYC Processor Selector Tool
- AMD EPYC Server Virtualization TCO Estimation Tool
- AMD EPYC Bare Metal and Greenhouse Gas Emissions TCO Estimation Tool
- AMD Cloud Cost Advisor
- AMD Instinct Benchmarks
- AMD CDNATM 2 Architecture
- AMD ROCm Information Portal
- AMD Infinity Architecture
- AMD Infinity Hub

AMD

Endnotes:

Visit https://www.amd.com/en/claims/epyc4 for more details on claims.

1 Top500 and Green500 lists as of November 2022:
https://ir.amd.com/news-events/press-releases/detail/1102/amd-drivesleadership-performance-and-energy-efficiency

2 See https://www.amd.com/en/corporate-responsibility/data-center-sustainability

3 See https://community.amd.com/t5/business/amd-epyc-processors-deliver-high-performance-confidential/ba-p/486207/jump-to/first-unread-message

4 See https://www.delltechnologies.com/asset/en-us/products/servers/industry-market/enabling-sev-es-on-amd-eypc-3rd-generation-processors.pdf

5 See https://www.amd.com/en/press-releases/2022-05-26-amd-expands-data-center-solutions-capabilities-acquisition-pensando

6 See https://www.amd.com/en/newsroom/press-releases/2022-6-9-amd-details-strategy-to-drive-next-phase-of-growth.html

7 AMD Manufacturing Suppliers are suppliers that AMD buys from directly and that provide direct materials and/or manufacturing services.

EPYC-032A: AMD EPYC 9004 CPUs support 12 channels of up to 4800 MHz DDR5 memory which is 460.8 GB/s of maximum memory throughput per socket. 4th Gen Intel Xeon Scalable/CPU Max supports 8 channels of up to 4800 MHz DDR 5 (per https://ark.intel.com/) with a maximum of 307.2 GB/s. EPYC 9004 CPUs have 1.5x the memory throughput per CPU. 460.8 ÷ 307.2 = 1.5x the max throughput or 50% more max throughput.

EPYC-035A: One AMD EPYC 9004 CPU supports 128 PCIe® Gen 5 lanes plus up to 8 PCIe3 lanes. One 4th Gen Intel Xeon Scalable CPU supports up to 80 lanes of PCIe5 per https://ark.intel.com/. 128 ÷ 80 = 1.6x.

EPYC-037: EPYC CPU-powered servers are more often selected for AI Inference Datacenter and Training solutions than Intel Xeon Scalable CPU-based servers posted on MLcommons.org as of 9/8/22. 2nd and 3rd Gen EPYC CPU-based servers power 35 of 63 inference scores in the Closed division and six of 15 Inference Closed-Power division winning ALL of the performance/W records for Image Classification, Object Detection, Medical Imaging, Speech-to-Text, NLP, and Recommendation task workloads Inference list https://mlcommons.org/en/inference-datacenter-21/. EPYC also runs on 73 of 118 platforms shown on the Training list https://mlcommons.org/en/training-normal-20/. The MLPerf™ name and logo are trademarks of MLCommons™ Association ("MLCommons") in the United States and other countries. All rights reserved. Unauthorized use strictly prohibited. See www.mlcommons.org for more information.

GD-183 AMD Infinity Guard features vary by EPYC Processor generations. Infinity Guard security features on AMD EPYC processors 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.

SP5-001C: SPECrate®2017_int_base comparison based on published results as of 11/10/2022. Configurations: 2P AMD EPYC 9654 (1790 SPECrate®2017_int_base, 192 total cores, www.spec.org/cpu2017/results/res2022q4/cpu2017-20221024-32607.html) vs. 2P AMD EPYC 7763 (861 SPECrate®2017_int_base, 128 total cores, www.spec.org/cpu2017/results/res2021q4/cpu2017-20211121-30148.html). SPEC® and SPECrate® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

SP5-002C: SPECrate®2017_fp_base comparison based on published results as of 11/10/2022. Configurations: 2P AMD EPYC 9654 (1480 SPECrate®2017_fp_base, 192 total cores, www.spec.org/cpu2017/results/res2022q4/cpu2017-20221024-32605.html) vs. 2P AMD EPYC 7763 (663 SPECrate®2017_fp_base, 128 total cores, www.spec.org/cpu2017/results/res2021q4/cpu2017-20211121-30146.html). SPEC® and SPECrate® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

SP5-003A: SPECrate®2017_int_base estimate based on internal AMD reference platform measurements and published score from www.spec.org as of 09/27/2022. Comparison of estimated 2P AMD EPYC 9534 (1070 SPECrate®2017_int_base, 560 Total TDP W, 128 Total Cores, $17606 Total CPU $, AMD Est) is 1.24x the performance of published 2P AMD EPYC 7763 (861 SPECrate®2017_int_base, 560 Total TDP W, 128 Total Cores, $15780 Total CPU $, http://spec.org/cpu2017/results/res2021q4/cpu2017-20211121-30148.html) [at 1.24x the performance/W] [at 1.11x the performance/CPU$]. AMD 1Ku pricing and Intel ARK.intel.com specifications and pricing as of 8/22/22. SPEC®, SPEC CPU®, and SPECrate® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information. OEM published scores will vary based on system configuration and determinism mode used (default cTDP performance profile).

SP5-004A: SPECrate®2017_fp_base estimate based on internal AMD reference platform measurements and published score from www.spec.org as of 09/27/2022. Comparison of estimated 2P AMD EPYC 9534 (1010 SPECrate®2017_fp_base, 560 Total TDP W, 128 Total Cores, $17606 Total CPU $, AMD Est) is 1.52x the performance of published 2P AMD EPYC 7763 (663 SPECrate®2017_fp_base, 560 Total TDP W, 128 Total Cores, $15780 Total CPU $, http://spec.org/cpu2017/results/res2021q4/cpu2017-20211121-30146.html) [at 1.52x the performance/W] [at 1.37x the performance/CPU$]. AMD 1Ku pricing and Intel ARK.intel.com specifications and pricing as of 8/22/22. SPEC®, SPEC CPU®, and SPECrate® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information. OEM published scores will vary based on system configuration and determinism mode used (default cTDP performance profile).

SP5-005C: SPECjbb® 2015-MultiJVM Max comparison based on published results as of 11/10/2022. Configurations: 2P AMD EPYC 9654 (815459 SPECjbb®2015 MultiJVM max-jOPS, 356204 SPECjbb®2015 MultiJVM critical-jOPS, 192 total cores, http://www.spec.org/jbb2015/results/res2022q4/jbb2015-20221019-00861.html) vs. 2P AMD EPYC 7763 (420774 SPECjbb®2015 MultiJVM max-jOPS, 165211 SPECjbb®2015 MultiJVM critical-jOPS, 128 total cores, http://www.spec.org/jbb2015/results/res2021q3/jbb2015-20210701-00692.html). SPEC® and SPECrate® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

SP5-012C: SPECjbb® 2015-MultiJVM Max based on published scores from www.spec.org as of 1/13/2023. Configurations: 2P AMD EPYC 9654 (815459 SPECjbb®2015 MultiJVM max-jOPS, 356204 SPECjbb®2015 MultiJVM critical-jOPS, 192 Total Cores, http://www.spec.org/jbb2015/results/res2022q4/jbb2015-20221019-00861.html) is 1.63x the max-jOPS performance of published 2P Intel Xeon Platinum 8490H (499,701 SPECjbb®2015 MultiJVM max-jOPS, 246,417 SPECjbb®2015 MultiJVM critical-jOPS, 120 Total Cores, https://www.spec.org/jbb2015/results/res2023q1/jbb2015-20221215-00979.html).

SPEC® and SPECjbb® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

SP5-013B: SPECrate®2017_int_base comparison based on published scores from www.spec.org as of 01/11/2023. The AMD EPYC scored 1790 SPECrate®2017_int_base is higher than all other 2P scores published on the SPEC® website. Comparison of published 2P AMD EPYC 9654 (1790 SPECrate®2017_int_base, 800 Total TDP W, 192 Total Cores, $23610 Total CPU $, http://spec.org/cpu2017/results/res2022q4/cpu2017-20221024-32607.html) is 1.81x the performance of published 2P Intel Xeon Platinum 8490H (991 SPECrate®2017_int_base, 700 Total TDP W, 120 Total Cores, $34000 Total CPU $, http://spec.org/cpu2017/results/res2023q1/cpu2017-20221206-33039.html) [at 1.58x the performance/W] [at 2.60x the performance/CPU$]. Published 2P AMD EPYC 7763 (861 SPECrate®2017_int_base, 560 Total TDP W, 128 Total Cores, $15780 Total CPU $, http://spec.org/cpu2017/results/res2021q4/cpu2017-20211121-30148.html) at 0.87x the performance, 1.09x the performance/W and 1.87x the performance/CPU$ for reference. AMD 1Ku pricing and Intel ARK.intel.com specifications and pricing as of 1/10/23. SPEC®, SPEC CPU®, and SPECrate® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

SP5-019: Estimated SPECrate®2017_int_base comparison based on AMD estimates for the 32-, 24-, and 16-core 4th Gen EPYC CPU as of 8/31/2022 and estimated scores for the comparable core count 3rd Gen EPYC CPU options as of 3/2021. OEM published scores will vary based on system configuration and determinism mode used (default performance profile). SPEC®, SPEC CPU®, and SPECrate® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

SP5-023B: SP5-023B: SPECrate®2017_int_base (est. where not published) comparison based on 2P AMD EPYC processors and select core count, top scoring Intel Xeon Scalable processors as of 1/10/23. SPEC® and SPECrate® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information. OEM published scores will vary based on system configuration and determinism mode used (default cTDP performance profile for AMD estimates 2P server processor Base result URL/Est).

2P server processor	Base result	URL/Est
AMD EPYC 72F3	193	http://spec.org/cpu2017/results/res2021q4/cpu2017-20210928-29648.html
AMD EPYC 7313	323	http://spec.org/cpu2017/results/res2021q3/cpu2017-20210913-29247.html
AMD EPYC 7343	331	http://spec.org/cpu2017/results/res2021q3/cpu2017-20210913-29251.html
AMD EPYC 73F3	352	http://spec.org/cpu2017/results/res2021q4/cpu2017-20211207-30371.html
AMD EPYC 7413	437	http://spec.org/cpu2017/results/res2021q3/cpu2017-20210816-28720.html
AMD EPYC 7443	454	http://spec.org/cpu2017/results/res2021q3/cpu2017-20210913-29231.html
AMD EPYC 7453	459	http://spec.org/cpu2017/results/res2021q3/cpu2017-20210816-28696.html
AMD EPYC 74F3	470	http://spec.org/cpu2017/results/res2021q2/cpu2017-20210510-25990.html
AMD EPYC 7513	538	http://spec.org/cpu2017/results/res2021q3/cpu2017-20210621-27511.html
AMD EPYC 7543	567	http://spec.org/cpu2017/results/res2021q4/cpu2017-20211011-29672.html
AMD EPYC 75F3	596	http://spec.org/cpu2017/results/res2021q2/cpu2017-20210409-25541.html
AMD EPYC 7643	683	http://spec.org/cpu2017/results/res2021q3/cpu2017-20210831-29186.html
AMD EPYC 7663	735	http://spec.org/cpu2017/results/res2021q4/cpu2017-20210928-29633.html
AMD EPYC 7713	778	http://spec.org/cpu2017/results/res2021q3/cpu2017-20210720-28438.html
AMD EPYC 7763	861	http://spec.org/cpu2017/results/res2021q4/cpu2017-20211121-30148.html
AMD EPYC 9124	354	http://spec.org/cpu2017/results/res2022q4/cpu2017-20221121-32869.html
AMD EPYC 9174F	428	http://spec.org/cpu2017/results/res2023q1/cpu2017-20221107-32784.html
AMD EPYC 9224	450	AMD Est
AMD EPYC 9254	582	http://spec.org/cpu2017/results/res2023q1/cpu2017-20221205-33020.html
AMD EPYC 9274F	550	AMD Est
AMD EPYC 9334	645	AMD Est
AMD EPYC 9354	700	AMD Est
AMD EPYC 9374F	815	http://spec.org/cpu2017/results/res2023q1/cpu2017-20221107-32788.html
AMD EPYC 9454	820	AMD Est
AMD EPYC 9474F	1090	http://spec.org/cpu2017/results/res2023q1/cpu2017-20221107-32789.html
AMD EPYC 9534	1070	AMD Est
AMD EPYC 9554	1300	http://spec.org/cpu2017/results/res2023q1/cpu2017-20221107-32790.html
2P server processor	Base result	URL/Est
AMD EPYC 9634	1325	AMD Est
AMD EPYC 9654	1790	http://spec.org/cpu2017/results/res2022q4/cpu2017-20221024-32607.html
Intel Xeon Gold 6334	157	http://spec.org/cpu2017/results/res2022q4/cpu2017-20221007-32522.html

Intel Xeon Gold 6342	396	http://spec.org/cpu2017/results/res2022q3/cpu2017-20220829-32379.html
Intel Xeon Gold 6346	304	http://spec.org/cpu2017/results/res2022q4/cpu2017-20221024-32597.html
Intel Xeon Platinum 8362	526	http://spec.org/cpu2017/results/res2021q3/cpu2017-20210802-28469.html
Intel Xeon Platinum 8380	602	http://spec.org/cpu2017/results/res2021q2/cpu2017-20210521-26364.html
Intel Xeon Platinum 8490H	991	http://spec.org/cpu2017/results/res2023q1/cpu2017-20221206-33039.html

SP5-030: Oracle 19c DSS comparison base on AMD measured scores on 2P 16-core EPYC 9174F compared to 2P 16-core EPYC 73F3 running HammerDB TPROC-H as of 9/29/2022. Configurations: 2x AMD EPYC 73F3 (535246 avg TPROC-H @ 1000SF) vs. 2x AMD EPYC 9174F (690226 avg TPROC-H @ 1000SF) for ~1.3x the performance. Results may vary.

SP5-032: WRF® CONUS 2.5KM workload benchmark comparison based on AMD measurements as of 10/4/2022. Configurations: 2x 40-core Intel Xeon Platinum 8380 vs. vs. 2x 96-core EPYC 9654 for ~2.5x the time-step function performance. Results may vary.

SP5-034A: Fluent® Release 2022 R2 test cases benchmark comparison based on AMD measurements as of 10/19/2022. Configurations: 2x 40-core Intel Xeon Platinum 8380 vs. vs. 2x 96-core EPYC 9654 for ~2.46x the rating performance. Results may vary.

SP5-049A: VMmark® 3.1.1 matched pair comparison based on published results as of 11/10/2022. Configurations: 2-node, 2P 96-core EPYC 9654 powered server running VMware ESXi 8 RTM (40.19 @ 44 tiles/836 VMs, https://www.vmware.com/content/dam/digitalmarketing/vmware/en/pdf/vmmark/2022-10-18-HPE-ProLiant-DL385Gen11.pdf) versus 2-node, 2P 40-core Xeon Platinum 8380 running VMware ESXi v7 U2 (14.19 @ 14 tiles/266 VMs, https://www.vmware.com/content/dam/digitalmarketing/vmware/en/pdf/vmmark/2021-04-20-Fujitsu-PRIMERGY-RX2540M6.pdf) for 2.8x the score and 3.1x the tile (VM) capacity. 2-node, 2P EPYC 7763-powered server (23.33 @ 24 tiles/456 VMs, https://www.vmware.com/content/dam/digitalmarketing/vmware/en/pdf/vmmark/2022-02-08-Fujitsu-RX2450M1.pdf) shown at 1.6x the performance for reference. VMmark is a registered trademark of VMware in the US or other countries.

SP5-097: SPECrate®2017_fp_base comparison based on published scores from www.spec.org as of 01/11/2023. Comparison of published 2P AMD EPYC 9654 (1480 SPECrate®2017_fp_base, 800 Total TDP W, 192 Total Cores, $23610 Total CPU $, http://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, 700 Total TDP W, 120 Total Cores, $34000 Total CPU $, http://spec.org/cpu2017/results/res2023q1/cpu2017-20221206-33040.html) [at 1.27x the performance/W] [at 2.09x the performance/CPU$]. AMD 1Ku pricing and Intel ARK.intel.com specifications and pricing as of 1/10/23. SPEC®, SPEC CPU®, and SPECrate® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

SP5TCO-016: As of 11/10/2022 based on AMD Internal analysis using the AMD EPYC™ SERVER VIRTUALIZATION and GREENHOUSE GAS EMISSIONS TCO ESTIMATION TOOL - version 10.75 estimating the cost and quantity of 2P AMD EPYC™ 9654 (96 core/CPU) powered server versus 2P Intel® Xeon® Gold 6130 (16 core/CPU) based server solutions required to deliver 1500 total virtual machines (VM), requiring 8 core and 16GB of memory per VM for a 3 year period. Environmental impact estimates made leveraging this data, using the Country / Region specific electricity factors from the '2020 Grid Electricity Emissions Factors v1.4 – September 2020', and the United States Environmental Protection Agency 'Greenhouse Gas Equivalencies Calculator'. This scenario contains many assumptions and estimates and, while based on AMD internal research and best approximations, should be considered an example for information purposes only, and not used as a basis for decision making over actual testing. For additional details, see https://www.amd.com/en/claims/epyc4#SP5TCO-016.

MI100-17 Calculations conducted by AMD Performance Labs as of Sep 18, 2020 for the AMD Instinct™ MI100 (32GB HBM2 PCIe® card) accelerator at 1,502 MHz peak boost engine clock resulted in 11.54 TFLOPS peak double precision (FP64) theoretical floating-point performance. Nvidia specifications from datasheets at www.nvidia.com/content/en-us/data-center and other sources.

MI200-69A Testing Conducted by AMD performance lab 11.14.2022 using HPL comparing two systems. 2P EPYC™ 7763 powered server, SMT disabled, with 1x, 2x, and 4x AMD Instinct™ MI250 (128 GB HBM2e) 560W GPUs, host ROCm 5.2.0 rocHPL6.0.0. AMD HPL container is not yet available on Infinity Hub. vs. 2P AMD EPYC™ 7742 server, SMT enabled, with 1x, 2x, and4x Nvidia Ampere A100 80GB SXM 400W GPUs, CUDA 11.6 and Driver Version 510.47.03. HPL Container (nvcr.io/nvidia/hpc-benchmarks:21.4-hpl) obtained from https://catalog.ngc.nvidia.com/orgs/nvidia/containers/hpc-benchmarks. Server manufacturers may vary configurations, yielding different results. Performance may vary based on use of latest drivers and optimizations.

MI200-81 HPL-AI comparison based on AMD internal testing as of 11/2/2022 measuring the HPL-AI benchmark performance (TFLOPS) using a server with 2x EPYC™ 7763 with 4x MI250 (128MB HBM2e) with Infinity Fabric running host ROCm™ 5.2.0, HPL-AI-AMD v1.0.0; AMD HPL-AI container not yet available on Infinity Hub. versus a server with 2x EPYC 7742 with 4x A100 SXM (80GB HBM2e) running CUDA® 11.6, HPL-AI-NVIDIA v2.0.0, container nvcr.io/nvidia/hpc-benchmarks:21.4-hpl. Server manufacturers may vary configurations, yielding different results. Performance may vary based on use of latest drivers and optimizations.

MLNTCO-001: As of 7/20/22 based on AMD internal analysis using AMD EPYC™ SERVER VIRTUALIZATION TCO ESTIMATION TOOL - v10.30 estimating the cost and quantity of 2P AMD EPYC 7763 powered servers with a SPECrate®2017_int_base score of 861, https://www.spec.org/cpu2017/results/res2021q4/cpu2017-20211121-30148.html compared to a 2P Intel Xeon® Gold 6338 based servers with a SPECrate®2017_int_base score of 425, https://spec.org/cpu2017/results/res2022q2/cpu2017-20220505-31645.html to compare annual costs of 3rd Gen Xeon CPU-based infrastructure to 3rd Gen EPYC CPU-based infrastructure both depreciated over three years. For details, see https://www.amd.com/en/claims/epyc3x#faq-MLNTCO-001 This scenario contains many assumptions and estimates and, while based on AMD internal research and best approximations, should be considered an example for information purposes only, and not used as a basis for decision making over actual testing. SPEC® and SPECrate® are trademarks of Standard Performance Evaluation Corporation. See www.spec.org for more information.

MLNTCO-002: As of 7/20/22 based on AMD internal analysis using AMD EPYC™ SERVER VIRTUALIZATION TCO ESTIMATION TOOL - v10.35 estimating the cost and quantity of 1P AMD EPYC 7313P powered servers with a SPECrate®2017_int_base score of 162, https://spec.org/cpu2017/results/res2022q1/cpu2017-20211220-30553.pdf compared to a 2P Intel Xeon® Silver 4309Y based servers with a SPECrate®2017_int_base score of 139, https://www.spec.org/cpu2017/results/res2022q1/cpu2017-20220214-30898.html to compare annual costs of 3rd Gen Xeon CPU-based infrastructure to 3rd Gen EPYC CPU-based infrastructure both depreciated over three years. For details, see https://www.amd.com/en/claims/epyc3x#faq-MLNTCO-002 This scenario contains many assumptions and estimates and, while based on AMD internal research and best approximations, should be considered an example for information purposes only, and not used as a basis for decision making over actual testing. SPEC® and SPECrate® are trademarks of Standard Performance Evaluation Corporation. See www.spec.org for more information.

MLNTCO-004: As of 7/20/22 based on AMD internal analysis using AMD EPYC™ SERVER VIRTUALIZATION TCO ESTIMATION TOOL - v10.35 estimating the cost and quantity of 2P AMD EPYC 7313 powered servers with a SPECrate®2017_int_base score of 323, https://spec.org/cpu2017/results/res2021q3/cpu2017-20210913-29247.html compared to a 2P Intel Xeon® Gold 6346 based servers with a SPECrate®2017_int_base score of 291, https://spec.org/cpu2017/results/res2022q2/cpu2017-20220419-31532.html to compare annual costs of 3rd Gen Xeon CPU-based infrastructure to 3rd Gen EPYC CPU-based infrastructure both depreciated over three years. For details, see https://www.amd.com/en/claims/epyc3x#-faq-MLNCFO-004 This scenario contains many assumptions and estimates and, while based on AMD internal research and best approximations, should be considered an example for information purposes only, and not used as a basis for decision making over actual testing. SPEC® and SPECrate® are trademarks of Standard Performance Evaluation Corporation. See www.spec.org for more information.