第22回PCクラスタシンポジウム

# Zen 4 アーキテクチャ搭載 AMD EPYC™ (Genoa) の技術概要

2022年12月5日
日本AMD株式会社

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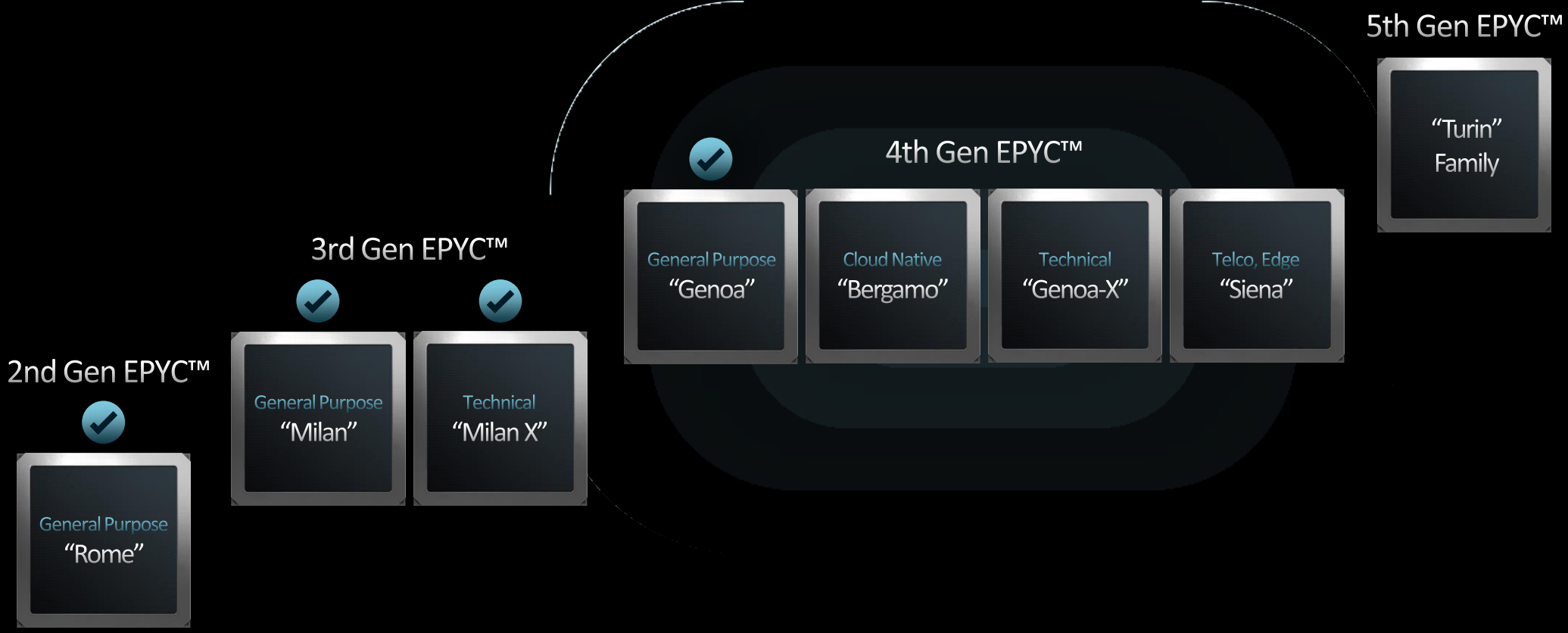
AMD
together we advance_

# 本日の内容

1. AMD EPYC™プロセッサーのこれまでのロードマップ
2. Zen 4 アーキテクチャ
3. 第4世代AMD EPYC™ プラットフォーム
4. 性能のご紹介

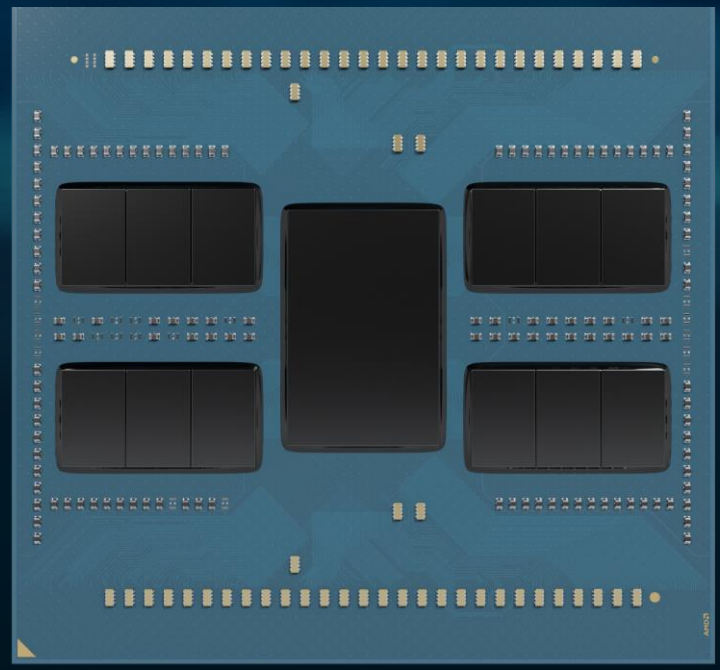
# ロードマップの着実な遂行




All roadmaps are subject to change.

# 第4世代AMD EPYC™ プロセッサー
## EPYCのリーダーシップを拡大

- ソケットあたり、コアあたりそれぞれの性能のリーダーシップ
  **Up to 96 “Zen 4” Cores in 5nm**
- メモリー帯域、メモリー容量のリーダーシップ
  **12 Channels DDR5**
- 次世代のI/O
  **Up to 160 Lanes of PCIe® Gen 5 | Memory Expansion with CXL**
- コンフィデンシャルコンピューティング能力の向上
  **~2X SEV-SNP Guests | Direct and CXL Attached Memory Encryption**



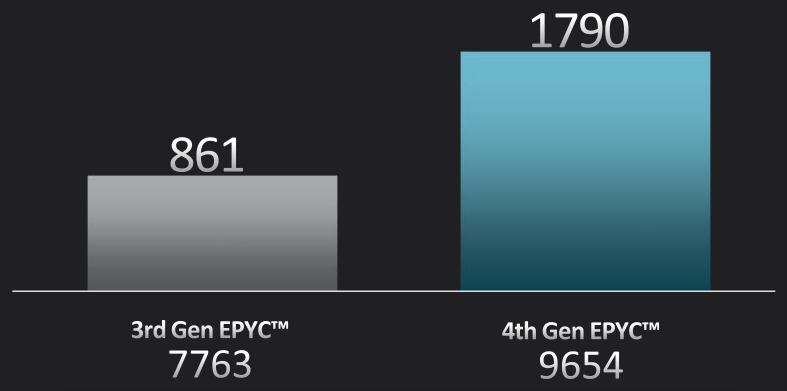
See Endnotes EPYC-032, EPYC-034A, SP5-013A, SP5-014. Preliminary data and projections subject to change

# Advancing AMD EPYC™ CPU Leadership

## Cloud

SPECrate®2017_int_base

**107%** higher performance




Integer Throughput

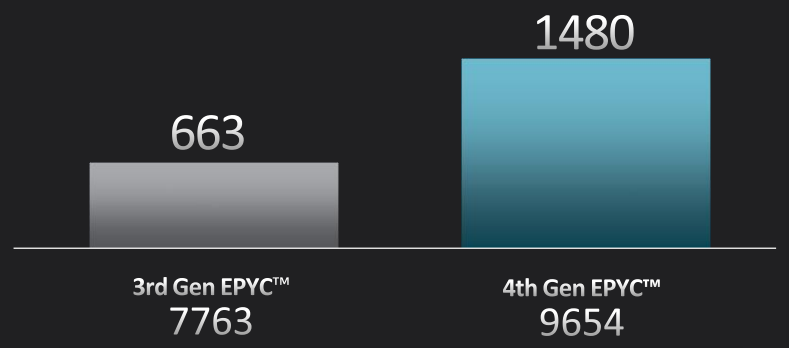
Cloud Service Providers

IaaS/PaaS | Search | Social | SaaS

## HPC

SPECrate®2017_fp_base

**123%** higher performance




Floating-Point Throughput

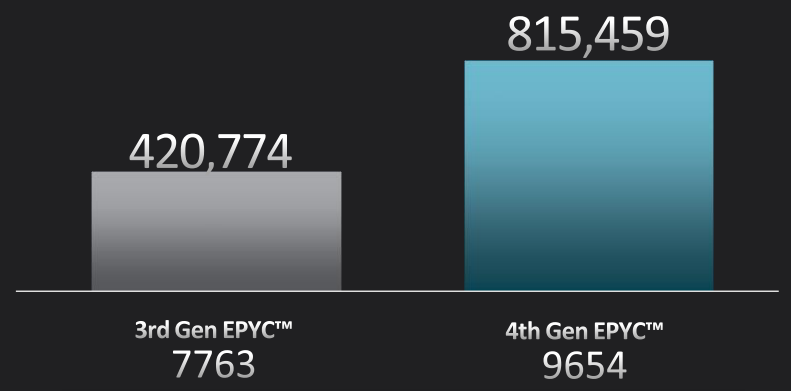
High Performance Computing

Design & Simulation | Research & Academia | Machine Learning | Super Computing

## Enterprise

SPECjbb®2015 MultiJVM max-jOPS

**94%** higher performance




Server-Side Java® Max Throughput

Enterprise IT

Virtualization | SDS/HCI | Hadoop | NoSQL



See endnotes: SP5-001C, -002C, -005C.

# “Zen 4” アーキテクチャ デザインゴール

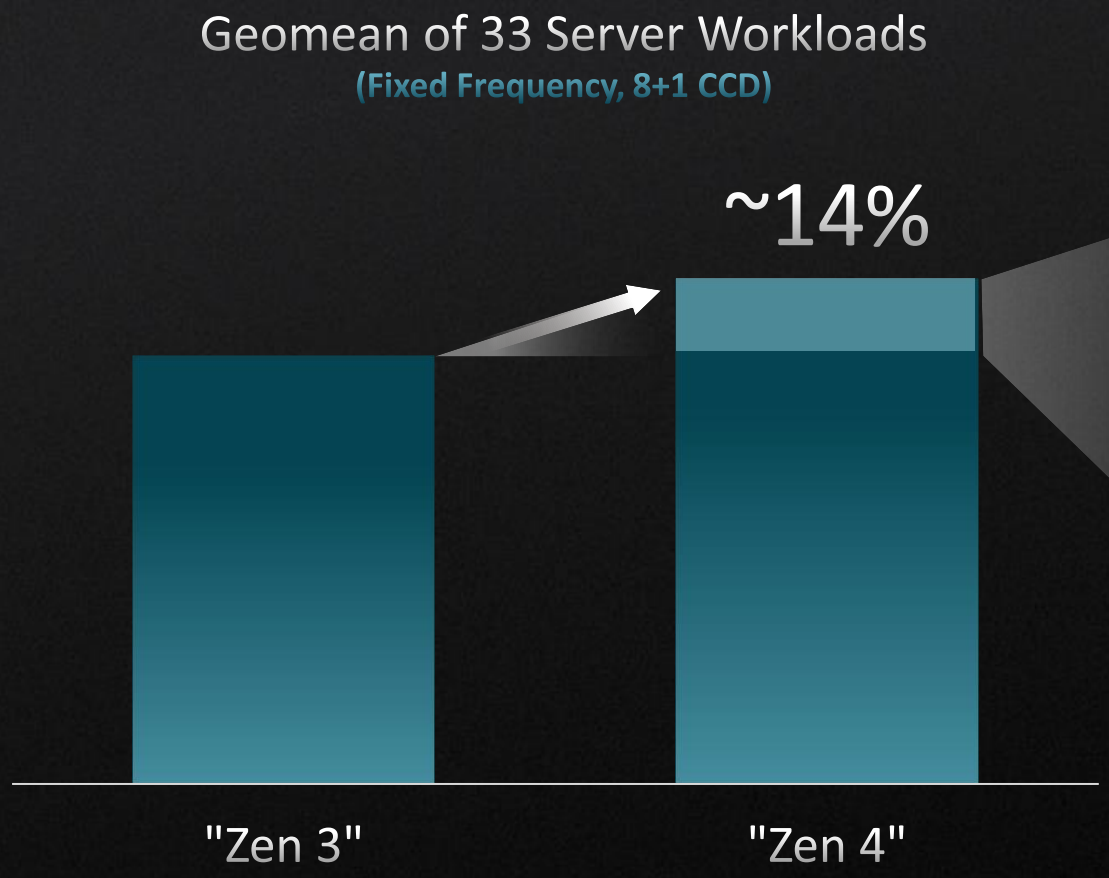
## Performance
IPCと周波数の向上

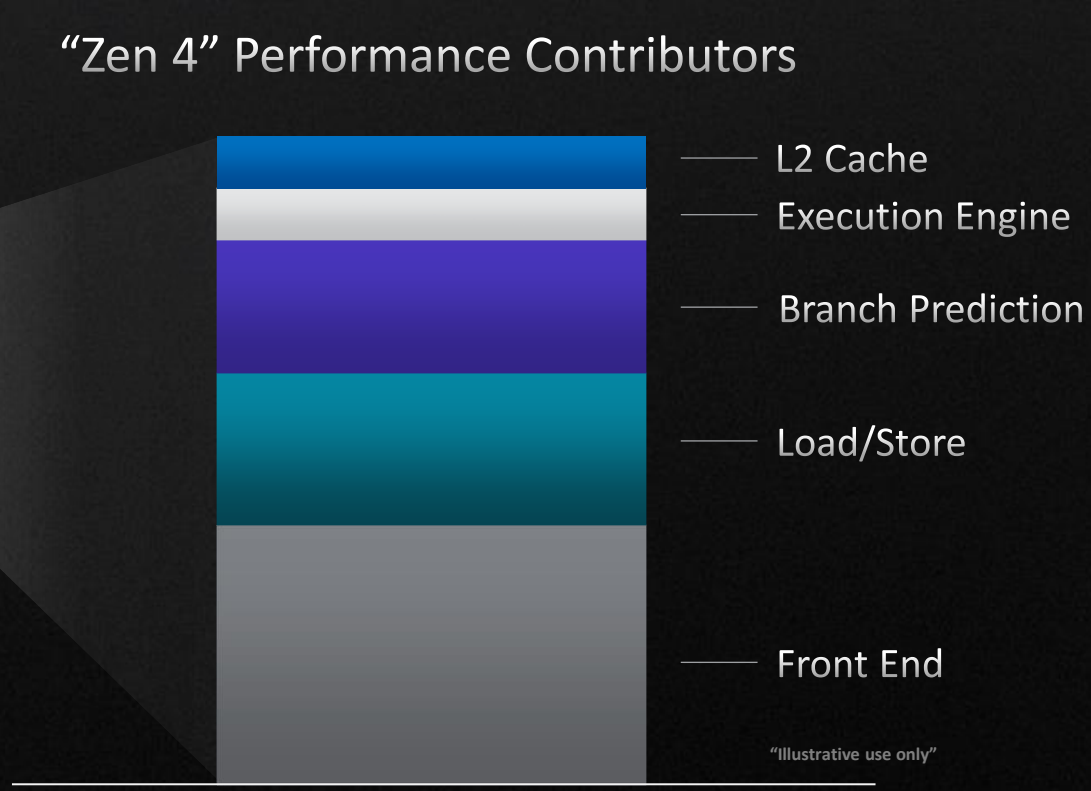
## Latency
L2キャッシュ増加により平均latencyを削減

## Throughput
コア数の増加を効率的に扱うため電力使用の大幅な削減

# Generational Improvements

## “Zen 4” ~14% IPC Uplift for Server CPUs[1]

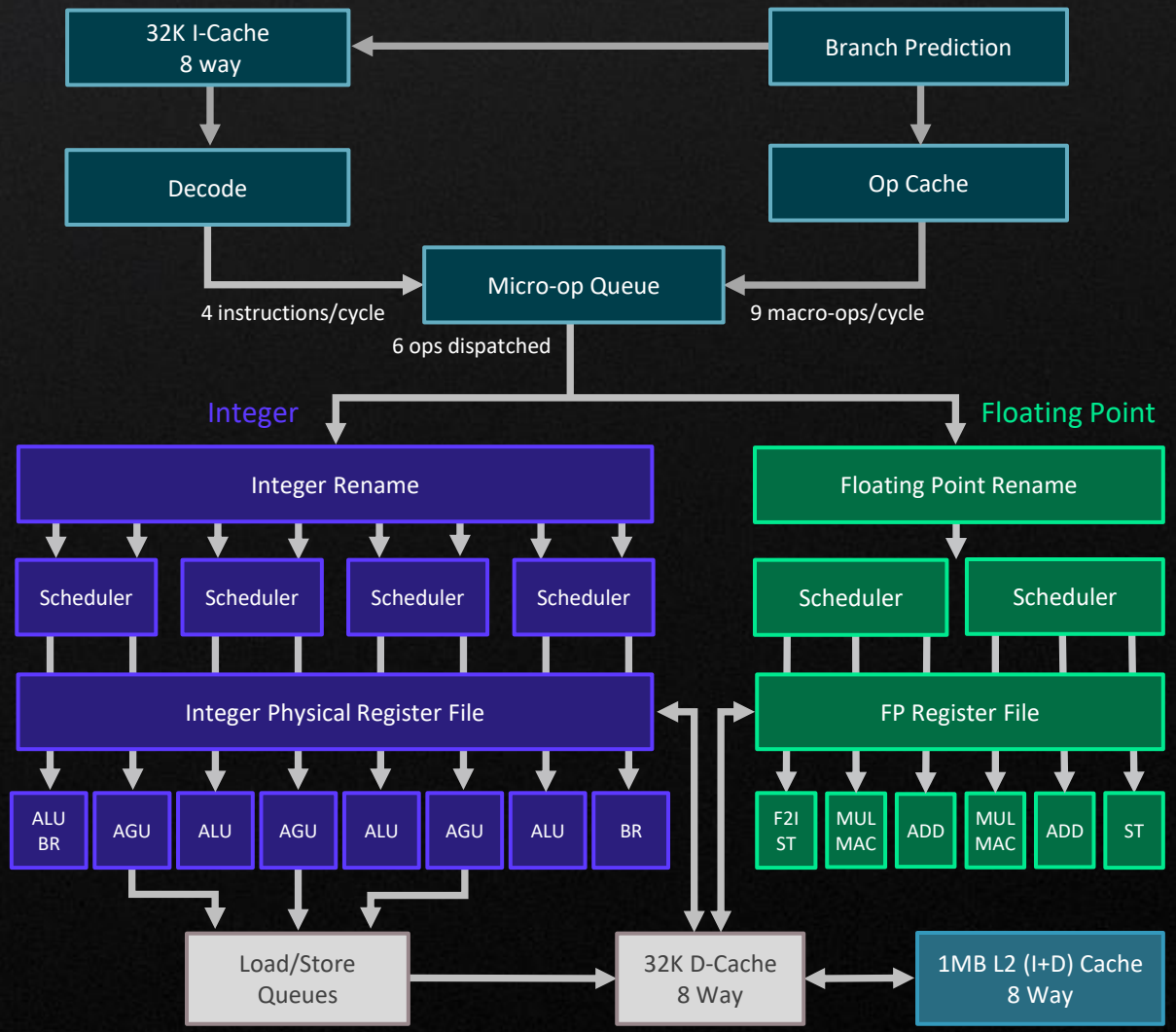



See endnote: EPYC-038

# “Zen 4” Microarchitecture Overview

- Based on “Zen 3” Microarchitecture
- Branch Prediction Improvements
  - **Predict 2 taken branches per cycle**
  - **Larger L1 BTB**
  - **Larger L2 BTB**
- Larger Op Cache
- Larger Instruction Retire Queue
- Larger Int/FP register file
- Deeper buffers throughout the core
- Power efficient AVX-512 support in the Floating-Point Unit
  - **On 256b data-path**
- Load/Store improvements
  - **Fewer port conflicts**
  - **Larger L2 DTLB**
- L2 Cache 1M, 8-way
- Large shared L3 cache



# “Zen 3” to “Zen 4” Evolution

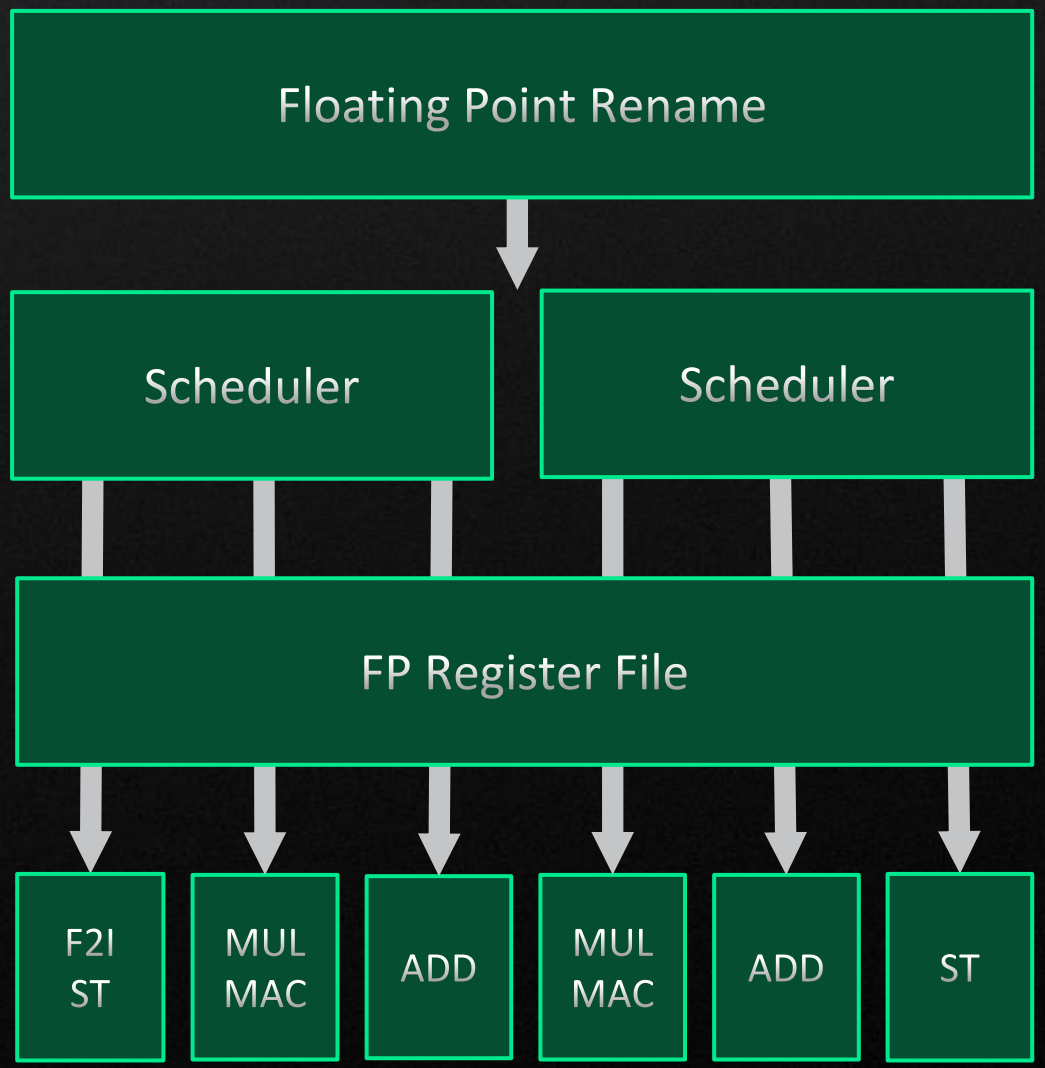
| | “Zen 3” | “Zen 4” |
|---|---|---|
| LDQ | 72 | 88 |
| STQ | 64 | 64 |
| Mirco-op cache | 4k ops | 6.75k ops |
| L1 I/D-cache | 32/32k | 32/32k |
| L2 cache | 512k | 1M |
| L3 cache/core | 4M | 4M |
| L2 TLB | 2k | 3k |
| L2 latency | 12 cycles | 14 cycles |
| L3 latency | 46 cycles | 50 cycles |

| | “Zen 3” | “Zen 4” |
|---|---|---|
| Issue width (Int + FP/SIMD) | 10+6 | 10+6 |
| Int reg | 192 | 224 |
| Int scheduler | 96 | 96 |
| FP reg | 160 | 192 |
| ROB | 256 | 320 |
| FADD/FMUL/FMA latency | 3/3/4 cycles | 3/3/4 cycles |
| L1 BTB* | 2 x 1k | 2 x 1.5k |
| L2 BTB* | 2 x 6.5k | 2 x 7k |

*“Zen 3” and “Zen 4” store up to two branches per BTB entry

# New AVX-512 Instructions for "Zen 4"

- Adds per lane masking capabilities
- Adds new Scatter/Gather instructions
- Implemented with 256b operations:
  - Area-efficient implementation
  - Throughput equivalent with reduced instruction fetch and control overhead, higher efficiency vs. AVX-256
  - Expected to see better frequency using AVX-512 instructions
- BFloat16 instruction support
- VNNI instruction support



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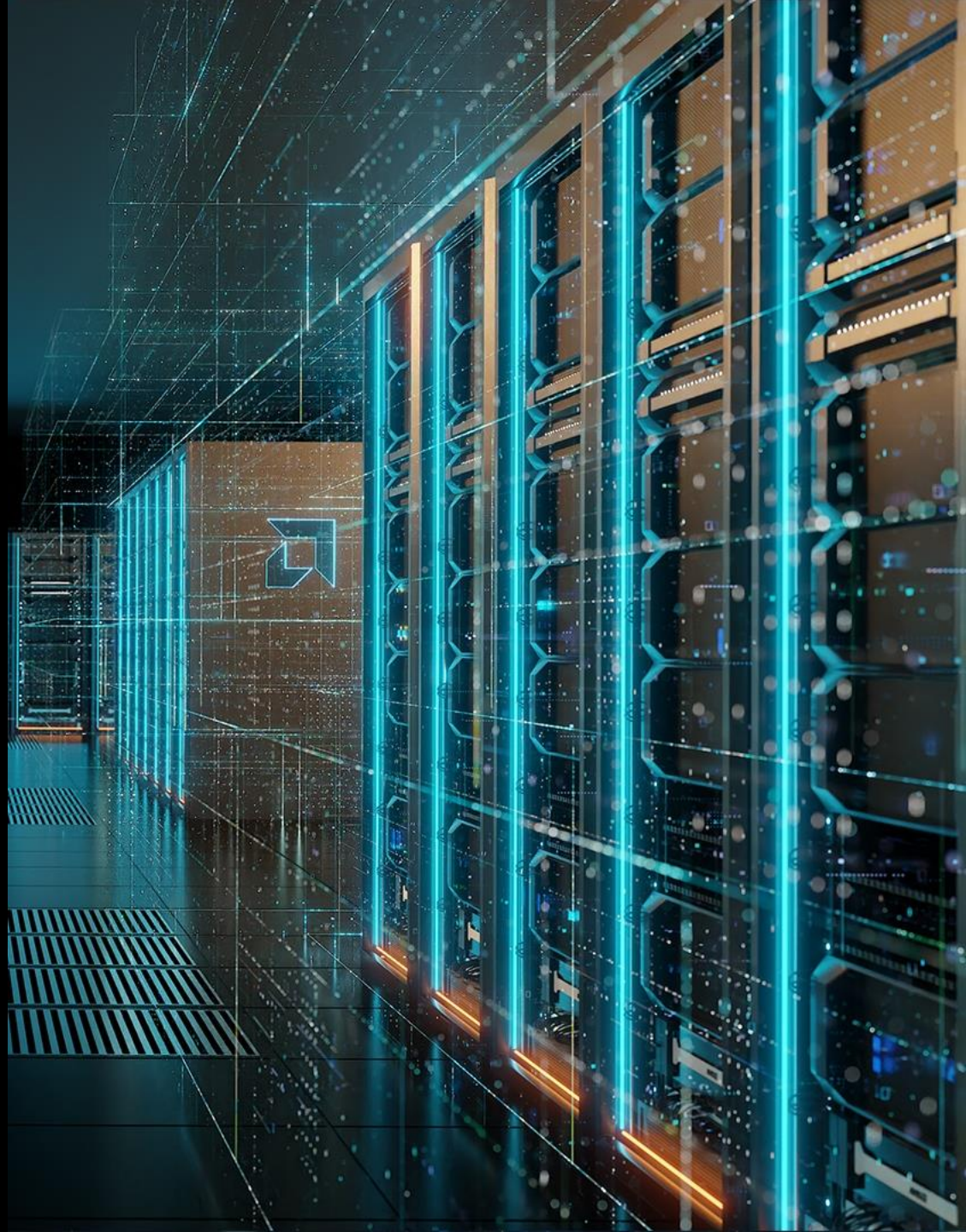
# EPYC™ 9004 Series
# プラットフォームの概要



# AMD EPYC™ 9004 の概要

## Compute

- AMD “Zen4” x86 cores (Up to 12 CCDs / 96 cores / 192 threads)
- 1MB L2/Core, Up to 32MB L3/CCD
- ISA updates: BFLOAT16, VNNI, AVX-512 (256b data path)
- Memory addressability with 57b/52b Virtual/Physical Address

- Updated IOD and internal AMD Gen3 Infinity Fabric™ architecture with increased die-to-die bandwidth

- Target TDP range: Up to 400W (cTDP)

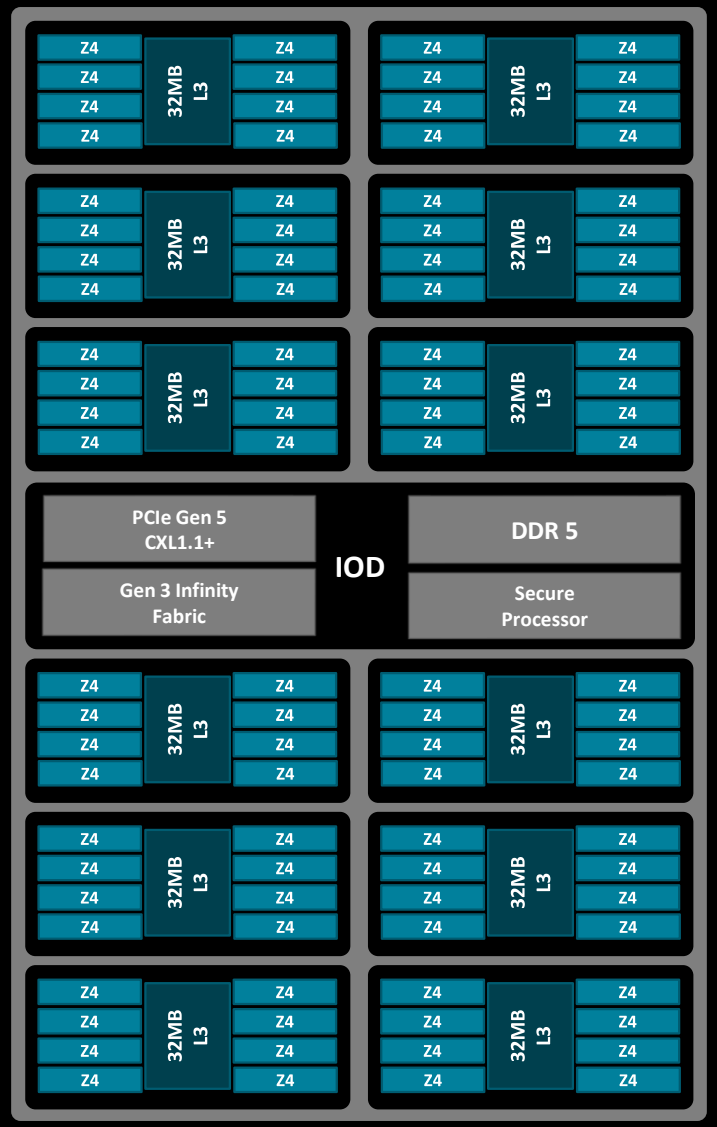
- Updated RAS

## Memory

- 12 channel DDR5 with ECC up to 4800 MHz
- Option for 2,4,6, 8, 10, 12 channel memory interleaving[1]

- RDIMM, 3DS RDIMM

- Up to 2 DIMMs/channel capacity with up to 12TB in a 2 socket system (256GB 3DS RDIMMs)[1]




## SP5 Platform

- New socket, increased power delivery and VR
- Up to 4 links of Gen3 AMD Infinity Fabric™ with speeds of up to 32Gbps
- Flexible topology options

- Server Controller Hub (USB, UART, SPI, I2C, etc.)

## Integrated I/O – No Chipset

Up to 160 IO lanes (2P) of PCIe® Gen5

- Speeds up to 32Gbps, bifurcations supported down to x1
- Up to 12 bonus PCIe® Gen3 lanes in 2P config (8 lanes–1P)
- Up to 32 IO lanes for SATA

- 64 IO Lanes support for CXL1.1+ w/bifurcations supported down to x4

## Security Features

Dedicated Security Subsystem with enhancements

Secure Boot, Hardware Root-of-Trust

SME (Secure Memory Encryption)

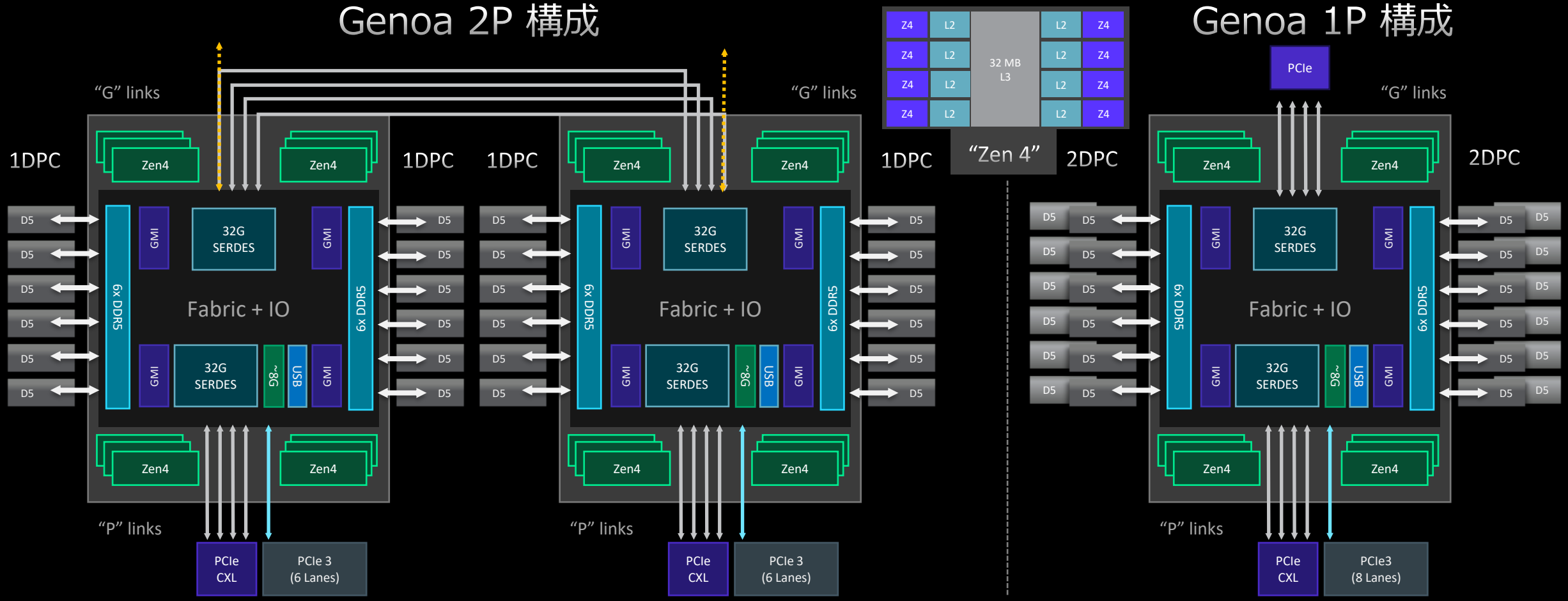
SEV-ES (Secure Encrypted Virtualization & Register Encryption)

SEV-SNP (Secure Nested Paging), AES-256-XTS with more encrypted VMs

Blue font indicates significant upgrades with EPYC 9004.

[1] With certain DIMM population rules.. GD-183: AMD Infinity Guard features vary by EPYC™ Processor generations. Infinity Guard security features must be enabled by server OEMs and/or Cloud Service Providers to operate. Learn more about Infinity Guard at https://www.amd.com/en/technologies/infinity-guard.

# EPYC™ 9004 Seriesプラットフォームの概要




SP5 Platform Delta vs. SP3

- 12ch DDR5, 2P-capable, Integrated Server Controller Hub (SCH)
- New socket: Improved SI, increased footprint (~72mm x ~75mm Pkg), 0.94x0.81mm pitch
- 128L: 32Gbps-capable SERDES; PCIe® 5 support, peak xGMI3 product speeds up-to 32Gbps; additional 6-8L PCIe3/socket
- Links: All 8 links PCIe-capable, 3Link or 4Link xGMI 2P topologies (not shown), "P" links CXL-capable

# EPYC™ 9004 の電力管理機能

サーバーシステムやその設置環境により熱の余裕は異なる。また、Siliconによっても以下の点が異なる。

- **Faster / higher leakage parts**
- **Slower / lower leakage parts**

確定的な(deterministic)な性能特性を好まれるお客様:

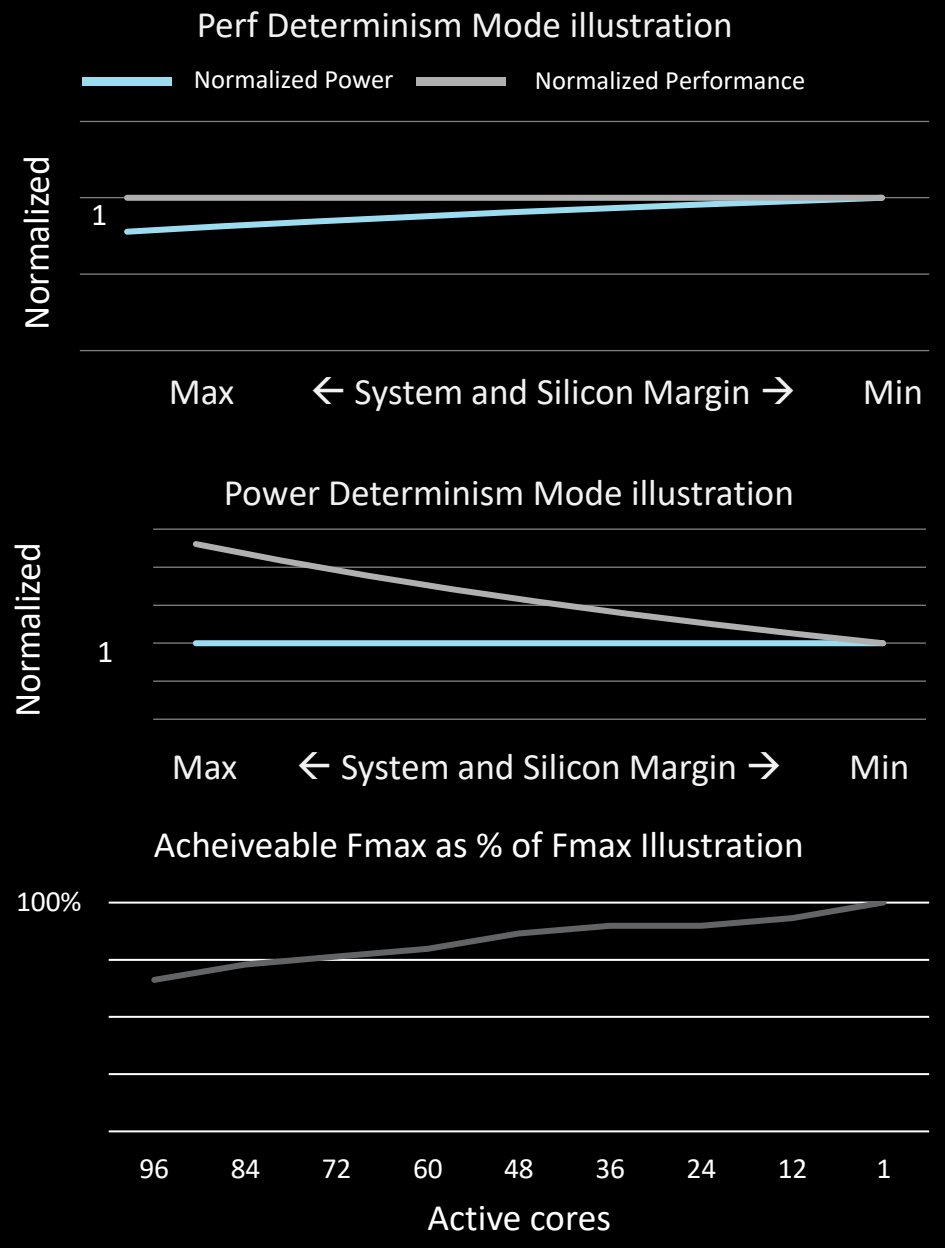
- **“Performance Determinism”モード: 電力消費はSiliconと設置環境で異なる**

プラットフォームの限界内での最大性能を好まれるお客様:

- **“Power Determinism”モード:**
- **“Performance Determinism”モード以上の性能となりえる**
- **BIOSでのデフォルトは”Performance Determinism”モード**
- **ピーク性能のチューニングでTDPをBIOSで変更することも可能**

ピークのブースト性能について

- **最大周波数(Fmax)はアクティブコア数、冷却、Siliconによって異なる**
- **混在した命令による制限はない**
- **CPU内部の管理機構が、プラットフォームレベルの平均とピーク電力の制限内に収める**
- **実際の周波数はワークロード、性能特性によって異なる**



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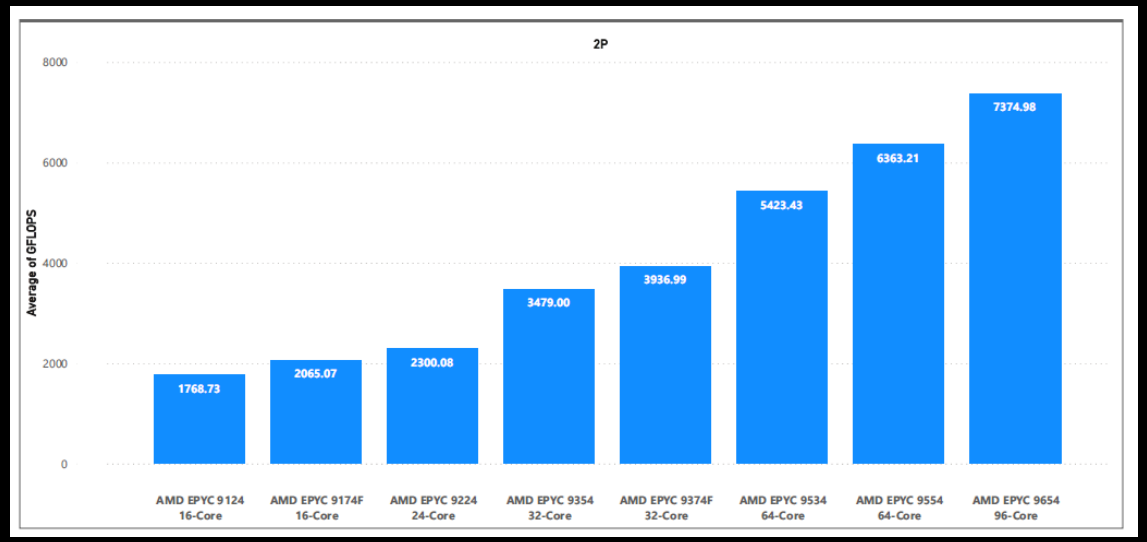
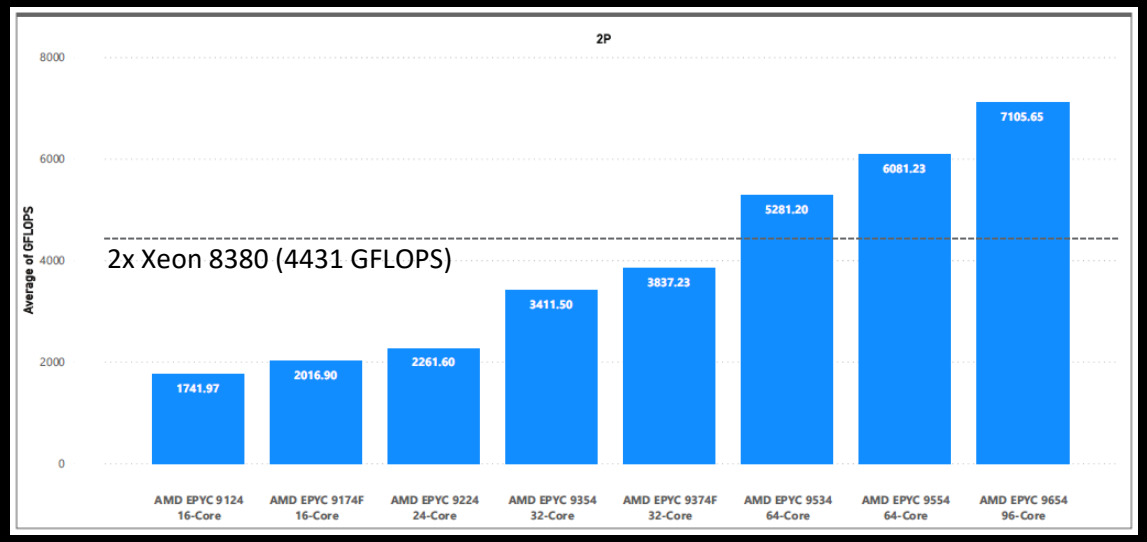
# AVX-512 HPL/DGEMM Performance Leadership




DGEMM

Performance Determinism Mode



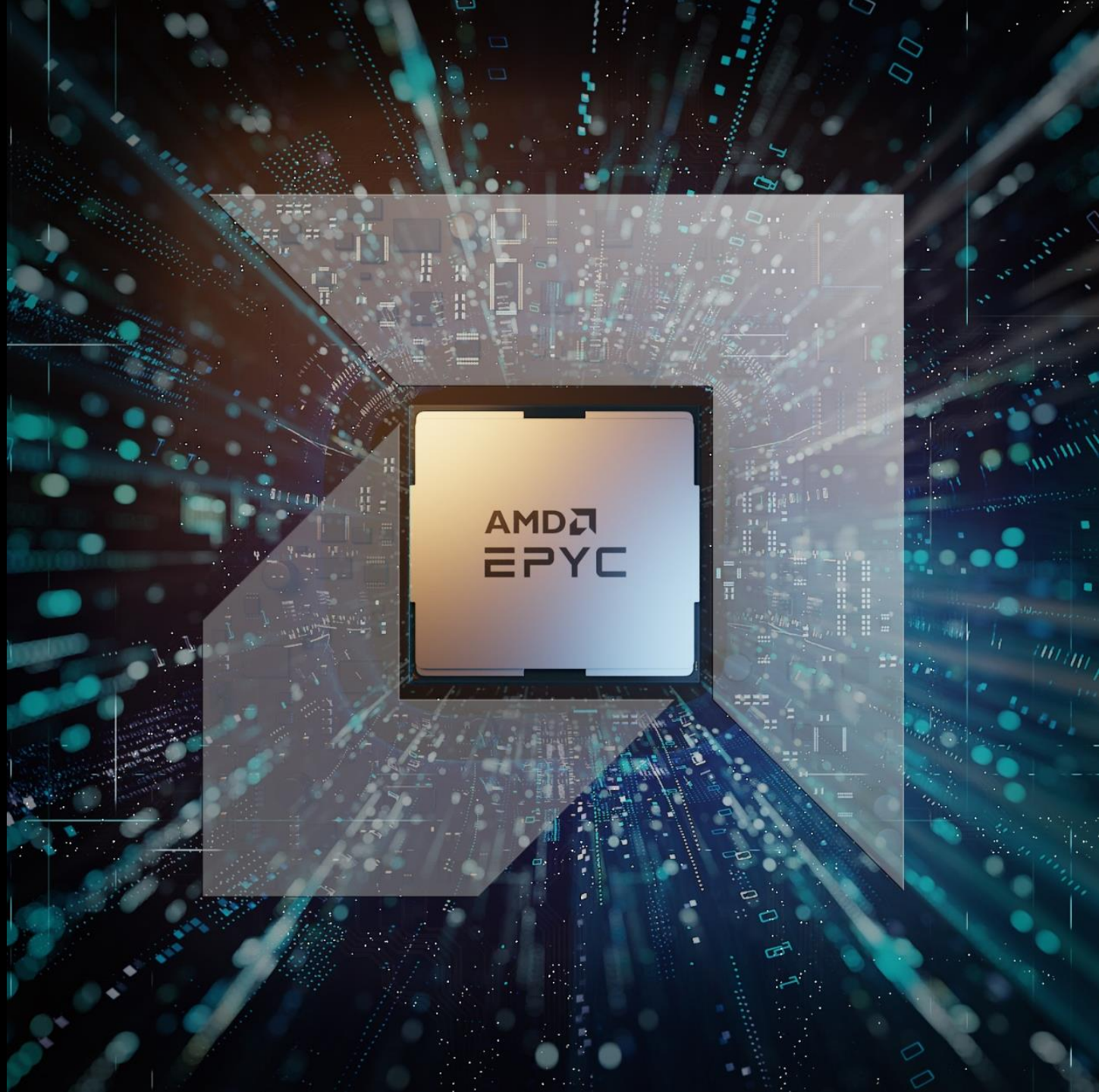

HPL

Performance Determinism Mode



See Endnotes SP5-086 / SP5-087.

# CXL の概要



# CXLの概要

CXL：キャッシュコヒーレントなインターコネクトを実現する業界標準の仕様。対象はプロセッサー、メモリー拡張、アクセラレータ。

第4世代AMD EPYC™ プロセッサーは、CXL 1.1(+)準拠のType3/Memoryをサポート

- **CXL1.1(+)： CXL2.0準拠のType3を含んだ仕様**
  - **永続メモリー(Persistent memory), RAS reporting, etc.**
- **Type 3 – サポート: メモリー拡張**
- **Type 1 – 未サポート**
- **Type 2 – 未サポート**

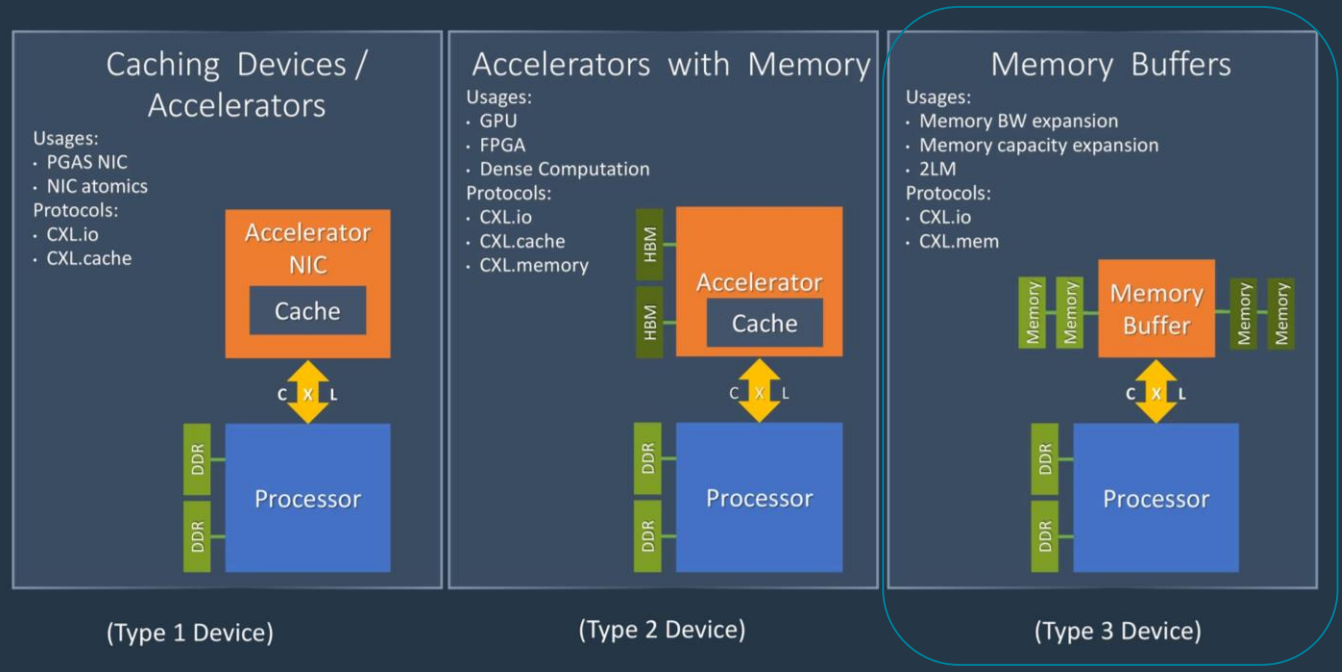
その他のCXL機能

- **階層化されたメモリーのサポート**
  - **複数のCXLデバイスが一つのインターリーブNUMAノードとして集約**
  - **ヘッドレスNUMAノード**
  - **メモリーのpinningとSecureなデータ移動**
  - **HV/Guestによるメモリープロファイリング (IBS filtering, IBS virtualization)**
- **x86 QoS サポート**
  - **DRAMとCXLメモリーでx86 MBM帯域の上限を分割**
- **AMD SEV/SNP機能はCXL Type 3 Memoryでもフルサポート**

低遅延なメモリーのアタッチ

- **デバイス依存; CXL Type3 Memoryへの遅延時間は2P構成でのリモートソケットに対するものと同等**

第4世代AMD EPYC™ のサポート対象




- CXL.io: **Discovery, configuration, register access, interrupts, DMA, etc.**
- CXL.cache: **Device access to processor memory**
- CXL.memory: **Processor access to device attached memory**

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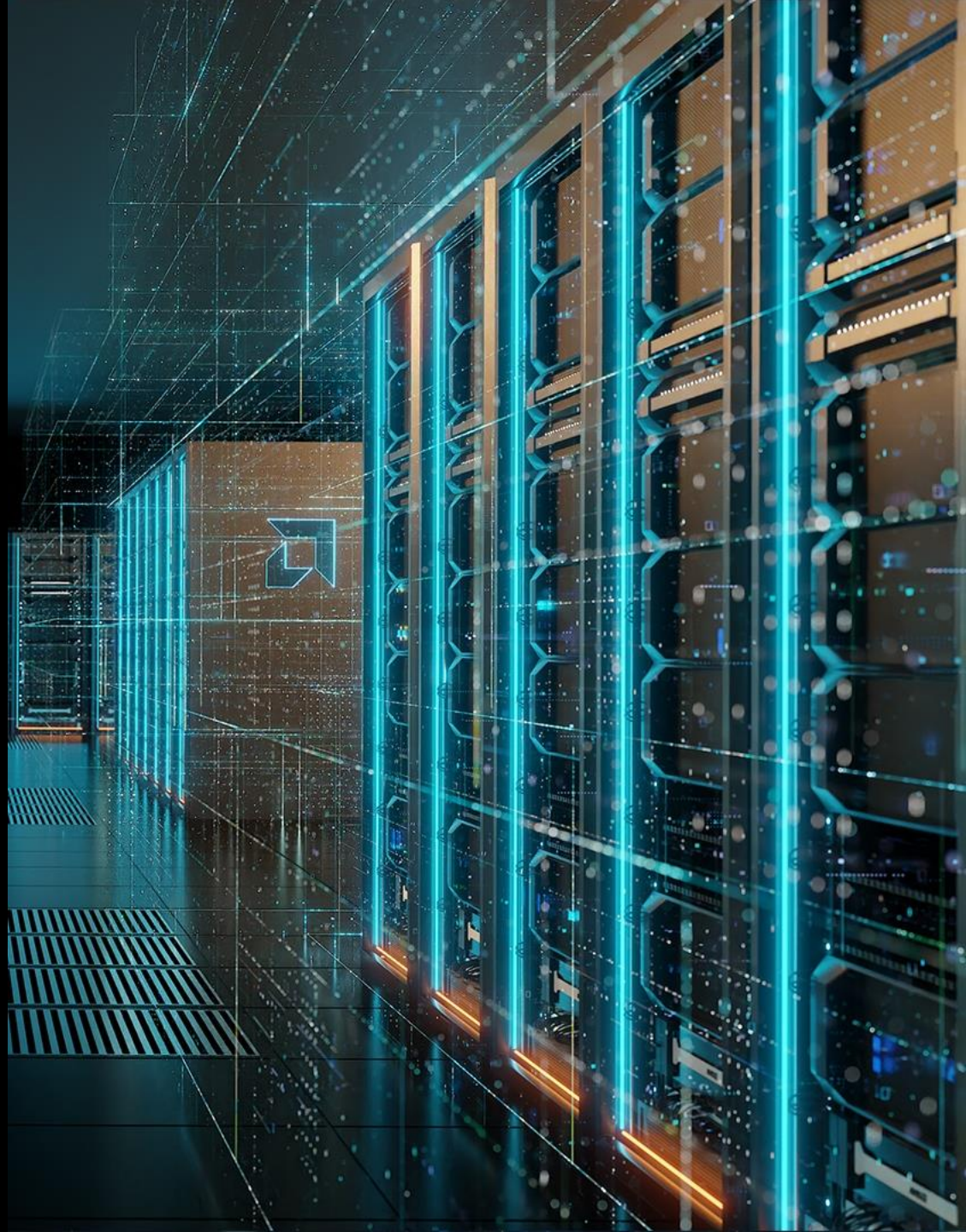
# AMD EPYC™ 9004 Series Product Deep Dive



# AMD EPYC™ 9004 Series Processor

## All-in Feature Set support

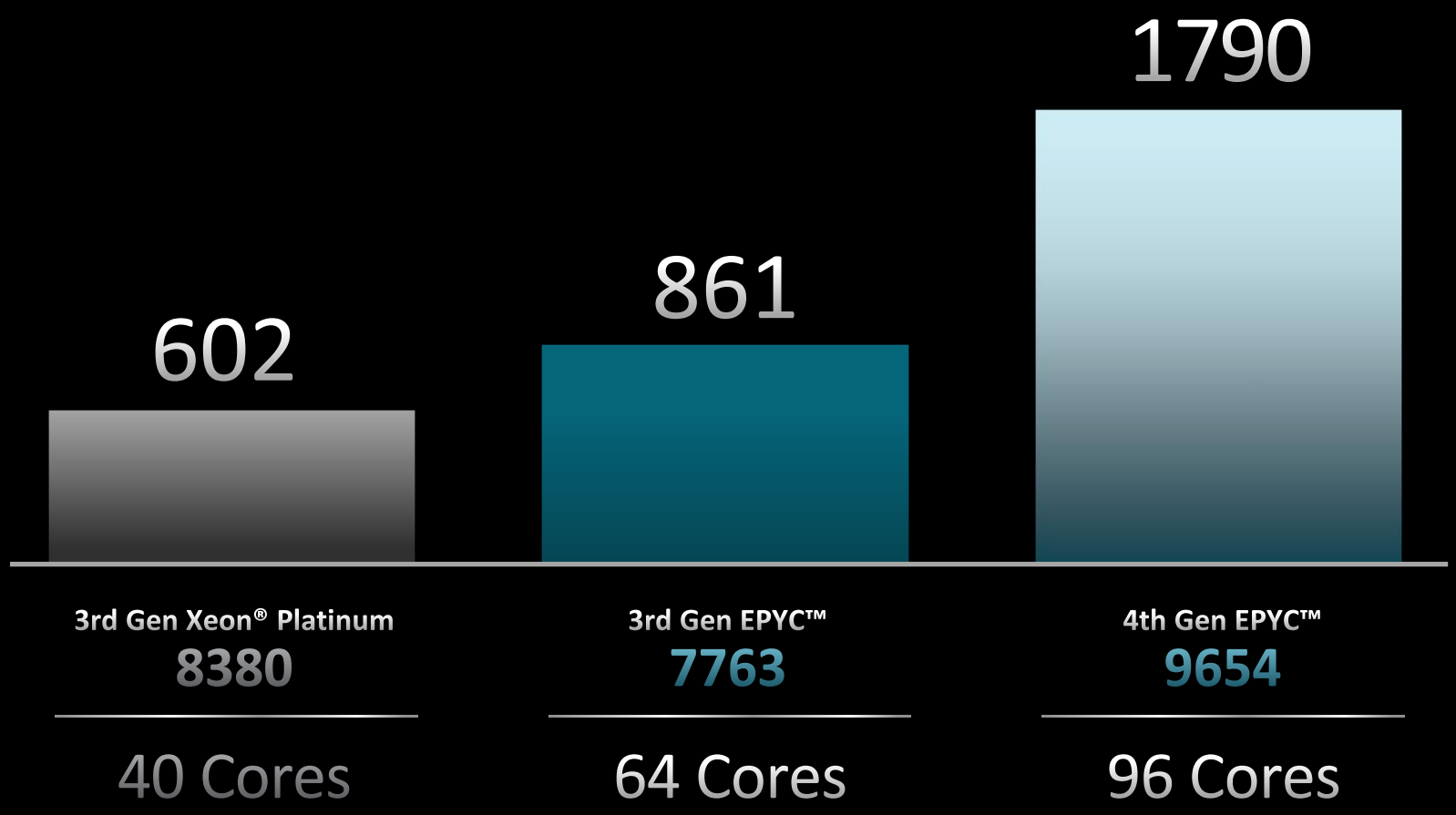
- 12 Channels of DDR5-4800
- Up to 6TB DDR5 memory capacity
- 128 lanes PCIe® 5
- 64 lanes CXL 1.1+
- AVX-512 ISA, SMT & core frequency boost
- AMD Infinity Fabric™
- AMD Infinity Guard

| Cores | AMD EPYC | Base/Boost* (up to GHz) | Default TDP (w) | cTDP (w) |
|---|---|---|---|---|
| 96 cores | 9654/P | 2.40/3.70 | 360w | 320-400w |
| 84 cores | 9634 | 2.25/3.70 | 290w | 240-300w |
| 64 cores | 9554/P | 3.10/3.75 | 360w | 320-400w |
| 64 cores | 9534 | 2.45/3.70 | 280w | 240-300w |
| 48 cores | → 9474F | 3.60/4.10 | 360w | 320-400w |
| | 9454/P | 2.75/3.80 | 290w | 240-300w |
| 32 cores | → 9374F | 3.85/4.30 | 320w | 320-400w |
| 32 cores | 9354/P | 3.25/3.80 | 280w | 240-300w |
| 32 cores | 9334 | 2.70/3.90 | 210w | 200-240w |
| 24 cores | → 9274F | 4.05/4.30 | 320w | 320-400w |
| | 9254 | 2.90/4.15 | 200w | 200-240w |
| | 9224 | 2.50/3.70 | 200w | 200-240w |
| 16 cores | → 9174F | 4.10/4.40 | 320w | 320-400w |
| | 9124 | 3.00/3.70 | 200w | 200-240w |

*SEE ENDNOTES: EPYC-018, GD-183

# Cloud Performance Leadership

## Most Threads per Rack for Hyperscale Deployments




4th Gen **AMD EPYC™** CPU

**~3x**

Performance
vs. Competition

**2P Integer Throughput**

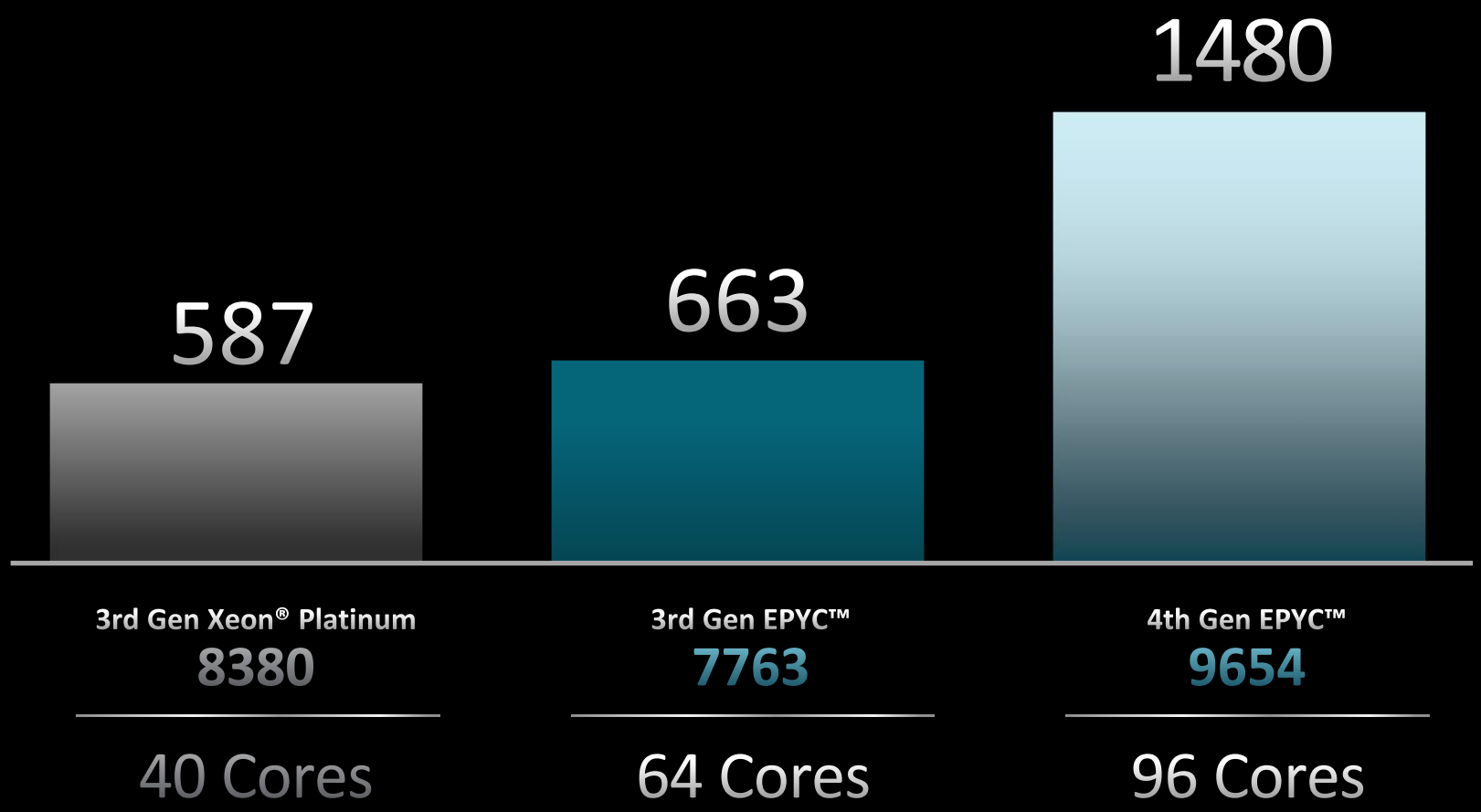
SPECrate®2017_int_base



Results May Vary. See Endnotes SP5-010B.

# HPC Performance Leadership

## Faster Time-to-Solutions




4th Gen AMD EPYC™ CPU

**2.5x**

Performance
vs. Competition

**2P Floating-Point Throughput**

SPECrate®2017_fp_base



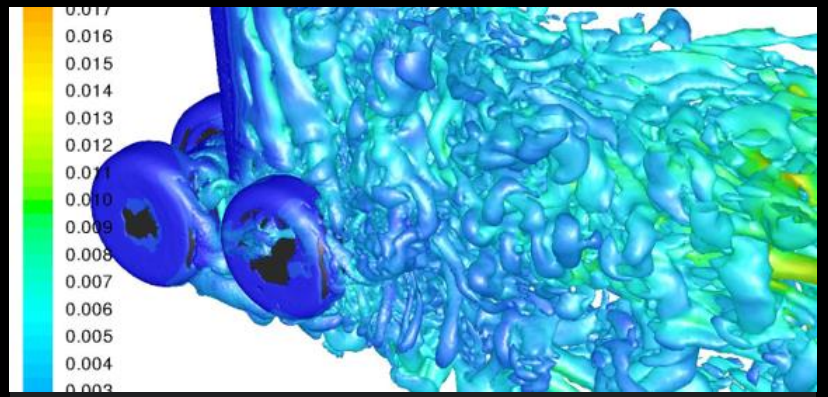
Results May Vary. See Endnotes SP5-009C.

# HPC Per-Core Performance Leadership

## Faster Time to Discovery at Equal Core Counts

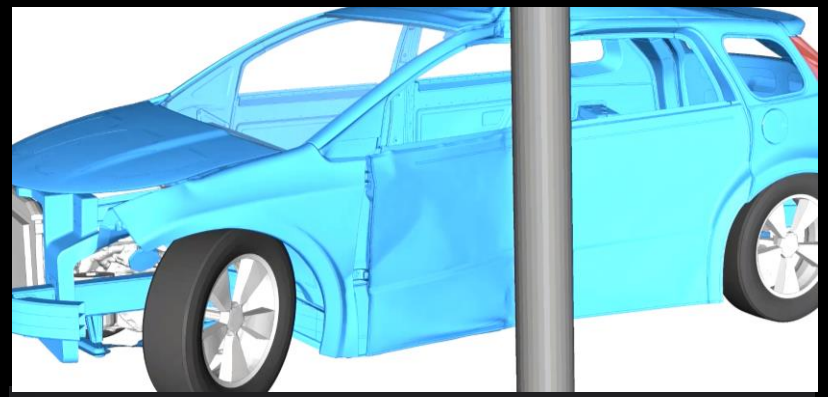
### Weather Forecasting

**~2x** WRF®
-CONUS 2.5km




### Computational Fluid Dynamics

**~1.7x** Ansys Fluent®
- 2022 R2 Test Cases



### Finite Element Analysis - Explicit

**~1.7x** Altair Radioss™
- Neon test case

2P EPYC™ 9374F (32C) vs. 2P Xeon® Platinum 8362 (32C)

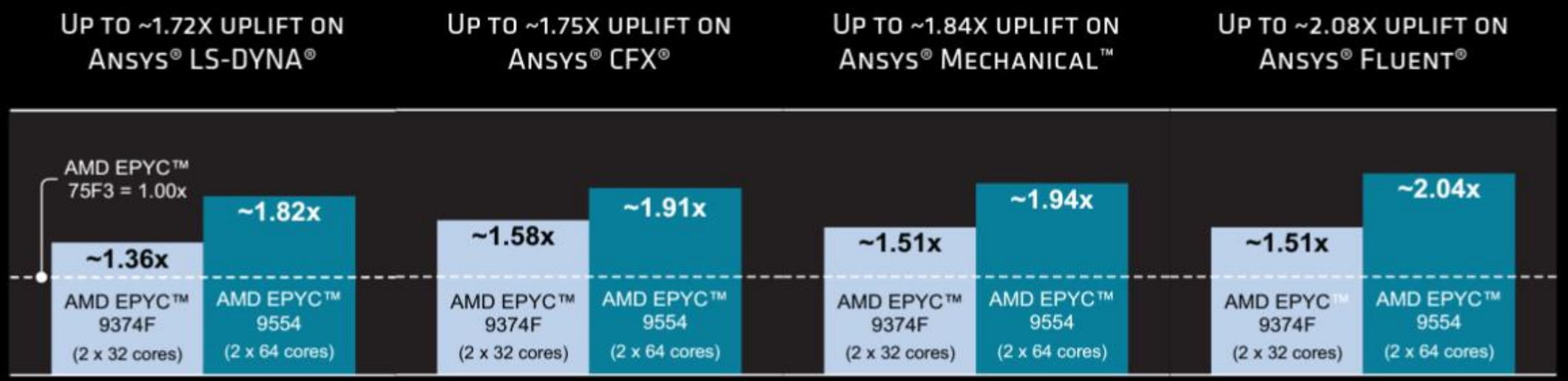


Results may vary. As of 11/10/2022 ,see endnotes SP5-033, -035A, -037.

# ANSYS® Applications on AMD EPYC™ 9004 Series Processors

## PERFORMANCE HIGHLIGHTS

These charts show the average generational uplift provided by 32- and 64-core 4th Gen AMD EPYC processors across a variety of Ansys® benchmarks:




75F3: 32C, 2.95/4.00GHz, 280W

9374F: 32C, 3.85/4.30GHz, 320W
9554: 64C, 3.10/3.75GHz, 360W

https://www.amd.com/system/files/documents/epyc-9004-pb-ansys-generational.pdf

# Delivering Optimized Foundational Software

Applications

**Platform Compilers**

GCC

Visual Studio®

LLVM™

**Performance Compilers**

AOCC

AMD Optimizing CPU Compilers

**Optimized Libraries**

AOCL — AMD Optimizing CPU Libraries

ZenDNN — CPU Inference Acceleration

Package Manager Integration (e.g., Spack)

**Developer Tools**

AMD µProf

Performance and Power Profiling Tools

**JAVA**

OpenJDK™

Java®

Linux®, Windows®, FreeBSD®

# References

- AMD EPYC™ Server Processors
  - https://www.amd.com/en/processors/epyc-server-cpu-family
- AMD EPYC™ Server Performance Tuning Guides
  - High Performance Computing Tuning Guide for AMD EPYC™ 9004 Series Processors
    - https://www.amd.com/system/files/documents/58002-epyc-9004-tg-hpc.pdf
  - High Performance Toolchain: Compilers, Libraries & Profilers Tuning Guide for AMD EPYC™ 9004 Series Processors
    - https://www.amd.com/system/files/documents/58020-epyc-9004-tg-high-perf-toolchain.pdf
- AMD EPYC™ Tech Docs and White Papers
  - https://www.amd.com/en/processors/server-tech-docs
- AMD Optimizing C/C++ and Fortran Compilers (AOCC)
  - https://developer.amd.com/amd-aocc/
- AMD Optimizing CPU Libraries (AOCL)
  - https://developer.amd.com/amd-aocl/
- AMD µProf
  - https://developer.amd.com/amd-uprof/
- Pre-built-applications
  - https://developer.amd.com/applications/pre-built-applications/

# ENDNOTES

EPYC-18: 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.

EPYC-028B: SPECpower_ssj® 2008, SPECrate®2017_int_energy_base, and SPECrate®2017_fp_energy_base based on results published on SPEC's website as of 11/10/22. VMmark® server power-performance (PPKW) based results published at https://www.vmware.com/products/vmmark/results3x.1.html?sort=score. The first 74 ranked SPECpower_ssj®2008 publications with the highest overall efficiency overall ssj_ops/W results were all powered by AMD EPYC processors. For SPECrate®2017 Integer (Energy Base), AMD EPYC CPUs power the first 4 of 5 SPECrate®2017_int_energy_base performance/system W scores. For SPECrate®2017 Floating Point (Energy Base), AMD EPYC CPUs power the first 8 of 9 SPECrate®2017_fp_energy_base performance/system W scores. For VMmark® server power-performance (PPKW), have the top two results for 2- and 4-socket matched pair results outperforming all other socket results. See https://www.amd.com/en/claims/epyc3x#faq-EPYC-028B for the full list.

EPYC-032: 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. Intel Scalable "Ice Lake" CPUs support 8 channels of up to 3200 MHz DDR 4 (per https://ark.intel.com/) have a maximum 204.8 GB/s. EPYC 9004 CPUs have 2.25x the memory throughput per CPU. 460.8 ÷ 204.8 = 2.25x the max throughput or 125% more max throughput.

EPYC-034A: AMD EPYC 9004 CPUs can support 12 memory channels with 2 DPC (DIMMs / channel) 12 x 2 = 24 DIMM slots x 256GB DIMMs = 6,144GB of standard DRAM (DDR) memory or 6TB per CPU. The highest supported total memory (not just DRAM) on https://ark.intel.com/ is the Intel Xeon Ice Lake is 6 TB per CPU - but with standard DRAM the limit is 4TB: 8 memory channels x 2 DPC = 16 total DIMM slots x 256GB DIMMs = 4,096GB of DRAM (DDR) memory, or 4TB per CPU. EPYC 9004 Series supports 50% more DRAM than Intel Ice Lake CPUs.

EPYC-38: Based on AMD internal testing as of 09/19/2022, geomean performance improvement at the same fixed-frequency on a 4th Gen AMD EPYC™ 9554 CPU compared to a 3rd Gen AMD EPYC™ 7763 CPU using a select set of workloads (33) including est. SPECrate®2017_int_base, est. SPECrate®2017_fp_base, and representative server workloads.

GD-83: Use of third-party marks / logos/ products is for informational purposes only and no endorsement of or by AMD is intended or implied.

GD-183: AMD Infinity Guard features vary by EPYC™ Processor generations. Infinity Guard security features must be enabled by server OEMs and/or Cloud Service Providers to operate. Check with your OEM or provider to confirm support of these features. Learn more about Infinity Guard at https://www.amd.com/en/technologies/infinity-guard.

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).

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). ormation.

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). ormation.

SP5-008: 4th Gen EPYC CPUs (96c) support up to 12 channels of DDR5-4800 memory (460.8 GB/s) versus 3rd Gen EPYC CPUs (64c) that support up to 8 channels of DDR4-3200 (240.8 GB/s) memory.

SP5-009C: SPECrate®2017_fp_base based on published scores from www.spec.org 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) is 2.52x the performance of published 2P Intel Xeon Platinum 8380 (587 SPECrate®2017_fp_base, 160 total cores, www.spec.org/cpu2017/results/res2022q4/cpu2017-20221010-32542.html).Published 2P AMD EPYC 7763 (663 SPECrate®2017_fp_base, 128 Total Cores, http://spec.org/cpu2017/results/res2021q4/cpu2017-20211121-30146.html) is shown at 1.13x for reference. SPEC®, SPEC CPU®, and SPECrate® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

# ENDNOTES

SP5-010B: SPECrate®2017_int_base based on published scores from www.spec.org 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) is 2.97x the performance of published 2P Intel Xeon Platinum 8380 (602 SPECrate®2017_int_base, 80 total cores, http://spec.org/cpu2017/results/res2021q2/cpu2017-20210521-26364.html). Published 2P AMD EPYC 7763 (861 SPECrate®2017_int_base, 128 total cores, http://spec.org/cpu2017/results/res2021q4/cpu2017-20211121-30148.html) is shown at 1.43x for reference. SPEC®, SPEC CPU®, and SPECrate® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information. NOTE: Red text only needs to be included with charts that show the 7763.

SP5-011B: SPECpower_ssj®2008 comparison based on published 2U, 2P Windows® results as of 11/10/2022. Configurations: 2P AMD EPYC 9654 (27501 overall ssj_ops/W, 2U, http://www.spec.org/power_ssj2008/results/res2022q4/power_ssj2008-20221020-01194.html) vs. 2P Intel Xeon Platinum 8380 (13670 overall ssj_ops/W, 2U, http://www.spec.org/power_ssj2008/results/res2022q4/power_ssj2008-20220926-01184.html). 2P AMD EPYC 7763 (23505 overall ssj_ops/W, 2U, http://www.spec.org/power_ssj2008/results/res2021q2/power_ssj2008-20210324-01091.html) shown at 1.72x for reference. SPEC® and SPECpower_ssj® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information. NOTE: Red text only needs to be included with charts that show the 7763.

SP5-012B: SPECjbb® 2015-MultiJVM Max based on published scores from www.spec.org 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) is 2.85x the performance of published 2P Intel Xeon Platinum 8380 (286125 SPECjbb®2015 MultiJVM max-jOPS, 152057 SPECjbb®2015 MultiJVM critical-jOPS, 80 Total Cores, http://www.spec.org/jbb2015/results/res2021q4/jbb2015-20211006-00706.html). 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) shown at 1.47x for reference. SPEC® and SPECjbb® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information. NOTE: Red text only needs to be included with charts that show the 7763.

SP5-013A: 96-core EPYC 9654 CPU processors results as of 11/10/2022 using SPECrate®2017_int_base. The AMD EPYC scored 1790 SPECrate®2017_int_base which is higher than all other 2P scores published on the SPEC® website. 2P AMD EPYC 9654 (1790 SPECrate®2017_int_base, 192 total cores, www.spec.org/cpu2017/results/res2022q4/cpu2017-20221024-32607.html). SPEC®, SPECrate® and SPEC CPU® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

SP5-014: Estimated 16-core 4th Gen EPYC CPU processors results as of 08/31/2022 using SPECrate®2017_int_base. The AMD EPYC scored ~418 or ~13.06/core (measured on AMD internal reference platform and marked estimate per SPEC Fair Use) which is higher performance-per-core than all other 2P scores published on the SPEC® website. SPEC®, SPECrate® and SPEC CPU® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

SP5-015A: SPECrate®2017_int_base comparison is based on a compliant ASUSTeK run and published scores from www.spec.org as of 11/10/2022. Comparison of compliant 2P AMD EPYC 9474F (1090 SPECrate®2017_int_base, 64 Total Cores, compliant run ASUSTeK RS700A-E12, 1536 GB - 24x 64 GB 2Rx4 PC5-4800B-R, SUSE Linux Enterprise Server 15 SP4, AOCC 4.0) is 1.81x the performance (51% per core adjusted) of published 2P Intel Xeon Platinum 8380 (602 SPECrate®2017_int_base, 540 Total TDP W, $17332 Total CPU $, http://spec.org/cpu2017/results/res2021q2/cpu2017-20210521-26364.html). Published 2P AMD EPYC 7643 (683 SPECrate®2017_int_base, 450 Total TDP W, 96 Total Cores, $9990 Total CPU $, http://spec.org/cpu2017/results/res2021q3/cpu2017-20210831-29186.html. SPEC®, SPEC CPU®, and SPECrate® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

SP5-016A: SPECrate®2017_int_base comparison is based on a compliant ASUSTeK run and published scores from www.spec.org as of 11/10/2022. Comparison of compliant 2P AMD EPYC 9374F (815 SPECrate®2017_int_base, 64 Total Cores, compliant run ASUSTeK RS700A-E12, 1536 GB - 24x 64 GB 2Rx4 PC5-4800B-R, SUSE Linux Enterprise Server 15 SP4, AOCC 4.0) is 1.55x the performance of published 2P Intel Xeon Platinum 8362 (526 SPECrate®2017_int_base, 64 Total Cores, http://spec.org/cpu2017/results/res2021q3/cpu2017-20210802-28469.html). Published 2P AMD EPYC 75F3 (596 SPECrate®2017_int_base, 64 Total Cores, http://spec.org/cpu2017/results/res2021q2/cpu2017-20210409-25541.html) is shown for reference. SPEC®, SPEC CPU®, and SPECrate® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

SP5-018A: SPECrate®2017_int_base comparison based on a compliant ASUSTeK run and published scores from www.spec.org as of 11/10/2022. Comparison of compliant 2P AMD EPYC 9174F (428 SPECrate®2017_int_base, 32 Total Cores, compliant run ASUSTeK RS700A-E12, 1536 GB - 24x 64 GB 2Rx4 PC5-4800B-R, SUSE Linux Enterprise Server 15 SP4, AOCC 4.0) is 1.47x the performance of published 2P Intel Xeon Gold 6346 (291 SPECrate®2017_int_base, http://spec.org/cpu2017/results/res2022q2/cpu2017-20220419-31532.html). Published 2P AMD EPYC 73F3 (352 SPECrate®2017_int_base, 480 Total TDP W, 32 Total Cores, $7042 Total CPU $, http://spec.org/cpu2017/results/res2021q4/cpu2017-20211207-30371.html) shown at 1.2x for reference. SPEC®, SPEC CPU®, and SPECrate® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

SP5-021A: As of 11/10/2022, the Intel exponential trendline from top SPECrate®2017_int_base published scores to date for 2P 1st, 2nd and 3rd Gen Intel based Xeon SP (LGA socketed) servers for each of 2015-2022 (expected). The AMD log trendline from top SPECrate®2017_int_base published score to date, for 2P Intel based AMD EPYC servers for each of 2017, 2018, 2019, 2020, 2021, and as of claim date for 2022. The lines below are organized as: Year, CPU model, SPEC score, URL. Intel: 2017, Intel Xeon Platinum 8180, 302, https://spec.org/cpu2017/results/res2017q4/cpu2017-20170928-00070.pdf; 2018, Intel Xeon Platinum 8180, 304, https://spec.org/cpu2017/results/res2018q3/cpu2017-20180709-07701.pdf; 2019, Intel Xeon Platinum 8280L, 364, should be 8280L https://spec.org/cpu2017/results/res2019q2/cpu2017-20190429-12779.pdf; 2020, Intel Xeon Gold 6258R, 397, https://spec.org/cpu2017/results/res2020q3/cpu2017-20200915-23981.pdf; 2021, Intel Xeon Platinum 8380, 602, https://spec.org/cpu2017/results/res2021q2/cpu2017-20210521-26364.html; 2022, Intel Xeon Platinum 8380, 602, https://spec.org/cpu2017/results/res2021q2/cpu2017-20210521-26364.html. AMD: 2017, AMD EPYC 7601, 275, https://spec.org/cpu2017/results/res2017q4/cpu2017-20171211-01594.pdf; 2018, EPYC 7601, 282, https://spec.org/cpu2017/results/res2018q3/cpu2017-20180827-08666.pdf; 2019, EPYC 7742, 701, https://spec.org/cpu2017/results/res2019q4/cpu2017-20191125-20001.pdf; 2020, EPYC 7H12, 717, https://spec.org/cpu2017/results/res2020q2/cpu2017-20200525-22554.pdf; 2021, EPYC 7763, 861, http://spec.org/cpu2017/results/res2021q4/cpu2017-20211121-30148.html; 2022, EPYC 9654, 1790, www.spec.org/cpu2017/results/res2022q4/cpu2017-20221024-32607.html; SPEC®, SPECrate® and SPEC CPU® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

# ENDNOTES

SP5-022: Neural Magic measured results on AMD reference systems as of 9/29/2022. Configurations:2P EPYC 9654 “Titanite” vs. 2P EPYC 7763 “DaytonaX” running on Ubuntu 22.04 LTS, Python 3.9.13, pip==22.12/deepsparse==1.0.2. BERT-Large Streaming Throughput items/sec (seq=384, batch 1, 48 streams, INT8 + sparse) using SQuAD v1.1 dataset; ResNet50 Batched Throughput items/sec (batch 256, single-stream, INT8 sparse) using ImageNet dataset; YOLOv5s Streaming Throughput ([image 3, 640, 640], batch 1, multi-stream, per-stream latency <=33ms) using COCO dataset. Testing not independently verified by AMD.

SP5-023: Estimated SPECrate®2017_int_base comparison based on internal AMD reference platform measurements/projections and best published scores at www.spec.org as of 11/10/2022. AMD internal measurements or projections* 2x AMD EPYC 9654 1550, 2x AMD EPYC 9634 1325*, 2x AMD EPYC 9554 1250, 2x AMD EPYC 9534 1070, 2x AMD EPYC 9474F 1040, 2x AMD EPYC 9454 820, *2x AMD EPYC 9374F 765, 2x AMD EPYC 9354 700, 2x AMD EPYC 9334 645, 2x AMD EPYC 9274F 550, *2x AMD EPYC 9254 480*, 2x AMD EPYC 9224 450, 2x AMD EPYC 9174F 419, 2x AMD EPYC 9124 340. Referenced: 2P Intel Xeon Platinum 8380 (602 SPECrate®2017_int_base, http://spec.org/cpu2017/results/res2021q2/cpu2017-20210521-26364.html) and 2P Intel Xeon Platinum 8362 (526 SPECrate®2017_int_base, http://spec.org/cpu2017/results/res2021q3/cpu2017-20210802-28469.html) 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 except EPYC 9654/9554 cTDP=400W)

SP5-024A: SPECrate®2017_fp_base comparison is based on a compliant ASUSTeK run and published scores from www.spec.org as of 11/10/2022. Comparison of compliant 2P AMD EPYC 9474F (1110 SPECrate®2017_fp_base, 96 Total Cores, compliant run ASUSTeK RS700A-E12, 1536 GB - 24x 64 GB 2Rx4 PC5-4800B-R, SUSE Linux Enterprise Server 15 SP4, AOCC 4.0) is 1.89x the performance (78% per core adjusted) of published 2P Intel Xeon Platinum 8380 (587 SPECrate®2017_fp_base, 540 Total TDP W, $17332 Total CPU $, http://spec.org/cpu2017/results/res2022q4/cpu2017-20221010-32542.html). Published 2P AMD EPYC 7643 (576 SPECrate®2017_fp_base, 450 Total TDP W, 96 Total Cores, $9990 Total CPU $, http://spec.org/cpu2017/results/res2021q4/cpu2017-20210928-29636.html) shown at 0.98x for reference. SPEC®, SPEC CPU®, and SPECrate® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

SP5-025A: SPECrate®2017_fp_base comparison is based on a compliant ASUSTeK run and published scores from www.spec.org as of 11/10/2022. Comparison of compliant 2P AMD EPYC 9374F (954 SPECrate®2017_fp_base, 64 Total Cores, compliant run ASUSTeK RS700A-E12, 1536 GB - 24x 64 GB 2Rx4 PC5-4800B-R, SUSE Linux Enterprise Server 15 SP4, AOCC 4.0) is 1.96x the performance of published 2P Intel Xeon Platinum 8362 (486 SPECrate®2017_int_base, 64 Total Cores, http://spec.org/cpu2017/results/res2022q3/cpu2017-20220729-32239.html). Published 2P AMD EPYC 75F3 (546 SPECrate®2017_fp_base, 560 Total TDP W, 64 Total Cores, $9720 Total CPU $, http://spec.org/cpu2017/results/res2021q2/cpu2017-20210409-25543.html) is shown at 1.12x for reference. SPEC®, SPEC CPU®, and SPECrate® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information

SP5-027A: SPECrate®2017_fp_base comparison is based on a compliant ASUSTeK run and published scores from www.spec.org as of 11/10/2022. Comparison of compliant 2P AMD EPYC 9374F (579 SPECrate®2017_fp_base, 32 Total Cores, compliant run ASUSTeK RS700A-E12, 1536 GB - 24x 64 GB 2Rx4 PC5-4800B-R, SUSE Linux Enterprise Server 15 SP4, AOCC 4.0) is 1.78x the performance of published 2P Intel Xeon Gold 6346 (325 SPECrate®2017_fp_base, 410 Total TDP W, 32 Total Cores, $5416 Total CPU $, http://spec.org/cpu2017/results/res2021q3/cpu2017-20210802-28471.html). Published 2P AMD EPYC 73F3 (398 SPECrate®2017_fp_base, 480 Total TDP W, 32 Total Cores, $7042 Total CPU $, http://spec.org/cpu2017/results/res2021q3/cpu2017-20210816-28714.html) shown at 1.22x for reference. SPEC®, SPEC CPU®, and SPECrate® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

SP5-028A: SPECrate®2017_fp_base comparison based on a compliant ASUSTeK run and published scores from www.spec.org as of 11/10/2022. Comparison of compliant 2P AMD EPYC 9554 (1200 SPECrate®2017_fp_base, 800 Total TDP W, 128 Total Cores, $18174 Total CPU $, compliant run ASUSTeK RS700A-E12, 1536 GB - 24x 64 GB 2Rx4 PC5-4800B-R, SUSE Linux Enterprise Server 15 SP4, AOCC 4.0) is 2.04x the performance (28% per core adjusted) of published 2P Intel Xeon Platinum 8380 (587 SPECrate®2017_fp_base, 540 Total TDP W, 80 Total Cores, $18718 Total CPU $, http://spec.org/cpu2017/results/res2022q4/cpu2017-20221010-32542.html). SPEC®, SPEC CPU®, and SPECrate® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

SP5-029A: SPECrate®2017_int_base comparison based on a compliant ASUSTeK run and published scores from www.spec.org as of 11/10/2022. Comparison of compliant 2P AMD EPYC 9554 (1300 SPECrate®2017_int_base, 800 Total TDP W, 128 Total Cores, $18174 Total CPU $, compliant run ASUSTeK RS700A-E12, 1536 GB - 24x 64 GB 2Rx4 PC5-4800B-R, SUSE Linux Enterprise Server 15 SP4, AOCC 4.0) is 2.16x the performance (35% per core adjusted) of published 2P Intel Xeon Platinum 8380 (602 SPECrate®2017_int_base, 540 Total TDP W, 80 Total Cores, $18718 Total CPU $, http://spec.org/cpu2017/results/res2021q2/cpu2017-20210521-26364.html). SPEC®, SPEC CPU®, and SPECrate® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

SP5-031: Black-Scholes European Option Pricing benchmark comparison based on AMD measurements for 100, 200, 400, 800, and 1600M options as of 10/4/2022. Max score is based on 200M options. Configurations: 2x 40-core Intel Xeon Platinum 8380 vs. 2x 64-core EPYC 9554 all systems on Ubuntu 22.04 and compiled with ICC 2022.1.0. Results may vary.2x 32-core EPYC 75F3 (shown for reference) at ~1.1x.

# ENDNOTES

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.

SP5-033: WRF® CONUS 2.5KM workload benchmark comparison based on AMD measurements as of 10/4/2022. Configurations: 2x 32-core Intel Xeon Platinum 8362 vs. vs. 2x 32-core EPYC 9374F for ~1.98x 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.

SP5-035A: Fluent® Release 2022 R2 test cases benchmark comparison based on AMD measurements as of 10/19/2022. Configurations: 2x 32-core Intel Xeon Platinum 8362 vs. vs. 2x 32-core EPYC 9374F for ~1.75x the rating performance. Results may vary.

SP5-036: Radioss™ neon 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 ~2.59x the solver speedup performance. Results may vary.

SP5-037: Radioss™ neon workload benchmark comparison based on AMD measurements as of 10/4/2022. Configurations: 2x 32-core Intel Xeon Platinum 8362 vs. vs. 2x 32-core EPYC 9374F for ~1.73x the solver speedup performance. Results may vary.

SP5-039: Autodesk® Arnold gtc_robot workload comparison based on internal AMD reference platform measurements as of 11/10/2022. Comparison of 2P AMD EPYC 9654 (99 avg. seconds/872.73 ray-traces/day) is ~2.4x the performance of 2P Intel Xeon Platinum 8380 (235 avg seconds/367.66 ray-traces/day). Results may vary.2P EPYC 7763 shown for reference (167 avg seconds/517.37 ray-traces/day) at ~1.4x.

SP5-049B: 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.

SP5-065: SPECrate®2017_int_energy_base comparison based on published results as of 11/10/2022. Configurations: 2P AMD EPYC 9654 (1890 SPECrate®2017_int_energy_base/1190 SPECrate®2017_int_base, 192 total cores, www.spec.org/cpu2017/results/res2022q4/cpu2017-20221024-32633.html) vs. 2P Intel Xeon Platinum 8380 (725 SPECrate®2017_int_energy_base/531 SPECrate®2017_int_base, 80 total cores, www.spec.org/cpu2017/results/res2021q2/cpu2017-20210412-25603.html). 2P AMD EPYC 7713 (1610 SPECrate®2017_int_energy_base/576 SPECrate®2017_int_base, 128 total cores, www.spec.org/cpu2017/results/res2021q1/cpu2017-20210301-25148.html) shown at 2.22x for reference. NOTE: Red text only needs to be included with charts that show the 7763.

SP5-067: SPECjbb® 2015-MultiJVM Max based on published scores from www.spec.org as of 11/10/2022. Configurations: 2P AMD EPYC 9374F (359294 SPECjbb®2015 MultiJVM max-jOPS, 167272 SPECjbb®2015 MultiJVM critical-jOPS, 64 total cores, http://www.spec.org/jbb2015/results/res2022q4/jbb2015-20221005-00856.html) is 1.71x the performance of published 2P Intel Xeon Gold 6338 (210635 SPECjbb®2015 MultiJVM max-jOPS, 111971 SPECjbb®2015 MultiJVM critical-jOPS, 64 total cores, http://www.spec.org/jbb2015/results/res2022q1/jbb2015-20220209-00717.html). 2P AMD EPYC 75F3 (276317 SPECjbb®2015 MultiJVM max-jOPS, 116628 SPECjbb®2015 MultiJVM critical-jOPS, 64 total cores, http://www.spec.org/jbb2015/results/res2021q2/jbb2015-20210408-00637.html) shown at 1.310x for reference. SPEC® and SPECjbb® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information. NOTE: Red text only needs to be included with charts that show the 75F3.

SP5-068: SPECrate®2017_int_base, SPECrate®2017_fp_base, and BERT-large estimates based on internal AMD reference platform measurements of 11/3/2022. Floating-point throughput comparison: 2P AMD EPYC 9534 (1030 est. SPECrate®2017_fp_base, 560 Total TDP W, 128 Total Cores) is 1.66x the performance/W of 2P AMD EPYC 7763 (622 est. SPECrate®2017_fp_base, 560 Total TDP W, 128 Total Cores). Integer throughput comparison: 2P AMD EPYC 9534 (1070 est. SPECrate®2017_int_base, 560 Total TDP W, 128 Total Cores) is 1.34x the performance/W of published 2P AMD EPYC 7763 (800 est. SPECrate®2017_int_base, 560 Total TDP W, 128 Total Cores). Bert-Large NLP sparse INT8 comparison: 2P AMD EPYC 9534 (345.6 items/sec, 560 Total TDP W, 128 Total Cores) is 2.67x the performance/W of published 2P AMD EPYC 7763 (129.7 items/sec, 560 Total TDP W, 128 Total Cores). 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).

# ENDNOTES

SP5-069: SPECrate®2017_int_base estimate based on internal AMD reference platform measurements and published score from www.spec.org as of 11/10/2022. Comparison of estimated 1P AMD EPYC 9554P (631 SPECrate®2017_int_base, 400 Total TDP W, 64 Total Cores, $7104 Total CPU $, AMD Est) is 1.05x the performance of published 2P Intel Xeon Platinum 8380 (602 SPECrate®2017_int_base, 540 Total TDP W, 80 Total Cores, $18718 Total CPU $, http://spec.org/cpu2017/results/res2021q2/cpu2017-20210521-26364.html) [at 1.42x the performance/W] [at 2.76x the performance/CPU$]. 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)

SP5-070: MySQL® 8.0.17 DSS comparison based on AMD measured median scores on 2P 96-core EPYC 9654 compared to 2P 40-core Xeon Platinum 8380 running virtualized HammerDB TPROC-H SF1 (KVM Hypervisor Virtualization server environment with 4 streams, 4 virtual units, calculating throughput with 4 streams x 22 queries x 3600 divided by the slowest VU completion time in seconds) as of 11/10/2022. Configurations: 2x AMD EPYC 9654 (~126,980 TPROC-H tpm) vs. 2x Xeon Platinum 8380 (~47452 TPROC-H queries/hour) for ~2.68x the tpm performance.

SP5-071: MySQL® 8.0.17 OLTP comparison based on AMD measured median scores on 2P 96-core EPYC 9654 compared to 2P 40-core Xeon Platinum 8380 running virtualized HammerDB TPROC-C (KVM Hypervisor Virtualization server environment with 400 WH and 64 users) as of 11/10/2022. Configurations: 2x AMD EPYC 9654 (~126,980 TPROC-C tpm/~531,183 NOPM) vs. 2x Xeon Platinum 8380 (~47452 TPROC-C tpm/~224,126 NOPM) for ~2.37x the tpm/NOPM performance.

SP5TCO-009K: As of 11/10/2022 based on AMD Internal analysis using the AMD EPYC™ Bare Metal Server & Greenhouse Gas Emission TCO Estimation Tool - version 6.35 estimating the cost and quantity of 2P AMD EPYC™ 9654 powered servers versus 2P Intel® Xeon® 8380 based server solutions required to deliver 8500 units of integer performance. 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. The analysis includes both hardware and virtualization software components. For additional details, see https://www.amd.com/en/claims/epyc3x#faq-SP5TCO-009K.

SP5TCO-010K: 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. The Bare Metal Server Greenhouse Gas Emissions TCO (total cost of ownership) Estimator Tool compares the selected AMD EPYC™ and Intel® Xeon® CPU based server solutions required to deliver a TOTAL_PERFORMANCE of 8,500 units of integer performance based on the estimated or published scores for Intel Xeon and AMD EPYC CPU based servers. This estimation reflects a 1-year time frame. This analysis compares a 1P AMD EPYC 64 core 9554P CPU powered server with an estimated SPECrate®2017_int_base score of 631, performance estimated using AMD reference platform; compared to a 2P Intel Xeon 40 core Platinum_8380 based server with a SPECrate®2017_int_base score of 602 https://spec.org/cpu2017/results/res2021q2/cpu2017-20210521-26364.pdf.

SP5TCO-011k: 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. The Bare Metal Server Greenhouse Gas Emissions TCO (total cost of ownership) Estimator Tool compares the selected AMD EPYC™ and Intel® Xeon® CPU based server solutions required to deliver a TOTAL_PERFORMANCE of 8,500 units of integer performance based on the estimated or published scores for Intel Xeon and AMD EPYC CPU based servers. This estimation reflects a 1-year time frame. This analysis compares a 1P AMD EPYC 96 core 9654P CPU powered server with an estimated SPECrate®2017_int_base score of 895, performance estimated using AMD reference platform; compared to a 2P Intel Xeon 40 core Platinum_8380 based server with a SPECrate®2017_int_base score of 602 https://spec.org/cpu2017/results/res2021q2/cpu2017-20210521-26364.pdf.

SP5TCO-012K: As of 10/10/2022 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® 8380 (40 core/CPU) based server solutions required to deliver 200 total virtual machines (VM), requiring 8 core and 16GB of memory per VM, for the 1st year. 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-012K.

SP5TCO-019K: 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 8380 (40 core/CPU) based server solutions required to deliver 1995 total virtual machines (VM) based on VMmark tiles in published results, for 1st year. 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-019K.

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