HPE X AMD パートナー倶楽部メンバー様向け
第8回 オンライントレーニング

AMD EPYC™第4世代GENOAについて

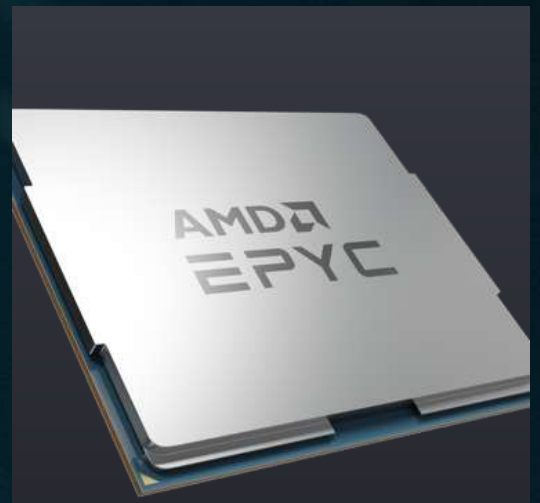
日本AMD株式会社
コマーシャル営業本部
2022/11/29

AMD
together we advance_data centers

AMD のコンピューティングが
数十億人の日常生活を支えています

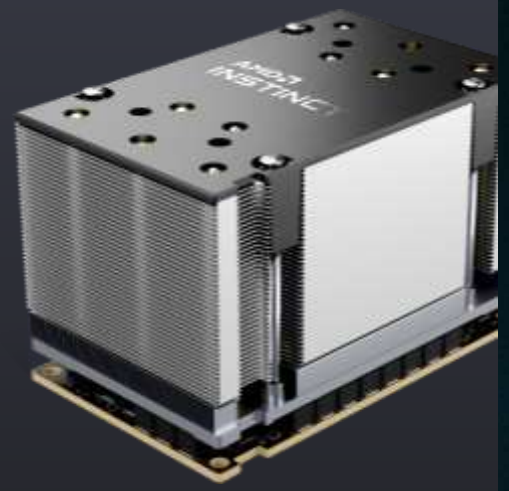
[AMD Official Use Only - General]

最新のデータセンターには
高性能なエンジンが必要です



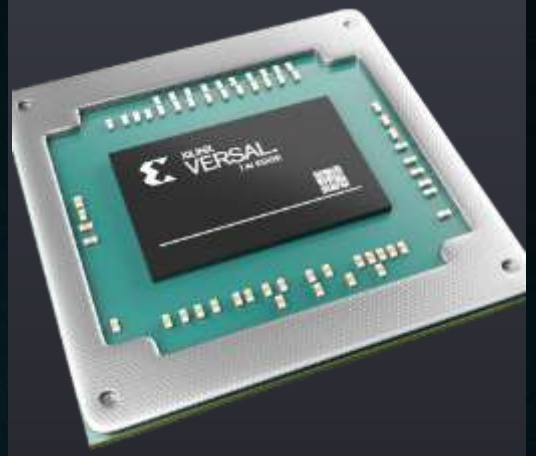
サーバー CPUs

AMD EPYC



GPU アクセラレーター

AMD INSTINCT



FPGAs
アダプティブ SoCs

XILINX ALVEO. XILINX VERSAL.

スマートNICs
& DPUs

AMD PENSANDO XILINX ALVEO.

[AMD Official Use Only - General]

第4世代AMD EPYC™

世界最高データセンター用 CPU

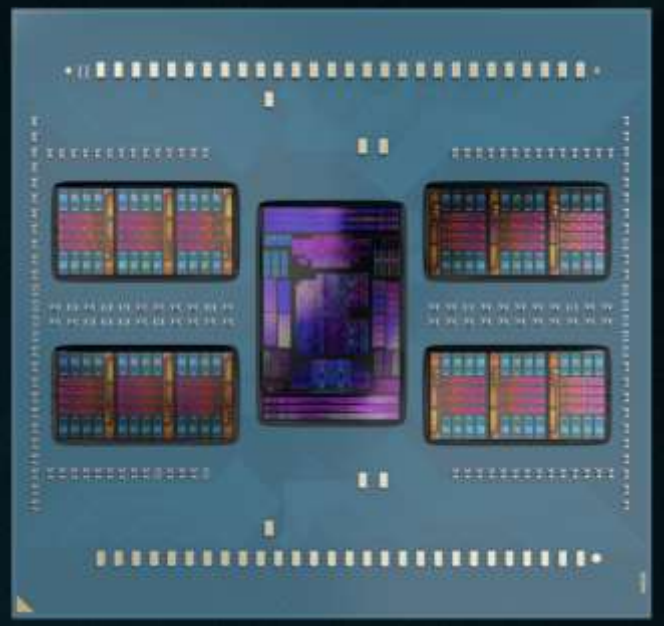
Endnote: SP5-013A

[AMD Official Use Only - General]

公約通りに製品投入を実現

All roadmaps are subject to change.

[AMD Official Use Only - General]



第4世代AMD EPYC™ CPUs

96 “Zen 4” コア	先端の 5nm	PCIe® 5.0	CXL™ メモリー 拡張	12 チャネル DDR5	~2x コンフィデンシャル VMs*

*Based on increase in security keys in 4th Gen of 1009 versus 3rd Gen with 509 keys.

[AMD Official Use Only - General]

AMD EPYC™ 9004 の概要

コンピュート

- AMD "Zen4" x86 コア (最大 12 CCDs / 96 コア / 192 スレッド)
- 1MB L2/コア, 最大 32MB L3/CCD
- ISA アップデート: BFLOAT16, VNNI, AVX-512 (256b data 幅)
- 57b/52bによるメモリアドレス指定可能
  仮想/物理アドレス

- IODと内部AMD Gen3 Infinity Fabric™アーキテクチャを更新し、ダイ間バンド幅を拡大

- TDP ：最大 400W (cTDP)

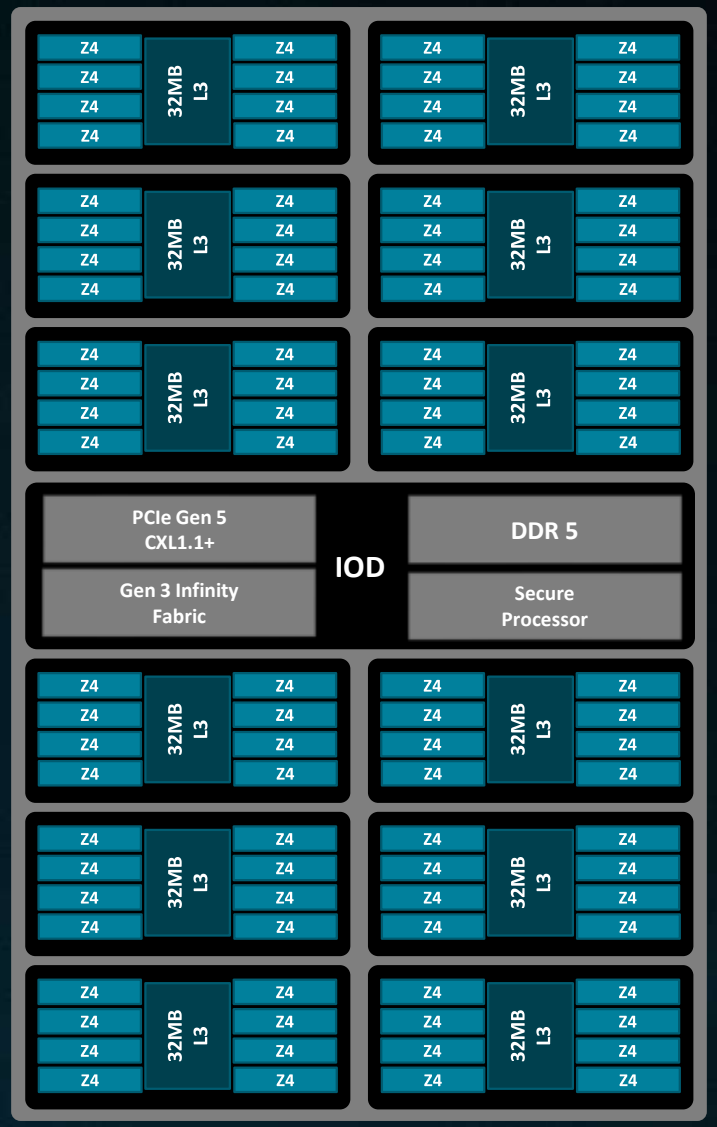
- RAS アップデート

メモリー

- 12 チャネル DDR5 with ECC 最大 4800 MHz
- 2,4,6, 8, 10, 12 チャネル メモリー・インターリービング[1] オプション

- RDIMM, 3DS RDIMM

- 最大 2 DIMMs/ チャネル、 最大 12TB / 2 ソケット (256GB 3DS RDIMMs)[1]



SP5 ソケット

- 新ソケット、パワーデリバリーの向上とVR
- 最大 4 リンク の Gen3 AMD Infinity Fabric™ 最大 32Gbps
- Flexible topology options

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

統合I/O - チップセットなし

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

セキュリティー機能

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.

[AMD Official Use Only - General]

AMD EPYC™ Processor Naming Convention

EPYC 9004 Series CPUs

Generation

EPYC™ 9554P CPU

Product Family

★ **Product Series**

Feature Modifier
- "P" = 1P OPNs
- "F" = Performance / Core Optimized

Core Count
- Indicates Core Count within the Series

100s Digit	0	1	2	3	4	5	6
Cores	8	16	24	32	48	64	84-96

AMD EPYC 9004 Series CPUs - SP5

Performance

10s digit - Perf
- Relative Performance w/in core count
- Higher number = higher perf

[AMD Official Use Only - General]

EPYC™ 9004 CPU ポートフォリオ

ワークロードを最適化
すべてのSKUにすべての機能を提供

クラウド & HPC		パフォーマンス・エンタープライズ		メインストリームエンタープライズ	
9654	96c | 360w	9474F	48c | 360w	9354	32c | 280w
9634	84c | 290w	9374F	32c | 320w	9334	32c | 210w
9554	64c | 360w	9274F	24c | 320w	9254	24c | 200w
9534	64c | 280w	9174F	16c | 320w	9224	24c | 200w
9454	48c | 290w			9124	16c | 200w

[AMD Official Use Only - General]

AMD EPYC™ 9004 シリーズプロセッサー

- 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

[AMD Official Use Only - General]

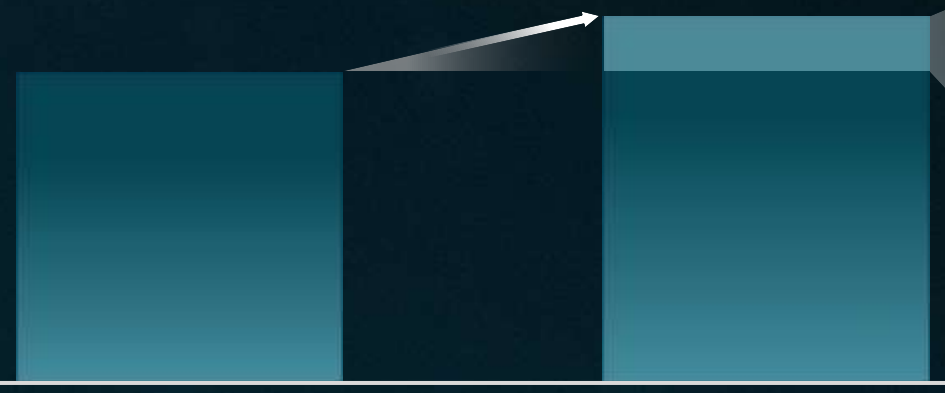
AMD EPYC™ プロセッサー
with “Zen 4”

[AMD Official Use Only - General]

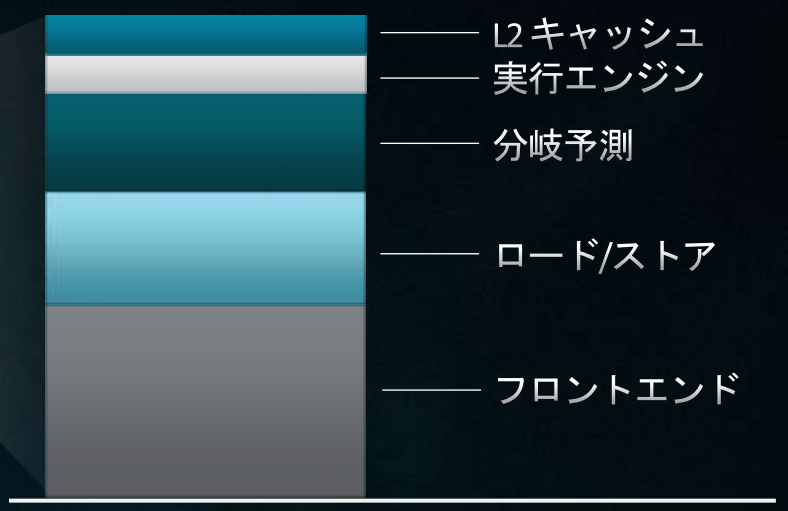
約14% IPC 向上

33 種のサーバーワークロードの相乗平均

(固定周波数、8 CCD、CCDあたり1 スレッド)



“Zen 4” IPC 向上の内訳

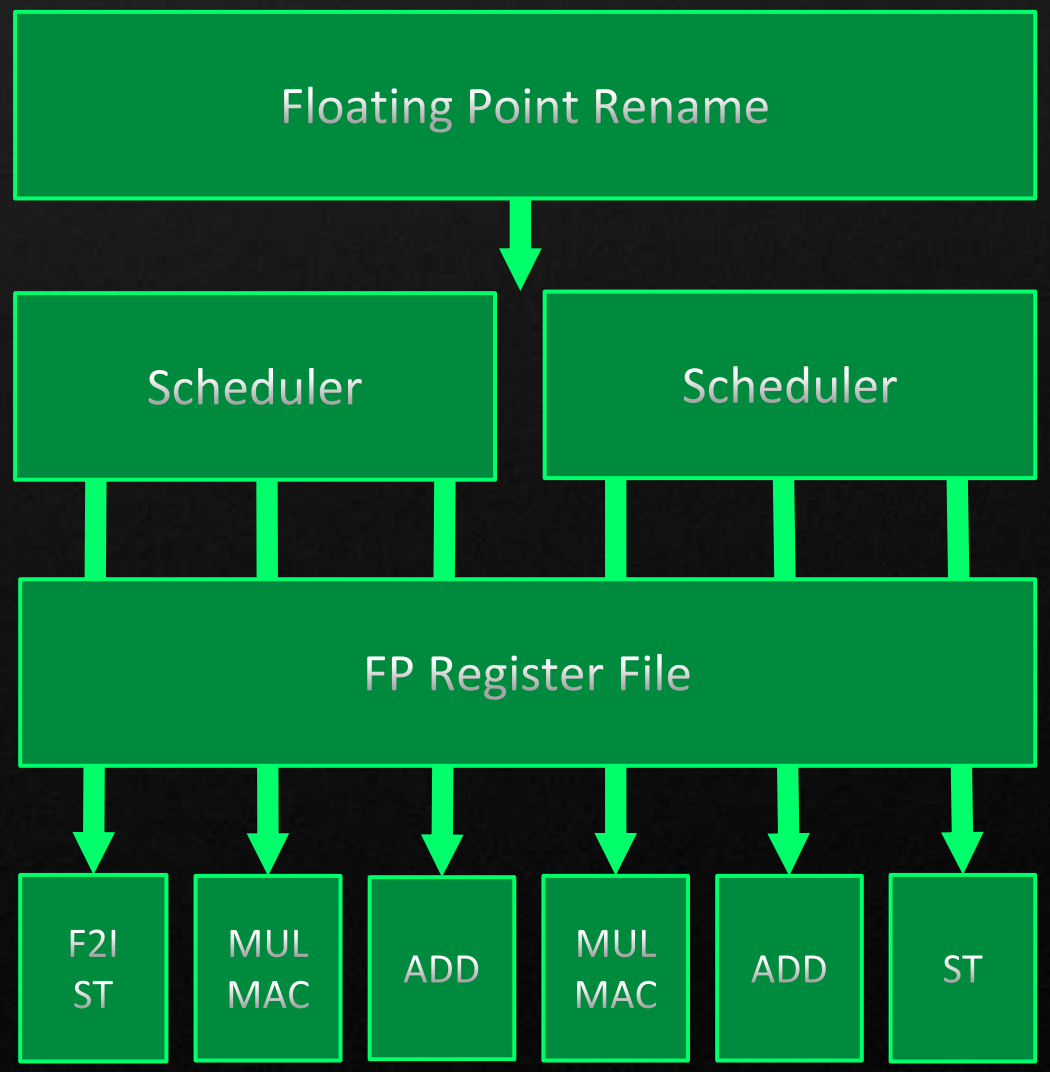


Illustrative purposes only

Endnote: EPYC-038

AVX-512 命令 “Zen4”

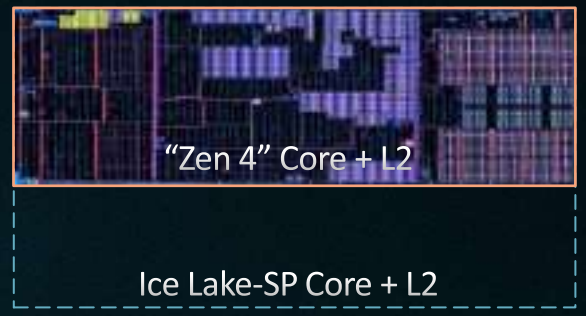
- レーンごとのマスキング機能を追加
- 新規Scatter/Gather命令の追加
- 256ビットオペレーションで実装。
  - サイズ効率の良い実装
  - AVX-512命令使用による周波数低下の影響なし
  - 命令フェッチと制御オーバーヘッドの削減によりスループットは同等、対AVX-256で高効率を実現
- BFloat16命令サポート
- VNNI命令のサポート



[AMD Official Use Only - General]

高性能、高効率のリーダーシップ

	AMD “Zen 4” コア	Intel Ice Lake Sunny Cove コア
ノード	TSMC 5nm	Intel 10 Process
コア + L2 サイズ	3.84 mm²	~6.5mm²
SOC 性能 / ワット	1.48x	1.0x



Illustrative purposes only

~40%
小面積
vs. 競合製品

最大
48%
以上のエネルギー効率
vs. 競合製品

Endnote: EPYC-041

[AMD Official Use Only - General]

消費電力性能
前世代(Milan)からの向上

Endnote: SP5-068

[AMD Official Use Only - General]

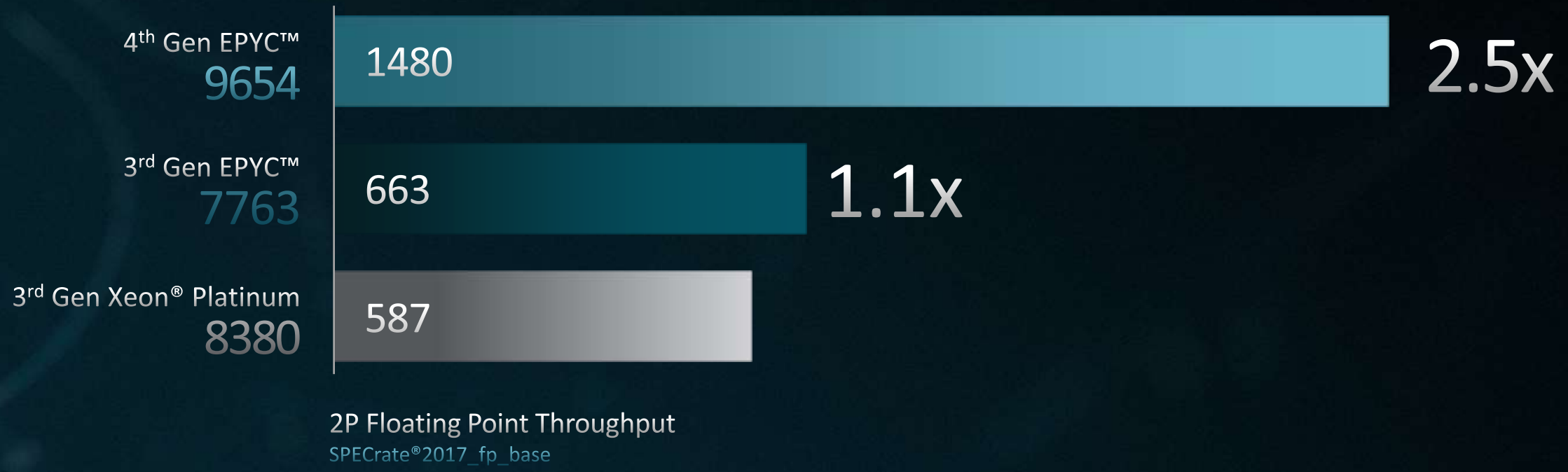
AMD EPYC™ 9004 シリーズ

汎用コンピューティングの性能一覧

*F = Performance / Core Optimized . 2x 4TH Gen AMD EPYC™ CPU estimates. Best performing 2x Intel Xeon Platinum processors published at www.spec.org as of 8/22/22. 3rd Gen Intel Xeon URLs: 2x Xeon Platinum 8380, Platinum 8362,; See endnote SP5-023.
OEM published scores will vary based on system configuration and determinism mode used (default cTDP performance profile except AMD EPYC 9654/9554 cTDP=400W)

[AMD Official Use Only - General]

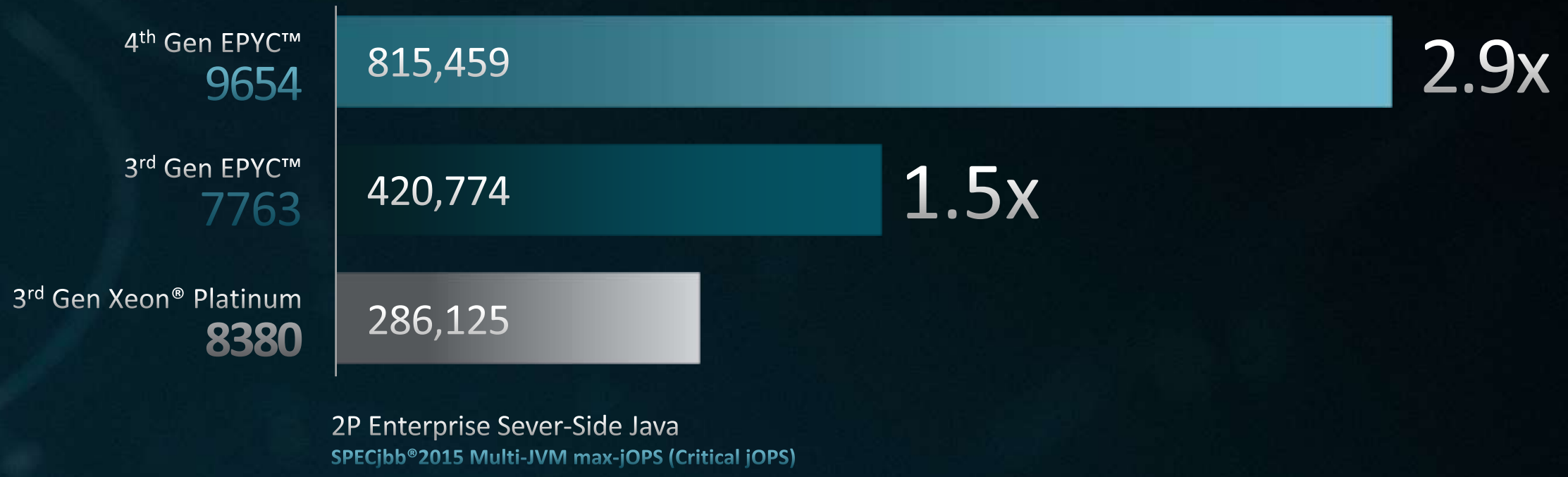
HPCにおける性能の優位性



Endnote: SP5-009C

[AMD Official Use Only - General]

エンタープライズにおける性能の優位性



Endnote: SP5-012B

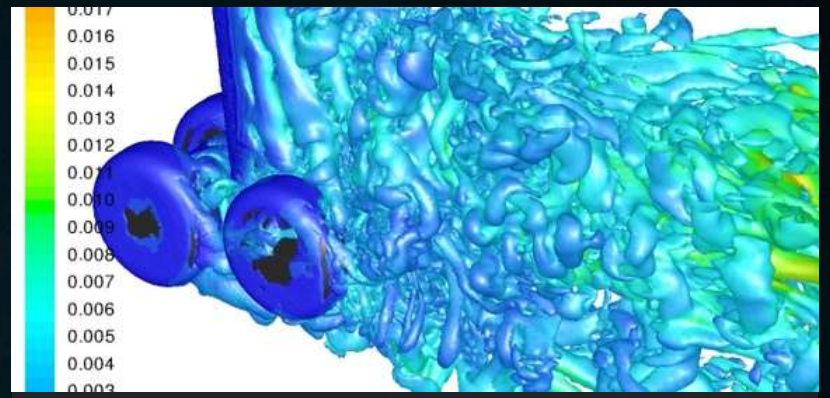
[AMD Official Use Only - General]

HPC Throughput Performance Leadership

Faster Time to Solution With High Core Counts and Memory Bandwidth

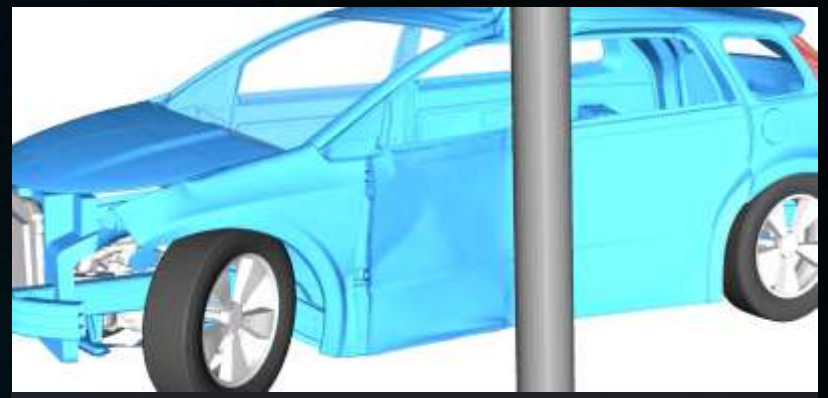
Weather Forecasting

~2.5x WRF®
-CONUS 2.5km



Computational Fluid Dynamics

~2.5x Ansys Fluent®
- 2022 R2 Test Cases



Finite Element Analysis - Explicit

~2.6x Altair Radioss™
- Neon test case

2P AMD EPYC™ 9654 (96C) vs. 2P Xeon® Platinum 8380 (40C)

Results may vary. As of 11/10/2022 See endnotes SP5-032, -034A, -036.

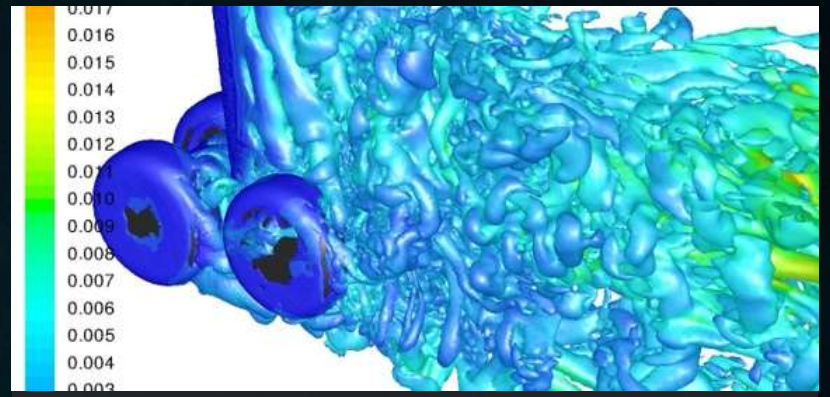
[AMD Official Use Only - General]

HPC Per-Core Performance Leadership

Faster Time to Discovery at Equal Core Counts

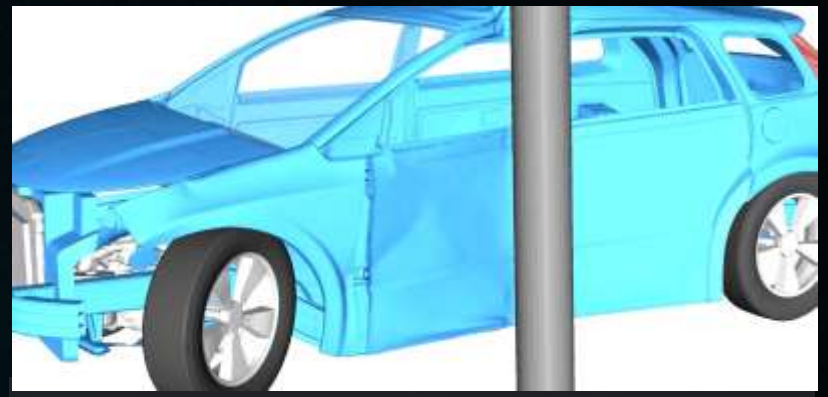
Weather Forecasting

~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

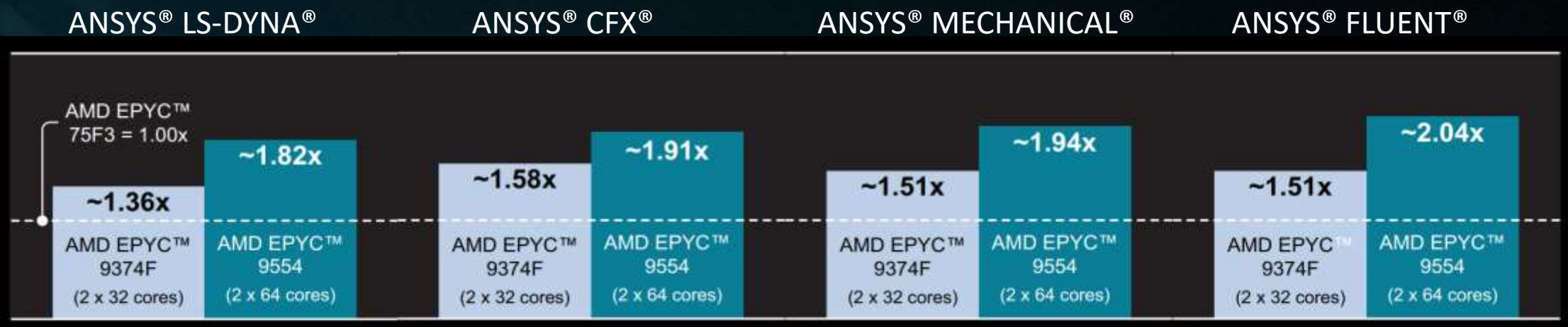
2P AMD EPYC™ 9374F (32C) vs. 2P Xeon® Platinum 8362 (32C)

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

[AMD Official Use Only - General]

ANSYS – ベンチマーク結果

以下のグラフは，さまざまな Ansysベンチマークにおいて 32コアと64コアの第４世代EPYC プロセッサによって提供される平均的な性能向上を表しています



EPYC 9554	360W	64C L3:256MB 3.10/3.75GHz
EPYC 9374F	320W	32C L3:256MB 3.85/4.30GHz
EPYC 75F3	280W	32C L3:256MB 2.95/4.0GHz

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

[AMD Official Use Only - General]

STAR CCM+ – ベンチマーク結果

以下のグラフは， Simcenter STAR CCM+ベンチマークにおいて 32コア, 64コア, 96コアの第４世代EPYCプロセッサによって提供される平均的な性能向上を表しています

ベンチマーク: emph, vtmben, lm100c, lm100s, vtmuhood, ca, kcs, hima, lmpoly, reactor, tcharg (elapsed time), Solver=17.04.008 with OpenMPI 4.1.2

最大 ~1.5x 32コア
第4世代 AMD EPYC CPU

最大 ~2.09x 64コア
第4世代 AMD EPYC CPU

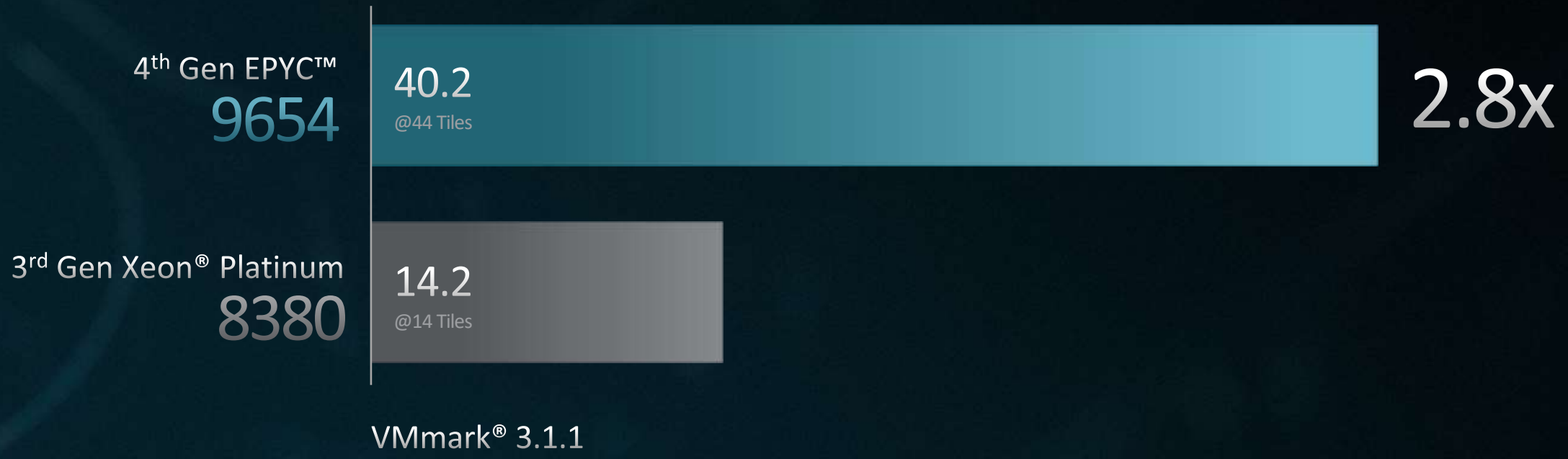
最大 ~2.34x 96コア
第4世代 AMD EPYC CPU

EPYC 9654	360W	96C L3:384MB 2.4/3.70GHz
EPYC 9554	360W	64C L3:256MB 3.10/3.75GHz
EPYC 9374F	320W	32C L3:256MB 3.85/4.30GHz
EPYC 75F3	280W	32C L3:256MB 2.95/4.0GHz

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

[AMD Official Use Only - General]

仮想化の性能



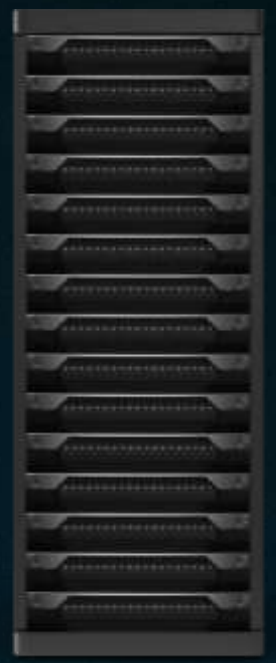
Endnote: SP5-049A

[AMD Official Use Only - General]

AMD EPYC™ CPU
仮想化における優位性

15 サーバー

2P Intel Platinum 8380



vs.

5 サーバー

2P AMD EPYC™ 9654

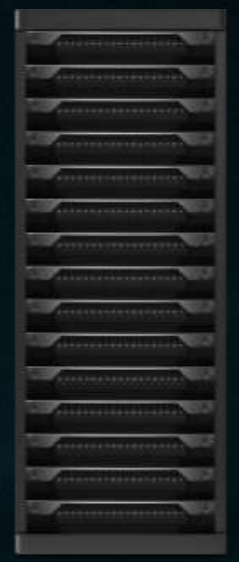
1995 VMs

Endnote: SP5TCO-019K

[AMD Official Use Only - General]

15 サーバー

2P Intel Platinum 8380



vs.

5 サーバー

2P AMD EPYC™ 9654

インフラ統合のメリット

67% 最大
少ないサーバー台数

52% 最大
低消費電力

40% 最大
導入コスト削減

61% 最大
運用コスト削減

Endnote: SP5TCO-019K

[AMD Official Use Only - General]

データセンター近代化の急務

現在インストールされている数百万台のサーバーはSkylakeまたはそれ以前のものです

5:1

第4世代EPYC™サーバ1台で、レガシーサーバ5台を置き換えることができます

Endnote: SP5TCO-022K

[AMD Official Use Only - General]

既存インフラの統合

~58% 年間エネルギーコストの削減

80% フットプリントの削減

10%+ より高い性能*

5 サーバー

2P Intel Xeon 8180 (28c)

vs.

1 サーバー

2P AMD EPYC™ 9654 (96c)

*Based on EPYC 9654 supporting 10% more VMs than Intel 8180. Endnote: SP5TCO-022K

[AMD Official Use Only - General]

EPYC™ の完全なエコシステム

[AMD Official Use Only - General]

第4世代 EPYC™ ファミリー
データセンターの高度化に向けて

汎用	クラウド・ネイティブ	テクニカル・コンピューティング	インテリジェント・エッジ／テレコ
“Genoa”	“Bergamo”	“Genoa-X”	“Siena”
ソケット性能、コア性能	スケール・アウト性能	科学技術計算やデータベースに最適	パフォーマンス・パー・ワットに最適
販売開始	2023 上半期 予定	2023年 上半期 予定	2023年 下半期 予定

[AMD Official Use Only - General]

戦略に沿ったロードマップを公約通りに実行

All roadmaps are subject to change.

AMD

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[AMD Confidential Internal Only - Internal]

Endnotes

EPYC-038: 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. SPEC® and SPECrate® are registered trademarks of Standard Performance Evaluation Corporation. Learn more at spec.org.

EPYC-040: 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. Prior generation of EPYC CPUs (7003 series) have a maximum 204.8 GB/s. EPYC 9004 CPUs have 2.25x the memory throughput per CPU. 460.8 ÷ 204.8 = 2.3x (2.25x) the max memory throughput.

EPYC-041: ~40% less area measures Core + L2 Area: "Zen 4" = 3.84 mm2 vs. "Sunny Cove" ~6.5mm2. ~48% estimated SPECrate®2017_int_base GCC -O3 Jemalloc results based on internal AMD reference platform and Intel platform measurements of 11/10/2022. Comparison of estimated 1P AMD EPYC 9534 (537 est. SPECrate®2017_int_base, set to 270 Total TDP W, 64 Total Cores, AMD Est) is 1.48x the performance per watt of 1P Intel Xeon Platinum 8380 (363 est. SPECrate®2017_int_base, 270 Total TDP W, 40 Total Cores, AMD est.) for 1.48x the SoC performance/watt. 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 (claim uses 270W cTDP performance profile).

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.

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.

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.

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.

SP5-016A: 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.

SP5-049A: 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.

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Endnotes

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. SPEC® 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.

SP5-068: 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 published 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).

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.

SP5-073K: As of Nov. 10, 2022 testing based on DELL measured median scores migrating 380 VMs (20 VMmark tiles) from 5 x 2P Xeon Platinum 8180 (28c) powered server to 1 x 2P EPYC 9654 (96c) powered server using VAMT 1.1 (VMware architecture Migration Tool). Storage is external to the servers so was not migrated.

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.

SP5TCO-021K: 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 (96 core/CPU) powered server versus 2P Intel® Xeon® Gold 8380 (40 core/CPU) based server solutions required to deliver 13 million 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-021K.

SP5TCO-022K: 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® Platinum 8130 (28 core/CPU) based server solutions required to deliver 380 total virtual machines (VM), requiring 1 core and 8GB of memory per VM for a 1 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-022K.

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Endnotes

SP5TCO-020K: "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 8500 units of integer performance based on the published scores for Intel Xeon and AMD EPYC CPU based servers. This estimation reflects a 1-year time frame. This server TCO model does not include any networking or storage that is external to the servers. This analysis compares a 2P AMD EPYC EPYC_7763 powered server with SPECrate®2017_int_base a score of 861, https://spec.org/cpu2017/results/res2021q4/cpu2017-20211121-30148.pdf; compared to a 2P Intel Xeon Platinum_8380 based server with a SPECrate®2017_int_base score of 602https://spec.org/cpu2017/results/res2021q2/cpu2017-20210521-26364.pdf. The Intel server chassis is 2RU with a cost of $2500. The AMD server chassis is 2RU with a cost of $2500. Both AMD EPYC and Intel based servers use the same cost for the following elements of the analysis: internal storage $380; physical servers managed per admin: 30; fully burdened cost per admin $110500; server rack size of 42; space allowance per rack of 27 sq feet; monthly cost of data center space $20 per sq foot; cost per kW for power $0.08198; power drop per rack of 8kW; the tool uses a PUE of 1.00 to illustrate 'server only' power consumption - PUE is Power Usage Effectiveness. The EPYC powered solution is estimated to take: 10 total 2P EPYC_7763 powered servers at a hardware only acquisition cost of $23012 per server, which includes $7890 per CPU, total system memory of 1024GB, which is 8GB of memory / core and a total system memory cost using DDR4 DIMMs of $4352; internal storage cost of $380. The total estimated AMD EPYC hardware acquisition cost for this solution is $230120. Each server draws ~581.81kWhr per month. For the 1 years of this EPYC powered solution analysis the: total solution power cost is ~$5724 which includes the PUE factor; the total admin cost is ~$36833, and the total real estate cost is ~$6480, using 1 racks. The total 1-year TCO estimate for the AMD solution is $279157. The Intel based solution is estimated to take 15 total 2P Platinum_8380 powered servers at a hardware only acquisition cost of $23782 per server, which includes $9359 per CPU, total system memory of 512GB, which is 6.4GB of memory / core and a total system memory cost using DDR4 DIMMs of $2144; internal storage cost of $380. The total estimated Intel hardware acquisition cost for this solution is $356730. Each server draws ~571kWhr per month. For the 1 years of this Intel based solution analysis the: total solution power cost is ~$8424 which includes the PUE factor; the total admin cost is ~$55250, and the total real estate cost is ~$12960 using 2 racks. The total 1-year TCO estimate for the Intel solution is $433364. AMD EPYC powered servers have an estimated $154207 lower 1-year TCO. Delivering 8500 estimated score of SPECrate®2017_int_base performance produces the following estimated results: the AMD EPYC solution requires 33% fewer servers [1-(AMD server count / Intel server count)]; 33% fewer sockets; -7% fewer cores; 50% less space [1-(AMD rack count / Intel rack count)]; 32% less power [1-(AMD power cost / Intel power cost)]; providing a 36% lower 1 year server TCO [1-(AMD TCO / Intel TCO)]. delivering ~5% Less w/ AMD SPECrate®2017_int_base solution score The AMD solution saves an estimated $2700 in power cost for the 1-year of this analysis. For power cost this analysis uses an estimated average Aug 2021 kWh cost in Germany of 0.0828 € or $0.08198 USD with the US$ to Euro exchange rate on 10/18/2022 of $0.99 to 1.00 €.

AMD EPYC_7763 powered servers save ~32938kWh of electricity for the 1 years of this analysis. 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', the AMD EPYC powered server saves ~14.93 Metric Tons of CO2 equivalents. This results in the following estimated savings based on United States data, Emissions Avoided equivalent to one of the following:

- 3 USA Passenger Cars Not Driven for 1 year; or
- 3.21 USA Passenger Cars Not Driven Annually; or
- 1687 Gallons of Gasoline Not Used; or
- 16511 Pounds of Coal Not Burned in USA; or

Carbon Sequestered equivalent to:

- 246 Tree Seedlings Grown for 10 years in USA; or
- 17.91 Acres of USA Forests Annually.

The 2020 Grid Electricity Emissions Factors v1.4 – September 2020 data used in this analysis can be found at https://www.carbonfootprint.com/docs/2020_09_emissions_factors_sources_for_2020_electricity_v14.pdf and the US EPA Greenhouse Gas Equivalencies Calculator used in this analysis can be found athttps://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator. AMD CPU pricing based on 1KU price as of Nov 2022. Intel® Xeon® Scalable CPU data and pricing from https://ark.intel.com as of Nov 2022. Memory pricing sourced online from https://memory.net/store/ on 09/28/2022. All pricing is in USD. SPECrate® scores as of Nov 2, 2022. SPEC®, SPECrate® and SPEC CPU® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information. AMD EPYC performance numbers based on the identified benchmark reported scores or the user provided score where indicated. Product and company names are for informational purposes only and may be trademarks of their respective owners. Results generated by: AMD EPYC™ Bare Metal Server & Greenhouse Gas Emission TCO Estimation Tool - version 6.35.

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Endnotes

SP5TCO-023K: 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 8500 units of integer performance based on the published scores for Intel Xeon and AMD EPYC CPU based servers. This is an estimate how a EPYC 9654 powered server would perform if it was available in Aug of 2021. This estimation reflects a 1-year time frame. This server TCO model does not include any networking or storage that is external to the servers. This analysis compares a 2P AMD EPYC EPYC_9654 powered server with an estimated SPECrate®2017_int_base a score of 1790, https://spec.org/cpu2017/results/res2022q4/cpu2017-20221024-32607.pdf; compared to a 2P Intel Xeon Platinum_8380 based server with a SPECrate®2017_int_base score of 602https://spec.org/cpu2017/results/res2021q2/cpu2017-20210521-26364.pdf. The Intel server chassis is 2RU with a cost of $2500. The AMD server chassis is 2RU with a cost of $3000. Both AMD EPYC and Intel based servers use the same cost for the following elements of the analysis: internal storage $380; physical servers managed per admin: 30; fully burdened cost per admin $110500; server rack size of 42; space allowance per rack of 27 sq feet; monthly cost of data center space $20 per sq foot; cost per kW for power $0.46466; power drop per rack of 8kW; the tool uses a PUE of 1.00 to illustrate 'server only' power consumption - PUE is Power Usage Effectiveness. The EPYC powered solution is estimated to take: 5 total 2P EPYC_9654 powered servers at a hardware only acquisition cost of $36590 per server, which includes $11805 per CPU, total system memory of 1536GB, which is 8GB of memory / core and a total system memory cost using DDR5 DIMMs of $9600; internal storage cost of $380. The total estimated AMD EPYC hardware acquisition cost for this solution is $182950. Each server draws ~780.37kWhr per month. For the 1 years of this EPYC powered solution analysis the: total solution power cost is ~$21756 which includes the PUE factor; the total admin cost is ~$18417, and the total real estate cost is ~$6480, using 1 racks. The total 1-year TCO estimate for the AMD solution is $229603. The Intel based solution is estimated to take 15 total 2P Platinum_8380 powered servers at a hardware only acquisition cost of $23782 per server, which includes $9359 per CPU, total system memory of 512GB, which is 6.4GB of memory / core and a total system memory cost using DDR4 DIMMs of $2144; internal storage cost of $380. The total estimated Intel hardware acquisition cost for this solution is $356730. Each server draws ~571kWhr per month. For the 1 years of this Intel based solution analysis the: total solution power cost is ~$47746 which includes the PUE factor; the total admin cost is ~$55250, and the total real estate cost is ~$12960 using 2 racks. The total 1-year TCO estimate for the Intel solution is $472686. AMD EPYC powered servers have an estimated $243083 lower 1-year TCO. Delivering 8500 estimated score of SPECrate®2017_int_base performance produces the following estimated results: the AMD EPYC solution requires 67% fewer servers [1-(AMD server count / Intel server count)]; 67% fewer sockets; 20% fewer cores; 50% less space [1-(AMD rack count / Intel rack count)]; 54% less power [1-(AMD power cost / Intel power cost)]; providing a 51% lower 1 year server TCO [1-(AMD TCO / Intel TCO)]. delivering ~1% Less w/ AMD SPECrate®2017_int_base solution score The AMD solution saves an estimated $25989.82778 in power cost for the 1-year of this analysis. For power cost this analysis uses an estimated average Aug 2022 kWh cost in Germany of 0.4694 € = $0.46466 USD with the US$ to Euro exchange rate on 10/18/2022 of $0.99 to 1.00 €.

AMD EPYC_9654 powered servers save ~55933kWh of electricity for the 1 years of this analysis. 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', the AMD EPYC powered server saves ~25.35 Metric Tons of CO_2 equivalents. This results in the following estimated savings based on United States data, Emissions Avoided equivalent to one of the following:

- 5 USA Passenger Cars Not Driven for 1 year; or
- 5.45 USA Passenger Cars Not Driven Annually; or
- 2865 Gallons of Gasoline Not Used; or
- 28037 Pounds of Coal Not Burned in USA; or

Carbon Sequestered equivalent to:

- 418 Tree Seedlings Grown for 10 years in USA; or
- 30.42 Acres of USA Forests Annually.

The 2020 Grid Electricity Emissions Factors v1.4 – September 2020 data used in this analysis can be found at https://www.carbonfootprint.com/docs/2020_09_emissions_factors_sources_for_2020_electricity_v14.pdf and the US EPA Greenhouse Gas Equivalencies Calculator used in this analysis can be found athttps://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator. AMD CPU pricing based on 1KU price as of Nov 2022. Intel® Xeon® Scalable CPU data and pricing from https://ark.intel.com as of Nov 2022. Memory pricing sourced online from https://memory.net/store/ on 09/28/2022. All pricing is in USD. SPECrate® scores as of Nov 2, 2022. SPEC®, SPECrate® and SPEC CPU® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information. AMD EPYC performance numbers based on the identified benchmark reported scores or the user provided score where indicated. Product and company names are for informational purposes only and may be trademarks of their respective owners. Results generated by: AMD EPYC™ Bare Metal Server & Greenhouse Gas Emission TCO Estimation Tool - version 6.35.

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ENDNOTES

AMD 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-AMD EPYC-028B for the full list. More information about SPEC® is available at http://www.spec.org. SPEC, SPECrate, and SPECpower are registered trademarks of the Standard Performance Evaluation Corporation. VMmark is a registered trademark of VMware in the US or other countries.

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.

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.

SP5-013A: 96-core AMD 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.

SP5-023: Estimated SPECrate®2017_int_base comparison based on internal AMD reference platform measurements and published scores at www.spec.org as of 09/27/2022.

AMD internal measurements

2x	AMD EPYC 9654	1550 (400W cTDP)
2x	AMD EPYC 9634	1230
2x	AMD EPYC 9554	1250 (400W cTDP)
2x	AMD EPYC 9534	1070
2x	AMD EPYC 9474F	1040
2x	AMD EPYC 9454	924
2x	AMD EPYC 9374F	765
2x	AMD EPYC 9354	700
2x	AMD EPYC 9334	645
2x	AMD EPYC 9274F	602
2x	AMD EPYC 9254	511
2x	AMD EPYC 9224	450
2x	AMD EPYC 9174F	418
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 AMD EPYC 9654/9554 cTDP=400W)

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 AMD 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 AMD EPYC 9374F for ~1.98x the time-step function performance. Results may vary.

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ENDNOTES

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 AMD 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 AMD 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 AMD 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 AMD EPYC 9374F for ~1.73x the solver speedup performance. Results may vary.

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. SPEC® 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.