[PCクラスターワークショップ IN 柏 2021]

AMD EPYC™ 7003 シリーズ プロセッサー

日本AMD コマーシャル営業本部

2021年 6月18日

AMD サーバー CPU ロードマップ

リーダーシップ と 長期コミットメント

Roadmaps subject to change

クロック当たりの性能を ~19% 強化

2年 毎に IPC 性能を強化

2017	2019	2021
分岐予測性能の強化	整数演算性能のスループット強化	INT8 浮動小数点性能を2倍に強化	メモリー への実効レイテンシーの低減

SEE ENDNOTE: MLN-003

AMD

“ZEN 2” から更に強化

~19%

INSTRUCTIONS PER CYCLE

FRONT-END ENHANCEMENTS

2X Larger L1 BTB (1024)
Improved branch predictor bandwidth
“No-bubble” branch prediction
Faster recovery from mispredict
Faster sequencing of Op-cache fetches
Finer-grained switching of Op-cache pipes

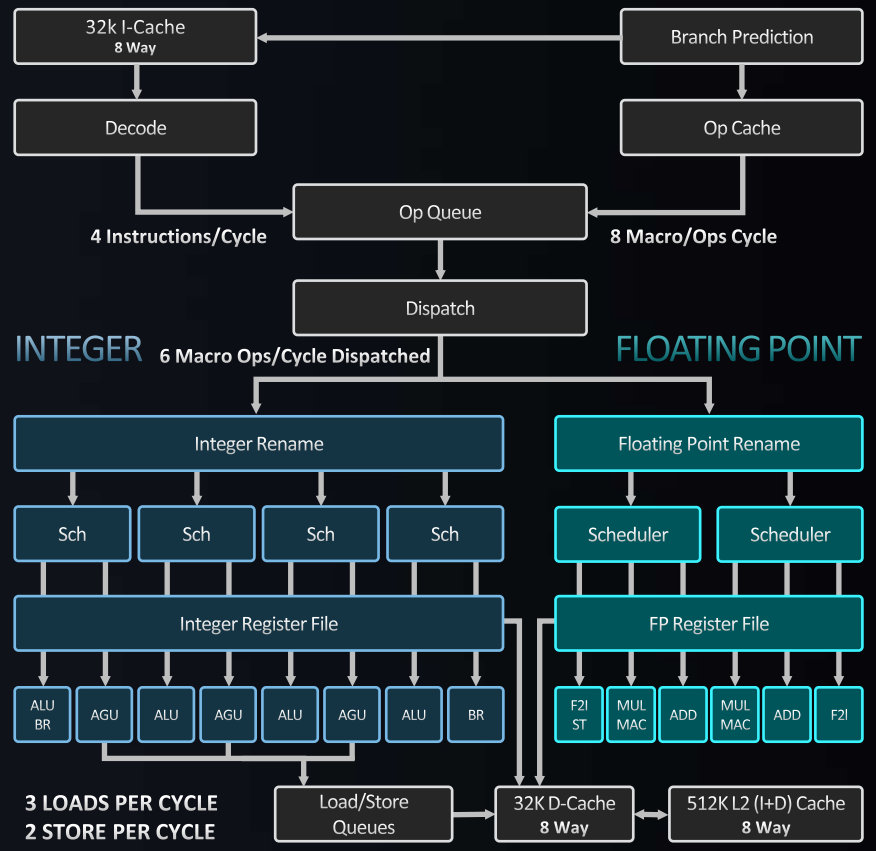
EXECUTION

Int: Dedicated Branch and St-data pickers
Int: Larger windows (+32)
FP/Int: Reduced latency for select ops
FP: 6-wide dispatch and issue (+2)
FP: Faster FMAC (-1 cycle)
FP: Two INT8 IMAC pipes (+1)
FP: Two INT8 ALU pipes (+1)

LOAD / STORE

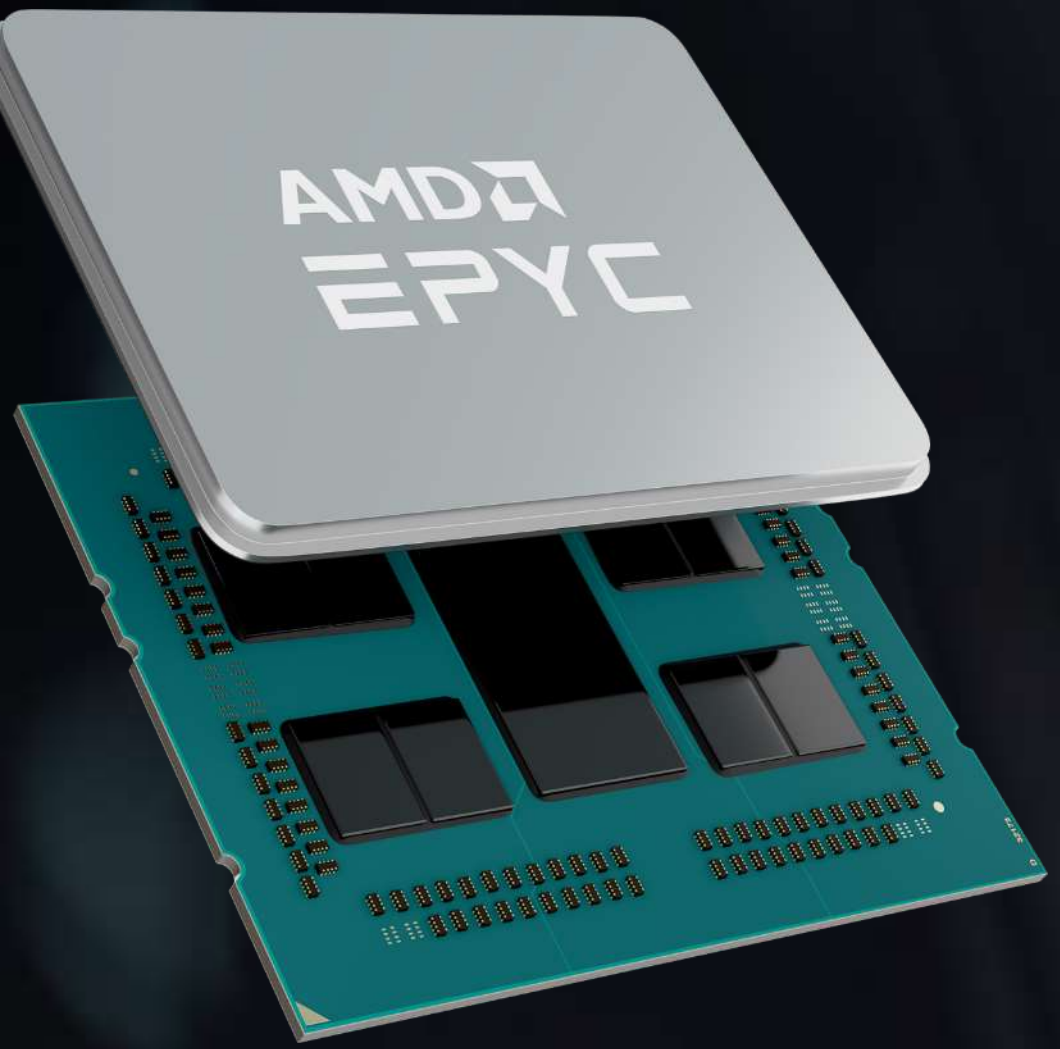
Higher load bandwidth (+1)
Higher store bandwidth (+1)
More flexibility in load/store ops
Improved memory dependence detection
TLB: 6 table walkers (+4)

“ZEN 3”



SEE ENDNOTE: MLN-003

AMD



第3世代 AMD EPYC™ プロセッサー

新機能 紹介

世界最高性能のサーバー CPU*

“Zen3” コア 採用による 性能の強化

メモリー 性能向上

- **Infinity Fabric™ (CPU 内部バス) と メモリークロックの同期**
- **新しい x86 L3 キャッシュ デザイン; 最大 32MB / コア**

セキュリティー機能の強化

4, 6 もしくは 8 チャネル メモリー構成 のサポート

第2世代 EPYC 7002 シリーズと ソケット互換

(要 BIOS アップデート)

SEE ENDNOTES: MLN-001 and MLN-016; * EPYC 7763 processor

AMD

第3世代 AMD EPYC™ プロセッサー

コンピュート

- AMD “Zen3” x86 コア (64 コア / 128 スレッド)
- 最大 32MB L3 キャッシュ / コア, チップレット内共有
- 扱いやすい NUMA ドメイン, レイテンシーの強化
- TDP : 120W-280W

メモリー

- 8 チャネル DDR4 最大 3200 MHz (ECC対応)
  6 チャネルメモリーインターリーブ対応[1]
- RDIMM, LRDIMM, 3DS, NVDIMM-N
- 2 DIMMs/チャネルで最大 4TB/ソケット (256GB DIMMs)

パフォーマンス

- Highestハイパフォーマンス サーバープロセッサー * として, シングルスレッド性能, コア当たりの性能 ** を強化
- 第2世代 インフィニティー ファブリック™ (xGMI-2)

内蔵 I/O – チップセット不要

- 128 レーン PCIe™ Gen3/4
  - PCIe, SATA, コヒーレントインターコネクト
  - 最大32 SATA or NVMe™ ダイレクトコネクト
  - 162 レーン オプション (2P 構成時)
- サーバーコントローラーハブ (USB, UART, SPI, LPC, I2C, 等.)

セキュリティー

- セキュリティー専用のサブシステム
- セキュアーブート, ハードウェア・ルート・オブ・トラスト
- SME (Secure Memory Encryption) メモリー暗号化機能
- SEV-ES (Secure Encrypted Virtualization & Register Encryption)　仮想マシンの暗号化機能
- SNP (Secure Nested Paging) 仮想マシンへのへ追加暗号化機能

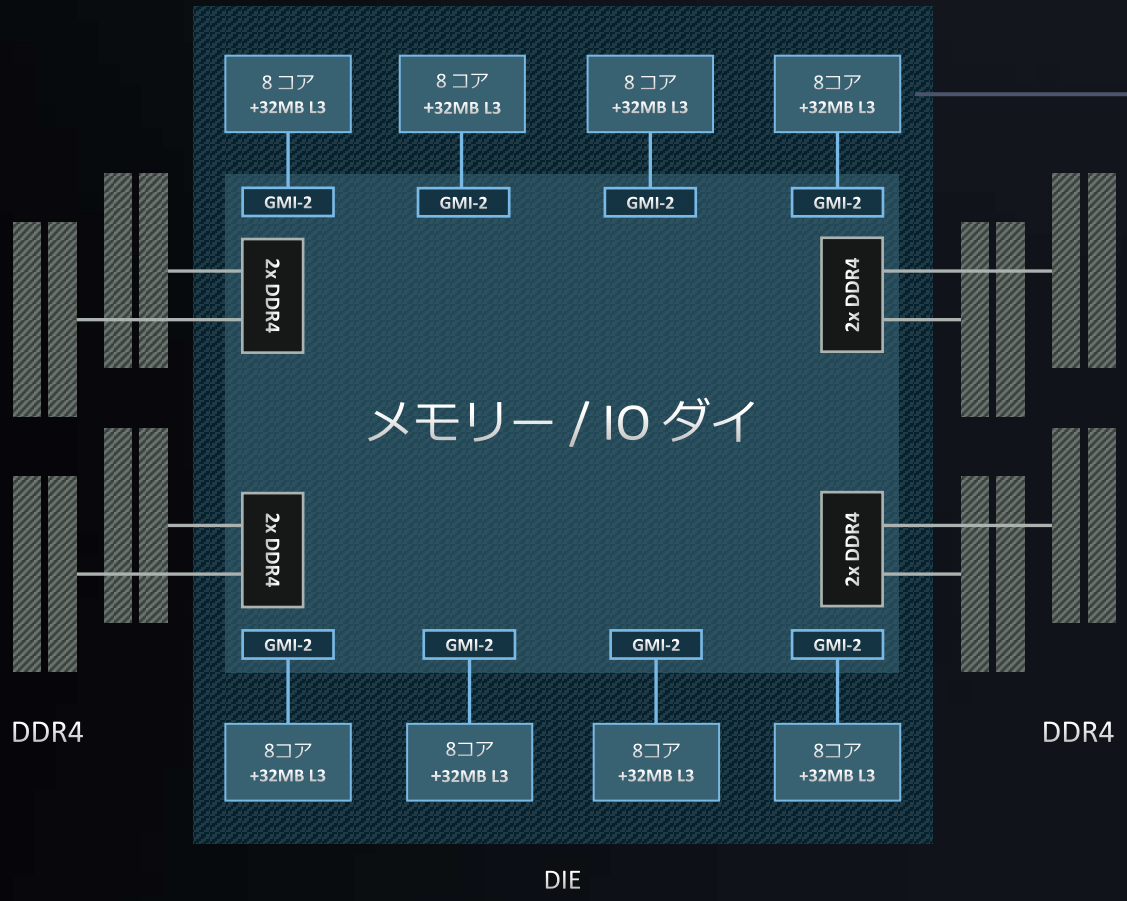
1) WITH CERTAIN DIMM POPULATION RULES. 2) INCREASED PERFORMANCE NUMBERS BASED ON AMD INTERNAL ESTIMATES. SUBJECT TO CHANGE BASED ON ACTUAL RESULTS.

1) With certain DIMM population rules. SEE ENDNOTES: MLN-003, MLN-016, MLN-057; *EPYC 7763,**EPYC 72F3

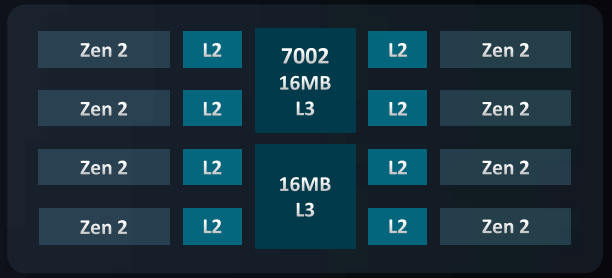
AMD

AMD EPYC™ SOC アーキテクチャー

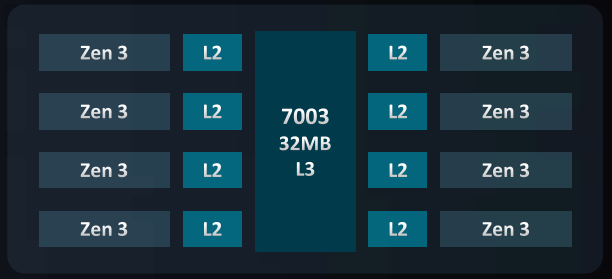
第2世代 EPYC VS. 第3世代 EPYC 比較 – 9 ダイ MCM (8 CCD + 1 I/O)



"ZEN 2"
AMD EPYC 7002



"ZEN 3"
AMD EPYC 7003



- CCX あたり L3 32MB，複数CPUを使う大型の仮想マシンや、キャッシュ共有型アプリケーションにおいて 性能強化
- シングルコアに対して 全 32MB を割り当てることも可能

AMD

AMD EPYC™ 7003 シリーズ プロセッサー

製品一覧

製品群で 一貫した 機能サポート

- 8 チャネル DDR4-3200
- 4TB メモリー 容量
- 128 レーン PCIe® 4
- マルチスレッド & ターボブースト
- 18G AMD Infinity Fabric™
- メモリー 暗号化機能 (Secure Memory Encryption)
- 仮想マシン暗号化機能 (Secure Encrypted Virtualization)
- 内部バスとメモリー スピードの同期

CORES	AMD EPYC	BASE/BOOST* (up to GHz)	DEFAULT TDP (W)
64 CORES	7763	**2.45/3.50**	**280W**
	7713/P	**2.00/3.675**	**225W**
56 CORES	7663	**2.00/3.50**	**240W**
48 CORES	7643	**2.30/3.60**	**225W**
32 CORES	→ 75F3	2.95/4.00	280W
	7543/P	**2.80/3.70**	**225W**
	7513	**2.60/3.65**	**200W**
28 CORES	7453	**2.75/3.45**	**225W**
24 CORES	→ 74F3	3.20/4.00	240W
	7443/P	**2.85/4.00**	**200W**
	7413	**2.65/3.60**	**180W**
16 CORES	→ 73F3	3.50/4.00	240W
	7343	**3.20/3.90**	**190W**
	7313/P	**3.00/3.70**	**155W**
8 CORES	→ 72F3	3.70/4.10	180W

"F" PERFORMANCE PER CORE OPTIMIZED

*EPYC-18

EPYC™ 7003 CPU ポジショニング

PROCESSOR GROUPS

コア性能 重視
高周波数 かつ コアあたりのキャッシュサイズが大きい

- 75F3 (32C-280W)
- 74F3 (24C-240W)
- 73F3 (16C-240W)
- 72F3 (8C-180W)

コア密度 重視
コア数 & スレッド数が 多い

- 7763 (64C-280W)
- 7713 (64C-225W)
- 7713P (64C-225W 1P)
- 7663 (56C-240W)
- 7643 (48C-225W)

性能 & コスト 最適化 重視
性能 & 運用コストのバランス

- 7543 (32C-225W)
- 7543P (32C-225W 1P)
- 7513 (32C-200W)
- 7453 (28C-225W)
- 7443 (24C-200W)
- 7443P (24C-200W 1P)
- 7413 (24C-180W)
- 7343 (16C-190W)
- 7313 (16C-155W)
- 7343 (16C-155W 1P)

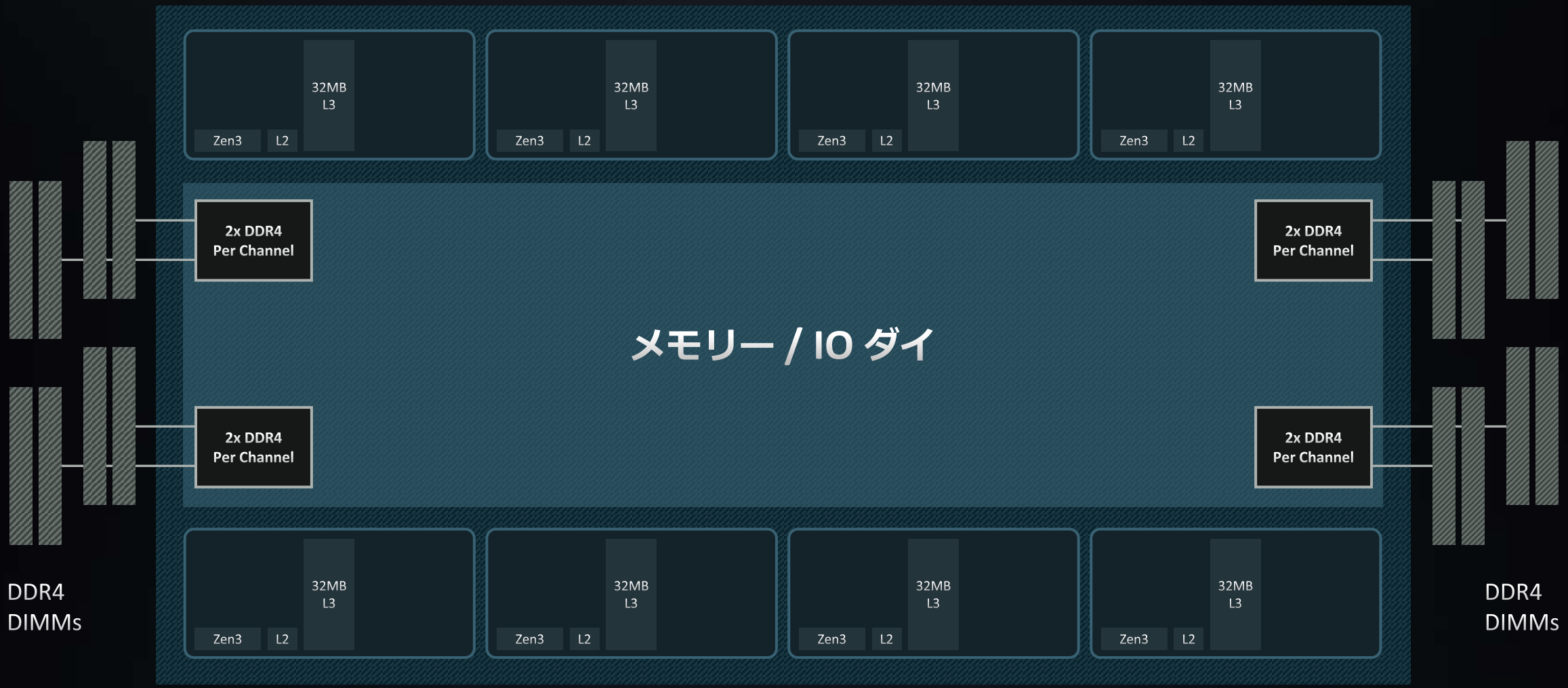
AMD EPYC™ 7003 CPU アーキテクチャー

75F3 CPU - 32 コア ハイパーフォーマンス / コア

AMD

AMD EPYC™ 7003 CPU アーキテクチャー

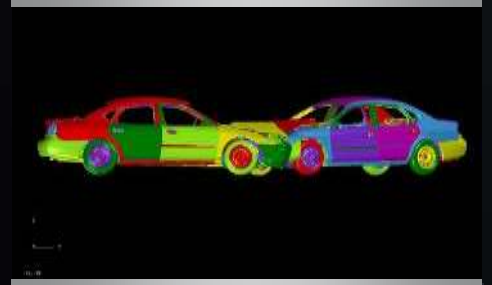
72F3 CPU - 8 コア ハイパーフォーマンス / コア



AMD

HPC パフォーマンスの優位性

実アプリケーションでの結果

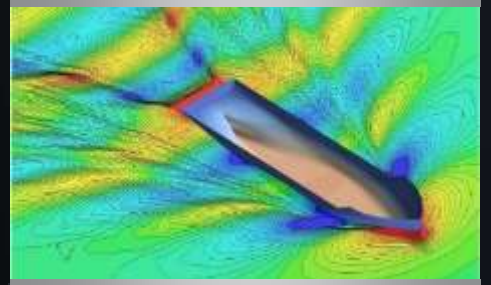


衝突解析

esi

最大 43%

HIGHER PERFORMANCE

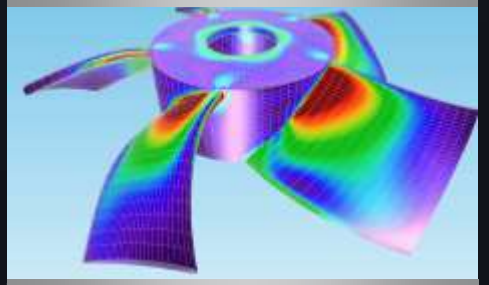


計算流体力学

STAR-CCM+

最大 55%

AVG HIGHER PERFORMANCE

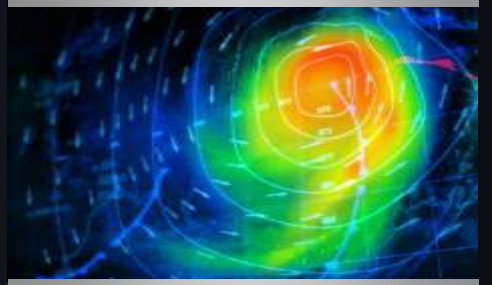


有限要素法解析

Ansys

最大 81%

AVG HIGHER PERFORMANCE

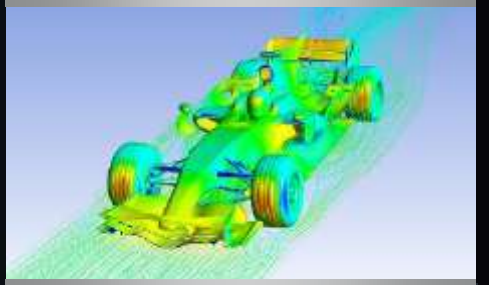


気象シミュレーション

Open Source

最大 67%

AVGHIGHER PERFORMANCE



流体力学

Ansys

最大 99%

AVG HIGHER PERFORMANCE

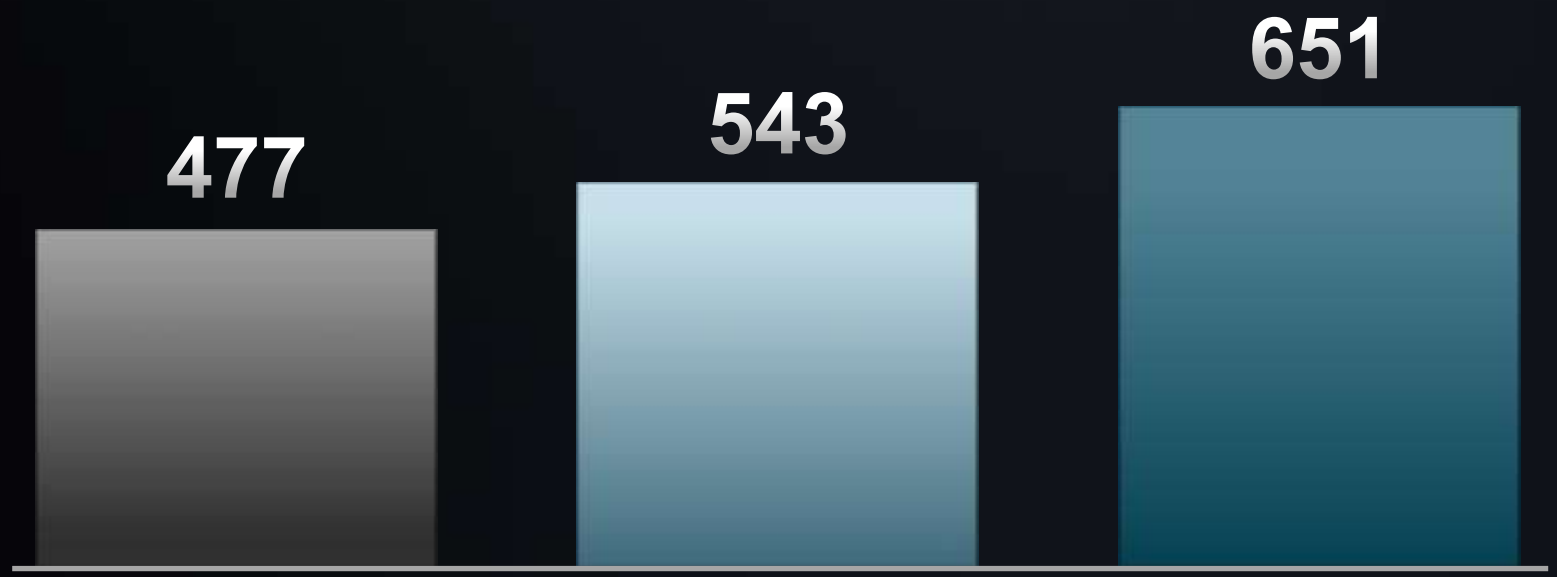
2X AMD EPYC™ 75F3 (32C) VS. 2X INTEL® XEON® GOLD 6258R (28C) AVERAGE PERFORMANCE ACROSS REPRESENTATIVE WORKLOADS

SEE ENDNOTES MLN-043, MLN-048, MLN-049, MLN-050, MLN-053

AMD

FASTER IN HPC

ACCELERATING SCIENTIFIC BREAKTHROUGHS



XEON® PLATINUM
8368Q

38 CORES

2ND GEN AMD EPYC™
7H12

64 CORES

3RD GEN AMD EPYC™
7763

64 CORES

3RD GEN AMD EPYC™

36%

FASTER THAN COMPETITION

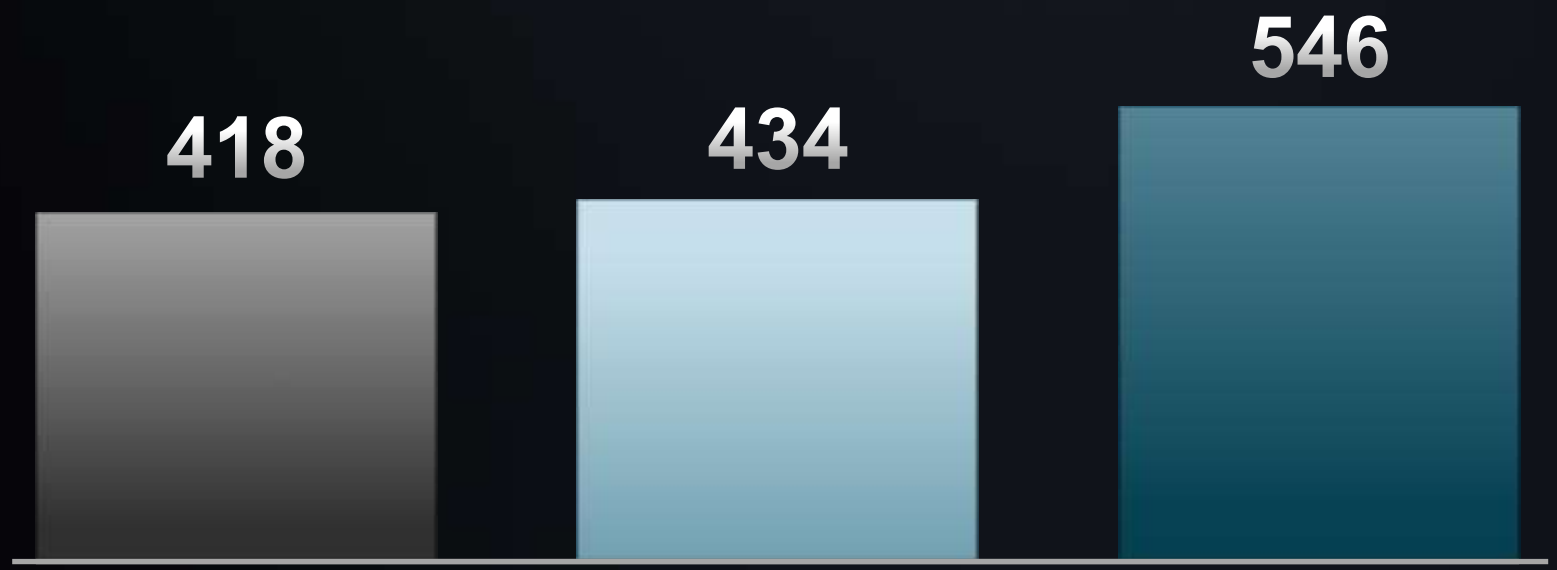
2S FLOATING POINT PERFORMANCE

SPECrate®2017_fp_base

See MLN-086A SPEC® and SPECrate® are registered trademarks of Standard Performance Evaluation Corporation. Learn more at spec.org.

THE BEST GETS BETTER

LEADERSHIP PERFORMANCE



XEON® PLATINUM
8358

32 CORES

2ND GEN AMD EPYC™
7532

32 CORES

3RD GEN AMD EPYC™
75F3

32 CORES

3RD GEN AMD EPYC™

31%

FASTER THAN COMPETITION

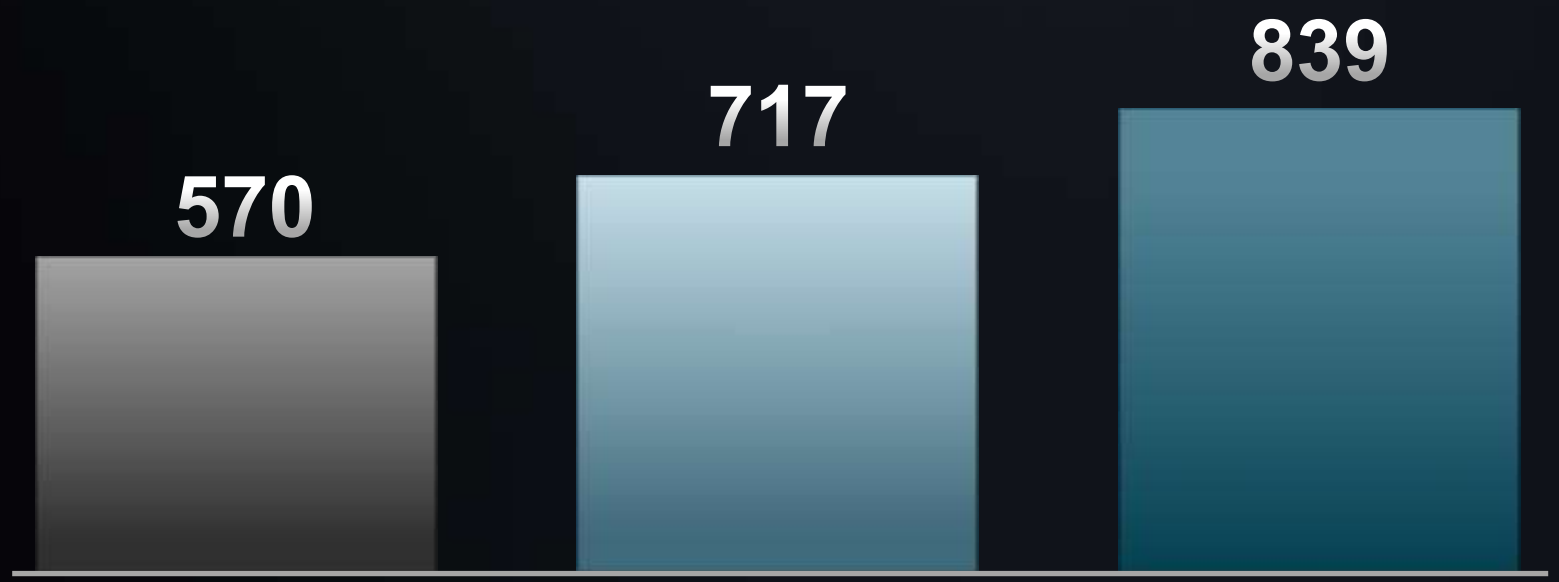
2S FLOATING POINT PERFORMANCE

SPECrate®2017_fp_base

See MLN-093. SPEC® and SPECrate® are registered trademarks of Standard Performance Evaluation Corporation. Learn more at spec.org.

FASTER IN CLOUD

BEST COMPUTE DENSITY FOR HYPERSCALE



XEON® PLATINUM
8368Q

38 CORES

2ND GEN AMD EPYC™
7H12

64 CORES

3RD GEN AMD EPYC™
7763

64 CORES

3RD GEN AMD EPYC™

47%

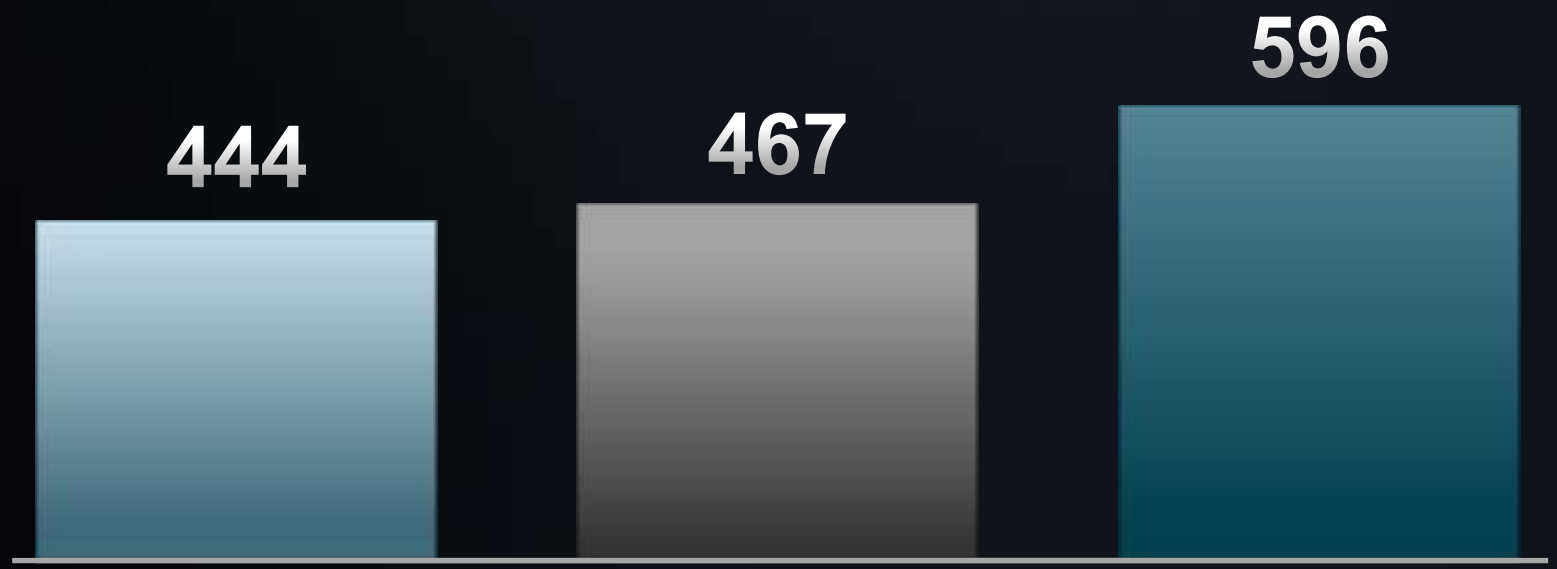
FASTER THAN COMPETITION

2S INTEGER PERFORMANCE

SPECrate®2017_int_base

THE BEST GETS BETTER

LEADERSHIP PERFORMANCE



2ND GEN AMD EPYC™
7532
32 CORES

XEON® PLATINUM
8358
32 CORES

3RD GEN AMD EPYC™
75F3
32 CORES

3RD GEN AMD EPYC™

28%

FASTER THAN COMPETITION

2S INTEGER PERFORMANCE

SPECrate®2017_int_base

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AMD DEVELOPER CENTRAL

SPACK (https://developer.amd.com/spack/)

Spack

Navigation

Spack

1. Spack usage disclaimer, copyright and trademark notice
2. Introduction to SPACK
3. Getting Started
4. Build Customization
5. Technical Support

AMD Toolchain with SPACK

1. AMD Optimizing C/C++ Compiler (AOCC)
2. AMD Optimizing CPU Libraries (AOCL)

Micro Benchmarks/Synthetic

1. HPCG
2. HPL
3. STREAM

SPACK HPC Applications

1. CP2K
2. GROMACS
3. LAMMPS
4. NAMD
5. Open MPI
6. OpenFOAM
7. WRF

Spack is an open source project that offers a package management framework and tool for installing complex scientific software. It is designed to support multiple versions and configurations of a software on many different platforms and environments. Spack supports large supercomputing centers comprising of many users and application teams. They share common installations of software on clusters with complex architectures using libraries without a standard Application Binary Interface (ABI). Many configurations can co-exist on the same system as installing a new version of Spack will not break the existing installations.

Spack provides a simple *spec* syntax, using which, the users can configure versions and options precisely. It simplifies the job of package authors as the package files are written in Python™. Also, the specs allow them maintain a single file for different builds of a package.

AMD supports the AMD Optimized CPU Compilers and Libraries (AOCC and AOCL) with Spack packages. AMD also supports Spack packages for commonly used HPC benchmarks and a growing catalogue of scientific, open-source applications with recommended command-line directives using AOCC and AOCL. Each application-specific page details the Spack command line, options, and example instructions to run the application.

Technical Support

For technical support of the tools, benchmarks and applications that AMD offers for Spack building and related inquiries, please reach us at toolchainsupport@amd.com.

For information specific to the Spack project and usage, please refer to the Spack documentation.

https://developer.amd.com/spack/

AMD EPYC™テクニカルドキュメント&ホワイトペーパー

(https://www.amd.com/ja/processors/server-tech-docs/search)

https://www.amd.com/ja/processors/server-tech-docs/search

ご清聴ありがとうございました

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.

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-177: AMD Infinity Guard security features on EPYC™ processors must be enabled by server OEMs and/or Cloud Service Providers to operate. Check with your OEM or provider to confirm support of these features. Learn more about Infinity Guard at https://www.amd.com/en/technologies/infinity-guard.

GD-177: AMD Infinity Guard security features on EPYC™ processors must be enabled by server OEMs and/or Cloud Service Providers to operate. Check with your OEM or provider to confirm support of these features. Learn more about Infinity Guard at https://www.amd.com/en/technologies/infinity-guard.

MLN-001: AMD EPYC™ 7003 Series processors require a BIOS update from your server or motherboard manufacturer if used with a motherboard designed for the AMD EPYC™ 7002 Series processors. A motherboard designed at minimum for EPYC 7002 processors is required for EPYC 7003 Series processors.

MLN-003: Based on AMD internal testing as of 02/1/2021, average performance improvement at ISO-frequency on an AMD EPYC™ 72F3 (8C/8T, 3.7GHz) compared to an AMD EPYC™ 7F32 (8C/8T, 3.7GHz), per-core, single thread, using a select set of workloads including estimated SPECrate®2017_int_base,SPECrate®2017_fp_base, and representative server workloads.

MLN-004: Login VSI™ Pro v4.1.40.1 comparison based on AMD internal testing as of 02/01/2021 measuring the maximum “knowledge worker” desktop sessions within VSI Baseline +1000ms response time using VMware ESXi 7.0u1 and VMware Horizon 8 on a server using 2x AMD EPYC 7763 versus a server with 2x Intel Xeon Gold 6258R for ~112% more max [~2.1x the] performance. Results may vary.

MLN-006: HammerDB 4.0 OLTP comparison based on AMD internal testing on Oracle® 19c RDBMS as of 02/01/2021 on a server using 2x AMD EPYC 75F3 versus a server using 2x AMD EPYC 7542 for ~19% more [~1.2x the] performance. TPROC-C: OLTP workload profile in HammerDB derived, from the TPC-C specification using 2000 Warehouses. Results may vary.

MLN-007: Results as of 01/28/2021 using SPECrate®2017_int_base. The 2P AMD EPYC 7763 a measured estimated score of 798, versus the current highest score Intel Cascade Lake Refresh server with a score of 397 using 2P Intel Gold 6258R, https://spec.org/cpu2017/results/res2020q3/cpu2017-20200915-23981.pdf. OEM published score(s) for EPYC may vary. SPEC®, SPECrate® and SPEC CPU® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

MLN-008: Results as of 01/28/2021 using SPECrate®2017_fp_base. The 2P AMD EPYC 7763 has an a measured estimated score of 614.7 versus the current highest score Intel Cascade Lake Refresh server with a score of 309 and 2P Intel Gold 6258R, https://spec.org/cpu2017/results/res2020q3/cpu2017-20200915-23979.pdf. OEM published score(s) for EPYC may vary. SPEC®, SPECrate® and SPEC CPU® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

MLN-016: Results as of 01/28/2021 using SPECrate®2017_int_base. The AMD EPYC 7763 estimated score of 798 is higher than the current highest 2P server with an AMD EPYC 7H12 and a score of 717, https://spec.org/cpu2017/results/res2020q2/cpu2017-20200525-22554.pdf. OEM published score(s) for EPYC may vary.

MLN-017: Results as of 01/28/2021 using SPECrate®2017_int_base. The AMD EPYC 75F3 a measured estimated score of 546 has up to 23% higher than a comparable 2P EPYC 7002 CPU powered server, the 7532 with a score of 444, https://spec.org/cpu2017/results/res2020q3/cpu2017-20200622-23002.pdf . OEM published score(s) for 3rd Gen EPYC may vary. SPEC®, SPECrate® and SPEC CPU® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information. "

MLN-018: Results as of 02/20/2021 using SPECrate®2017_int_base. The AMD EPYC 7763 a measured estimated score of 804 which is higher than the current highest 2P server with an AMD EPYC 7H12 and a score of 717, https://spec.org/cpu2017/results/res2020q2/cpu2017-20200525-22554.pdf. OEM published score(s) for EPYC may vary. SPEC®, SPECrate® and SPEC CPU® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

MLN-040: Results as of 02/20/2021 using SPECrate®2017_int_base. The 2P AMD EPYC 7763 has a measured estimated score of 804, versus the current highest score Intel Cascade Lake Refresh server with a score of 397 using 2P Intel Gold 6258R, https://spec.org/cpu2017/results/res2020q3/cpu2017-20200915-23981.pdf. OEM published score(s) for EPYC may vary. SPEC®, SPECrate® and SPEC CPU® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

ENDNOTES

MLN-041: Results as of 02/20/2021 using SPECrate®2017_fp_base. The 2P AMD EPYC 7763 has a measured estimated score of 625 versus the current highest score Intel Cascade Lake Refresh server with a score of 309 with a 2P Intel Gold 6258R based server, https://spec.org/cpu2017/results/res2020q3/cpu2017-20200915-23979.pdf. OEM published score(s) for EPYC may vary. SPEC®, SPECrate® and SPEC CPU® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

MLN-043: WRF version 4.1.5 comparison based on AMD internal testing completed on 2/17/2021 on a reference platform with 2x EPYC™ 75F3 (32C) compared to an Intel server on a production system with 2x Intel® Xeon® Gold 6258R (28C) processors. Results may vary.

MLN-044: SPECjbb®2015-MultiJVM Critical-jOPS comparison based on Supermicro compliant run and best spec.org published 2x Intel Xeon Platinum 8280 result as of 02/22/2021. The 2x AMD EPYC 7763 has a score of 295,335 SPECjbb®2015-MultiJVM Critical-jOPS (351,175 SPECjbb®2015-MultiJVM Max-jOPS) using the following configuration: Supermicro A+ AS-1124US-TNRP Server (Model H12DSU-iN), 2x AMD EPYC 7763, 16x 64 GB Quad-Rank LR-DIMM DDR4-3200 memory, SUSE Enterprise Linux 15 SP2, OpenJDK 15.0.2. versus the highest published SPECjbb®2015-MultiJVM Critical-jOPS score of a 2x Intel Xeon Platinum 8280 server of 138,942 SPECjbb®2015-MultiJVM Critical-jOPS (165,958 SPECjbb®2015-MultiJVM Max-jOPS), http://www.spec.org/jbb2015/results/res2019q2/jbb2015-20190314-00428.html for ~112% more [~2.12x the] performance. SPEC® and SPECjbb® are trademarks of the Standard Performance Evaluation Corporation. See more at www.spec.org.

MLN-046: STREAM Triad GB/s comparison based on AMD internal testing as of 02/01/2021 on a server with 2x AMD EPYC 7763 versus the 2x AMD EPYC 7742 processors score. Results may vary.

MLN-047: STREAM Triad GB/s comparison based on AMD internal testing and a published competitive Intel result as of 02/01/2021 Configurations: on a server with 2x AMD EPYC 75F3 (371.5 GB/s) versus the 2x Intel Xeon Gold 6258R processors score at (224 GB/s, https://newsroom.intel.com/news/product-fact-sheet-accelerating-5g-network-infrastructure-core-edge) for ~66% more [~1.7x the] performance. Results may vary.

MLN-048: ANSYS® CFX® 2021.1 comparison based on AMD internal testing as of 02/05/2021 measuring the time to run the Release 14.0 test case simulations (converted to jobs/day - higher is better) using a server with 2x AMD EPYC 75F3 versus 2x Intel Xeon Gold 6258R. The External Flow Over a LeMans Car test case individually was 112% [2.1x the] per node or 85% per core performance. Results may vary.

MLN-049: ANSYS® LS-DYNA® version 2021.1 comparison based on AMD internal testing as of 02/05/2021 measuring the time to run neon, 3cars, PPT-short, odb10m-short, and car2car test case simulations (converted to jobs/day - higher is better) Configurations using a server with 2x AMD EPYC 75F3 (17555 total seconds) versus a server with 2x Intel Xeon Gold 6258R. (28774 total seconds) for ~81.0% more [~1.8x the] per node or ~59% [~1.6x the] per core average performance. The 3cars test case gain individually was 126% [~2.26x the] per node or ~98% per core jobs/day performance. Results may vary.

MLN-050: ESI Virtual Performance Solution (VPS better known as PAM-CRASH®) version 2020.0 comparison based on AMD internal testing as of 02/05/2021 measuring the neon test case simulation (converted to jobs/day - higher is better) using a server with 2x AMD EPYC 75F3 versus a server with 2x Intel Xeon Gold 6258R for ~43% more [~1.4x the] per node or ~25% per core jobs/day performance. Results may vary.

MLN-053: Star-CCM+ 2020.3 comparison based on AMD internal testing as of 02/05/2021 measuring the average seconds to complete 11 test cases and converted to jobs/day (higher is better) using a server with 2x AMD EPYC 75F3 versus a server with 2x Intel Xeon Gold 6258R. The KCS Marine Hull with No Rudder in Fine Waves test case individually was ~79% more [~1.7x the] per node or ~57% better per core performance. Results may vary.

MLN-055: AMD EPYC 7003 CPUs with PCIe4 lanes have 2X the I/O throughput capacity per lane than any Intel Xeon Scalable CPU which use PCIe3. PCIe4 provides 16GB/s of link bandwidth versus PCIe3 with 8Gb/s, https://pcisig.com/pci-express-delivering-needed-bandwidth-open-compute-project.

MLN-056: Each AMD EPYC 7003 processor has 8 memory channels. Each Intel Xeon Scalable processor has 6 memory channels. 8 – 6 = 2 ÷ 6 = 0.33 AMD EPYC has 33% more memory bandwidth. Class based on industry-standard pin-based (LGA) X86 processors.

MLN-057: A 2P AMD EPYC 72F3 8 core CPU powered server has a measured estimated SPECrate®2017_int_base score of 176 with a per core score of 11.00. The posted score on SPEC.org as of 02/20/2021 yielding the highest per core performance is a server with two Intel Gold 6250 8 core CPUs with a per core score of 9.875, from a published score of 158, https://spec.org/cpu2017/results/res2020q3/cpu2017-20200915-23977.pdf. Scores are as of 02/20/2021. SPEC®, SPECrate® and SPEC CPU® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

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MLN-058: A 2P AMD EPYC 72F3 8 core CPU powered server has a measured estimated SPECrate®2017_int_base score of 220 yielding a per core score of 13.75. The posted score on SPEC.org as of 02/20/2021 yielding the highest per core performance is a server with one AMD EPYC 7F32 8 core CPU with a per core score of 12.875, from a published score of 103, https://spec.org/cpu2017/results/res2020q2/cpu2017-20200316-21228.pdf. SPEC®, SPECrate® and SPEC CPU® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

MLN-059: EPYC 7313 and 7343 CPU powered 2P servers have measured estimated SPECrate®2017_int_base scores of 287 and 295 respectively (287+295= 582, 582/2=291), is up to 25% higher than than highest posted score 2P EPYC 7282 and 7302 powered servers with SPECrate®2017_int_base scores of 215 and 246 respectively (215+246= 461, 461/2=230.5). 291/230.5= 1.26. 16 core EPYC 7003 CPUs have 126% the perf or 26% more performance of 16c 7002 CPUs. OEM published score(s) for 3rd Gen EPYC may vary. SPEC®, SPECrate® and SPEC CPU® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

MLN-060: EPYC 7643 and 7763 CPU powered 2P servers have measured estimated SPECrate®2017_fp_base scores of 510 and 614.7 respectively (average score 562.35), is up to 15% higher than than 2P EPYC 7552 and 7662 powered servers with SPECrate®2017_fp_base scores of 435 and 546 respectively (average score 490.5). OEM published score(s) for 3rd Gen EPYC may vary. SPEC®, SPECrate® and SPEC CPU® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

MLN-061: As of Feb. 20, 2021, the Intel log trendline from top SPECrate®2017_int_base published scores to date for 2P Intel based Xeon SP (LGA socketed) servers for each of 2017, 2018, 2019, 2020, and 2021. 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, and 2020, and for 2021 the measured estimate score for the EPYC 7763 for SPECrate®2017_int_base.The lines below are organized as: Year, CPU model, SPEC score, URL.2017, Intel 8180, 302, https://spec.org/cpu2017/results/res2017q4/cpu2017-20170928-00070.pdf2018, Intel 8180, 304, https://spec.org/cpu2017/results/res2018q3/cpu2017-20180709-07701.pdf2019, Intel 8280L, 364, should be 8280L https://spec.org/cpu2017/results/res2019q2/cpu2017-20190429-12779.pdf2020, Intel 6258R, 397, https://spec.org/cpu2017/results/res2020q3/cpu2017-20200915-23981.pdf2021, Intel 6258R, 397, https://spec.org/cpu2017/results/res2020q3/cpu2017-20200915-23981.pdf.2017, AMD EPYC 7601, 275, https://spec.org/cpu2017/results/res2017q4/cpu2017-20171211-01594.pdf2018, EPYC 7601, 282, https://spec.org/cpu2017/results/res2018q3/cpu2017-20180827-08666.pdf2019, EPYC 7742, 701, https://spec.org/cpu2017/results/res2019q4/cpu2017-20191125-20001.pdf2020, EPYC 7H12, 717, https://spec.org/cpu2017/results/res2020q2/cpu2017-20200525-22554.pdf2021, EPYC 7763, 802 measured estimate, no link available.OEM published score(s) for 3rd Gen EPYC may vary. SPEC®, SPECrate® and SPEC CPU® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

MLNTCO-001 The Bare Metal TCO (total cost of ownership) Estimator solution compares the selected AMD EPYC™ and Intel® Xeon® CPU based server solutions required to deliver a TOTAL_PERFORMANCE of 25000 unit of integer performance based on published the SPECrate®2017_int_base scores for Intel and AMD measured estimated scores for AMD EPYC 7003. This analysis is based on tool VERSION: 02/20/2021 v0.9982. This estimation reflects a 4 year time frame. This analysis compares a 2 CPU AMD EPYC EPYC_7763 powered server with a measured estimated SPECrate®2017_int_base score of 802; compared to a 2 CPU Intel Xeon Gold_6258R based server with a SPECrate®2017_int_base score of 397, https://spec.org/cpu2017/results/res2020q3/cpu2017-20200915-23981.pdf. Both AMD EPYC and Intel based servers use the same estimated cost for the following elements of the analysis: server chassis size of 2RU at a cost of $2500 per chassis; 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 $0.12; power drop per rack of 12kW; and a PUE (power usage effectiveness of 2).The EPYC powered solution estimates are: 32 2P EPYC 7763 powered total servers at a hardware only acquisition cost of $19232 per server, which includes total system memory of 768GB, which is 6GB of memory / core and a total system memory cost of $3072; internal storage cost of $380. The total AMD EPYC hardware acquisition cost for this solution is $615424. Each server draws ~611kWhr per month. For the 4 years of this EPYC powered solution analysis the: total solution power cost is ~$225240 which includes the PUE factor; the total admin cost is ~$471468, and the total real estate cost is ~$77760. The total 4 year TCO estimate for the AMD solution is $1389892.The Intel based solution estimates are: 63 2P Xeon Gold 6258R based total servers at a hardware only acquisition cost of $12316 per server, which includes total system memory of 384GB, which is 6.9GB of memory / core and a total system memory cost of $1536; internal storage cost of $380. The total Intel hardware acquisition cost for this solution is $775908. Each server draws ~476kWhr per month. For the 4 years of this Intel based solution analysis the: total solution power cost is $345460 which includes the PUE factor; the total admin cost is ~$928200, and the total real estate cost is ~$103680. The total 4 year TCO estimate for the Intel solution is $2153248.Delivering 25000 of estimated SPECrate®2017_int_base performance, produces the following estimated results: the AMD EPYC solution requires 49% fewer servers [1-(AMD server count / Intel server count)]; 25% less space [1-(AMD rack count / Intel rack count)]; 35% less power [1-(AMD power cost / Intel power cost)]; providing a 35% lower 4 year TCO [1-(AMD TCO / Intel TCO)].AMD processor pricing based on 1KU price as of February 2021. Intel® Xeon® Scalable processor data and pricing from https://ark.intel.com as of September 2020. All pricing is in USD. Results shown here are estimates and actual results may vary. Product and company names are for informational purposes only and may be trademarks of their respective owners. SPECrate® scores as of 02/20/2021. AMD EPYC performance numbers based on AMD internal estimates and are subject to change based on actual results. 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 AMD measured internal estimates and are subject to change based on actual results.Results generated by the AMD EPYC™ BARE METAL SERVER TCO ESTIMATION TOOL, VERSION: 02/20/2021 v0.9982.

AMD

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EPYC-22: For a complete list of world records see http://amd.com/worldrecords.

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.

MLN-003: Based on AMD internal testing as of 02/1/2021, average performance improvement at ISO-frequency on an AMD EPYC™ 72F3 (8C/8T, 3.7GHz) compared to an AMD EPYC™ 7F32 (8C/8T, 3.7GHz), per-core, single thread, using a select set of workloads including SPECrate®2017_int_base,SPECrate®2017_fp_base, and representative server workloads. SPEC® and SPECrate® are registered trademarks of Standard Performance Evaluation Corporation. Learn more at spec.org.

MLN-016A: Results as of 04/14/2021 using SPECrate®2017_int_base. The AMD EPYC 7763 scored 839, http://www.spec.org/cpu2017/results/res2021q1/cpu2017-20210219-24936.html which is higher 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.

MLN-057A: Based on SPECrate®2017_int_base on 04/14/2021, a server powered by two 8c AMD EPYC 72F3 CPU has scored 185, http://www.spec.org/cpu2017/results/res2021q2/cpu2017-20210329-25427.html with a per core score of 11.5 which is a higher per core integer base performance score than any currently posted in any SPEC.org publication. SPEC®, SPECrate® and SPEC CPU® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

MLN-071A: Based on SPECrate®2017_int_base on 04/14/2021, a server powered by one 64c AMD EPYC 7763 CPUs has a score of 424, http://www.spec.org/cpu2017/results/res2021q1/cpu2017-20210219-24941.html which is higher than any currently posted SPEC score/chip (socket). SPEC®, SPECrate® and SPEC CPU® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

MLN-077: SPECrate®2017_int_base comparison based on highest system results published at spec.org as of 4/14/2021.2x AMD EPYC 7763 (64C) scores 839, https://www.spec.org/cpu2017/results/res2021q1/cpu2017-20210219-24936.txt versus 2x Intel Xeon E5-2699A v4 (22C) SPECrate®2017_int_base score of 199 http://spec.org/cpu2017/results/res2018q1/cpu2017-20180109-02607.html for 4.2x the performance. It would then take five 2x EPYC 7763 CPU-based servers to meet/exceed the performance of 20x 2x Intel Xeon E5-2699A v4 CPU-based servers. SPEC®, SPECrate® and SPEC CPU® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

MLN-078: SPECrate®2017_int_base comparison based on highest system results published at spec.org as of 4/14/2021 : 2x AMD EPYC 7763 (64C) scores 839, https://www.spec.org/cpu2017/results/res2021q1/cpu2017-20210219-24936.txt versus 2x AMD EPYC 7601 (32C) SPECrate®2017_int_base score of 304 http://spec.org/cpu2017/results/res2019q2/cpu2017-20190411-11817.html for 2.76x the performance. It would take eight 2x EPYC 7763 CPU-based servers to meet/exceed the performance of 20x 2x AMD EPYC 7601 CPU-based servers. SPEC®, SPECrate® and SPEC CPU® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

MLN-086A: SPECrate®2017_fp_base comparison based on best performing systems published at www.spec.org as of 04/28/2021. Configurations: 2x AMD EPYC 7763 (651 SPECrate®2017_fp_base, http://spec.org/cpu2017/results/res2021q1/cpu2017-20210219-24944.html) versus 2x Intel Xeon Platinum 8368Q (477 SPECrate®2017_fp_base, http://spec.org/cpu2017/results/res2021q2/cpu2017-20210330-25511.html) for ~36.5% more performance. SPEC®, SPEC CPU®, and SPECrate® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

MLN-088: SPECrate®2017_int_base comparison based on highest system results published at spec.org as 4/14/2021, 2x AMD EPYC 7763 (64C) scores 839, http://spec.org/cpu2017/results/res2021q1/cpu2017-20210219-24936.html versus 2x Intel Xeon Platinum 8380 (40C) SPECrate®2017_int_base score of 558 http://spec.org/cpu2017/results/res2021q2/cpu2017-20210330-25513.html for 1.5x the performance. It would take only ten 2x EPYC 7763 CPU-based servers to meet/exceed the performance of 15x 2x Intel Xeon Platinum 8380 CPU-based servers. SPEC®, SPECrate® and SPEC CPU® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

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MLN-089: Based on SPECrate®2017_int_base as of 4/14/2021, 2x AMD EPYC™ 7763 ($7890 1Ku) scored 839 (0.106 score/$) https://spec.org/cpu2017/results/res2021q1/cpu2017-20210219-24936.html which has 47% higher throughput and 25% better performance/$ than the top "Ice Lake" score is 2x Intel® Xeon® Platinum 8368Q ($6743 1Ku) that scored 570 (0.085 score/$) https://spec.org/cpu2017/results/res2021q2/cpu2017-20210330-25512.html. AMD 1Ku pricing and Intel 1Ku pricing from ark.intel.com as of 4/14/2021. SPEC®, SPECrate® and SPEC CPU® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

MLN-090A: SPECrate®2017_int_base comparison based on best performing systems published at www.spec.org as of 04/28/2021. Configurations: 2x AMD EPYC 75F3 (596 SPECrate®2017_int_base, http://spec.org/cpu2017/results/res2021q2/cpu2017-20210409-25541.html) versus 2x Intel Xeon Platinum 8358 (467 SPECrate®2017_int_base, http://spec.org/cpu2017/results/res2021q2/cpu2017-20210329-25456.html) for ~27.6% more performance. 2x AMD EPYC 7532 (444 SPECrate®2017_int_base, http://spec.org/cpu2017/results/res2020q3/cpu2017-20200622-23002.html). SPEC®, SPEC CPU®, and SPECrate® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

MLN-092: SPECjbb® 2015-MultiJVM Critical comparison based on best performing systems published at www.spec.org as of 4/28/2021, 2x AMD EPYC™ 7763 scored 301,297 SPECjbb® 2015-MultiJVM Critical-jOPS (359,067 max-jOPS, https://spec.org/jbb2015/results/res2021q1/jbb2015-20210224-00612.html) which has 50% higher critical server-side Java® operations than the top "Ice Lake" 2x Intel® Xeon® Platinum 8380 that scored 201,334 critical-jOPS (258,368 max-jOPS, https://spec.org/jbb2015/results/res2021q2/jbb2015-20210324-00635.html). 2x AMD EPYC 7H12 scored 248,942 critical-jOPS (315,663 max-jOPS, http://spec.org/jbb2015/results/res2020q2/jbb2015-20200423-00550.html). SPEC® and SPECjbb® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

MLN-093: SPECrate®2017_fp_base comparison based on best performing systems published at www.spec.org as of 04/28/2021. Configurations: 2x AMD EPYC 75F3 (546 SPECrate®2017_fp_base, http://spec.org/cpu2017/results/res2021q2/cpu2017-20210409-25543.html) versus 2x Intel Xeon Platinum 8358 (418 SPECrate®2017_fp_base, http://spec.org/cpu2017/results/res2021q2/cpu2017-20210329-25455.html) for ~30.6% more performance. 2x AMD EPYC 7532 (434 SPECrate®2017_fp_base, http://spec.org/cpu2017/results/res2020q3/cpu2017-20200622-23004.html). SPEC®, SPEC CPU®, and SPECrate® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

MLN-095: SPECrate®2017_int_base comparison based on best performing systems published at www.spec.org and AMD estimates as of 04/28/2021. Configurations: 2x AMD EPYC 72F3 (185 SPECrate®2017_int_base, http://spec.org/cpu2017/results/res2021q2/cpu2017-20210329-25427.html) versus 2x Intel Xeon Gold 6334 (est ~131 SPECrate®2017_int_base, AMD cores*frequency model using published Intel specifications at ark.intel.com) for ~39% more performance. SPEC®, SPEC CPU®, and SPECrate® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

MLN-096: SPECrate®2017_int_base comparison based on best performing systems published at www.spec.org and AMD estimates as of 04/28/2021. Configurations: 2x AMD EPYC 73F3 (338 SPECrate®2017_int_base, http://spec.org/cpu2017/results/res2021q2/cpu2017-20210412-25561.html) versus 2x Intel Xeon Gold 6346 (est ~262 SPECrate®2017_int_base, AMD cores*frequency model using published Intel specifications at ark.intel.com) for ~29% more performance. SPEC®, SPEC CPU®, and SPECrate® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information..

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MLN-097: SPECrate®2017_int_base comparison based on best performing systems published at www.spec.org and AMD estimates as of 04/28/2021. Configurations: 2x AMD EPYC 74F3 (451 SPECrate®2017_int_base, http://spec.org/cpu2017/results/res2021q2/cpu2017-20210412-25565.html) versus 2x Intel Xeon Gold 6342 (est ~361 SPECrate®2017_int_base, AMD cores*frequency model using published Intel specifications at ark.intel.com) for ~25% more performance. SPEC®, SPEC CPU®, and SPECrate® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

MLN-098: SPECrate®2017_int_base comparison based on best performing systems published at www.spec.org as of 05/12/2021. Configurations: 2x AMD EPYC 7543 (560 SPECrate®2017_int_base, http://spec.org/cpu2017/results/res2021q2/cpu2017-20210426-25663.html, $3761) versus 2x Intel Xeon Platinum 8358 (467 SPECrate®2017_int_base, http://spec.org/cpu2017/results/res2021q2/cpu2017-20210329-25456.html, $3950) for ~16.7% more performance at ~1.20x the score per CPU $. AMD 1Ku pricing and Intel ARK.intel.com pricing as of 4/1/21. SPEC®, SPEC CPU®, and SPECrate® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information. Pricing subject to change.

MLN-099: SPECrate®2017_int_base comparison based on best performing systems published at www.spec.org and AMD estimates as of 04/28/2021. Configurations: 2x AMD EPYC 7443 (421 SPECrate®2017_int_base, http://spec.org/cpu2017/results/res2021q2/cpu2017-20210413-25629.html, $2010) versus 2x Intel Xeon Gold 6342 (361 SPECrate®2017_int_base, AMD estimated using published Intel specification at ark.intel.com, $2529) for ~16.6% more performance at ~1.48x the score per CPU $. AMD 1Ku pricing and Intel ARK.intel.com pricing as of 4/1/21. SPEC®, SPEC CPU®, and SPECrate® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information. Pricing subject to change.

MLN-100: SPECrate®2017_int_base comparison based on best performing systems published at www.spec.org and AMD estimates as of 04/28/2021. Configurations: 2x AMD EPYC 7313 (309 SPECrate®2017_int_base, http://spec.org/cpu2017/results/res2021q2/cpu2017-20210329-25434.html, $1083) versus 2x Intel Xeon Gold 6326 (241 SPECrate®2017_int_base, AMD estimated using published Intel specifications at ark.intel.com, $1300) for ~28.2% more performance at ~1.54x the score per CPU $. AMD 1Ku pricing and Intel ARK.intel.com pricing as of 4/1/21. SPEC®, SPEC CPU®, and SPECrate® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information. Pricing subject to change.

MLN-101: SAP® SD 2-tier comparison based on best performing systems published at www.sap.com/benchmarks as of 5/5/2021, 2x AMD EPYC™ 7763 scored 75,000 benchmark users (https://www.sap.com/dmc/benchmark/2021/Cert21021.pdf) which supports 56% more benchmark users than the top "Ice Lake" 3rd Gen 2x Intel® Xeon® Platinum 8380 that scored 48,000 benchmark users (https://www.sap.com/dmc/benchmark/2021/Cert21026.pdf). 2x AMD EPYC 7H12 scored 69,499 benchmark users, https://www.sap.com/dmc/benchmark/2020/Cert20023.pdf). SAP and SAP logo are the trademarks or registered trademarks of SAP SE (or an SAP affiliate company) in Germany and in several other countries.

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MLN-102: VMmark® 3.1 matched pair comparison based on best performing systems published at https://www.vmware.com/products/vmmark/results3x.html as of 5/5/2021, 2x AMD EPYC™ 7763 scored 21.58 @ 24 tiles (https://www.vmware.com/content/dam/digitalmarketing/vmware/en/pdf/vmmark/2021-05-04-Lenovo-ThinkSystem-SR665.pdf) which performs 52% better than the top "Ice Lake" 2x Intel® Xeon® Platinum 8380 that scored 14.19 @ 14 tiles (https://www.vmware.com/content/dam/digitalmarketing/vmware/en/pdf/vmmark/2021-04-20-Fujitsu-PRIMERGY-RX2540M6.pdf). 2x AMD EPYC 7H12 scored 18.23 @ 19 tiles, https://www.vmware.com/content/dam/digitalmarketing/vmware/en/pdf/vmmark/2020-11-17-Lenovo-ThinkSystem-SR665.pdf). VMmark is a registered trademark of VMware in the US or other countries.

MLN-103: SPECrate®2017_int_base comparison based on best performing systems published at www.spec.org as of 4/28/2021. Configuration: 2X AMD EPYC 7763 (128C total, 560W TDP total, $15,780 CPU 1Ku total cost, 839 score, http://spec.org/cpu2017/results/res2021q1/cpu2017-20210219-24936.html) versus 4X Intel Xeon Platinum 8380H (112C total, 1000W TDP total, $40,036 CPU 1Ku total cost, 814 score, http://spec.org/cpu2017/results/res2021q1/cpu2017-20210128-24857.html). AMD 1Ku pricing and Intel ARK.intel.com specifications and pricing as of 4/1/21. SPEC®, SPEC CPU®, and SPECrate® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information. Pricing subject to change.

MLN-104: SPECrate®2017_int_base comparison based on AMD estimates as of 5/12/2021. Configuration: 1X AMD EPYC 7543P (32C total, 225W TDP total, $2,730 CPU 1Ku total cost, 271 score, https://www.spec.org/cpu2017/results/res2021q2/cpu2017-20210402-25537.html) versus 2X Intel Xeon Gold 6346 (32C total, 410W TDP total, $4,600 CPU 1Ku total cost, 262 AMD estimated using published Intel specification on ark.intel.com). AMD 1Ku pricing and Intel ARK.intel.com specifications and pricing as of 4/1/21. SPEC®, SPEC CPU®, and SPECrate® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information. Pricing subject to change.

ENDNOTES (CONT'D)

MLNTCO-003: 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. This estimate compares the selected AMD EPYC™ and Intel® Xeon® CPU based server solutions required to deliver ~10,000 units of integer performance based on the published scores for 3rd Gen Intel Xeon Scalable ("Ice Lake") and AMD 7003 CPU based servers. This analysis is based on Bare Metal Server TCO v1.3 - Master.xlsm. This estimation reflects a 3 year time frame.

This analysis compares a 2P AMD EPYC EPYC_7763 powered server with a best SPECrate®2017_int_base score of 839 (https://spec.org/cpu2017/results/res2021q1/cpu2017-20210219-24936.html) compared to a 2P Intel Xeon Platinum_8380 based server with a best SPECrate®2017_int_base score of 558 (https://spec.org/cpu2017/results/res2021q2/cpu2017-20210330-25513.html) as of 4/8/2021

Both AMD EPYC and Intel based servers use the same cost for the following elements of the analysis: server chassis size of 2RU at a cost of $2500 per chassis; 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 $0.12; power drop per rack of 12kW; and a PUE (power usage effectiveness) of 2.0.

The EPYC powered solution estimates are: 12 total 2P EPYC 7763 powered servers at a hardware only acquisition cost of $23,908 per server, which includes total system memory of 1024GB, which is 8GB of memory / core and a total system memory cost of $5248; internal storage cost of $380. The total estimated AMD EPYC hardware acquisition cost for this solution is $286,896. Each server draws ~680 kWhr per month. For the 3 years of this EPYC powered solution analysis the: total solution power cost is ~$70503 which includes the PUE factor; the total admin cost is ~$132600, and the total real estate cost is ~$19440. The total 3 TCO estimate for the AMD solution is ~$509,439.

The Intel based solution requires 18 total 2P Xeon Platinum 8380 powered servers at a hardware only acquisition cost of $24326 per server, which includes total system memory of 1024GB, which is 12.8GB of memory / core and a total system memory cost of $5248; internal storage cost of $380. The total estimated Intel hardware acquisition cost for this solution is $437,868. Each server draws ~741 kWhr per month. For the 3 years of this Intel based solution analysis the: total solution power cost is ~$115239 which includes the PUE factor; the total admin cost is ~$198900, and the total real estate cost is ~$38880. The total 3 TCO estimate for the Intel solution is ~$790,887.

Delivering 10000 of estimated 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)]; 50% less space [1-(AMD rack count / Intel rack count)]; 39% less power [1-(AMD power cost / Intel power cost)]; costing 34% less ([1-(AMD hardware acquisition cost/Intel hardware acquisition cost)], providing a 36% lower 3 year TCO [1-(AMD TCO / Intel TCO)]. AMD processor pricing based on 1KU price as of April 1, 2021. Intel® Xeon® Scalable processor data and pricing from https://ark.intel.com as of April 6, 2021. All pricing is in USD.

ENDNOTES (CONT'D)

ROM-787: A server powered by two AMD EPYC 7H12 CPUs has a SPECint® score of 717, https://spec.org/cpu2017/results/res2020q2/cpu2017-20200525-22554.pdf. 70% higher than score for a Intel Gold 6258R 2P server of 397, https://spec.org/cpu2017/results/res2020q3/cpu2017-20200915-23981.pdf, for SPECrate®2017_int_base as of 02/20/2021. SPEC®, SPECrate®, SPECint® and SPEC CPU® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

ROM-788: A server powered by two AMD EPYC 7H12 CPUs has a SPECfp® score of 543, https://spec.org/cpu2017/results/res2020q3/cpu2017-20200707-23397.pdf. 70% higher than score for a Intel Gold 6258R 2P server of 309, https://spec.org/cpu2017/results/res2020q3/cpu2017-20200915-23979.pdf, for SPECrate®2017_fp_base as of 02/20/2021. 543 / 309 = 1.76 = 1.76x The Performance or 76% More Performance of the 6258R. SPEC®, SPECrate®, SPECfp® and SPEC CPU® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

ROM-789: A server powered by two AMD EPYC 7532 CPUs has a score of 434, https://spec.org/cpu2017/results/res2020q3/cpu2017-20200622-23004.pdf. 40% higher than score for an Intel Gold 6258R 2P server of 309, https://spec.org/cpu2017/results/res2020q3/cpu2017-20200915-23979.pdf, for SPECrate®2017_int_base as of 02/20/2021. SPEC®, SPECrate® and SPEC CPU® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

ROM-790: A server powered by two AMD EPYC 7532 CPUs has a score of 444, https://spec.org/cpu2017/results/res2020q3/cpu2017-20200622-23002.pdf. 12% higher than score for an Intel Gold 6258R 2P server of 397, https://spec.org/cpu2017/results/res2020q3/cpu2017-20200915-23981.pdf, for SPECrate®2017_int_base as of 02/20/2021. SPEC®, SPECrate® and SPEC CPU® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information.

ROM-792: SPECrate®2017_int_base comparison based on best performing systems published at www.spec.org and AMD estimates as of 04/28/2021. Configurations: 2x AMD EPYC 7252 (120 SPECrate®2017_int_base, http://spec.org/cpu2017/results/res2021q1/cpu2017-20210104-24738.html, $348) versus 2x Intel Xeon Silver 4309Y (124 SPECrate®2017_int_base, AMD estimated using published Intel specifications at ark.intel.com, $501) for ~-3.2% more performance at ~1.39x the score per CPU $. AMD 1Ku pricing and Intel ARK.intel.com pricing as of 4/1/21. SPEC®, SPEC CPU®, and SPECrate® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information. Pricing subject to change.

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