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DR. LISA SU
President and CEO

OUR JOURNEY

High-Performance Technologies | Great Products | Ambitious Goals | Undaunted Determination

OUR STRATEGY AND FOCUS

GRAPHICS

Gaming

Compute & AI

Virtual & Augmented Reality

COMPUTE

Client Systems

Infrastructure & Cloud

SOLUTIONS

Semi-Custom

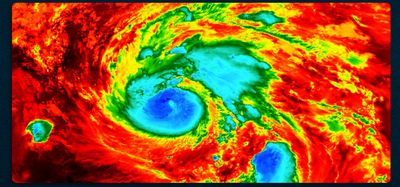
Vertical Platforms

Partnerships

THE DATACENTER HOLDS ENORMOUS POTENTIAL TO IMPROVE OUR WORLD

THE WORLD'S TOUGHEST PROBLEMS
DEMAND NEW THINKING

LARGE SCALE SIMULATIONS



CLIMATE CHANGE

EDUCATION

ENERGY SOLUTIONS

COMPUTATIONAL BIOLOGY

DISEASE PREVENTION

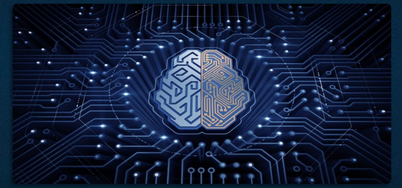
THE WORKLOADS OF THE FUTURE REQUIRE

INCREDIBLE AMOUNTS OF COMPUTE POWER

HIGH PERFORMANCE COMPUTING

CLOUD, HYPERSCALE AND VIRTUALIZATION

MACHINE INTELLIGENCE

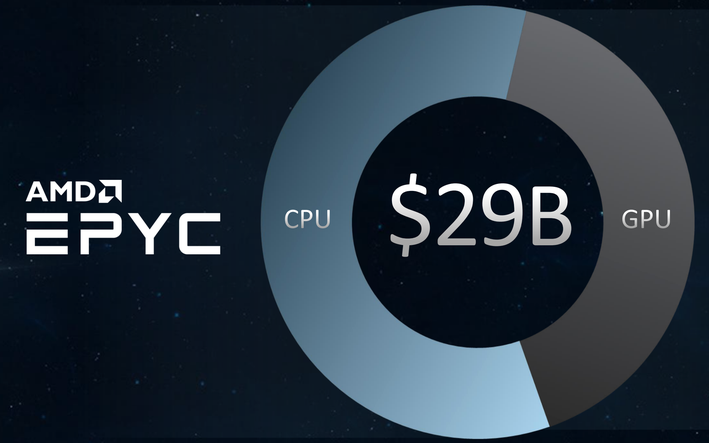


IMMERSIVE AND INSTINCTIVE COMPUTING

BIG DATA ANALYTICS

SOFTWARE-DEFINED STORAGE

...AND REPRESENTS AN INCREDIBLE OPPORTUNITY



DATACENTER TAM
by 2021

AMD Estimate For 2021

MODERN DATACENTERS
REQUIRE NEW THINKING

All-New Design Approach
to CPU and GPU Architecture

Leadership Interconnects
for System Performance

Aggressive
Long-Term Roadmaps

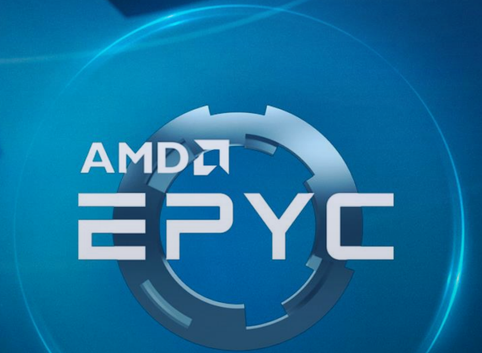
IN 2017, AMD EPYC™ DELIVERED

A NEW ERA IN THE DATACENTER

Performance Leadership at Every Competitive Price Point

More Cores, More Memory Bandwidth, More I/O

Unmatched Total Cost of Ownership



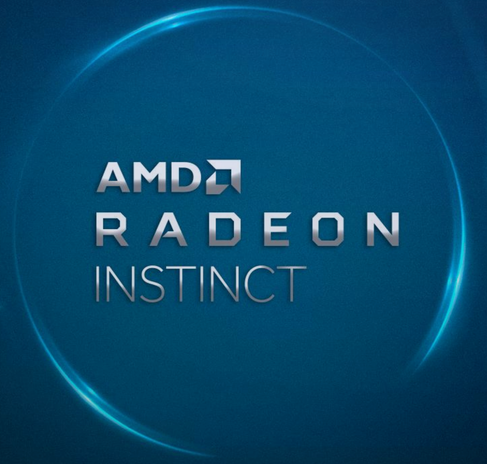
See Endnotes NAP-42, 44, 56, NAP-87-90; NAP 98,99

AMD RADEON INSTINCT™ MI25 BROUGHT CHOICE TO THE CLOUD

Designed for Compute and Cloud Workloads

~25 Teraflops of Performance

Optimized MIOpen Libraries for Deep Learning



ROCm ENABLED THE FIRST COMPLETE

OPEN SOURCE PLATFORM FOR GPU COMPUTE

Unlocked GPU Power To Accelerate Computational Tasks

Optimized for HPC and Ultra-Scale Class Computing

Enabling Innovation, Collaboration, and Efficiency

THE INDUSTRY RESPONDED

AMD DATACENTER MOMENTUM

OEM/ODM

Hewlett Packard Enterprise
DELL EMC
cisco
Lenovo
SUPERMICRO
ASUS
TYAN
wistron
GIGABYTE
Inventec
Sugon
H3C
QCT

SYSTEM INTEGRATORS/PARTNERS

CIARA
AMAX
CRAY
inspur
atipa technologies
SILICON MECHANICS
INTERNATIONAL COMPUTER CONCEPTS
BOXX
KOI COMPUTERS
PENGUIN COMPUTING
EQUUS
Atos
EXXACT
Aspen Systems
Microway

THE INDUSTRY RESPONDED

AMD CLOUD MOMENTUM

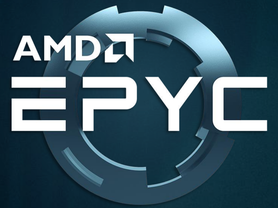
CPU CLOUD DEPLOYMENTS

Microsoft Azure
Baidu 百度
Tencent Cloud
Dropbox
packet
ORACLE CLOUD
HIVELOCITY
HETZNER ONLINE

GPU CLOUD DEPLOYMENTS

Alibaba Cloud
Baidu 百度
aws

ANNOUNCING TODAY



Matt Garman

Vice President, Compute Services

–

AMD EPYC™ NOW POWERING THREE NEW INSTANCES FOR

AMAZON ELASTIC COMPUTE CLOUD (EC2)

Exceptional Performance-per-Dollar for General Purpose and Memory Optimized Workloads

AVAILABLE TODAY

See Endnotes

ANNOUNCING AVAILABILITY OF AMD EPYC™ CPU BASED

R5a, M5a AND T3a INSTANCES

Features AMD EPYC™ Processors' Industry-leading Core Density And Memory Bandwidth

Exceptional Performance-per-Dollar for General Purpose and Memory Optimized Workloads

Seamless Application Migration

See Endnotes

TODAY, WE REVEAL
THE NEXT HORIZON

EXTENDING OUR LEADERSHIP DESIGN APPROACH TO DATACENTER CPUs

New “Zen 2”
High-Performance Core

Modular System Design Extends Compute,
Memory Bandwidth and I/O Leadership

7nm Process Technology for
Performance, Density and Power

See Endnotes NAP-42, 44, 56

DESIGNING INNOVATIVE

GPUs FOR THE CLOUD

High-Performance Compute Engines

Extensive Mixed Precision Ops for Optimum Deep Learning Performance

Leadership Bandwidth and Interconnect Technology

INTRODUCING TODAY

AMD RADEON INSTINCT™ MI60

World's First 7nm GPU

World's Fastest
HPC PCIe® Capable Accelerator

Industry's Only
Hardware-Virtualized GPU

See Endnotes

PREVIEWING TODAY

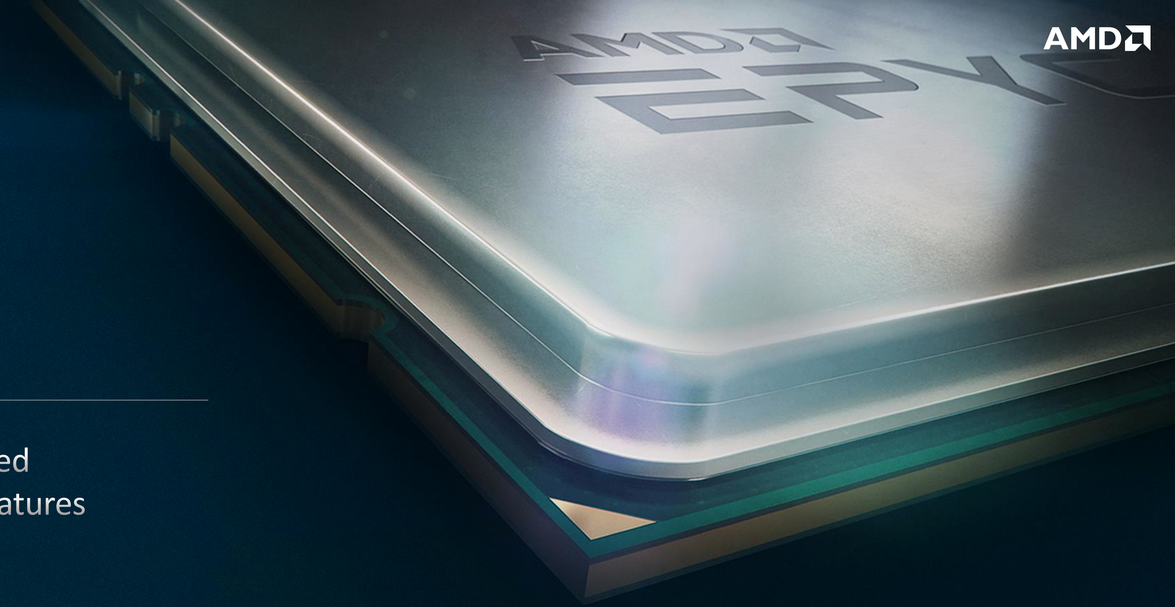
"ROME"

AMD NEXT GENERATION EPYC™ CPU

World's First
7nm Datacenter CPU

Increased IPC and Significant
Total Performance Uplift

Advanced
Security Features



See Endnotes

AMD
TOTAL DATACENTER COMMITMENT

ENDNOTES

Slide 8

Claim: Datacenter TAM will be $29M by 2021.

Substantiation: AMD internal estimate for 2021. Forward looking statement – please see cautionary statement.

ENDNOTES

Slide 10

Claim: Performance leadership at every competitive price point.

Substantiation: NAP-87 – Estimates based on SPECrate®2017_int_base using the GCC-02 v7.2 compiler. AMD-based system scored 196 in tests conducted in AMD labs using an "Ethanol" reference platform configured with 2 x AMD EPYC 7601 SOC's, 512GB memory (16 x 32GB 2R DDR4 2666MHz), Ubuntu 17.04, BIOS 1002E. Intel-based Supermicro SYS-1029U-TRTP server scored 169.8 in tests conducted in AMD labs configured with 2 x Xeon 8160 CPU's, 768GB memory (24 x 32GB 2R DDR4 2666MHz), SLES 12 SP3 4.4.92-6.18-default kernel, BIOS set to Extreme performance setting.

NAP-88 – Estimates based on SPECrate®2017_int_base using the GCC-02 v7.2 compiler. AMD-based system scored 149 in tests conducted in AMD labs using an "Ethanol" reference platform configured with 2 x AMD EPYC 7401 SOC's, 512GB memory (16 x 32GB 2R DDR4 2666MHz), Ubuntu 17.04, BIOS 1002E. Intel-based Supermicro SYS-1029U-TRTP server scored 118.1 in tests conducted in AMD labs configured with 2 x Xeon 6130 CPU's, 768GB memory (24 x 32GB 2R DDR4 2666MHz), SLES 12 SP3 4.4.92-6.18-default kernel, BIOS set to Extreme performance setting.

NAP-89 – Estimates based on SPECrate®2017_int_base using the GCC-02 v7.2 compiler. AMD-based system scored 123 in tests conducted in AMD labs using an "Ethanol" reference platform configured with 2 x AMD EPYC 7351 SOC's, 512GB memory (16 x 32GB 2R DDR4 2666MHz), Ubuntu 17.04, BIOS 1002E. Intel-based Supermicro SYS-1029U-TRTP server scored 86.2 in tests conducted in AMD labs configured with 2 x Xeon 5118 CPU's, 768GB memory (24 x 32GB 2R DDR4 2666MHz running at 2400), SLES 12 SP3 4.4.92-6.18-default kernel, BIOS set to Extreme performance setting.

NAP-90 – Estimates based on SPECrate®2017_int_base using the GCC-02 v7.2 compiler. AMD-based system scored 113 in tests conducted in AMD labs using an "Ethanol" reference platform configured with 2 x AMD EPYC 7351 SOC's, 512GB memory (16 x 32GB 2R DDR4 2666MHz), Ubuntu 17.04, BIOS 1002E. Intel-based Supermicro SYS-1029U-TRTP server scored 78.7 in tests conducted in AMD labs configured with 2 x Xeon 4116 CPU's, 768GB memory (24 x 32GB 2R DDR4 2666MHz running at 2400), SLES 12 SP3 4.4.92-6.18-default kernel, BIOS set to Extreme performance setting.

NAP-98 – Based on SPECrate®2017_int_peak results published on www.spec.org as of April 2018. AMD-based system scored 310 on a Supermicro A+ Server 2123BT-HNC0R configured with 2 x AMD EPYC 7601 SOC's ($4200 each at AMD 1ku pricing), 1TB memory (16 x 64GB DDR4 2666MHz), SUSE 12 SP3, Supermicro BIOS 1.0b, using the AOCC 1.0 complier. Intel- based system scored 309 on a Cisco UCS C220 M5 server configured with 2 x 8180M CPU's ($13,011 each per ark.intel.com), 384GB memory (24*16GB 2R DDR4 2666MHz), SLES 12 SP2, BIOS v3.2.1d, using the ICC 18.0.0.128 complier.

NAP-99 – Based on SPECrate®2017_fp_peak results published on www.spec.org as of April 2018. AMD-based system scored 279 on a Supermicro A+ Server 4023S-TRT configured with 2 x AMD EPYC 7601 SOC's ($4200 each at AMD 1ku pricing), 1TB memory (16 x 64GB DDR4 2666MHz), SUSE 12 SP3, Supermicro BIOS 1.0b, using the AOCC 1.0 complier. Intel-based system scored 250 on a Cisco UCS C220 M5 server configured with 2 x 8180M CPU's ($13,011 each per ark.intel.com), 384GB memory (24*16GB 2R DDR4 2666MHz), SLES 12 SP2, BIOS v3.2.1d, using the ICC 18.0.0.128 complier

ENDNOTES

Slide 10

Claim: More cores, more memory bandwidth, more I/O.

Substantiation: NAP-42 – AMD EPYC™ 7601 processor supports up to 8 channels of DDR4-2667, versus the Xeon Platinum 8180 processor at 6 channels of DDR4-2667.

NAP-43 – AMD EPYC 7601 processor includes up to 32 CPU cores versus the Xeon Platinum 8180 processor with 28 CPU cores.

NAP-44 – A single AMD EPYC™ 7601 processor offers up to 2TB/processor (x 2 = 4TB), versus a single Xeon Platinum 8180 processor at 768Gb/processor (x 2 = 1.54TB).

NAP-56 – AMD EPYC™ processor supports up to 128 PCIe® Gen 3 I/O lanes (in both 1 and 2-socket configuration), versus the Intel® Xeon® SP Series processor supporting a maximum of 48 lanes PCIe® Gen 3 per CPU, plus 20 lanes in the chipset (max of 68 lanes on 1 socket and 116 lanes on 2 socket).

Claim: Unmatched total cost of ownership.

Substantiation: Dell EMC PowerEdge R7415 AMD EPYC VMware vSAN Mixed Workloads Performance: https://www.demartek.com/Reports_Free/Demartek_Dell_AMD_vSAN_Mixed_Workloads_Performance_Summary_Report_2018-04.pdf.
Results not independently verified by AMD.

ENDNOTES

Slide 17

Claim: Exceptional Performance-per-Dollar for General Purpose and Memory Optimized Workloads

Substantiation: Source: Amazon Web Services Press Release “AWS Introduces New Amazon EC2 Instances Featuring AMD EYPC Processors at LINK (actual cost savings with AMD may vary)

Slide 18

Claim: Exceptional Performance-per-Dollar for General Purpose and Memory Optimized Workloads

Substantiation: Source: Amazon Web Services Press Release “AWS Introduces New Amazon EC2 Instances Featuring AMD EYPC Processors at LINK (actual cost savings with AMD may vary)

Claim: EPYC delivers seamless application migration for Amazon Elastic Compute Cloud (EC2).

Substantiation: Source: Amazon Web Services Press Release “AWS Introduces New Amazon EC2 Instances Featuring AMD EYPC Processors at LINK (actual cost savings with AMD may vary)

ENDNOTES

Slide 20

Claim: Modular system design extends compute, memory bandwidth and I/O leadership.

Substantiation: NAP-42 – AMD EPYC™ 7601 processor supports up to 8 channels of DDR4-2667, versus the Xeon Platinum 8180 processor at 6 channels of DDR4-2667.

NAP-43 – AMD EPYC 7601 processor includes up to 32 CPU cores versus the Xeon Platinum 8180 processor with 28 CPU cores.

NAP-44 – A single AMD EPYC™ 7601 processor offers up to 2TB/processor (x 2 = 4TB), versus a single Xeon Platinum 8180 processor at 768Gb/processor (x 2 = 1.54TB).

NAP-56 – AMD EPYC™ processor supports up to 128 PCIe® Gen 3 I/O lanes (in both 1 and 2-socket configuration), versus the Intel® Xeon® SP Series processor supporting a maximum of 48 lanes PCIe® Gen 3 per CPU, plus 20 lanes in the chipset (max of 68 lanes on 1 socket and 116 lanes on 2 socket). Based on Zen2 design parameters versus Zen1 and currently shipping products – core count increase from 32 to up to 64 per socket. Memory bandwidth with "Zen 2" design parameters including increased memory speed across eight memory channels, I/O leadership extending to PCIeGen4"

Slide 22

Claim: Radeon Instinct MI60 has the world's fastest HPC PCIe capable accelerator.

Substantiation: Calculated on Oct 22, 2018, the Radeon Instinct MI60 GPU resulted in 7.4 TFLOPS peak theoretical double precision floating-point (FP64) performance. AMD TFLOPS calculations conducted with the following equation: FLOPS calculations are performed by taking the engine clock from the highest DPM state and multiplying it by xx CUs per GPU. Then, multiplying that number by xx stream processors, which exist in each CU. Then, that number is multiplied by 1/2 FLOPS per clock for FP64. TFLOP calculations for MI60 can be found at https://www.amd.com/en/products/professional-graphics/instinct-mi60 External results on the NVidia Tesla V100 (16GB card) GPU accelerator resulted in 7 TFLOPS peak double precision (FP64) floating-point performance. Results found at: https://images.nvidia.com/content/technologies/volta/pdf/437317-Volta-V100-DS-NV-US-WEB.pdf AMD has not independently tested or verified external/third party results/data and bears no responsibility for any errors or omissions therein. RIV-3

ENDNOTES

Slide 23

Claim: “Rome” is the world’s first 7nm datacenter CPU.

Substantiation: Based on AMD’s internal competitive assessment of all currently shipping or publicly disclosed X86 Server CPU products as of 9/6/2018

Claim: “Rome” delivers increased IPC and significant total performance uplift.

Estimated increase in instructions per cycle (IPC) is based on AMD internal testing for ”Zen 2” across microbenchmarks, compared to prior “Zen 1” generation CPU using combined floating point and integer benchmarks.

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MARK PAPERMASTER
CTO and SVP, Technology & Engineering

OUR HIGH-PERFORMANCE JOURNEY CONTINUES

“Zen” Delivered as Promised	“Zen 2” High-Performance Leadership	Strong CPU Roadmap for the Future

DELIVERING

AS PROMISED

ZEN IN THE MARKET

7nm PROCESS NODE

LEADING EDGE
7nm PROCESS TECHNOLOGY

Major Node, Significant Investment

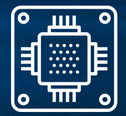
Faster, Smaller, Lower Power Transistors

Multiple Products in Development

Deep Partnerships with TSMC and Design Automation Vendors

7nm DRIVES SIGNIFICANT

COMPUTE EFFICIENCY

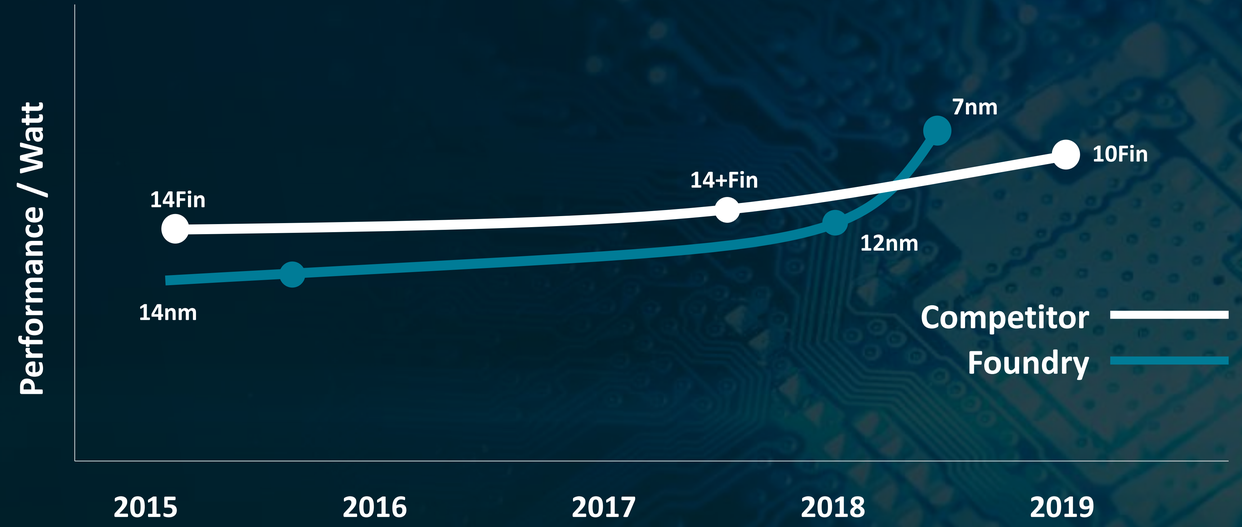


DENSITY 2x

POWER 0.5x
(Same Performance)

PERFORMANCE >1.25x
(Same Power)

7nm LEVELS COMPETITIVE PLAYING FIELD



Based on publicly available data as of August 2018 for foundry slide

TSMC

Dr. Y.J. Mii, Senior Vice President Research & Development & Technology Development

ZEN
2

ZEN 2 DESIGN

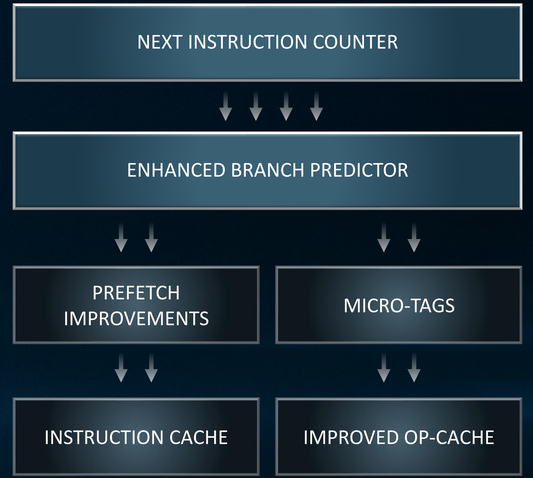
World's First High-Performance x86 7nm CPU	CPU Core Execution Enhancements	Further Security Enhancements	Modular Design for Configurability and Ease of Manufacture

DELIVERS UP TO 2x THROUGHPUT

Improved Execution Pipeline	Doubled Floating Point and Load Store	Doubled Core Density	Half the Energy Per Operation

NEW FRONT END ADVANCES

Improved Branch Predictor	Better Instruction Pre-Fetching	Re-Optimized Instruction Cache	Larger Op Cache



FLOATING POINT ADVANCES

Doubled Floating Point Width to 256-Bit	Doubled Load / Store Bandwidth	Increased Dispatch / Retire Bandwidth	Maintained High Throughput for All Modes

STRONG SECURITY GETS STRONGER

"Zen" Delivered Industry Leading Memory Encryption with Increased Flexibility

"Zen" Software Mitigations Robust

Hardware Enhanced Spectre Mitigations with "Zen 2"

“ZEN”

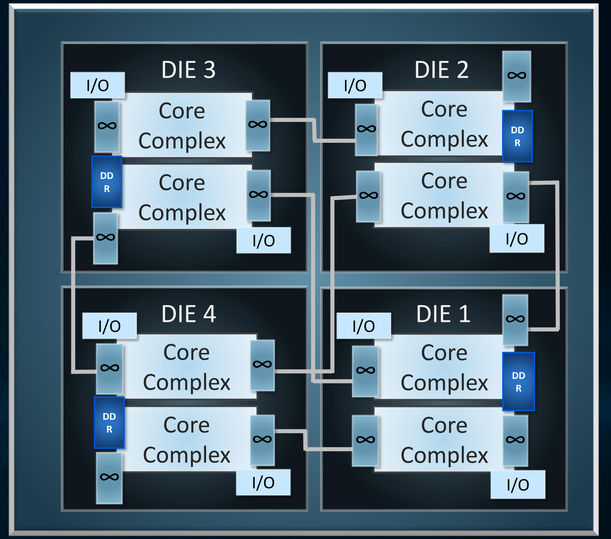
INTRODUCED OUR MULTI-CHIP APPROACH

Inherent Yield Advantage

Increased Peak Compute

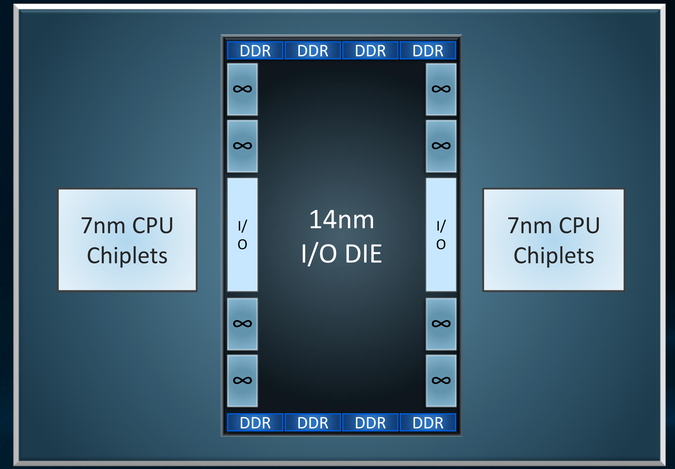
Highly Configurable

“Zen” Based EPYC™ Processors



REVOLUTIONARY CHIPLET DESIGN

Each IP in its Optimal Technology	Infinity Fabric Enabled Modularity	Optimized I/O Die Improves Latency and Power	7nm Tech for CPU Performance and Power



"Zen 2" Based EPYC Processors

LEADING-EDGE PERFORMANCE

Double Throughput at Same Power

Higher Instructions Per Clock

Revolutionary Chiplet System Design

Enhanced Security

HIGH-PERFORMANCE MOMENTUM

AMD
NEXT HORIZON

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DAVID WANG
Senior Vice President of Engineering,
Radeon Technologies Group

AMD RADEON™ GRAPHICS MOVING TO THE DATACENTER

Consumer and Professional

ADDRESSING EVOLVING

DATACENTER GPU USE CASES

$12 BILLION COMBINED TAM BY 2021

Cloud Gaming

Virtual Desktop & Workstation

Machine Learning

High Performance Computing

TAM Source: AMD Internal Estimates

DESIGNED FOR THE CLOUD

AMD RADEON INSTINCT™ MI60

World's First 7nm GPU

High-Performance, Flexible Vega Architecture

Leading Edge Memory and Scalability

Industry's Only Hardware-Virtualized GPU

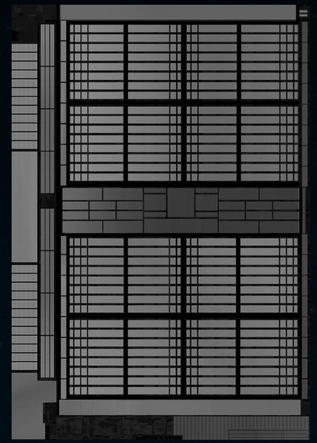
WORLD'S FIRST 7nm GPUs

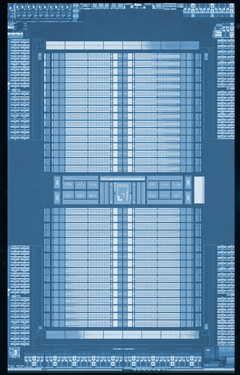
UP TO
2x MORE DENSITY
13.2B TRANSISTORS, 331 mm2

>1.25x HIGHER PERFORMANCE
AT THE SAME POWER

50% LOWER POWER
AT THE SAME FREQUENCY

Higher Performance per Watt


MI25


MI60

HIGH-PERFORMANCE, FLEXIBLE

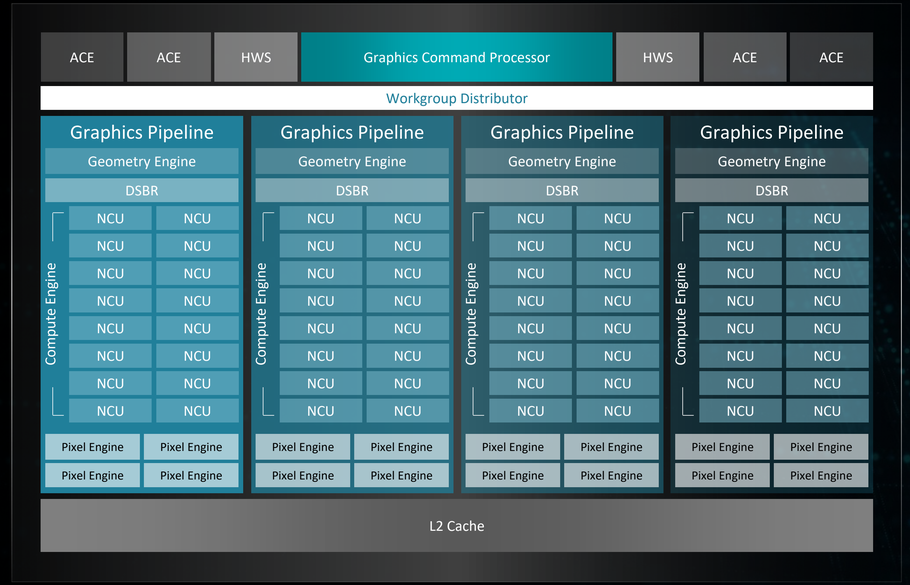
VEGA ARCHITECTURE

MI60: World's Fastest FP64 and FP32 PCIe Capable GPU

Machine Learning Operations for Training and Inference

Flexible Architecture for Different Workloads

End-to-End ECC Protection



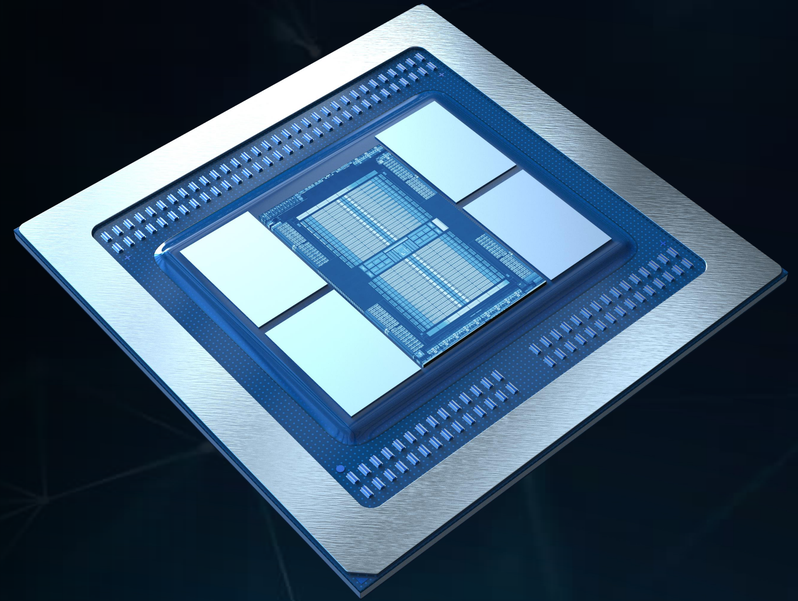
HIGHLY EFFICIENT MEMORY SUBSYSTEM WITH

1 TB/S MEMORY BANDWIDTH

32 GB of High Bandwidth Memory (HBM2)

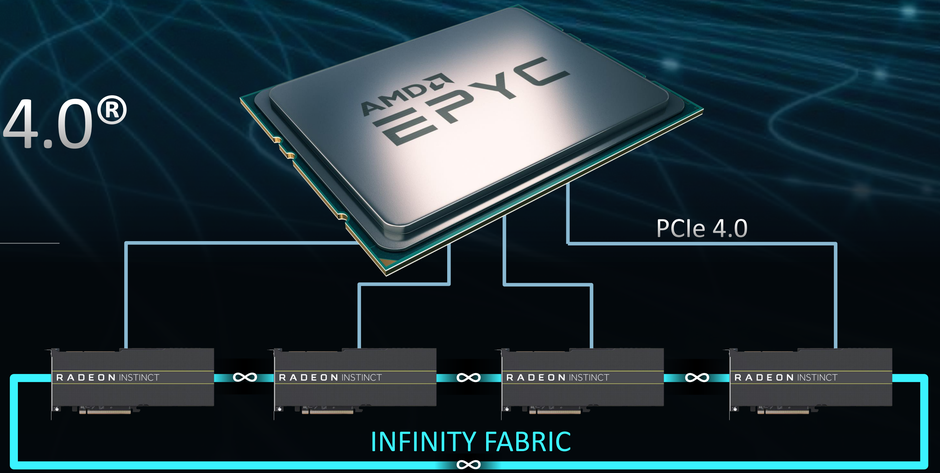
Built-in Error Detection and Correction with ECC

Support Huge Datasets with Enterprise Class Reliability



INDUSTRY-FIRST PCIe 4.0® CAPABLE GPU

64 GB/s Bi-Directional
CPU-to-GPU Bandwidth



Leading Edge Connectivity

INFINITY FABRIC LINKS

100 GB/s per Link for
GPU-to-GPU Bandwidth

THIRD-GENERATION

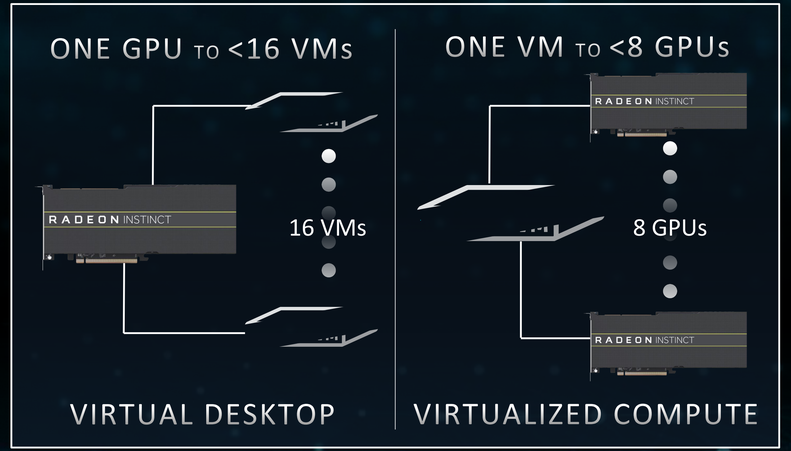
HARDWARE-VIRTUALIZED GPU

Deploy without Software Overhead

Data Isolation Helps with Security

Drive Many Virtual Machines per GPU

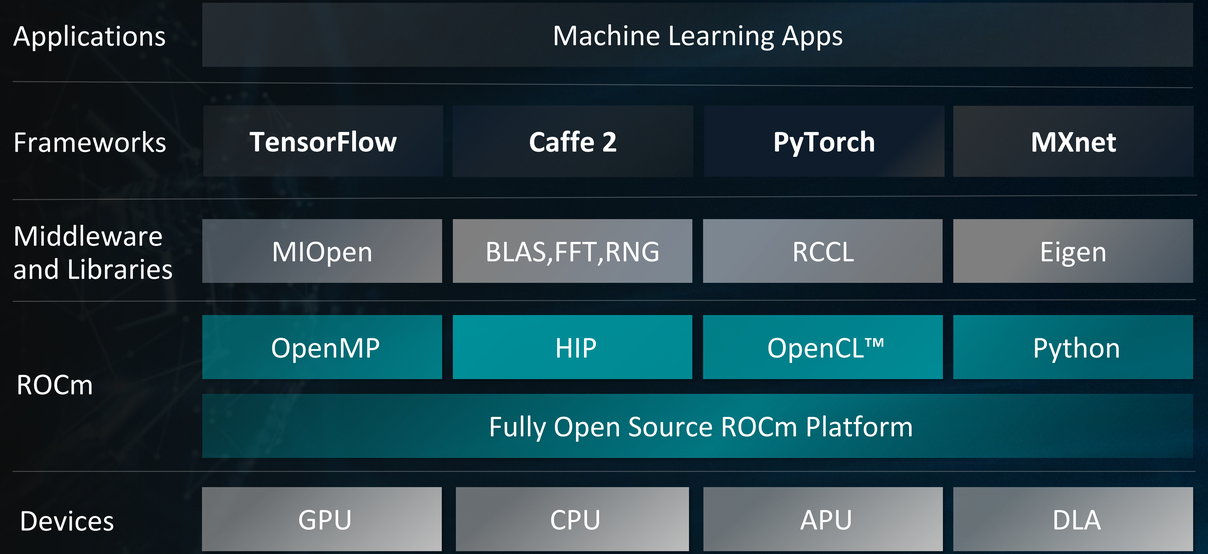
Scale Up Performance with Multiple GPUs



OPEN SOURCE FOUNDATION FOR MACHINE LEARNING

Announcing ROCm 2.0

- Latest Machine Learning Frameworks
- Optimized Math Libraries
- Dockers and Kubernetes Support
- Up-Streamed for Linux Kernel Distributions



EMBRACED BY THE
OPEN SOURCE COMMUNITY
Extends ROCm Access to
MILLIONS OF LINUX KERNEL USERS
Caffe2
PYTORCH
tvm
TensorFlow
PaddlePaddle
LLVM
COMPILER INFRASTRUCTURE
GitHub
docker
Numba

EMBRACED BY INDUSTRY LEADERS

"Google believes that open source is good for everyone. We've seen how helpful it can be to open source machine learning technology, and we're glad to see AMD embracing it. With the ROCm open software platform, TensorFlow users will benefit from GPU acceleration and a more robust open source machine learning ecosystem."

TensorFlow

Rajat Monga
Engineering Director
TENSORFLOW, GOOGLE

EMBRACED BY INDUSTRY LEADERS

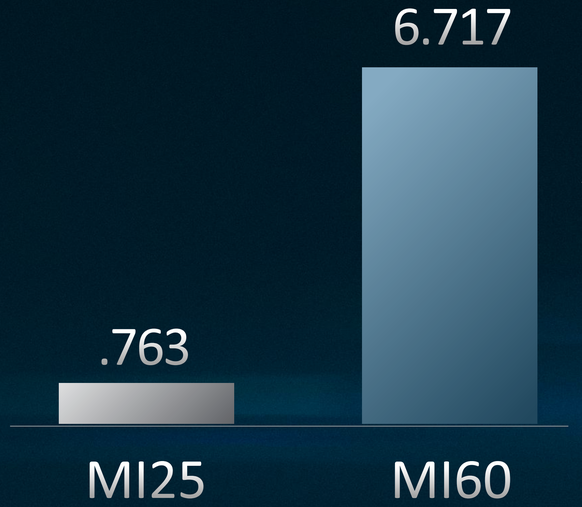
Zhenyu Hou

Executive Director, System Technologies

AMD

AMD RADEON INSTINCT™ MI60

Generational Improvement



DGEMM
TFLOPS

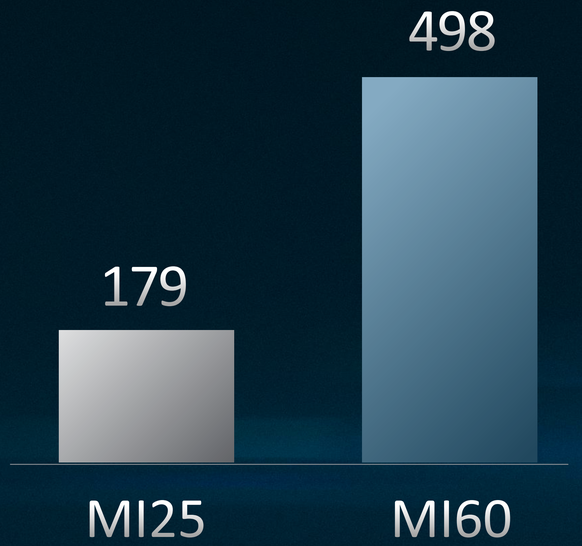
~8.8x FASTER
vs. MI25

See RIV-6 in End Notes.

AMD

AMD RADEON INSTINCT™ MI60

Generational Improvement



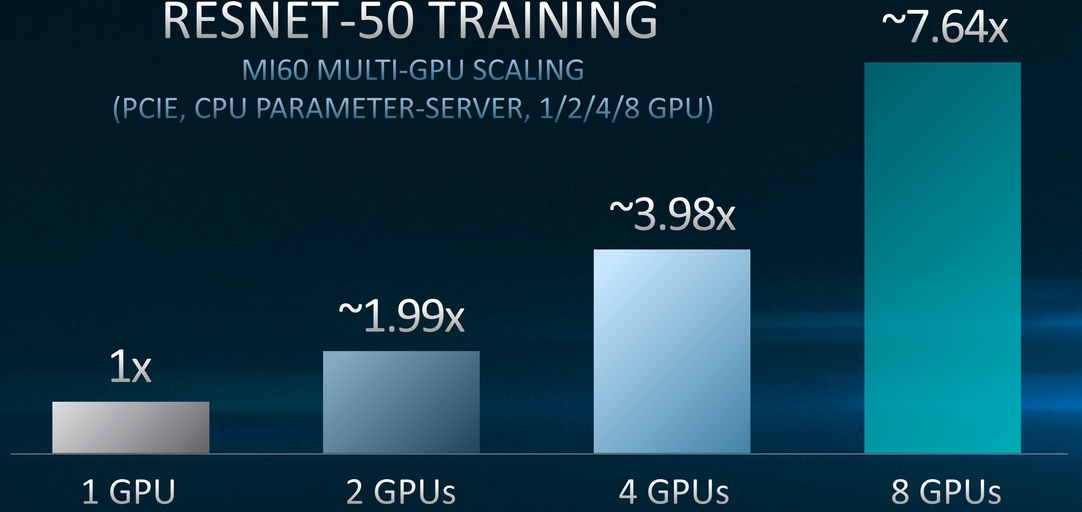
RESNET-50
IMAGES PER SECOND

~2.8x FASTER
vs. MI25

See RIV-8 in End Notes.

AMD RADEON INSTINCT™ MI60

Excellent Performance Scalability

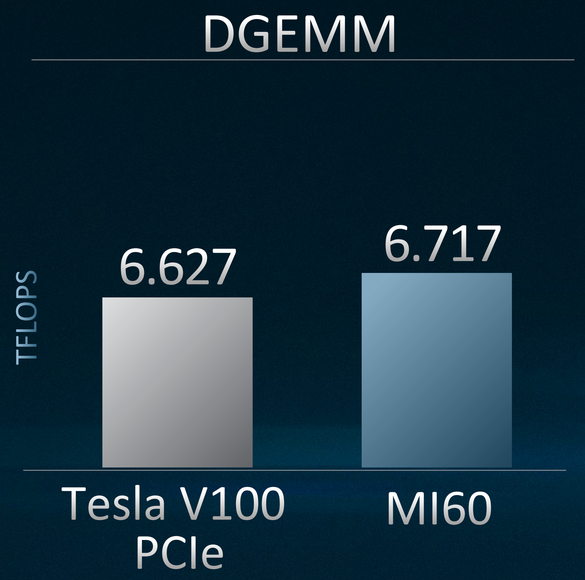


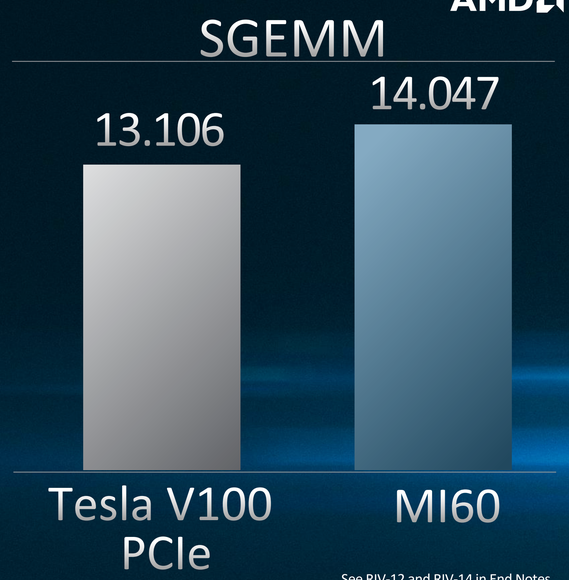
See RIV-11 in End Notes.

AMD RADEON

INSTINCT™ MI60

Competitive Performance



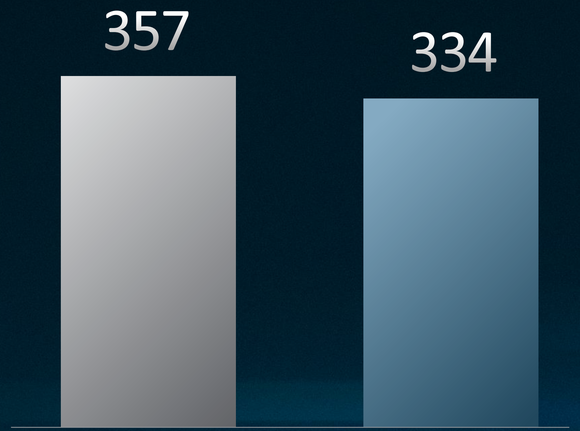


See RIV-12 and RIV-14 in End Notes.

AMD RADEON

INSTINCT™ MI60

Competitive Performance



RESNET-50 Training

IMAGES PER SECOND

Comparable Performance

vs. Tesla V100 PCIe

See RIV-13 in End Notes.

SIMULATED WORLDS FOR MACHINE LEARNING

Real-time Data Capture is Inefficient

Simulation Can Produce Massive Datasets

Safe for Corner Cases and Variations

Peter McGuinness
CEO

STEP 1

SIMULATION

Generate Data for Neural Network Training

STEP 2

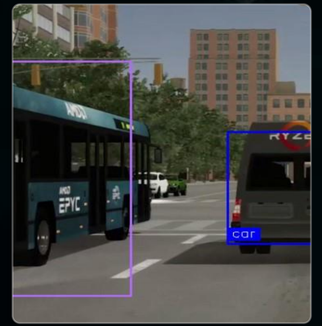
TRAINING

Train Neural Networks with Simulated Data

STEP 3

VALIDATION

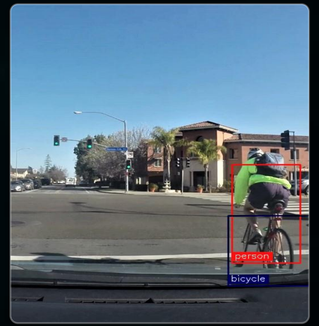
Verify Training with Simulated and Real Data



STEP 4

DEPLOYMENT

Apply to Real-world Problems



AMD RADEON INSTINCT™ MI60

MACHINE LEARNING DEMONSTRATION

AMD RADEON INSTINCT™ MI60

SHIPPING THIS QUARTER

WORLD'S FIRST 7nm GPU

FIRST PCIe® 4.0 CAPABLE GPU + INFINITY FABRIC LINKS

EFFICIENT 1 TB/S MEMORY BANDWIDTH

WORLD'S ONLY HARDWARE-VIRTUALIZED GPU

7.4 TFLOPS FP64 FOR HPC

14.7 TFLOPS FP32 FOR TRAINING

118 TOPS INT4 FOR INFERENCE

CHOICE AND INNOVATION FOR THE FUTURE

DATACENTER GPU ROADMAP

AMD Radeon Instinct™ MI25

14nm GPU
PCIe® 3.0
16 GB of HBM2 Memory

AMD Radeon Instinct™ MI60

First 7nm GPU
First PCIe® 4.0 Capable GPU
32 GB of HBM2 Memory
Infinity Fabric Links

"MI-NEXT"

Higher Performance
Increased Connectivity
Software Compatibility

Predictable Product Cadence with Generational Performance Gains

Roadmaps subject to change.

AMD
NEXT HORIZON

END NOTES

RIV-6: As of Oct 22, 2018. The results calculated for Radeon Instinct MI60 designed with Vega 7nm FinFET process technology resulted in 118 TOPS INT4, 59 TOPS INT8, 29.5 TFLOPS half precision (FP16), 14.8 TFLOPS single precision (FP32) and 7.4 TFLOPS double precision (FP64) peak theoretical floating-point performance. The results calculated for Radeon Instinct MI50 designed with Vega 7nm FinFET process technology resulted in 107 TOPS INT4, 53.6 TOPS INT8, 26.8 TFLOPS peak half precision (FP16), 13.4 TFLOPS peak single precision (FP32) and 6.7 TFLOPS peak double precision (FP64) floating-point performance. The results calculated for Radeon Instinct MI25 GPU based on the "Vega10" architecture resulted in 24.6 TFLOPS peak half precision (FP16), 12.3 TFLOPS peak single precision (FP32) and 768 GFLOPS peak double precision (FP64) floating-point performance. AMD TFLOPS calculations conducted with the following equation for Radeon Instinct MI25, MI50, and MI60 GPUs: FLOPS calculations are performed by taking the engine clock from the highest DPM state and multiplying it by xx CUs per GPU. Then, multiplying that number by xx stream processors, which exist in each CU. Then, that number is multiplied by 2 FLOPS per clock for FP32, 4 FLOPS per clock for FP16, 8 FLOPS per clock for INT8, and 16 FLOPS per clock for INT8 to determine TFLOPS or TOPS. The FP64 TFLOPS rate or MI50 and MI60 is calculated using 1/2 rate. The FP64 TFLOPS rate for MI25 is calculated using 1/16th rate.

RIV-8: Testing Conducted by AMD performance labs on October 31, 2018, on a system comprising of Dual Intel Xeon Gold 6132, 256GB DDR4 system memory, Ubuntu 16.04.5 LTS, AMD Radeon Instinct MI25 graphics, AMD Radeon Instinct MI60 graphics, ROCm 19.224 driver, TensorFlow 1.11. Benchmark application: Resnet50 FP16 batch size 256. AMD Radeon Instinct MI25 = 179 images/s. AMD Radeon Instinct MI60 = max 498.99 images/s. Performance differential: 498.99/179 = up to2.8x more performance than Radeon Instinct MI25. Server manufacturers may vary configurations, yielding different results. Performance may vary based on use of latest drivers and optimizations.

RIV-11: Testing Conducted by AMD performance labs on October 31, 2018, on a system comprising of Dual Intel Xeon Gold 6132, 256GB DDR4 system memory, Ubuntu 16.04.5 LTS, AMD Radeon Instinct MI60 graphics running at 1600e/500m, ROCm 19.224 driver, TensorFlow 1.11. Benchmark application: Resnet50 FP32 batch size 256. 1x AMD Radeon Instinct MI60 = 278.63images/s, 2x Radeon Instinct MI60 = 553.98 images/s. Performance differential: 553.98/278.63 = 1.99x times more performance than 1x Radeon Instinct MI60. 4x Radeon Instinct MI60 = 1109.24 images/s. Performance differential: 1109.24/278.63 = 3.98x times more performance than 1x Radeon Instinct MI60. 8x Radeon Instinct MI60 = 2128.33 images/s. Performance differential: 2128.33/278.63 = 7.64x times more performance than 1x Radeon Instinct MI60. Server manufacturers may vary configurations, yielding different results. Performance may vary based on use of latest drivers and optimizations.

END NOTES

RIV-12: Testing Conducted by AMD performance labs on October 31, 2018, on a system comprising of Dual Socket Intel Xeon Gold 6130, 256GB DDR4 system memory, Ubuntu 16.04.5 LTS, AMD Radeon Instinct MI25 graphics, AMD Radeon Instinct MI60 graphics, ROCm 19.211 driver. Benchmark application: rocBLAS DEGEMM N=M=K=5760. AMD Radeon Instinct MI25 GFLOPS = 763. AMD Radeon Instinct MI60 TFLOPS = 6.717. Performance differential: 6717/763 = 8.8x more performance than Radeon Instinct MI25. Server manufacturers may vary configurations, yielding different results. Performance may vary based on use of latest drivers and optimizations. Calculated on Oct 22, 2018, the Radeon Instinct MI60 GPU resulted in 7.4 TFLOPS peak theoretical double precision floating-point (FP64) performance. AMD TFLOPS calculations conducted with the following equation: FLOPS calculations are performed by taking the engine clock from the highest DPM state and multiplying it by xx CUs per GPU. Then, multiplying that number by xx stream processors, which exist in each CU. Then, that number is multiplied by 1/2 FLOPS per clock for FP64. TFLOP calculations for MI60 can be found at https://www.amd.com/en/products/professional-graphics/instinct-mi60.

RIV-13: Testing Conducted by AMD performance labs on October 31, 2018, on a system comprising of Dual Socket Intel Xeon Gold 6130, 256GB DDR4 system memory, Ubuntu 16.04.5 LTS, NVIDIA Tesla V100 PCIe with CUDA 10.0.130 and CUDNN 7.3, AMD Radeon Instinct MI60 graphics, ROCm 19.224 driver, TensorFlow 1.11. Benchmark application: Resnet50 FP32 batch size 256. NVIDIA Tesla V100 PCIe = 357 images/s. AMD Radeon Instinct MI60 = 334 images/s. Server manufacturers may vary configurations, yielding different results. Performance may vary based on use of latest drivers and optimizations.

RIV-14: Testing Conducted by AMD performance labs on October 31, 2018, on a system comprising of Dual Socket Intel Xeon Gold 6130, 256GB DDR4 system memory, Ubuntu 16.04.5 LTS, NVIDIA Tesla V100 PCIe with CUDA 10.0.130 and CUDNN 7.3, AMD Radeon Instinct MI60 graphics with ROCm 19.224 driver. Benchmark application: cuBLAS/rocBLAS SGEMM N=M=K=5760. AMD NVIDIA Tesla V100 PCIe TFLOPS = 13.106. AMD Radeon Instinct MI60 TFLOPS = 14.047. Server manufacturers may vary configurations, yielding different results. Performance may vary based on use of latest drivers and optimizations.

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FORREST NORROD
Senior Vice President and General Manager
Datacenter and Embedded Solutions Group

THE DATACENTER REPRESENTS AN INCREDIBLE OPPORTUNITY

$17B
TAM

AMD EPYC

*AMD ESTIMATE FOR 2021

DRAMATIC CHANGE IN THE DATACENTER

THE MODERN DATACENTER REQUIRED NEW THINKING

A DECADE AGO

- Top 10 Customers: <10%
- Scale Up
- Physical
- On-Premise
- Proprietary Software

TODAY

- Top 7 Customers: ~40%
- Scale Out
- Virtual ➡ Container
- Hybrid – Cloud
- Open Source

*Based on AMD Internal Analysis

AMD

AMD EPYC™ LEADERSHIP FOR THE MODERN DATACENTER

Core Density | Memory Bandwidth | Leadership I/O | Advanced Security Features

See Endnotes NAP-42, NAP-43, NAP-44, NAP-56

AMD EPYC™ LEADERSHIP

Cloud Service Providers

- IaaS/PaaS
- Media
- Social
- SaaS

Enterprise IT

- Virtualization
- SDS/HCI
- Hadoop
- NoSQL

High Performance Compute

- Design & Simulation
- Research & Academia
- Machine Learning
- Supercomputing

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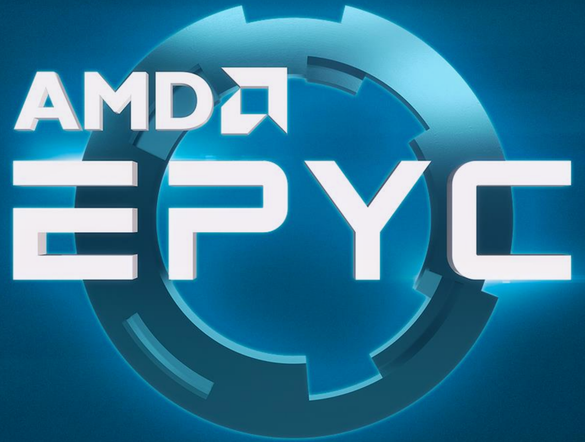
AMD EPYC™ YEAR ONE

MOMENTUM


AMD
EPYC

AMD EPYC™ DESIGNED FOR

CLOUD SERVICES

Accelerating and Securing the Journey to the Cloud

ROBUST AMD EPYC™-BASED

CLOUD SERVICE OFFERINGS

Baidu 百度 | Microsoft Azure | ORACLE CLOUD | aws | Tencent Cloud | HIVELOCITY | HETZNER ONLINE | packet

DIFFERENTIATED CLOUD SERVICES

LV Series for Demanding Storage and I/O Intensive Applications

Hb Series for High Performance Computing

Highest Throughput of Any Cloud Provider

Microsoft Azure

See Endnotes

GENERAL PURPOSE CLOUD SERVICES

Exceptional Virtual Machine Costs & Easy to Adopt

New “M” & “T” Instances for General Purpose Workloads

New “R” Instances for Memory Optimized Performance

ENTERPRISE APPS AND BARE METAL

Up to 66% Less Cost/Core Hour

Virtual Machines & Bare Metal Shapes for Maximum Price/Performance

Full Support for Oracle Enterprise Applications

ORACLE®

CLOUD

See End Notes

ENTERPRISE HOSTING PARTNERS

Wide and Robust Range of Enterprise Hosting and Managed Services based on AMD EPYC

packet

HIVELOCITY

HETZNER ONLINE

AI, BIG DATA, CLOUD "ABC" DATACENTERS

Unrivaled Scale and Efficiency for AI, Big Data, and Cloud Computing Services

Single Socket Efficiencies Delivering Dual Socket Performance

Baidu 百度

See Enddnotes

INFRASTRUCTURE AS A SERVICE

Exceptional Performance and 30% Lower Cost Per Virtual Machine

Balanced Computing, Memory and Network Resources

Extremely Cost Effective for a Wide Range of Enterprise Applications

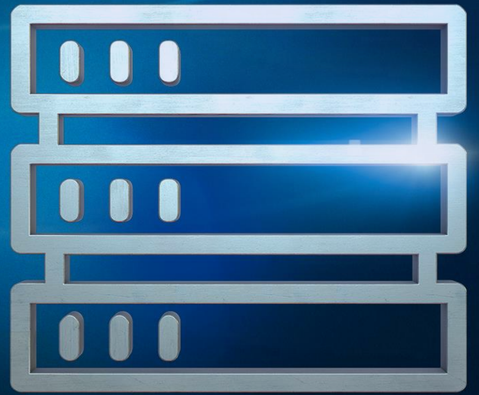
Tencent Cloud

See Endnotes

AMD

AMD EPYC™ DESIGNED FOR VIRTUALIZATION

Reclaiming Budget to Revitalize and Modernize the Datacenter



AMD EPYC™ VIRTUALIZATION LEADERSHIP AND INNOVATION

SUPERIOR TCO

Best-in-Class
Price Performance

HIGHER DENSITY

Up to 2.7X Greater Virtual
Machine Density

See Endnotes

REVITALIZING THE HEART OF THE VIRTUALIZED DATACENTER

REVITALIZING THE HEART OF THE

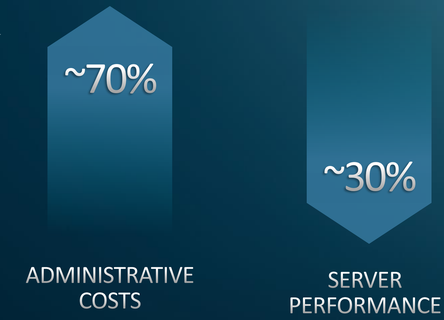
VIRTUALIZED DATACENTER

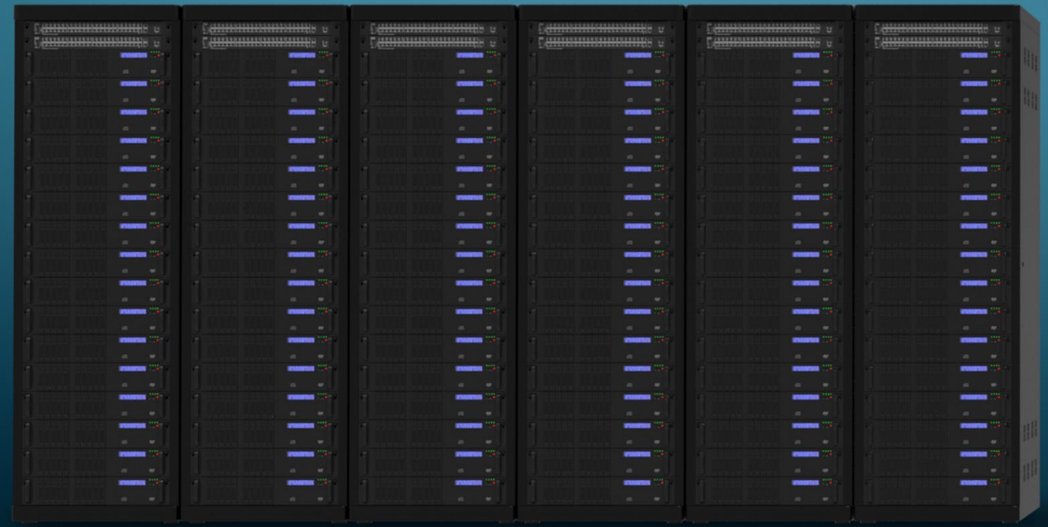
TYPICAL 4-YEAR OLD DEPLOYMENT

96 Dual Socket 2U Servers

~1900 Cores/Virtual Machines

Intel Xeon E5-2660v3





Source: IDC; See Endnotes

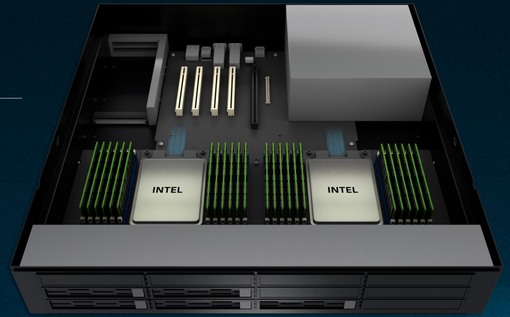
RETHINKING THE VIRTUAL SERVER

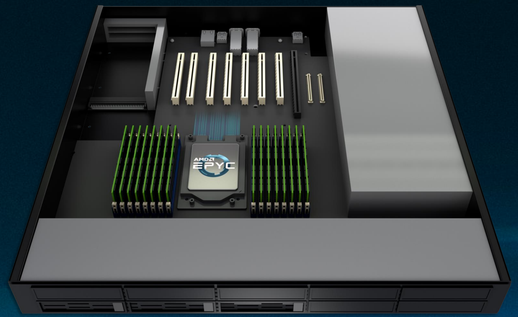
TRADITIONAL DUAL SOCKET

Dual Intel Gold 5118 Processors

24 Cores

1.5TB





NO COMPROMISE SINGLE SOCKET EPYC™

Single Socket AMD EPYC 7551P Processor

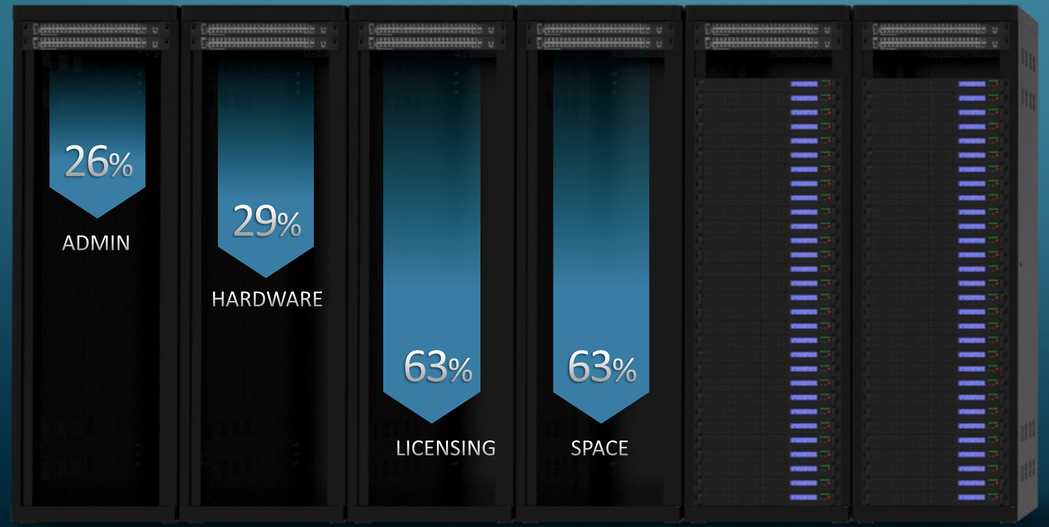
32 Cores

2TB

REVITALIZING THE HEART OF THE

VIRTUALIZED DATACENTER

EPYC SINGLE SOCKET = DISRUPTIVE TCO



See Endnotes

REVITALIZING THE HEART OF THE

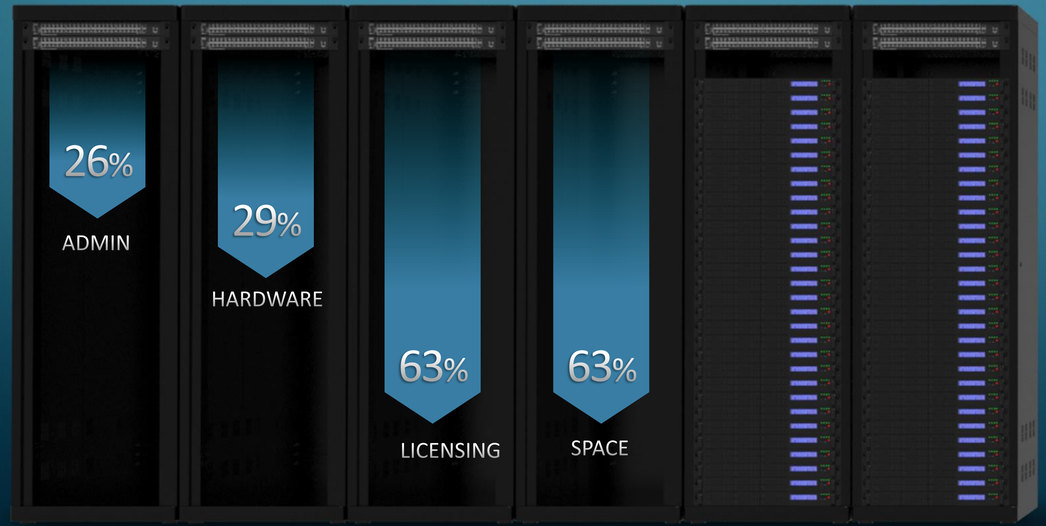
VIRTUALIZED DATACENTER

REDUCE TCO UP TO **45%**

Cost / Year / VM

AMD EPYC $239

Intel $424



See Endnotes

AMD EPYC™ DESIGNED FOR

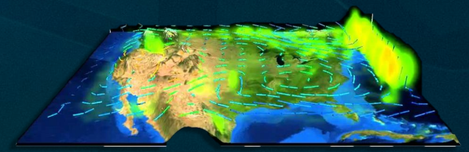
HIGH PERFORMANCE COMPUTING

Superior Performance for Today's Commercial and Scientific Workloads

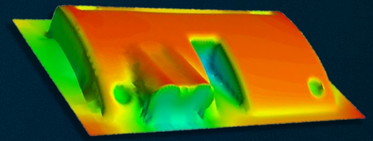
#1

FLOATING POINT PERFORMANCE

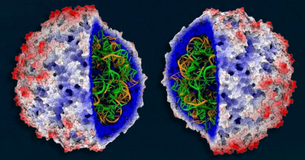
SPECrate2017_fp_peak (2P)



44% Faster WRF Weather Modeling



25% Faster ANSYS Fluent



41% Faster NAMD Molecular Dynamics

See Endnotes

Peter Ungaro

President and CEO

—

CRAY

PARTNERSHIP

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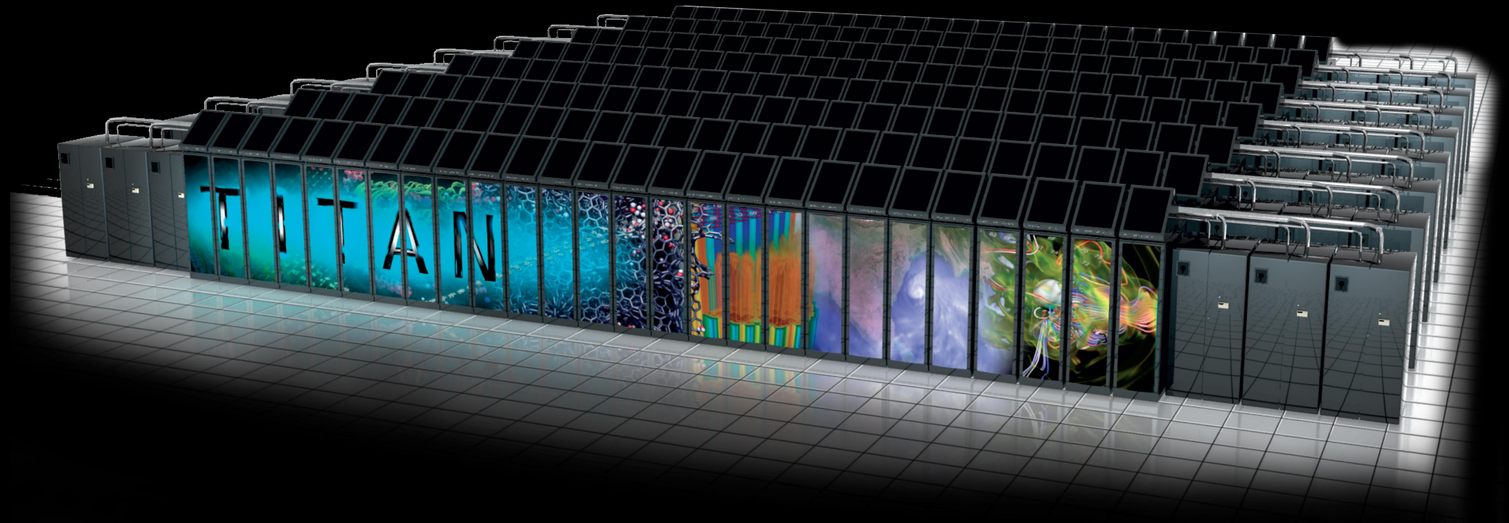

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LAWRENCE BERKELEY
NATIONAL LABORATORY

NATIONAL ENERGY RESEARCH
SCIENTIFIC COMPUTING CENTER

THE ROAD TO EXASCALE

AMD
EPYC
WE'RE JUST
GETTING STARTED

ENDNOTES

NAP-42 – AMD EPYC™ 7601 processor supports up to 8 channels of DDR4-2667, versus the Xeon Platinum 8180 processor at 6 channels of DDR4-2667.

NAP-43 – AMD EPYC 7601 processor includes up to 32 CPU cores versus the Xeon Platinum 8180 processor with 28 CPU cores.

NAP-44 – A single AMD EPYC™ 7601 processor offers up to 2TB/processor (x 2 = 4TB), versus a single Xeon Platinum 8180 processor at 768Gb/processor (x 2 = 1.54TB). NAP-56 – AMD EPYC™ processor supports up to 128 PCIe® Gen 3 I/O lanes (in both 1 and 2-socket configuration), versus the Intel® Xeon® SP Series processor supporting a maximum of 48 lanes PCIe® Gen 3 per CPU, plus 20 lanes in the chipset (max of 68 lanes on 1 socket and 116 lanes on 2 socket).

Microsoft Azure: “Highest Throughput of any cloud” Based on “33 percent more connectivity than available two-socket solutions to address an unprecedented number of NVMe drives directly”. https://www.amd.com/en/press-releases/microsoft-azure-becomes-2017dec05

“Oracle : Up to 66% less cost per core hour” Source: https://blogs.oracle.com/cloud-infrastructure/announcing-the-launch-of-amd-epyc-instances Cost savings not verified independently by AMD

Baidu: Single Socket Efficiencies Delivering Dual Socket Performance Source: https://www.amd.com/en/press-releases/baidu-deploys-amd-2017dec13

Tencent: 30% lower cost per VM Source: https://segmentnext.com/2018/06/25/amd-epyc-sa1-server/ Cost savings not verified independently by AMD

ENDNOTES

“Superior TCO, Best in class price/performance & Higher Density” Best in class price performance based on SPECvirt_sc2013 results and configuration details for the HPE ProLiant DL385 Gen10 and Lenovo ThinkSystem SR650. The HPE ProLiant DL385 scored 2,958 with 168 vm’s at a price of $30.32 per vm versus the Lenovo ThinkSystem SR650 scoring 3,376 with 189VM’s at a price of $39.69 per VM. Configuration and details for the HPE ProLiant DL385 Gen10: 2 x 32-core AMD EPYC 7601 processors, 16 x 64 GB PC4-2666 MHz DDR4 LRDIMMs, 6 x 1.6 TB 12G SAS SSDs, 1 x HPE SA P408i-a and 1 x HPE SA P408i-p adapters, 4 x 10GbE 2-port 562 SFP+ adapters. Price of $89,699. Specvirt_sc2013 score of 2,958@168 VMs. Price Performance of $30.32. Configuration and details for the Lenovo ThinkSystem SR650: 2 x 28-core Xeon Platinum 8180 processors, 24 x 32 GB PC4-2666 MHz RDIMMs, 8 x 3.84 TB 12G SAS SSDs, 2 x ThinkSystem RAID 930-8i-2GB 12Gb Adapters, 2 x Intel X710-DA2 10GbE 2-port adapters. Specvirt_sc2013 score of 3,376@189 VMs. Price Performance of $30.32 $39.69. NAP 105

“70% increased maintenance and 30% decreased performance” Source: Opinion July of 2016 “Why Upgrade Your Server Infrastructure Now” Data not independently verified by AMD

ENDNOTES

Revitalizing the Heart of the Virtualized Datacenter - 26% Less Administration Costs; 29% Less Hardware Costs; 63% Less Licensing Costs; 63% Less Space; Reduce TCO up to 45%; $239 per vm per year; $424 per vm per year: Compares 3-year total cost of ownership for 1920 virtual machines of 1 virtual machine per core with 8GB of DRAM per core with similar performance. (80) PowerEdge R740 Configuration Chassis with up to 8 x 3.5" SAS/SATA Hard Drives for 2CPU Configuration, with (2) Intel® Xeon® Gold 5118 2.3G, 12C/24T, 10.4GT/s, 16.5M Cache, Turbo, HT (105W) DDR4-2400, Performance Optimized Memory Capacity of (12) 16GB RDIMM, 2666MT/s, Dual Rank DIMMs, Hard Drives including (1) 120GB SSD SATA Boot 6Gbps 512n 2.5in Hot-plug Drive & (6) 480GB SSD SAS Mix Use 12Gbps 512n 2.5in Hot-plug Drives, No Operating System 3 Years Basic Hardware Warranty Repair: 5x10 HW-Only, 5x10 NBD Onsite Deployment Services, No Installation. Configuration priced on 8/30/2018 at www.dell.com for $14,271 per server; $1,141,680 total Hardware Acquisition Cost. Facilities and administration costs include $91,450 for power and cooling, $3,240 for space, and $231,549 for IT administration costs for a total of $326,239 over 3 years - calculated based on AMD EPYC™ TCO calculator at https://uatfast.valuestoryapp.com/AMD/sales. SW Licensing costs include (80) vSphere with Ops Manager Ent Plus, 2 CPU License,5Yrs ProSupport + Subscription for $12.163 each for a total SW licensing costs of $973,040. Pricing obtained at www.dell.com on 8/30/18. **Total 3 yr. Cost of Ownership of $2,440,959. Total Cost per year per VM of $424**. (60) PowerEdge R6415 Configuration Chassis with up to 8 x 3.5" SAS/SATA Hard Drives for 2CPU Configuration, with (1) AMD EPYC™ 7551P 2.00GHz/2.55GHz, 32C/64T, 64M Cache (180W) DDR4-2666, Performance Optimized Memory Capacity of (8) 32GB RDIMM, 2666MT/s, Dual Rank DIMMs, Hard Drives including (1) 120GB SSD SATA Boot 6Gbps 512n 2.5in Hot-plug Drive & (6) 400GB SSD SAS Mix Use 12Gbps 512n 2.5in Hot-plug Drives, No Operating System 3 Years Basic Hardware Warranty Repair: 5x10 HW-Only, 5x10 NBD Onsite Deployment Services, No Installation. Configuration priced on 8/30/18 at www.dell.com for $13,585 per server; $815,100 total Hardware Acquisition Cost. Facilities and administration costs include $23,760 for power and cooling, $2,160 for space, and $171,518 for IT administration costs for a total of $197,438 over 3 years - calculated based on AMD EPYC™ TCO calculator at https://uatfast.valuestoryapp.com/AMD/sales. SW Licensing costs include (60) vSphere with Ops Manager Ent Plus, 1 CPU License,5Yrs ProSupport + Subscription for $6,077 each for a total SW licensing costs of $364,620. Pricing obtained at www.dell.com on 8/30/18. Total 3yr Cost of Ownership of $1,377,158. Total Cost per vm per year of 239.

Superior TCO: of up to 45% at 320 VM's and 44% at 1920 VM's

2.8 greater density: 80 2RU Intel servers = 160 RU. 60 1RU AMD EPYC servers is 60RU. 63% Less Space and 2.7X greater VM density

Hardware costs: $1,141,680 vs $815,100 = 29% less

Administration costs: $231,549 vs $171,518 = 26% less

Licensing costs: $973,040 vs $364,620 = 63% less NAP-104

ENDNOTES

#1 SPECrate2017_fp_peak: AMD has #1 spec_fp_peak scores for both 1P and 2P. 1P at https://www.spec.org/cpu2017/results/res2018q2/cpu2017-20180426-05035.html. 2P at https://www.spec.org/cpu2017/results/res2018q2/cpu2017-20180319-04087.html. SPECrate®2017_fp_peak as of Oct 30, 2018. https://www.spec.org/cpu2017/results/. NAP106

44% WRF: Internal AMD testing using the WRF v.3.9.1.1 benchmark, 12km model size, compiled with gcc 7.3.0, using OpenMPI v.3.1.1 and NetCDF v.1.1.3 comparing a Supermicro AS -1123US-01-AM036 configured with 2x EPYC 7601 CPUs, 16x16GB DDR4 2666MHz DIMMs and Ubuntu 18.04 vs a Supermicro SYS-1029U-TRTP configured with 2x Intel Xeon Platinum 8180 CPUs, 24x16GB DDR4 2666MHz DIMMs and Ubuntu 18.04

25% ANSYS: Based on Dell internal testing using the ANSYs Fluent benchmark test in November 2017, comparing a Dell PowerEdge R7425 configured with an AMD 7601, 32-core processor to a traditional 2-socket server with an Intel 6148, 20 core processor. Actual performance will vary based on configuration, usage and manufacturing variability. Not verified by AMD.

41% NAMD: Results from AnandTech testing - https://www.anandtech.com/show/11544/intel-skylake-ep-vs-amd-epyc-7000-cpu-battle-of-the-decade/21. Results not independently verified by AMD

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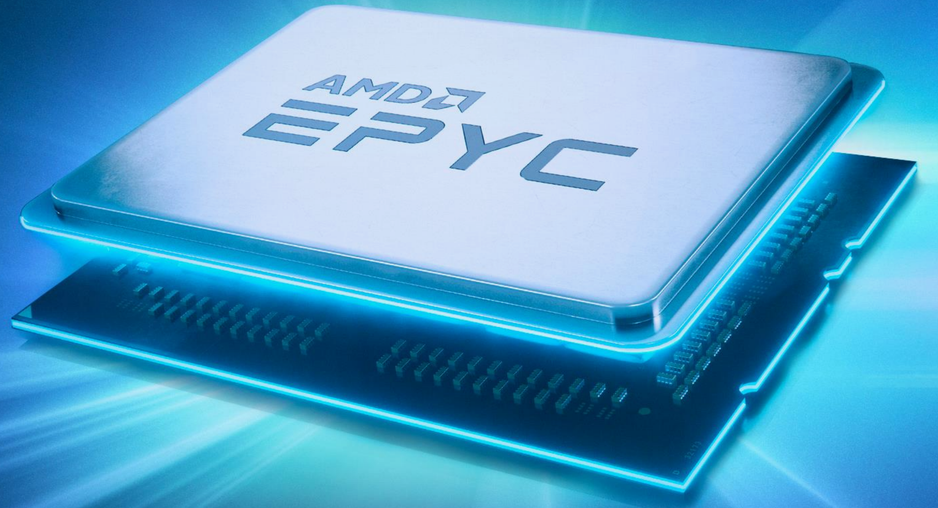
AMD
NEXT HORIZON
DR. LISA SU
President and CEO

AMD EPYC™ "ROME" PREVIEW

THE WORLD'S FIRST 7nm DATACENTER CPU



See Endnotes

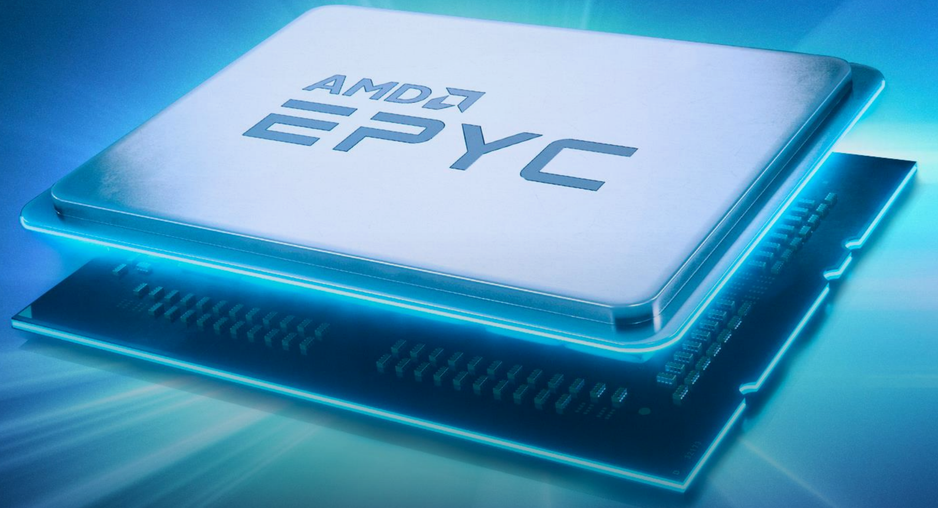
AMD EPYC™ "ROME" PREVIEW

THE WORLD'S FIRST 7nm DATACENTER CPU

Up to 64 "Zen 2" Cores

Increased Instructions-Per-Cycle

Leadership Compute, I/O and Memory Bandwidth



See Endnotes

AMD EPYC™ "ROME" PREVIEW

LEADING THE ECOSYSTEM FORWARD

First PCIe® 4.0 Capable x86 Server CPU

Doubles the Bandwidth/Channel

Dramatically Improves Accelerator Performance

See Endnotes

THE ROAD TO "ROME" IS THROUGH "NAPLES"

Socket Compatible with Existing "Naples" Platforms

Forward Compatible with Next-Generation "Milan" Platforms

AMD EPYC™ "ROME" PREVIEW

THE WORLD'S FIRST 7nm DATACENTER CPU

2x

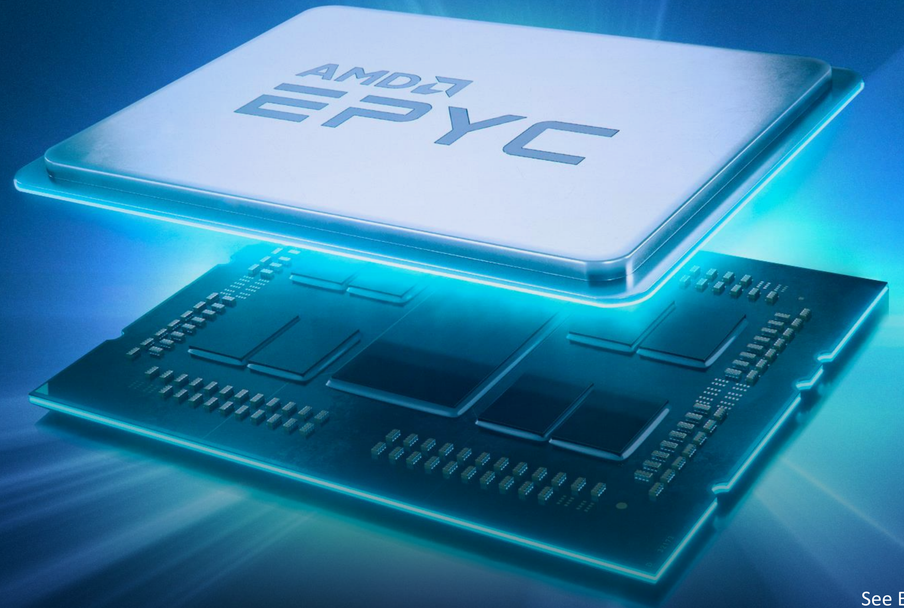
Performance Per Socket

vs. Previous Generation

4x

Floating Point Per Socket

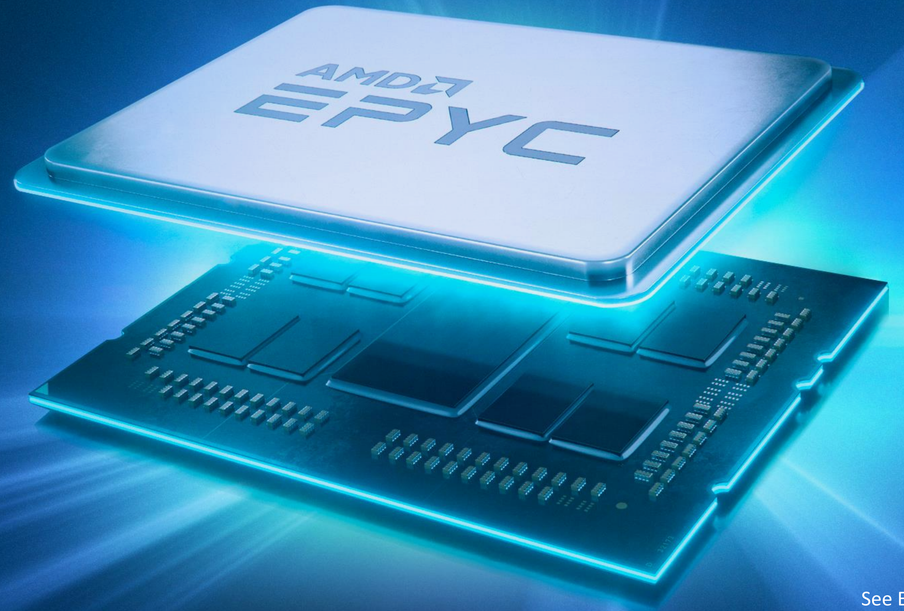
vs. Previous Generation



See Endnotes

AMD EPYC™ "ROME" PREVIEW

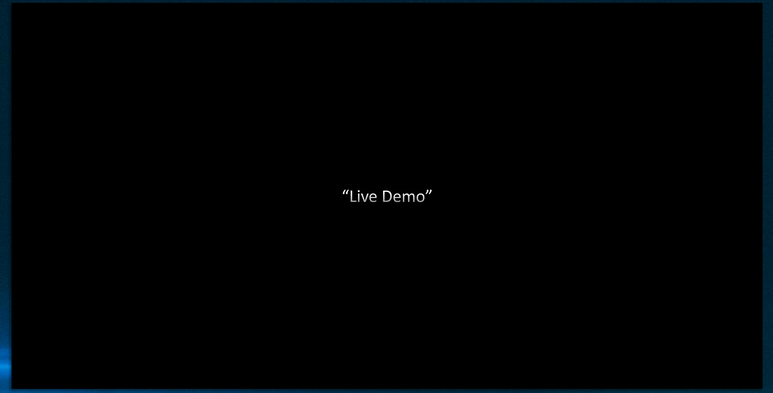
THE WORLD'S FIRST 7nm DATACENTER CPU



See Endnotes

WORLD'S FIRST 7nm DATACENTER CPU AND GPU DEMO

AMD EPYC™ "ROME" WITH RADEON INSTINCT™ MI60



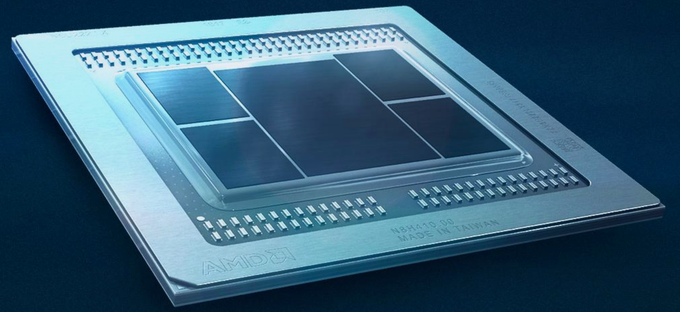
AMD EPYC™ "Naples" and
AMD Radeon Instinct™ MI25

WORLD’S FIRST 7NM DATACENTER CPU AND GPU DEMO

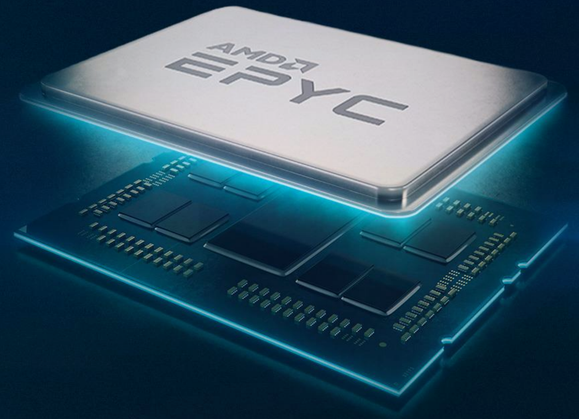
AMD EPYC™ "ROME" and
AMD Radeon Instinct™ MI60

ONLY AMD

DESIGNS DATACENTER CPU AND GPU ARCHITECTURES TOGETHER



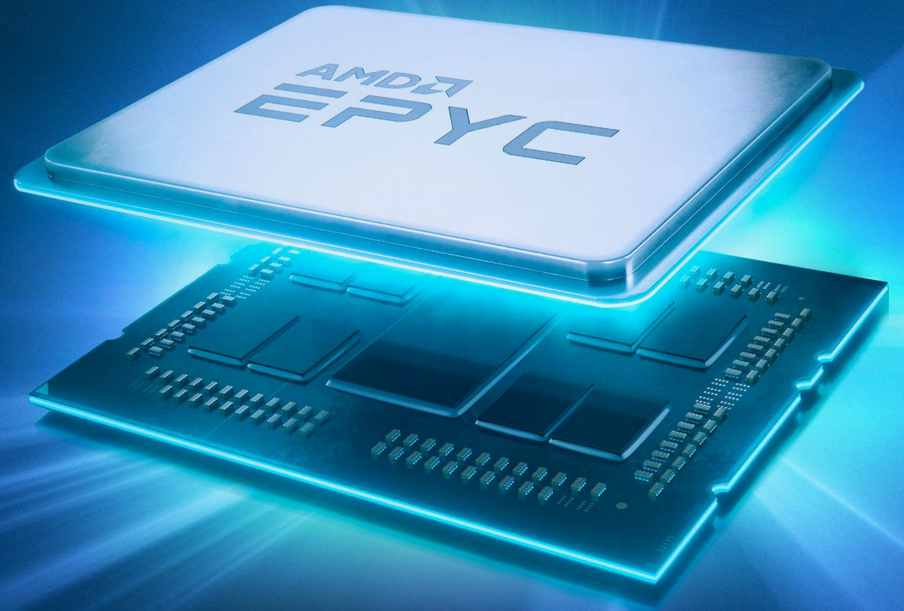
World's First 7nm GPU
AMD RADEON INSTINCT MI60



World's First 7nm Datacenter CPU
"Rome"

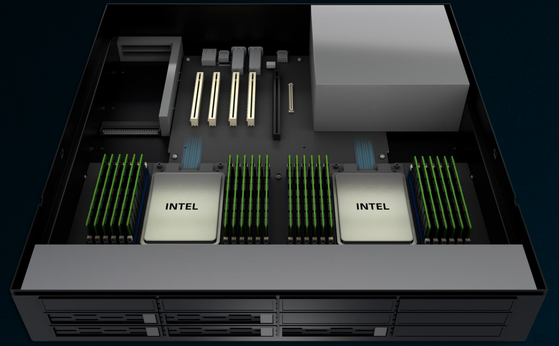
WORLD'S FIRST COMPETITIVE DEMO WITH "ROME"

AMD EPYC™ "ROME" VS. BEST-IN-CLASS "SKYLAKE"



AMD EPYC™ "ROME"

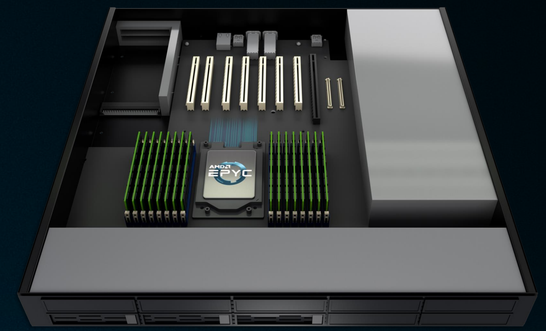
HEAD-TO-HEAD PREVIEW



DUAL INTEL 8180M PLATINUM PROCESSORS

Up To 3 TB of DRAM

96 Lanes of PCIe® 3.0



SINGLE SOCKET AMD EPYC "ROME"

Up To 4 TB of DRAM

128 Lanes of PCIe® 4.0

AMD EPYC™ "ROME"

HEAD-TO-HEAD PREVIEW

"C-RAY" INDUSTRY STANDARD BENCHMARK

Intel Xeon Scalable 8180M

TWO SOCKET

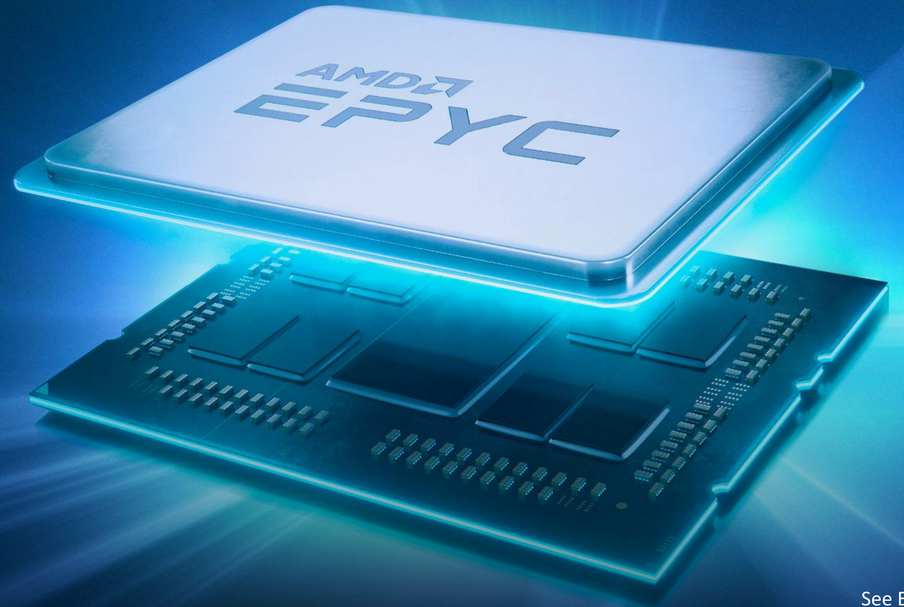
AMD EPYC "Rome" Preview

ONE SOCKET

AMD EPYC™ "ROME" PREVIEW

WORLD'S FIRST 7nm DATACENTER CPU

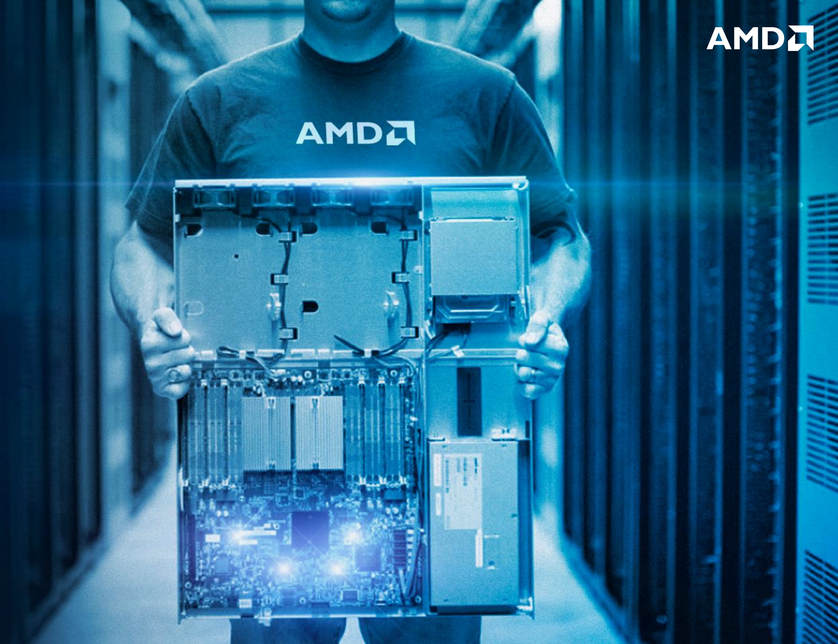
AVAILABLE 2019



See Endnotes

A NEW SET OF HIGH PERFORMANCE COMPUTE REQUIREMENTS

DEMANDS NEW INDUSTRY LEADERS



AMD DATACENTER ROADMAP

AMD

AMD EPYC

"NAPLES"	"ROME"	"MILAN"
"Zen" Shipping	"Zen 2" Available 2019	"Zen 3" On Track

AMD RADEON INSTINCT

MI25	MI60	"MI-NEXT"
14nm GPU Shipping	First 7nm GPU Available Q4	On Track

AGGRESSIVE LONG-TERM COMMITMENT

AMD

AMD EPYC

AMD RADEON INSTINCT

ROCm Open Compute

TODAY, AMD DELIVERS TOTAL DATACENTER COMMITMENT

ENDNOTES

Slide 3, 4, 5, 7, 8

Claim: “Rome” is the world’s first 7nm datacenter CPU.

Substantiation: Based on AMD’s internal competitive assessment of all currently shipping or publicly disclosed X86 Server CPU products as of 9/6/2018

.

ENDNOTES

Slide 4

Claim: Increased instructions-per-cycle.

Estimated increase in instructions per cycle (IPC) is based on AMD internal testing for ”Zen 2” across microbenchmarks, compared to prior “Zen 1” generation CPU using combined floating point and integer benchmarks.

Claim: Leadership compute, I/O and memory bandwidth.

Substantiation:

NAP-42 – AMD EPYC™ 7601 processor supports up to 8 channels of DDR4-2667, versus the Xeon Platinum 8180 processor at 6 channels of DDR4-2667.

NAP-43 – AMD EPYC 7601 processor includes up to 32 CPU cores versus the Xeon Platinum 8180 processor with 28 CPU cores.

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Based on “Zen2” design parameters versus “Zen1” and currently shipping products – core count increase from 32 to up to 64 per socket. Based on “Zen2” design parameters versus “Zen1” and currently shipping products – core count increase from 32 to up to 64 per socket. Memory bandwidth with “Zen 2” design parameters including increased memory speed across eight memory channels, I/O leadership extending to PCIeGen4.

Claim: Dramatically Improves Accelerator Performance

Substantiation: Estimates based on AMD design and AMD internal testing versus currently shipping AMD EPYC processors.

ENDNOTES

Slide 5

Claim: “Rome” doubles the bandwidth/channel.

Substantiation: Per Silicon Labs, provider of the PCIe Gen 4 solutions. (website here: https://www.silabs.com/community/blog.entry.html/2015/12/04/what_is_pcie_gen4a-oobp). PCIe Gen4 is a new standardized data transfer bus that will double the data transfer rate per lane of the prior Gen3 revision from 8.0 GT/s (gigatransfers/second) to 16.0 GT/s. This means that a single PCIe Gen4 interconnection will allow data rate transfers of up to 2GB/s (gigabytes/second), and a full 16 slot PCIe Gen4 interconnection for graphics cards and high-end solid state drives will allow data transfer rates of up to 32GB/s.

Slide 7

Claim: “Rome” delivers 2x performance-per-socket v. previous generation.

Substantiation: Product not yet available, details to be shared at launch.

Claim: “Rome deliver 4x floating point per socket vs. previous generation

Substantiation: AMD Internal Estimates.

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