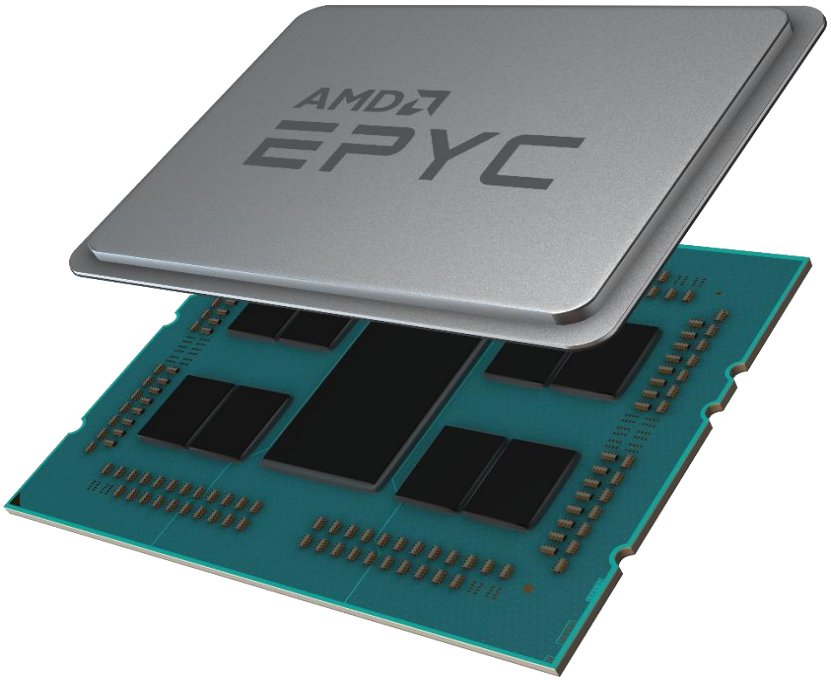
Introduction

The last time AMD disrupted the data center was with the introduction of the 64-bit Opteron processor back in 2004. Then in July 2017 AMD launched its EPYC processor that began the next revolution in processor and data center design. The first generation EPYC processor offered more cores, more bandwidth, and more I/O than a competing Intel Xeon. This year, AMD is upping the ante once again with a second generation EPYC processor, code named "Rome." The AMD second generation EPYC processor delivers faster I/O, more performance, and more security features, which sets the new standard for the modern datacenter. And with over twice the performance per socket of the first generation EPYC processor, it redefines data center economics by making single-socket motherboard designs a no-compromise option and will typically offer lower initial costs.



AMD EPYC 7002 Series of server processors.

More details are still being revealed about the new EPYC design, but these are the top-level facts: over twice the performance of the first generation EPYC processor, in the same socket, with a similar thermal envelope. (Some supported features and functionality of second-generation AMD EPYC processors require a BIOS update from your server manufacturer when used with a motherboard designed for the first generation EPYC 7001 series processor. Some first-generation motherboards may not support TDPs greater than 200W. A motherboard designed for 2nd Gen EPYC processors is required to enable all available functionality.)

The CPU cores are upgraded second generation "Zen" cores with 15% more performance at the same clock speeds as the original Zen core. Compared with the original Zen core, the "Zen 2"

core adds better branch prediction, additional execution engines, and a new cache architecture with a larger L3 cache. It also doubles the width of the floating-point unit. Each refinement of the Zen 2 core was designed to increase the instructions executed per clock cycle (IPC) and improve the power efficiency and still maintain clock speeds. The end result is that AMD could double the number of CPU cores, with a modest increase in the total thermal design envelope of the package. That's pretty amazing!

Feature	EPYC 7001 Series	EPYC 7002 Series
CPU	Zen (1)	Zen 2
Cores	8 to 32	8 to 64
PCI Lanes	128	128
PCI Generation	3	4
Process Technology	14nm	7nm (CPU and Cache)
Power	Up to 180W	Up to 225W
Max. Memory Capacity	2 TB	4 TB

Table 1. EPYC 7001 Series ("Naples") vs. EPYC 7002 Series ("Rome") comparison

The EPYC 7002 Series PCIe connections support the latest fourth-generation specification, which doubles the I/O bandwidth from PCIe 3. AMD is the first x86 server processor with PCIe Gen 4 support, which will enable faster connections to future accelerators (like GPUs), high speed interconnects (like 200GB Ethernet), and storage. If support for 128 Gen. 4 PCI connections wasn't quite enough, AMD has the option to boost I/O bandwidth even further by allocating additional lanes for I/O (rather than socket-to-socket connections) when in a dual-socket configuration. AMD's new EPYC processor is a compute throughput beast!

The comparisons against Intel's Cascade Lakes Xeon in Table 2 shows the tremendous increase in capabilities the new EPYC processor brings to market.

Feature	EPYC 7002	Xeon Cascade Lakes-SP	Xeon Cascade Lakes-AP
Cores	8 to 64	6 to 28	32 to 56
PCI Generation	4	3	3
PCI Lanes	128	48	64 (40 avail.)
Memory Channels	8	6	12
Max. Memory Speed	3200MHz	2933Mhz	2933Mhz
Max. Memory Capacity	4TB	1-4.5TB	3TB
Lithography	7nm/12nm	14nm	14nm

Table 2: AMD's AMD EPYC 7002 vs. Intel's Cascade Lakes comparison

To Infinity Fabric and Beyond: Introducing Infinity Architecture

The heart of the original EPYC design was the AMD Infinity Fabric that ties the cores and the multiple die together on the multichip module (MCM) package. Each chip die had eight cores, a memory controller, and PCIe controllers with up to four die per package for up to 32 cores per socket. The EPYC 7002 Series doubles the maximum number of CPU cores per socket, increases cache memory and doubling both the Infinity Fabric and PCIe bandwidth to support the additional processing capability, all by using an innovative hybrid multi-die packaging approach shown in Figure 1.

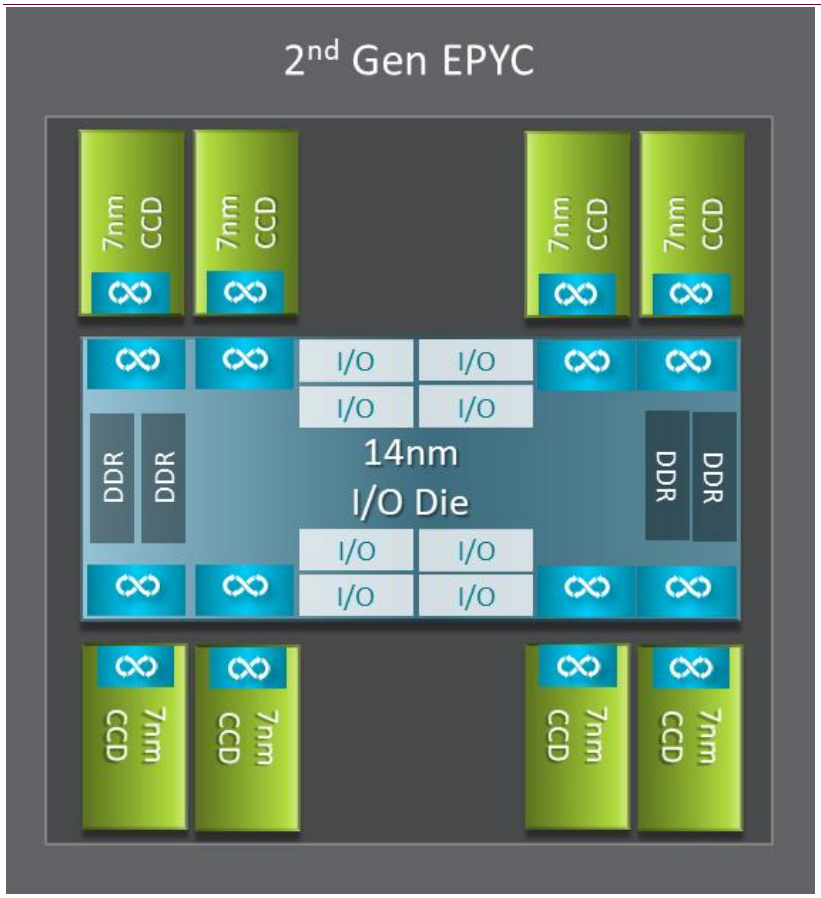


Figure 1. EPYC 7002 Hybrid Multi-Die package configuration.

For the 2nd generation EPYC processor, AMD made a strategic decision to split the CPU and cache from the PCIe controllers and memory controllers onto separate die. The CPU and cache complexes need the leading edge 7nm process node to reduce the power and space needed to double the cores and add more cache. The memory and PCIe functions are pretty much the same size as the previous generation (just faster) and didn't need to scale to 7nm. This partitioning optimizes the use of leading-edge (and expensive) semiconductor process technology for the areas that most need them: the CPU and cache complex. Meanwhile the PCIe and memory controllers are quite capable of using a slightly older, but very cost-effective process nodes. AMD has already proven the technology in the Ryzen 3000 series of PC processors. AMD calls this packaging hybrid multi-die system on chip (SoC) design.

The AMD Infinity Fabric then ties the CPU die to the I/O die. Beyond that, Infinity Fabric can be used to connect the CPU and I/O to a GPU sometime in the future. No company is better prepared for a heterogeneous processing future.

AMD is calling combination of hybrid multi-die packaging, the increased number of CPU cores per package, the enormous bandwidth with PCIe 4.0 and the advanced security features the AMD Infinity Architecture (Figure 2).

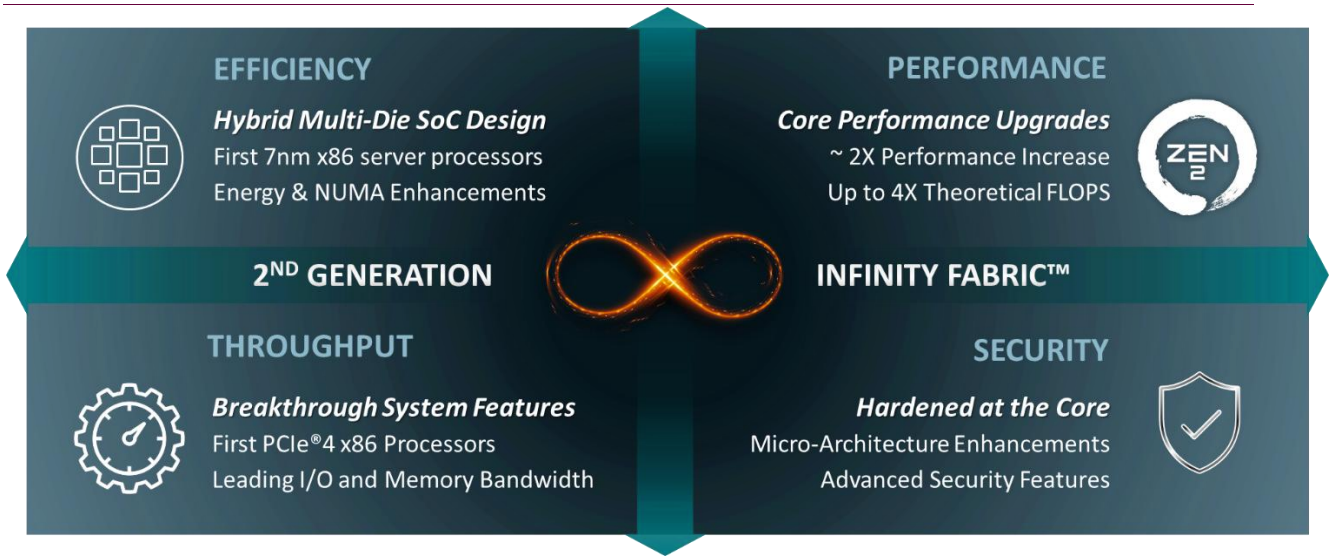


Figure 2. AMD Infinity Architecture Features.

EPYC Sockets It To Intel Xeon

The new AMD EPYC processor family will now offer more cores, I/O bandwidth, and comparable performance in a single socket than Intel can offer in mainstream dual-socket configurations (see Figure 3). This new standard redefines the economics of the data center and re-architects the optimal data center platform. And for those who want the most performance, AMD is setting records for two socket servers as well.

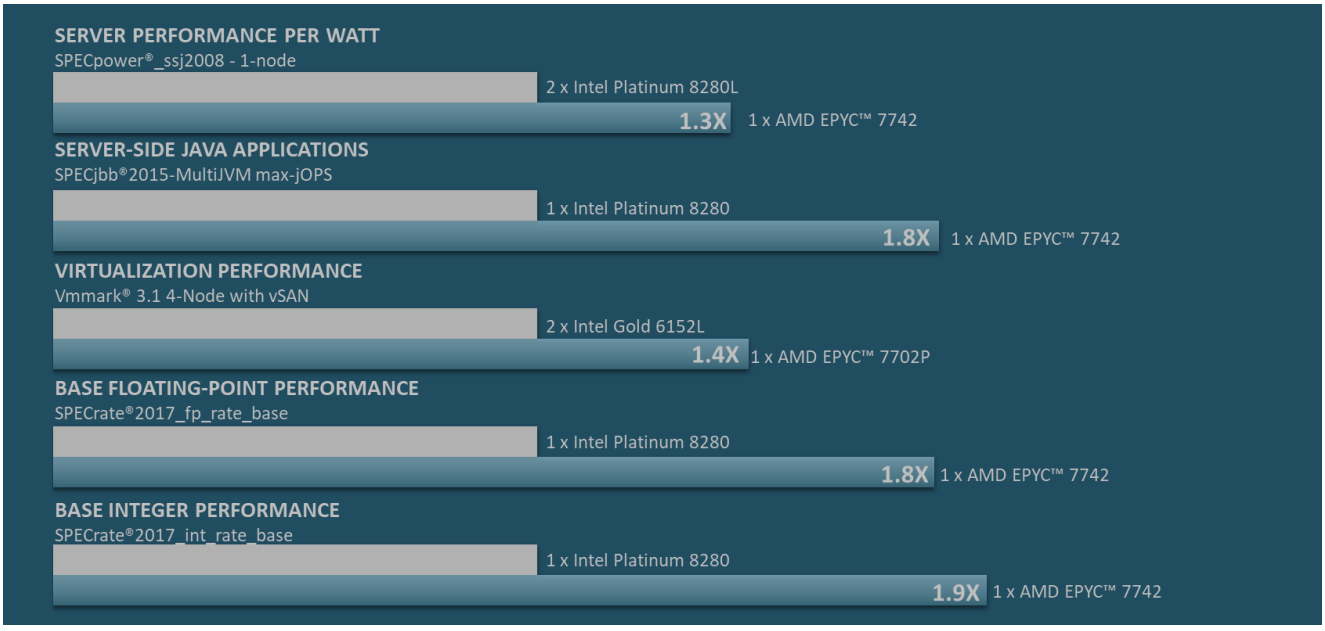


Figure 3. Performance of single-socket EPYC processors compared with Intel mainstream dual-socket configurations. See backup for supporting benchmark information. (Source: AMD)

Using single-socket processors to replace dual-socket configurations can reduce chassis power and software licensing fees. The new EPYC processor is more than an evolution of the EPYC

7001 Series processor, in fact, it is the beginning of a new revolution in data center design, and not just for hyperscale data centers.

You can expect to see the benchmarking numbers evolve over time, but some early SPECint performance numbers (listed above) and Stream numbers look very good for EPYC. For example, AMD's internal testing has shown that the top 64-core EPYC processor crushed a published best Intel STREAM memory bandwidth benchmark for the Xeon Platinum 8280, beating it up to 66%!

Security Is A Key Foundation For EPYC

The new Zen 2 architecture offers security features that help protect the CPU from the bottom up. For example, TLB look ups automatically check authorization levels of software for proper permissions before executing the look up. This is part of AMD's secure design DNA. These design decisions can reduce the likelihood of a security exploit.

AMD also provides secure memory encryption (SME) and secure encrypted virtualization (SEV) features that Intel does not. In addition, EPYC processors offer secure root-of-trust technology to boot to an embedded security coprocessor inside. SME helps protect against physical memory attacks by encrypting system memory and can be used on systems with virtual machines (VMs) or containers. The operating system or hypervisor can choose the pages to encrypt through the page tables. Hardware devices (networking, storage, or graphics cards) can still seamlessly access encrypted pages through DMA control.

SEV is used to help protect VMs/Containers from each other, from administrator tampering, and from an untrusted hypervisor. It uses a separate encryption key for the main hypervisor and one key per VM, groups of VMs, or VM/Sandbox with multiple containers. This cryptographically isolates the host hypervisor from the guest VMs. AMD SEV can provide active encryption by virtual machine ID for up to 509 unique VM's (or groups of VM's) per host while enabling the movement and management of those machines across cloud infrastructures. SEV is compatible with existing AMD-V™ virtualization technology.

Conclusion

The AMD EPYC 7002 series processors change the server ecosystem – offering the best single socket experience that exceeds most server needs. The single socket offers "no compromise" on cores, memory, and I/O. But, even with this single socket capability, EPYC supports a dual-socket configurability, as well, for more cores, more I/O, and more memory. It all starts with the advancements AMD made in chip design and packaging with the AMD Infinity Architecture.

The new EPYC processor raises the bar for performance per socket and sets a new standard for the modern data center. AMD is ready for the heterogeneous computing future and ready to redefine your data center.

Backup Information

Claim	Footnote
1.3x better SPEC Power	1P AMD EPYC™ 7702P server scored 18,051 overall ssj_ops/watt on SPEC Power® 2008 with the Microsoft Windows® Datacenter 2019 OS, as published at https://www.spec.org/power_ssj2008/results/res2019q3/power_ssj2008-20190716-00982.html, which is higher than all other Windows publications on the SPEC® website as of 7/27/2019. SPEC® and SPEC Power® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information. ROM-147
1.8x better SPECjbb	"AMD EPYC™ 7702P processors set the new World Record x86 for 1P SPECjbb2015-MultiJVM Max. OR A 1P EPYC™ 7702P powered server scored 84% higher than the highest scoring Intel powered 1P server in SPECjbb2015-MultiJVM Max. ROM-115"
1.4x better Vmmark	Results as of 8/7/2019 using VMmark(R) 3.1 vSAN. AMD 7702 score of can be found at https://www.vmware.com/products/vmmark/results3x.0.html. Product available Aug 7, 2019. The next highest score, with the 8280, can be found at,ttps://www.vmware.com/products/vmmark/results3x.0.html . VMware VMmark 3.x results can be found at https://www.vmware.com/products/vmmark/results3x.html. ROM-36
1.8x better fp base	A 1P EPYC 7742 powered server has SPECrate®2017_fp_base score of 268, http:/spec.org/cpu2017/results/res2019q3/cpu2017-20190722-16244.html as of August 7, 2019. The next highest base score is a 1P Intel Platinum 8280 server with a score of 148, http://spec.org/cpu2017/results/res2019q2/cpu2017-20190318-11231.pdf as of July 28, 2019. SPEC®, SPECrate® and SPEC CPU® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information. ROM-98.
1.9x better int base	A 1P EPYC 7742 powered server has SPECrate®2017_int_base score of 349, http://spec.org/cpu2017/results/res2019q3/cpu2017-20190722-16290.html as of August 7, 2019. The next highest score is a 1P Intel Platinum 8280 server with a score of 181, http://spec.org/cpu2017/results/res2019q2/cpu2017-20190318-11230.pdf as of July 28, 2019. SPEC®, SPECrate® and SPEC CPU® are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org for more information. ROM-96