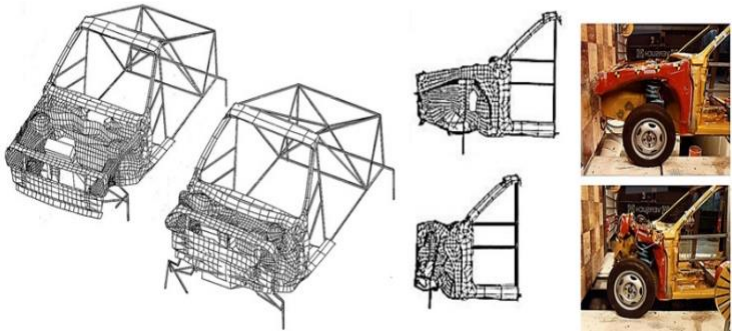
ESI® Virtual Performance Solutions® **Performance with AMD EPYC™ 7003 Series Processors**

AMD EPYC™ 7003 Processors

Built on the x86 architecture innovations of the record setting AMD EPYC™ 7002 series processors, the new AMD EPYC™ 7003 Series Processors set a new standard for the modern data center. With high frequencies, high core counts, high memory bandwidth and capacity, and up to 32MB of L3 cache per core, AMD EPYC 7003 series processors enable exceptional HPC performance across multiple industry verticals.



Balance is critical when driving HPC performance. 3rd Gen AMD EPYC CPUs achieve that balance by pushing performance in several areas. Along with the high memory bandwidth achieved with 8 channels DDR4-3200 memory, AMD EPYC 7003 series CPUs also synchronize the data fabric clock to match the memory clock speeds, further improving both memory bandwidth and latency. And support for up to 4TB of memory per socket enhances the ability to efficiently utilize very large datasets. Data access is further enhanced with extra-large caches, reaching up to 256MB per CPU. All of this helps enable the ability to efficiently utilize up to 64 cores per CPU. 128-160 lanes of PCIe® Gen4 offered by AMD EPYC 7003 series CPUs pushes the ability to efficiently access high-speed network interface cards, high-speed storage, and multiple accelerators.

AMD EPYC 7003 Series Processors are designed to bring faster time-to-value by delivering performance and scalability, while also helping keep your data secure. Secure Memory Encryption (SME) and Secure Encrypted Virtualization[2] (SEV) security features help protect your data both on-prem and in the cloud.

Time is the new metric for efficiency. AMD EPYC 7003 Series processors raise the bar once more for workload performance, helping to drive faster time to results for delivering improved business outcomes.

AMD EPYC 7003 FOR HPC

3rd Gen AMD EPYC CPUs can deliver the highest per-core performance in the industry[3] by taking advantage of fast CPU frequencies, lower latency memory and unified cache structure.

With AMD EPYC, the HPC community can propel innovations and insights with ground-breaking high-performance computing and advanced security features to deliver excellent results.

"ZEN 3" CORE & SECURITY

Featuring up to:

- 64 physical cores, 128 threads
- 256MB of L3 cache per CPU
- 32 MB of L3 cache per core
- 4 TB of DDR4-3200 memory
- 128-160 PCIe® Gen 4 lanes

Industry leading security with Infinity Guard

- Encrypted memory with SEV and SME
- Secure Boot

SCALE OUT AND SCALE UP

Scaling is critical to HPC applications. AMD EPYC 7003 processors provide high bandwidth between nodes with support for PCIe Gen 4 enabled network devices and accelerators.

Within a node, take advantage of up to 64 cores, support for 8 memory channels of DDR4-3200, and up to 256 MB of L3 cache–per-CPU.

ESI VPS

ESI Virtual Performance Solution (VPS) is a cross-industry application; it is mostly known for its use in the automotive industry. ESI VPS relies on an end-to-end Virtual Prototyping of structures.

EPYC 7003 Series Architecture Quick Look

The AMD EPYC 7003 Series Processor retains the proven Multi-Chip Module (MCM) Chiplet Architecture of prior successful AMD EPYC server-class processors while making further improvements. One of the most important upgrades is the new "Zen 3" core. The "Zen 3" core is manufactured using a 7nm process and designed to provide a significant instructions per cycle (IPC) uplift over prior generation "Zen 2" cores. Like EPYC 7002 Series processors, each core supports Simultaneous Multi-Threading (SMT), allowing up to 2 threads per core. In a typical 2-socket system with 64-core processors, EPYC 7003 Series processors offer up to 128 physical cores per system and up to 256 threads per system.

The L3 cache was also improved in the Gen 3 EPYC processors. EPYC 7003 Series CPUs took the same total L3 cache as the prior generation (up to 256MB/CPU) and created significantly more cache sharing between cores. The Gen 3 EPYC processors now offer a unified 32MB of L3 cache per compute die. Up to 8 cores per compute die can now share 32MB of unified L3 cache in this generation of processors.

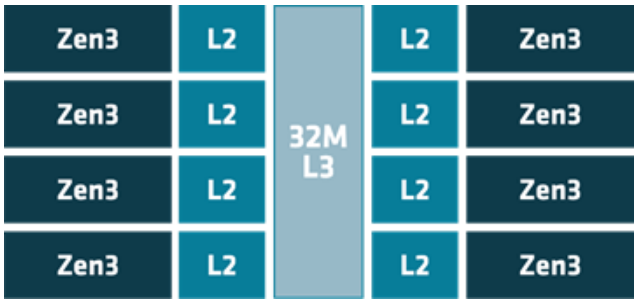


Figure 1 7003 Processor L3 Cache layout

The new L3 Cache design can increase the cache hit to miss ratio over the previous design. Improved cache sharing also allows larger blocks to fit directly into the cache whereas previously they would fall into the main memory. Improvements made in the cache fetching and eviction policies manage data more efficiently. All these benefits result in an uplift on HPC workloads in addition to the core and memory improvements.

EPYC 7003 Series CPU Options and Recommendations by Segment

AMD EPYC 7003 Series CPUs offer 19 different CPU configurations. Below is a table of each CPU with a summary of their features. For driving up per-core performance, pay special attention the 7xF3 processors, which offer the highest cache and frequencies at each core-count.

HPC applications come in a wide range of unique characteristics. There is no one-size fits all CPU for the HPC market. Below are the general recommendations. You are encouraged to talk to your AMD sales representative for more detailed guidance and CPU suggestions based on your unique environment and needs.

Model	# CCDs	Cores / Threads	Base Freq (GHz)	Max Boost Freq (Up to GHz)[3]	Default TDP (W)	cTDP (W)	L3 Cache (MB)	NPS	2P/1P
7763	8	64 / 128	2.45	3.50	280W	225-280W	256	1,2,4	2P/1P
7713	8	64 / 128	2.00	3.675	225W	225-240W	256	1,2,4	2P/1P
7713P								1,2,4	1P
7663	8	56 / 112	2.0	3.5	240W	225-240W	256	1,2,4	2P/1P
7643	8	48 / 96	2.3	3.6	225W	225-240W	256	1,2,4	2P/1P
75F3	8	32 / 64	2.95	4.0	280W	225-280W	256	1,2,4	2P/1P
7543	8	32 / 64	2.8	3.7	225W	225-240W	256	1,2,4	2P/1P
7543P								1,2,4	1P
7513	4	32 / 64	2.6	3.65	200W	165-200W	128	1,2,4	2P/1P
74F3	8	24 / 48	3.2	4.0	240W	225-240W	256	1,2,4	2P/1P
7453	4	28 / 56	2.75	3.45	225W	225-240W	64	1,2,4	2P/1P
7443	4	24 / 48	2.85	4.0	200W	165-200W	128	1,2,4	2P/1P
7443P								1,2,4	1P
7413	4	24 / 48	2.65	3.6	180W	165-200W	128	1,2,4	2P/1P
73F3	8	16/ 32	3.5	4.0	240W	225-240W	256	1,2,4	2P/1P
7343	4	16 / 32	3.2	3.9	190W	165-200W	128	1,2,4	2P/1P
7313	4	16 / 32	3.0	3.7	155W	155-180W	128	1,2,4	2P/1P
7313P								1,2,4	1P
72F3	8	8 / 16	3.7	4.1	180W	165-200W	256	1,2,4	2P/1P

Table 1: AMD EPYC 7003 CPU Options

Listed in the table below are a few examples of different HPC market segments, a general sense of the characteristics and sensitivities of applications per segment, and specific AMD EPYC 7003 Series processor recommendations per segment.

Segment	Sensitivity	Example Applications	Suggested Models	Comments
FEA Explicit	Frequency & Cache	LS-DYNA®, Radioss™, Abaqus™, VPS™	75F3 | 7543 74F3 | 73F3	Look for CPUs with high frequencies, and large caches. Mid core-counts help increase performance per core to help maximize software investment.
FEA Implicit		Mechanical™, Abaqus Standard™, OptiStruct™		
Molecular Dynamics	Core Count & Frequency	GROMACS, LAMMPS	7763 | 7713 7663 | 7643 75F3 | 7543	Look for CPUs with high core-counts and frequency. These applications scale very well with cores.
Weather	Memory BW & Cache	WRF, IFS	7763 | 7713 7663 | 7643 75F3 | 7543 74F3	Look for CPUs with 256 MB of cache. Large caches help relieve the potential memory bandwidth bottleneck if using high core counts. Look for mid core-count CPUs for per-core licensed codes.
CFD		Fluent®, AcuSolve™		
Oil & Gas		Reveal®, Echos, SAVA		
EDA	Frequency & Cache	VCS®, RedHawk™	73F3 | 72F3	This market segment is dominated by low core-counts to drive up the frequency and cache per core, helping maximize software investment.

Table 2: HPC Segment Recommendations

ESI Virtual Performance Solutions

VPS, formerly known as PAM-CRASH, ESI's first packaged software, originated from research aimed at simulating aerospace and nuclear applications. The company presented the simulation of the accidental crash of a military fighter plane into a nuclear power plant. German automobile manufacturers became alerted to the possibility of using this technology for the simulation of destructive car crash tests. It is now used for crash simulation and the design of occupant safety systems, primarily in the automotive industry. The software enables automotive engineers to simulate the performance of a proposed vehicle design and evaluate the potential for injury to occupants in multiple crash scenarios.

As ESI's flagship software, VPS is a unique solution allowing manufacturers to face emerging design challenges including those related to lightweight, green, and autonomous vehicles, while avoiding over-engineering. It enables design and simulation engineers to rapidly test their innovations on virtual prototypes, rather than real ones. Virtual Performance Solution (VPS) also offers a distinctive approach, allowing the virtual testing of product performance across multiple domains using a single core model.

Test Methodology

This document focuses on performance and scaling of the AMD EPYC 7003 Series Processors as well as competitiveness with Intel Xeon Gold 6258R.

Testing was performed on dual-socket AMD EPYC™ 7413, AMD EPYC™ 74F3, AMD EPYC™ 7543, and AMD EPYC™ 75F3-based systems. The compute nodes were each populated with 1 DIMM per channel of 64GB, dual-rank, DDR4-3200 DIMMs from Micron®, for a total of 1TB of memory per node. A Mellanox® ConnectX-6 200 Gb/s HDR InfiniBand adapter, utilizing the support for PCIe Gen 4, is also populated on each AMD EPYC processor-based system.

Testing was also run on dual-socket Intel® Xeon® 6258R-based platform. The 6258R was selected because it offers the highest frequency of the highest core-count (28c) in the Intel Xeon Gold family of processors. The Intel platform was populated with 1 DIMM per channel of 64GB, dual-rank, DDR4-2933 DIMMs (768GB total memory), matching the maximum memory speed supported for this processor.

VPS performance is typically measured in elapsed time. To show relative performance, elapsed time was converted to performance (1/elapsed time), then performance was used as the basis for the comparison (AMD Performance/Intel Performance, higher is better).

Every benchmark was run a minimum of 3 iterations, with the average of the performance results used in the brief. Results of each benchmark were also confirmed to have <1% variability between all runs.

System Configuration

AMD System Configuration				
CPUs	2 x AMD EPYC 7413	2 x AMD EPYC 74F3	2 x AMD EPYC 7543	2 x AMD EPYC 75F3
Frequency: Base | Boost[3]	2.65GHz | up to 3.6GHz	3.2GHz | up to 4.0GHz	2.8GHz | up to 3.7GHz	2.95GHz | up to 4.0GHz
Cores	24 cores/socket (48c/node)		32 cores/socket (64 per node)	
L3 Cache	128MB	256MB		
Memory	1TB (16x) Dual-Rank DDR4-3200 64GB DIMMs, 1DPC			
NIC	Mellanox ConnectX-6 HDR 200Gb InfiniBand x16 (OFED-5.2-1.0.4.0)			
Storage: OS | Data	1 x 256 GB SATA | 1 x 1 TB NVMe			
BIOS and Settings	SMT=off, X2APIC=on, IOMMU=off, APBDIS=1, Fixed SOC P-state=0, Determinism=power, NPS=4, DF C-states=off, PIO, EPIO, TSME=off, PCIe 10 bit tag=on			
OS Settings	clear caches before every run, NUMA balancing 0, randomize_va_space 0, cc6 disabled, Governor=Performance			

Table 3: AMD EPYC System Configuration

Intel System Configuration	
CPUs	2 x Intel Xeon Gold 6258R
Frequency: Base | Turbo	2.7GHz | 4.0GHz
Cores	28 cores per socket (56 per node)
L3 Cache	38.5MB
Memory	768 GB (12x) Dual-Rank DDR4-2933 64GB DIMMs, 1DPC
NIC	Mellanox ConnectX-6 HDR 200Gb InfiniBand x16 (OFED-5.2-1.0.4.0)
Storage: OS | Data	1 x 256 GB SATA | 1 x 1 TB NVMe
BIOS and Settings	3.3a: Power Management=Extreme Performance, Hyper-threading=Off, SNC=On, ADDDC=Off
OS Settings	clear caches before every run, NUMA balancing 0, randomize_va_space 0

Table 4: Intel System Configuration

Software	
Solver Version	ESI Virtual Performance Solutions 2020.0
MPI	Intel MPI 2018
OS	SLES 12 SP 5

Table 5: Software

ESI VPS Single-Node Performance

Single-node performance is a critical starting point for evaluating a cluster performance. In this section we compare single-node relative performance.

The AMD EPYC 75F3, 7543, 7413, and 74F3 processors show truly exceptional performance. When compared with the Intel Xeon "Cascade Lake Refresh" CPU, the EPYC 75F3 CPU delivers an average of up to 1.52x (~52%) higher performance and the AMD EPYC 7543 CPU delivers an average of up to 1.44x (~44%) higher performance. Even the 24 Core processors, AMD EPYC 7413 and AMD EPYC 74F3, outperform the Xeon 6258R by an average of up to 1.13x (~13%) and 1.26x (~26%) respectively while having 4 fewer less cores.

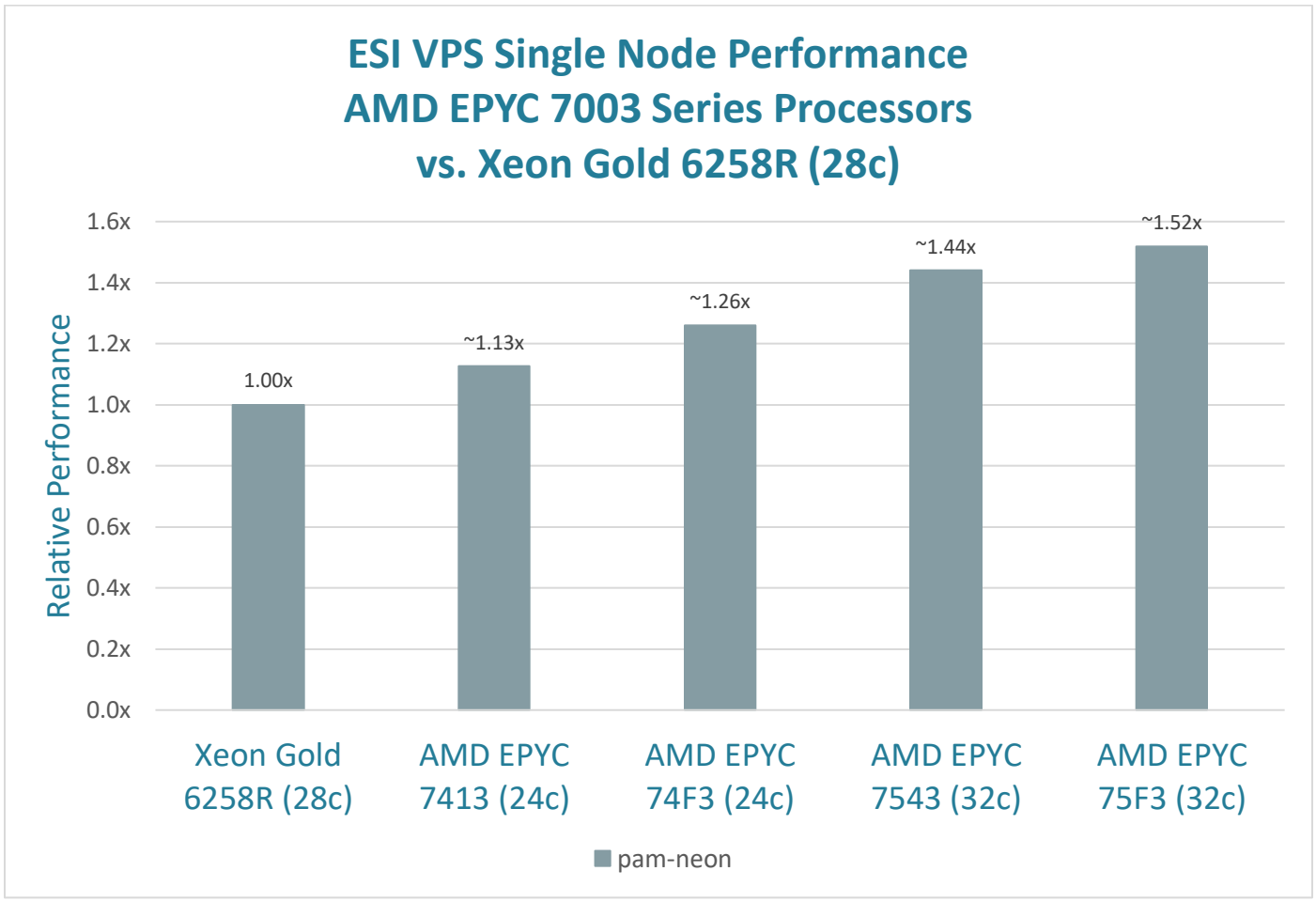


Figure 2: AMD EPYC Single-Node Performance

ESI VPS Per Core Performance

Understanding workload performance at the core level provides a better picture of the potential TCO of a hardware purchase:

- *Maximize Software Investment*: Many software vendors, including ESI, offer per-core software licensing. It may be beneficial, depending on your specific situation, to maximize performance-per-core to minimize your TCO. Understanding how performance relates to core counts helps right-size how many licenses are required and enables running simulations at higher fidelity.
- *Precise Installation Sizing*: Core-level performance makes it easier to fine-tune decision-making when sizing the application footprint of your hardware purchase.

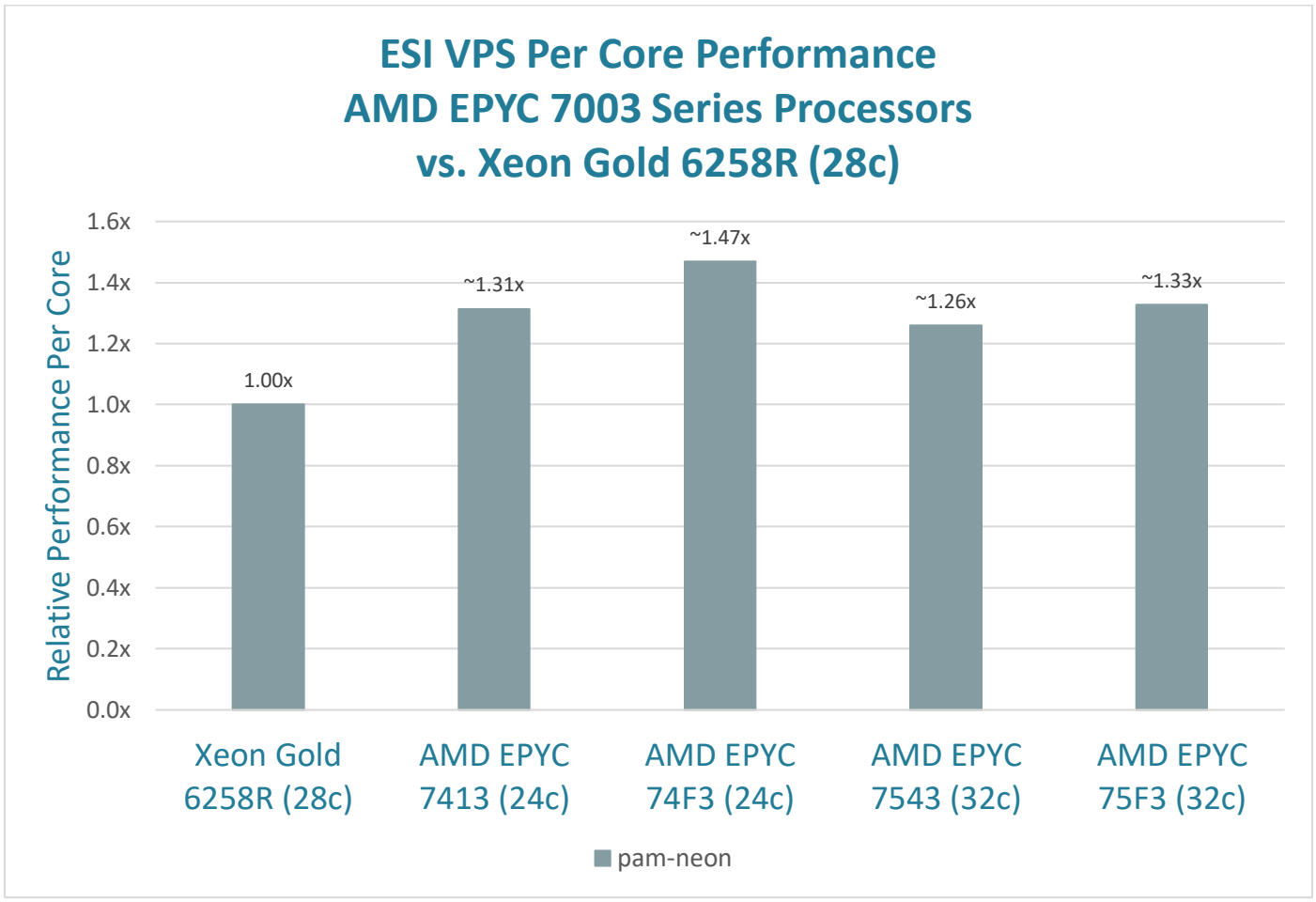


Figure 3: AMD EPYC Per Core Performance

Looking at a per core comparison, all four EPYC CPUs outperformed the Xeon 6258R.The AMD EPYC 7543 and AMD EPYC 75F3 outperformed the Intel Xeon 6258R by an average of up to 1.26x (~26%) and 1.33x (~33%) respectively. The AMD EPYC 7413 and AMD EPYC 74F3 outperformed the Intel Xeon 6258R by an average of up to 1.31x (~31 %) and 1.47x (~47%) respectively.

Per-core software licensing makes per-core performance a critical part of the overall TCO for the solution, balancing the performance per system and the performance per core. Generally, as you go up higher in core counts, the efficiency per core trends lower. While using very high core-counts can get more work done faster, when you have incremental software licenses per core, it makes sense to consider lower core counts to drive up your performance per core to utilize your software investment more efficiently.

ESI VPS Multi-Node Scaling

Virtual Performance Solutions (VPS) scales exceptionally well on AMD EPYC 7003 series processors. The chart below shows scaling of the AMD EPYC 75F3 CPU in two-socket platforms vs. linear scaling running the pam-neon4M benchmark. At 32-cores per processor, each node has 64 physical cores for a total of 256 cores at 4 nodes.

FEA Explicit workloads generally do not scale linearly, VPS exhibits very good scaling. At 2 nodes (128 cores), the speedup is ~2.07x, and at 4 nodes (256 cores), the speedup stays very high at ~4.1x.

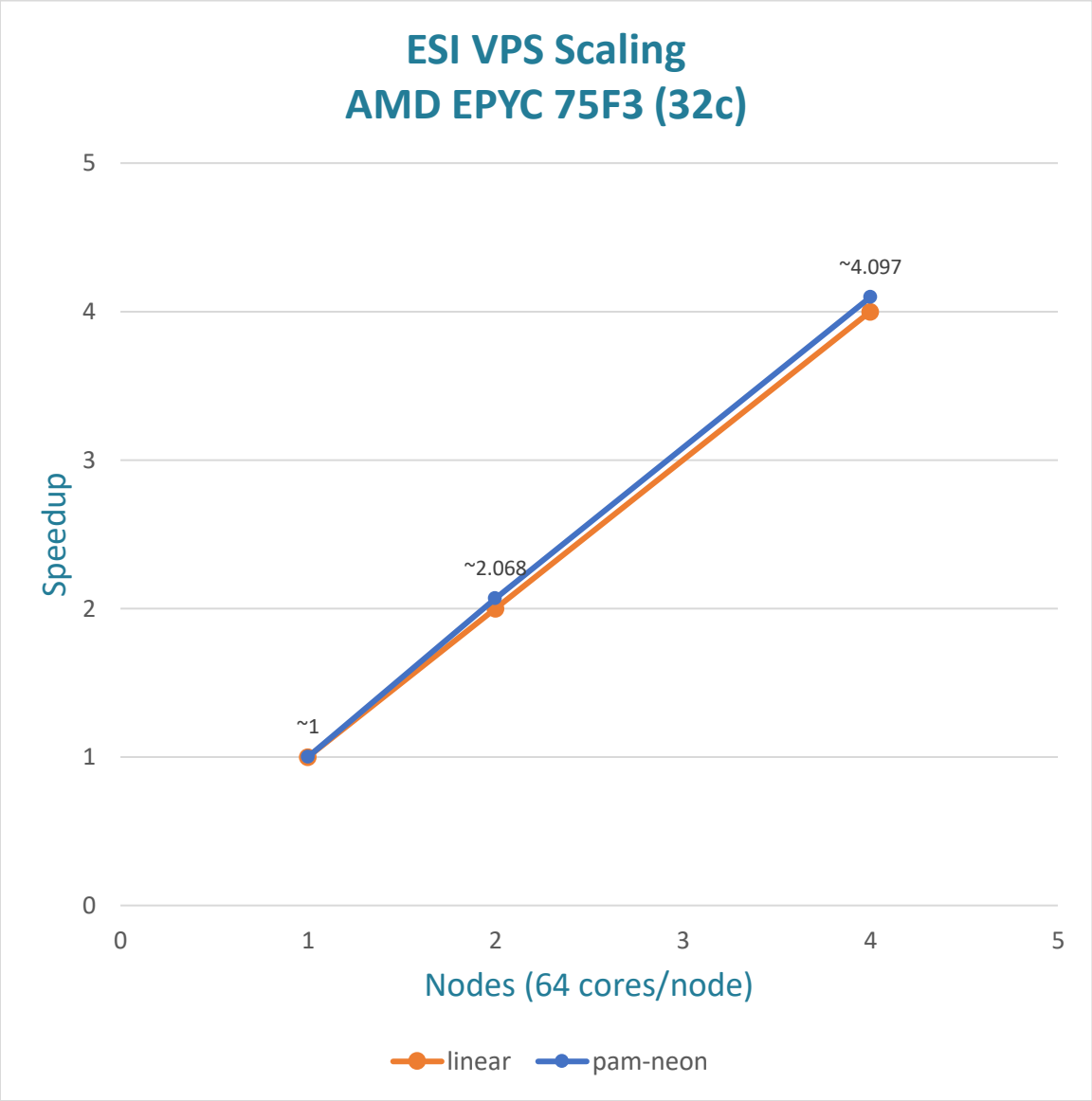


Figure 4: AMD EPYC Multi-Node Scaling Performance

Conclusion

The ESI VPS benchmark comparison tests of AMD EPYC CPUs and Xeon 6258R processors make it clear that AMD EPYC 7003 series processors should be your platform of choice for all ESI VPS simulations, as reliability and efficiency are the key factors for realistic solutions. ESI VPS performed extremely well under the per single node, per core, and multi-node scaling tests, taking full advantage of the advanced architecture of the AMD EPYC 7003 series processors. AMD EPYC 7003 series processors leverage the performance balance in your favor, providing time and cost savings for your most complex simulations.

RELATED LINKS

- AMD EPYC™ Processors
- AMD EPYC Technical Briefs and Tuning Guides
- ESI Group*
- ESI VPS*

FOOTNOTES

1. *For a complete list of world records see **http://www.amd.com/worldrecords** EPYC-22*
2. *AMD Infinity Guard features vary by EPYC™ Processor generations. Infinity Guard security features must be enabled by server OEMs and/or Cloud Service Providers to operate. Check with your OEM or provider to confirm support of these features. Learn more about Infinity Guard at **https://www.amd.com/en/technologies/infinity-guard** GD-183*
3. *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.*
4. *For AMD EPYC processors is the maximum frequency achievable by any single core on the processor under normal operating conditions for server systems. EPYC-18*

ACKNOWLEDGEMENTS
This document is created with contributions from Aditya Nishtala.