



AMD
THREADRIPPER
PRO

AMD Ryzen™ Threadripper™ PRO Processors: Introducing the Third Wave of Workstation Computing

Exploiting a trio of novel technologies, AMD Ryzen™ Threadripper™ PRO processors disrupt the status quo and reset professionals' expectations of workstation-caliber computing. With the introduction of the Ryzen™ Threadripper™ PRO processors, AMD is ushering in a third wave of high performance workstation computing, marrying the best of superscalar and multi-core CPU design with AMD infinity architecture. The end result delivers on a long sought-after goal of high-demand computing professionals: access to dramatic performance scaling with additional computing cores without sacrificing single-thread performance for those workloads that still demand it. To get there, AMD Ryzen™ Threadripper™ PRO processors achieved several technical milestones, becoming the first professional workstation-caliber CPU built on a 7 nm process technology, implementing a significantly enhanced "Zen 2" microarchitecture, and leveraging AMD infinity architecture and chiplet design methodology.

Each represents a compelling accomplishment on its own, but the power of these technologies harnessed together yields far more than their individual parts. With that combination, the four members of the Ryzen™ Threadripper™ PRO 3900WX processor family can make the ultimate argument for a workstation-caliber CPU: many cores capable of running at high sustained base frequencies. That inflection point in turn opens up the opportunity to not only speed today's typical professional workflows in CAD, DME, oil/gas, it can enable the jump to a range of high-demand, heavily-threaded emerging uses, like 8K video production, next-generation intelligent manufacturing (i.e. Industry 4.0), machine learning, and data science.

Multi-core: the Undeniable Path Forward, But Not a Computing Panacea

The multi-core CPU era got its start in the mid-00s, marking a sensible and essential turn from a historical focus on advancing superscalar techniques to drive computing throughput forward. Designed to squeeze as much possible parallelism from a single thread of code, while minimizing execution pipeline stalls, the industry rode superscalar refinements for years, but ran into two major roadblocks: thermal limits and diminishing performance returns. With the low-hanging fruit of superscalar techniques long picked, architectures were getting incredibly complex yet yielding much more modest generation-to-generation returns. Worse, relying on ever-higher clock frequencies to achieve that goal was pushing thermal output to levels beyond the means to cool them.

By contrast, a multi-core approach leverages additional transistor budgets to double core counts, thereby doubling the theoretical aggregate throughput at the same frequency while easing (albeit not nearly

eliminating) the thermal challenges engineers were facing with ever higher clock frequencies. As elegant a solution as multi-core is, there's a catch. Because while there are many multi-thread friendly workloads that can realize the theoretical level – or at least get close – for many tasks the theoretical doesn't track the actual, for one or a combination of three primary reasons: Data can't keep up with execution, software places limits on parallelism, or ever-present thermal and electrical limits constrain clock frequency and voltage, exacerbated by both the increasing density and size of monolithic silicon chips.

Now, every architectural step forward has to address the potential problem of data starvation, as all the additional instruction and execution processing promised is only viable when accompanied by a commensurate increase in effective data movement. But this is an issue that's not specific to multi-core architectures and is mostly fixable, or at least mitigated, by architects (which is precisely another axis of AMD Ryzen™ Threadripper™ PRO advancements, discussed ahead). A more significant issue in the multi-core age –one beyond the control of CPU design – is software: some code can be threaded effectively to make use of all that additional parallel horsepower, but some just can't. No surprise, the transition to multi-core technology has driven performance up dramatically for those applications that lend themselves well to multi-thread execution. But the move hasn't been nearly as beneficial to a whole lot of legacy software, based on algorithms that remain fundamentally sequential in nature. Parametric modeling, the foundation of so many CAD workflows, is a classic example.

Reason number three involves arguably the most daunting challenge facing designers pushing the limits of performance. CPU architects love to work with ever-larger silicon budgets, as it provides the real estate to populate more transistors and drive up performance. For engineers slated with ensuring the chip can function at high frequencies and within strict thermal envelopes, however, scaling up silicon density is far from a trivial matter. The more power consumption concentrated on a single piece of monolithic silicon, the more difficult it is to dissipate the resulting heat and the bigger the die, the more difficult to maintain adequate signal integrity.

Today's Frustrating Choice for Workstation Professionals: the Downside of Scaling Core Count

Over the past decade and more, the industry has achieved tremendous scaling by populating more and more CPU cores. But the same can't be said for per-core throughput with all cores active, nor the work one or a few of those cores can manage on their own with others idle, as processors that integrate more cores on a monolithic piece of silicon must consequently dial down their base clock rates. That's made for a frustrating tradeoff for workstation professionals in two respects. One, performance for still-essential single-thread tasks gets penalized for having all those cores they don't use. And two, the more cores you buy to boost your heavily-threaded workloads, the less each incremental core provides to up your throughput – another example of diminishing returns.

Processor vendors have mitigated the penalty to some degree with technologies like AMD Turbo Core and Intel® Turbo Boost Technology (most recently advanced in Intel® Turbo Boost Max Technology 3.0). While clever and an absolutely sensible use of available, temporary thermal headroom, Turbo levels aren't a panacea, as they can't last indefinitely, with the maximum duration a function of many situational factors, for example the specific silicon implementation, number of active cores, package, motherboard, cooling and enclosure. Transient overdrives are of value in many workloads, but are more useful for low to moderate demand applications that bump into occasional, short-term compute bottlenecks.

By Alex Herrera, commissioned by AMD

Such techniques are fundamentally limited when the CPU is under long-term stress with extended heavy-duty computation, particularly when multiple cores are active. And that's precisely the situation workstation users are most likely to face. Increased thermal dissipation at beyond-base frequencies, for example, will eventually require the system to throttle back clock rates. For consistently loaded multi-thread workloads, it's the base frequency that users can count on for continuous high-demand throughput, and the same often applies for heavily-loaded single-thread processing (though the latter a function of many things, like packaging and cooling technologies).

That's where workstation computing professionals have remained stuck. They clearly can't rely on few-core processors anymore, not without decimating performance for the increasing number of multi-to-massively threaded applications that add value and drive up productivity for workflows dependent on design, modeling, rendering, analysis and simulation – mission-critical workloads for workstation professionals. In the end, they're faced with a frustrating choice: processor options that offer plenty of cores, but ask for big compromises in performance as the core count scales higher.

AMD Ryzen™ Threadripper™ PRO Processors: an inflection point in workstation computing

While engineers can't break physical laws, they can adapt their design to soften their constraints. Built on a unique set of innovative, industry-first technologies, AMD Ryzen™ Threadripper™ PRO processors do just that, resetting expectations of what a workstation can offer running the full-range of a modern professional workflow's compute-heavy variable-thread applications,. The initial family of four Threadripper™ PRO SKUs in the 3900WX family offer more cores at higher base frequencies than the workstation industry has ever seen¹. For example, the 12 core Threadripper™ PRO 3945WX processor can sustain an operating base frequency of 4.0 GHz, while the top-end 3995WX processor scales up to a massive 64 cores, more than twice as many as available in a single workstation socket today².

¹ Based on AMD internal analysis June 1, 2020, comparing specifications of AMD Ryzen™ Threadripper™ PRO to Intel Xeon Gold 6256 and Intel Xeon W-2265. CPP-01. The AMD Ryzen™ Threadripper™ PRO 3995WX has up to 64 cores compared to the highest core count Intel Xeon Scalable workstation processor, the 8280 at 28-cores. CPP-03

² The AMD Ryzen™ Threadripper™ PRO 3995WX has up to 64 cores compared to the highest core count Intel Xeon Scalable workstation processor, the 8280 at 28-cores. CPP-03

By Alex Herrera, commissioned by AMD

Processor	Cores / Threads	Base / Boost ³ Frequency (GHz)	L3 Cache (MB)	PCIe® Gen 4 Lanes	Memory Channels
Ryzen Threadripper PRO 3995WX	64 / 128	2.7 / up to 4.2	256	128	8
Ryzen Threadripper PRO 3795WX	32 / 64	3.5 / up to 4.2	128	128	8
Ryzen Threadripper PRO 3955WX	16 / 32	3.9 / up to 4.3	64	128	8
Ryzen Threadripper PRO 3945WX	12 / 24	4.0 / up to 4.3	64	128	8

Figure 1 The first generation of AMD Ryzen™ Threadripper™ PRO 3900WX workstation CPUs⁴ (Source: AMD)

AMD Ryzen™ Threadripper™ PRO processors manage to create this inflection point in the typical core-count-versus-frequency curve on the back of three key technologies: 7 nm silicon manufacturing, AMD's "Zen 2" microarchitecture with significant second-generation enhancements, and AMD's infinity architecture, a novel approach to scaling up CPU resources while minimizing the frequency tradeoff.

AMD Ryzen™ Threadripper™ PRO processor is the first and only professional workstation-caliber CPU to exploit a 7 nm silicon manufacturing process, allowing engineers to double the density⁵ and fueling the transistor budget needed to substantially drive up core throughput. With the unveiling of the first generation of "Zen" CPU technology, AMD disrupted the status quo with a microarchitecture completely rebuilt from the ground up and optimized for modern single and multi-threaded workloads. With the Threadripper™ PRO processor's "Zen 2" microarchitecture, improvements are many, but two carry most of the weight, especially where high-demand professional computing is concerned: up to 15% faster instructions per cycle (IPC)⁶, and an impressive *quadrupling* of the peak floating point throughput rate⁷. The former comes primarily by the way of improved branch prediction and pre-fetching, supported by much deeper and broader allocation of cache, while the latter is the result achieved by both doubling the width of the FPU datapath and doubling density. Supporting the increased compute throughput, architects doubled load-store bandwidth and dialed up dispatch and retire bandwidth to minimize the chances the higher throughput ALUs would be starved of data.

For a much deeper dive focused specifically on "Zen" technology and the "Zen 2" microarchitecture, check out <https://www.amd.com/en/technologies/zen-core>.

³ Max boost for AMD Ryzen and Athlon processors is the maximum frequency achievable by a single core on the processor running a bursty single-threaded workload. Max boost will vary based on several factors, including, but not limited to: thermal paste; system cooling; motherboard design and BIOS; the latest AMD chipset driver; and the latest OS updates. GD-150

⁴ Max boost for AMD Ryzen™ and Athlon processors is the maximum frequency achievable by a single core on the processor running a bursty single-threaded workload. Max boost will vary based on several factors, including, but not limited to: thermal paste; system cooling; motherboard design and BIOS; the latest AMD chipset driver; and the latest OS updates. GD-150

⁵ Based on June 8, 2018 AMD internal testing of same-architecture product ported from 14 to 7 nm technology with similar implementation flow/methodology, using performance from SGEMM. EPYC-07

⁶ AMD "Zen 2" CPU-based system scored an estimated 15% higher than previous generation AMD "Zen" based system using estimated SPECint®_base2006 results. SPEC and SPECint are registered trademarks of the Standard Performance Evaluation Corporation. See www.spec.org. GD-141

⁷ Based on standard calculation method for determining FLOPS. ROM-04
By Alex Herrera, commissioned by AMD

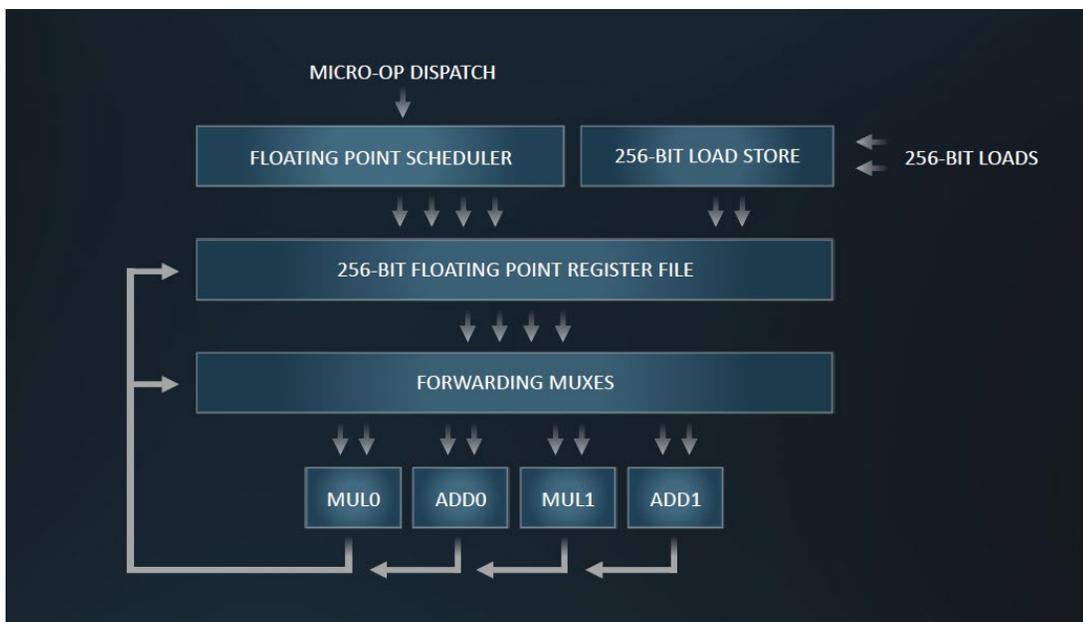


Figure 2 The 4X throughput Floating Point Unit: Not the only “Zen 2” enhancement, but for high-demand professionals, it offers dramatic impact on performance (Source: AMD)

The Third Wave in CPU performance scaling: Chiplet Scaling

So no, multi-core technology isn’t a panacea to the goals of advancing throughput for the most demanding client applications, those most notably served by the modern workstation. It isn’t, just as pushing only on superscalar techniques no longer became the only reasonable path forward. Moving to multi-core made sense over a decade ago and it will continue to represent a critical component in a multi-pronged strategy to advance silicon-driven computing performance, at least as far forward as we can see in the context of conventional CMOS technology. Its ability to be reasonably engineered and provide meaningful increases in total available throughput make it an overwhelmingly sensible choice. And with multi-core the norm today, software providers are more aggressively supporting high-demand professional applications with optimized multi-threading (albeit only to the extent their algorithms allow).

But that doesn’t mean the industry is limited to those two existing axes of advancement, driving only superscalar and multi-core approaches. And the historical tradeoff of core count and frequency doesn’t have to represent just a frustrating roadblock ... it also presents an opportunity ripe for innovation.

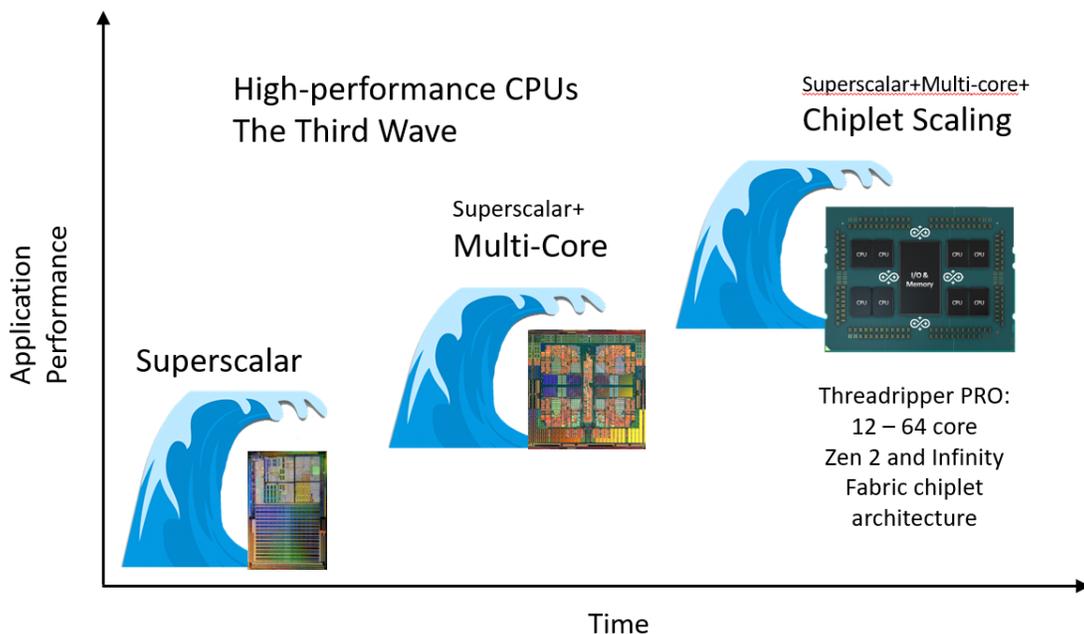


Figure 3 Threadripper™ PRO pioneering a third wave in high-performance workstation computing

Enter the era of chiplet scaling and AMD infinity architecture. Along with 2nd generation “Zen 2” and its 7^{nm} process, AMD’s chiplet technology enabled by Infinity™ Fabric interconnect forms a linchpin to Threadripper™ PRO breakthrough combination of core count and sustained clock rates⁸. Rather than simply forcing geometrically higher core counts onto the same monolithic die, AMD Ryzen™ Threadripper™ PRO processors integrate multiple 8-core “Zen 2” based chiplets, each tied to memory, I/O and each other via AMD Infinity™ Fabric interconnect.

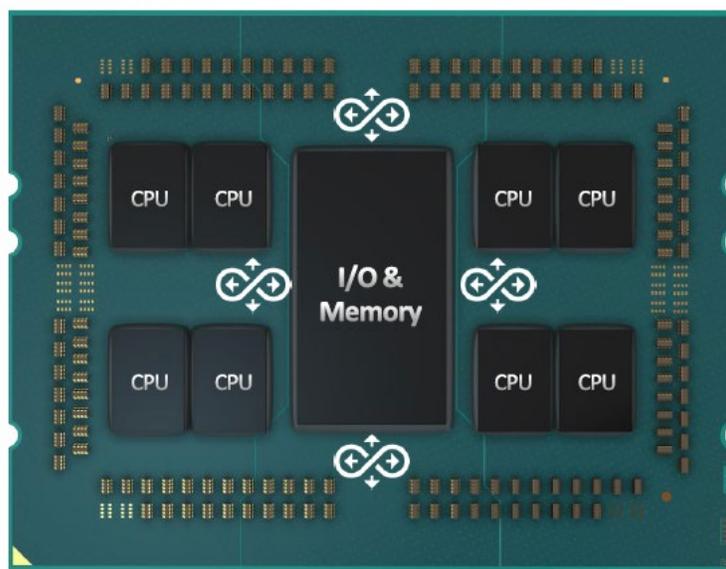


Figure 4 AMD Infinity™ Fabric enables Threadripper™ PRO processors’ chiplet implementation, providing a breakthrough combination of more cores running at higher clock rates (See Figure 5).

⁸ Based on AMD internal analysis June 1, 2020, comparing specifications of AMD Ryzen™ Threadripper™ PRO to Intel Xeon Gold 6256 and Intel Xeon W-2265. CPP-01. The AMD Ryzen™ Threadripper™ PRO 3995WX has up to 64 cores compared to the highest core count Intel Xeon Scalable workstation processor, the 8280 at 28-cores. CPP-03
By Alex Herrera, commissioned by AMD

The architecture eases the electrical and thermal constraints of monolithic design, helping engineers keep base frequencies up while driving core counts to breakthrough levels. The figure below charts core count versus base frequency for four AMD Ryzen™ Threadripper™ PRO processor SKUs, relative to Intel Xeon W-2200 family (choosing W-2200 SKUs that offer the highest base frequency at the given core count!).

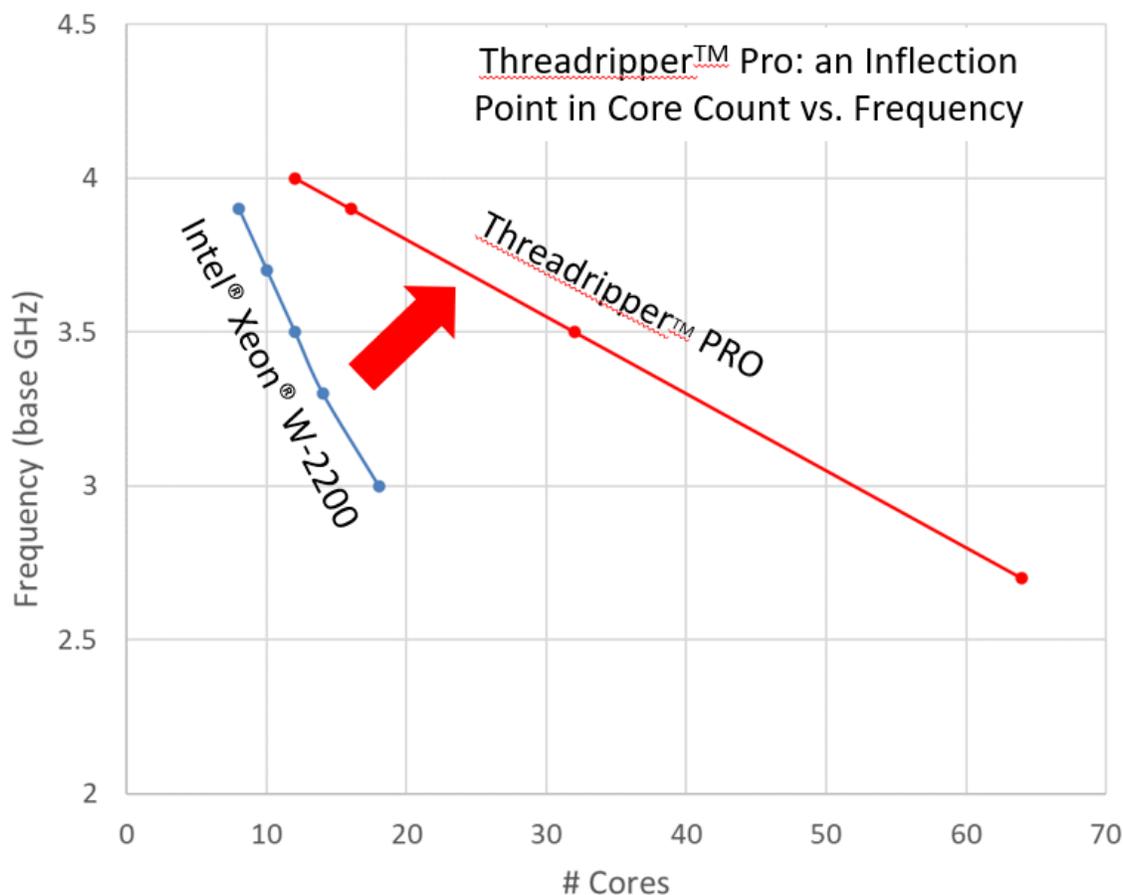


Figure 5 The End Result: AMD Ryzen™ Threadripper™ PRO processors, an Inflection Point in Core Count vs. Base Frequency (Source: AMD and Intel)

Chiplet and core scaling only as good as interconnect and memory will allow.

One Threadripper™ PRO integrates up to eight chiplets, each with access to memory, I/O and each other via the established hyper-speed AMD Infinity™ Fabric interconnect. Threadripper™ PRO bar-raising core counts would count for naught were they supported by insufficient memory, with respect to not just bandwidth, but capacity and latency as well. AMD ensured Threadripper™ PRO memory subsystem would be up to the task, as the 3900WX processor family is backed up with the most on-chip cache and highest performing memory available in a single x86 CPU socket: eight 3200 MHz DDR4 memory channels with ECC, supporting up to 2 TB capacity, and delivering up to 204 GB/s of aggregate bandwidth, more than double that of Intel Xeon W-2200 family.

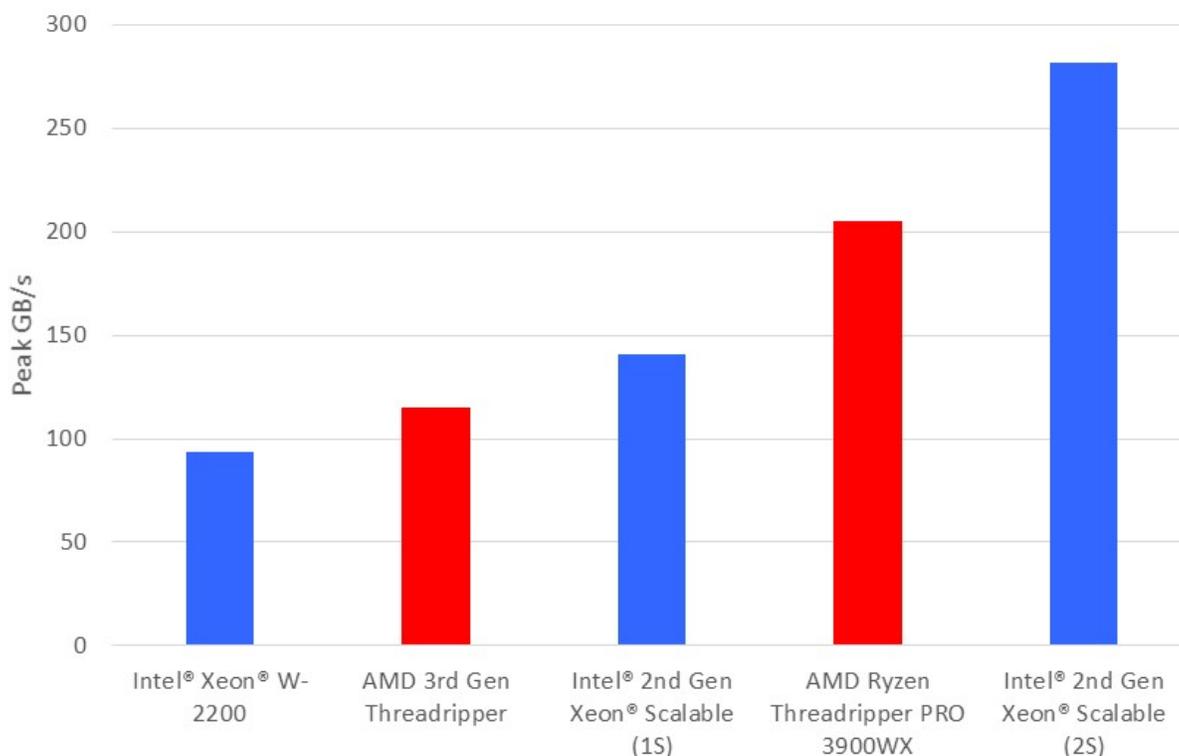


Figure 6 AMD Ryzen™ Threadripper™ PRO 3900WX processors' 8 channels of DDR4-3200 ECC memory offer more maximum memory bandwidth than any workstation CPU in a single socket available today (Source: AMD and Intel)

PCIe® 4.0 Ready, with up to 136 lanes

Like its memory interface, the PCI® Express I/O on a Threadripper™ PRO 3900WX processor is faster and wider than any other single-socket workstation platform available today. The first professional workstation platform to support PCI® Express 4.0 speeds (with twice the peak data transfer rate of Gen 3), a Threadripper™ PRO 3900WX processor offers 128 PCIe® 4.0 lanes (with another eight available from the platform chipset), making for a wider I/O interface than even a dual-socket Intel 2nd Generation Xeon Scalable workstation can manage with 48 lanes each. What's all that faster, wider I/O mean for workstation users? Plenty, for example, letting workstations populate more PCI® Express expansion slots that promise full electrical connectivity. By contrast, workstations today touting more than two *mechanical*/PCIe® x16 slots (for graphics cards) often don't have enough lanes to support those slots with the full 16-bit *electrical*/width. As a result, some GPUs will be hamstrung to only a half or even a quarter of the bandwidth they should have available.

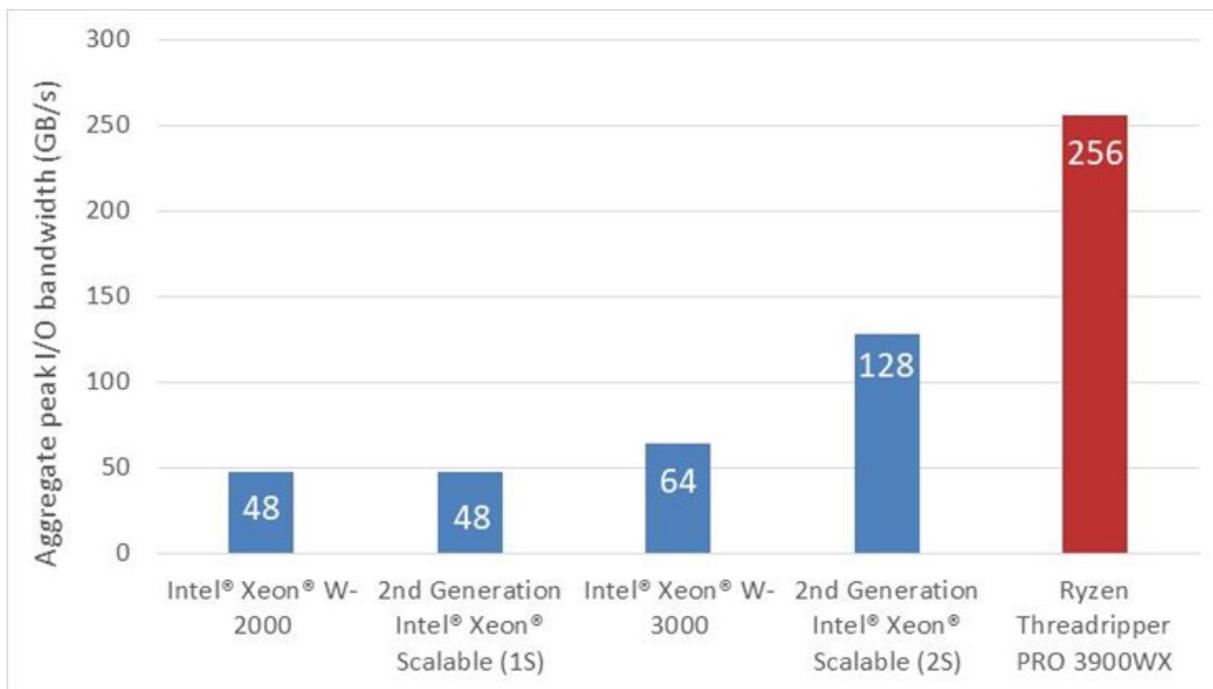


Figure 7 AMD Ryzen™ Threadripper™ PRO 3900WX processor offers 128 lanes of PCI® Express 4.0 I/O, delivering twice the aggregate peak bandwidth of Intel's best dual-socket workstation (Source: AMD and Intel)

And consider the brand new generation of NVMe SSDs, supporting PCIe® 4.0 rates and slashing fetch times for big CAD design, video, scan or survey data files, while minimizing the performance hit for the occasional page miss in memory. In third party testing, a Threadripper™ PRO 3955WX processor can see up to 86% higher read bandwidth and up to 58% higher write bandwidth when paired with a PCIe® 4.0 NVMe SSD compared to the previous Gen 3⁹. See Figure 8, below.

⁹ Data collected in Lenovo labs, as of 14-July-2020.
By Alex Herrera, commissioned by AMD

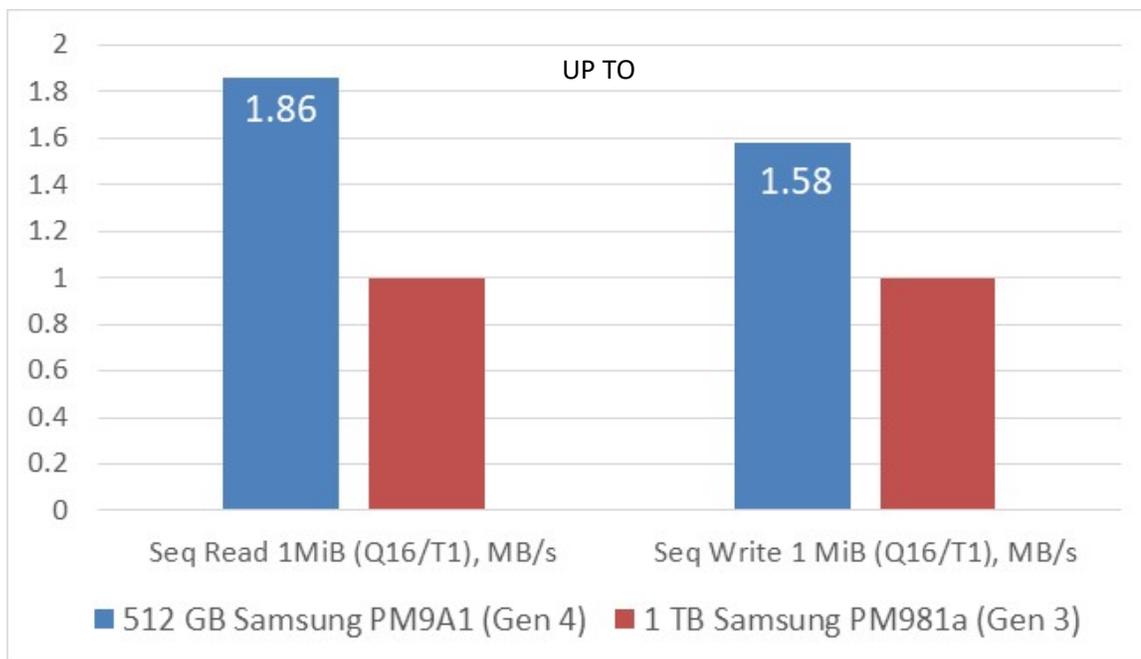


Figure 8 AMD Ryzen™ Threadripper™ PRO processors anchor the first professional workstation-caliber CPU platform to offer PCIe® 4.0 speeds, ideal for minimal dataset fetch and store times with latest generation NVMe SSDs. (Source: AMD)

Threadripper™ PRO 3945WX Processor Benchmarking

The ability of Threadripper™ PRO processors to scale up performance by core count is evident throughout the family, starting with the 12C Ryzen™ Threadripper™ PRO 3945WX processor. Compared to the Intel Xeon W-2265, complemented with nearly equivalent memory, storage and graphics hardwareⁱⁱ, the 3945WX processor managed to yield up to 9% and up to 24% higher throughput in tests most relevant to the types of workloads seen in common workstation applications^{ii,iii}. Specifically, running the battery of CPU specific tests from SPECworkstation 3.0.4, the Threadripper™ PRO 3945WX processor scored up to 9% higher; on Cinebench R20, up to 20% higher; and on a combined workstation-focused aggregate of PassMark PerformanceTest 10.0 Floating Point, Compression and Physics subset, up to 24% higher. (Overall, the Threadripper™ PRO 3945WX processor scored up to 29% higher on the composite CPU Mark)^{ii,iii}.

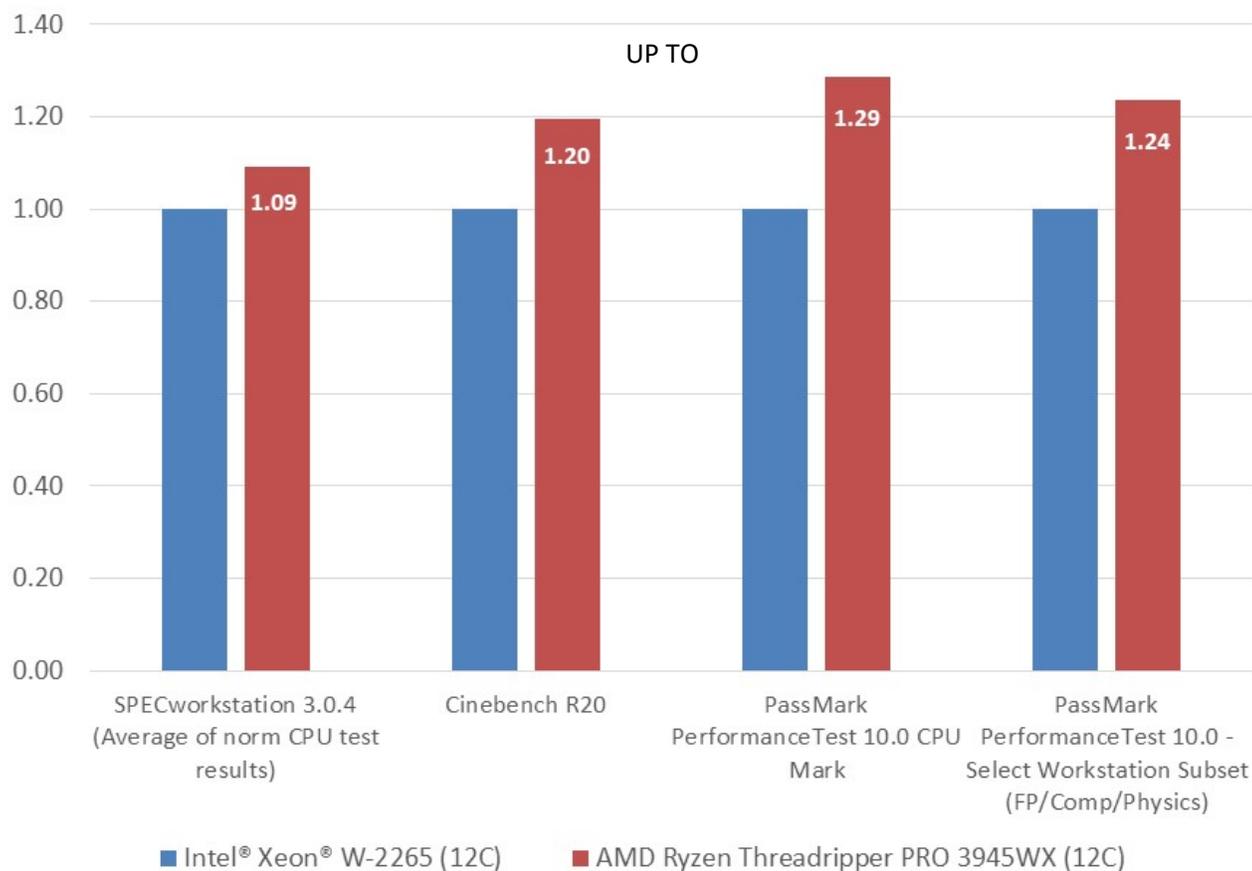


Figure 9 12-Core Multi-thread (MT) test results for similarly configured systems^{ii,iii}

And in applications where single-thread performance still matters, Ryzen™ Threadripper™ PRO processor's ability to scale down to 1T can be just as critical to many professional workflows. On 1T Cinebench R20 testing, the 3945WX processor managed up to a 3% higher score, and on the same aggregate of PassMark PerformanceTest 10.0 Floating-Point/Compression/Physics tests, the 3945WX processor scored ~ 1% lower. (Overall, the Threadripper™ PRO 3945WX workstation scored up to 93% of the Intel Xeon W-2265 system on the composite CPU Mark).

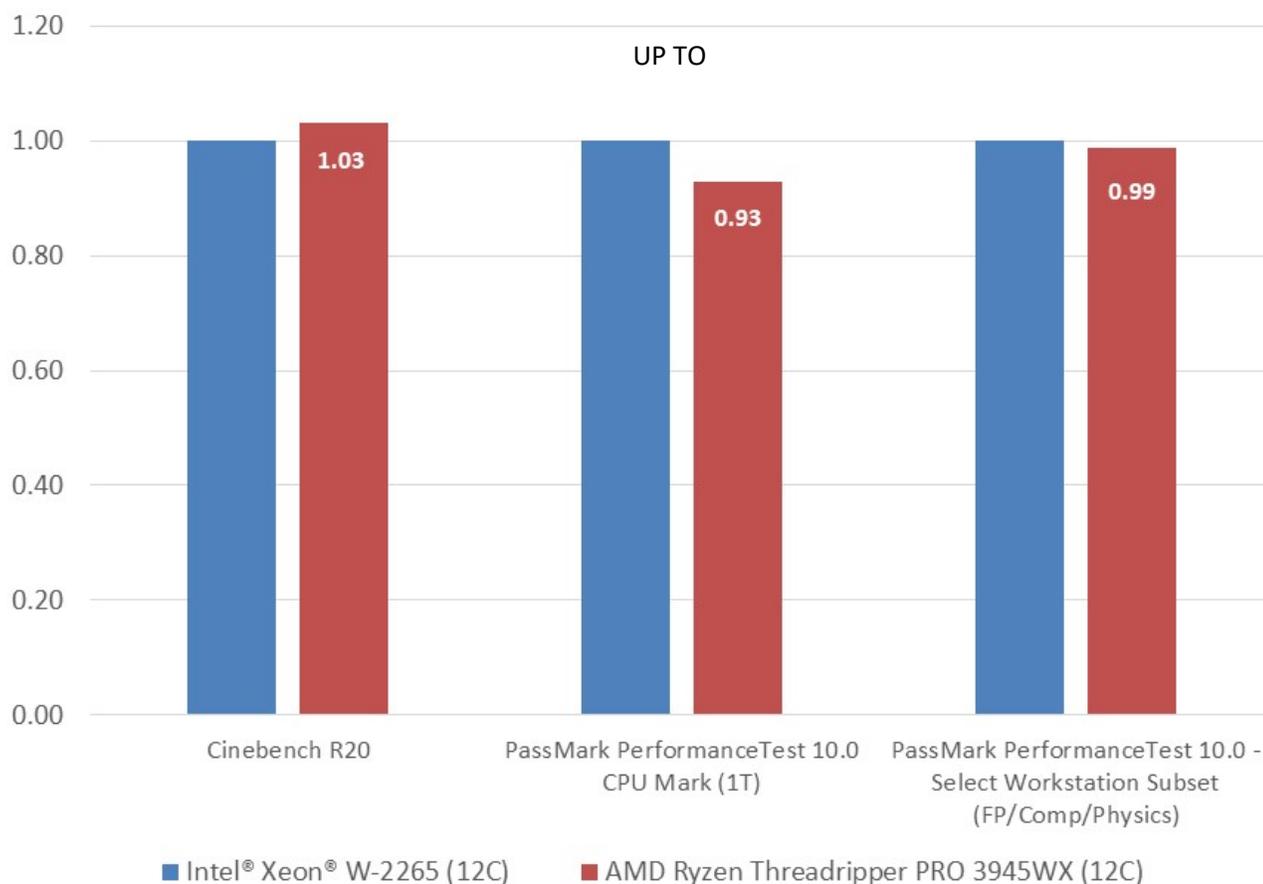


Figure 10 12 Core Single-thread (1T) test results for similarly configured systems^{ii,iii}

Workstation performance wrapped up in a professional package: AMD PRO technologies

Regardless of performance, no workstation platform will get far without as much attention given to reliability and availability as to throughput. Built with AMD PRO technologies, Threadripper™ PRO processors check those boxes and then some. The cornerstone of AMD PRO technologies is the AMD Security Processor (ASP), a dedicated security co-processor integrated directly on CPU silicon to implement security protocols.

Consider Memory Guard, a unique feature providing memory-level encryption to reduce the chance of data theft should a machine be stolen or compromised. For professionals entrusted with clients' golden IP, Memory Guard provides valuable peace of mind, particularly appealing for a workstation out in the field or on location, or any situation where security is paramount. Secure Boot prevents malware from accessing critical and otherwise vulnerable code prior to and during the load of the system operating system. In addition, AMD PRO technologies provide support for Microsoft Endpoint Manager and Windows Defender Application Guard malware prevention.

Convinced a dual-socket workstation is mandatory to secure big core counts? It's time to rethink.

When AMD introduced the Opteron™ processor back in the 00's, the computing landscape was forever changed. With two major architectural enhancements – 64-bit extensions to x86 and Direct Connect memory eliminating the old North Bridge interface – Opteron made buyers, system builders and CPU rivals rethink their default choices and assumptions on what they needed out of their computer. Most significantly, AMD Opteron processors' 64-bit extensions triggered the tide that eventually obsoleted the presumptive transition to the 64-bit Itanium architecture the industry was largely anticipating.

With its wide range of available core counts, AMD's Ryzen™ Threadripper™ PRO processors offer a similar opportunity to again rethink the default, in this case whether it's really necessary to climb up to a dual-socket workstation (2S) to get the ultimate in core counts your workflow demands. Now granted, there is certainly more than one reason a buyer looks to make that jump up to a 2S platform: for example, to get the absolute maximum memory and storage that may come from the more ample capacity of a typical 2S chassis. But that aside, if the goal is to secure as many CPU cores as possible, and your application doesn't demand the 99th percentile in memory or drive capacity – a Threadripper™ PRO processor-based workstation will have you questioning the default decision to upgrade to a dual-socket workstation. Supporting 2 TB of memory served by 204 GB/s peak across 8 channels, completed by both more and faster PCI® Express Gen 4 lanes than two 2nd Generation Intel Xeon Scalable processors can manage with Gen 3, a 32 or 64 core Threadripper™ PRO processor today can serve the bulk of demands that used to require a dual socket machine.

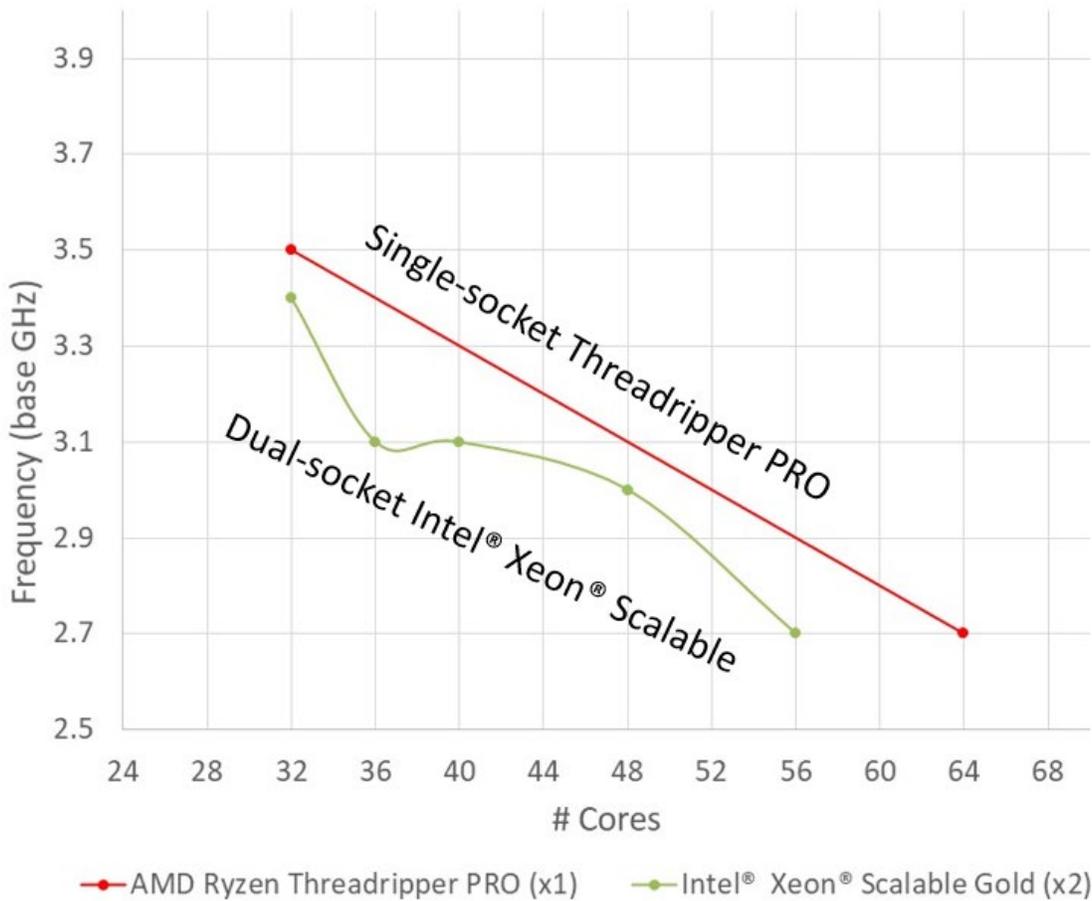


Figure 11 Threadripper™ Pro processor offers core counts in the domain – and beyond – of dual-socket workstations (Source: Intel^{IV})

Why would a buyer prefer a single-socket machine over a dual, if the former can deliver comparable performance and capacity? Reasons might include minimizing power consumption or reducing the machine's physical footprint. But for the majority, the overriding factor is price: the jump to a full-featured 2S workstation with both sockets populated (to achieve the desired core count) will likely cost thousands more.

A randomly-timed sample (June, 2020) of major workstation vendors' wares contrasted the costs of moving up from a single-socket workstation with an 18C, 3.0 GHz (base) Intel Xeon W-2295 up to a dual-socket workstation featuring Xeon Gold Scalable processors of similar base frequencies, and with all other major components identical (or extremely close), including GPU, memory and storage. Based on the price comparisons, a buyer might have to spend \$6,000 or more to move up to a 32-core (2 x 16C @ 3.4 GHz base frequency) machine and around \$8,000 more to get to 56 total cores (2 x 28C @ 2.7 GHz base)^v.

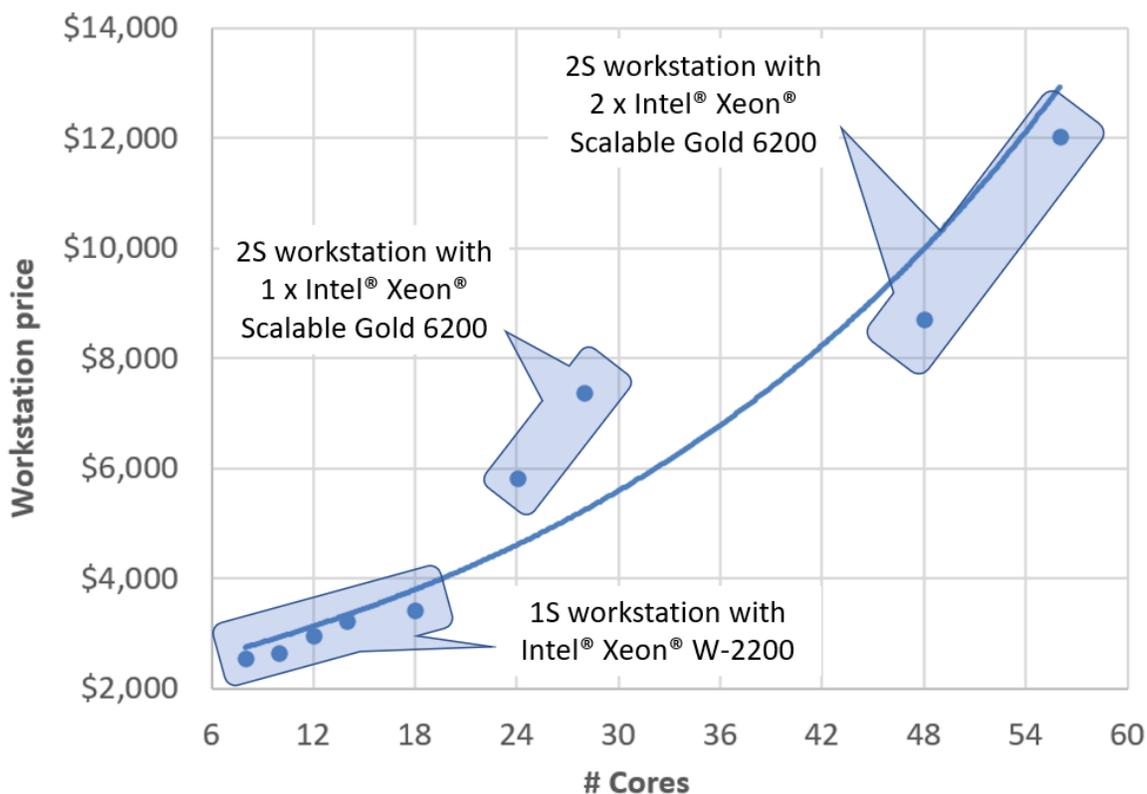


Figure 12 Example system pricing as a function of core counts, moving from a 1S workstation to a 2S model (all else configured as equally as possible)^{vi}

Ryzen™ Threadripper™ PRO 3995WX Benchmarking

While integrating 32 and 64 cores in a single CPU socket is no small engineering achievement, there would be no point if performance couldn't scale to that level effectively. Threadripper™ PRO processors' comprehensive design approach, dedicated to the goal of efficient scaling, proves that ability in spades, even compared with today's leading dual-socket workstation platform. Compared to a workstation built not on one but two Intel Xeon Scalable Platinum 8280 CPUs, complemented with nearly equivalent memory, storage and graphics hardware^{vii}, a Ryzen™ Threadripper™ PRO 3995WX processor scored up to 13% and up to 16% higher throughput in testing relevant to the types of workloads seen in common workstation applicationsⁱⁱⁱ. Specifically, running the CPU specific tests from SPECworkstation 3.0.4, the Threadripper™ PRO 3995WX

processor scored up to 9% higher, and on both Cinebench R20 and the combined workstation-focused aggregate of PassMark PerformanceTest 10.0 Floating Point, Compression and Physics subset, it managed up to 16% higher throughput. (Overall, the Threadripper™ PRO 3995WX scored up to 29% higher on the composite CPU Mark)^{iii,vii}.

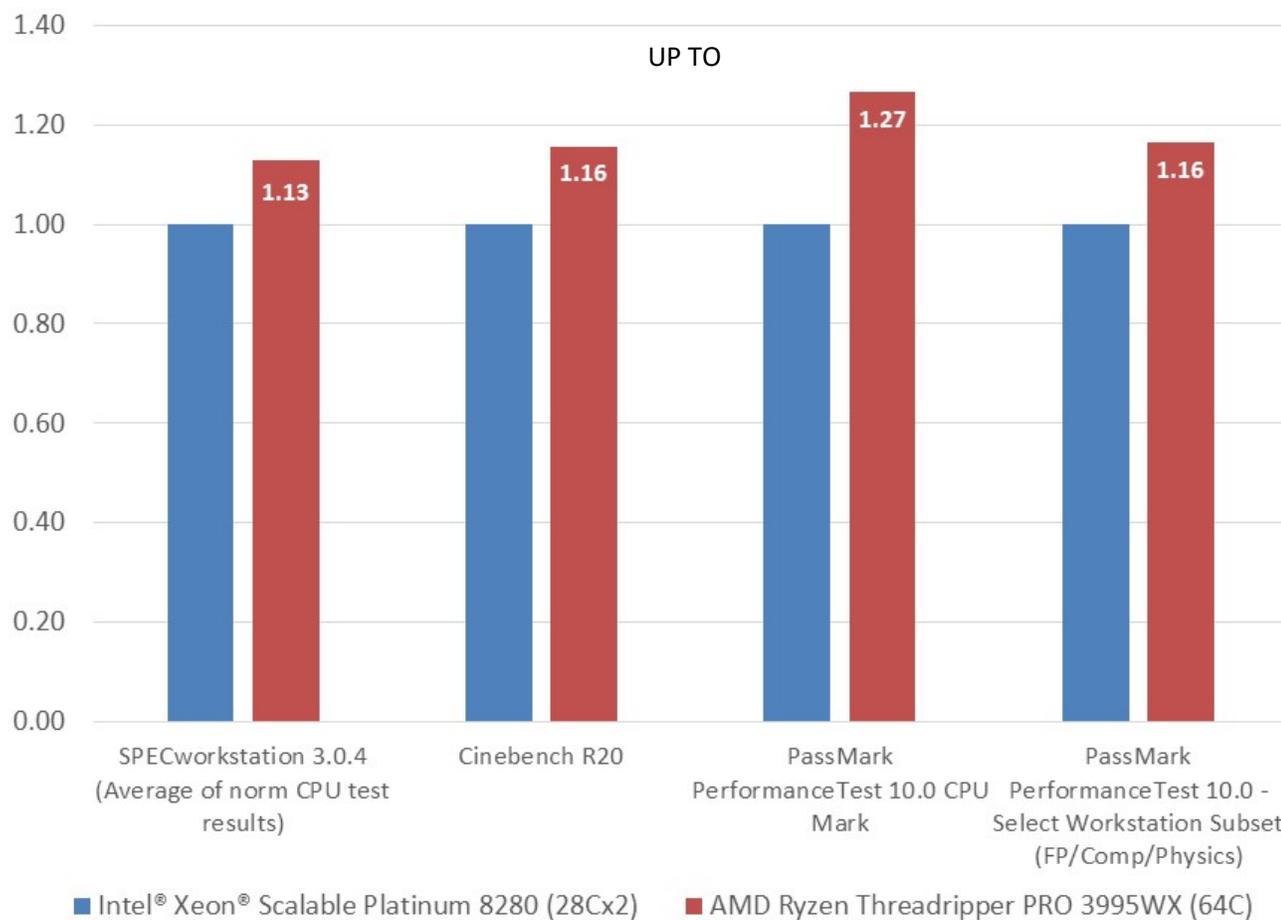


Figure 13 Multi-thread test resultsⁱⁱⁱ for similarly configured systems^{vii}

Ryzen™ Threadripper™ PRO processors' edge isn't limited to multi-threaded workloads. On 1T Cinebench R20 testing, a Threadripper™ PRO 3995WX processor scored up to 18% higher than a similarly equipped^{vii} dual-socket Intel Scalable Platinum workstation, and on the workstation-relevant aggregate of PassMark Performance Test 10.0 Floating-Point/Compression/Physics tests, the 3995WX processor scored up to 11% higher. (Overall, the Threadripper™ PRO 3945WX processor scored up to 28% higher on the composite CPU Mark)^{iii,vii}.

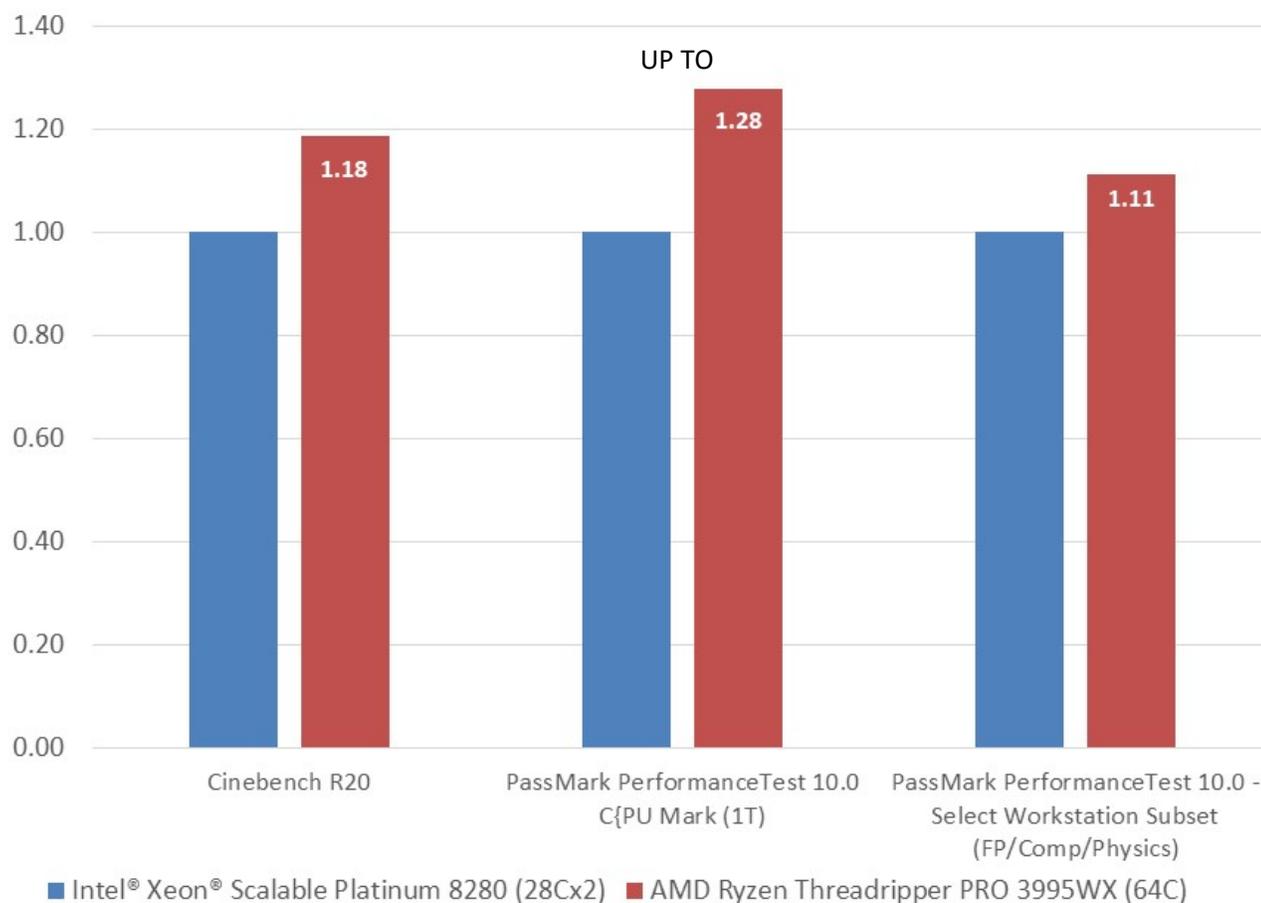


Figure 14 Single-thread (1T) test resultsⁱⁱⁱ for similarly configured systems^{vii}

Threadripper™ PRO processors' unique performance proposition invites new workstation usage and workflows

With AMD Ryzen™ Threadripper™ PRO processors' combination of 7 nm, "Zen 2," and Infinity™ Fabric design architecture, users can exploit a leap forward in multi-threaded performance scaling, without having to give up on single-thread throughput. And that can lead not only to improvements in professional visual computing workflows as they look today, but also open the door to re-structuring those workflows to both compress time and dial up efficiency.

Brute-force performance for applications that need it

With core counts far beyond what any single CPU socket has ever allowed in a workstation –comparable to the best of today's dual-socket platforms – AMD Ryzen™ Threadripper™ PRO processors have the obvious aptitude to power workflows that depend heavily on multi-thread throughput. Think final-frame rendering, video encode and color correction for media creators, both post and real-time, place brute force demands on a platform as any, with performance relying on lots of cores, supported by lots of memory and storage bandwidth. Or consider digital signal processing and volumetric rendering for applications from seismic analysis to medical visualization and diagnoses, where more frequent and fine-grained analysis afforded by up

By Alex Herrera, commissioned by AMD

to 64 cores could make all the difference. In corners of science and research, brute force can make the difference between DNA sequencing or molecular dynamic simulation that results in minutes or hours versus days or weeks. In the rapidly evolving areas of data science and artificial intelligence, the more data that can be processed, the more accurate the analysis. And in the financial world, a machine capable of quicker and more accurate stochastic modeling for real-time asset valuation and modeling offers its owner a compelling business weapon.

So yes, sometimes there's just no substitute for brute force, with applications hungry for a solution that can offer more cores, higher clock rates and a memory and storage subsystem that can keep up. With industry-leading metrics – the most cores at highest base frequencies¹⁰, the most available memory bandwidth¹¹ and the fastest and widest I/O to store and retrieve data¹² – AMD Ryzen™ Threadripper™ PRO epitomizes the brute force workstation platform that high-demand, heavily-threaded workloads call for.

Structure your workflow the way you want to, not how your hardware allows

Too often we make the mistake of measuring computational demand in black and white. You have to have a certain level of performance, or you don't. In some cases, like real-time broadcast video, that hard threshold between what's enough compute power and what's not is certainly valid. But the majority of high-demand professional applications live in the gray area in between. Yes, users can get the job done with less than the preferred level of performance, but access to more power can open up the door to significantly better productivity. Think of all the computing tasks that professionals have been forced to ration, employ as scarcely as possible, simply because they take too long to exploit frequently with a compute engine limited to a handful of compute cores.

Sure, designers would prefer to render more often to validate lighting or aesthetics, and engineers would love to run CFD or FEA simulations more frequently, for longer duration periods, or to finer-grained detail. Media professionals would be happy to employ more complex pre-vis to best prepare for live action. Researchers could always find good reasons to kick off more scientific simulations or analyses, and software developers might want to merge and compile more often than they've done in the past to ensure robust version control.

With a massively cored CPU like the AMD Ryzen™ Threadripper™ PRO, the handcuffs are off. Forget the workflow you always thought you had to follow, one dictated by the limits of few-core CPUs. With 12 to 64 cores available with AMD Ryzen™ Threadripper™ PRO processors, professionals across the spectrum can leverage more of those “too slow”, value-add compute tasks both more often and earlier in the workflow. Consider typical CAD workflows, with work time dominated by the sequential and iterative modify/visualize/verify cycle. That verify portion can now integrate more simulations more often early on – ditto for renderings – without waiting until later stages of workflow. Virtual prototyping with photorealistic quality can reveal valuable insight earlier in design cycles. Longer-duration, more fine-grained simulations can catch potential issues earlier, can work those luxury-but-valuable high demand usage models into the primary modify-visualize-test interactive pieces, rather than once or twice at the end.

Furthermore, we as users continue to raise are multi-tasking game to rethink and streamline the workflow itself to accelerate our project timelines. That is, if a few applications don't lend themselves well to multi-

¹⁰ Based on AMD internal analysis June 1, 2020, comparing specifications of AMD Ryzen™ Threadripper™ PRO to Intel Xeon Gold 6256 and Intel Xeon W-2265. CPP-01. The AMD Ryzen™ Threadripper™ PRO 3995WX has up to 64 cores compared to the highest core count Intel Xeon Scalable workstation processor, the 8280 at 28-cores. CPP-03

¹¹ Based on AMD internal analysis June 1, 2020, comparing memory bandwidth specifications of AMD Ryzen™ Threadripper™ PRO to Intel Xeon Scalable 8280. CPP-06

¹² Based on AMD internal analysis June 2020. CPP-11

thread execution, then why not run more in parallel, leveraging users' own resourcefulness to juggle compute jobs? With a platform that can finally span the range to many cores while preserving single-thread throughput, professionals have an opportunity to re-think the historical sequential workflows and look for more places to impart workflow-level parallelism.

No need to compromise on single-thread workloads

Threadripper™ PRO processors offer more than just a means to throw more cores at existing multi-thread workloads. Rather, the unique combination of more cores at higher base clock rates¹³ offers the opportunity to not only drive up throughput for multi-core friendly applications, it means users don't have to give up performance on those still-critical workloads throttle by single-thread throughput. With a 12C AMD Ryzen™ Threadripper™ PRO 3945WX processor, for example, get twice the cores of today's mainstream workstation hex-core CPU, while retaining a 4 GHz base frequency for can't-do-without performance on workloads like parametric modeling^{viii}.

Ready to exploit rapidly emerging heavily-threaded workloads

Looking forward, professionals can expect an onslaught of multi-thread code to permeate their workflows – some running in the foreground and others hidden in the back, running constantly and concurrently – and all demanding more processing cores. Consider machine learning, which is quickly finding uses to improve current professional workflows. Think about generative design in CAD, pattern detection in data science, real-time analysis and recognition in video and 2D or 3D imaging, not just in digital media fields but with compelling uses in geoscience and medical applications. Or consider the eventual proliferation of intelligent digital assistants executing in the background, for example in software development running continuous auto-analysis of code looking for optimizations or faulty paths, or in financial platforms searching real-time for subtle trends and opportunities. And those ideas are just the possibilities we can imagine today, most likely representing the tip of the eventual iceberg of use cases. Access to more processing cores will become only more valuable in a world where parallel computing algorithms dominate.

The best of both worlds: Threadripper™ PRO processors usher in the third wave of high performance workstation computing

AMD Ryzen™ Threadripper™ PRO processors boast a bunch of marketing firsts for workstations: “Zen 2” microarchitecture, chiplet-focused infinity architecture, PCIe® 4.0 I/O, and 8-channel memory. Those are all well and good, but the achievement of individual tech specs doesn't concern professionals in CAD, media and entertainment, finance, software development, geoscience, medicine, research and data analytics. What does concern them is an avenue to secure maximum throughput for heavily-threaded workloads, the kind they've always been wanting to use more of, if not for sluggish throughput. They want it, without having to sacrifice top-end single-thread performance for some of the common workloads that remain sequential in nature – and

¹³ Based on AMD internal analysis June 1, 2020, comparing specifications of AMD Ryzen™ Threadripper™ PRO to Intel Xeon Gold 6256 and Intel Xeon W-2265. CPP-01. The AMD Ryzen™ Threadripper™ PRO 3995WX has up to 64 cores compared to the highest core count Intel Xeon Scalable workstation processor, the 8280 at 28-cores. CPP-03

By Alex Herrera, commissioned by AMD

always will. And they have to have it all in a package that doesn't take shortcuts in reliability and security features, because a machine that's down due to mechanical failure or malware produces no throughput at all.

Built upon the triad foundation of 7 nm manufacturing, "Zen 2" microarchitecture and chiplet technologies supported by AMD Infinity™ Fabric, AMD Ryzen™ Threadripper™ PRO processors represent a tipping point in workstation-caliber computing. With AMD Ryzen™ Threadripper™ PRO processors offering far more cores at higher frequencies to crank through both heavily threaded and minimally threaded code – supported by the fastest and most advanced memory and storage subsystems available¹⁴ – workstation professionals can now come closer than ever to having the best of both worlds.

¹⁴ Based on AMD internal analysis June 1, 2020, comparing memory bandwidth specifications of AMD Ryzen™ Threadripper™ PRO to Intel Xeon Scalable 8280. CPP-06 Based on AMD internal analysis June 2020. CPP-11
By Alex Herrera, commissioned by AMD

Disclosures / Notes

ⁱ Intel® Xeon® W-2200 series SKUs selected for highest base frequency at given core count (8 cores and higher) from among SKUs offered by workstation OEMs Dell, HP, and Lenovo as of 6/1/2020, in models Dell Precision 5820, Lenovo ThinkStation P520, and HP Z4 G4.

Intel® Xeon® W-2200 series SKU	# Cores	Base frequency (GHz)
Xeon® W-2245	8	3.9
Xeon® W-2255	10	3.7
Xeon® W-2265	12	3.5
Xeon® W-2255	10	3.8
Xeon® W-2265	12	3.5
Xeon® W-2275	14	3.3
Xeon® W-2295	18	3.0

ⁱⁱ 12C test system configurations

	Intel® Xeon® W-2265 (12C)	AMD Ryzen™ Threadripper™ PRO 3945WX (12C)
CPU cores (physical)	12	12
CPU base frequency (GHz)	3.5	4.0
Memory size (GB)	64 (4 x 2R x 8 GB)	64 (8 x 8 GB)
Memory channels	4	8
DDR Memory speed (ECC RDIMM)	2933	3200
Primary storage	PCIe Gen 3 M.2 NVMe SSD	PCIe Gen 3 M.2 NVMe SSD
GPU	NVIDIA® Quadro® RTX 6000	NVIDIA® Quadro® RTX 6000
OS	Windows 10 Pro	Windows 10 Pro

ⁱⁱⁱ Benchmark procedures and parameters

All benchmarks were run twice on each system, with best results selected.

SPECworkstation 3.0.4 CPU tests: Blender, handbrake, LuxRender, CalculiX, WPCcfd, RodiniaCFD, lammmps, namd, rodiniaLifeSci, FSI, Convolution, FFTW, Kirchhoff, poisson, srmp, 7zip, octave, and python36. Each result was normalized to the comparison Intel® Xeon® system's result and then averaged to the aggregate value.

PassMark PerformanceTest 10.0: All PerformanceTest CPU tests run to produce the CPU Mark. For this subjective "Select Workstation Subset", each of three results from Floating Point, Compression, and Physics were normalized to the comparison Intel® Xeon® system's result and then averaged to the aggregate value.

^{iv} Intel® Xeon® Scalable Gold SKUs chosen by highest GHz at given core count (16 cores and more) from among SKUs offered by workstation OEMs Dell and HP on 6/1/2020, and available in 2S models Dell Precision 7920 and HP Z8 G4.

Intel® Xeon® Scalable Gold SKU	# Cores	Base frequency (GHz)
Xeon® Scalable Gold 6248R	24	3.0
Xeon® Scalable Gold 6258R	28	2.7
Xeon® Scalable Gold 6246R (x2)	32	3.4
Xeon® Scalable Gold 6254 (x2)	36	3.1
Xeon® Scalable Gold 6242R (x2)	40	3.1
Xeon® Scalable Gold 6248R (x2))	48	3.0
Xeon® Scalable Gold 6258R (x2)	56	2.7
Xeon® Scalable Gold 6248 (x2)	48	2.5
Xeon® Scalable Gold 6238R (x2)	56	2.2

† Online pricing sample in June, 2020, with common components NVIDIA Quadro P2200 GPU, 32 GB 2x16 GB DDR3-2666 ECC memory, and 256 GB SATA SSD.

Intel® Xeon® W-2200 series SKU	# cores	Base frequency (GHz)	Dell Precision 7920 online pricing
Xeon® W-2295	18	3.0	\$3,425.92

Intel® Xeon® Scalable Gold SKU	# cores	Base frequency (GHz)	Dell Precision 7920 online pricing
Xeon® Scalable Gold 6248R	24	3.0	\$5,821.30
Xeon® Scalable Gold 6258R	28	2.7	\$7,477.53
Xeon® Scalable Gold 6246R (x2)	32	3.4	\$10,467.85
Xeon® Scalable Gold 6254 (x2)	36	3.1	\$11,669.85
Xeon® Scalable Gold 6242R (x2)	40	3.1	\$8,189.65
Xeon® Scalable Gold 6248R (x2)	48	3.0	\$8,720.76
Xeon® Scalable Gold 6258R (x2)	56	2.7	\$12,033.24

Intel® Xeon® W-2200 series SKU	# cores	Base frequency (GHz)	HP Z4 G4 online pricing
Xeon® W-2295	18	3.0	\$3,425.92

Intel® Xeon® Scalable Gold SKU	# cores	Base frequency (GHz)	HP Z8 G4 online pricing
Xeon® Scalable Gold 6248R	24	3.0	\$5,821.30
Xeon® Scalable Gold 6258R	28	2.7	\$7,477.53
Xeon® Scalable Gold 6246R (x2)	32	3.4	\$10,467.85
Xeon® Scalable Gold 6254 (x2)	36	3.1	\$11,669.85
Xeon® Scalable Gold 6242R (x2)	40	3.1	\$8,189.65
Xeon® Scalable Gold 6248R (x2)	48	3.0	\$8,720.76
Xeon® Scalable Gold 6258R (x2)	56	2.7	\$12,033.24

^{vi} Online pricing sample in June, 2020, with common components NVIDIA Quadro P2200, 32 GB 2x16 GB DDR3-2666 ECC memory, and 256 GB SATA SSD.

Dell Precision Fixed Workstation Model	Intel® Xeon® SKU	Cores	Price
5820 (15)	W-2245	8	\$2,559.89
	W-2255	10	\$2,664.65
	W-2265	12	\$2,971.95
	W-2275	14	\$3,237.35
	W-2295	18	\$3,425.92
7920 (25)	Xeon® Scalable Gold 6248R	24	\$5,821.30
	Xeon® Scalable Gold 6258R	28	\$7372.49
	Xeon® Scalable Gold 6248R (x2)	48	\$8,720.76
	Xeon® Scalable Gold 6258R (x2)	56	\$12,033.24

^{vii} 64C test system configurations

	Intel® Xeon® Scalable Platinum 8280 (28Cx2)	AMD Ryzen™ Threadripper™ PRO 3995WX (64C)
CPU cores (physical)	56 (2 x 28)	64
CPU base frequency (GHz)	2.7	2.7
Memory size (GB)	384 GB (2 x 6 x 32 GB)	256 (8 x 32 GB)
Memory channels	12 (2 x 6)	8
DDR Memory speed (ECC RDIMM)	2933	3200
Primary storage	PCIe Gen 3 M.2 NVMe SSD	PCIe Gen 3 M.2 NVMe SSD
GPU	NVIDIA® Quadro® RTX 6000	NVIDIA® Quadro® RTX 6000
OS	Windows 10 Pro	Windows 10 Pro

^{viii} Comparing to the popular 6-core Intel® Xeon® W-2235 CPU with a base frequency of 3.8 GHz.