Opteron Vs. Xeon

Spotlight
June 2005 • Vol.5 Issue 6
Page(s) 64-69 in print issue

Opteron Vs. Xeon

The Workstation Juggernauts Do Battle

The ASUS K8N-DL is a great platform on which to build an entry-level workstation.

Flash back to 1998 when Intel's Pentium II Xeon had just emerged on the scene, fusing the advantages of the Pentium II with the Pentium Pro, Intel's previous workstation flagship. AMD was still little more than an annoyance to Intel at that point, selling its K6 architecture as an alternative desktop solution. Although AMD stood up well against Intel's mainstream line, there simply wasn't any competition when it came to high-end workstations and servers.

It goes without saying that times have certainly changed. AMD's Athlon surfaced in 1999, immediately scoring fans amongst the gaming community and driving Intel's once-astronomical prices down. Athlon XP followed, earning AMD further accolades. But despite continued success on the desktop, AMD trudged on without an enterprise-worthy contender. Sure, it let loose with the Athlon MP dual-processor architecture, but that design never really convinced IT managers they should stray from Intel's established infrastructure. Besides, Xeon was already a full NetBurst-based core, similar to the Pentium 4, delivering high clock speeds and copious bandwidth. At the time those were the features that sold processors.

Even the single-core Opteron is a complex beast, with 1MB of L2 and 128KB of L1 cache.

Then, in 2003, Opteron hit store shelves, going on to thoroughly impress journalists and early adopters alike. By combining components of the preceding K7 core, an integrated memory controller, and 64-bit software extensions, AMD pulled even with Xeon's performance characteristics in many cases and zipped right past in others. At last there were two workstation candidates worth pitting against each other.

A Broadside Exchange

Epic battles are the subject of celebrated lore. From sports events to Wild West shootouts to battleship showdowns, there's nothing quite like two titans going toe to toe. After a relatively uncontested run at the top, Intel had finally met the Monitor to its Merrimac in AMD's Opteron. It seemed such a capable competitor took Intel by surprise. Without even touching performance in a 64-bit environment (operating system support wasn't quite there yet), Opteron laid down impressive 32-bit numbers that reflected a large on-die cache, low-latency memory accesses, and rapid inter-chip communications enabled through HyperTransport.

Although perhaps caught off guard, Intel wasted little time in preparing a comeback. Its 90nm manufacturing process was nearly ready for desktop retail consumption (finally realized in the Q1 2004), and Intel expected higher clock frequencies, lower power consumption, and enough flexibility to add such features as L2 cache. As it turned out, 90nm was certainly able to help bolster operating speed, but it didn't do much for the architecture's mounting power and thermal limitations. Fortunately, new features were added. Prescott, the desktop variant of Intel's new architecture, emerged with 1MB of L2, a 16KB L1 data cache, and SSE3 instruction support. The stage was officially set for Xeon to strike back.

AMD's Opteron Dissected

The naming scheme assigned to AMD's Opteron is somewhat arbitrary, yet it's easy enough to follow. All Opterons feature 1MB of L2 cache and populate a 940-pin socket. Where each model differs is in clock frequency. An Opteron x40 (where x represents the number 1, 2, or 8) runs at 1.4GHz. The x42 bumps that number up to 1.6GHz, and so on, up to the x52 models running at 2.6GHz.

Beyond core speed, Opteron processors are also divided into three families according to their multiprocessing capabilities. Workstations with just one chip tap the 100 series. Dual-processor setups require models in the 200 series. AMD's 800 series is reserved for four- and eight-way servers. As you ascend the hierarchy, price increases accordingly.

Although you can buy an Opteron through the channel for less money, AMD's boxed product gives you a retail heatsink, too.

Despite their multiprocessing differences, every Opteron features three HyperTransport links with which to communicate. On a single-processor platform, all three links may be used to attach core logic devices, such as PCI-X or PCI Express tunnels. A DP configuration leverages one link for inter-processor connectivity, while the other two support I/O devices. Some of the most intricate motherboards feature multiple chipset components attached to different processors through HyperTransport, enabling innovative features, such as dual x16 PCI-E ports with SLI support on Tyan's K8WE.

As mentioned, Opteron processors also boast an integrated memory controller operating at the host frequency. Because it's part of the silicon die, the controller isn't easily upgraded and as such still tops out with two, 64-bit channels of DDR400 memory. AMD claims that Opteron runs best using older DDR memory modules anyway, due to their timing advantages.

The culmination of AMD's subsequent revisions, advances in manufacturing, and progressive speed improvements is the Opteron 252. Running at 2.6GHz on a new 90nm lithography process, the 252 is a revision E chip. The 252 wields SSE3 support and an improved memory controller. A 1.4V-core voltage reduces the its power consumption, easing thermal constraints, too. Just bear in mind that recognizing a revision E Opteron requires an updated motherboard BIOS.

For Opteron processors manufactured after May 2004, a BIOS update will also enable PowerNow! technology, says Pat Patla, AMD's director of server and workstation marketing. In large server clusters, the addition means reduced air conditioning costs. Workstations are more likely to run cooler and quieter thanks to clock throttling capabilities switched on by the PowerNow! feature.

Intel's Xeon Analyzed

Intel's dual-processor contender, the Xeon DP, was ill-prepared to face off against Opteron back in 2003. No time was wasted in improving the workstation chip, though. Cache was doubled from 512KB to 1MB. Frontside bus speeds were accelerated from 400 to 533MHz, and core frequencies broke the 3GHz barrier. But that

still wasn't quite enough to topple Opteron.

Intel's Xeon DP is architecturally similar to the Pentium 4, but it utilizes a completely different interface designed with multiprocessing in mind.

Finally, early in 2004, Intel presented the "Nocona" core. Heavily laden with new functionality, Intel had an answer to AMD's challenge from a year prior. Recognizing that AMD's point-to-point topology and integrated memory controller gave Opteron an I/O advantage, Intel made a special effort to again augment bus frequency, this time to 800MHz. A larger L1 data cache further improved the processor's responsiveness. For a time the addition of SSE3 distinguished Xeon's multimedia alacrity, though AMD implemented the feature into its own products a year later.

The other notable architectural improvement was DBS (Demand-Based Switching), which is basically Enhanced Intel SpeedStep Technology for the enterprise. DBS throttled back voltage and clock speed to conserve energy. More importantly, it represented a power-saving feature that AMD didn't offer with Opteron.

Another of AMD's weaknesses was platform support. Workstation systems notoriously wield powerful graphics cards and robust disk I/O subsystems. Intel's PCI Express initiative signified a major step forward in this area by accelerating those critical data pathways. The "Tumwater" chipset emerged alongside Nocona, enabling significant bandwidth increases beyond what PCI-X or AGP could previously handle. Unfortunately, backward compatibility with those standards wasn't possible. Graphics card manufacturers led the way in adopting PCI-E, and Intel now expects that more than 50 PCI-E devices will be available by the end of this year. As you would expect, exclusive support for such a pervasive technology lent considerable credence to Intel's direction.

Another powerful workstation board, the Tyan K8WE is SLI capable, sports dual Gigabit Ethernet, and comes with optional Ultra320 SCSI.

Intel didn't stop there, however. The latest iteration of its Xeon DP processor centers on the Irwindale core, which in many ways is similar to the Pentium 4 600-series of processors with 2MB of L2 cache. Irwindale is an interim solution while the dual-core Xeon is polished, and the processor benefits from an 800MHz frontside bus, 64-bit capabilities, NX-bit support, DBS, and the same beefy E7525 platform introduced previously. The fastest model operates at 3.6GHz. The processor is great competition for AMD's Opteron 252.

AMD Emphasizes Dual-Core Workstations

Both AMD and Intel have had dual-core processor technology on their radars for a while now. Intel planned to assault the desktop market first with its Pentium D, which has already made a debut in limited press sampling. AMD, hoping to duplicate Opteron's initial success, chose to focus on the server and workstation dual-core variant, leaving mainstream desktops for the last half of 2005.

AMD's approach seems to make the most sense. Much of the software written for workstations and servers is already multithreaded, meaning that upper echelon of content designers, administrators, and programmers stand to benefit from dual-core technology immediately. AMD's cause is further strengthened by platform support. Dual-core Opteron and Athlon 64 processors are fully socket-compatible with existing Socket 940 and Socket 939 configurations. So long as the motherboard can support existing 90nm Opteron processors, a BIOS update guarantees that the new chip will be properly recognized and utilized.

How did AMD manage such a smooth transition? According to Patla, the architecture was conceptualized in 1999 with dual-core in mind. In essence, the pieces have always been there. However,

"Tumwater" is the premier workstation chipset for the Xeon DP, enabling PCI Express connectivity, DDR2 memory, and support for an 800MHz bus.

AMD's Damon Muzny says that only now as AMD completes its shift to 90nm manufacturing is a single die with two cores reasonable to produce.

The dual-core Opteron architecture mates two processing cores, each featuring 64KB of instruction cache, 64KB of data cache, and 1MB of L2 cache, with a system request queue and crossbar. The crossbar interfaces with three Hyper-Transport links that deliver 32Gbps of bandwidth each, along with an integrated memory controller supporting two channels of DDR400 RAM. Although both cores are forced to share the available memory, AMD claims less than a 10% performance reduction. The Hyper-Transport links are also shared, but thanks to a recent bump to 1GHz, there's plenty of bandwidth to satiate both cores.

Intel: Us, Too!

With more than 10 multicore projects spanning the desktop, server, and mobile markets, Intel is being forced to prioritize. For now that means dual-core workstations will have to wait until Q1 2006. It's not all bad news, though. Intel's first dual-core Xeon (Dempsey) will center on an upcoming 65nm manufacturing process, suggesting faster clock speeds and diminished power-consumption requirements.

There will also be architectural improvements that may give Intel a leg up on AMD, including I/O Acceleration Technology, Virtualization Technology, and Active Management Technology. The combined effect of those new features, according to Intel, will be up to 30% more network I/O, hardware accelerated RAID functionality, the ability to run multiple OSes in independent partitions, and remote troubleshooting capabilities, which is a boon to SMBs and enterprise customers.

While it wasn't necessarily designed for the job, ASUS tweaked the 875P chipset for workstation applications in its NCCH-DL. It lacks PCI Express but is still more than capable of battling an Opteron board.

Whereas AMD will quickly remind you that dual-core Opteron fits in today's platform infrastructure, Xeon doesn't enjoy the same luxury. For the value-conscious, such a situation is understandably frustrating, especially if you recently acquired a single-core workstation. On the flip side, however, a fresh chipset means improved features and, hopefully, increased performance. A 1,066MHz FSB is said to be on tap, as is a new Gigabit Ethernet physical layer and ESB2 enterprise-level southbridge. Those features, together with Intel's improved processor architecture, will undoubtedly heat things up.

Even more compelling than the performance characteristics boasted by upcoming dual-core workstation processors is the true value that they'll enable in environments that are sensitive to threaded software. Tally up the costs of a dual-processor workstation today. Start with the requisite motherboard, add a pair of CPUs, factor in the memory necessary to keep both chips populated with 128-bit buses, and consider the other high-end components. With dual-core you start with a single-socket motherboard, which immediately shaves hundreds of dollars off the price. When you factor in the processor price, a single dual-core system enables much better threaded performance for significantly less than a traditional DP setup.

A Secret Weapon Springs Forth

Given Intel's buzz about dual-core workstations later in 2005, you would think the technology was still some way off. In actuality, AMD is already manufacturing its dual-core Opteron in 100, 200,

and 800 series trims. The incredibly complex chip consists of 205 million transistors on a 90nm process. As such it's still a bit limited in how fast it operates; the flagship Opteron 875 cruises at 2.2GHz, as do the 275 and 175 models.

Clearly, AMD's dual-core nomenclature deviates somewhat from established convention. It's still easy enough to decipher, though, with successive models emerging in multiples of five, each representing a 200MHz jump. According to AMD the new Opteron processors will initially carve out higher price points and over time fall to the levels of single-core chips.

But that does no't mean single-core CPUs will disappear any time soon. In fact, AMD recommends that workstations primarily tasked with nonthreaded applications stick with single-core Opteron or Athlon 64 FX chips, which run at higher frequencies and, in turn, yield better performance than today's dual-core products.

In Retrospect

Now that AMD and Intel are competing more aggressively in the workstation market, expect to see innovation transpire at a dizzying pace. Already AMD has motivated Intel to adopt 64-bit computing, while Intel's DBS pressured AMD to add PowerNow! to the Opteron. Both processing architectures populate powerful platforms, with PCI-E and massive memory support. Without question, the next step is dual-core.

AMD has already laid its dual-core plans on the table, along with retail product. Intel's response is nearing completion. The two companies are taking somewhat different approaches, yet they'll both forever impact the workstation market by improving value and ratcheting performance.

For the time being, the epic battle between Opteron and Xeon wages on without a decisive victor. AMD clearly leads in a majority of our benchmarks, but Intel's efforts to pull even are clear. No matter which way you slice it, power users will realize the most benefit as processor, graphics, and storage manufacturers one-up each other in the workstation marketplace. ■

by Chris Angelini

Build vs. Buy

The decision to build or buy is difficult enough when it involves a gaming PC. Workstations can get even trickier. Sure, there's money to save by doing it all yourself. But do you already know what hardware best suits your needs? Engineering-design software is heavily CPU dependant, while content creation and MCAD (mechanical computer-aided design) apps often emphasize graphics performance. Wouldn't it just be better to let the professionals handle the configuration side of things?

We priced out a top-tier workstation from HP and pit it against a home-brewed kit to see which one offered more value. The HP xw6200, equipped with two Xeon 3.2GHz 1MB processors, Windows XP Pro, an NVIDIA Quadro FX 3400, 2GB of registered DDR400 memory, a pair of 160GB hard drives, and a 16X DVD writer came out to $4,151, excluding the price of a display.

The same setup with two retail Xeon chips, an ASUS NCT-D "Tumwater" motherboard, 2GB of Kingston memory, the same Quadro card, Seagate hard drives, Plextor's PX-716A, an EPS12V power supply, and a $200 workstation

chassis cost just $3,200, including Windows XP. So long as you're comfortable putting the pieces together, building your own workstation is an easy way to save a cool grand vs. a prebuilt configuration.

Workstation Applications

Things are getting "hairy" here with Maya at work.

The differences between workstations and desktop PCs are often subtle, especially for power users who regularly run demanding applications at home. However, a handful of software applications characterize the heavy usage typical of the workstation environment.

Among the titles you'll likely find on a multiprocessor (or multicore) workstation, AMD cites computer-aided engineering tools such as MSC Software's Nastran, Fluent's computational fluid dynamics software, and ANSYS' applications. Digital content creation solutions, such as Maya, SoftImage XSI, and 3D Studio Max, are also quite taxing. Electronic design automation is a focus of attention, too, as are scientific applications driven by the medical and energy industries.

No, that's not an in-game screenshot. It's a development photo from the artists at DICE who use Maya to render car models in the Rallisport games.

You might need a workstation if you use computer-aided engineering tools, such as MSC Software's Nastran.

Fancy software isn't requisite for workstation qualifications, though. Even Microsoft's Windows Media Encoder 9, a free download, stands to benefit from high-caliber hardware. The same goes for iTunes and DVDShrink, both popular mainstream programs that really take off when you bring out the big guns.

What Does SLI Mean To Workstations?

If you drool at the thought of dual-core processors, multiple graphics cards likely whet your whistle, too. Previously, cooperative-rendering workstations involved proprietary equipment, including expensive hardware and comparably priced software support. Quantum3D and Evans & Sutherland are two recognizable names in that high-end graphics market.

With a motherboard, such as Tyan's K8WE, and a pair of Quadro graphics cards, you can add SLI to a workstation, multiplying graphics performance.

However, the development of SLI technology makes powerful workstations more accessible by multiplying graphics performance. NVIDIA claims that MCAD (mechanical computer-aided design), DCC (digital content creation), and nonlinear video-editing applications will all run faster on workstations outfitted with an nForce Professional chipset and a pair of compatible Quadro FX graphics cards.

The clear caveat is that NVIDIA is now in the position to support SLI and cultivate its benefits. Performance gains aren't automatic. Rather, SLI functions as advertised only after software drivers have been optimized on a per-application basis. The current list of compatible programs is laden with games but doesn't name a single professional title. SLI has the potential to make a major impact on workstation graphics, but we're not quite there yet.

Workstations Put To The Test

Anxious to determine which processor delivers optimal performance, we assembled three workstation configurations representing the very best from Intel and AMD.

The first setup was armed with a pair of Opteron 252 processors running at 2.6GHz. ASUS' K8N-DL served as the test platform, centering on NVIDIA's nForce Professional 2200 chipset. The board's single PCI Express x16 slot was populated with a GeForce 6800 Ultra graphics card, and we used 2GB of Corsair's best registered DDR400 low-latency memory.

The second system leveraged two Intel "Irwindale" Xeon DP chips, each with 2MB of L2 cache running at 3.6GHz. ASUS was kind enough to send its NCCH-DL, an 875P-based motherboard limited to AGP 8X graphics support. The original plan was to feature another PCI-E platform, but Supermicro, Iwill, and Tyan all turned down the invitation to send an E7525 motherboard for testing. Consequentially, the NCCH-DL was outfitted with an AGP 8X GeForce 6800 Ultra and 2GB of Corsair DDR400 RAM.

We also took a pair of new Opteron 875 dual-core processors running at 2.2GHz

and dropped them into the same ASUS K8N-DL motherboard with its latest BIOS. Again, one GeForce 6800 Ultra did the trick, along with 2GB of the Corsair registered DDR400 memory.

Perhaps these results will surprise you. After all, the dual-core Opteron 875 only sweeps one test, the Cinebench 2003 render benchmark. Remember that a pair of 3.6GHz Xeon processors also enables four threads through Hyper-Threading and most of the applications tested seem most responsive to two threads running simultaneously. Two Opteron 252s do the best job of combining raw processing power with multithreaded alacrity here. There are indeed instances where the 875 sprints ahead, such as 2D content creation and PCMark's memory test. However, at 2.2GHz you're not going to see a major improvement unless your software is heavily optimized for multithreading.

Multitasking is another story entirely. The Opteron 875 and Xeon DP systems were able to run Windows Media Encoder at full tilt with roughly 48% processor utilization, leaving plenty of power left over to run other apps.

Workstations Benchmarked	**Dual Opteron 252 (2.6GHz)**	**Dual Opteron 875 (2.2GHz)**	**Dual Xeon DP 3.6GHz (2MB)**
SYSmark 2004			
Overall	276	248	264
Internet Content Creation	351	315	330
3D Creation	316	214	301
2D Creation	418	427	392
Web Publication	327	323	304
Office Productivity	217	196	212
Communication	208	193	192
Document Creation	263	235	232
Data Analysis	188	166	213
SPECviewperf 8.01			
3dsmax-03	19.56	17.85	19.11
catia-01	13.18	12.6	12.92
ensight-01	13.5	12.98	13.77
light-07	11.89	11.27	10.41
maya-01	22.02	19.71	21.73
proe-03	17.54	15.54	18.14
sw-01	15.75	15.4	16.16
ugs-04	5.268	5.223	5.579
PCMark04	7414	6438	6811

CPU	7122	6177	6776
Memory	3735	4289	5589
Dr. DivX	12:11	14:35	11:54
Windows Media Encoder 9	3:39	4:09	4:23
Cinebench 2003	0:38	0:25	0:38

Want more information about a topic you found of interest while reading this article? Type a word or phrase that identifies the topic and click "Search" to find relevant articles from within our editorial database.

Enter A Subject (key words or a phrase):

(•) ALL Words ('digital' AND 'photography')

( ) ANY Words ('digital' OR 'photography')

( ) Exact Match ('digital photography'- all words MUST appear together)

Search

Return to Previous Page