Athlon XP 2600+ Reviewed

By Johan De Gelas – August 2002

AMD Takes Up the Gauntlet with Flair

The last few quarters have been pure agony for AMD. Sales and turnover figures plunged to terrible lows and AMD's results where written in bloody red ink. Thoroughbred, the 130 nanometer Athlon XP was limited to a 66 MHz increase over its older brother Palomino. The race with Intel was lost: Intel's 2.53 GHz Pentium 4 was arguably the fastest x86 processor in the world. After launching the Thoroughbred Athlon XP 2200+, many people on the Internet were forecasting doom scenarios for AMD.

The disappointing initial clockspeeds were, however, no surprise for the hardware veterans among you. When Thoroughbred was launched, we stated:

> "Our sources indicate that AMD's yields at 0.13µ are pretty good, but the current bin splits have a lot of room for improvement. While 1.5V is good enough to get the Thoroughbred up to 1600 MHz, higher clockspeeds are only attained with some kind of overclocking. Now this is hardly of a reason for panic, as it is even sort of a "tradition" for AMD. With far fewer resources for debugging and tuning, new process technology almost always experiences some teething problems."

Contrary to Intel, AMD has neither funds nor fabs for backup plans, so moves to new process technology or new processor layouts are always somewhat risky. New process technology or layout changes often initially result in yield, clock scaling, and/or binsplit problems, and the time that it takes to resolve these issues tends to be very variable. The Palomino started at a bleak 1.2 GHz while its less advanced brother, Thunderbird, happily ran at 1.5 GHz with good cooling. But in the end, AMD's engineers once again solved the initial process problems, and it was pretty impressive to see that the 0.18-micron Palomino reached no less than 1.733 GHz.

History repeats itself again, because today, AMD launches the Thoroughbred Athlon XP 2600+ at no less than 2.133 GHz! And contrary to its 2200+ brother, this processor not only breaks the 2 GHz barrier, but runs overclocked at up to 2.4 GHz. This 12.5% aircooled overclock shows that the newest addition to AMD's processor line still has a lot of headroom.

Turn Up the Volume!

How did AMD squeeze over 300 MHz more out of their flagship CPU? Damon Muzny sent this report to all reviewers:

> "AMD has successfully implemented a process change for the "Thoroughbred" processor core that involved adding an additional layer of metal to reduce resistance and capacitance. AMD has also engineered additional decoupling capacitors to reduce electro magnetic interference. Finally, AMD always takes an active approach to rebalance and improve speed paths throughout the processor core design."

Let us take try to explain this statement in a bit more detail. I discussed the matter with our own Chris Rijk, which I like to thank for his help with the following paragraphs.

Process technology and making best use of it for a particular CPU is a matter of continuous improvement, so AMD would likely have had some engineers working on what they'd need to do to achieve 2.1GHz+ by this time, in addition to the work to get the initial Thoroughbred CPUs to market. There's not much that's unusual about the improvements AMD has made.

Let us start by discussing *"involved adding an additional layer of metal to reduce resistance and capacitance".* The new Thoroughbred has 7 metal layers, instead of 6, which enables the wires connecting different parts of the CPU to be packed more densely. Comparisons to objects on a human scale aren't terribly accurate, but imagine a very wide building with just a few floors - an alternative design with one more floor would have the same floor area with a narrower design, and the average distance between two offices would be shorter. However, the die size seems unchanged (84 mm^2, so it is possible the layout changes cancelled out any reduction in die size.

Shorter wires have lower resistance, and allow the **critical paths to become faster**, improving the maximum clockspeed of the CPU. This also **makes the CPU slightly smaller, and reduces power consumption by a small amount** at the same clock rate. The downside is that yields suffer because it's harder to stack additional metal layers flawlessly. With a shorter pipeline, the Athlon probably benefits more from extra metal layers than the Pentium 4. The Pentium 4 has many more pipeline stages (+/- 28 versus 12 to 15 for the Athlon), so critical paths are already shorter.

Most CPUs have the number of metal layers increased once or twice in their life-time, and AMD had announced some time ago that their 0.13µ process would support up to 8ML - maybe ClawHammer will be 7ML and SledgeHammer will be 8ML. The high-end RISC chips use 7ML at 0.18µ and some will likely use 8ML at 0.13µ. For example, the UltraSPARC-III and POWER4 are both 7ML at 0.18µ. Intel uses 6ML at 0.18 and 0.13µ, and plans to use 7ML when migrating to 0.09µ.

So what about *"AMD has also engineered additional decoupling capacitors to reduce electro magnetic interference"*? CPUs have tiny capacitors on the die itself to help separate (decouple) different parts of the CPU. Improving signal integrity (due to less electromagnetic interference between the different parts) means the CPU can operate reliably at higher clock rates.

Finally, The third line suggests that AMD has improved the layout of the design and indicates that the rumors about a problematic layout with the original design were indeed correct. Speed paths are often improved with minor steppings, and are much more common than layout changes. Of the nearly 20% clock rate improvement, most probably comes from the extra metal layer, layout rebalance, and speed path improvements, with the decoupling capacitors providing the rest. In addition, with AMD rapidly migrating to 0.13µ the simple volume of production will make it easier to add another speed grade.

Week 31 of 2002: AMD is back on track

Cheers to Quantispeed!

The Quantispeed (QS) rating of the Athlon XP 2600+ is slightly conservative. The Athlon XP 2200+ is a 1.8 GHz chip and using the "add 100 to the QS rating for each 66 MHz" rule; you would have expected the 2600+ to be a 2066 MHz CPU. However, to make sure that the Athlon XP 2600+ really lives up to the claim that it can beat a 2.6 GHz Pentium 4, AMD added another 66 MHz.

We will investigate this claim further, but I would like to point out that in most cases, this kind of Performance Rating system is a good thing for consumers. Provided that the Athlon XP 2600+ really perform as well as competing 2.6 GHz processors in the most popular applications, it gives the consumers who do not want to take the time to read publications like Ace's Hardware with a quick performance indicator.

The buyers of Intel chips should be fond of AMD's QS rating for another reason. When the Athlon XP 2200+ was the fastest AMD processor, all Intel processors running at 2.2 GHz and below were competitively priced. Before the introduction of the Athlon XP 2600+, a 2.4 GHz Pentium 4, cost up to twice as much as a 2.2 GHz Pentium 4, despite the fact that it was less than 10% faster. Would Intel have priced its 2.2 GHz processor competitively if AMD's fastest processor was advertised as being 1.8 GHz?

Let's take a look at the thermal characteristics of the new Athlon XP.

Processor Model	MHz	Nominal Voltage	Typical Thermal Power (130 nm "Thoroughbred")	Typical Thermal Power (180 nm- 1.75V- "Palomino")	Difference	Maximum Thermal Power (130 nm "Thoroughbred)"	Maximum Thermal Power (180 nm- 1.75V "Palomino")
1700+	**1467**	1.50V	44.9W	57.4 W	28%	49.4W	64.0 W
1800+	**1533**		46.3W	59.2 W	28%	51.0W	66.0 W
1900+	**1600**		47.7W	60.7 W	27%	52.5W	68.0 W
2000+	**1667**	1.60V	54.7W	62.5 W	14%	60.3W	70.0 W
2100+	**1733**		56.4W	64.3 W	14%	62.1W	72.0 W
2200+	**1800**	1.65V	61.7W	N/A	N/A	67.9W	N/A
2600+	**2133**	1.65V	62W	N/A	N/A	68.3W	N/A

Indeed, the seventh metal layer has reduced power dissipation. The dissipated thermal power of the Athlon XP 2600+ is hardly higher than the 333 MHz slower Athlon XP 2200+. Time for some benchmarks.

Benchmarked Configurations

All systems were tested with NVIDIA's Detonator 30.82 drivers. The desktop was set at a resolution of 1024x768x32bpp with an 85 Hz refresh rate. V-sync was off at all times.

We used Corsair's XMS 3200 CAS 2 DDR (DDR400) for maximum overclocking possibilities and stability. We will discuss DDR400 in more detail in the next review. In this review, the XMS32000 were running at 166 MHz DDR (333 MHz) and configured in all systems to work with a CAS latency of 2. To make the comparison as fair as possible, both the Athlon and the Pentium 4 were tested on platforms supporting DDR333.

Systems

1 GHz, 1.4 GHz Athlon (Thunderbird), Athlon XP 2000+, Athlon XP 2200+ (Thoroughbred), Athlon XP 2600+ (Thoroughbred)

- **ASUS A7V333 BIOS version 1.008**

Pentium 4 (Northwood) 2 GHz (400 MHz FSB), 2.4 GHz (400 MHz FSB), 2.4 GHz (533 MHz FSB), 2.53 GHz (533 MHz FSB)

- **MSI 845G-MAX (i845G chipset) BIOS version 1.4**

Shared Components

- **512 MB Corsair PC3200 XMS (DDR-SDRAM) running at 333 MHz CAS 2**
- **Seagate Barracuda ATA III ST320414A Model ST320414A (7200 rpm, ATA-100)**
- **ASUS Geforce Ti4400 128 MB**
- **AT 2700 10/100 Mbit NIC**
- **Sound Blaster Live!**

Software

- **Via 4 in 1 Drivers 4.42**
- **Intel chipset inf update 4.09.1011**
- **Windows XP**
- **DirectX 8.1**

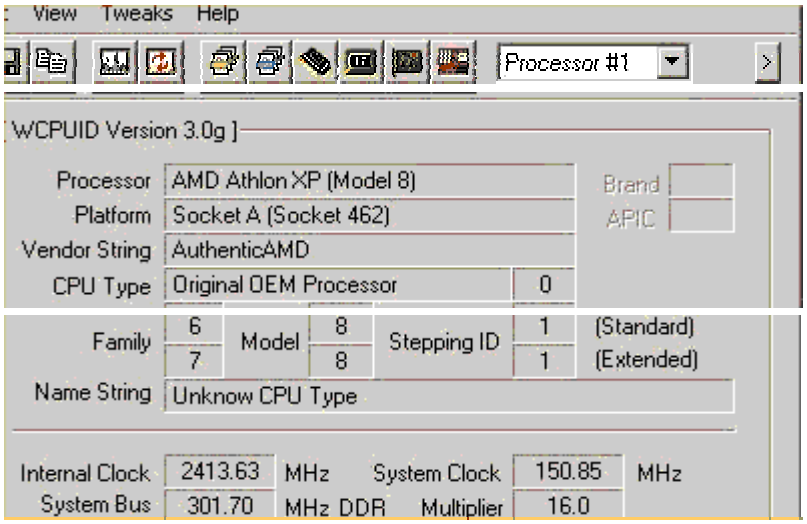
We'd like to thank the following helpful people for their support and important contributions to this review:

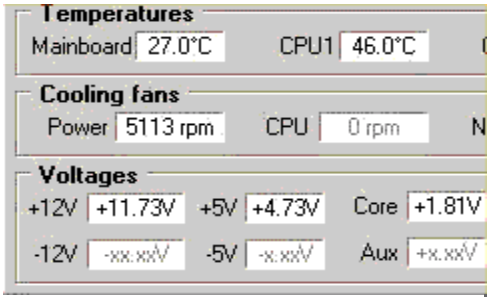
- Damon Muzny (AMD) made sure we were able to test the Athlon XP 2600+ and Athlon XP 2200+ Thoroughbred.
- Thanks to Augustine Chen, Carol Chang (ASUS) and Sharon Tan (BAS computers Netherlands) for the ASUS A7V333
- Angelique Berden and Saskia Verhappen of MSI provided us with the MSI 845 GMax
- Jurgen Eymberts (Intel) and Marieke Leenhouts (MCS) made sure we could test the Pentium 4 2.0A GHz, 2.4 and 2.53 GHz.
- Robert Pearce of Corsair, provided us with Corsair's PC3200CAS2 XMS.

Overclocking the Athlon XP 2600+

We have already given away that the new Athlon XP overclocks rather well. While the Athlon XP 2200+ was hardly capable of overclocking more than 7%, the Athlon XP 2600+ has reached up to 2.4 GHz.

At first, we simply tried out the large 60x80 mm Taisol CGK760172 heatsink and fan combination. To get the Athlon up to 2.4 GHz, we had to push the voltage to 1.85V, which is not really a safe thing to do. With no significant load, the temperature of the processor stayed around 56°C. However, the processor became unstable after heavy benchmarking, as the temperature rose to 60°C and beyond when we ran 3DSMax and some gaming benchmarks.





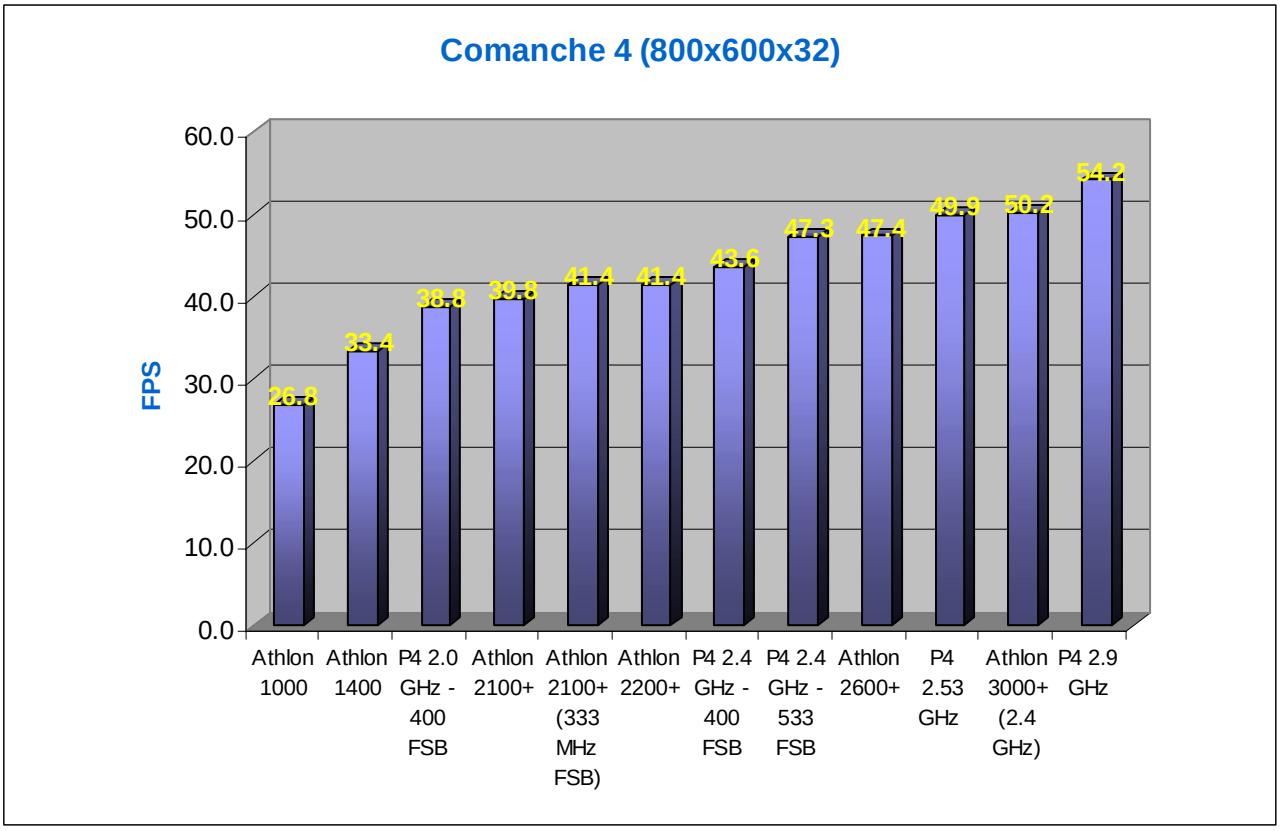
Next, we used the same large Taisol CGK760172 heatsink but we installed a 6800 RPM Delta AFB-60HP fan on top of it. We were now able to run at 2413 MHz, and we could lower the voltage to 1.8V. This way, the temperature stayed around 46°C, which is cool for a 2.4 GHz Athlon processor. With 1.85V, we could even come close to 2.5 GHz, but the system never proved to be stable, not even at 2.44 GHz.

So a stable overclock to 2.4 GHz is possible with good aircooling. This 12.5% overclock allowed us to demonstrate what an Athlon XP 3000+ might be able to do. At 2.4 GHz, our Corsair XMS 3200 DIMMs were definitely running under their capabilities, as they were only running at 300 MHz (150 MHz DDR) CAS2. The VIA KT333 chipset seems to force a 1:1 relationship between the FSB and memory once you overclock beyond 133 MHz.

The 2.53 GHz Pentium 4 reached 2.9 GHz (1.7V), but it must said that our processor was an older one. Current 2.53 GHz models can reach 3 GHz. I'd like to thank Loveno (Belgium) and OC Shop Netherlands for borrowing the Delta AFB-60HP fan and offering their overclocking expertise.

Gaming Benchmarks

No less than 7 different game engines were tested! Comanche 4, the military helicopter simulator, is our first benchmark.



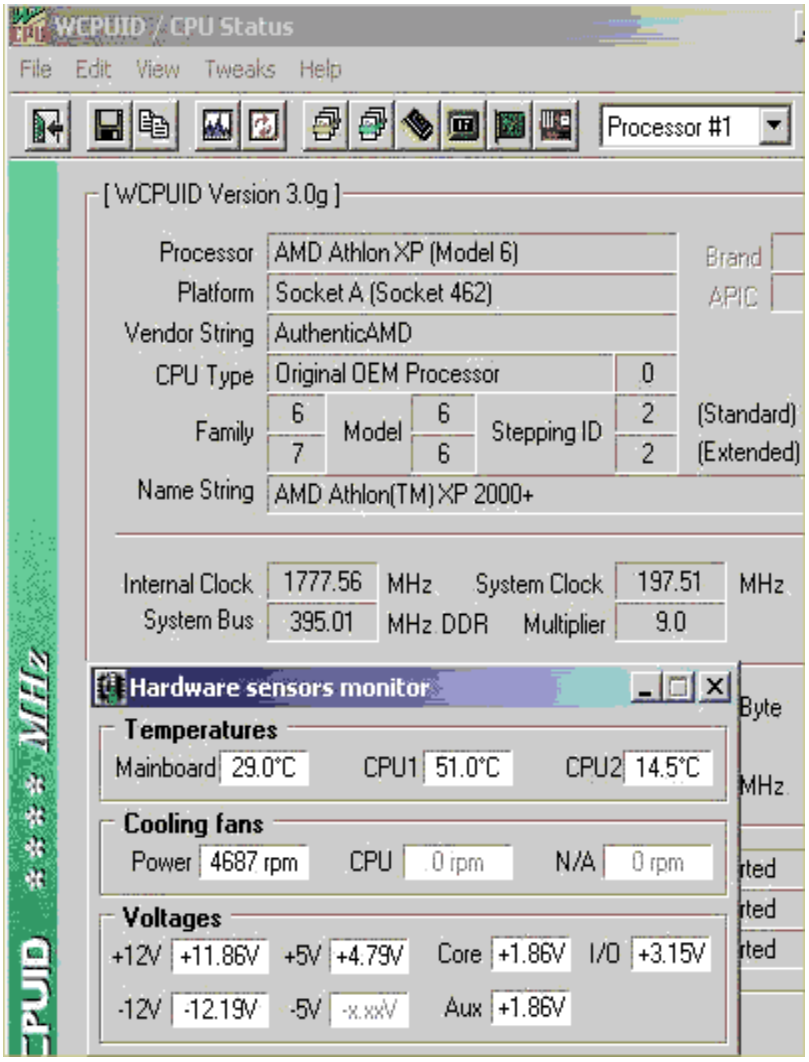
To make the benchmark more interesting, I included an Athlon MP 2000+ processor. This CPU has an unlocked multiplier which allowed us to run it at 10.5 x 166 MHz and 13 x 133 MHz, which resulted in a 1733 MHz CPU (Athlon 2100+) in both cases. The Athlon 2100+ with the 333 MHz FSB was roughly 4% faster than the 266 MHz FSB version. Nice, but not an earth shattering boost. Now let us compare the two 2.4 GHz Pentium 4 CPUs in this test. The first 2.4 GHz CPU runs with a 400 MHz FSB, and the i845G chipset forces the DDR SDRAM to run at 266 MHz. The second one runs with a 533 MHz FSB, and we were allowed to run the memory at 333 MHz. This difference in FSB and memory speed made Comanche 4 run 8.5% faster, which is rather impressive. From this limited amount of data, we can speculate that the Pentium 4 benefits slightly more from faster memory than the Athlon. Of course, you can reverse the statement and say that the Athlon doesn't depend so much on memory performance as the Pentium 4. High multipliers and thus clockspeeds make the Pentium 4 more sensitive to the speed of the memory.

There is another factor, however. To illustrate this we tested the different platforms with "membench" which is part of Tim Wilkens' superb ScienceMark 2.0 benchmarking tool.

ScienceMark 2.0 Bandwidth			
CPU	**FSB**	**DDR Speed**	**Bandwidth**
Athlon 2100+	**266 MHz**	**266 MHz**	**1908 MB/s**
Athlon 2100+	**266 MHz**	**333 MHz**	**1943 MB/s**
Athlon 2100+	**333 MHz**	**333 MHz**	**2254 MB/s**
P4 2.4 GHz	**400 MHz**	**266 MHz**	**1826 MB/s**
P4 2.4 GHz	**533 MHz**	**333 MHz**	**2290 MB/s**

The Athlon platform, currently at 266 MHz FSB and 333 MHz DDR, would gain about 300 MB/s from upgrading the FSB to 333 MHz. The Pentium 4 platform, however, gains almost 450 MB/s from the recent upgrade of the FSB to 533 MHz and the ability to use 333 MHz DDR on the i845G.

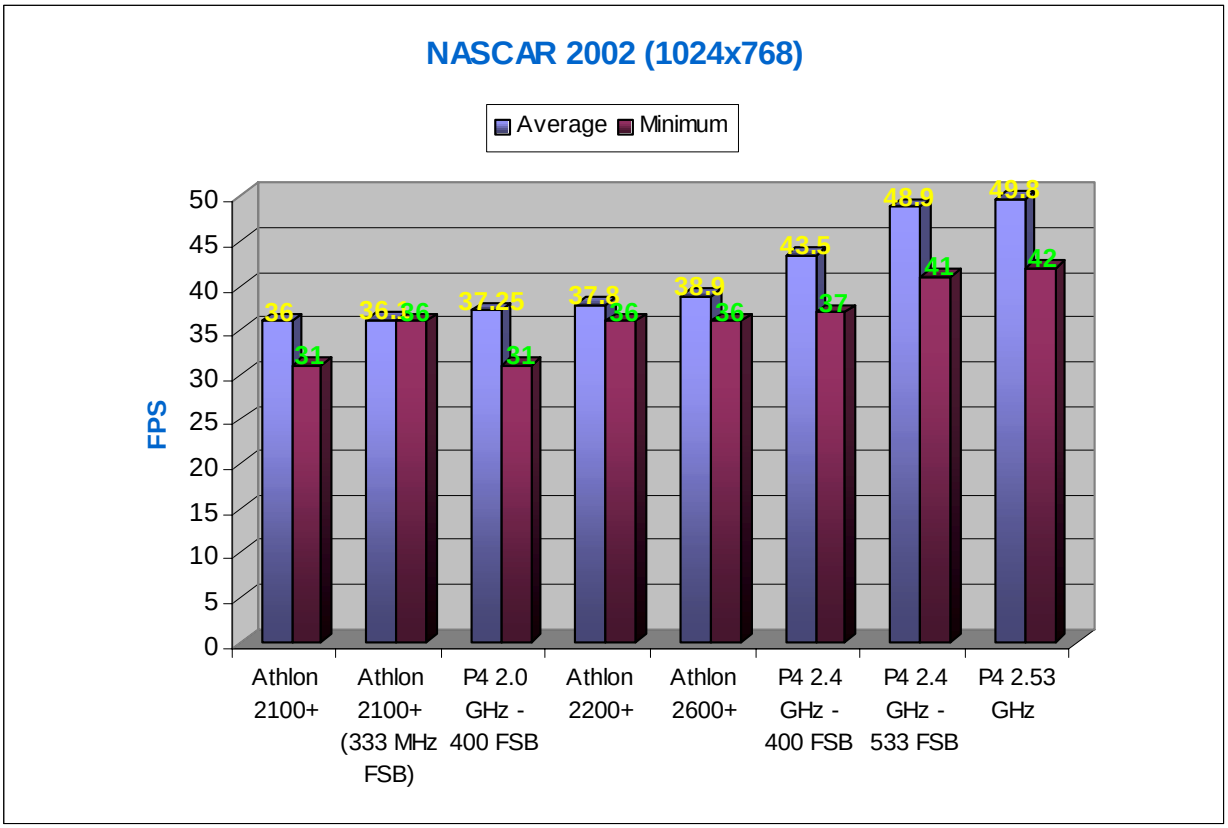
This doesn't mean of course that moving the Athlon platform to a 333 MHz FSB will not pay off. The 4% performance gain that we report at 1.733 GHz might grow to maybe 5 or 6% when we test with Athlons running at 2.1 GHz and more. Out of curiosity, I boosted the FSB of the Athlon MP to 395 MHz (197 MHz DDR), and lowered the multiplier to 9.



It is quite impressive what the combination of the Corsair XMS 3200, ASUS A7V333 and the old Athlon MP 2000+ are capable off. A 400 MHz FSB was just a few MHz too much.

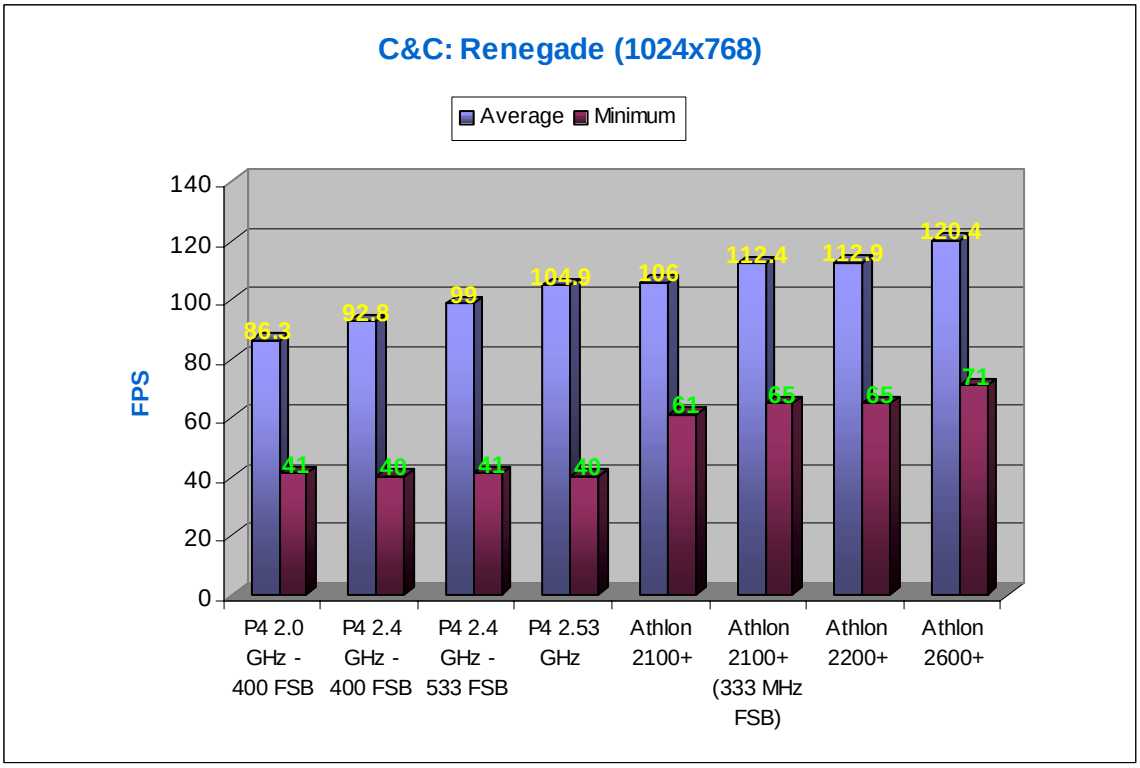
When we benchmarked this 1780 MHz CPU with its 395 MHz FSB, Comanche 4 ran at 43.4 fps, which is a 5% boost from an original 1800 MHz (266 MHz FSB) Athlon. We will have to benchmark many more game engines, but for now, it seems that the boost that the Athlon platform will get from migrating to a 166 MHz FSB will be significant, but not spectacular.

Let us take a look at a racing simulator, Nascar 2002.

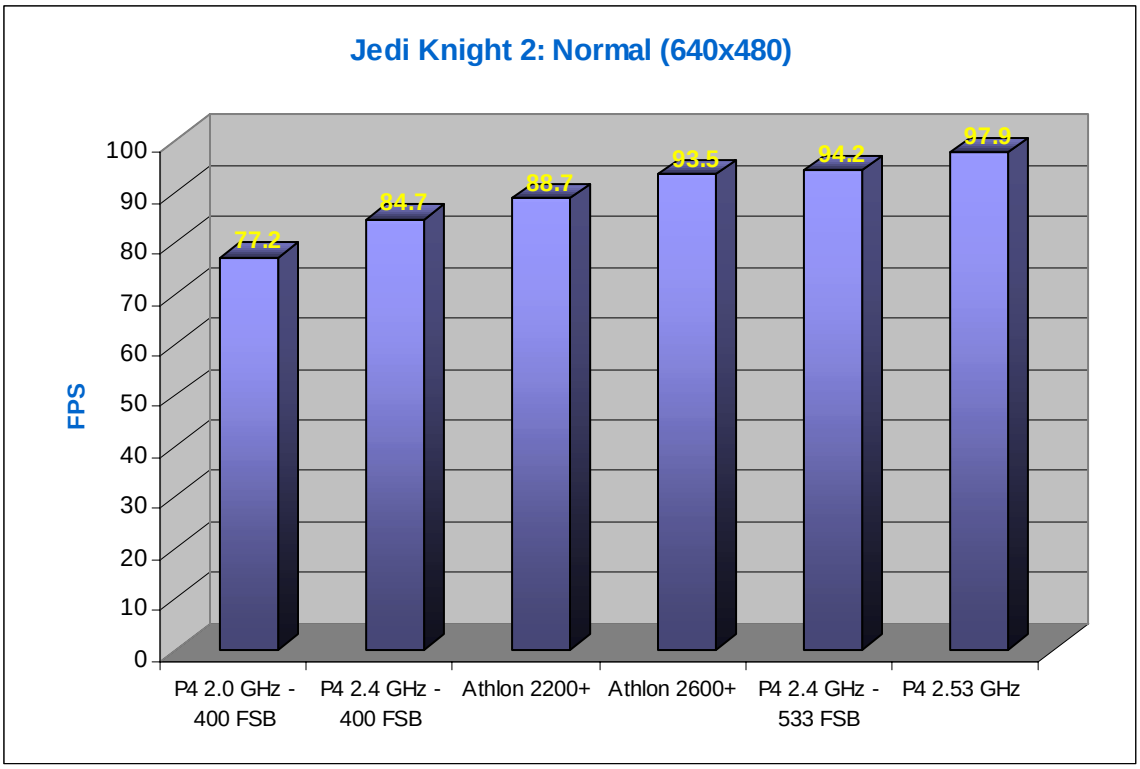


Again, the Athlon XP 2600+ is not capable of beating the Pentium 4 2.53 GHz. Might the QS rating be too high? Well, both Nascar 2002 and Comanche 4 are optimized for the Pentium 4. And looking at Intel's rather short list here, we will only find out if we try to test as many game engines as possible... the next two being first person shooters.

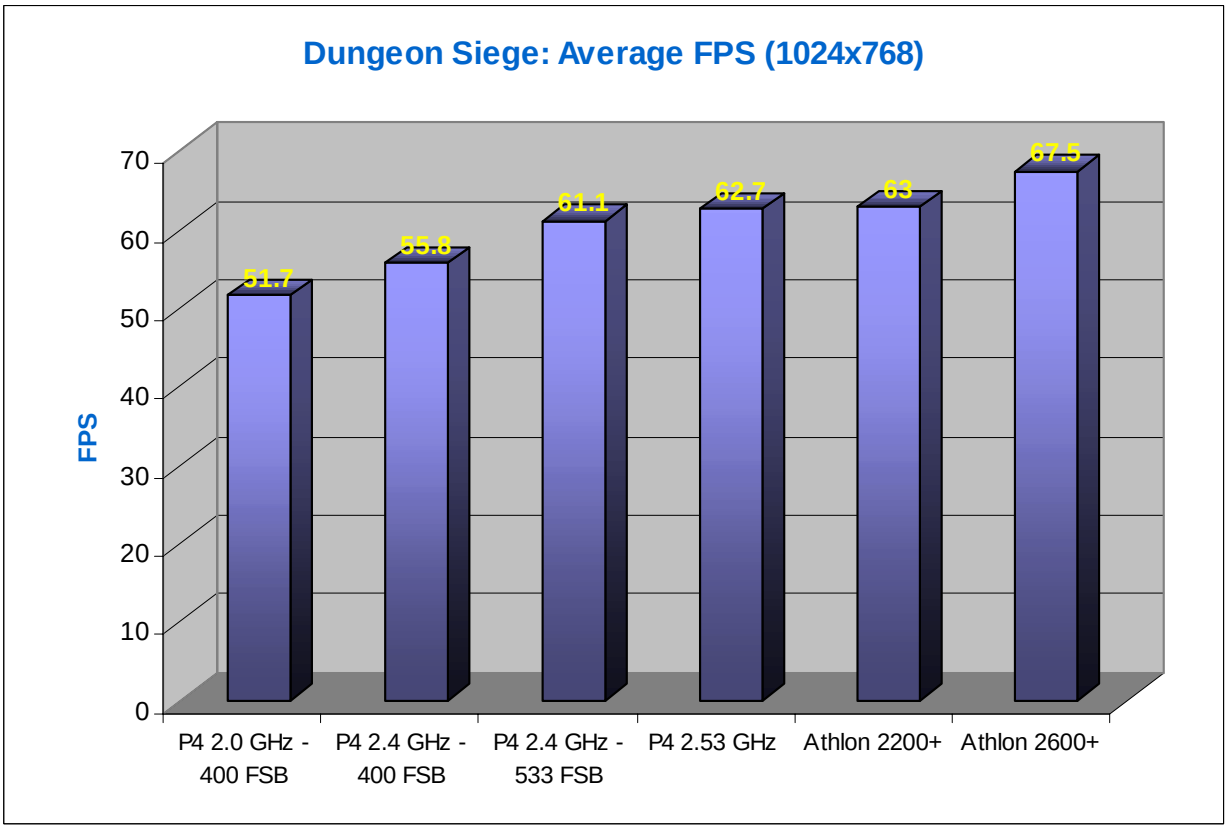
More Gaming Benchmarks



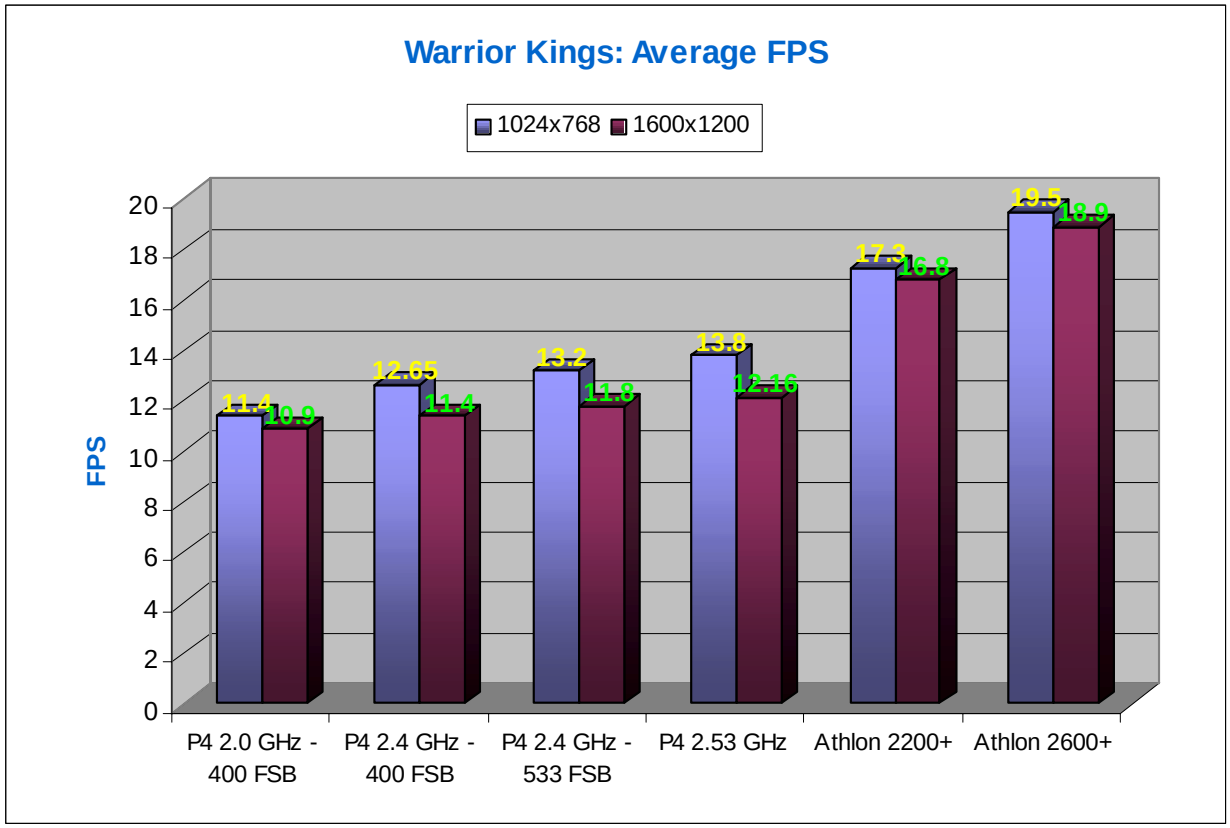
C&C Renegade, one of the most popular first person shooters, brings better news for the Athlon. This time, the Athlon XP 2600+ is no less than 15% faster than the 2.53 GHz Pentium 4.



Jedi Knight 2, on the other hand, prefers the 533 MHz FSB Pentium 4. The Athlon Thoroughbred family easily outperforms the 400 MHz FSB (DDR266) Pentium 4, but is slightly slower than 533 MHz FSB (DDR333) version. First person shooters and simulators are not the only popular game genres, though. Role playing games have made a big comeback in past years. Let us try out Chris Taylor's Dungeon Siege.

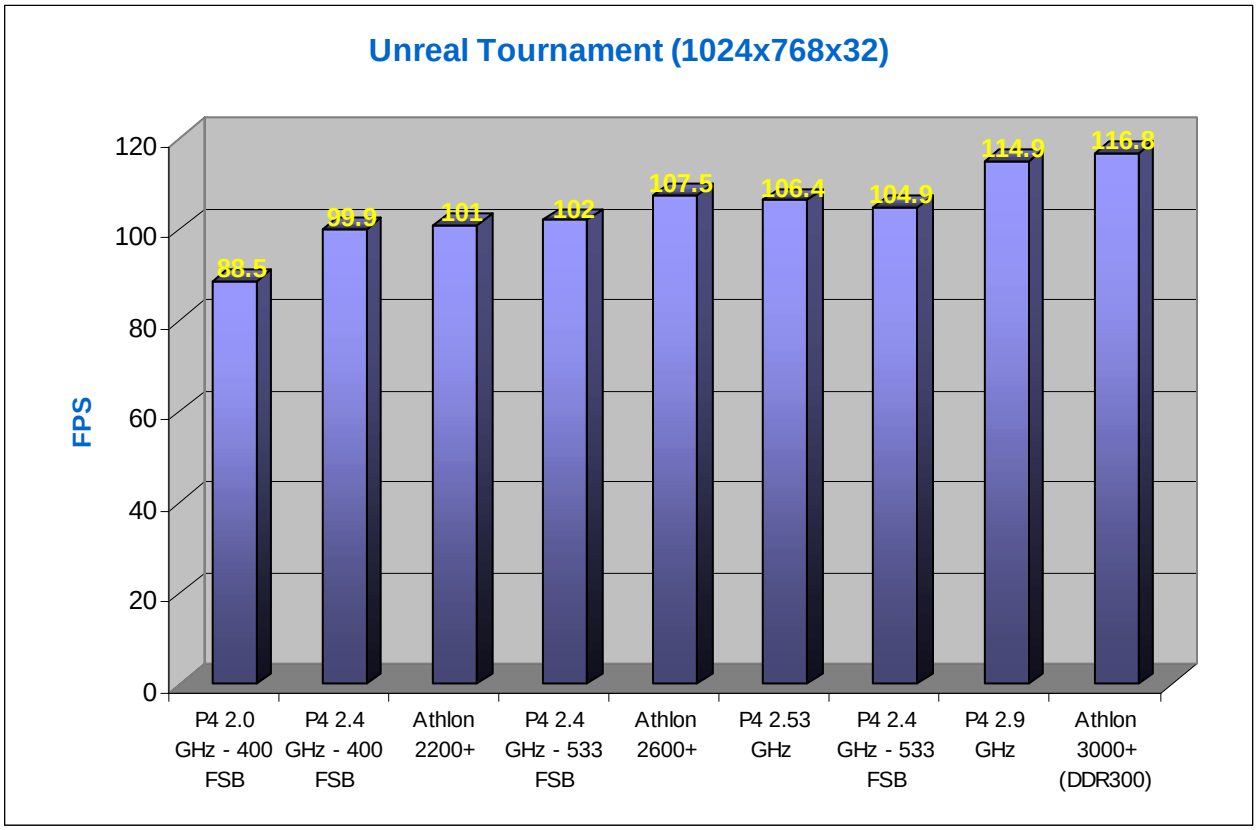


Even the Athlon XP 2200+ beats the best Pentium 4 in our test. RPG gaming is a homerun for the Athlon processors. The last very popular genre of gaming is Real-Time Strategy Games. Warrior Kings is probably one of the most advanced RTS' available today, as it has a full 3D landscape and the Level of Detail (LOD) is scaled in relationship to the size of an object on the screen.



I have repeated these tests at least 5 times, and the numbers are indeed correct. The Athlon XP 2600+ simply destroys its competitor by outperforming it by 40%! Pretty ironic is that Intel featured Warrior Kings on their Pentium 4 page as Intel optimized. Well, the original version surely is not running superb on the Pentium 4, but the latest patch may have some P4 optimizations. However, due to time constraints I was only capable of testing the original version as I only noticed Warrior Kings to be on Intel's list just before this article was going online. We will report back with the latest patch applied.

Our seventh and last game engine is Unreal Tournament, and older but still popular online fps.

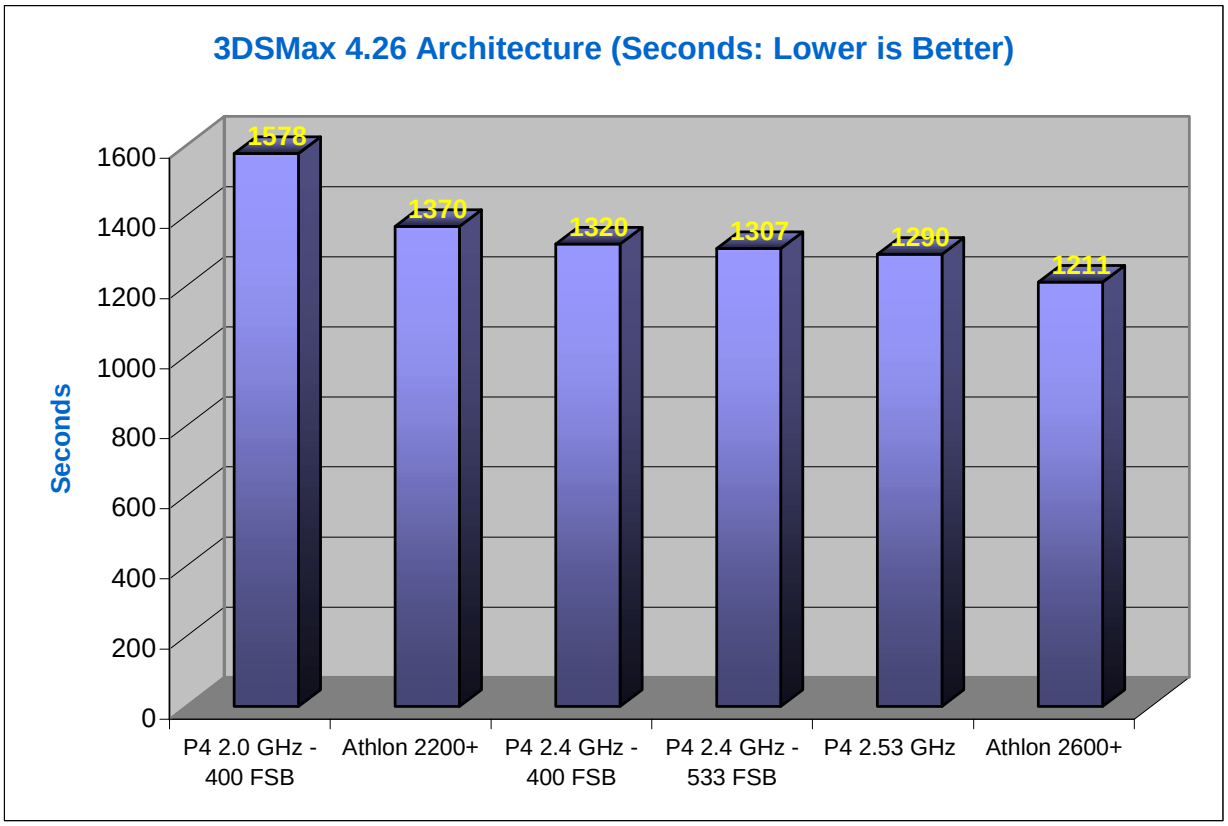


A very small victory for the Athlon XP 2600+, which seems to confirm that the QS rating is not exactly conservative, but still more or less accurate.

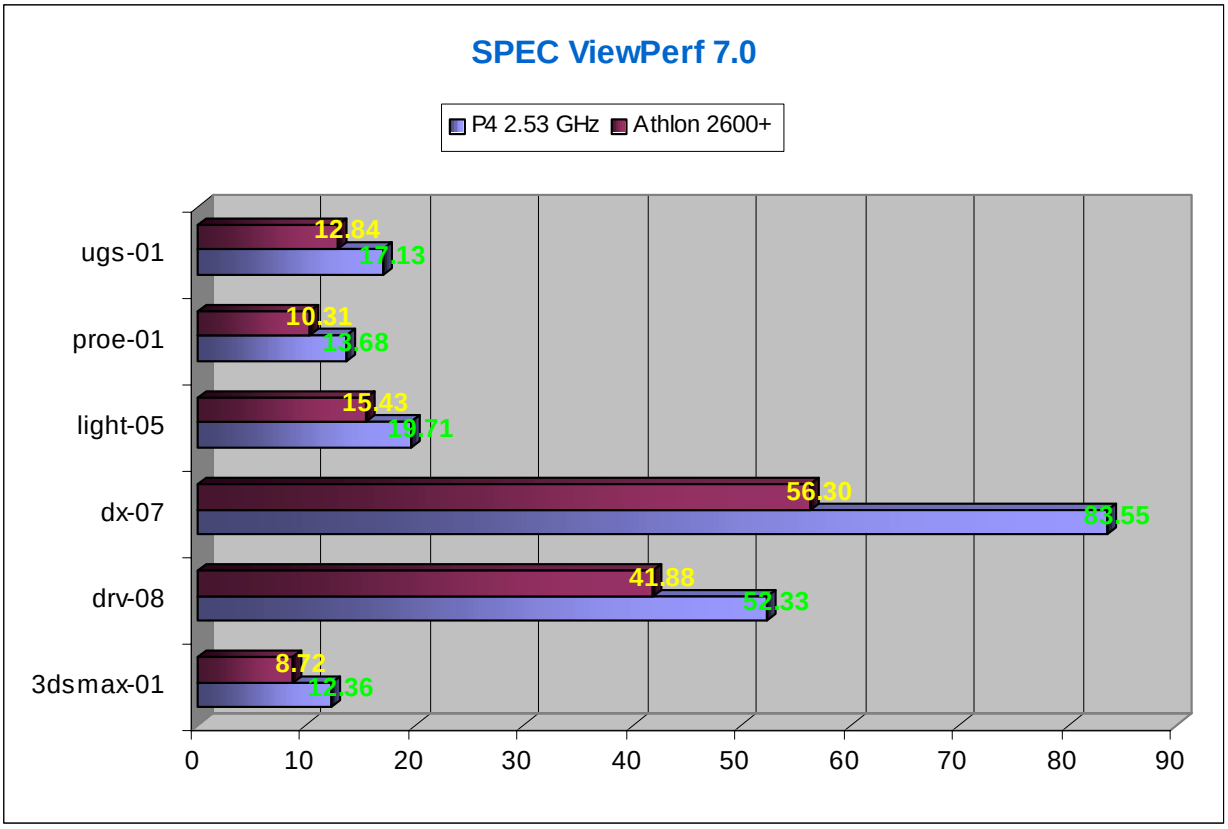
Professional Benchmarks: 3D Animation and CAD

Besides gaming, three categories of software are always begging for more CPU power: scientific applications, 3D animation and 3D CAD. We have tested with 3DSMax version 4.2.6, which is optimized for the Pentium 4 and Pentium III, and should provide up to 30% better performance for Pentium 4 and Pentium III configurations.

We tested the architecture scene from the SPECapc 3DS MAX R4.2 benchmark. This test has a moving camera that shows a complicated building, a virtual tour of a scale model. This complex scene has no less than 600,000 polygons and 7 lights. It runs with raytracing and fog enabled. Frames 20 to 22 were rendered at 500x300 to the virtual frame buffer (memory).



The Athlon beats the Pentium 4 by a slight margin. But rendering is, of course, only the final stage. To find out how the Athlon platform compares to the Pentium 4 in the actual modeling work, we benchmarked two systems with SpecViewPerf 7.0. **The Geforce 4 Ti4400 was replaced by a Quadro 4 900XGL in both systems.**

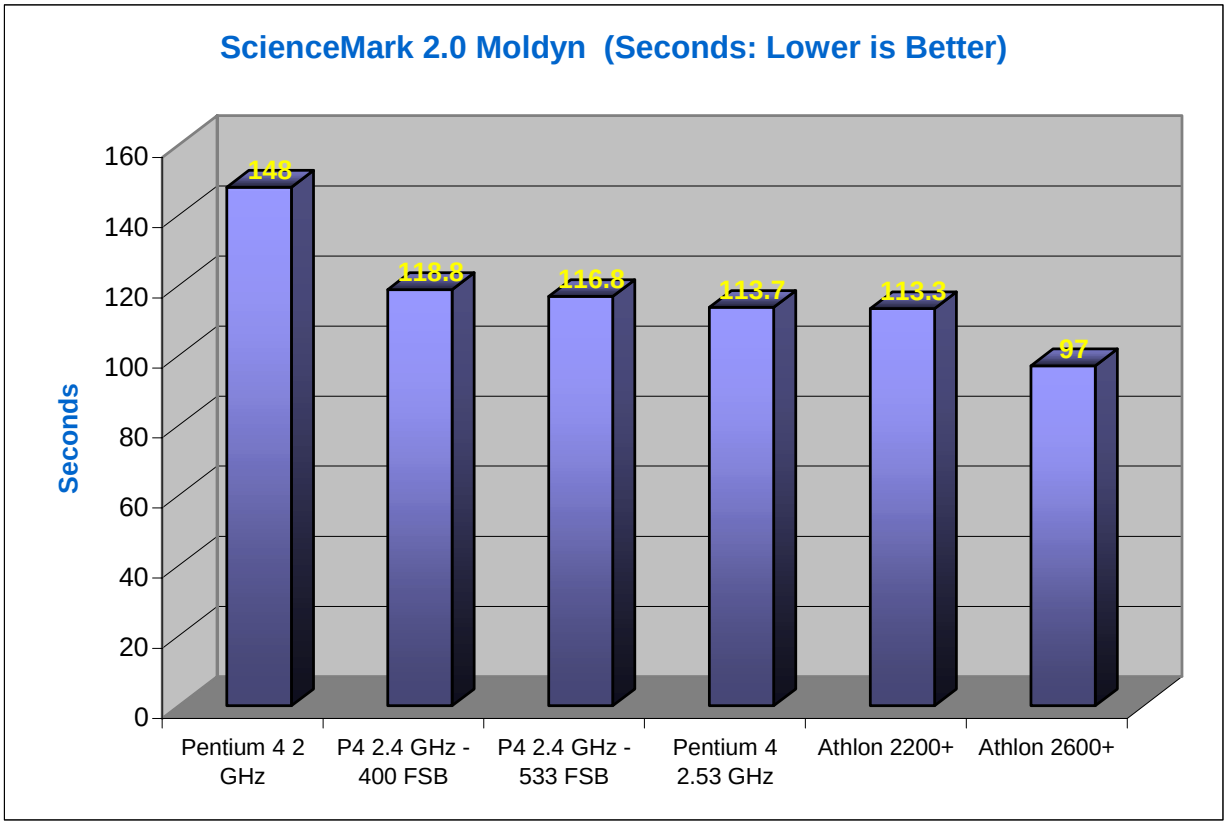


We are not absolutely sure what happened here. More testing is necessary, and our latest tests indicate that with some different BIOS settings we might get 5% better performance out of the Athlon XP. Nevertheless, it is clear that the Athlon XP 2600+ is not even close to the Pentium 4 in this kind of workload. We suspect that VIA's AGP driver and chipset implementation might not be so effective and rather poorly optimized for professional OpenGL applications. Typically these kinds of applications move around huge amounts of geometry data, and therefore memory bandwidth and AGP drivers can make a big difference. Both systems were running at AGP 4x, though. In any event, the 2.53 GHz Pentium 4 is the clear leader in this benchmark.

Professional Benchmarks: Scientific Workloads

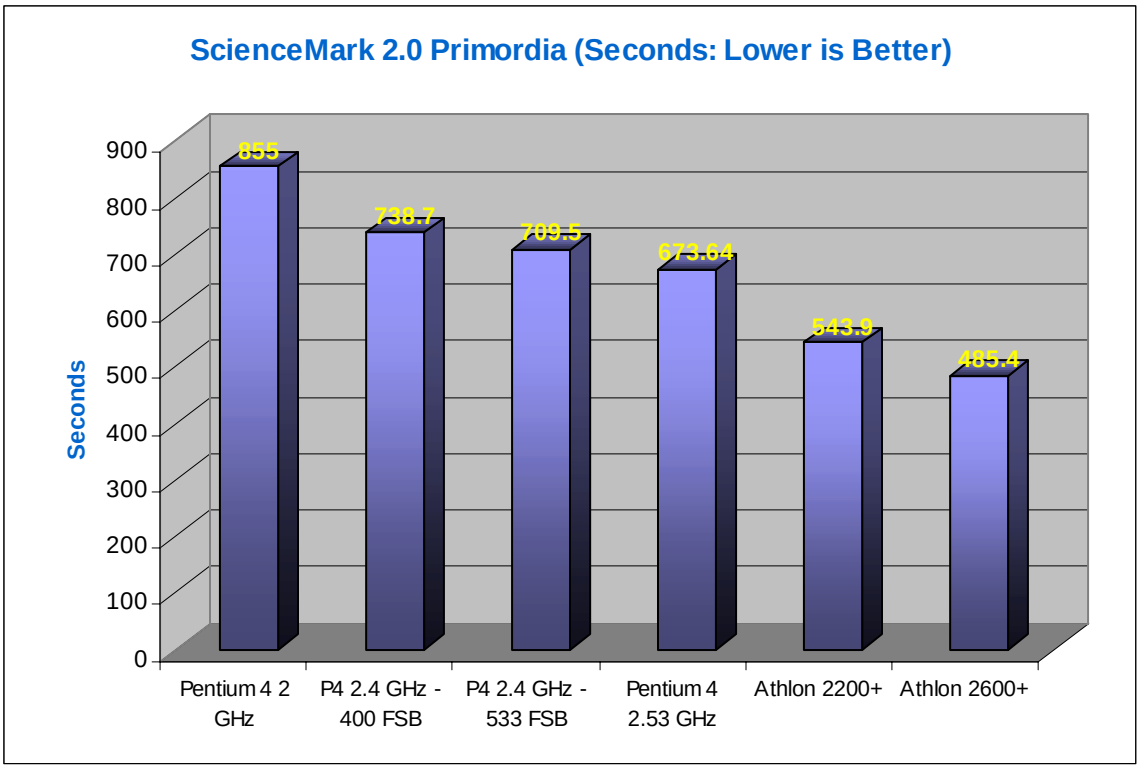
Tim, Alex and Julian made our work a lot lighter by offering ScienceMark 2.0 BETA a while ago. As scientific workloads never can have enough CPU power, we decided to see how the different CPUs compare.

Molecular Dynamics is a method for simulating the thermodynamic behavior of materials using their forces, velocities, and positions. The most important of these is the force. Moldyn performs a molecular dynamics simulation of 216 Argon atoms at 140 Kelvin. More information can be found here.



From Sciencemark.org:

> "This code calculates the Quantum Mechanical Hartree-Fock Orbitals for each electron in any element of the periodic table. The problem involved in solving for the orbitals is discussed in great detail here. A Self-Conistent loop is performed. At each step in the loop the hartree, exchange, and the correlation potentials for each orbital are evaluated. The user has a choice of a variety of algorithms with which to evaluate these potentials."



Both Primordia and Moldyn run a lot faster on the Athlons. The strong x87 FPU might the one of the most important reasons why the Athlon's performance so impressive compared to Intel's flagship processor.

Conclusion

AMD told us that they have begun shipping Athlon XP 2600+ and 2400+ processors to major OEMs, with worldwide availability expected by September. So most likely, the Athlon XP 2600+ we review today is not some vaporware product only available for reviewers, but a product that will be available soon. A clockspeed boost of 333 MHz (20%) in 2-3 months is nothing short of impressive.

Four out of seven gaming benchmarks proved to be faster on the Athlon XP 2600+ than on the 2.53 GHz Pentium 4. So, for gamers, the Athlon XP 2600+ lives up to its QS rating and will be a very attractive alternative considering its price.

However, the 2.53 Pentium 4 outperforms the Athlon XP 2600+ by a significant margin in typical workstation creative work. For those kinds of applications, AMD's platform will not outperform Intel's before the Hammer family arrives. We strongly suspect that the Athlon has enough firepower on board to perform well in CAD and 3D-modeling workloads, but that the AGP port and memory bandwidth of the current AMD platform is simply not up to par with Intel's. On the flipside, the Athlon XP 2600+ is clearly the fastest processor in the scientific workloads.

This shows clearly that it is pretty hard to give PR ratings that work for everybody. Of course, both "content creation on high end workstation applications" and scientific workloads are smaller markets, compared to the amount of people that buy a processor to run their games smoothly, but that doesn't necessarily mean they are any less important.