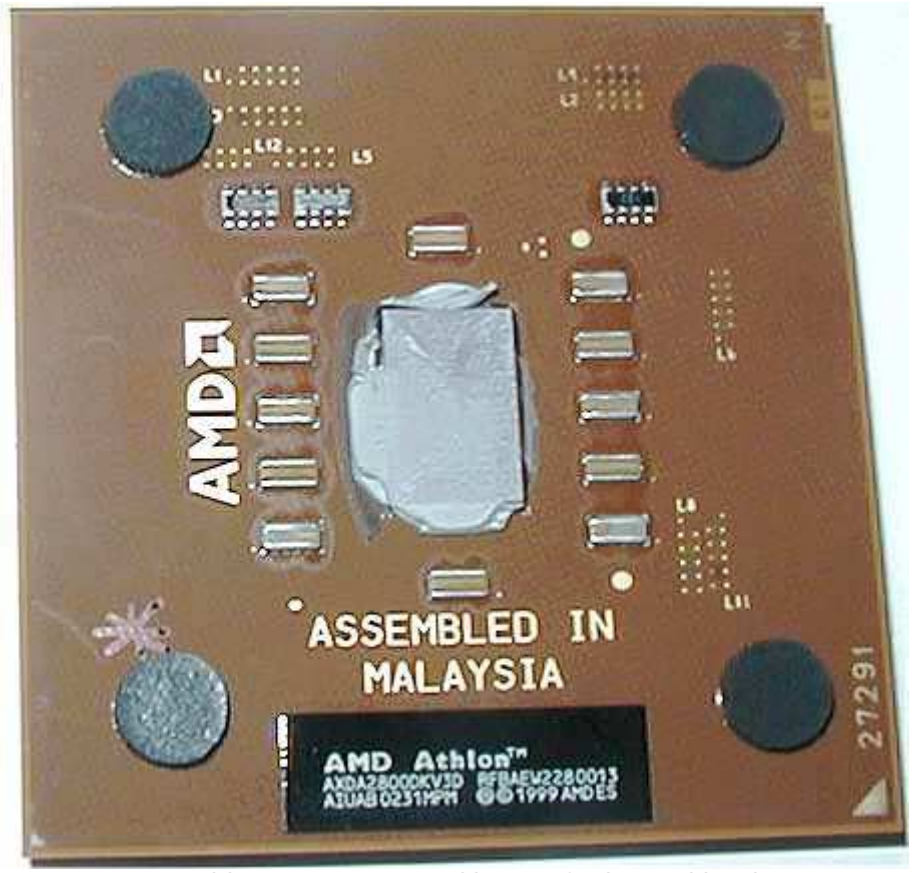
Athlon XP 2800+: 333 MHz FSB and nForce 2

By Johan De Gelas – October 2002

As we indicated in our **Athlon XP 2600+ review**, the new Thoroughbred "B" has a lot of headroom. With forced aircooling, a typical Athlon XP 2400+ or Athlon XP 2600+ reaches 2.3 GHz to 2.4 GHz. AMD has used this extra headroom to introduce the Athlon XP 2800+ (2.25 GHz) and 2700+ (2.16 GHz) today.

Unfortunately, this does not mean you will be able to buy AMD's fastest CPU in the next few weeks. In November, the 2700+ will only available to the OEMs, and around Christmas, the latest AMD CPU should finally be available in retail. The Athlon XP 2800+ will only be available in small quantities in Q4 2002, while AMD estimates that everybody should be able to get one in Q1 2003. This puts a damper on the party of course...



AMD Athlon XP 2800+: speed bump of "Thoroughbred B"

Last time, we compared the Athlon XP 2600+ to the 2.53 GHz Pentium 4. While the Athlon XP 2600+ was able to live up to "2600" rating, there was some doubt as to whether or not the Athlon really lived up to it's "+" rating. And this time, the fastest Athlon must face an even better armed Intel CPU, namely **the 2.8 GHz Pentium 4**.

AMD seem to have understood that a simple speed bump would not make the Athlon XP 2800+ competitive. The new Athlon XP 2800+ and 2700+ parts come with a 166 MHz DDR (333 MHz) FSB and AMD points out that the new nForce 2 chipset pushes the performance of the Athlon even higher.

But this wouldn't be Ace's Hardware if we didn't take an in-depth look at the Pentium 4 versus Athlon XP battle. So let us first examine how the Athlon and Pentium 4 platforms compare.

The CPU Race

While "Intel Prescott versus AMD Hammer" is a hot topic, it is clear that the Athlon and the Pentium 4 will be the main actors in the ongoing CPU war between AMD and Intel for at least another year. The speed of the FSB and memory, and the use of SSE-2 optimizations have influenced this battle significantly.

We felt that our review wouldn't be complete without some analysis of these important factors. And we found a great tool for this kind of analysis: ScienceMark 2.0. It is said that "the best things in life are free," and Sciencemark 2.0 is the perfect example of this proverb. The MemBench feature gives us both latency and bandwidth figures for each platform.

First of all, we tested the Athlon XP 2800+ on the "normal" KT333 platform with a 17x multiplier, the FSB set at 133 MHz DDR (266 MHz) and the memory set at 166 MHz DDR (333 MHz), CAS at 2, RAS to CAS at 3, Precharge at 3. The second time, the KT333 platform (ASUS A7V333) was set at a FSB of 166 MHz (333 MHz) and the multiplier was set to 13.5x.

CPU	Type of DRAM	FSB	DRAM Clockspeed (MHz)	Latency - 64 byte stride (clockcycles)	Latency - 128 byte stride (clockcycles)	Bandwidth (MB/s)
Athlon 2.66 GHz - KT333	PC2700	266	333	181	246	1926
Athlon 2.25 GHz - KT333	PC2700	333	333	185	250	2202
Athlon 2.25 GHz - nForce	PC2700	333	333	160	218	2425
Pentium 4 2.8 GHz - i845G	PC2700	533	333	78	252	2315
Pentium 4 2.8 GHz - i850E	RIMM4200	533	1066	73	318	2803

Where do I start? There is an enormous amount of info hidden is this table. Let us first start with the 266 MHz versus 333 MHz FSB discussion.

There have been many reports that show that the Athlon does not benefit much from an increase in FSB clockspeed, moving from 266 MHz to 333 MHz. But Membench tells us exactly why. First of all, compare the two KT333 latency numbers (64 byte strides). All BIOS settings were exactly the same, only the FSB speed, and thus the multiplier, are different. Normally one would expect, everything else being equal, that the Athlon with the 166 MHz FSB would see 25% lower latency, but the CPU with the 166 MHz FSB version actually sees a higher latency! **This shows that the (ASUS) KT333 board, in order to guarantee proper stability, increases certain latencies of the memory controller.** Memory bandwidth increases by 14%, which is also less than expected.

Now what does this mean for "real world" performance? It means that many applications will see either a very small performance increase or none at all, as it is latency and not bandwidth that is the most important performance factor. Let us explain this in more detail.

Prefetch...AMD's Work is in Progress?

To better understand what is going on, you must understand the difference between the latency of a 64 byte stride and a 128 byte stride. When you are fetching data (and instructions) with a 64 byte stride, or exactly one cache-line apart, you are fetching information in a very organized way. This is the best case scenario, and well written and optimized code (think Quake 3 engine, Kribi, etc.) which needs to get information from memory will always try to behave this way. This makes it very easy for the prefetcher to kick in and get the information before it is actually needed. Indeed, prefetching has been very successful with regular data structures such as arrays. In an array, you can reference different elements in parallel.

The latency numbers for 128 byte and higher strides, however, indicate the latency the CPU sees when the prefetcher fails. Sometimes the programmer must make use of data structures which are linked to other data structures and so on. You get a whole chain of linked data structures ("The pointer chasing problem") and it is (almost) impossible for the prefetcher to predict which piece of data it should get next.

So let us compare the Athlon and the Pentium 4. A 3.06 GHz Pentium 4 will be here soon, and will probably be available in large quantities before the Athlon XP 2700+ will. Intel has already shown a Pentium 4 running at 4.7 GHz with exotic cooling. Why am I telling you this? Because the current GHz madness might make you believe that the "speed demons" architecture (optimized to reach the highest clockspeed even at the expense of IPC) has nothing but advantages and will always prevail over other more "Brainiac" (= higher IPC) approaches. If the Pentium 4 overpowers all other architectures, then the high clockspeeds surely won't be the only reason.

Besides branch misprediction penalties, the speed demon CPU has a serious problem: memory latency. To make my point clear, let us forget about prefetching and assume that the Athlon and Pentium 4 run on the same platform and motherboards, like Intel and AMD CPUs used to do back in 1997. In this hypothetical case, assume that the Athlon XP 2800+ runs all programs that fit perfectly in the cache as fast as the 2.8 GHz Pentium 4. Then ideally the Athlon should have a serious advantage because the 2.25 GHz core is running only 6.75 times faster than the memory (333 MHz). The Pentium 4's core is running 8.4 times faster than the memory and therefore the latency seen by the CPU should be - theoretically - 25% higher. So, the Athlon should be the one with the best memory latency. But what does reality show us?

CPU	Type of DRAM	FSB	DRAM Clockspeed (MHz)	Latency - 64 byte stride	Latency - 128 byte stride	Bandwidth
Athlon 2.25 GHz - KT333	PC2700	333	333	185	250	2202
Pentium 4 2.8 GHz - i845G	PC2700	533	333	78	252	2315

Reality contradicts our - in theory - logical assumption. The 128 byte stride latency numbers indicate that the better chipset support and the faster FSB (533 MHz) of the Pentium 4 negate the fact that the clockspeed gap between CPU and memory is lower for the Athlon. The "brainiac memory latency advantage" of the Athlon is nonexistent in practice.

Even worse are the 64 byte stride latency numbers. These show us that the Pentium 4's prefetch is far superior to the Athlon XP's. Again, to lower the latency seen by the CPU by the same amount, the Pentium 4 prefetcher must be smarter (be able to recognize memory access patterns better) or prefetch further ahead than the Athlon prefetcher. The Pentium 4 latency numbers do not match the Athlon's, they are twice as good!

AMD has a lot of work to do on the prefetcher if they want to keep up with Intel. Intel is also looking into lowering the latency in software where the prefetcher fails. With **Speculative Precomputation Intel gets performance boosts of 7 to 45%(!)** in small pieces of code. As the Athlon XP current prefetcher is mediocre, we speculate that Hammer will have an improved prefetcher. But back to our Athlon XP 2800+ review...

In other words, the Athlon does not benefit that much from a faster FSB because:
- Chipsets (KT333 being one example) run with more conservative settings with a 166 MHz FSB
- The Athlon's prefetcher performance is mediocre.

Nvidia nForce2 versus VIA KT333/KT400

A pleasant surprise was the fact that our ASUS A7V333 (KT333) could be easily upgraded with the Athlon XP 2800+. A simple BIOS upgrade to version 1.013 did the trick, a testimony to ASUS' excellent board design and BIOS support.

ASUS A7V333: no trouble upgrading to 166 MHz DDR FSB

The board was rock stable in all benchmarks. But as you will see below, performance did not improve by much.

Yes, the review kit that AMD sent us came with an ASUS nForce 2 prototype board. Notice the word "prototype." There are times when being a hardware reviewer is a lot of fun because you get access to the latest hardware. And then there are times that you are in front of a screen at ungodly hours with red eyes and a painful headache because some prototype hardware behaves "shifty" and illogically. The prototype board was pretty stubborn and unreliable with many hard locks in many games, especially with sound enabled. This is the reason why you will not find any sound enabled benchmarks on the nForce 2 platform.

Both Nvidia and ASUS assured more than once that the actual production model, which should be available to the public by the end of October, will run perfectly and be 100% stable. Nvidia told us that AMD had sent us an "early prototype" board, "which can be tricky" to run reliably. So why did AMD send us this board, even though it was not ready for prime time? One look at our ScienceMark 2.0 numbers make it clear: the nForce 2 memory controller simply kicks ass!

CPU	Type of DRAM	FSB	DRAM Clockspeed (MHz)	Latency - 64 byte stride	Latency - 128 byte stride	Bandwidth
Athlon 2.66 GHz - KT333	PC2700	266	333	181	246	1926
Athlon 2.25 GHz - KT333	PC2700	333	333	185	250	2202
Athlon 2.25 GHz - nForce	PC2700	333	333	160	218	2425

The nForce 2 chipset offers 10% better bandwidth and, more importantly, 16% lower latency, which is very impressive compared to the KT333 at 166 MHz. While the KT333 with a 166 MHz FSB is hardly faster than with a 133 MHz bus, you will see further that the nForce 2 paired with the faster FSB is quite a superb performer.

Our (MSI) KT400 board needs a BIOS update to function with the Athlon XP 2800+. As this BIOS update is not yet available, we could not yet make the comparison between the KT400 and nForce 2. With the limited data we have now, the KT400 seems to show only marginally better latency numbers.

Anyway, we postpone our nForce 2 review and conclusions to a later date, as we feel that it would not be accurate to base our conclusions on this early and rather unstable prototype. It is still possible that some latencies in the BIOS must

be set to less aggressive numbers to achieve production quality stability. But if the production boards can match the performance of our board and offer the promised stability, NVIDIA's nForce 2 has a great future ahead.

The nForce 2 is very similar to the nForce. Below you'll find the newest additions to NVIDIA's chipset:

- Dual Channel DDR333 instead of Dual Channel DDR266
- USB 2.0 (6 ports)
- IEEE-1394a (3 ports)
- UltraATA 133
- Integrated TV Encoder (IGP) included
- Integrated Geforce 4 MX instead of Geforce 2 MX.
- AGP 8X

Motherboards based on the NForce2 will be available from ABIT, ASUS, Chaintech EPOX, MSI and Leadtek.

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 modules were running at 166 MHz DDR (333 MHz) and configured in all systems to work with a CAS latency of 2.

Systems

Athlon XP 2000+, Athlon XP 2200+, Athlon XP 2600+, Athlon XP 2800+

- **ASUS A7V333 BIOS version 1.013**
- **ASUS "prototype" nForce 2 BIOS version 1.08 (only with Athlon XP 2800+)**

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) and 2.8 GHz

- **MSI 845G-MAX (i845G chipset) BIOS version 1.4**
- **ASUS P4T 533 BIOS Version 1.004 with 512 MB RIMM4200 at 1066 MHz (only with Pentium 4 2.8 GHz)**

Shared Components

- **512 MB Corsair PC3200 XMS (DDR-SDRAM) running at 333 MHz CAS 2 (2-3-3-6)**
- **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:

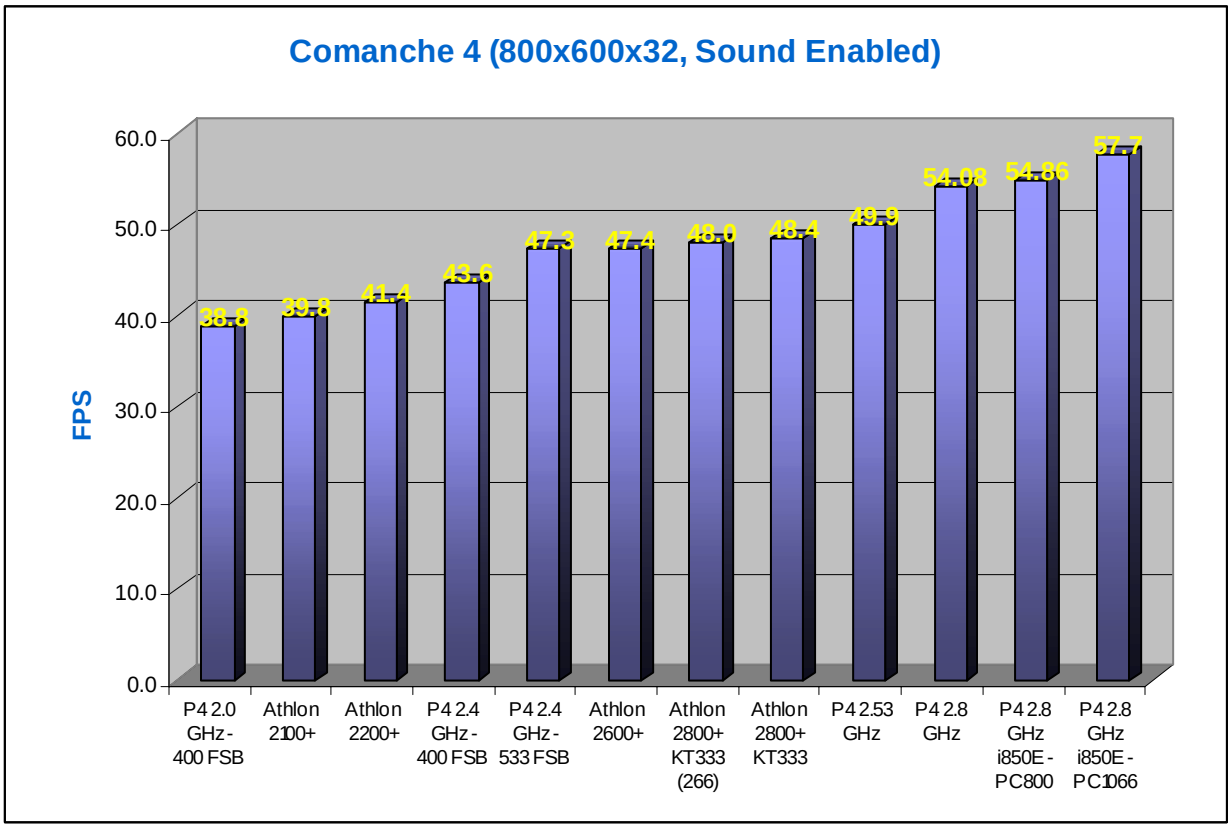
- Luciano Alibrandi and Bryan Del Rizio (**nvidia**) for their excellent support
- Jurgen Eymberts and Kristof Semhke (**Intel**) made sure we could test the Pentium 4 2.0A GHz, 2.4, 2.53 and 2.8 GHz.
- Thanks to Augustine Chen, Carol Chang (**ASUS**) and Sharon Tan (**BAS computers Netherlands**) for the ASUS A7V333 and ASUS P4T533
- Angelique Berden and Saskia Verhappen of **MSI** provided us with the MSI 845 GMax
- Damon Muzny (**AMD**) made sure we were able to test the Athlon XP 2600+ and Athlon XP 2200+ Thoroughbred.
- Robert Pearce of **Corsair**, provided us with Corsair's **PC3200 CAS2 XMS**.

Gaming Benchmarks

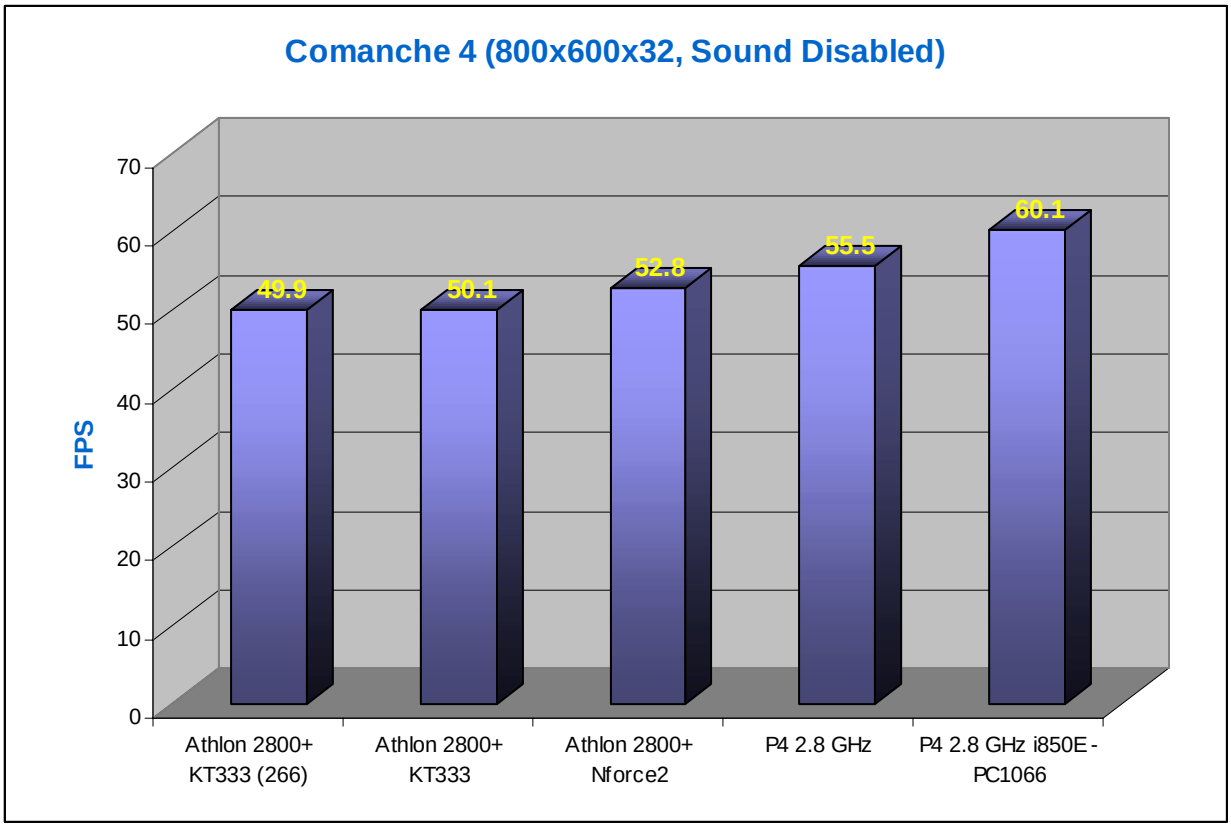
Before reading our benchmarks, let me make a few things clear:

- "KT333 (266)" means that that the VIAKT333 FSB was set at 266 MHz and the DDR memory at 333 MHz
- All Pentium 4 systems except the ones with "i850E" were based on the i845G board and were running the DDR memory at 333 MHz. nForce 2 platform benchmarks were in many cases not possible, especially in benchmarks that require sound.

Comanche 4, the military helicopter simulator, is our first benchmark.



Comanche contains SSE-2 optimizations, but there are good indications that the Pentium 4 benefits from its excellent (prefetched) memory latency. The nForce 2 platform would only work if we disabled sound.



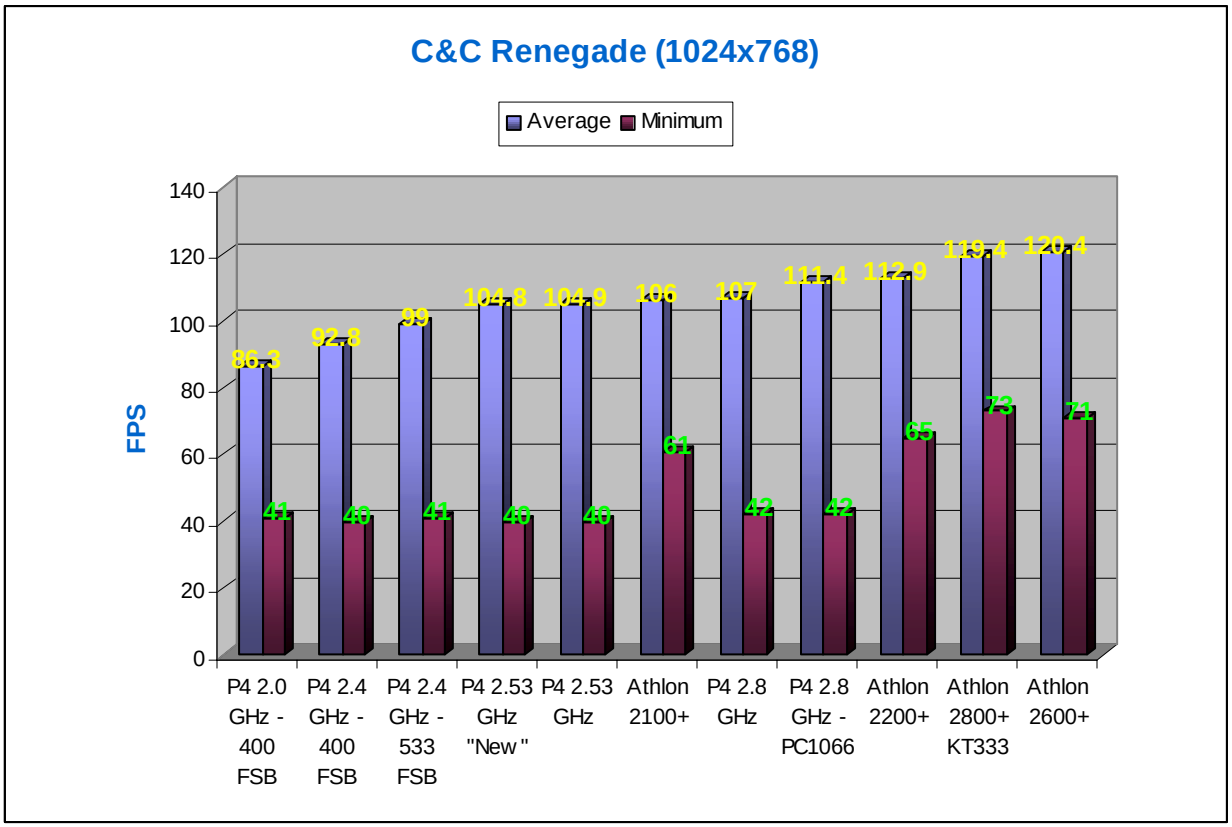
The numbers above confirms that SSE-2 is not the only reason why the Athlon is performing rather poorly compared to the Pentium 4. The 16% lower memory latency makes the nForce 2 platform perform 5% faster than the KT333. This makes the Athlon XP 2800+ perform like a 2.6 GHz P4 with DDR memory. The Athlon doesn't have a chance against the 1066 MHz Rambus P4 however, which reigns supreme in this benchmark.

Normally our next benchmark would be NASCAR 2002. However, we found one out of five benchmark runs produces much lower figures for the Pentium 4 platform (around 45 instead of more than 50) and we still have to investigate what we can do to make our benchmark more repeatable. Work in progress...

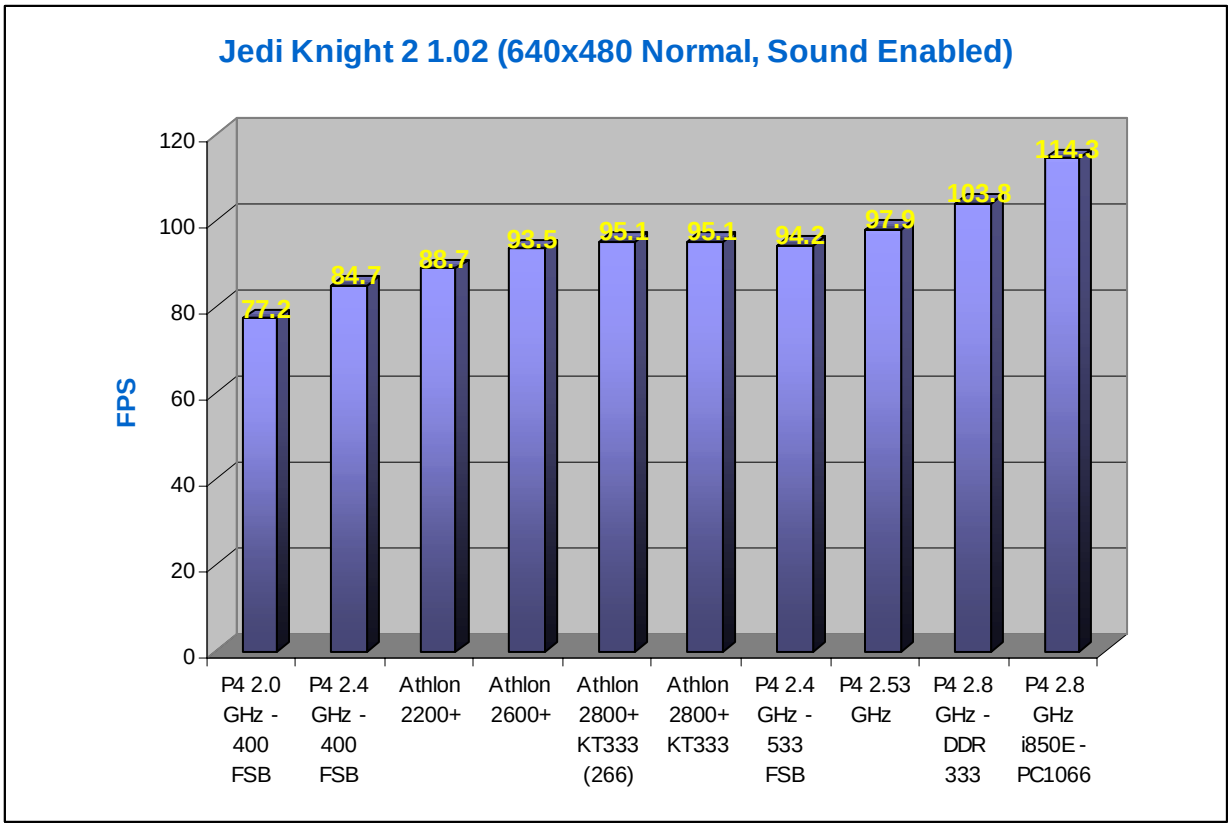
Let there be no doubt, the Pentium 4 is clearly the fastest CPU in NASCAR 2002, which has been optimized for SSE-2.

More Gaming Benchmarks

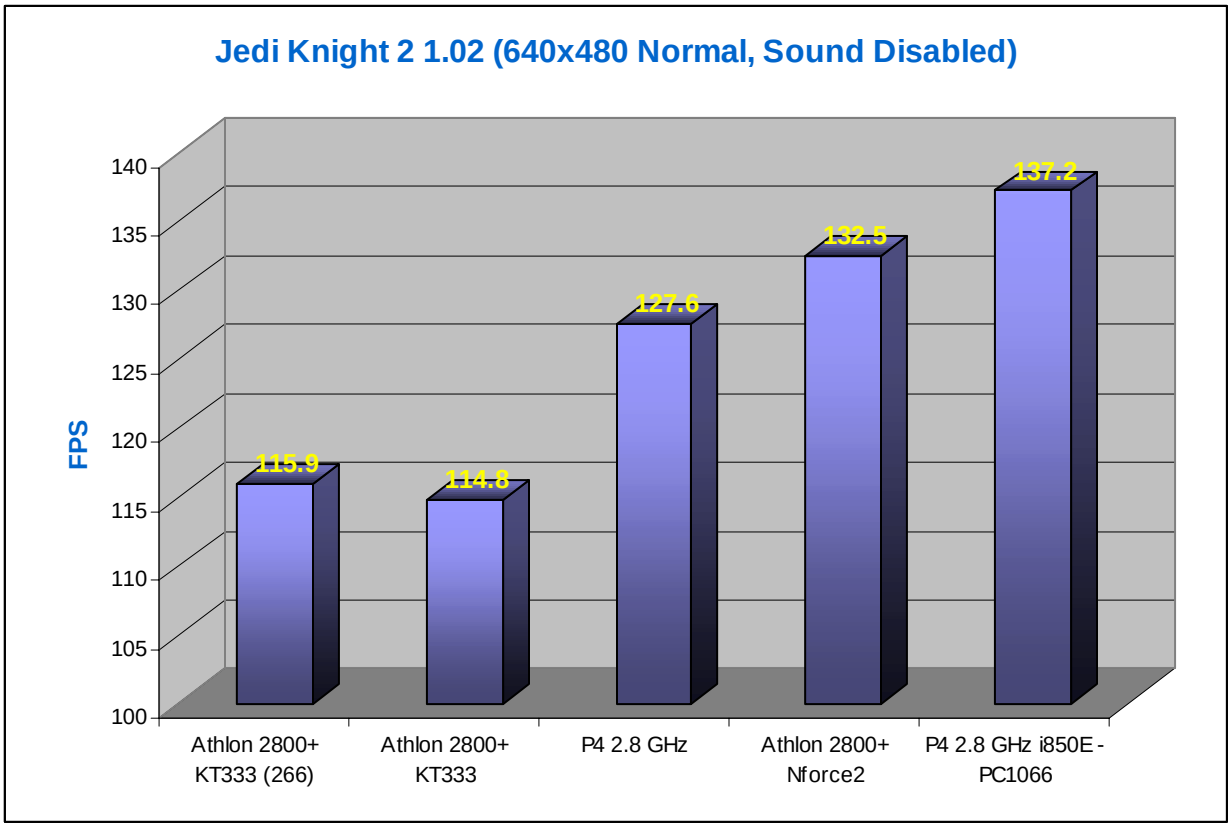
Contrary to NASCAR racing, the results of C&C Renegade are very repeatable. Being one of the most popular first person shooters, we felt C&C makes a nice addition to our benchmark suite, even though it relies slightly more on the video card than the CPU (compared to Comanche).



This time, not even RIMM4200 can save the Pentium 4, the Athlons take the lead. It seems that the Athlon are pushing the Geforce 4 Ti4400 we used to the limit, as even the Athlon XP 2800+ can not break the 120 fps limit. Unfortunately, we were not able to complete this test with the nForce 2 as it kept locking up.



Remember how well the Pentium 4 did on Quake 3? A few people at our message board hinted that the superior prefetcher combined with well written software was the reason and they have been proven right. Bandwidth is not the prime reason why the Pentium 4 performs so well with Quake 3 engines. The real reason will be revealed in the next benchmark (with Sound disabled), which includes the nForce 2 platform.



Quake 3 engine based games access memory in a very organized way. Consecutive data and instructions can be found in adjacent addresses. To understand why we feel that the "prefetch" (64 byte stride) latency is a very important factor for the Quake 3 engine, compare the Jedi Knight benchmarks with the MemBench numbers. Let's take a look at them again.

CPU	Type of DRAM	FSB	DRAM Clockspeed (MHz)	Latency - 64 byte stride (clockcycles)	Latency - 128 byte stride (clockcycles)	Bandwidth (MB/s)
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Pentium 4 2.8 GHz - i850E	RIMM4200	533	1066	73	318	2803

Although the KT333 with 166 Mhz FSB offers more bandwidth, the KT333 with 266 MHz FSB performs slightly better, or to be more precise, within the margin of error. The slightly higher clockspeed (2266 MHz vs 2251 MHz) and slightly lower latency give the 266 MHz FSB the edge, against all theoretical logic. This shows that bandwidth is NOT the prime concern for the Quake 3 engine.

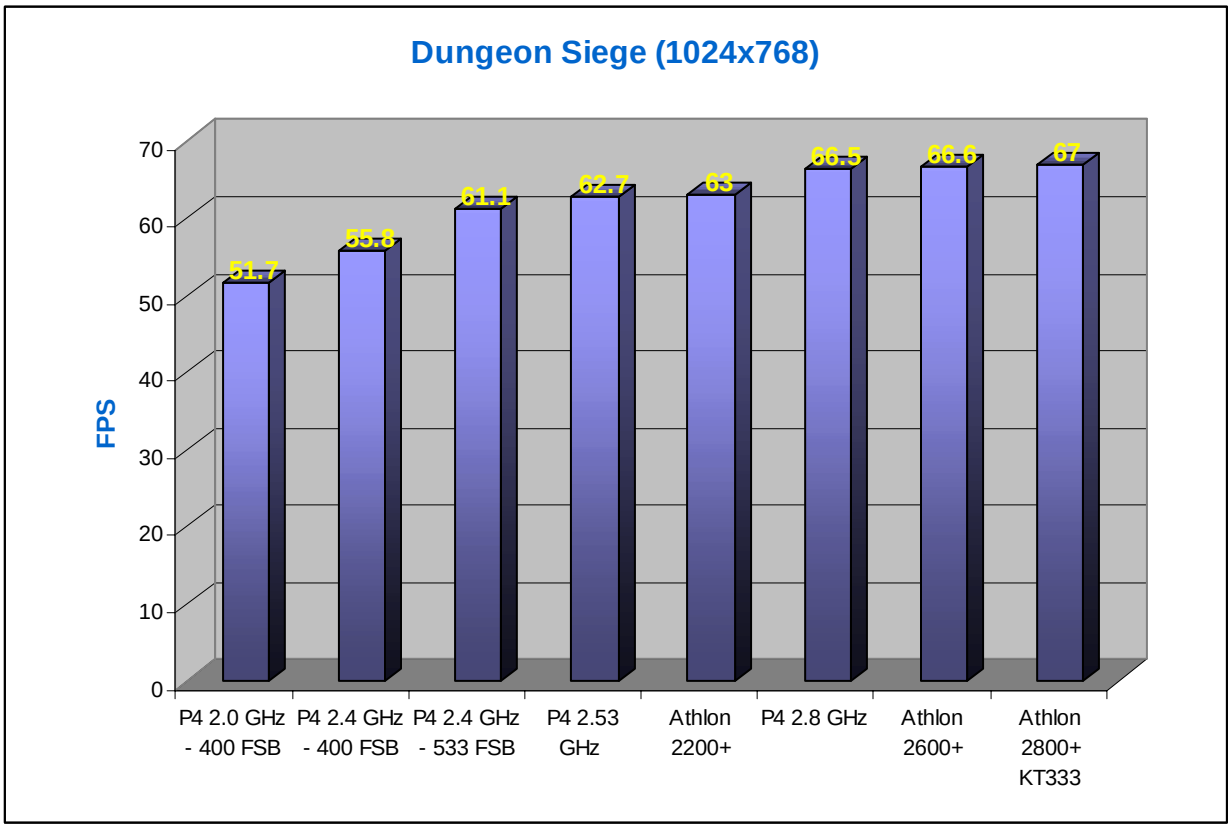
At the same time, the nForce 2 simply blows the competition (KT333) away with 15.4% better performance. The 15.4% performance boost is almost identical to the decrease in latency that we have measured with MemBench. So, we think only a small portion of 15% boost comes from the 10% extra bandwidth and big portion is a result of the better latency.

The fact that the P4 with 1066 MHz RDRAM is about 7% faster confirms this. In terms of bandwidth, the PC1066 solution has a 20% advantage over the DDR333 platform. But the "prefetch latency" is only 6.8% better.

The 1066 MHz RDRAM also shows that the Quake 3 engine organizes the memory very well. If memory was accessed randomly, the 1066 MHz RDRAM would perform much worse than DDR333.

RPG Gaming

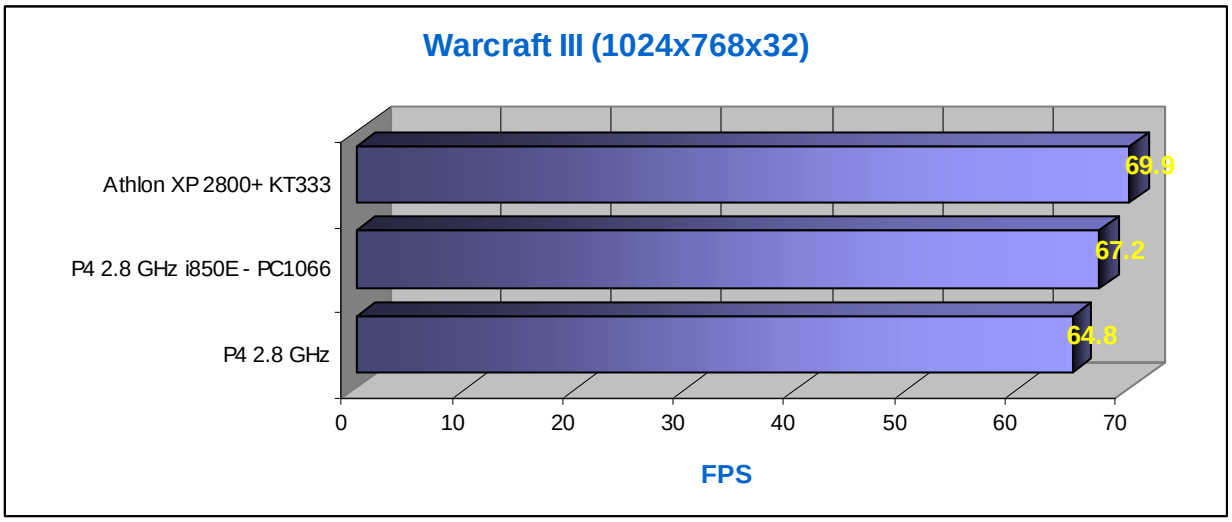
Just like the Ace's crew, many Ace's readers like a good RPG game. Let us try out Chris Taylor's Dungeon Siege.



While the P4 takes the top spot, we have little doubt that a little nForce 2 boost could push the Athlon XP 2800+ beyond Intel's best.

Before we try out RTS games, let us take a look at how a very popular mix of RPG and RTS, Warcraft III, runs on the different CPU beasts.

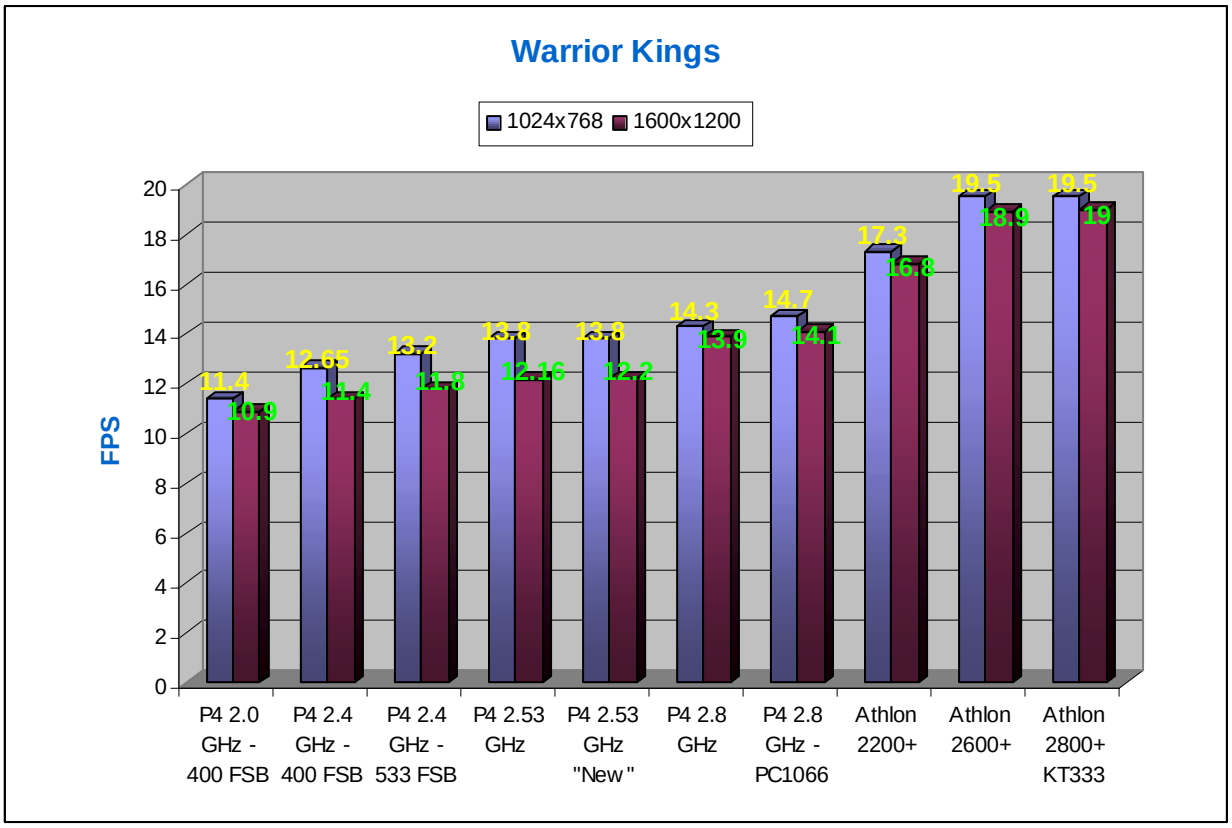
We benchmarked one of the in-game cut scenes



The RPG Genre seems to love the Athlon XP. While the error margin on this benchmark is quite high (+/- 1.5 fps) the Athlon XP 2800+ is the better performer here.

Strategy

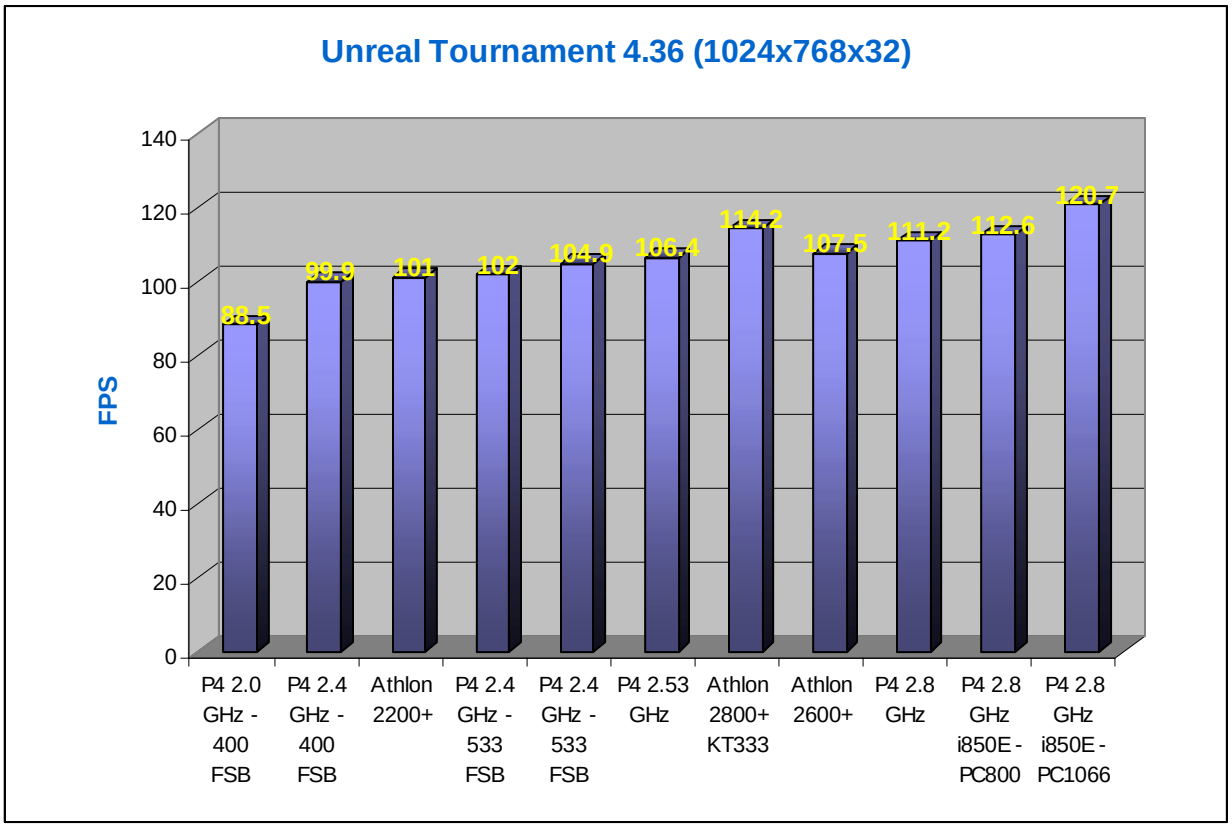
Next, we try a Real-Time Strategy Game. Warrior Kings is probably one of the most advanced RTS' available today, as it has a full 3D landscape and the Level of Detail (LOD) is scaled in relationship to the size of an object on the screen.



The Athlon remains the top choice for the Warrior king gamers. SSE-2 patches are on the way, but it is doubtful that this will close the gap with the Athlon.

Online Games

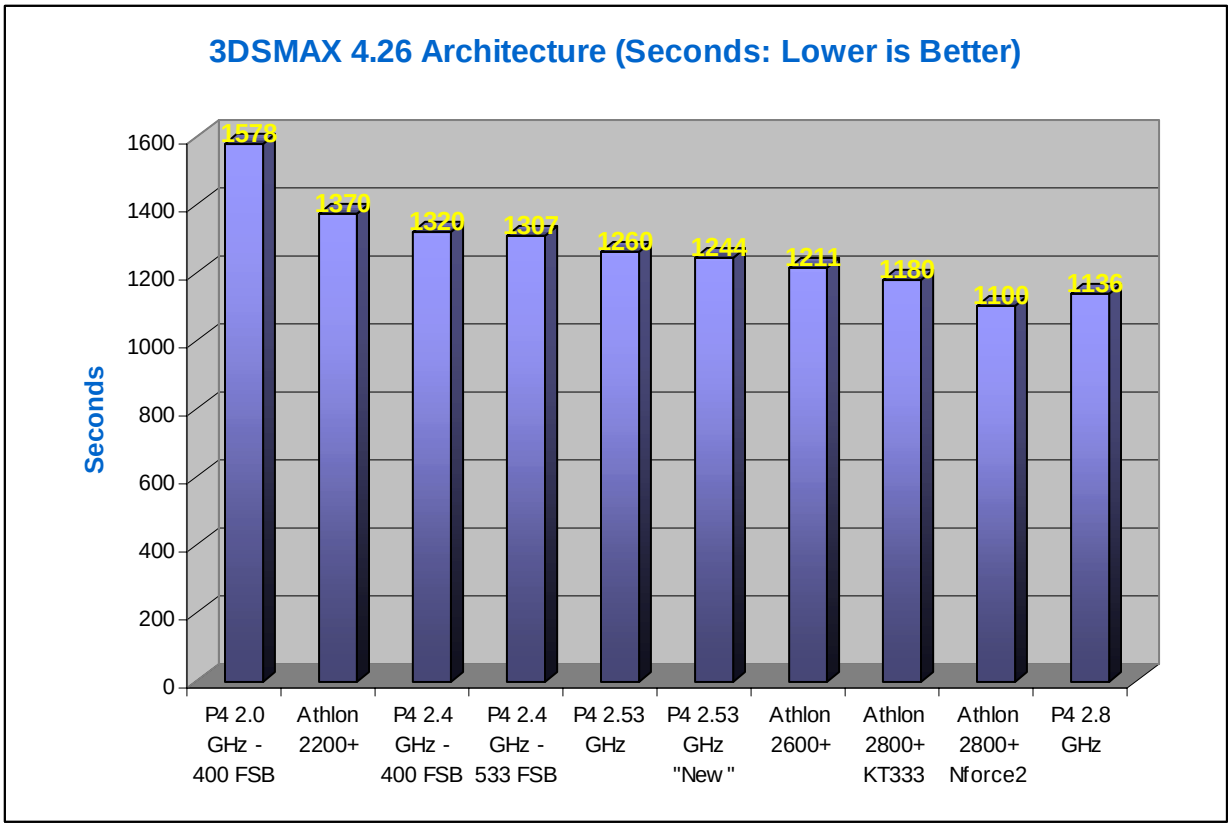
Being one of the most popular online games ever, we tested with Unreal Tournament 4.36 ("Game of the Year Edition") and our own "Demoace2" demo.



It is impressive how the 1066 MHz RDRAM wins so many battles for the 2.8 GHz Pentium 4. Based on our first experiences with the nForce 2, the Athlon XP when paired with this new platform should come close the fastest Pentium 4 platform.

3D Studio Max

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).



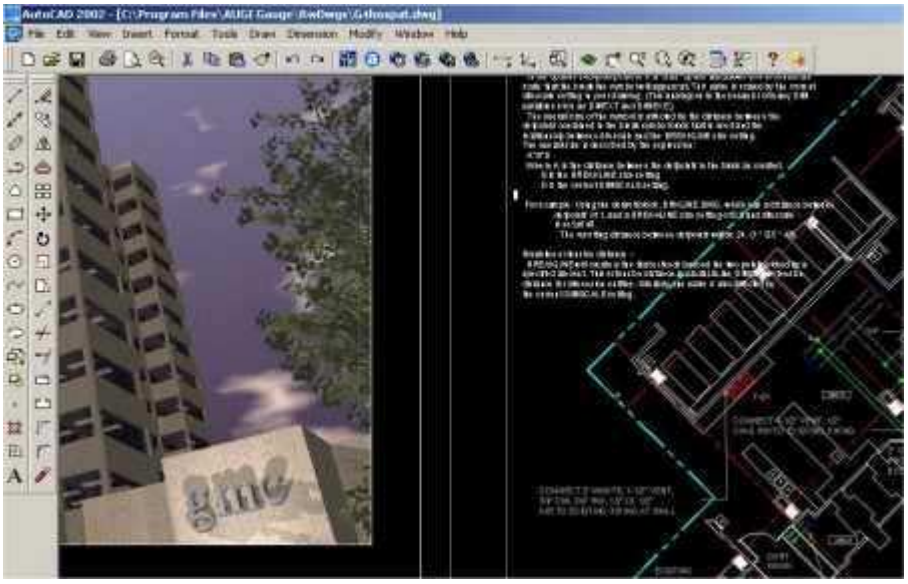
The nForce 2 does it again. While the 3DSMax benchmark is not exactly the most memory intensive benchmark, the nForce 2 is able to outperform the competition by 7%! This makes the Athlon XP 2800+ clearly the fastest 3DSMax processor again.

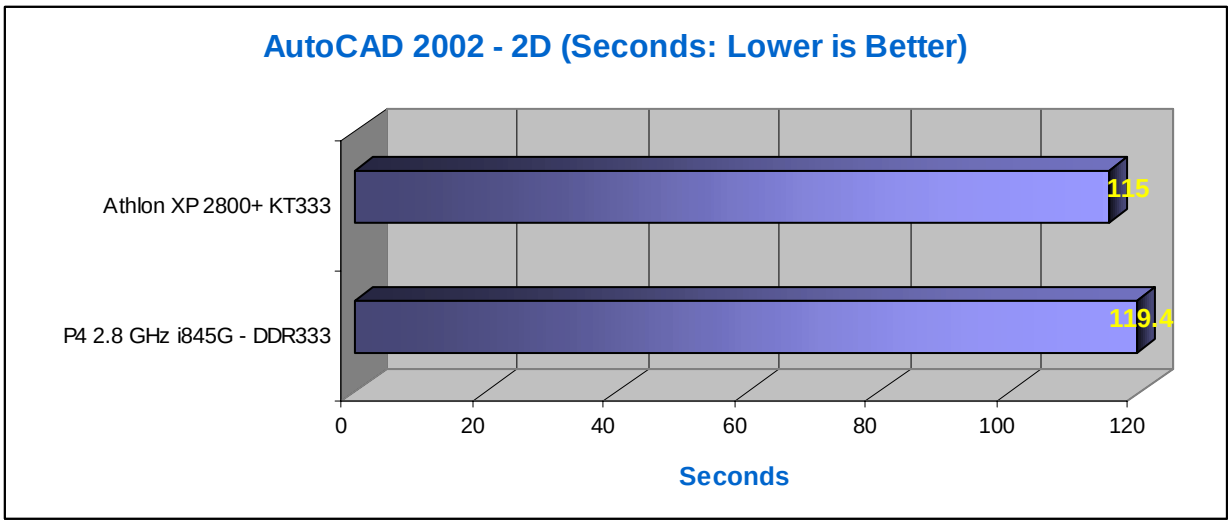
AutoCAD 2002

To benchmark AutoCAD, we used the AUGI Gauge benchmark from Autodesk Users Group International. From the AUGI Gauge site:

> The AUGI Gauge is a performance-testing tool that can be used to develop benchmark scripts for testing different operations and different drawings. The testing tool comprises a Visual Basic front end and an AutoLISP testing engine. The AUGI Gauge prints completion times for each test operation to a text file, which can be imported into a spreadsheet for data manipulation. The original AUGI Gauge testing tool was designed to work with AutoCAD Release 12 (DOS), Release 13 (Windows) and Release 14. The current version works with AutoCAD Release 14 and AutoCAD 2000.

The benchmark itself consists of two sections and we have used the real-world test that performs various file, edit, and display operations (totalling 30) on a series of 15 drawings that each average 2 MB in size.



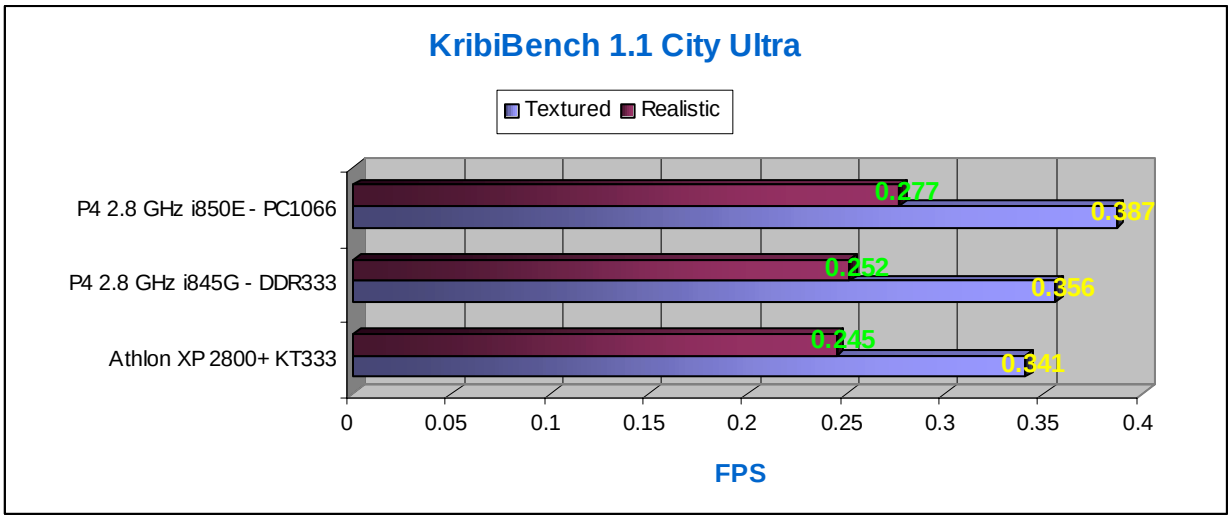


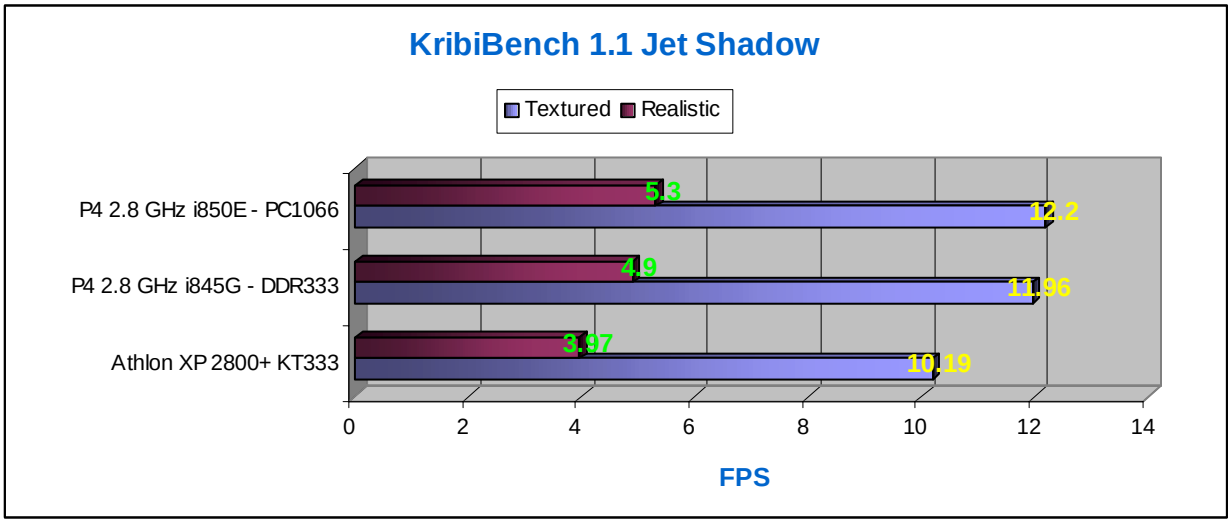
Unfortunately, the AutoCAD 2002 benchmark takes a lot of time, and as the NDA date came close, we were running out of time. But our first benchmark shows a small performance advantage for the Athlon in 2D AutoCAD tasks.

Software Rendering

What do you need all this CPU power for? Well, you can save yourself an OpenGL card if you use Kribi. Kribi, a product of **Adept Development**, is an ultra powerful software rendering 3D engine. Originally developed by Eric Bron, a regular visitor of Ace's Hardware, it is designed to handle up to 10 billion polygons and enable real-time photorealistic rendering. The Kribi engine uses 100% software rendering (a pure CPU benchmark) and cannot work without SSE instructions. It is thus a sort of SSE and FPU benchmark.

The engine is marketed to developers who wish to develop full-fledged 3D-applications. We tested with the version 1.1 of KribiBench.



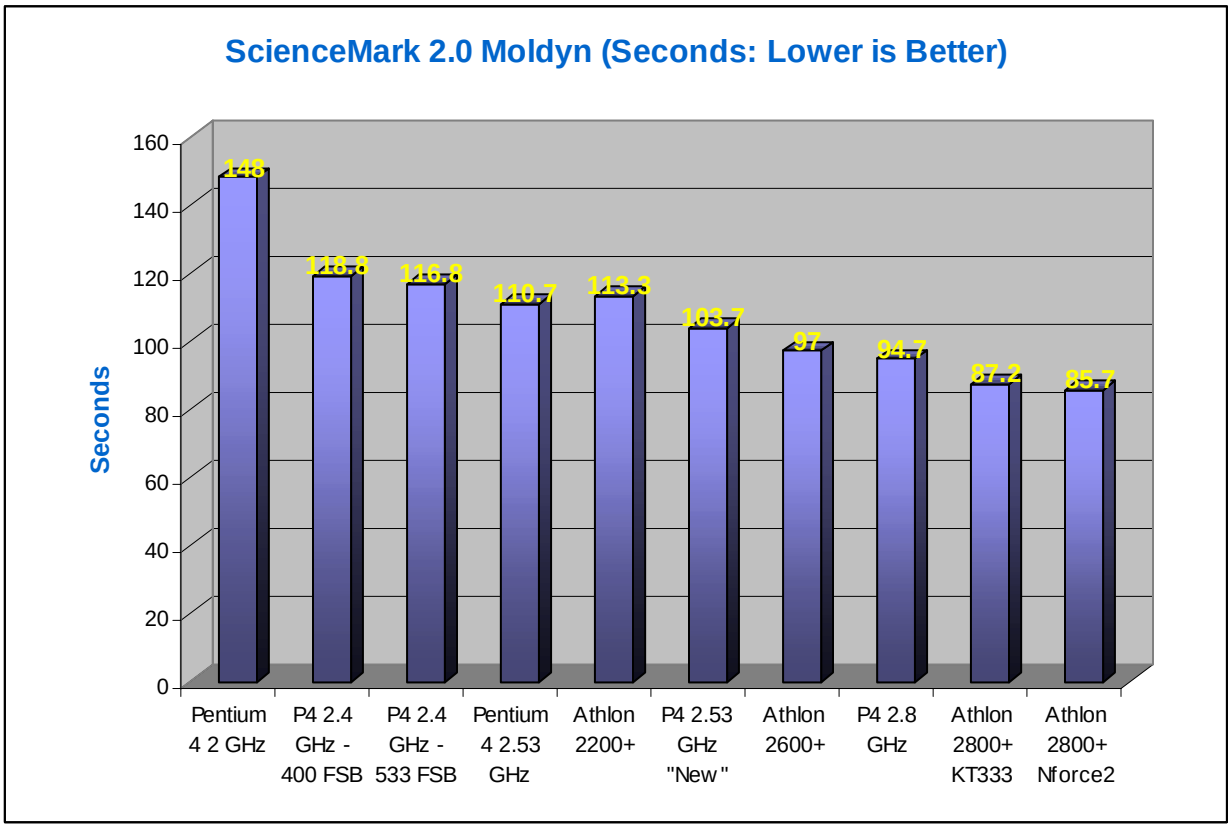


We will investigate SSE performance in one of our upcoming articles, but the higher clockspeed of the Pentium 4 really pays off here. Not hampered by many branch mispredictions or dependencies, the CPU with the highest clockspeed wins.

Professional Benchmarks: Scientific Workloads

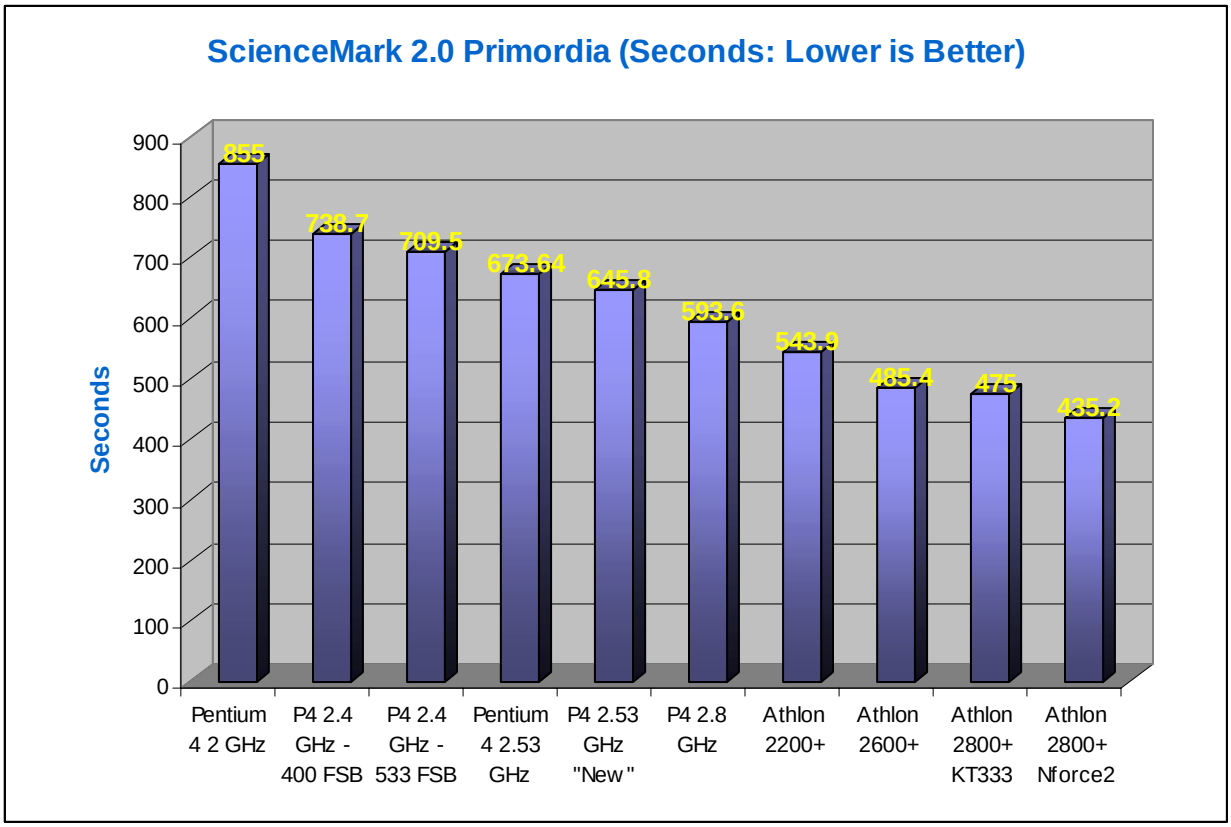
The ScienceMark 2.0 (16/08/2002) is, of course, more than MemBench. It is a well-optimized benchmark for both the Athlon and the Pentium 4 that gives us an idea of how the different CPUs perform with scientific workloads.

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**.



The next benchmark is Primordia. 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.



Again, the nForce 2 flexes its muscles and beats the KT333 by a healthy 9% margin. We are really curious as to whether or not the nForce 2 production boards will show the same impressive performance.

Conclusion

Contrary to popular belief, the Athlon can benefit quite a bit from a FSB at 166 MHz FSB. The nForce 2 shows that an aggressively optimized chipset can push the performance of the Athlon XP up to 15% higher. That is enough to make sure that the Athlon XP 2800+ is indeed competitive with the 2.8 GHz Pentium 4.

However, this is nothing more than a preview of the nForce 2. The memory controller rocks, but it remains an open question if the stable production boards will be as aggressively tuned as our rather unstable prototype board. In our humble opinion, this launch comes a bit too soon. We would have preferred to run our benchmarks on a fully stable nForce 2 platform and with an Athlon XP CPU which would available to our readers in a few weeks.

Nevertheless, this review also shows that the Athlon platform can remain very competitive with the Pentium 4. AMD leaves a lot of performance on the table with the small L2-cache and the mediocre prefetcher. AMD may decide to pick this low-hanging fruit with future Athlon revisions and or Hammer.