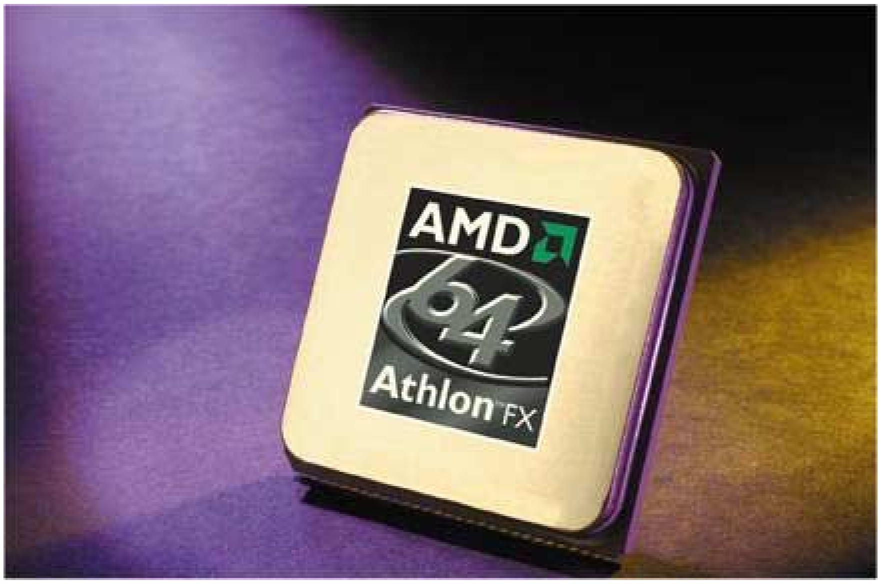
Athlon 64, Athlon 64 FX and Pentium 4 Extreme Edition

By Johan De Gelas – September 2003



The first 64-bit x86 CPU for the Windows desktop is here: the Athlon 64 FX and Athlon 64 have been launched and are available today. AMD's newest CPU has been improved where it matters the most: a much faster memory controller, a more intelligent branch predictor and a faster and larger L2-cache.

AMD's ambitions for the Athlon 64 FX are very high, it is "simply the fastest desktop CPU, period!"

But Intel isn't sitting still. Despite being a huge company, it is not slow on the draw.

History shows that the whole Intel fleet can perform a U-turn at lightning speed, and this time is no exception. In a preemptive strike, Intel is launching the Pentium 4 Extreme Edition, precisely timed to spoil AMD's launch. Or is the new Pentium 4 with 2 MB L3 cache an *Emergency Edition* chip as some of our readers like to call it?

Before we start, I would like to quickly discuss what you may expect from this review. Let us begin with the bad news: don't expect a lot of 64-bit benchmarks in Windows XP/64. At the moment, the number of 64-bit Windows applications is very limited, and all that was available to us were some benchmarks that AMD suggested and sent. We did not have a compiler available, so even developing and compiling our own benchmarks was essentially impossible. While the 64-bit Windows environment behaved very well, the 64-bit applications have yet to arrive, so we did not spend a lot of time in this new 64-bit OS.

The good news: many of our 32-bit benchmarks should interest you quite a bit. We know all too well that you expect us to come up with a few surprises and new refreshing benchmarks here at Ace's. First of all, **no less than 15 different game engines** have been tested, including Unreal II, Jedi Knight Academy, X² (brand new space simulator), and of course, Ace's classics like Medieval War, Age of Mythology, and Battlefield 1942 "Road To Rome". Even the performance of Artificial Intelligence in a very popular game has been measured...

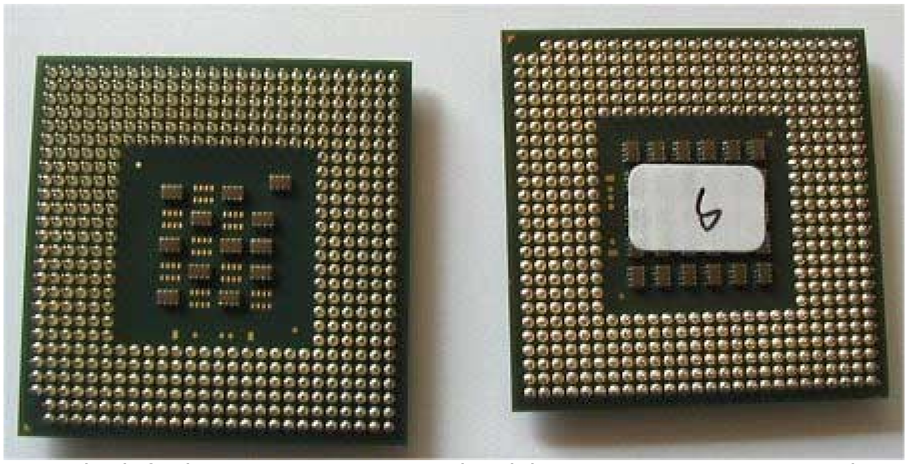
That is not all, a few new benchmarks, like MS Access, have been developed in house and we have worked together with a number of experts to present you with some lesser known, but important real-world benchmarks. A big thanks to these professionals:

- 3DS Max benchmarks (Fremer, Studio PC)
- Kribi (Eric Bron, Adept development)
- Diep Chess engine (Vincent Diepeveen)
- Pandromeda MojoWorld (Bryn Forbes)
- R - statistical analyses (Michael Williams)
- Plasma (Dr. Simon Bland and Dr. Jerry Chittenden, Imperial College)

This should keep you busy for a few hours... Oh yes, I forget to tell you: besides the 3 CPUs discussed further, we have a **fourth one, which is even more powerful in the next article!**

Three New CPUs

We welcome three new CPUs today: the **Pentium 4 Extreme Edition**, the **Athlon 64 FX-51**, and the **Athlon 64 3200+**. The Pentium 4 EE is a Xeon MP at 3.2 GHz with a 800 MHz FSB. It has been repackaged to fit in a 478-pin FC-PGA2 straight-jacket. This chip will most likely be introduced at $740.



On the left the P4 3.2 GHz "C", on the right our 3.4 GHz P4 EE sample.

Notice that the Pentium 4 EE has a lot more discrete capacitors and resistors on the bottom of the processor than the "normal" Pentium 4. A fat chip like the Pentium 4 EE needs more precise power, because the larger the chip the more complex power and clock signal distribution is. According to documentation, the TDP of the 3.2 GHz Pentium 4 EE is 94W.

The 940 pin **Athlon 64 FX-51** is in fact a disguised Opteron at 2.2 GHz and the memory controller requires registered or buffered DDR RAM. This type of RAM comes at a slight premium and the buffer introduces a few extra clocks of latency. On the flip-side, most buffered RAM is also equipped with ECC (Error Correcting Code) which makes the memory subsystem more reliable since it can correct 1-bit errors and detect 2-bit errors. The Athlon 64 FX can access pairs of 64-bit DDR400 DIMMs as one large 128-bit channel, resulting in a peak theoretical bandwidth of 6.4 GB/s. Buffered DDR400 is however very rare at the moment.

Priced at $733, the Athlon 64 FX-51 is not exactly a bargain, but you are in fact buying a workstation CPU. Athlon 64 FX boards allow you to use up four 2 GB DIMMS (very expensive) for a total of 8 GB of RAM. So the Athlon 64 FX is a true 64 bit workstation CPU: ECC, 64-bit addressing, and a platform that can break the 4 GB memory limit.

No more broken or barbecued chips: the Athlon 64 is protected

The 754-pin **Athlon 64 3200+**, a 2 GHz CPU, is much less demanding: it works with "normal" unbuffered DDR400 and is yours for $417. The little brother of the Opteron only has access to one 64-bit memory channel and finds a place in motherboards based on the VIA K8T800 (ASUS, MSI) or nForce3 150 (Gigabyte). These boards are faced with the limitations of a typical DDR chipset: support for at most 2 GB (K8T800) or 3 GB (nForce 150) and it is likely that inserting a third DIMM throttles DDR400 back to 333 MHz, as indicated by MSI's manual.

A Superior Athlon!

We've already discussed the **architectural differences** between the "K7" (Athlon) and "Hammer" (Athlon 64) cores in **our Opteron review**, so I am going to limit myself to a quick overview.

The Athlon 64 (FX) and Opteron are architecturally superior to an Athlon XP for these reasons:

- Integrated memory controller, dual channel registered (buffered) DDR400 or single channel unbuffered DDR400
- 16-bit 600/800 MHz DDR (dual simplex) HyperTransport links for communication with the AGP Tunnel and Southbridge
- SSE-2 instruction support with 16 registers in 64-bit long mode
- 12-stage integer pipeline (Athlon = 10), 17-stage FP pipeline (Athlon: 15) for slightly higher frequency headroom
- An extra pipeline stage also analyzes instruction interdependencies, just after decoding
- Slightly deeper integer buffers (3x8 instead of 3x6)
- L1-instruction cache TLB increased from 24 to 40 entries
- L2-cache TLB twice as big (512 entries instead of 256)
- Flush filter allowing multiple processes to share the TLB
- Better branch prediction and branch predictor with 16K instead of 4K entries in the global history counter
- 128-bit memory access to two DIMMs (Athlon 64 FX)

Below, you'll find an updated table of the different CPU features:

Features	**Athlon 64 FX**	**Athlon 64**	**Pentium 4 "C"**	**Pentium 4 EE**	**Athlon XP 3200+**
clockspeed	2.2 GHz	2 GHz	2.4-3.2 GHz	3.2 GHz	2.2 GHz
process technology (µm)	0.13 SOI Cu	0.13 SOI Cu	0.13 Cu	0.13 Cu	0.13 Cu
Transistors (million)	105.9	105.9	55	168	37.5
voltage	1.55V	1.550V	1.5-1.55V	1.55V	1.65V
die size (mm²)	193	193	131	230?	80
Adress Space	**Athlon 64 FX**	**Athlon 64**	**Pentium 4 "C"**	**Pentium 4 EE**	**Athlon XP 3200+**
Typical Multi processor system	(Opteron: 1-8) Athlon 64 FX: 1	n/a	n/a	n/a	n/a
Max. Physical Address Space	1024 GB flat (40 bit)	1024 GB flat (40 bit)	64 GB PSE (36 bit)	64 GB PSE (36 bit)	4 GB
Max. Virtual Address Space	256 TB (48 bit)	256 TB (48 bit)	4 GB	4 GB	4 GB
SIMD	SSE2/3DNow!/SSE	SSE2/3DNow!/SSE	SSE2/SSE	SSE2/SSE	3DNow!/SSE
Cache configuration	**Opteron**	**Athlon 64**	**Pentium 4 "C"**	**Pentium 4 EE**	**Athlon XP 3200+**
L1-cache (Data/Instr)	64/64 KB	64/64 KB	8 KB/ +-20 KB**	8 KB/ +-20 KB**	64/64 KB
L1-cache latency (load to use)	3	3	2	2	3
L2-cache	1 MB	1 MB	512 KB	512 KB	512 KB
L2-cache Width	128 bit	128 bit	256 bit	256 bit	64 bit
L2-cache Latency load to use (+L1-latency)	16	16	9-20	9-20	11-20 (*)
L3-cache	-	-	-	2 MB	-
Memory	**Opteron**	**Athlon 64**	**Pentium 4 "C"**	**Pentium 4 EE**	**Athlon XP 3200+**
Memory configuration	(Opteron: 2x DDR333) 2x DDR400	1x DDR400	2 x DDR400	2xDDR400	DDR400
Max. Memory Bandwidth to CPU	(Opteron: 5.4 GB/s) 6.4 GB/s	3.2 GB/s	6.4 GB/s	6.4 GB/s	3.2 GB/s

*** 12000 Micro ops, which is probably comparable to about 20 KB x86 instructions cache*

The Athlon 64 FX has, just like the Opteron, a die size of 193mm. When AMD moves to 90nm (0.09-micron) technology next year, the corresponding die shrink will bring die size down to about 120 mm².

We know, these are only specs on paper. A bit further, armed with Sciencemark 2.0, we will find out how these paper specs compare to the real world. You will be amazed...

A Safer Athlon!

If you build a lot of systems, and you are as handy as yours truly, you know that one of the weakest points of the Athlon was the fragile and highly "inflammable" die. I once killed an Athlon XP 2000+ because the heatsink was not firmly attached to the die, and I am sure I am not the only one who has encountered these kind of accidents (smile Kyle ;-).

AMD seems to have learned a lot, and finally we can say that the Athlon 64 is as safe as a Pentium 4. The sturdy heat spreader protects the fragile die and "Thermtrip" - fast on-die hardware circuitry that enforces an "over temperature failure prevention mechanism" - powers down the CPU in heated situations, fast enough to prevent avoid damage.

As **we've mentioned before**, all recommended Athlon 64 heatsinks support a CPU that dissipates up to 89 Watts. In order to be recommended by AMD, motherboard/heatsink manufacturers have to design for a "worst-case" Athlon 64 that dissipates up to 89 Watts.

For the AMD64 family (Opteron and Athlon 64), AMD wants all motherboards and heatsinks to be capable of supporting even the fastest CPUs (well, if the number of pins stays the same), so people might be tempted to upgrade their CPU more quickly. It is very questionable if the Hammer cores will ever need that kind of power at the current process and package. 89 Watts gives AMD a lot of headroom, and upgrading your current 754/940 pin motherboard should be much easier than it ever was with the Athlon XP. Also note that ***while the 940-pin Athlon FX will be replaced by a 939 pin model next year (no need for buffered RAM), AMD has promised to produce new 940 Pin Athlon FX throughout 2004.***

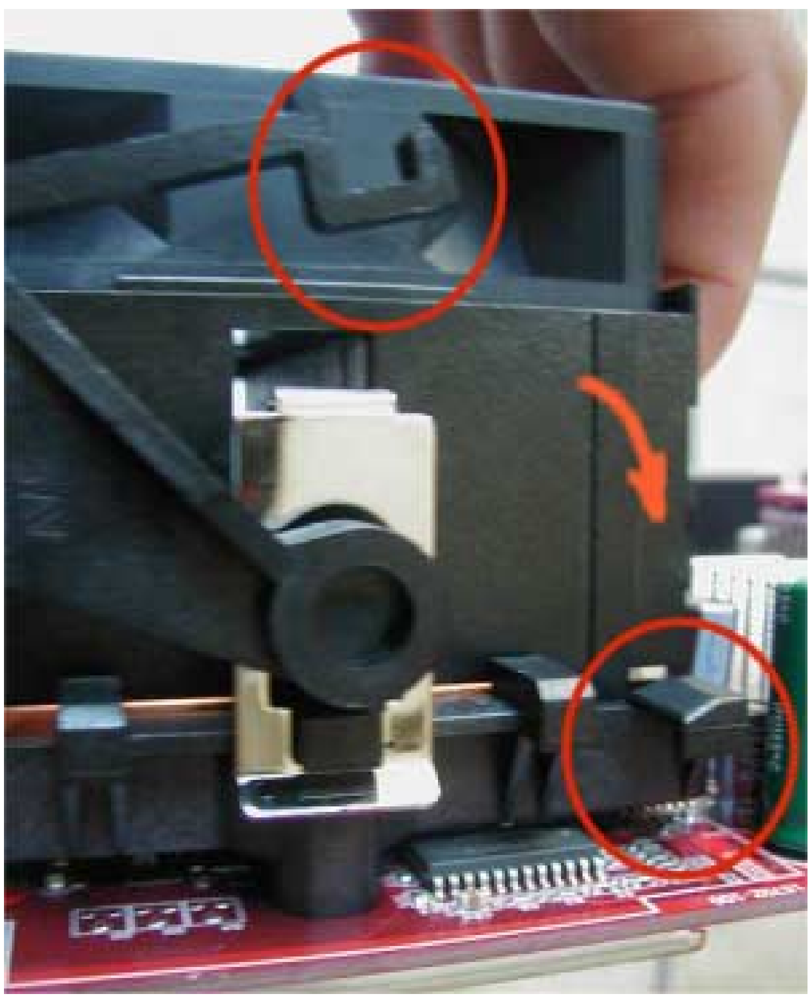
AMD has yet to release the power dissipation figures (work in progress according to Damon Muzny), but rest assured the current 2.2 GHz model does not dissipated 89 Watts.

Typical heatsink solution for the Athlon 64: massive heatsink but slow 3000 rpm fan.
Note the special safety hook on the lever

There is more. As you can see, excessive force is no longer needed to attach a heatsink firmly on your CPU. A backplate is attached to the back of the motherboard, and is fastened by two screws through the motherboard and the retention mechanism.

The Athlon 64 retention mechanism (here on the MSI K8T Neo) is efficient and user-friendly

A new locking mechanism on the heatsink makes it much easier to lock the heatsink down in the retention mechanism.



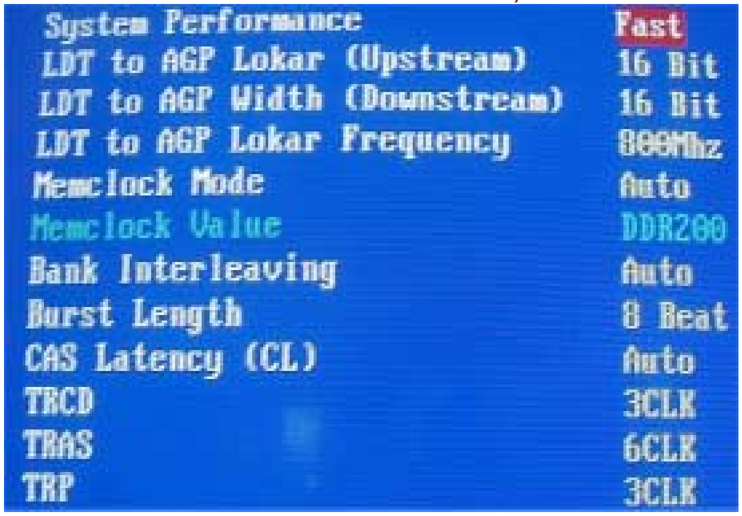
At one side a simple clip has to be pushed down (no force necessary) and on the other side a "fix lever" is lifted up and fastened with a safety hook to a fixed bolt.

MSI's K8T Neo FISR, VIA's K8T800

MSI was - as always - the first OEM to send a new Athlon 64 (754-pin) motherboard. The board is based on VIA's K8T800 chipset, which still uses a two-chip north and south-bridge arrangement. Basically, VIA has connected this "classic" chipset layout (South, V-link, North) with a 2 x 16-bit 800 MHz DDR (3.2 GB/s up and down) Hypertransport connection from the CPU to the Northbridge. This probably reduced the development time necessary for the K8T800.

As is traditionally the case, MSI's NEO board is extremely feature rich. The VIA southbridge support two Serial ATA devices, and MSI added a Promise 20378 controller to support an additional two SATA devices (4 SATA devices in total) along with one extra Parallel ATA connector (6 devices supported in total).

Gigabit Ethernet is provided by the Realtek 8110S, and the two different firewire connectors can be found in the backpanel of the motherboard together with the S/PDIF port. The Realtek ALC655 chip is able to send analog and digital sound to 6 different channels. Four USB ports are immediately available and a fifth one is provided on a seperate bracket, which also contains diagnostic leds. SATA and rounded PATA cables are included.



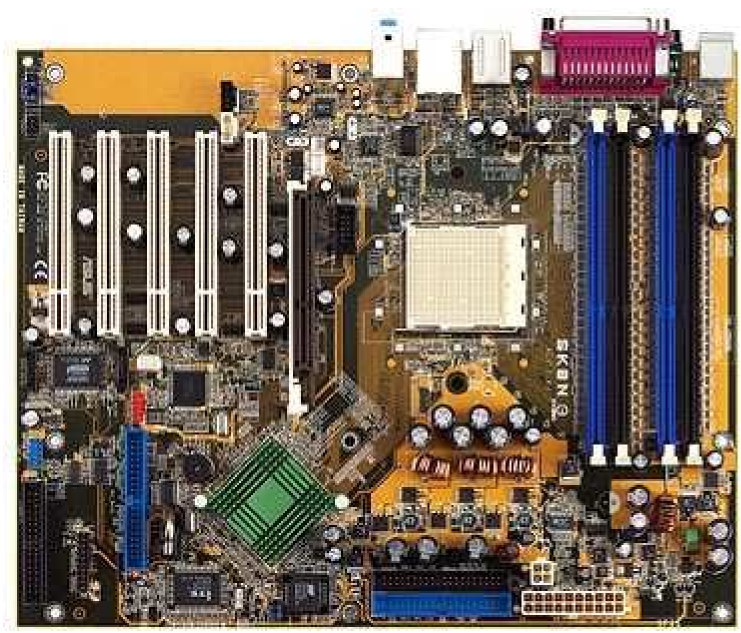
As you can see the BIOS is highly tweakable. The Hypertransport P2P connection can be set to 8 bit/16 bit and 800/600/400/200 MHz. CPU, DDR, and AGP voltages can be adjusted and you can increase the FSB in steps of 1 MHz to 280 MHz. This doesn't seem to work very well, as our board froze in the bios at 205 MHz.

Luckily, the MSI board also equips MSI's famous Dynamic Overclocking Technology (D.O.T.) which allows you to overclock the CPU by 3, 5, 7 and 10%. The beauty is of course that a special CoreCell chip only overclocks the CPU when it is under load, and throttles the CPU to its original value when it is idle. MSI's CoreCell is also capable of reducing power consumption when the system is idle ("PowerPro").

This worked very well, and allowed us to overclock the Athlon 64 3200+ by 7% with normal aircooling and 10% (2.2 GHz) with forced (heavy noise) aircooling.

Asus SK8N: NVIDIA nForce3 150 Chipset

The ASUS SK8N is based on NVIDIA's nForce3 150 chipset and features one immediately available Firewire (IEEE 1394) port, 4 USB 2.0 ports, S/PDIF digital audio, and 100 Mbit onboard LAN.



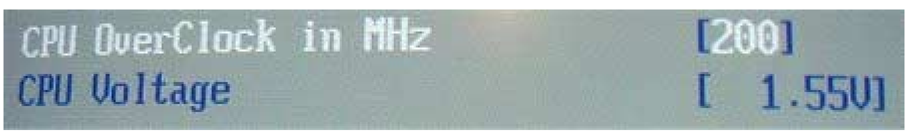
I must say I was absolutely impressed by the stability of this motherboard, I didn't encounter any problems whatsoever, even when I set the memory module settings to slightly over-aggressive settings (ECC was not enabled). This might not seem very surprising, but I can tell you that, for example, the first 400 MHz FSB nForce2 boards and i875P boards were very sensitive to the memory settings and the memory used. These platforms experienced occasional reboots after hours of intensive benchmarking.

This was most likely a result of the fact that both the margin of error on the nForce2 and i875P was smaller, and that some the SPDs of the DDR400 modules that we used were set too aggressively. For example, we heard from Corsair that on some of their DDR400 modules, the RAS to CAS latency should be set to "3" and not "2" (which was the default). You could argue that this is not the fault of the chipset vendors, but it is clear that both the i875 and the nForce2 400 didn't have much error margin. And personally I prefer to have a little wiggle room.

Back to the nForce3 150 and the ASUS SK8N: both are very elegantly designed. The nForce3 is not a nForce2 with Hypertransport glued on it, NVIDIA made optimal use of the possibilities offered by Hypertransport and the Athlon 64. The AGP tunnel has been integrated into the southbridge. This makes it easier to route all the signals, as the chipset is in fact only a single chip.

The nForce3 150 was designed with a 16-bit downlink and 8-bit uplink running at 600MHz DDR (1.2GHz effectively). Peak bandwidth is thus 2.4 GB/s down (VIA: 3.2 GB/s) and 1.2 GB/s up (VIA: 3.2 GB/s). NVIDIA believes this single chip solution is more efficient than VIA's because the throughput of all the devices on VIA's southbridge is limited by the V-link (533 MB/s) between the south and nortbridge, whereas NVIDIA has a 3.6 GB/s connection between the chipset and CPU. Of course, it will be very hard to measure the difference, as the bottleneck will only occur if USB 2.0 devices (80 MB/s) are trying to access the memory controller at the same time as SATA RAID (300 MB/s) and ATA-133 drives (133 MB/s). That seems quite unlikely as the hard disks can only achieve these kinds of speeds when fetching data out of their caches.

The nForce3 150 also has a big brother, the 250 which features both a 16-bit uplink and 16-bit downlink running at 800MHz (1.6GHz DDR). NVIDIA went for a faster HT link since nForce3 250 includes onboard Gigabit Ethernet (Full Duplex) and quad SATA support (600MB/s).



ASUS' overclocking possibilities are quite sober, but we can tell you that there is a special BIOS (not publicly available) that allows you to change the multiplier that seems to be unlocked on our Athlon 64.

The ASUS SK8N is a stable, well performing board but ...

What happened to NVIDIA's SoundStorm?

...was the first question when we read the nForce3 150 and ASUS SK8N specifications. Where is that lovely sound chip?!

Bryan Del Rizio, NVIDIA:

> "We have opted to take SoundStorm out of the MCP for the initial launch and in early 2004, we will be introducing a discrete version of SoundStorm (with major updated features) that can be added by the motherboard manufacturers to their board designs or perhaps even used for an add-in card. The benefit is that this provides our partners the cost and design flexibility for incorporating high-level of audio with their products. We'll have more information about SoundStorm later this year."

I cannot say I am happy with this. This means motherboard manufacturers are saving a few pennies but customers don't get Dolby Digital sound and superior 5.1 output. Maybe we, enthusiasts, should educate our friends and family a bit better so they are willing to pay a little more for a quality and feature-rich motherboard. The price competition is so intense that manufactures are doing everything to save a few pennies. In this case this will not affect the stability of the board, but I have seen too many poor and even unstable motherboard sell well because they were so cheap (remember the ECS SIS730 boards?).

What about the "64" in Athlon 64?

Windows 64 should offer advantages to both 32-bit and 64-bit applications. 64 bit applications can be faster than their 32-bit counterparts thanks to speedier 64-bit integer calculations (in some cases) and ISA improvements like an additional 8 GPRs (16 registers in total). Additionally, they can use much more memory than the 4 GB limit imposed on 32-bit applications. To benefit from this, you need at least an Athlon 64 FX motherboard which supports up to four 2 GB DIMMs, or better yet, a quad Opteron motherboard capable of supporting up to 32 GB.

32-bit applications benefit as well, though. When they are running in 32-bit Windows XP only 2 GB is available as 32-Bit Windows maps 2 GB (or in some cases, 1 GB) for I/O. Running 32-bit applications in Win64 means that they have almost 4 GB of address space available to themselves instead of only 2 GB.

32-bit apps must have the "large image aware" bit set to get access to the full 32-bit (4 GB) address space. Otherwise, they get the usual 2/3 GB. For example, MS SQL Server, and several high end CAD applications have been already developed making use of Very Large Memory (VLM) APIs. The reason is that (32 bit) Windows 2000/2003 Enterprise and DataCenter Editions already permit the shifting of memory allocation to allow additional dedicated memory for application support

A small piece of the 32-bit address space is mapped for I/O purposes, like for example AGP cards. Most AGP cards cannot address beyond 32-bits, so that is why the AGP aperture is mapped into the 4 GB/32-bit range.

There's more: 32 bit applications should also get a small performance boost. The heap manager in Windows 64 has been improved, as has context switching. WOW64 thunking (32-bit on 64-bit, 32-bit apps can only use 32-bit DLLs and visa-versa) only has a very small performance hit. The result is that many 32-bit applications actually run slightly faster under Windows 64 than normal 32-bit Windows, despite the (very small) thunking penalty.

We have tested the 64-bit extension to Windows XP, and we can honestly say the OS is stable and as good as ready for primetime. There were a few caveats, however, that we will discuss a bit further down.

64-bit Software Support

What's a 64-bit CPU without any 64-bit software? We'll try to give you a small overview of how software support for the AMD64 family is shaping up. Software marked in bold will have 64-bit support, the other ones will just support, optimize and recognize the Opteron/Athlon 64 as a 32-bit (SSE-2 etc.) chip:

Linux OS

- **MandrakeSoft**
- **Red Hat**
- **SuSE**
- **UnitedLinux**

All Linux distributions support the AMD64 family, but only four of them really have a 64-bit version ready. It is pitty that Debian is not among them, as it is one of the most "enthusiast-friendly" (very tweakable) distributions out there.

Other OS

- **FreeBSD**
- **NetBSD**
- Novell
- OpenBSD
- Sun Solaris x86

Sun supports the Opteron and Athlon 64 in their Solaris x86 OS, but 64-bit support is, of course, limited to the UltraSPARC family. Both FreeBSD and NetBSD also have ports to AMD64.

Enterprise Database

- **Computer Associates**
- **IBM DB2**
- **MySQL**
- **Oracle**

This is a pretty impressive list as Oracle and DB2 together have a very large portion (>50%) of the medium and large enterprise market. MySQL is of course the most popular open source database, and probably the most popular website database. Curiously, MS SQL Server is not included in this list.

Web Server

- **Apache**
- **Zeus**

According to Netcraft, 64% of the Internet's web sites run Apache, while 24% run MS IIS. The high performance webserver Zeus is good for 2% while Sun One has a 3.5 - 4% market share. Many open source HTTP servers like AOLserver and so forth are available with source code, so it is possible that they may be recompiled into full-fledged 64-bit versions with a minimum of effort.

64-bit Tool Vendors & Compilers

- **Atlas**
- **GNU**
- **Blackdown Java**
- **Perl**
- **MPICH**
- **Compuware**
- **MigraTEC™**
- **NAG**
- **PGI**

Microsoft's .NET framework is under development for AMD64, MS Visual C++ for AMD64 has been developed but does not seem to be widely available right now.

CAD/CAE/Energy

- Adapco
- Ansoft
- Ansys
- Autodesk
- Bentley
- **CEI**
- Fluent
- Landmark
- LSTC
- Parasolid
- Spatial
- Solid Edge
- SolidWorks
- Wai

EDA

- **Cadence**
- Mentor Graphics
- **Synopsis**

DCC

- Canopus
- Discreet
- Linux Media Arts
- **Mental Images**
- Newtek
- Adobe Premiere
- Softimage

Video

- Canopus
- Cyberlink
- **DivX**
- Intervideo
- Ulead

CAD and DCC ISVs support the Athlon 64 and Opteron, but the step to investing time and money in a 64-bit version is too steep. Obviously they are waiting to see whether or not the AMD64 platform will become a viable and thus popular enough platform to develop for.

Gaming

- **Epic**
- **Valve**
- **Crytek**
- **SCI**

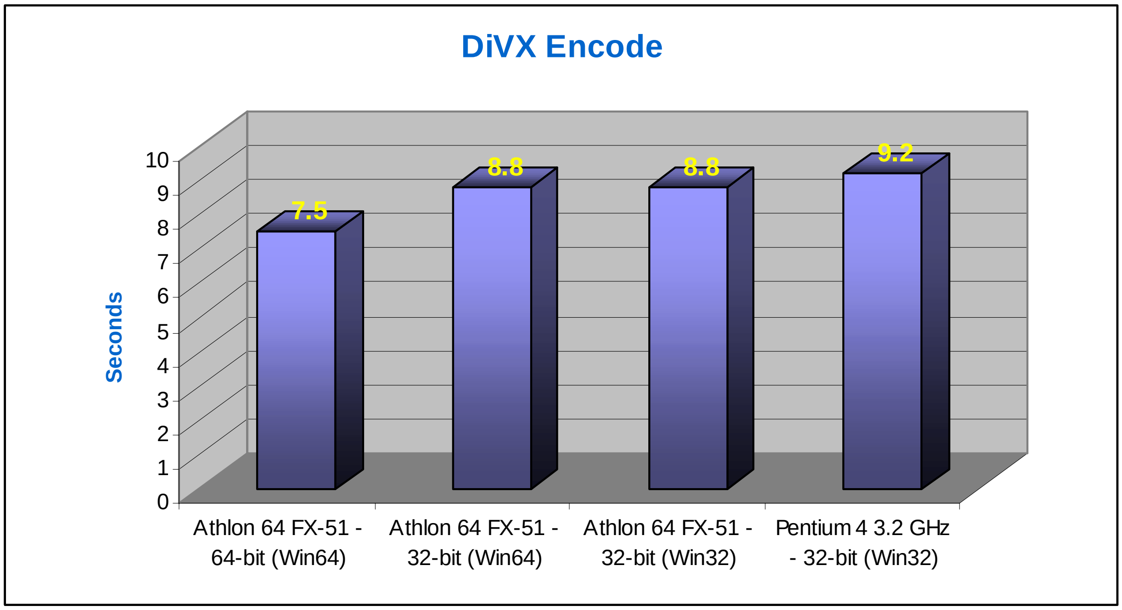
With EPIC and Valve developing 64-bit versions of their popular games, the AMD64 platform has made its first steps to becoming a true gaming platform. Crytek are the people behind "Far Cry," which was nominated as "the best PC Game of the ECTS Show."

Cryptography is the basis of every secure (HTTPS) website and is one of the few applications that can benefit significantly from faster 64-bit integer calculations. Optimized AMD64 RSA libraries are available, as you will see below.

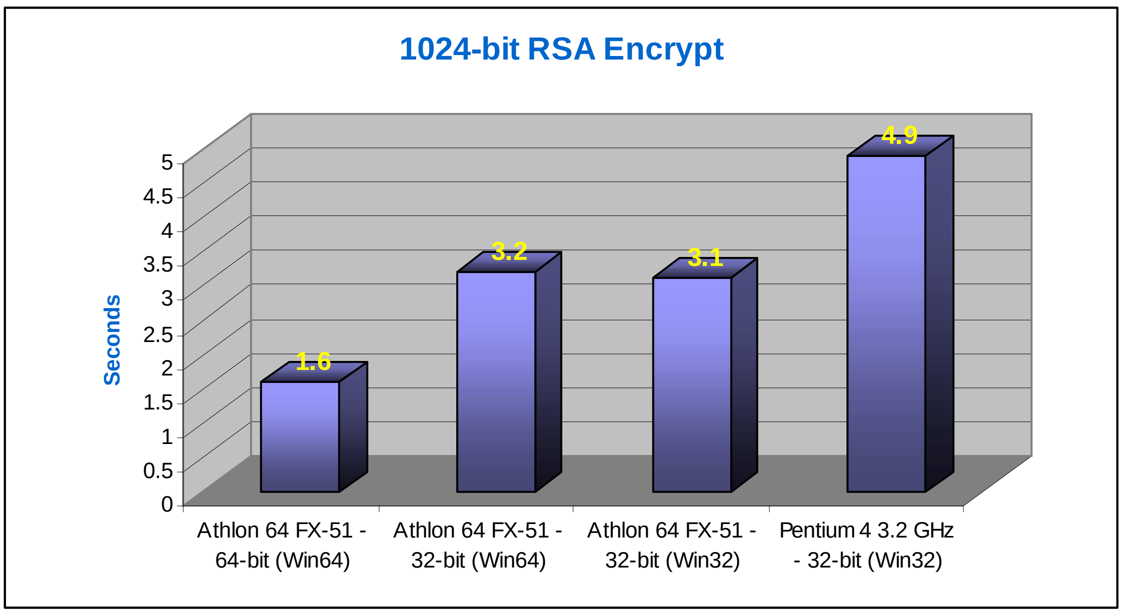
64-bit Benchmarks

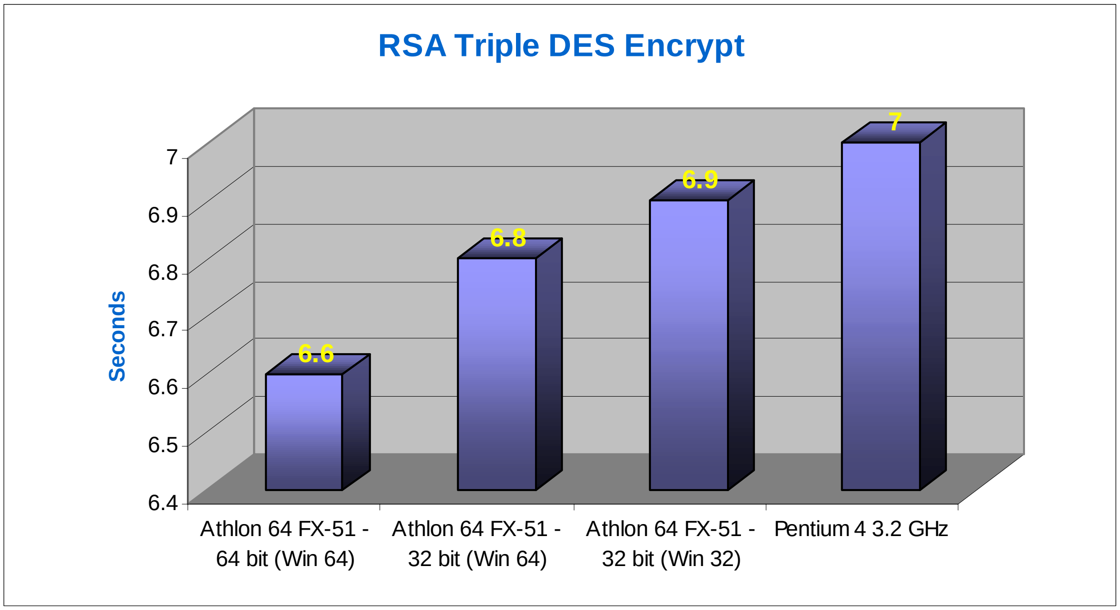
The following tests have been conducted by AMD. I have quickly verified a few of them and picked out the most interesting. We'll conduct more 64-bit benchmarking later, because reproducing manufacturers benchmarks is not my idea of fun ;). We decided to include them to see what kind of improvements 64-bit applications can bring in various cases;

The DivX encoder benchmark contains both a 32-bit and a 64-bit benchmark that measures the performance of raw video encoding of the AMD optimized DivX video encoder version 503. The encoder has been optimized for the AMD64 platform (both the 32-bit and 64-bit versions).

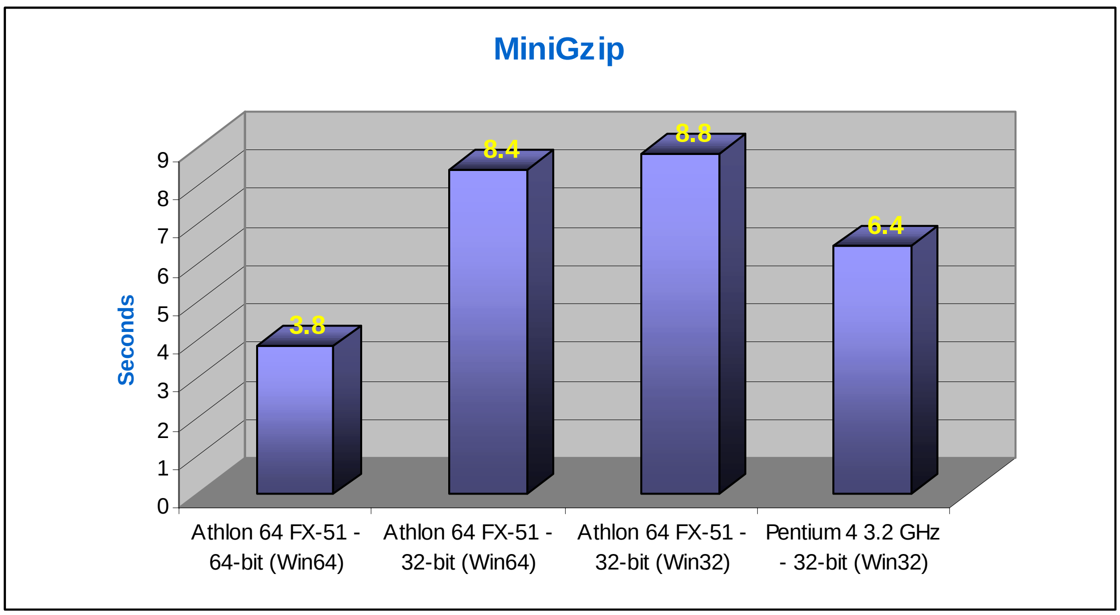


The RSA benchmarks consist of a set of 32-bit and 64-bit executables that measure the performance of key RSA cryptography routines. The 64-bit executables use RSA code that has been optimized for AMD64. The 32-bit executables have also been optimized for AMD64.





The Mini-GZIP benchmark contains a 64-bit binary that measures the performance of an AMD64-optimized version of ZLIB. The 32-bit benchmark is implemented with the standard (unmodified) ZLIB.

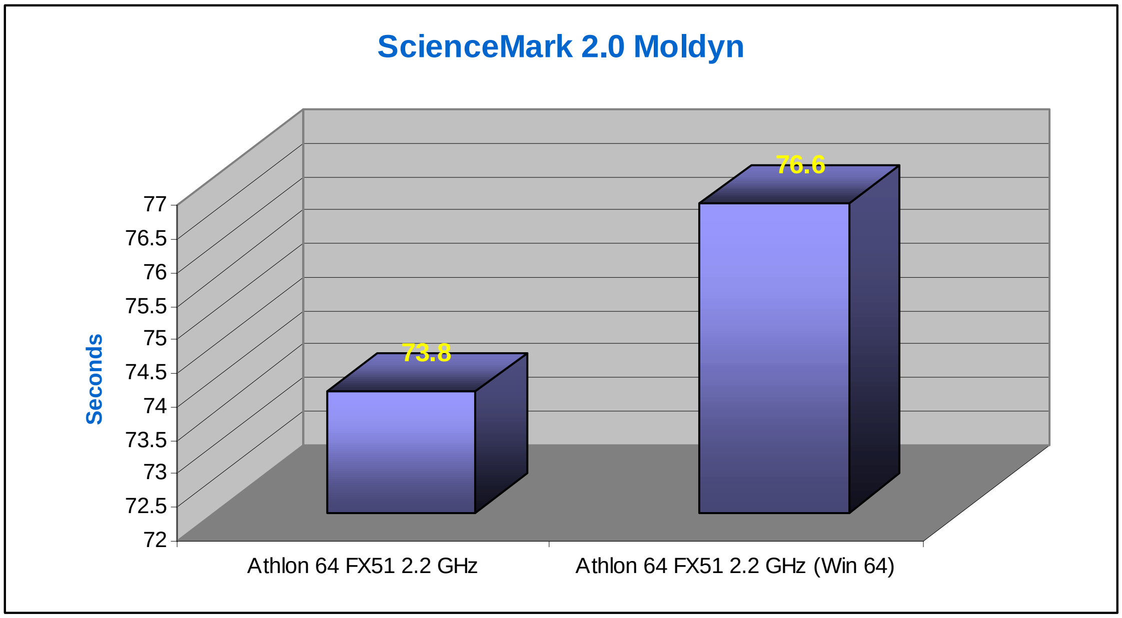


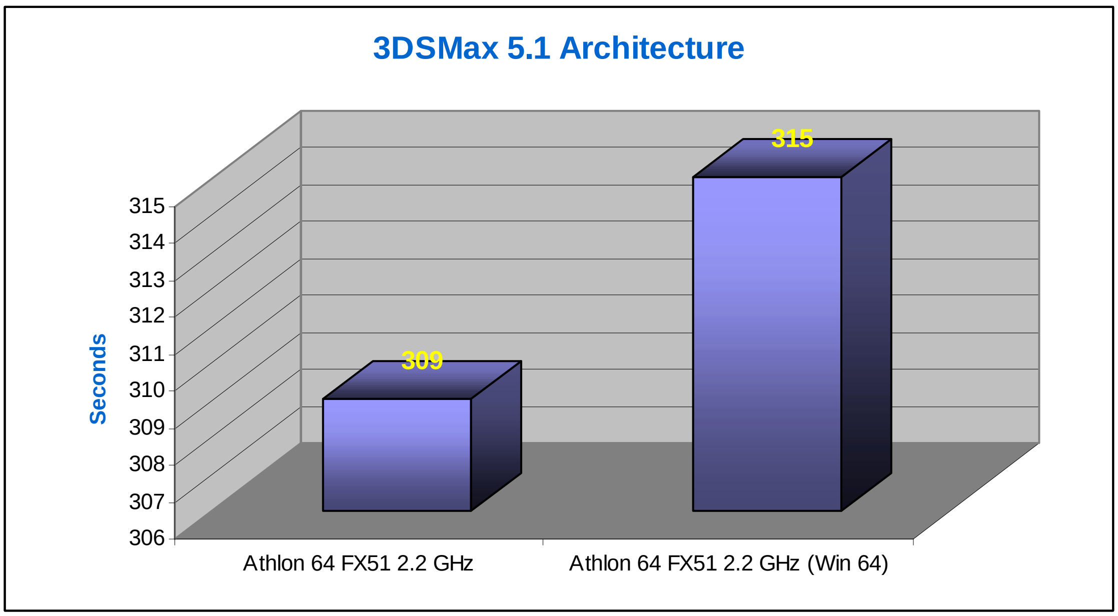
Don't pay too much attention to the Pentium 4 scores. We'll have to check first if there are no more-optimized P4 versions.

More interesting is that two applications, MiniGzip and RSA encryption see performance double, probably because these applications work with 64-bit integers. DES and DIVX show 5 and 17 percent performance improvements, respectively. Most developers we talk to say that faster 64-bit integer calculations will only benefit a very limited of applications, but most applications are more likely to benefit from 16 instead 8 registers, with performance increases ranging from 15 to 30 percent. This kind of optimization would make a 2.2 GHz Athlon perform like it was a 2.6 or 2.8 GHz chip.

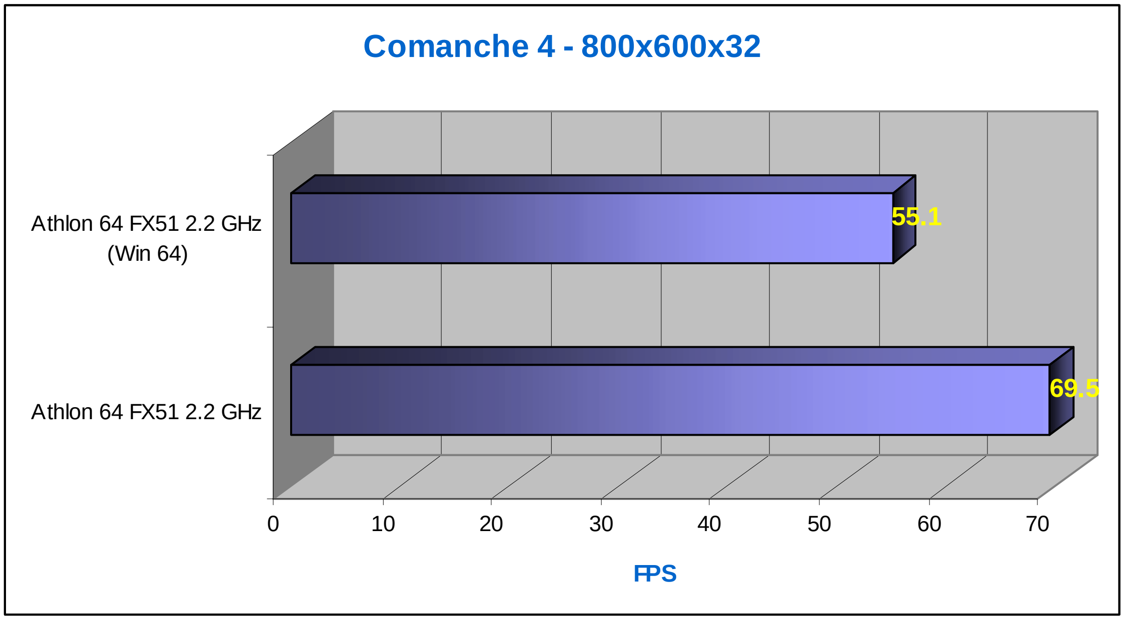
32-bit Applications on 64-bit

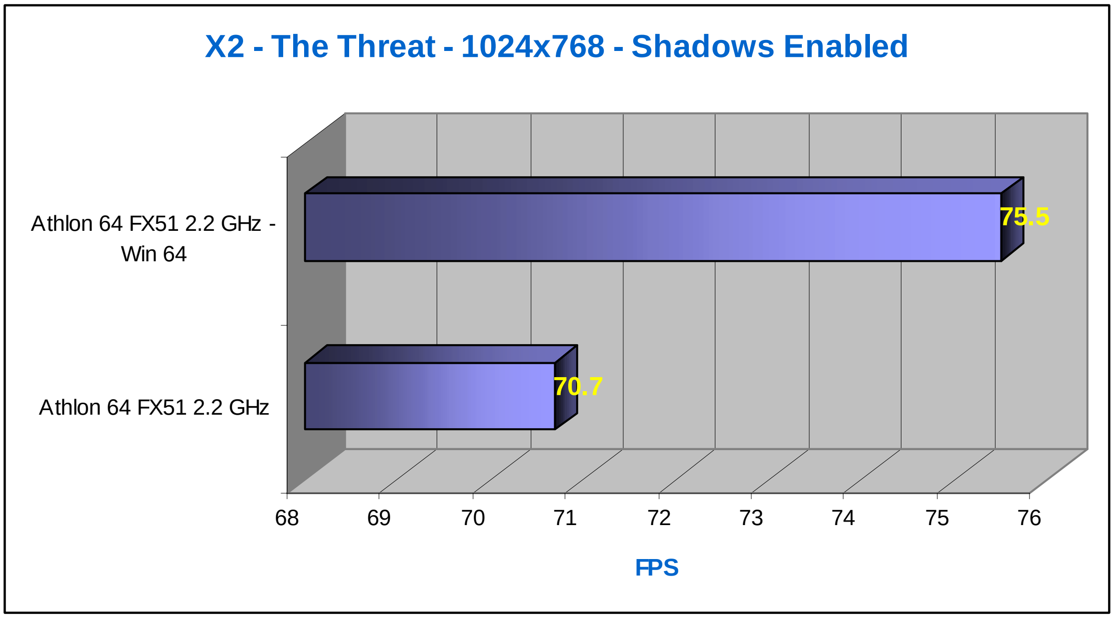
Back to our own testing. How do 32-bit applications perform on the 64-bit Windows Beta? We did a quick check with several of our classic benchmarks.

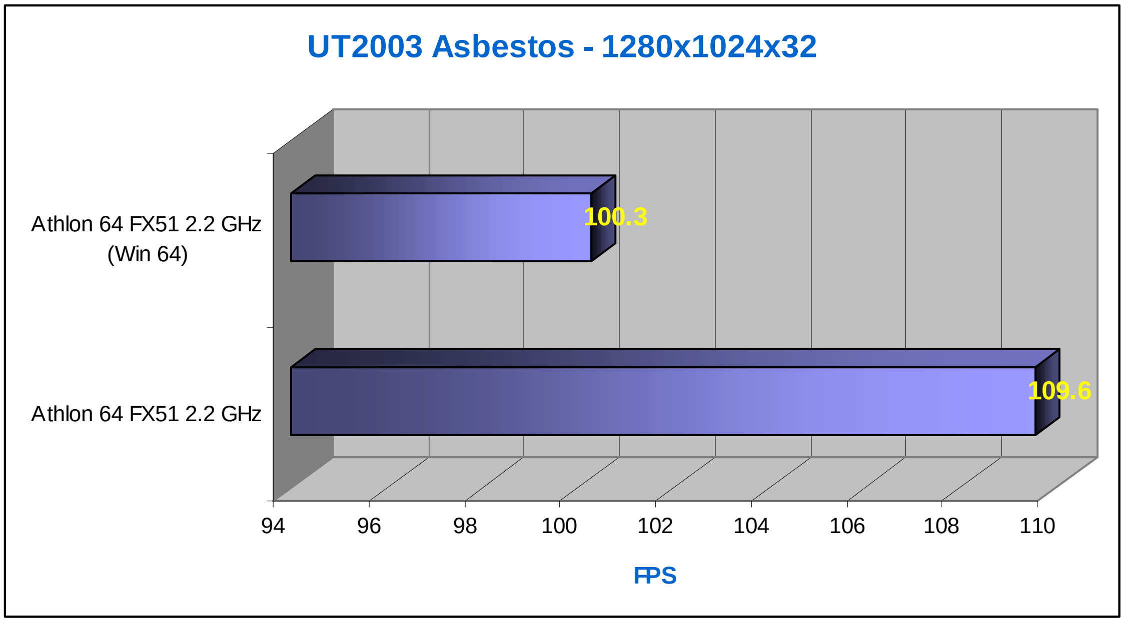




Most applications perform a little slower on Windows 64 than on Windows XP, but considering Windows 64 is in a beta state and 32-bit applications must go through the thunking process, this is only natural. The 64-bit driver (50.xx) from NVIDIA needs some tuning though:


Comanche 4 - 800x600x32
Athlon 64 FX51 2.2 GHz (Win 64)
Athlon 64 FX51 2.2 GHz
55.1
69.5
0
10
20
30
40
50
60
70
FPS


X2 - The Threat - 1024x768 - Shadows Enabled
Athlon 64 FX51 2.2 GHz - Win 64
Athlon 64 FX51 2.2 GHz
75.5
70.7
68
69
70
71
72
73
74
75
76
FPS



We tried a few other games too, and with the exception of X² all games ran slower. Wolfenstein: Enemy Territory, the only OpenGL game we tried, crashed. It seems that the OpenGL part of this driver is not ready, because Cine2003, for example, reported much higher numbers with software shading than with OpenGL hardware or software acceleration.

Cinema 4D Cinebench 2003	Athlon 64 FX-51 (Windows XP)	Athlon 64 FX-51 (Windows 64 bit)
Shading (OpenGL software Lighting)	**1710**	**237**
Shading (OpenGL Hardware Lighting)	**2964**	**134**
Shading (CINEMA 4D)	**367**	**366**

Notice that hardware acceleration is not working at all: it is even slowing down the shading process. With a good OpenGL driver (such as 45.23 in Windows XP), hardware acceleration is much faster than any software solution.

Benchmarked Configurations

You will notice that we did not test all CPUs in every benchmark. As always, time was limited, so we sometimes opted to test only the most important CPUs, especially in synthetic benchmarks.

We used **Corsair's XMS 3700 CAS 2 DDR** (DDR400) for maximum overclocking possibilities and stability.
The desktop was set at a resolution of 1024x768x32bpp with an 85 Hz refresh rate. V-sync was off at all times.

We refer to an *Athlon 64 FX-53* in various parts of this article, this is actually an *Athlon 64 FX-51* running at **12 x 200 MHz** (2.4 GHz).

Athlon 64 FX-51

- Asus SK8N rev. 1.03, BIOS 1002.007, NVIDIA nForce3 150 chipset
- Legacy PC3200 Registered (2x512MB) CAS2.5, 1GB total Memory

Athlon 64 3200+

- MSI K8T Neo rev. 1.0, BIOS , VIA K8T800
- 2x512 MB Corsair PC3200 XMS (DDR-SDRAM) running at 400 MHz CAS 2 (2-3-3-7)
- VIA Hyperion 4.49

Pentium 4 2.4, 2.8 GHz & 3.2 GHz C (Hyperthreading enabled) - 800 MHz FSB

- AOPEN AX4C-MAX, BIOS 1.10, i875P "Canterwood" Chipset Dual DDR400
- 2x512 MB Corsair PC3200 XMS (DDR-SDRAM) running at 400 MHz CAS 2 (2-3-3-7)
- Intel chipset INF update 5.09.1012

Athlon 1400 (T-bird), Athlon XP 2700+ (T-bred) and Athlon 3200+ (Barton)

- ASUS A7N8x Deluxe nForce 2 rev. 2.0, BIOS version 1.06
- 2x512 MB Corsair PC3200 XMS (DDR-SDRAM) running at 400 MHz CAS 2 (2-3-3-6)
- Build-in APU
- NVIDIA nForce 2 2.03 drivers

Shared Components

- Leadtek Geforce FX5900 Ultra 256 MB
- AC '97 Sound (integrated on all boards)
- Maxtor 80 GB DiamondMax 740X (7200 rpm, ATA-100/133)

Software

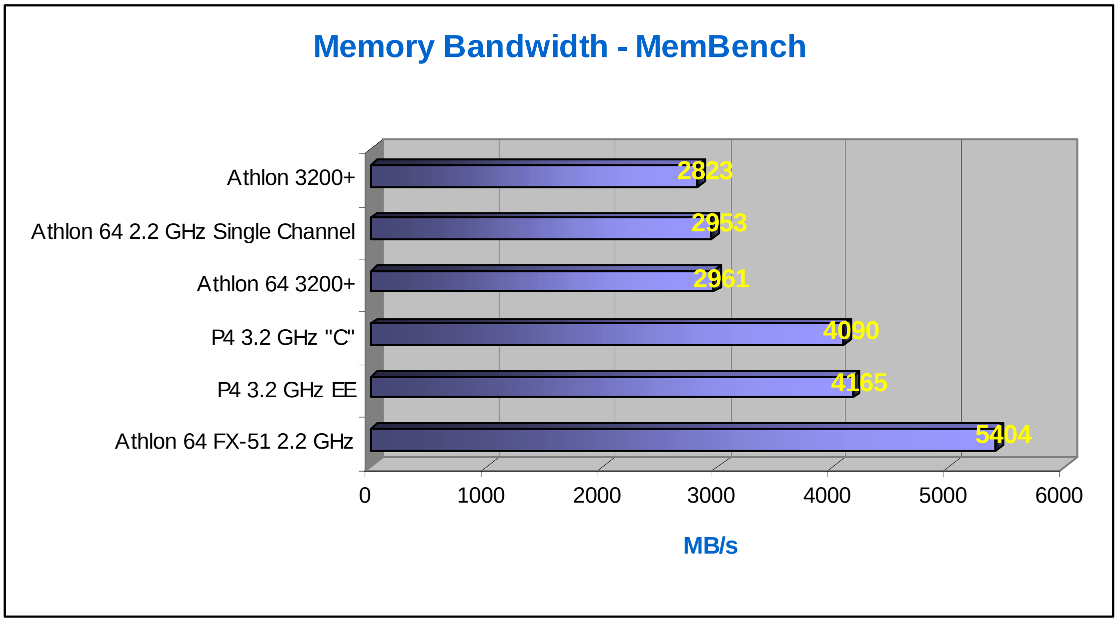
- **NVIDIA 45.23 Drivers (Video Card)**
- **Windows XP Service Pack 1A**
- **DirectX 9b**

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

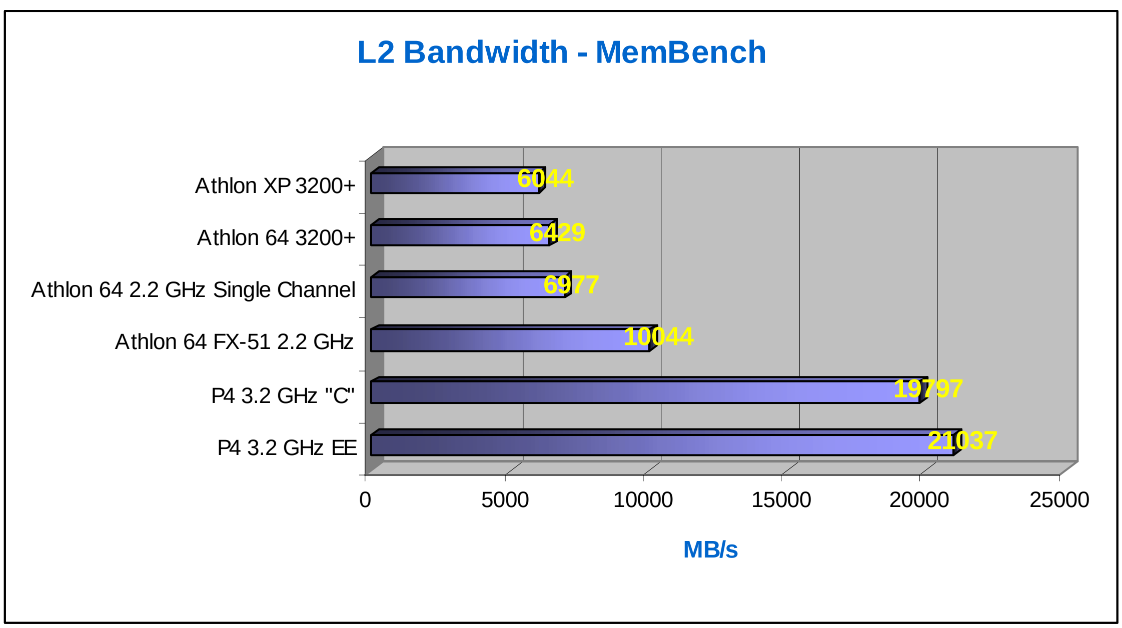
- Damon Muzny (**AMD**)
- Kristof Semhke and Markus Weingarter (**Intel**)
- Marga Zanders en Angelique Berden (**MSI**)
- Sandra Kuo (**Aopen**)
- Bryan Del Rizio (**Nvidia**)
- Robert Pearce (**Corsair**)
- Will Teng and Carol Chang (**ASUS**)
- Sharon Tan (**BAS computers Netherlands**)

Memory and Cache Performance

We have "hammered" on **the subject** more than once: modern CPU are essentially incredibly fast devices that spend most of their time waiting on the slow DRAMs. Very few applications run perfectly in-cache, even though they are 512/1024KB+ in size. These gigahertz monsters must be fed with delicious data or they will perform poorly. So, how do the memory subsystems of the Athlon 64 and Pentium 4 compare? We did a little investigating with **ScienceMark 2.0**:



Both the Athlon 64 FX51 and the Pentium 4 "C" versions have access to - in theory - a memory bus that can serve up to 6.4 GB/s. However the Athlon 64 FX with its memory controller close to the core and running at core speed is much more efficient: the Athlon 64 FX achieves 84% of the theoretical peak bandwidth, while the i875p northbridge only manages 64%. 5.4 GB/s is nothing short of incredibly impressive, 31% better than the best P4.



Curiously, the Athlons achieved their highest bandwidth numbers with MMX/SSE instructions while the L2-cache of the P4 preferred "REP MOVSD" moves. Even more interesting is the fact that the Athlon 64 FX-51 is the first "Athlon-ish" core with a fast L2-cache. Those who think that a large cache solves all "memory wall" problems, are proven wrong: the fast L2-cache of the new Athlon 64 can only reach its peak when fed by a 128-bit memory controller. With a 64-bit memory interface, the 128-bit L2-cache is only 16% faster than the 64-bit L2-cache of the Athlon XP. Fed by a 128-bit path (to the memory), the L2-cache is no less than 67% faster than the Athlon XP's. This is a huge advantage when running MMX/SSE/3DNow!/SSE-2 codepaths, as we will see further.

The same effect can be seen with the 3.2 GHz P4EE: the L2-cache of the Pentium 4 performs 6% better when fed by the large L3-cache.

What about latency? A low latency memory subsystem was the prime reason to build the memory controller into the Opteron/Athlon 64 core. The results measured in Sciencemark 2.0 (4 MB datasize) are summarized below:

CPU - Northbridge	Latency - 64 bit	Latency - 128 bit	Latency - 256 bit
Athlon 64 FX-53 (2.4 GHz) Dual Channel	53	114	117
Athlon 64 FX-51 Dual Channel	52	115	118
Athlon 64 FX-51 Single Channel	61	116	118
Athlon 64 3200+ (Single channel)	49	83	86
P4 3.2 GHz EE	57	224	260
P4 3.2 GHz	59	243	247
Athlon 3200+ - Nforce 2 FSB400	132	179	183

Note that our Athlon 64 FX-53 is **NOT** a CPU with an overclocked FSB (218 MHz x 11), but instead an unlocked Athlon 64 FX-51 at 12 x 200, exactly the same as the upcoming FX-53. Using the classic CPU-FSB-separate Northbridge on the motherboard as example you would assume that latency would be about 9% higher, but this rule does not apply to the Athlon 64 FX. The latency stayed the same... this promises excellent IPC scaling as clockspeed increases.

Nevertheless, the real star here is the Athlon 64 3200+ which offers a latency which is almost 30% (!) lower than the Athlon 64 FX-51. Granted the clockspeed of the Athlon 3200+ is 10% lower, but the use of unbuffered DRAM shows that the latency to the DDR400 is extremely low for the Athlon 64, up to 3 (!!) times lower than for the competing Pentium 4 3.2 GHz. No wonder that Intel decided to add a L3-cache which has a typical total latency of 33-40 cycles..

RAW FPU Performance

We ran the "BLAS" benchmark of ScienceMark 2.0, a matrix multiplication floating point test similar to Linpack. However, contrary to our C linpack binary, the BLAS bench is extremely optimized to ensure it makes the most of the CPUs caches. So the BLAS bench gives us a very realistic view of how fast large matrix multiplications will perform on a certain CPU.

Even more interesting is the fact that it can measure SSE-2 and x87 performance, as well as compiled performance from a high-level language (no ASM). It is, however, a single-threaded benchmark, so even though it is run on dual-processor systems, only one processor is utilized. First we take a look at double precision:

CPU	SSE-2 Scalar	SSE-2 Vector	Compiled	x87 - assembly
Athlon 64 FX-51	3093	3096	1846	3112
Athlon 64 3200+	2776	2795	1680	2803
P4 3.4 GHz EE	1457	4058	1895	2187
P4 3.2 GHz EE	1379	3840	1793	2070
P4 3.2 GHz "C"	1350	3677	1701	2015
Athlon 3200+	n/a	n/a	1542	3178

The Pentium 4's SSE-2 unit is not very flexible when it comes to scalar SSE-2 (only one FADD/FMUL per clockcycle), and it therefore does very poorly in this test.

Alexander Goodrich explains:

> "According to Intel's optimization docs, the P4 has 4 issue ports - port 0, 1, 2, 3. Ports 0 and 1 can issue 2 uops per clock, but only on the first half of the cycle can they issue fp instructions. Port 1 exclusively handles fp instructions, executing them at a peak rate of 1 uop/clock.
>
> The issue rate seems to be the same between scalar and double, and the throughput is the same 1 every other clock (adds only muls only). In order for a P4 to achieve 1 FLOP per clock using scalar the code has to be interweaved in such a manner (addsd one clock mulsd 2nd clock) to accomplish this. ADDSD only code will only give you .5 FLOPS/cycle using scalar code. For packed double precision code, you'll get 2 FLOPS every 2 cycles, or if you interweave, 4 FLOPs every 2 cycles. (2 1st cycle from an add, 2 2nd cycle from a mul). The problem appears to be one of issue restriction rather than the backend not being capable of doing it."

However when it comes to Vectorized SSE-2 (packed), the P4 is unbeatable. The much higher clockspeed allows superior peak FLOPs performance.

Single precision performance is important too, though, especially for games.

CPU	SSE	3DNow!	Compiled
Athlon 64 FX-51	6249	5463	1926
Athlon 64 3200+	5501	4857	1753
P4 3.4 GHz EE	7918	n/a	1787
P4 3.2 GHz EE	7488	n/a	1687
P4 3.2 GHz "C"	7274	n/a	1663
Athlon 3200+	3949	5050	1542

Same story: the Pentium 4 is unbeatable thanks to its high clockspeed. Note that the Athlon 64 has improved SSE performance vastly compared to the Athlon XP. Branch misprediction penalties, one of the worst enemies of the Pentium 4 play no role in this kind of SSE intensive software. However, it must be noted that the Athlon 64 FX is only 17% slower in SSE than the 3.2 GHz Pentium 4, which has a 46% faster clockspeed. This means that the Athlon 64 core is still a bit more efficient in this kind of code per clock. The "compiled" results show that, unless code has been carefully optimized for SSE, the Athlon 64 could still prevail.

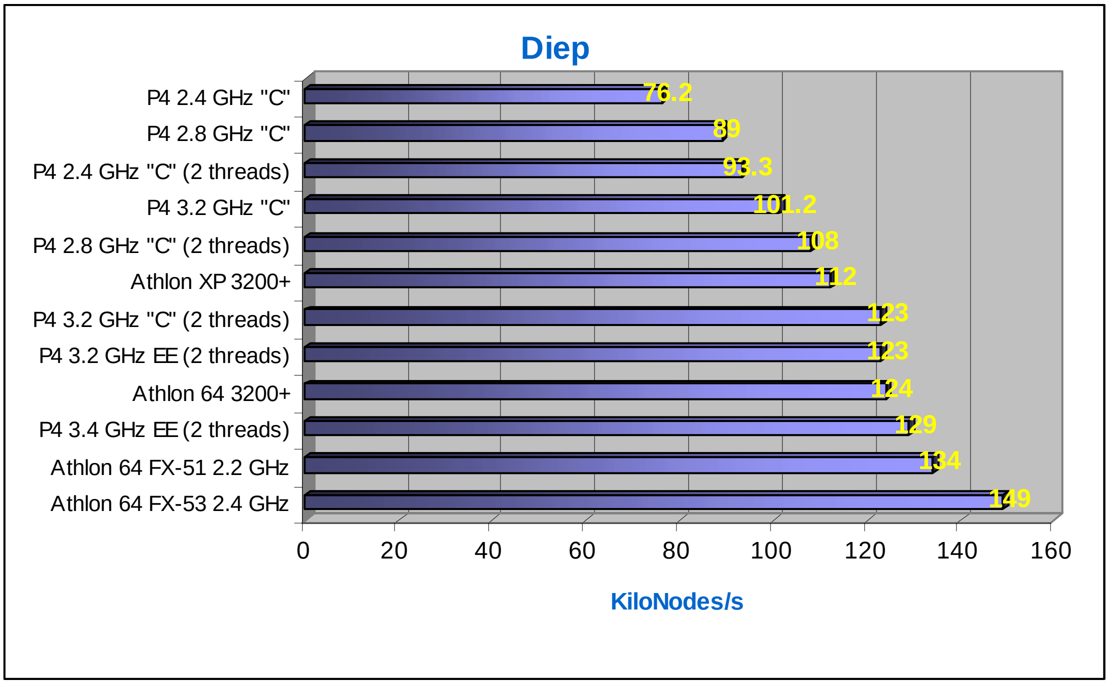
In conclusion, we could say that the Pentium 4 has two important weapons to counter the Athlon 64 invasion: Hyperthreading (**see here**) and better (vector) SSE (-2) performance.

Chess: DIEP

Vincent Diepeveen is a talented programmer who is completely obsessed with chess and fast CPUs. NUMA systems, whether they run on Itaniums, Opterons, or SGI MIPS processors and SMP machines based on dual Athlon MP and Xeon DP CPUs have all been running Vincent's chess program: DIEP. DIEP is an extremely complex and intensive application and it is also a 100% integer program.

The program in only 550KB in size, and has been improved a lot since we introduced it in our first workstation tests. DIEP now makes use of even larger 350MB hash tables (data) in our benchmark, and so the benchmark results we publish today can not be compared with those from previous tests. While the benchmark depends somewhat on the memory sub-system, pure CPU power is the primary bottleneck. We believe DIEP makes a good addition to our benchmark suite, as good branch prediction is extremely important for the next generation of software that is based on advanced AI algorithms (Neural Network, for example).

A chess program is a good start to test the BPU improvements in the Athlon 64, as it is infested with pesky conditional branches. We tested 13 steps deep.



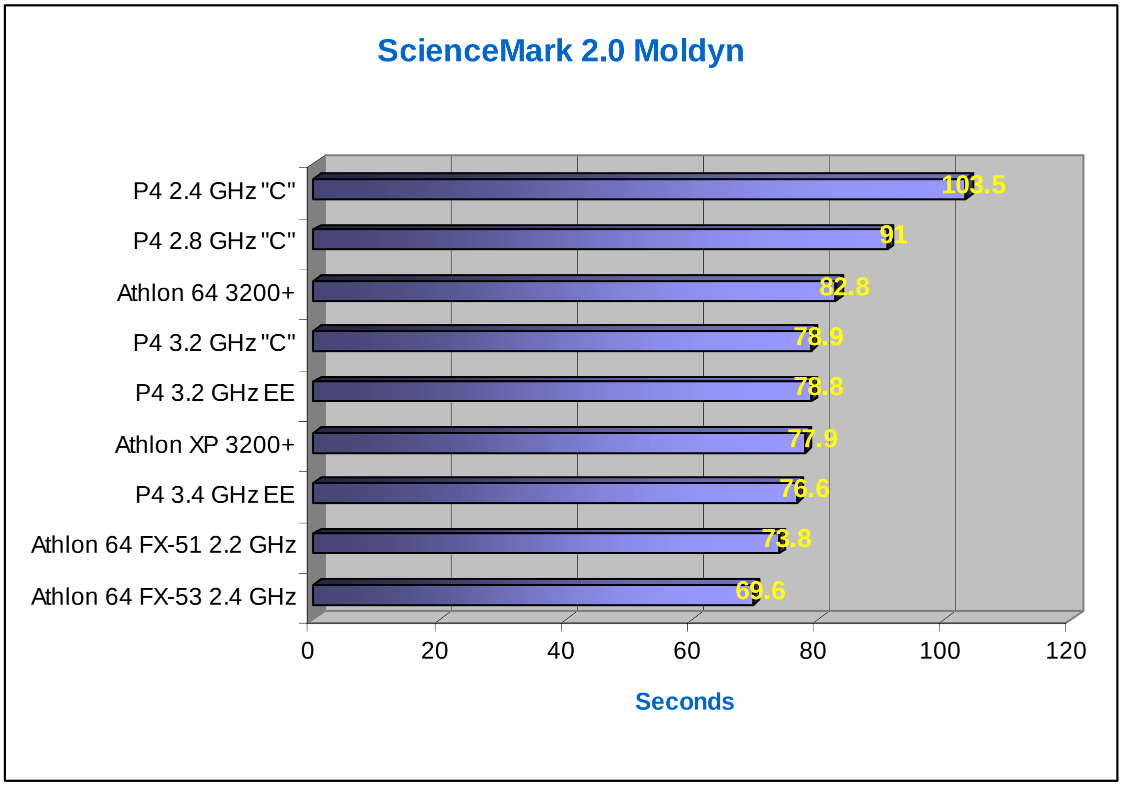
This kind of software used to be the favorite kind of code for the Athlon, but Vincent's programming skills and multi-threading additions come to the rescue. Hyperthreading simply saves day for the Pentium 4: with one thread, the P4 3.2 GHz is no less than 33% slower, but add a second thread and hyperthreading narrows the gap to 8%.

ScienceMark

Tim, Alex and Julian made our work a lot lighter by offering ScienceMark 2.0 more than a year ago. Tim Wilkens is now working at AMD, but as ScienceMark is purely his hobby, and we have been noticing better SSE and SSE-2 optimizations with with every new release (just like we have seen with commercial software), we have no reason to believe that Sciencemark is biased in any way.

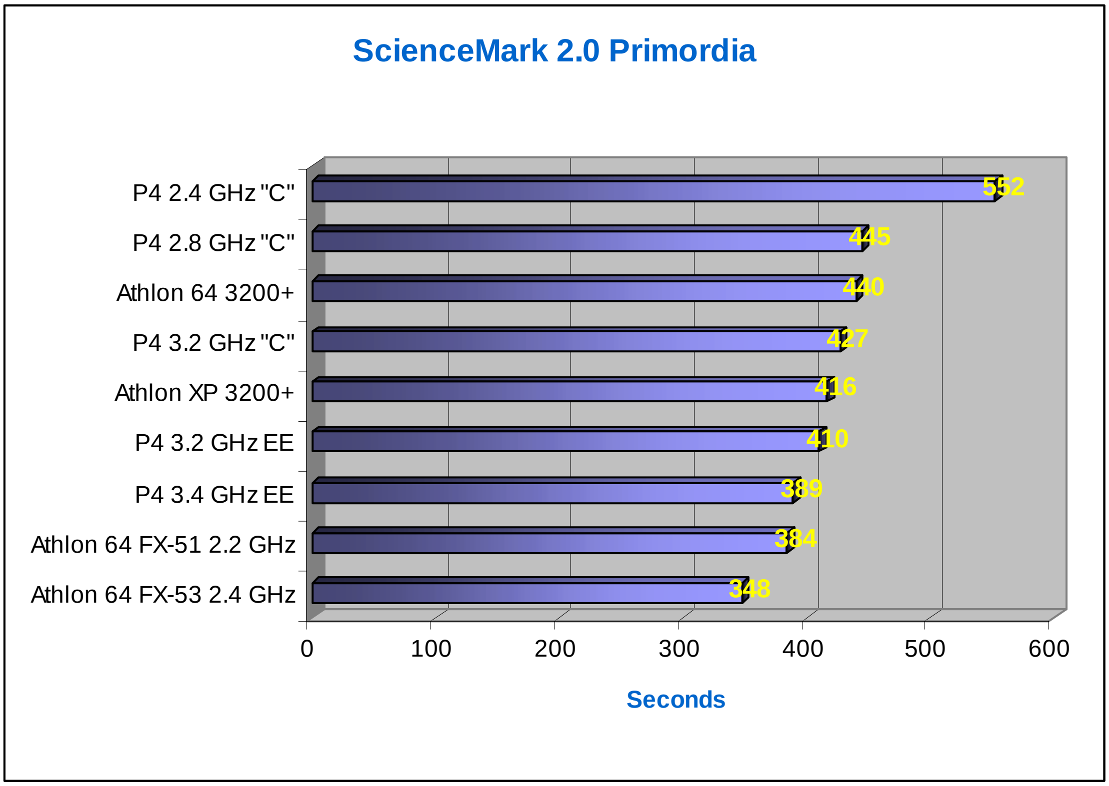
As scientific workloads never can have enough CPU power and justify the need for this kind incredibly fast number crunching silicon, we decided to see how the different CPUs compare once more.

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**.

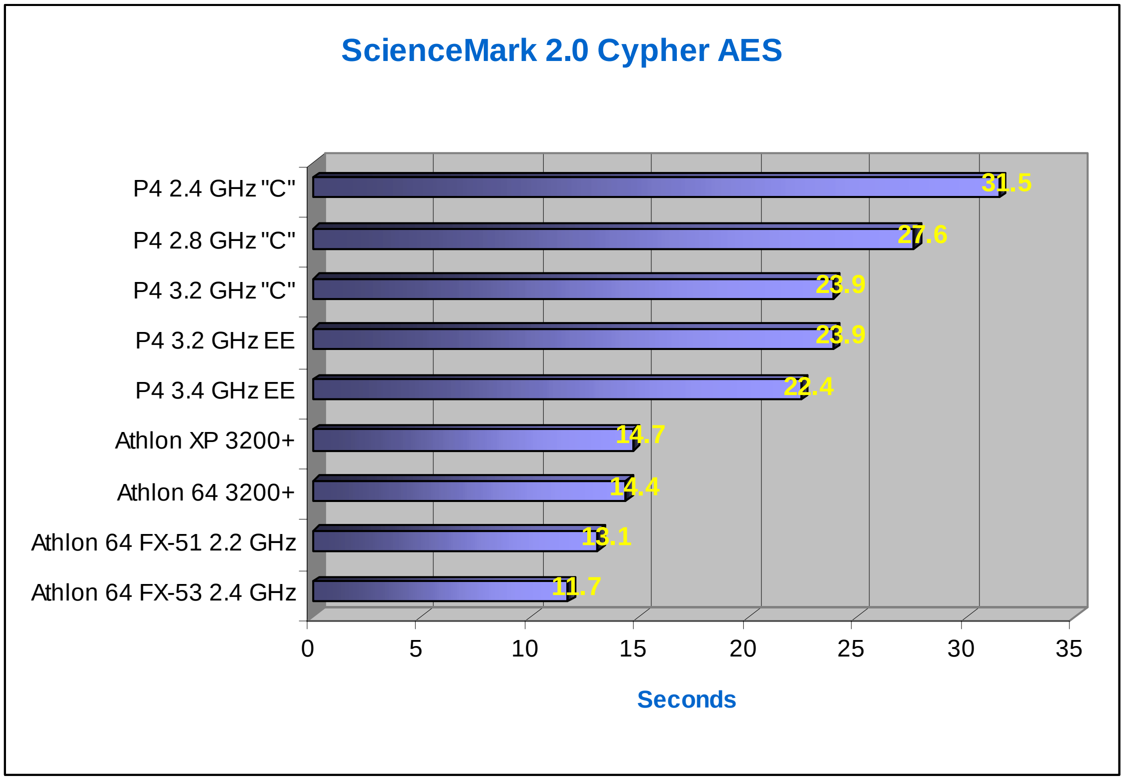


Next up is Primordia. From **Sciencemark.org**:

> "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."



While the Athlon XP 3200+ experiences some difficulty fending off the P4 in what is traditionally an application that benefits well from its triple FPU power, the Athlon 64 FX simply puts the pedal to the medal and beats even the 3.2 GHz P4EE by a decent margin. Encrypting messages for safe e-commerce and other applications has become an incredibly important business. ScienceMark also gives us the opportunity to test one of those popular "make it secret" algorithms: AES.



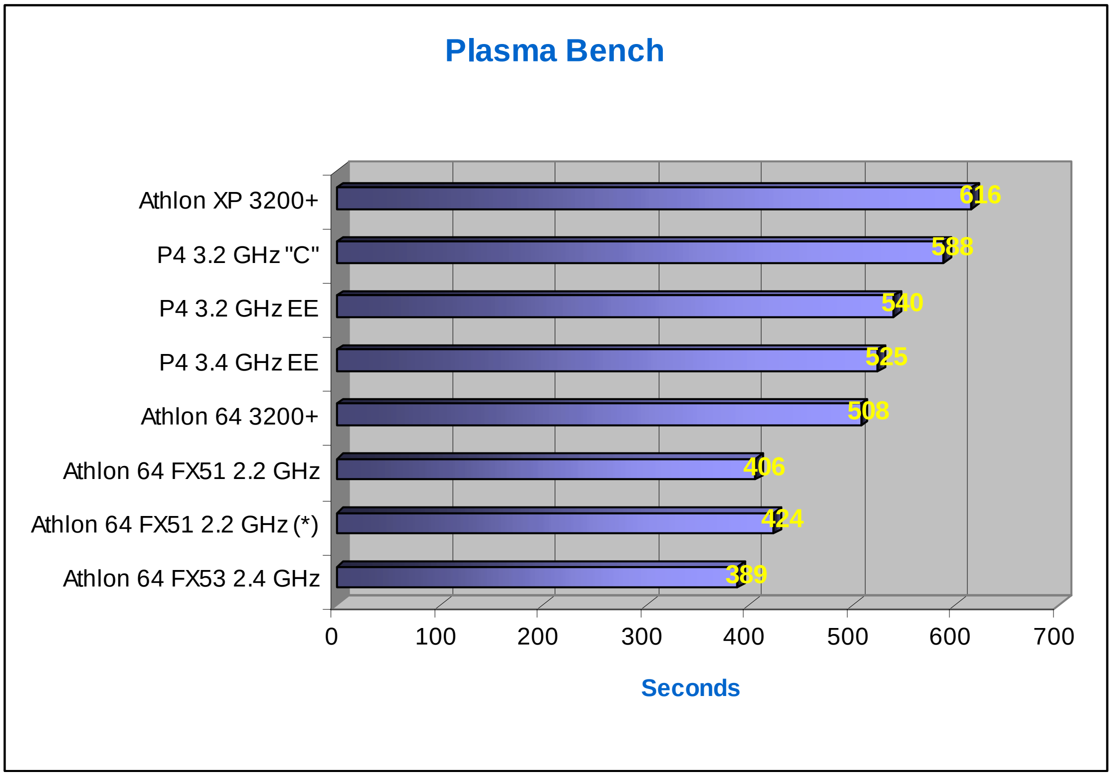
A complete home run for the Athlon cores.

Plasma Benchmark

The Plasma benchmark is our last scientific benchmark, you can read **more about it here**. Dr. Simon Bland:

> "The MHD code is speed limited by the matrix inversion. The matrix consists of 2.1 million rows by 2.1 million columns, all values to double precision. It is, however, very sparsely populated... there are 29 non-zero diagonals. The current matrix solving method is an iterative solving method (bi-conjugate gradient solutions method). It uses 100 iterations to solve the matrix, each iteration consisting of ~5 matrix multipliers. As mentioned we are actively looking for better solving methods both for single and parallel."

Basically performance of this scientific simulation depends a lot on memory latency and a little on the memory bandwidth and FPU power. This used to be the favorite playground of the Pentium 4.



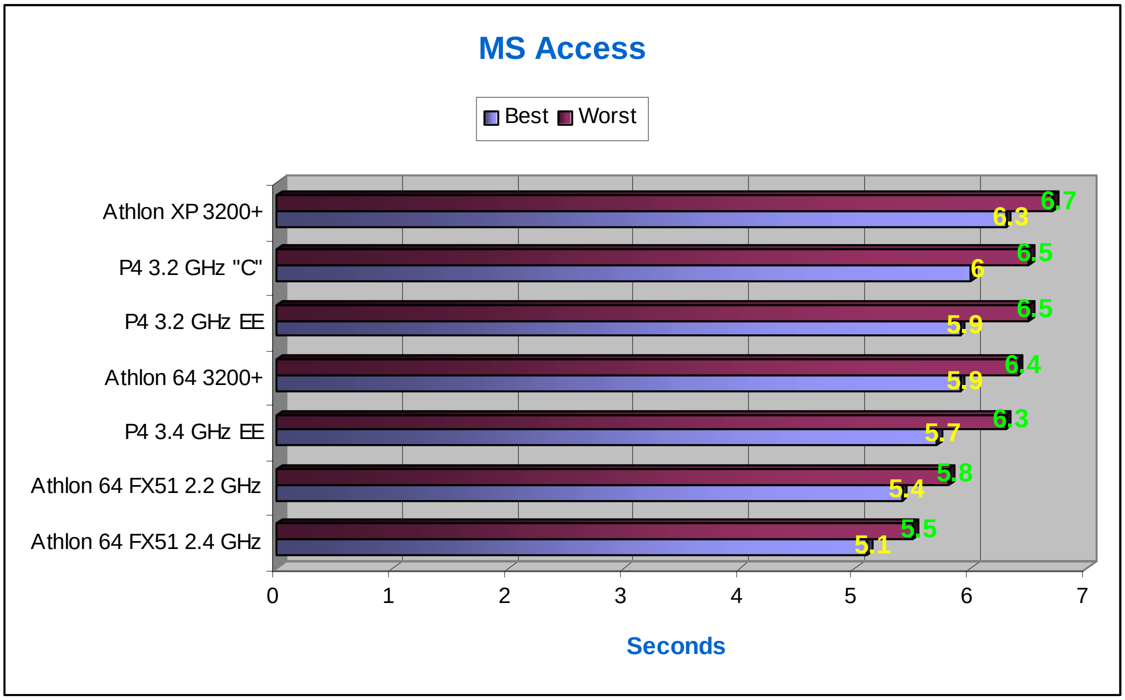
(*) P4 optimized binary, All other Athlon benchmarks were run with an Athlon optimized version. Pentium 4 ran with a P4 optimized version.

I say "used to" because the Athlon 64 makes a clean sweep of all other CPUs. No less than 50% faster than its older brother, even the Pentium 4 EE can not come close to the newest AMD CPU.

MS Access

Considered a "toy database" by many database specialists, MS Access is one of the most used databases in the world. If you do not need to access and update a database with tens of users, MS Access allows you to develop a database application at incredible speed.

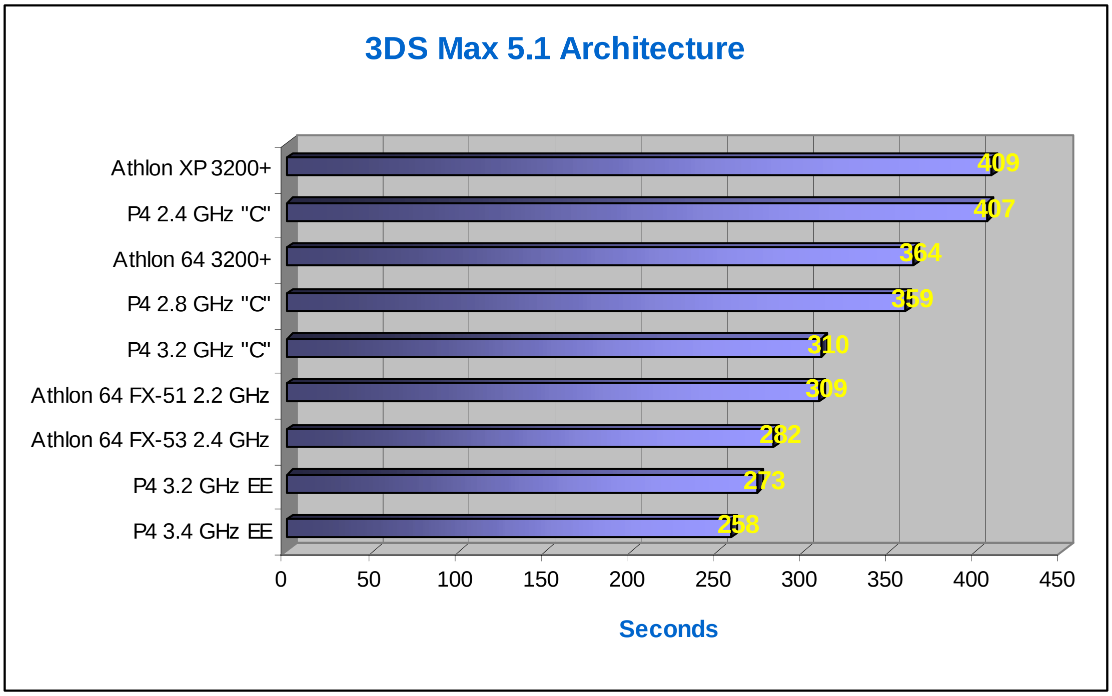
As we don't trust benchmarks that just run a mix of office applications simultaneously and then spit out a simple and single benchmark number, we developed our own benchmark. MS Access has a decent built in timer, so we perform a query with joins between 4 databases (one with more than 100,000 records) and measure the time it takes to perform the query. As MS Access has to load the database the first time, we discard the result of the first run which is mostly hard disk dependent. After the first run, the databases are cached. We then repeat the benchmark at least 3 times and measure the worst and best times, in seconds.



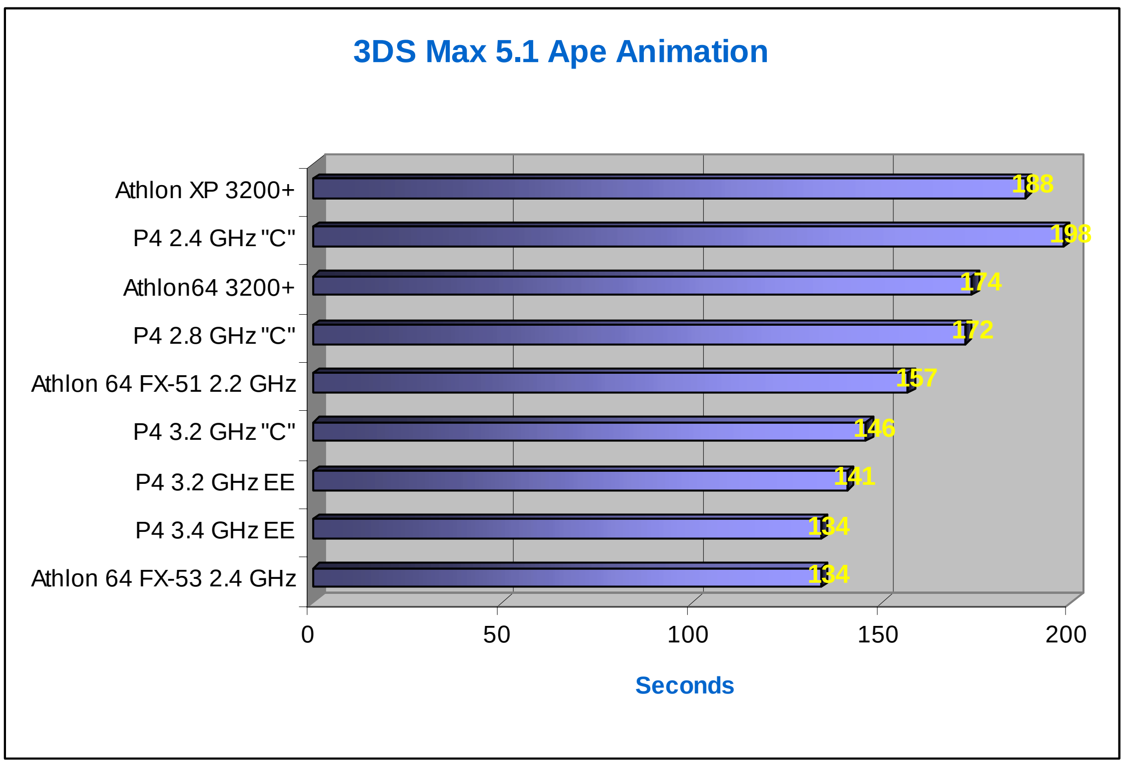
The Athlon XP and Pentium 4 are close, but the Athlon 64 family wins again, albeit by a relatively small margin.

3DS Max 5.1

Our first 3DSMax test is our classical "architecture" rendering test. We test 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).

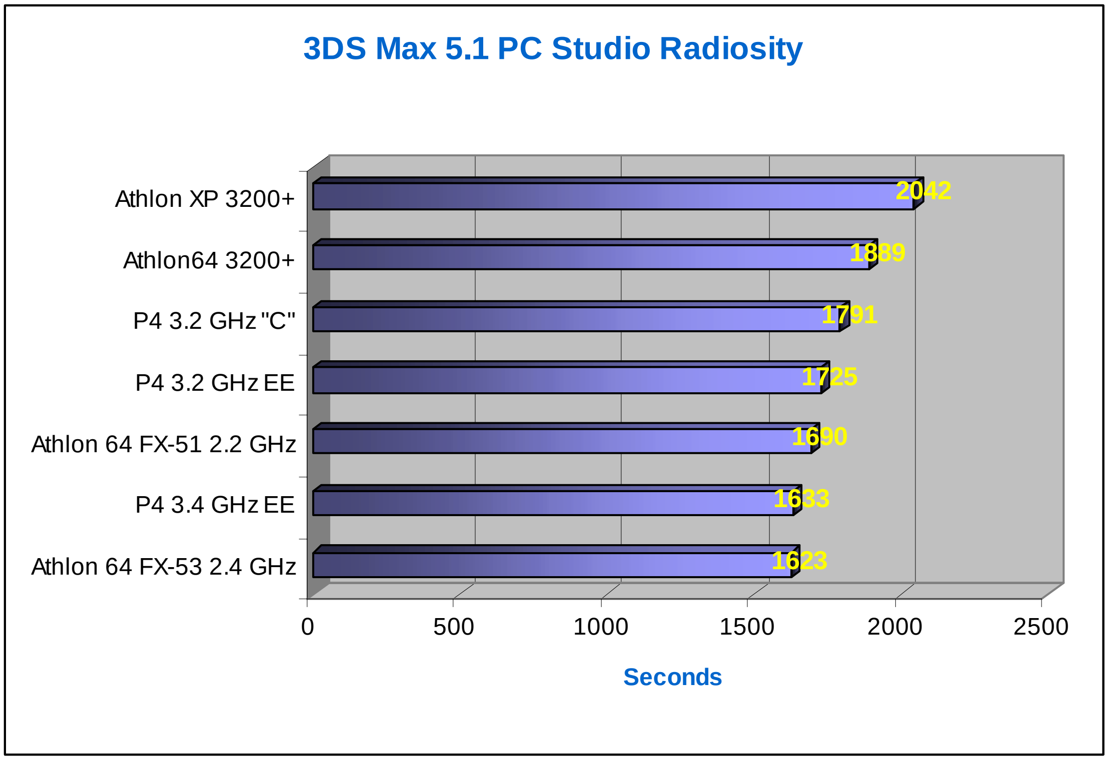


While the Athlon XP has no chance at all against the Pentium 4s, the Athlon 64 FX is only beaten by the Pentium 4 Extreme Edition. The Athlon 64 3200+ fails to beat the 3.2 GHz Pentium 4 "C" here. The Ape animation benchmarked below is a typical game character rendering setup making heavy use of lighting: no less than 44 different light sources. The scene also features complicated inverse kinematics: bone manipulation to control the facial animation and parameter wiring to move the fingers. Maxscript (macro language) is used to control various movements. The polygon count is relatively low, only 26,000 polygons. Motion blur, which is one of the functions optimized for SSE-2, is achieved by rendering the scene in six passes. We rendered frames 20 to 25 at 320x240 to the virtual frame buffer.



Studio PC, an authorized reseller of Discreet's 3DSMax animation software, is specialized in 3D software and hardware solutions. Specialized in virtual reality applications for 3DSMax and building custom build workstations, Studio PC handles anything pertaining to 3D Studio Max, from hardware maintenance to software tools… the perfect partner for us to make a real professional benchmark.

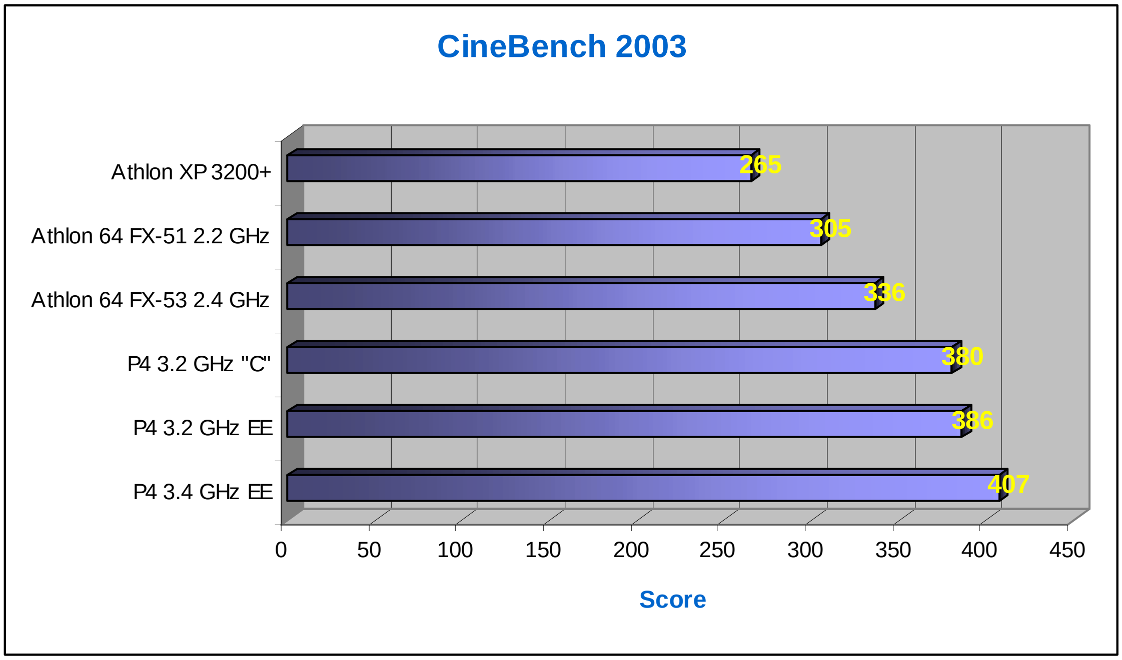
Fremer, together with the team of Studio PC, took the standard radiosity demo scene on the 3DSMax 5.1 and transformed it into a scene that is very similar to what 3DSMax professionals use. For example they were able to reduce the number of shadow area rays from 45 million to 16 million "fast occlusion rays" to improve rendering speed, without loss of realism. More than 75% of the time is spent handling radiosity and Studio PC believes that this complex radiosity scene with many lights is exactly the kind of scene where professionals need CPU performance the most.



The Athlon XP 3200+ is beaten silly by the Pentium 4s in radiosity scenes, but the Athlon 64 turns the tables. Even hyperthreading cannot save the 3.2 GHz Pentium 4 Extreme Edition from being a tad slower than AMD's newest champion. Quite remarkable.

Cinema4D: Cinebench 2003 (MP)

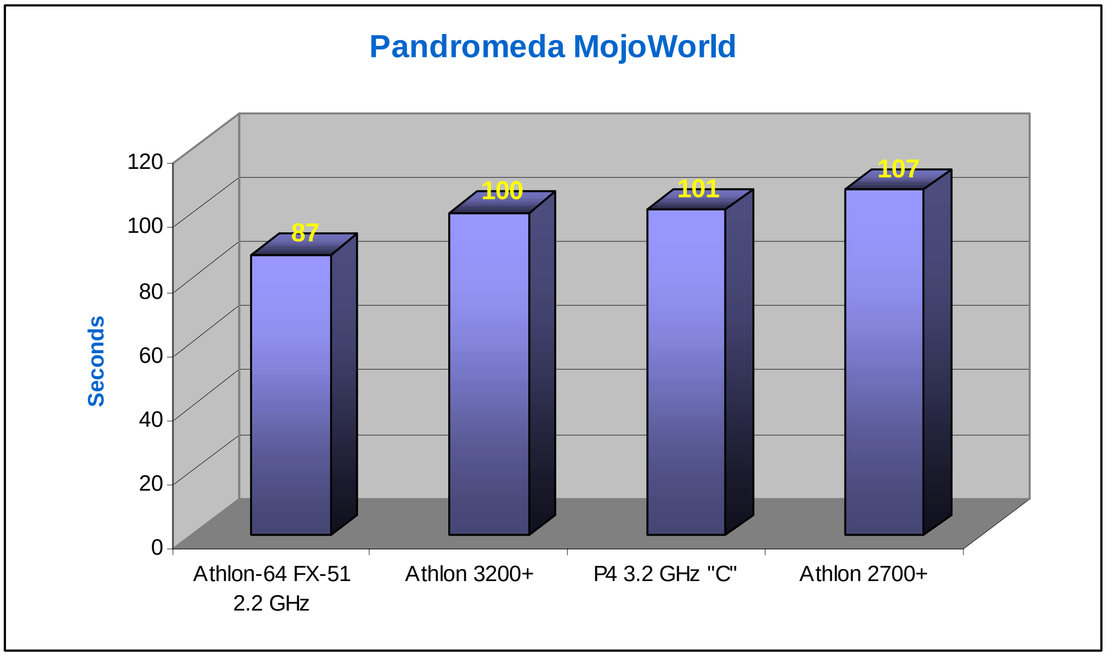
Cinebench is based on Maxon's Cinema 4D modeling, rendering, and animation app. Cinema 4D's renderer is multithreaded, and takes very well advantage of HyperThreading. We report the best rendering scores for all systems (so 2 threads were used for P4).



A 3.2 GHz Pentium 4 "C" scores about 320 with one thread, but Hyperthreading pushes it to 380, beyond the reach of any AMD core.

Pandromeda Mojoworld Generator

While far from a mainstream application, Mojoworld (made by **Pandromeda**) gives you a visual IDE for combining fractal equations and generating whole planets with terrain and shading. Version 2.0 includes a new tiled rendering feature to reduce its memory dependency. We followed the **benchmark instructions of Calyxa**:



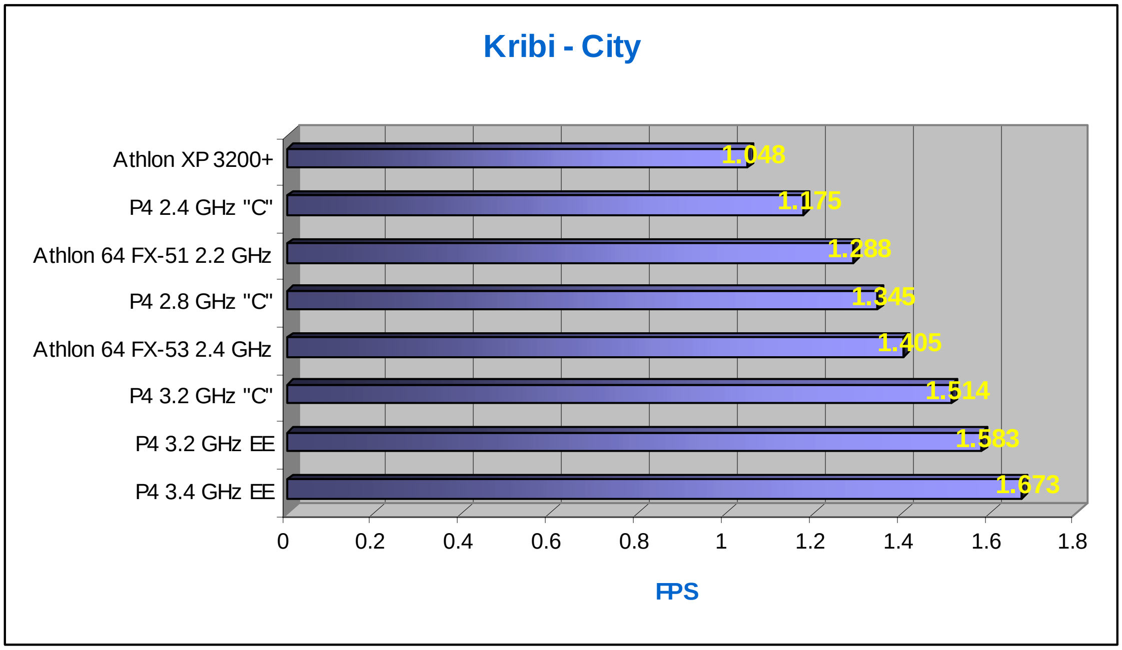
Unfortunately, by the time the Athlon 64 3200+ and P4 EE arrived, our license already expired, but it is clear that generating landscapes based on fractal algorithms is faster on the Athlon 64.

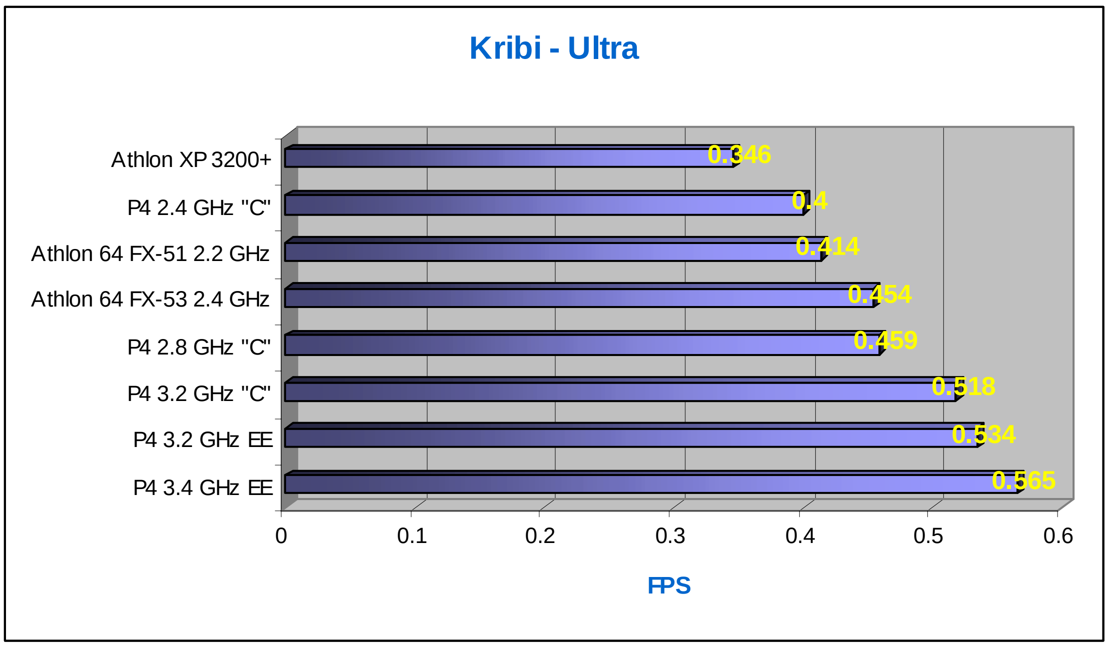
Kribi

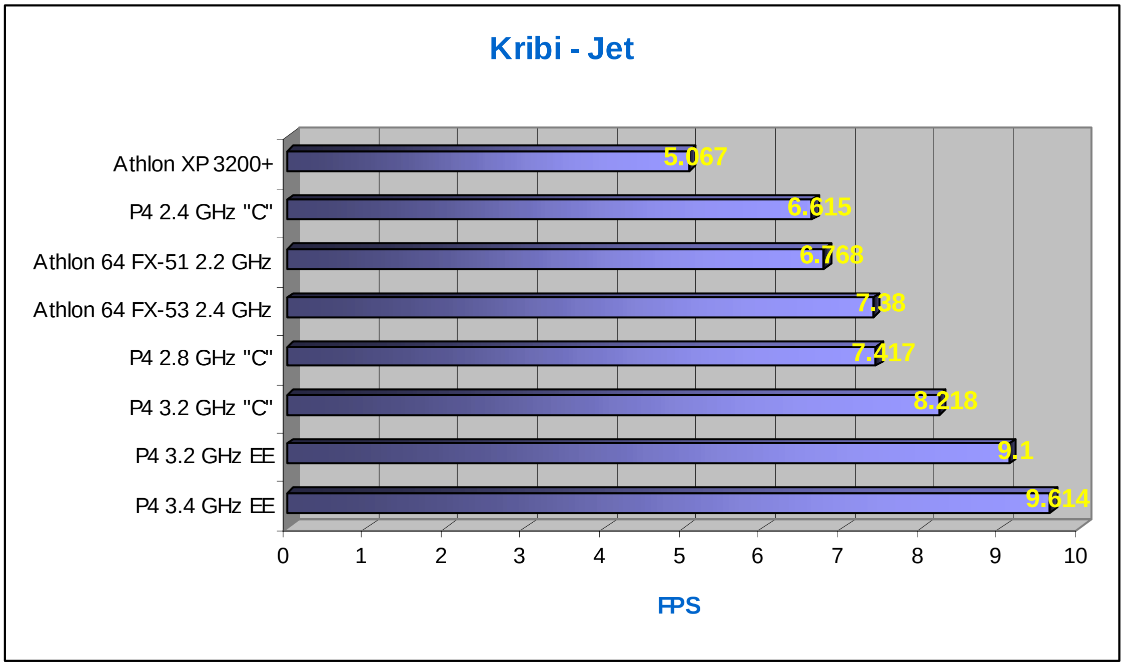
Eric Bron is the mind behind Kribi, a product of **Adept Development**. Kribi is an ultra powerful software rendering 3D engine. Originally developed by Eric Bron, a regular visitor of Ace's Hardware. It is designed to handle up to 10 billion polygons and enable real-time photorealistic rendering. The 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.

There is more. Few people master the art of optimizing software as much as Eric. Squeezing the last drop out of SSE and multiprocessing, Kribi is probably one of the most optimized pieces of software for the Pentium 4. As we have pointed out, hyperthreading and SSE are the best weapons of the P4, and Kribi version 1.1 has been carefully optimized for both.

We tested with several models to evaluate whether or not the used model has a significant influence on performance. The first scene, City Ultra, is the most spectacular: no less than 16.7 billion polygons in total. All results are expressed in frames per second (FPS).


Kribi - City
Athlon XP 3200+
P4 2.4 GHz "C"
Athlon 64 FX-51 2.2 GHz
P4 2.8 GHz "C"
Athlon 64 FX-53 2.4 GHz
P4 3.2 GHz "C"
P4 3.2 GHz EE
P4 3.4 GHz EE
1.048
1.175
1.288
1.345
1.405
1.514
1.583
1.673
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
FPS


Kribi - Ultra
Athlon XP 3200+
P4 2.4 GHz "C"
Athlon 64 FX-51 2.2 GHz
Athlon 64 FX-53 2.4 GHz
P4 2.8 GHz "C"
P4 3.2 GHz "C"
P4 3.2 GHz EE
P4 3.4 GHz EE
0.346
0.4
0.414
0.454
0.459
0.518
0.534
0.565
0
0.1
0.2
0.3
0.4
0.5
0.6
FPS

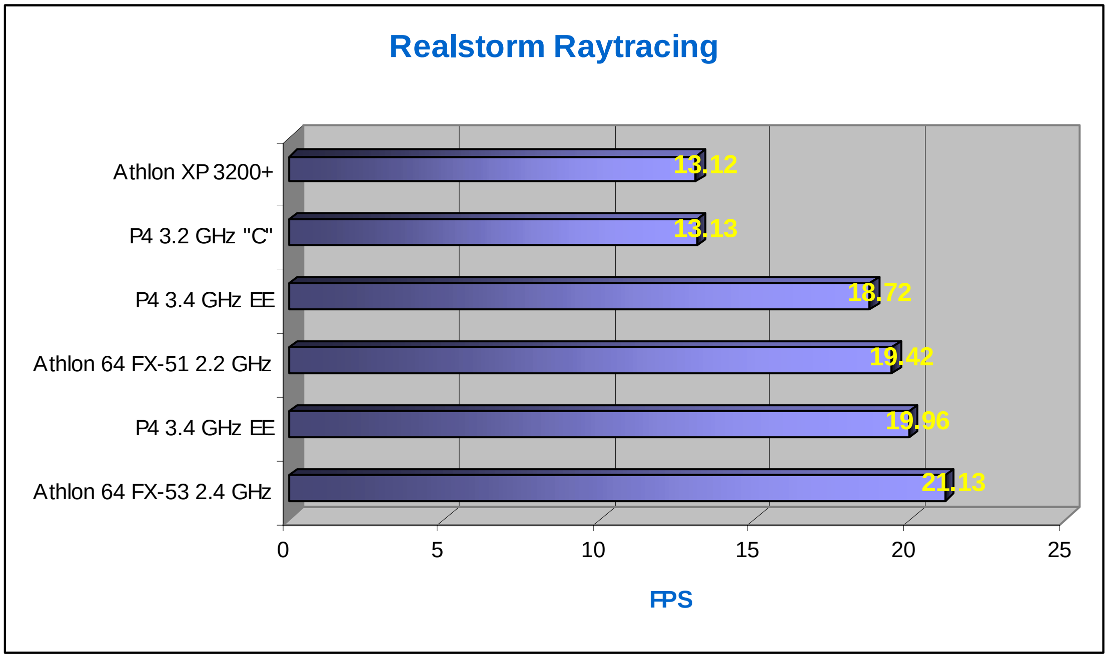


Being a software render, which naturally benefit from multi-threading and SIMD, Kribi is a showcase of the Pentium 4's strength. Unless it is poorly optimized, this kind of software will always run best on a highly clocked hyperthreaded CPU. Period.

Real Time Raytracing

Real-time software renderers are pretty cool CPU benchmarks, so even if only a few people really use them, we did a quick test run with "RealStorm Benchmark Final v1.10" to see how fast the current fastest CPUs can render raytraced frames.

All tests were done at 640x480, with shadows and reflections enabled.



The Athlon 64 FX is a lot faster than the "regular" 3.2 GHz Pentium 4, but the extra L3-cache gives the P4EE an enormous boost. Nevertheless, if the Athlon 64 FX-53 and 3.4 GHz P4EE enter the market together, the FX-53 clearly wins.

Gaming Performance

The Athlon 64 and 64 FX are positioned as desktop CPUs and games probably rank as the most common CPU intensive applications that most people run on their desktops. For this review, we've decided to do as many game benchmarks as possible, and so we've tested no less than 15 different game engines.

However, some of these game benchmarks took us a lot of time and required us to stay in front of the screen and be very attentative. In the case of a "just run it and come back later to see the score" benchmark I tested a lot of CPUs to give you good overview. The most difficult benchmarks were only run on a few CPUs.

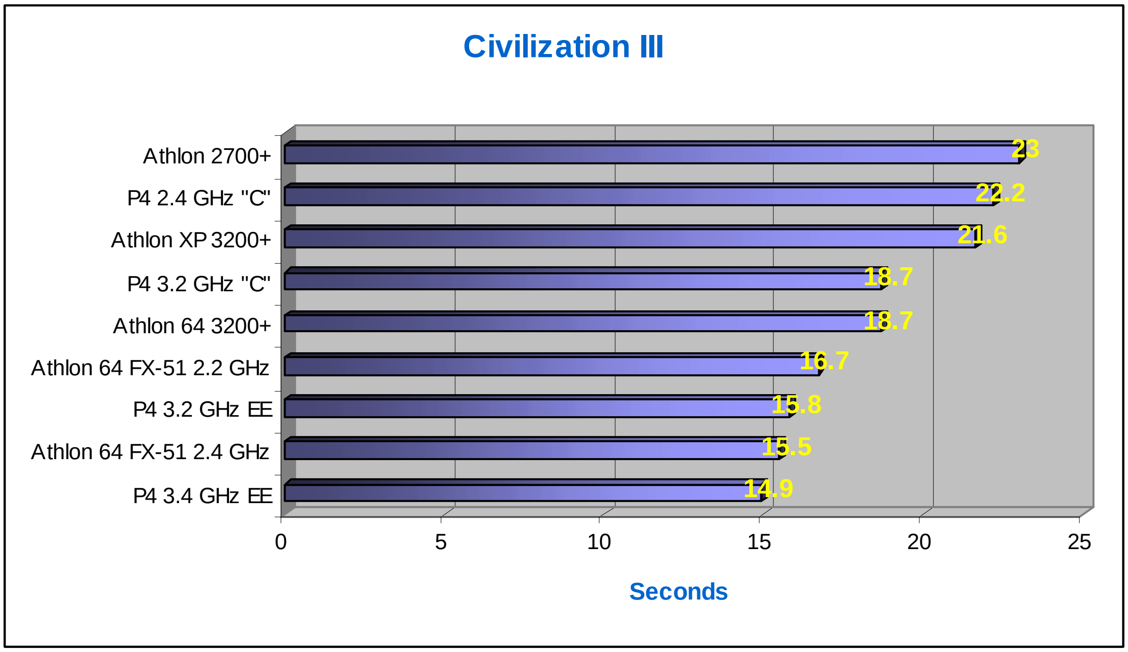
Civilization III v1.29F

If you love Civilization III like me, you quickly understand that this game is one serious threat to your social life. I have spend hours and days trying to conquer, negotiate, and trade with other nations in Civilization III.

So what did we benchmark? Well, we noticed that in many situations the AI of the computer opponents spends a great deal of time thinking between each turn. As you can see below, this thinking time can be up to 23 seconds on fast CPU, and as you can imagine, this can seriously impact your gaming experience when you are playing hundreds of turns.

"Fuego" sent us a rather large and complex CIV III map. We made sure that no movements were shown after pushing the "next turn" button, i.e. only AI time is recorded, not the animation of moving units. We tested the time the hourglass was shown, i.e. the time that the game is not responsive. This proved to be very consistent as long as we restarted the game for each test.

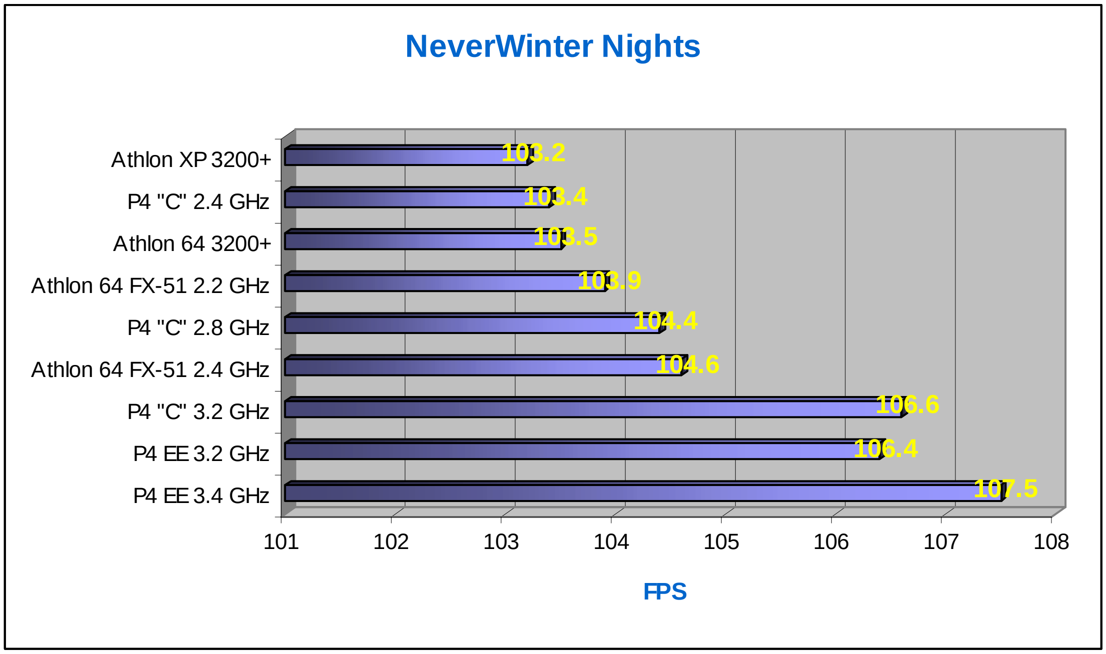
This must be one of the first AI benchmarks we've ever conducted, a nice change of pace after so much "FPS hunting."



These are very interesting and remarkable results. Basically, the Athlon 64 is a lot faster than the Pentium 4 and Athlon XP, most likely because the Athlon 64 has the lowest latency to the memory and best BPU. But caches seems to be extremely important, as the 3.2 GHz P4 EE is 16% faster than the 3.2 GHz P4 and ultimately faster than even the Athlon 64 FX 51.

NeverWinter Nights

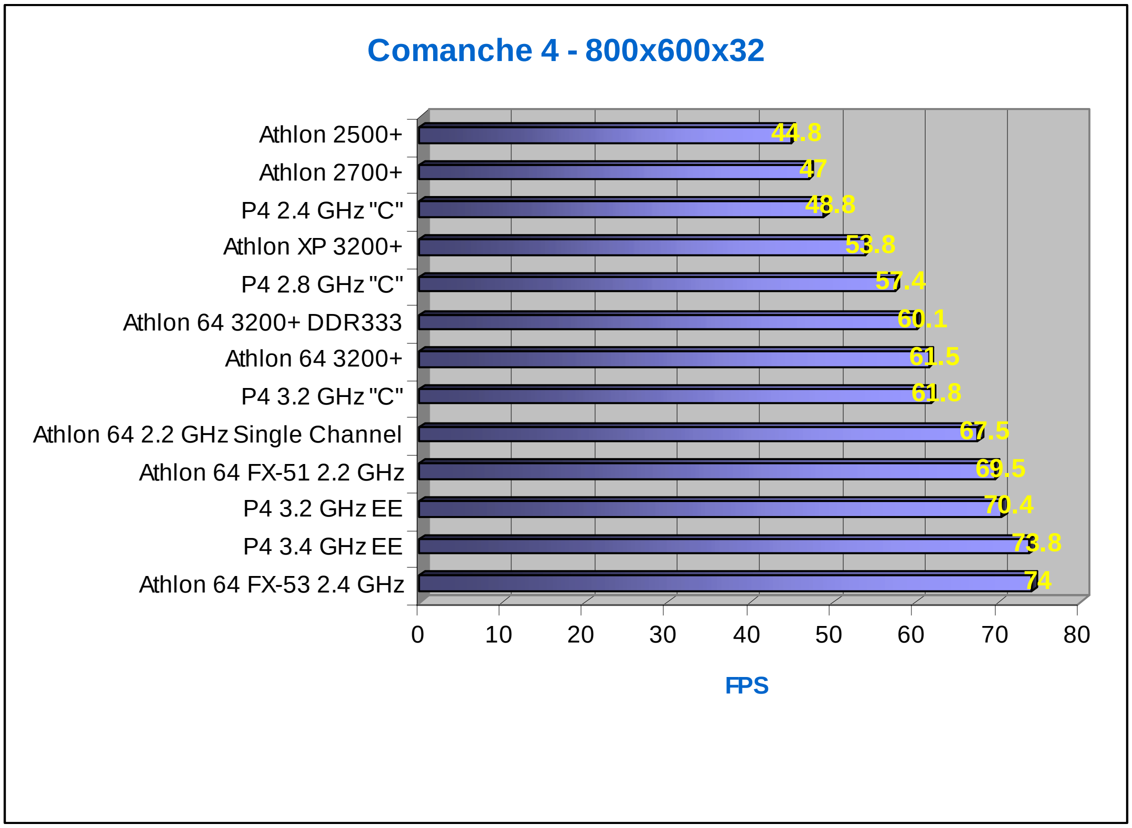
NeverWinter Nights is an RPG based on the BioWare's 3D engine, Aurora, which features a powerful particle system, superb dynamic lighting, and key frame interpolation.



Even with the GeForce FX 5900 Ultra, we came to the same conclusion as in our last upgrade guide: NWN is limited by the video card.

Comanche 4

The military helicopter simulator, Comanche 4, is one of the easiest and most consistent benchmarks. It's also a simulator, which gives us some perspective into this facinating and often CPU-intensive genre.



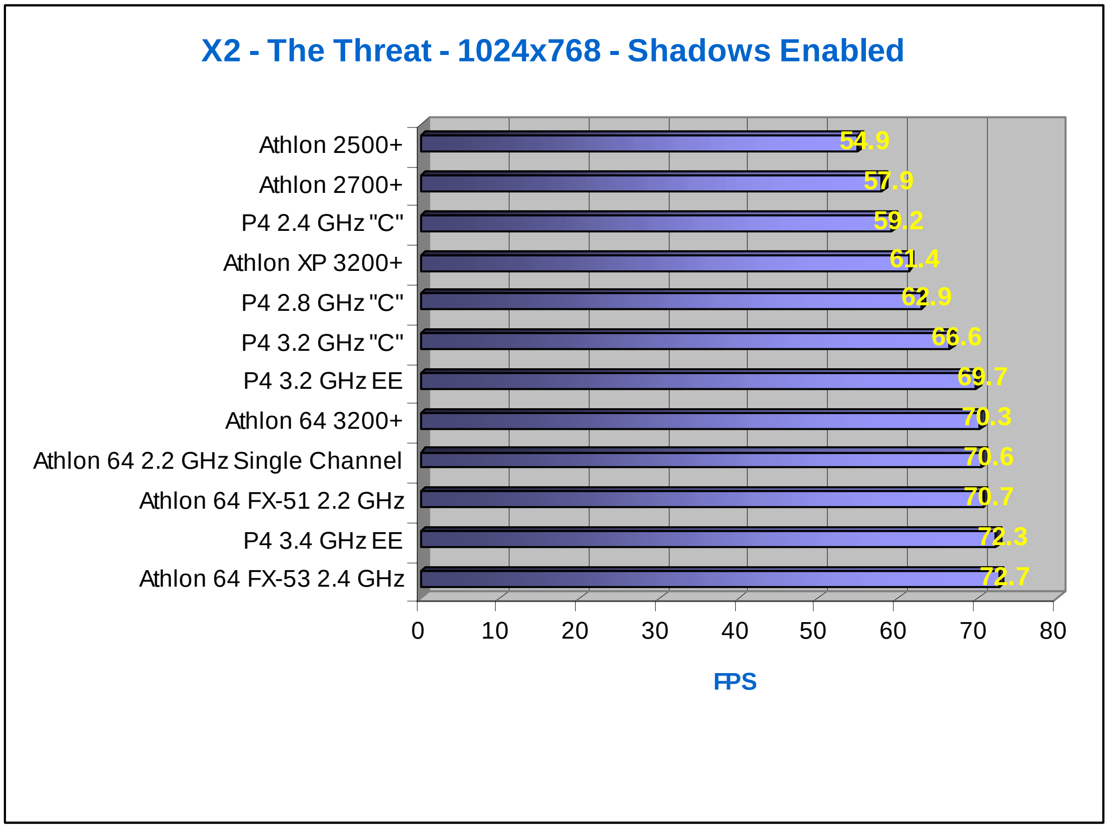
Comanche used to be a showcase game for the Pentium 4. However, the Athlon 64 FX equipped with SSE-2 turns the tables, only to have them turned yet again by the Pentium 4 Extreme Edition. But it appears that the Athlon 64 FX may yet claim the top spot in the future, as at 2.4 GHz, the Athlon 64 passes the P4 EE at 3.4 GHz.

X² - The Threat

As always we like to include a very popular Space Simulator too. X² features:

> "... a completely rewritten 3D engine based on DirectX8 encompasses many visual effects such as volumetric Nebulae (gas clouds) that have a real impact in the game (you can hide in them), many new engine, shield, weapon and explosion effects. Objects cast real dynamic 3D shadows! Dynamic DP3 bump mapping allows a previously unseen level of detail."

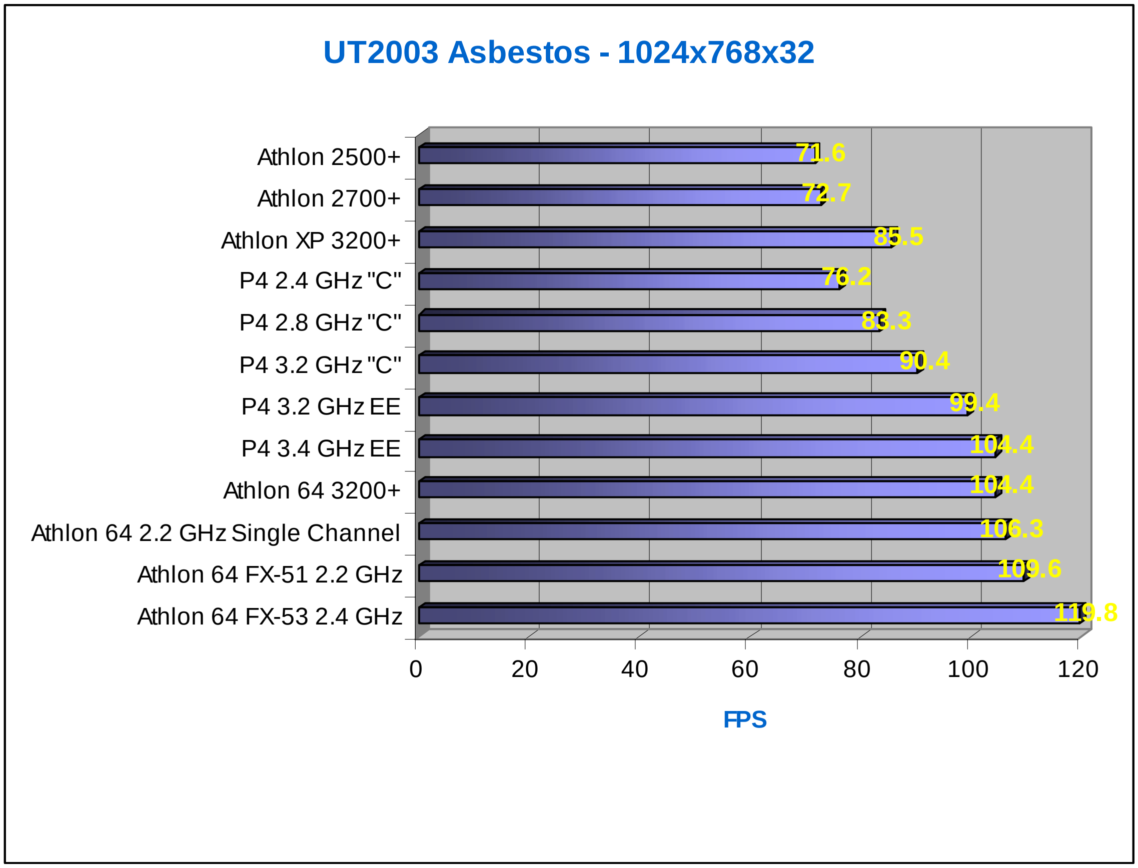
...and it has a built-in benchmark tool. To compare your results with ours, simply enable "shadows" and "run as benchmark" before you start the demo.



A small victory for the Athlon 64, but nothing really decisive, since the difference between the 2.2 GHz Athlon 64 FX and the 3.2 GHz P4 EE is only 1 FPS.

Unreal Tournament 2003

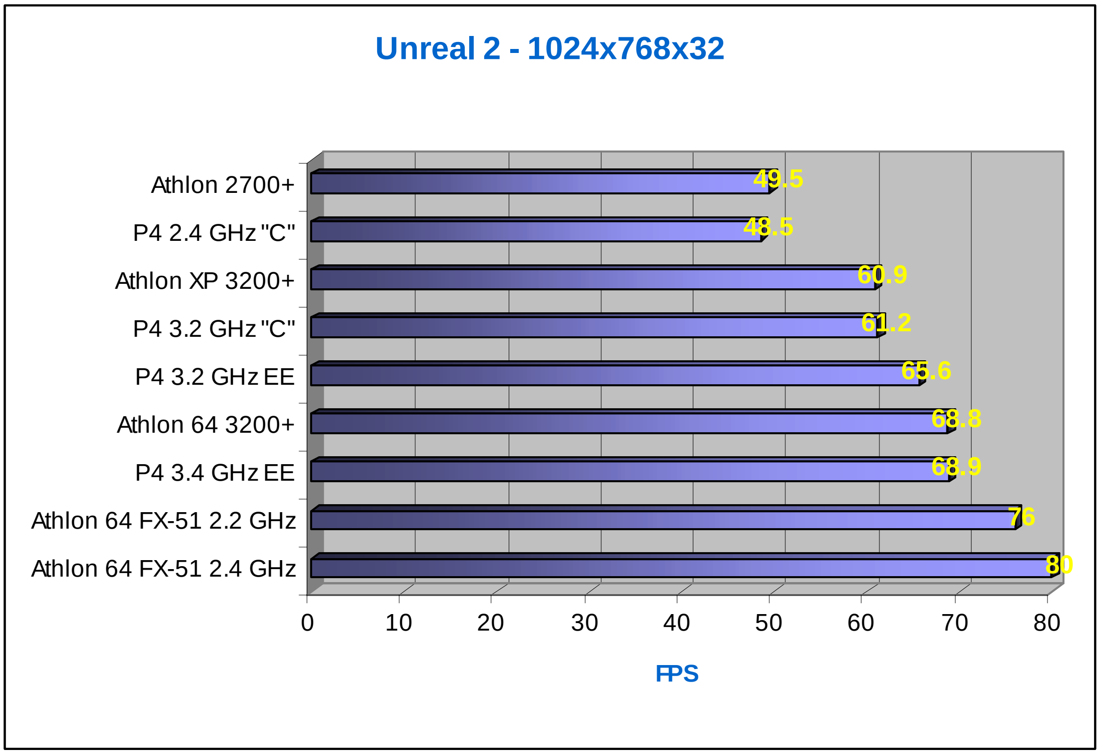
Unreal Tournament 2003 has lost a bit of thunder in the realm of online shooters, as better FPSes have begun to appear. However, this EPIC engine will still be used in quite a few games and there's also the upcoming UT2004. We chose the Asbestos Botmatch benchmark as it is one of the most intensive UT2003 benchmarks.



The Athlon 64 family outperforms even the 3.4 GHz Pentium 4 EE, which is right now nothing but an overclocked P4 EE. Quite an impressive showing from the Athlon 64 3200+ and FX-51.

Unreal 2

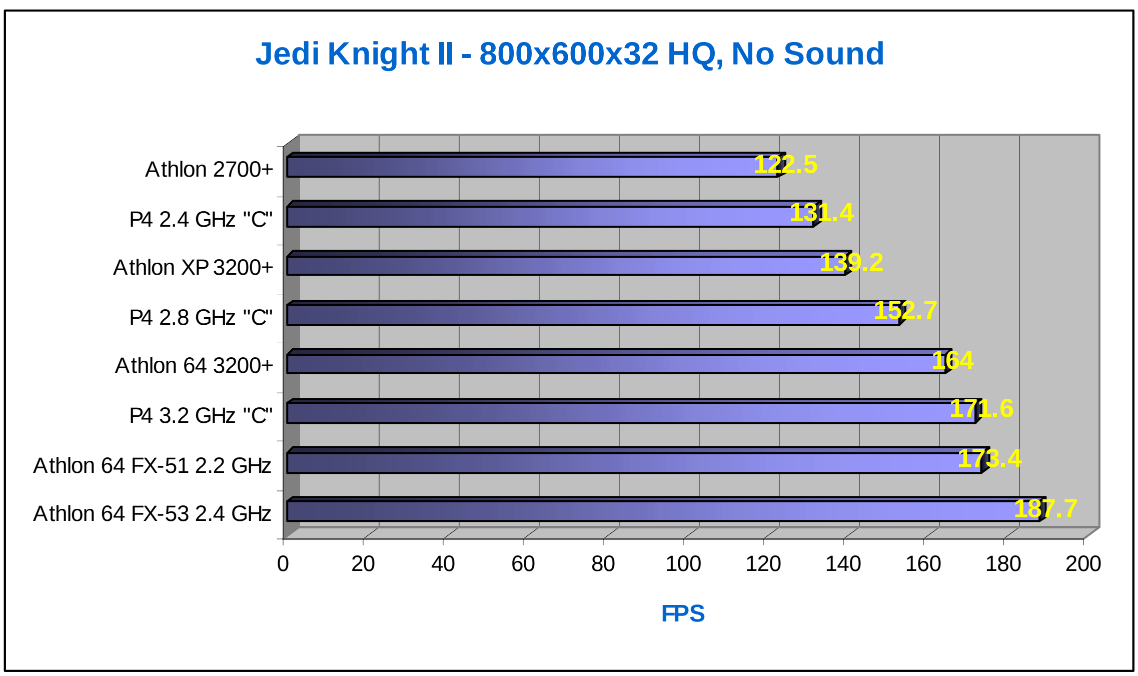
We benchmarked the "Swamp" rolling demo from the smoking spaceship to the first step in the jungle with FRAPS at 1024x768x32. While the built-in benchmark does not work yet, it must be said that our FRAPS benchmarks have proven to be quite repeatable with a low error margin (<3%).



As with UT2003, Unreal 2 is a landslide victory for the Athlon 64, with even the Athlon 64 3200+ managing to best the 3.2 GHz P4 EE.

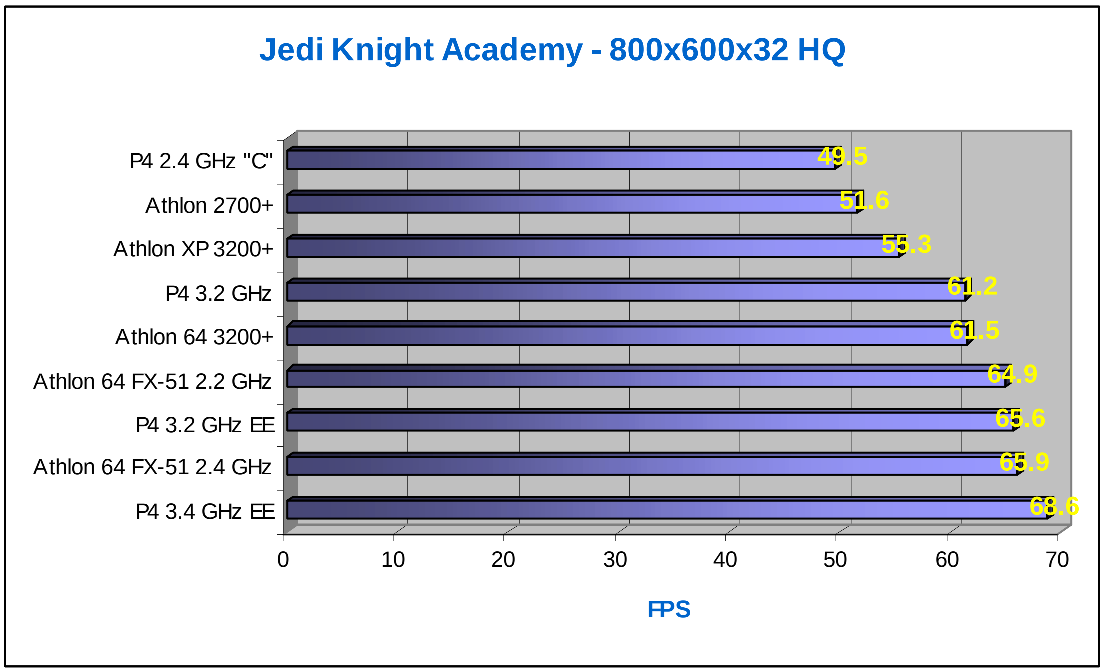
Jedi Knight II

Jedi Knight II is based on a vastly improved Quake 3 engine. This is the only game where we tested with sound off. For some reason, the Pentium 4 EE was not able to run this game. This might be resolved with BIOS update for our motherboard.



Another game that used to be ruled by the Pentium 4 family but which has now been conquered by the Athlon 64 FX, at least in absence of the P4 EE in this benchmark. Of course few people will be excited by the fact that you can play at fps >150 fps. Jedi Knight Academy, however, is a much more demanding game. I have noticed that explosions can cause the framerate to drop slightly below 30 fps when you are running, even on a 2.4 GHz Pentium 4 "C".

JKA might be based on the Quake 3 engine, but it boasts vastly more detailed models, a skeletal system and very beautiful terrain created by the terrain generator ("Arrioche").

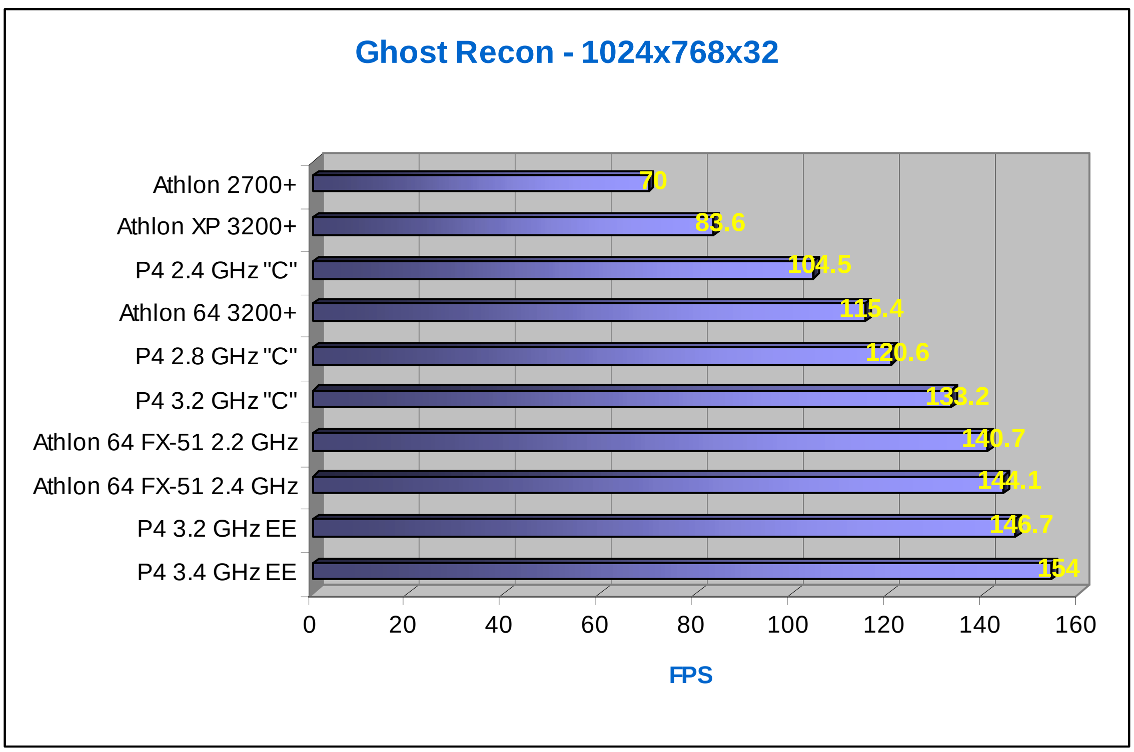


The Athlon XP might have been a Padawan, but big brother Athlon 64 is a real Jedi Knight which can take on the latest Pentium 4 CPUs.

Ghost Recon: Desert Siege

In our **last upgrade guide**, many people where happy to see **Ghost Recon** among the gaming benchmarks. The "Realistic Combat" First Person Shooter is the favorite game of no less than 17 to 18% of our readers! Just like in previous articles, we set all graphics settings to the highest quality.

Ghost Recon excels in detailed shadows and enemy AI, both of which are very processor intensive. The error margin of our Ghost Recon benchmark is very low (1%), with very repeatable benchmark scores.

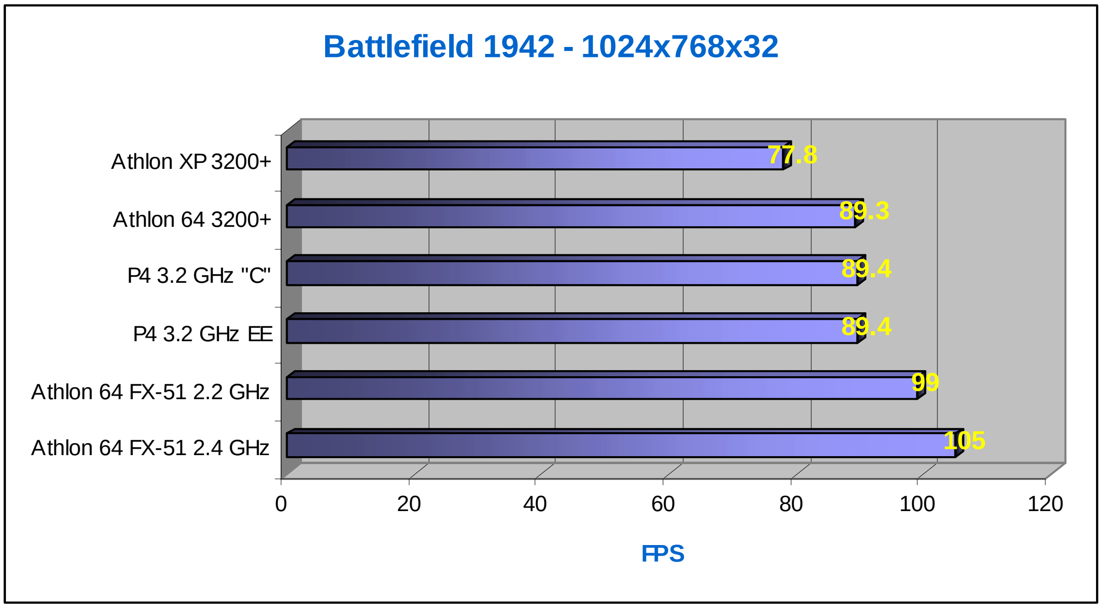


This was the benchmark were AMD suffered one humiliating defeat after another. The Athlon 64 FX has restored the balance: only the P4 EE with their fat L3 caches can outperform the best AMD chips with a small margin. Ghost Recon really requires a fast memory subsystem because a Athlon 3200+ outfitted with DDR333 was only capable of 101 fps.

Battlefield 1942

This first person, team-based action game places you in the midst of a WWII battle, letting you drive tanks and jeeps and fly Spitfires and Stukas. . While it is not as realistic as Ghost Recon, enemy and ally AI is very important. In fact, AI takes up at default 20% of the CPU time, and we raised it manually to its maximum of 25%. You can find **the other settings and more benchmarks here**.

The AI in Battlefield 1942 is quite advanced and not scripted. Shadows are calculated by the video card, and if a DirectX 8 compliant video card is available, it takes over the calculations of hardware skinning on animated meshes -- what makes the soldiers look more life like. We repeated our benchmarking with FRAPS several times to make sure the results are acceptable. This benchmark has been run in the "Stalingrad" episode. Unfortunately this benchmark requires many trials before it becomes somewhat consistent. Be careful with this benchmark, because we still do not have very precise numbers. The error margin between repeated tests is rather high (5%) and the only reason we still use it is to get a general idea of how these CPUs compare in B1942.

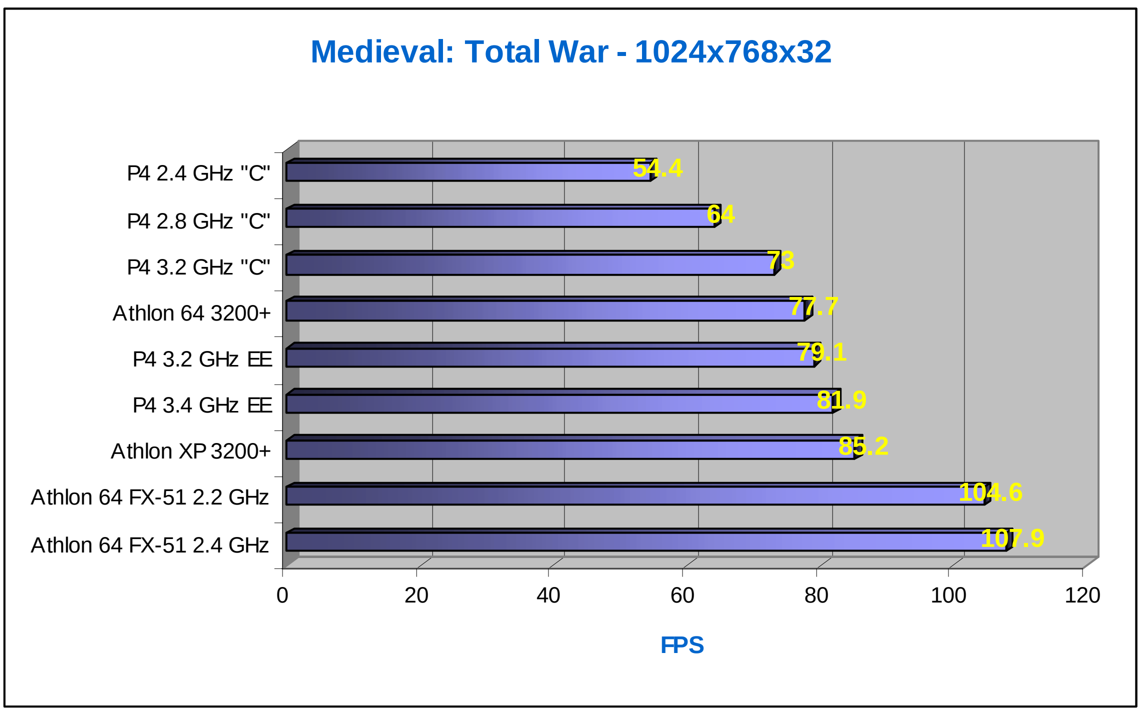


While the error margin is high, there is little doubt that the Pentium 4 core is a bit faster than the Athlons, though the exception here is the Athlon 64-FX 51, which manages to climb to the top of the pile.

Medieval: Total War

As I am something of a megalomaniac when it comes to playing games, I enjoy playing "Total War" a great deal. Medieval: Total War is based on the an improved version of the game engine that powered "Shogun." It contains a strategy "board game" element as well as a tactical, stunning "Real Time Strategy" battlefield element that features superb 3D landscapes. Thanks to the replay feature, our FRAPS benchmarking is very repeatable, and error margins are low.

The performance of Medieval War

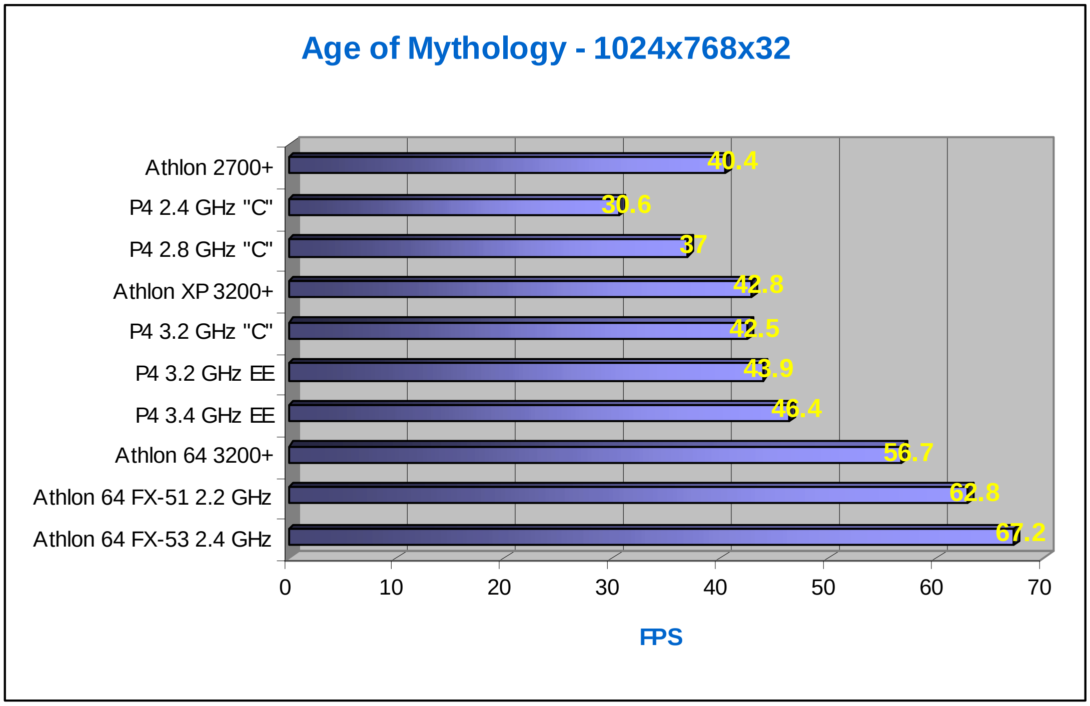


I have run this benchmark over and over again: the Athlon 64 FX simply kills the competition. 43% faster than the 3.2 GHz Pentium 4, and no less than 32% faster than the Extreme Edition. The Athlon 64 FX is the ultimate 3D strategic CPU.

Notice that the Athlon 64 3200+ is slower than the Athlon XP 3200+ for once. This is not impossible as the XP has a 200 MHz higher clockspeed and has essentially the same backend.

Age of Mythology

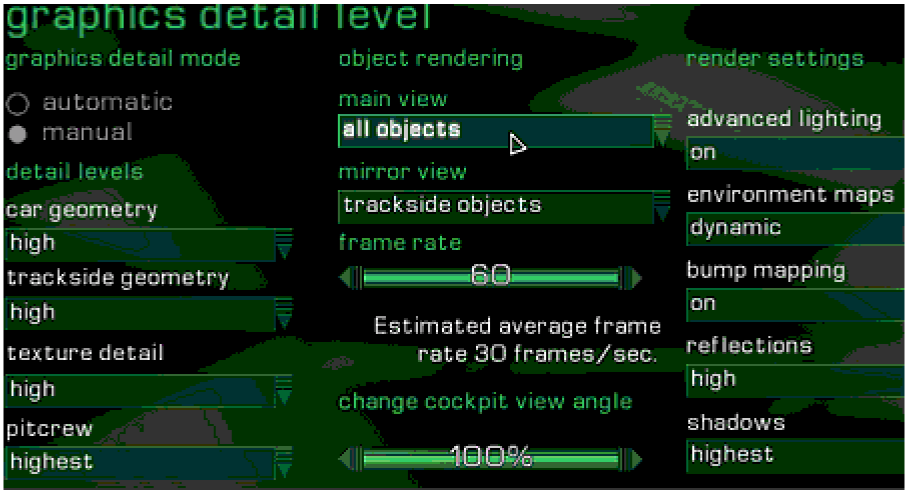
Age of Mythology is the third incarnation of Microsoft's and Ensemble Studio's very popular Age of Empires series. The 2D genie engine of Age of Empires has been replaced with a new 3D engine. Age of Mythology **is a mostly CPU limited game**, which makes it very interesting for this review. We tested the frame rate of a battle with a few tens of units.



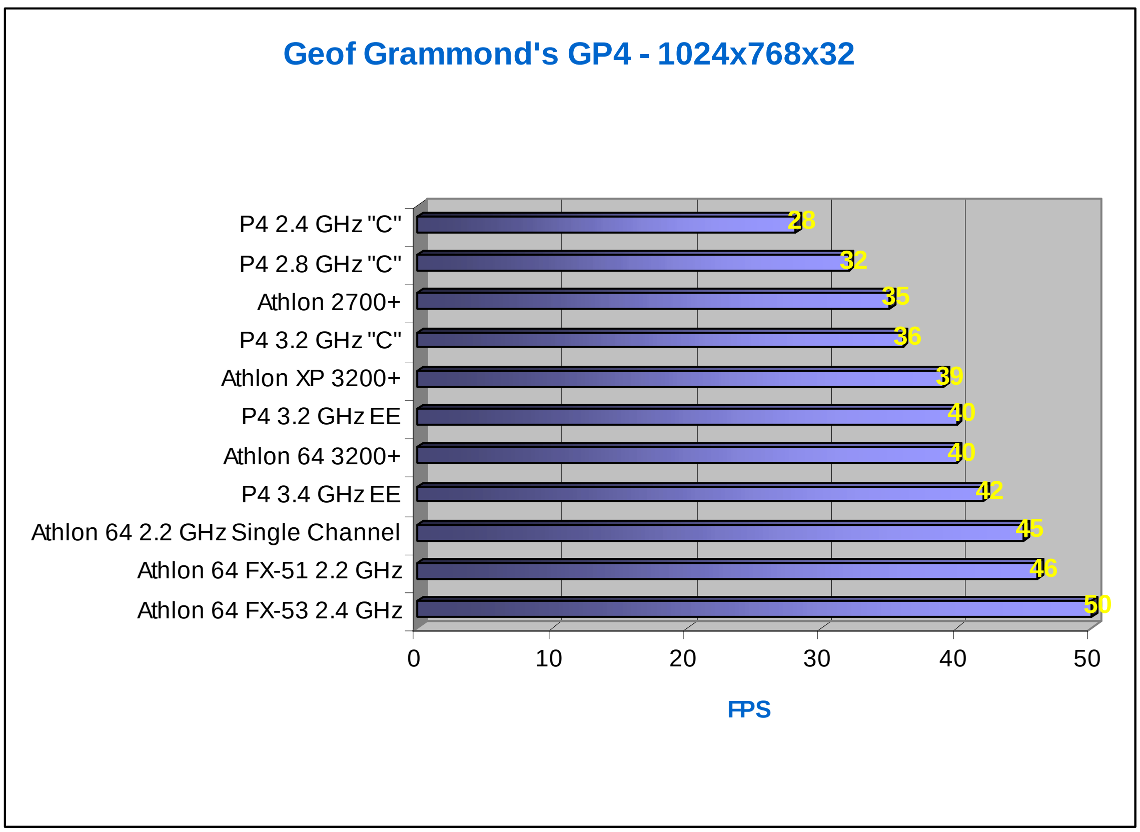
Benchmarks scores became remarkably lower when we replaced our typical Ti4600 card with the 5900 Ultra. Nevertheless, AOM's message is clear: the Athlon 64 is easily the best CPU for this game, as even the Athlon 64 3200+ manages to outperform an overclocked (3.4 GHz) Pentium 4 EE. It's interesting to look at the contrast in the results between the Athlon XP and the Athlon 64. An Athlon XP 3200+ is slightly slower than a 3.2 GHz P4C, but the Athlon 64 3200+ is significantly ahead.

Simulator: Grand Prix 4

We finish with one of the more popular Formula One simulators, Grand Prix 4. This engine is a typical DirectX 7 engine, which takes advantage of hardware/fixed transform and lighting, environment mapping (cars, reflections in wet surfaces) and bump mapping (heat haze from engine heat).



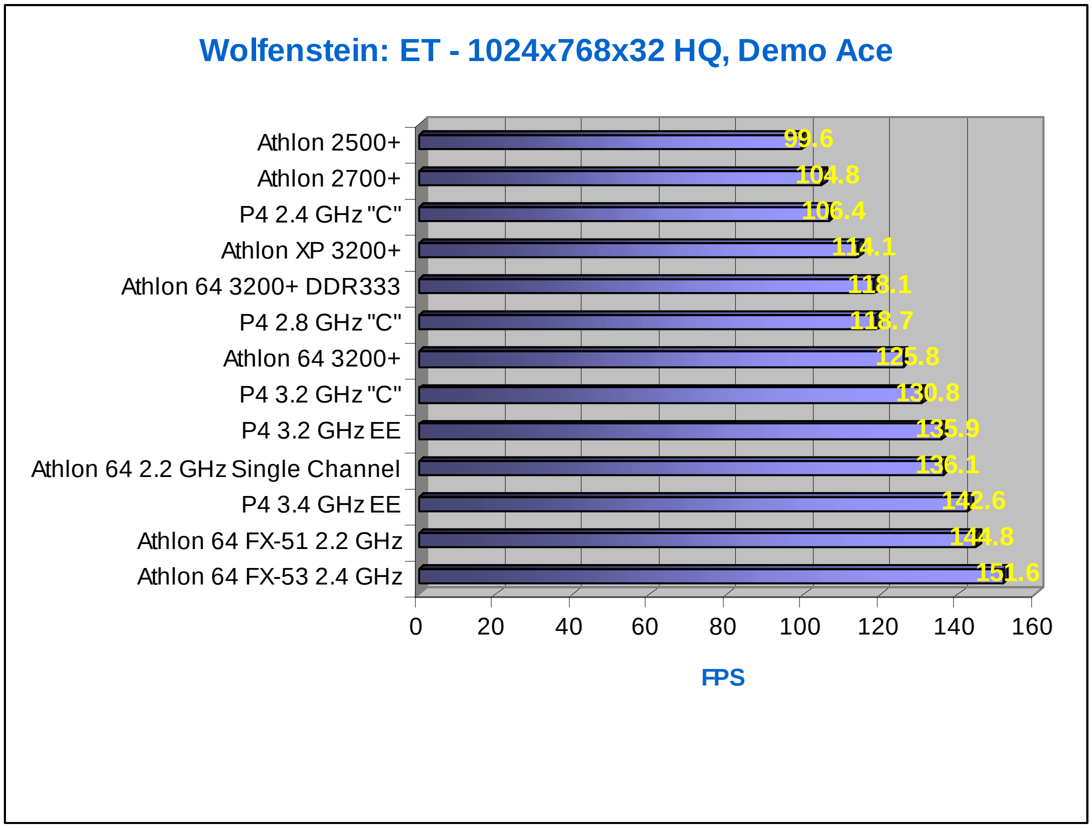
We used the built-in benchmark of Grand Prix 4 which is rather "coarse-grained" as it can only report whole numbers.



Here we see the Athlon 64 FX is even faster with a single channel. Very impressive for a 2.2 GHz chip! The 3.2 GHz P4 EE

Wolfenstein: Enemy Territory

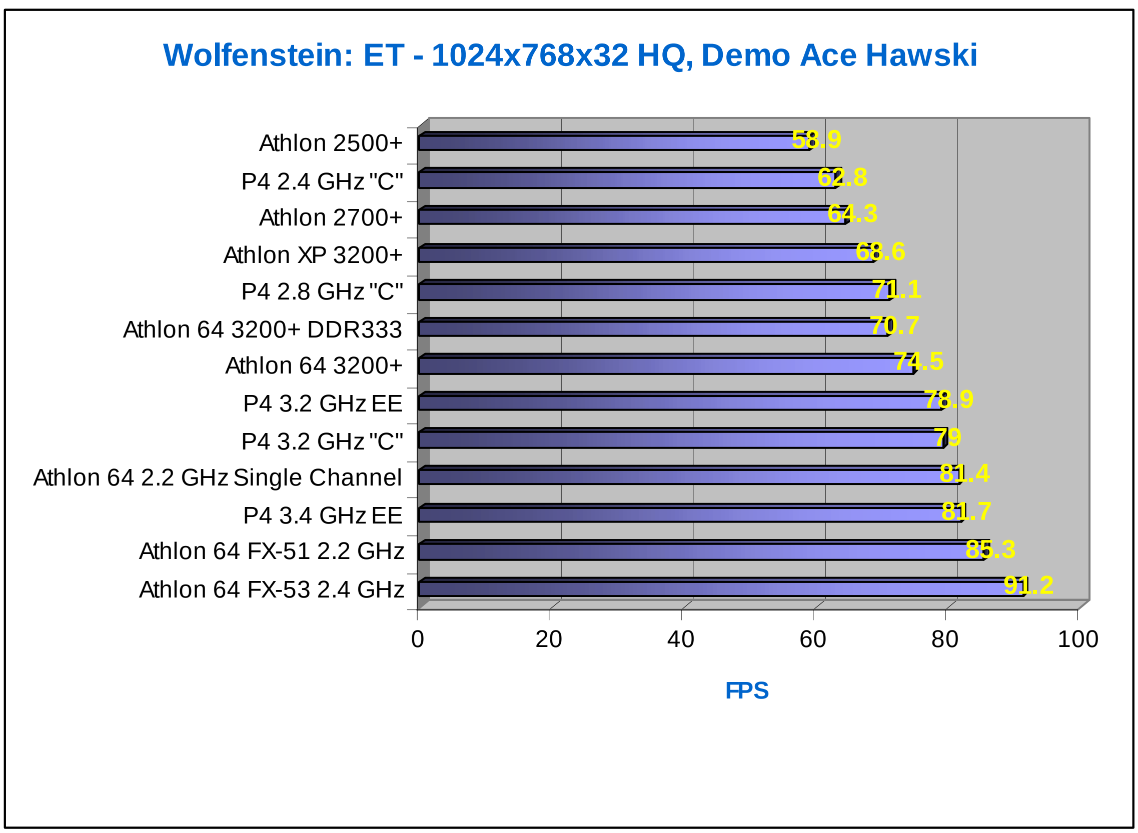
Veteran Ace's Hardware contributor and reader, Uffe Merrild, contacted me with two very interesting Enemy Territory benchmarks. Wolfenstein: ET is an incredibly popular multiplayer online FPS that is a lot of fun to play whether it is as an assault trooper, engineer, or medic.



The first demo does not contain massive movement of troops and explosions, and when we are testing CPU we want a worst case scenario. Meet the "Ace Hawski" demo, where German troops fight the allies in icy Scandinavia.

This time no remorse for these expensive CPUs!

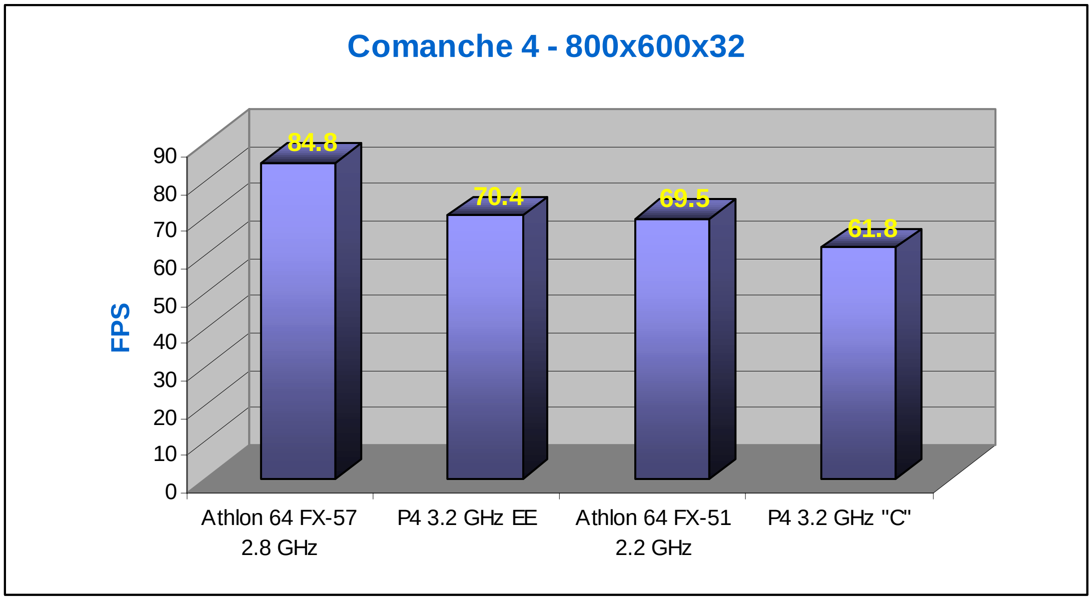
Wolfenstein Enemy Territory, Demo "Ace Hawski"("High quality 1024x768")



A lot of data to process... first of all, it seems that raw processing power is very important, as a clockspeed increase of a x% results almost in an equal performance increase. The L3-cache of the P4 EE does not help at all.

Overclocking Results: Coming This Week...

I did not spend much time talking about overclocking because our aircooled results were not really earth shattering. Both the Athlon 64 and FX-51 overclock at most 8-9% but only if you apply forced cooling and rather high voltages (1.65V). Not that bad, but nothing compared to this:



How on earth were we able to get a 2.8 GHz FX-57? Let **nVentive** answer that question:

The nVentive Prometeia Mach II is capable of keeping a 2.8 GHz Athlon 64 (1.75V) at -39°C even when running 3D benchmarks. In fact, even 2.94 GHz (14x 210) is not totally out of the question...

Overclocking the CPU by simply raising the multiplier does not always yield very good results. But in case of the Athlon 64 this does not seem to be the case, and nVentive's Micro Freezer Technology (MFT) makes it quite flexible in terms of CPU upgrades.

More in the next article, where you will see the FX-57, FX-55 and Prometeia Mach II in action!

Summary

How good is the Athlon 64 FX-51 and it's little brother, the Athlon 64 3200+, anyway? In the case of applications, I'll leave that up to you to decide, as it depends greatly on the application you use the most. In general, the workstation applications that are well optimized for SSE-2 and SMP/multithreading perform best on the Pentium 4. Most other applications in our benchmark suite seem to run better on the AMD64 family.

As we have tested so many games, we've made a small overview to help put things into perspective. We excluded NWN as it was clearly limited by the video card and Jedi knight because we could not run it on the P4 EE.

Gaming Benchmark	AMD Athlon 64+ 3200+ versus Pentium 4 3.2 GHz "C"	AMD Athlon 64+ FX-51 versus Pentium 4 3.2 GHz "C"	MD Athlon 64+ FX versus Pentium 4 3.2 GHz "EE"
Age of Mythology	**33% faster**	**48% faster**	**43% faster**
Comanche 4	**Equal**	**12% faster**	**1% slower**
Civilization III	**Equal**	**11% faster**	**12% slower**
Enemy Territory	**5% slower**	**8% faster**	**8% faster**
Ghost Recon	**13% slower**	**6% faster**	**4% slower**
Grand Prix 4	**5% faster**	**28% faster**	**15% faster**
Jedi Knight Academy	**Equal**	**6% faster**	**1% slower**
Medieval War	**6% faster**	**43% faster**	**32% faster**
Unreal Tournament 2003 Asbestos	**15% faster**	**21% faster**	**10% faster**
Unreal II	**12% faster**	**24% faster**	**16% faster**
X^2	**5% faster**	**6% faster**	**1% faster**

Final Thoughts

The Athlon 64 3200+ ($417) is definitely the most interesting offering. With the exception of Ghost Recon and Enemy Territory, it outperforms its direct competitor, which is about 50% more expensive. Intel will lower the price next month from $637 to $417, but until then is the Athlon 64 a bargain for the enthusiast (and AMD will probably adapt prices too).

The Athlon 64 FX-51 is indeed the fastest desktop processor right now as the Pentium 4 EE is not really available to the enthusiast. The large L3-cache of Pentium 4 EE gives it an advantage in applications like 3D Animation, but in games the Athlon 64 FX-51 is overall the fastest processor. However, the high price tag plus the fact that you have to buy buffered RAM makes the Athlon FX-51 less interesting from a price/performance perspective.

We can't help it but geeks as we are we also like to look at the architecture. From an architectural point of view, the Athlon 64 shines: all the rough edges of the K7 architecture have been perfected, and the Athlon 64 architecture is- despite still being based on ancient x86 - a very balanced and elegant design. The rough K7 diamond has been cut and polished and shines brightly now, especially when you look at how well this CPU scales with higher frequencies. We will show you more in our next review.

One thing that could justify the rather high system cost of an Athlon 64 FX based PC is the extra memory space and performance in Windows 64. Windows 64 is not ready yet, though. NVIDIA OpenGL Drivers, for example, do not seem to support hardware acceleration and few applications have been ported so far as the OS in a beta phase. The future of

AMD64 is a bit murky: many companies want to support the Opteron and Athlon 64 as a 32 bit chip, but have "a wait and see attitude" when it comes to porting their applications to 64-bit.

There are so many 64-bit roads that Intel may take, and therefore it is very hard to predict what future AMD64 has. Intel and HP are very committed to the Itanium, and the performance and industry acceptance of the Itanium are finally taking off. So we definitely can forget the scenario where Intel will ditch IA-64 for some form of x86-64, even though it is very likely that Prescott has some 64-bit functionality **hidden away**.

The most likely scenario is that Intel will try to push the Itanium towards the gigantic dual processor market more quickly, at the expense of the Xeon. While Madison and McKinley were typically CPUs for scientific and large database applications (backend of 3-tier model), Deerfield is already destined to find a place in front end (application servers like webservers, etc.) and blade market (HPC).

When the Itanium family finally begins to replace the Xeon in both the workstation and server market, Intel can proceed with extending x86 to 64-bit as well and try to pull the plug out of AMD64. Because at that point, the Itanium will no longer be so vulnerable to poor ISV support. Introducing a form of Intel x86-64 in the coming moths would trample the Itanium sapling just at a time when it shows promise to grow faster.

Essentially, AMD has a few years to gather enough support and market share. AMD will have to do better than ever before, but the first steps in right direction have been taken.

For the moment, the future of AMD64 is no concern to the average user. The Athlon 64 (non-FX) line gives you excellent 32-bit performance for a decent price, and maybe even more importantly it is a much safer CPU. Replacing or inserting an AMD CPU is no longer a risky endeavor. Computer shops and enthusiasts, in particular, will appreciate this.