Intel versus AMD

2 GHz Northwood versus Athlon XP 2000+

By Johan De Gelas – January 2002

Intel's Pentium 4 is currently not the tremendous success the company might have hoped it would be, certainly not compared to Intel's high standards for success. As usual Intel did rather well in the corporate market, a segment dominated by the tier-one OEMs where Intel's strongest ally, Dell, is now the biggest of all. In the retail market, however, Intel's showpiece was washed away by the Athlon XP tsunami. Before the launch of the i845 DDR chipset, some of our industry sources reported that the Intel Pentium 4 held less than 10% of the retail market. AMD's Athlon and Duron took the lead in Europe, netting more than a 50% share in that region. Intel's Pentium III and Celeron account for about 35%, still outselling the Pentium 4 by a wide margin. This is changing, of course, but it clearly shows that the retail market has not exactly been fond of the Pentium 4.

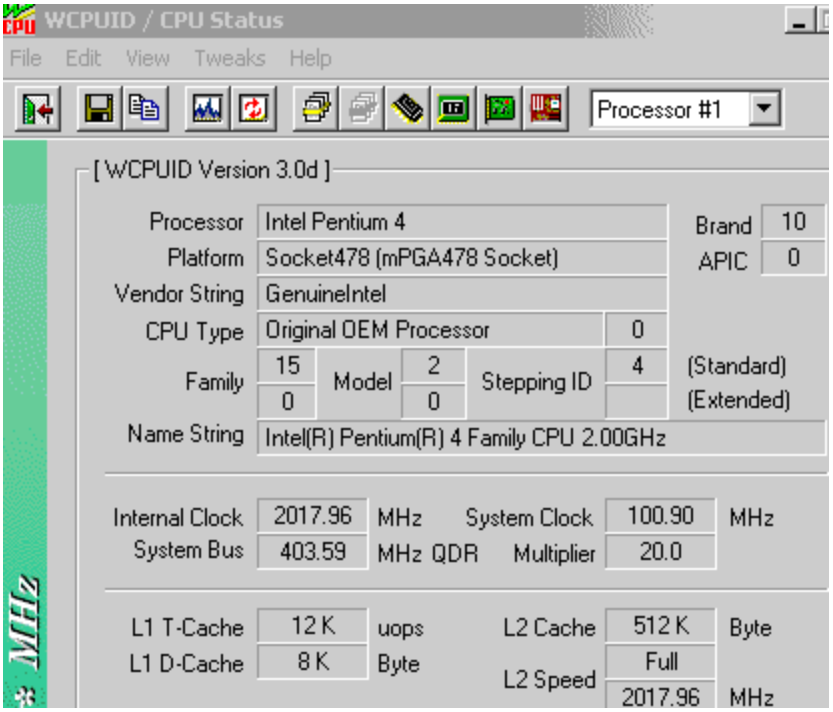
Why? Excluding a few benchmarks like Media Encoder, Lightwave 7.0b, and Quake 3, the Pentium 4 has not been able to hold a performance advantage over the venerable Athlon XP, let alone a price advantage. The introduction of the i845 SDRAM chipset made the Pentium 4 platform quite a bit cheaper, but did so only at a very high cost to overall performance.

Despite this, Intel has executed very well in the process technology department, and the Pentium 4 is now being produced on the company's new 0.13-micron process with copper interconnects as opposed to the older 0.18-micron Aluminum process. Smaller process technology allows more transistors in the same die space, allowing Intel's engineers to boost the performance of the Pentium 4 doubling the 256 KB L2 cache to 512 KB. This means that the new Northwood Pentium 4 is not only smaller, but it delivers higher performance as well.

But AMD has not been sitting still, either. Today they are launching the 1.667 GHz Athlon XP 2000+. Prepare for an in-depth comparison of the new Northwood Pentium 4 at 2 GHz and 2.2 GHz, as well as the new Athlon XP 2000+.

Intel's New Cache

If there is one area where Intel's engineers truly excel, it is in designing high performance caches. You probably recall the incredibly fast 256-bit, 7 cycle L2-cache of the Pentium III Coppermine. The Pentium 4 has a high performance cache as well...



As the L2-cache of the Pentium 4 must be able to run at much higher clockspeeds, L2-cache latencies are higher than what is the case for the Pentium III's L2-cache. Still the current L2-cache of the Pentium 4 is superior to that of the Athlon XP's, as you can see in the table below.

CPU	Latency	Theoretical Bandwidth
1.667 GHz Athlon XP 2000+	11-20	13.4 GB/s
2.0 GHz Pentium 4	9-18	64 GB/s
1.0 GHz Pentium III	7	16 GB/s

How good is the 512 KB cache of new Pentium 4, alias Northwood? We investigated the matter with Luciano's famous cachemem utility.

To determine the latency, we looked at the L2- cache refill latency (steps of 64 bytes and 128 bytes) or block sizes of 128 KB and 256 KB.

CPU	Latency	Read Bandwidth	Write Bandwidth
1.667 GHz Athlon XP 2000+	20	4.9 GB/s	5.1 GB/s
2.0 GHz Pentium 4	17-18	8.1 GB/s	6.7 GB/s
2.0 GHz Northwood	16-17	8.1 GB/s	6.7 GB/s

According to cachemem, the Northwood L2 has a slightly lower latency than the Pentium 4's smaller 256 KB cache. We are not sure if this is not a side effect of the larger cache, but Intel's officials have confirmed that aside from the larger size, Northwood's cache has been otherwise slightly improved. Notice that the real world bandwidth numbers of the L2-cache of the Athlon and Pentium 4 are much closer than what the theoretical numbers suggest. We have explained this in a previous article, Pentium 4 Architecture In-Depth, Part 1, available at the following location:

http://www.aceshardware.com/read.jsp?id=20000190

Comparing Platforms

There used to be a time where it was very easy to compare Intel and AMD CPUs. You simply plugged them into the same motherboard and ran a few benchmarks. Nowadays, it is possible to make either chip look bad or fantastic just by using another platform. Therefore we have tested all CPUs on several different motherboards. You'll find the bandwidth and latency numbers of each board and chipset combination that we have tested below. The i850 boards were 423 pin boards and were not used in this review, those numbers are only for comparison.

ASUS' KT266A motherboard delivers exceptional performance with an equally excellent layout, but the price is, accordingly, higher than some of its competitors. While MSI's board is a solution that delivers slightly lower-performance overall, it is more affordable and comes with the same features as the ASUS KT266A motherboard, namely USB 2.0 and extensive hardware monitoring.

As you will see in the next few pages of this article, the ASUS i845D P4B266 is again one of the best performing Intel motherboards available. Tyan's Trinity 510 (VIA P4X266) is a bit slower, and does not pack the same rich feature set as the ASUS board, but the latter costs twice as much as Tyan's inexpensive offering ($170 versus $90).

We will provide more information about these different motherboards in another article. The objective here is to benchmark on at least one fast and expensive motherboard as well as one more affordable but slightly slower motherboard to show you how the overall performance of a given platform can vary. Also it gives you more information for your next upgrade: should you pay more for the fastest board or save that money for something else? Let's find out...

STREAM and Cachemem

Benchmark	Athlon XP 2000+ ASUS KT266A	Athlon XP 2000+ MSI KT266A	2.0 GHz Pentium 4 ASUS i850 (PC800)	2.0 GHz Pentium 4 ASUS i850 (PC1066)	2.0 GHz Pentium 4 SuperMicro i845 (PC133)	2.0 GHz Pentium 4 Tyan P4X266	2.0 GHz Pentium 4 ASUS i845D (PC2100)
Copy 32	693	641	1109	1460	604	814	885
Copy 64	698	618	1226	1627	623	970	958
Scale	795	744	1271	1662	613	972	946
ADD	881	801	1500	1979	727	1178	1152
Triad	853	776	1496	1979	718	1166	1141
Average Bandwidth (MB/s)	**784**	**716**	**1320**	**1741**	**657**	**1020**	**1016**
Latency (128 Byte) (clockcycles)	203	208	301	233	258	266	230
Latency (64 Byte) (clockcycles)	156	156	N/A	N/A	127	83	70

STREAM and Cachemem provide some very interesting information. Even if both CPUs are equipped with the same memory solution and a similar chipset from the same manufacturer (VIA), the Pentium 4 has still an advantage in terms of bandwidth. The quad-pumped FSB absorbs 30% more bandwidth than the AMD's DDR EV6 bus.

Upgrading to Northwood

We tested several motherboards with Northwood to see if you can successfully upgrade a Pentium 4 rig to a Northwood system:

- The ASUS P4B and P4B266 support both the 2.0 GHz and 2.2 GHz Northwood processors.
- Very early versions of MSI's i845 SDRAM (i845 Pro2) motherboard seem to have problems with Northwood, which a BIOS revision should correct. The MSI i845 Pro4 has no problems at all.
- Tyan's Trinity 510 was able to power the 2 GHz Northwood, but not the 2.2 GHz part. A BIOS revision should be able to resolve this issue.
- SuperMicro's P4SBA supports both the 2.0 GHz and 2.2 GHz Northwood chips.
- Lucky Star's P4A845D supports both Northwood chips (2.0 GHz and 2.2 GHz).

In general, all 478-pin motherboards should be able to support Northwood, as long as they are flashed with BIOS that supports the requisite higher multipliers. The 0.13µ Pentium 4 takes care of the voltage regulation to 1.5V.

Choosing a CPU

Most of our readers are knowledgeable do-it-yourself people who choose a CPU on the sole basis of price/performance. If you are a PC builder, responsible for a huge amount of PCs or if you build servers, there are some other considerations:

- How durable is a CPU?
- How much power does the CPU consume and what are its cooling requirements?
- What kind of power supply does it need?
- What happens if fans mechanically fail?

Giving credit where credit is due, Intel's 478-pin Pentium 4/Northwood is an extremely sturdy CPU. The heat-spreader and the clock throttling mechanism, that slows the CPU down when cooling is inadequate, makes the Pentium 4/Northwood less vulnerable to heat problems than the Athlon XP. If the fan stops spinning for some reason, the Athlon XP will not burn, as every good Socket A motherboard will power down if the CPU heats up too much. The Intel CPU will throttle and keep the PC running.

And there is more. Intel's new heatsink retention system is superb. The four clips of the retention mechanism attach themselves in the loops of the socket framework. With two levers, you can fix the heatsink firmly onto the CPU.

In our humble opinion, a similar system should be developed and used for the Athlon XP. Many decent and Athlon XP approved heatsinks come with only one clip on each side, and the result is that you have to apply an enormous amount of pressure to attach the heatsink.

The Athlon XP also requires a better power supply than the Pentium 4. This is a bit surprising, since the 0.18µ Pentium 4 requires more power than the Athlon XP. Take a look at the power dissipation table below:

CPU Power Dissipation

CPU - Codename	Frequency	Nominal core voltage	Max. Thermal Power	Typical Thermal power	Power dissipation / 100 MHz
Duron - Spitfire	950	1.6	41.5	37.2	3.92
Duron - Morgan	1000	1.75	46	41.2	4.12
Athlon - Thunderbird	1000	1.75	54	49	4.90
Athlon MP - Palomino	1000	1.75	46.1	41.3	4.13
Athlon MP - Palomino	1200	1.75	54.7	49.1	4.09
Athlon - Thunderbird	1200	1.75	66	59	4.92
Athlon - Thunderbird	**1400**	**1.75**	**72**	**65**	**4.64**
Athlon XP 1600+	1400	1.75	62.8	56.3	4.02
Athlon XP 1700+	1466	1.75	64	57.4	3.92
Athlon XP 1800+	**1533**	**1.75**	**66**	**59.2**	**3.86**
Athlon XP 1900+	1600	1.75	68	60.7	3.79
Athlon XP 2000+	1667	1.75 (1.8?*)	72	62.5	3.75
Pentium 4 1700 MHz	1700	1.7	84	66	3.88
Pentium 4 2000 MHz	2000	1.7	92	72	3.6
Pentium 4 2000 MHz 0.13	**2000**	**1.5**	**66**	**52.4**	**2.62**
Pentium 4 2200 MHz 0.13	**2200**	**1.5**	**70**	**55.1**	**2.5**

** The ASUS A7V266 board automatically set the voltage to 1.8-1.84V (XP2000+), while the XP1900+ was set to 1.75V - 1.79V*

A decent motherboard can run a 2.0 GHz Pentium 4 with a 250 Watt power supply, while an Athlon XP 2000+ system requires at least a 300 Watt supply, preferably a 350 Watt supply. The reason is that the 12V lines feed the Pentium 4, and the Athlon XP uses the 5V and 3.3V lines. The 2.0 GHz Pentium 4 draws about 8 amps from the 12V line and so will future Northwood's. That is a bit too much for the one 12V line of the ATX power cable, as the connector is speced for only 6-7 amps. Therefore, Intel demands a second 12V cable. Aside from a second 12V cable, the new ATX-12V specification requires a third AUX cable with another 12V line. Unless you want to use an AGP Pro 50/110 OpenGL video card, however, you do not need 3 12V lines.

Two lines are necessary if you want to be able to upgrade to a future 3 GHz Northwood, though. Resultantly, ASUS has developed a very interesting solution, that has also been adopted by Gigabyte and MSI in some of their products, they use one of the ATX connectors that normally attach to one of the hard disks or CDROMs to provide an additional 12V line.

The vertical arrow points to the ATX connector that provides an additional 12V line, the horizontal arrow points to the square 12V connector.

The result is that you can use the ASUS P4B266 to upgrade your PC without the need to upgrade to an ATX-12V power supply, so long as it is able to provide 235W to 250W and 8 amps on the 12V lines. An original and inexpensive approach, thanks to the ASUS engineers.

Knowing that the Pentium 4 is fed by the 12V lines, and that the Athlon XP needs about 10 amps from the 5V and 3.3V lines also explains why some 350W power supplies are more than adequate for the Pentium 4, yet still fail to deliver in an Athlon-based PC.

There is one area where the Athlon platform is safer than the Pentium 4 platform: older video cards. If you insert a 3.3V video card you can damage an i845 motherboard specified to work with AGP 4x at 1.5V. The AGP 4x standard specifies a 1.5V signal between the chipset and the video card, while older 3.3V cards such as the 3DFx Voodoo 3000, Matrox G200, ATI Rage, and Nvidia TNT lack a notch to prevent these cards from being installed in an i845 motherboard.

There a few older cards based on the SiS305, TNT, and Savage4 chipsets that do have a typical 1.5V notch but which are, in fact, 3.3V. These video cards can destroy an i845 motherboard! In other words, if you are still using a video card bought back in 1998, you should not attempt to use this 3.3V card in your new i845 motherboard, even you are able to.

The advantages of the Pentium 4 over the Athlon mentioned above, do not alter the fact that price/performance is of course still king for most DIY folks. What we like to point out is that, in order to make great strides in the corporate/OEM and especially the server market, a few technical improvements should be made to make the Athlon XP an even more robust CPU.

You should make sure that that you get a good heatsink and power supply, and should be careful when attaching the heatsink. We would advise you also to pay a bit more for the Athlon XP instead of going for the cheaper Thunderbird CPUs, as the former is a much safer CPU than the Thunderbird: lower power consumption and the voltage regulators are no longer on top of the CPU. The Athlon XP 1900+ at 1600 MHz dissipates less heat than the Thunderbird at 1400 MHz!

Enough about safety, let's see some benchmarks!

Benchmark Configuration

All systems were tested with NVIDIA's Detonator 21.85 drivers. The VIA-based systems were tested with VIA's 4-in-1 4.35 drivers, and the Intel-based systems were tested with Intel's latest December 2001 INF update.

The Intel Family! Top: left Celeron Tualatin, right Celeron Coppermine
Bottom: Pentium 4 Willamette 423, Pentium 4 Willamette 478 pin, Pentium 4 Northwood

As you can see we have tested with Windows 2000 SP2. Why not Windows XP? Well, we have simply run into too much trouble with XP as of late. Max Payne would not run properly, Serious Sam crashed from time to time, and the list goes on. Windows 2000 SP2 was a completely different story, as all benchmarks ran flawlessly. Furthermore, we believe that most professionals and hardcore power users still prefer the more mature Windows 2000 to the new Windows XP.

Athlon 1400

- ASUS A7V266-E (VIAKT266A) BIOS version 1.004
- 512 MB Corsair DDR-RAM CAS 2

Athlon XP 2000+

- MSI K7T266 Pro 2 (VIAKT266A) BIOS version 3.3 and ASUS A7V266-E (VIAKT266A) BIOS version 1.004
- 512 MB Corsair DDR-RAM CAS 2

"Pentium 4 2.0 GHz SDRAM & Pentium 4 2A GHz Northwood SDRAM"

- Super Micro P4SBA
- 512 MB PC133 Corsair CAS 2

"Pentium 4 2.0 GHz & 2.0 A (=Northwood) GHz P4X266"

- Tyan Trinity 510 (S2266) BIOS version 1.04 (VIA P4X266 chipset)
- 512 MB Corsair DDR-RAM CAS 2

Pentium 4 2A i845 DDR and 2.2 GHz (Northwood)

- ASUS P4B266 (i845 DDR chipset) BIOS version 1.005
- 512 MB Corsair DDR-RAM CAS 2

Common Hardware

- IBM Deskstar DPTA-373420 ATA/IDE 34.2 GB (7200 RPM, ATA-100)
- ASUS GeForce 3 Ti500 64 MB
- AT 2700 10/100 NIC
- Sound Blaster Live!

Software

- Windows 2000 Service Pack 2, DirectX 8.1

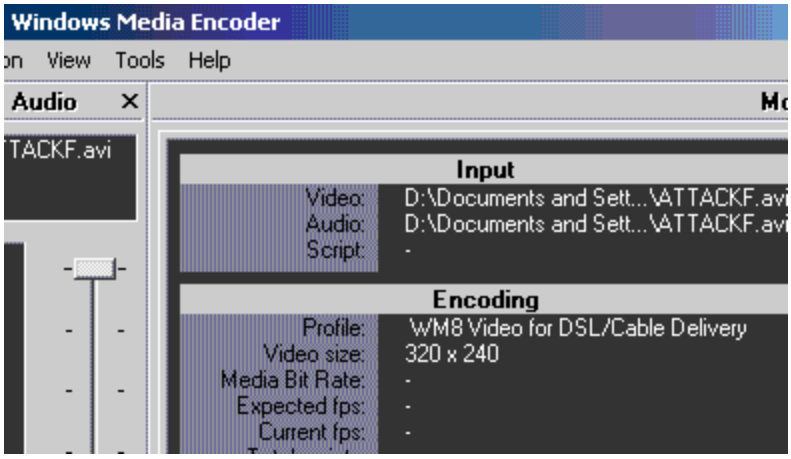
We'd like to thank the following helpful people for their support and crucial contributions to this review:

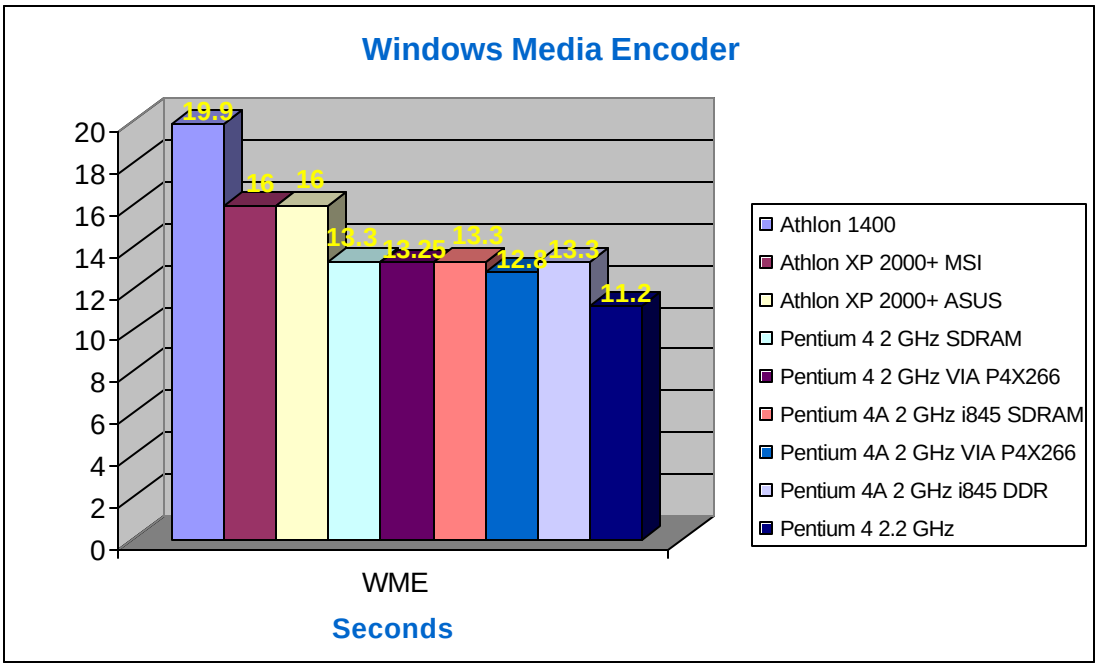
- Damon Muzny (AMD) for giving us the chance to test the Athlon XP 2000+.
- Jamel Tayeb and Jurgen Heymbrechts (Intel) , Marieke Leenhouts (MCS) made sure we could test the Pentium 4 2A GHz and 2.2 GHz.
- Robert Pearce of Corsair, provided us with Corsair's PC2100 DDR CAS2 and PC133 CAS2 SDRAM
- Thanks to Augustine Chen, Carol Chang (ASUS) and Sharon Tan (BAS computers Netherlands) for the ASUS motherboards.
- Joe James and Mat Vernon of Tyan sent us the Tyan S2266
- Angelique Berden of MSI provided us with the MSI KT266 Pro-2.
- Doncevski B. Robert sent us the Lucky Star i845DDR p4a845d solution.

Much appreciated!

Streaming Applications

These are the kind of applications the Pentium 4 was made for. We used Windows Media Encoder 7.1 to encode a 24 MB AVI file to a streaming 1 MB WM8 video with a bit rate of 242 kbps. The results are reported in seconds, so keep in mind that lower is better.





Although the Athlon XP 2000+ (1.667 GHz) is clocked only 20% faster than the 1.4 GHz Athlon, it can beat its older brother by a margin of 24%. Clearly, this is an example of a benchmark that benefits from SSE and hardware prefetch. And while the Athlon XP manages to exceed the performance of the other Thunderbird, this remains the Pentium 4's home territory. In fact, the Pentium 4 holds a 20% lead over the fastest Athlon XP, the 2000+.

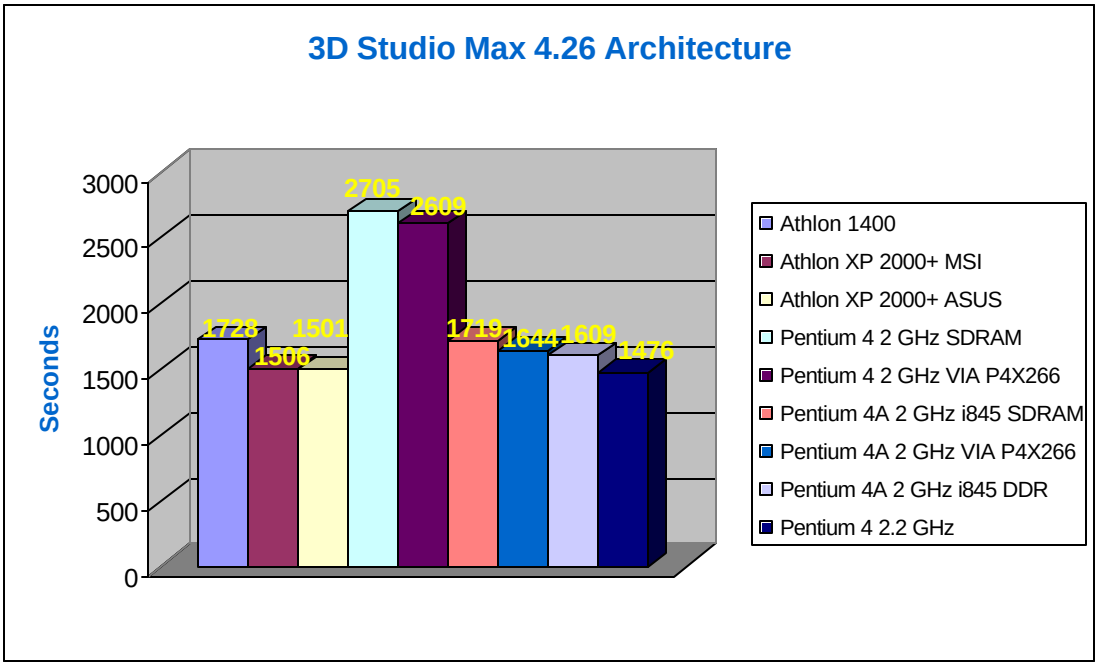
Streaming applications consist of small loops, which handle large data streams and do not benefit from large caches. Accordingly, the 2 GHz Northwood manages only a 2% lead over the original 2 GHz Pentium 4.

Workstation Applications

So far, the Athlon XP has defeated the Pentium 4 by a large margin in workstation applications. The big question is, of course, can the extra 256 KB close the gap? Watch and be amazed...

We used the 4.2.6 update of 3DSMax, which contains highly optimized routines for raytracing that make use of SSE-2. These include the "blur rendering effect" and "volumetric lighting."
The complex architecture scene from the SPEC APC 3DSMAX R3.1 benchmark was the first 3DSMax benchmark. This test has a moving camera that shows a complicated building, as a sort of virtual tour of a scale model. This scene has no less than 600,000 polygons and 7 lights. Raytracing and fog were both enabled for the test.

We rendered 3 frames, 20 to 22, at 500x300 to the virtual frame buffer. Results are indicated in seconds.



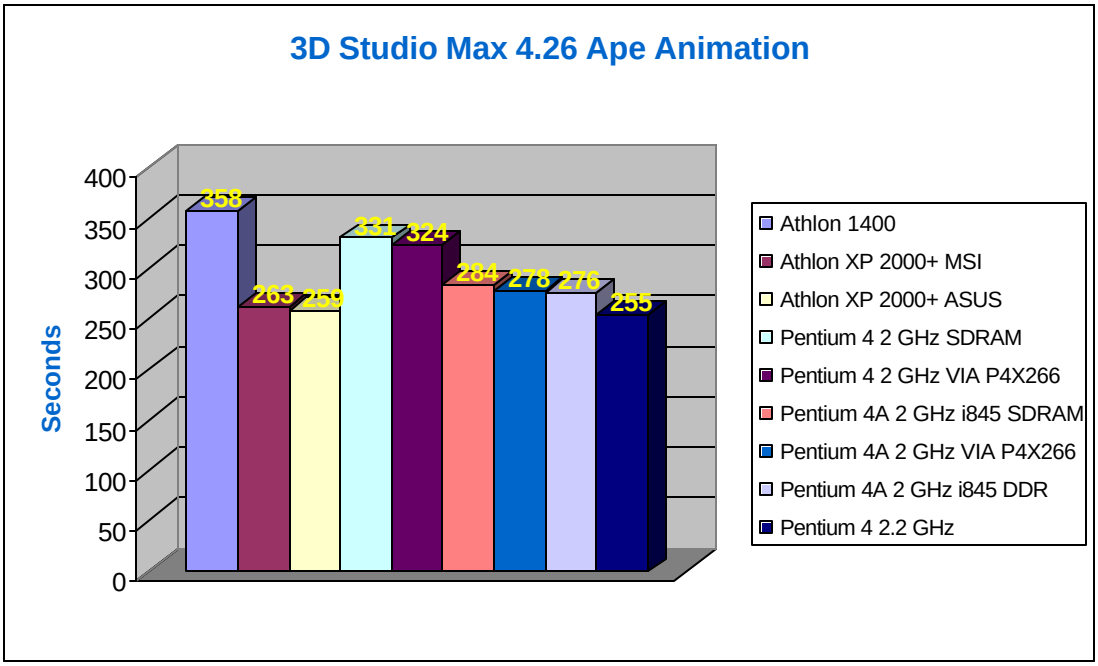
Believe it or not, the new Pentium 4A, aka the Northwood is, clock for clock, **61% faster** than the "old" Pentium 4. Incredible! Of course, this is an exception, not the rule. A 256 KB or 384 KB cache is simply not enough for this complex scene. The benchmark probably trashes the Willamette Pentium 4's 256 KB cache by swapping out data, which is needed in a few cycles for the data that was needed a few cycles ago. Caching the polygon data more efficiently can help the performance of a rendering engine significantly, as polygon data is used over and over again for hidden surface removal, polygon sorting and, of course, final rendering.

It is still amazing that a 2.2 GHz Pentium 4 Northwood is able to beat AMD's fastest processor by a small margin, while the older 2 GHz Pentium 4 is 73% slower!

3D Studio Max: Ape Animation

Let's try another 3DSMax 4.26 benchmark, this time using the Ape model, an example object that is included on every 3DSMax 4 CD.

The Ape animation is a typical game character rendering setup making heavy use of light: 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.

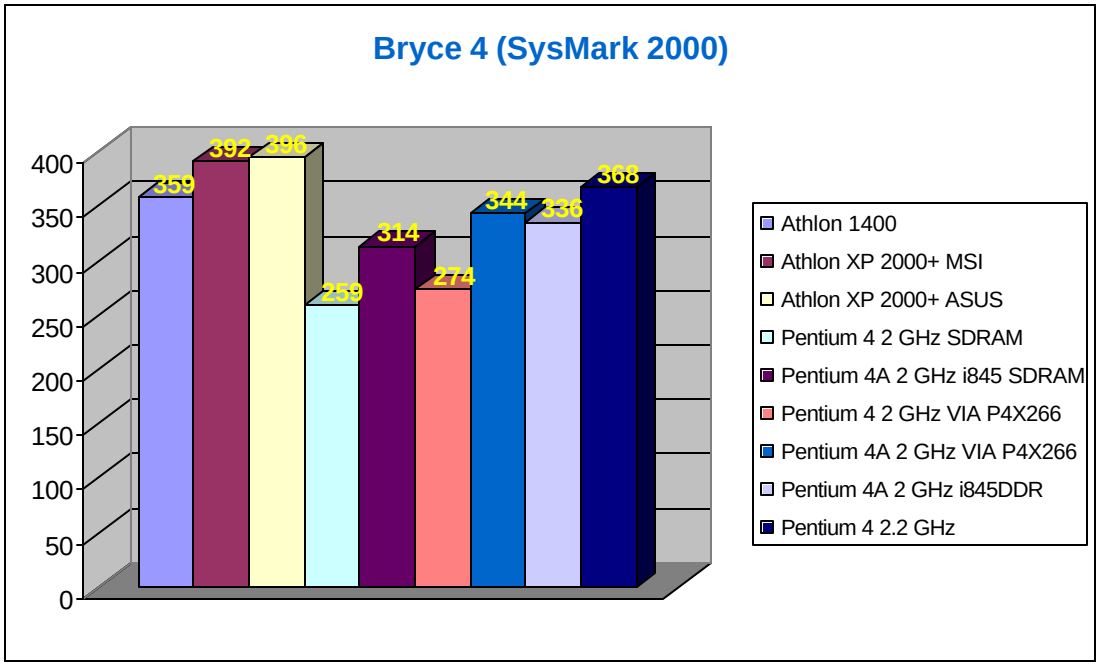


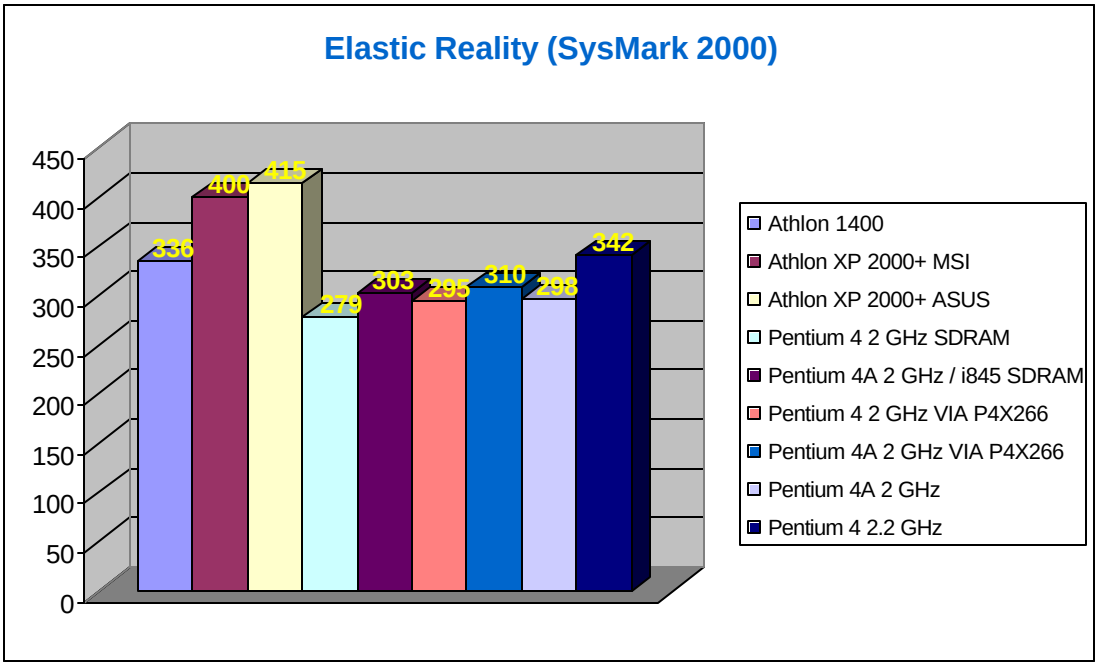
This time the performance gap between Willamette (P4 256 KB) and Northwood (P4 512 KB) is only 17%. This shows that we should be very careful when interpreting rendering benchmarks. Use a very simple scene with few polygons, and you will probably see almost no difference between the Pentium 4 and Pentium 4A. But that is hardly a realistic benchmark, as an artist is not buying a $5000 package to do some simple animation. Most models are quite complex and have a benchmark profile which lies between the "Ape" and the "architecture" benchmark. The more complex the scene, the more it will gain from a larger cache.

The combination of decent SSE-2 optimization, higher clockspeeds and larger caches allow the Pentium 4A to shine and outperform the Athlon XP. The Athlon XP is still the price/performance king, but the fastest CPU here is the 2.2 GHz Northwood Pentium 4. While the overall performance margin varies from scene to scene, as some rendering operations (with "motion blur") seem to be more SSE-2 friendly than others (raytracing - see Architecture benchmark). The 2.2 GHz Northwood is the fastest, but the Athlon XP 2000+ is right on its heels.

SYSMark 2000

To get more insight in the performance battle between the Athlon XP and the Intel Northwood, we tested with SYSMark 2000. It is a somewhat older benchmark, but it is one of the few benchmarks that provide individual scores for each application. We are not really happy with Sysmark 2001, as we have strong suspicions that it tries to simulate multi-tasking by running WME in the background. Although this might be interesting for some people, this is hardly a typical use of a workstation or desktop PC. This way of benchmarking exaggerates the importance of WME, and as such gives the Pentium 4 an unrealistic advantage. Therefore, we have tested with WME and SYSMark 2000 to clearly show the strong and weak points of each CPU.



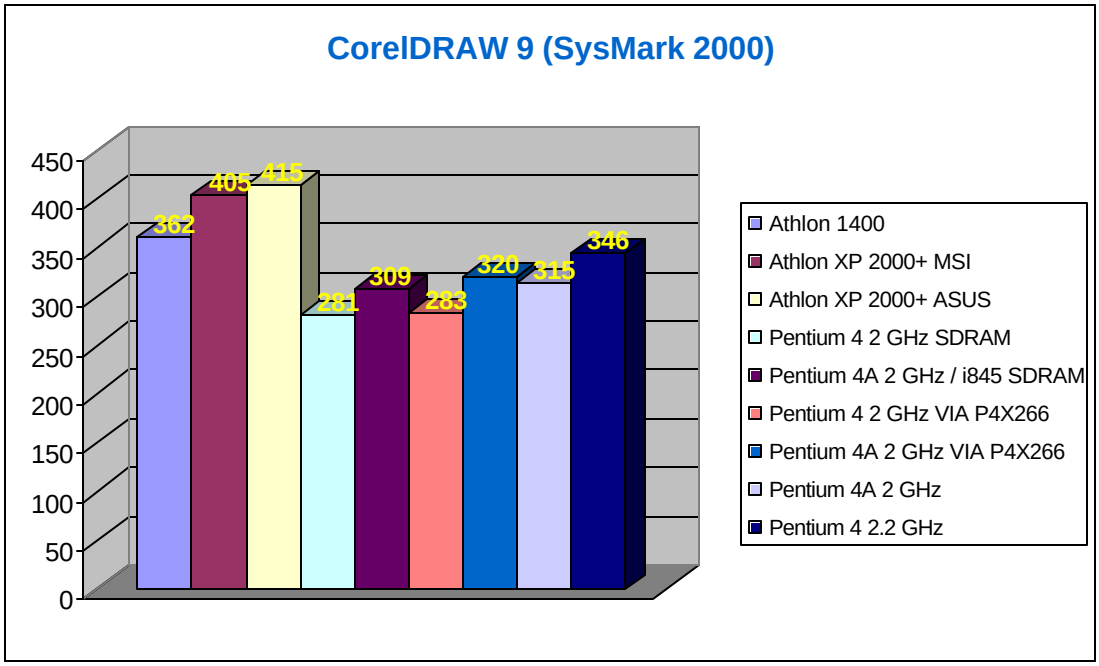


Bryce 4, a landscape rendering application, and Elastic Reality (3D modeling) show that older 3D software depends most on raw FPU performance. The Athlon XP sweeps the floor with the competition, even against Intel's mighty 2.2 GHz Northwood Pentium 4. The developers of these low-end 3D applications will probably put less energy into SSE-2 optimizations than those of 3DSMAX and Lightwave, so it is not so likely that Intel will later claim the speed crown for this kind of software.

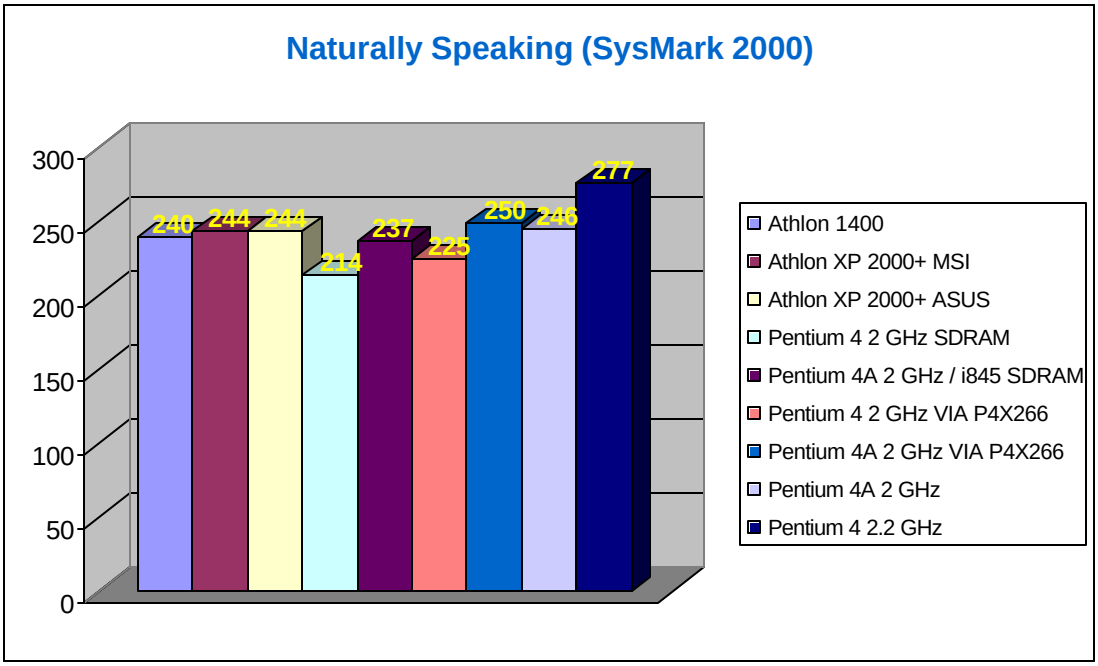
Still, you can observe that Bryce, which works with fairly complex models (high polygon count), gets a very decent boost +20% from the extra 256 KB of L2-cache. The i845 SDRAM platform is still bad news for the Pentium 4 in terms of performance, but this is one area where the Northwood's larger L2 cache can help. i845 SDRAM owners can still get good performance if they upgrade to a Northwood processor. A Northwood can still offer decent performance when paired with SDRAM, at least in this benchmark.

CorelDRAW

What about CorelDRAW, one of the most popular 2D graphics applications?



Again, a landslide victory for the Athlon XP.



Naturally speaking seems to be totally limited by memory bandwidth on the Athlon, as the 1667 MHz Athlon XP is hardly faster than the Athlon 1400. The Pentium 4 "Northwood" does not have that problem (with DDR) and continues to scale at higher clockspeeds.

WinStone 99

The final workstation benchmark that we ran was WinStone 99. Again, it is an old benchmark, which is a disadvantage for the Intel chips. Nevertheless, it is interesting to see which kind of applications benefit from the larger cache and several of these applications - Visual C++ for example - are not optimized for "Netburst" in the more recent versions.

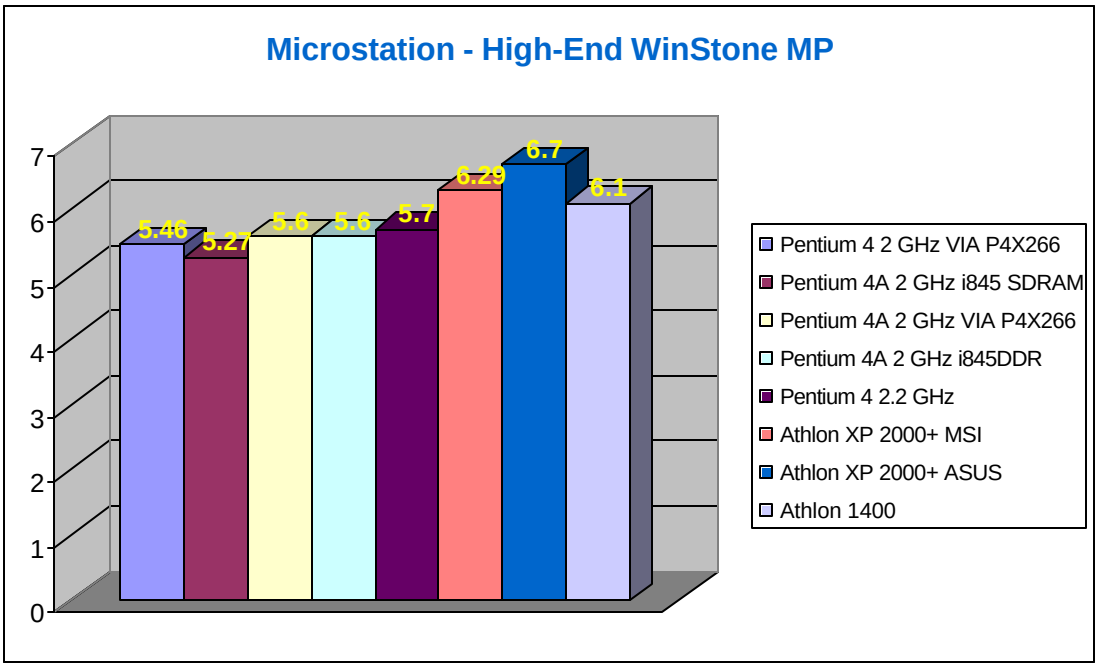
CPU - Configuration	AVSExpress 3.4	FrontPage 98	MicroStation SE	Sound Forge 4.0	Visual C++ 5.0
Pentium 4 2 GHz i845 SDRAM	10.8	5.35	6.24	4.6	6.26
Pentium 4 2 GHz VIA P4X266	11.8	5.4	6.42	4.57	6.35
Pentium 4 2A GHz i845 SDRAM	11.3	5.79	6.82	4.67	6.6
Pentium 4 2A GHz VIA P4X266	12.5	5.88	6.96	4.85	6.87
Pentium 4 2A GHz i845 DDR	12.8	5.98	6.92	4.8	6.91
Pentium 4 2.2 GHz	14	6.1	7.4	4.9	7.33
Athlon XP 2000+ MSI	12.9	6.27	7.88	5.7	8.19
Athlon XP 2000+ ASUS	13.3	6.35	8.4	6.95	9.05
Athlon 1400	11.9	6.13	7.71	6.74	8.56
SDRAM vs DDR	9%	1%	3%	0%	1%
Performance Increase Extra 256 KB L2-cache	6%	9%	8%	6%	8%
Performance Increase 10% Higher Clockspeed	9%	2%	7%	2%	6%
Athlon XP 2000+ vs P4 2.0 GHz	13%	18%	31%	52%	43%
Athlon XP 2000+ vs P4A 2.0 GHz	4%	6%	21%	45%	31%

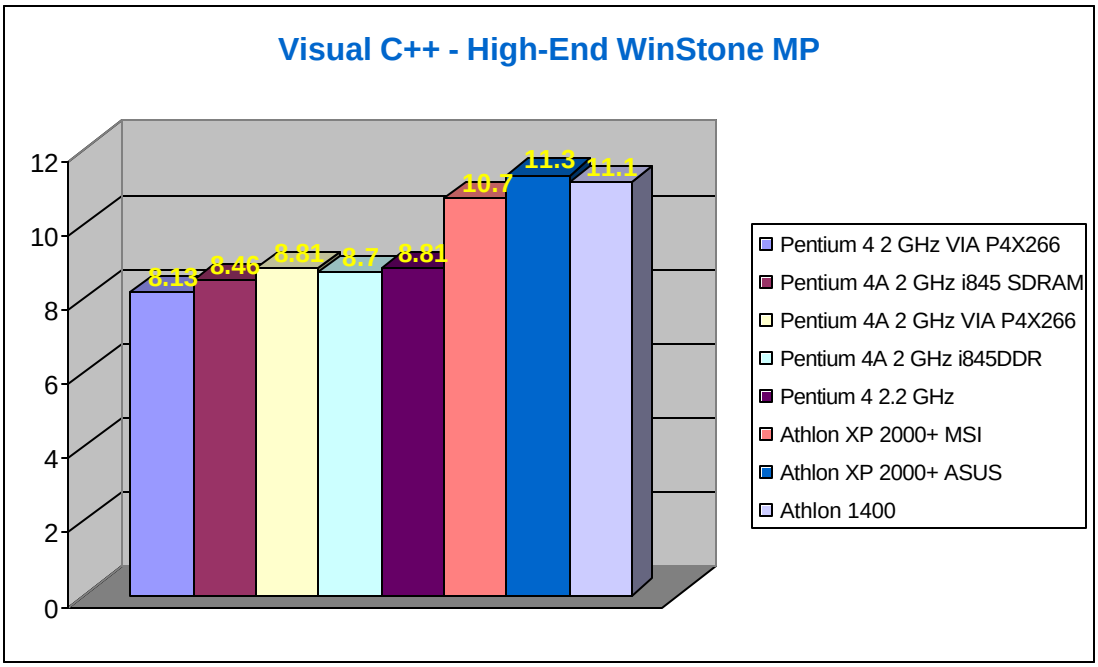
Judging by these results CAD engineers, software developers, and audiophiles are best served by the Athlon XP, which has no trouble beating the fastest Intel processor available today. Scientific visualization runs slightly better on the fastest clocked Pentium 4.

High-End WinStone MP

The High-End WinStone suite also includes several multi-threaded SMP Inspection benchmarks. While none of the systems featured in this review are multi-processor configurations, it is still interesting to see the results for these benchmarks as they can be compared to the results from our previous Workstation reviews, such as The Workstation Guide: Part 1:

http://www.aceshardware.com/read.jsp?id=45000255





Office Applications

Most of time, these applications are not limited by the CPU, but rather disk and memory performance. Only in some complex mail mergers, Excel macro's and SQL queries can somewhat increase the demand on the CPU.

CPU	Excel	Netscape	Paradox	Word 2000
Athlon 1.4 GHz	345	310	238	240
Athlon XP 2000+ MSI	365	326	245	238
Athlon XP 2000+ ASUS	351	328	241	240
Northwood 2 GHz (i845 SDRAM)	232	221	171	194
Pentium 4 2 GHz (P4X266)	239	240	184	213
Northwood 2 GHz (P4X266)	282	267	195	228
Northwood 2 GHz	286	287	145	221
Northwood 2.2 GHz	288	326	198	230

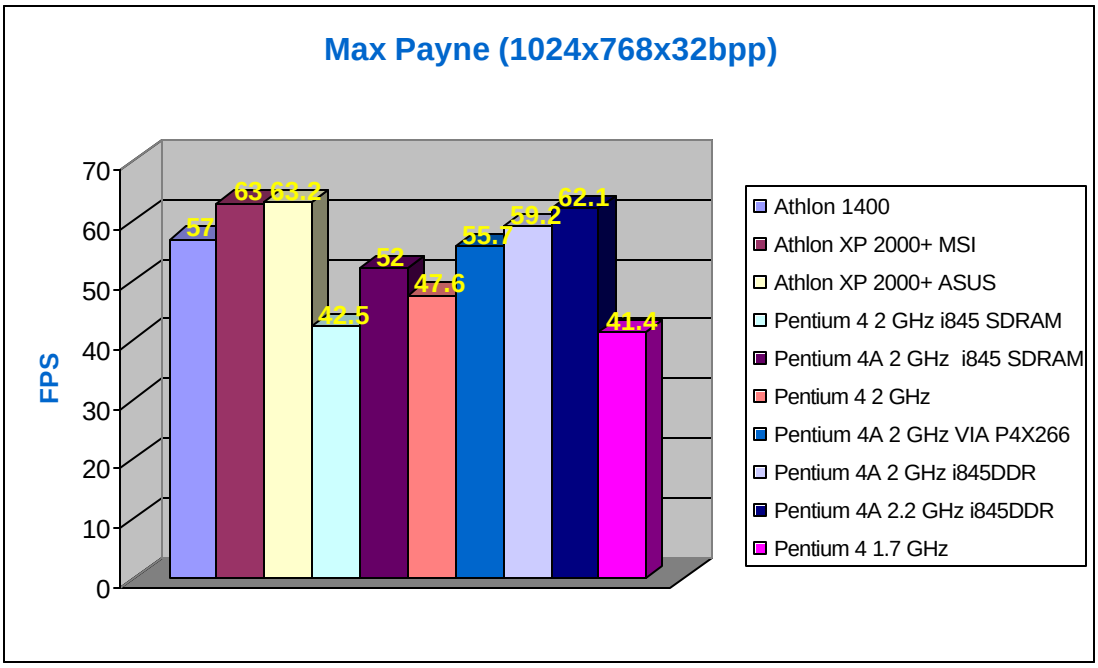
Not really a surprise, you cannot accelerate Word with more CPU power. A branch intensive application like Paradox clearly runs better on the Athlon. Enough work, though, let us have some fun.

Gaming

To benchmark Max Payne, the PCGH CPU Demo was used. You can download this benchmarking mod at the following URL:

http://www.3dcenter.de/artikel/maxpayne_benchmarking/index2_e.php3

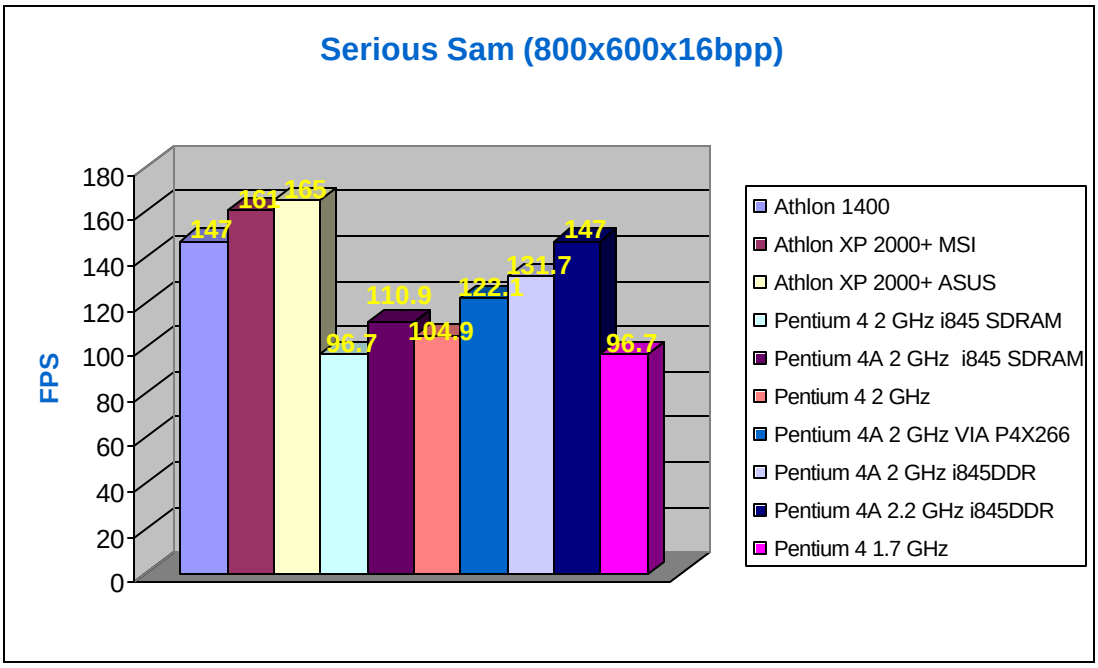
I set the resolution to 1024x768x32bpp and every slider set to maximum, with trilinear filtering and 16 bit textures enabled. As you know, Max Payne is one of the most CPU intensive games out there.



Frame rates in Max Payne improve by up to 17% with the help of Northwood's larger L2 cache, showing that the memory footprint of a modern game is quite big. The ASUS board with its i845 chipset is quite a bit faster than Tyan's P4X266 board. One of the reasons is that we had to leave the memory settings of the Tyan board on "auto" to insure stability. This resulted in disabling "4-bank memory interleaving." As we have pointed out before, memory interleaving can increase the performance of the memory subsystem by quite a few percentage points.

Serious Sam

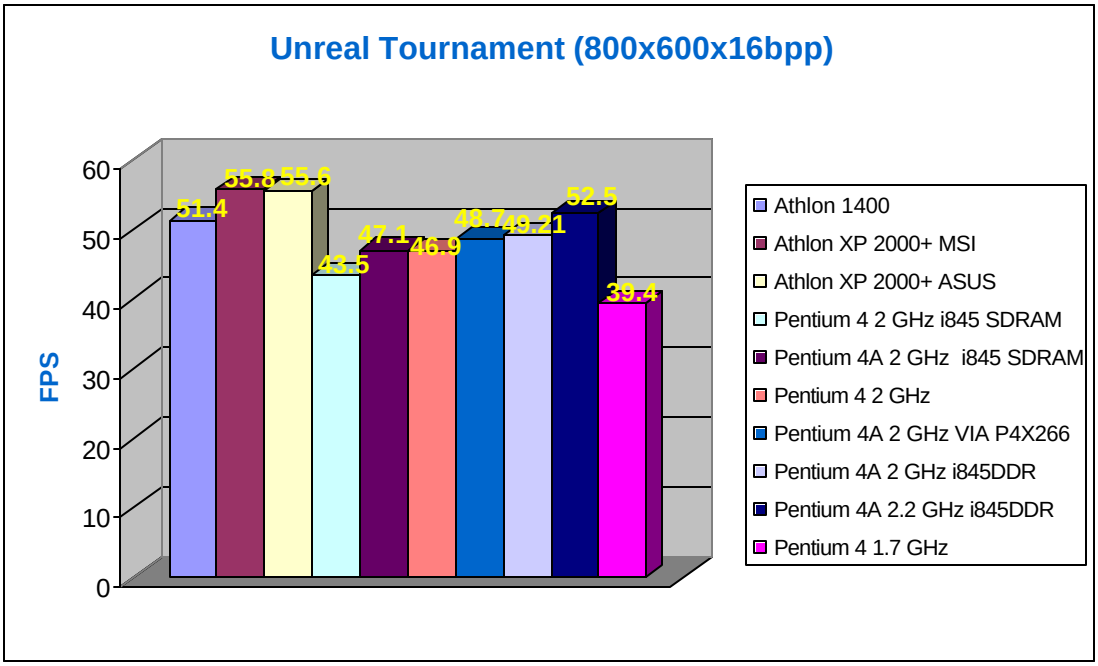
Serious Sam auto-detects the CPU speed and the type of video card, and then applies various preset settings based upon its findings to ensure the game runs fast and still looks reasonably well on almost every recent PC. So, we used the special BeyondNormal.INI file that Anthony "Reverend" Tan wrote. This configuration is actually based on what the game uses for its "Normal" setting. Anisotropic filtering is not used, texture compression is used. We tested with the built-in demo "Dunes" which displays a very open desert area.



Serious Sam is one of the many modern game engines, which requires quite a bit of memory bandwidth. The large 512 KB cache can make the Northwood perform even on an i845-SDRAM-based PC, but it cannot hide the fact that this kind of system leaves the Pentium 4 craving for more bandwidth. A Pentium 4 with DDR is faster than a Northwood with SDRAM. The impressive ASUS and MSI boards push the Athlon XP far beyond the Intel rivals.

Unreal Tournament

We also tested Unreal Tournament, as it is one of those popular online / LAN Party games. I am sure you've seen enough Quake 3 benchmarks on the rest of the Internet, so we won't bother with that one.

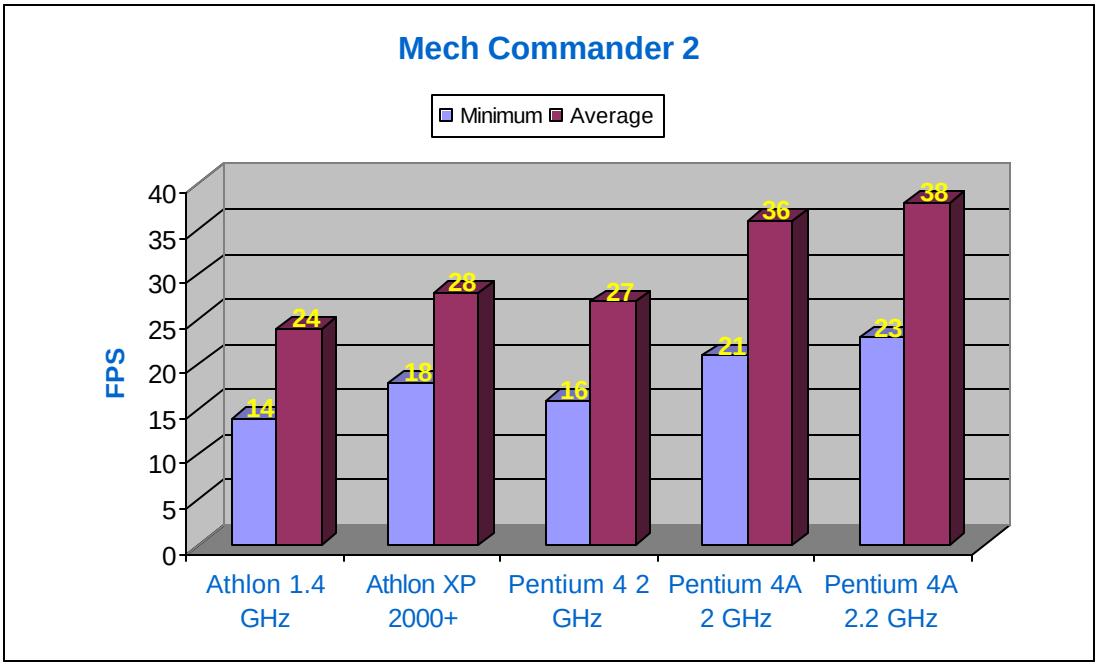


Unreal Tournament illustrates how older games were relatively satisfied with only 256 KB of L2-cache. Northwood is only 3% faster than the Willamette Pentium 4 at the same clockspeed. I keep repeating myself; the Athlon beats the competition without any trouble.

The Real CPU Hog

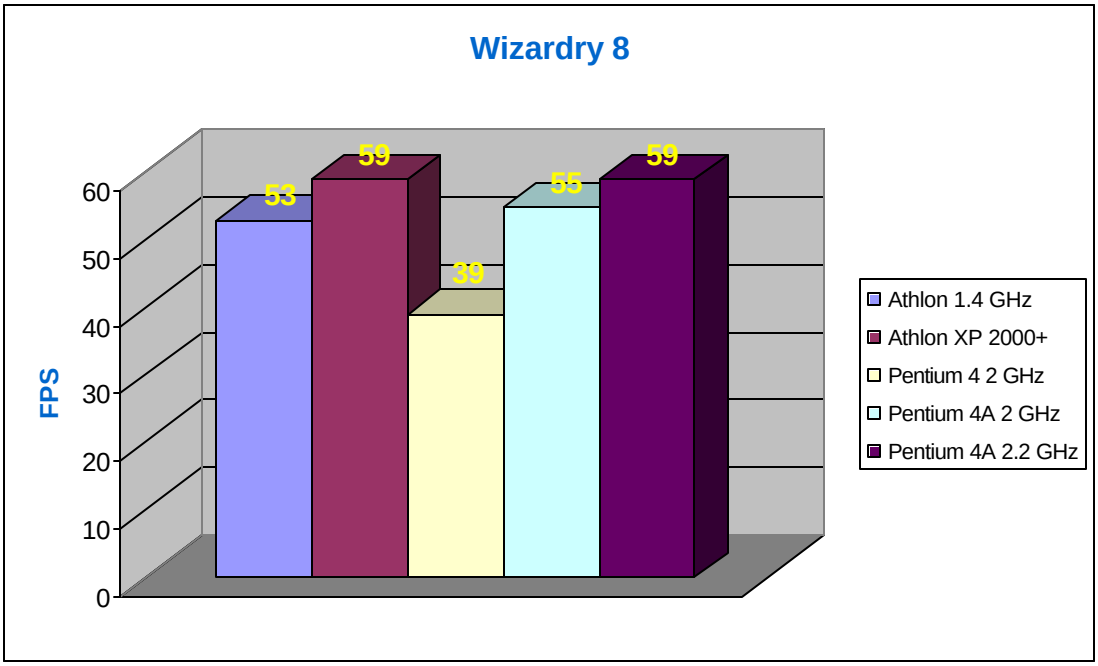
As most benchmarked games are first person shooters, I decided to make use of FRAPS once again. The latest version of FRAPS is now capable of measuring the average frame rate for certain amount of time, but take the results with a grain of salt as the error margin is around 5% instead of the typical 1% error margin we experience with "non-FRAPS" benchmarks. The following games were only tested on the ASUS boards.

Mech Commander 2, a real-time strategy game, is the first game we tested in this manner, and this game is a real CPU hog. At certain times, the game was almost unplayable on an 800 MHz Pentium III, with frame rates as low as 9 fps.



Wizardry 8

Mech Commander 2 feels more comfortable with the large 512 KB L2 cache of the Northwood, and finally Intel's flagship can beat the fastest chip out of Dresden. Our final game is Wizardry 8, one of the latest RPG games. It is quite blocky, but features good sound (we used DirectSound 7) and beautiful reflections.



Wizardry 8 confirms what most benchmarks have been pointing out. Northwood closes the gap with the superb Athlon XP somewhat, but the AMD chip continues to surprise us by keeping up with the higher-clocked 2.2 GHz Intel chip.

The Future of the AMD vs Intel Battle

Looking at the pure numbers you might think that Intel Northwood chip is a bit of a failure, as even at 2.2 GHz it is hardly faster than the Athlon XP, and quite a few times, in fact, it is slower. It must be said, however, that the Northwood chip overclocks very well. The 2.0 GHz Northwood was able to achieve 2.3 GHz at 1.6V (115 MHz FSB), and it was able to run at 2.4 GHz at 1.7V (120 MHz FSB). The Northwood 2.2 GHz was able to reach 2.53 GHz (115 MHz FSB) at 1.65v and 2.574 GHz at 1.7V. I am sure you will read of much more spectacular overclocks on the Internet, but note that 1.7V is already to much for a 0.13-micron chip.

In fact, did you know that these kinds of overclocks (voltage >110%, clockspeed >115%) are used to evaluate the durability of a CPU? CPUs that can last 10 years or more at their normal voltage should be able to live a few weeks at these kinds of voltages. Don't use such high voltages (>1.65v) when overclocking because the finer the process, the fewer the number of atoms are used to make a transistor and the more likely it becomes that electromigration damages your chip.

The new "AGOGA" Athlon XP 2000+ was not such a good overclocker, on the other hand. Overclocking to 1775 MHz, or a 6% overclock, was the best we could do. At that speed, the chip was able to run the WME encoding benchmark in 15 seconds and the Serious Sam benchmark at 173 FPS! The Northwood 2.4 GHz finished the WME encode in 10.8 seconds, but still wasn't able to beat the Serious Sam scores of the Athlon XP 2000+, as it delivered only 158.4 FPS.

It is clear, however, that the new Intel chip scales very well. Our best industry sources close to Intel report that we will see a 2.26 GHz and a 2.4 GHz Pentium 4 with a 533 MHz FSB in the March - April timeframe. In the June - July timeframe, the Pentium 4 should be reaching 2.53 GHz.

According to our industry sources, AMD will introduce the 1800 MHz 0.13-micron Thoroughbred, otherwise known as the Athlon XP 2200+, sometime in March or April. This new Athlon will have a 256 KB exclusive L2-cache and run with a 266 MHz FSB just like the Athlon XP we know today. Many Socket A chipsets will arrive in that same timeframe, including the VIA KT333, SIS745, ATI A4-K. These chipsets will have support for PC2700 DDR but feature a 266 MHz FSB. There is also a VIA KT333A coming but the only real improvement seems to be in VIA's V-link. The connection between VIA's south and northbridge is twice as fast: 533 MB/s versus 266 MB/s.

We estimate that such async memory and FSB configuration will not perform much better than the chipsets we know today, excluding a few AGP-intensive applications (scientific visualization, some MCAD applications). Most of our benchmarks show that it is better for the FSB to be a bit faster. However, this FSB status quo has some merits too: it should make it easier to upgrade the Socket A boards of today to faster Athlon XP processors.

Although it is likely that Intel's flagship processors will continue to scale higher in clockspeed than AMD's best, AMD has still one trump card left: die size. Thoroughbred measures only 80 mm², while Northwood is still 146 mm² in size (according to Intel), 18 mm² larger than the 0.18-micron Athlon XP (128 mm²). This will make the new Athlon XP very inexpensive to produce, and the solid performance this 384 KB cache, triple FPU chip has been churning out will make it very fierce competitor for Northwood, even if the latter achieves high clockspeeds at a rapid pace.

Intel has also a secret weapon hidden inside Northwood: Hyperthreading silicon is present, but disabled. It is not clear whether this silicon is ready for prime time, but it is clear that this secret weapon can only be used in multi-threaded applications, which are not ubiquitous in the desktop market. Proper OS support must also be available.

Conclusion

Intel's Northwood packs some heavy punch in some of the Workstation applications. The extra 256 KB cache turns the anemic Pentium 4 into a bruiser of a workstation chip. Prestonia, Intel's workstation/server chip will compete much better with the Athlon MP than the Foster Xeon did. If AMD wants to beat Intel in this market like they have done before, the Athlon MP will need more cache.

The following Northwood prices are courtesy of The Inquirer:

CPU	Price (ea @1KU)
Intel Pentium 4 2.2 GHz	$562
Intel Pentium 4 2.0A GHz	$364
Intel Pentium 4 2.0 GHz	$342
Intel Pentium 4 1.9 GHz	$241
Intel Pentium 4 1.8 GHz	$193
Intel Pentium 4 1.7 GHz	$163
Intel Pentium 4 1.6 GHz	$133
AMD Athlon XP 2000+ (1.67 GHz)	$339
AMD Athlon XP 1900+ (1.60 GHz)	$269
AMD Athlon XP 1800+ (1.53 GHz)	$223
AMD Athlon XP 1700+ (1.47 GHz)	$190
AMD Athlon XP 1600+ (1.40 GHz)	$160

* Pentium 4 prices indicated in red do not take effect until January 27, 2002

In the desktop market, it is a different game. Northwood features better gaming performance than the Willamette Pentium 4, but fails to leave the fastest Athlon XP behind. Knowing that a 2.2 GHz Pentium 4 costs $562 and that an Athlon XP 2000+ (on average slightly faster) comes with a $339 pricetag, it is crystal clear that the Athlon is still the king in the price/performance department. Even the Pentium 4 2.0A GHz costs slightly more, about $364. Intel made a nice comeback, but more SSE-2 optimized software and higher clockspeeds will be needed to beat their crafty competitor...