Granite Bay: Memory Technology Shootout

By Johan De Gelas – December 2002

Dual-Channel DDR SDRAM Arrives for the Pentium 4

DDR400/333/266, Dual DDR, RDRAM 16 bit and 32 bit, SDRAM... almost every memory technology on the market is available for the Pentium 4 platform. One of **our previous technical articles** discussed the advantages and disadvantages of the different architectures of Rambus and SDRAM based memory technology such as DDR and DDR-II. In this article, we will investigate how the different memory technologies and their supporting chipsets compare on the test bench.

The following motherboards were tested:

- The ASUS P4T533 features the i850E chipset and 32 bit RDRAM
- The ASUS P4T533-C comes with the same chipset but uses two channels of 16 bit RIMMs
- The MSI 648 Max comes with SIS 648 chipset which unofficially supports DDR400
- The MSI i845PE comes with Intel's newest i845 chipset, which officially support DDR333
- The Tyan Trinity 7205 and MSI GNB Max feature the Dual DDR266 Granite Bay chipset

We are well aware that there have already many tests with Pentium 4 chipsets, Granite Bay included. So why bother to publish another on Ace's Hardware?

The focus of this article is on the memory technology supported by these chipsets. This article will offer you a insight in how the different memory technologies compare in a wide variety of applications. We'll investigate in depth what the advantages and disadvantages are of each memory technology and try to find out what are the reasons behind this. Whether you are a die-hard gamer, a workstation user or a scientific researcher, you should be able to make an informed memory decision after reading this article. There is more of course... In good old Ace's tradition we try to find the technical and architectural particularities that can explain our benchmark results.

Before we take a look at the benchmarks, let us talk about DDR400 and 32 bit RDRAM, two relatively new DRAM variants.

DDR400

As we have indicated in our previous articles, with a cycle time of 5ns, DDR400 is pushing the limits of what DDR-I can do. Many memory manufactures do not have high hopes for DDR400. Samsung Electronics Co. Ltd. and **Micron Technology Inc.**, the first- and second largest memory suppliers, respectively, however broke away from the pack and announced DDR400 samples a few months ago.

A big disadvantage of DDR400 is that motherboard and memory manufacturers only guarantee stability if you use one double sided DIMM. This will come to no surprise to our readers, as our previous article pointed out that the **heavily loaded address bus** is one of the biggest problems of the DDR SDRAM architecture.

In practice, module manufacturers are limited to 16 (18 with ECC) chips. Right now, most of the biggest memory chips (512 Mbit) are not capable of reaching 200 MHz DDR. Almost all DDR400 use less expensive 256Mbit chips, 512 Mbit, which run at DDR400, are very expensive. A 512 Mbit IC typically costs about 5 times more than a 256 Mbit one, so a module of 512 MB will cost 2.5 times more if you equip it with 512 Mbit chips.

The result is that you are limited to 16 times 256 mbit or 512 MB. This makes DDR400 only suitable for the high-end desktop. Workstations and especially servers need much more memory. Also note that many DDR400 come with higher CAS, RAS to CAS or precharge latencies.

Corsair DDR 400...CAS 2!

Corsair seems to be the exception of the rule. While Micron and Samsung are targeting a more conservative DDR400 3-4-4, Corsair is happily shipping DDR400 2-3-3. A CAS latency of 2 at 200 MHz is quite impressive. It is almost like the limitations of DDR-I do not apply to Corsair's products. A few weeks ago, Corsair has started shipping PC3500.

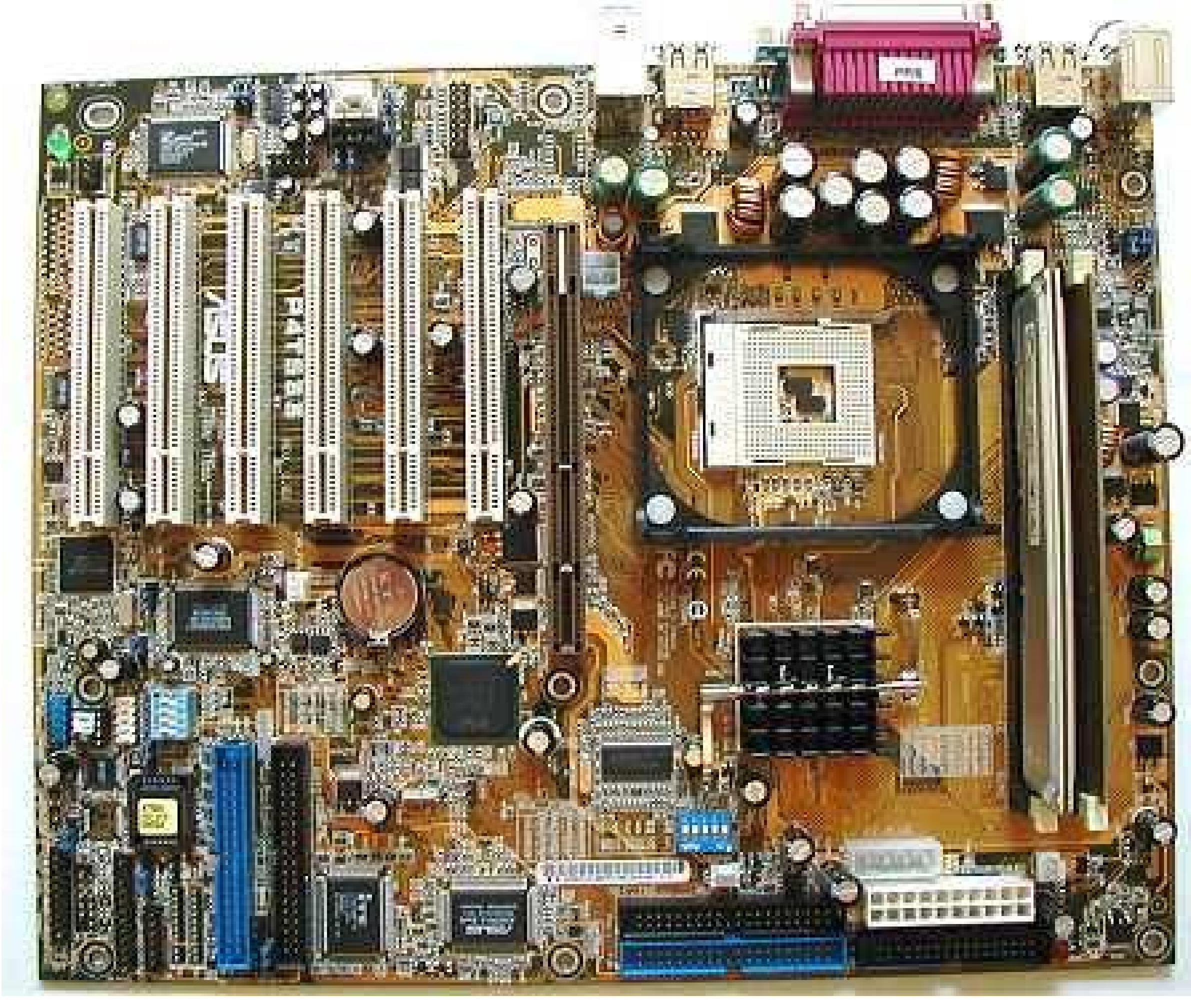
This doesn't mean that DDR400 will become a mass market product soon however. Both SIS and VIA have decided that their DDR400 capable chipset (SIS648, KT400 and P4X400) does not officially support DDR400. The reason is motherboards which support DDR400 very strict signaling requirements and tight margins are quite expensive to produce. At the same time many DDR400 products out there, are not even worth calling DDR400 or PC3200. Corsair is, most likely the exception that confirms the rule.

Corsair invests in a very meticulous qualification process. They buy the fastest revisions of certain manufactures. And it must be said that Corsair uses high quality components and a well designed PCB. This results of course in a more expensive modules, which is less attractive for a big OEM, but the more for a die hard overclocker.

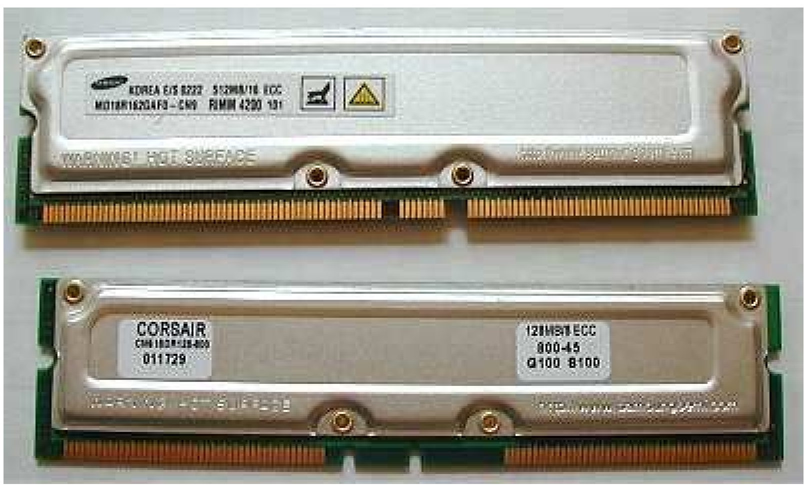
The XMS3000 and XMS3200 we tested are based on 256Mbit Winbond rev B 6ns IC's. The XMS3200 use the best 6ns chips. This might be a bit weird, considering that there are many 5ns IC out there. But most of the current 5ns chips only work at 3-4-4, which is worse than what the 6ns Winbond chips can do. Only the newest Winbond 5ns chips seems to be able to better, and these are the chips that power Corsair's XMS3500

32-bit RDRAM and the ASUS P4T533

32 bit RDRAM is not (yet?) widely available. And the first board that supports RDRAM 32 bit, the ASUS P4T533, was at first plagued with power circuitry problems. With 2.8 GHz or faster Pentium 4, we experienced many lock ups when playing games and we tested with five (!) different boards. We have described the problem in our Pentium 4 3.06 GHz review. Avoid these revision 1.02 and early 1.03 boards at all costs.



Luckily, the RDRAM channels were not the problem. When we lowered the clock multiplier to 16, the system was able to run rock stable at 150 MHz Quad (600 MHz) and even 159 MHz Quad was able to boot in Windows.



ASUS has corrected the problem now. You can distinguish the "good" boards from the "ones with power circuitry noise" in two ways. The nicely behaving board had a fan on the northbridge heatsink and the box was marked with "support HT processor".

Granite Bay

The newest addition to the Pentium 4 chipset lines has been Granite Bay. Granite Bay is not your average Pentium 4 chipset, using two channels of DDR266 can provide the 4.2 GB/s peak bandwidth that the 533 MHz FSB of the Pentium 4 needs. The two channels do not work independently as is the case with the Nforce. No, the two 64 bit channels are fused together to one big 128-bit memory channel by the chipset.

But there is more.

Chipset feature	Intel Granite Bay	Intel i845PE	SIS 648	Intel i845E	Intel i850E
Max. Memory bandwidth	**4.2 GB/s**	2.7 GB/s	2.7 GB/s*	2.1 GB/s	4.2 GB/s
RAM supported	**DDR266 DDR200**	DDR333 DDR266 DDR200	DDR400* DDR333 DDR266 DDR200	DDR266 DDR200	32 bit/16 bit PC1066/PC800 RDRAM **
Max. RAM capacity (Theory	**4 GB**	2 GB	3 GB	2 GB	2 GB
Max. RAM capacity (In Practice)	**4 GB**	2 GB	2 GB(*)	2 GB	1 GB(**)
Max bandwidth	**4.2**	2.7	2.7 (3.2)	2.1	4.2
USB Controllers/USB ports/Firewire	**3/6/0**	3/6/0	3/6/2	3/6/0	2/4/0
AGP	**4x 8x**	4x	8x	4x	4x
North/Southbridge connection	**266 MB/s**	266 MB/s	1 GB/s	266 MB/s	266 MB/s

* not officially supported
** Chipset supports all these RDRAM, but not on the same board
(*)3 GB is possible in theory but not at 333 MHz
(**) 1 GB RDRAM is not available

First of all, Granite Bay, being targeted toward the server and workstation market, supports up to 4 GB unbuffered memory. No P4 chipset was able to do this before. Secondly, Granite Bay only supports a memory bus, which works synchronously with the Front Side Bus. In other words, if you use a Pentium 4 with a 400 MHz FSB, the DDR RAM will be running at 200 MHz and vice versa.

Thirdly, Granite Bay is quite expensive, costing up to twice as much as the i845PE chipset. And the Granite Bay boards are 6 layer boards instead of 4 layers. As a result, Granite Bay motherboards sell for a considerable premium over motherboards based on the 845PE chipset.

We took a look at Pricewatch and noted the prices of the different ASUS boards. We chose ASUS because both 32 bit RDRAM i850E, 16 bit RDRAM i850E, i845PE and Granite Boards are available from ASUS.

Motherboard	Price (Pricewatch 12/12/2002)
ASUS P4T-533 (32 bit RDRAM)	$165
ASUS P4T-533-C (16 bit RDRAM)	$155
ASUS P4G8X (Granite Bay)	$230
ASUS P4PE (i845 PE)	$130

The Granite Bay board is considerably more expensive than the other Pentium 4 boards. Of course the cost of the RAM is also important. As you cannot compare the quality of brand memory with generic, we looked up the prices of Samsung based DIMMs and RIMMs.

Memory	PC800 RDRAM (400 MHz DDR)	PC1066 RDRAM (533 MHz DDR)	PC1066 RDRAM -32 bit (533 MHz DDR)	DDR PC2700 (166 MHz)	DDR PC2100 (200 MHz)
256 MB	$70	$100	$110	$70	$61
512 MB	$150	$250	$350	$130	$110

RDRAM is competitively priced at 256 MB and smaller capacities, but DDR is definitely cheaper when you like to use 512 MB and bigger DIMMs. This makes RDRAM less attractive for workstations and servers.

Tyan Trinity 7205

Tyan has solid reputation when it comes to workstation and server boards. And let there be no doubt, although Tyan's Trinity line is normally aimed at the high-end desktop market, this is really is a workstation board.

AGP Pro50 8x, (Intel) Gigabit LAN and special power connectors for power supplies that you only find in workstations are some of the features that confirm its true destiny. At the same time, this is probably also the reason why Tyan keeps it rather simple compared to the extremely feature rich boards of Gigabyte and MSI. You won't find firewire, extra USB 2.0 brackets etc. on this board. This makes the Tyan one of the cheapest Granite Bay board available. Tyan estimates the street price at around $230, and in Europe you should find the board for 270 Euro and less. You will probably find even lower prices online.

The board behaved rock solid in all benchmarks, and performed within the error of margin of the two other boards. Nevertheless, we would have like to see a few DRAM tweaking options, as some workstation users (a minority) might invest in speedy DDR SDRAM that can work at low latencies.

Nevertheless, this no-nonsense board is very attractive for those who don't want to pay for features they are not going to use anyway. Another positive point is the sturdy heatsink without fan. This way the heatsink won't collect dust so fast in dusty environments (like most student rooms...).

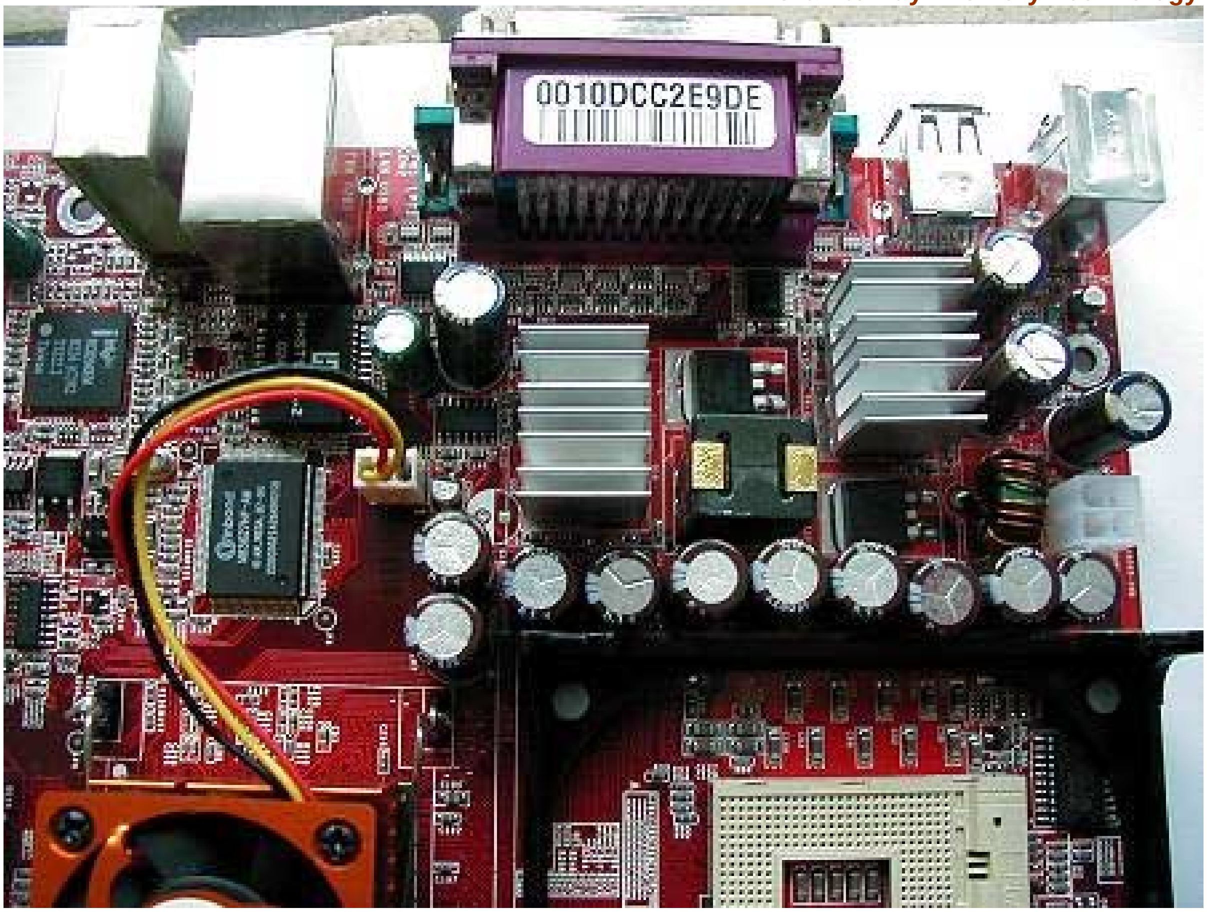
Anandtech indicated that Tyan US offers excellent support and a clear RMA procedure. We talked to a few European distributors and they all confirmed that Tyan is one of the few manufacturers that is fast and correct when it comes to RMA.

MSI GNB MAX FISR

MSI has a different philosophy: the more features, the better. The VIA VT6306 controller can drive 3 firewire (IEEE 1394) devices and Gigabit Ethernet is available courtesy of the Intel RC82540EM chip. One of the big advantages of buying an MSI board is that you get all the necessary brackets, which is very convenient. A Firewire bracket, a D-bracket with bluetooth support, two extra USB ports and Diagnostic LEDs and a S-bracket (Audio, S/PDIF) is included in the box.

Although the board is equipped with the Promise PDC20376 RAID controller, RAID 0 or 1 will not be very fast on this board. The controller has only one IDE port, so yo attach two IDE hard drives or 2 S-ATA drives, but not both at the same time. For RAID 0 harddisk setup however, it is best to put each harddisk on a different IDE port/channel to optimize performance.

The NVRAM setup (also incorrectly called "CMOS setup") allows you to adjust CAS, RAS to CAS, RAS precharge and Active to Precharge Delay. This allowed us to get slightly better performance out of our Corsair DIMMs, something which was not possible with Tyan's board.

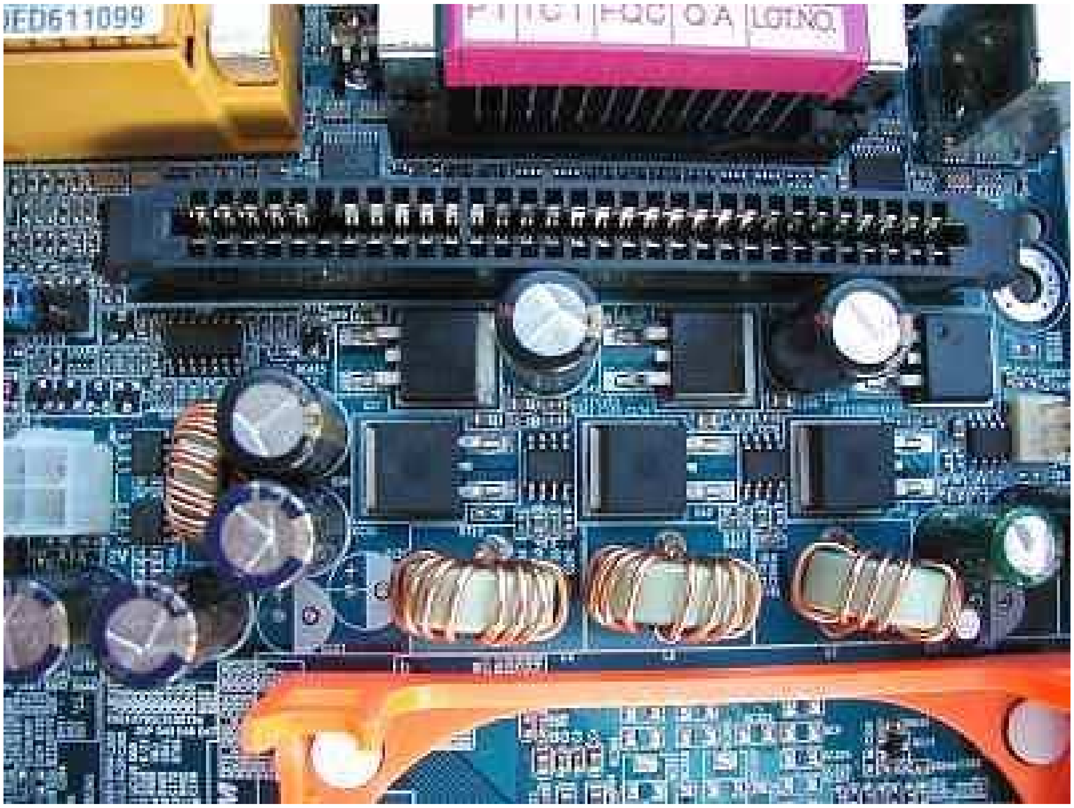


Contrary to other MSI boards, no real overclocking possibilities are available. You can overclock by using MSI's "Fuzzy logic" tool, but AGP and PCI frequencies are not locked. The power circuitry, which is decent, but not superb, wouldn't allow it anyway. According to the hardware monitor, the core voltage fluctuates between 1.49V and 1.5V when we installed a 2.8 GHz CPU, which is 0.03V too little (we used a 400Watt power supply of Antec). This is not really a problem, as the board had not trouble with running a 3.06 GHz Pentium 4, but we doubt that the power circuitry has much headroom. We could only overclock to a 140-145 MHz FSB with an unlocked P4 2.8 GHz.

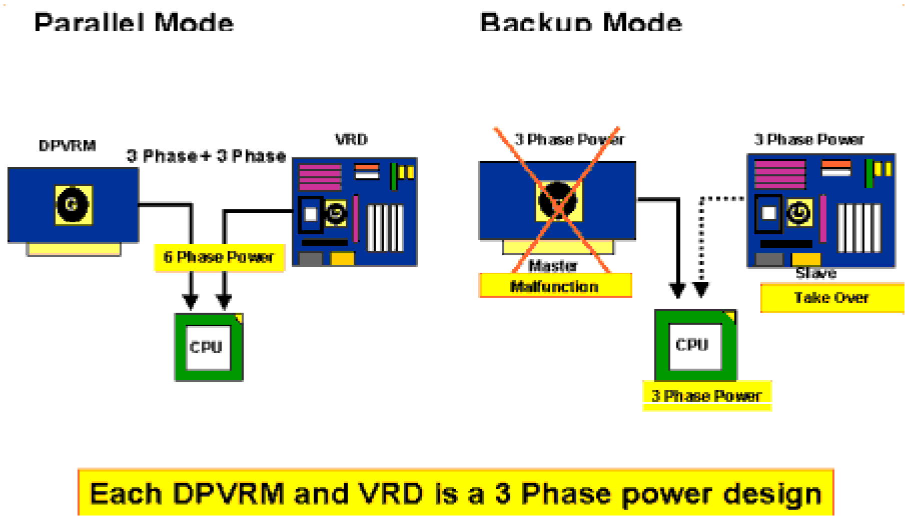
The streetprice of the MSI board is around 330 Euro in Europe (US price around $240-260).

Gigabyte GA-8INXP

Gigabyte's board seems to be squarely targeted at the hardware enthusiast. It does not feature a AGP Pro slot nor firewire, but it offers everything an overclocker can ask for. While MSI and ASUS seem a bit conservative on the power circuitry side, Gigabyte offers a dual Tri phase power circuitry. A separate add-in card with a 3 phase power circuitry can be plugged in a special socket in the motherboard.



Gigabyte's "Dual Power Voltage Regulator Module" (DPVRM) can work in two modes: parallel and backup mode.

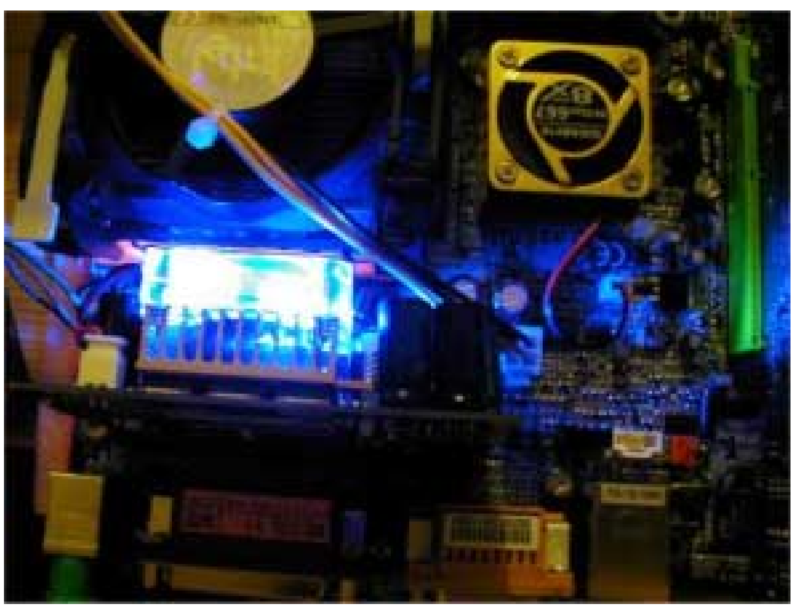


In parallel mode (default) the two 3 phase power regulators should, according to Gigabyte be able to support CPU's up to 10 GHz (up to 150 A!). If one of the VRM fails, the other VRM takes automatically over (backup mode). Gigabyte claims that in parallel mode, the VRMs warm up to 76°C (70 A current) while a single VRM gets 81°C hot.

We were able to run our unlocked 2.8 GHz at an impressive 168 MHz (Quad) FSB, and were even able to bootup at 180 MHz Quad. We are still investigating the stability at 168 MHz Quad or 672 MHz FSB, but in our humble opinion this board is overclocker's paradise...

More overclocking goodies:

- CPU core up to 1.75V (in 0.025V increments)
- DRAM Voltages Supported up to 2.8V (in 0.1V increments, + 0.1,0.2,0.3V)
- CAS, Ras to CAS, RAS Precharge, Active to Precharge Delay and Refresh mode are tweakable (You have to Press CTRL+F1 to access Advanced chipset features)
- The Voltage Regulator Module radiates a very cool "blue curacao" light (ideal for Case modding...)



The board also sends out a warning light if you push a AGP 2x card in the AGP slot. Normally this isn't possible as only AGP 4x have the right notches, but some AGP 2x cards that draw 3.3V (instead of AGP 4x's 1.5V) have these notches too. If you plug in one of these, you will damage the AGP slot and the motherboards. Older TNT2, SIS315 and Savage3D cards are the most likely culprits. The Gigabyte board has special circuitry to prevent such damage and a LED warns that such a "fake AGP4x" card has been inserted.

The board also features two RAID controllers: one Silicon Image's 3112A Serial ATA controller which can support two Serial ATA devices in RAID 0 or RAID 1 and one Promise PDC20276 RAID controller which supports the "old" parallel ATA cabled disks. This means you can have up to 10 (!) harddisk with these board! Better get a spacy case...

To ice the cake, Gigabyte threw in the same Intel Gigabit chip as Tyan and MSI. The Gigabyte board costs about 340 Euro in Europe and probably around $250-$260 in the US. These are "street" prices, only to be used to compare with the other prices mentioned in this review. You'll find lower prices online of course. Nevertheless, it is clear that the Granite Bay boards are quite expensive. But if you want the fastest Pentium 4 board with a six phase voltage regulator and so many features, you probably forgive the Gigabyte's rather steep price.

The excellent overclocking possibilities and the "Titan667" mark on the Northbridge fan seems to indicate that Gigabyte designed this board for a 667 MHz FSB Pentium 4. We'll report back with more overclocking information and benchmarks.

Benchmarked Configurations

All systems were tested with NVIDIA's Detonator 40.91 drivers. The desktop was set at a resolution of 1024x768x32bpp with an 85 Hz refresh rate. V-sync was off at all times.

We used **Corsair's XMS 3200 CAS 2 DDR** (DDR400) for maximum overclocking possibilities and stability.

Pentium 4 2.8 GHz

- DDR platform:
- Gigabyte GA-8INXP
- MSI 845PE MAX2 (i845PE chipset) BIOS version 1.4
- MSI GNB (E7205) BIOS version 2.0
- Tyan Trinity i7205 (E7205
- Gigabyte GA-8INXP
- 512 MB Corsair PC3200 XMS (DDR-SDRAM) running at 333 MHz CAS 2 (2-3-3-6)
- RDRAM platform:
- ASUS P4T533-C
- ASUS P4T533 BIOS Version 1.005
- 512 MB Samsung RIMM4200 - 32 (at 1066 MHz)

Shared Components

- Maxtor 80 GB DiamondMax 740X (7200 rpm, ATA-100/133)
- ASUS Geforce Ti4400 128 MB
- AT 2700 10/100 Mbit NIC (If no NIC was integrated on the board)
- Sound Blaster Live!

Software

- Intel chipset inf update 4.09.1012
- SIS 1.12 AGP driver
- Windows XP Service Pack 1
- DirectX 8.1

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

- Saskia Verhappen and Angelique Berden (**MSI**)
- Sandy Tsau (**Tyan**)
- Brenda Chen and Leo Chu (**Gigabyte**)
- Robert Pearce (**Corsair**)
- Kristof Semhke and George Alfs (**Intel**)
- Will Teng and Carol Chang (**ASUS**)
- Sharon Tan (**BAS computers Netherlands**)

Let us see some benchmarks!

Benchmarks

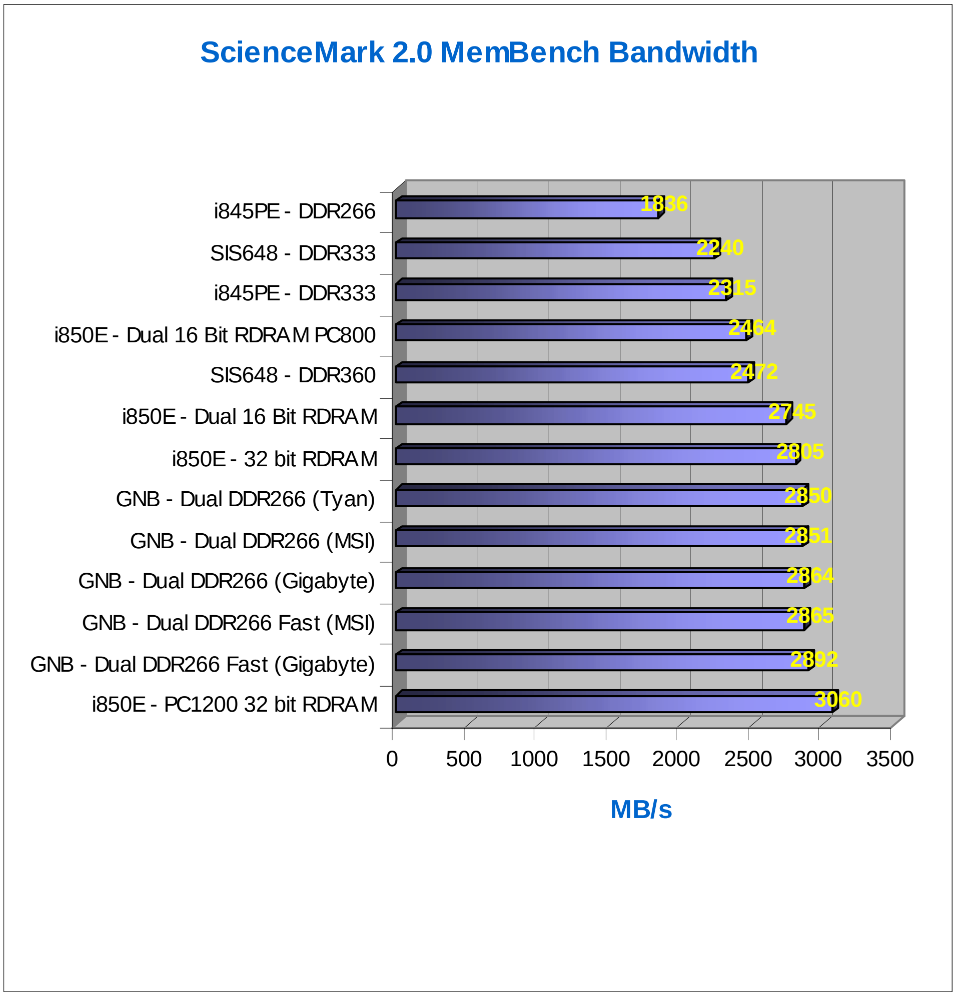
We decided to test Granite Bay with both 2-2-2-6 timings as 2-3-3-6 timings. The Granite Bay benchmark with 2-2-2-6 timing is the "Dual DDR266 Fast" in the benchmark tables. In my humble opinion, 2-3-3-6 benchmarks are the closest to the real world. First of all, even the Corsair XMS 3200, which can run 2-3-3-6 at 400 MHz (200 MHz DDR) were automatically set (SPD) to 2-3-3-6. Secondly, if you use 4 DIMMs, all Granite Bay boards refuse to work well with 2-2-2-6, even with the speediest Corsair DDR400 DIMMs. Thirdly, There still a lot of DDR333 CAS 2.5-3-3 on the market, which are not able to run at DDR266 2-2-2.

This means that only hardware freaks will force 2-2-2-6 with the best DDR DIMMs, the rest of the world will use 2-3-3-6 and "normal" DDR266 DIMMs.

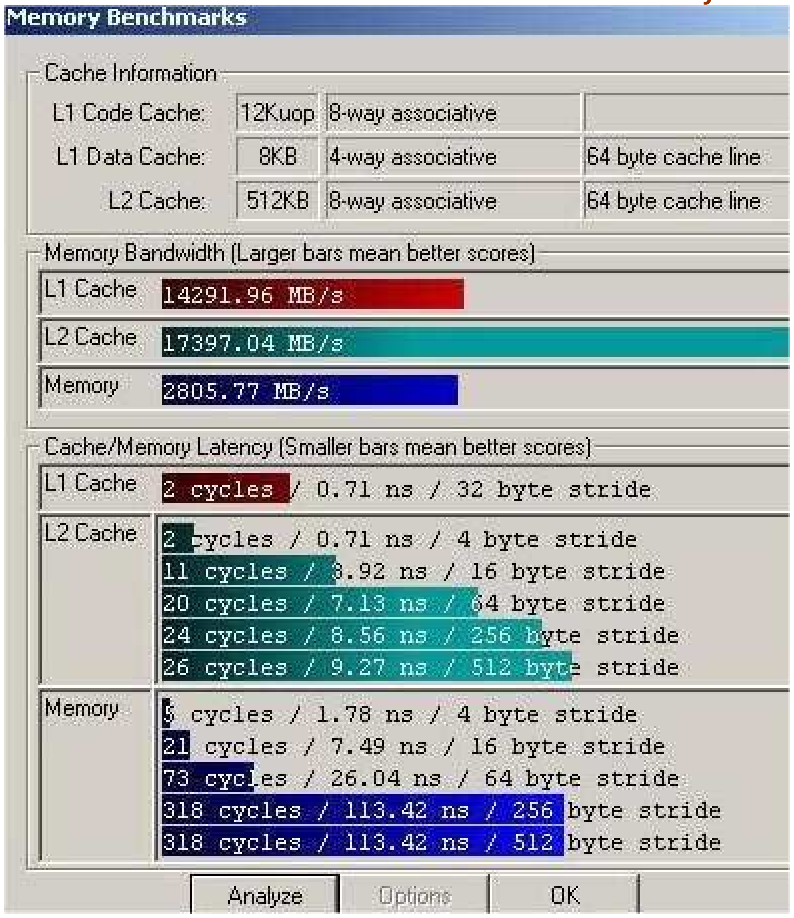
The biggest advantage of the Granite Bay should be a much lower latency, while offering the same bandwidth that the fastest RDRAM systems can offer today. Let us what **Sciencemark 2.0** (Beta 11-07-2002) can tell us.

Type of DRAM	Clockspeed of DRAM	Latency 32 byte stride	Latency 64 byte stride	Latency 128 byte stride	Latency 256 byte stride
DDR266	133 MHz DDR	48	92	266	274
DDR333	166 MHz DDR	40	78	252	257
DDR360	180 MHz DDR	38	75	286	292
Dual DDR266	133 MHz DDR	34	62	238	243
PC800 RDRAM	400 MHz DDR	45	85	394	394
PC1066 RDRAM	533 MHz DDR	42	75	320	321
PC1066 RDRAM 32 bit	533 MHz DDR	41	73	318	319
PC1200 RDRAM 32 bit	600 MHz DDR	37	68	289	290

A Dual Channel DDR offers only a 20% better latency than DDR333. When a cache miss occurs, the chipset has to sent the right addresses to the memory controller. With DDR266 memory, this happens at 133 MHz. DDR333 gets the addresses with 166 MHz. Once the data has been found, dual DDR266 is able to send back the replacement for the 64 byte cacheline twice as fast as DDR266 and about 60% faster than DDR333. So while sending back the data goes faster with a dual Channel, the addresses are received slower.



Interesting is that 32 bit RDRAM, which consists of two 16 bit channels on the RIMM, offers a little more bandwidth and slightly better latency than combining two channels of 16 bit RDRAM on a motherboard. Apparently, combing the two channels on a RIMM somewhat shortens the Rambus Transmission line and thus lowers the latency. This results in a small increase of the effective bandwidth.



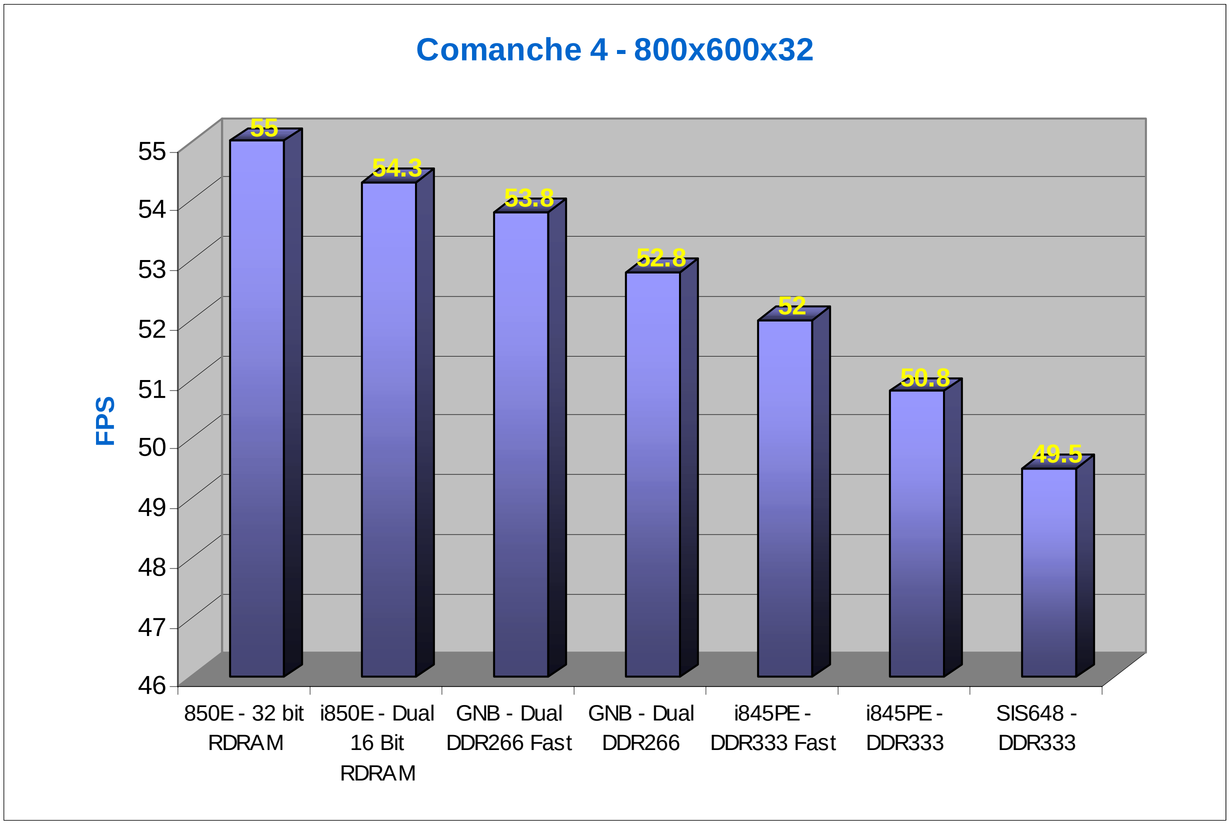
Granite Bay, which has the same theoretical peak bandwidth as the i850E with PC1066, is able to edge the latter out with a few MB/s more. Much lower latency, and slight more bandwidth, that is very promising…

Next up, some real world benchmarks. After those, we will try to explain the benchmarks in more detail with more specialized latency and bandwidth benchmarks.

Gaming

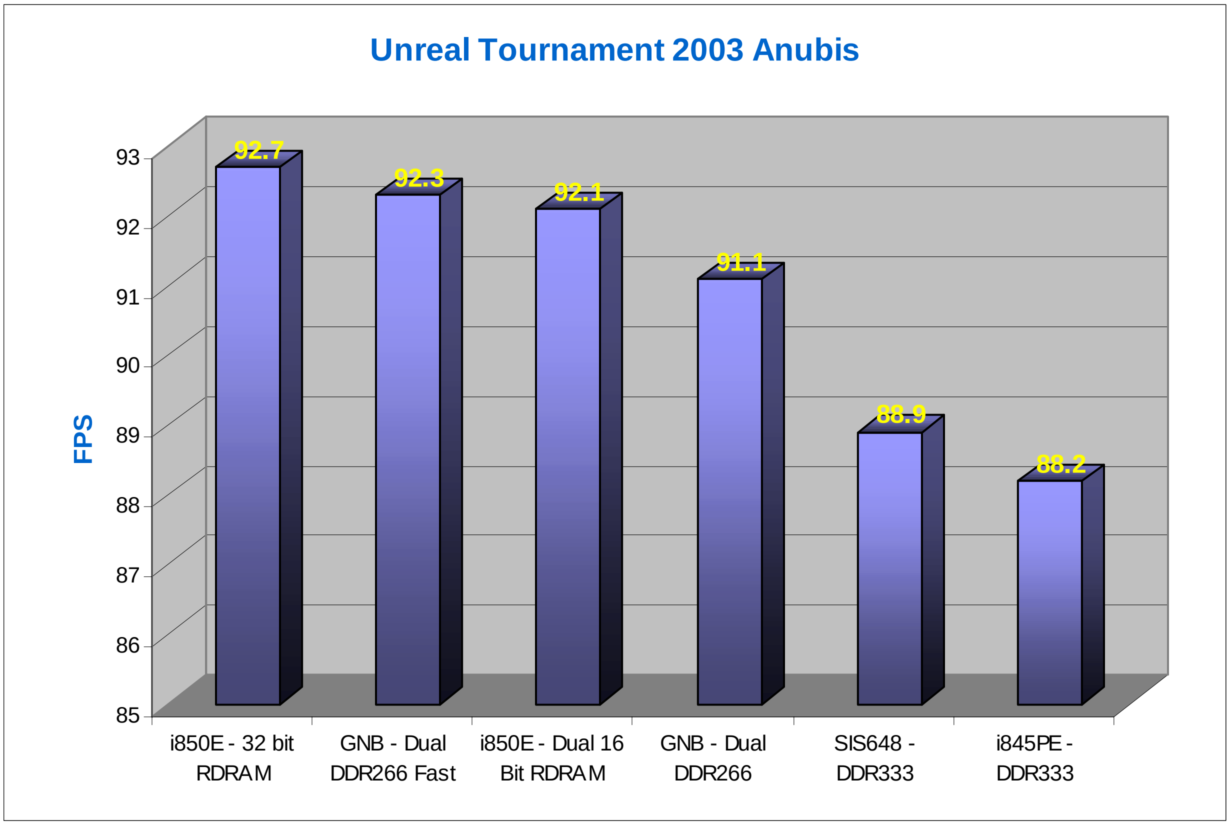
When you set the MSI, Gigabyte and Tyan board to the same settings, all differences where in the margin of error. Gigabyte and MSI could make a small difference though, as we were able to force the boards to run the DIMMs at 2-2-2-6, where this was not possible with the Tyan board. You can see the difference by comparing the "Dual DDR266 Fast" (2-2-2-6) with "Dual DDR266".

Here are the Comanche 4 results, the military helicopter simulator, which is one of the few games that uses DirectX 8's pixelshader effects.

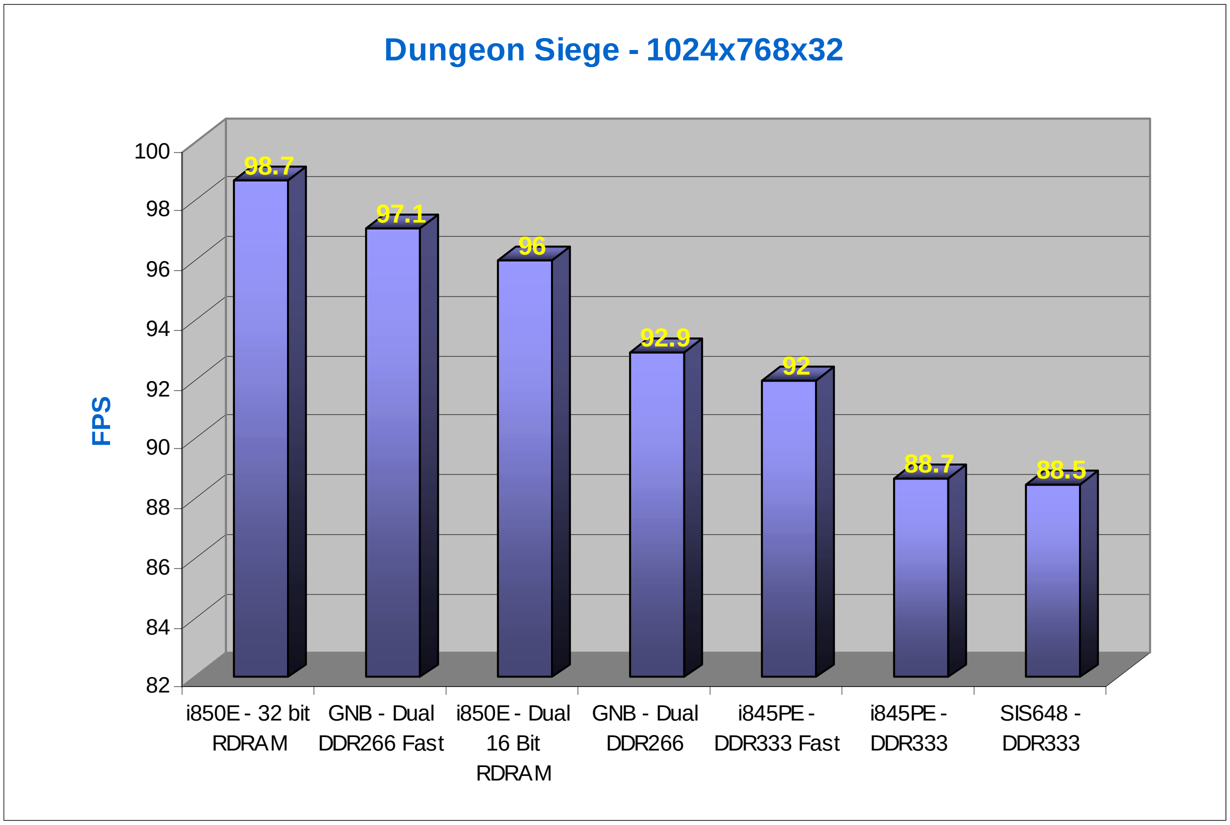


The Rambus board stays slightly ahead of the Granite Bay boards, even at 2-2-2-6.

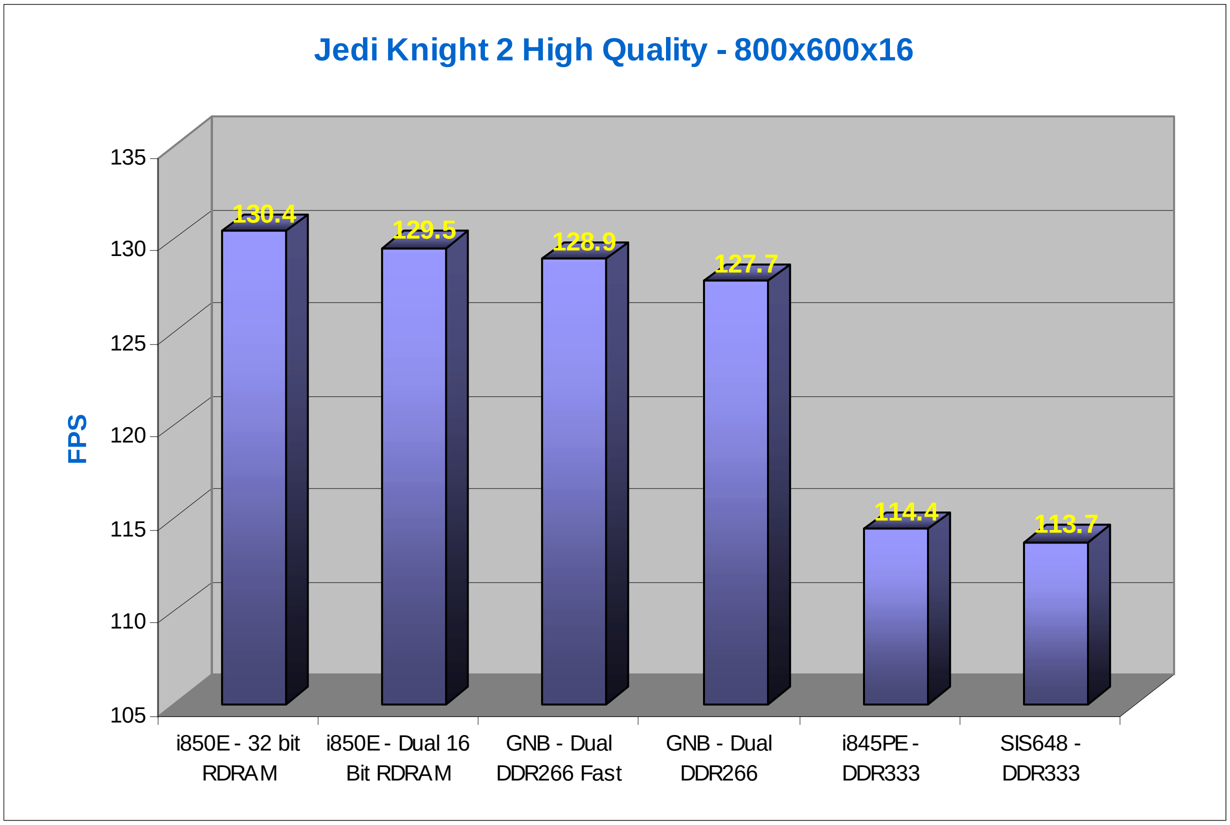
No review can be complete without some Unreal Tournament 2003 benchmarks, as the latest Unreal game is by far the most popular first person shooter.



Again, a neck and neck race. Dual 16 bit RDRAM is a little slower, 32 bit RDRAM (or Dual 16 bit on RIMM) is a little faster than Intel's latest chipset.



Dungeon siege shows a 4.5% difference between Granite Bay with DDR266 2-2-2-6 and DDR 2-3-3-6, which is quite remarkable. Granite Bay seems to need good quality DDR333 to keep up with the i850E. DDR333 is simply not good enough for the Pentium 4.



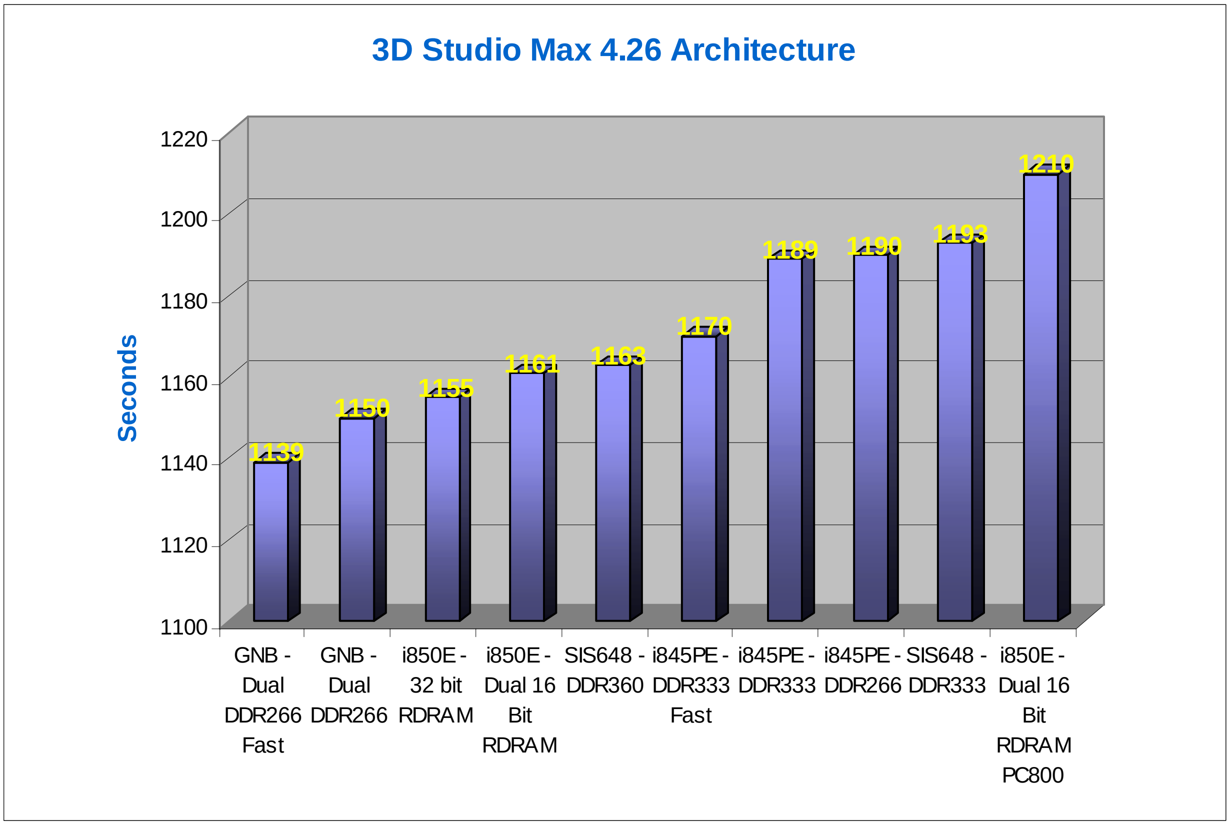
It is interesting to note that the Athlon 2800+ with the Nforce2 achieves about 128 fps in this test. Right now the 2700+ is available in Europe and it has been for some time in the US. So while it might seem that AMD is far behind if you look at the 3 GHz and i850E PC1066 benchmarks, we might see some different results when we would actually test the AMD and Intel machines in the shops. The i845 PE is far more popular than Granite Bay ever will be. Only hardware enthusiasts and workstation users such as our readers choose for the i850E and Granite Bay.

Anyway, Jedi Knight confirms our other gaming benchmarks: the i850E with 32 bit RDRAM is the fastest chipset, but the margins with Granite Bay are small.

Workstation Tests

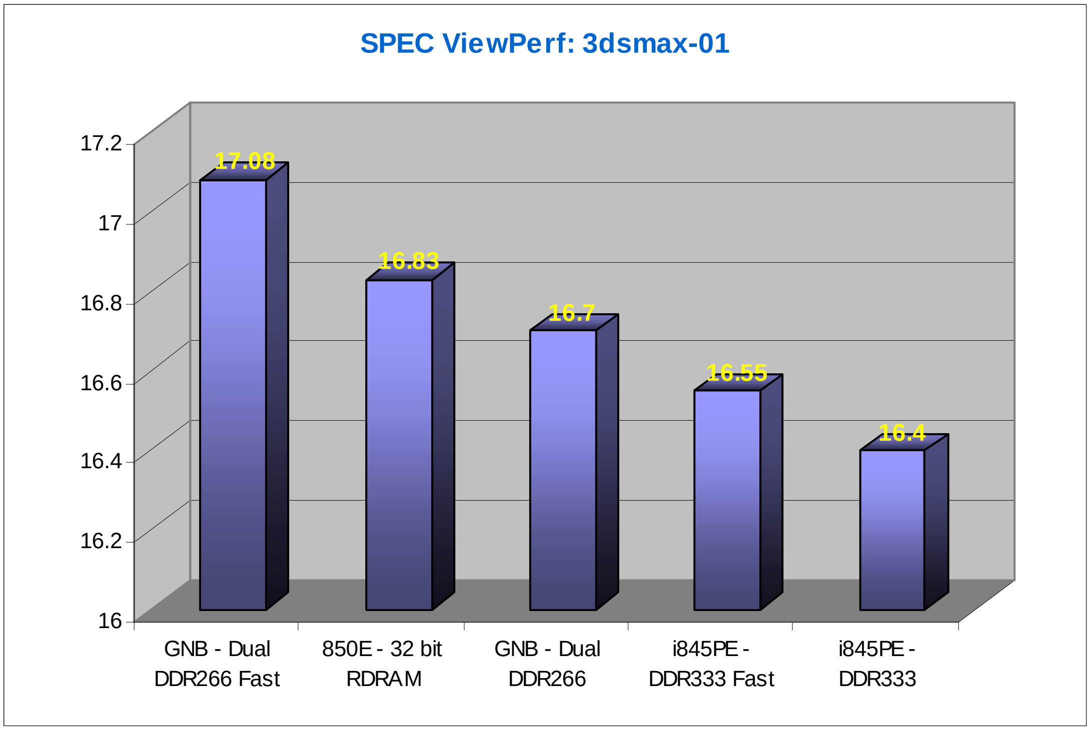
As Granite Bay's first objective is to conquer the workstation market, we tested with the most typical workstation application. **Note that for all OpenGL tests (SpecViewPerf) we used a Quadro 4 XGL 900**, a real OpenGL workstation card, and not the Geforce 4 Ti 4400.

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

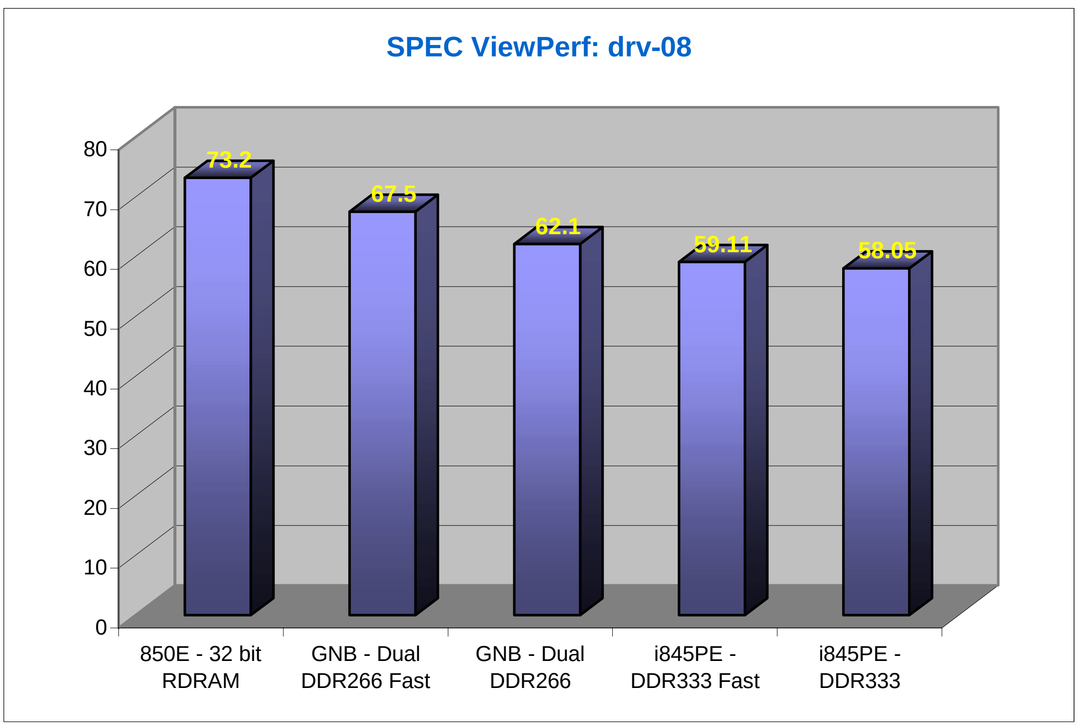


If rendering is the most important purpose of your workstation, Granite Bay is definitely the answer. Renderings require a lot of memory but even slower DDR266 will do. Rendering is still mostly a CPU intensive job, and the 512 KB cache of the Pentium 4 seems to make sure that memory accesses are not slowing down the renderprocess significantly. Invest in a fast CPU (or Dual CPU) and a lot of memory not in faster speedgrades of memory.

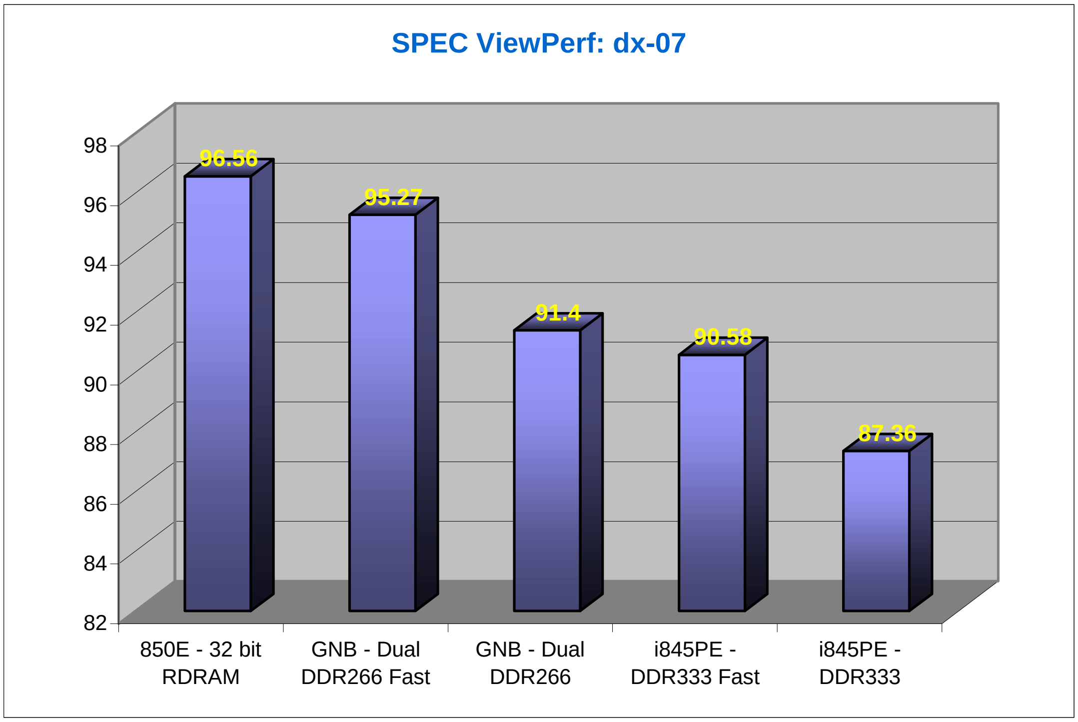
Modelling is a whole different story. Let us see what SpecViewPerf tells us. All benchmarks were done with the same 2.8 GHz Pentium 4, but our videocard was the **Quadro 4 XGL 900.** We did not test with the SIS648 chipset because we were running out of time.



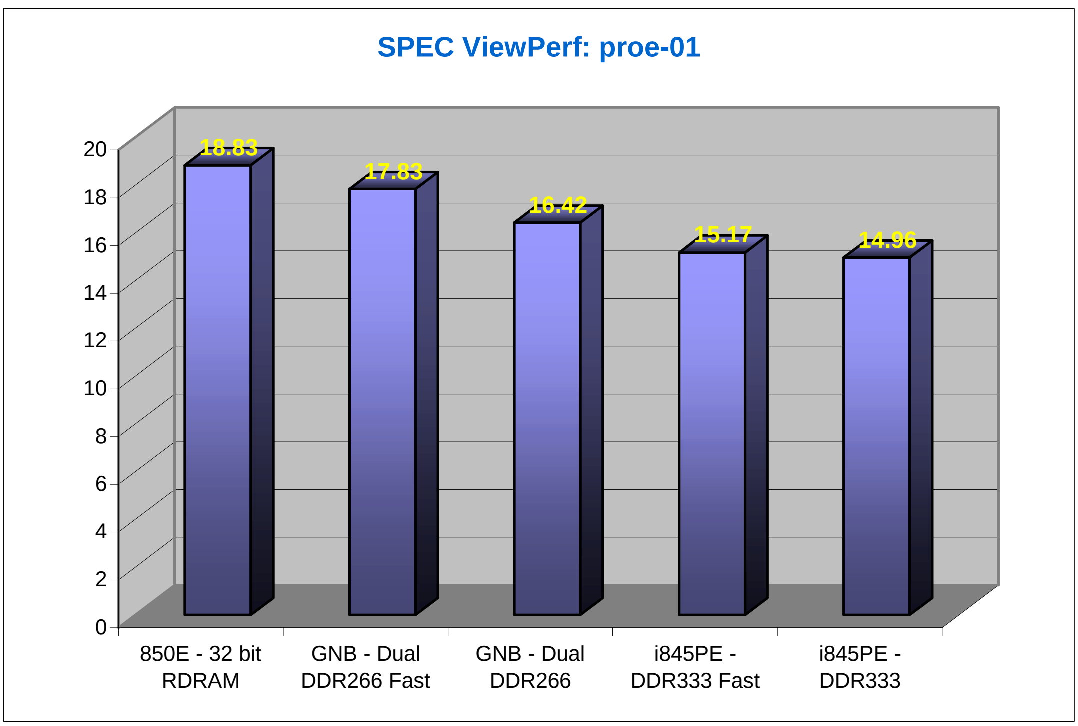
Granite Bay is a tad faster, but needs the boost of the fastest timed DDR266 to pass the i850E. Still, fast DRAM is not that important for 3DSMax modeling, as the fastest chipset is only 3% faster than the cheap i845PE.



If your workstation is your main tool for designing plants and other complex structures, it is clear that you must invest in the speediest DRAM available. Compared to DDR333, RDRAM is no less than 25 to 31% faster! However, i850E 32 bit RDRAM boards are not an option for this category of software as 1 GB RDRAM are not available. If 2 GB is enough, you can opt for a i850E 16 bit board otherwise a i860 board or a Granite Bay board might be worth considering.



Scientific simulation runs the fastest on the i850E, but the difference with Granite Bay is negligible. Note how the E7205 chipset (GNB) again needs 2-2-2 DDR to shine.



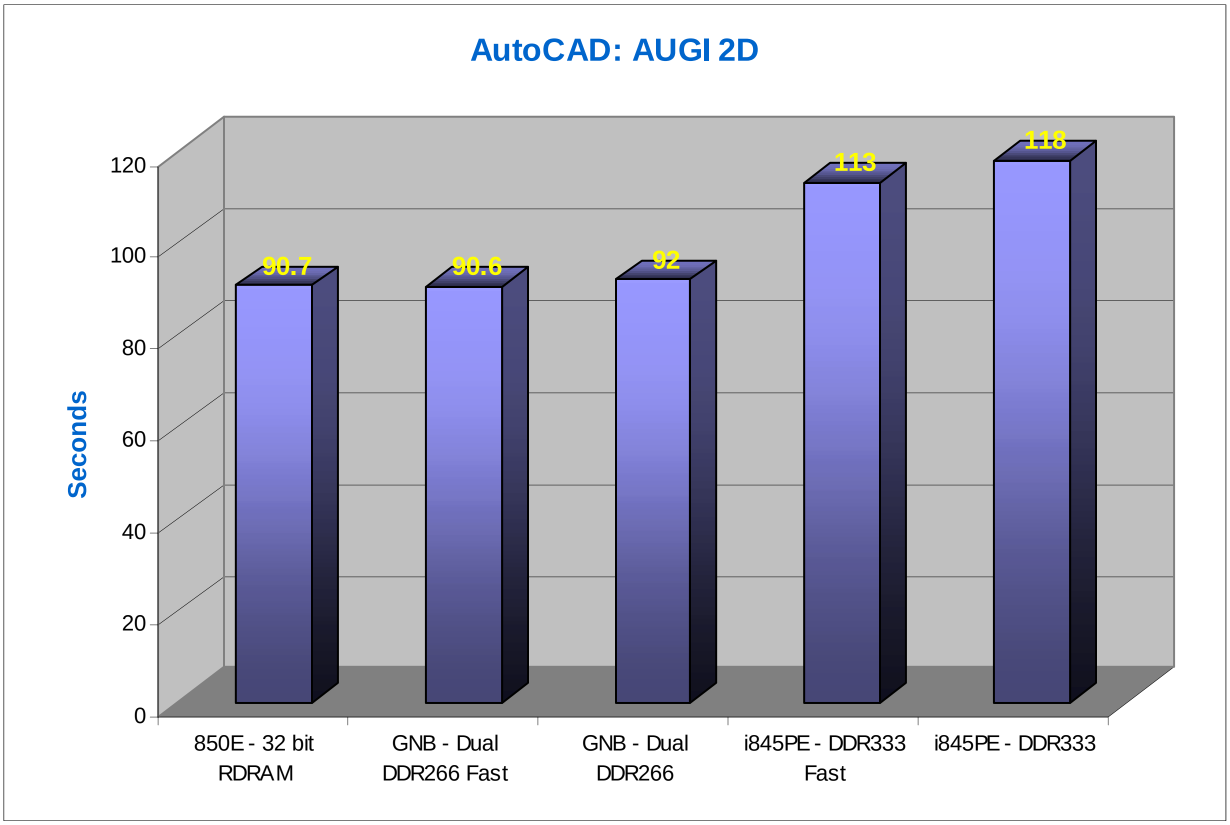
Again, the i850E board is the winner. But again we have to say to note that the slots of the P4T533 (1 GB max) are not enough for Pro-E. Indeed Pro-E professionals would like 4 GB and more. With UGS (CAD), all systems achieved a 17.5-17.53 score, so in this case the E7205 board is the most interesting option.

AutoCAD

We used the AUGI Gauge benchmark from Autodesk Users Group International. From the AUGI Gauge site:

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

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



It is remarkable how most workstation applications demand fast memory. DDR333 is a lot slower than the E7205 chipset and all Rambus powered chipsets.

Photoshop 7.0

Photoshop 7.0 has optimizations for all MMX capable CPUs as well as special optimizations for the Pentium 4.

To test Photoshop, we used **PS6Bench 1.11**, a Photoshop action that runs 21 different operations on Photoshop 6.01 and measures the run time with Adobe's timing feature. We used the PS6Bench "Advanced" benchmark which manipulates a 50 MB image. With Photoshop 7 running, 300-340 MB physical RAM memory (out of 512 MB) was used, so disk swapping did occur on occasion, though not often.

Each filter was run 3 times, and the results you see here are the average of these 3 iterations. "History" was set to "1" instead of the default "20" to make the tests more repeatable. The typical error margin of some tests is still high, between 4 and 10 percent. In particular Rotate 90 and reduce size filters have rather high error margins. Tests 5, 8, 9, 13, 15 to 21 have very low error margins (1-2%), all other tests are in between.

Test Nr.	Photoshop 7.0 Filter	GNB-Dual DDR266	i850E -PC1066	i845PE -DDR333
1	Rotate 90	0.3	0.3	0.3
2	Rotate 9	7	6.8	8.9
3	Rotate .9	4.6	4.7	6.7
4	Gaussian Blur 1	1	0.9	0.9
5	Gaussian Blur 3.7	2.1	2.2	3.3
6	Gaussian Blur 85	2.7	2.5	2.4
7	Unsharp 50/1/0	1.2	1.2	1.2
8	Unsharp 50/3/7/0	2.4	2.3	3.6
9	Unsharp 50/10/5	2.4	2.3	3.7
10	Despeckle	4	3.9	4
11	RGB-CMYK	11.7	11.6	15
12	Reduce Size 60%	1	1	1.1
13	Lens Flare	3.8	3.8	5
14	Color Halftone	3	2.6	2.5
15	NTSC Colors	2.7	2.6	2.7
16	Accented Edges	11.8	12	11.9
17	Pointillize	18.8	18.7	27.1
18	Water Color	29	29	29
19	Polar Coordinates	11.5	10.7	12.1
20	Radial Blur	44.3	44.1	46.6
21	Lighting Effects	2.2	2.1	2.2

Granite Bay (E7205) and the i850E chipset perform equally, but the DDR333 i845PE chipset is quite a bit slower in several filters.

Understanding the Granite Bay Performance

When you look at all the benchmark data above, it is clear that something very interesting is going on. Granite Bay has it all: slightly higher bandwidth than the fastest available 32 bit RDRAM channels, and up to 25% lower latency than the i850E and Rambus combination. Still, this fat 1005 pin chipset with its ultramodern memory controller is not able to beat the old i850E chipset with PC1066 RDRAM. Look at the table below, which summarize the benchmarks above.

Application	I850E 32 bit RDRAM versus Dual DDR266 Fast
Games	i850E (32 bit RDRAM) slightly faster in all games
SpecViewPerf 7.0 (3D modelling, CAD, Scientific simulation)	i850E is 2-19% faster in 4 of 5 benchmarks
3DS Max (3D Rendering)	Small advantage for Dual DDR266
Photoshop 7.0 (Photo Editing)	no tangible difference
AutoCAD (CAD)	no tangible difference

From a performance point of view, the i850E is clearly the better workstation chipset. Still, it doesn't matter too much, because the i7205 makes up for this as it supports up to 4 GB of relatively cheap DDR266. Nevertheless, it is quite surprising that the better theoretical bandwidth and latency numbers of the Granite Bay do not result in a performance advantage. We could not resist to dig deeper in this, with a little help of our friends...

So, we asked for some insight from the posters on our Technical Message Board in **this thread**, and we learned a number of things in the discussion. I cannot emphasize how helpful the forum contributors have been and I strongly recommend reading through the referenced thread for more in-depth information on the subject. We appreciate their contributions greatly.

First of all, our memory benchmarks (Cachemem and ScienceMark MemBench) access memory in a very regular fashion (incrementing addresses). Many applications behave contrary to this, accessing memory in a very irregular manner (pointer chasing, linked lists). For these cases, bandwidth and latency numbers might look very different.

Another potential factor is that out-of-order CPUs can make multiple memory requests simultaneously. Address bandwidth make make a difference in this case, and this would end up favoring RDRAM, as DDR SDRAM still uses single-data-rate for addresses.

Yet another possibility is differences in the bus turnaround time. This is the time that it takes a DRAM to switch between a read and write cycles (or vice versa), and it is indeed a critical performance factor. With DDR, the "write" or "read" command are sent and decoded simultaneously with the addresses. Because of this, you could say that the controller doesn't "know" in advance what's going to happen next. If a write is decoded just before a read has been ordered, the write command will have to be delayed to avoid collisions on the data bus. The databus can only send signals in one direction. Reading data from and writing data to the DRAM will cause the two signals to collide and corrupt the signals.

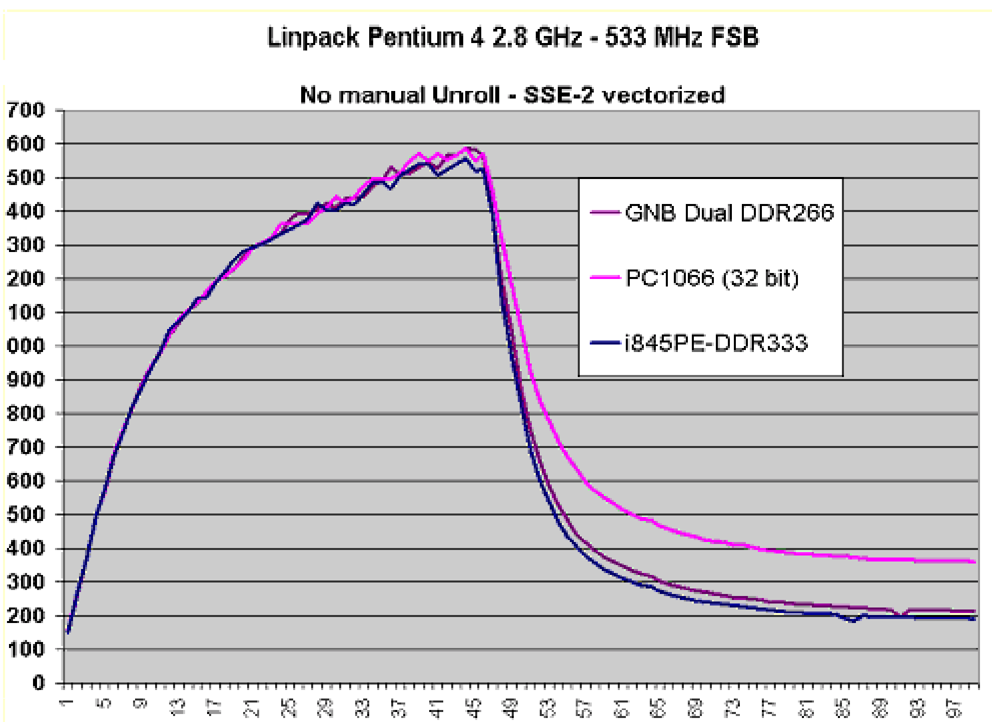
Turning around the bus takes a number of nanoseconds. During this time, no data traffic is possible as the DRAM does not get any commands. The higher the clockspeed of the controller, the longer the turnaround will take in terms of clockcycles. In other words, the higher the clockspeed, the more critical bus turnaround delays are. And that is not all. As DDR transfers twice as much data per clock, it also means that DDR loses more twice as much "data bandwidth" than SDRAM during the bus turnaround.

RDRAM also uses the DDR technique, but it is designed to minimize bus turnaround latencies. The address and control busses work (more) independently and the Rambus chips are intelligent devices in the Rambus transmission line, somewhat similar to several PCs in a network. The more efficient protocol and carefully planned timings of the control bus and address RDRAM bus makes the bus turnaround in roughly one clockcycle. That is one clockcycle of 1.87 ns that two 16 bit data transfers cannot happen. In case of DDR, the control bus has to introduce up to two cycles (DDR333=6 ns) to turn the bus around. Considering that the Granite Bay chipset considers the DRAM subsystem as one big 128 bit DRAM, this means that four transfers of 128 bit can not happen during the bus around. Of course, you want cold hard numbers:

PCMark 2002	I850E 32 bit RDRAM	Dual DDR266 (2-3-3-6)	Dual DDR266 Fast (2-2-2-6)	DDR333
Read bandwidth (MB/s)	2345	2696	**2734**	**2181**
Write bandwidth (MB/s)	**1345**	**709**	**851**	728
Modify (Read and Write) (MB/s)	**1320**	761	**904**	**711**
Random Read (MB/s)	**1968**	2340	**2373**	1979

While the Dual DDR266 channel is up to 15% faster in reading long datastreams, the Rambus channels are up to 60% more efficient when handling writes and interspersed read and writes. So while most memory benchmarks report "read bandwidth" numbers, the reality is that overall, the i850E offers more bandwidth on average. The result is the (very) small performance advantage that we have seen in most benchmarks.

Note that the DDR-II standard includes a few tricks like "posted CAS" or "late write" to soften the "SDRAM turnaround" problem. Need even more benchmarks? Check out what out linpack (Floating point matrix multiplication) has to say about the RDRAM versus DDR issue. As our "normal" linpack benchmark (source code was manually unrolled) was compiled with Visual C++ 5.0, we recompiled the original Linpack source code (without manual unroll) with Intel's 5.0 C++ compiler, which was able to optimize the code for SSE-2.



Linpack's results seem very similar to the modify test of PCMark 2002. RDRAM is definitely more efficient here.

Conclusion

Which one is the best? Granite Bay, the i845 PE, SIS648 or the i850E? Most people like a simple answer. Unfortunately the truth is - in our humble opinion - rather complex. Each chipset has some some advantage but also some serious disadvantages.

The ASUS P4T533, the only i850E board with support for 32 bit RDRAM, is still overall the fastest chipset for the desktopuser. 32 bit RDRAM is a little faster than two channels of 16 bit RDRAM and in some quite a few workstation applications it significantly outperformed the i845PE and DDR333.

But at the same time, it seems to be harder to produce high capacity RDRAM chipsets than DDR SDRAM chips. 512 MB 32 bit RDRAMs are pretty expensive, 1 GB RIMMS are unavailable. This means that with a ASUS P4T533 board, which has only two RIMM slots, you are limited to 1 GB of memory. This is enough for desktop use, but might be insufficient for a lot of workstation users.

For the desktop user, the ASUS P4T533 and P4T533-C are a pretty good deal. Excellent performance and overclockablility push the Pentium 4 to the highest framerates possible. As most desktop users do not need more than 512 MB, the price It is no accident that Intel's own 3.06 GHz evaluation kit shipped with a PC1066 RDRAM based board, and not Granite Bay.

For the people who hardly overclock, there is no need to buy DDR400. Wait until DDR400 is officially supported by Intel in about six months. Intel tends to make sure that the quality of DRAM at a certain speed

Even if it is beaten by the i850E, Granite Bay is no failure. It supports 4 GB of cheap unbuffered DDR266, which is something that no current Pentium 4 chipset is able to do. Nevertheless, it should be noted that Granite Bay only performs well with DDR266, which can run at 2-2-2. While DDR that can run at 2-2-2 is easily accessible to the review sites, I doubt strongly that most PC users will buy and use it. Most DDR333 and DDR266 runs easily at CAS 2 (2-3-3), but is not able to run at 2-2-2. So basically, the performance delta between the i850E-PC1066 and Granite Bay systems is in reality higher than most reviews indicate.

So that is the main reason why Granite Bay's performance is a bit disappointing, it needs fast DDR333 run at DDR266 2-2-2 to keep up with the old i850E chipset and is at the same time much more expensive than the old RDRAM chipset.

The i845PE will remain the most popular Pentium 4 chipset of all, as it is a little faster than the SIS648 and a lot cheaper than Intel's E7205.