

# AMD 2009 performance preview: taking Phenom II to 4.2GHz

by Joel Hruska

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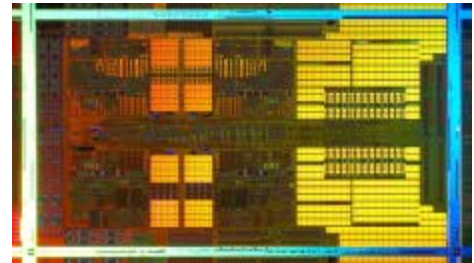
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# AMD 2009 performance preview: taking Phenom II to 4.2GHz

By Joel Hruska

When it launched in early January, Phenom II's sole purpose, its *raison d'être*, was to rejuvenate AMD's ability to compete against Intel with something other than price cuts. Viewed in aggregate, benchmarks of the new CPUs prove that Sunnyvale succeeded; the X4 940 and 920 are tough opponents in the mainstream quad-core market. I don't want to downplay this achievement; a strong Deneb launch was vital if AMD is to continue as a going concern.



The problem is that Sunnyvale's future competition is locked, loaded, and launched. In the past, the question of whether AMD or Intel would hold a performance advantage "next time" was fueled by speculation and odd bits of data. In this case, Intel's "next-gen" design is already on the market and has been for several months. Nehalem is no paper tiger—it's here right now, and it'll hit the 940's current price point within 2009 (barring a major roadmap change).

So can AMD scale Phenom II to match Nehalem? We wanted to find out, because the answer will tell us how the AMD vs. Intel battle will shape up in 2009. So, we took one Phenom II 940, added coolant, overlocked it to 4.2GHz, and ran the benchmarks listed below.

## Cost comparison

We've known from the start that Phenom II would primarily target Core 2 Quad processors rather than Core i7. AMD definitely hit its target; Phenom II compares well against Intel's 45nm Yorkfield processors. A Phenom II X4 940 (3GHz) is currently \$229 at Newegg while the Phenom II X4 920 (2.8GHz) is \$195. Intel currently offers the Q9400 (2.66GHz, 6MB L2) at \$229, the older 65nm Q6600 Kentsfield at 2.4GHz at \$194.99, and the Q8300 (2.5GHz, 4MB L2) at \$189.99. All of the Core i7 parts are significantly more expensive than the Phenom II X4 940; the Core i7 920 is \$294.99 while the 940 is \$565.

So how much bang does Phenom give for the buck?

## Performance Summary

- **Worldbench 6b2:** Phenom II is more than adequate for any office or content creation work, but can't match Intel's Core i7-965 even when overlocked. Typically, however, these types of workloads don't require anything like ultra-powerful hardware.
- **Photoshop CS4:** Intel's Core i7-965 led our Photoshop benchmark with the overlocked Phenom II not far behind. The standard Phenom II trailed the pack, but again, all of the processors turned in good performance numbers.
- **Handbrake 0.9.3:** This x264 encoder scales well across all eight of Core i7's logical processors; Phenom II at 4.2GHz can't match the slower Core i7-920.
- **Cinebench R10:** Phenom II X4 940 is the slowest of the four cores we tested (though not by much), while the 4.2GHz flavor smashes everyone else in single-thread testing. Core i7-965 still wins the multi-threaded test, but our overlocked AMD chip makes Intel work for it.
- **Valve Particle, Map Compilation Tests:** Another set of overall wins for Intel; Phenom II 4.2GHz can't quite match the Core i7-920. Phenom II X4 940 at stock speeds is at the back of the pack.
- **Crysis:** Phenom II is an excellent gaming chip. The X4 940 beats the Core i7-920 here while the 4.2GHz chip is only a hair back from the Core i7-965.
- **Call of Duty 4:** This is one game that's quite fond of Phenom II; the Phenom II X4 940 at 4.2GHz wins the benchmark with the stock-clocked flavor in a tie for second.
- **Unreal Tournament 3:** In UT3, our overlocked chip leads the rest; the standard X4 940 still outperforms Intel's Core i7-920.

- **Assassin's Creed:** Another game, another good showing from AMD. Our overclocked Phenom II outperforms the Core i7-965 while the Phenom II X4 940 is again well ahead of the Core i7-920.

AMD's Phenom II X4 940 doesn't lead a majority of our tests at stock speeds, but both the Core i7-920 and the Core 2 Quad Q9650 are significantly more expensive than the AMD part. The Core i7-920 is a bit better in that regard, but LGA1366 motherboards and DDR3 still command a price premium over AM2+ and DDR2.

AMD's new chip competes well against the Intel parts it's priced against, has plenty of overclocking headroom even if you don't have a phase-changer handy, and offers excellent gaming performance. Compared to the Phenom that preceded it, Phenom II is a slam dunk. Whether or not that's enough to save AMD, particularly in the current economic climate, is regrettably an open question.

## Test Setup, SiSoft Sandra

Components	Nehalem	Deneb
Processor	Core i7-965/920	Phenom II X4 940
Clockspeed	3.2GHz/2.67GHz	3.0GHz/4.2GHz
Motherboard	Intel DX58SO "Smackover"	Asus M3A79-T Deluxe
Operating System	Vista Ult. 64-bit w/SP1	Vista Ult. 64-bit w/SP1
Video Card	ATI Radeon HD 4870	ATI Radeon HD 4870
Storage	80GB Intel SSD	80GB Intel SSD
Power Supply	PC Power & Cooling 750W	PC Power & Cooling 750W

Results for the QX9650 are only intermittently available; configuration details on that system are available [here](#). Other reviews at other places have done a thorough job comparing Phenom II's performance against that of Intel's Core 2 Quad series; we've focused our review in a different direction.

On that note: I've labeled the QX9650 as a "Core 2 Quad QX9650" in the review. Technically, the part we tested is an Intel Core 2 Extreme QX9650, but that \$1,000 part has been replaced by a Core 2 Quad Q9650 selling at a third the price of the original.

Both test systems were configured for dual-channel / triple-channel operation; the same brand of DDR2 and DDR3 was used in all cases. The Phenom system used 4GB of DDR2-1066 RAM in a 2GB/2GB configuration while the Core i7 processors used 4GB of DDR3-1066 in a 2GB-1GB-1GB deployment.

Configuring the Core i7 in this manner **could** result in a performance loss but only one test—Sandra's theoretical memory bandwidth benchmark—gave results that might be interpreted as evidence of such. All of the Core i7-965 benchmarks were run again on the system; a comparison between the performance of the processor in this review vs. the performance we saw in our Nehalem launch coverage shows little-to-no difference.

The Asus M3A79-T will not run in dual-channel mode if three DIMMs are inserted. I'm not sure if this is a characteristic of the 790GX chipset or an errata that's unique to the Asus board, but it makes it impossible to perfectly synchronize the DIMM loadouts between the two processors while keeping both in triple channel/dual channel mode. Given this fact, 2GB-1GB-1GB for Core i7 was deemed the best option.

As for why we didn't compare an overclocked Nehalem against an overclocked Deneb, the answer is fairly straightforward: the point of our investigation is to look at how Phenom II scales, and not at how Nehalem scales.

The cooler head on the phase change unit I used hovered between -50C and -60C; actual CPU temp as reported in the BIOS was -40C. The accuracy of BIOS temperature readings at these temperatures is questionable, but that's what the ASUS board consistently reported.

I also tested the Gigabyte GA-MA790GP-UD4H, but ultimately opted for the ASUS board. Stability between the two was equal, but the ASUS model proved more overclocking-friendly—I was able to reach 4.2GHz on the M3A79-T vs. just 4GHz stable on the Gigabyte system.

HyperThreading was kept on for all of the Core i7-965 and Core i7-920 benchmarks.

## Note: defining the phrase "stable overclock"

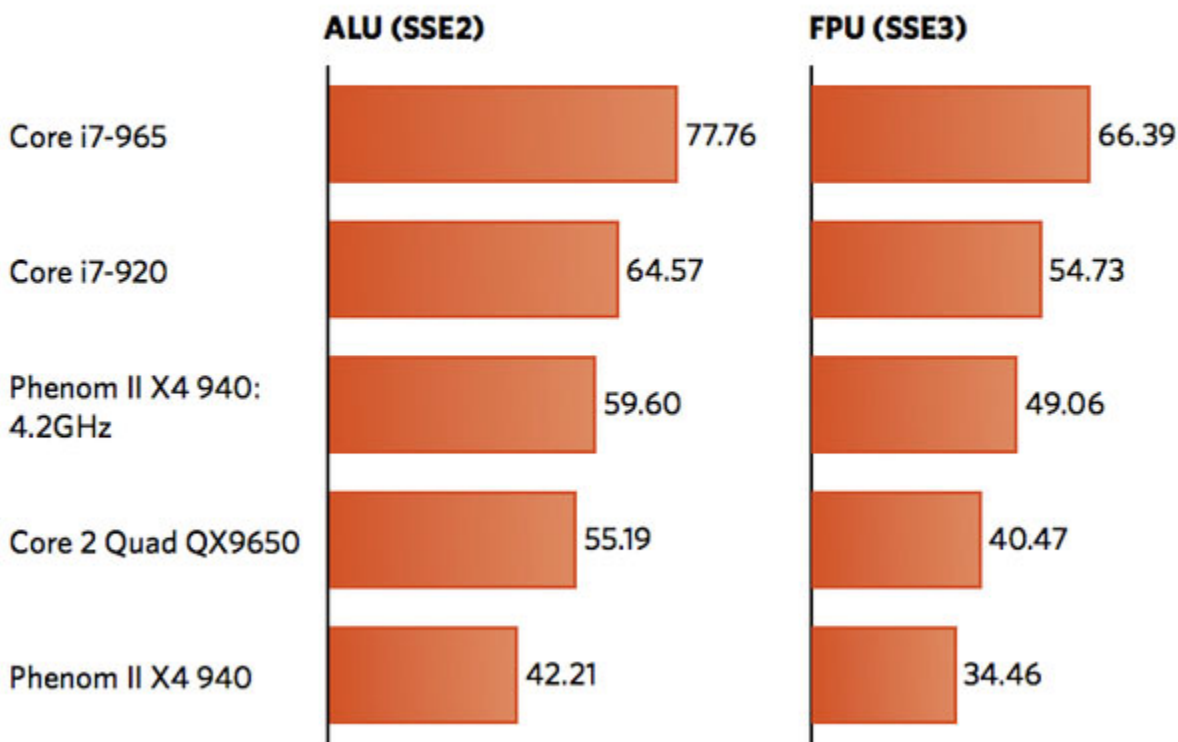
For a word that's defined as *able or likely to continue or last; firmly established; enduring or permanent*, "stable" becomes exceptionally slippery when combined with "overclock." To some in the overclocking community, a stable overclock is achieved when one is able to boot into Windows, run SuperPi (a single-threaded benchmark that's long-since outlived whatever dubious worth it once possessed), and take a few CPUID screenshots. This is far below what I personally find acceptable.

I consider an overclock to be stable if and **only** if the system is capable of executing a review-level/comprehensive suite of benchmarks without crashing, rebooting, or exhibiting any behavior that is not also displayed when the system is running at stock speeds. If a CPU can loop 3DMark Vantage's CPU tests or continuously re-render an animation for an indefinite period of time at stock speeds but crashes after 30 minutes when asked to do so in an overclocked state, the overclock is unstable. This is still the case even if the system has completed multiple iterations of the benchmark in question.

It's not easy to fine-tune a system to such a standard while simultaneously attempting to push a processor as far as it can go; it took me several weeks to find the precise edge between stable/unstable for the Phenom II X4 940 that's the subject of this review. Meanwhile, the Phenom X4 9950 that we also tested presented its own unique challenges when combined with a phase-change cooler—I'll provide additional detail on my overclocking adventures later in the review. In the end, I was able to completely stabilize our Phenom II X4 940 at 4.2GHz even with an HT link speed of 210MHz (1.89GHz effective), an IMC/L3 clock of 2.53GHz (up from 1.8GHz base) and an 1170MHz memory clock. Setting the HT link multiplier to 1x and keeping the IMC/L3 clocked at 1.8GHz increased my maximum stable clockspeed, but I thought the tradeoff a poor one. More details to follow.

## Sandra 2009 SP2: Arithmetic Tests

GB/s, higher is better

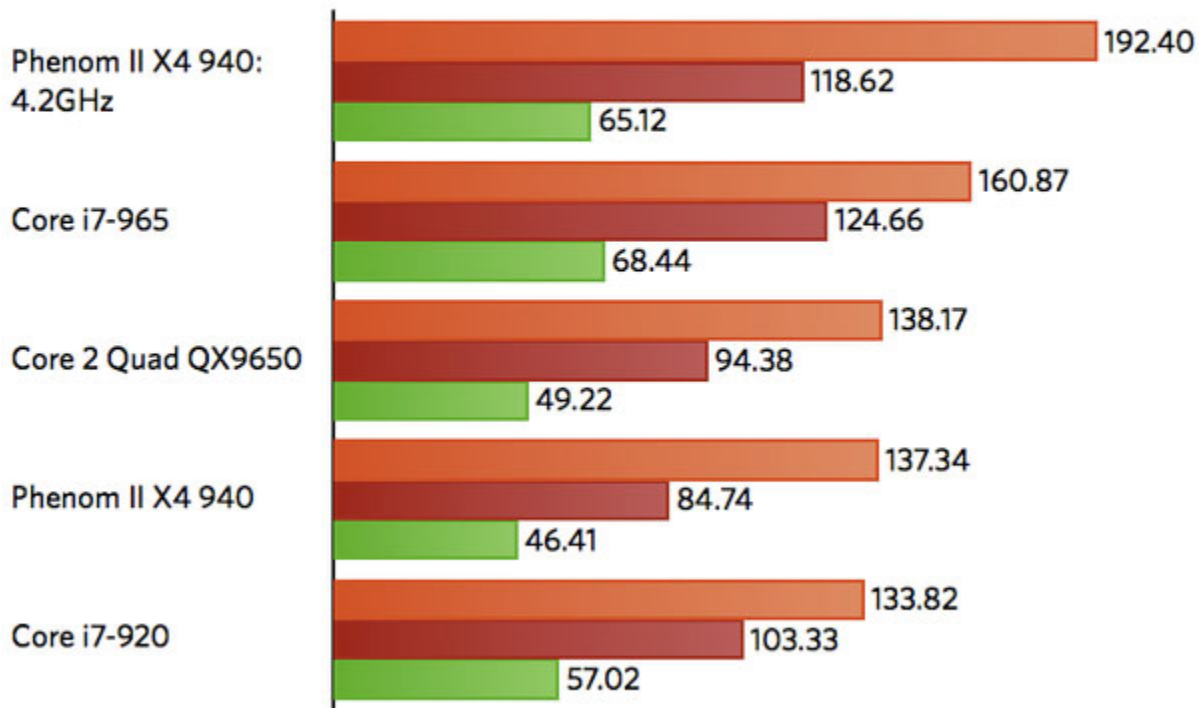


Sandra's ALU/FPU graphs and multimedia tests are self-explanatory; the QX9650 maintains a moderate lead over the Phenom II 940 but gets creamed by the 4.2GHz Deneb. At 4.2GHz, Phenom II is close on the tail of the Core i7 920 (remember, these tests take advantage of HyperThreading) but ultimately pulls up 10 percent short.

## Sandra 2009 SP2: Multimedia

MPixels/s, higher is better

Integer x16  
Float x8  
Double x4



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Turning to multimedia testing, we see a bit more give and take. Sandra describes this benchmark as involving "the generation of Mandelbrot Set fractals that are used to realistically describe and generate natural objects such as mountains or clouds. By using various multi-media extensions better performance is achieved." Phenom II 940's integer performance is competitive with both the Core i7-920 and the QX9650, but the chip lags in Float x8 and double float x4 tests.

## Sandra 2009 SP2: Cryptography

MB/s, higher is better



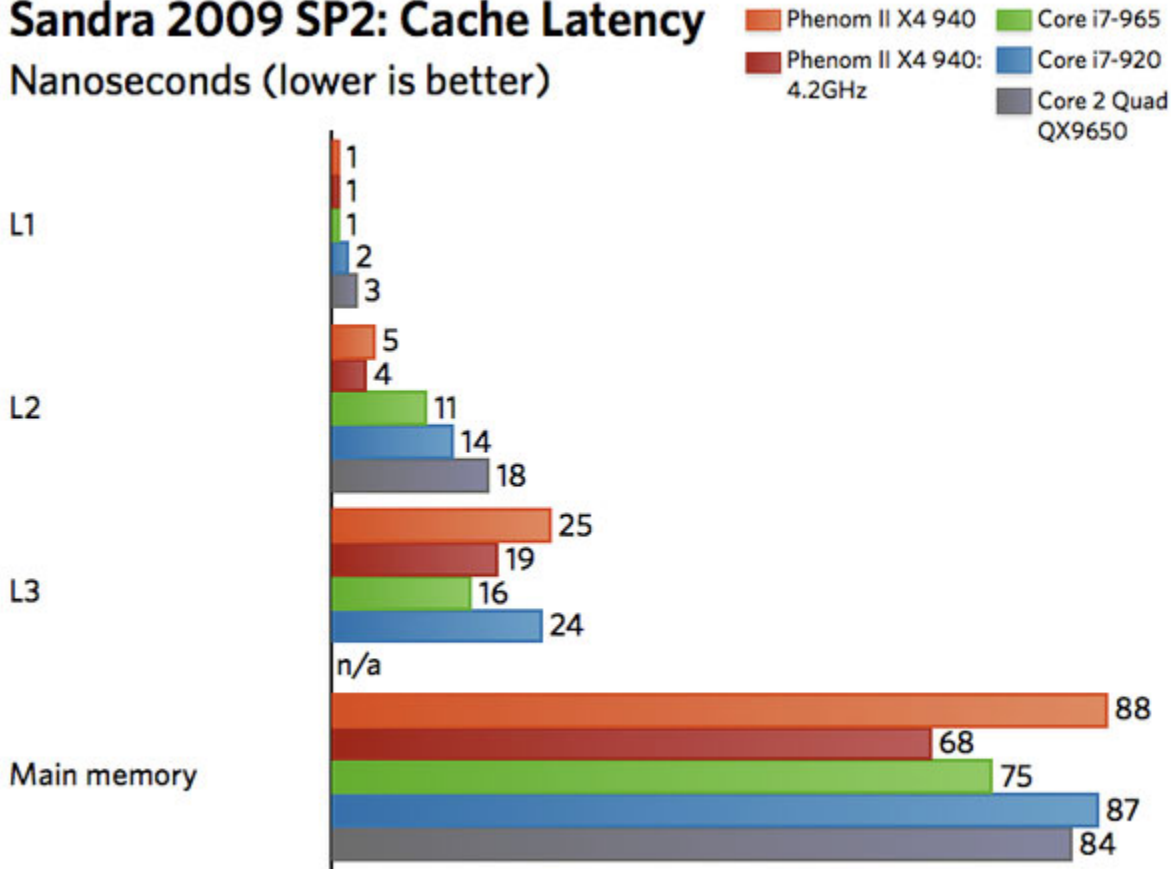
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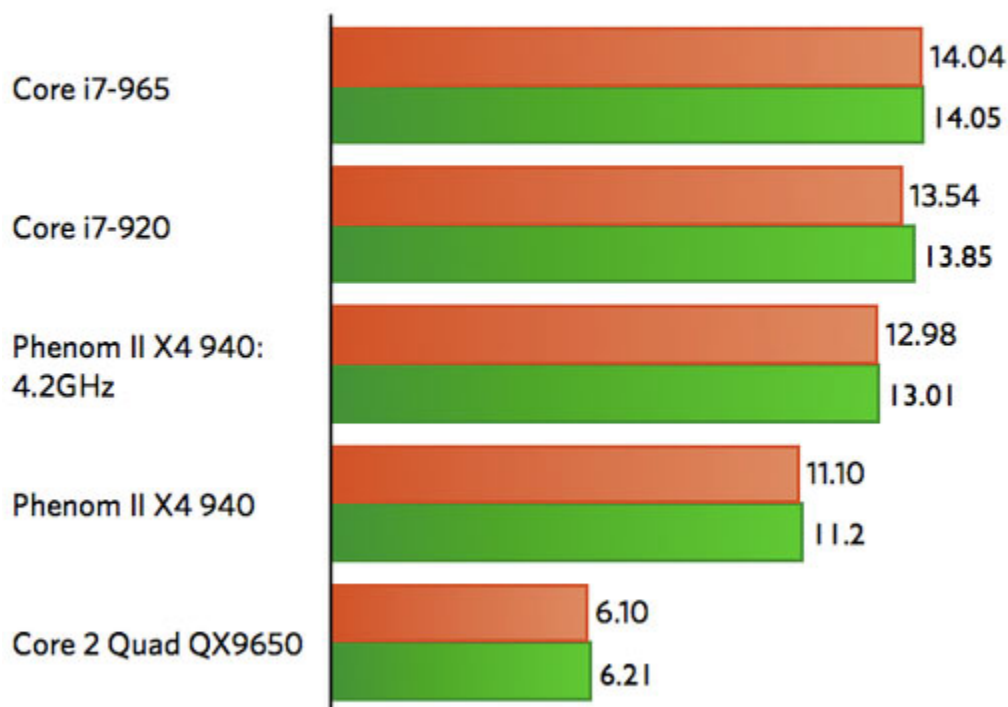
The cryptographic benchmark is straightforward and consists of two separate tests. The AES256 benchmark tests how quickly the CPU can encrypt and decrypt data when using that standard, while the SHA256 benchmark tests a processor's throughput when hashing information with SHA-1. Intel's Nehalem doesn't seem particularly fond of Sandra's SHA benchmark; the QX9650 takes home top honors here among the stock-speed processors with Phenom II 940 in second place. Deneb 4.2GHz outstrips everyone else, but only leads the Core i7 by about nine percent, despite its 31 percent clockspeed advantage.

## Sandra 2009 SP2: Cache Latency

Nanoseconds (lower is better)



## Sandra 2009 SP2: Memory bandwidth (Int/Float) GB/s (Higher is Better)



The QX9650 lags all our other processors in cache latency but, according to Sandra's test, is still much quicker than Phenom II when it comes to core-to-core communication. Phenom II is a bit quicker to access L1 and significantly faster in L2. AMD uses a 512K L2 on Phenom II (double the size of Nehalem's), but Intel's L2 path is twice as wide as AMD's; Core i7's theoretical L2 bandwidth is roughly double Phenom II's. Our 4.2GHz Denenb still can't match the i7-965's L3 latency, but this has more to do with the relatively low clock rate on AMD's integrated memory controller and L3 cache—even at 2.53GHz, Deneb 4.2's IMC is 26 percent slower than Nehalem's.

Our memory bandwidth benchmarks for Nehalem were down significantly from what we saw last December, possibly because we had to mix RAM brands to hit 4GB of memory. That fact didn't change overall performance, however—again, our overclocked Phenom II can't match the available bandwidth on either part.

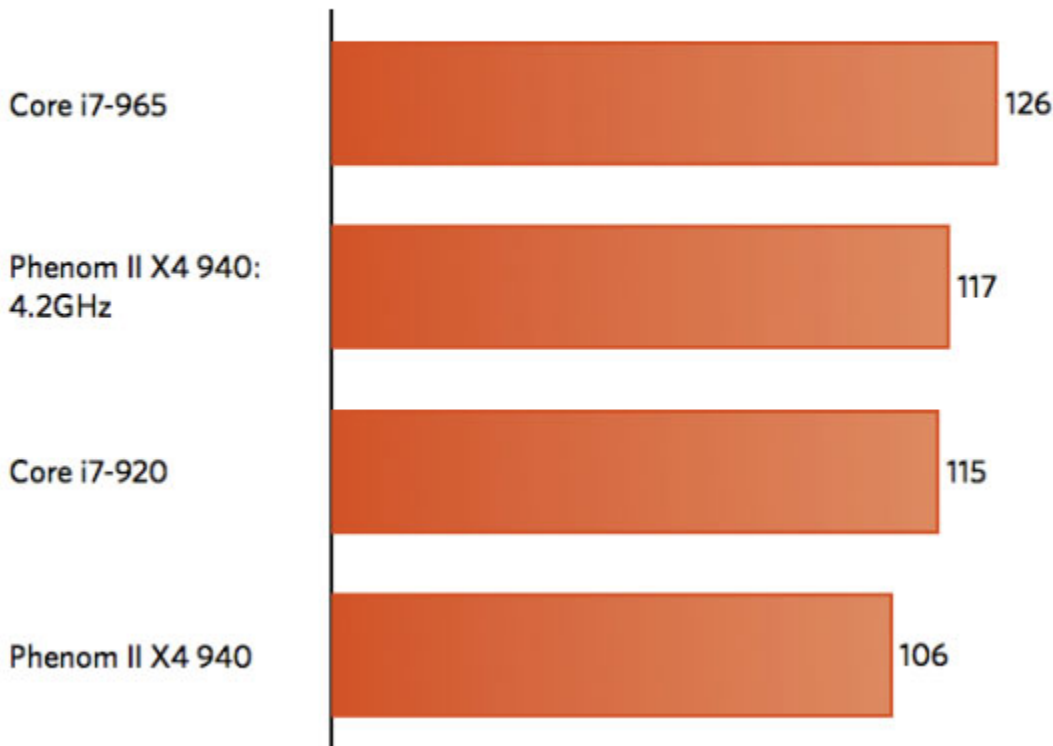


## Worldbench 6 Beta 2

Worldbench 6 Beta 2 is an application suite designed by PCWorld; it's designed to evaluate PC platform performance in a variety of applications. We ran the entire suite of tests available in Worldbench save for Adobe CS2—that particular test has a tendency to throw registration errors under Vista 64-bit and I tested Photoshop CS4 separately. When completed, the benchmark returns an "Overall" score as shown below, but each individual test is measured in terms of how many seconds it took to complete the run (lower is better).

### Worldbench 6b2 (Overall)

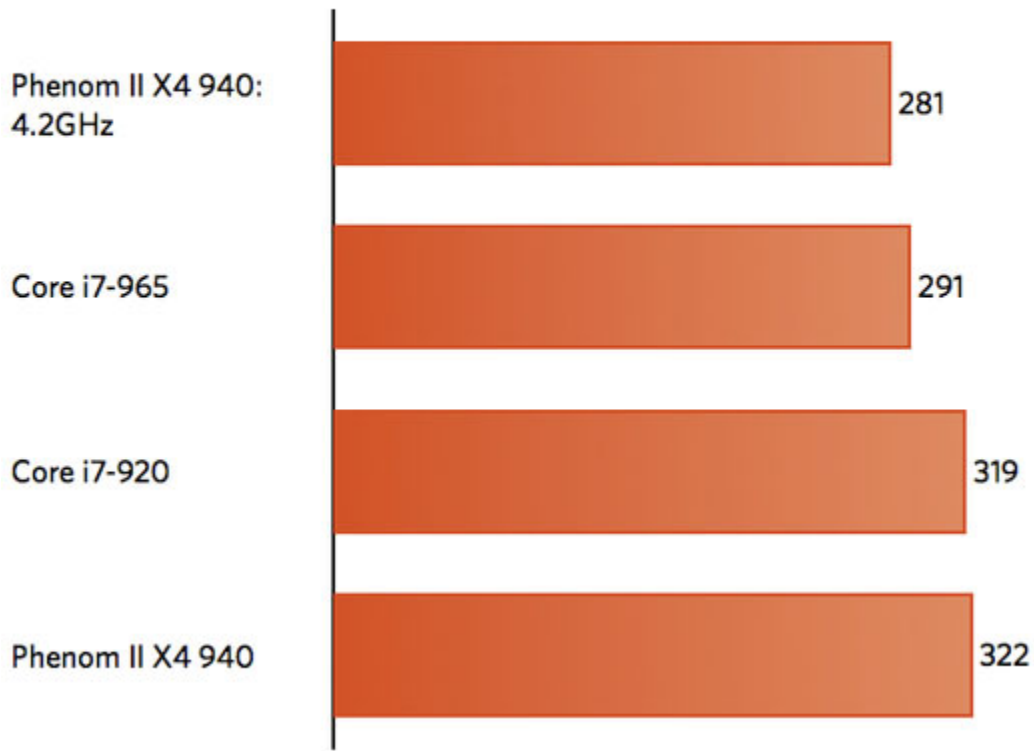
Score, higher is better



The Core i7-965 is still the overall victor over even our overclocked Phenom II, which just passes the Core i7-920. Phenom II X4 940 is at the bottom of the heap with a respectable, but somewhat disappointing 106.

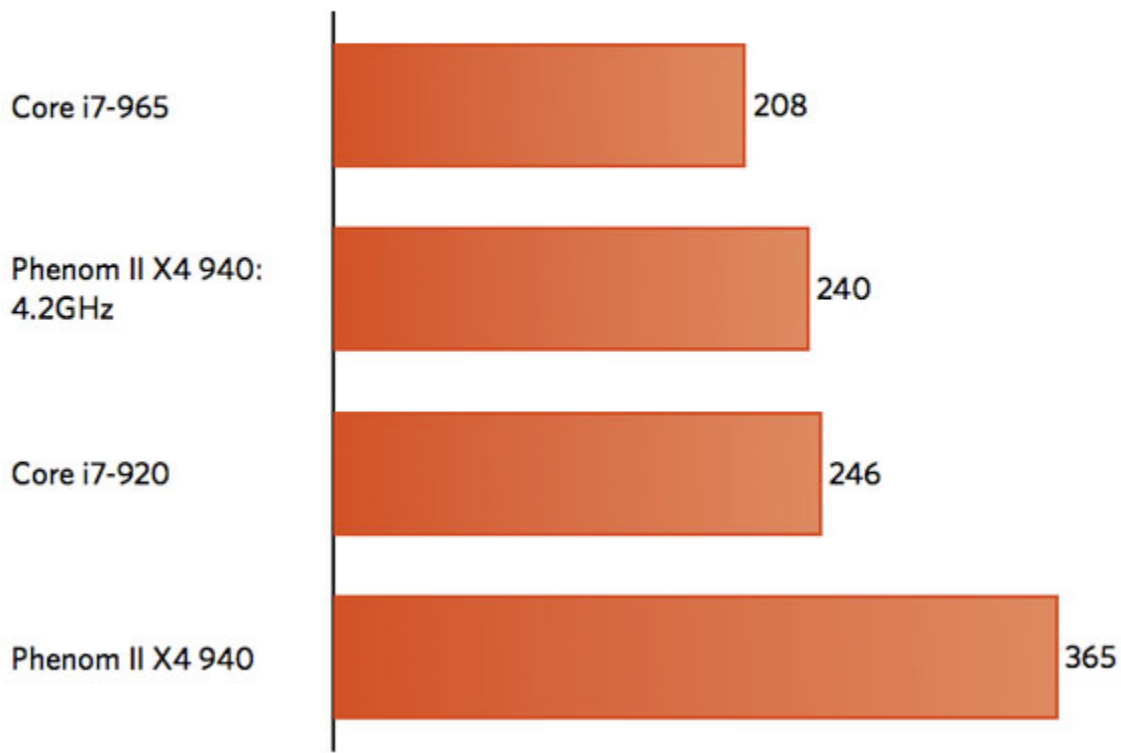
## Worldbench 6b2: 3ds Max Rendering (D3D)

Seconds, lower is better



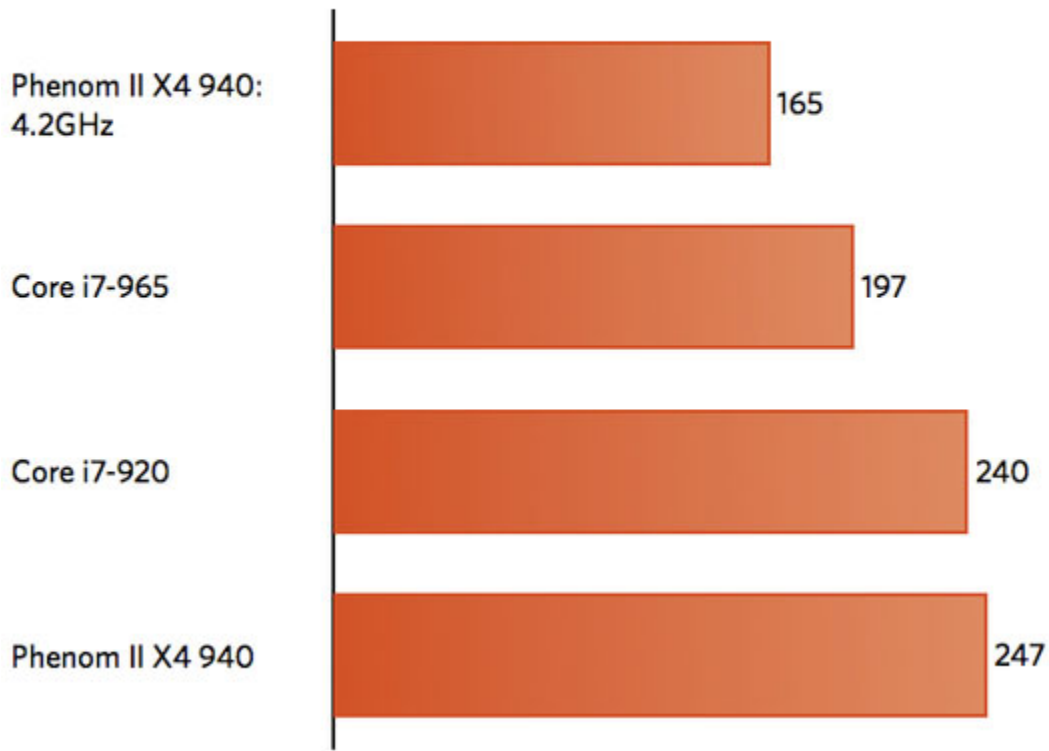
## Worldbench 6b2: 3ds Max Rendering (Software)

Seconds, lower is better



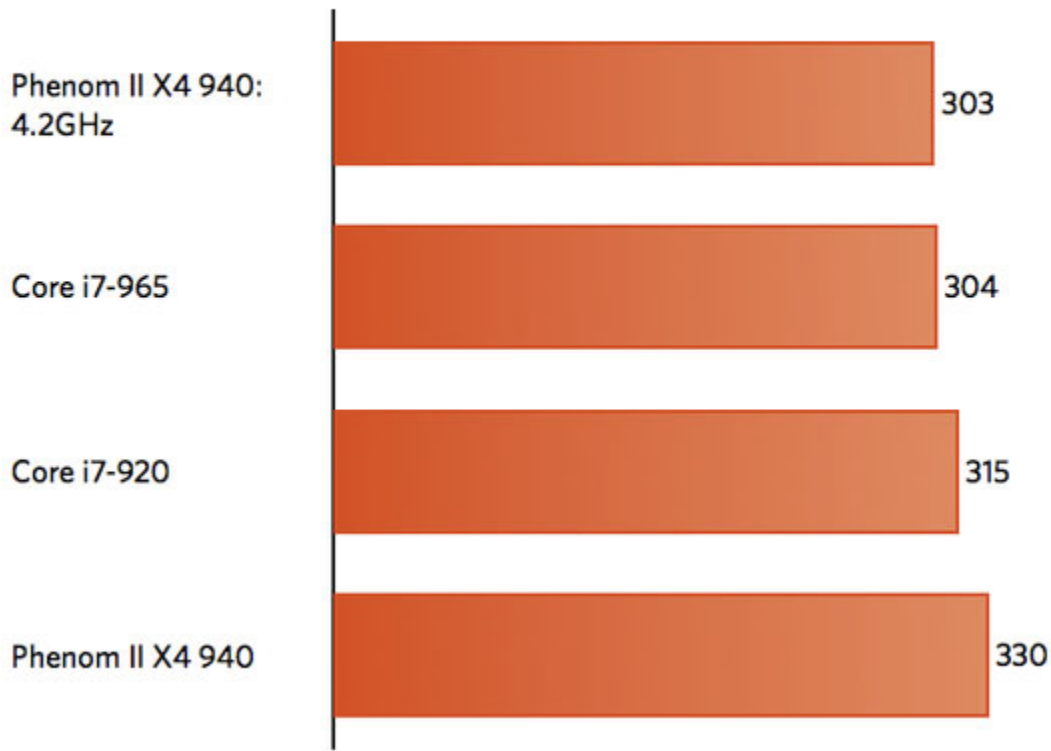
## Worldbench 6b2: Firefox 2

Seconds, lower is better



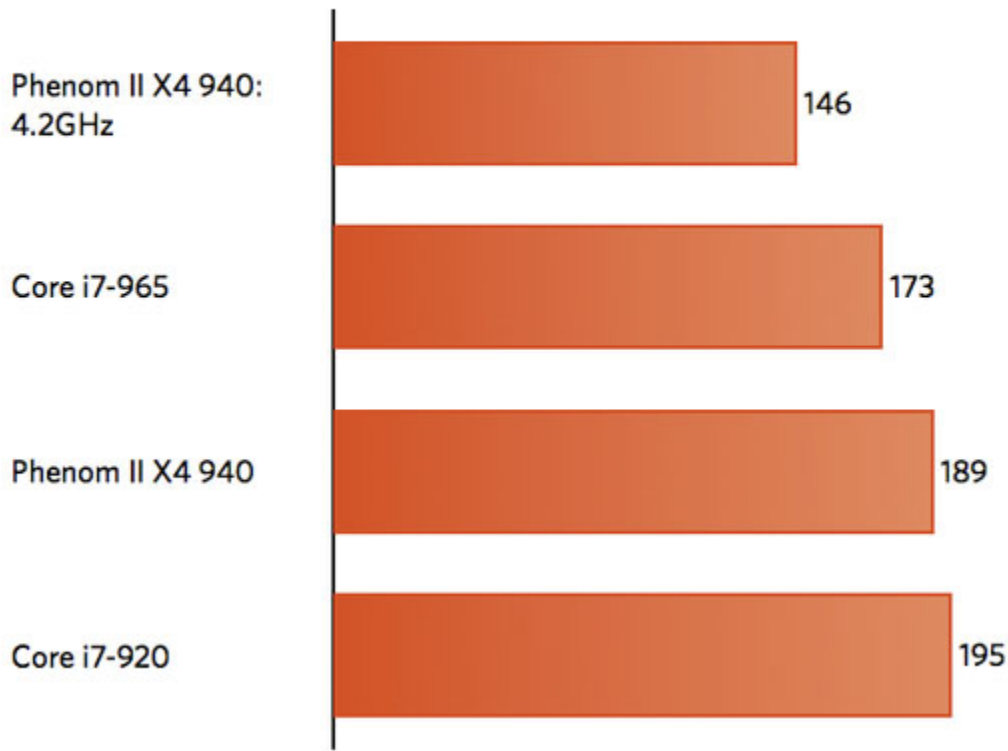
## Worldbench 6b2: MS Office 2003

Seconds, lower is better



## Worldbench 6b2: Windows Media Encoder 9

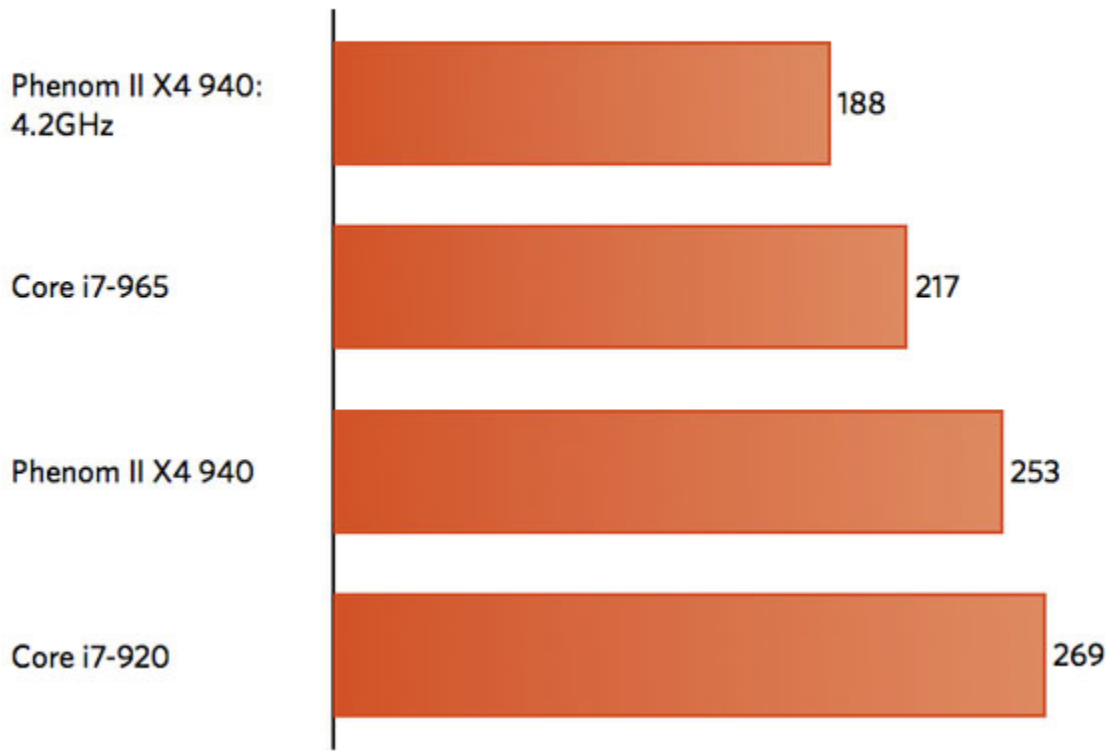
Seconds, lower is better





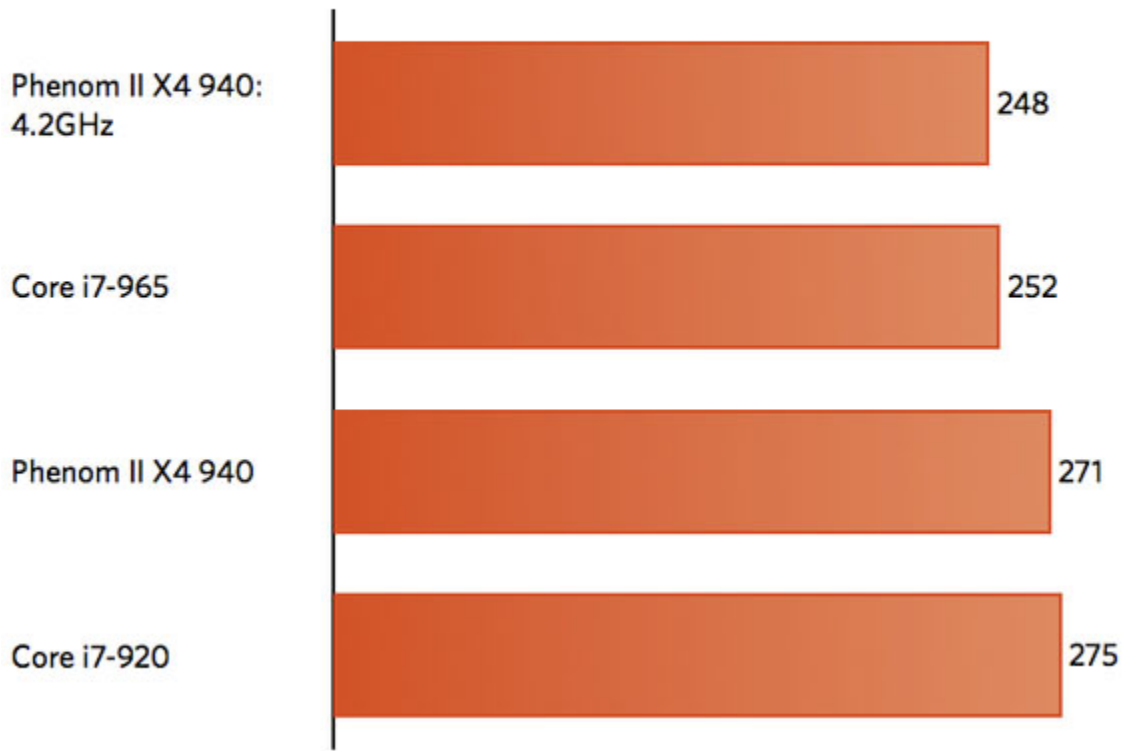
## Worldbench 6b2: Firefox 2 + WME 9

Seconds, lower is better



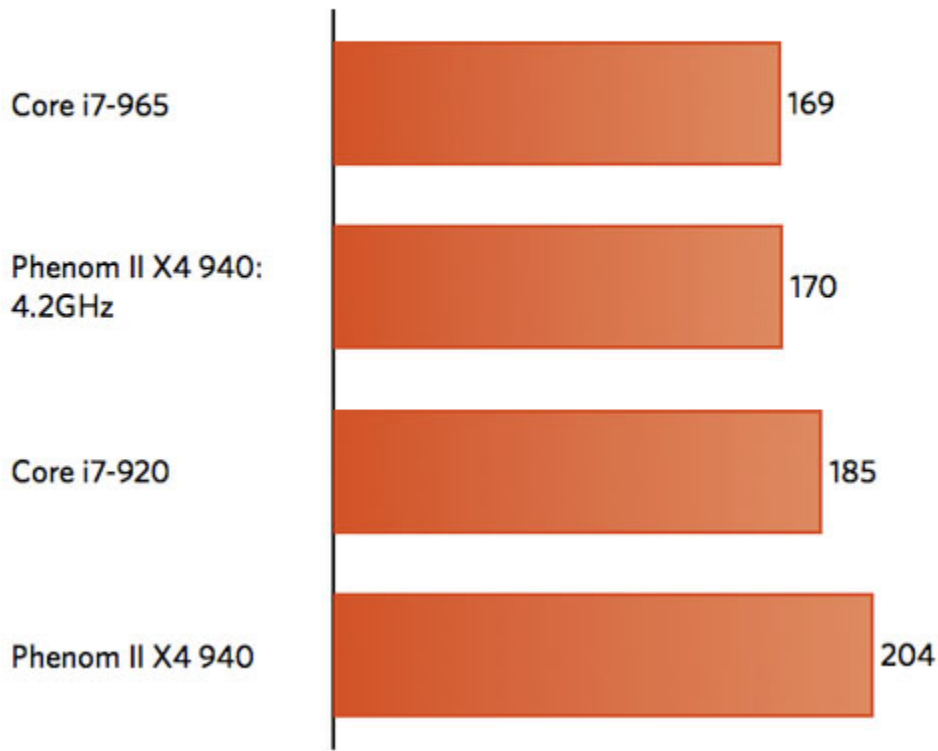
## Worldbench 6b2: Nero 7 Ultra

Seconds, lower is better



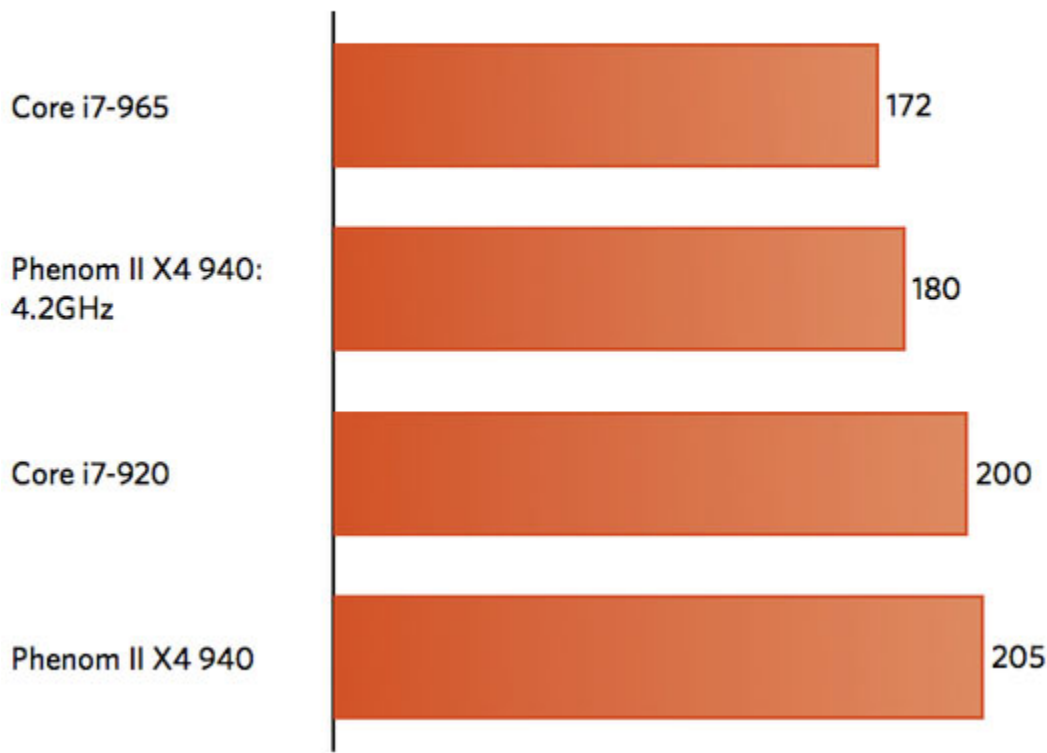
## Worldbench Roxio Videowave 1.5

Seconds, lower is better



## Worldbench 6b2: WinZip 10

Seconds, lower is better



ars

## Photoshop CS4

I tested three separate benchmarks and tabulated total run time. First came an Adobe CS2-era test developed by DriverHeaven a few years ago, one released by Retouch Artists, and the old classic, PS7bench. I used the default images provided in the DriverHeaven and Retouch Artists tests, but updated PS7Bench's image to a 9600x7200 uncompressed PNG that weighs in at just under 200MB. I did this partly as a means of ensuring the test remained at least marginally difficult, but also out of a desire to create meaningful, measurable differences between processor performance. Photoshop can be set up to measure the time it takes to perform any particular filter or action, but the program only reports to the nearest tenth of a second.

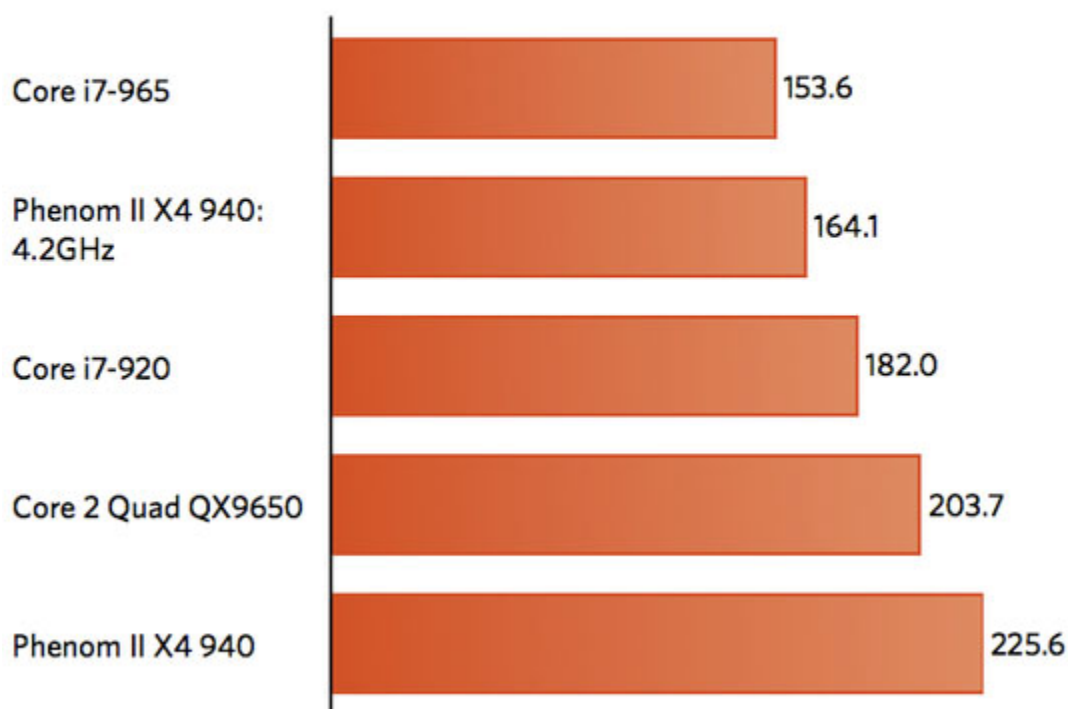
Note: OpenGL acceleration was disabled for these benchmarks. Other relevant settings included:

- History States: 1
- Cache Levels: 4
- Memory Allocation: 75% for both DriverHeaven and PS7Bench. Retouch Artists specify that 100% of available memory should be available to Photoshop, and we followed that instruction.

The machine was rebooted for each Action run; all actions were run 3x and averaged.

## Photoshop CS4, All Tests Combined

Seconds, lower is better

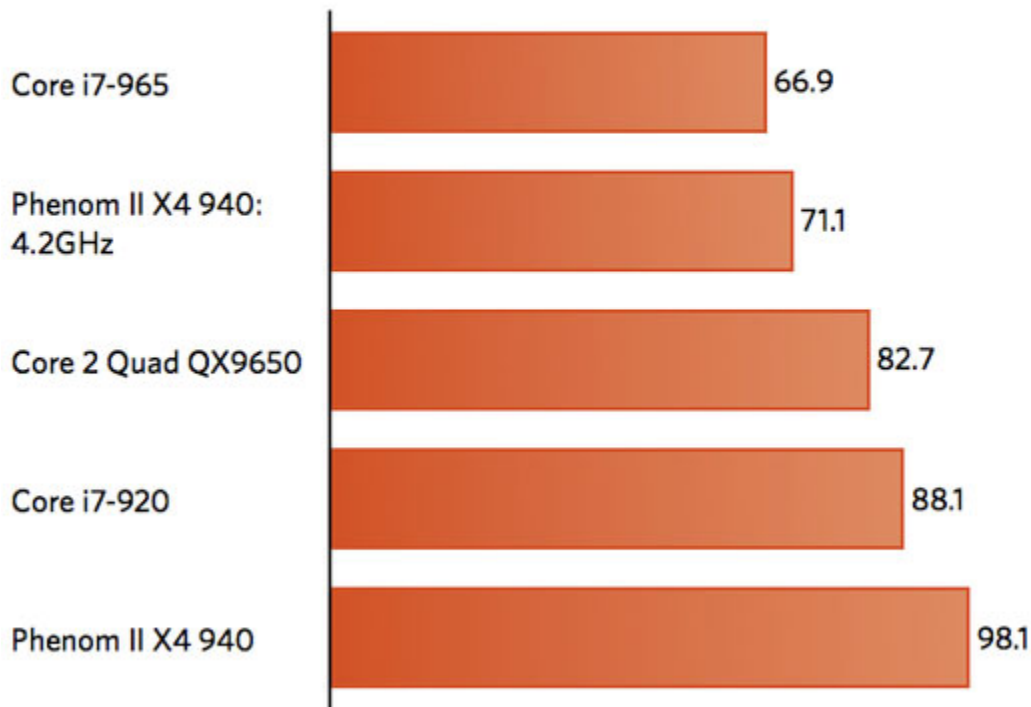


In the interest of fairness, I should note that the Phenom II X4 940 is markedly faster than the QX9650 when applying a watercolor filter (29.7s vs. 39.2s) and in the Accented Edges Brush Strokes test—11.4s vs. 17s for the other chip. Photoshop and our Deneb 4.2 are good friends, but AMD can't quite catch Intel's best, even when overclocked.

I've broken out results for PS7Bench and DriverHeaven below. Since we're evaluating the tests in terms of time-to-completion, PS7Bench carries more weight than DriverHeaven—it's the longer test. Note that while Phenom II and Nehalem separate out by approximately the same percentages in the two tests, the QX9650's performance standing jumps dramatically. The implication here is that certain tests included in the older PS7Bench stress memory bandwidth in a way that exposes the weaknesses of the Core 2 Quad's platform.

## Adobe Photoshop CS4: DriverHeaven Test

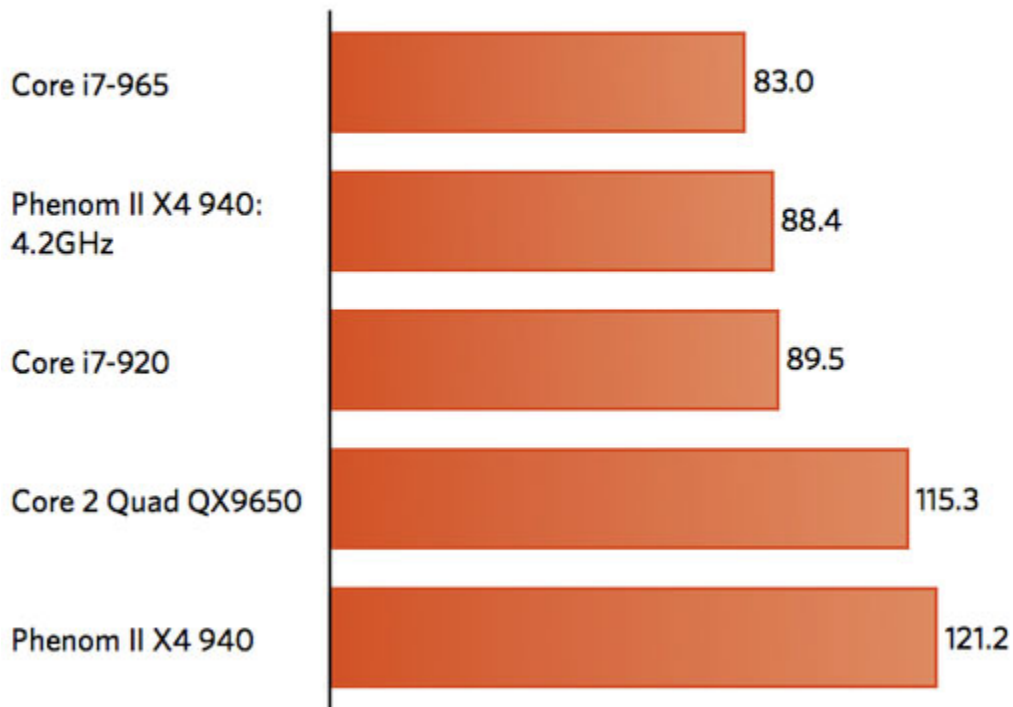
Seconds, lower is better





## Adobe Photoshop CS4: PS7Bench

Seconds, lower is better



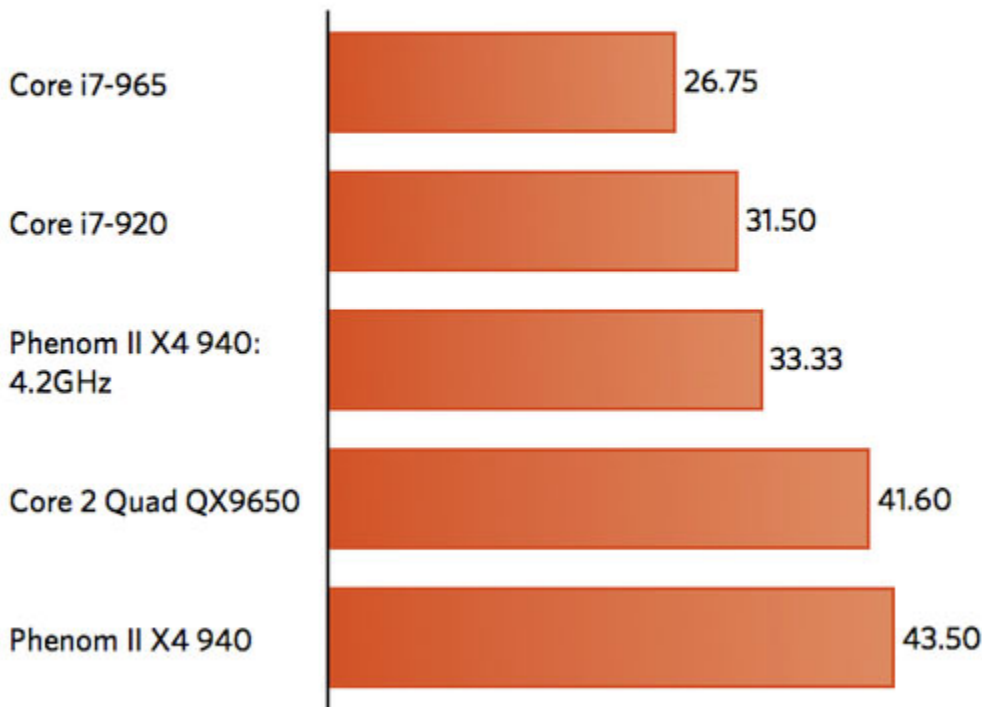
## Handbrake 0.9.3

We've upgraded to Handbrake 0.9.3, as it uses a much newer version of libx264 than Handbrake 0.9.2. The newer version of the program packs in some Nehalem optimizations, and made a difference in that CPU's time-to-encode. I tested with all video settings at default (2-pass encode, turbo first encode enabled) and set audio to rip in MP3 with a 320 bit-rate. After seeing the results here I also checked the other audio encode methods to ensure there was no hidden variable effecting performance. Encode time varied slightly as a result, but never more than a couple of minutes.

I chose to rip and encode the movie Stargate: The Ark of Truth—if you haven't seen it, you should definitely buy a copy (assuming you're a Stargate fan. Then again, who isn't?)

### Handbrake 0.9.3

Minutes (Lower is Better)



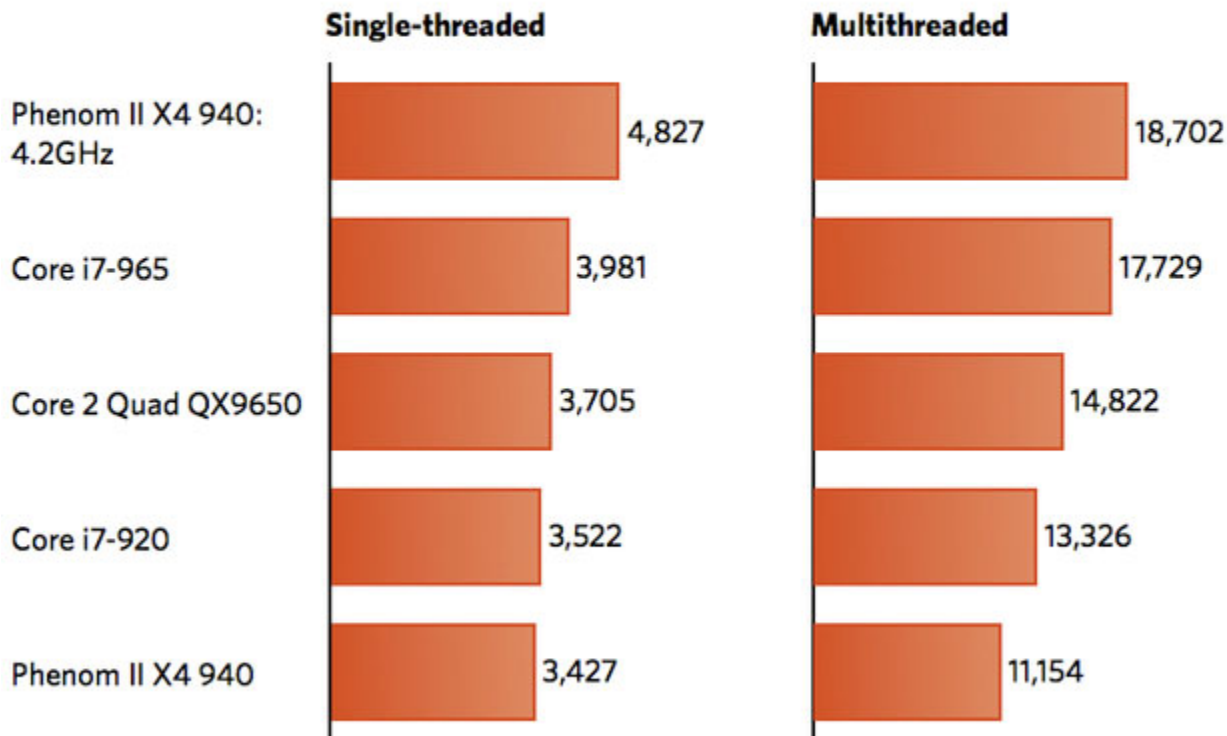
The Core i7 actually takes a hit here compared to what we saw with 0.9.2; encode time is now 26 minutes, 44 seconds compared to 22 minutes, 50 seconds in the earlier version. I didn't have time to retest the QX9650; the values here are based on 0.9.2, not .3. Based on what we saw from Nehalem, the QX9650's performance may have shifted a few percent upwards or downwards—the Phenom II X4 is in the ballpark of the Core 2 Quad's performance. Again, Deneb 4.2GHz puts up a valiant effort but can't quite catch the Core i7-920. Even if its encode time is now a bit longer; Core i7 965 still leads the pack.

## Cinebench R10

Cinebench is a staple of the review circuit, and is included here as such. This rendering test is developed by Maxon and based on that company's Cinema 4D R10 rendering/design package. In theory, this means the performance trends and results we observe in Cinebench should apply to Cinema 4D as well. We used the 64-bit version of the test and set the number of rendering threads to Auto.

### Cinebench R10 64-bit

Higher is better



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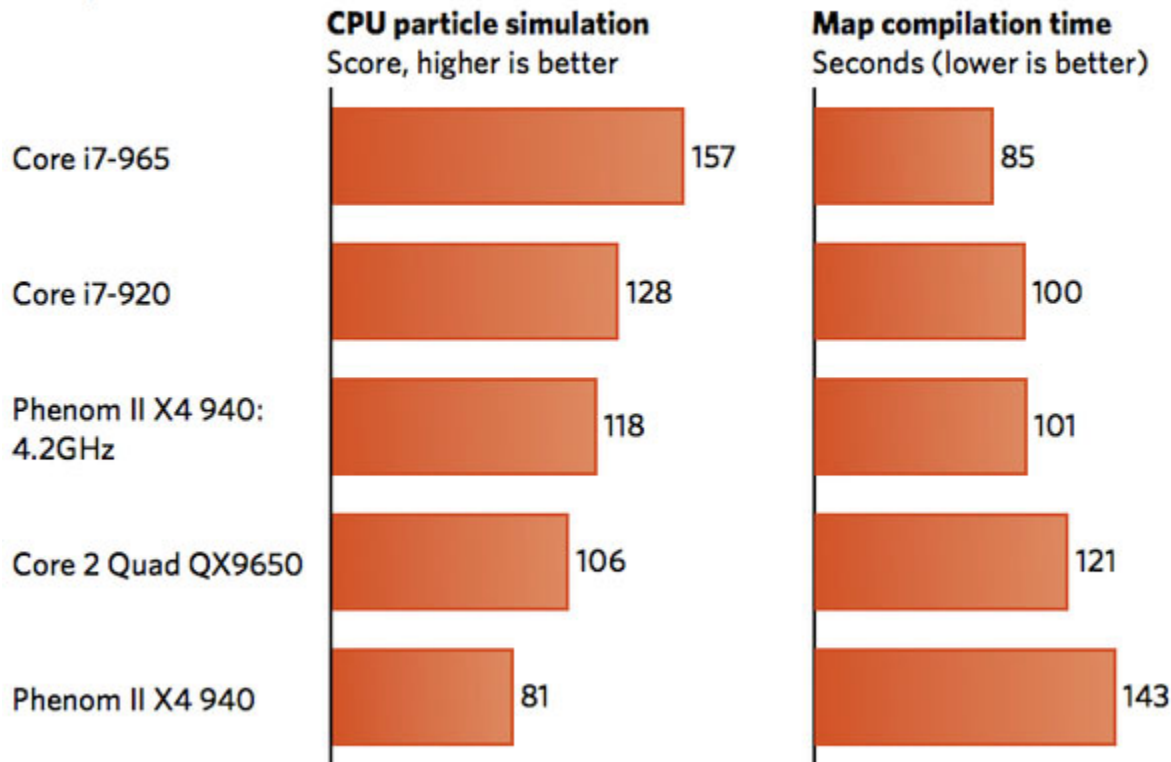
Phenom II's rendering performance is solid if not spectacular. The QX9650 scales more effectively than Phenom II 940 here, but it's also a much more expensive processor. The Nehalem-based processors outstrip the other architectures—rendering programs tend to love HyperThreading; Cinebench is no exception.

Our frozen Deneb shines here and outstrips even the Core i7-965 by 21 percent. The i7-965 reclaims its lead position once HyperThreading is again available, but 4.2GHz of Phenom-y goodness give it a run for its money; Deneb 4.2 misses the checkered flag by 5.5 percent.

## Valve particle simulation and map compilation benchmarks

### Valve hardware tests

MB per second



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Valve's hardware tests are several years old at this point, but both scale well across multiple processors. The map build test is exactly what it sounds like, while the CPU particle test asks the processor to render several complex scenes with a great deal of collision/movements occurring within them.

AMD's Athlon 64 X2 and Phenom processors have often struggled with both of these tests; the results here show that hasn't changed. Core i7-965 is running at nearly double the speed of the Phenom X4 940. It's not just HyperThreading, either—even the QX9650 is ahead by 31 percent. Our overclocked Deneb closes the gap and bests the QX9650, but can't catch the Core i7-920 in particle simulation and only ties it in the map compilation benchmark.

### How we benchmark games

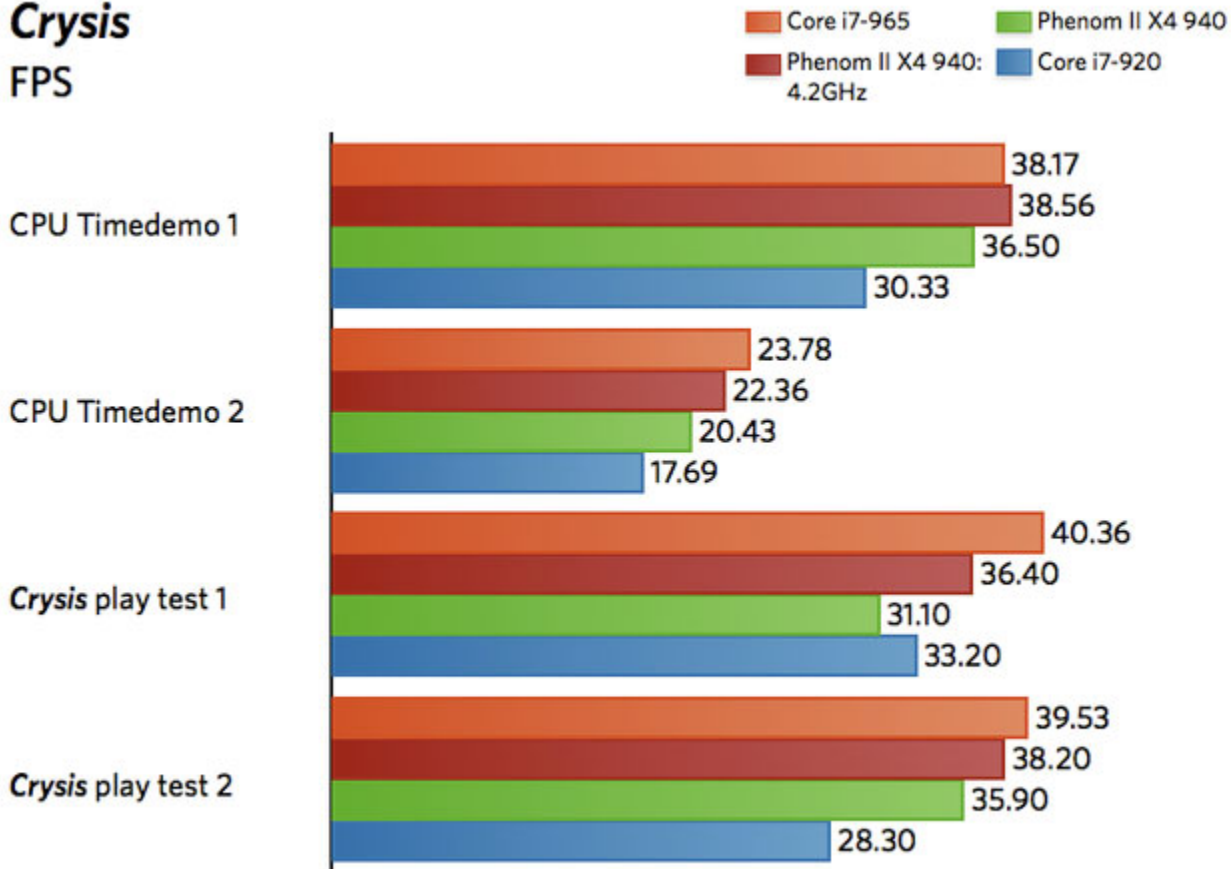
Here's the point in this review where we take all the other performance characteristics we've observed and throw them out the window. Games present a unique benchmarking challenge in that quality settings can be adjusted to yield almost any type of comparison. Games almost never take advantage of quad-core CPUs, which makes single/dual-thread performance more important.

The bottom-line is that I, the reviewer, can make the graphs say *nearly* anything. There's a practical limit—a single-core 1.6GHz Sempron or equivalent Celeron isn't going to match a \$200 quad-core—but the vast majority of games are video-card bound before CPU performance becomes a major issue. Using extremely low settings and resolutions throws the burden back on the CPU, but inaccurately models performance—no one invests in \$200 quad-cores to play games at 800x600 all graphics low unless you happen to own a system based on Intel integrated graphics and don't have a PCIe x16 slot.

I've opted to generally test in 1280x1024 with 4xAA enabled and game settings at "High." AA was enabled in-game rather than on a driver-level. (Unreal Tournament 3 is an exception to this, as I'll cover). Ya'll have requested that I do more in-game testing; that's been added as well. Unreal Tournament 3 and Assassin's Creed are new additions to the list of games we test—if you've got requests for other games you'd like to see evaluated, drop them in the comments.

## Crysis (64-bit)

### Crysis FPS



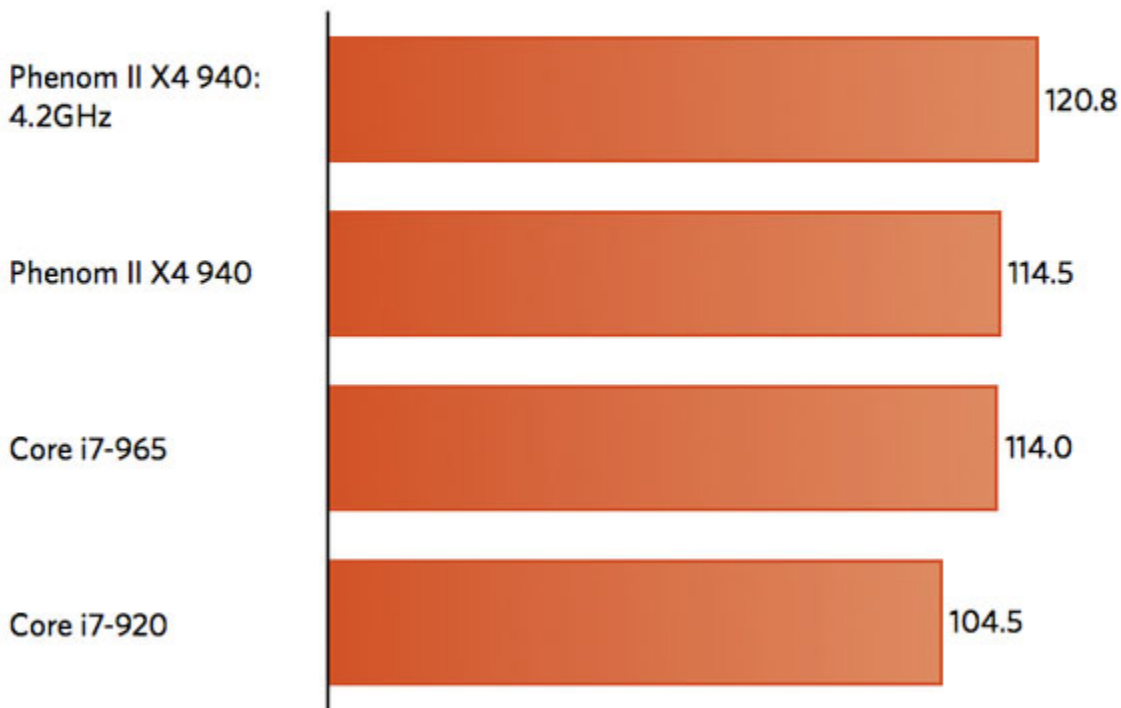
I ran through both Crysis' CPU tests (both are timedemos with a heavy and even heavier emphasis on physics and particle effects), then ran a set of play sessions through the game as well. I played through each saved game session several times, doing my best to replicate my path and actions. Game graphics settings were "High", 4xAA was enabled in-game. Deneb shines in all four tests; the Phenom II X4 940 beats the Core i7-920 overall. Our overclocked 4.2GHz processor doesn't quite beat the Core i7-965, but ties it in three of our four benchmarks.

## Call of Duty 4

I played through the last mission of the game, "Game Over." I chose this particular mission after field-testing several others, including several missions that take place in larger, more open areas. There are several qualities about "Game Over" that make it a solid benchmark. First and foremost, the path the mission follows plays out the same way each time. In this particular game segment, the player is tasked with defending an escaping jeep from multiple attack waves. The jeep moves through the mission on a rail, and the various enemy troop transports arrive at preset times. All of this more-or-less requires that the player remain facing the rear of the vehicle.

### Call of Duty 4

FPS



Again, Phenom II does quite well here. The Phenom II 940 ties its \$1000 competitor while Deneb 4.2 wins it all. Crysis responded moderately to CPU performance, but Call of Duty 4 scarcely cares; increasing the Phenom II's clockspeed by 40 percent yields just a five percent framerate increase.

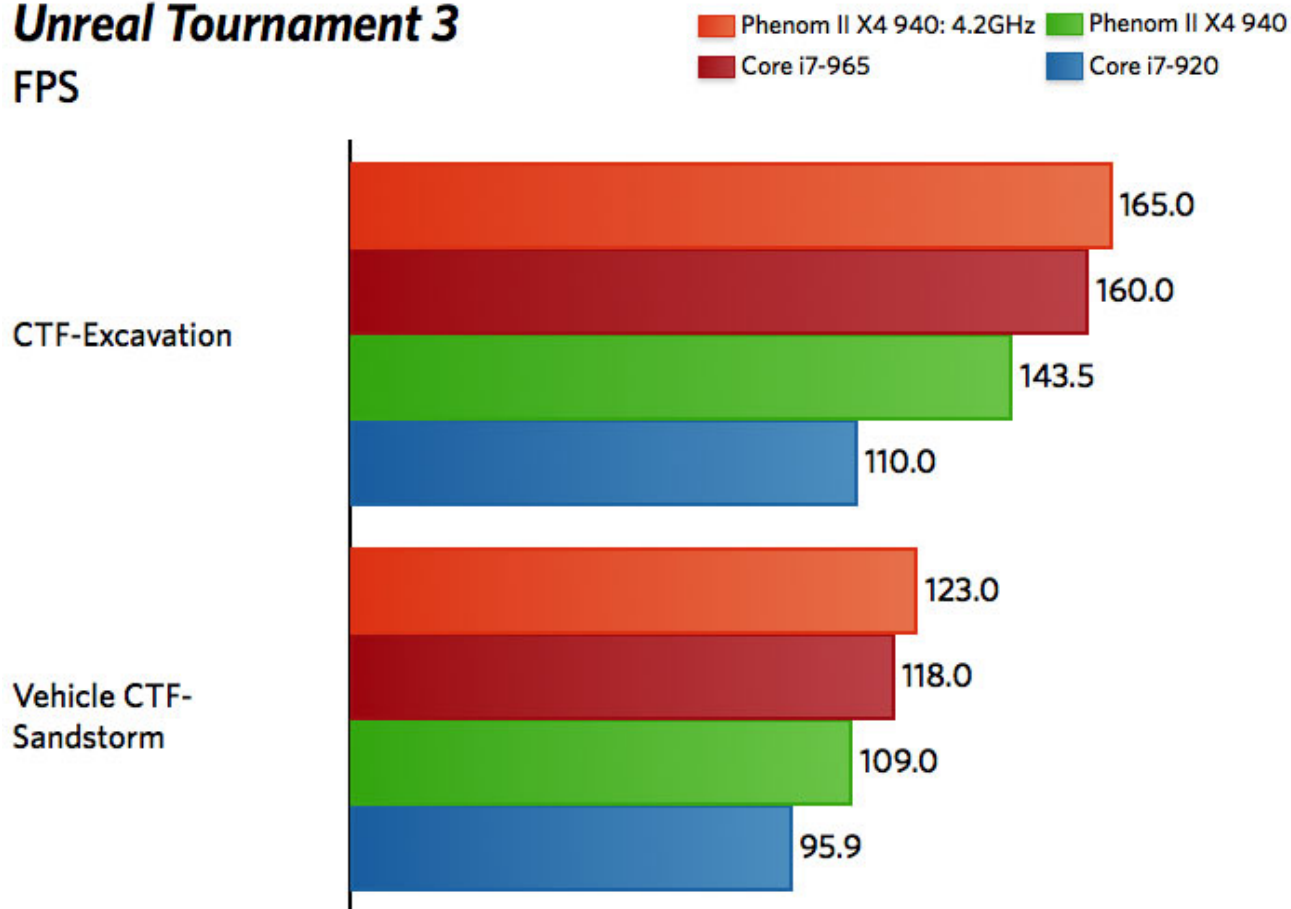


## Unreal Tournament 3

I tested two maps in Unreal Tournament 3, both with the maximum number of bots available (31). I tested one CTF map from UT3's unofficial bonus pack (TheExcavation) and one Vehicle CTF map (Sandstorm). I played through complete sessions on both maps and ran through each map three times.

### Unreal Tournament 3

FPS



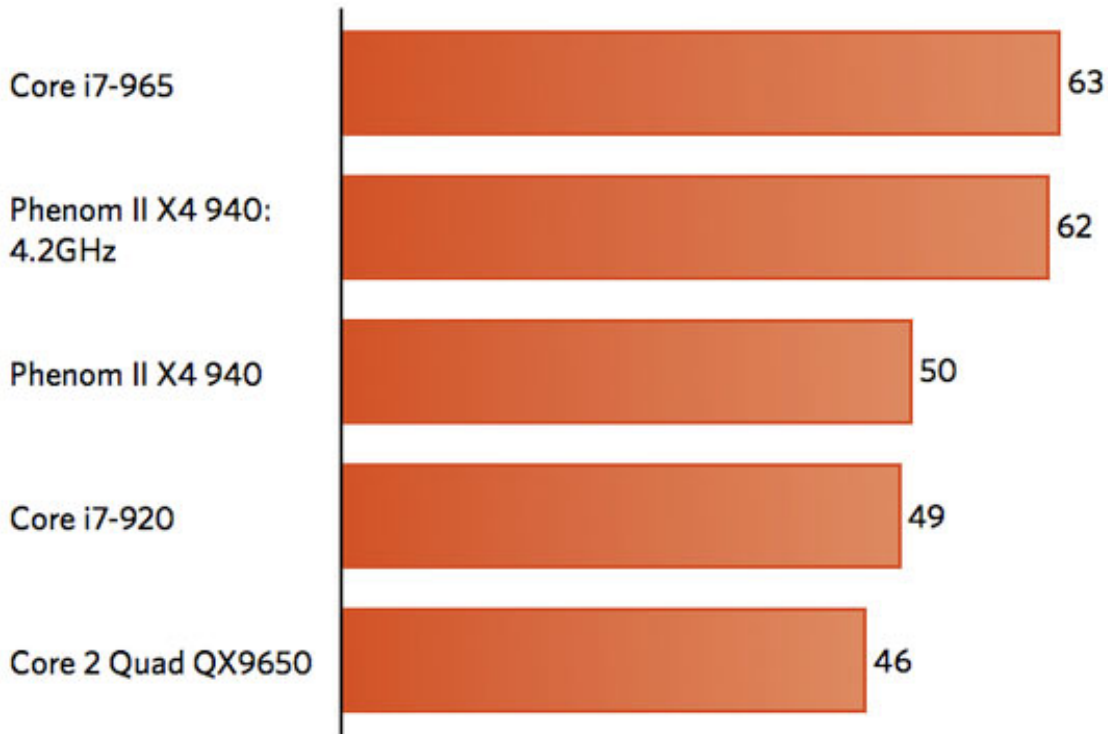
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Unreal Tournament 3 scales differently depending on which maps you use. Excavation is clearly CPU-bound; upgrading to the Core i7 965 boosted framerates by a whopping 45 percent over the 920 (which honestly seems to run low here). Core i7 920's performance is much more in-line with what I'd expect in Sandstorm. At 4.2GHz, Deneb takes both tests, but the i7-965 puts up a tough fight regardless.

## World in Conflict

### *World in Conflict*

Score (higher is better)

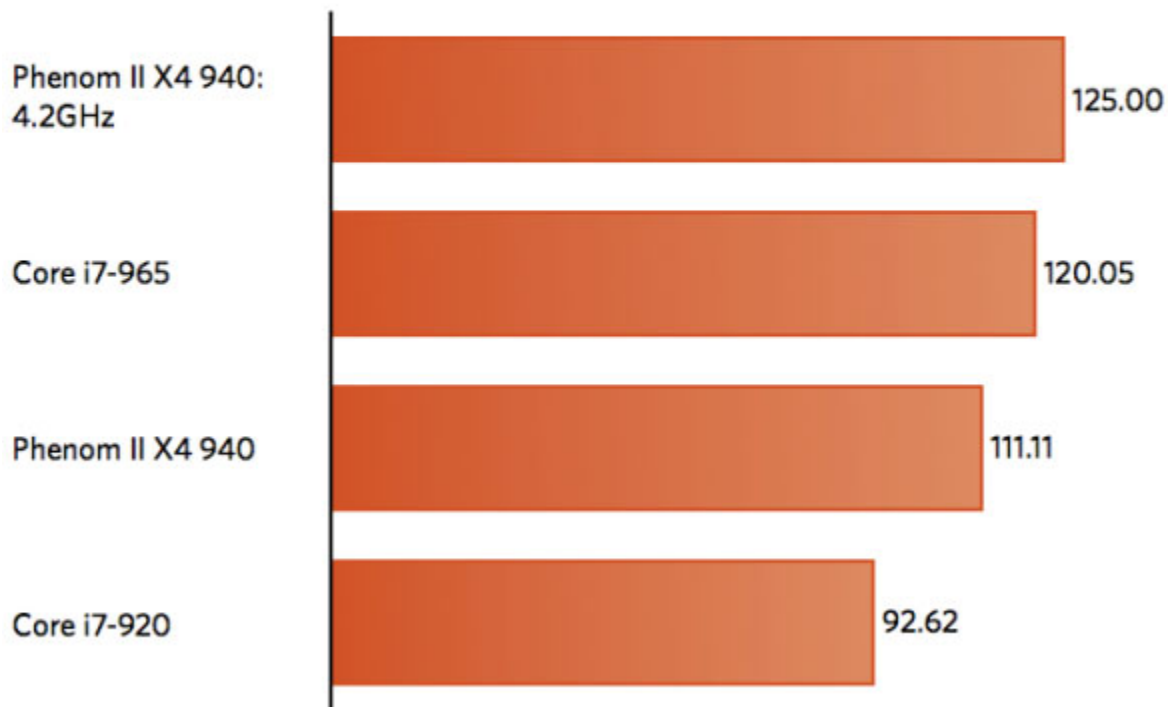


World in Conflict is a benchmark I've found extremely useful when testing overall system performance; various aspects of the game are impacted by both video card and CPU. In this case, Phenom II 940 and the i7-920 tie it up with the QX9650 a few fps behind. The Core i7-965 ekes out a narrow win, with our frozen Deneb hot (heh) on its tail.

## Assassin's Creed

### *Assassin's Creed*

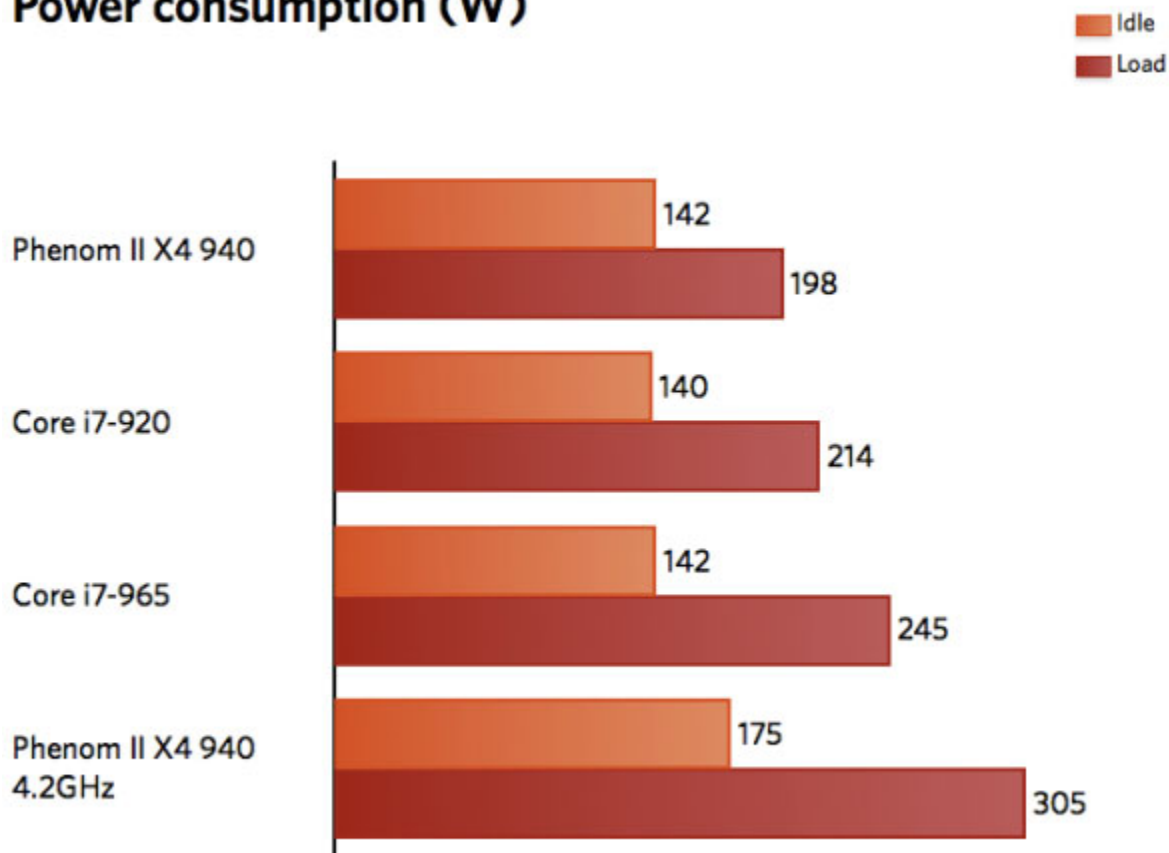
FPS



We benchmarked the patched version of Assassin's Creed (aka, the version that uses DX10.0 rather than DX10.1. The X4 940 is a worthy gaming competitor, even at settings that stress the CPU more than the GPU.

## Power consumption

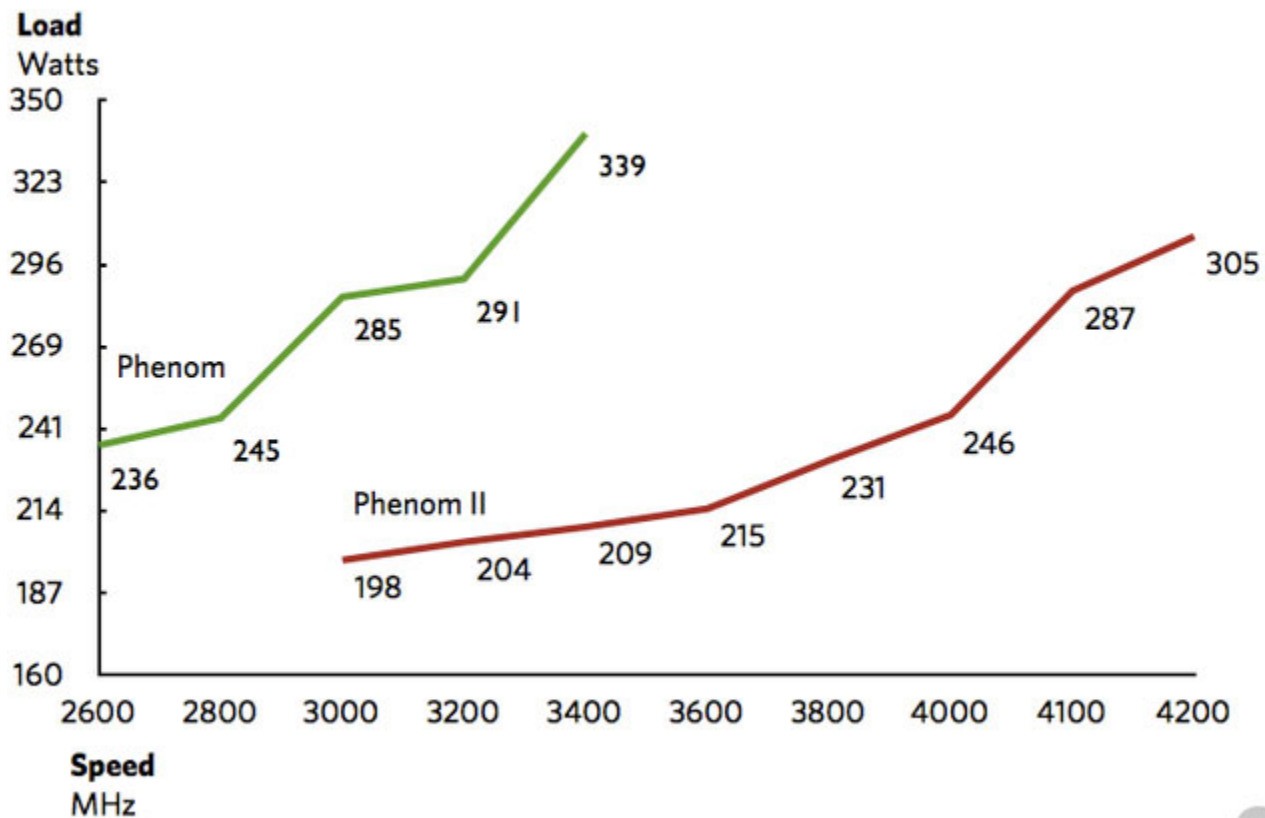
### Power consumption (W)



All power consumption figures are based on total system power as drawn at the wall.

Power consumption for the various processors are given above at both idle and load. Shanghai is a dramatic improvement over AMD's 65nm Phenom (we'll examine that in a moment) and pulls slightly less power at load than Intel's Core i7-920. Power consumption is measured using DIEP with that program configured to run across four or eight cores (depending on the system). We had to run our Deneb at a Vcore of 1.70v in order to hit 4.2GHz and the CPU's power consumption shows it; Deneb 4.2GHz is the most power-hungry of the bunch.

## Power Consumption Scaling



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The graph above compares Phenom's scaling vs. Phenom II's in terms of clockspeed per watts of power consumed. The steep jumps in both processors' power consumption occur when we raise the voltage; simply increasing the clockspeed creates a relatively small increase in power draw.

Phenom starts at 1.45v and 2.6GHz, the chip's first major voltage jump is to 1.55v at 3GHz. 1.55v stabilizes the chip at 3GHz and 3.2GHz, but 3.4GHz requires a further voltage kick (1.70v). IMC remains clocked at 2GHz in all cases.

Phenom II runs at 1.35v and 3GHz by default; the chip holds this voltage (and stock IMC speed) until 3.6GHz. 3.8GHz required a voltage tap up to 1.40v; IMC speed was increased at this point from 1.8GHz to 2.4GHz. We hit 4GHz on 1.50v and 4.2GHz on 1.70v. At this point, the IMC was running at 2.53GHz, and this required a northbridge voltage of 1.45v.

There's no question regarding which CPU consumes more power as clockspeeds and Vcore rise. At 3.4GHz—just 30 percent above stock clockspeed and with a stock-clocked IMC—our Phenom I is pulling 10 percent more power than Deneb, despite the fact that the latter is running both IMC and core clock 40 percent above stock. Phenom I's IMC voltages, meanwhile, are set to "Auto", while Deneb's were pushed to 1.45v (as high as the Asus board allowed).

Based on these results, we can expect to see AMD scale Phenom II more aggressively than Phenom; the latter barely budged from launch speeds. Clockspeed and voltage increases, however, are simply not the way forward for AMD. The company should have room enough to keep pace with its current midrange market target over the next 6-12 months; Deneb's efficacy beyond that point is questionable.

## Conclusion

Make no mistake, I like AMD's new 45nm Opteron and Phenom II CPUs immensely. They're competitive at their current price points and as we've seen here, they've got overclocking headroom to spare. According to AMD, retail parts actually OC better than the press sample we received; a different chip might have hit 4.4-4.6GHz. I feel comfortable saying that I agree with the positive commentary from other reputable websites—Phenom II puts AMD back on the map, and gives the company a competitive solution against Core 2 Quad for the first time in several years. Thanks to Phenom II, AMD's second-generation Dragon platform is a very good choice for gamers or anyone who wants decent integrated performance for now with the ability to step up later.

Deneb's comparative performance against the Core i7-965 and Core i7-920, however, is rather troubling. Even at 4.2GHz and with an IMC running at 2.53GHz (1120MHz memory clock), Deneb doesn't always outperform Intel's lower-end, 2.67GHz solution, much less the top-end i7-965. It's true that the i7-965 is a \$1,000 part today, but a Deneb clocked at the rates we tested (if such a thing existed for the commercial market) would run at least \$1K as well.

Our data indicates that AMD has a long-term problem it's not going to be able to solve with clockspeed. The company's next 45nm refresh will have to include architectural improvements that result in significantly higher performance clock-for-clock—bolting more L3 cache on the core isn't going to be the magic answer. Socket AM3 arrives soon with support for DDR3-1300, but that's no silver bullet, either—desktop applications tend to be latency-sensitive, not bandwidth-limited. Meanwhile, both CPU manufacturers have reportedly reduced the rate at which they intend to push customers towards DDR3 platforms thanks to the current economic environment.

Whether AMD can even survive the current recession is itself in question; the company is in dire financial straits. AMD has slashed jobs, sold off various pieces of itself, and announced still more layoffs after releasing its fourth quarter 2008 results. CEO Dirk Meyer pledged to return to profitability in the second half of 2009, but *simultaneously* announced that the company would reduce its break-even point to \$1.3 billion dollars, down from \$1.5 billion. That sort of reduction means spending cuts and layoffs across the board, leaving fewer and fewer people to handle an increasingly desperate situation.

Today, right now, Deneb is great, especially for gaming. AMD could conceivably relaunch a gaming-centric Phenom II FX chip without watching it get laughed off the market (provided it was relatively cheap). Down the road, things don't look even half so certain. Even if Deneb picked up an additional 15 percent performance clock-for-clock right now, it *still* wouldn't be enough to put the chip on an even footing clock-for-clock with the Core i7-965. That's a problem AMD has to solve on a shoestring budget in the worst economic conditions we've seen in decades. Good luck.