ATHLON WINS RACE TO 1GHZ BY HAIR

In Virtual Dead Heat, AMD and Intel Break Barrier Ahead of Expectations

By Keith Diefendorff {3/13/00-02}

AMD must be starting to really annoy Intel. Amidst rumors that AMD would announce a 1GHz Athlon at the end of this month, Intel accelerated its 1GHz Pentium III announcement by several months, to March 8, in an effort to preempt its ambitious rival.

But its effort fell short. Desirous of the leadership position and marketing capital that would accrue from reaching the mystical 1GHz mark first, AMD put on a final burst of speed to edge out Intel by the slimmest of margins: two days.

Left to their own devices, we suspect that neither company would have announced 1GHz parts so soon. But competition being what it is, the lure of the 1GHz winner's circle sucked both companies in, causing them to announce products they probably would not have otherwise launched. Which company forced the other's hand first isn't clear. But AMD may have hoped to pressure Intel into making another mistake, as it did when it forced the company to prematurely announce 800MHz parts. While such pressure succeeded in putting Intel into a serious supply bind at that juncture, AMD will probably not be lucky enough to catch Intel flat-footed a second time.

In fact, both companies are claiming adequate yields to meet all near-term demand for 1GHz parts. AMD said it would ship "hundreds of thousands" of processors in the second quarter at 900MHz and above, with a "significant portion" at the 1GHz speed. Intel said it would ship limited volumes in the second quarter, ramping to high volume by the beginning of the third quarter.

Several large OEMs have already taken delivery of 1GHz parts from both companies and have committed to shipping boxes forthwith. On the day of AMD's announcement, both Compaq and Gateway announced the availability of 1GHz Athlon systems. Dell, HP, and

IBM did the same with Pentium III-1000 systems on the day of Intel's announcement.

Athlon Is One Hot Processor

Both AMD and Intel seem to have made the jump to gigahertz speed with little difficulty. The 1GHz parts from both companies are apparently the same as their current 800MHz parts, the only changes being voltage tweaks. Intel had to boost its core voltage slightly from 1.65V to 1.7V. AMD boosted Athlon's core voltage from 1.6V to 1.7 when it delivered its 800- and 850MHz processors, and it had to boost the voltage another 6%, to 1.8V to coax Athlon the remainder of the way to 1GHz.

That's not good: the increase in frequency from 850MHz to 1,000MHz brings with it a 17% increase in power dissipation, and the 0.1V voltage boost adds another 12%. With the Athlon-850 already at a sizzling 45W (typical), the new 1GHz Athlon will consume almost 60W. Luckily, power dissipation in this range isn't a debilitating defect in the performance-PC and workstation markets that AMD is initially targeting. It is a problem for AMD, however, as its Pentium III competitor throws off only a fraction of Athlon's heat. At 800MHz and 1.65V, the Pentium III runs at a cool 18W (typ), which will translate to about 23W at 1GHz and 1.7V—much less than half the power of the Athlon-1000 at 1.8V.

This power difference is remarkable, considering that both parts use an aluminum 0.18-micron process and both

operate at the same core voltage. AMD has never satisfactorily explained Athlon's high power dissipation, but the reasons for it might also explain why Athlon appears to have somewhat more frequency headroom than the Intel part. Compaq's Alpha 21264 microprocessor, which bears a striking resemblance to Athlon through the common influence of Athlon's chief architect, Dirk Meyer, is also not known for its low power, but it is famous for its high frequency.

AMD Wins, But Loses

AMD's effort to beat Intel to 1GHz is to be commended. Beating Intel at anything is an impressive feat. But Athlon appears to have lost ground to Pentium III in terms of performance. While it is still too early to get a clear picture of the performance situation, the benchmark results so far indicate that the Pentium III-1000 will outscore Athlon-1000 by a convincing margin on virtually every mainstream PC benchmark, as it does at the 800MHz level. The gap is likely to be even wider at 1GHz than at previous speeds, however, due to the fact that AMD had to slow Athlon's external L2 cache speed another notch (from a 2:5 to a 1:3 ratio to core frequency) to accommodate commodity SRAMs.

This situation must be frustrating for AMD. Knowing that Athlon has a superior core microarchitecture (see *MPR 10/26/98-01*, "K7 Challenges Intel"), and probably more frequency headroom, makes the benchmark results even more distasteful. Unfortunately for AMD, however, the pesky issues related to memory, chip sets, and software factor heavily into benchmark results. On all three of these fronts, AMD lags far behind.

On the memory front, Pentium III's smaller, but faster, on-chip L2 cache is superior to Athlon's larger, but slower, external L2 cache for most benchmarks and PC applications. Furthermore, Pentium III's cache scales perfectly with core frequency, while Athlon's does not. Athlon's deficiency in this regard will not be remedied until the second half of the year, when AMD delivers Thunderbird, which will have a 256K on-chip L2.

Another performance problem for AMD is chip sets, which are tossing much of Athlon's performance onto the trash heap. Although Athlon has a faster system bus than Pentium III (200MHz vs. 133MHz), this advantage is nullified by AMD's 750 and VIA's KX-133 chip sets, which do not offer the memory throughput of Intel's now-ancient 440BX or its newer 820 with RDRAM memory. As a result, Athlon's 50% theoretical advantage in system-bus bandwidth is for naught. Such is the lot of a company stuck with a system-bus standard different than Intel's.

Software presents a third problem area for AMD. Today, most benchmark code is created and optimized for the Pentium III microarchitecture. This situation is likely to get worse rather than better: for example, software vendors are increasingly optimizing their multimedia applications for Pentium III's SSE, making Athlon's 3DNow hardware more irrelevant each day.

How Did Intel Get Into This Mess?

While Pentium III may outperform Athlon on benchmarks, AMD is hot on Intel's heels and is pushing the leader faster than it would like to go. If nothing else, with the original Athlon, the 800MHz Athlon, and now with the 1GHz version, AMD has put Intel into a far more reactive mode than it has ever been in. If AMD can keep up the pressure, it could force Intel to make more mistakes that AMD could potentially exploit.

The question of how Intel allowed AMD to get so close in the first place is one that is probably asked repeatedly in the executive conference rooms of Intel's Robert Noyce Building. The answer seems clear: Intel underestimated the threat from AMD and, because of indecision and internal conflict, it failed to have its next-generation core ready in time to head off Athlon.

But deep pockets make Intel a resilient company. By pouring massive design resources and advanced IC processing into Pentium III, Intel has managed to match Athlon's frequency at each step and stay ahead in performance. Once Willamette appears, Intel can aggressively push Pentium III down into the low reaches of the value and mobile segments, clobbering the K6 family. This will force AMD to respond simultaneously at both the high and low ends of its product line. With nearly empty pockets, AMD will be hard pressed to mount multiple designs to meet this threat.

The current performance situation should be a lesson for AMD. Because of cache, chip-set, and software deficiencies, the company cannot get away with simple frequency parity in the CPU. If AMD wants to legitimately claim performance leadership, or even just equality, it must sustain a clear frequency advantage over Intel. Beating Intel to 1GHz by 48 hours is a good thing, but hardly enough to make a sizable difference in AMD's prospects.

On the other hand, considering Intel's strengths—which the industry correctly views as nearly overwhelming—just matching Intel puts AMD in a positive light. Over time, assuming it can keep the pace, AMD will break down more barriers and penetrate new OEMs and markets, allowing it to sustain a profitable business. If all AMD can muster is parity, however, Jerry Sanders' goal of 30% market share is likely to remain elusive.

Who Needs a Gigahertz Anyway?

The irony for both companies is that the demand for 1GHz PC processors today is vanishingly small, and the battle in which the companies are engaged is largely self-created. As with muscle cars, the battle is more one of egos and bragging rights than one of meeting customer demand. The humbling fact is that most of today's PC software runs fine on a 600MHz processor, and the prospects for software that demands—or can even utilize—1GHz processors is bleak. This situation isn't likely to change until a sizable installed base of such machines is in place to attract software vendors, putting demand a year or more away.

In the meantime, AMD and Intel will try to drive 1GHz processors into markets that have low volume requirements, high performance sensitivity, and low price sensitivity. Low volume demand is desirable because initial manufacturing yields are usually poor, which makes for low capacity and high costs. Performance sensitivity and price insensitivity allow a processor vendor to charge high prices to cover high manufacturing costs and recoup development costs. AMD says it is focusing its initial efforts on professional users of performance PCs and workstations. Intel says it is concentrating on home enthusiasts.

Surprisingly, the companies have taken different pricing strategies. AMD, evidently quite proud of its processors, priced its new speed grades well above its current crop of processors (850MHz and below). The Athlon-1000 in quantities of 1,000 units lists for a whopping $1,299; the 950 and 900MHz parts will list for $999 and $899, respectively. Intel is being far more aggressive with its pricing, listing its 1GHz part at $990; no processors were announced for the space between the 800MHz and 1GHz versions.

The aggressiveness of Intel's price is curious, especially since Intel was aware of AMD's $1,299 bogie at the time of its announcement. Conventional wisdom would call for Intel to charge as much as possible for a part that it hopes it won't have to ship in high volume. Perhaps Intel became aware of AMD's price too late to change its plans. Or perhaps, knowing that AMD would have to drop its price to match, Intel chose to sacrifice its own short-term margins to damage AMD's. The loss would not be large for Intel, since it doesn't plan to sell many 1GHz processors in the near future anyway, and it can certainly afford such a gambit more easily than AMD can afford to respond.

Regardless of the reasons for Intel's surprisingly low price, AMD will have to correct the disparity quickly. But doing so puts AMD in an awkward position. It must squeeze three processors into the narrow $250 gap between its 850MHz part and Intel's 1GHz part. Although such a squeeze might be uncomfortable for AMD, it may be preferable to lowering prices across the product line to make room for three new speed grades at the top.

Continued Frequency Growth Likely

Despite the lack of pull from consumers, the drive toward higher frequency is likely to continue unabated for the foreseeable future. Since the market seems to have decided that frequency is the metric by which it prefers to value processors, chip vendors have focused on delivering megahertz, even at the cost of other equally important factors. As a result, we expect to see more companies follow Intel's lead with Willamette, which will trade off instruction-level parallelism to stay on the frequency curve.

Over the past several years, frequency has compounded at a rate of about 60% per year. While the jump to 1GHz appears to represent an uptick in this rate, it is probably an anomaly created by the companies' drive to cross the mark first. Now that both companies have achieved this goal, they will probably relax somewhat to let manufacturing yields catch up with marketing. In general, however, frequency is likely to continue its 60% compound annual growth for at least the next couple of years. If it does, vendors will make the next leg to two gigahertz in about 18 months, nearly 30 years faster than the one-gigahertz leg.

AMD's Win Too Thin

Although the 1GHz mark is a important milestone in microprocessor history, the emphasis placed on it by the press and by the contestants has been out of proportion to its actual significance. In point of fact, there is nothing any more remarkable about 1,000MHz than any other frequency—except the number of decimal digits. As a result, winning the 1GHz race is not likely to have the same long-lasting impact as breaking the sound barrier or stepping first onto the moon.

Moreover, the fact that the race was virtually a dead heat, and that the winner will be further obscured by the inevitable debate over which company actually shipped the first 1GHz system, makes AMD's victory rather hollow. If the company had won by a significant margin, say several months, it might have taken the victory to the bank. But, while it may have bruised some egos over at Intel, AMD's margin of victory was too thin to damage Intel in the market. ◇