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2001 PC Survivor Challenge

AMD and Intel Continue Battle, Transmeta Hits Glitch

By Kevin Krewell {2/11/02-01}

The year 2001 was a tough odyssey for the PC industry—a year in which the market contracted and average selling prices (ASP) suffered. After Intel released the long-awaited Pentium 4 in 2000, it became, in 2001, the industry's first PC processor to reach 2GHz. Intel also began transitioning to the 0.13-micron semiconductor process about nine months ahead of AMD. AMD rolled out the Palomino core and resurrected an updated version of the performance-numbering (P-rating) scheme to keep pace with the Pentium 4's higher clock speeds. Transmeta and VIA also made some news in 2001, offering 0.13-micron processors during the year; at last count, however, the two companies together accounted for only about 1% of the market.

The Upstarts

Transmeta, the new kid on the block, saw only meager sales in 2001. The company's high-profile Crusoe processor generated more controversy than actual sales. Crusoe allocates some of the system's main memory for code-morphing operations, and system performance has been shown to vary significantly, depending on application and code-caching history. Despite its shortcomings, Crusoe has appeared in some innovative mini- and subnotebook designs, providing excellent battery life, and Transmeta has high hopes for its new 0.13-micron TM5800. Unfortunately, a manufacturing glitch prevented Transmeta from shipping significant volumes of the TM5800 in 4Q01. Whether notebook vendors will stick with the single-sourced Crusoe processor after this debacle is yet to be seen. Of the group in 2001, Transmeta would likely be voted the "weakest link."

VIA launched its latest version of the C3 processor mid 2001. The chip is finding acceptance mostly in developing nations. We estimate that VIA sold between one and two million C3 processors in 2001. VIA, at least, could have won a game show entitled "Who Wants to Ship a Million Chips?"

VIA has been unable to keep pace with the clock frequency battle between AMD and Intel. At the end of 2001, the C3 was available at up to 933MHz, while AMD and Intel were at 1.2GHz for Duron and Celeron. VIA remains focused instead on reducing manufacturing costs. At 52mm^2, the 0.13-micron version of the C3 processor has the smallest die size of any PC processor in the business.

Neither Transmeta nor VIA had enough impact on the market during 2001 to justify nominating its PC processor for an award this year. After promising beginnings, both vendors have become largely irrelevant to the market.

Secret G4 Gigahertz Power

After the end of 2001, Apple released a Power MAC G4 with dual 1GHz G4 (MPC7455) processors. Each processor has 2MB of external L3 cache, using 500MHz DDR SRAM. Unfortunately, Apple's secretive nature kept us from evaluating the 1GHz G4 as a candidate for best PC processor of 2001. Motorola and Apple would be the stars if the show "I've Got a Secret" were revived.

While the G4 still lags in clock speed, the seven-stage pipeline, powerful AltiVec instructions, L3 cache, and silicon-on-insulator (SOI) semiconductor process make the chip effective on typical Mac content-creation applications. The MPC7455 is Motorola's first microprocessor fabricated in SOI. It is pin compatible with the current MPC7450, making the upgrade largely painless.

The previous best clock speed for the G4 (the Motorola MPC7450) was the 867MHz version in mid-2001.

No Rest for AMD

Recent research reports indicate that in 2001, AMD made some market share progress against Intel in desktop PCs and notebooks. That market share progress came at the expense of ASPs and profits. AMD delivered good products—but a little later than planned (see *MPR 12/26/01-01*, "AMD Maps Servers to 2003"). AMD will begin the transition to the 0.13-micron process almost nine months after Intel.

In mobile systems, AMD had an uphill battle against Intel's mobile Pentium III-M processors, as Intel offers something AMD cannot—a processor for every segment of the mobile market, from mini- to full-size notebooks. AMD will improve its ability to reach the thin-and-light notebook segment in 2002, when it releases the 0.13-micron Thoroughbred processor. Despite AMD's limited product line, it reached a market share of almost 40% of U.S. retail notebook sales. We wish AMD would put as much design effort into the mobile processor business, where it has a track record of success, as it is putting into larger servers with the SledgeHammer processor. AMD should focus on competing with Banias in 2003, where it has a reasonable chance of success, instead of putting so much effort into the uphill battle it will face in four-way and above servers.

AMD's Duron has provided excellent value and performance, and it was the first "value" processor to reach 1GHz on the desktop. AMD continues to use the same Socket A for value and performance processors, simplifying support. At the end of 2001, Duron (and Celeron) were at 1.2GHz, not too bad for value processors. The Duron processor, with its more recent microarchitecture, and with twice the bus bandwidth, easily outperforms the Celeron processor. We therefore nominated the Duron processor because of its terrific price and good performance. Duron also reached the mobile gigahertz realm in 2001.

AMD's flagship processor is Athlon. The latest version of Athlon is based on the Palomino core and was renamed Athlon XP. Athlon XP added SSE instructions, improved TLBs, prefetch, and reduced power consumption. The last factor was essential to increased frequencies and to keeping up with Intel, as the Thunderbird core was reaching a thermal barrier. AMD survived a slow Palomino rollout for the desktop, from the original 1Q01 schedule to 4Q01. AMD pushed the smaller Thunderbird core as long as possible, we assume, to reduce manufacturing costs.

We nominated Athlon XP because it has proved to be an excellent, scalable, and well-balanced processor, with very good floating-point performance (for an x86 processor). Athlon XP offers an excellent price and performance mix, despite the distractions of the model-numbering system.

Intel's Execution Recovers in 2001

In the two years before 2001, Intel had some difficulty delivering its platform technology. The task of integrating RDRAM technology into mainstream desktop PCs proved more complex and difficult than Intel expected. In 2001, Intel loosened its reliance on RDRAM with the 845 chip set, which supported SDRAM and, more recently, DDR SDRAM (see *MPR 9/17/01-02*, "Intel 845 Gives P4 Memory Choice").

One of the most interesting developments of 2001 was the details of Intel's Jackson technology. Officially named HyperThreading technology (see *MPR 09/17/01-01*, "Intel Embraces Multithreading"), the Intel-branded version of simultaneous multithreading (SMT) made its first formal appearance in the FosterMP processor, which began sampling in 2001. HyperThreading is present in the Pentium 4 microarchitecture, but it is not enabled in current parts. Available public information indicates that HyperThreading seems to be a good first attempt at adding SMT to a processor with a minimum of die overhead. The FosterMP processor is based on the Pentium 4 microarchitecture, and Intel has validated the concepts on the Willamette processor. HyperThreading will be able to extract more efficiency from the processor and therefore deliver more processing performance on multithreaded software. FosterMP should offer clock speeds nearing 2GHz and excellent processor front-side bus bandwidth. The 2GHz Xeon processor also produces excellent SPEC scores, surpassing the 800MHz Itanium on SPECfp.

To address the nascent blade-server market, Intel took its 0.13-micron mobile Pentium III processors and adapted them—sans SpeedStep—for blade-server designs. The lower power requirements of the low-voltage processors make them a good fit in blade designs. The new 0.13-micron Pentium III processor, code-named Tualatin, also offers a 512KB L2 cache and clock speeds up to 1.4GHz.

The Tualatin die has become the Swiss Army Knife of processors. Intel has used the die for mobile performance, mobile value, desktop performance, desktop value, and even low-end servers—a remarkable performance in adaptability for one processor design. Tualatin had a tough act to follow: Coppermine was also exceptionally versatile. It was Intel's first gigahertz desktop processor, and in 2001, it became Intel's first mobile gigahertz processor. When Transmeta challenged Intel on low power, Intel responded by adapting Coppermine. As excellent as Tualatin is, qualifying as one of our nominees for best PC processor of 2001, it's still just a stepping-stone to the next generation of Intel mobile processors: Banias.

One of the biggest stories of 2000 was Intel's Pentium 4 processor. Although productivity benchmark scores were disappointing, the Pentium 4 excelled in some media benchmarks and in a key computer game, Quake III Arena.

PC Processor Events of 2001

The year 2001 started out slowly as PC vendors struggled with slow sales and a weak economy. Intel started the year focused on gaining acceptance for Pentium 4. AMD was quickly being outrun on clock frequency and relegated to the slowest Pentium 4 speed grade (see *MPR 4/02/01-02*, "AMD Heats Up Athlon to 1.3GHz").

AMD revised the Athlon core to add SSE instructions, improved power management, and added other performance enhancements. The new core, Palomino, was rolled out piecemeal—first in servers, then in notebooks (see *MPR 5/29/01-01*, "AMD Saddles Up Palomino"), then for desktops. To keep pace with Intel's Pentium 4 clock speeds, AMD responded with a model-numbering system that put it in closer competition with Intel (see *MPR 11/12/01-02*, "Athlon XP Eschews GHz").

Intel responded to AMD with a process shrink to 0.13-micron: Northwood. Northwood delivered more frequency and increased the L2 cache of Pentium 4 (see *MPR 1/22/02-02*, "Intel's 2.2GHz P4 Pulls Ahead").

The Power PC that drives Apple's Mac G4 did not reach 1GHz in 2001 (see *MPR 08/20/01-02*, "PowerPC 867MHz Fuels New MAC"). PowerPC has lagged AMD and Intel in this clock-speed race, but what it lacked in clock speed, it made up for with lower power and a better SIMD instruction set (Altivec).

Notebook processors fought the tradeoffs of speed versus power. Intel was challenged in 2000 by Transmeta's offering processors with lower power. Intel responded in 1Q01 with a sub-1V Pentium III (see *MPR 3/12/01-01*, "Mobile PIII Goes Lower (Voltage)"). Intel showed how serious it was about mobile by announcing the development of a processor specifically for mobile: Banias (see *MPR 3/26/01-02*, "Intel Mobilizes at IDF"). Transmeta ended 2001 with a whimper as it hit a production glitch on the promising 0.13-micron TM5800 (see *MPR 7/02/01-01*, "Crusoe Gets Skinny With TM5800").

Of course, the clock-speed race is still important, even in mobile. Pentium III became the first mobile processor to reach 1GHz (see *MPR 4/2/01-01*, "Notebooks Enter the Gigahertz Era"). Midyear, Intel released its first processor in the 0.13-micron copper semiconductor process (see *MPR 8/06/01-01*, "Intel Debuts 1.13GHz Tualatin").

Value processors had their own speed race. AMD won this one by introducing the 1GHz Duron before Intel's 1GHz Celeron (see *MPR 8/27/01-04*, "AMD Ships First 1GHz Duron"). Throughout the year, AMD and Intel went toe to toe on speed grades, both ending the year at 1.2GHz. VIA could not keep pace with the AMD and Intel juggernaughts, even with the 0.13-micron process (see *MPR 10/08/01-02*, "Ezra: A New Chapter for VIA"). At the end of the year, mobile value processor also crossed the 1GHz mark (see *MPR 12/26/01-02*, "Tidbits").

It also excelled in cranking up clock frequencies (see *MPR 8/27/01-03*, "Intel Opens IDF With P4 2.0GHz"), becoming the first—and still the only—PC processor to reach 2GHz.

The 0.18-micron Willamette-based Pentium 4 at 2GHz pushed thermal power to the limit in desktop systems. It was also too large, at 216mm^2, for very high volume manufacturing. The solution to these problems was the first process shrink of the Pentium 4, the 0.13-micron, 146mm^2 Northwood processor. Although the Northwood-based Pentium 4 officially debuted in 2002, it was shipping in production volume in 2001.

Northwood bumped up the size of the L2 cache to 512KB, improving clock-for-clock performance 4–9% and making it a better candidate for dual-processor servers. SPEC numbers had not been posted at the time this article was written, but using the scores posted by the 2GHz Willamette core as a basis, we believe Northwood should have the second-best SPECint and second- or third-best SPECfp scores in 1Q02. Northwood should scale to 3GHz by the end of 2002 and keep well ahead of AMD's Athlon XP, at least in clock frequency. Northwood will also be the first mobile Pentium 4 processor to have clock speeds exceeding 1.6GHz when it is introduced to that market in 1Q02.

And the Survivor Is…

This year saw the closest competition for our Analysts' Choice Award in years. AMD's Athlon XP showed that clock speed is not everything, and its predecessors have won the last two years in a row. This contest is not too close for us to call, however, and the sole survivor is not the Athlon XP. Because of its industry-leading benchmark scores and clock frequencies, and because it improved on the IPC and power consumption of its predecessor, allowing Intel to offer a mobile P4 processor, we give **Intel's Pentium 4/Northwood** the ***Microprocessor Report*** **Analysts' Choice Award** for **Best PC Processor** of 2001. ◇

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