What Is a Seventh-Generation Processor?

AMD's New Athlon Attempts to Clear the Bar

AMD recently introduced Athlon (see MPR 7/12/99, p. 1) as a seventh-generation x86 processor. Indeed, the device was code-named K7 and is the follow-on to the K6, putatively a sixth-generation device. But AMD still has some work to do to prove its seventh-generation credentials.

From a microarchitecture standpoint, AMD's design shows some clear advantages over Intel's sixth-generation Pentium II. But microarchitecture is merely a tool to deliver performance to the end user. Instead of judging a chip by its internal design, I propose qualifying generations on the basis of performance.

Because Intel sets the standard in the x86 market, I researched the performance impact of each of Intel's x86 processor generations back to the 286. The table below compares each processor generation to the previous generation. (In the case of the 286, its predecessor is the 8088.) To neutralize the effect of IC process, each comparison uses devices built in the same IC process. Because of the long time span, I had to rely on several different CPU-intensive benchmarks—including SPECint95, SPECint92, and, for the older devices, Dhrystone MIPS—but each pair of generations is compared using the same metric. Finally, I ignored midlife kickers such as the 486DX4 and Pentium/MMX, comparing only baseline devices in each generation.

The results are amazingly consistent. Each new Intel generation doubled the integer performance of the previous generation until the P6, which delivered "only" 70% more performance than Pentium. The shortfall probably occurred because the P6 used only twice the die area of the P5, whereas previous generations tripled in die size. The P6 appeared only one IC process generation after the P5, limiting its die size.

On the basis of this analysis, a seventh-generation device should deliver at least 70% more, if not 100% more, performance than the P6 in the same IC process. Since Intel could have shipped a 500-MHz Pentium II in a 0.25-micron process, I will use that as a baseline (not including the 550-MHz Pentium III, which is a midlife kicker). This would hypothetically scale to 750 MHz in a 0.18-micron process.

Generation	Per-Cycle Performance Gain (Benchmark Used)	Clock Speed Gain in Same Process	Total Gain
P6	1.3x at 200 MHz (SPECint95)	1.3x (300 / 233)	**1.7x**
Pentium	2.0x at 66 MHz (SPECint92)	1.0x (66 / 66)	**2.0x**
486	2.4x at 33 MHz (Dhrystone)	0.83x (33 / 40)	**2.0x**
386	1.5x at 12 MHz (Dhrystone)	1.33x (16 / 12)	**2.0x**
286	1.6x at 8 MHz (Dhrystone)	1.25x (10 / 8)	**2.0x**

Intel has consistently doubled performance with each CPU generation, except for the P6 (Pentium II). (Source: MDR)

To clear the 70% bar, the 0.18-micron Willamette, Intel's future seventh-generation processor, will have to deliver 10% better integer performance per cycle than Pentium II and achieve a clock speed of 1.2 GHz. Intel has already said that Willamette will exceed 1 GHz in its 0.18-micron process, so these numbers seem achievable.

AMD is introducing Athlon in a 0.25-micron process, lowering the bar. According to initial benchmarks, Athlon beats Pentium II by 9% on SPECint95. To deliver 70% better performance, Athlon must reach 780 MHz in a 0.25-micron process, much faster than the initial 600-MHz parts.

AMD believes Athlon has frequency headroom. The company also says its SPEC numbers are based on non-optimized binaries, whereas Intel is well known for its intensive compiler tuning. A 750-MHz Athlon could clear the 70% bar with a 5% gain from the compiler.

Athlon does much better on floating-point tests, tromping Pentium II by 38%. But FP performance has been increasing faster than integer since the 486—rising 120% in the P6 generation alone. Athlon needs to demonstrate higher clock speeds to clear the bar on this metric as well.

A new system bus is typically required with each CPU generation to support the higher performance of the new core. Athlon meets this criterion with Slot A, which delivers twice the bandwidth of today's Pentium II and is scalable to higher speeds in the future, due to its more advanced point-to-point connection.

Athlon's die is less than twice the size of Deschutes (P6), a smaller increment than in previous generations. If Athlon can advance a full generation in performance with this die size, it would be a marvel of efficiency.

Because Intel has yet to ship a seventh-generation part, and because AMD may yet improve its Athlon scores, it's too soon to make a final judgment. If AMD can push Athlon to 750 MHz in the 0.25-micron process and tune its SPEC results a bit, the new chip will open a larger performance gap over Pentium III and have a strong claim to the seventh-generation title. If not, Athlon will be competitive with Pentium III but is likely to fall behind the performance of Intel's seventh-generation effort once that part emerges. M