HP Pumps Up PA-8x00 Family

PA-8200 in 2Q97, PA-8500 in 2Q98 Aim to Grab Performance Lead

by Linley Gwennap

Two years ago, HP's Steve Manglesdorf proclaimed at the Microprocessor Forum that the PA-8000 would be the fastest microprocessor in the world when it shipped. Although the chip didn't appear until this past spring, it did indeed fulfill Manglesdorf's bold projection. At last week's Forum, Paul Perez laid out a plan for not one but two follow-on chips in the PA-8x00 family. This time, his claims that these chips will also provide leadership performance carry more weight.

The plan makes it clear that HP will not rest on its laurels until the appearance of Merced, the first processor from its partnership with Intel, which we project to begin shipping in 2H98. Although Merced and its IA-64 successors will eventually do away with PA-RISC, HP will continue to enhance its existing PA-RISC processor cores to ensure its competitiveness in the interim. The company expects to do so without developing a completely new PA-RISC CPU core; instead, it will take advantage of headroom in the PA-8000 to extend that chip's performance.

PA-8200 Fine-Tunes CPU Core

HP's CPU design resources, which have always been small compared with those of other major microprocessor makers, are now divided between working on PA-RISC and working on future IA-64 processors. Thus, HP can't afford to extensively remodel its CPU. The PA-8200 strikes a balance between improving performance and minimizing the number of changes. In fact, the chip fits within the same pinout and die size as the PA-8000.

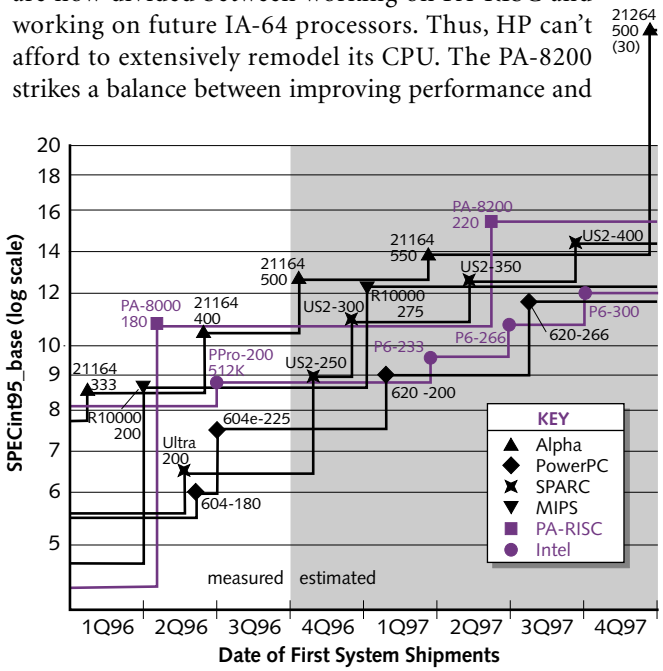

Figure 1. Although Digital has wrested the performance lead from HP's PA-8000, the forthcoming PA-8200 should regain the lead until Digital's 21264 debuts. (Source: SPEC, MDR estimates)

Performance studies of that chip found performance bottlenecks in two areas. Not surprisingly, the small branch history table (BHT) has a relatively poor prediction rate. Given the PA-8000's lengthy misprediction penalty *(see* **081501.PDF***)*, cycles lost due to mispredicted branches were the top performance inhibitor for most applications. The PA-8000 includes an unusual feature for compiler-driven branch prediction; this feature helps SPEC benchmarks but does nothing for unrecompiled binaries.

To address this problem, the PA-8200 increases the size of the BHT from 256 to 1,024 entries, about in the middle of the pack compared with other high-end processors. The designers also fixed a problem in the PA-8000. In that chip, if two branches retire in the same cycle, only one can update the BHT; the history of the other is ignored. The PA-8200 can update multiple entries in the BHT in a single cycle, preserving all available branch history.

The performance studies found the second-biggest bottleneck in some applications is TLB misses. To address this problem, the PA-8200 has a 120-entry TLB rather than the 96-entry TLB of the PA-8000. For both the BHT and TLB, the size increase was limited by what could be wedged in without inflating the PA-8000's already portly die size.

A Need for Speed

The PA-8000 tops out at 180 MHz in HP's 0.5-micron CMOS process. For the PA-8200, the designers had to stick with this aging process, so they focused on modifying the circuit design to speed critical internal timing paths. Next-generation SRAM technology, which will support 4-Mbit synchronous parts in excess of 200 MHz, gave HP another break. These SRAMs allow the processor to sport twice as much cache with half as many chips; the latter feature reduces the propagation delay across the board to the furthest SRAM by 750 ps, about 15% of the cycle time.

The result, according to Perez, is that the PA-8200 will reach 220 MHz, a 22% increase over the current part. The new processor will run with 2M of instruction cache and 2M of data cache at this speed; the PA-8000 allows only half that much cache at its top speed. Combined with the changes in the CPU core, this configuration should deliver a performance increase of 35% to 75%.

Perez believes the new chip will deliver 15.5 SPECint95 and 25 SPECfp95 (base), putting the increase in SPEC95 performance near the bottom of the 35–75% range. Older programs that have not been aggressively recompiled, particularly commercial applications with many branches and TLB references, are likely to be near the top of that range.

HP has built and tested versions of the PA-8000 adding most of the PA-8200 improvements, but it has yet to tape out one with the full PA-8200 feature set. This tapeout is planned to occur within the next couple of months, and given the small degree of change, the company is confident that the new device will be in systems by 2Q97.

Performance Leapfrog with Alpha

Figure 1 shows how the 220-MHz PA-8200 is likely to stack up against the top chips from other vendors, based on integer performance. By the middle of next year, both the R10000 and UltraSparc-2 should be shipping 0.25-micron versions, reaching about 275 MHz and 350 MHz, respectively. We expect the PowerPC 620 to begin shipping (finally) at clock speeds of up to 266 MHz in 1H97. Coincidentally, these processors are all likely to deliver between 12 and 13 SPECint95 (base), matching the integer performance of the 500-MHz 21164, which currently tops the charts.

The PA-8200 should best all of these contenders when it appears. Digital has intimated that it can squeeze a bit more out of the 21164, but it would have to push that part to 600 MHz to top HP's projected performance, which seems unlikely without an unscheduled process shrink. Even the 400-MHz UltraSparc-2, due in 2H97, will probably fall short of the PA-8200's projected scores.

On floating-point code, the PA-8200 is in even better shape: neither a hypothetical 600-MHz 21164 nor a 400-MHz UltraSparc is likely to top 25 SPECfp95. In fact, except for the 21264 at the end of next year, none of the chips shown in Figure 1 can match this mark. Thus, the PA-8200 has a good chance to vault HP back into the performance lead.

MICHAEL MUSTACCHI

At the Microprocessor Forum, HP's Paul Perez said the PA-8200 will surpass Alpha's performance.

PA-8500 Aims to Top 21264

HP and Digital will continue to wrestle for the performance lead into 1998. Digital expects to pin HP's hopes with its muscular 21264 *(see* **101402.PDF***)*, a fearsomely complex processor projected to deliver at least 30 SPECint95 and 50 SPECfp95 (base). The 21264, due to appear at the end of 1997, will easily surpass the performance of the PA-8200.

HP will counter with the PA-8500, a new device discussed for the first time at the Microprocessor Forum. The major performance boost will come from a move from a 0.5- to a 0.25-micron process. Skipping an entire process generation could boost the CPU core speed as high as 400 MHz, giving the chip the power it needs to contend with the 21264. Perez is confident that, when it appears in 1H98, the PA-8500 will outrun the Alpha chip and all other contenders.

Although continuing to eschew major rework, HP will need to make more significant modifications to the PA-8x00 core than it did in the PA-8200. Finding 400-MHz SRAM, even in 1998, seems unlikely, so the design may have to run its external primary caches at less than the CPU core speed. With the highly out-of-order architecture of the PA-8x00, cache bandwidth, not latency, is the key factor, so slower primary caches can be tolerated with a few design changes.

One likely change is further improvement in branch prediction, reducing the impact of an extended instruction-fetch latency. With the 0.25-micron shrink, the PA-8500 will have plenty of die area available for branch prediction. Other possible changes include enlarging the reorder buffer (which HP calls the instruction queue), increasing the TLB size, and replacing the 0.77-Gbyte/s system bus with something more akin to Digital's 2.2-Gbyte/s interface.

The PA-8500 will probably be HP's first high-end processor that it doesn't fab itself, although that chip won't be the last, given the eventual move to Intel's Merced. HP has not implemented the 0.35-micron CMOS process it codeveloped with AMD, although AMD has been producing chips in that process for nearly a year. HP's deal with Intel provides access to Intel's 0.25-micron technology, but whether HP will invest in such a fab is unclear.

HP would not disclose the foundry for the PA-8500, but assuming it does not build the chip itself, the possibilities are limited. Among those vendors with a 0.25-micron process in 1H98, IBM and Digital, for example, are unlikely to build a chip for a key competitor. Intel would be HP's obvious choice, but the partner may not wish to devote its precious fab space to the PA-8500. In that case, HP may look to AMD or Texas Instruments for help.

HP Delivers Despite Older IC Process

The PA-8000's ability to deliver leadership performance using a previous-generation IC process is amazing. If the PA-8200 meets its goals, it will outperform processors that are two process generations ahead, an unprecedented feat. By matching the high-performance PA-8x00 core with a leading-edge 0.25-micron process, the PA-8500 could finally put HP's CPU designers in the best light.

HP's new roadmap shows it has the ability to stay close to Alpha in the performance race for the foreseeable future. Both are likely to take turns in the lead, leaving the other processor vendors to fight for the number-three spot. M

For More Information

HP does not sell its PA-RISC processors on the merchant market. For more information on the PA-8x00 family, contact HP (Cupertino, Calif.) at 408.447.2683.