IBM Delivers on Copper Promise With 750-400

To the amazement of skeptics, IBM has made good on the promise it made last year to deliver copper microprocessors in 1998. The company recently began shipping a PowerPC 750, code-named Lonestar, in its new 0.22-micron copper CMOS-7S process (see MPR 9/14/98, p. 1) at 400 MHz.

The PowerPC 750, which occupies 67 mm^2 of silicon in IBM's aluminum 0.28-micron CMOS-6S2 process, requires only 40 mm^2 in the new 7S process. After process startup costs have been amortized and infant yield wrinkles ironed out, Lonestar should cost about 45% less to manufacture than the original 750 (according to the MDR Cost Model).

The new 750 burns 5.7 W (max) at 2.0 volts, approximately 52% less than the 6S2 version if it were cranked up to 400 MHz (at 2.6 V). This is about the same as the 5.8 W consumed by Motorola's 366-MHz 750 (see MPR 8/24/98, p. 13), which runs at 1.9 V. IBM has chosen to run the part at 2.0 V, rather than the process nominal 1.8 V, to improve the yield at 400 MHz. This decision will also give IBM headroom to boost the frequency further without forcing a voltage change on its customers at that time.

We estimate that the 7S transistor has about 20% lower capacitance than the HIP 3.4 transistor, indicating that the capacitance of the interconnect must also have been reduced by 20%. This is impressive evidence of the value of copper interconnects, since the tighter metal pitches of 7S would otherwise have raised the capacitance.

IBM estimates the SPECint95 (base) of Lonestar at 17.6 and the SPECfp95 (base) at 12.2 (with 1M of half-speed backside L2 cache). This compares with 17.2 and 12.9, respectively, for the new Pentium II-450 (with 512K of half-speed backside L2), but Lonestar runs at 20% of the power! Thus, Lonestar could, theoretically, allow Apple to deliver a PowerBook with the speed of a top-of-the-line desktop PC. Apple, however, has made no product announcements based on Lonestar.

IBM is initially asking $605 for the 750-400 in quantities of 1,000 units, 13% less than Intel asks for its Pentium II-450. IBM's price seems high—considering the die is 70% smaller than Pentium II's—so it should come down quickly; Apple is probably already paying much less. Assuming that IBM can manufacture Lonestar in high volume, the price will put pressure on Motorola to lower the $589 price of its 750-366. IBM's 750-400 is available now, and a 740-400 will be ready in 1Q99 for customers needing pin-compatibility with the 603e. No price was announced for the new 740. —*K.D.*

Alpha 21264 Whiffs on Performance Targets

Q: When is the fastest processor in the world not fast enough?
A: When it misses its performance target by a third.

In a classic good news/bad news story, Compaq has measured its Alpha 21264 processor at 26.0 SPECint95 (base) and 40.9 SPECfp95 (base), a whopping 55% better than the fastest non-Alpha systems available today. The 21264 will be available as an upgrade board, priced at an outrageous $65,000 per CPU, for the AlphaServer 8200 and 8400. The company expects to begin shipments by November.

The bad news is that these results are nowhere near the 40 int/60 fp estimates that Digital has been touting for the 21264 (see MPR 12/29/97, p. 1). In addition, the chip is well behind initial plans to ship in 4Q97 as well as the revised schedule of 2Q98 shipments. Part of the problem is the initial systems run the cache at one-third speed instead of two-thirds, but even with the faster cache and additional compiler tuning, the chip is unlikely to exceed 30 int/50 fp.

Despite these shortcomings, the 21264 extends Alpha's performance lead, beating the 600-MHz 21164 by 30% on SPECint95 and 50% on SPECfp95. The performance shortfall, however, leaves an opening for HP's PA-8500 to slip into the lead late this year, as that chip is said to achieve 30 int/50 fp. The PA-8500 is also behind schedule, however, and may not meet its targets either.

The 21264's problems also benefit Merced. Our previous projections showed a 0.18-micron 21264 exceeding Merced's performance (see MPR 6/22/98, p. 1). Based on the current numbers, we now expect the 21264 shrink to reach 45 int/70 fp in 2000, giving Merced more room to deliver on its claim of "industry-leading performance." —*L.G.*

Intel Accelerates Desktop Price Cuts

For the third time in four months, Intel has cut the price of its desktop Pentium II products. This unprecedented event has resulted in extraordinary declines, as Intel has in many cases maintained its typical 20% reduction while delivering two reductions per quarter instead of one. For example, both the 333-MHz and 350-MHz Pentium II are down more than 40% from their June prices, as the table below shows.

	7-Jun	26-Jul	13-Sep	Since June	Since July
Pentium II-450	—	—	$669	—	—
Pentium II-400	$722	$589	$482	-33%	-18%
Pentium II-350	$519	$423	$299	-42%	-29%
Pentium II-333	$412	$316	$234	-43%	-26%
Pentium II-300	$305	$209	$192	-37%	-8%
Pentium II-266	$198	$159	$159	-20%	0%
Celeron-333	—	—	$192	—	—
Celeron-300A	—	—	$149	—	—
Celeron-300	$159	$112	$106	-33%	-5%
Celeron-266	$106	$86	$86	-19%	0%

Although Intel has discontinued the Pentium II-233, there is still an overlap between the Pentium II line and the new Celeron parts. The 300-MHz Pentium II and the 333-MHz Celeron (Mendocino) are both priced at $192; the Celeron part delivers slightly better performance on most benchmarks. Intel continues to offer Pentium II at 266 MHz as an option for those system makers that have not yet

converted their low-end PCs to Celeron. The new Mendocinos should quickly obsolete the low-end Pentium II parts.

Intel has removed the desktop Pentium/MMX from its price list, although a few last parts are still available from inventory. As the 266- and 300-MHz Pentium II processors, based on the 0.35-micron Klamath, disappear by the end of the year, Intel will convert entirely to 0.25-micron processors.

Although the 0.25-micron conversion has reduced Intel's manufacturing costs, the company historically has not been so generous in passing along its savings in the form of rapid price cuts. We believe Intel's recent price moves are instead an attempt to drive Socket 7 out of the market and to address increased demand for low-cost PCs until the Celeron line is established. Now that the "real" Celeron parts have arrived and largely eliminated Socket 7, Intel is likely to ease back on the throttle and catch its breath. Watch for processor prices to stabilize over the next few quarters.

Intel also trimmed the prices of its mobile processors, but the reductions for this line haven't been as frequent or dramatic. As the table below shows, prices for the Mobile Pentium II processors dropped an average of 16% from the previous quarter, making room for the new 300-MHz part (see following item). Mobile Pentium/MMX prices have dropped further, an average of 32%, as Intel continues to phase out the product. Pentium/MMX will continue to play a role in Intel's mobile line, however, well into 1H99.

	28-Jun	13-Sep	Change
Mobile Pentium II-300	—	$637	—
Mobile Pentium II-266	$444	$391	-12%
Mobile Pentium II-233	$262	$209	-20%
Mobile Pentium/MMX-266	$241	$159	-34%
Mobile Pentium/MMX-233	$134	$95	-29%
Mobile Pentium/MMX-200	$95	$95	0%

Competition in the mobile market remains almost nonexistent, so Intel doesn't need to cut prices as deeply as in the more competitive desktop market. In addition, Socket 7 is less of an issue in notebook systems, as many vendors have already converted to Mobile Modules instead. —*L.G.*

Mobile Pentium II Hits 300 MHz

Shortly after announcing that improved yields from its 0.25-micron process enabled a faster desktop Pentium II (see MPR 8/24/98, p. 1), Intel unsurprisingly disclosed that the same effect applies to the mobile version. The company is now shipping a 300-MHz Mobile Pentium II, one speed grade faster than it had previously achieved (see MPR 4/20/98, p. 14). In quantities of 1,000, the new part lists for $637, 43% more than the 266-MHz version.

The mobile line wasn't improved as easily as the desktop line. The 266-MHz Mobile Deschutes CPU (see MPR 4/20/98, p. 14) dissipates 7.8 W, just under Intel's notebook design limit of 8 W. Simply increasing the clock speed would result in a part too hot for many notebook PCs. To compensate, the new 300-MHz part runs at 1.6 V, a bit lower than the 1.7-V supply used by the other Mobile Deschutes processors. As a result, the new CPU dissipates the same 7.8 W, although the cache is slightly hotter because its voltage is not reduced.

Unfortunately, the lower voltage makes it more difficult to yield faster versions of Deschutes, due to normal CMOS speed characteristics. The stiff price premium for the 300-MHz part reflects the relatively low yields at that speed and the lower voltage. We expect 300 MHz to be the end of the line for Mobile Deschutes.

The next mobile product will be Dixon, a version of Mendocino (see MPR 8/24/98, p. 1) with 256K of on-die L2 cache instead of 128K. At the same clock speed, Dixon will deliver at least as much performance as Pentium II, if not slightly more. Dixon's advantage is lower power dissipation, due to its integrated cache, as moving the L2 cache onto the die greatly reduces the power needed to move data between the CPU and the cache. As a result, Intel should be able to fit a 333-MHz Dixon within the mobile thermal envelope. By 1Q99, that part should offer a performance upgrade to the 300-MHz Mobile Deschutes. Greater advances await the debut of 0.18-micron parts in 3Q99. —*L.G.*

Intel Delivers Final OverDrive Processor

Fulfilling the plan it laid out last year, Intel has delivered the final product in its OverDrive line, an upgrade chip for Pentium Pro systems. The new chip upgrades early P6 systems from 150 or 180 MHz to 300 MHz, or from 200 MHz to 333 MHz. It also adds MMX functions, which Pentium Pro lacks. The chip carries a suggested retail price of $599.

Although Pentium Pro shares the same bus as today's faster Deschutes processor, the older systems use Socket 8 instead of Slot 1, making the upgrade mechanically challenging. To satisfy this need, Intel engineers wedged a Deschutes CPU die and the 512K Xeon SRAM (see MPR 7/13/98, p. 1) onto a small card that plugs into Socket 8. As in Pentium Pro, the Xeon cache runs at the same speed as the CPU. Users must remove the original Pentium Pro chip from their system before installing the upgrade chip.

The OverDrive line was never intended to make much money on its own; instead, it was to enhance the value of Intel's standard processors. The OverDrive concept was meant to assure PC buyers that their systems wouldn't become obsolete; instead, they could simply plug in a faster processor as necessary.

Whether Intel ever actually believed this message is unclear, but its fallacy was quickly revealed. By the time a PC's CPU grew too slow, other components—such as the main memory, graphics, and hard drive—also needed to be upgraded. Thus, most PC buyers just bought a new system, selling or keeping the old one.

Since the introduction of the first OverDrive part (see MPR 6/17/92, p. 7), Intel has sold only a few million upgrade chips by our estimate, not enough to be profitable, at least by Intel standards. More important, the concept of CPU upgradability never made a big impression on PC buyers.

By shifting out of OverDrive, Intel will cease to deliver a CPU upgrade for Pentium/MMX or Pentium II systems (although vendors such as Evergreen may step into this breach). This lack isn't likely to faze owners of these systems, however; in the age of sub-$1,000 PCs, the best system upgrade method will continue to be tossing out the old box and buying a new one. —*L.G.*

Faster Xeon Parts Delayed

Just as it cured the bugs in its initial 400-MHz Xeon parts, Intel acknowledged delays in the forthcoming 450-MHz versions. The company is already shipping 450-MHz processors in the standard Pentium II line but has yet to move the Xeon line (see MPR 7/13/98, p. 1) to the new speed. A 450-MHz Xeon with 512K of L2 cache, intended mainly for workstations, is expected to be announced in 4Q98, but the 1M and 2M versions have slipped into 1Q99.

The parts with the larger caches will be used mainly in four-processor servers and thus require more extensive testing. If Intel cannot reduce the lag between the time a new clock speed enters the desktop Pentium II line and the time it enters the Xeon line, however, some workstation makers may ignore Xeon and continue using the fastest PC processors. The delay also leaves Intel without a 2M part for the rest of 1998.

In the meantime, Intel is now shipping 400-MHz Xeon processors with both 512K and 1M caches (there is no 2M version) for all types of systems. Initial shipments had been limited, due to two bugs, one affecting four-processor systems and the other affecting operation in ECC mode. The latter problem was more serious, since nearly all workstations and servers use ECC to improve reliability. Both bugs were worked around without requiring a physical design change to the CPU, enabling Intel to resume shipments within a few weeks after the bugs were detected.

These glitches make it appear that Intel has more problems with its high-end processors than do the RISC vendors, which dominate that market today. Of these competitors, however, only MIPS publishes its errata, so it is impossible to compare their bug rates with Intel's. On the other hand, the RISC vendors are often able to ship both single- and multiple-processor systems simultaneously, indicating that Intel needs to improve its test procedures to become a stronger competitor in the high-end CPU market. —*L.G.*

AMD Ships K6-2 at 350 MHz, Readies K6-3

In August, AMD began shipping its 0.25-micron K6-2 (see MPR 6/1/98, p. 16) at 350 MHz. The K6-2/350 competes directly against the Pentium II-350 in overall performance, but K6-2 offers higher 3D-geometry performance with its 3DNow technology. IBM's Aptiva E4N is the first system to use the K6-2/350 and is available now. AMD says other systems will be announced soon.

In the second quarter, AMD shipped 2.7 million units, a few hundred thousand of which were K6-2s and half of which were 0.25-micron parts. In the second half, we expect AMD to ship more than nine million processors, nearly all of which will be in 0.25-micron technology, and the majority of which will be K6-2s at 300 MHz and above.

The new K6-2/350 was introduced with a list price of $317 in quantities of 1,000 units. Intel's September price cuts (see MPR 9/14/98, p. 4) may have caught AMD by surprise, leaving the K6-2/350 more costly than the $299 Pentium II-350—a situation AMD will have to rectify quickly.

In the fourth quarter, AMD expects to begin volume shipments of the K6-2 at 400 MHz. The company also said it will ship a 450-MHz "K6 family member" in 1Q99, but this is more likely to be a K6-3 than a K6-2.

The K6-3, which AMD calls Sharptooth, will be a K6-2 enhanced with a 256K on-chip L2 cache. K6-3 will eliminate a major disadvantage K6 has against Pentium II: no backside cache. K6-3 is scheduled to go into production in 4Q98, with systems at 400 MHz and above available in 1Q99. With 21.3 million transistors, the 0.25-micron K6-3 die will be 135 mm^2—12% smaller than Intel's Mendocino but with twice the L2 cache. If K6-3 actually ships at 400 or 450 MHz in 1Q99, it will have a 20–35% higher clock rate than Mendocino allowing it to compete favorably with Intel's Celerons and low-end Pentium IIs. —*K.D.*

SiS Adds 3D to Slot 1, Too

Close on the heels of its SiS530, a Socket 7 chip set with integrated 2D and 3D graphics (see MPR 8/24/98, p. 4), Silicon Integrated Systems (SiS) has released the SiS620 chip set for Intel's Celeron and Pentium II processors. The new chip set uses the same core logic found in the SiS5600 (see MPR 6/1/98, p. 26) and the 3D engine from the company's SiS6326.

Like the 530, the 620 can be used in a unified memory architecture (UMA) configuration that shares system memory between the CPU and the chip set's integrated graphics controller, limiting the performance of both but eliminating the cost of a separate frame buffer. Both chip sets support an optional discrete graphics memory array that should improve both CPU and graphics performance. Sources say Intel's forthcoming Whitney chip set, similarly equipped with a P6-bus host interface and integrated 3D acceleration, will also support UMA and non-UMA modes.

SiS (*www.sis.com.tw*) says the 620 will begin sampling this month and enter production in October, putting it several months ahead of Whitney. We expect a similar product from VIA soon. Intel will have an advantage in 3D performance and branding—the Intel740 is already faster and better known than the SiS6326 3D chip, and we expect these benefits to carry over into Whitney.

PC OEMs interested in offering sub-$800 Celeron PCs will not need to wait for Whitney, however; at just $29, the SiS620 has the right price and the right feature set for this growing niche. —*P.N.G.*