Dixon Revamps Intel's Mobile Line

Integrated Cache Reduces Power, Boosts Speed; Celeron Brand Goes Mobile

by Linley Gwennap

In one fell swoop, Intel today obsoleted its entire line of mobile products, replacing them with something better. Code-named Dixon, the new processor with integrated cache will be marketed under two brand names: Mobile Pentium II and Mobile Celeron. The former replaces the older Deschutes-based Mobile Pentium II, while the latter replaces Mobile Pentium/MMX (Tillamook). Although Intel will continue to ship the older parts for a few more months, Dixon will quickly dominate the mobile line.

Rarely has Intel made such a rapid and significant technology change throughout an entire product line. But Dixon brings a set of clear advantages for mobile systems. Integrating the level-two (L2) cache reduces power dissipation. By trading off power for speed, this change allows Intel to offer faster parts, up to 366 MHz, within the same thermal limit as earlier 300-MHz parts. The integration also eliminates the need for the bulky minicartridge (see MPR 4/20/98, p. 14), allowing Dixon to fit into small systems, where Deschutes could not.

Derived From Mendocino

Intel's first CPU with on-die L2 cache was Mendocino (see MPR 8/24/98, p. 1). That device, sold as the desktop Celeron, adds 128K of L2 cache to the Deschutes CPU core. Because power and space savings are not as important in desktop PCs, Intel has used Mendocino simply as a cost reduction from the Pentium II module. With only 128K of cache, Mendocino typically delivers slightly less performance than a Pentium II with 512K of cache, even though the on-die cache operates at twice the speed of the cache on the Pentium II module.

Dixon solves this performance problem by expanding the L2 cache to 256K. With this cache, Dixon slightly outperforms a Deschutes/512K on most programs. In fact, Intel says it hasn't found a single application that is slower on Dixon than on Deschutes. This solid performance makes Dixon a drop-in replacement for Deschutes at the same clock speed.

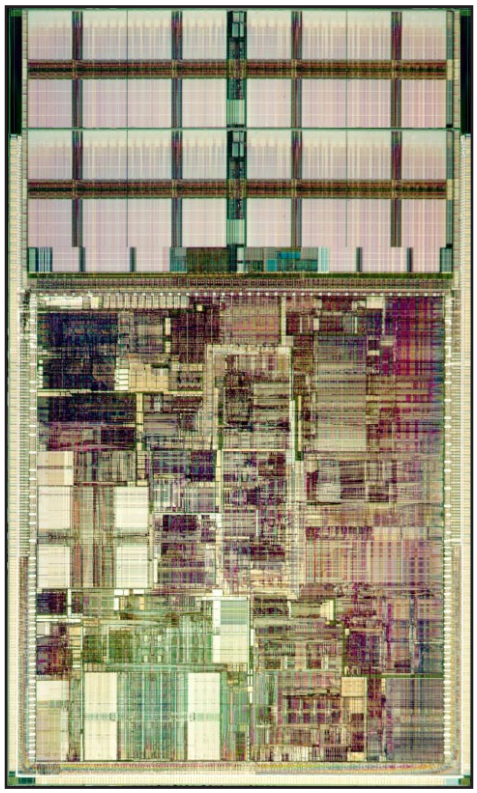

Figure 1. Dixon's 256K of L2 cache consumes 32% of the die, which contains 29 million transistors and measures 10.4 mm × 17.3 mm in Intel's 0.25-micron five-layer-metal CMOS process. (Source: MDR photoillustration based on Mendocino die photo from Intel)

Dixon comes in a 615-contact plastic BGA package, making it Intel's first device to use a BGA. (Deschutes is packaged in an LGA, which is similar, but customers receive the processor only in a module that hides the CPU package.) At 31 mm × 35 mm, this BGA is more than 80% smaller and 80% lighter than the minicartridge. The new BGA is smaller even than Pentium/MMX's TCP (tape carrier package), although it is slightly thicker. This modest package should fit into the thinnest notebook PCs. Dixon will also be sold in a minicartridge for compatibility with existing systems, but this option costs $18 extra.

With the larger cache, Dixon measures 180 mm^2 in Intel's 0.25-micron process, significantly larger than the 154-mm^2 Mendocino. The cache consumes a third of the die, as Figure 1 shows, and is protected by redundant columns to improve yield. The MDR Cost Model estimates Dixon's manufacturing cost at about $65, the same as a Mobile Deschutes module. Although Dixon's larger die costs more to build, it eliminates the cost of the external L2 cache and the minicartridge. Thus, Dixon's power and performance advantages come almost for free, except for the greater fab capacity needed to build the bigger die.

At 300 MHz, Dixon dissipates a maximum of 7.7 W (TDP), 14% less than a Mobile Deschutes module at the same clock speed. Both parts operate at a core voltage of 1.6 V; Dixon saves power by not driving the L2-cache signals out of the chip. The L2 cache itself also uses less power, as it operates at 1.6 V instead of 2.5 V. The smaller size of the cache is balanced by its faster speed. At its top speed of 366 MHz, Dixon draws 9.5 W, a half watt more than the 300-MHz Deschutes but still within Intel's established thermal envelope for the CPU/L2-cache subsystem.

Intel is offering Dixon at speeds from 266 to 366 MHz. To distinguish the slower speeds from the existing Mobile Deschutes-266 and -300, the slower Dixon chips will be marketed as Pentium II-266PE and -300PE. The faster parts will eschew the extension. Thus, PE (for performance enhanced) plays the same transitory role as the A in Celeron-300A.

Celeron Goes Mobile

At the same time, Intel introduced the Celeron brand to the mobile line. Mobile Celeron plays the same role as the desktop Celeron (see MPR 3/30/98, p. 1), keeping Pentium II out of budget PCs. As Table 1 shows, Intel rolled out Mobile Celeron at 300 and 266 MHz, with the latter priced at just $106. At this price, Mobile Celeron should quickly displace Mobile Pentium/MMX from Intel's line.

As on the desktop, Mobile Celeron has only 128K of L2 cache, half as much as the new Mobile Pentium II. Oddly, Intel is not using the Mendocino die for Mobile Celeron; instead, Intel will simply use Dixon chips with half of the cache disabled. Although some Dixons with partially defective caches will be remarked as Mobile Celerons, the redundancy should provide high yields in the cache. Thus, Intel will probably have to sell many perfectly good Dixons as Mobile Celerons just to meet demand.

Intel says it doesn't want to requalify Mendocino in the BGA package used for Dixon. Had Intel planned ahead, it could have qualified Mendocino in the BGA originally rather than in its current LGA package, but the entire Celeron effort has been a rush job since the designs were started just over a year ago. Even if Intel sells only a few million Mobile Celeron parts this year, the company could save $30 million by switching from Dixon to Mendocino; perhaps, at some point, it will make this switch.

At up to 300 MHz, Mobile Celeron overlaps much of the Mobile Pentium II line. In fact, at $187, the Mobile Celeron-300 costs 42% less than the Mobile Pentium II-300, while offering slightly lower performance. Intel offers the same rationale as for its desktop parts (see MPR 1/25/99, p. 18): Celeron will be used in low-cost notebooks aimed at the emerging mobile consumer market, while Pentium II will handle beefier systems designed for mobile business professionals. Intel faces minimal competition in the mobile space, so it can be less aggressive with its Celeron line here than on the desktop. But AMD's new Mobile K6-2 (see MPR 1/25/99, p. 4) will put pressure on Mobile Celeron.

The Ephemeral Tillamook-300

With Mobile Celeron, Intel at last has a product that can completely obsolete Mobile Pentium/MMX. The new chip delivers better performance at the same power levels and in a similar compact package; it even integrates the L2 cache, which Pentium/MMX does not. But to ease the transition, Intel has done something it hasn't in the past: increase the speed of the older product even as it introduces a new product.

The new Tillamook-300 (formally known as the 300-MHz Mobile Pentium processor with MMX technology) gives the Pentium/MMX line a going-away present of one more speed grade. The extra speed will be attractive to makers of Pentium/MMX notebooks, particularly mini-notebooks that aren't big enough for the mobile module (see MPR 2/17/97, p. 9) or the minicartridge. These systems can easily be upgraded to the faster Tillamook without a new motherboard.

Product	L2 Cache	Package	List Price (1,000s) 9/13/98	List Price (1,000s) 1/24/99
Pentium II-366	256K on-die	BGA	—	$696
Pentium II-333	256K on-die	BGA*	—	$465
Pentium II-300PE	256K on-die	BGA*	—	$321
Pentium II-300	512K module	minicart.	$637	—
Pentium II-266PE	256K on-die	BGA*	—	$187
Pentium II-266	512K module	minicart.	$391	—
Pentium II-233	512K module	minicart.	$209	—
Celeron-300	128K on-die	BGA	—	$187
Celeron-266	128K on-die	BGA	—	$106
Tillamook-300	external	TCP	—	$144
Tillamook-266	external	TCP	$159	$95
Tillamook-233	external	TCP	$95	—

Table 1. Intel new mobile pricing shows how Dixon allows both higher clock speeds and significant price reductions for the slower speed grades. All parts are available now. *price for BGA package; also available in minicartridge for $18 more. (Source: Intel)

Because notebooks typically have custom-designed motherboards, it takes longer to switch them to a new processor than for desktop PCs. The faster Tillamook will help bridge this gap. The new part won't be around for long though. By 2Q99, most mobile systems will have switched over to Mobile Celeron, given its significant advantages and growth path to higher clock speeds.

Like earlier Tillamooks, the 300-MHz part comes in a TCP and runs at 2.0 V. It burns a maximum of 6.1 W (TDP) at this speed, about the same as a Mobile Celeron-300 CPU core. Yield at 300 MHz should be no problem; Intel could have deployed this speed grade much earlier but had been holding off in hopes that notebook vendors would make the switch to the P6 line instead. Perhaps it is not a coincidence that the 300-MHz Tillamook appeared on Intel roadmaps shortly after AMD introduced its first mobile product, the 300-MHz Mobile K6 (see MPR 10/5/98, p. 4).

Notebook Market Beginning to Surge

There are signs that notebook PC shipments could surge over the next few years. Today, notebooks are about a fifth of the overall PC market. Sales have been hampered by the high price of these systems and by their inferiority to desktops in CPU speed, screen size, and configurability.

New technologies address many of these problems. Many notebook PCs are now available for less than $2,000, with a few below $1,000. The price of LCD panels has fallen dramatically, even as sizes have edged up to the equivalent of a 15-inch CRT. The 366-MHz Dixon reduces the gap between mobile and desktop CPUs to just two speed grades, and Intel plans to close the gap entirely within a year with its Geyserville technology (see MPR 3/30/98, p. 4). Mobile computing fits well with modern lifestyles, and Intel's newest products should increase the popularity of notebook PCs. M