

Intel Proliferates P6 Chip Sets

440EX and 440BX Support Low-End, High-End, and Mobile Users

by Linley Gwennap

With P6 processors reaching into all market segments (see MPR 4/20/98, p. 14), Intel has deployed a full range of P6-bus chip sets to support these new processors. While the new chip sets are similar to the current 440LX AGPset (see MPR 8/25/97, p. 4), they each offer a specific set of features tuned for the needs of their target markets.

The 440BX raises the maximum bus speed from 66 to 100 MHz and adds other features to improve performance for mainstream PCs. It also supports a mobile mode. The 440EX is aimed at the low-cost PC (i.e., Celeron-based) market and eliminates certain LX features for cost reasons.

440BX Designed for Speed

The 440BX is Intel's first chip set built in its 0.28-micron P854 process. With most of Intel's microprocessors moving to the more advanced 0.25-micron process, P854 capacity is opening up for the new chip set. Compared with the older 0.5-micron P852 process, the new process provides faster interfaces, lower power consumption, and more die area.

Taking advantage of the faster process, the BX gains most of its performance from 100-MHz buses. Transfers from the north bridge of the chip set to the CPU occur 50% faster than with the older LX. The BX is required for Intel's new 350- and 400-MHz Pentium II processors as well as for future Pentium II processors that use the faster bus.

The BX also supports a 66-MHz system bus, for compatibility with older Pentium II processors such as the 300- and 333-MHz versions. With these processors, the BX can

still support 100-MHz SDRAM, providing a small performance advantage over the LX. Given the 37% price premium for the BX, however, OEMs will probably continue to use the LX in systems with a 66-MHz bus while using the BX only for 100-MHz motherboards.

To feed the faster bus, the BX supports 100-MHz synchronous DRAM (SDRAM), also 50% faster than SDRAM in LX-based systems. This increase allows the processor to access main memory at the full system-bus speed. Some of the 800-Mbyte/s memory bandwidth can also be used to speed the performance of AGP and PCI bus masters, particularly graphics cards that keep texture data and other information in main memory. Note that the BX does not support slower 66-MHz SDRAM with the 100-MHz bus.

Additional performance gains come from the BX's more sophisticated paging scheme. The new chip set supports up to 32 open pages, compared with only 2 in the LX. Accesses to an open page in main memory complete more quickly than accesses to a new page. A single program can access multiple instruction and data pages within a short period of time, while the graphics chip uses a different set of pages. In this situation, the LX frequently loses track of useful pages, whereas the BX can keep all of these pages open.

Other improvements include deeper buffers between the CPU and the PCI bus and between the CPU and main memory. These buffers reduce bus stalls when multiple transactions are occurring. Intel says it has also improved the bus arbitration scheme.

440BX Supports Big Systems

The BX has new features for high-end systems, as Table 1 shows. The memory controller handles up to 1G of SDRAM, twice as much as the 440LX. Like the LX, it supports ECC as well as parity memory, but the new chip adds "scrubbing." When the memory array is not otherwise being used, the north bridge cycles through the array reading data, performing any needed correction using the ECC bits, and writing the data back. These read/write cycles remove single-bit errors, in many cases before they become double-bit errors.

Intel's benchmark results show the BX offers a 1.6% improvement on SPECint95 over an LX-based system using the same 333-MHz processor and 66-MHz bus. On SPECfp95, which accesses main memory more often, the BX advantage increases to 5.8%. These differences show the value of the internal design changes, not the 100-MHz bus.

In other ways, the 440BX is similar to its predecessor, the LX. Both include a north bridge with the same quad-port architecture (CPU, AGP, main memory, PCI) and the

Feature	440LX	440EX	440BX
IC Process	0.5μ P852	0.5μ P852	0.28μ P854
System Bus	66 MHz	66 MHz	100 MHz
Memory Bus	66 MHz	66 MHz	100 MHz
DRAM Type	SDRAM	SDRAM	SDRAM
Max Memory	512M	256M	1G
Max DIMMs	4 DIMMs	2 DIMMs	4 DIMMs
ECC?	ECC/parity	Parity only	ECC/parity
ECC Scrubbing?	No	No	Yes
AGP Support	AGP 2x	AGP 2x	AGP 2x 2nd gen
PCI Slots	4 slots	3 slots	5 slots
DMA Support	UltraDMA-33	UltraDMA-33	UltraDMA-33
Mobile Support	No	No	Yes
Max CPUs	2 CPUs	1 CPU	2 CPUs
List Price (10k)	\$38.00	\$34.75	\$52.00

Table 1. The 440BX replaces the 440LX in mainstream PCs, while the 440EX fits into low-end PCs. (Source: Intel)

same 492-contact BGA, making system upgrades a snap. Both include the PIIX4 south bridge, with ISA and IDE connections. List pricing in 10,000-unit quantities is \$52.

BX Also Goes Mobile

Like the 430TX, which supports both desktop and mobile Pentium systems, the 440BX also has a mobile mode. Because Intel has only recently introduced the first mobile Pentium II processors, the LX didn't need to support mobile systems, although it does include ACPI power management.

In mobile systems, the BX will typically be used at the 66-MHz bus speed and with 66-MHz SDRAM, since Intel has not released any mobile Pentium II processors that use the 100-MHz bus. In fact, we do not expect mobile systems to move to the 100-MHz bus until 2H99, since the 0.25-micron mobile parts probably won't exceed 333 MHz.

The good news is that the lower bus and memory speeds reduce power. For similar reasons, many notebook makers are likely to stick with PCI instead of AGP for graphics, as the 2× AGP bus consumes more power. AGP is needed mainly for 3D games, which are popular among consumers but not among the businesses that buy most mobile systems. Some mobile vendors, however, will use AGP for differentiation if nothing else.

The BX achieves a low power rating due to its use of a 0.28-micron CMOS process. Advanced power-management circuitry further reduces power. In extreme cases, the BX can throttle back the main-memory speed under software control to further reduce power.

440EX for Basic PCs

The 440EX is Intel's chip set for low-end systems. There is no technical requirement to use the EX chip set with only Celeron processors and the BX with only Pentium II, but that is Intel's marketing position.

The EX is derived from the LX, not the BX, so it does not have the performance-enhancing features of the BX core, such as the improved paging scheme and deeper buffers. It is built in the older 0.5-micron process and does not support the 100-MHz bus, as the Celeron line is likely to stay with the 66-MHz bus for at least the next year. The main-memory speed is also limited to 66 MHz, a reasonable restriction because 100-MHz SDRAMs will carry a price premium for the near future.

Main memory is limited to 256M and only two DIMM slots. As Table 1 shows, the EX supports only three PCI slots, versus five for the BX, and does not support ECC memory. Finally, the EX supports only single-processor systems. Few of these restrictions are onerous in the low-cost PC market; the most significant are the very small number of DIMM and

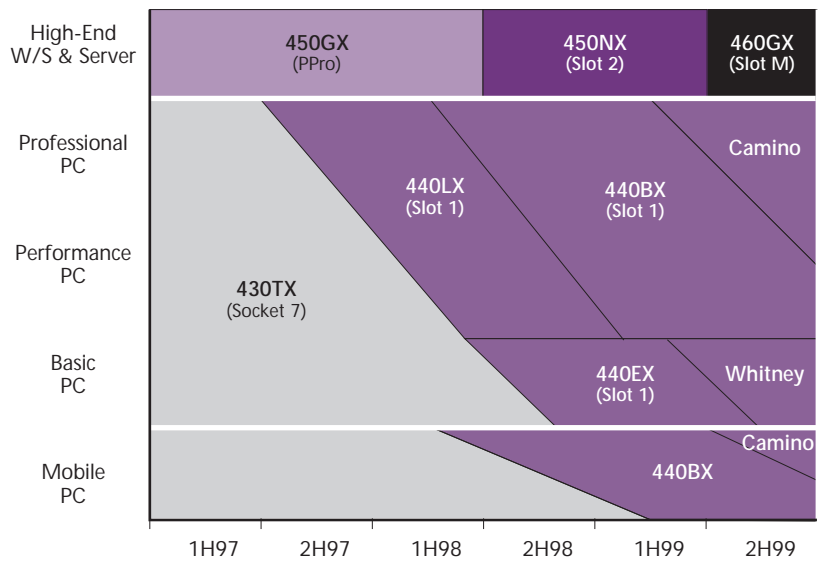


Figure 1. During 2H98, the 440BX and 440EX will become Intel's mainstream chip sets. In 1999, we expect Camino to replace the BX and Whitney to replace the EX while the 460GX appears in the server market. (Source: MDR)

PCI slots. Many sub-\$1,000 systems use such limited configurations today, and these configurations will become standard once the EX becomes widespread in this market.

Of course, the point of these restrictions is to prevent the EX from being used in mainstream PCs, forcing designers of those systems to buy up to the LX or BX. At a list price of \$34.75, the EX costs \$17 less than the BX. This strategy allows Intel to offer a relatively low-priced chip set for the low end while charging more for its mainstream chip set.

More Chip Sets on the Way

Although Intel has not disclosed any future chip sets, the next product likely to be announced is a chip set for Slot 2 workstations and servers. This chip set, rumored to be called the 450NX, will probably be announced in June in conjunction with the Slot 2 processors. Sources indicate the NX will include the same features as the BX, plus support for up to four processors and 8G of four-way interleaved main memory. Hot-plug PCI support would also be desirable in the server market, but AGP may be omitted, as it is not needed.

As Figure 1 shows, the 440BX should displace the LX over the course of 1998 as the Pentium II-350 and faster parts displace the older processors with 66-MHz buses. Sources indicate that Intel will deploy a new chip set, code-named Camino, along with its Katmai processor by mid-1999. As Katmai displaces Pentium II, Camino will displace the 440BX, although this transition is likely to last well into the year 2000.

Intel has disclosed plans to add IEEE 1394 (FireWire) and UltraDMA/66 to its chip sets in the future and to move the AGP port from 2× to 4× mode. These features are likely to appear in Camino. Like the 430TX and 440BX, Camino is likely to support both mobile and desktop systems.

Price & Availability

In quantities of 10,000, the list price of the 440EX AGPset is \$34.75; the list price of the 440BX AGPset is \$52. Both are currently available. For more information, check out developer.intel.com/design/pcisets/datashts.

Intel plans to move directly from 100-MHz SDRAM to Direct RDRAM, and Camino is likely to be Intel's first chip set with RDRAM support. Camino will probably not support DDR (double data rate) SDRAM, which the company continues to pooh-pooh as "not production-ready."

Camino will probably also support a faster CPU bus. At 800 Mbytes/s, the 100-MHz bus is a poor match for a Direct RDRAM memory system, which can deliver 1.6 Gbytes/s of data. Moving the P6 bus to 200 MHz may be difficult, even with its low-voltage GTL+ signals; an alternative is to transfer data on both clock edges, effectively doubling the bandwidth. This double-data-rate technique is also used by both AGP and Direct RDRAM, so Intel may adopt it for the P6 bus as well.

For servers, the 450NX should last for quite some time. Intel will also offer Corollary's Profusion chip set for eight-processor systems. The company will need a new chip set for Merced-based systems using Slot M; sources indicate this chip set will be called the 460GX and may support up to 16G of main memory. To achieve this large memory size, the chip

set may support DDR SDRAM, due to memory-size limitations of Direct RDRAM channels (see MPR 10/27/97, p. 25).

For the basic PC, the company is developing an integrated chip set code-named Whitney, according to sources. This chip set supposedly combines the 440BX north bridge, a graphics controller based on the i740, and possibly the south bridge into a single chip. It will support Mendocino processors at clock speeds of up to 450 MHz and could debut as early as 1H99, displacing the 440EX.

Although Whitney should offer substantial cost advantages to makers of low-cost PCs, some vendors may balk at the integrated chip set, which prevents the use of non-Intel graphics accelerators. For these vendors, Intel may need to maintain the nonintegrated EX alongside Whitney. If so, Intel must move the EX to its 0.28-micron process by mid-1999, as it will need to support versions of Mendocino with a 100-MHz bus.

Intel Dumps Socket 7

The latest announcements make one thing clear: from Intel's standpoint, Socket 7 is dead in the water. The new chip sets push Slot 1 into all of Intel's markets. The EX in particular aims to eliminate Socket 7 from OEMs' portfolios and will drive the 430TX from Intel's lineup by year end.

As Intel aims to serve a broader range of markets, it is expanding its chip-set strategy from the "one size fits all" concept of the 430TX to a range of products for different markets. This strategy results in a more complex product line but one that is better suited to each market. 