THE EDITORS' VIEW

Continuing to Push the Limits of Integration

Failure of 486SL Strategy Won't Keep Others From Trying

For years, processor vendors have been packing more and more system functions onto their chips. Intel's 486SL, introduced last fall, was a major step forward in this progression, combining Intel's leading CPU, a math coprocessor, cache controller, cache memory, DRAM controller, and ISA bus interface onto one chip. The ultimate solution, a single-chip PC, seemed just around the corner. Isn't that what everyone wants?

Apparently not. Intel's introduction of the so-called "S-Series" ends the development of new 486SL chips *(see **070801.PDF**)*. At the same time, Intel and IBM have quietly ended their partnership to develop other highly integrated 486 chips; the remaining effort has been moved from the jointly owned Noyce Development Center to Intel's Folsom plant and redirected toward low-power Pentium chips for notebook systems.

Despite Intel's turnaround, other vendors are continuing to pursue the path toward higher integration. Sun's microSPARC design is remarkably similar to the 486SL in system integration with SBus substituted for ISA. MicroSPARC left out power management, a deficiency that will be remedied in microSPARC-2 next year. The high integration of microSPARC helped Sun deliver the SPARC Classic as the first fully-configured RISC system for under $5000.

Not to be left out, both Hewlett-Packard and Digital are taking a similar tack with processors due later this year. DEC's 21066 includes the same system features as microSPARC except that it uses a PCI bus interface. The HP PA7100LC is not nearly as integrated but takes the unusual (for HP) steps of adding a DRAM controller and a small instruction cache to the main processor chip.

That the RISC system vendors are moving in a different direction than Intel is simply another indication of the vast differences between the PC market and the RISC system market. HP, DEC, and Sun all design, manufacture, and sell complete systems (although Sun uses other companies to fabricate its chips). Adding system-logic functions to the processor chip reduces system component count and board manufacturing cost while slightly increasing the manufacturing cost of the CPU chip. All three of these companies believe the cost tradeoffs to be in favor of more integration.

Intel's profits come from its processor chips, not from systems. Intel is uninterested in adding features to its processors unless it maintains its typical large profit margins. With the high unit volumes of the PC market, there are plenty of companies willing to provide system logic at margins too low to pique Intel's interest. Thus, in looking at profitability instead of system cost tradeoffs, Intel found the 486SL to be inadequate.

Another problem with the integration strategy is a lack of diversification. Intel has many customers designing many different systems, and these customers want to differentiate their products. By "hardcoding" the system design into a single piece of silicon, a highly integrated processor reduces the freedom of the system designer.

For the RISC system vendors, this type of differentiation is not as much of an issue. DEC, Sun, and HP have designed their chips specifically for the needs of their in-house system designers; the few other vendors that might use these chips are forced to live with whatever they get. Even for the RISC vendors, some diversity is needed; HP's insistence on putting the first-level cache off-chip allows it to create multiple price/performance points more easily than Sun can with microSPARC, which is limited to a single cache configuration.

Even for these system vendors, integration tradeoffs must be made carefully. In general, two small pieces of silicon are less expensive to manufacture than one large piece. The cost savings of integration must come from eliminating chip-to-chip buses, thus reducing the number of high-current drivers, bonding pads, and package pins in the system. Integrated designs can also reduce board assembly and test costs. As a side effect, performance sometimes increases because on-chip signals are much faster than chip-to-chip communication.

Over-integrated chips may inadvertently increase costs by lowering volume, since specialized parts have smaller markets. For example, it will always be cheaper to use standard DRAM than to integrate that memory onto the microprocessor.

For compact portable systems, higher integration is clearly an advantage. Despite giving up on future 486SL developments, Intel continues to pursue a partnership with VLSI Technology to develop integrated x86 chips for the PDA market. Hitachi's new SH7000 *(see **070802.PDF**)* already provides a highly integrated solution for handheld systems, where added cost is an acceptable tradeoff for smaller size and lower weight. For larger systems, market dynamics will continue to push system vendors toward higher integration while chip vendors slowly and reluctantly follow. ♦