Notebook Performance Leaves Gap

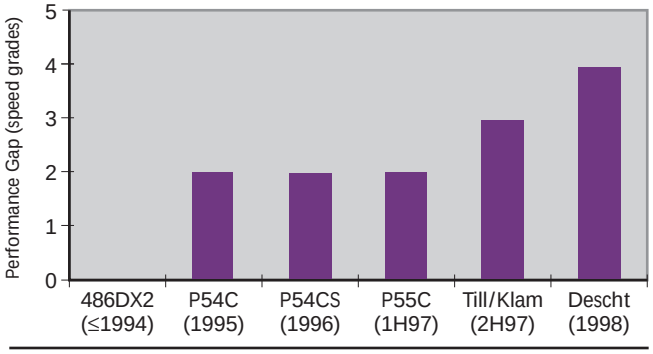
New Design Focus Needed to Address Mobile Market

Intel has been relentless in arranging its products to leave no openings in its lineup that competitors might exploit. Despite its best efforts, however, the gap between Intel's notebook and desktop processors, which started as a crack a few years ago, has now expanded to a sizable fissure. This gap has frustrated notebook PC buyers and could provide an opening for a wily competitor.

As the chart below shows, the performance difference between Intel's fastest desktop processor and its fastest notebook processor has been growing by roughly one speed grade per year. The 486DX2 dissipated so little power that it fit into notebooks without any modification, so there was no gap. Once Intel moved to Pentium (P54C and P54CS), however, the standard parts were too hot for notebooks. Intel compensated by cutting the supply voltage to reduce power, but this change also slows the clock speed.

Intel's fastest mobile part today is the 266-MHz Mobile Deschutes (see MPR 4/20/98, p. 14), but the same chip is shipping on the desktop at 400 MHz, four speed grades better. The mobile part might run faster, but then it would dissipate more power than a standard notebook can handle.

The root of the problem is simple: ongoing changes to improve processor performance also increase power dissipation. In particular, adding transistors and raising the clock speed both have a direct impact on power dissipation, according to the basic equation $P=cv^2f$ (see MPR 8/5/96, p. 3). New IC processes, often paired with reduced supply voltage, can compensate somewhat, but these improvements are generally overwhelmed once CPU designers create a larger core with more transistors.



The performance gap between Intel's desktop and mobile processors has been expanding from zero in the 486 days to four full speed grades with the latest Deschutes announcements.

Exacerbating this problem have been innovations in CPU design such as superscalar and speculative execution. Superscalar processors add function units that are only sometimes used, yet these units consume power most of the time. Speculative execution attempts to make better use of these function units by scheduling operations that might be useful, but often they are not.

These techniques increase overall performance, but only by wasting power, a critical resource in a notebook system. Design features such as branch prediction and x86 instruction translation also waste power on operations that don't directly contribute to program execution. As a result, many modern CPUs have become power hogs.

Intel's *modus operandi* has been to introduce new processor cores for the desktop, where power considerations are less of an issue, and later move them into mobile systems. This method reduces Intel's CPU design costs, but by driving the adoption of power-wasting techniques, it has caused mobile performance to fall further and further behind.

A processor designed solely for the mobile market would attempt to achieve the best possible performance per watt. It would probably eschew instruction translation, speculative execution, and perhaps even superscalar execution. In fact, it might look a lot like IDT's C6 processor, which has a fast scalar pipeline with minimal bells and whistles.

So far, IDT hasn't been able to push the C6 clock speed high enough to exceed the performance of Intel's fastest mobile parts. But a more focused competitor might be able to pull this off, if it built a design from scratch to deliver high x86 performance within the mobile power limit.

Intel is, of course, aware of this growing problem. In addition to thwarting competitors, Intel would like to spur sales of notebook PCs. The Geyserville approach (see MPR 3/30/98, p. 4) of running faster when docked offers a partial solution, but it doesn't help truly mobile users.

It's too late to make fundamental changes to the P6 core, but the designers of the next-generation Willamette processor are probably paying more attention to power dissipation than their predecessors did. If not, the mobile performance gap could become a chasm that swallows advances in the notebook market. M

For a more detailed discussion of Intel's mobile and desktop roadmaps, see MDR's latest Technical Library report, Intel Microprocessor Forecast, Third Edition.