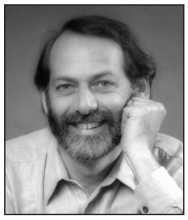
The Microprocessor Millennium

Ruminations on Microprocessors, Computing, and Thinking



On the verge of the new millennium, I have succumbed to the millennial fervor. In this column, I step back and take a 50,000-foot view of the microprocessor today, where its great successes have come, and what the future may hold.

It was roughly 30 years ago that the first microprocessors were created. Their remarkable success has come from their programmability, which made them nearly universal, fueled by unrelenting advances in semiconductor technology. From humble beginnings of a few thousand transistors per chip, today's microprocessors routinely have tens of millions of transistors—and the largest exceed 100 million.

More than 10 billion microprocessors have been manufactured. Personal computers, enabled by microprocessors, are on nearly every business desk and in half of U.S. homes; about three-quarters of a billion have been sold. Embedded microprocessors surround us—within a few years, microprocessor shipments will exceed one processor per year for every person on earth. The largest manufacturer of microprocessors now dwarfs all other semiconductor companies and is among the most profitable corporations in the world.

In the past five years, the Web, and all the resulting social and economic changes, have proved to be the microprocessor's most profound consequence. At the same time, computers crossed the threshold of being able to economically process and store audio, still images, and video. Because of these developments, computers have become vastly more useful to ordinary people.

The PC market, now more than 120 million units per year, will continue to grow for at least a few years, thanks in part to a belated evolution away from the ancient IBM standard. It is a huge industry, with tremendous momentum. Within a decade, however, PCs will be far outnumbered by application-focused information appliances, and today's PC will be seen as a sort of hot-rod Model T. The changes this shift will trigger in the industry are unlikely to be any less than those caused by the shift from mainframes to PCs.

What about smarter, rather than simpler, products? By the end of the next decade, microprocessors will exceed one billion transistors per chip, running at speeds of several gigahertz. Will it deliver 2001's HAL by 2010?

I think not. Among all the great successes of microprocessors and computers, the area of artificial intelligence has yielded the greatest disappointments. It is striking that there is nothing remotely close to "intelligence" being displayed by computers in the vast majority of applications. Word processing, spreadsheets, databases, desktop publishing, graphics, email, Web browsing—in every case, computers perform straightforward mechanical tasks.

This is not to say that progress will not be made toward more natural interfaces, increased automation, and smarter programs; surely it will. There will be agents that handle tasks for us, and expert systems for tasks like medical diagnosis, but these are simulated intelligences in narrow domains. A large collection of such simulated intelligences will make computing more powerful and more pleasant to use—but it isn't thinking.

Some observers argue that there is no real boundary between computation and thinking, and that when a big enough computer is built, it will exceed human capabilities. I think it far more likely that the distinctions between computing and thinking, between information and knowledge (much less wisdom), will remain clear. We can build machines that learn, but not machines that understand.

It is sometimes asserted that we will have thinking computers when the number of transistors per chip matches the number of neurons in the brain. The limits of semiconductor technology will be reached well before a microprocessor approaches the complexity of the brain, however. A typical human brain not only has 10 billion or more neurons, each of those neurons connects to thousands of synapses—and the neuron itself is a complex element of which we understand very little. A system with 10 billion microprocessors, each with a direct link to thousands of other processors, is probably closer to the complexity of the brain than is a device with a mere 10 billion transistors. And then you have to program it!

Computers and people are good at different things, and the greatest benefits will come from devices that augment, not replace, human capabilities. I look forward to a world in which all the text, music, pictures, and video I've collected are available to me wherever I am, on a variety of access devices optimized for different media and settings; in which I can communicate with most anyone nearly instantaneously, using any of these media; in which access to digital media is so transparent that it is no longer thought of as computing; and in which things just work. The industry will have accomplished a great deal if it can deliver simple, powerful access devices with seamless, pervasive networking: tools for human thoughts, rather than thinking machines. M

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