Forgetting Moore's Law

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Some ideas, such as Moore's law, are so ingrained in our thought that we sometimes miss articles that tell us how those ideas are changing.

Are we beginning to forget Moore's law? Certainly, we're never going to forget Gordon Moore, who identified the phenomenon that now bears his name. Back in 1965, when he was the head of R&D at Fairchild Semiconductors, Moore wrote a paper that considered the number of active elements that could be placed on an integrated circuit. It argued that that number should double roughly every year.[7] During the decade when Moore was president of Intel Corporation, he revised his estimates. At that point, he argued that the number of active elements on an integrated circuit would increase at a slightly slower rate. Instead of doubling every 12 months, it would double every 18 months.[8]

There is a substantial difference between the analysis that Moore actually completed and the popular understanding of Moore's law. Moore was discussing the technical aspects of integrated circuits design and manufacture. This work was supported by the research of a number of scientists. Perhaps the most notable of these contributions was the work of Robert Dennard. Dennard and his fellow researchers studied the circuits that would support the computing industry through the 1980s and 1990s.

ARTICLE FACTS

- Article: "Leakage Current: Moore's Law Meets Static Power"
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His 1974 paper, "Design of Ion-Implanted MOSFET's With Very Small Physical Dimensions," gave a clear description of how to increase the number of elements on a silicon chip and reduce power consumption.[3]

In roughly 1990, Moore's law moved from the technical literature to the popular press. At this point, writers started using the term "Moore's law" to refer to a slightly broader phenomenon. This version of Moore's law stated that computers would double in power and halve in cost every 18 months.[4,6] Behind this change was the growing recognition that computers and integrated circuits were important to nation-states and national security. The United States, for example, established a senior level advisory committee and started looking for ways to incorporate Moore's law into national policy.[1,9]

While the ideas of Moore's law may have been new to the public in 1990, they were commonly known to computer scientists and computer engineers. These individuals had grown accustomed to working in an environment that produced steady, predictable growth in computing power. Every 18 months, they were able to purchase a computer that cost half as much as their current machine, consumed half the power, and delivered twice the performance. This environment fundamentally shaped the way that they worked. The systematic growth of computing power encouraged them to design systems for the future. They wouldn't design systems for the machines that they had on hand. They would design for the machines that would be available when the system was completed.

Between 1990 and 2015, ideas of Moore's law were guided and shaped by the Semiconductor Industry Association (SIA). Every four years, they would publish a roadmap that would describe the goals that would need to be achieved to meet the targets of Moore's law. Since they published their final roadmap in 2015, many commentators have stated that we are living in a post-Moore's law world. Scaling "will not be able to address the upcoming needs in [Information and Communication Technology] performance and utilization of energy resources," notes a report of the SIA. "Therefore, radically new technologies for energy efficient analysis and storage of massive volumes of data are needed in the face of a growing flood of data."[2]

There are many commentators, including those who write for *Computer*, who feel that Moore's law is still operational and that we can still expect a steady and regular expansion of computing power. While we continue to see growth in both computing power and data storage, we also have to admit that the era described in 1975 by Gordon Moore is over. We can no longer increase our computing power by putting more transistors on silicon chips.[10]

Even if the traditional aspects of Moore's law have not come to an end, we still need to consider the role that *Computer* played in developing these ideas and how we need to include these ideas in our body of knowledge. Moore only contributed a few pieces to *Computer* and published most of his technical articles in other periodicals of the IEEE. Indeed, *Computer* has never been a major forum for articles on semiconductor design or manufacture. If anything, *Computer* has primarily been a way of explaining the effects of Moore's law to technical professionals.

Our most prominent contribution to this literature is an article that appeared well after the publication of Moore's papers (see "Article Facts"). In 2003, we offered our readers an article about how Moore's law interacted with static power consumption, "current that leaks through transistors even when they are turned off." It helped explain to *Computer* readers that static power was "one of two principal sources of power dissipation in today's microprocessors."[5] The astute reader would have grasped that we would need to reduce this form of consumption to make portable devices practicable. Furthermore, it suggested that portable devices would contain chips that were quite different from the most common computing devices of the era, which were, of course, laptop computers.

The article "Leakage Current: Moore's Law Meets Static Power" ultimately teaches us a great deal about the dynamic nature of our computing environments, although those lessons had less to do with Moore's law than the rise of mobile computing platforms. It appeared at a time when the conventional development that had been predicted by Moore's law was coming to an end and mobile cloud computing was just on the horizon. Kim and his coauthors explained the issues of low power computing and gave *Computer* readers a tutorial on the nature of lower power computing and the problems that would need to be solved to deliver low power computing. They had no interest in having us forget Gordon Moore or his law. They were just telling us that the world was about to change and that we should be prepared.

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