MORE ON MOORE

Dear Linux Magazine Reader,

Joe Casad, Editor in Chief

One of the more interesting threads in the news this month was on the time-honored and much acclaimed precept known to the world as Moore's law. The famous Moore's law, first posed by Intel co-founder Gordon Moore, is often used by industry analysts to predict the rapid advance in the complexity of integrated circuits. Eric Lai, at the Computerworld site, wrote a column pointing out that the recent popularity of the tiny, low-capacity ARM chips used in iPods and Blackberries seems to violate Moore's Law. Slashdot picked up the story, and all the bloggers weighed in.

Lai is certainly correct that the recent trend toward low-tech high-tech has confounded the predictions of experts. In addition to the iPods are netbook computers and other small, portable gadgets that appear immune from the once-certain wisdom that computers just keep getting more complicated. The question of whether this trend actually violates Moore's Law, though, calls for a little more analysis.

The original formulation of what we now know as Moore's Law first appeared a paper titled "Cramming More Components into Integrated Circuits," which was published in the April 19, 1965, issue of *Electronics Magazine*. Intel actually provides this paper for download in PDF form [1]. In fact, Moore's original article doesn't attempt to address how many components *could* go on a chip or how many components *should* go on a chip. The study maps the rise in the number of electronic components that produce a chip with the lowest cost per component.

Moore's observation that a theoretical complexity level leads to the minimum cost per component is based on the interaction of a pair of important factors affecting chip design. First is the simple notion that more components leads to economies of scale. On the other hand, counter-balancing factors ranging from precision of production equipment to dissipation of heat lead to reduced efficiency when the chip is overly complex. The result of these competing forces is that, for the state of technology at any given moment, a theoretical chip complexity exists that yields the minimum cost per component. The logarithmic rise in that theoretical chip complexity is the phenomenon that came to be known as Moore's law.

This original paper, which was written for engineers and electronics buffs, was strictly about production technology and made no grand predictions about what people would actually *buy*. Also, Moore never stated that a complex circuit would ever cost less – or even cost the same – as a simple circuit. He said that, over time, a more complex chip would produce a lower cost per component. His viewpoint fully anticipates that a more complex chip (with more components) would cost more overall even if the per component cost is lower, and therefore, nothing in Moore's law indicates that processors will become more powerful in cases where that power is not necessary.

Moore revisited the law 10 years later in a 1975 speech at an IEEE meeting. By this time, he had moved from research scientist to Intel exec. With the PC industry just starting to take flight, the world was hungry for more processing cycles, and the most cost effective chip the industry could produce was very much what the public wanted. In this later document (which is also at the Intel site [2]), his statements are directed more generally to overall trends in the industry itself, rather than to theoretical relationships within the production process. This 1975 speech appears to mark the first steps of his famous law from engineering principle to marketing axiom.

A confluence of demographic and commercial interests has led to an era in which processing power is no longer the overriding concern in electronics design. Portability, power consumption, and other factors also play a role in what we buy. But this trend alone does not mark an end to Moore's law – just an end to the presumption that this one mere conjecture about chip manufacturing can serve as a foundation for building a whole industry.

INFO

[1] "Cramming More Components onto Integrated Circuits" by Gordon E. Moore, *Electronics*, April 19, 1965. *http://download.intel.com/museum/Moores_Law/Articles-Press_Releases/Gordon_Moore_1965_Article.pdf*

[2] "Progress in Digital Electronic Circuits" by Gordon E. Moore. *http://www.intel.com/museum/archives/history_docs/mooreslaw.htm*