



Excerpts from A Conversation with Gordon Moore: Moore's Law

Moore's Law

Gordon Moore: The original Moore's Law came out of an article I published in 1965 this was the early days of the integrated circuit, we were just learning to put a few components on a chip. I was given the chore of predicting what would happen in silicon components in the next 10 years for the 35th anniversary edition of "Electronic Magazine". So I looked at what we were doing in integrated circuits at that time, and we made a few circuits and gotten up to 30 circuits on the most complex chips that were out there in the laboratory, we were working on with about 60, and I looked and said gee in fact from the days of the original planar transistor, which was 1959, we had about doubled every year the amount of components we could put on a chip. So I took that first few points, up to 60 components on a chip in 1965 and blindly extrapolated for about 10 years and said okay, in 1975 we'll have about 60 thousand components on a chip. Now what was I trying to do was to get across the idea that this was the way electronics was going to become cheap. It wasn't true of the early integrated circuits, they cost more than the bits and pieces that you could assemble cost, but from where I was in the laboratory, you could see the changes that were coming, make the yields go up, and get the cost per transistors down dramatically. I had no idea this was going to be an accurate prediction, but amazingly enough instead of ten doubling, we got 9 over the 10 years, but still followed pretty well along the curve. And one of my friends, Dr. Carver Mead, a Professor at Cal Tech, dubbed this Moore's Law.

So the original one was doubling every year in complexity now in 1975, I had to go back and revisit this... and I noticed we were losing one of the key factors that let us make this remarkable rate of progress... and it was one that was contributing about half of the advances were making.

So then I changed it to looking forward, we'd only be doubling every couple of years, and that was really the two predictions I made. Now the one that gets quoted is doubling every 18 months... I think it was Dave House, who used to work here at Intel, did that, he decided that the complexity was doubling every two years and the transistors were getting faster, that computer performance was going to double every 18 months... but that's what got on Intel's Website... and everything else. I never said 18 months that's the way it often gets quoted.

Interviewer: So just to be accurate, it's two years?

Gordon Moore: Two years in this day in age, and we're doing a little better than that.

Interviewer: 40 years later? Be true?

Gordon Moore: Of course, that was my plan from the beginning, no you can never see that far down the road in this sort of thing. When Intel was founded the entire semiconductor business worldwide was about two billion dollars... now it's kind of 200 billion dollars. The entire market has grown about 100 fold in that time. There was no way we could predict very far down the road what was going to happen. It was just a lucky guess, I guess on my part... lucky extrapolation.

Interviewer: What are your thoughts now, knowing its significance?

Gordon Moore: It's important to certainly change. Initially, just an observation an attempt to predict this was a way to cheap electronics... but the industry made it a self-fulfilling prophecy now, the industry road maps are based on that continued rate of improvement, various technology nodes come along on a regular basis to keep us on that curve, so all the participants in the business recognize that if they don't move that fast they fall behind technology, so essentially from being just a measure of what has happened, it's become a driver of what is going to happen. Something I never would have imagined initially.

Interviewer: How long can it continue?

Gordon Moore: I think Moore's Law will continue as long as Moore does anyhow! Ha ha ha... I'm periodically amazed at how we're able to make progress. Several times along the way, I thought we reached the end of the line, things taper off, and our creative engineers come up with ways around them. I can think of at least 3-4 things that seemed like formidable barriers that we just blew past without any hesitation and in fact, the board meeting we came up I saw pictures that go a couple of generations beyond anything I had seen previously in regards to the highest transistors we can build... so I think we've got quite a bit of life yet. I've never been able to see beyond the next three generations of technology. Three generations of technology is about 6-8 years and I can see that far now, things haven't really changed. Eventually they're going to have to. Materials are made of atoms, and we're getting suspiciously close to some of the atomic dimensions with these new structures, but I'm sure we'll find ways to squeeze even further than we think we presently can.

Past and future

Interviewer: Reflect on 36 years... Thoughts as look back on entire career? Founding greatest companies in the world?

Gordon Moore: It sure is nice to be at the right place at the right time. I was very fortunate to get into the semiconductor industry in its infancy. And I had an opportunity to grow from the time where we couldn't make a single silicon transistor to the time where we put 1.7 billion of them on one chip! It's been a phenomenal ride... if you measure the industry in terms of the number of transistors it makes which I like to do occasionally, there's no industry that I can identify that is remotely comparable in how it's expanded over that period of time. We've grown a lot in dollars but we've grown a heck of a lot more in our output.

Message to employees

Gordon Moore: First of all, I thank them for the contributions they made because really it is our employees who got us where we are today... and are going to take us where we want to go in the future.



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