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The Moore's Law

Introduction

The Moore's Law, a very famous, accurate, and now almost dead law, says the number of transistors in a single Integrated Chip will double every 18 months. It was given by Intel's co-founder Dr. Gordon Moore. This statement was taken as a target by the Silicon Industry to achieve every year. The law had a huge success and impact in the Tech Industry. But we finally have the evidence that the law really is coming to an end.

The "Actual" Moore's Law

"The complexity for minimum component costs has increased at a rate of roughly a factor of two per year (see graph on next page). Certainly over the short term this rate can be expected to continue, if not to increase. Over the longer term, the rate of increase is a bit more uncertain, although there is no reason to believe it will not remain nearly constant for at least 10 years." ***~Cramming more Components onto Integrated Circuits, Electronics, Volume 38, Number 8, April 19, 1965***

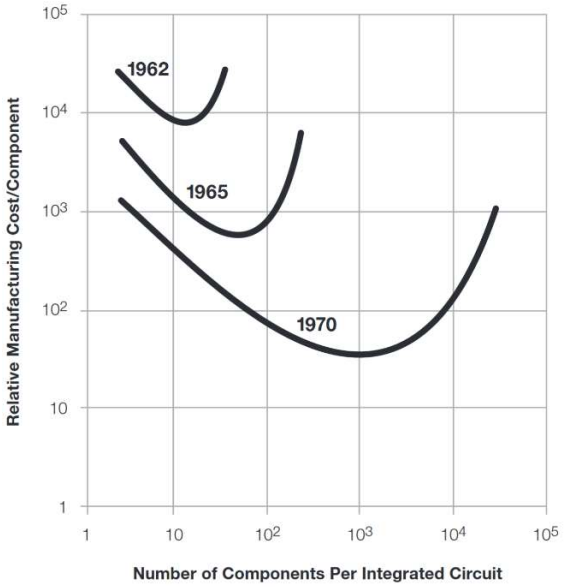

Figure 1

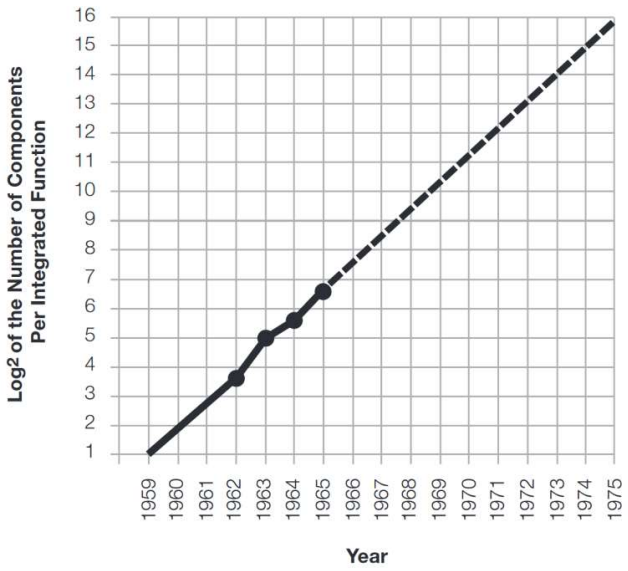

Figure 2

(Cramming More Components Onto Integrated Circuits)

This statement somewhat modified later was taken by the world as "The Moore's Law". But when we really say the term "Moore's Law", normal people think of a Law that says that the transistors in a particular system will double every two years or so.

It was not until 10 years from the publishing of the paper when the term "Moore's Law" was coined in by Dr. Carver Mead of Caltech, who was also a friend of Dr. Moore. As to the real Moore's Law paper, Dr. Moore detailed his past year observations and predicted that the future electronics were likely to have a similar trend. His prediction was not just about the number of transistors in a chip, but also about the cost of making those chips. There were some deviations in the real world from the actual law, so the law had to be corrected to a certain extent. The corrected law was a more accurate one, numbers started to be the way they were predicted. In fact, as mentioned by Dr. Moore himself, one of the employees at Intel, came up with the 2 years or 18 months approximation (for the corrected Law).

The Accuracy led Success

Dr. Moore predicted the doubling of transistors in a chip every year, whereas, in reality, that exponential growth was observed in nearly every 2 years, thus the law was modified accordingly. When talking about its success, the law turned out to be one of the most accurate predictions in history. Even though Doctor himself predicted the outcome for just 10 years, which I personally believe was a leap in itself. But the Law surprisingly, sustained for about 40 years since then.

Last year, the Tech Industry celebrated its 50th Anniversary on April 19. This very well indicates the success the law has seen, in its tenure of fifty years. This incredible success was also added to the reasons of why people recognized his words as "The Moore's Law".

The Predictions

Since the date, when Moore's Law was acknowledged, there have been predictors, predicting the end of it. Most of them being about humans reaching the peak limits of physics.

But opposing to all, the law turned out to be very much similar to petroleum. There have been many predictions about the petroleum reserves in earth. Scientists have all along been predicting/calculating that the world would reach peak oil in the nearly 10 years, but all turned out false, we still haven't reached the peak oil. Petroleum seems perpetual, and such is the case of Moore's law. Every time someone predicted that Moore's law is about to end, it disobeyed them and "did not end".

The reasons why the “prognosticators” were wrong, was their unaccountability for the future physics endeavors. They predicted that the humans will reach the physics’ peak limits in a few years. Science is never an easy topic to predict, statistically and logically most of the predictions (including both famous and non-famous) that have been made were false. Moore’s Law is not a scientific law, but a statistical one. But, it does rely on Science! The prognosticators also overlooked the faith of Tech Companies in the Moore’s Law. Faith & Will have made the man do many impossible things. This was one good example.

The faith in Moore’s Law became self-fulfilling. It inspired advances in miniaturization and architecture that kept the burgeoning chips’ computing power.

Effects on Hardware and Software Development

The first few years of the Moore’s Law did not really have a lot of effects on the development. But as soon the “Law” saw success, all the Silicon Chip Tech Companies took note and started using it not merely as a descriptive or predictive observation, but as a prescriptive law. It became a target that the entire industry should hit. They were motivated by the Law, they endeavored to make the law exist, i.e. attempted to double the “transistors” in the computer chips. They succeeded. Companies and engineers “saw the benefits of Moore’s Law and did their best to keep it going, or else risk falling behind the competition,”. This was an observation made by Dr. Chris A. Mack.

When talking about its effects on the software development, all the effects were indirect. More the complexity of the hardware, more the complexity of software. Even though the relation between the two is anything but directly proportional, the improvement in hardware definitely

gives a greater space and scope for the code or program to be written. In fact, there is another law in the field called the “May’s Law”, which says that “Software efficiency halves every 18 months, compensating the Moore’s Law.” The reasoning and evidence to this law are perfect, according to Moore’s law the number of transistors in a chip increases exponentially, but the software built inside that chip would not, because the field progress of programming and hardware is not related by any means.

The End is Near…

In prior years, Moore’s Law was considered as somewhat immortal, but now it has seen its limits. Currently, the limiting situation has gone into the spectrum of quantum physics. Complications are getting atomic. The biggest obstacle to cramming more transistors onto a single chip has come down to one thing, how small can we make the gap between the silicon channels? Currently, available commercially, the difference between a 0 and a 1 is just a few hundred atoms. When a transistor gets really small, say to a size of a few atoms, electrons start to jump gaps across for no reason apparently, a phenomenon known as Quantum Tunneling. This can create some serious data corruption issues, but even before that the heat created by that would melt down the whole Integrated Chip, and sometimes the floor beneath it!

According to the law, by now we should have about 10 billion transistors, but we just have a couple of billion in a chip. Now economically, the cost per transistor in an IC chip has stalled since 2012. The statistics provide a better evidence of the Law’s ending. (See the graph below).

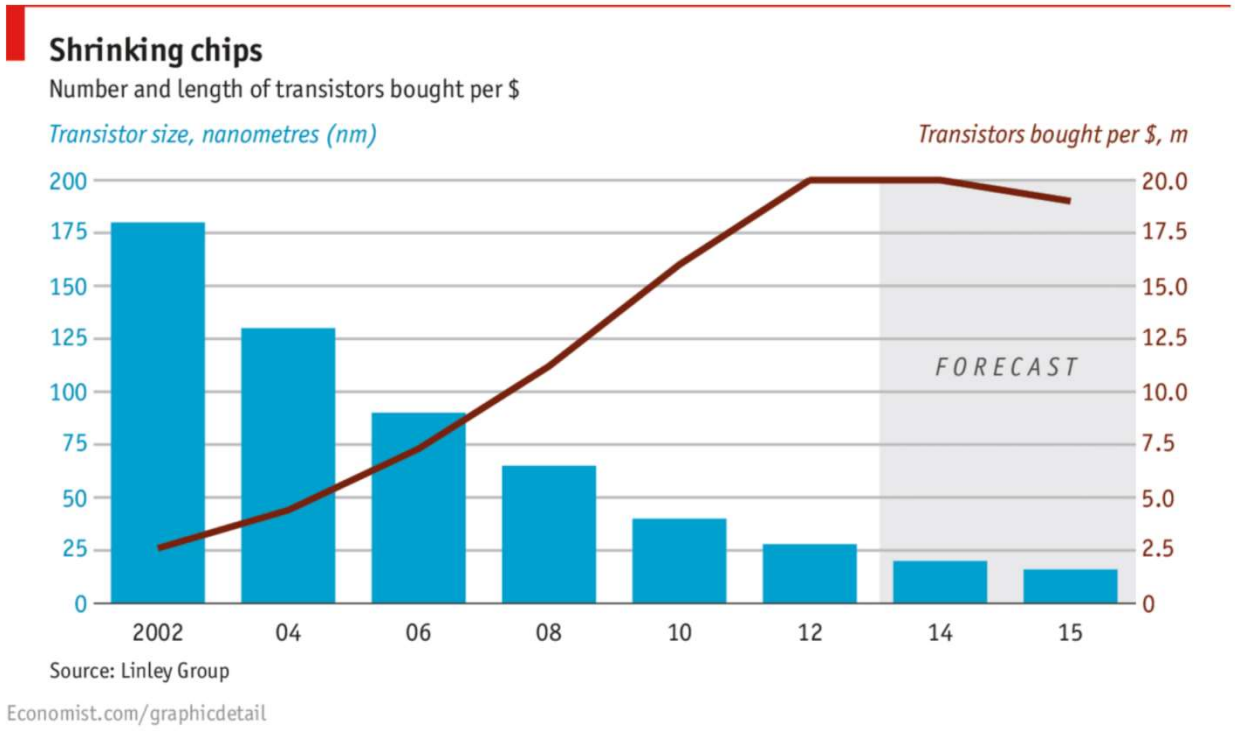

Figure 3 (TheEconomist.com)

We may be improving, but not according to the law. We are constantly creating new materials, but none of them, which can revive the great law. It really is coming to an end.

Dr. Moore's views about the end of his law

Dr. Moore himself was never really comfortable with the term "Moore's Law". A lot of times he thought that they've reached "end of the line", but scientists somehow found a way. He himself was surprised by the success the law has seen this far. The law was just for those 10 years, but it continued to be true for 30 more years, that itself is a great accomplishment.

He admits to the fact that now the science of transistors and circuits is now reaching the level of atoms. Even then, he has asserted optimistically, that "we'll find ways to squeeze even further than we think we presently can." He also said about his past thoughts, which were, that the

people of future, when hitting the limit of the number of transistors in a single integrated chip, will start to invest on bigger chips to get more processing power.

What Now? And What of the Future?

In the early days, the gap between any two silicon channels was so big, that we could see them with our naked eyes. Right now we require an electron microscope to see it. Maybe Moore's law is coming to an end, but we humans, have always found a way around things. We can still tweak the processing chips, and probably transcended from two dimensional chips to three dimensional ones.

In today's world, the smallest transistor that we have created is just one nanometer big. It was recently created at the Lawrence Berkeley National Laboratory.

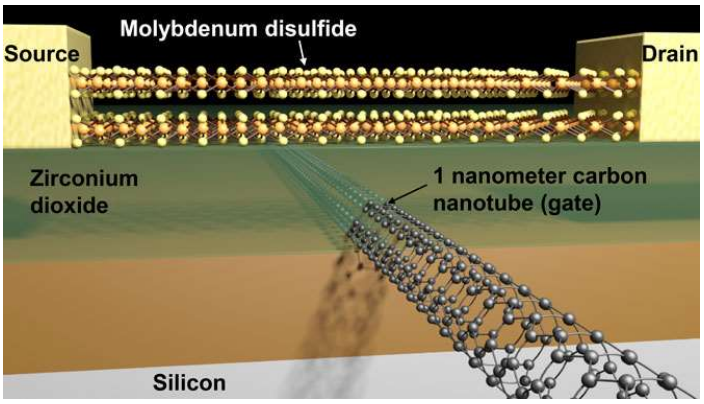

Figure 4

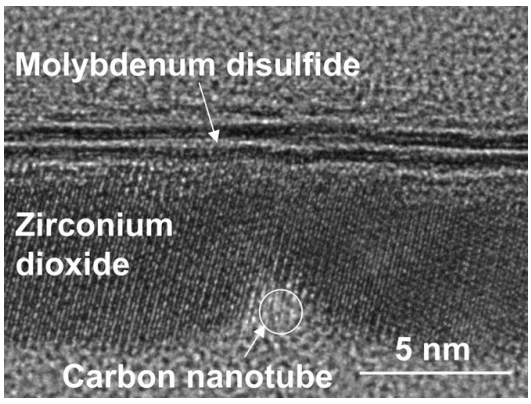

Figure 5

(Lawrence National Berkeley Lab)

I am eager to see it available commercially. We learned about the "May's Law" earlier, if the Moore's Law is dead, then because of the interdependence the May's Law will be dead soon too. We can actually improve our systems by making better working software, they'll be more

compatible with the hardware we already have. I also believe that this is some sort of a final call for the industries to find a different way or outlook to solve the problem.

Conclusion

Moore's Law has seen its peak; it now is heading to its resting place. Even though the Law is almost dead, we can still increase the processing power. Maybe not by increasing the transistors, but tweaking ways around it, like making 3Dimensional ICs. Also we should be making better software, to end the "May's Law". I do think that, now or at least near future would be a good time to say good-bye to silicon, and start using other materials, such as Graphene, black Phosphorus or even Light! We may even build an entirely different type of computer system, such as optical computers, quantum computers, thermal computers et cetera.

When the silicon semiconductors were new to us, we faced problems and 'resistance', but we gradually adapted to them, and made them adapt to us. Similarly, Presently, to sort everything out, we eventually just need the old-timer "more Time and Money"! History repeats itself!

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    - *Figure 3*