BBC NEWS

Law that has driven digital life

By Jo Twist
BBC News science and technology reporter

Moore's Law was never about pure physics or maths or science.

The proposition that the Intel co-founder, Gordon Moore, made in a 1965 paper that the number of transistors on a chip could double every 24 months, was more a guide.

Although many working in the semiconductor industry back then had noticed the same trend, he was the first to publish the idea, so it stuck.

But for 40 years, it has continued to push the digital revolution.

It has also driven competition between the industry players that rely on chip technology to make electronics faster and able to do more.

The influence of what he articulated has been hugely significant, Professor Ian Mackintosh, a retired silicon chip pioneer, explained to the BBC News website.

> **Practically anything digital has depended critically on the swift improvement in chip density**
> Professor Ian Mackintosh

Professor Mackintosh was one of the leading silicon figures at what was then Bell Telephone Laboratories in the US where he developed and published the first theory of the thyristor, a semiconductor device similar to a diode.

"Moore's Law reflects the extraordinary improvements in silicon technology in last 40 years.

"There are no words to describe its impact. It is immense. Most people don't have the faintest idea what it is has done," he told the BBC News website.

What Dr Moore wrote about in the 1960s quickly became a benchmark for competing electronics industries, as well as the scientists and engineers working in the field of semiconductors.

"If all of these thousands of scientists had not contributed, then Moore's Law would have seen an increase of 9% every five years, or something like that, and we would still be in the Dark Ages electronically speaking," thinks Professor Mackintosh.

No lagging

Even Dr Moore is surprised about the longevity of the observation, but he admits the "law" has become a self-fulfilling prophesy.

"Amazingly enough, we have been staying on or a little ahead of that trend for the last 40 years," Dr Moore said in a telephone conference last week.

"It has gotten to the point where participants in the semiconducting industry recognise they have to move along at least at that rate or fall behind technologically."

> **If you are a generation behind in technology, you suffer not only in performance disadvantage to your competitors, but also in cost disadvantage**
> Gordon Moore, Intel co-founder

To fall behind would be a disaster in a business where making ever more complex circuits at smaller and smaller dimensions improves performance and lowers cost.

"If you are a generation behind in technology, you suffer not only in performance disadvantage to your competitors, but also in cost disadvantage," Dr Moore said.

A transistor is a basic electronic switch in the chip. It was invented at Bell Labs in 1947. Every chip needs a certain number of transistors, and the more there are, the more chips can do.

"Practically anything digital has depended critically on the swift improvement in chip density," explains Professor Mackintosh.

"We wouldn't have mobile phones, laptops, digital cameras, some of the advances in medical technology, electronic games, satellites, GPS, and on and on."

End in sight?

But Moore's Law will not be an effective benchmark for the next 40 years. It is reaching technological limits in terms of how dense silicon chips can be - in other words, how many transistors can fit on to chips.

"The industry now believes that we are approaching the limits of what classical technology - classical being as refined over the last 40 years - what that technology can do."

"Feature size is becoming so small we are now getting into the realm of quantum mechanics - atoms thick."

Intel, for instance, will start using 65-nanometre (billionths of a metre) manufacturing processes later this year. Rivals AMD are also moving in the same direction.

At that level, there are some challenges, and problems of unwanted current leakage start to occur.

"When it gets down to 10 atoms, it is a different realm of physics altogether and funny things start to happen," explains Professor Mackintosh.

Researchers in nano and microelectronics across the world are putting in a great deal of effort to develop some sort of substitute or innovation that will get over this problem.

Some are experimenting with nanostructured novel materials, such as carbon nanotubes, to replace transistors and diodes, and quantum mechanics.

Intel is also pioneering the use of lasers to improve the accuracy of circuit lithography.

Many of the possibilities are still a long way off, however, not least because complete circuits using these methods on a large scale are difficult and expensive to produce.

Some of the innovations on the nano-scale are improving on the existing technology, but in

several other ways.

"There are other technology enablers that you need as you continue to scale Moore's Law," explains Josh Walden, Intel's Northern Ireland fabrication plant manager.

"We continue to come up with new materials to have lower interlayer electrical properties and we continue to innovate to reduce power and shrink transistor size to enable Moore's Law."

But when Moore's Law is effectively slowed down in about 10 to 20 years' time, Professor Mackintosh thinks technology lovers will not necessarily notice much.

"As that progress slows down, computer manufacturers will put effort into the peripherals, such as better LCD [liquid crystal] displays, better batteries and so on.

"Otherwise, innovation will come to a grinding halt and we won't be buying them anymore."

Not something the electronics industry or gadget fans ever wish to see.

Story from BBC NEWS:
http://news.bbc.co.uk/go/pr/fr/-/2/hi/science/nature/4449711.stm

Published: 2005/04/18 23:19:57 GMT