No More Moore's Law?
July 22nd 2004

It's amazing to think that the height of 1970's technology was many times less powerful than a fairly inexpensive modern PDA. The incredible shrinking chip is something we all take for granted but, as Spencer Kelly's been finding out, it can't keep shrinking forever.

See Spencer's Report (Windows Media) Low | Medium | High
(Real Player) Low | Medium | High

The more transistors we can fit on a chip, the more processing power your computer has. The closer together the transistors are, the quicker they can transfer signals between them, and so the faster they run. We've been squeezing more and more onto our chips at a pretty constant rate.

In 1965 Gordon Moore, co-founder of Intel, the chip people, stated that the number of transistors on a chip will continue to double every 18-24 months. In the next 40 years, transistor counts went from 2,300 to 55 million, as Moore's Law continued to hold true.

Gordon Moore: "In many respects we're still in the infancy of microprocessors. There are many things we can do to make them more capable and we're pushing those as hard as we can."

Today, Japan's Earth Simulator is the world's fastest supercomputer, tearing along at over 35 million million calculations a second. But how did we get here? How has something so powerful been made to fit into such a relatively small box?

In a process called lithography, circuits are etched onto silicon by shining light through a mask. As we learn to use shorter wavelengths of light, we can make finer and finer circuits.

Dr Dave Watson, IBM: "There are difficulties in continuing to refine the current lithography process indefinitely and people are moving towards different wavelengths of light, moving away from visible light into what's called extreme ultraviolet. That offers the opportunity to use a shorter and shorter wavelength, which allows you to etch smaller and smaller components into integrated circuits."

Even if you could keep refining the lithography process, there are other problems associated with bringing things really close together - chips are getting hot.

Dr Dave Watson: "Chips use more power to create heat in themselves than they actually do to work, and that's because of the density of components on the chip. It's got to the stage where you can't use all of the chip at the same time, you have to use parts of it at a time to keep heat down to a minimum."

If you look at current chip technology the actual core component in the chip can only be about 25 atomic layers thick of silicon, and the problem is that you get jumps of electricity between different components. So you have two copper conductors separated by 25 atomic layers and the electrons can literally jump from one side to the other and you get shorts in chips. If you go much smaller you simply cannot control the electrons within the chip."

Developers have encountered barriers like this before, but Moore's law always finds a way. The change from aluminium to copper as the conductor in chips meant they
could use 30% less power. Even silicon isn't safe - newer, more expensive chips made from gallium arsenide could prove 40% faster.

But even if you can overcome the heat, power and materials problems, you can't just go on shrinking forever. It's estimated that sometime in the next decade, Moore's Law will reach its final, impenetrable barrier - you can't make a wire thinner than an atom. At that point, it's game over.

If, by the time we reach the atom barrier, we still want more oomph in our machines, we'll have to do things differently. At that point, it will be time for some major 'thinking outside of the box'.

Even now, there are projects afoot to use DNA to perform calculations that just wouldn't be possible for normal computers, no matter how fast they ran, things like protein folding, or full human body simulations.

Meanwhile, at Oxford University, under an electron microscope, there are the hazy beginnings of a very different type of computer - a quantum computer.

In a quantum computer the calculations are performed by bending the laws of classical physics, and data is manipulated by rows of caged atoms called Qbits. (Click Online's David Jamieson investigated Qbits last year. You can see his report here.)

Prof. Andrew Briggs: "The difference between quantum computing and classical computing is that whereas in a classical computer you work with bits that at any given moment can be either 1 or 0, in a quantum computer we use what we call Qbits, and I know it sounds weird but each Qbit can be both 1 and 0 at the same time.

The benefit that brings you is that in a quantum computer you can try different solutions to a problem simultaneously."

An array of Qbits is made by lining up rows of caged atoms, and instead of having to work out the answer to a problem an array of Qbits will come up with all possible answers in one single step.

We will never need a quantum computer for word processing and answering emails, but there are some jobs which may require more power than Moore's Law could ever give us, so it's good to know that one day that law could be broken.