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A simple guide to microprocessors and their manufacture

The Internet - bringing down the walls

With astonishing speed and momentum, the Internet has become a primary medium for business, entertainment and communication. For enterprises and consumers alike, the Internet and e-business are starting to change the function of the personal computer. From being an electronic productivity aid, it is becoming a primary means of communication and the medium on which huge amounts of business are being conducted. Suddenly, in a way never before possible, individuals within, between and outside business are able to communicate, share information and trade with each other.

This sea-change brings with it a number of challenges for the IT industry. The more people communicate electronically, the greater the need for security. Electronic business needs very high levels of encryption. E-mail sent over the Internet must be secure. Virus checking must become ever more sophisticated.

For the individual user, the level of information arriving at their desktop is increasing exponentially, and some degree of automatic synthesis and prioritisation is essential.

These challenges require complex software running on powerful computers. Those computers rely on the microprocessor to make that happen.

The microprocessor is the brain of the computer, making all the calculations the software needs to do its job. From simple word-processing to number crunching to displaying the most complex 3D environments, the microprocessor is driving the performance of the computer.

What are microprocessors?

A microprocessor is a 'chip' of silicon on which several layers of circuits are etched. Although it looks flat, it is a 3D structure with up to 20 layers of microscopically thin circuits connected via tiny metal lines. To get an idea of the complexity of each microprocessor, imagine shrinking a detailed street map of a city to the size of your fingernail, and then layering twenty of them on top of each other, each only a few atoms thick. Each of these layers contains millions of transistors, around which electrons flow while the processor is running.

This miraculous process is achieved by coating the silicon in a light-sensitive metal, and shining light onto it to create a negative image (rather like the process of making a photographic negative). The areas touched by light are hardened, and the unwanted metal washed off.

Over the years, the width of the lines projected onto the silicon has become thinner and thinner. New technology is able to achieve 0.18 microns, 1/500th the thickness of a human hair. The 0.18-micron process technology features structures that are smaller than bacteria and smaller than the visible wavelength of light detectable by the human eye. Structures on this new process are as small as 0.13-microns.

Changing from the current 0.25 micron process to the new 0.18 micron process will mean Intel can put the same number of transistors onto a chip of roughly half the size of current models.

This has huge benefits:

- Processors run faster, because electric signals within the processor have less distance to travel.
- Processors are cooler, because they consume less electricity - with great implications for the power and the battery-life of laptops.
- Processors are cheaper to manufacture.

How are microprocessors made?

Processors are manufactured, hundreds at a time, on circular silicon wafers. The more processors per wafer, the lower the unit cost. Only a certain number of processors per wafer pass the quality tests. The rest have probably been contaminated with microscopic splashes of dust or other particles. The more processors per wafer, the smaller the percentage damaged with each contamination and the higher the yield.

Microprocessors are extremely difficult to manufacture, the costs of fabrication plants are phenomenal, and the environment in which they are made is quite extraordinary.

The primary danger during manufacture is contamination by dust, pollen or other airborne particles. A typical cubic meter of unfiltered air contains some 450 million such particles, each of which could be fatal to the creation of a microprocessor. To combat this, the heart of the factory is a huge clean room where the processors are made.

More than 10,000 times cleaner than an operating theatre, Intel's clean rooms have no more than 30 particles per cubic meter (the equivalent - scaled up - of one particle the size of a pea in an area of twelve cubic kilometres). To achieve this, the air is filtered and re-circulated ten times a minute, and all workers wear sterile 'bunny suits'.

What's next?

Technology does not stand still. As long as 30 years ago, Intel founder, Gordon Moore, predicted that the number of transistors on an integrated circuit will double every 18 months. 'Moore's law' is one of the fundamental dynamics of the industry today. To keep delivering against it, Intel has to continue to innovate both in microprocessor design and in manufacturing technology. Intel is already investing in developing the next generation of process technology - ploughing billions of dollars into designing the processors and factories of the future.