THE OFFICIOUS BYSTANDER

THE QUANTUM LEAP

The human mind, and particularly the human memory, works in strange ways. The Officious Bystander (TOB) has a mind like a down-market antique shop, crammed from the floor-boards to the ceiling with useless bits of old junk. Like the proud owner of such a shop, TOB has convinced himself that some of his junk is very valuable, although others are unable to see its worth. But on any view, most of it is totally useless - and very hard to get rid of.

In TOB's case, 1969 was a golden year for the acquisition of useless information. He was then in fifth grade, at a one teacher State primary school. The teacher seemed quite old, although he was probably younger than TOB is now. He was also a stern disciplinarian, and had enormous faith in the benefits of rote learning.

TOB will not deny that some of this rote learning was distinctly beneficial - spelling, and the "times tables", for example. TOB has never regretted being compelled to learn, by heart, the capitals of Europe, from Oslo in Norway to Sofia in Bulgaria; though it seems strange that, at a time when young Australian men were fighting and dying in Vietnam, it was thought more important for Australian children to know that Lisbon is the capital of Portugal, than to know that Djakarta (as it was then spelt) is the capital of our nearest neighbour.

Amongst the many lists of information which TOB and his class-mates had drummed into them was "the Sunshine Route" - a list of cities and towns along the Queensland coast from Brisbane to Cairns. It is surprising how often it proves useful to recall that Home Hill comes after Bowen, and before Ayr.

One category of information, learnt by rote, has proved to have a less enduring relevance - namely, the Imperial system of weights and measures. But in 1969, nobody could have foreseen the adoption of the metric system by Gough Whitlam's francophile government. Had Whitlam not introduced this reform, in emulation of his hero Napoleon, one might still have regular occasion to utilise the knowledge that there are

5½ yards (or 16½ feet) in a "rod, pole or perch"; that there are (confusingly) 112 pounds in a hundredweight; or that there are four pecks in a bushel. We were even taught the old monetary system (pounds, shillings and pence) - although this had been replaced three years earlier, on 14 February 1966 - perhaps because the educational authorities were concerned that the move to decimilisation might be reversed, but more probably because the text-books which we were using had not yet been updated.

The acquisition of all this inutile information was more than compensated by rote learning of great and enduring significance. It is difficult to imagine how any responsible educational system could send students out into the world without the ability to recite, from memory, at least one poem by each of Banjo Patterson and Henry Lawson.

There is, however, one thing which has stuck in TOB's mind these past 32 years, which was not learnt by rote. It appeared in a science text-book, which was a companion to the science lessons which we received by "wireless radio" broadcasts from the ABC. The long-forgotten author of this text predicted that, "by the year 2000" (which then seemed a very long way off), computers would be so small and so powerful that a machine no larger than a television set would be able to perform the work then undertaken by huge main-frame computers; and, moreover, that these devices would become so inexpensive that it would be common to see them in business offices, and perhaps even in people's homes.

In 1969, this was a remarkable prediction. This was the year of the Apollo 11 moon landing, and Neil Armstrong's "great step for mankind". It is said that the computer processing power available aboard Apollo 11 was the equivalent of what is now contained in a pocket calculator. The enormous main-frame computers at Mission Control in Houston could not process the volume of data being transmitted, to the point that Armstrong had to take manual control of the lunar module (the Eagle), and land it with no more assistance from computers than Captain Cook had when he landed at Botany Bay.

In 1969, apart from the obscure writer of an obscure science text for school children, nobody had any conception of how computers would revolutionise all aspects of society over the next quarter-century. Even those closest to the action had little idea. In 1943, the founder and chairman of IBM, Thomas Watson, expressed the view that “there is a world market for maybe five computers”. In 1949, *Popular Mechanics* magazine predicted that “Computers in future may weigh no more than 1.5 tons”. Even as recently as 1977, the founder and chairman of Digital Electronics Corporation, Ken Olsen, could not understand why “anyone would want a computer in their home”. And Bill Gates, of MicroSoft, is on record as saying that he could not see why anyone “would ever need more than 640K of RAM”. These predictions are on a par with the pronouncement by Richard Woolley, the British Astronomer Royal, in 1956, that “Space travel is utter bilge”; less than 12 months later, *Sputnik* went into orbit.

Anyone who has seen the recent cinema release, *Enigma*, will have noticed the huge and primitive computer which was used by the code-breakers at Bletchley Park to crack the Germans’ “Enigma” codes during the Second World War. (*Enigma*, by the way, was the British term; the Germans’ term was *Ultra*). This computer was the work of a mathematician, Alan Turing, who in 1938 published a mathematical paper entitled *On Computational Numbers*, proposing a calculating machine which he (immodestly) called the “Universal Turing Machine”. The machine constructed at Bletchley Park, called *Colossus*, was capable of performing about 5,000 calculations per second - that is, it had what would now be called a “clock speed” of 5,000 hertz (Hz), or 5 kilohertz (KHz). Today, computer processing power is measured in megahertz (MHz) or gigahertz (GHz). A desktop or laptop computer with a processing capacity of 100 MHz could perform, in about eight minutes, the decoding process which Colossus took 15 hours to achieve. The latest microprocessors have “clock speeds” in excess of 1 (GHz) - that is, one thousand million hertz, or about 200,000 times faster than Colossus.

Later in the war, Turing went to New York to explain his invention, and seek support for its improvement. At a meeting of corporate executives in the technology sector, he was asked whether what he was proposing could be described as a “powerful brain”. Turing’s reply was, “No, I’m not interested in developing a *powerful* brain. All I’m after is just a *mediocre* brain, something like the President of the American Telephone and

Telegraph Company".

To describe the growth in computer processing power since the 1960s as "exponential" is literally accurate. In 1965, Dr Gordon Moore, a founder of Intel Corporation, predicted that computer processing power would double every 18 months, whilst the cost would remain constant. This algorythm has proved remarkably accurate for more than 35 years. On the other hand, cynics suggest that the benefits of "Moore's Law" are neutralised by "Gates's Law" - the proposition (attributed to Bill Gates) that "the speed of software halves every 18 months". In other words, whilst new computers may have the capacity to perform twice as many calculations per second as compared with computers manufactured 18 months earlier, the latest software requires twice as many calculations to be performed in order to achieve the same result. It is ironic that Gates's company, MicroSoft, is the worst culprit of the "software bloat" which produces this result.

Can Moore's Law continue to hold good in the future? Computer industry commentators suggest that it can - for at least another 5 or 10 years. Ultimately, however, it must hit a brick wall; a real and (possibly) insuperable obstacle to increased speed. This is the point at which "Moore's Law" runs into "Einstein's Law".

In simple terms, microprocessing speeds are enhanced by cramming increased numbers of transistors on to smaller microchips. But there is a finite limit beyond which the size of a microprocessor chip can be reduced no further. Already, the printed circuits on a silicon chip are no more than one or two atoms wide. According to conventional physics, they cannot be made any smaller.

Electromagnetic signals travel within a microprocessor at a speed approaching the speed of light, which again is an insuperable barrier - at least according to conventional physics. Whilst the speed of light (300 million metres per second) is incredibly fast, it is a threshold which the "clock speeds" of modern microprocessors are rapidly approaching. If a silicon chip is (say) 2 centimetres wide, then, at the speed of light, only 15 thousand million electromagnetic signals can pass across it every second - which equates to a "clock speed" of 15 GHz. If the size of the chip can be reduced to (say) 1 centimetre, a maximum speed of 30 GHz is conceivable. But if it is accepted (in accordance with conventional physics) that circuits cannot be thinner than 1 atom, and that electromagnetic charges cannot travel faster than the speed of light, Moore's Law cannot continue to function beyond the end of this decade.

If this is the effect of "conventional physics", what about "unconventional physics" - that is, quantum physics. This seems to be the logical future of computer technology. Quantum physics is concerned with the behaviour of sub-atomic particles, offering the prospect that the size of central processing units can be reduced even further. And the remarkable thing - the truly remarkable thing - about quantum particles is that, at least in theory, they can travel faster than the speed of light.

The use of quantum particles in computing is fraught with problems. Not the least of these are the purely mechanical problems in containing and manipulating particles which are smaller than atoms. You cannot keep sub-atomic particles in a sealed container, any more than you can carry water in a butterfly net - and for the same reason. Sub-atomic particles can only be contained by other sub-atomic particles; and even then, there is the problem of "quantum tunnelling". According to classical (Newtonian) physics, if a body has sufficient energy to pass through a barrier, it will always do so; if it has insufficient energy to pass through a barrier, it will never do so. Sub-atomic particles do not seem to understand this principle. If a quantum particle possessing a certain energy level is confined by a greater force, there is a finite probability that the particle will escape; eventually, it will inevitably do so.

Even more perplexing, however, is the impact of "Heisenberg's uncertainty principle". Essentially, this principle dictates that the behaviour of a sub-atomic particle can never be predicted with certainty, only as a matter of probability - hence the (mercifully theoretical) paradox of Schrodinger's cat, which is placed in a sealed chamber along with a mechanism which is capable of killing the cat, depending on whether or not a quantum event occurs. Accordingly to quantum theory, the cat is in an indeterminate state - that is, it is both alive and dead - until someone opens the container and observes its condition. Einstein had a lot of trouble accepting the “uncertainty principle”, declaring his belief that “God does not play dice”. Yet the “uncertainty principle” is still a mainstay of quantum theory.

Despite these extraordinary difficulties, research institutions are currently exploring the prospects of quantum computing. Whilst this research is being undertaken at a range of institutions around the world, one of the leading research teams is the Special Research Centre for Quantum Computing Technology, at the University of Queensland.

The fact that sub-atomic particles can travel faster than light also raises the possibility, at least in theory, of “backward causation” - that is, the idea that an event at one moment in time can be caused by an event occurring at a later moment in time - which is the nearest thing to practical “time travel” which serious physicists are prepared even to conceptually entertain. This does not infringe Stephen Hawking’s “chronology protection conjecture” - that quantum effects “make the universe safe for historians” - for the very reason that the Heisenberg uncertainty principle makes it impossible to regulate the phenomenon of “backward causation”. So even quantum computers will not be able to calculate tomorrow’s prices on the stock exchange, or the winner of next year’s Melbourne Cup. But quantum computers do offer the prospect of a “quantum leap” in computer technology, so that today’s Pentium IVs will one day be considered as cumbersome and inefficient as Alan Turing’s Colossus.

Such computers will be highly efficient at storing, retrieving and manipulating the kinds of data which formed the basis of rote learning in TOB’s primary education. But TOB expects, and indeed hopes, that even a quantum computer will never be able to write poetry like Patterson’s and Lawson’s.