MICROCOMPUTING IN SINGAPORE
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Introduction

Sometime in 1978, I thought of forming a society in Singapore for the many people who were then enthusiastically engaged in the new and fast-growing area of microprocessors and microcomputers. I was then a young Lecturer in the Department of Physics of the then University of Singapore, and had recently introduced microprocessors into the Physics curriculum, perhaps the first teaching staff member in the University to do so.

But let me start at the beginning. Since my school days, I have had a keen interest in electronics and computers, reading up as much as I could about these subjects and trying my hand at making simple transistor radios and electronic circuits. I am old enough to remember listening to my parent's radio set (there was no TV or Internet then) which used glass valves (vacuum tubes) which you could see inside the set with their filaments glowing like very dim electric light bulbs. I don't know if during that time (the early 1950s) if there were any computers in Singapore. If there were, they would have been large first-generation computers also using vacuum tubes.

As some of you might know, transistors were already in existence, having been invented in 1948 at Bell Labs in the US by William Shockley, John Bardeen and Walter Brattain (who were to receive the Nobel Prize in Physics for their invention). However, the very first portable radio I received as a present from my parents was still a vacuum tube model, which needed a large high voltage battery pack! But by the mid-fifties, the transistor radio had been invented by Sony, and second-generation computers in which vacuum tubes were replaced by transistors were displacing first-generation computers.

When I went to the University of Singapore from 1962 to 1965 to major in Physics, I can still remember being taught vacuum tube electronics, and learning how to draw load lines on the output characteristics of devices such as triodes and pentodes. I do not recall any courses on computers, or having any access to any type of computer during my undergraduate days. Of course, there were no calculators at all. So how did we do our calculations? I certainly remember that in secondary school (1956-59) when we had to multiply two numbers with many digits, we had to resort to something called a log (for logarithms) table. Later on, as an undergraduate, we used a calculating device called a slide rule.

First encounter with a computer

It was only when I went to the UK for my postgraduate studies at Oxford University did I have my first encounter with a real computer. This was a second-generation mainframe computer called a KDF9, manufactured by English Electric, using 20,000 transistors and with

192 Kbyte magnetic core memory. Like all mainframes of those days, we humble users did not have any direct contact with the computer itself, which was housed in a separate building in a suite of large rooms [1]. I wrote my programs in a language called ALGOL (a precursor of PASCAL and other structured languages), and typed out my program on a teletype machine designed for the preparation of telegraphic messages, called the ASR33.

The ASR33 was an electromechanical machine with a keyboard on which you inputted your program, and the product of your efforts was a role of paper tape, on which your program was encoded in ASCII code on a length of 8-hole paper tape, one of the standard ways in which you submitted your program to the computer (the other standard input method was IBM punched cards). You then submitted your paper tape to the computer centre on a tray or other receptacle, and went away. The next day you came back to see if you had the results of your program in the output tray (you never actually saw the computer).

If you were lucky, you would get a nice printout of your results. However, it was much more likely that your printout would not have your desired results, but would have a long list of errors in your program. You then went back to retype your program, correcting the errors, and resubmitted your amended program. It was very likely that the output would give you a new set of errors, and you would have to go through the process again (and again …).

When I returned to Singapore in November 1968 and joined the University of Singapore as a lecturer, the university was acquiring its first proper computer at the Bukit Timah campus, an IBM 1130. This was designed as a small business oriented machine, much less powerful than the KDF9 at Oxford. Sometime in the early 1970s, the Public Utilities Board (PUB) upgraded its mainframe computer, and gave its old mainframe – an ICT1300 – to the Physics Department. This was placed in one of the ground floor laboratories of the Physics Department at the University's Bukit Timah campus, and to be honest, nobody in the Department knew how to program it.

Nobody except for my very determined colleague, Tang Seung Mun, who set out to learn from scratch the native machine code language of the computer, as there seemed to be no way to program it in a higher-level language like FORTRAN or COBOL (maybe the PUB did not give us the compilers for these languages). By sheer persistence, he mastered the machine code and programmed the computer to play music – nothing complicated though, just a melodic line of a tune which was output through a built-in tone generator. So when the Physics Department had visitors, we would proudly show them the mainframe playing a simple song!

Integrated circuits

During the late 1960s and early 1970s, computer and electronic technology made great advances. Instead of individual transistors, integrated circuits which combined many electronic components on a single chip became commonplace and gave rise to third-generation computers. The first germanium ICs were made in 1958 by Jack Kilby (who received the Physics Nobel Prize in 2000) of Texas Instruments, closely followed in 1959 by Robert Noyce of Fairchild with the first silicon ICs which became the industry standard and gave rise to Silicon Valley [2].

In particular, the miniaturization of circuits and circuit boards gave birth to a new type of computer – the minicomputer, which was small enough to fit into a single rack or even in a tabletop box, with circuit boards plugged into slots on the main board. The most popular minicomputers were the PDP series from DEC (Digital Electronics Corporation) – the PDP-8 (8-bit) and the PDP-11 (16-bit) – and the Data General's Nova, the first 16-bit minicomputer. Programming these computers was also easier, as their operating systems made it possible to interact directly with them through a CRT terminal.

Powerful desktop calculators were launched which were not only programmable, but which could store their programs on magnetic cards from which you could input the programs into the machine, so that you did not have to reprogram the calculator by pressing a long series of keystrokes. The pioneering machine of this type was the Olivetti Programma 101 launched in 1964, a beautiful desktop machine which was acquired by the Physics Department. It was programmed in a manner similar to that of the later HP calculators like the later HP-65 (1974) and the TI-55 (1984), and the programs were stored on long magnetic cards.   I must say that it was far superior to antiquated electromechanical calculating machines, like the Rheinmetall Superautomat calculator (1932), similar to a calculator the Physics department had been using since the 1930s and which I used as an undergraduate!

Even smaller computing devices were also coming out in the market. One of the earliest handheld calculators which had a programmable capability was the Compucorp 324 launched in 1971. This was not a pocketable machine which you could carry around, like the HP-65 and the TI-55 calculators which became very popular amongst scientists and engineers later, but a heavy machine which was not easy to carry around [3]. Nevertheless, it was truly groundbreaking for a scientist to have personal access to a programmable device to solve complex mathematical problems without having to use a big computer. Some of my colleagues bought Compucorp calculators which were priced at around S$600-S$700 – a big sum in those days!

The microprocessor revolution

The central processing unit or CPU is the heart of a digital computer, which also consists of memory and input and output units for data to enter and leave the computer. The CPU processes the data and consists of logic circuits to process data, registers to temporarily store data and a control unit to oversee its operations. Digital computers input, store, process and output data in binary form with ones and zeros. The term "microprocessor' means that an entire central processing unit (CPU), the heart of a computer, has been miniaturized and fabricated on a single semiconductor chip. Hence it was sometimes known as an MPU, a micro processing unit.

In 1971, the semiconductor company Intel introduced the first commercially available microprocessor, the 4004. The 4004 had been designed by Intel for the Japanese calculator company Busicom, but it was soon evident that it could be used for a wide variety of applications other than calculators [4]. The 4004, as its name implied, was a 4-bit microprocessor, but Intel soon followed it up in 1972 with a more powerful 8-bit microprocessor, the 8008.

The 8008 gave rise to the world's very first microcomputer i.e. a computer with a microprocessor as its CPU. This was the famous Mark-8, but it was not sold as an off-the-shelf unit. It was in fact a build it yourself project presented by the electronics magazine Radio-Electronics in their July 1974 issue, with complete plans sold for US$5. Those who wanted to build the Mark-8 had to gather all the parts themselves and make the main circuit board themselves too (though for US$50 you could obtain a circuit board kit from a company). The microprocessor circuit board was plugged into one of several slots on the main board, like a minicomputer system. It is not known how many hobbyists actually built the Mark-8, though the magazine sold a couple of thousand booklets with detailed plans. (I have the magazine and the plans but did not build the Mark-8.)

The Altair 8800

Intel followed up the 8008 in 1974 with an improved model, the 8080, which became very successful. The small company MITS quickly designed a microcomputer based on the 8080, called the Altair 8800, and it was featured on the cover of the rival magazine to Radio-Electronics, Popular Electronics, in its January 1975 issue. Like the Mark-8, the Altair 8800 called itself a minicomputer computer, possibly because the term "microcomputer" had not yet come into general use, and it indeed resembled the much more expensive desktop minicomputers. It cost US$395 as a kit or US$650 fully assembled.

Like the corporate minicomputers, the front panel featured a bank of toggle switches, through which one was supposed to laboriously input the individual bits of the microprocessor's machine code! Just as for the Mark-8, it had a minicomputer bus system with circuit boards plugged into slots on a common bus. The Altair's bus became the standard S-100 bus adopted by many other manufacturers.

Other microprocessors

The Intel 8080 soon established itself as an industry standard 8-bit microprocessor, and it became the CPU for many other microcomputers after the Altair 8800. Other semiconductor manufacturers were not slow in coming out with successors to the 8080 to tap the fast-growing market for microprocessors. The head start which the 8080 had gained over its rivals enabled it to become the dominant player, and its machine code instruction set also became a kind of standard. Intel introduced an improved and compatible version of the 8080, the 8085, in 1976.

However, the 8080's most important successor was the Zilog Z-80 microprocessor also introduced in 1976, which added extra features, but which was designed such that it could run machine code programs written for the 8080. A notable example of a microcomputer using the Z-80 was the hugely popular Radio Shack TRS-80 series. The first portable computer, the Osborne-1 also used the Z-80. It ran the popular operating system CP/M, designed for the 8080 but which also be run on the Z-80.

The Motorola 6800

In 1974, at about the same time that the 8080 was launched, Motorola introduced an 8-bit microprocessor of a completely different design from the Intel microprocessors – the 6800. This was an elegant design which may have been inspired by the CPU of the PDP-11 minicomputer. At around that time, I was thinking of starting a course on microprocessor programming. It turned out that the Singapore distributor for the Motorola 6800, General Electronics and Instrumentation Corporation or GEIC, and its representative Steven Tan, was more accessible and helpful than the Intel distributor, and so I decided to adopt the 6800 as the microprocessor for my course. This was a good decision as the manuals, chips, software and programming tools for the 6800 were more easily obtainable than for the 8080 or the Z-80.

Teaching microprocessors

I was already teaching electronics courses in the Physics Department since I had become a Lecturer there in 1968. After I returned from overseas and started teaching at the Physics Department, I took over the electronics lecture course and based it on transistors and semiconductors. I taught semiconductor device principles and transistor circuit design. When simple integrated circuits became available, I also taught digital electronics – devices such as NAND and NOR gates, and how these could be used to make the parts of a computer such as the arithmetic unit (the core of the CPU) and the shift register, also an essential part of the CPU [5].

Why did I want to teach microprocessor programming in a Physics department? Physicists often need to interface electronic equipment with their experiments in their laboratories, and the data sent and collected was now often digital in nature, and best handled by a digital computer. It seemed to me that the microprocessor would be an important tool for physics research, as it would be a cheap and easy way for physicists to incorporate and embed computers into their experimental research, which would have been prohibitively expensive with mainframe computers or minicomputers. In my course, I taught my students the programming model of the 6800, its instruction set used for writing machine code programs, and how to interface and connect the microprocessor to laboratory equipment and apparatus.

Programming the microprocessor was really very primitive. We used very rudimentary single board microcomputers whose input consisted of a numerical keyboard and whose output was a 6 or 8 digit LED numerical display. The built-in operating system or monitor program in ROM enabled you to look at the contents of the small RAM memory, and to enter numbers into each of the memory locations. In this way, you could enter a machine code program by loading the machine code instructions (usually as hexadecimal numbers, which were a short form for binary numbers) which made up the program.

Once you had entered a short program into the machine, you could run the program and hopefully see the correct output on the LED display. The most prominent of such simple microcomputer sets for learning machine code were the Motorola D2 and D5 sets, and the KIM-1 which was based on the 6502 microprocessor, of which more later.

There were better ways of writing machine code programs, by using a more understandable language called assembly language, which could be translated into machine code to be run on a microprocessor. However, this was possible only with a more capable microcomputer, not with the rudimentary single board microcomputers like the D2 and D5 sets. Today's Arduino microcomputers are similar in principle to these rudimentary machine code microcomputers, but are much easier to program as you can use a high-level language like C to write your programs.

The SWTPC 6800

In November 1975, the Southwest Technical Products Corporation released a desktop microcomputer similar in concept to the Altair 8800, but based on the Motorola 6800. Unlike the 8800, it had no front panel toggle switches to enter machine code, as it was designed to interface with a CRT terminal through a serial connection. Around 1976 or 1977 (I think), I decided to acquire an SWTPC 6800 for the Physics Department to provide hands-on programming experience for our students.

At that time, the first and only personal computer company in Singapore was a small shop called the Computer Center, located in the Golden Mile Shopping Complex at the end of Beach Road. If I remember, the shop was started and owned by a resident American, Lee Miles, who was very helpful. I found out that they were the local agents for the SWTPC 6800 and bought one for the Department. It might well have been the very first microcomputer acquired by the University, though I of course cannot prove this to be the case.

Anyway, the computer came in kit form, and when I brought the kit back to the Physics Department, I enlisted the help of a Physics Department technician, Lee Soo Mien, to assemble the computer. On the whole, we did not have too much trouble, even though we were confused by the circuit board in the kit not have the same exact configuration as the diagram in the instructions for the kit. It turned out the instructions were for a different revision of the circuit board, but we did manage to figure it out anyway.

We interfaced the computer to a CRT terminal, and were able to communicate directly with the SWTPC's built in operating system in ROM, which was called a monitor program. This controlled the flow of information from the computer to the serial terminal and enabled you to look at the RAM memory and enter a machine code program, just as for the rudimentary machine code microcomputers described earlier. Like the Altair 8800, the SWTPC 6800 was structured like a minicomputer, with circuit boards for expansion plugged into slots on a computer bus.

The SWTPC did not use the S-100 bus, but had its own bus, the SS-50. You could attach a floppy disk drive to it, and load programs and data from floppy disks, which made the computer much more useful and powerful. In this way, you could program using assembly language using an assembler program, and also use high level languages such as BASIC by loading a BASIC interpreter which would translate the BASIC instructions to machine code to be run by the microprocessor.

The SWTPC 6800 had an open architecture, and if you opened the box you would see a number of circuit board slots into which you could plug circuit boards to expand the SWTPC's capabilities. The computer came with the circuit board carrying the 6800 microprocessor, and a serial circuit board which enabled you to connect a serial terminal. The floppy disk drive was connected to yet another circuit board. The slots made the computer very flexible and versatile, and later on both the Apple II and the IBM PC would be designed with circuit board slots.

However, we initially did not have the floppy disk drive, but we bought a cassette tape interface which was able to load and store programs and data, but at a much slower rate than a floppy drive. In fact, for early personal computers and microcomputers, a cassette tape interface became the standard way to store programs and data inexpensively. We had also acquired a very simple BASIC interpreter occupying just 4K memory, which had to be loaded from cassette tape. As I recall, this BASIC came from Microsoft, then a very small company, and may have been personally written by Bill Gates himself.

We happily used the SWTPC 6800 to teach our Physics students microprocessor technology for many years. The slots in the computer enabled us to plug-in circuit boards designed to connect to external equipment and hardware, which was important to us as experimental physicists. Unfortunately, this SWTPC 6800 is not with us in the Physics Department anymore, as it was inadvertently sold off as junk without my knowledge and to my great regret. But I always remember the SWTPC 6800 very fondly as our very first personal computer.

The Apple II

One day, when I was at the Computer Center at Golden Mile, the owner Lee Miles took me into the back room of the shop to show me something very special. It was a one-piece computer in which the keyboard had been incorporated, and looked very sleek and stylish, with a colour graphics display and 24 lines of 40 column text. This was of course the Apple II, which had just been released in 1977 by the very young Apple Corporation. Naturally, when I saw this beautiful machine, I knew we had to have one for the Physics Department! So I promptly ordered one and it was very likely the first Apple II acquired by the University.

Like the SWTPC 6800, we initially loaded programs and data into the Apple II using a cassette tape, which was easy as the cassette tape interface was built into the machine. The Apple II also had a built-in video interface, which could output 24 line by 40 character text and colour graphics to a colour TV or monitor. This was important as the Apple II was also designed to be a computer games machine, to compete with other colour games machines like the Atari.

However, as we were using the Apple II for serious programming and interfacing, we opted to use a cheaper green monitor which actually showed the alphanumerics more sharply than a colour display. The Apple II, like the SWTPC, was designed with 7 slots to plug in additional circuit board cards for interfacing, such as a floppy disk drive card, a serial card, a modem card, an 80-column text card and even a Z-80 coprocessor card. My colleague Tang

Seung Mun's complete Apple II system, with Apple II, floppy drives. monitor and dot-matrix printer cost almost S$10,000!

Unlike the SWTPC 6800, the Apple II's microprocessor was an 8-bit 6502. This microprocessor was designed by a small company called MOS Technology, and intended to be a cheaper version of the 6800 for consumer level personal computers. The 6502 programming model was similar to but not identical with that of the 6800. I was also to use the 6502 in my machine language programming course alongside the 6800.

<u>The Microcomputer Society</u>

BY 1978, it was clear that the microprocessor had brought about a computing revolution. The first wave of microcomputers – the Mark-8, the Altair 880, the SWTPC 6800 and similar machines all aimed at hobbyists were being supplanted by a new generation of consumer oriented machines such as the Apple II, the Radio Shack TRS-80 and the Commodore PET (also based, like the Apple II, on the 6502 and introduced in 1977). The term "personal computer" was now being used for these new machines which were all inexpensive enough to be owned by the individual man in the street. You also had machines like those made by Atari which were more geared to the computer games market, using easy to use ROM cartridges which the most uninitiated user could plug into the machine.

Indeed, the personal computer was becoming useful and powerful enough not just for games and entertainment, but to be used as a serious business machine. The CP/M operating system began to become a standardized operating system running on 8080 and Z-80 business oriented machines (some with an S-100 bus for expansion) like the Radio Shack TRS-80 Model 4, the Cromemco and the Northstar Advantage. CP/M offered excellent word processing programs like WordStar and WordPerfect. Even the Apple II could be made to run CP/M, by inserting a Z-80 coprocessor card in one of its slots, and many Apple II users were happily using it as a business machine. The first spreadsheet, VisiCalc, was designed for the Apple II running on its 6502 operating system, but before long Microsoft Multiplan became the standard spreadsheet running on many different platforms.

I therefore thought that the time was ripe to form a society for all those who were interested in the microcomputer or the personal computer. While contacting other microcomputer users, I learnt of another move to form such a society. On investigation, I found out that the person behind this was an expatriate American engineer working in Singapore, Jack Page. I therefore contacted Jack and we agreed that it would be rational and logical to form just one society for microcomputer enthusiasts, and hence we decided to combine out efforts.

And so, sometime in November 1978, the Inaugural General Meeting of the new Singapore Microcomputer Society was held in a small seminar room at the Physics Department of the University of Singapore, at the Bukit Timah campus [6][7]. This seminar room could seat about 60 people, and it was almost full for the Inaugural Meeting. Those present unanimously agreed that the Singapore Microcomputer Society should be set up, and proceeded to elect a committee. Jack Page as elected as the first President, and I was elected as the first Honorary Secretary. Unfortunately, I cannot remember who else were elected to fill the other committee positions, as all my files on the Society have been lost!

We had modelled our new society on the many similar societies which had been set up in the U.S., and in California in particular, the birthplace of the microprocessor and microcomputer. We certainly had in mind the very famous Homebrew Computer Club founded in Silicon Valley in 1975, whose members included many famous pioneers of the personal computer revolution, including the founders of Apple, Steve Wozniak and Steve Jobs.

We hoped that with the new society, we would be able to stimulate the growth of microcomputers and personal computers in Singapore. Unlike the more well-established Singapore Computer Society, we were not a professional society, but simply a group of people who were enthusiastic and excited about the fact that the microprocessor had made computing accessible to the layman. Our meetings drew a diverse group of people who were deeply into the new technology, plus those who were simply curious to know what all the excitement was about. It is fair to say that in those early days, the entire field of personal computing was driven not by professional computer scientists but by people who simply wanted to take advantage of the fact that the microprocessor had made computing available to the layman.

The vast majority of the members of the new society were indeed made up of people who were not professional computer scientists, but whose raw enthusiasm made the Society a success. Indeed, at that time I never imagined that the Singapore Microcomputer Society would thrive for such a long time and be such a vibrant Society today, celebrating 40 years of existence! When I stepped down from the Society's Committee due to taking on administrative duties at the University, I asked one of my younger colleagues, Hari Gunasingham from the Chemistry Department who had been keenly involved in microcomputing for chemical applications, to join the Committee.

<u>Spreading microprocessor technology</u>

Once we had microcomputers like the SWTPC 6800 and the Apple II, we could really go into the teaching of microprocessors in depth. With the SWTPC 6800 and later the Apple II, we could write machine code programs much more easily with assembly language. However, I still used those rudimentary microcomputers like the D2, D5 and KIM-1 sets. In those early days of expensive memory, microcomputers came with just very small amounts of RAM. The D2 had only 128 bytes of RAM, the D5 only 256 bytes, and the KIM-1 had about 1K RAM. Even the Apple II had a maximum of only 64 Kbytes RAM.

Therefore when writing a machine code program, it was very important to write code which was as compact as possible and which used as little RAM as possible. When you had only 128 bytes to play with on the D2, saving one or two bytes could be very crucial to whether your program could fit into the machine! I became quite fascinated with machine code programming, and wrote a few articles on this for the leading microcomputer magazines of the day, such as Dr Dobb's Journal and Microcomputer (I had an article accepted by BYTE but which was not published) [8][9][10].

Because of the Apple II, I also stared to use the 6502 to teach microprocessor programming. I even concocted a hybrid microprocessor which I called the 5800, whose programming model and instruction set was compatible with both the 6800 and the 6502 [11]. I also tried to use microprocessors in my research, and published a number of research papers in which the 6800, 6502 and the successor to the 6800, the 68000 were featured. One such paper was about a single board 6502 microcomputer for dedicated applications which could be tested using the Apple II [12].

At around the time I had started to teach microprocessors at the University, the Ministry of Defence (MINDEF) heard about this and invited me to teach a course on microprocessors to SAF personnel. I was already a part-time national serviceman serving in the PDF (Peoples' Defence Force), and I had been attached since the early 1970s to a unit at Tanglin called C and E HQ (Communications and Electronic HQ under COL Chew Bak Khoon), which was actually the command unit for all signallers in the SAF. While at C and E, I introduced the 6800 microprocessor to the technical officers there. I would like to think that this might have been the earliest introduction of microprocessors to the SAF.

The MINDEF unit which asked me to teach microprocessors to the SAF was the famous S and C (Systems and Computers) Organisation founded by the now legendary Philip Yeo, who was to become Singapore's computing pioneer and founder of the National Computer Board later. I worked with S and C's Tan Chin Nam who was to go on to a highly successful civil service career as a Permanent Secretary and Chairman of the NCB. We held the teaching sessions at the now demolished SAFRA at Redhill (around the corner from IKEA), and my other course instructor was Stephen Yeo, who would go on to be one of the pioneers of the Singapore computer industry. We used the Apple II as a teaching tool for the course, going into how to write machine code and assembly language programs, as well as BASIC programs.

Home-made Apple II!

At that time, the Apple II was not being built or assembled in Singapore, as the Apple factory in Singapore was still far in the future. One of my Physics Department technicians told me that the circuit boards for the Apple II were being made in a factory in Singapore. He said that he had a friend working there who could acquire an Apple II circuit board. This was most interesting as the Apple II was made using only standard off-the-shelf integrated circuits and components. The circuit diagram of the Apple II was easily available, and equally important, the contents of the Apple II's ROM which made up its built-in monitor program were also well known.

The Apple II circuit board was acquired, and my technician, Steven Ng, and I set out to build a working Apple II, using standard components and burning the Apple II monitor program into a number of EPROMS – ROMS which could be user programmed. When we had completed the project, we connected the circuit board to a keyboard and a CRT and switched on the power supply and voila - the familiar Apple II start-up screen appeared on the monitor! This meant that we had successfully made a working Apple II – possibly the first in Singapore or even in South East Asia!

However, our machine did not look like an Apple II – it was a bare circuit board, power supply, keyboard and monitor. We needed to make it look like an Apple II, which meant that we needed to put it in an Apple II case. How on earth were we to get one? Making an Apple II case was obviously out of our expertise. Then I remembered that I had seen an Apple II case which was damaged, in Lee Miles' shop. I went there and asked him if I could buy the Apple II case. He gave me a flat no, as he was obviously worried that I was up to some no-good scheme maybe involving piracy.

I then pleaded with him, explaining that I needed it for a University project. He relented and agreed to sell it to me on condition that I write him a letter, on official University letterhead, declaring that the Apple II case would be used only for educational purposes and would never be resold. I then brought the case back to the Physics Department, glued back the broken part of the case, and happily put our home-made Apple II into the case. I still have this very first Singapore-built Apple II to this day, and it still works and boots up!

Microcomputer Industry develops

I should briefly mention a little-known microcomputer which I believe was the very first microcomputer designed and made in Singapore and sold commercially. This was the Pico-M computer, which was an inexpensive 6800-based microcomputer with an integrated low-cost keyboard and with video and serial interfaces [13]. It was conceived and sold by ECOM Pte Ltd, the company of my good friend in microcomputing, Philip Teo, who was even more crazy about microcomputing than I was. It was launched in 1982; I used to have a Pico-M, but sadly, I only have the manual now.

By this time, the Computer Center in the Golden Mile was no longer the only personal computer shop in Singapore. Lots of computer shops were beginning to spring up in various shopping centres. One of the earliest was Creative Technology's shop at Pearls Centre started by Sim Wong Hoo and his schoolmate Ng Kai Wah. Creative of course went on to be a highly successful home-grown multinational company. Other shops started up in Peoples' Park Complex, but the neighbouring Peoples' Park Centre soon became the main computer hobbyists' centre with computer companies like Aztech, which started up in 1986. Later on, Funan Centre would become the premier centre for personal computer users, with Creative opening a shop there too. Computer clones and pirated software were freely and openly sold!

The business oriented microcomputer market would be legitimized in 1981 when IBM launched the IBM Personal Computer, a 16-bit computer using the 8088 microprocessor (an upgrade of the 8080), with an 80-column display, 640 Kbytes of RAM, built in twin floppy disks and a new Microsoft designed operating system, MS-DOS. The new IBM PC bus was soon established as the standard bus for expansion cards like Creative Technology's highly successful Sound Blaster card. It was not too long before this first IBM PC XT became the standard corporate microcomputer, and it was followed by more powerful machines like the IBM PC AT which had an even more powerful microprocessor, the Intel 80286.

While the IBM PC was a watershed in the development of the personal computer, it was Apple's launch of the revolutionary Macintosh personal computer in 1984 which completely transformed the industry. With its small footprint and elegant GUI (graphical user interface), It brought personal computing to a whole new generation of users who found the Mac much more easy to use than any previous personal computer.

The Mac had a new 32-bit microprocessor from Motorola, the 68000, but had less RAM i.e. 128 Kbytes than the IBM PC. It also had no expansion slots, as Apple intended the Mac to be a consumer rather than a hobbyist machine. Its upgrade, the Macintosh Plus, came with 1 Mbyte of RAM, followed by even more powerful Macs such as the Mac SE/30 with its highly capable 68030 microprocessor.

<u>Modems and bulletin boards</u>

The next development in the Singapore personal computing scene was the introduction of the computer bulletin boards system (BBS). With personal computers like the Apple II, the PET Commodore and the Radio Shack TRS-80, their built-in serial interfaces made it much easier to connect them to telephone lines for remote communication. The simplest way then to connect your computer to a telephone was to get an acoustic modem. This device was connected to your computer, and with the aid of a communications program, you could then send information to and from your computer to the modem.

The acoustic modem sent the signals to your telephone by converting the information into a stream of audible signals which could go into the microphone of your telephone handset. Actually, the acoustic modem included an interface into which your handset fitted snugly. This allowed the modem's acoustic signals to be sent to the handset's microphone, and the handset's speaker to send acoustic signals to the modem's microphone. With the acoustic modem, you could have 2-way communications sent over the phone line through your telephone to a distant telephone, which could be connected to a computer terminal. In this way, the distant computer terminal could interact with your computer as though it were right next to your computer.

Instead of a remote terminal, a remote computer connected to an acoustic modem could be at the other end of the telephone line. The two computers would thus be able to communicate with each other. The sound of the acoustic modem as it received and sent the acoustic signals was very characteristic and became a very familiar sound to those of us using such modems. Later on, one could connect a modem, such as a Hayes Smartmodem, directly to the telephone line without going through the telephone's handset. Some computers had a built-in modem for easy connectivity to phone lines.

Once modems and computer connectivity through phone lines became well-established, computer BBS programs became available for all the major personal computers, including the Apple II [14]. By installing a BBS program on your computer, and connecting the computer to a phone line through a modem, another personal computer user could use a communications program on his computer and a modem to dial into your phone line and make contact with your computer. Your computer's BBS program would then request the other computer to log on to the BBS, or to register as a user of the BBS if not yet a registered user.

What was available to the user who was logged on? As the system operator (sysop) of the BBS, you could make available a whole lot of information and data. Indeed, the BBS functioned much like a normal real-world bulletin board on which notices, news, pictures, messages and other information could be pinned up. The user could also download useful stuff, Including software, to his computer. Anyone who was logged on to your BBS could have access to all this software and other information and data from your BBS.

The modem only allowed one user at a time to be logged on (unless it was a multi-line modem), but anyone who had a modem and your telephone number could connect to your BBS. Hence one really important function of the BBS was for one user to send a message to another user, who would retrieve that message when logged on later. This also mirrored a real-world bulletin board on which people could pin up messages for other people. With the BBS, messages could be sent to and received by a specific user, and the BBS ensured that only that user would be able to read your message. You could of course also post messages which could be read by everyone.

Bulletin boards in Singapore

When did computer BBSs start to operate in Singapore? As far as I can remember, there was one single BBS operating in Singapore perhaps for over a year, sometime in the early 1980s. I cannot exactly say when this was, but as I accessed this BBS on a Radio Shack TRS-80 Model 100, it had to be still operational in 1983, as the Model 100 was only introduced by Radio Shack in 1983.

The TRS-80 Model 100 was possibly one of the very first notebook computers ever produced. It ran on a CMOS version of the Intel 8085 microprocessor, compatible with the 8080. It was actually designed and made by the Japanese company Kyocera, and NEC sold a variant of the Model 100 known as the NEC PC-8201. Unlike today's notebook computers, it was a compact single piece without a foldout screen, in which a small LCD screen was set above a QWERTY keyboard. The LCD screen could display only 8 lines by 40 character of text, and had a maximum RAM of only 32 Kbytes. The BASIC language was built in, as well as a cassette tape interface, a serial interface, a 300 baud modem and a communications program in ROM.

I registered as a user with this first and only Singapore BBS on my Model 100, using the built-in 300 baud modem and communications program. The 8 line, 40 character display was functional enough for me to interface with the BBS, and though 300 baud sounds glacially slow today, it did allow the Model 100 to receive ASCII text faster than I could read it. The Model 100 also had a built-in text editor, and was much used by journalists filing stories over its modem.

I cannot remember the name of this pioneering BBS or the name of its sysop, but I do remember that he was an American medical doctor. Personal computer users learnt about his BBS by word of mouth, and he must have had least a few hundred registered users.

Unfortunately, he returned home to the US not too long after he had set up his BBS, and it thus had to close down, much to the disappointment of its users including me. I regret that I did not keep any records of his BBS, so it only lives in my memory. I hope anyone who remembers this first BBS will get in touch with me to share information about it.

After a break of at least a year or so, the BBS scene in Singapore restarted, this time really in earnest with several BBSs starting up at around the same time, maybe in 1985 or so. Singapore BBS pioneer Zit Seng mentions in his blog that he started his BBS in 1987 [15]. The number of BBSs quickly mushroomed as it became pretty essential for a personal computer user to be registered in at least one BBS. Modem speeds improved too, going from 300 baud to 1,200 baud then 2,400 baud and 9,600 baud. At the height of the BBS scene in the late 1980s, there must have been dozens of BBSs operating in Singapore, maybe even hundreds, as the personal computer became widespread.

FidoNet

The BBS functioned as a kind of primitive email system, but only for the registered users of a particular bulletin board. You could not send your message to someone registered on another BBS. However, this restriction could be overcome if messages could be moved from one BBS to another BBS. It was perhaps inevitable that someone would come up with a program which would enable BBSs to connect with one another and so allow messages to flow from BBS to BBS. This was really a kind of computer network, and it became the well-known FidoNet international bulletin board network established in 1984 [16].

FidoNet enabled a user on a BBS to send email messages to users on other BBSs, if they were connected to FidoNet. The other BBSs could even be overseas, if there was a connection from a BBS in Singapore via FidoNet to an overseas BBS. The snag was that the FidoNet connections were not continuous permanent connections, due to the high costs of leasing overseas phone lines. In fact, the messages might be sent to the overseas FidoNet node just once a day or even once every few days, so messages would take a long time to reach their destination. The first FidoNet hub in Singapore was operated by Zit Seng and started up in 1989 with the FidoNet address 6:600/16.

Online services, Teletext and Teleview

These were the days before the Internet, so the BBS can be regarded as a kind of precursor to the Internet, enabling personal computer users to form communities, sharing information and messages with each other. In the US, online services such as CompuServe (founded in 1979) and America Online or AOL (founded in 1983), became effectively gargantuan BBSs, serving thousands of users who could form a huge user community, sharing information, accessing a wide range of online services, and sending email to each other.

In France, the Minitel system introduced in 1978 provided users with a compact terminal which replaced the telephone directory, and offered not only phone directory services, but a whole host of online services including online shopping, train and airline ticket sales, and email [17]. Minitel became very successful and popular and survived till 2009, co-existing with the Internet. The UK launched a much less successful online system in 1979 called Prestel which did not gain wide pubic support, reaching only a maximum of 90,000 subscribers.

In Singapore, we had a TV-based information system known as Teletext (using a standard international TV-based protocol) launched in 1983 on channels 5 and 8, known as SBCText. This was a one-way system, which TV viewers could use if they bought or rented a set-top box connected between the TV set and the TV antenna. Even though the information flow was only one way, carried on the TV signal sent over the air, it became very popular since no charge was levied for the information and the set-top box rental was very low. My father loved it because he had a mania for weather reports, as he could monitor the changing weather forecasts on SBCText. One highly popular service was the stock market live quotes which enabled you to closely monitor the price of your shares. Even more importantly, you could get the 4D results immediately!

In 1987, trials started in Singapore for a new pubic online information service known as Teleview, which was fully launched in 1991. This was really a modified version of the UK's Prestel system, but it was different that it included some features of Teletext [18]. Prestel was a pure online system using telephone land lines, and the Teleview box was also connected to the central Teleview information server through the telephone line. However, the information sent back to the subscriber would return not through the telephone, but through dedicated television channels just as Teletext information came on a TV signal.

This was done to enable much more information to be sent to the subscriber than possible through the telephone line, such as detailed photographs of high resolution (supposedly a World's first). The Teleview box would receive the return signal from the TV antenna and display it on the subscriber's TV screen or computer screen. The return information through the TV signal would be decoded and read only by the specific individual subscriber for whom it was meant. I am not sure if such a system could have handled and decoded information for several hundred thousand subscribers simultaneously. The Teleview system was jointly developed by Singapore Telecom and GEC-Marconi.

<u>BITNET and Internet</u>

The Teleview system, it must be said, was not a success. Take-up rate was much less than anticipated, and may not even have reached 100,000 subscribers. In any case, the subscriber numbers were nowhere near enough to justify the capital and maintenance costs of the system. Hence it was never known whether the return information flow through TV signals would have been viable for a large number of subscribers. The set-top box costs and subscription costs were relatively high, and the box was quite large and cumbersome.

The real reason for Teleview's lack of success was that it was too little too late. The year that Teleview started its trials (1987) was precisely the same year in which Singapore joined the international computer networking community. I have already described FidoNet and how it served as an intermittent and slow International email facility. At around the same time as FidoNet, email messages could also be sent to and from Singapore internationally through the international network of Unix-based computers using the uucp communications protocol. The Singapore uucp node was the TATA-ELXSI office then in Science Park I. However, like FidoNet, uucp was an intermittent dial-up link which did not provide 24/7 network connections.

In 1985, I represented the National University of Singapore (NUS) at the annual conference in Austin Texas of EDUCOM, the US higher education computer consortium. On my return, I made a recommendation to the Vice-Chancellor Lim Pin that NUS should join EDUCOM and connect as soon as possible to BITNET, which was EDUCOM's international computer network [19]. He readily accepted my proposal, and in 1987, NUS established Singapore's first 24/7 international network connection, connecting to the City University of New York's BITNET node on 13 January 1987. I was a recipient of the first email sent from overseas to Singapore over a permanent 24/7 international network connection (my email address then was tbernard@nusvm).

BITNET was cheap and relatively easy to connect to, since it used the communications protocol called VNET built into IBM mainframes, which was later ported to VAX/VMS computers. When our BITNET connection had been established, we could send and receive information and email to and from all BITNET nodes, and to all Internet nodes through gateways between BITNET and the Internet. My colleagues in the NUS Computer Centre, led by its Director Thio Hoe Tong and networking expert Tommi Chen, immediately started work on establishing direct links to the Internet using TCP/IP protocols. By 1990, NUS was effectively directly connected to the Internet proper. I have given a fuller personal account of how we joined BITNET and Internet elsewhere [20].

Hence Teleview had come rather too late to be successful, as we already had BITNET then, and were well on the way to joining Internet proper. At a later stage Teleview subscribers were given limited access to the Internet, but this was not enough to prevent Teleview's demise.

Internet's growth in Singapore

The official launch of the Internet in Singapore took place at NUS on 11 April 1991, with Tay Eng Soon, Senior Minister of State for Education, officiating at the launch. With NUS as the first true internet node in Singapore, it was not long before NTU followed suit and joined the Internet. Everyone on our campus network NUSNET was connected to the Internet, and soon NUS was the main node of a Singapore network (sponsored by the NSTB) connecting universities and research institutions to the Internet called Technet, which eventually became the ISP Pacific Internet in 1995. The Internet remained a research network for a number of years, and it was only around the mid-1990s that it began to become a network for general public access, after Singnet became Singapore's first ISP in 1994.

I was still teaching my microprocessor programming course at NUS in the 1990s, and decided to use the Internet to enable me to more effectively communicate with my students. I had set up an Internet server on a Mac SE/30 in the office of the Dean of Science, and used this server to host the web pages for my microprocessor course. I have the html file of a webpage for my course during the 1994/95 academic year, but I am pretty sure that my microprocessor webpage dates back even earlier. Anyway, my microprocessor webpage must have been one of the earliest (if not the earliest) webpages being used for teaching at NUS.

By 1996, the Internet and the World Wide Web had become firmly established in Singapore and were being used by rapidly increasing numbers of netizens. From the first Singapore websites established simultaneously by Tan Tin Wee (www.nus.sg) and Jek Kian Jin in 1993, the number of Singapore webservers had also grown phenomenally. In 1996, Minister for Information and the Arts George Yeo formed the National Internet Advisory Committee (NIAC) to advise his Ministry on the growth and regulation of the internet [21].

Minister Yeo asked me to chair the NIAC which I did for its entire ten-year life, and with the help of many wise members of the public, government, education and the industry, we played a key role in enabling the Internet to grow in Singapore with the minimum of regulation [22], while ensuring that it remained a reliable and safe medium for the public and for children in particular. One important spinoff of NIAC was PAGi, the Parents Advisory Group for the Internet chaired by Carmee Lim, which did so much to promote children's safety on the net. Another key member of NIAC was Johnny Moo, Singapore IT industry pioneer who ably chaired the NIAC Industry sub-committee.

As we mark the 40th anniversary of the Singapore Microcomputer Society, new and exciting advances in information technology, artificial intelligence and telecommunications offer us myriad opportunities as well as daunting challenges in ensuring that these technologies benefit society without causing severely deleterious consequences. We look forward to the Society's next 40 years!

References

1. Wikipedia, "English Electric KDF9", https://en.wikipedia.org/wiki/English_Electric_KDF9 (accessed 12 April 2018)
2. Wikipedia, "Integrated Circuit", https://en.wikipedia.org/wiki/Integrated_circuit (accessed 12 April 2018)
3. Wikipedia, "Olivetti Programma 101", https://en.wikipedia.org/wiki/Programma_101 (accessed 12 April 2018)
4. Wikipedia, "Microprocessor", https://en.wikipedia.org/wiki/Microprocessor (accessed 12 April 2018)
5. Reutens Lulin, "Chapter 4 Manpower Drive" in The Big Switch (1981-1985) vol 1 of Innovationation: 25 Years of Infocomm in Singapore (IDA, Singapore 2006)
6. Clubs and Newsletters, "Attention Singapore readers", BYTE (November 1978) p 148
7. Page, Jack "Microcomputer society forming in Singapore" Infoworld (17 January 1979) p 12
8. Tan B T G, "Common instructions of the 6800 and 6502", Dr Dobb's Journal, October 1979, pp 38-39.
9. Tan B T G, "Relieve SWTP tape drudgery - generating MIKBUG tapes with the D2 kit", Microcomputing, May 1980, p 186.
10. Tan B T G, "The SBC, TSX and TXS instructions of the 6800 and 6502", Dr Dobb's Journal, May 1983, pp 67-68, 85

11. Tan B T G, “A microprocessor teaching model”, International Journal of Electrical Engineering Education, vol 17, no.6 (1980), p 183. (United Kingdom)
12. Tan B T G and A K Tan, “Standalone low-cost interface controller and emulator for the Apple II”, Microprocessors and Microsystems, vol 8, no.2 (1984), pp 67-72. (United Kingdom).
13. Tsang Sau Yin, “Local team develops personal computer”, Straits Times, 11 February 1982
14. Wikipedia, “Bulletin board system”, https://en.wikipedia.org/wiki/Bulletin_board_system (Accessed 12 April 2018)
15. Lai Zit Seng, “Zit Seng’s Blog”, https://zitseng.com/about/about-zitseng/computers-and-me (Accessed 13 April 2018)
16. Wikipedia, “Fidonet”, https://en.wikipedia.org/wiki/FidoNet (Accessed 12 April 2018)
17. Wikipedia, “Minitel”, https://en.wikipedia.org/wiki/Minitel (Accessed 12 April 2018)
18. Wikipedia, “Singapore teleview”, https://en.wikipedia.org/wiki/Singapore_Teleview (Accessed 12 April 2018)
19. Tan Bernard, Report on Educom conference (NUS internal document 1985)
20. Tan Bernard, “Origins of the Internet in Singapore” Envision, Jan/Mar 2000 pp 18-20 & Apr/June 2000 pp 19-21
21. Tan Bernard, “The National Internet Advisory Committee (NIAC) – a brief history“ in Intelligent island : the untold story of Singapore's tech journey eds Grace Chng & P. Ramakrishna (SITF, Singapore 2017)
22. George C, "Calibrated coercion and the maintenance of hegemony in Singapore," Asia Research Institute, 2005.