Computer Science

COMPSCI 111 S1C - Lecture 6
March 2004

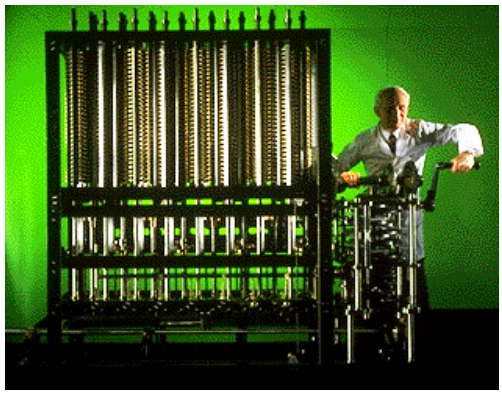
Development of the Computing Machine

Abacus (1000 - 500 BC) - The first aid to calculation, possibly invented in Babylonia (now Iraq). The improved speed of calculation ensured the success of the abacus, which is still used today in some countries.

Arabic numerals were introduced to Europe (800-1000 AD). The Arabic system included a number for zero, and greatly simplified calculations. This system was in base 60, or sexagesimal, unlike our base 10 decimal system.

Wilhelm Schickard (1592 - 1635) built a mechanical calculating clock. It could add and subtract. It never made it past the prototype stage.

Blaise Pascal (1623 - 1662) was the son of a tax collector. He spent many hours involved in mathematical operations, which inspired him to build a mechanical calculator in 1642, the Pascaline. It had the capacity for eight digits, and could do both addition and subtraction. It was gear driven, and had a tendency to jam.



Gottfried Wilhelm von Leibniz (1646 - 1716) followed Pascal and built a digital calculating machine. It was gear and lever driven, and could do multiplication, division, addition, and subtraction. It was however, somewhat unreliable.

Joseph Jacquard (1752 - 1834) built an automatic Weaving Loom, which used punch cards to control the selection of threads for weaving into complex patterns

Charles Babbage (1792 - 1872), a mathematics professor of Cambridge, inspired by the Jacquard Loom, designed an automatic calculating machine called a Difference Engine. In 1822 he had a working model, which was to be fully automated, and steam powered. He lost interest in 1833 and began designing another more general machine called an Analytic Engine. It was never completed, partially due to a lack of engineering precision.

Ada Augusta (1816 - 1852), Countess of Lovelace and daughter of Lord Byron is generally considered to be the first computer programmer. She corrected some of Babbage's errors and added her own ideas about the calculating machine. She is credited as developing the programming loop.

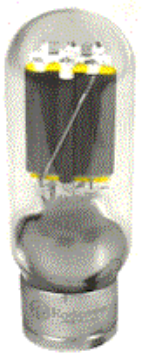
William Burroughs (1855 -1898) introduces a reliable mechanical adding machine in 1886. These machines were extremely popular, and over a million were sold by 1926. They were so popular in fact, that Henry Ford released a motor car with a space set aside for the adding machine. Burroughs computer were widely used in the Banking industry until very recently (1990's).

Dr. Herman Hollerith (1860 - 1929) recognised a problem in the US Census Office where he worked. The 1880 US Census took 7 years to tabulate, and the population was steadily increasing. It was estimated that the 1890 Census would not be tabulated before starting on the 1900 census. He developed an Electro-mechanical punch card tabulator, which automatically totalled the cards. The 1890 Census

was tabulated in 3 years, and Hollerith formed the Tabulating Machine Company. Thomas Watson joined the company in 1914 and with Watson as president it was renamed International Business Machines (IBM) in 1924

Prof. Howard Aiken (1900 - 1973) sought backing from Watson in 1939, and with IBM support, the Harvard Mark I was produced in 1944. It used relays (electromagnetic switches) instead of gears, which was a large step forward. It took approx. 3 seconds to multiply numbers together.

1st Generation Computers (1946-1959) – The Tube Era



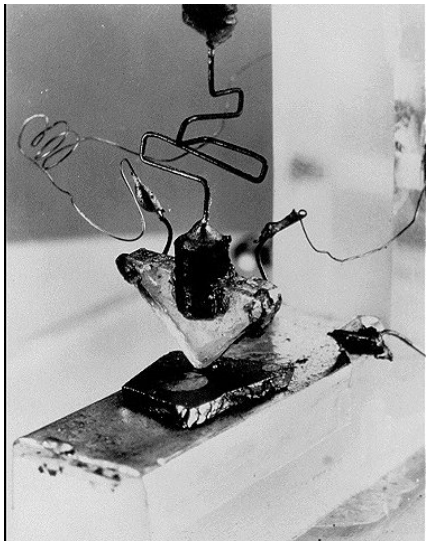
Vacuum tubes were 3-5cm long and 1000 times faster than relays. They also had a tendency to break frequently, meaning running costs for a vacuum tube computer were very high.

John Eckert, and John Mauchly were the principle designers of ENIAC (Electronic Numerical Integrator and Computer), which was completed in 1946 under Army sponsorship. The ENIAC used 18,000 vacuum tubes, was 100 feet long by 10 feet high by 3 feet wide and weighed 30 tons. However, it could do a multiplication in 3 milliseconds. They later created the UNIVAC I, which became an industry standard computer until 1970.

In 1945, Grace Hopper discovers a moth stuck to a computer relay – the world's first computer bug. Coined the term "debugging", which is a term used in computer programming ever since.

2nd Generation Computers (1959 – 1964). – The Transistor

The invention of the transistor in 1947 (see picture to right) by Bell Telephone Lab resulted in the old glass vacuum tubes (3 - 5cm long) being replaced with a small, cheap and reliable electronic component (approx. 0.5 cm long), and defined the second generation of computers



The first high level programming languages were introduced: FORTRAN, COBOL and ALGOL. Some of these computers also had simple operating systems also, but could only run one program at a time.

The first supercomputers were introduced. One example was the IBM 7030 – nicknamed "stretch". A supercomputer is simply a computer that is several magnitudes more powerful than any other computer around at the time.

Transistors had a tendency to heat up and damage the internal components of the computer.

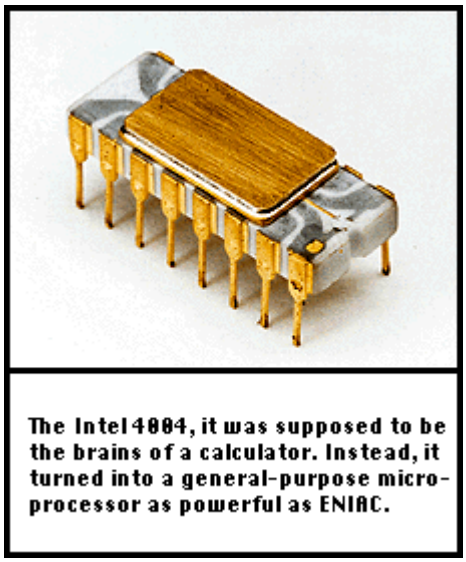
3rd Generation (1965 – 1971) – Integrated Circuits

Later, the invention of the Integrated Circuit in 1959 by Texas Instruments/Fairchild Semiconductor started the third generation of computers. These silicon chips stored over 1000 transistors on a single piece of silicon. They also could place various resistors and capacitors on the chip also. This made them cheaper and they did not generate as much heat as the standard transistors.

Operating systems were developed that could run multiple programs at a time, with programs sharing the computer's memory, disk and other resources. Mostly this was so companies could be billed individually for CPU time, as this was quite expensive. (Imagine the university charging you per second of CPU time much like *Netaccount*)

4th Generation Computers (1971 - Now) – The birth of the PC

New advances meant that components got smaller and therefore silicon chips (Now called microchips) got smaller and more powerful.
One of the first fourth generation chips was the Intel 4004 developed in 1971. It had all the components of a computer contained in a single chip. (E.g. memory, input/output controls and central processing unit – more on what these mean in the next lecture)



The Intel 4004, it was supposed to be the brains of a calculator. Instead, it turned into a general-purpose micro-processor as powerful as ENIAC.

Once computers were this small, people started putting them into everything – e.g. microwaves, videos, cars and video games like Pac Man. This also meant that a computer could be made cheap enough to have at home for your own personal use.

Personalities and Personal Computers

The personal computer industry is unique in the business world in many ways. It grew incredibly quickly from its beginning in 1975 to a billion dollar industry within 5 years. The industry was created and controlled by kids who had no formal business training. It is an industry where products must be recreated every 18 months, and competition is intense.

Mainframes

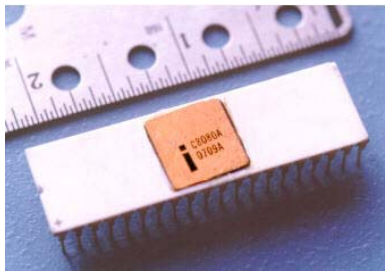
Computers were once large complex machines that were only affordable to large businesses. Large companies built the computers, sold them directly to the customer (business or government), serviced them for a monthly fee, and wrote the software which they licensed to the customer for another monthly fee. The computer maker made as much money from the post-sales servicing as they did from selling it in the first place. There was only a small market for these machines, primarily in Research Institutions, Government Departments or very Big Businesses. An ordinary person had to get permission to even get close to them, and had to pay for the time spent using them. Many of these computers were controlled by IBM.

Xerox

In 1969, Xerox opened the Palo Alto Research Centre (PARC). During the early 70's, Xerox decided not to enter the computing market. At this time they were already being investigated for monopolistic business practices. By 1977, half of Xerox's revenue was spent on defence in court. However, Xerox PARC's research contributed significantly to many of the advances in computer technology, including Ethernet, WYSIWYG, the development of the GUI (as we know it), the invention of Laser Printers and the development of Smalltalk (the first functional language).

Intel

The first integrated circuit was announced by Fairchild Semiconductors in 1959. Nine years later, in 1968, Robert Noyce and Gorden Moore left Fairchild Semiconductors and formed Intel Corporation. Their microprocessors became more and more powerful, and in 1974 they created the Intel 8080 chip. This chip was powerful enough to power a personal computer much like the ones we know today. This microprocessor had all the components needed for an entire computer. These chips were available to anyone, and the time was right for people to build their own machines.



Altair

Ed Roberts was interested in computers, but could not afford to own one. Like many other enthusiasts, he wanted to build his own computer with the new affordable microprocessors from Intel. He ran a small calculator company called MITS, but nobody was buying his calculators, and MITS was going bankrupt. Ed hoped to save MITS by marketing a kitset computer, and the bank reluctantly agreed to loan him the $65,000 he needed. He was considered an optimist for expecting to sell 800 in a year. The first Altair kitset appeared on the cover of *Popular Electronics* in January 1975. Within a month he was receiving 250 orders a day. The personal computer industry was born. Ed Roberts assembled 40,000 Altairs before he sold the business in 1978 when it became just too competitive.

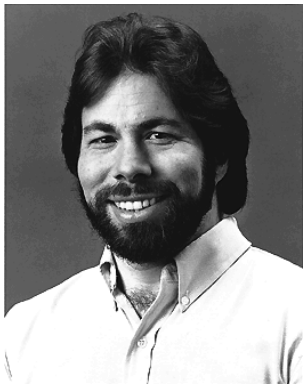
Microsoft

Paul Allen and Bill Gates had been friends since high school, and had already had experience writing software for mainframe computers. The picture on the Popular Mechanics cover excited Allen and Gates who realised that there would be a market for software, and a lot of money could be made. Fearing they were already too late, they wrote a version of BASIC which would work on the 8080 chip. Ed Roberts was shown a demo after which he agreed to package the BASIC language with the Altair. Gates quit Harvard University and together with Allen formed Microsoft.

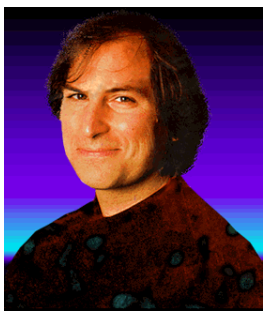
Homebrew Computer Club

The Altair took about 40 hours to put together, and even then it didn't always work. If it did work, you ended up with a box with a row of switches and a set of lights. There was no keyboard, no screen, and no storage device for information. It was difficult to use, so people formed clubs where they could discuss problems, and show off new developments. The Homebrew Computer Club was one such club in which everyone shared their solutions and helped each other to learn. It was here that Steve Wozniak and Steve Jobs first met.

Apple



Steve Wozniak was a hardware genius who began building his own computer at the Homebrew Computer Club. His technical ability attracted Steve Jobs who lacked the expertise of Wozniak, but had vision, drive and charisma. Wozniak's first computer was called the Apple 1, and consisted of a single circuit board without even a case. Steve Jobs managed to sell 50 Apple 1's which convinced him that there was a market for a personal computer. His dream was to make computing available to everyone, at an affordable price. Some venture capital made the dream a possibility. Steve Wozniak designed the hardware, and Steve Jobs did the rest, demanding the Apple II looked like a piece of consumer electronics. The Apple II was completed in 1977 and launched in 1978 at the West Coast Computer Faire. Two years later when Apple became a public company, both Steve Jobs and Steve Wozniak became millionaires.



VISICALC

Apple computers initially had trouble finding a market. Businesses used mainframes, and nobody had a use for a computer at home, so sales of the Apple II were limited to enthusiasts... that is, until VISICALC. Dan Bricklin and Bob Frankston invented what they called a visible calculator. It was a program which helped in financial planning. A table was created where the value in each cell in the table was related to the others. This meant that changing the value in one cell altered the value in the other cells accordingly. Today we call such programs Spreadsheets. After a slow start, businessmen everywhere became exited about the spreadsheets, and they all had to have it. VISICALC was only available on the Apple, and it was so useful that it justified buying an Apple computer. Sales soared.

IBM's Open Architecture

By 1980, the personal computer market was worth over 1 billion dollars. IBM wanted to enter the market, but due to internal structuring of the company, it would take too long to develop a product. Bill Lowe proposed a daring plan. To save time, they would not build a computer from scratch, but would buy existing components from other companies and assemble them. This concept of "open architecture" was alien to IBM, and difficult to sell to the corporate executives, but with the backing of the Chairman, Bill Lowe's team developed an IBM PC within a year. IBM realised that competitors could copy the same architecture, but knew that they would always be able to buy in bulk, and thought that the bulk discount would ensure that they could always produce the machines for a lower price than competitors. The only remaining step to secure entry to the PC market was software development. A computer needs an operating system and a language used to write programs before it can be really useful, and IBM had neither.

CPM

Gary Kildall was a PhD graduate who programmed mainframes. During the early 70's he wrote an operating system for himself, and found that others were interested in purchasing it, so he formed a company called Digital Research. As personal computers were developed, Gary produced a version of his operating system known as CPM for them. By 1980, he had already sold 600,000 copies, so he was the obvious choice for IBM. However, he was arrogant, and refused to sign a contract with IBM because of a non-disclosure clause. IBM looked for alternatives.

Microsoft DOS

At the time IBM needed software, Microsoft was already the biggest supplier of languages for the PC market, but they had never written an operating system. IBM was willing to buy languages from Microsoft, but not without an operating system to run them on. Fearing that they would lose the contract, Bill Gates promised to produce an operating system for IBM. The solution was provided by Tim Patterson, a programmer who wrote an operating system based on CPM. He called it QDOS, and sold it to Seattle Computer Products. Bill Gates bought the license for QDOS from SCP for $50,000. Two days later they handed it over to IBM under the name MS-DOS.

Microsoft was paid a fixed fee (about $80,000) with no royalties for both MS-Dos and BASIC. In itself, this deal wasn't worth much, but the key to Microsoft's success was that IBM had no control over the licensing of the software to other people. Microsoft expected other people to build machines compatible with the IBM PC to whom they could licence their software. And that is just what happened.

IBM Clones

The chips used in IBM's open architecture were made by Intel. These chips were sold to anyone who was interested, and many people were. In 1982, one year after the IBM PC was shipped; a group of engineers got together and formed a company called Compaq in order to create a computer compatible with the IBM PC. They bought the same chips from Intel, and by reverse engineering, produced a computer which behaved the same as an IBM computer, but was a little cheaper. In the first year of business, Compaq sales reached $111 million. Soon, there were many companies repeating the process and producing their own clones, always a little cheaper than IBM.

Driving the sales of both the IBM PC and all the Clones was another spreadsheet. Based on VISCALC, Lotus 1-2-3 provided a spreadsheet for the IBM PC. Within a year, Lotus was worth $150 million, and you no longer needed to buy an Apple II.

Macintosh

In 1968 Doug Engelbart of the Stanford Research Institute publicly demonstrated a word processor which used windows to display the text. Xerox PARC developed this idea further by creating a Graphical User Interface for the computers they were using for research. These computers featured windows, pull down menus, a mouse and a corresponding pointer for operating the system. In 1979 Steve Jobs was given a tour of PARC, and it was this graphical interface which caught his attention. He

had the vision to see that an easy to use interface (like the one in PARC) would open up computing to the masses, and allow everyone to share the computing experience. Steve Jobs set about creating a computer that anyone could use. It began as the Lisa, and was later redesigned and renamed the Macintosh. It was released in January 1984. Over time, driven by Lotus 1-2-3 and backed by its good name, IBM began to overtake sales of the Apple II. The Macintosh had to be good, and it needed software. It needed something that IBM PC's couldn't do.

Adobe

John Warnock had developed a new technology, which allowed laser printers to print exactly what was displayed on the screen. He left Xerox PARC and founded Adobe systems to develop the concept of WYSIWYG (What you see is what you get). Steve Jobs recognised the value of his work, and Apple invested in 20 percent of Adobe. The quality of laser printed images, combined with Macintosh's ease of use created a brand new industry; desk-top publishing. The Macintosh had found its place in the market, a position which it still holds today. Apple was still in trouble however, but Steve Jobs would not admit it. He disagreed with the management of Apple, and in 1985 sold all his shares in Apple and left in disgust.

Compaq's 386

Once IBM had entered the personal computer industry, it threatened to dominate the entire market. The early success of Apple computers was beginning to fade in the mid 80's and IBM held 50% of the market. People were concerned that IBM would swallow the personal computer market and maintain a complete monopoly over computer technology. The turning point for IBM came in September 1986 when Compaq released a new IBM compatible computer based on the new Intel 80386 chip. This computer was released before IBM had released its own version based on the same chip. Compaq showed the world that IBM could be beaten, and others could compete against Big Blue. The prices of the clones keep falling, and IBM could not keep pace. By the early 90's, IBM was losing enormous amounts of money (5-6 million dollars a day), and it retreated from the PC industry, defeated by its own open architecture design.

Microsoft Windows

Impressed by the GUI concept of the Macintosh, Microsoft began to build its own version. The first couple of versions weren't very good, but then in 1990, Windows 3.0 was launched, and it was good enough to compete with the Macintosh. People could now do the same things on a Macintosh that they did on an IBM compatible, but for lower cost, since the IBM clones were much cheaper than the Macintosh. Apple computers became a fading influence in the PC industry. In August 1995 Microsoft released Windows 95 with a GUI that was extremely similar to the Macintosh, and Apple was consigned to a niche in the market.

5th Generation – Where to from here?

At one stage it was thought that artificially intelligent computers, perhaps robots, would be the next generation in computing. This was at a time when it seemed that an artificial intelligence was only 20-50 years away. AI still has a long way to go and other areas, such as quantum computing, seem a lot closer. At this time it still remains to be seen what the next stage of evolution computers will enter.

Conclusion

The computer industry is driven by technology that gets more powerful, yet cheaper every day. In order for a computer to survive this terrible competition, it must have both hardware and software. The software available for a machine has an overriding influence upon the consumer. The IBM compatible computer has become so popular because of a self-reinforcing cycle in the marketplace. People write software for the most popular machine because they can sell more programs. The more software that is available, the more popular the machine will become. Good products are ignored or overshadowed by marketing, and market forces. Steve Jobs had a vision of every home owning a computer. Bill Gates had a vision that they would all run Microsoft software. Both visions are coming true.

Timeline

1959 - Texas Instruments and Fairchild Semiconductor both announce first Integrated Circuit
1964 - BASIC developed
1968 - Doug Engelbart of SRI demonstrates mouse, keypad, keyboard, windows, word processor
1968 - Robert Noyce and Gorden Moore leave Fairchild Semiconductor and form Intel Corp.
1971 - Xerox opens Palo Alto Research Center (PARC)
1974 - First WYSIWYG program developed at PARC
1975 - Ed Roberts at MITS releases the Altair
- Bill Gates and Paul Allen form Micro-Soft, and license BASIC to MITS
1976 - Steve Wozniak and Steve Jobs form Apple Computer
1977 - Apple II released for $1300
- Microsoft becomes an official company
1978 - Microsoft sales reach $1 Million
- Space Invaders developed and released
1979 - Steve Jobs given tour of PARC in exchange for Xerox buying shares in Apple Computers
- VISICALC released
1980 - Apple computers becomes public company
- Apple computers holds 50% of the personal computer market
- Microsoft buys rights to QDOS from SCP for $50,000, ships as MS-DOS
1981 - IBM PC shipped
1982 - First IBM clone released by Columbia Data Products
- Japanese companies enter market (Matsushita, Toshiba, NEC, Hitachi, Anritsu, Sanyo)
1983 - Apple release Lisa based on Xerox costing $50 million to develop
- IBM XT released for $5000
- Lotus 1-2-3 released
1984 - Macintosh introduced by Apple Computer for $2,500
- IBM AT released using the Intel 80286 chip
1985 - IBM and Microsoft sign deal to collaborate on future OS
- Steve Jobs leaves Apple and founds NeXT Incorporated
- Microsoft ships Windows version 1.0
- VISICALC rights sold to Lotus
1986 - Microsoft sells shares to public, Bill Gates becomes worlds youngest Billionare
- Steve Jobs buys Pixar from Lucasfilm
1989 - Apple develops True-Type font system
1990 - Federal Trade Commission investigates Microsoft for monopolistic practices
- Microsoft sales reach $1 Billion for past year
- Microsoft Windows 3.0 shipped
1995 - Steve Jobs releases hit movie Toy Story, sells shares in Pixar and becomes a billionaire
- Windows 95 released. Sells 4 million copies in 6 weeks
1997 - Microsoft held in contempt of court for continuing to ship IE4 with Windows 95

Further reading (for interest only) -
http://plato.stanford.edu/entries/computing-history/
http://csep1.phy.ornl.gov/ov/node8.html

References:

Accidental Empires. Robert Cringely
A Short History of the Computer, Jeremy Meyers