Chapter 6
IBM

Key Topics

Hermann Hollerith
Thomas Watson Sr. and Jr.
Harvard Mark 1 (IBM ASCC)
IBM 701
IBM system/360
CICS
IBM personal computer

6.1 Introduction

This chapter considers the history of International Business Machines (IBM). This company is a household name and has a long and distinguished history. It is a major corporation that has made major contributions to the computing field and in developing the computers that we are familiar with today. Its origins go back to the processing of the 1880 population census of the United States.

The processing of this census was done manually, and it took 7 years to complete. It was predicted that the 1890 census would take in excess of 10 years to process, and the US Census Bureau recognised that its current methodology was no longer fit for purpose. It held a contest amongst its employees to find a more efficient methodology to tabulate the census data, and the winner was Hermann Hollerith who was the son of a German immigrant.

His punch card tabulating machine used an electric current to sense holes in punch cards, and it kept a running total of the data. The new methodology enabled the results of the 1890 census to be available in 6 weeks, and the population was recorded to be over 62 million.

G. O'Regan, *A Brief History of Computing*, DOI 10.1007/978-1-4471-2359-0_6,

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Fig. 6.1 Hermann Hollerith (Courtesy of IBM Archives)

Fig. 6.2 Hollerith's tabulator (1890) (Courtesy of IBM Archives)

Hollerith formed the Tabulating Machine Company in Washington, DC, in 1896, and this was the first electric tabulating machine company. It later merged with the International Time Recording Company to form the Computing Tabulating Recording Company (CTR) in 1911. The company changed its name to IBM in 1924 (Fig. 6.1).

Thomas Watson Sr. became president of CTR in 1914 and transformed the company into a highly successful international selling organisation based around punch card tabulating machines. He was responsible for the famous 'THINK' signs that have been associated with IBM for many years. They were introduced in 1915 (Fig. 6.2).

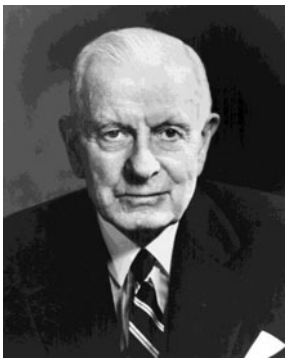

Fig. 6.3 Thomas Watson Sr. (Courtesy of IBM Archives)

Watson considered the motivation of the sales force to be an essential part of his job, and the sales people were required to attend an IBM sing-along. The verses in the songs were in praise of IBM and its founder Thomas Watson Sr.

These songs were published as a book titled *Songs of the IBM* in 1931 and included 'Ever Onward', 'March on with IBM' and 'Hail to the IBM'. Watson renamed CTR to International Business Machines (IBM) in 1924. It employed over 3,000 people, had revenues of $11 million and a net income of $2 million. It had manufacturing plants in the United States and Europe. By 2005, IBM had revenues of over $91 billion, net income of $7.9 billion, and it employed over 300,000 people.

IBM has successfully adapted its business to a changing world for over a 100 years. Its early products were designed to process, store and retrieve information from tabulators and time-recording clocks. Today, the company is an industry leader that produces powerful computers and global networks and provides professional services to its customers around the world (Fig. 6.3).

It developed the popular IBM punch card in the late 1920s which provided almost double the capacity of existing cards. The company introduced a mechanism by which staff could make improvement suggestions in the 1920s.

The great depression of the 1930s affected many Americans. Its impact on IBM was minimal, and IBM's policy was to take care of its employees. It was one of the first corporations to provide life insurance and paid vacations for its employees. Watson kept his workers busy during the depression by producing new machines even while demand was slack. He also won a major government contract to maintain employment records for over 26 million people.

He recognised the importance of research and development and created a division in the early 1930s to lead the engineering and research and development efforts for the entire IBM product line. The education and development of employees was seen as essential to the success of its business. IBM launched an employee and customer magazine called 'Think' in the 1930s. This magazine included topics such as education and science.

IBM placed all of its plants at the disposal of the US government during the Second World War, and it expanded its product line to include military equipment. It commenced work on computers during the war years with the Harvard Mark I

Fig. 6.4 Harvard Mark 1 (IBM ASCC) (Photo public domain)

(also known as the IBM Automatic Sequence Controlled Calculator (ASCC)). It was completed in 1944 and presented to Harvard University. It was essentially an electromechanical calculator that could perform large computations automatically.

The machine was designed by Howard Aiken of Harvard University to assist in the numerical computation of differential equations. It was funded and built by IBM and was 50 ft long, 8 ft high and weighed 5 tons. It performed additions in less than a second, multiplications in 6 s and division in about 12 s. It used electromechanical relays to perform the calculations.

The ASCC could execute long computations automatically. It used 500 miles of wiring and over 700,000 components. It was the industry's largest electromechanical calculator and had 60 sets of 24 switches for manual data entry. It could store 72 numbers, each 23 decimal digits long (Fig. 6.4).

The announcement of the Harvard Mark 1 led to tension between Aiken and IBM, as Aiken announced himself as the sole inventor without acknowledging the important role played by IBM.

6.2 Early IBM Computers

The company developed the Vacuum Tube Multiplier in 1943 which was an important move from electromechanical to electronic machines. It was the first complete machine to perform arithmetic electronically by substituting vacuum tubes for electric relays. The key advantages of the vacuum tubes is that they

Fig. 6.5 IBM 701 (Courtesy of IBM Archives)

Fig. 6.6 Thomas Watson Jr. (Courtesy of IBM Archives)

were faster, smaller and easier to replace than the electromechanical switches used in the Harvard Mark I. This allowed engineers to process information thousands of times faster (Fig. 6.5).

It introduced its first large computer based on the vacuum tube in 1952. This machine was called the IBM 701, and it executed 17,000 instructions per second. It was used mainly for government work and for business applications. Thomas Watson, Sr., retired in 1952, and his son, Thomas Watson, Jr., became chief executive officer the same year (Fig. 6.6).

Thomas Watson, Jr., believed that the future of IBM was in computers rather than in tabulators. He recognised the future role that computers would play in business and realised that IBM needed to change to adapt to the new technology. He played a key role in the transformation of IBM to a company that would become the world leader in the computer industry.

IBM introduced the IBM 650 (Magnetic Drum Calculator) in 1954. This was an intermediate-sized electronic computer designed to handle accounting and scientific computations. It was the first mass-produced computer and was used by universities and businesses from the 1950s to the early 1960s. It was a very successful product for IBM with over 2,000 built and sold between its product launch in 1954 and its retirement in 1962. The machine included a central processing unit, a power unit and a card reader.

The IBM 704 data processing system was a large computer introduced in 1954. It included core memory and floating-point arithmetic and was used for scientific and commercial applications. It included high-speed memory which was faster and much more reliable than the cathode ray tube memory storage mechanism used in earlier machines. It also had a magnetic drum storage unit which could store parts of the program and intermediate results.

The interaction with the system was either by magnetic tape or punch cards entered through the card reader. The program instructions or data were initially produced on punch cards. They were then either converted to magnetic tape or read directly into the system, and data processing performed. The output from the processing was then sent to a line printer, magnetic tape or punch cards. Multiplication and division was performed in 240 μs.

The designers of the IBM 704 included John Backus and Gene Amdahl. Backus was one of the key designers of the FORTRAN programming language introduced by IBM in 1957.This was the first scientific programming language and is used by engineers and scientists. Gene Amdahl later founded the Amdahl Corporation in 1970, and this company later became a rival to IBM in the mainframe market.

The first IBM product to use transistor circuits without vacuum tubes was the 608. This transistorised calculator was introduced in late 1957, and it contained 3,000 germanium transistors. It was similar to the operation of the older vacuum tube 604.

The IBM 7090 which was introduced in 1958 was one of the earliest commercial computers with transistor logic. It was designed for large-scale scientific applications. It was over 13 times faster than the older vacuum tube IBM 701 and could perform 229,000 calculations per second. It used a 36-bit word and had an address space of 32,768 words. It was used by the US Air Force to provide an early warning system for missiles and also by NASA to control space flights. It cost approximately $3 million, but it could be rented for over $60 K per month.

IBM introduced the first computer disk storage system in 1957. This medium was called the Random Access Method of Accounting and Control (RAMAC), and it became the basic storage medium for transaction processing. The RAMAC's random access arm could retrieve data stored on any of the 50 spinning disks.

IBM was involved in the development of the Semi-Automatic Ground Environment (SAGE) early warning system during the Cold War. This was

described in more detail in Chap. 4. IBM provided the hardware for the air defence system. The initial installation was completed in 1958, and the system was fully implemented in 1963. It remained operational until 1984.

There were 24 SAGE direction centres and 3 SAGE combat centres located in the United Sates. Each centre was linked by long-distance telephone lines, and Burroughs provided the communications equipment that allowed the centres to communicate with one another. It was one of the earliest computer networks. Each centre contained a large digital computer that automated the information flow and provided real-time control information on aircraft and on weapons systems. It tracked and identified aircraft and presented the electronic information to operators on a display device (cathode ray tube).

The IBM 1401 data processing system and the IBM 1403 printer were launched in 1959. The 1401 was an all-transitorised data processing system, and it was aimed at small businesses. This computer replaced punch card–based tabulating equipment. It included high-speed card punching and reading, magnetic tape input and output and high-speed printing. The 1403 printer was four times faster than any competitor printer. IBM introduced a program termed 'Speak Up' to enhance staff communication in 1959. It opened its research division headquarters at Yorktown Heights, New York, in 1961.

6.3 The IBM System/360

Thomas Watson announced the new System/360 to the world at a press conference in 1964 and said:

> The System/360 represents a sharp departure from concepts of the past in designing and building computers. It is the product of an international effort in IBM's laboratories and plants and is the first time IBM has redesigned the basic internal architecture of its computers in a decade. The result will be more computer productivity at lower cost than ever before. This is the beginning of a new generation – not only of computers – but of their application in business, science and government.

The IBM 360 was a family of small to large computers, and the concept of a 'family of computers' was a paradigm shift away from the traditional 'one size fits all' philosophy of the computer industry. The family ranged from minicomputers with 24 kB of memory to supercomputers for US missile defence systems. However, all these computers had the same user instruction set, and the main difference was that the larger computers implemented the more complex machine instructions with hardware, whereas the smaller machines used microcode (Fig. 6.7).

Its architecture potentially allowed customers to commence with a lower-cost computer model and to then upgrade over time to a larger system to meet their evolving needs. The fact that the same instruction set was employed meant that the time and expense of rewriting software was avoided.

The S/360 was used extensively in the Apollo project to place man on the moon. The contribution by IBM computers and personnel were essential to the success of the project. It was a very successful product line.

Fig. 6.7 IBM System/360 Model 91 at NASA in the 1960s (Public domain)

6.4 The 1970s

IBM introduced the Customer Information Control System (CICS) in 1969. This is a transaction processing system designed for online and batch processing. It was originally developed at IBM's Palo Alto laboratory, but development moved to IBM's laboratory at Hursley, England, from the mid-1970s.

It is used by banks and insurance companies in the financial sector for their core business functions. It can support several thousand transactions per second and up to 300 billion transactions flow through CICS every day. It is available on large mainframes and on several operating systems, including Z/OS, AIX, Windows and Linux. CICS applications have been written in COBOL, PL/1, C and Java.

The IBM System/370 was introduced in 1970. It was backwards compatible with the older 360 system (i.e. programs that ran on the 360 could still run on the 370). This made it easier for customers to upgrade from their System/360 to the System/370. The S/370 employed virtual memory.[1]

[1] Virtual memory was developed for the Atlas Computer at Manchester University in England in the early 1960s. It allowed the actual memory space of a computer to appear much larger by using the space available on the hard drive. The Atlas Computer was a joint venture between the Manchester University, Ferranti, and Plessey.

The floppy disk was introduced in 1971, and it became the standard for storing personal computer data. The IBM 3340 Winchester disk drive was introduced in 1973. It doubled the information density on disk surfaces and included a small light read/write head that was designed to ride on an air film that was 18×10^{-6} in. thick. Winchester technology was employed up to the early 1990s.

IBM introduced the Systems Network Architecture (SNA) networking protocol in 1974, and this protocol provided a set of rules and procedures for communication between computers. It remained an important standard until the open architecture standards appeared in the 1990s.

It introduced the IBM 5100 Portable Computer in 1975 which cost under $20,000. This was a desktop machine used by engineers and scientists. IBM's Federal Systems Division built the flight computers and special hardware for the space-shuttle program.

IBM developed the Data Encryption Standard (DES) in the mid-1970s. DES provides a high degree of security during the transmission of data over communication channels. It specifies an algorithm that enciphers and deciphers a message. The effect of enciphering is to make the message meaningless to unauthorised viewing as the task of breaking the encryption algorithm is extremely difficult.

6.5 The IBM Personal Computer Revolution

This section provides a brief overview of the introduction of the IBM Personal Computer, and it was discussed in more detail in Chap. 5. The IBM Personal Computer (or PC) was introduced in 1981, and it was intended to be used by small businesses and personal users in the home. Its price was $1,565, and it provided 16 kB of memory (that was expandable to 256 kB), a floppy disk and a monitor. The IBM Personal Computer became an immediate success and became the industry standard.

It led to a new industry of 'IBM-compatible' computers which had all of the essential features of the IBM PC but were cheaper. The IBM Personal Computer XT was introduced in 1983. This model had more memory, a dual-sided diskette drive and a high-performance fixed-disk drive. It was followed by the Personal Computer/AT introduced in 1984.

The development of the IBM PC meant that computers were now affordable to ordinary users, and this led to a huge consumer market for personal computers and software.

The introduction of the personal computer represented a paradigm shift in computing, and it placed the power of the computer directly in the hands of millions of people.

IBM had traditionally produced all of the components for its machines. However, it outsourced the production of components to other companies for the

IBM PC. This proved to be a major mistake as they outsourced the production of the processor chip to a company called Intel,[2] and the development of the Disk Operating System (DOS) was outsourced to a small company called Microsoft.[3] Intel and Microsoft would later become technology giants.

6.6 The 1980s and 1990s

The IBM token-ring local area network was introduced in 1985. This enabled personal computer users to share printers, files and information within a building. It is essentially a computer network in which all of the computers are arranged in a circle (or ring). There is a special data frame termed a token, and the token moves from computer to the next computer until it arrives at a computer that needs to transmit data. This computer then converts the token frame into a data frame for transmission; that is, the computer that wishes to transmit catches the token, attaches a message to it and then sends it around the network. The token-ring network later became the IEEE 802.5 standard.

The Ethernet local area network was developed by Robert Metcalfe at Xerox, and its performance was superior to the IBM token-ring network. Ethernet was first published as a standard in 1980, and it was later published as the IEEE 802.2 standard. Metcalfe formed the technology company 3-Com to exploit the Ethernet technology. IBM introduced the Advanced Peer-To-Peer Networking (APPN) architecture in 1984. This was widely used for communication by mid-range systems, and it allowed individual computers to talk to one another without a central server.

IBM developed the reduced instruction set computer (RISC) architecture. This technology boosts computer speed by using simplified machine instructions for frequently used functions. It reduces the time to execute commands and is the basis of most workstations in use today. This led to the design of the RS/6000 and the subsequent development of the Power PC architecture. The RISC System/6000 was introduced in 1990. It is a family of workstations that were amongst the fastest and most powerful in the industry.

IBM introduced the next generation of personal computers termed the Personal System/2 (PS/2) in 1987. It included a new operating system called Operating System/2 (OS/2). The latter gave users of personal computers access to multiple applications and very large programs and data and allowed concurrent communication with other systems. It was the first offering in IBM's Systems Application Architecture (SAA) which was designed to make application programs look and

[2] Intel was founded by Bob Noyce and Gordon Moore in 1968.

[3] Microsoft was founded by Bill Gates and Paul Allen in 1975.

Fig. 6.8 Personal System/2. Model 25. (Courtesy of IBM Archives)

work in the same manner across different systems such as personal computers, mid-range systems and larger systems (Fig. 6.8).

A research group at IBM developed a suite of antivirus tools to protect personal computers from attacks from viruses. This led to the establishment of the High Integrity Computing Laboratory (HICL) at IBM. This laboratory went on to pioneer the science of computer viruses.

IBM researchers introduced very fast computer memory chips in 1988. These chips could retrieve a single bit of information in 2×10^{-8} of a second. IBM introduced the IBM Application System/400 (AS/400) in 1988. This was a new family of easy-to-use computers designed for small and intermediate-sized companies. It became one of the world's most popular business computing systems.

A team of IBM researchers succeeded in storing a billion bits of information (i.e. a gigabit) on a single square inch of disk space in 1989. IBM introduced a laptop computer in 1991 to give customers computing capabilities on the road or in the air.

IBM, Apple Computers and Motorola entered an agreement in 1991 to link Apple computers to IBM networks and to develop a new reduced instruction set microprocessors for personal computers. IBM and Motorola completed development and fabrication of the PowerPC 620 microprocessor in 1994. The new open-systems environment allowed both IBM AIX and Macintosh software programs to run on RISC-based systems from both companies (Fig. 6.9).

IBM created the world's fastest and most powerful general-purpose computer in 1994. This was a massively parallel computer capable of performing 136 billion calculations per second. The increase in computational power of computers was becoming phenomenal.

The Deep Blue computer-programmed chess program defeated Garry Kasparov in 1997. Kasparov was then the existing world champion in chess, and the IBM

Fig. 6.9 Deep Blue processors (Courtesy of IBM Archives)

victory showed that the computational power of computers could match or exceed that of man. It was also the first time that a computer had defeated a top-ranked chess player in tournament play. Deep Blue had phenomenal calculating power, and it could calculate 200 million chess moves per second.

IBM and the US Energy Department introduced Blue Pacific which was the world's fastest computer in 1998. It was capable of performing 3.9 trillion[4] calculations per second and had over 2.6 trillion bytes of memory. An indication of its computability is given by the fact that the amount of calculations that this machine could perform in one second would take a person using a calculator over 63,000 years.

6.7 Challenges for IBM

IBM had traditionally provided a complete business solution to its clients with generally one key business person making the decision to purchase the IBM computer system for the company. The personal computer market and the client/server architecture had now fragmented this traditional market, as departments and individuals could now make their own purchasing decisions. The traditional customer relationship that IBM had with its clients was fundamentally altered. Further, the decision to outsource the development of the microprocessor and the operating system proved to be costly mistakes.

It took IBM some time to adjust to this changing world, and it incurred huge losses of over $8 billion in 1993. The company embarked on cost-cutting measures

[4] We are using the US system with a trillion defined as 10^{12} and a billion defined as 10^{9}.

which involved reducing its work force and rebuilding its product line. IBM's strength in providing integrated business solutions proved to be an asset in adapting to the brave new world.

IBM faced further challenges to adapt to the rise of the Internet and to network computing. The Internet was another dramatic shift in the computing industry, but IBM was better prepared this time after its painful adjustment in the client/server market. IBM's leadership helped to create the e-business revolution, and IBM actually coined the term 'e-business'. IBM outlined to customers and to its employees how the Internet had the ability to challenge older business models and to transform the nature of transactions between businesses and individuals.

IBM is a highly innovative company and is awarded more patents[5] in the United States than any other company. It earned over 3,000 patents in 2004. The company is a household name, and it has a long and distinguished history. The history of computing is, in many ways, closely related to the history of IBM, as the company has played a key role in the development of the computers that we are familiar with today.

6.8 Review Questions

1. Discuss the contribution of IBM to computing.
2. Discuss the development of the Systems/360 and its importance.
3. Discuss the introduction and impact of the introduction of the IBM personal computer.

6.9 Summary

IBM is a major corporation with a long and distinguished history. Its origins go back to the development by Hermann Hollerith of a tabulating machine to process the population census of the United States in 1890.

IBM became involved in the computer field during the war years with the development of the Harvard Mark 1. This machine was designed by Howard Aiken of Harvard University to assist in the numerical computation of differential equations. It was funded and built by IBM.

IBM played a key role in the implementation of the SAGE air defence system in North America. It provided the hardware for each of the SAGE centres, with each

[5] A patent is legal protection that is given to an inventor and allows the inventor to exploit the invention for a fixed period of time (typically 20 years).

centre containing a large digital computer to automate the information flow, and provided real-time control information on aircraft and weapons systems.

Its first computer, the 701, was introduced in 1952. This was a large vacuum tube computer, and it was followed by the 650 in 1954. This was a popular machine used for business computing. It introduced its first transistorised machine, the 608, in 1957, and this was followed in 1958 by the 7090, a large transistorised machine for business computing.

It introduced the IBM 360 family of small to large computers in 1964, and the family ranged from minicomputers with 24 kB of memory to supercomputers for US missile defence systems. However, all these computers had the same user instruction set, and the main difference was that the larger computers implemented the more complex machine instructions with hardware, whereas the smaller machines used microcode. The S/360 was used extensively in the Apollo project to place man on the moon.

It introduced the IBM Personal Computer (or PC) in 1981, and this machine was intended to be used by small businesses and personal users in the home. The IBM Personal Computer became an immediate success and became the industry standard. However, IBM's strategy in the introduction of the personal computer was flawed, and it enabled companies such as Microsoft and Intel to become industry giants.

IBM is a highly innovative company that has made important contributions to computing.