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Key concepts

- **Computing milestones and machine evolution**
  - Counting and the evolution of the positional number system
  - Evolution of the computing machine
- **Generations of computers**
  - First generation computers
  - Second generation computers
  - Third generation computers
  - Fourth generation computers
  - Fifth generation computers
- **Evolution of computing**
  - Programming languages
  - Algorithm and computer programs
  - Theory of computing

The Discipline of Computing

Computers now play a major role in almost every aspect of life and influence our lives in one way or the other. Today, almost everyone is a computer user and many are computer programmers. Getting computers to do what you want them to do requires intensive hands-on experience. But computer science can be seen on a higher level, as a science of problem-solving. Computer scientists must be able to analyse problems and design solutions for real world problems. The Computer Science discipline covers a wide range of topics from theoretical aspects like design of algorithms to more practical aspects like application development and its implementation. The discipline of Computer Science involves the systematic study of algorithmic processes – their theory, analysis, design, efficiency, implementation and application – that describe and transform information.

The concept of computing has evolved from the abacus to super computers of today. This chapter discusses the evolution of computing devices and provides an overview of the different generations of computers. The evolution of programming languages and the contributions of Alan Turing to computer science are also discussed.

1.1 Computing milestones and machine evolution

In ancient times people used stones for counting. They made scratches on walls or tied knots in ropes to record information. Progressively many attempts had been made to replace these manual computing techniques with faster computing machines. In this section, we will have a look at the ancient methods of counting and the evolution of the positional number system.

1.1.1 Counting and the evolution of the positional number system

The idea of number and the process of counting goes back far before history began to be recorded. It is believed that even the earliest humans had some sense of 'more' or 'less'. As human beings differentiated into tribes and groups, it became necessary to be able to know the number of members in the group and in the enemy's camp. And it was important for them to know if the flock of sheep or other animals was increasing or decreasing in size. In order to count items, such as animals, 'sticks' were used, each stick representing one animal or object.

Let us now see how the number system evolved. It is important to note that the system that we use everyday is a product of thousands of years of progress and development. It represents contributions of many civilisations and cultures. The number system is a method in which we represent numbers. The chronological development of the number system throughout the history is discussed below.

To begin with let us see the Egyptian number system that emerged around 3000BC. It used 10 as a radix (base). They had unique symbols for 1 to 9, 10 to 90, 100 to 900 and 1000 to 9000. As the Egyptians write from right to left, the largest power of ten appears to the right of the other numerals.

Later on, the era of Sumerian/Babylonian number system began. It used 60 as its number base, known as the sexagesimal system. Numerals were written from left to right. It was the largest base that people ever used in number systems. They did not use any symbol for zero, but they used the idea of zero. When they wanted to express zero, they just left a blank space within the number they were writing.

The Chinese number system emerged around in 2500 BC. It was the simplest and the most efficient number system. The Chinese had numbers from 1 to 9. It had the base 10, very similar to the one we use today. They used small bamboo rods to represent the numbers 1 to 9.

Approximately in 500 BC, the Greek number system known as Ionian number system evolved. It was a decimal number system and the Greeks also did not have any symbol for zero.

The Romans started using mathematics for more practical purposes, such as in the construction of roads, bridges, etc. They used 7 letters (I, V, X, L, C, D and M) of the alphabet for representing numbers.

The Mayans used a number system with base 20. There is a simple logic behind this base 20. It is the sum of the number of fingers and toes. This number system could produce very accurate astronomical observations and make measurements with greater accuracy.

The Hindu-Arabic numeral system actually originated in India, around 1500 years ago. It was a positional decimal numeral system and had a symbol for zero. This invention can indeed be termed as one of India's greatest contributions to the world. Later on many of the countries adopted this numeral system. Now let us discuss the evolution of computing machines.

1.1.2 Evolution of the computing machine

During the period from 3000 BC to 1450 AD, human beings started communicating and sharing information with the aid of simple drawings and later through writings. The introduction of numbers led to the invention of Abacus, the first computing machine. In the following section, we will examine some important milestones in the evolution of computing machines.

a. Abacus

Abacus was discovered by the Mesopotamians around 3000 BC. The word 'abacus' means calculating board. An abacus consisted of beads on movable rods divided into two parts. The abacus may be considered the first computer for basic arithmetical calculations. An abacus is shown in Figure 1.1.

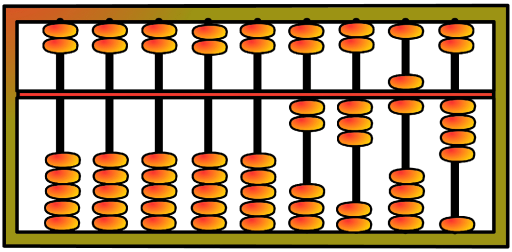


Fig. 1.1 : Abacus

The abacus is also called a counting frame, a calculating tool for performing arithmetic operations. The Chinese improved abacus as a frame holding vertical wires, with seven beads on each wire. A horizontal divider separates the top two beads from the bottom five. Addition and multiplication of numbers was done using the place value of digits and position of beads in an abacus.

The abacus works on the basis of the place value system. Reading it is almost like reading a written numeral. Each of the five beads below the bar has a value of 1. Each of the two beads above the bar has a value of 5. The beads which are pushed

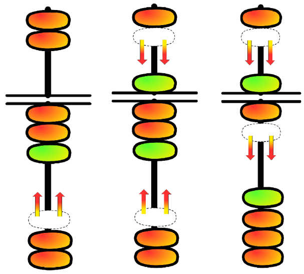


Fig. 1.2(a) : Addition using Abacus

against the bar represent the number. The number on the abacus given in Figure 1.1 is 2364.

Abacus is used even today by children to learn counting. A skilled abacus operation can be as fast as a hand held calculator. Figures 1.2(a) shows the addition of two single digit numbers. Figure 1.2(b) shows how two numbers (54 and 46) are added.

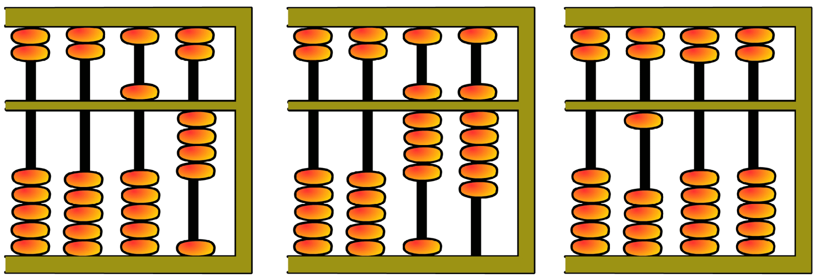
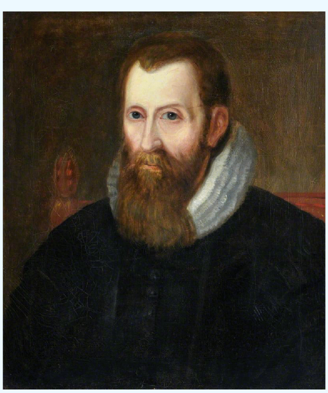


Fig. 1.2(b) : Addition using Abacus

b. Napier's bones

John Napier was a mathematician who devised a set of numbering rods known as Napier's bones in 1617 AD, by which a multiplication problem could be easily performed. These numbered rods could perform multiplication of any number by a number in the range of 2-9. There are 10 bones corresponding to the digits 0-9 and a special eleventh bone that is used to represent the multiplier. This device was known as Napier's bones. John Napier also invented logarithm in 1614, that reduced tedious multi-digit multiplications to addition problems. A representation of Napier's bones is given in Figure 1.3.



1	1	2	3	4	5	6	7	8	9
2	2	4	6	8	1/0	1/2	1/4	1/6	1/8
3	3	6	9	1/2	1/5	1/8	2/1	2/4	2/7
4	4	8	1/2	1/6	2/0	2/4	2/8	3/2	3/6
5	5	1/0	1/5	2/0	2/5	3/0	3/5	4/0	4/5
6	6	1/2	1/8	2/4	3/0	3/6	4/2	4/8	5/4
7	7	1/4	2/1	2/8	3/5	4/2	4/9	5/6	6/3
8	8	1/6	2/4	3/2	4/0	4/8	5/6	6/4	7/2
9	9	1/8	2/7	3/6	4/5	5/4	6/3	7/2	8/1

Fig. 1.3 : John Napier (1550 – 1617) and Napier's Bones

The strips of Napier's bones are the times tables. Each square gives 2 × number, 3 x number and so on, but the tens and units are written above and below a slanting line respectively. Napier's bones is good for multiplying a long number by a single digit number. Let us multiply 425928 by 7. First take the strips for 4, 2, 5, 9, 2 and 8, and fit them into the frame. Look at the squares next to the 7 on the side. It is coloured green in Figure 1.4. Now read the digits – any number within slanting lines must be added. So the answer is 2(8+1)(4+3)(5+6)(3+1)(4+5) 6 or 297(11)496. All the digits except 11 are in their position. 11 needs to have 10 carried to the left. This makes 29(7+1)1496 or 2981496, which is the correct answer.

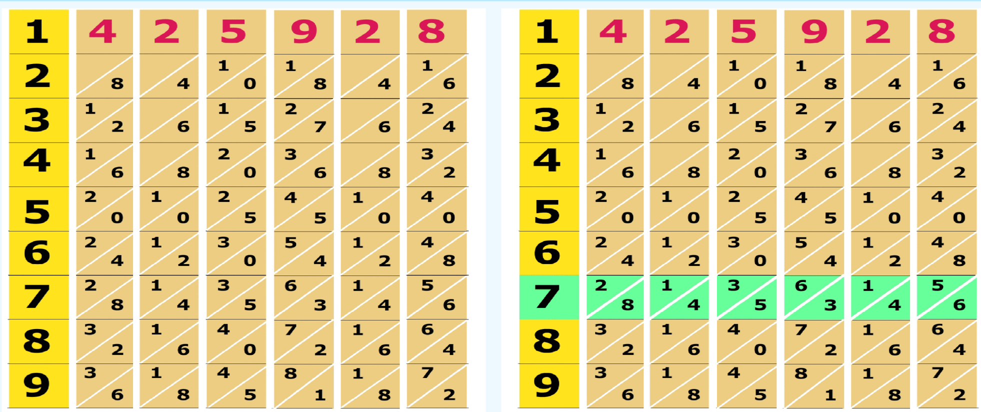


Fig. 1.4 : Multiplication using Napier's Bones

c. Pascaline

Blaise Pascal was a French mathematician and one of the first modern scientists to develop a calculator. In 1642, at the age of 19, he developed a computing machine that was capable of adding and subtracting two numbers directly and that could multiply and divide by repetition. Pascal invented this arithmetic calculator to assist his father in his work as a tax collection supervisor. This machine was operated by dialing a series of wheels, gears and cylinders. He called it 'Pascaline'. Figure 1.5 shows a Pascaline.

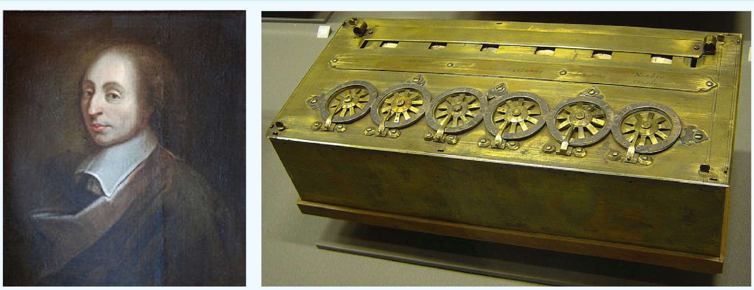
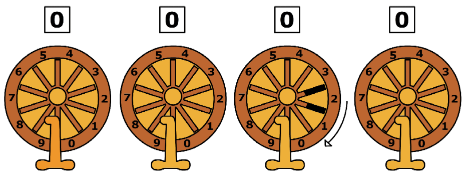


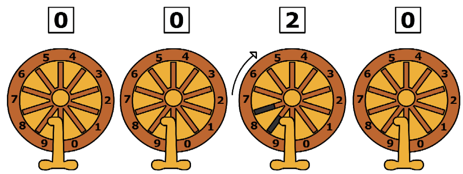
Fig. 1.5 : Blaise Pascal (1623 - 1662) and Pascaline

Consider adding the numbers 20 and 81 using Pascaline. Initially, the Pascaline will be set to 0 for all the six digits. To dial 20, you just have to put your finger into the space between the spokes next to digit 2 of the second wheel and rotate the wheel in clockwise direction until your finger strikes against the fixed stop on the bottom of the wheel. This rotation transmits the value of two into the second window from the right. Now the machines will display number 0020.

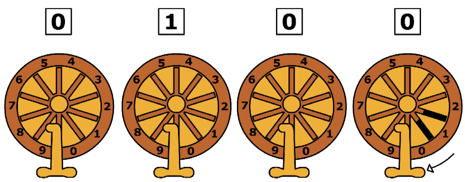
Pascaline wheel



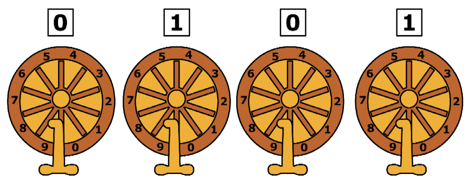
1. Dialing the digit 2 of 20



2. Dialing the digit 8 of 81



3. Dialing the digit 1 of 81



4. Sum of 20 and 81, 101 on Pascaline

Fig. 1.6 : Adding using Pascaline

To dial 81, put your finger into the space between the spokes next to digit 8 of the second wheel and rotate it. After the second drum reaches number 9, the gears inside Pascaline will carry to the next drum one unit and the third drum of the machine will rotate by one tenth. So after the end of dialing number 8, the machine will display the number 100. Now put your finger into the space between the spokes next to digit 1 and rotate it in the same way you did before. Now the machine will display the number 0101, which is the final result of addition.

d. Leibniz's calculator

In 1673 the German mathematician-philosopher Gottfried Wilhelm von Leibniz designed a calculating machine called the Step Reckoner. The Step Reckoner expanded on Pascal's ideas and extended the capabilities to perform multiplication and division as well. Leibniz successfully introduced this calculator onto the market. His unique, drum-shaped gears formed the basis of many successful calculator designs in later years.

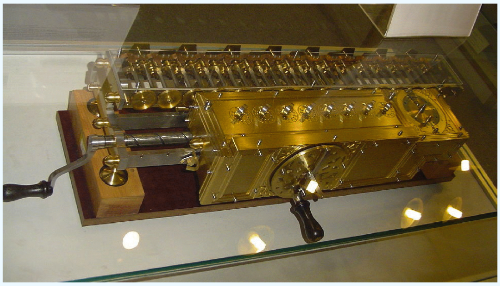


Fig. 1.7 : Gottfried Wilhelm von Leibniz (1646 - 1716) and Leibniz Calculator

e. Jacquard's loom

The Jacquard loom is a mechanical loom, invented by Joseph Marie Jacquard in 1801, that simplifies the process of manufacturing textiles with complex patterns. The loom is controlled by punched cards with punched holes, each row of which corresponds to one row of the design. Multiple rows of holes are punched on each card and the many cards that compose the design of the textile are joined together in order. The Jacquard loom not only reduced the amount of human labour, but also allowed to store patterns on cards to be utilised again to create the same product. These punched cards were innovative because the cards had the capability to store information on them. This ability to store information triggered the computer revolution. The punched card concept was adopted by Charles Babbage to control his Analytical Engine and later by Herman Hollerith.

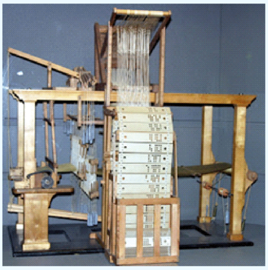
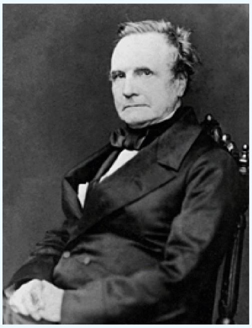


Fig. 1.8 : Joseph Marie Jacquard (1752 - 1834) and Jacquard's Loom

f. Difference engine

The first step towards the creation of computers was made by a mathematics professor, Charles Babbage. He dreamed of removing the human element from the calculations. He realised that all mathematical calculations can be broken up into simple operations which are constantly repeated and these operations could be carried out by an automatic machine. Charles Babbage started working on a

Difference Engine that could perform arithmetic calculations and print results automatically. In 1822, Babbage invented the Difference Engine to compile mathematical tables. On completing it, he conceived the idea of a better machine that could perform not just one mathematical task but any kind of calculation.



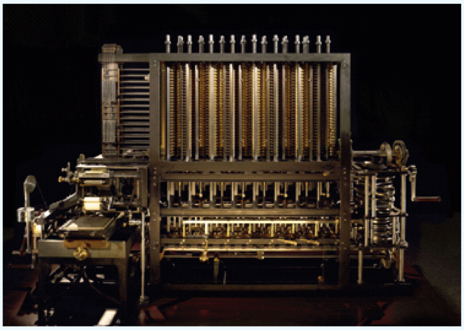


Fig. 1.9 : Charles Babbage (1791 - 1871) and Difference Engine

g. Analytical engine

In 1833, Charles Babbage started designing the Analytical Engine – the real predecessor of the modern day computer. Analytical Engine marks the development from arithmetic calculation to general-purpose computation. The Analytical Engine has many features found in the modern digital computer. The Engine had a 'Store' (memory) where numbers and intermediate results could be stored, and a separate 'Mill' (processor) where arithmetic processing could be performed. Its input/output devices were in the form of punched cards containing instructions. These instructions were written by Babbage's assistant, Agusta Ada King, the first programmer in the world. Owing to the lack of technology at that time, the Analytical Engine was never built, but Babbage established the basic principles on which today's modern computers work. Charles Babbage's great inventions – the Difference Engine and the Analytical Engine earned Charles Babbage the title 'Father of Computer'.

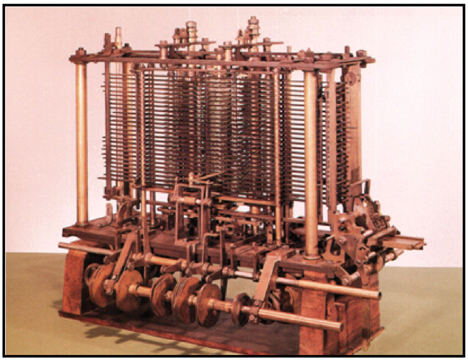


Fig. 1.10 : A model of Analytical Engine

h. Hollerith's machine

In 1887, an American named Herman Hollerith fabricated the first electromechanical punched card tabulator that used punched cards for input, output and instructions.

The card had holes on them in a particular pattern, having special meaning for each kind of data. In 1880's, the US Census Bureau had huge amounts of data to tabulate. It would take at least ten years to analyse population statistics manually. Herman Hollerith's greatest breakthrough was his use of electricity to read, count and sort punched cards whose holes represented data. His machines were able to accomplish the task in one year. In 1896, Hollerith started the Tabulating Machine Corporation which after a series of mergers, became International Business Machines (IBM) Corporation in 1924.

Fig. 1.11 : Herman Hollerith (1860 - 1929) and Hollerith Census Machine

i. Mark - I

In 1944, Howard Aiken, in collaboration with engineers at IBM, constructed a large automatic electromechanical computer. Aiken's machine, called the Harvard Mark I, based on Babbage's Analytical Engine, handled 23-decimal-place numbers and could perform all four arithmetic operations. It was preprogrammed to handle logarithms and trigonometric functions. Using Mark I, two numbers could be added in three to six seconds. For input and output, it used paper-tape readers, card readers, card punch and typewriters.

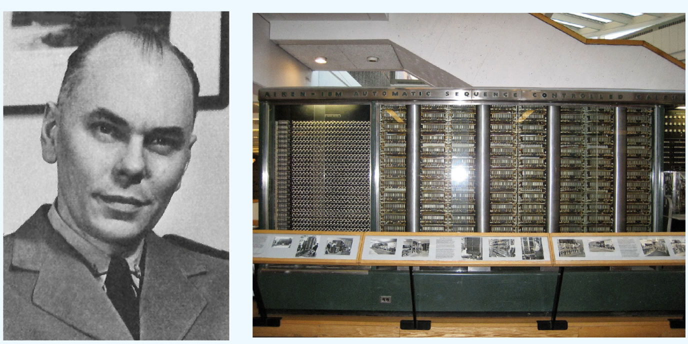


Fig. 1.12 : Howard Aiken (1900 - 1973) and Mark I computer

Check yourself

1. The Sumerian Number System is also known as _______.
2. What are the features of Hindu Arabic Number system?
3. How is the zero represented in the Babylonian Number System?
4. Who is the first programmer in the world?
5. The computing machine developed by Balaise Pascal is known as ______.

1.2 Generations of computers

The evolution of computer started from the 16th century, resulting in today's modern machines. It is distinguished into five generations of computers from the first programmable computer to the ones based on artificial intelligence. Each generation of computers is characterised by a major technological development that fundamentally changed the way computers operate, resulting smaller, cheaper, more powerful, more efficient and reliable computing devices. Based on various stages of development, computers can be divided into different generations. They are:

- First Generation Computers (1940 – 1956)
- Second Generation Computers (1956 – 1963)
- Third Generation Computers (1964 – 1971)
- Fourth Generation Computers (1971 – Present)
- Fifth Generation Computers (Present and beyond)

1.2.1 First generation computers (1940 – 1956)

The first generation computers were built using vacuum tubes. This generation implemented the stored program concept. A vacuum tube is a device controlling electric current through a vacuum in a sealed container. This cylindrical shaped container is made of thin transparent glass. The input was based on punched cards and paper tapes and output was displayed on printouts.

The first general purpose programmable electronic computer, the Electronic Numerical Integrator and Calculator (ENIAC) belongs to this generation. ENIAC was built by J. Presper Eckert and John V. Mauchly. The ENIAC was 30-50 feet long, weighed 30 tons, contained 18,000 vacuum tubes, 70,000 registers, 10,000 capacitors and required 1,50,000 watts of electricity. First generation computers

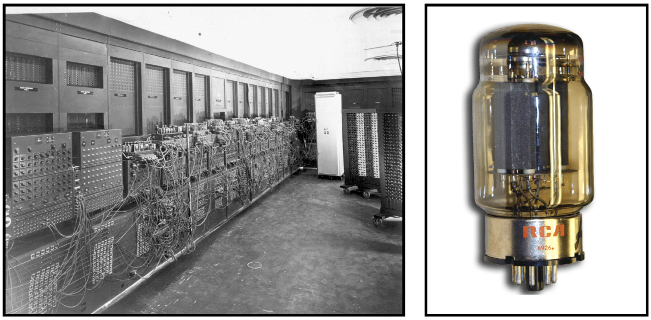


Fig. 1.13 : ENIAC and Vaccum tube

were too bulky in size, required a large room for installation and used to emit large amount of heat. Consequently, air-conditioner was a must for the proper working of computers.

Before ENIAC was completed, Von Neumann designed the Electronic Discrete Variable Automatic Computer (EDVAC) with a memory to hold both stored program as well as data. Eckert and Mauchly later developed the first commercially successful computer, the Universal Automatic Computer (UNIVAC), in 1952.

Von Neumann architecture

The mathematician John Von Neumann conceived a computer architecture which forms the core of nearly every computer system in use today. This architecture known as Von Neumann architecture consists of a central processing unit (CPU) containing arithmetic logic unit (ALU) and control unit (CU), input-output unit and a memory for storing data and instructions. This model implements the 'Stored Program Concept' in which the data and the instructions are stored in the memory.

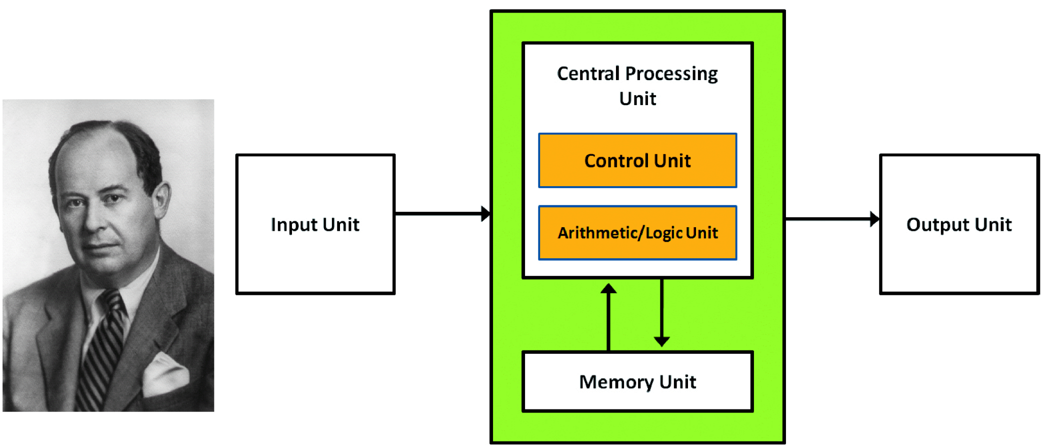
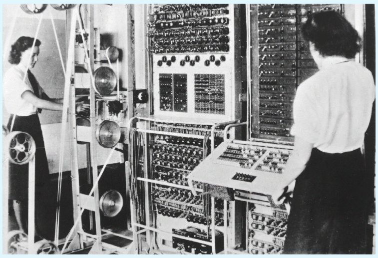


Fig. 1.14 : John Von Neumann (1903 - 1957) and Von Neumann architecture

In 1943, the British developed a secret code-breaking computer called Colossus to decode German messages. It was designed using vaccum tubes by the engineer Tommy Flowers. The Colossus's impact on the development of the computer industry was rather limited for two important reasons. First, Colossus was not a general-purpose computer; it was only designed to decode secret messages. Second, the existence of the machine was kept secret until 1970s. This deprived most of those involved with Colossus of credit for their pioneering advancements in electronic digital computing.



1.2.2 Second generation computers (1956 – 1963)

In second generation computers, vacuum tubes were replaced by transistors. It was developed at Bell Laboratories by John Bardeen, Walter Brattain and William Shockley in 1947. Replacing vacuum tubes with transistors, allowed computers to become smaller and more powerful and faster. They also became less expensive, required less electricity and emitted less heat. The manufacturing cost was also less.

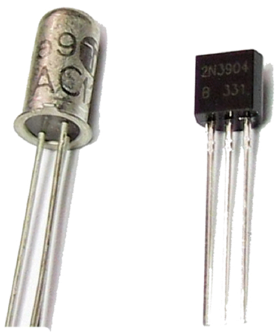


Fig. 1.15 : IBM 1401and Transistors

It is in the second generation that the concept of programming language was developed. This generation used magnetic core memory and magnetic disk memory for primary and secondary storage respectively. Second-generation computers moved from cryptic binary machine language to symbolic or assembly languages. During second generation, many high level programming languages like FORTRAN and COBOL were introduced that allowed programmers to specify instructions in English like words. IBM 1401 and IBM 1620 are popular computers in this generation.

1.2.3 Third generation computers (1964 – 1971)

Third generation computers are smaller in size due to the use of integrated circuits (IC's). IC's or silicon chips that contained miniaturised transistors were developed by Jack Kilby, an engineer with Texas Instruments. IC drastically reduced the size and increased the speed and efficiency of computing. Multilayered printed circuits were developed and core memory was replaced by faster, solid state memories with large capacity.

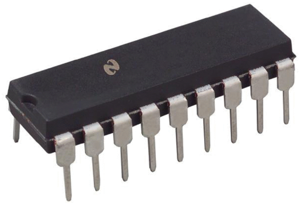
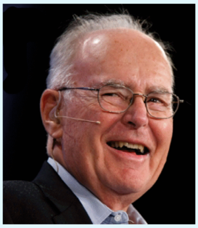


Fig. 1.16 : IBM 360 and Integrated Circuit

This generation of computers had better processing speed, consumed less power and was less costly. Integrated circuits, improved secondary storage devices and new input/output devices like keyboards and monitors were introduced. Arithmetic and logical operations were performed in microseconds or even nanoseconds. These computers could run many different programs at one time with a central program that monitored the memory. The high level language BASIC which made programming easy was developed during this period. Computers for the first time became accessible to a mass audience because they were smaller and cheaper than their predecessors. Some computers in this generation are IBM 360 and IBM 370.



Moore's Law states that the number of transistors on integrated circuits doubles approximately every two years. The law is named after Gordon E Moore, who described the trend in 1965. He noted that the number of components in IC had doubled every year from 1958 to 1965. He predicted that the trend would continue 'for at least ten years'. His prediction has proven to be accurate. Although this trend continued for more than half a century, Moore's Law is considered only as an observation and not a physical or natural law.

1.2.4 Fourth generation computers (1971 onwards)

The computers that we use today belong to this generation. These computers use microprocessors and are called microcomputers. Microprocessor is a single chip which contains Large Scale of Integration (LSI) of electronic components like transistors, capacitors, resistors, etc. Due to the development of microprocessor, it is possible to place computer's Central Processing Unit (CPU) on a single chip. Because of microprocessors, the fourth generation includes more data processing capacity than third generation computers. Later LSI circuits were replaced by Very Large Scale Integrated (VLSI) circuits which further increased the scale of integration. The fourth generation computers are smaller in size and have faster accessing and processing speeds.

The computer which occupied a very large room in earlier days could now fit in a palm. These computers were interconnected to form computer networks, which eventually led to the development of the Internet. As computers became less costly and more user-friendly, large number of people began buying them for personal use. Some computers in this generation are IBM PC and Apple II.

Fig. 1.17 : VLSI Chip

1.2.5 Fifth generation computers (future)

Fifth generation computers are based on Artificial Intelligence (AI). AI is the ability to simulate human intelligence. Such intelligent systems are still in the development stage, though there are some applications, such as speech recognition, face recognition and robotic vision and movement that are already available.

AI is the branch of computer science concerned with developing computer programs (intelligent systems) for solving complex problems (which are normally done by human beings without any effort) by the application of process that are analogues to human reasoning process. The two most common AI programming languages are LISP and Prolog. The fifth-generation computing also aims at developing computing machines that respond to natural language input and are capable of learning and self-organisation.

Table 1.1 shows comparative features of five generations of computers.

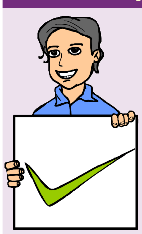
The first processor Intel 4004 was developed in 1971 by Intel Corporation and consisted of 2,300 transistors integrated into a single IC. Some popular microprocessors and the number of transistors integrated in them are given below.

Processor	Transistor Count
Intel 8086	29,000
Motorola 68000 (used in Apple)	68,000
Intel Pentium	31,00,000
AMD K7	2,20,00,000
Core i7	73,10,00,000

Criteria	Generation				
	First	Second	Third	Fourth	Fifth
Technology	Vacuum Tube	Transistor	Integrated Circuit	Microprocessor	Artificial Intelligence
Operating System	None	None	Yes	Yes	Yes
Language	Machine	Assembly	High Level	High Level	High Level
Period	1940-1956	1956-1963	1964-1971	1971-Present	Present and Yet to come

Table 1.1 : Comparative features of five generations of computers

Check yourself



1. UNIVAC belongs to ______ generation..
2. What is meant by stored program concept?
3. Say True or False "Computers can understand only machine languages".
4. First generation computers are characterised by the use of ______.
5. What is the major technological advancement in the fourth generation computers?

1.3 Evolution of computing

Computing machines are used for processing, storing, and displaying information. The processing is done according to the instructions given to it. Early computers built during 1940's were only capable of performing series of single tasks, like a calculator. They were special-purpose systems programmed by rows of mechanical switches or by jumper wires on plug. The implementation of branching/looping statements, subroutine calls, etc. was not possible or was difficult. Later computers solved this problem by implementing John Von Neumann's revolutionary innovation the 'Stored Program Concept', which suggested storing data and programs in memory. The set of detailed instructions given to computer for executing a specific task is called a program.

Agusta Ada Lowelace

Augusta Ada King, Countess of Lowelace commonly known as Ada Lowelace, was an English mathematician and writer known for her work on Charles Babbage's early mechanical general-purpose computer, the Analytical Engine. Her notes on the engine included the first algorithm intended to be carried out by a machine. Because of this, she is often described as the world's first computer programmer.

Fig.1.18 : Agusta Ada Lowelace (1815 - 1852)

1.3.1 Programming languages

A programming language is an artificial language designed to communicate instructions to a computer. Programming languages can be used to create programs that control the behavior of a machine and/or to express algorithms.

The first programming language developed for use in computers was called machine language. Machine language consisted of strings of the binary digits 0 and 1. Introduction of this language improved the overall speed and efficiency of the programming process. This language had many drawbacks like difficulty in finding and rectifying programming errors and its machine dependency. The programmer also needed to have a good knowledge of the computer architecture.

To make programming easier, a new language with instructions consisting of English-like words instead of 0's and 1's, was developed. This language was called assembly language. Electronic Delay Storage Automatic Calculator (EDSAC) built during 1949 was the first to use assembly language. Although this made writing programs easier, it had limitations. It is specific to a given machine and the programs written in this language are not transferable from one machine to another.

This led to the development of new languages called high level languages which are machine independent and which used simple English-like words and statements. It allowed people having less knowledge of computer architecture to develop easy-to-understand programs. A-0 programming language developed by Rear Admiral Dr. Grace Hopper, in 1952, for UNIVAC-I computer is the first language of this type. FORTRAN developed by the team led by John Backus at IBM for IBM 704 machine and 'Lisp' developed by Tim Hart and Mike Levin at MIT are other examples.

Fig. 1.19 : Dr. Grace Hopper (1906-1992)

1.3.2 Algorithm and computer programs

A programmer cannot write the instruction to be followed by a computer, unless he/she knows how to solve the problem manually. In order to ensure that the program instructions are appropriate for solving the given problem, and are in the correct sequence, program instructions are to be planned before they are written. An effective tool for planning a computer program is an algorithm. An algorithm provides a step by step solution for a given problem. These steps can then be converted to machine instructions using a programming language.

1.3.3 Theory of computing

The theory of computation is the branch that deals with how efficiently problems can be solved based on computation models and related algorithms. In order to perform a rigorous study of computation, computer scientists work with a mathematical abstraction of computers called a model of computation. There are several models in use, but the most commonly examined is the Turing Machine named after the famous computer scientist Alan Turing.

a. Contribution of Alan Turing

Alan M. Turing (1912 - 1954) was a British mathematician, logician, cryptographer and computer scientist. He made significant contributions to the development of computer science, by presenting the concepts of algorithm and computing with the help of his invention the Turing Machine, which is considered as a theoretical model of a general purpose computer. In 1950's, Alan Turing proposed to consider the question, 'Can machines think?' and later it turns out to be the foundation for the studies related to the computing machinery and intelligence. Turing proposed an imitation game which is later modified to Turing test and it is considered to be the test for determining a machine's intelligence. Considering these contributions he is regarded as the Father of Modern Computer Science as well as Artificial Intelligence.

b. Turing machine

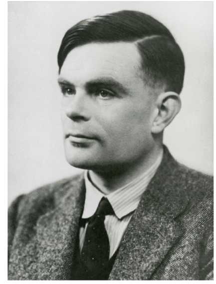


Fig. 1.20 : Alan Turing (1912 - 1954)

Turing machine is a model of a computer proposed by Alan Turing in 1936. It is conceived as an ideal model of 'computing'. Alan Turing reasoned that any computation that could be performed by a human involved writing down intermediate results, reading them back and carrying out actions that depend only on what has been read and the current state of things. Turing machine is a theoretical computing device that could print symbols on a paper tape in a manner that emulate a person following a series of logical instructions.

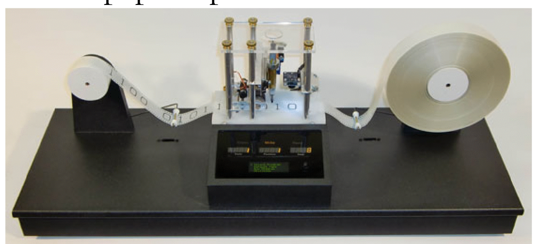


Fig. 1.21 : Turing machine

A Turing machine consists of an infinitely-long tape which acts like the memory in a computer. The cells on the tape are usually blank at the start and can be written with symbols. In this case, each cell can contain the symbols '0', '1' and ' ' (blank), and is thus said to be a 3-symbol Turing machine (refer Figure 1.22). At each step, the machine can read the symbol on the cell under the head, edit the symbol and move the tape left or right by one square so that the machine can read and edit the symbol in the neighbouring cells.

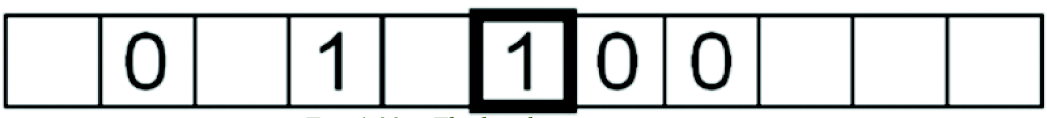


Fig. 1.22 : The head movement over tape

Any particular Turing machine is defined by a rule which specifies what the head should do at each step.The action of a Turing machine is determined by (a) the current state of the machine (b) the symbol in the cell currently being scanned by the head and (c) a table of transition rules, which serve as the 'program' for the machine.

In modern terms, the tape serves as the memory of the machine, while the read-write head is the memory bus through which data is accessed and updated by the machine. The initial arrangement of symbols of cells on the tape corresponds to the input given to the computer. The steps of the Turing machine correspond to the running of the computer. For a given input, each part of the rule specifies what 'operation' the machine should perform. Even though Turing machines are equivalent to modern electronic computers at a certain theoretical level, they differ in many details.

The Turing test

Alan Turing introduced the 'Turing test' in his paper titled 'Computing Machinery and Intelligence'. The 'Turing Test' involves a human interrogator and two contestants - a computer and a human. The interrogator converses with these contestants via computer terminals, without knowing the identity of the contestants. After a sufficiently long period of conversation, if the interrogator is unable to identify the computer, then the computer is said to have passed 'Turing test' and must be considered intelligent. Turing predicted that by 2000, computers would pass the test. There have been various programs that have demonstrated some amount of human like behaviour, but no computer has this far passed the Turing test.

Let us sum up

In this chapter, we briefly sketched the evolution of the number system and counting. We went through the development of computing machines and described the structure of the modern computing system. The evolution of computing was also discussed along with the different types of programming languages. The concepts of algorithms and computer programs were also discussed. The detailed description of generations of computers was also seen. Finally we discussed the theory of computation, in which the contributions of Alan Turing and the concept of Turing Machine were outlined.

Learning outcomes

After the completion of this chapter the learner will be able to

- categorize the basic concept of computing milestones in history.
- sketch the modern computing machine.

- recognise the impact of John Von Neumann's Architecture in today's world.
- identify the pioneers of Computer Science.
- list the characteristics of computers in each generation.
- explain the contribution of Alan Turing and the concept of Turing Machine.

Sample questions

Very short answer type

1. Which is the base of Mayan's Number System?
2. Greek Number System is known as ________.
3. Which was the first computer for basic arithmetic calculations?
4. Who invented logarithms?
5. What is the name of the machine developed by Blaise Pascal?
6. Who was the first programmer in the world?
7. Computing machines recognizes and operates in ___________ language.
8. What does EDVAC stand for?
9. Give the name for a simple kind of theoretical computing machine.

Short answer type

1. Discuss the developments of the number system from the Egyptian to the Chinese Era.
2. Discuss the impact of Hindu-Arabic numeral system in the world.
3. Compare the Roman Number system and Mayan's Number System.
4. Discuss the features of Abacus.
5. Compare the Analytical Engine and Difference Engine of Charles Babbage.
6. Bring out the significance of Hollerith's machine.
7. What are the developments in computing machines that took place during the Second World War?
8. Discuss the evolution of computer languages.
9. Discuss the working of Turing Machine.

Long answer type

1. List out and explain the various generations of Computers.
2. Prepare a seminar report on evolution of positional number system.
3. Discuss the various computing machines emerged till 1900's.