Unit 1: Introduction to Computers

Introduction

Computer science is a subject of wide spread interest. To provide a general flavour of the subject, this unit presents the introductory concepts of a computer system with its working principle and the basic elements. It provides detail description of different types of computers, based on purpose, types and capacity. Traces of historical development and generations of computers are also explored in this unit. Throughout the unit three different lessons provide a broad overview of computer systems and introduce most of the concepts that are described in details in the later units.

Lesson 1: Introduction and Basic Organization

1.1 Learning Objectives

On completion of this lesson you will be able to

- grasp the introductory concepts of a computer and its working principle
- understand the basic elements of a computer system.

1.2 What is a Computer?

A computer is an electronic machine that stores, retrieves and manipulates, or processes data. It cannot think or reason; it can only carry out instructions given to it.

A computer is an electronic machine that stores, retrieves, and manipulates or processes data. It cannot think or reason; it can only carry out instructions given to it. A set of instructions that directs its actions is called a program. Different programs are used to solve different problems. Ability to accept, store, and execute various sets of instructions (or programs) makes the computer the invaluable, all-purpose business tool.

The first step of solving a problem by a computer is to develop a suitable computer program and then store in its memory. The computer then carries out the instructions in the program. The instructions of a program generally direct the computer to perform three basic functions over and over again; these functions are input, processing, and output. Collectively, these functions constitute the data processing cycle.

Input: input devices are connected to feed the computer facts or data to be processed.

Data processing cycle

Processing: the control and storing of data, numerical comparisons, and arithmetic operations are performed on the input data to produce the desired results.

Output: the computer feeds the processed data or information, to the output devices.

- The computer reads a program and stores it in the memory. The computer executes program instructions to:
- Input data from the disk, the keyboard, or other storage media,
- process the data and
- Output results to the display screen, disk or other media.

A ***computer system*** *contains hardware, soft-ware, humanware and procedures.*

Figure: 1.1 Solving a problem with a microcomputer.

1.3 Components of a Computer System

A computer is used to process data and a data processing system must consist of more than just machines. A computer system must contain: hardware, software, humanware and operational procedures.

Hardware

Hardware *generally refers to the machines or physical equipment that performs the basic functions of the data processing cycle.*

Hardware generally refers to the machine or physical equipment that performs the basic functions of the data processing cycle. In addition to the computer itself, other hardware devices are also required. These devices may be off-line that is detached from the computer and operating independently or they may be on-line that is directly connected to and controlled by the computer. A printer is an off-line device and a keyboard is an on-line device.

Software

*Programs are referred to as **software.***

A program is a sequence of instructions which directs a computer to perform certain functions. A computer must have access to prewritten, stored programs to input and store data, make decisions, arithmetically manipulate and output data in the correct sequence. Programs are referred to as software. Computer system must be supported by extensive software systems. Software is generally categorized as either system software or application software.

System software consists of programs that facilitate the use of computer by a user. These programs are sometimes referred to as utility programs. They perform such standard tasks as organizing and maintaining data files, translating programs written in various languages to a language acceptable to the computer, scheduling jobs through the computer, as well as aiding in other areas of general operations. Of all the systems software supplied by the manufacturer of a computer, the most important one is known as the operating system.

Application software consists of programs to perform specific user applications. A computer program giving instructions for the steps involved in preparing results of a public examination is an example of applications software. Application programs are either purchased or written by the computer users for specific applications.

Humanware

***Humanware** refers to the persons who design, program, and operate a computer installation.*

Humanware refers to the persons who design, program, and operate a computer installation. There are numerous categories of jobs, but the three principal positions required in a large computer installation are system analyst, programmer, and computer operator. People in each of these areas generally perform special-purpose tasks under the supervision of a director or manager.

The position of a systems analyst requires the broad background and extensive understanding of the above three job categories. The main task of the system analyst is to study information and processing requirements. A systems analyst defines the applications problem, determines systems specifications, recommends hardware and software changes, and designs information processing procedures.

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A programmer requires a comprehensive knowledge of one or more programming languages and standard coding procedures. This position does not require the broader understanding of the structure and inner workings of an application. A programmer's principal job is to code or prepare programs based on the specifications made by the systems analyst.

A computer operator requires the least extensive background of the three categories. A computer operator generally performs a series of well defined tasks that will keep the computer operating at maximum efficiency. The operational efficiency of a computer installation is dependent on the quality and abilities of the operational staff.

Procedures

Operations of a data processing center require an extensive and clearly defined set of ***procedures*** *for performing the essential functions of the installation.*

Operations of a data processing center require an extensive and clearly defined set of procedures for performing the essential functions of the installation. These functions generally include obtaining, preparing, and entering data into the computer, processing jobs, initiating new programs and changing or deleting old ones etc. Such procedures must have provision for actions to be taken in the event of hardware or software malfunctions.

1.4 Exercise

1. Multiple choice questions

a. Which of following are three basic functions of a computer?

(i) Input, addition and output.
(ii) Input, multiplication and output.
(iii) Input, processing and output.
(iv) Type, read and print.

b. In general, the categories of software are :

(i) Package program and application software.
(ii) System software and application software.
(iii) Programming language and operating system.
(iv) Programming algorithm and operating system.

c. Which one of the following is the off-line device?

(i) Computer.
(ii) Key-board.
(iii) Printer.
(iv) Mouse.

2. Questions for short answers

a. What is a computer?
b. Name the elements of a computer system.
c. What is the difference between system software and application software?

3. Analytical questions

a. Describe the elements of a computer system.
b. How does a computer work?

Lesson 2 : Types of Computers

2.1 Learning Objectives

On completion of this lesson you will be able to

- classify computers based on purposes
- classify computers based on types
- classify computers based on capacity.

2.2 Outline

The computer systems are available in various sizes and with a variety of peripheral or support devices to cover just about every processing need. Because of the variety of computer power and functions available, computers are classified on the basis of purpose, type, and capacity.

2.3 Purpose

Special-purpose computers are designed for a specific application or type of application.

There are either special-purpose or general-purpose computers. Special-purpose computers are designed for a specific application or type of application. They are also known as dedicated computers. Many such computers have instructions permanently programmed into them that are designed to perform only one major function. Special-purpose computers are used, to control traffic lights, to control the collection of tolls on certain highways, and in automobiles, weapons, appliances and games etc.

General-purpose computers are used to handle a variety of tasks.

General-purpose computers are used to handle a variety of tasks. This is possible by the stored-program concept. By this concept, a program containing a series of instructions is prepared for each application and input to and temporarily stored in the computer. Once stored in the computer's memory, this program can be executed, causing the computer to perform the specific function. After the completion of the execution of this program, another program can be input to the computer and the cycle repeated. That is, the same combination of hardware can be used to execute many different programs.

General-purpose computers have the advantage of versatility over special-purpose computers. But typically general purpose computers are less efficient and slower than special-purpose computers when applied to the same task.

2.4 Analog and Digital Computers

An analog computer represents quantities by physical analogies.

Two types of computers currently available. These are analog and digital computers. Earlier discussion was only on digital computers. An analog computer represents quantities by physical analogies. It represents physical quantities, such as distance, velocity, acceleration, temperature, pressure, or angular position, forces or voltages in mechanically or electrically equivalent circuits. That is, it functions by setting up physical models corresponding to mathematical functions.

An automobile speedometer is an example of an analog computing device. It converts the rotational rate of the drive shaft of an automobile into the numerical value of the speed of the vehicle. Similarly, a thermometer functions as an analog device by converting the movement of a column of mercury into a temperature reading.

Data inputs to an analog computer results from a measuring processes. These computers are ideal in situations where data can be accepted directly from measuring instruments. The ability to collect data at high speeds and to process data at equally high speeds, makes analog computers uniquely suited to controlling processes of oil refineries, steel mills, weapon systems and similar operations. An analog computer does not require any storage capability as it measures and compares quantities in a single operation. The output from an analog computer is generally in the form of readings on a dial (as in the speedometer and odometer of a car) or a graph on the screen of a cathode ray tube.

Analog computers were in use before the invention of the digital computers. There are far more digital computers in use today than analog computers. For the remainder of this book concentration will be on digital computers.

2.5 Capacity

The capacity of a computer refers to the volume of data that a computer system can process.

The capacity of a computer refers to the volume of data that a computer system can process. Previously a computer's size was an indication of its capacity - the larger the physical size of the computer, the larger its capacity. However, with the current state of micro-miniaturization, measurement is based on the size of a computer by its throughput. Throughput is the amount of processing that can be performed in a given amount of time. Based on throughput, computer systems can be divided into three categories: microcomputers, minicomputers, and mainframe computers, with costs increasing proportional to size.

Microcomputers

***Microcomputers** are micro-processor based small laptop or desktop systems.*

A microprocessor is an integrated circuit consisting of thousands of transistors squeezed onto a tiny chip of silicon.

Microcomputers are microprocessor based small laptop or desktop systems with varying capability depending on the input/output and secondary storage devices supporting it. The brain of a microcomputer is the microprocessor, a silicon chip containing the necessary circuits to perform arithmetic/logic operations and to control input/output operations. A microprocessor is an integrated circuit consisting of thousands of transistors squeezed onto a tiny chip of silicon. The chip is packaged as a single integrated circuit. A microcomputer system is formed by adding an input/output capability and a memory to the microprocessor.

Early microcomputers had a limited processing potential and limited choice of input/output devices. Present day microcomputers have wider processing capabilities and support a wide range of input/output devices. Today microcomputers are available with a selection of input/output devices varying from a cassette recorder to a voice synthesizer. In addition to general-purpose computations, microcomputers are used for special purpose applications in automobiles, airplanes, toys, clocks, appliances etc.

The workstation represents the bridge between the microcomputers and mini-computers.

High-end supermicros are known as workstations. The workstation represents the bridge between the microcomputers and minicomputers. It is a microcomputer with many of the capabilities of larger minicomputers but costing much less. Initially designed for use by engineers and designers, and today they are popular for general uses. These workstations can run more than one application for a user. This is known as multitasking. A workstation is also a multi-user system that can be shared by several users at the same time.

Minicomputers

A Minicomputer system performs the basic arithmetic and logic functions and support some of the programming languages used with large computer systems.

A Minicomputer system performs the basic arithmetic and logic functions and supports some of the programming languages used with large computer systems. They are physically smaller, less expensive, and have a small storage capacity than mainframes. Minicomputers are ideally suited for processing tasks that do not require access to huge volumes of stored data . As a result of their low cost, ease of operation, and versatility, minicomputers have gained rapid acceptance from their introduction in the mid-sixties. Some of the larger and expensive minicomputers are capable of supporting a number of terminals in a time-shared mode.

Mainframe Computers

Larger computers generally consists of modules mounted on a chassis or mainframe and are known as mainframe computers.

Larger computers generally consist of modules mounted on a chassis or mainframe and are known as mainframe computers. They vary in size, from those slightly larger than a minicomputer to supercomputers (like the Cray and Control Data Cyber computers). Mainframe computer systems offer substantial advantages over mini-computers or microcomputers. Some of these are; greater processing speed, greater storage capacity, a larger variety of input/output devices, support for a number of high-speed secondary storage devices, multiprogramming, and time sharing.

Owing to tremendous expense in operating a mainframe computer, this computer system must be operated efficiently. Operating a mainframe at the required level of efficiency requires a very large and highly trained staff. Mainframe Computer systems are generally used by large businesses, universities, governmental agencies, and the military. These systems are often coupled with other computer systems in a large network to provide enormous computing power. This is what is referred to as a distributed data processing system.

Supercomputers

The large and powerful mainframe computer is called a supercomputer.

The large and powerful mainframe computer is called a supercomputer. The astronomical cost of the super-computers has limited their development to only a few hundred worldwide. The Cray X-MP, Cray XTS-HE is an example of a supercomputer. Such supercomputers are applied to the solution of very complex and sophisticated scientific problems and for national security purposes of some advanced nations.

Smaller, less costly minisupercomputers have been developed by several manufacturers. These computers provide approximately half the power of the supercomputer but at a fraction of the cost. The relative low cost has made the minisupercomputer an attractive to buy for mid-sized to large applications. Many Wall Street brokerage firms in the United States use computers to speed up the processing of large financial models to keep track of securities that have tendencies to fluctuate greatly.

2.6 Exercise

1. Multiple choice questions

a. Based on capacity, types of computer systems are :

(i) Microcomputers, minicomputers, mainframe computers and supercomputers.
(ii) Microcomputers, personal computers and IBM computers.
(iii) Minicomputers, supercomputers and digital computers.
(iv) Analog computers and digital computers.

b. Which one is the supercomputer?

(i) Large and powerful mainframe one.
(ii) Mini and low powerful mainframe one.
(iii) Physical smaller and less expensive.
(iv) Not requirement access to high volume of stored data.

2. Questions for short answers

a. Distinguish between analog computer and digital computer.
b. Classify the computer systems on the basis of capacity.

3. Analytical questions

a. Briefly describe the classification of computer systems.

Lesson 3: History and Generations of Computers

3.1 Learning Objectives

On completion of this lesson you will be able to :

- trace the history of computers
- follow the computer generations.

3.2 The Beginning

Abacus and Napier's bones

Different devices and tools have been employed in calculation and processing of data. An ancient calculating device is the abacus, a mechanical calculating device first used around 2500 B.C. to add and subtract. Scientists and mathematicians later sought other means to aid their endeavors. John Napier, a Scottish mathematician, developed (about 1610) a series of rods made of bones (commonly called Napier's bones) that could be arranged to produce the products of selected numbers. He used these rods to produce the first table of logarithms. In 1865 the French mathematician Blasé Pascal improved on this concept and produced a mechanical calculator called Pascaline. It was more compact and easier to use than Napier's bones. The Pascaline was capable of performing addition and subtraction. All attempts to produce a calculator capable of performing all the four arithmetic operations and producing mathematical tables quickly and accurately were not successful until 1820. Thomas de Colmar of France produced the arithmometer, the first four-function practical mechanical calculator.

A young English mathematician named Charles Babbage, of Cambridge University contributed substantially towards the development of computers. Babbage gave much thought to the design of a device to produce mathematical and navigational tables and came upon a principle that used the “differences” between previous values in a table to produce new values. Babbage was able to construct a working model to illustrate the principle of the difference engine. Babbage started work on a steam-driven version of the difference engine capable of calculating and printing results at a rate of two twenty-digit numbers per minute.

Babbage built part of the machine but abandoned it in favor of a more powerful and versatile machine, the analytical engine. The analytical engine was designed to use punched cards to provide a constant flow of information through the machine's elaborate series of columns, gears, wheels, and levers. The analytical engine included all the functional units of modern computers: input of data, arithmetic unit for computation, memory for data and instructions, and display for output. This was an ambitious project during a time when electronics, transistors, and chips did not exist. The engine was a puzzle to all but a few mathematicians. This machine, however, was never built. Nearly a century later a new generation of scientists and engineers equipped with new developments brought Babbage's vision back into focus for future advancements in computer technology.

Insignificant progress took place over the next decades. In the United States the 1890 census was approaching, and there was no foreseeable way that it could be completed by 1900, as required by the constitution. Herman Hollerith, an employee of the Census Office in Washington, started to develop an automated device to complete this task in the allotted ten years. The result was Hollerith's tabulator. A manual card puncher, a card reader, and an electromechanical card sorter were the main components of the census tabulator.

Hollerith's tabulator

With this tabulator, Hollerith was able to complete the census count in only two years. Hollerith's success paved the way for further research and development. Analog computers, a new class of computing devices, emerged. These devices used electrical voltages to represent physical quantities. They functioned by establishing an analogy between a physical quantity and a voltage level. They were very fast but not sufficiently exact, or dependable.

ABC, ENIAC and EDSAC

The first electronic computers, the ABC (Atanasoff Berry Computer) and the ENIAC (Electronic Numerator, Integrator, Analyzer, and Computer) were built in the early 1940s. The ABC, built by Atanasoff and Berry, was the first, electronic computer using vacuum tubes. The ENIAC, built by Eckert and Mauchly, was an extensively used special-purpose computer. In 1949, at Cambridge, the first general-purpose electronic computer operating under the control of a stored program, the EDSAC (Electronic Delay Storage Automatic Computer), was completed. A stored program is a set of instructions stored in memory that guides the computer, step by step, through a process.

John Von Neumann, an originator of the stored-program concept, developed the IAS (Institute for Advanced Study) computer at Princeton University. This machine was the realization of John Von Neumann, ideas on computer design. Most computers built after the IAS computers have “Von Neumann” characteristics.

A group of MIT scientists headed by Ken Olsen developed the Whirlwind computer, more than twenty times faster than the ENIAC. Both the IAS and Whirlwind computers introduced computational innovations of astronomical proportions.

UNIVAC Universal Automatic Computer

Computers were not available commercially until early 1951. In 1951, the Sperry Rand Corporation built the UNIVAC I (Universal Automatic

Computer). The UNIVAC I built for the Bureau of Census of the United States was the first commercially available computer. The first computer installation to handle business applications was set up in 1954 at Louisville, Kentucky in the USA. The UNIVAC I is now on display in the Smithsonian Institution in Washington D.C.

Day by day computers were becoming smaller, faster, and more powerful and they were being applied to more and varied tasks. In 1956, MIT in the USA introduced its compact TX-0 transistorized computer system. A few years later, in 1960, the first integrated circuit was produced by Jack Kilby of Texas Instruments and the DEC PDP-1 was being used with the first video game, “Space War”. In the Mid-1960s, minicomputers began appearing as did a forerunner of today’s supercomputers, the CDC 6600, designed by Seymour Cray.

3.3 Computer Generations

Developments over the years have resulted in machines with greatly increased speeds, storage or memory, and computing power. These developments were so far-reaching and numerous that they are generally categorized by generations. Each generation is initiated by significant advances in computer hardware or computer software that run the machines.

First Generation (1942-1959)

First-generation computers utilized vacuum tubes in their circuitry and for the storage of data and instructions.

First-generation computers utilized vacuum tubes in their circuitry and for the storage of data and instructions. The vacuum tube was bulky, caused tremendous heat problems, and was never a completely reliable device, it caused a great number of breakdowns and inefficient operations. Magnetic cores began to replace the vacuum tube as the principal memory device in the early machines. Small doughnut-shaped cores were strung on wires within the computer. Programs were written in machine language employing combinations of binary digits 0 and 1.

Second Generation (1959-1965)

The second generation computers saw the replacement of the vacuum tubes with the transistors.

The second generation of computers saw the replacement of the vacuum tubes with the transistors. A transistor can be thought of as a switch, but with no moving parts. Because of the high speed operation and its small size, computers were developed that were able to perform a single operation in microseconds and were capable of storing tens of thousands of characters. Manufacturers began producing business-oriented computers with more efficient storage and faster input and output capabilities. Second generation computers were reliable, compact in size, and virtually free of heat problems. Programming was done in both machine and symbolic language. Symbolic language utilized symbolic names of representations for computer commands and allowed the use of symbolic names for items of data. This language is also known as assembly language.

Third Generation (1965-1970)

These computers were characterized by integrated circuits with components so small that in many cases they were hardly visible to the naked eye.

These computers were characterized by integrated circuits with components so small that in many cases they were hardly visible to the naked eye. Third generation computers were characterized by increased input/output, storage, and processing capabilities. Input/output devices could communicate with computers over great distances via ordinary telephone lines or special communication lines, could scan a page and input the "observed" information directly into the computer, could display pictures on a television-like screen, could make musical sounds, and could even accept limited voice input.

Storage capabilities were increased and millions of characters could be stored and randomly accessed in fractions of a second. Third-generation computers could process instructions in nanoseconds. In addition, computers were able to process several programs or sets of instructions simultaneously. Programmers were able to make use of high-level problem oriented and procedure oriented languages that closely resemble the commonly used form of expressions.

Fourth Generation (1970 -)

In the fourth generation computers monolithic storage devices were introduced.

The fourth generation computers pass still greater input, output storage, and processing capabilities. In the fourth generation of computers monolithic storage devices were introduced. In the early 1970s IBM introduced the concept of virtual storage into their 5000 and 370 series of computers. Machines previously limited to a maximum internal storage capability of approximately 1 million characters now possessed a virtual storage capability in billions and trillions of characters. With this capability a machine could execute a program many times the size of the machine's actual memory capacity.

Compact disk Read-only Memory (CD ROM).

Now a days, the compact disk (CD) promises to become the data storage medium of choice. A compact disk read-only memory (CD ROM) is encoded with on and off bits. Bits are stored on the disk's (3.5-inch dia) aluminum surface as tiny pits at varying depths. The average CD can store about 4,800 million bits or 600 million characters of data. This is approximately a quarter of a million pages of text.

The most impressive advancement has occurred with respect to software. As a result of these changes, access to substantial computer power, previously only affordable by very large business concerns, is now economically feasible for the small business and personal applications.

Fifth Generation

Fifth generation of computers will be capable of reasoning, learning and making inferences.

Fifth generation of computers is on the horizon. They will be unlike any computer existing today. They will be capable of reasoning, learning, making inferences and otherwise behaving in ways usually considered exclusive of humans. These computers will be equipped with massive primary-storage capabilities and extremely fast processing speeds. Software will proliferate and get much bigger and much cheaper. Hardware will continue to shrink in size but internal memory will increase dramatically. "Talking machines" will be common place. Voice-recognition, the ability for a machine to understand and obey spoken words, will also advance. Industrial and personal robots will roll and walk into our lives. Expert systems software will place the knowledge of experts and consultants (such as doctors, lawyers, teachers) at our disposal. Huge computers will be linked in parallel offering computing power of an inconceivable magnitude.

3.4 Exercise

1. Multiple choice questions

a. Who developed the concept of the difference engine?

(i) Blaise Pascal.
(ii) John Von Neumann.
(iii) Herman Hollerith.
(iv) Charles Babbage.

b. Which one is the characteristic of 3rd generation computers?

(i) Built with small scale integration integrated circuit.
(ii) Greater input output, storage and processing capacity.
(iii) Utilized vacuum tubes.
(iv) Expert system software will place the knowledge of experts..

2. Questions for short answers

a. Who is Charles Babbage ? Mention his contribution in the history of computers?
b. What is meant by computer generations?

3. Analytical questions

a. Write an essay on the history of computers.
b. Briefly describe the computer generations.
c. Describe the characteristics of fifth generation computers.