UG CA S1- 01
(DSE)

FOUR YEAR BACHELOR'S DEGREE COURSE

(CBCS in Accordance with NEP 2020)

SEMESTER - I

COMPUTER FUNDAMENTALS

COMPUTER SCIENCE

Hiranya Chandra Bhuyan School of Science and Technology
KRISHNA KANTA HANDIQUI STATE OPEN UNIVERSITY

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COURSE INTRODUCTION: COMPUTER FUNDAMENTALS

This course has been prepared for the beginners as well as advanced learners to provide an introductory knowledge of computer fundamentals. As the name of the course suggests, this course includes fundamental concepts of computer from different topics which we will come across in later semesters. This course on Computer Fundamentals consists of 14 units and provides an introduction to various fundamental concepts in computer science. It includes topics like basic components of computer system, computer memory and storage and buses. Basics of different operating systems are also discussed in this course along with an introduction to system software. Introductory units on computer languages, algorithms and flowchart are also included in this course. Concepts on file structure and database are also included in the course. Preliminary knowedge on various computer security issues and security mechansims are also covered in this course. The basics of different types of cyber crime like hacking, fraud, cyber terrorism and software piracy along with an introduction to Information Technology Act of 2000 is also covered in this course.

Each unit of these blocks includes some along-side boxes to help you know some of the difficult, unseen terms. Some “EXERCISES” have been included to help you apply your own thoughts. You may find some boxes marked with: “LET US KNOW”. These boxes will provide you with some interesting and relevant additional information. Again, you will get “CHECK YOUR PROGRESS” questions. These have been designed for you to self-check your progress of study. It will be helpful for you if you solve the problems put in these boxes immediately after you go through the sections of the units and then match your answers with “ANSWERS TO CHECK YOUR PROGRESS” given at the end of each unit.

UNIT 1: INTRODUCTION TO COMPUTER

UNIT STRUCTURE

1.1 Learning Objectives

1.2 Introduction

1.3 Computer– a Definition

1.4 Characteristics of Computer

1.5 Generations of Computers

1.6 Structural Evolution of Computers

1.7 File Structure of Computers

1.8 Flynn's Classification of Computer Architecture

1.9 Applications of Computer

1.9.1 Advantages of Computer

1.10 Let Us Sum Up

1.11 Answers to Check Your Progress

1.12 Further Reading

1.13 Model Questions

1.1 LEARNING OBJECTIVES

After going through this unit, you will be able to:

- define the term ‘‘Computer’’
- describe the key characteristics of a computer
- describe the generations of computers
- trace the structural evolution of computers
- describe the applications of computer.

1.2 INTRODUCTION

Computer is the most powerful tool man has ever created. Computers have made a great impact on our everyday life. Today, computer technology has permeated every sphere of existence of modern human beings. With the growing information needs the computer has become one of the vital components for the survival of the business houses. Their presence is felt

at almost every working place from the bus and railway ticket reservation to satellite launching, from retail stores to medical diagnosis and from home use to research and design organization– everywhere, we witness on elegance, sophistication and efficiency that have been made possible only with the help of computers.

In this unit, we shall introduce you to the computer fundamentals including its various components and functionality. We shall discuss the characteristics of computers including its evolution and generations. We will also discuss the categories of computers along with its application in the various fields of the modern world.

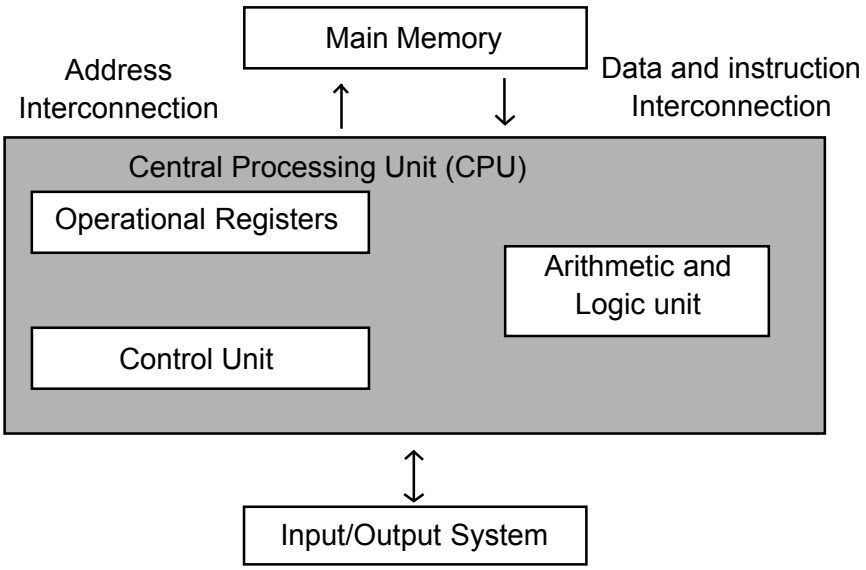
1.3 COMPUTER– A DEFINITION

The term ***computer*** is derived from the word ***compute***, which means ***to calculate.*** In the simplest form a computer can be defined as a ***programmable machine.*** In a more formal way it can be defined as an ***electronic machine*** capable of performing calculations and other manipulations of various types of data, under the control of a stored set of instructions. A computer accepts data from an input device and processes it into useful information which it displays on its output devices. Actually, a computer is a collection of ***hardware*** and ***software*** components that help us to accomplish many different tasks. The machine itself is the hardware; and the instructions are the program or software.

Most of today's computer designs are based on the concepts developed by ***John Von Neumann*** referred to as the ***"Von Neumann architecture"***. According to this structure, a computer must have two units - a processing unit and a single separate storage unit. The term "stored program computer" is generally used to mean a computer of this design. The processing unit is termed as ***Central Processing Unit (CPU)*** which mainly comprises with two other units namely ***Arithmetic and Logic Unit (ALU)*** and ***Control Unit (CU)***. The ALU performs the arithmetic operations on data such as addition, subtraction, multiplication and division, and the logical operations such as >, <, >=, <= etc. The control unit directs the ALU to perform specific arithmetic and logical functions on the data.

The storage unit is used to store instructions and data temporarily. This component is referred to as memory. The memory unit stores all the information in a group of memory cells, also called memory locations, as ***binary digits (bits).*** Each memory location has a unique address and can be addressed independently.

The instruction and data can be put into the computer with the help of the input module. Similarly, it needs another component that will report the results in proper format and form. This component is called output module. The following figure shows the basic structure of a conventional *Von Neumann machine:*



1.4 CHARACTERISTICS OF COMPUTER

Some of the main characteristics of computers that make them an essential part of every emerging technology and a desirable tool in human development can be cited as follows:

- **Speed:** In a few seconds a computer can perform such a huge amount of task that a normal human being may take days or even years to complete. At present, a powerful computer can perform billions of operations in just one second.
- **Accuracy:** The computers are very accurate. The level of accuracy depends on the instructions and the type of machine used.

- **Diligence:** Being a machine, computers do not suffer from tiredness and lack of concentration even if the same job has to be done repeatedly unlike we human beings. It can perform even millions of calculations all with the same accuracy and speed.
- **Reliability:** Computers are reliable, because at the machinery level, they do not require any human intervention between its processing operations. Computers also have built-in diagnostic capabilities, which help in continuous monitoring of the system.
- **Storage Capacity:** Computers can store large amounts of data and can recall the required information almost instantaneously.
- **Versatility:** Computers can perform multiple tasks simultaneously.
- **Resource Sharing:** With the tremendous growth in computer technologies resource sharing is easily possible.
- **Lack of Intelligence:** A computer can only perform what it is programmed to do. It cannot take any decision. This is the main limitation of a computer.

1.5 GENERATION OF COMPUTERS

The history of computer development is often considered with reference to the different generations of computing device. Each generation of computers is characterized by a major technological development that had fundamentally changed the way computers operate, resulting in increasingly smaller, cheaper, and more powerful and more efficient and reliable devices. There are five generations of computers as follows:

- **First Generation (1945 - 55):** Examples of computers of this generation are:

  ENIAC– Electronic Numerical Integrator And Calculator

  EDSAC– Electronic Delay Storage Automatic Calculator

  EDVAC– Electronic Discrete Variable Automatic Computer

  UNIVAC– Universal Automatic Computer IBM 701

  Characteristics of first generation computers:

  - Vacuum tubes were used
  - Basic arithmetic operations took few milliseconds

- Bulky i.e., very large in size
- Consume more power with limited performance
- High cost
- Use assembly language to prepare programs. These were translated into machine level language for execution
- Electrostatic memories were used
- Punched cards and paper tape were invented to feed programs and data and to get results
- Magnetic tape /magnetic drum were used as secondary memory
- Mainly used for scientific computations.

- **Second Generation (1955-65):** Examples of computers of this generation are– IBM 7030, Digital Data Corporation's PDP 1/5/8 Honeywell 400.

  Characteristics of second generation computers:

  - Transistors were used in place of vacuum tubes
  - Smaller in size
  - Less power consumption and better performance
  - Lower cost
  - Magnetic ferrite core memories were used as main memory which is a random access non-volatile memory
  - Magnetic tapes and magnetic disks were used as secondary memory
  - High level languages such as FORTRAN, COBOL etc. were used
  - Separate input-output processors were developed that could operate in parallel with CPU.
  - Punched cards continued during this period also
  - Increasingly used in business, industry and commercial organizations for preparation of payroll, inventory control, marketing, production planning, research, scientific and engineering analysis and design etc.

- **Third Generation (1965-75):** Examples of computers of this generation are– 360 Mainframe from IBM, PDP-8 Mini Computer from Digital Equipment corporation).

Characteristics of third generation computers

- ICs were used
- Small Scale Integration and Medium Scale Integration technology were implemented in CPU, I/O processors etc.
- Smaller and better performance
- Comparatively lesser cost
- Faster processors
- In the beginning magnetic core memories were used. Later they were replaced by semiconductor memories (RAM & ROM)
- Introduced microprogramming
- Operating system software were introduced
- Cache and virtual memories were introduced (Cache memory makes the main memory appear faster than it really is. Virtual memory makes it appear larger)
- Database management, multi-user application, online systems like closed loop process control, airline reservation, interactive query systems, automatic industrial control etc. emerged during this period.

- **Fourth Generation (1975-89):** Examples of computers of this generation are– Intel's 8088, 80286, 80386, 80486, .., Motorola's 68000, 68030, 68040, Apple II, CRAY I/2/X/MP etc)

  Characteristics of fourth generation computers

  - Microprocessors were introduced as CPU-Complete processors and large section of main memory could be implemented in a single chip
  - Tens of thousands of transistors can be placed in a single chip (VLSI design implemented)
  - CRT screen, laser & inkjet printers, scanners etc were developed.
  - Semiconductor memory chips were used as the main memory.
  - Secondary memory was composed of hard disks - Floppy disks and magnetic tapes were used for backup memory
  - Parallelism, pipelining cache memory and virtual memory were applied in a better way

- Local Area Networks (LAN) and Wide Area Networks (WAN) were developed
- Introduced C language and Unix OS
- Introduced Graphical User Interface (GUI).

- **Fifth Generation (1989 to present):** Examples of computers of this generation are- IBM notebooks, Pantium PCs-Pentium 1/2/3/4/ Dual core/Quad core. SUN work stations, Origin 2000, PARAM 10000, IBM SP/2).

  Characteristics of fifth generation computers:

  - Computers based on artificial intelligence are available
  - Computers use extensive parallel processing, multiple pipelines, multiple processors etc
  - Massive parallel machines and extensively distributed system connected by communication networks fall in this category.
  - Introduced ULSI (Ultra Large Scale Integration) technology - Intel's Pentium 4 microprocessor contains 55 million transistors millions of components on a single IC chip.
  - Superscalar processors, Vector processors, SIMD processors, 32 bit micro controllers and embedded processors, Digital Signal Processors (DSP) etc. have been developed.
  - Memory chips up to 1 GB, hard disk drives up to 180 GB and optical disks up to 27 GB are available.
  - Object oriented language like JAVA suitable for internet programming has been developed.
  - Portable notebook computers introduced
  - Storage technology advanced– large main memory and disk storage available
  - Introduced World Wide Web. (and other existing applications like e-mail, e-Commerce, Virtual libraries/Classrooms, multimedia applications etc.)
  - New operating systems developed– Windows 95/98/XP/…, LINUX, etc.
  - The recent development in the application of internet is the Grid technology which is still in its upcoming stage.

- Quantum mechanism and nanotechnology will radically change the phase of computers.

1.6 STRUCTURAL EVOLUTION OF COMPUTERS

The ABACUS can be considered the ancestor of today's computer. It was built by the people of Asia Minor almost 2000 years ago. It was simply a wooden rack holding parallel wires on which beads were strung. When these beads were moved along the wire according to some rules that the user must memorize, all ordinary arithmetic operations could be performed.

An English mathematics professor, named **Charles Babbage**, in the early 1800s designed a machine to perform differential equations, called **Difference Engine.** It was a steam powered machine as large as a locomotive and had a stored program and could perform calculations and print results automatically.

After Babbage, between 1850 and 1900, many of the new advances in mathematics and physics took place which involved complex calculations and formulas that were very time-consuming for human calculation. Then people started rethinking of the development of a device to help complex calculations.

In the 1890's census of the United States, a machine developed by **Herman Hollerith** was used. Hollerith developed a new punched-card system that could automatically read information on cards without human intervention.

In 1942, John P. Eckert, John W. Mauchley, and their associates at the University of Pennsylvania built a high-speed electronic computer to do the job known as **ENIAC(Electrical Numerical Integrator And Calculator).** It could multiply two numbers at the rate of 300 products per second, by finding the value of each product from a multiplication table stored in its memory. ENIAC was about 1,000 times faster than the previous generation of Computers. ENIAC used vacuum tubes to make the internal parts of the computer and electricity to run. It used punched-card input and output.

In 1945 **John Von Neumann** undertook a theoretical study of computation that demonstrated that a computer could have a very simple

architecture and yet be able to execute any kind of computation effectively by means of proper programmed control without the need for any changes in hardware. Von Neumann came up with incredible ideas which came to be referred to as the **stored-program technique** that became fundamental for future generations of high-speed digital computers and were universally adopted.

With the first wave of modern programmed electronic computers to take the advantage of these improvements there came the first group of modern programmed electronic computers. This group included computers using random access memory (RAM),which is a memory designed to give almost constant access to any particular piece of information. This group of machines included EDVAC, EDSAC(Electronic Delay Storage Automatic Calculator) and UNIVAC, the first commercially available computers. The UNIVAC was developed by John W. Mauchley and John Eckert, Jr. in the 1950s.

In the 1960s efforts to design and develop the fastest possible computers with the greatest capacity reached a turning point with the completion of the **LARC** machine for **Livermore Radiation Laboratories** by the Sperry-Rand Corporation, and the Stretch computer by IBM. During this time the major computer manufacturers began to offer a range of computer capabilities, as well as various computer-related equipment. Input means such as consoles and card feeders; output means such as page printers, cathode-ray-tube displays, and graphing devices; and optional magnetic-tape and magnetic-disk file storage.

In the 1970s entire assemblies, such as adders, shifting registers, and counters, became available on tiny chips of silicon. In 1971 Marcian E. Hoff, Jr., an engineer at the Intel Corporation, invented the microprocessor and another stage in the development of the computer began.

A new revolution in computer hardware was now well under way, involving miniaturization of computer-logic circuitry and of component manufacture by what are called ***large-scale integration*** techniques. In the 1980s ***very large scale integration (VLSI),*** in which hundreds of thousands of transistors are placed on a single chip, became increasingly common.

The trend of reduction in size led to the introduction of Personal Computers (PCs), which are programmable machines small enough and inexpensive enough to be purchased and used by individuals. By the late 1980s some PCs were run by microprocessors, a processor on a single ***integrated circuit (IC)*** chip. The trend continued leading to the development of smaller and smaller microprocessors with a proportionate increase in processing powers.

1.7 FILE STRUCTURE OF COMPUTERS

File structure is the way we organize our folders on our computer. Keeping all our documents under one folder is a great way to keep ourselves organized and making things easy for backing up our computer.

1.8 FLYNN'S CLASSIFICATION OF COMPUTER ARCHITECTURE

Computer architecture has been classified into four categories according to Flynn's classification based upon the number of concurrent instruction (or control) streams and data streams available in the architecture. These four categories are:

a) Single instruction stream, single data stream (SISD)
b) Single instruction stream, multiple data streams (SIMD)
c) Multiple instruction streams, single data stream (MISD)
d) Multiple instruction streams, multiple data streams (MIMD)

a) Single instruction stream, single data stream (SISD): A sequential computer which exploits no parallelism in either the instruction or data streams. Single control unit (CU) fetches single instruction stream (IS) from memory. The CU then generates appropriate control signals to direct single processing element (PE) to operate on single data stream (DS) i.e., one operation at a time.

Examples of SISD architecture are the traditional uniprocessor machines like older personal computers (PCs of 2010, many PCs had multiple cores) and mainframe computers.

b) Single instruction stream, multiple data streams (SIMD): A computer which exploits multiple data streams against a single

instruction stream to perform operations in a parallel manner. For example, array processors or graphics processing unit (GPU)

c) **Multiple instruction streams, single data stream (MISD):** Multiple instructions operate on one data stream. This is an uncommon architecture which is generally used for fault tolerance. For example, the Space Shuttle flight control computer.

d) **Multiple instruction streams, multiple data streams (MIMD):** Multiple autonomous processors simultaneously execute different instructions on different data. MIMD architectures include multi-core superscalar processors, and distributed systems, using either one shared memory space or a distributed memory space.

1.9 APPLICATIONS OF COMPUTERS

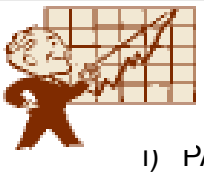
Now a days, computers are being used almost in every aspect of life. Every company, small or large, government offices, educational institutions are now directly or indirectly dependent on computers mainly for information processing. Computer based railway and airway reservation system is a common example of computer application. Computer system is helping in the efficient management of the banking sector, hospital records, payroll records and so on.

1.9.1 Advantages of Computers

Some of the areas where computers are being used to our advantage can be listed as below:

- **Science:** Scientists are using computers to carry out their research works based on complex computations because of the computer's fast speed and accuracy.
- **Education:** Computers are used now-a-days in schools and colleges, to make education much more interesting. Computer Aided Education (CAE) and Computer Based Training (CBT) packages are making learning much more interactive.

- **Health and Medicine:** Starting from diagnosing illness to monitoring a patient's status during surgery, in pathological analysis, in CAT scans or MRI scans etc., doctors are using computers. Some special purpose computers are available which can even be operated within the human body.
- **Engineering:** Engineers and architects are using computers in designing machineries, drawing design layouts. Architects can design objects that can be viewed from all the three dimensions by using techniques like virtual reality. In manufacturing industries, using computerized robotic arms hazardous jobs can be performed. The packages like Computer Aided Designing (CAD), Computer Aided Manufacturing (CAM) and so on are used in designing the product, ordering the parts and planning production.
- **Entertainment:** With the use of multimedia facilities, computers are now greatly used in the entertainment industry. Computers are used to control and bring special effects on image and sound.
- **Communication:** Computer network and the internet have brought drastic changes in communication system. Through email or electronic mail, it is possible to send messages and reports very fast from one person to another or a group of persons with the aid of computers and telephone lines.
- **Business and Banking:** In order to deposit or withdraw cash from bank, people can use ATM (Automated Teller Machine) services 24 hours of the day. Through the computer networks among different branches of a bank, inter branch transactions can be carried out without delay.



CHECK YOUR PROGRESS

Q.1: State True or False:

i) PARAM is a super computer.

ii) A laptop is a portable computer.

iii) Vacuum tubes were part of the second generation computers.

iv) EDSAC is an example of a second generation computer.

Q.2: Fill in the blanks:

i) Physical components of a computer are called .....

ii) The basic components of first generation computers was .....

iii) PDA stands for .....

iv) ..... is a very small computer that can be held in the palm of the hand.

v) Analytical Engine was developed by .....



1.10 LET US SUM UP

- The computer is an electronic device that is used to perform diverse operations with the help of instructions to process the data in order to produce desired results.
- Speed, accuracy, reliability, versatility, diligence, lack of intelligence are the characteristics of computers.
- There are five generations of computers. In the first generation of computers, **vacuum tubes** were used for circuitry and **magnetic drums** for memory.
- In the second generation of computers, **vacuum tubes** replaced by **transistors.**
- **Integrated circuits** were used in the third generation of computers.
- The fourth generation of computers based on **microprocessors.**
- Fifth generation computers are based on **artificial intelligence.**



1.11 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q. No. 1: i) True, ii) True, iii) False, iv) False

Ans. to Q. No. 2: i) Hardware, ii) Vacuum tubes, iii) Personal Digital Assistant, iv) Palmtop, v) Charles Babbage.



1.12 FURTHER READING

1) Goel, A. (2010): *Computer Fundamentals*; Pearson Education India.
2) Rajaraman, V. & Adabala, N. (2014): *Fundamentals of Computers*; PHI Learning Pvt. Ltd.
3) Sinha, P. K. & Sinha, P. (2010): *Computer Fundamentals* (Vol. 4); BPB publications.



1.13 MODEL QUESTIONS

Q.1: Who invented the concept of stored program? Why is this concept so important?

Q.2: List the key hardware technologies used in building computer of each of the five generations.

Q.3: What are the advantages of transistors over vacuum tubes?

Q.4: What is an IC? How does it help in reducing the size of computers

Q.5: Discuss the important features of various generations of computers. Give some examples of the computers of each generation.

Q.6: Describe in brief Flynn's classification of computer?

Q.7: Describe the evolution of computers.

Q.8: What are the characteristics of a Computer? Do you think computers are superior to human being?

*** ***** ***

UNIT 2: BASIC FEATURES OF COMPUTER ORGANIZATION

UNIT STRUCTURE

2.1 Learning Objectives

2.2 Introduction

2.3 Computer Classification based on Operating Principles

- 2.3.1 Analog Computers
- 2.3.2 Digital Computers
- 2.3.2 Hybrid Computers

2.4 Computer Classification based on Applications

- 2.4.1 General Purpose Computers
- 2.4.2 Special Purpose Computers

2.5 Computer Classification based on Size and Capability

- 2.5.1 Micro Computers
- 2.5.2 Mini Computers
- 2.5.3 Mainframe Computers
- 2.5.4 Super Computers

2.6 Let Us Sum Up

2.7 Answers to Check Your Progress

2.8 Further Reading

2.9 Model Questions

2.1 LEARNING OBJECTIVES

After going through this unit, you will be able to:

- describe the different classifications of computers
- learn analog, digital and hybrid computers
- describe general and special purpose computers
- describe minicomputers, microcomputers, mainframe and supercomputers.

2.2 INTRODUCTION

In the previous unit we got an introduction to the computer system. We discussed the evolution and generations of computers.

In this unit we shall learn about the different classifications of computers. We shall discuss how the computers are classified based on operating principle and on the basis of applications. In addition, we shall learn about the classification of computers based on their size and power.

2.3 COMPUTER CLASSIFICATION BASED ON OPERATING PRINCIPLES

Based on the operating principles, computers can be classified into one of the following types:

- Digital Computers
- Analog Computers
- Hybrid Computers

2.3.1 Analog Computers

An analog computer is a form of computer that uses the continuously changeable aspects of physical phenomena such as electrical, mechanical, or hydraulic quantities to model the problem being solved. In contrast, digital computers represent varying quantities symbolically, as their numerical values change.

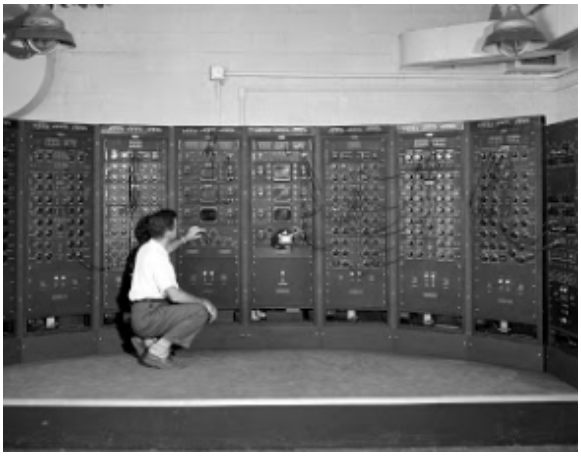


Fig. 2.1: Analog Computers

2.3.2 Digital Computers

Digital computers operate essentially by counting. All quantities are expressed as discrete or numbers. Digital computers are useful for evaluating arithmetic expressions and for manipulations of data (such as preparation of bills, ledgers, solution of simultaneous equations etc.)



Fig. 2.2: Digital Computer

2.3.3 Hybrid Computers

Hybrid computers are computers that exhibit both the features of analog computers and digital computers. The digital component normally serves as the controller and provides logical operations, while the analog component normally serves as a solver of differential equations.



Fig. 2.3: Hybrid Computers

2.4 COMPUTER CLASSIFICATION BASED ON APPLICATIONS

Modern computers depending upon their applications are classified as: -

- General Purpose Computers
- Special Purpose Computers

2.4.1 General Purpose Computers

General purpose computers are designed to meet the needs of many different applications. In these computers, the instructions needed to perform a particular task are wired permanently into the internal memory. When one job is over, instructions for another job can be loaded into the internal memory for processing. Thus, a general purpose machine can be used to prepare pay-bills, manage inventories, print sales report and so on.



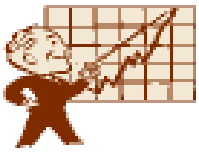
Fig. 2.4: General Purpose Computer

2.4.2 Special Purpose Computers

Special purpose computers are designed to meet the requirements of a particular task or application. The instructions needed to perform a particular task are permanently stored into the internal memory, so that it can perform the given task on a single command. It therefore doesnot possess unnecessary options and is less expensive.



Fig. 2.5: Special Purpose Computer



CHECK YOUR PROGRESS

Q.1: What are the different categories of computers based on applications?

Q.2: What are the different categories of computers based on operating principles?

Q.3: What are hybrid computers?

Q.4: What is the need of special purpose registers?

2.5 COMPUTER CLASSIFICATION BASED ON SIZE AND CAPABILITY

Computers can be classified according to their size and power into four categories. They are:

- Micro Computers
- Mini Computers
- Mainframe Computers
- Supercomputers

Let us look at each of these categories in detail now.

2.5.1 Micro Computers

A microcomputer uses a microprocessor as its Central Processing Unit. Microcomputers are tiny computers that can vary in size from a single chip to the size of a desktop model. They are designed to be used by only one person at a time. Microcomputers are small to medium data storage capacities 500MB-2GB or more. The common examples of microcomputers are chips used in washing machines, TVs, Cars and Notebook/Personal computers. They are: IBM PC, PS/2 and Apple Macintosh.

Micro computers are used in the field of desktop publishing, accounting, statistical analysis, graphic designing, investment analysis, project management, teaching, entertainment etc. The different models of microcomputers are given below:

a) **Personal computers:** The name PC was given by IBM for its microcomputers. PCs are used for word processing, spreadsheet calculations, database management etc.

b) **Notebook or Laptop :** Very small in terms of size. The notebook or laptop can be folded and carried around. The monitor is made up of LCD and the keyboard and system units are contained in a single box. These machines contain all the facilities of a personal computer (HDD, CDD, aound card, network card, modem etc) and a special connection to connect to the desktop PC which can be used to transfer data.

c) **Palm Top:** A smaller model of the microcomputer. A palm top is similar to a calculator– pocket size. It has a processor and memory and a special connection to connect to the desktop PC which can be used to transfer data.

d) **Wrist PC:** The smallest type of microcomputer. The wrist PC can be worn on our wrist like a watch. It has a processor and memory and a wireless modem.

The following figures show the various types of micro computers:



a) Personal Computer



b) Notebook Computer



c) Laptop Computer



d) Palmtop Computer



e) PDA (Personal Digital Assistant)

Fig. 2.6: Micro Computer

2.5.2 Mini Computers

Mini computer uses a microprocessor and performs better than micro computers. Mini computers are large in size and costlier than micro computers. These computers are designed to support more than one user at a time. They posses large storage capacities and operate at higher speed. They are used to support faster peripheral devices like high speed printers and can also be used to communicate with main frames.

Some of the applications of mini computers are given below. These computers are:

- used when the volume of processing is large for e.g., data processing for a medium sized organization
- used to control and monitor production processes

- to analyze results of experiments in laboratories
- used as servers in LANs (Local Area Networks)

Examples of mini computers are: Digital Equipments PDP 11/45 and VAX 11 etc. The following figure shows a mini computer:



Fig. 2.7: Mini computer

2.5.3 Maintrame Computers

Mainframe computers are able to process large amounts of data at very high speed. They support multi-user facility. The number of processors varies from one to six. The cost ranges from 3500 to many million dollars. They are kept in air conditioned room to keep them cool. Mainframe computers support many I/O and auxiliary storage devices and also support network of terminals. Some of the applications of mainframe computers are as follows. They are:

- used to process large amount of data at very high speed such as in the case of banks/ insurance companies/ hospitals/ railways etc. which need online processing of large number of transactions and requires massive data storage and processing capabilities
- used as controlling nodes in WANs (Wide Area Networks)
- used to manage large centralized databases

Examples of main frame computers are: IBM 370, IBM 3081, IBM 3000 series, Univac 1180, DEC IBM 3000 series, CDC Cyber-2000V etc.



Fig. 2.8: Mainframe computer

2.5.4 Super Computers

Super computer is a broad term for one of the fastest computers currently available. The main characteristics of a super computer are:

- The most powerful computer system– needs a large room
- Minimum world length is 64 bits
- CPU speed: 100 MIPS (Million instructions per second)
- Equivalent to 4000 computers
- High cost: 4-5 millions dollars
- Able to handle large amount of data
- High power consumption
- High precision

Some of the applications of supercomputers are:

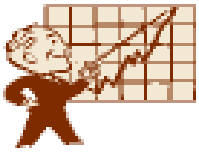
- In Petroleum industry– to analyze volumes of seismic data which are gathered during oil seeking explorations to identify areas where there is possibility of getting petroleum products inside the earth.
- In Aerospace industry– to simulate airflow around an aircraft at different speeds and altitude. This helps in producing an effective aerodynamic design for superior performance.

- In Automobile industry– to do crash simulation of the design of an automobile before it is released for manufacturing - for better automobile design.
- In structural mechanics– to solve complex structural engineering problems to ensure safety, reliability and cost effectiveness. Eg. The designer of a large bridge has to ensure that the bridge must be proper in various atmospheric conditions and pressures from wind, velocity etc and under load conditions.
- Meteorological centers use super computers for weather forecasting
- In Biomedical research - atomic nuclear and plasma analysis - to study the structure of viruses such as that causing AIDS
- For weapons research and development, sending rockets to space etc.

Examples of supercomputers are: Cray-1(1976), Cray-2(1985), Cray T3D(1993), NEC's SX-S/44(1991), Fujitsu VP 2600/10(1991), Hitachi 820/80(1987), C-DAC's PARAM Series of supercomputers etc. A PARAM 10000 series super computer of IIT Guwahati is shown in the above below.



Fig. 2.9: PARAM 1000 Series Super Computer



CHECK YOUR PROGRESS

Q.5: What are the different categories of computers based on size and power?

Q.6: Mention two applications of supercomputers.

Q.7: How are mini computers different from micro computers?

Q.8: Give two properties of mainframes.



2.6 LET US SUM UP

- An analog computer is a form of computer that uses the continuously changeable aspects of physical phenomena such as electrical, mechanical, or hydraulic quantities to model the problem being solved.
- Digital computers operate essentially by counting. All quantities are expressed as discrete or numbers.
- Hybrid Computers are computers that exhibit features of analog computers and digital computers. The digital component normally serves as the controller and provides logical operations, while the analog component normally serves as a solver of differential equations.
- General purpose computers are designed to meet the needs of many different applications. In these computers, the instructions needed to perform a particular task are wired permanently into the internal memory.
- Special purpose computer is designed only to meet the requirements of a particular task or application.
- A microcomputer uses a microprocessor as its Central Processing Unit. Microcomputers are tiny computers that can vary in size from a single chip to the size of a desktop model.
- A mini computer uses a microprocessor performs better than micro computers. They are large in size and costlier than micro computers. These computers are designed to support more than one user at a time.
- A mainframe computer is able to process large amount of data at very high speed. They support multi-user facility. The number of processors varies from one to six.



2.7 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q. No. 1: The different categories of computers on applications are:

1) General Purpose Computers
2) Special Purpose Computers

Ans. to Q. No. 2: The different categories of computers on operating principles are:

1) Analog Computers
2) Digital Computers
3) Hybrid Computers

Ans. to Q. No. 3: Hybrid Computers are computers that exhibit features of analog computers and digital computers. The digital component normally serves as the controller and provides logical operations, while the analog component normally serves as a solver of differential equations.

Ans. to Q. No. 4: Special purpose computer is designed only to meet the requirements of a particular task or application. The instructions needed to perform a particular task are permanently stored into the internal memory, so that it can perform the given task on a single command.

Ans. to Q. No. 5: The different categories of computers based on size and power are:

1) Mini Computers
2) Micro Computers
3) Mainframe Computers
4) Super computers

Ans. to Q. No. 6: Two applications of supercomputer are in:

1) In Aerospace industry– to simulate airflow around an aircraft at different speeds and altitude. This helps in producing an effective aerodynamic design for superior performance.
2) In Automobile industry– to do crash simulation of the design of an automobile before it is released for manufacturing– for better automobile design.

Ans. to Q. No. 7: A minicomputer uses a microprocessor performs better than micro computers. They are large in size and costlier than micro computers. These computers are designed to support more than one user at a time. They posses large storage capacities and operates at higher speed.

Ans. to Q. No. 8: Two properties of mainframes are:

1) They process large amount of data at very high speed.
2) They support multi-user facility. The number of processors varies from one to six.



2.8 FURTHER READING

1) Goel, A. (2010): *Computer Fundamentals*; Pearson Education India.
2) Rajaraman, V. & Adabala, N. (2014): *Fundamentals of Computers*; PHI Learning Pvt. Ltd.
3) Sinha, P. K. & Sinha, P. (2010): *Computer Fundamentals* (Vol. 4); BPB publications.



2.9 MODEL QUESTIONS

Q.1: Give the importance of special purpose computers.

Q.2: Why do we need supercomputers? How are they different from mainframes?

Q.3: How are analog computers different from digital computers? Are hybrid computers better than analog and digital computers? Give reasons explaining your answer.

Q.4: Give the basic properties that differentiate between mini, micro, mainframes and supercomputers.

Q.5: Why do we need general purpose computers? Give its two applications.

Q.6: Give two examples where analog and digital computers are used.

*** ***** ***

UNIT 3 : BASIC COMPONENTS OF COMPUTER

UNIT STRUCTURE

3.1 Learning Objectives

3.2 Introduction

3.3 Concepts of Bits and Bytes

3.4 Block Diagram of a Computer

3.5 Computer Memory

- 3.5.1 Primary Memory
- 3.5.2 Secondary Memory

3.6 Input Devices

- 3.6.1 Keyboard
- 3.6.2 Mouse
- 3.6.3 Hand-held Devices
- 3.6.4 Optical Input Devices

3.7 Output Devices

- 3.7.1 Display Devices
- 3.7.2 Printers

3.8 Computer Bus

3.9 Let Us Sum Up

3.10 Answers to Check Your Progress

3.11 Further Reading

3.12 Model Questions

3.1 LEARNING OBJECTIVES

After going through this unit, you will be able to :

- describe the concept of bits and bytes
- understand the block diagram of a computer
- discuss the primary and secondary memory in computer
- analyse the different types of input and output devices
- describe the different types of buses

3.2 INTRODUCTION

A computer system is composed of various components which perform many functions. In this unit, we will introduce you to the basic components of a computer system where, you will first learn how the data is represented in the form of bits and bytes. Through this unit you will be acquinted with the types of computer memory. Various types of input and output devices and the basic functioning of a bus are also included as a part of discussion in this unit.

3.3 CONCEPTS OF BITS AND BYTES

You may be surprised to know that the computer is made up of millions of tiny electric circuits that are not visible to us. The memory elements are also built with these tiny circuits which are used for storing data. For every circuit in a computer chip, there are two possibilities:

- an electric current flows through the circuit, or
- an electric current does not flow through the circuit.

When an electric current flows through a circuit, the circuit is on. When no electricity flows, the circuit is off. An “on” circuit is represented by the number one (1) and an off circuit is represented by the number zero (0). The number 1 or 0 is called ***bit***. A number system that uses only two digits, 0 and 1, is called the ***binary number system***. The binary number system is also called the base two system. The two symbols 0 and 1 are known as binary digits. The word **bit** comes from “**bi**nary digi**t**”.

Always remember that each time a computer reads an instruction, it translates that instruction into a series of bits, 1’s and 0’s. On most computers

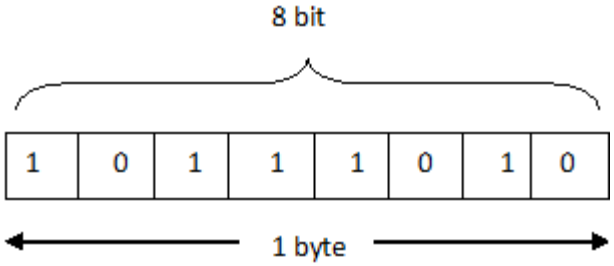


Figure 3.1 Byte representation

every character from the keyboard is translated into eight bits, a combination of 1's and 0's. Each group of 8 bits is called 1 byte as shown in figure 3.1. Each group of four bits is called a nibble.

Thus, 8 bits = 1 byte and 4 bits = 1 nibble

and 1024 byte = 1 kilo byte

We know that, all the quantities, physical or abstract, can be measured in some units. For example, time is measured in seconds; length is measured in metres, and mass in grams. Similarly, the computer memory can be measured in terms of bits, bytes, kilobytes, megabytes, gigabytes etc.

The followings are the measuring units given in terms of bytes :

1 kilobyte (KB) = 1,024 byte

1 megabyte (MB) = 1,048,576 bytes

1 gigabyte (GB) = 1,073,741,824 bytes

1 terabyte (TB) = 1,099,511,627,776 bytes

3.4 BLOCK DIAGRAM OF A COMPUTER

All general-purpose computers require the following hardware components:

Input Unit : This is the unit through which data and instructions are entered into a computer. Usually a keyboard and mouse are the common input devices.

Output Unit : This unit communicates the results to the user. A display screen and a printer are the common devices that let you see the results in the computer.

Central Processing Unit (CPU) : Execution of programs is the main function of the computer. The program is a set of instructions that is stored in the computer's memory. A task becomes completed when the instructions of the program are executed by the central processing unit. All the major calculations and comparisions are carried out inside the CPU. The CPU is responsible for activating and controlling the operations of various units (input & output) of the computer system.

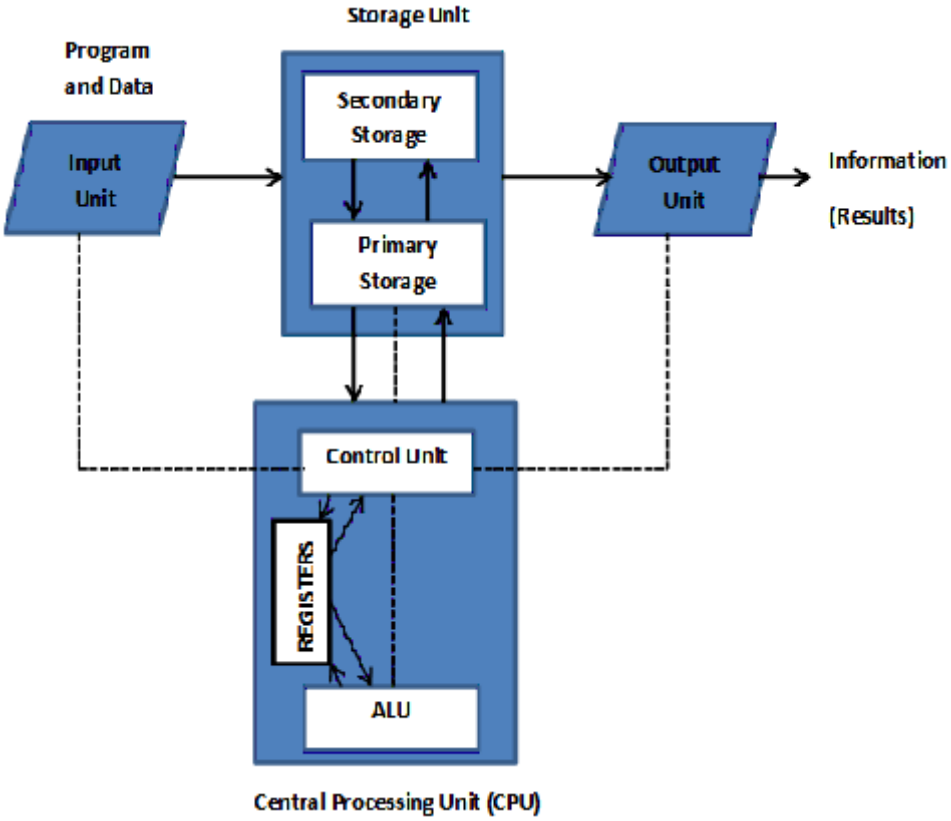


Figure 3.2: Central Processing Unit

The CPU is made up of three major components : the **registers,** the a**rithmetic and logic unit (ALU)** and the **control unit**. The registers are responsible for storing the intermediate data during the execution of program. The control unit supervises the transfer of information between the registers and instructs the ALU to perform the required operation.

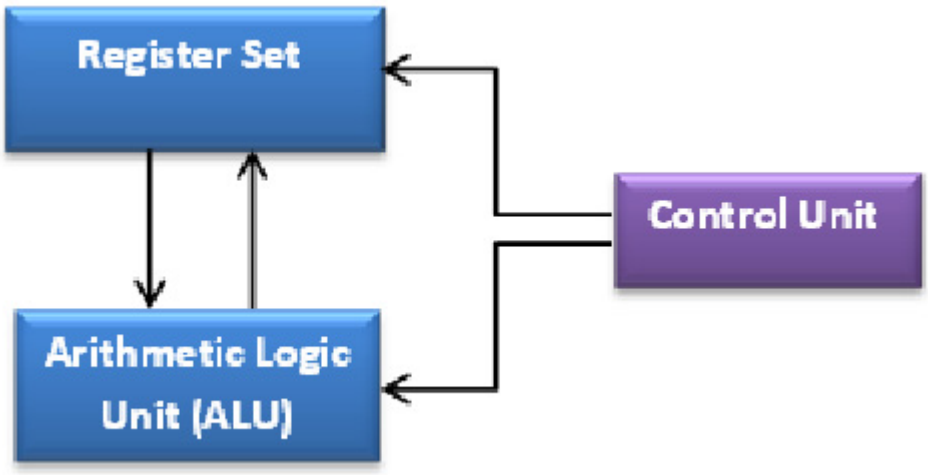


Figure 3.3 : Components of CPU

Control Unit (CU) : The control unit controls and guides the interpretation, flow and manipulation of all the data and information. It does not perform the actual processing of data, but manages and coordinates the entire computer system, including the input and output (I/O) devices. Control unit retrieves and interprets the instructions from the main memory and send signals to the other units to execute them one after the other. Some special purpose registers found inside the CPU like *instruction register, program counter* etc. help the CU to perform its function smoothly.

Arithmetic Logic Unit (ALU) : The ALU performs all the arithmetical functions +, -, *, / and some logical functions like <, >, =, <=, >=, <> etc. When two numbers are required to be added, these numbers are sent from memory to ALU where addition takes place and the result is sent back to memory. ALU has special circuits to carry out the logical operations.

Storage Unit : The storage unit allows a computer to permanently store large amount of data. The storage unit can be categorised into two types namely *primary storage* and *secondary storage,* which we will discuss in the next section. Common mass storage devices include disk drives and tape drives etc.

3.5 COMPUTER MEMORY

The term ***memory*** usually refers to a form of semiconductor storage and sometimes other forms of fast but temporary storage. In a computer, the data and instructions are stored and subsequently retrieved from the memory. We know that the CPU has some storage elements known as registers for storing data and instructions during the program execution. Every computer requires storage space for storing programs and data temporarily during the time of program execution or storing the data permanently for future use. Generally, a computer has three set of memories:

a) **Primary storage or main memory :** Primary memory, also known as *memory*, is the only one *directly accessible to the CPU*. The CPU continuously reads instructions stored there and executes them. Any data actively operated on is also stored there in uniform manner. It is a form of semiconductor storage known

as random access memory (**RAM**) and sometimes other forms of fast but temporary storage. It is small-sized, light, but quite expensive. This type of memory is divided into the following two types : *RAM (Random Accress Memory) & ROM (Read Only Memory).*

b) **Secondary storage or auxiliary memory :** Secondary memory or *storage* provides the facility of storing information and programs permanently. It differs from primary storage in that it is *not directly accessible by the CPU*. The computer usually uses its input/output channels to access secondary storage and transfers the desired data using intermediate area in primary storage. Secondary storage does not lose the data when the device is powered down; it is non-volatile. It is less expensive than primary storage.

c) **Internal processor memory :** It consists of a small set of high-speed registers that are used as temoprary locations inside the processors during the execution of instructions.

Another type of memory, is the *cache memory*. Its logical position is between the main memory and the internal memory(registers). Its primary function is to store and cache part of the main memory's contents that the processor is currently using.

The computer system has a memory hierarchy consisting of the storage devices in it. A typical memory hierarchy is illustrated in the figure 3.4.

There are three key characteristics of the memory. They are cost, capacity and access time. On moving down the memory hierarchy, it is found that the cost of the storage devices decreases but their storage capacity as well as the memory access time increases. In other words, the smaller memories are more expensive and much faster. These are supplemented by the larger, cheaper and slower storage devices.

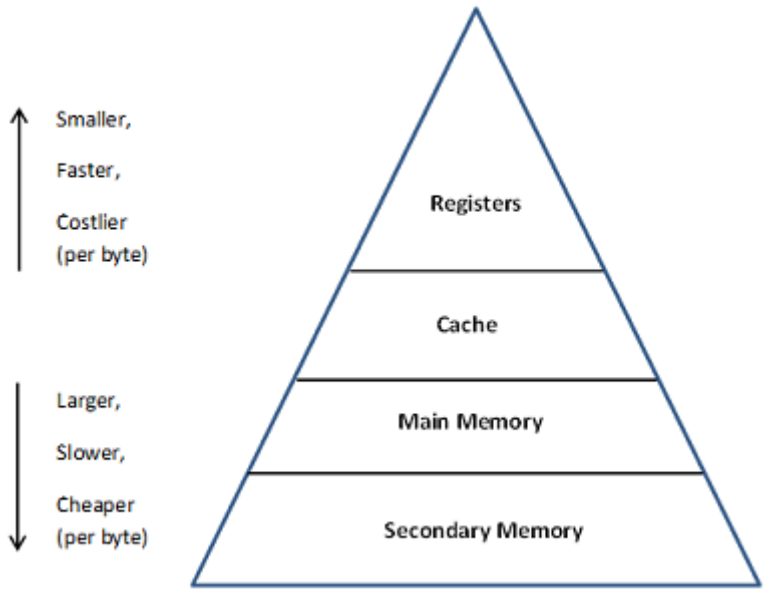


Figure 3.4 : Memory hierarchy

Thus, from the above figure it can be seen that the registers are at the top of the hierarchy and so provides the fastest, the smallest and the most expensive type of memory device for the CPU to access data.

Memory Capacity : Capacity in a computer system is defined in terms of the number of bytes that it can store in its main memory. This is usually stated in terms of kilobytes (KB) which is 1024 bytes or megabyte which is 1,048,576 bytes. The rapidly changing memory capacity of computer system has resulted in defining the capacity in terms of gigabytes (GB) which is 1,073,741,824 bytes. Thus, a computer system having a memory of 1GB is capable of storing (1024 X 1024 X 1024) bytes.

3.5.1 Primary Memory

Primary memory can be categorised into two types - RAM and ROM. We will now briefly describe RAM and ROM.

Random Access Memory (RAM) : A computer's **main memory** is often referred to as RAM - an area in the computer system unit that temporarily holds user data, operating system instructions and program instructions. Every time we turn on our computer, a set of operating system instructions is copied from hard disk into RAM.

These instructions, which help control basic computer functions, remain in RAM until we turn the computer off.

RAM features :

a) RAM is the place which holds the data that has to be processed by the computer's processor. Moreover, it holds the operating system and other application programs also.

b) RAM is made up of different ICs (Integreted Circuits). They are also called *semiconductor memory*.

c) Each element of RAM is a memory location in which data can be stored. Each location has a **unique address**. Using this address, data can be directly retrieved or stored.

d) Since RAM must hold both the data to be processed and the instructions for processing, its size or capacity is one of the measures of power of the computer.

e) RAM is a volatile memory. It loses its data when the computer is turned off.

There are generally two broad categories of random access memory :

i) **DRAM** memories (*Dynamic Random Access Memory*)

ii) **SRAM** memories (*Static Random Access Memory*)

DRAM : Dynamic RAM is a type of RAM in which data is stored in a storage cell, consisting of transistors and capacitors. A common property of a capacitor is its tendency to get discharge, it means the current goes down in the circuit and data cannot hold for long time. To overcome this effect, the DRAM needs to be continuously refreshed with power supply and thus it has one *refreshing circuit* which rewrites the data in certain time intervals. This circuit refreshes or rewrites the data several hundred times in a second.

SRAM : Static RAM is a type of RAM that holds its data as long as power is supplied to the circuit. The SRAM does not need any refreshing circuit. SRAMs are used for specific applications within the PC. The SRAM has the following advantages:

- **Simplicity :** SRAMs don't require external refresh circuits to keep their data intact.
- **Speed :** SRAM is faster than DRAM.

In contrast, SRAMs have the following weaknesses, compared to DRAMs:

- **Cost :** SRAM is more expensive than DRAM.
- **Size :** SRAMs take up much more space than DRAMs

Read Only Memory (ROM) : One major type of memory that is used in PCs is called *read-only memory*, (*ROM*). ROM is the memory that stores the data permanently i.e. the instructions in ROM are permanent whether the power is on or off. We have no way to change them, unless we remove the ROM chips from the main board and replace them with another set.

Read-only memory is most commonly used to store system-level programs that we want to be made available to the PC at all times. For example, the ROM-BIOS (ROM basic input and output services) programs are stored in ROM chips which are used to boot up (start up) the computer.

The following are the different types of ROMs:

Programmable ROM (PROM) : This is a type of ROM that can be programmed using special equipment; it can be written to, but only once.

Erasable Programmable ROM (EPROM) : *EPROM* is a ROM that can be erased and reprogrammed. Ultraviolet light of a specific frequency is used for erasing the EPROM and for allowing it to be reprogrammed again.

Electrically Erasable Programmable ROM (EEPROM) : The next level of erasability is the *EEPROM*, which can be erased under software control. This is the most flexible type of ROM, and is now commonly used for holding BIOS programs.

3.5.2 Secondary Memory

Secondary memory or *storage* provides the facility of storing information and programs permanently. It differs from primary storage in that it is not directly accessible by the CPU. The computer usually uses its input/output channels to access secondary storage and transfers the desired data using intermediate area in primary storage. Secondary storage does not lose the data when the device is powered down; it is non-volatile. It is also typically less expensive than primary storage. Consequently, modern computer systems typically have an order of magnitude more secondary storage than primary storage and the data is kept for a longer time there. The figure 3.5 shows the commonly used secondary storage devices and their classification.

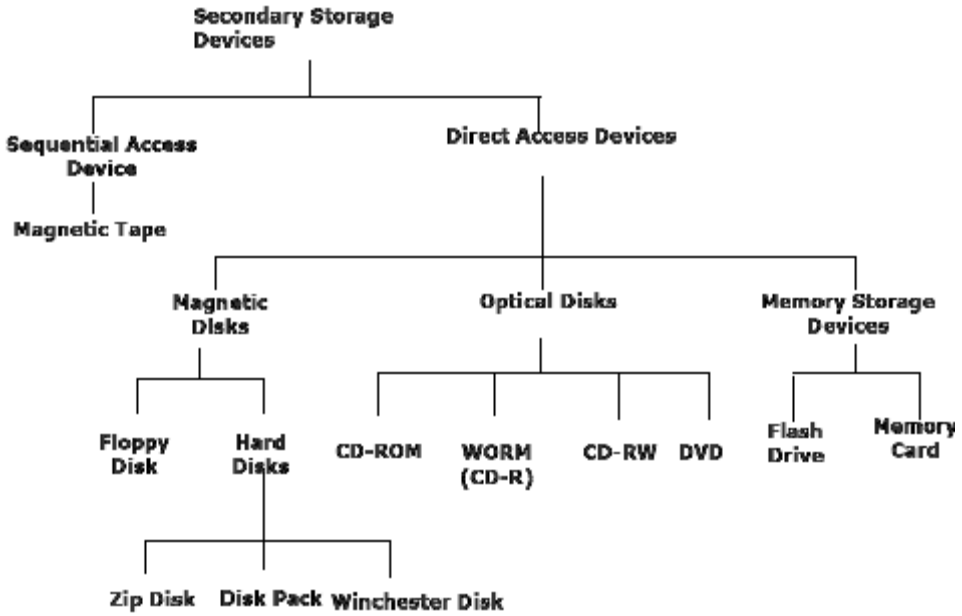
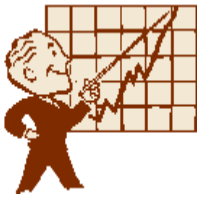


Figure 3.5 : Secondary storage devices and their classification

In modern computers, hard disks are usually used as secondary storage. The time taken to access a given byte of information stored on a hard disk is typically a few thousandths of a second, or milliseconds. By contrast, the time taken to access a given byte of information stored in random access memory is measured in

thousand-millionths of a second, or nanoseconds. Some other examples of secondary storage technologies are: Flash Memory (e.g. USB sticks or keys), Floppy Disks, Magnetic tape, Paper tape, Punch Cards, standalone RAM disks, and Zip drives.



CHECK YOUR PRPOGRESS

Q.1. State True or False:

i) The secondary memory is slower than the main memory but has a large capacity.

ii) In random access memory any memory location can be accessed independently.

iii) Cache memory increases load on main memory.

iv) Flash memory is one kind of ROM.

v) High speed memories are needed to bridge the gap of speed between I/O device and memory.

vi) Registers are the fastest memory element in computer system.

vii) Main memory of a computer system cannot store very large data.

Q.2. Which memory is known as the main memory of the computer system ?

.....

.....

Q.3. What are the differences in :

a) Volatile versus Non-volatile memory

.....

.....

.....

b) Static RAM versus dynamic RAM

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.....

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.....

Q.4. What is the similarity between ROM and PROM?

.....

.....

3.6 INPUT DEVICES

The main function of the input unit of a computer system is to provide information for execution. Programs and data must be entered into the computer memory for processing through the input devices, and the results obtained from the execution by the CPU must be displayed or recorded for the user's. The most commonly used input devices can be classified into the following categories :

- **Keyboard devices**
- **Point and draw devices** (mouse, track ball, joystick, light pen, touch screen)
- **Scanning devices** (optical mark recognition, magnetic ink ch aracter recognition, optical bar code reader, digitizer, electronic card reader)
- **Voice recognition devices**
- **Vision-input devices** (Webcam, video camera etc)

3.6.1 Keyboard

It is the main input device used in most of the computer systems. It has letter and number (alphanumeric) keys, function keys, computer specific task keys, that allow the user to use an English-like language to issue instructions to an electronic environment. It uses a cursor to keep your place on the screen and to let you know where to begin typing. You are able to input commands, type data into documents, compose documents, draw pictures with use of certain keys, pull down menus, and respond to prompts issued by

the computer. The keyboard contains s*pecial function keys* labelled F1, F2, ..., F12 to manipulate the user interface. When a key is touched, an electrical impulse is sent through the device which is picked up by the operating system software, and sent through the computer to be processed.

The keyboard operates as a typical typewriter and uses a standard “QWERTY” keyboard. QWERTY is the way the keyboard is set up for typing. If you look at the keyboard under the top number row, you will see that the alphabet top row begins with QWERTY.

Some special purpose keyboards are also found which are used for specific applications. An example of such kind of keyboards can be seen at the Automatic Teller Machines or the ATMs where the keyboard is required for limited functionality by the customers.

3.6.2 Mouse

The mouse is a hand held pointing device that lets you to point and select items on your screen. In any mouse there are mostly 2-3 buttons and on a Mac there is one. A ball under the mouse senses movement. The mouse is included in almost every computer that is sold today. Besides becoming an important input tool, it has provided access to the computer for many individuals with disabilities that might not otherwise have the opportunity to use the computer.

Variants of a Mouse :

Touchpad : A touchpad is a touch sensitive input device which takes user input to control the onscreen pointer and perform other functions similar to that of a mouse. Instead of having an external peripheral device such as a mouse, the touchpad enables the user to interact with the device through the use of one or multiple fingers being dragged across the relative positions on a sensitive pad. These touch pads are mostly found in Notebook and Laptops.Touchpads are pressure and touch sensitive.



Figure 3.6 : Touchpad of a Laptop

3.6.3 Hand-held Devices

Trackball : The trackball is an upside-down mouse. It uses the same principle as the mouse except that the rollers are reversed and the ball is on top. This ball does not need as much attention as the normal mouse because the only thing that touches it is your hand as the normal mouse touches a surface.

Joystick : The joystick is a vertical stick that moves the graphic cursor in the direction the stick is moved. It consists of a spherical ball, which moves within a socket, and has a stick mounted on it.The user can move the ball with the help of the stick in any direction. Video games, training simulators and control panel of robots are some common uses of a joystick.



Figure 3.7 : Trackball



Figure 3.8 : Joystick

Light pen : The light pen is a pen shaped tool that allows the user to touch the computer screen with a lighted pen to activate commands and make selections. Light pens are typically used in CAD (Computer Aided Design) applications to directly draw on screen.

Touch Screen : A touch screen is probably one of the simplest and most intuitive of all input devices. It uses optical sensors in, or near, the computer screen that can detect the touch of a finger on the screen.

3.6.4 Optical Input Devices

Scanner : Scanning devices are input devices used for direct data entry from the source document into the computer system. Scanners capture and store information in a graphical format, and then display it on the graphical screen. A scanner consists of two parts, one that illuminates the page for capturing the optical image, and the other that converts and stores the graphical image in a digital format. Once this is done, the computer can then see and directly process this scanned graphical image. A scanner's sophistication is the ability to translate an unlimited number of analog voltage levels to digital values. The scanner takes the information it sees on a page and converts into code that the computer can use. A picture once scanned can be edited, printed, or used in an application. Capturing information by using scanners reduces the possibility of human error typically seen during large data entry.

Optical Mark Recognizer (OMR) : Optical mark recognization devices sense the marks on computer readable paper. They are usually used by academic institutions for grading aptitude tests where the correct option is marked from multiple options given on special kinds of answer sheets. The OMR device directly reads this paper, and the computer can then use it for further processing.



Figure 3.9: Magnetic Ink Character Recognizer

Magnetic Ink Character Recognition (MICR) : MICR is similar to optical mark recognition and is used exclusively by the banking industry. The banking industry makes use of MICR devices for directly reading the account numbers written on cheques and for processing them further as required. MICR characters are printed in special typefaces with a magnetic ink or toner, usually containing iron oxide.

Optical Barcode Reader (OBR) : Data coded in the form of small vertical lines forms the basis of barcoding. Alphanumeric data is represented using adjacent vertical lines called barcodes. These are of varying width and the spacing between them is used to uniquely identify books, merchandise in stores, postal packages etc. A barcode reader uses laser beam technology. The laser beam is moved across the patterns of bars in a barcode. These bars reflect the beams in different ways. The reflected beam is then sensed by a light-sensitive detector, which then converts the light patterns into electrical pulses, thereby transmitting them to logic circuits for further conversion to alphanumeric value.



Figure 3.10: Optical Bar Code

Digitizer : The digitizer is another kind of input device used for converting (digitizing) picture,maps and drawings into digital form for storage in computers. These devices are commonly used in the

area of Computer Aided Design (CAD) by architects and engineers to design car, buildings, medical devices, robots and mechanical devices.

Electronic Card Reader : Card readers are devices that allow direct data input into computer system. The electronic-card reader is connected to a computer system and reads the data encoded on an electronic card and transfers it to the computer system for further processing. Typical example of electronic cards are the plastic coated cards provided by the banks to its customers for use in Automatic Teller Machines or ATMs.

3.7 OUTPUT DEVICES

The outputs produced by a computer system can be in two forms : *hard copy and soft copy*.

Hard copy : The output produced in a physical form is called hard copy output. This type of output is permanent and a relatively stable form of output. Paper is one of the most commonly used hard copy output media. The most widely used hard copy output device is the printer.

Soft copy : The output that remains in electronic form, stored in computer memory or on disk are called soft copy outputs. This kind output is not permanent and is usually displayed on monitor or screen. It includes both audio and visual forms of output.

A wide range of output devices are available today which are :

- Display device (monitors, multimedia projectors, terminals)
- Plotters (flatbed, drum)
- Voice response system (voice response system, speech synthesizer)
- Printers

3.7.1 Display Devices

The display device shows the processed output from a computer system. The increasing demand for displaying the graphics and

pictures for presenting information in a visual form has led to the popularity of graphics display device. Display screen technology may belong to one of the following categories :

a) **Cathod Ray Tube(CRT) :** The CRT is a vacuum tube containing an electron gun (a source of electrons) and a fluorescent screen, with internal or external means to accelerate and deflect the electron beam. It is used for creating images in the form of light emitted from the fluorescent screen. A CRT display can be either of the following two types : *Raster scan display and Vector display*.

b) **Liquid Crystal Display(LCD) :** The LCD technology is a thin, flat electronic visual display that uses the light modulating properties of liquid crystals. They are common in consumer devices such as video players, gaming devices, clocks, watches, calculators, and telephones. LCDs have replaced cathode ray tube (CRT) displays in most applications. They are usually more compact, less energy consuming, lightweight, portable, less expensive, more reliable, and easier on the eyes.

Monitor : The monitor is one of the most commonly by used output devices. It can be thought of as a high resolution TV set. The monitor displays text and images (pictures) converted to output from the video adapter. The video adapter is an expansion card that plugs into the motherboard. The adapter changes the instructions from the central processing unit (CPU) into a way that the monitor can understand it.

Most computer monitors are based on Cathode Ray Tube (CRT) technology. The basic operation of these tubes is similar to that in television sets. With the widespread use of smaller computers like PDAs and laptops now-a-days, a new type of display screen Liquid Crystal Display (LCD) has been used.

3.7.2 Printers

It is a widely used output device. A printer prints information and data from the computer onto a paper. Some printers can produce only textual information but some others can produce graphics also.

Printers can be classified into categories based on : *printing technology, printing speed, printing quality.*

Printing technology : Printers can be divided into two types - *(i)impact printers* and *(ii)non impact printers*.

(I) Impact printers : The printers that work by physically striking a head or needle against an ink ribbon to make mark. Impact printers are divided into *Dot matrix printers , Daisy-Wheel printers* and *Drum printers.*

Dot Matrix Printer : This printer is the cheapest but loudest of all the printers. This printer prints one character at a time. The printer uses a fine stripe of carbon and depending on what pin it is, will determine the quality of the printing. The pin sizes range from 9-24. The print head hits the ink ribbon with one of its many pins causing it to form a letter number or character.



Figure 3.11 : A Dot-Matrix Printer

With the pins hitting the ribbon this printer becomes quite loud. The ppm (page per minute) ranges from 1 to 3. But with new changes in the technology it is being more and more used in offices today and it can also print 3 - 6 ppm. The drawback in most dot matrix printers is the on-roll paper which has a track which feeds it through

the printer. Also, in most new dot matrix printers there is a paper feed which allows most forms of paper.

Daisy Wheel Printer : Daisy-wheel printers operate in much the same fashion as a typewriter. A hammer strikes a wheel with petals (the daisy wheel), each petal containing a letter form at its tip. The letter form strikes a ribbon of ink, depositing the ink on the page and thus printing a character. By rotating the daisy wheel, different characters are selected for printing.You can change the daisy wheel to print different fonts. This printer is also called the letter quality printer.

Drum printer : Drum printer is one of the most commonly used line printers.

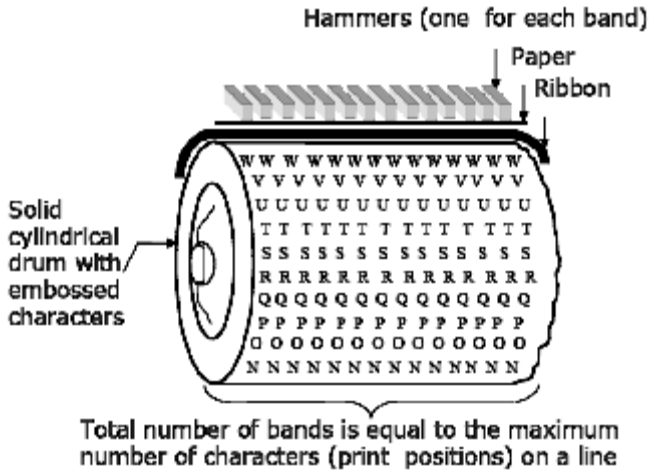


Figure 3.12 : Printing Mechanism of a Drum Printer

In a typical drum printer design, a fixed font character set is engraved onto the periphery of a number of print wheels, the number matching the number of columns (letters in a line) the printer could print. The wheels, joined to form a large drum (cylinder), spin at high speed and the paper and an inked ribbon are stepped (moved) past the print position. As the desired character for each column passes the print position, a hammer strikes the paper from the rear and presses the paper against the ribbon and the drum, causing the desired character to be recorded on the continuous paper. Because the drum

carrying the letterforms (characters) remains in constant motion, the strike-and-retreat action of the hammers has to be very fast. Typically, they are driven by voice coils mounted on the moving part of the hammer.

(II) Non impact printers : These printers work by not physically striking a head or needle against an ink ribbon to make a mark. Inkjet, Laser and thermal printers fall under this category of printers.

The ***non impact printers*** commonly used are :

Inkjet Printer : This printer is generally used in homes. It is a non impact printer and it does not touch the paper while printing. Instead, the print head sprays ink onto paper forming an image or text.

For business letters, a injet printer is the most common as it is used for its high quality printing. The common speed on an ink jet printer is about 3 ppm and 300 dpi (dots per inch).

Laser Printer : Among the different types of printers, laser printers remain the fastest, and the most efficient way to reproduce text and images, offering high resolution and quick speeds at a relatively low cost. A laser printer uses an electrostatic process similar to a photocopier. The laser charges the areas of a photosensitive image drum. Toner particles are then attracted to these areas of the drum. By rolling this drum against a piece of paper, the printer creates an image on a page.In the final stage, heat is used to fuse the toner to the paper.



Figure 3.13 : Inkjet printer and Laser Printer

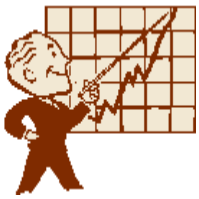
Plotter : A plotter is a hard copy output device which is used to draw high-resolution charts, graphs, maps, and other line based diagrams. It is a pen based output device, attached to a computer for making vector graphics, that is, images created by a series of many straight lines. A plotter is a very slow and expensive output device. It is mainly used for Computer Aided Design(CAD) and Computer Aided Manufacturing applications. Plotters are classified as Drum plotters and Flatbed plotters.



Figure 3.14 : Plotter

Audio Output : Voice response systems enable the computer to talk to its users. It consists of an audio-response device that produces the audio output. Voice response systems are of *two* types : *voice reproduction system* and *speech synthesiser.*

Voice reproduction system produce an audio output by selecting the appropriate response from a predefined set of responses. These responses may be in the form of speech (words or phrases spoken by human beings), musical sounds, alarms, or other sounds. Text is converted into spoken words by speech access systems.



CHECK YOUR PROGRESS

Q.5. State true or false

a) One of the most common input device is keyboard.

b) Plotters are devices used for outputting pictures, drawings.

c) Digitizers are used as output devices.

d) In case where graphical user interfaces are common mouse should not be used.

e) Speech recognition devices are input devices.

Q.6. Answer the followings :

a) What are electronic card readers?

b) Compare and contrast the Laser and Dot Matrix Printers.

c) What is an OMR device?

d) On what basis are the printers classified?

3.8 COMPUTER BUS

Bus is an electrical pathway through which the processor communicates with the internal and external devices that are assembled with the computer. Buses resposible to carry memory address as well as data to the control location in memory. Computer system contains a number of different buses that provide pathways between components at various levels of the computer system hierarchy. The name of the bus is determined by the type of the signals it carries and the operations it performs. A bus that connects major computer components (CPU, memory, I/O) is called a *system bus*.

The interaction between the CPU and memory and CPU and I/O takes place very frequently. To enable this interaction, some type of connectivity is needed between the units of a computer system. This connectivity channel is known as *bus*. A key characteristic of a bus is that it

is a shared transmission medium. Physically, a bus is set of wires, which carries a group of bits in parallel and has an associated control scheme. The bus width is defined as the number of parallel lines in the bus. Every computer has three types of buses for interconnecting the CPU and memory and CPU and I/O. The functions performed by bus are as follows :

- Bus transfers data between the computer subsystem. It sends instructions and commands to and from the processors.
- It connects all internal computer components to the main memory and the CPU.
- It logically connects various peripheral devices which can easily communicate with the CPU.
- It has clock speed which is measured in MHz.

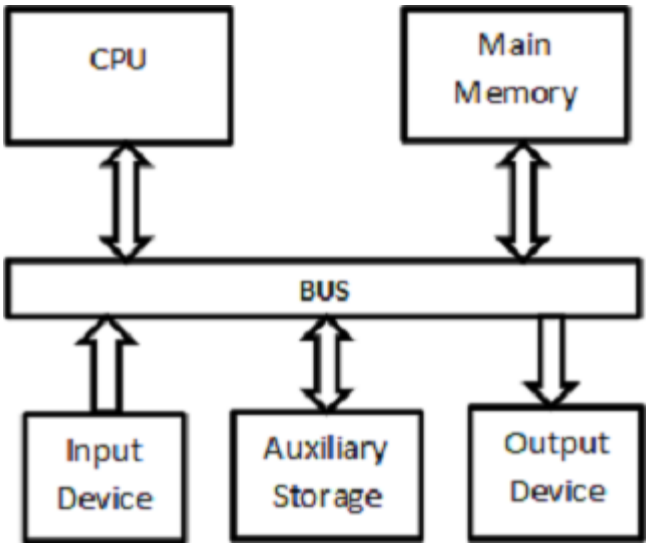


Figure 3.15: Computer Bus

Data Bus : The data bus is used to transfer data between the CPU and memory and CPU and I/O. The one that you hear most about is the data bus. The bus width of the data bus is an important parameter that affects the overall speed of a computer system. This is because each wire of a bus can transfer one bit at a time. Hence, a 8-bit bus can move 8 bits data time, a 16 bit bus can transfer two bytes, and 32 bit bus can transfer four bytes at a time. This is similar to a multi-lane highway. The wider the highway, the more traffic can flow simultaneously. Similarly the wider the bus enables more bits of data to travel, simultaneously resulting in faster

exchange of data. The data bus is also referred to as a *memory bus* which is often called *system bus.*

Address Bus : Every location in the memory has a unique address. The address of a location does not change, but the data stored in it can change. In order to retrieve some data from memory, it is necessary to specify the address of the location where the data is stored. The address bus is used to carry the address of a memory location whenever data is to be transferred to or from memory.

Again, a computer system normally has multiple I/O devices like disk, tape, network etc simultaneously connected to it. Each I/O device has a unique identifier associated to it. The address bus is used to carry the address of the I/O device to be accessed by the CPU.

Control Bus : In addition to sending address and exchanging data with the memory, the CPU also needs to send control signals to the memory to specify whether the data is to be read from or written to the specified address location. The control bus carries such signals, which are in the form of READ/WRITE commands. A typical bus structue is shown in the figure 3.16.

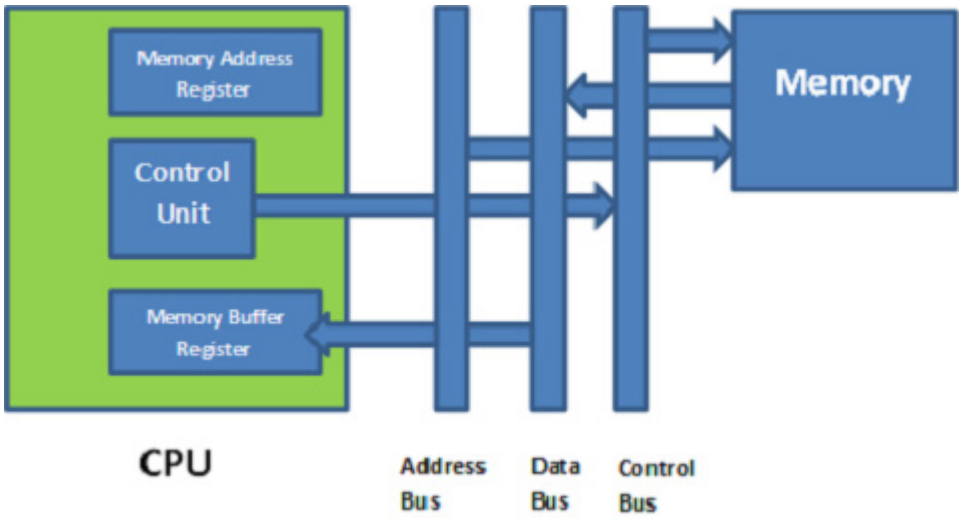


Figure 3.16: Different types of Bus



ACTIVITY

- Find out the capacity and structure of the memory types used in a computer system.
- Prepare a list of all old and new input and output devices with illustrations.



3.9 LET US SUM UP

- Data inside a computer is stored in the form of 0s and 1s. These 0 and 1s are called bit. 4 bit constitute a nibble and 8 bit constitute a byte.
- The ***memory*** usually refers to a form of semiconductor storage i.e. primary memory and ***storage*** refers to mass storag i.e. secondary memory.
- Random access memories are the semiconductor memory. They are volatile in nature. RAMs are of two types - dynamic RAM and static RAM.
- ROMs are also the semiconductor memory. The instructions in ROMs are permanent whether the power is on or off. PROM, EPROM, EEPROM are the types of ROMs.
- Cache memory is a special type of RAM which is the faster memory used in a computer system in between the CPU and main memory.
- Secondary memory also called secondary storage stores information and programs permanently. In personal computer, secondary memory typically consists of hard disk or any removable media, if present, such as a CD or DVD etc.
- Magnetic tapes are the magnetic-coated plastic tapes, which are used for storing data and audio or video files.
- Input device is an electromechanical device that accepts data or information from the user in user readable form, and translates them into computer readable form.

- An output device is an electromechanical device, which produces the output of processing by the computer to the user. Computer produces the output in a machine readable form, and the output device converts it to a human readable form.
- Bus is an electrical pathway through which the processor communicates with the internal and external devices that are assembled with the computer. Basically ,the buses are of three types : data bus, address bus and control bus.



3.11 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q. No. 1 : i) True, ii) True, iii) False, iv) True, v)True, vi)True, vii) True

Ans. to Q. No. 2 : Random Access Memory is known as the main memory of the computer system.

Ans. to Q. No. 3 :

a)	**Volatile Memory**	**Non-volatile memory**
i)	Power is required all the time	i) Power is not required once data is stored
ii)	Temporary storage	ii) Permanent storage
iii)	Normally faster than non-volatile types	iii) Slower than volatile memories.
b)	**Static memory**	**Dynamic memory**
i)	Loses its signal	i) Doesnot lose signal strength
ii)	Periodic refreshing of memory is needed	ii) No refreshing
iii)	Expensive	iii) Cheap
iv)	Used as Cache	iv) Used as main memory

Ans. to Q. No. 4 : The similarity in ROM and PROM is that both write operations which can be performed only once and whatever has been written cannot be changed.

Ans. to Q. No. 5 : a) True, b) True, c) False, d) False, e) True

Ans. to Q. No. 6 : a) Card readers are devices that allow direct data input into a computer system. The electronic-card reader is connected to a computer system and reads the data encoded on an electronic card and transfers it to the computer system for further processing.

b)

	Laser Printer		**Dot Matrix Printer**
i)	High cost	i)	Low cost
ii)	Forms character using laser beam	ii)	Use Dot Matrix to print character
iii)	Non-impact printer	iii)	Impact printer
iiv)	High quality output	iv)	Output is of low quality
v)	Noiseless operation	v)	Noisy
vi)	Cannot produce multiple copies of a single print	vi)	Can produce multiple copies in a single print with the help of carbon paper.

c) An input device (a scanner) is capable of recognizing a pre-specified type of mark made by pencil or pen. Any input data that is of a choice or selection nature can be recorded for OMR input.

d) Printers can be classified into categories based on : printing technology, printing speed, printing quality. Printing technology : Printers can be divided into two types - *impact printers* and *non impact printers*.



3.10 FURTHER READING

1) Ram, B. (2000). *Computer Fundamentals: Architecture and Organization*. New Age International.
2) ITL Education Solutions Limited, & Sargunar, J. (2011). *Introduction to Computer Science*. Pearson Education India.
3) Morris, M. M. (1987). Digital Logic and Computer Design.
4) Sinha, P. K., & Sinha, P. (2010). *Computer Fundamentals* (Vol. 4). BPB publications.



3.12 MODEL QUESTIONS

Q1. Differentiate between a bit and a byte.

Q2. What is computer memory? List the two different categories of memory.

Q3. What is a RAM? What are its two types? Differentiate between them.

Q4. What is a ROM? Why is it called so? List the differenet types of ROMs and their key features.

Q5. What is a cache memory? How is it different from a primary memory?

Q6. Differentiate between

a) PROM and EPROM.

b) Static RAM and Dynamic RAM

Q7. Why are input and output devices necessary for a computer system?

Q8. What are pointing devices? Discuss some of the commonly used pointing devices.

Q9. Explain the different types of printers. Make a clear difference among them in terms of speed, cost, and method of operation.

Q10. What is a bus? List out the main functions performed by buses in a computer system.

Q11. Write short note :

a) RAM b) Light pen

c) MICR d) Scanner

e) Computer Bus

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UNIT 4 : COMPUTER MEMORY AND STORAGE

UNIT STRUCTURE

4.1 Learning Objectives

4.2 Introduction

4.3 Memory Representations

4.4 Memory Hierarchy

4.5 CPU Registers

4.6 Primary Memory

- 4.6.1 Random Access Memory
- 4.6.2 Read Only Memory

4.7 Secondary Memory

4.8 Cache Memory

4.9 Virtual Memory

4.10 Let Us Sum Up

4.11 Answers to Check Your Progress

4.12 Further Reading

4.13 Model Questions

4.1 LEARNING OBJECTIVES

After going through this unit, you will be able to:

- define how memory is represented in computers
- learn about memory hierarchy
- describe the role of CPU registers
- state usefulness of cache memory and virtual memory
- learn about primary memory and secondary memory
- describe RAM and ROM.

4.2 INTRODUCTION

In the previous unit we discussed some hardware components that are essential for a computer system. In this unit we will discuss representation of memory in a computer system and memory hierarchy. Here, we will also discuss primary memory elaborately.

A memory system is a hierarchy of storage devices with different capacities, costs, and access times. Memory hierarchies work because well-written programs tend to access the storage at any particular level more frequently than they access the storage at the next lower level. So the storage at the next level can be slower, and thus larger and cheaper per bit. The overall effect is a large pool of memory that costs as much as the cheap storage near the bottom of the hierarchy, but that serves data to programs at the rate of the fast storage near the top of the hierarchy.

4.3 MEMORY REPRESENTATIONS

Binary digit (or bit) is the smallest unit of memory. A bit is the basic unit of representation of data in a computer. A bit can have only two possible states: 1 or 0. As humans, we may find it useful to think of this in terms of "yes or no", "true or false", "on or off", and so on.

Most computers do not work with bit individually, but instead group 8 bits together to form a byte. One byte can store 2^8, i.e., 256 different combinations of bits, and thus can be used to represent 256 different symbols. In a byte, the different combinations of bits fall in the range 00000000 to 11111111. A group of bytes can be further combined to form a word. A word can be a group of 2, 4 or 8 bytes.

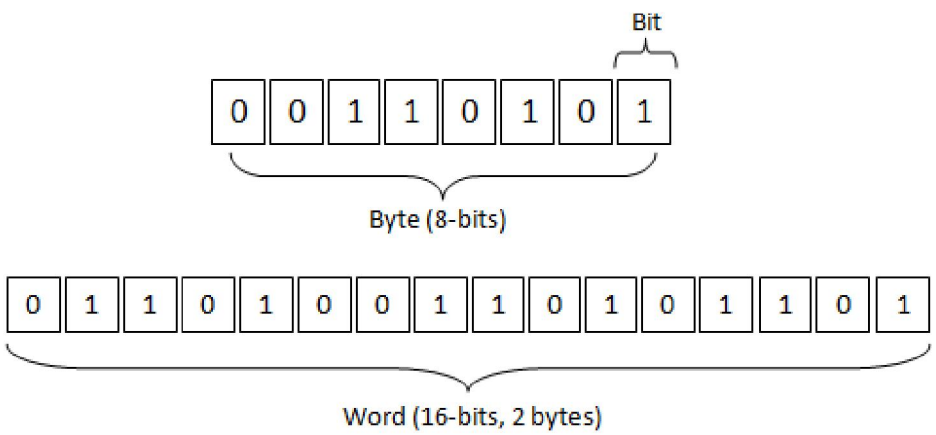


Fig. 4.1: Bit and bytes

One byte = grouping of 8 bits.

For example, 0 1 0 0 0 0 0 1. This one byte can store one letter, e.g., 'A'. The relationship between bit and byte is given below:

1 bit = 0 or 1

1 Byte = 8 bits

1 Kilobyte (KB) = 2^{10} = 1024 Bytes

1 Megabyte (MB) = 2^{20} = 1024 KB

1 Gigabyte (GB) = 2^{30} = 1024 MB = 1024 *1024 KB

1 Terabyte (TB) = 2^{40}= 1024 GB = 1024 * 1024 *1024 KB

1 Petabyte (PB) =2^{50}=1024 TB =1024 * 1024 * 1024 * 1024 KB

The main memory consists of many memory locations, each having a physical address, a code, which the CPU (or other device) can use to access it. For a processor, the range of the memory address is 0 to the maximum size of memory. Figure. 4.2 shows the organization of a 16 MB block of memory for a processor with a 32-bit word length.

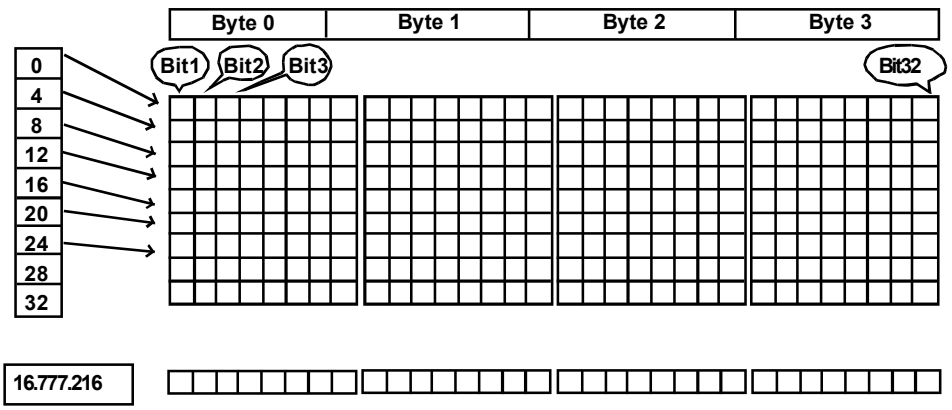


Fig. 4.2: Organization of a 16 MB Block Memory

4.4 MEMORY HIERARCHY

Memory is characterized on the basis of two key factors—storage capacity and access time. Storage capacity is the amount of information (in bits) that a memory can store. Access time is the time required to locate and retrieve stored data from the memory unit in response to a program instruction. The lesser the access time, the faster is the speed of memory. Ideally, the memory with fast access time and large capacity is preferred. However, the cost of fast memory is very high.

The computer uses a hierarchy of memory that is organized in a manner to enable the fastest speed and largest capacity of memory. The hierarchy of the different memory types is shown in Fig.4.3. A memory

hierarchy in computer storage distinguishes each level in the hierarchy by response time.

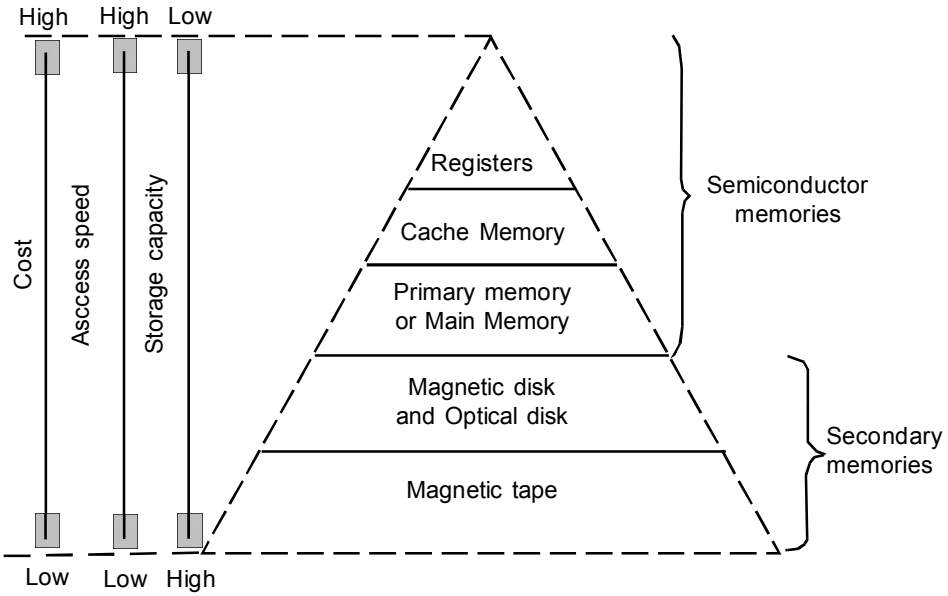


Fig. 4.3: Memory Hierarchy

We can categorize the memory used in a computer as internal and external memory. The internal memory consists of the CPU registers, cache memory and primary memory. The internal memory is used by the CPU to perform the computing tasks.

4.5 CPU REGISTERS

We have heard about CPU registers in Unit 2. A register is a very fast computer memory used to speed up the execution of computer programs by providing quick access to commonly used values inside the CPU. CPU registers are the top of the memory hierarchy, and are the fastest way for the system to manipulate data. In a very simple microprocessor, it consists of a single memory location, usually called an accumulator. Registers are built from fast multi-ported memory cell. The result of ALU operation is stored in registers and could be re-used in a subsequent operation or saved into memory. We have already learnt that registers are usually measured by the number of bits that they can hold. For example, 8-bit register, 32-bit register etc.

Although, the number of registers varies from computer to computer, there are some registers common to all computers. There registers with their role are described below:

a) **Accumulator (A):** It is the most frequently used register. It holds the data to be operated upon, the intermediate results, and the results of processing. It is used during execution of most instructions. Results of arithmetic operations are returned to accumulator register for transfer to main memory through the memory buffer register (MBR). In some computers, there is more than one accumulator.

b) **General Purpose Registers:** General purpose registers are used to store data and intermediate results during program execution. Its contents can be accessed through assembly language programming.

c) **Special Purpose Registers:** Users do not access these registers. These are used by the computer system at the time of program execution. Some types of special purpose registers are given below:

   1) **Memory Address Register (MAR):** It holds the address of the active memory location.

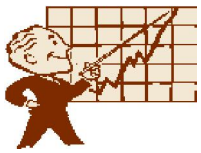
   2) **Memory Buffer Register (MBR):** It holds the contents of the accessed (read/written) memory word. An instruction word placed in this register is transferred to the instruction register. A data word placed in this register is accessible for operation with accumulator register or for transfer to I/O register. A word to be stored in a memory location must be transferred first to MBR from where it is written in memory.

   3) **Instruction Register (IR):** It holds the current instruction being executed. As soon as the instruction is stored in this register, the operation part and the address part of the instruction are separated. The address part of the instruction is sent to MAR while its operation part is sent to control unit. In control unit the operation part is decoded and interpreted. Finally, the CU generates command signals for execution of the task specified in the instruction.

   4) **Program Counter (PC):** It holds the address of the next instruction to be executed. Normally, the instructions of a program are stored

in consecutive memory locations, and are executed in sequence unless a branch instruction is encountered.

5) **Input/output Register (I/O):** It is used to communicate with input/ output devices.



CHECK YOUR PROGRESS

Q.1: Fill in the blanks:

a) A group of 8 bits form a .....

b) Memory is organized as a linear ..... of locations.

c) A memory hierarchy in computer storage distinguishes each level in the hierarchy by .....

d) ..... is the amount of information that a memory can store.

e) ..... is the time interval between the read/write request and the availability of data.

f) A CPU .....is a very fast computer memory used to speed up the execution of computer programs.

g) ..... registers are used to store data and intermediate results during program execution.

4.6 PRIMARY MEMORY

Primary memory (or main memory) is the area of a computer from which the processor can store and retrieve data very quickly. It is active only while the computer is switched on. Every computer should have a primary memory which is a temporary storage area built into the computer hardware. Instructions and data of a program reside mainly in this area when CPU is executing the program. The rate of data fetching from primary memory is about 100 times faster than that from a high speed secondary storage like disk.

Physically, primary memory consists of some integrated circuit (IC) chips either on the motherboard or on a small circuit board attached to the motherboard of a computer system. Primary memory is made up of several

small storage areas called locations or cells. Each of these locations can store a fixed number of bits called word length of the memory. Each word or location has a built-in and unique number assigned to it. This number is called the address of the location and is used to identify the location. For example, if a memory has 1024 locations, then the address ranges from 0 to 1023. We have also heard about 8-bit computers, 16-bit computers, 32-bit computers, 64-bit computers, etc. The numbers refer to the total numbers of bits per memory word. More bits mean more rapid flow of electronic signal and this implies a faster computer. Main memory capacity is defined in terms of number of bytes a computer system can store.

There are two main categories of primary memory. These are:

- **Random Access Memory** (RAM), and
- **Read Only Memory** (ROM)

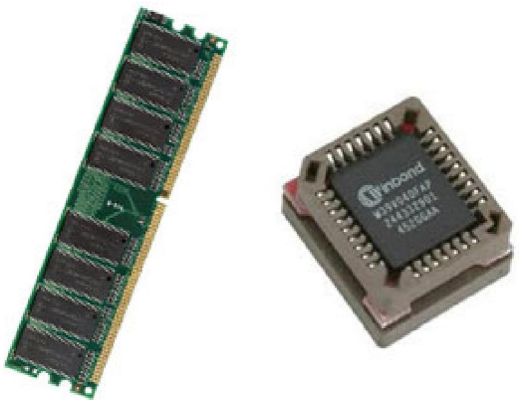


Fig. 4.4: RAM and ROM

4.6.1 Random Access Memory

Random Access Memory (RAM) is used to store data and instructions during the operation of a computer. The data and instructions that need to be operated upon by the CPU are first brought to RAM from the secondary storage devices like the hard disk. RAM loses its information when the computer is powered off. It is a type of volatile memory. When the power is turned on again, all the files that are required by the CPU are loaded from the hard disk to RAM. Since RAM is volatile memory, any information that needs to be saved for a longer duration of time must not be stored

in RAM. RAM provides random access to the stored bytes, words, or larger data units. This means that it requires the same amount of time to access information from RAM, irrespective of where it is located inside it. The size of RAM is limited due to its high cost. The size of RAM is measured in Megabytes or Gigabytes. The performance of RAM is affected by–

- Access speed (how quickly information can be retrieved). The speed of RAM is expressed in nanoseconds.
- Data transfer unit size (how much information can be retrieved in one request).

RAM typically contains portions of the operating system as well as applications and data in active or frequent use. A part of the operating system is loaded in the primary memory when the computer is turned on, and it stays there until the computer is turned off. RAM is also used for the temporary storage of input data, output data and intermediate results. The input data entered into the computer using the input device is stored in RAM for processing. After processing, the output data is stored in RAM before being sent to the output device. Any intermediate results generated during the processing of program are also stored in RAM.

RAM affects the speed and power of a computer. The more the amount of RAM available in a machine the better is its performance. Now a days computers with 1GB, 2GB, 4 GB or more are available in the market.

4.6.2 Read Only Memory

Read Only Memory (ROM) is a non-volatile memory chip in which data is stored permanently and cannot be altered by usual programs. Once data has been written onto a ROM chip, it cannot be removed/changed and can only be read. This is the reason why it is called read-only memory (ROM). ROM comes programmed by the manufacturer so that they cannot be modified by the users. ROM stores special micro-programs that permanently reside inside it.

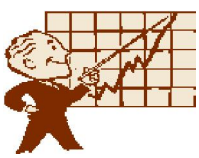
A good example of micro-program is "system boot program" which contains a set of start-up instructions to check if the system hardware like memory, I/O devices, etc. is functioning properly. It looks for an operating system and loads its core part in the volatile RAM of the system to produce the initial display-screen prompt. ROM stores the data needed for the start up of the computer.

ROM is categorized in the following two ways:

- **Manufacturer-programmed** and
- **User-programmed**

Manufacturer-programmed ROM chips are supplied by the manufacturers of electronic devices and it is not possible for a user to modify the programs or data stored in ROM chip.

On the other hand, a user-programmed ROM is one in which a user can load and store read-only programs and data. Such a ROM is commonly known as ***Programmable Read-Only Memory (PROM)*** because a user can program it. Once a user's programs are stored in a PROM chip, PROM becomes a ROM. Contents of ROM and PROM cannot be altered. In ***Erasable Programmable Read-Only Memory (EPROM),*** it is possible to erase information stored in an EPROM chip and the chip can be reprogrammed to store new information. A content of EPROM can be erased by exposing it to ultra violet light and reprogramming it.



CHECK YOUR PROGRESS

Q.2: Fill in the blanks:

a) ..... memory transparently stores data so that future requests for that data can be served faster.

b) Hardware implements cache as a block of memory for ..... of data likely to be used again.

c) ..... loses its information when the computer is powered off.

d) The more the amount of RAM available in a machine the better is its .....

e) ..... is defined as the computer memory on which data has been prerecorded.

4.7 SECONDARY MEMORY

Secondary Memory, also known as secondary storage, auxiliary memory or external memory is used primarily to store large volumes of data on permanent basis for a longer period of time in a computer system. Those data can be partially transferred to primary storage whenever required for processing. Secondary storage does not lose any data when the computer is powered down. It is non-volatile and has lower cost per bit stored as compared to primary storage. But it generally has an operating speed far slower than that of primary storage. Secondary storage differs from primary storage since it is not directly accessible by the CPU.

The most common form of auxiliary memory devices used in consumer systems is flash memory, optical discs, and magnetic disks.

4.8 CACHE MEMORY

Fetching of data by the CPU from the main memory is about 100 times faster than that from a secondary storage like disk. Main memory helps in minimizing the mismatched of processor-disk speed to a large extent. Even with the use of main memory, there is a mismatch of speed between the processor and memory. The rate at which the data can be fetched from memory is about 10 times slower than the rate at which CPU can process data.

Cache memory is used to overcome this problem. It minimizes the processor-memory speed mismatch. Cache memory is an extremely fast, small memory between CPU and main memory whose access time is closer to the processing speed of CPU. It is used to temporarily store very active data and instructions during processing. It is made up of static RAM and it acts as high-speed buffer between CPU and main memory.

4.9 VIRTUAL MEMORY

Virtual memory is a memory management technique that is implemented using both hardware and software. It maps memory addresses used by a program, called virtual addresses, into physical addresses in computer memory. Main storage as seen by a process or task appears as a contiguous address space or collection of contiguous segments. The operating system manages virtual address spaces and the assignment of real memory to virtual memory. Address translation hardware in the CPU, often referred to as a memory management unit or MMU, automatically translates virtual addresses to physical addresses. The primary benefits of virtual memory include freeing applications from having to manage a shared memory space, increased security due to memory isolation, and being able to conceptually use more memory than might be physically available, using the technique of paging.



4.10 LET US SUM UP

- ***Primary memory*** is the area of a computer from which the processor can access data quickly.
- ***Computer memory*** stores different kinds of data like input data, output data, intermediate results, etc., and the instructions.
- The ***internal memory*** and ***external memory*** are the two broad categories of memory used in the computer.
- ***Registers*** are built from fast multi-ported memory cell.
- ***RAM i***s used to store data and instructions during the operation of a computer.
- ***RAM*** can be read from and written to with the same speed.
- Once data has been written onto a ***ROM*** chip, it cannot be removed and can only be read.
- ***Cache memory*** is a very fast memory which is used to minimize the processor-memory speed mismatch.



4.11 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q. No. 1: a) byte, b) array, c) response time, d) Capacity, e) Access time, f) register, g) General purpose

Ans. to Q. No. 2: a) Cache, b) temporary storage, c) RAM, d) performance, e) ROM.



4.12 FURTHER READING

1) Rajaraman, V. & Adabala, N. (2014): *Fundamentals of Computers*; PHI Learning Pvt. Ltd.
2) Sinha, P. K. & Sinha, P. (2010): *Computer Fundamentals* (Vol. 4); BPB publications.
3) Thareja, R. (2012): *Computer Fundamentals & Programming in C*; OXFORD University Press.



4.13 MODEL QUESTIONS

Q.1: Write a note on memory representation in computers.

Q.2: Describe the memory hierarchy in computers.

Q.3: What are CPU registers? Describe the different classes of registers.

Q.4: What is cache memory? Describe its usefulness.

Q.5: What is Primary Memory in a computer? Describe its functionality.

Q.6: What is the use of Random Access Memory? What are its types?

Q.7: Differentiate between Static Ram and Dynamic Ram.

Q.8: What is Read Only Memory? What are its different types?

Q.9: What is the advantage of using virtual memory?

*** ***** ***

UNIT 5: BUSES

UNIT STRUCTURE

5.1 Learning Objectives

5.2 Introduction

5.3 Bus Structure

- 5.3.1 Address Bus
- 5.3.2 Data Bus
- 5.3.3 Control Bus

5.4 Types of Buses

- 5.4.1 ISA (Industry Standard Architecture) Bus
- 5.4.2 PCI (Peripheral Component Interconnect) Bus
- 5.4.3 EISA (Extended Industry Standard Architecture) Bus
- 5.4.4 VESA (Video Electronics Standards Association) Local Bus
- 5.4.5 MCA (Micro Channel Architecture) Bus

5.5 Let Us Sum Up

5.6 Answers to Check Your Progress

5.7 Further Reading

5.8 Model Questions

5.1 LEARNING OBJECTIVES

After going through this unit, you will be able to:

- learn the concept of bus and its function
- describe internal bus and external bus system and its architecture
- define the characteristics of various buses
- describe the categories of different buses and their uses.

5.2 INTRODUCTION

A typical computer system is composed of various components such as Central Processing Unit (CPU), Memory Unit and Input/Output (I/O) devices. A bus is a common pathway or a set of wires that interconnect these various subsystems. The buses thus allow the different components to

communicate each others. Actually, a bus in a computer system is a channel or parallel lines over which information flows between units or devices. Buses that transfer several data bits at the same are called parallel buses, for example ISA, PCI, VESA are parallel buses. Serial buses use the same line to transfer the different data bits of the same byte or words for example USB. There are generally three set of parallel lines or buses that are found. These are– (i) Address Bus, (ii) Data Bus and (iii) Control Bus.

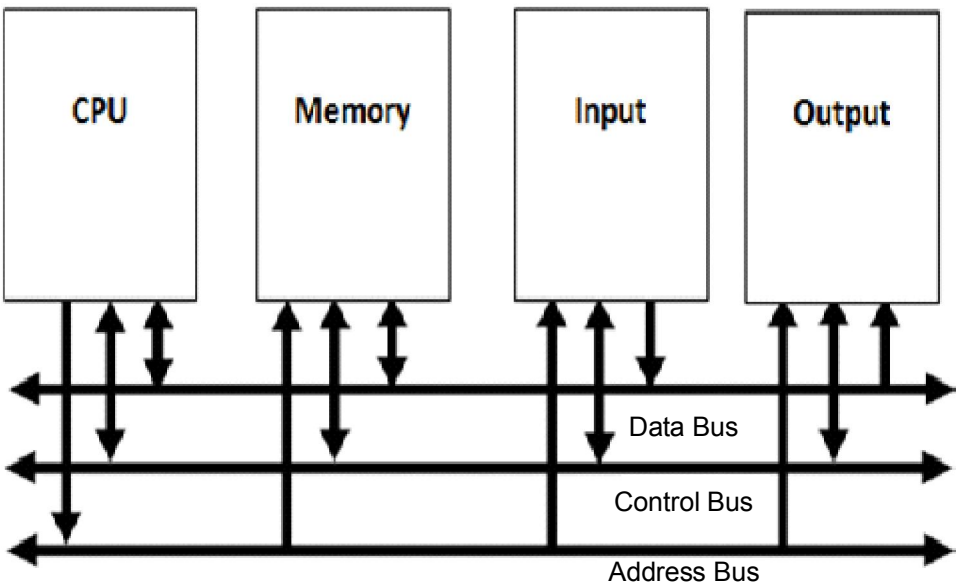


Fig. 5.1: Three Buses Architecture

5.3 BUS STRUCTURE

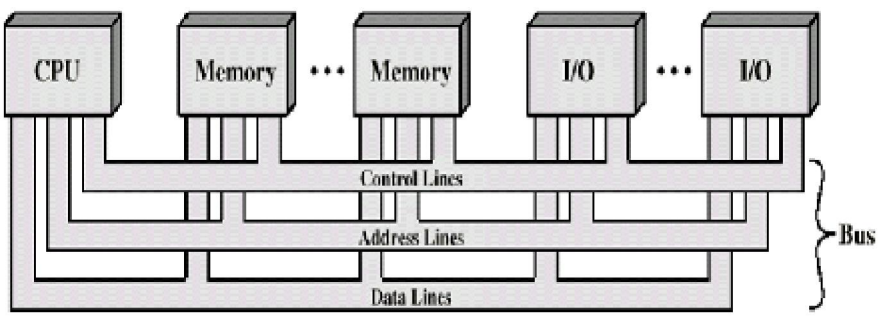


Fig. 5.2: Bus Interconnection Scheme

5.3.1 Address Bus

Through the address bus the processor issues the address of the instruction byte or word to the memory system. As CPU needs

to read an instruction or data from a given location in memory. With the help of address bus CPU identifies the source or destination of data. The bus width determines the maximum memory capacity of the computer system. For example, a 32-bits address bus fetches the instruction or data from an address specified by a 32-bit number. Some other features of address bus are:

- The address bus consists of 16, 20, 24, or 32 parallel signal lines. On these lines the CPU sends out the address of the memory location that is to be written to or read from.
- The number of memory locations that the CPU can address is determined by the number of address lines. If the CPU has N address lines, then it can directly address 2N memory locations. CPU with 16 address lines can address 65,536 memory CPU with 20 address lines can address 1,048,576 locations.
- When the CPU reads data from or writes data to a port, it sends the port address out on the address bus.

5.3.2 Data Bus

The function of a data bus is to send data from one device to another. Data is passed in a serial or a parallel manner. In serial bus communication one bit data is passed per unit time and in parallel, normally multiple of 8 bits passes per unit time. Parallel data bus is faster than the serial bus but it requires an extra handshaking line to synchronize the data transfer. Some important features of data buses are–

- The data bus consists of 8, 16, or 32 parallel signal lines. The data bus lines are bidirectional.
- Many devices in a system will have their outputs connected to the data bus, but only one device at a time will have its outputs enabled.
- Any device connected on the data bus must have three-state outputs so that its outputs can be disabled when it is not being used to put data on the bus.

5.3.3 Control Bus

The control bus issues the signal to control the timing of various actions during interconnection. Also it signals to synchronize the subsystem. Control bus control signals as per CPU design. Some other characteristics of control bus are:

- The control bus consists of 4 to 10 parallel signal lines.
- The CPU sends out signals on the control bus to enable the outputs of addressed memory devices or port devices.
- Typical control bus signals are Memory Read, Memory Write, I/O Read, and I/O Write.
- To read a byte of data from a memory location, the CPU sends out the memory address of the desired byte on the address bus and then sends out a Memory Read signal on the control bus.
- The Memory Read signal enables the addressed memory device to output a data word onto the data bus. The data word from memory travels along the data bus to the CPU.

5.4 TYPES OF BUSES

Today all computers utilize two types of buses, an internal or local bus and an external bus.

An internal bus enables a communication between internal components such as a computer video card and memory (e.g. ISA, EISA, PCI, AGP, etc.)

An external bus is capable of communicating with external components such as a SCSI bus, GPIB, etc.

A computer or devices bus speed or throughput is always measured in bits per second or megabytes per second.

A bus is not only a cable connection but also can be a hardware (bus architecture), protocol, software, and bus controller.

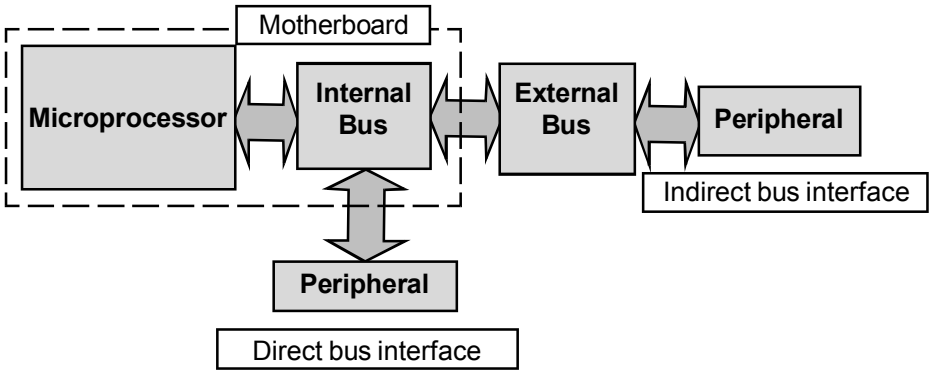


Fig. 5.3: Internal and External Bus

5.4.1 ISA (Industry Standard Architecture) Bus

Introduced by IBM, ISA or Industry Standard Architecture bus was originally an 8-bit bus that was later expanded to a 16-bit bus in 1984. In 1993, Intel and Microsoft introduced a PnP ISA bus that allowed the computer to automatically detect and setup computer ISA peripherals such as a modem or sound card.

Using the PnP technology an end-user would have the capability of connecting a device and not having to configure the device using jumpers or dipswitches.

Many manufacturers are trying to eliminate the usage of the ISA slots however for backwards compatibility you may find 1 or 2 ISA slots with additional PCI slots.

5.4.2 PCI (Peripheral Component Interconnect) Bus

Introduced by Intel in 1992, PCI is short for Peripheral Component Interconnect and is a 32-bit computer bus that is also available as a 64-bit bus today. The PCI bus is the most commonly used and found bus in computers today.

Mini PCI is a new standard developed by leading notebook manufacturer. This technology could allow manufactures to lower their price as the motherboards would be simpler in design.

At least 3 or 4 PCI connectors are generally present on motherboards and can generally be recognized by their standardized white color.

The PCI interface exists in 32 bits with a 124-pin connector, or in 64 bits with a 188-pin connector. There are also two signaling voltage levels for PCI connectors:

i) 3.3V, for laptop computers

ii) 5V, for desktop computers

The signaling voltage does not equal the voltage of the motherboard power supply but rather the voltage threshold for the digital encryption of data.

The original version of the PCI bus is 32-bits wide and has a clock speed of 33 MHz, which allows it to theoretically provide a throughput of 132 Mb/s on 32 bits. On 64-bit architectures, the bus operates on 64 bits and offers a theoretical throughput of 264 Mb/s.

PCI-X is a high performance bus that is designed to meet the increased I/O demands of technologies such as Fiber Channel, Gigabit Ethernet and Ultra3 SCSI.

PCI-X capabilities include:

– Up to 133 MHz bus speed

– 64-Bit bandwidth

– 1GB/sec throughput

PCI-X uses register-to-register protocol and can operate at three different frequencies

i) 66 MHz

ii) 100 MHz

iii) 133 MHz

Connection between ISA and PCI Buses: One of the PCI slots is placed close to one ISA slot and share the (but not at the same time) a back-plate. Some motherboards only offer two ISA slots and as many as five PCI slots.

5.4.3 EISA (Extended Industry Standard Architecture) Bus

Short for Extended Industry Standard Architecture, EISA was announced in September of 1988. EISA is a computer bus designed by 9 competitors to compete with IBM's MCA BUS.

The EISA Bus provide 32-bit slots at an 8.33 MHz cycle rate for the use with 386DX, or higher processors.

EISA Bus never became widely used and is no longer found in computers today. EISA data transfer can reach a peak of 33 megabytes per second

5.4.4 VESA (Video Electronics Standards Association) Local Bus

VESA (Video Electronics Standards Association Local Bus) Local Bus is a standard interface between your computer and its expansion slots that provides faster data flow between the devices controlled by the expansion cards and your computer's microprocessor. A ‘‘Local Bus’’ is a physical path on which data flows at almost the speed of the microprocessor, increasing total system performance. VESA Local Bus is particularly effective in systems with advanced video cards and supports 32-bit data flow at 50 MHz. A VESA Local Bus is implemented by adding a supplemental slot and card that aligns with and augments an ISA expansion card.

VESA is a 33MHz extension of the ISA Bus used for high-speed data transfer applications. It contains 32-bit address and Data Bus and is mainly used for video and disk interfaces. It requires a third connector (VESA connector) to be added behind the standard 16-bit ISA connector.

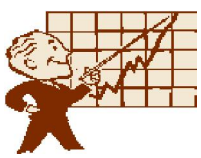
5.4.5 MCA (Micro Channel Architecture) Bus

Short for Micro Channel Architecture i.e., MCA was introduced by IBM in 1987, The MCA Bus offered several additional features over the ISA such as a 32-bit Bus.

The MCA BUS never became widely used and has since been phased out of the desktop computers.

Table 5.1: Various Buses and its Width, Speed and Bandwidth

BUS	Width (bits)	BUS Speed (MHz)	BUS Bandwidth (Mbytes/sec.)
8-bit ISA	8	8.3	7.9
16-bit ISA	16	8.3	15.9
EISA	32	8.3	31.8
VLB	32	33	127.2
PCI	32	33	127.2
64-bit PCI 2.1	64	66	508.6
AGP	32	66	254.3
AGP (×2 mode)	32	66×2	508.6
AGP (×4 mode)	32	66×4	1,017.3



CHECK YOUR PROGRESS

Q.1: Select the correct option from the following questions:

i) Which is the example of serial bus in computer system–

a) ISA b) PCI

c) VESA d) USB

ii) The control bus consists of parallel signal lines–

a) 4 to 10 b) 8 to 16

c) 6 to 10 d) None of the above

iii) A bus which is 33MHz extension of the ISA bus used of high-speed data transfer applications–

a) VESA b) PCI

c) USB d) ISA

iv) The Bus MCA Stands for–

a) Micro Channel Architecture

b) Master Channel Architecture

c) Macro Channel Architecture

d) Mini Channel Architecture

v) The original version of the PCI bus has–

a) 16-bits wide, clock speed of 33 MHz

b) 32-bits wide, clock speed of 33 MHz

c) 64-bits wide, clock speed of 33 MHz

d) 32-bits wide, clock speed of 64 MHz

vi) The EISA bus supports–

a) 16-bits wide, clock speed of 33 MHz

b) 32-bits wide, clock speed of 33 MHz

c) 64-bits wide, clock speed of 33 MHz

d) 32-bits wide, clock speed of 8.3 MHz



5.5 LET US SUM UP

- A bus is a common pathway or a set of wires that interconnect these various sub systems. The bus thus allows the different components to communicate with each others
- There are generally three set of parallel lines or buses. These are– (i) Address Bus, (ii) Data Bus and (iii) Control Bus.
- Data bus transfer data from and to processor. Function of a data bus is to send data from one device to another.
- Address bus issues the address from processor to address memory and I/O system. Through the address bus, processor issues the address of the instruction byte or word to the memory system.
- Control bus issues the signal to control the timing of various actions during interconnection.
- An internal bus enables communication between internal components such as a computer video card and memory (e.g. ISA, EISA, PCI, AGP, etc.)



5.6 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q. No. 1: i) (d), ii) (a), iii) (a), iv) (c), v) (b), vi) (d)



5.7 FURTHER READING

1) Godse, A. P. & Godse, D. A. (2009): *Computer Organization*; Technical Publications.

2) Hamacher, C., Vranesic, Z. & Zaky, S. (2002): *Computer Organization*; McGraw-Hill.

3) Stallings, W. (2000): *Computer Organization and Architecture: Designing for Performance*; Pearson Education India.



5.8 MODEL QUESTIONS

Q.1: What do you mean by Bus? Explain different categories of buses in Computer architectures,

Q.2: How do internal buses differ from external buses?

Q.3: What is PCI Bus? Explain its significance in computer system.

Q.4: What are the advantages of VESA buses?

Q.5: Write short notes on the followings:

i) ISA Bus ii) USB Bus

iii) EISA Bus iv) PCI-X Bus

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UNIT 6: INTRODUCTION TO SYSTEM SOFTWARE

UNIT STRUCTURE

6.1 Learning Objectives

6.2 Introduction

6.3 Compiler

6.4 Assembler

6.5 Linker

6.6 Loader

6.7 Editor

6.8 Let Us Sum Up

6.9 Answers to Check Your Progress

6.10 Further Reading

6.11 Model Questions

6.1 LEARNING OBJECTIVES

After going through this unit, you will be able to:

- describe about application software and system software
- learn about low level and high level language
- describe the translation of a high level language program into a machine level language program
- learn how a program gets executed by the computer
- describe the task performed by complier, assembler, linker, loader and editor.

6.2 INTRODUCTION

The computer system performs various tasks with the help of hardware and software. The hardware of a computer system is the part we can see and touch. On the other hand software is the set of computer code or program written to perform a particular task. These software's are broadly of two types– Application Software and System Software. Software's such

as MS Office package, Internet Browser, Oracle DBMS, MySQL etc. those take care of some real world problems are called Application Software. On the other hand, software's such as UNIX OS, Windows OS, Android OS, C Compiler etc., those help users to run the application software in the computer are called System Software.

As we know that the computer performs different tasks as commanded by the user so to provide a command or a set of commands, the user has to write a set of code or a program. The program written by the user should be understandable by the computer system so as to perform the task accordingly. The computer can understand only binary language that is the language comprising of 0s and 1s also called machine language. Thus the user has to write the program in this computer understandable machine language. Since writing programs in machine language is difficult, time consuming and not easily understandable by human users it was required to write the programs in a different language other than machine language. Those other languages are assembly language and high level languages. But the programs written in assembly language and other high level languages are not directly understandable by the computer. To solve this problem, we need assembler, compiler and interpreter. They translate assembly language and high level languages to machine understandable language.

6.3 COMPILER

The compiler is a computer program that translates source code from a high-level programming language to a lower level programming language (e.g., assembly language or machine code).

The codes generated by the compiler are machine specific (the code generated in a particular computer system does not work in other computer system). If the code generated by the compiler can be executed on a computer whose CPU or operating system is different from the one on which the compiler runs, the compiler is known as a cross-compiler.

Often the process of compiling a program includes the task of compiler, assembler and linker. During this process of compiling a program, problems

may arise which are reported to the user by compiler message. There are two types of compiler messages- Compiler Warnings and Compiler Errors. A compiler warning indicates that you have done something bad but not something that will prevent the code from being compiled. On the other hand a compiler error indicates something that must be fixed before the code can be compiled.

The compiler is a component of the language processing system as shown in Figure 6.1. In a language processing system, the source program goes through a preprocessor. For example, when we write a C program, we have a number of macros such as hash define, hash include and so on. These are passed through the preprocessor. The preprocessor expands these macros and takes appropriate action at the compiler level. This modified source code is then fed to the compiler. The compiler generates the machine code. The machine code could be in the form of an assembly code or it could be directly binary code. In the case that the machine code generated by the compiler is an assembly language program, it is fed to an assembler. The assembler converts it into the machine language of target machine.

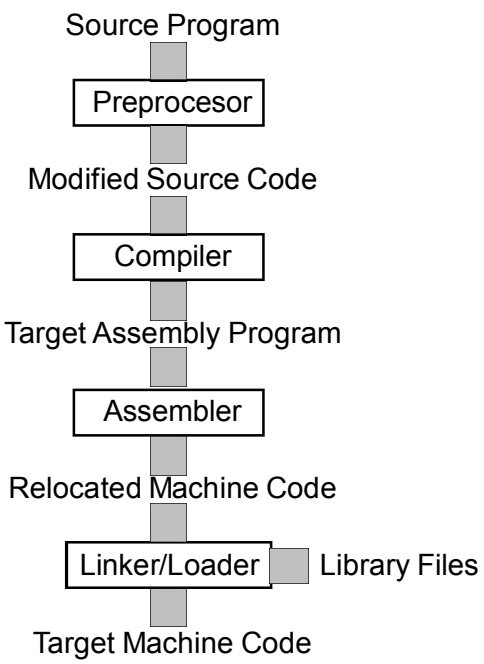


Fig. 6.1: Language Processing System

The linker or loader is needed in order to combine the modules generated by the assembler. Finally, the loader gives out a complete target machine code that can be run on a machine.

Compilation of a program proceeds through a fixed series of phases. Each phase use an (intermediate) form of the program produced by a previous phase. Subsequent phases operate on lower-level code representations.

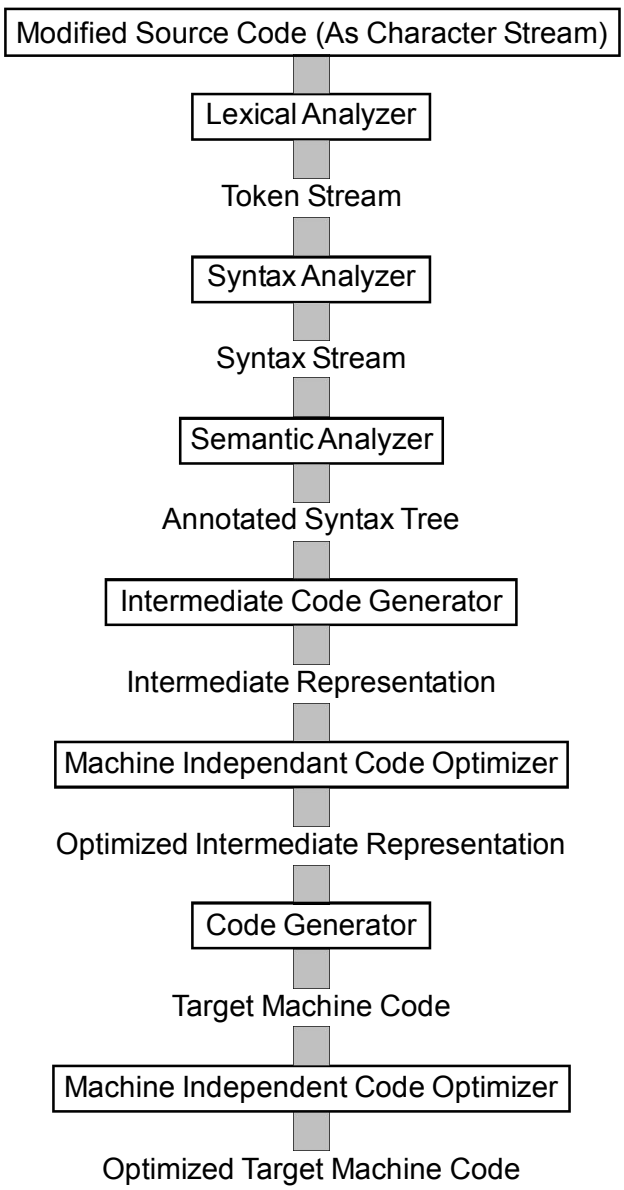
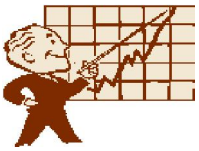


Fig. 6.2: Block Diagram of Phases of Compiler

As shown in Figure 6.2, the compiler has the following phases–

- Lexical analyzer
- Syntax analyzer
- Semantic analyzer
- Intermediate code generator
- Machine independent code optimizer
- Code generator
- Machine dependent code optimizer.

- **Lexical Analyzer** takes the program, which is given in the form of characters. The characters are all read from a file and then the lexical analyzer divides it into a token stream. The token stream is then fed to a syntax analyzer.
- **Syntax Analyzer** checks whether the syntax of the program according to the programming language rules are all satisfied. If they are satisfied, it produces a syntax stream; otherwise, it gives error. The syntax stream is then fed to a semantic analyzer.
- **Semantic Analyzer** checks the mistakes that are not taken care of by the previous phase, and then if everything is right, it produces annotated syntax tree. The annotations are nothing but the semantic information of the program such as what are the symbol names, what are the various constant values and so on. These are all fed to the intermediate code generator.
- **Intermediate Code Generator** produces an intermediate representation.
- **Machine Independent Code Optimizer** makes necessary improvements of the intermediate representation. Then, the optimized intermediate representation is fed to the code generator.
- The **Code Generator** actually is specific to every machine. It converts the optimized intermediate representation into target machine code.
- The **Machine Dependent Code Optimizer** takes the machine code generated by the previous phase. Finally, all possible improvements are made to on the target machine code and we get a very compact optimized target machine code.



CHECK YOUR PROGRESS

Q.1: Can you execute application software without system software?

6.4 ASSEMBLER

The assembler is a computer program that translates assembly language programs into object files. The object files contain a combination of machine language codes, data and information needed to load these instructions properly into the memory.

To assemble a program automatically the assembler needs information in the form of assembler directive that controls the process of assembling the program. The assembler directives are the commands placed in the program by the designer that provides information to the assembler. These directives neither become a part of the final program nor translate into executable code. Therefore, they are also known as pseudo instruction or false instructions.

Each assembler has its own unique pseudo instruction written in assembly language format.

6.5 LINKER

The linker is a computer program or tool that resolves the references and merges the object files produced by separate compilation or assembly and creates an executable file (As shown in Figure 6.3). The linker also searches the program to find library routines or functions used by program. It also determines the memory location that is going to be occupied by the instructions in the program and relocates the instructions accordingly. During this process of linking, if some function or library function that is needed by the program cannot be found then, linker error is generated.

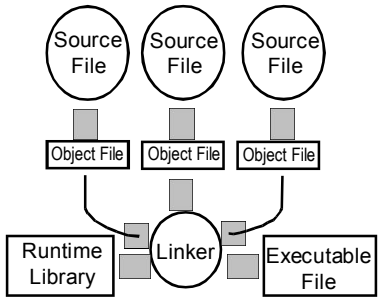


Fig. 6.3: Block Diagram of Linker

6.6 LOADER

The loader is a part of the operating system that brings an executable file residing on the secondary memory into the main memory to start its execution.

The loader basically reads executable file to determine the size the required memory and creates the address space for the program and copies the instructions and data into the address space. It also copies the arguments passed to the program on the stack and initializes the machine registers including the stack pointer. Finally the loader calls the program's main function to start execution. During the execution of the program, if any error occurs that is termed as run time error. Run time errors are fatal error and logical error. Fatal error occurs when the executable file crashes or when the program tries to access illegal memory, which the program is not allowed to use or that doesn't exist in the computer.

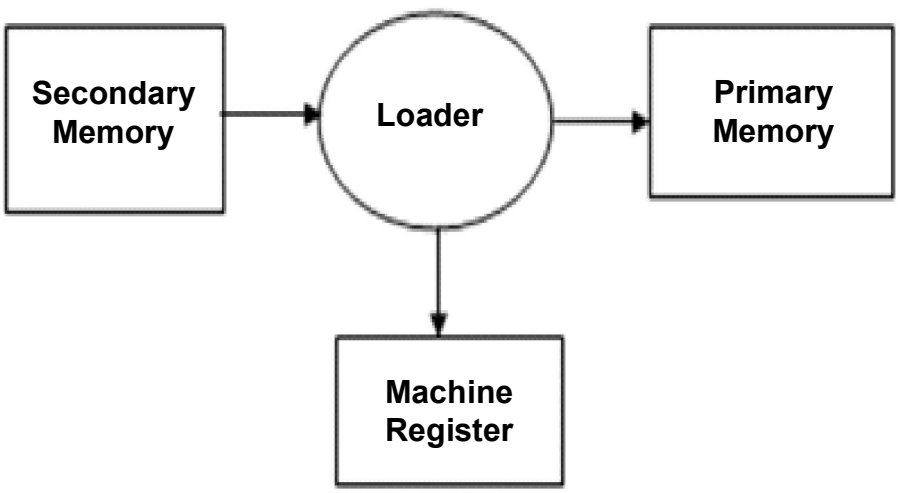
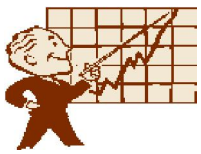


Fig. 6.4: Block Diagram of Loader

6.7 EDITOR

Editor is a computer program that enables the user or programmer to create and modify the source program. An editor may be a standalone application (not a part of the compiler) or it may be a part of an integrated development environment (IDE) or web browser.



CHECK YOUR PROGRESS

Q.2: Why do we need an assembler?

Q.3: Who links the library functions (e.g. printf(), scanf() in C language) to the original program?

Q.4: Who places the machine codes of the program into the main memory?



6.8 LET US SUM UP

- System Software helps to run the application software in the computer system.
- Machine language comprises of 0s and 1s. It is the only language directly understandable by the computer.
- The compiler translates high-level programming language to a lower level programming language.
- The assembler translates assembly language to machine language.
- The linker creates an executable file by merging the object files produced by separate compilation or assembly.
- The loader loads an executable file residing on the secondary memory into the main memory to start its execution.



6.9 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q. No. 1: No, we cannot run application software without the help of system software. Without installing system software in the

computer, the necessary compiler, linker and loader will not be available to support the application software's.

Ans. to Q. No. 2: Assembler is used to translate assembly language to machine level language.

Ans. to Q. No. 3: The Linker links the library functions (e.g. printf(), scanf() in C language) to the original program.

Ans. to Q. No. 4: The Loader places the machine codes of the program into the main memory. The size of the memory required to place the machine codes is estimated by the assembler during the generation of the object code.



6.10 FURTHER READING

1) Dhamdhere, D. M. (1999): *Systems Programming and Operating Systems*; Tata C McGraw-Hill
2) Dhamdhere, D. M. (1986): *Introduction to System Software*; Tata McGraw-Hill Pub.



6.11 MODEL QUESTIONS

Q.1: What is application software and system software?

Q.2: Why do we need system software?

Q.3: What is language processing system?

Q.4: What is Compiler?

Q.5: What are the different phases of a compiler?

Q.6: Briefly describe the task of different phases of a compiler.

Q.7: What is an assembler?

Q.8: What is pseudo code?

Q.9: Describe the task of linker in the process of compilation.

Q.10: Describe the task of loader in the process of compilation.

*** ***** ***

UNIT 7: INSTRUCTION TYPES

UNIT STRUCTURE

7.1 Learning Objectives

7.2 Introduction

7.3 Instruction Format

7.4 Different Types of Instruction Format

7.5 Bit Manipulation Instructions

7.6 Data Transfer Instructions

7.7 Let Us Sum Up

7.8 Answers to Check Your Progress

7.9 Further Reading

7.10 Model Questions

7.1 LEARNING OBJECTIVES

After going through this unit, you will be able to:

- learn about instruction format
- describe the different types of instruction format
- explain bit manipulation
- learn about data transfer instruction.

7.2 INTRODUCTION

In this unit we shall be able to learn about instruction format and its different types including bit manipulation and data transfer instructions.

A microprocessor is a chip that performs all the essential functions of the central processor unit (CPU) in a computer. ‘‘The function of a microprocessor system is implemented by a sequence of data transfer between register in the memory and the microprocessor as well as between register in the memory and input/output devices as shown in Figure 7.1.’’ The data transformation occurs primarily in register within the microprocessor. Each programmable register in the memory has an address, allowing it to be singled out for use in a data transfer or transformation.

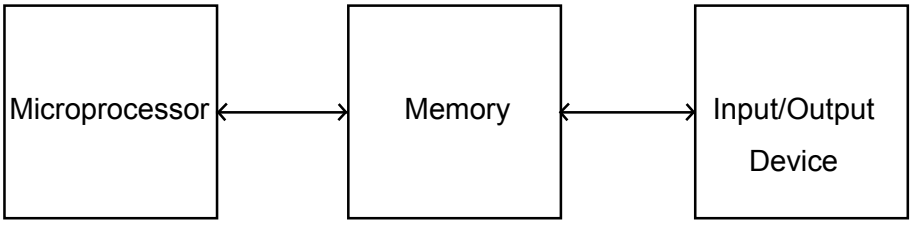


Fig. 7.1: Data transfer between Memory and Microprocessor, I/O Device

The types of individual transfer and transformation possible are specified by the microprocessor instruction sets. Each instruction in the set causes one or more data transfer or transformation. A sequence of such instructions consist a program.

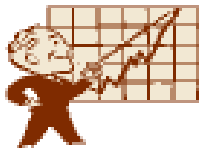
7.3 INSTRUCTION FORMAT

Computer instructions are the basic components of a machine language program. A machine instruction has an Operation Code (also called opcode) and zero or more operands. The opcode denotes the type of operation that is going to be performed by the microprocessor and the operands are the data on which the respective operation will be performed. Based on the architecture of the microprocessor- the number of bits allowed per instruction, the number of operands allowed per instruction, the types of instructions and data it can process are different.

More specifically, the instruction sets are differentiated by the following features:

- Operand storage in the CPU (data can be stored in a stack structure or in registers)
- Number of explicit operands per instruction– zero, one, two and three.
- Operand location (e.g. In register-memory instructions, operands are fetched into the registers from the memory. In typical register-register instructions, operands are fetched from the registers. In memory-memory instructions, operands are read from the memory and stored in registers then again write in a different memory location)
- Operation (Based on the type of operation performed or based on whether the instructions are allowed to access memory and not)

- Type and size of operands (Whether the operand is an addresses or numbers or some other format of data)



CHECK YOUR PROGRESS

Q.1: How can you differentiate the instruction sets?

Let us now see what could be the different types of instruction format.

7.4 DIFFERENT TYPES OF INSTRUCTION FORMAT

The most common instruction formats include zero, one, two or three operands. Arithmetic and logical operations typically have two operands but can be executed with one operand if the accumulator is implicit (i.e. if the other operand is present in accumulator). We can extend this idea to three operands if we consider the final destination as a third operand. We can also use a stack that allows us to have zero operand instructions. The following are some common instruction formats:

- **OPCODE only** (zero address)

Opcode

  e.g.

  NOP (defined as: no operation)

- **OPCODE + 1 Address** (usually a memory address)

Opcode	Address 1

  e.g.

  LDA ADDR

  (defined as: LOAD ACCUMULATOR DIRECT. Which means, the content of the memory location ADDR is loaded into the accumulator)

- **OPCODE + 2 Addresses** (usually both registers or one is register and the other one is memory address)

Opcode	Address 1	Address 2

  e.g.

MOV r1,r2

(defined as: MOVE. Which means, move the contents of the register r2 into register r1)

- **OPCODE + 3** Addresses (usually registers or combinations of registers and memory)

Opcode	Address 1	Address 2	Address 3

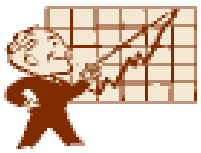
e.g.

ADD r1, r2, r3

(defined as: Addition. Which means, the contents of the registers r2 and r3 are added and the result is stored in register r1)

The above 4 instruction formats are obtained based on the number of operands used. While on the basis of other features, instructions can further be classified as:

- Data transfer instructions
- Arithmetic instructions
- Branch instructions
- Boolean instructions
- Logical instructions



CHECK YOUR PROGRESS

Q.2: What are the different types of instruction format?

Q.3: What are the different types of instructions?

7.5 BIT MANIPULATION INSTRUCTIONS

A bit is the smallest unit of digital data. It has binary value either 0 or 1. The bit manipulation instructions are used to modify bit level data or binary data. They are mainly classified as:

1) Logic Instructions
2) Shift Instructions
   a) Logical Shifts
   b) Arithmetic Shifts

3) Rotate Instructions

1) Logic Instructions: The instructions which are used to support logical expressions by performing bitwise AND, OR, XOR and NOT operations are called logic instructions.

e.g. AND, OR, XOR, NOT

2) Shift Instructions: Shift instructions are generally used to shift the bits either to the left or right depending on some condition.

- Logical Shifts

  e.g. SHL , SHR, SHRD, SHLD

The logical shift instructions are mainly used when you want to get rid of bits on the beginning or end of a number. They are also used when you want to position the bits in a register.

- Arithmetic Shifts

  e.g. SAL , SAR

3) Rotate Instructions

e.g. ROL , ROR , RCL , RCR

7.6 DATA TRANSFER INSTRUCTION

Data transfer instruction consists of 15 basic operations and 86 variations. The basic operation involved is the transfer of DATA between two registers of a microprocessor system. One of the registers is always located in the microprocessor and the other may be located in an input/ output device or memory in the microprocessor.

The registers located in the microprocessor are referred to as internal registers e.g. A, B, C, D, E, H, L, SP, PC. Here Register A is the accumulator, SP is the stack pointer, PC is the program counter and rest are general purpose registers. Accumulator is also a general purpose register. On the other hand ROM (Read Only Memory), RWM (Read Write Memory) and Input/Output are referred to as external registers. The data transfer among these different registers is performed by data transfer instructions. The register from which data is transferred is the source register and the register to which data is transferred is the destination register. A transfer involves copying the contents of the source register into the destination register.

Each data transfer instruction identifies the source register and the destination register. Identification of one or both of these registers may be implied by the instruction in memories or may be explicit. Internal registers are frequently implied whereas the external registers are usually identified by an explicit address that is part of the instruction.

Example of Data transfer instructions: MOV, MVI, LXI, LDA, STA, LHLD, SHLD, LDAX, STAX etc.



7.7 LET US SUM UP

- The function of a microprocessor system is implemented by a sequence of data transfer and transformation operations.
- Each programmable register in the memory has an address.
- A sequence of instructions consist a program.
- A machine instruction has an Operation Code (also called opcode) and zero or more operands.
- Features to classify instruction sets are: Operand storage in the CPU, Number of explicit operands per instruction, Operand location, Operation by the instruction, Type and size of operands.
- Based on the number operands there are 4 types of instruction formats containing zero, one, two or three operands.
- The BIT manipulation instructions are used to modify BIT level data or binary data.
- Data transfer instructions performs Data transfer among different registers.



7.8 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q. No. 1: The instruction sets are differentiated by operand storage in CPU, number of explicit operands per instruction, operand location, operation, type and size of operands.

Ans. to Q. No. 2: Different types of instruction formats are:

- Opcode only
- Opcode+1 Address
- Opcode+2 Addresses
- Opcode+3 Addresses

Ans. to Q. No. 3: Instructions can be further classified as:

- Data transfer instructions
- Arithmetic instructions
- Branch instructions
- Boolean instructions
- Logical instructions



7.9 FURTHER READING

1) Mano, M. M. (1993): *Computer System Architecture*; Prentice Hall, 3, 299.

2) Stallings, W. (2000): *Computer Organization and Architecture: Designing for Performance*; Pearson Education India.



7.10 MODEL QUESTIONS

Q.1: Discuss the different types of instruction formats along with examples.

Q.2: Explain different types of bit manipulation instructions with examples.

Q.3: What do you mean by data transfer instructions? Explain.

Q.4: What are the different logic instructions and shift instructions?

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UNIT 8: BASICS OF OPERATING SYSTEMS

UNIT STRUCTURE

8.1 Learning Objectives

8.2 Introduction

8.3 Functions of Operating System

8.4 Types of Operating System

- 8.4.1 DOS
- 8.4.2 LINUX
- 8.4.3 UNIX
- 8.4.4 XENIX
- 8.4.5 WINDOWS

8.5 Multiprocessing OS

8.6 Time Sharing Operating System

8.7 Let Us Sum Up

8.8 Answers to Check Your Progress

8.9 Further Reading

8.10 Model Questions

8.1 LEARNING OBJECTIVES

After going through this unit, you will be able to:

- what is an operating system
- main functions of operating system
- brief idea of different operating systems commonly used
- the concept of multiprocessing operating system
- the concept of time sharing operating system.

8.2 INTRODUCTION

Computers have changed the way we think and live today. We have become dependent on the power and the capability of the computer system. We all are concerned with the application of computers. Whether it is booking a flight tickets or typing a document we all use computer now-a-days. Even

our smart phone can also be called a mini computer. The same computer can be seen from different perspectives. For the laymen, a computer is a very useful device, which can help them to fulfill their requirements. For engineers and other technical person, a computer is an electronic device which can be utilized to aid the different requirements. A computer system consists of some physical components known as hardware. The hardware components are connected to each other to perform any activity. In the past, any work to be carried out in the computer needed to be performed manually. Users needed to be very efficient and skilled to use the hardware. As time passes by, technology has changed a lot resulting in the development of new and improved hardware. However, hardware components are not functional if software is not installed. This software is known as Operating System. Operating system is an interface between the user and the hardware. In fact we can say that the hardware complexities are eliminated by the operating system software.

Operating system can be defined as a system software, which works as an interface between the user and computer hardware, which eliminates the hardware complexities.

Microprocessor system is implemented by a sequence of data transfer between register in the memory and the microprocessor as well as between

8.3 FUNCTIONS OF OPERATING SYSTEMS

Operating system performs a set of activities which can be broadly categorized into two different viewpoints. They are user viewpoint and system viewpoint. The user viewpoint describes the functions in a top-down manner where as the system viewpoint describes the functions in a bottom-up manner. Now let us discuss the functions of operating systems from both the views.

- **User View:** User view describes the functions without looking into the complexities of the core hardware and system. For example, a user can do lot of works in the computer. But how the data is got processed or how the resources are allocated to the process, the user is not concerned about it. The operating system itself is taking

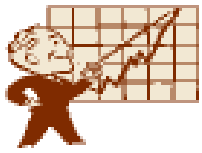
care of it. Thus, the operating system makes the hardware abstraction and thereby provides a user friendly interface to the user. Thus the operating system acts as a mediator between the user and computer hardware. Some of the operating system functions that can be realized from the user point of view are as follows:

- **User Interface:** Operating system provides an interface so that the user can make use of the computer hardware. The interface can be categorized into two types. They are:
  a) **Command Line Interface (CLI):** This provides a command line interface to the user. The user need to type in the command to interact with the system.
  b) **Graphical User Interface (GUI):** This provides a graphical interface, where the users mainly need to interact with the computer using some pointing device such as mouse.
- **Program Execution:** When a program is executed, there are some events like allocating memory, loading the program to that memory need to take place. All these happen without the concern of the user. The operating system takes care of all these so that each program executes smoothly.
- **Controlling of I/O Devices:** When we interact with the computer, for example, giving input to the computer or receiving output from the computer it happens without any difficulty. Most of the time, the user is not required to control the input and output device manually. The operating system itself handles the input and output operations. For example, when we press some keys from the keyboard, the characters are displayed on the monitor. These are all controlled by the operating system.
- **Accessing File System:** Data in a computer can be stored either temporarily and upto some extent permanently. To sore the data upto some extent permanently, files are used. But file is a logical concept and it is associated with the mapping of some physical memory. The mapping of logical memory to physical memory is managed by the operating system. The operating system also

performs all the file management related activities without the concern of the user.

- **Error Detection and Recovery:** When we work with a computer, there is a chance that many errors may occur. If proper action is not taken in a timely manner, it ultimately leads to the pushing of the system to a dead lock situation. The operating system, detects any circumstances that may lead to a deadlock situation and takes preventive action against it. If in any case dead lock happens, the system automatically recovers from the deal lock. This corrective measure and prevention is performed by the operating system without the concern of the user.

- **System View:** Besides providing support to the user and helping user to interact with the computer, operating system also perform some other activity for the smooth functioning of the system. These functions can be considered under the category of the system view. Some of the important functions are:
  - **Resource Manager:** The CPU, memory and I/O devices are termed as resource present in a computer. Each of these resources to managed properly. In each operating system, there is a module that can be used to manage the resources.
  - **Control Program Address Space:** When multiple programs run in a computer, each of them need some amount of memory. At the same time, there should not be any conflict regarding the use of the memory by multiple programs. Operating system takes care of this so that same address space is not allocated to multiple programs running simultaneously.



CHECK YOUR PROGRESS

Q.1: Fill in the blanks:

a) The operating system acts as a .....

b) ..... ensures that two processes occupies different address space.

c) CLI stands for .....

d) GUI stands for .....

8.4 TYPES OF OPERATING SYSTEM

The following are some commonly used operating system.

8.4.1 DOS

DOS is the acronym for Disk Operating System. This operating system was originally developed by Microsoft, so it is also known as MS-DOS. It is one of the simplest types of operating systems available. It supports only a single user at a time and can perform only one task at a particular time. So, it is also known as a single user-single tasking operating system. MS-DOS provides a command line interface to interact with the computer. Although it is a very simple operating system and requires very less space to install, it is one of the most successful operating systems that have been developed to date.

The first version of MS-DOS, i.e. MS-DOS 1.0 was installed in IBM PC in August 1981. It was a 16 bit operating system.

History of DOS: When IBM launched its revolutionary personal computer, the IBM PC, in August 1981, it came complete with a 16-bit operating system from Microsoft, MS-DOS 1.0. This was Microsoft's first operating system, and it also became the first widely used operating system for the IBM PC and its clones.

MS-DOS 1.0 is actually a renamed version of QDOS (Quick and Dirty Operating System). The QDOS was written by Tim Paterson, a Seattle Computer Products employee that supports Intel 16-bit 8086 CPU (central processing unit). Tim Paterson was later hired by Microsoft Corporation.

Microsoft eventually came up with two versions of DOS. They are PC-DOS (the IBM version) and MS-DOS (the Microsoft version). Although, initially there were no difference between PC-DOS and MS-DOS, but with time both PC-DOS and MS-DOS acquired specific features which distinguishes them from one another.

Gradually MS-DOS gained popularity in the personal computer market and it provided a support for Microsoft to grow further. Even after launching of Windows as well, MS-DOS provides a good contribution towards the income of the company. The subsequent versions of MS-DOS provide few features similar to the features possessed by UNIX. In the improved versions of MS-DOS, it has support for multiple HDD partitions, disk compression, improved memory management, improved text editors, etc.

8.4.2 LINUX

Linux is a UNIX-based operating system which has a graphical user interface. It was created by Linus Torvalds. Linus Torvalds a Helsinki university student has developed it as a hobby and announced formally on 25th August, 1991 and named it as Linux. It is a free operating system. It means it is free to download and use for customization. Anyone can change the code of the operating system and because of this it has gradually become very powerful and at the same time provides the best in security features. At the present time it has many features and capable to compete with most of the existing operating system including windows operating system.

Being an open source software the core of the operating system can be modified by anyone. There is no need of acquiring license to debug and improve the list of existing features. Linux is one of the operating system which is developed by using many programming languages. The operating system code is written mainly by using C and C++. Along with these two popular languages the contribution of Java, Perl and Lisp is also found in traces. As far as the kernel of java is concern, the presence of C code is about 95 per cent.

Another very significant benefit of Linux is the cost. The core operating system is free and most of the software that supports Linux comes with a GNU General public License. It means everything in LINUX is free. Another significant advantage of LINUX operating system is its support for strong networking.

Linux File Systems: LINUX supports many file systems each with its advantages and disadvantages. Linux doesn't require to have only one file system. Many file systems are supported at the same time in LINUX. The following is a small list of popular file systems used by LINUX.

- **The ext2 file system:** It is the oldest file system supported by LINUX yet simple which is still one of the popular operating system. Ext2 stands for extended 2 file system.
- **The ext3 file system:** It is an improvement over the ext2 file system, very significant addition to it is the concept of adding journaling.
- **The ext4 file system:** It is an improvement over the ext3 file system. In addition to the other features of that ext3, this file system has a support for large files.
- **The reiserfs file system:** It is completely a new file system written from scratch. The main feature of this file system is its speed. It can quickly access the location with hundreds of files inside.
- **The btrfs file system:** It is a file system supported by LINUX with some promising features. It supports huge storage backend volumes, multi-device spanning, snapshotting ets.
- **The xfs file system:** It is an enterprise-ready, high performance journaling file system. It offers very high parallel throughput and is therefore a common choice amongst enterprises.
- **The zfs file system (ZFSonLinux):** It is a multi-featured file system and most significantly it supports block-level checksumming, snapshotting, compression, extremely large volumes, copy-on-write, deduplication, remote replication and many more.

8.4.3 UNIX

In the mid 1960s, AT&T bell laboratories got involved in developing a new operating system called Multics. The main objective behind Multics is providing large-scale computing services to the others. The people that were involved in the designing of Multics

later involve d in the design of UNIX operating system. Like other operating systems UNIX also provides the layer between the hardware and the applications that runs on the computer.

UNIX is one of the very fast and powerful operating systems which can give a better competition to the windows operating system. The main advantage of UNIX is its security. As far as the architecture of the operating system is concerned, it is centered around the kernel. The kernel is considered as the heart of the UNIX operating system. The kernel is responsible for allocating memory, loading and executing programs, keeping track of the users file and directory. The kernel accomplishes these tasks by providing an interface between the other programs running under its control and physical hardware of the computer. When a request is made to use the system resource, the kernel determines whether or not the request is valid and if it is found valid, the kernel reads the required block of data and passes it back to the program. The UNIX system programs do not have access to physical hardware of the computer rather they uses the kernel services to fulfill the requirement. Apart from the kernel the UNIX operating system also contain the following:

- Shell

Whenever we login to a UNIX system, we are taken into a shell program. Each shell is provided with a prompt that usually displayed on the interface. To interact with the operating system, we need to enter command at this prompt. The shell is a command interpreter; which takes the command, passes it to the operating system kernel to be acted upon. It then displays the results of this operation on your screen. There are several shells are available which are as follows:

- Bourne shell (sh)
- C shell (csh)
- Korn shell (ksh)
- TC Shell (tcsh)
- Bourne Again Shell (bash)

The different users has the flexibility to use different shells as pre their requirement. Initially the system administrator will supply a default shell, which can be overridden or changed. Apart from the above each shell also contain it own programming language known as shell script.

- Utilities

UNIX provides several hundred utility programs, often referred to as commands. The UNIX operating system accomplishes the following tasks with the help of utilities. Some of the common tasks are:

- editing
- file maintenance
- printing
- sorting
- programming support
- online info, etc.

The hierarchical File Structure of UNIX: All of the files in the UNIX file system are organized into a multi-leveled hierarchy called a directory tree. A family tree is an example of a hierarchical structure that represents how the UNIX file system is organized. The top of the file system consists of a single directory called ‘‘root’’ which is represented by a / (slash). All other files comes under the root.

File Types: The UNIX file system contains several different types of files:

- **Ordinary Files:** This type of files is used to store information, such as some text you have written or an image you have drawn. The file that we create comes under this category. The ordinary files are always located within or under a directory file.
- **Directories:** This types of file is used to organized group of files. It may contain ordinary files, special files or other directories.
- **Special Files:** In UNIX each hardware device is considered as a file. For example the keyboard and monitor is considered as standard input and output file respectively.

➢ **Pipes:** One of the important utility that UNIX provides is pipe. This concept is used to take the output of the previous command as input for the next command. The (|) symbol is used as the pipe symbol.

8.4.4 XENIX

Microsoft XENIX is a 16 bit operating system developed by Microsoft. It is one of the interactive, multiuser, multitasking operating system developed by Microsoft. The XENIX can be considered as advanced version of UNIX. It runs on Intel 8086, Zilog Z8000, Motorola M68000, and DEC PDP-11 series processor. The XENIX operating system is one of the early operating system based on UNIX. In fact XENIX is a version of Unix from Microsoft that was equipped with some interesting enhancements such as multiple virtual consoles accessible via Alt-F1, Alt-F2,... Alt-F10. These features were later acquired by LINUX in its successive versions.

The XENIX kernel performs all the functions that a typical operating system kernel performs. The basic functions of the kernel are management of mass storage, processes, memory, and devices, and it checks for any errors during operation.

The main features of the XENIX operating system are:

- **Standard System Calls:** As in other operating system, it also has a set of system calls which can be used by programmers to perform different jobs. The programmers can use over 60 different system calls to request different services from the kernel.
- **Speed:** The speed at which the XENIX performs its job depends on the speed of the processor and because of the support of iAPX 286, the processing speed is convincing.
- **Small Size:** One of the promising features of the XENIX kernel is that it has about 10,000 lines of code. As a result of this the size of the kernel is very small and so it is easier to maintain and debug.

- **High-level Language:** The major portion of the kernel is written in C programming and not in assembly language. Because of this the operating system runs on variety of different computer.
- **Hierarchical File System:** Like UNIX, XENIX has a hierarchical file system. Because of this the organization of files become very easy and systematic.
- **Interpretation of Devices as File:** Like UNIX, each device I is treated as file. Because of this the exchange of data between device and operating system become easier. This introduces the concept of device independence within the operating system.
- **Code-Data Independence:** The program code and data are kept in separate areas of memory independent of each other. This provides independence on the user's data and same code can be shared by multiple users at the same time.
- **Device Driver Support:** The XENIX has a set of pre-loaded drivers especially for terminals, Winchester disks, flexible disks, and tapes. It also has a set of guidelines for writing new drivers so that a new hardware can be added to the existing OS without much difficulty.

The Root Directory: Like other operating system, XENIX also contains a root directory (/), which has few subdirectories as discussed below:

/bin – This directory has the XENIX commands that users execute frequently.

/boot – This directory has the code for a program that is required to start the system.

/dev – This directory contains special device files.

/etc – This directory has commands that are usually reserved for the system administrator plus files that the system administrator uses for various administrative purpose.

/lib – This directory has libraries of subroutines.

/lost+found – This directory lists directories that are not linked into the file system because of some problem. The

entries are placed in this directory automatically by the fsck command that the System.

Administrator uses regularly to check the integrity of the file system.

/mnt – This directory is normally used for file systems that are mounted on the root file system.

/sys – This directory has the code for the XENIX kernel.

/tmp – This directory is used for temporary files that are created by programs. These files may be removed during normal operations and they are usually removed each time the system is started.

/usr – This directory is used for all login directories. It is the ancestor of all user files and directories.

/xenix – This file has executable code for the XENIX kernel for the hard disk system.

/xenix.f – This file has executable code for the XENIX kernel for the flexible disk system.

XENIX Shells: The XENIX operating system contains various shells which works as a command interpreter. The user can choose the most suitable shell appropriate as per his or her requirement. The most commonly used one is Bourne shell which interprets commands and passes information to the programs that we want to execute. Apart from the Bourne shell, the XENIX contains the following other shells:

- restricted shell
- visual shell and
- C shell

8.4.5 WINDOWS

History of Windows: Windows operating system is developed and sold by Microsoft. Microsoft started their operation commercially during August 1981 by releasing 1.0 version of the operating system Microsoft DOS (MS-DOS), which is a 16-bit command-line operating system.

As MS-DOS was missing the graphical user interface, the company realized the importance of user-friendly interface and they came up with the first version of Microsoft Windows (Microsoft Windows 1.0) in November 1985. Although it was able to attract the people because of the user-friendly interface, but it could not gained much popularity. In December 9, 1987, Microsoft launched Microsoft Windows 2.0, but it also did not do much better.

On May 22, 1990 Microsoft launched Windows 3.0, which was a success for them. The Windows 3.1 was launched in 1992, and finally the Microsoft Windows for Workgroups, later renamed it was renamed as Windows 3.11, which added network capabilities to the per-existing set of features.

Later, on August 24, 1995, Microsoft launched the operating system Microsoft Windows 95. Windows 95 gained popularity and reveals Microsoft's intension to transfer some of MS-DOS's capabilities into Windows. The operating system has got the disadvantage of heavy reliance 16-bit DOS and continue with the limitations of the FAT16 file system, that retards the capability of giving long file system.

Eventually many versions of Windows 95 were released namely 95A OSR1, Windows 95B OSR2, Windows 95B OSR2.1 and Windows 95C OSR2.5 to incorporate few additional features.

Microsoft released the next version of Windows on June 25, 1998, known as Windows 98. Windows 98 natively supported features other than those of MS-DOS but was still based upon it. Windows 98 also suffered from poor memory handling when multiple applications were running at the same time, which could cause system to not function properly. A second edition of Windows 98 came out on February 17, 2000; it was named Windows 98 SE (for ‘‘Second Edition’’). The Windows 98 SE could handle some of the previously identified issues in a much better way.

On September 14, 2000, Microsoft released Windows Me (for Millennium Edition), also called Windows Millennium. The

foundation of Windows Millennium was based largely on Windows 98 and eventually on MS-DOS. This version of windows incorporated additional multimedia and software capabilities. Moreover, it also included a system-restore mechanism for returning to a previous state in the event of a crash.

Side by side Microsoft also released another operating system to cater the requirement of other sets of user. It was named as Windows NT (for Windows ‘‘New Technology’’).

On May 24, 1993, the first version of Windows NT was released. It was called Windows NT 3.1, and was followed by Windows NT 3.5 in September 1994 and Windows 3.51 in June 1995. Later on August 24, 1996, Windows NT 4.0 was launched for sale, and it became a true success for the company.

In July 1998, Microsoft released Windows NT 4.0 TSE (Terminal Server Emulation), the first Windows system that allowed terminals to be plugged into a server, i.e. use thin clients to open a session on the server.

The next version of windows NT was launced on February 17, 2000, and was named as Windows 2000. Windows 2000 is a 32-bit operating system with characteristics of Windows NT, along with improved task manager and full compatibility with USB and FireWire peripherals.

Finally, on April 24, 2003, a server operating system was released by Microsoft: Windows Server 2003.

On October 25, 2001, Windows XP was released and it gave a new look and feel to the existing operating system and in a short time it became very popular. It gave a new dimension towards navigating the Start menu, taskbar, and Control Panel.

In 1996, Windows Vista was released with the strongest security system yet. Windows Vista also featured enhancements to Windows Media Player as more and more people came to see their PCs as central locations for digital media. Here, one could watch television, view and send photographs, and edit videos.

Because of the increasing demand by wireless technology, Windows 7 was released for the wireless world of the late 2000s. Gradually the desktop market replaced by laptops having the wireless features and many wireless device were developed to fulfill the requirement of the people. So, it became a need to change the operating system as well. In late 2000s, Windows 7 was released to fulfill this requirement.

Windows 7 made the interface more fun to use by including features like Snap, Peek, and Shake.

During the year 2012, Windows 8 was launched which had a state of the art windows interface which smoothly worked with touch, mouse and keyboard. This operating system provided a new dimension to a variety of hand held devices like tablet, smart phone etc. This operating system also provided an enhancement to the Windows desktop, a new look to the taskbar and provides new features towards the file management.

Windows 8 provide flexibility towards the interface by providing tiles that connects to different programs.

In the year 2013-14, some enhancement to the Windows was made and as a result of that Windows 8.1 was launched. The significant additions were introduction of many powerful apps as well connectivity to cloud. This version of windows also added so many new apps such as Bing Food & Drink, Bing Health & Fitness, and great utility apps like Reading List, Calculator, and Alarms.

During the early 2015, Windows 10 arrived and Microsoft made the initial versions of the operating system available to enthusiasts via the Windows Insider Program. They invited customers to contribute towards the development of the operating system. This Windows operating system can be considered the best operating system ever in which Insider Program plays an important role.

Windows File Systems: There are two major file systems that are used by Microsoft Windows operating system. They are FAT, which is inherited from MS DOS and later in was enhanced to FAT32, and

the second one is most widely used NTFS file systems. Recently Microsoft has also released ReFS a new generation file system for Windows 8 Servers.

FAT (File Allocation Table): FAT file system is one of the most widely used yet simple file systems used in windows environment. It consists of file system descriptor sector (boot sector or superblock), file system block allocation table (referenced as File Allocation Table) and plain storage space to store files and folders. Files on FAT are organized in directories. Each directory is an array of 32-byte records, each defines file or file extended attributes (e.g. long file name).

The number in FAT12, FAT16, FAT32 stands for the number if bits used to enumerate file system block. This means that FAT12 may use up to 4096 (212) different block references, FAT16 – 65536 (216) and FAT32 (232) – 4294967296. Actual maximum count of blocks is even less and depends on implementation of file system driver.

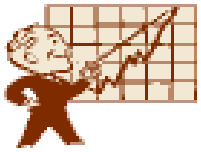
The old floppy disks uses FAT12. The FAT16 (or simply FAT) and FAT32 are widely used for flash memory cards and USB flash sticks. The mobile phones, digital cameras and other portable devices also support this file system.

FAT or FAT32 is a file system, used on Windows-compatible external storages such as external hard disks or disk partitions with size below 2GB (for FAT) or 32GB (for FAT32). Windows cannot create FAT32 file system over 32GB.

NTFS (New Technology File System): NTFS was introduced in Windows NT for the first time and at present it is the most widely used file system for Windows. This file system supports disk partitions above 32 GB and is a default file system for latest windows operating system. The file system has a support for access control, encryption, disk compression etc.

ReFS (Resilient File System): Another latest file system developed by Microsoft is ReFS.It is presently available for Windows 8 Servers. File system architecture of this file system is completely different

from the existing windows file system which is mainly organized in the form of B+-tree. ReFS has high tolerance to failures and included many new features such as Copy-on-Write (CoW) in which no data is written over the existing ones and rather into a new disk space. With any file modifications a new copy of metadata is created into any free storage space, and then the system creates a link from older metadata to the newer ones. As a result a system stores significant quantity of older backups in different places which provides for easy file recovery unless this storage space is overwritten.



CHECK YOUR PROGRESS

Q.2: Do as directed:

a) DOS stands for ..... (Fill in the blank)
b) DOS is a single user operating system. (True / False).
c) Linux was developed by ..... (Fill in the blank)
d) LINUX is a open source software. (True / False)
e) The core of UNIX operating system is the kernel. (True / False)
f) FAT stands for ..... (Fill in the blanks)
g) ReFS stands for Resilient File System (True / False).

8.5 MULTIPROCESSING OS

Multiprocessor system refers to the type of computer system that contains two or more central processing units (CPU) within a single computer system. These multiple CPUs are in a close communication with each other sharing the common computer bus, memory and other peripheral devices. All the CPU share the same memory among themselves. These systems are referred as tightly coupled systems.

These types of systems are used when time plays a very important role and it is needed to process data at high speed moreover the operation takes place on a large volume of data. These systems are generally used in environment like satellite control, weather forecasting, air traffic control etc.

The operating system installed is known as multiprocessing operating system which is based on the symmetric multiprocessing model. In symmetric multiprocessing model, each processor runs an identical copy of operating system and these copies communicate with each other. In multiprocessing system each processor is assigned a specific task. There is a master processor that regulates the tasks and controls the entire system. In fact it follows a master-slave concept. This type of system can be considered better sometimes because they share the common bus, memory and other peripheral devices. The main advantage of multiprocessor system is to get more work done in a shorter period of time. At the same time it also provides reliability to the system because of the presence of the multiple CPUs. When any one of the CPU faces problem, its responsibility is taken care of by the other available CPU's. So, it does not stop the system from functioning, It only slows down the output.

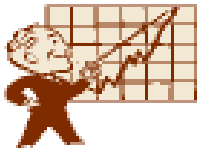
The whole task of multiprocessing is managed by the operating system, which allocates different tasks to be performed by the various processors in the system.

In order that the multiprocessing operating system functions effectively, the computer system must have the followings:

1) **Motherboard Support:** As the system possess multiple CPUs the motherboard also need to be capable of handling multiple processors. This means additional sockets or slots for the extra chips and a chipset capable of handling the multiprocessing arrangement.
2) **Processor Support:** The processors capable of being a part of multiprocessing system must be used.

Applications designed for use in multiprocessing are said to be multi-threaded, which means that they are broken into smaller routines that can be run independently. This allows the operating system to let these threads run on more than one processor simultaneously, which is multiprocessing that results in improved performance.

In a multiprocessor system, the dynamically sharing of resources among the various processors may cause therefore, a potential bottleneck. There are three main sources of contention that can be found in a multiprocessor operating system.



CHECK YOUR PROGRESS

Q.3: Do as directed:

a) Multi processing system needs all the time multiple processor. (True / False)

b) Multi-processing is managed by ..... (Fill in the blanks)

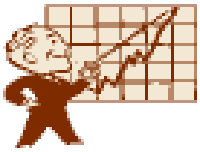
8.6 TIME SHARING OPERATING SYSTEM

In some system it may become a necessity that the same system need to the shared by several users during the same period of time. A time sharing system allows many users to share the computer resources simultaneously. In this type of system, the resources of a computer are allocated to multiple users or multiple programs in time slots. For example when a server is shared by multiple users to run programs, each user feels that the server resources are exclusively granted to him /her. But by having a single CPU, it is not possible. So, the same CPU and other resources are shared among each user in terms of time slots.

The time sharing systems were developed to provide an interactive use of the computer system. A time shared system uses CPU scheduling and multiprogramming to provide each user with a small portion of a time-shared computer. It allows many users to share the computer resources simultaneously. As the system switches rapidly from one user to the other, a short time slot is given to each user for their executions.

The time sharing system the operating system schedules the programs so that each program gets fare share of the CPU. This is done by dividing the available time among all the programs. The OS allocates a slot of time to each user. When this time expires, it passes control to the next user on the system. The time allowed is extremely small and the users are given the impression that they each have their own CPU and they are the sole owners of the CPU. This short period of time that a user gets attention of the CPU; is known as a time slice or a quantum.

The time-shared systems are more complex than the multi-programming systems. In time-shared systems multiple processes are managed simultaneously which requires an adequate management of main memory so that the processes can be swapped in or swapped out within a short time.



CHECK YOUR PROGRESS

Q.4: Do as directed:

a) Time sharing system is shared by multiple users. (True / False).

b) Linux is not a Time Sharing System. (True / False).



8.7 LET US SUM UP

- Operating system can be defined as a system software, which works as an interface between the user and computer hardware, which eliminates the hardware complexities.
- Operating system performs a set of activity which can be broadly categorized into two different viewpoints. They are:
  - user view point and
  - system view point
- User view describes the functions without looking into the complexities of the core hardware and system.
- System view addresses the issues of smooth functioning of the system.
- There are different operating systems from different vendors. Some of the commonly used operating systems are:
  - DOS
  - LINUX
  - UNIX
  - XENIX
  - WINDOWS
- Multiprocessor system refers to the type of computer system that contains two or more central processing units (CPU) within a single computer system.

- The time sharing systems were developed to provide an interactive use of the computer system by multiple users.



8.8 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q. No. 1: a) Resource allocator; b) Operating System; c) Command Line Interface; d) Graphical User Interface.

Ans. to Q. No. 2: a) Disk Operating System; b) True; c) Linus Torvalds; d) True; e) True; f) File Allocation Table; g) False

Ans. to Q. No. 3: a) False; b) Operating system

Ans. to Q. No. 4: a) True; b) False



8.9 FURTHER READING

1) Andrew S. Tanenbaum (2002): *Modern Operating Systems* (Second Ed.); New Delhi: Prentice Hall of India.
2) Deitel, H. M.: *Operating Systems* (Second Ed.); Pearson Education.
3) Silberschatz, Galvin: *Operating System Concepts* (Fifth Ed.); John Wiley and Sons (Asia) Pte Ltd.
4) William Stallings: *Operating Systems* (Fourth Ed.); New Delhi: Prentice Hall of India.



8.10 MODEL QUESTIONS

Q.1: State and explain the functions of Operating System.

Q.2: What are the different views of operating system are there? Explain.

Q.3: What is DOS? Explain its main feature.

Q.4: Discuss the file system of UNIX.

Q.5: Explain the different file system of Linux.

Q.6: What is a shell in UNIX? Explain? State different types of Shell.

Q.7: What is a time sharing system? Explain.

Q.8: What is multiprocessing? Explain.

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UNIT 9: COMPUTER LANGUAGES

UNIT STRUCTURE

9.1 Learning Objectives

9.2 Introduction

9.3 Computer Language

9.3.1 Machine Language

9.3.2 Assembly Language

9.3.3 High-Level Language

9.4 Procedural Programming Language

9.5 Object-Oriented Programming Language

9.6 Let Us Sum Up

9.7 Answers to Check Your Progress

9.8 Further Reading

9.9 Model Questions

9.1 LEARNING OBJECTIVES

After going through this unit, you will be able to:

- learn about computer language
- define machine level language
- learn about the merits and demerits of machine language
- learn about assembly language and high-level language with their advances and disadvantages.
- get an overview of procedural and object-oriented programming
- differentiate between procedural and object-oriented programming language

9.2 INTRODUCTION

In the previous unit we have discussed the basics of operating system. We have already been acquainted with functions of operating system and types of operating system.

In this unit we will learn about the concept of computer language.

Computer languages evolved after a long journey from binaries to mnemonics and algorithms. At the beginning, we will discuss machine language and assembly language and then about high-level language. At the end of this unit, we will discuss procedural and objected-oriented programming language with their basic differences.

The next unit is about algorithms and flowcharts where we will discuss how to write algorithms and draw flowcharts for different problems.

9.3 COMPUTER LANGUAGE

Language is a means of communication. To communicate our ideas, thoughts and emotions to other we use natural language such as Assamese, English, Hindi, Urdu etc. In the same way we need computer language to instruct a computer to perform some tasks according to our requirements. Computer languages help in communicating between computer and people as well as computer to computer.

Both human language and computer language have been evolved after a long period of time. Human languages like English, Hindi, Urdu are not the output of one day, one year, one decade or one century. It took centuries and centuries in bringing out this form of language that we speak today. New words are being added. The main difference between a natural language and a computer language is that natural languages have a large vocabulary but most computer languages use a very limited or restricted vocabulary. Every natural language has some definite rules for writing the words and symbols in that language defined by the grammar of the language. Similarly, there exists syntax rules for writing symbols and words of a computer language. In both the languages grammatical and syntactic mistakes may lead to wrong message.

All computer languages can be classified broadly into following three categories:

- Machine Language
- Assembly Language
- High-level Language

9.3.1 Machine Language

Every computer understands only one language without using translation program. This language is called machine language of the computer. The ***machine language*** of a computer is written normally as strings of binary 1s and 0s. The circuitry of a computer is wired in such a way that it recognizes the machine language instructions immediately, and converts them into electrical signals needed to execute them.

Different machine code is used by different processor architectures; however, machine code includes combination of 1s and 0s. There are two parts in a machine language instruction. The first part is **operation code** (or opcode) that tells the computer what function to perform, and the second part is **operand** that tells where to find or store the data to be manipulated. Hence, each instruction tells the computer what operation to perform and the length and location of the data fields involved in the operation. Every computer has a set of operation codes called its instruction set. Each operation code in the instruction set is meant to perform a specific basic operation or task. These operations include mainly arithmetic, logical, branching, data movement operations between memory locations, registers and input/output devices.

Advantage of Machine Language:

- The only advantage of machine language is that machine instructions are executed very fast by the computer. This is due to the reason that machine instructions are in binary format (combinations of 0's and 1's) which are easily understood by the CPU without the need for any translation.

Disadvantages Machine Language:

- **Machine Dependent**: Machine language differs from computer to computer as the internal circuit design of every type of computer is different. Thus, programs written in machine language of one computer will not work with computers of different circuit design.

- **Difficult to Program:** It is difficult to write programs in machine language because the programmer has to know details of hardware to write program. Again, it is difficult for the programmer to memorize dozens of operation code numbers for commands in the machine instruction set. Sequence of binary codes are not easily readable. Again, memory locations are manipulated directly, requiring the programmer to keep track of every memory location on the computer.
- **Error Prone:** The programmer has to remember a lot of codes (binary as well as hexadecimal code) to write a program in machine language which results in program errors.
- **Difficult to Modify:** It is very difficult to debug or modify machine language programs.

9.3.2 Assembly Language

In order to make programming easier and to communicate with the machine, more "human-like" languages were developed by computer scientists. These languages need to be translated into machine language so that computer can easily recognize and use. These languages are known as **assembly language**.

A processor understands only machine language instructions, which are strings of 1's and 0's. A symbolic code written in assembly language can be translated to machine language with the use of an **assembler**, and the resultant machine language code can be directly executed on a computer.



Assembly language is one step closer to human languages as the commands are like English words or combination of letters. For example, START, SET, LOD, SUB, ADD etc. This language is designed for a specific family of processors that represents various instructions in symbolic code and a more understandable form as compared to machine language.

Advantages of Assembly Language:

- The use of symbolic names for commands rather than arbitrary numeric codes gives assembly language an important advantage over machine language. For example, the assembly language code for addition is ADD which is binary 1110 in machine language. Similarly, for subtraction, we use SUB instead of binary 1111.
- Learning assembly language makes one aware of how programs interface with operating system, processor and BIOS.
- Knowing assembly language helps programmers aware of how data is represented in memory and other external devises.
- Assemble language programs requires less memory and execution time.

Disadvantages of Assembly Language:

- In assembly language, there are no symbolic names for memory locations. We need to keep track of the exact memory location that a piece of data is stored.
- Assembly language code is machine dependent. We still need to rewrite every piece of code for every machine.
- Difficult to read as the command names are not always clear.
- Hard to maintain and debug. It is difficult in finding mistakes in machine code.
- Proper documentation is necessary to understand assembly language program.

9.3.3 High-Level Language

A high-level language enables a programmer to write programs that are more or less independent of a particular type of computer. Such languages are considered high-level because they are closer to human languages. A program is a collection of instructions that describes a task, or a set of tasks to be carried out by a computer. In simple term, a program is an expression of computational steps written in some high-level language. A

programming language is an artificial language that can be used to control the behaviour of a computer. Programming languages have definite syntactic rules.

The first high-level languages were designed in the 1950s. Now there are dozens of different high-level programming languages, including COBOL, FORTRAN, ALGOL, BASIC, Pascal, Prolog, C, C++, Java, Python etc.

Before discussing the advantages of high-level language, let us recall the common limitations of machine and assembly languages. They have the following common limitations:

- They are machine dependent. This means a machine and assembly language program cannot be executed on any computer other than the one for which it is written.
- The programmers of both the languages must have an adequate knowledge of the internal structure of the computer used.
- It is difficult, error prone and time consuming to write programs in machine/assembly language.

Due to these limitations, machine and assembly languages are often referred to as ***low-level programming languages***. High-level programming languages were designed to overcome these limitations of low-level programming languages.

Advantages of High-Level languages: The main advantage of high level languages over low level languages is that they are easier to read, write, and maintain. Programs written in a high-level language must be translated into machine language by a translator like compiler or interpreter. High-level language has the following advantages over the machine as well as assembly language programming:

- High-level languages are machine independent. These are standardized in such a way that they may run on any machine/ operating system/platform and produce the same results when run anywhere.

- Symbolic names are used rather than direct memory locations.
- Logical and branching operations are included in high level language. Due to this, certain code might or might not be performed depending on certain conditions.
- The facility of adding comments helps programmer in documentation inside the program.
- With proper use of loop, the same block of code can be repeatedly executed depending on certain conditions in high level language.

9.4 PROCEDURAL PROGRAMMING LANGUAGE

Basically, procedural programming involves dividing the program into various procedures or functions or routines. Procedural programming is based upon the concept of calling procedures. A procedure consists of a series of some computational steps to be carried out to perform a specific task. There may be numbers of procedures or functions in a program. These procedures can be called as per our requirements during the program's execution. Some examples of procedural programming language are BASIC, Pascal and C.

9.5 OBJECT- ORIENTED PROGRAMMING LANGUAGE

Object-Oriented Programming (OOP) is based upon the concept of objects. An object is referred to as a data field that has unique attributes and behaviour. Objects are often used to model the real-world objects that we find in everyday life. The main aim of Object-Oriented programming is to bind together the data and the methods that operate on them. It is the most popular programming model among developers. It is a suitable programming language for solving large and complex problems. Examples

of Object-Oriented Programming languages are C++, Java, etc. Some languages, such as JavaScript, Python, and PHP, allow for both procedural and Object-Oriented programming styles.

Let us list some of the differences between procedural and object-oriented programming language:

Procedural Programming	**Object-Oriented Programming**
Procedural Programming divides the program into small programs and refers to them as functions.	Object Oriented Programming divides the program into small parts and refers to them as objects.
Procedural programming is less secure.	Object-oriented programming is more secure as it has data hiding features.
Code reusability absent in procedural programming,	Code can be reused in object-oriented programming with the feature of inheritance.
It is good for general-purpose programming.	It is effective for large and complex problem solving.
Difficult to relate to real-world objects.	Related to real-world objects.
Examples: FORTRAN, ALGOL, COBOL, BASIC, Pascal, C etc.	Examples: Java, C++ etc.



CHECK YOUR PROGRESS

Q.1: Fill in the blanks:

a) ..... language run very fast because no translation program is required for the CPU.

b) Every computer has a set of operation codes called its .....

c) ..... language is the only language that is directly understood by the computer.

d) High-level languages are machine .....

Q.2. State True or False

a) Machine and Assembly languages are machine dependent.

b) BASIC, Pascal, C are examples of Assembly language programming.

c) Machine and assembly languages are often referred to as low-level programming language.

d) Machine level instructions are in binary format.

e) C language is an example of Object-Oriented programming language.

Q.3. What is a computer program?



9.6 LET US SUM UP

- Computer language are used to instruct a computer to perform some tasks according to our requirements. There are different types of computer language.
- Machine Language is the only language that is directly understood by the computer. It does not need any translator program.

- Machine language codes are written as strings of 1's (one) and 0's (zero).
- Machine language programs are efficient for the computer to understand as it does not require any translator programs but very inefficient for programmers.
- Program of machine language run very fast because no translation program is required for the CPU.
- Assembly language is a low-level programming language.
- Assembly language is machine dependent. Each assembly language is specific to a particular computer architecture.
- In assembly language, symbolic names for commands are used rather than arbitrary numeric codes.
- A symbolic code written in assembly language can be translated to machine language with the use of an assembler.
- High-level language is any programming language that enables development of a program in much simpler programming context.
- High-level language is machine independent. I.e., independent of the computer's hardware architecture.
- High-level language focuses more on the programming logic rather than the underlying hardware components such as memory addressing, register utilization etc.
- BASIC, C, C++, Java, Python are popular examples of high-level languages.
- Procedural programming language is based upon the concept of calling procedures or functions.
- Object-Oriented Programming is based upon the concepts of objects, or where everything is represented as an object.



9.7 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q. No. 1: a) Machine; b) instruction set; c) Machine; d) independent

Ans. to Q. No. 2: a) True b) False c) True d) True e) False

Ans. to Q. No. 3: A program or a computer program is a collection of instructions that describes a task, or a set of tasks



9.8 FURTHER READING

1) Goel. A (2010) : Computer Fundamentals; Pearson Education India.
2) Rajaraman. V. & Adabala. N. (2014) : Fundamentals of Computers; PHI Learning Pvt.Ltd.
3) Sinha. P. K. & Sinha. P. (2010) : Computer Fundamentals (Vol. 4); BPB publications.



9.9 MODEL QUESTIONS

Q.1: What are the different types of computer language? Briefly discuss.

Q.2: List the relative advantages and disadvantages of Machine and Assembly language programming.

Q.3: Briefly discuss the advantages of high-level language.

Q.4. State the disadvantages of Machine Language.

Q.5. Describe briefly about procedural and object-oriented programming language.

Q.6. Differentiate between Procedural and Object-Oriented Programming. Give examples of both the languages.

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UNIT 10: INTRODUCTION TO ALGORITHMS AND FLOWCHART

UNIT STRUCTURE

10.1 Learning Objectives

10.2 Introduction

10.3 Algorithms

- 10.3.1 Conventions used in Writing Algorithms
- 10.3.2 Method for Developing an Algorithms

10.4 Pseudocode

10.5 Flowchart

- 10.5.1 Symbols of Flowchart
- 10.5.2 Advantages and Limitations of Flowchart

10.6 Let Us Sum Up

10.7 Answers to Check Your Progress

10.8 Further Reading

10.9 Model Questions

10.1 LEARNING OBJECTIVES

After going through this unit, you will be able to:

- define algorithm
- learn the conventions used for writing algorithms
- develop algorithm for various computational problems
- define and write pseudocode
- learn about flowchart
- learn different symbols of flowchart
- draw flowcharts for computations, decision making etc.

10.2 INTRODUCTION

In the previous unit we have learnt about computer languages. In this unit, learners will be acquainted with Algorithms, Pseudocodes, and

Flowcharts which are useful for the programmers as well as the users to clearly understand the solution to the problem at hand. In this unit we will learn the method of writing algorithms and pseudocodes, and pictorially represent a flow of logic in the form of flowcharts. In the next unit, we will learn about the file structure.

10.3 ALGORITHM

Algorithm is a sequence of instructions to solve a problem. An algorithm gives the logic of the program, that is, a step-by-step description of how to arrive at a solution. In general terms, an algorithm provides a blueprint to writing a program to solve a particular problem. Once we have an blueprint of a solution, we can implement it in any high-level language, such as C, C++, Java etc.

An algorithm has a finite number of steps and some steps may involve decision-making and repetition.

10.3.1 Conventions used in Writing Algorithms

The following are the conventions used in writing algorithms:

- Name of the Algorithm: Every algorithm is given a name which reflects the task performed by it.
- Introductory Comments: Within this, the task performed by the algorithm is described briefly. The variables used along with their data types are mentioned here.
- Steps: An algorithm comprises of a sequence of steps which should be numbered. The statements within a step are executed in a left to right manner.
- Comments in Steps: Each step is preceded by a brief comment describing it's function. Comments within a step are enclosed in parentheses.

The algorithm shown in Example 6:(Finding the largest of three numbers) is written considering all the above conventions. For better understanding, let us write some more algorithms of simple problems.

10.3.2 Method for Developing an Algorithm

- State the problem you are trying to solve in clear and concise terms.
- List the inputs (information needed to solve the problem) and the outputs (what the algorithm will produce as a result)
- Identify the steps needed to convert or manipulate the inputs to produce the outputs.
- Test the algorithm: choose data sets and verify that your algorithm works.

Example 1: Write an algorithm to add two numbers.

Solution: Step 1: Input the first number as A
Step 2: Input the second number as B
Step 3: Set Sum = A + B
Step 4: Display Sum
Step 5: End

The algorithm for adding two numbers can also be written as:

Step 1: Read a
Step 2: Read b
Step 3: Sum a + b
Step 4: Write Sum
Step 5: Stop

Both the two algorithms for adding two numbers are correct, but only the word/text are different. While writing algorithms, it is good to keep the following points in mind:

- Usually, words like Read, Input or Accept can be used to represent input operation to give values of variables to the computer.
- Display, Show, Write or Print can be used to represent output operation to show the result computed by the computer.
- Back arrow ‘’ represents the value obtained by evaluating the right side variable/expression to the left side variable. The symbol ‘=’can also be used instead of ‘’.

- In case of branching or conditional statements, **If-Then** or **If-Then-Else** is used. The conditional statement usually contains relational operators such as <, >, <=, >= etc.
- The iterative or repetitive statements can be written between **Repeat For or Repeat While.**

Example 2: Write an algorithm to find whether a number is even or odd.

Solution:
```
Step 1:  Input the first number as A
Step 2:  if A % 2 = 0
             then print "Even"
             else
                 print "Odd"
Step 3:  End
```

Example 3: Write an algorithm to find the larger of two numbers.

Solution:
```
Step 1:  Input first number as A
Step 2:  Input second number as B
Step 3:  if  A > B
             then  print A
         else if A < B
             then print B
         else
             print "The numbers are equal"
Step 4:  End
```

Example 4: Write the algorithm to convert the temperature on F (Fahrenheit) to C(Centigrade) using the formula C = 5/10 (F – 32).

Solution:
```
Step 1:  Read F
Step 2:  C=5/10*(F - 32)
Step 3:  Print C
Step 4:  Stop
```

The input variable is F (temperature in Fahrenheit) and the output variable is C (temperature in Centigrade).

Example 5: Write an algorithm to find the sum of first N natural numbers.

Solution: Step 1: input N
Step 2: set i = 0, sum = 0
Step 3: repeat Step 3 and 4 while i <=N
Step 4: set sum = sum + i
set i = i + 1
Step 5: print sum
Step 6: end

Example 6: Write an algorithm to compute the largest of three numbers.

Solution: Algorithm: Largest
This algorithm computes the largest of three numbers.
The variable names are:
a, b, c: type integer
large: type integer, storing the value of the largest number
Step 1: [Input three integers]
read a, b, c
Step 2: [Compute the largest of three numbers]
large =a;
if (b > large) large = b
if (c > large) large = c
Step 3: [Display the largest number]
Print (large)
Step 4: [Finished]
exit

The steps in an algorithm are normally sequence, selection, and iteration type statement.

- **Sequence** means that each step of the algorithm is executed in the specified order. The algorithm in **Example 1** performs the steps in a sequential order.

- **Selection** or Decision statements are used when the outcome of the process depends on some condition. The general form is

  if condition

  then statement1

  else statement2

  For example, if x = y

  then print ‘‘Equal’’

  else

  print ‘‘Not Equal’’

  The algorithm shown in **Example 2** contains decision statements.

- **Iteration** or **Repetition** involves executing one or more steps for a number of times. This can be implemented using constructs **Repeat-For, Repeat-While**. Repition occur one or more steps untill some condition is true. The algorithm shown in **Example 5** contains repetitive statements.



CHECK YOUR PROGRESS

Q.1: State True / False:

i) An algorithm solves a problem in a finite number of steps.

ii) The conditional statement usually contains relational operators.

iii) Reptation occur one or more steps until some condition is false.

Q.2: Write an algorithm for interchanging/swapping two values.

10.4 PSEUDOCODES

Pseudocode is a kind of structured English for describing algorithms. It allows the designer to focus on the logic of the algorithm without being distracted by details of language syntax. At the same time, the pseudocode needs to be complete.

There are no standards defined for writing a pseudocode, because a pseudocode is not an executable program. Indentation is used to increase clarity. It helps even non-programmers to understand the logic of the problem.

The aim of pseudocode is to get the idea quickly and also easy to read without details. It is like a young child putting sentences together without any grammar. For simplicity, let us represent one's daily life work in the form of pseudocode:

Brush teeth
Wash face
Comb hair

Some examples of pseudocodes in terms of computer programming are given below:

Example 7: Write the pseudocode for finding the area of rectangle.

Solution: READ length of rectangle
READ breadth of rectangle
COMPUTE area as length *breadth

Example 8: Write a pseudocode for finding the average of 5 numbers.

Solution: **input** 5 numbers
sum = add numbers together
avg = sum / 5
display avg

Example 9: Write a pseudocode to read the marks of 10 students. If marks is greater than 150, the student passes, else the student fails. Count the number of students passing and failing.

Solution: 1) **Set** totalpass to 0
2) **Set** totalfail to 0
3) **Set** no.of students to 0

4) **While** no. of students < 10
   a) Input the marks
   b) **If** marks >=150
      Set totalpass = totalpass +1
      Else
      Set totalfail = totalfail + 1
      EndIf
   EndWhile
5) **Display** totalpass, totalfail
6) **End**

Variable used in Example 9 are: totalpass, totalfail, no.of students, marks.

Some **advantages** of pseudocodes are given below:

- The language independent nature of pseudocode helps the programmer to express the design in plain natural language.
- It can be designed based on the logic of the problem without concerning the syntax or rule.
- It is compact in nature.

The main **disadvantages** of pseudocode are:

- It does not have any standard format or syntax of writing.
- It cannot be compiled or executed.

10.5 FLOWCHART

We have already acquainted with the meaning of "pseudocode" and "algorithm" in the previous section. Before we start coding a program it is necessary to plan the step-by-step solution to the problem. Such a systematic plan can be symbolically represented with the help of a diagram. This diagram is called a flowchart. A flowchart is a symbolic representation of a solution to a given task. In this section we will learn to draw flowcharts using various symbols associated with it.

A flowchart is a pictorial representation of an algorithm. It shows the logic of the algorithm and the flow of control. The flowchart uses symbols to represent specific actions and arrows to indicate the flow of control.

Normally, an algorithm is expressed as a flowchart and then the flowchart is converted into a program with any programming language. Flowcharts are independent of the programming language being used. Hence one can fully concentrate on the logic of the problem solving at this stage.

It is always recommended for a beginner, to draw flowcharts prior to writing programs in the selected programming language.

10.5.1 Symbols of Flowchart

Flowchart uses many standard symbols. The boxes which are used in flowcharts are standardized to have specific meanings. These flowchart symbols have been standardized by the American National Standards Institute (ANSI). The symbols of a flowchart include:

- **Start and End:** (or, Start and Stop)Every flowchart has a unique starting point and an endi START inside the terminator symbol. The ending point is indicated with the word STOP inside the terminator symbol.
- **Input/Output:** Input/Output symbols are used to denote any input/output function in the program. These are represented using a **parallelogram** and are used to get inputs from the users or display the results to them.

Thus, if there is any input to the program via an input device, like a keyboard, tape etc. it will be indicated in the flowchart with the help of the Input/Output symbol. Similarly, all output instructions, for output to devices like printers, monitors etc. are indicated in the Input/Output symbol.

- **Process:** A process or computation represents arithmetic and data movement instructions in the flowchart. It is generally represented using a **rectangle**. All arithmetic processes of addition, subtraction, multiplication and division are indicated in

the process symbol. If there are more than one process instructions to be executed sequentially, they can be placed in the same process box (rectangle), one below the other in the sequence in which they are to be executed.

- **Decision:** The decision symbol is represented by using a **diamond.** It is used in a flowchart to indicate the point where a decision is to be made and branching done upon the result of the decision to one or more alternative paths. The criteria for decision making are written in the decision box.

It is basically used to depict a Yes/No question or a True/False test. The two arrows coming out of it, one from the bottom point and the other from the right point, corresponds to Yes or True, and No or False., respectively. The arrow should always be labelled.

- **Flow lines/Arrows:** Flow lines (or, Arrows) are solid lines with arrowheads which indicate the flow of operation. They show the exact sequence in which the instructions are to be executed. The normal flow of the flowchart is depicted from top to bottom and left to right.
- **Connectors:** In situations, where the flowcharts become big, it may so happen that the flow lines start crossing each other at many places causing confusion. This will also result in making the flowchart difficult to understand. Also, the flowchart may not fit in a single page for big programs. Thus, whenever the flowchart becomes complex and spreads over a number of pages connectors are used.

  The connector represents entry from or exit to another part of the flowchart. A connector symbol is indicated by a circle and a letter or a digit is placed in the circle. This letter or digit indicates a link. A pair of such identically labelled connectors is used to indicate a continued flow in situations where flowcharts are complex or spread over more than one page. Connectors do not represent any operation in the flowchart. Their use is only

for the purpose of increased convenience and clarity. The flowchart symbols discussed above are given in together in Figure 10.1:

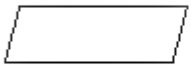
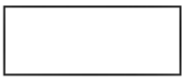
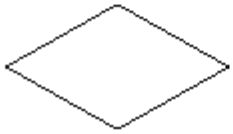
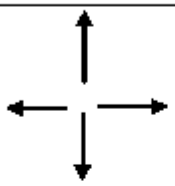
Symbol	Purposes
	Start/End
	Input/Output
	Process
	Decision
	Data Flow
	Connector

Fig. 10.1: Flowchart Symbols

10.5.2 Advantages and Limitations of Flowchart

Advantages of Flowchart: There are a number of advantages of flowcharts in problem solving.

- A flowchart being a pictorial representation of a program makes it easier for the programmer to explain the logic of the program to others rather than a program.
- It shows the execution of logical steps without the syntax and language complexities of a program.
- In real life programming situations, a number of programmers are associated with the development of a system and each programmer is assigned a specific task of the entire system. Hence, each programmer can develop his own flowchart and later on all the flowcharts can be combined for depicting the overall system. Any problems related to linking of different modules can be detected at this stage itself and suitable modifications carried out. Flowcharts can thus be used as working models in design of new software systems.
- Flowchart has become a necessity for better documentation of complex programs.
- Flowchart also enables us to trace and detect any logical or other errors before the programs are written. Hence, a flowchart is very helpful in the process of debugging a program.
- Flowcharts are very helpful during the testing of the program as well as incorporating further modifications.

Limitations of Flowchart:

- Drawing flowchart for large complex problem is a laborious and time-consuming activity. Many a times, the flowchart of a complex problem becomes complex and clumsy.
- At time, a little bit of alteration in the solution may require complete re-drawing of the flowchart.



CHECK YOUR PROGRESS

Q.3: Is there any standard rule when writing pseudocode?

Q.4: What is pseudocode?

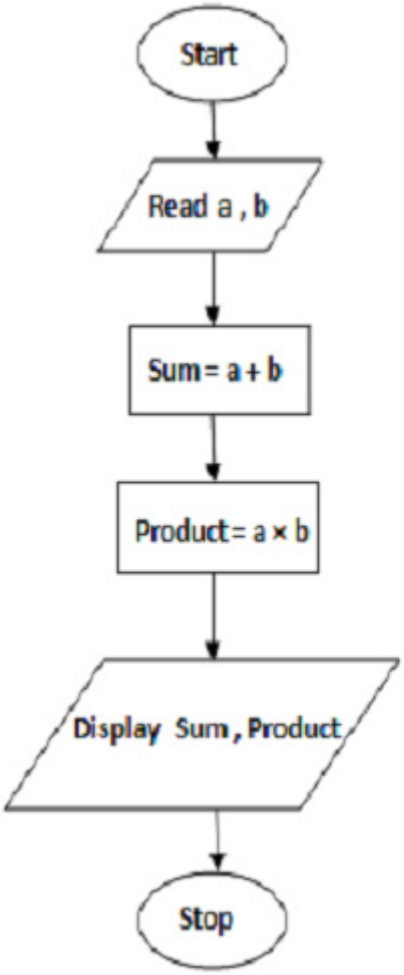
Q.5: What is a flowchart?

Q.6: Give any two advantages of flowcharts.

Here are few examples of flowcharts are given:

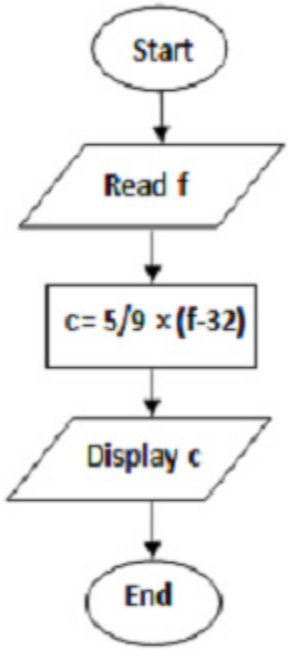
Example 1: Draw the flowchart to find the sum and product of given two numbers.

Solution:



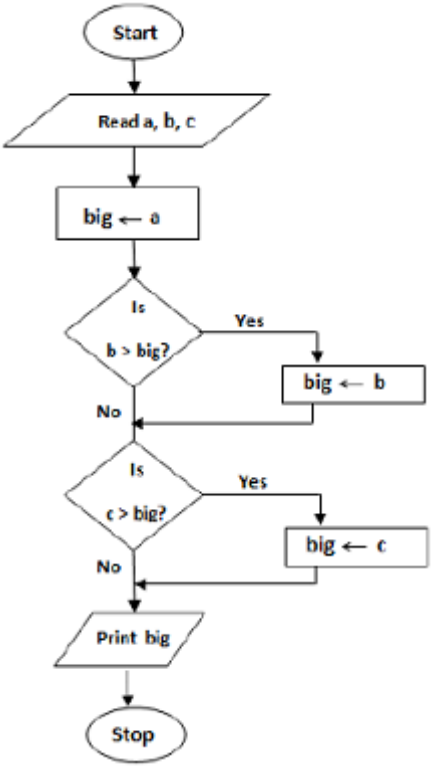
Example 2: Draw the flowchart to convert the temperature in Fahrenheit (0f) to Centigrade (0c).

Solution:



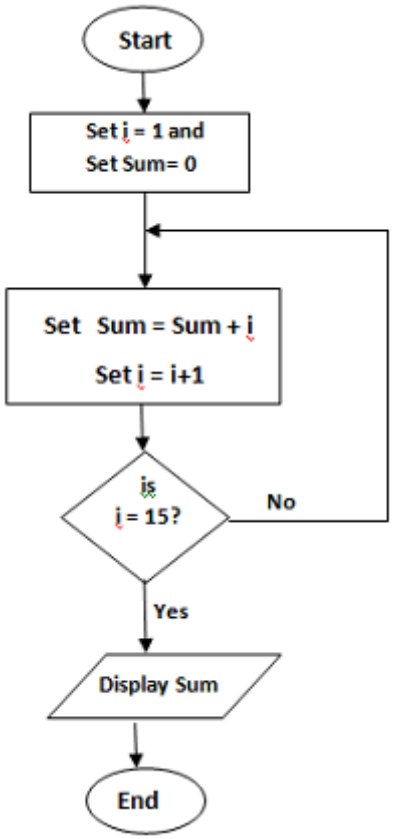
Example 3: Draw a flowchart to find the biggest of three given numbers.

Solution:



Example 4: Draw a flowchart to calculate the sum of first 15 natural numbers.

Solution:





CHECK YOUR PROGRESS

Q.7: In a flowchart, which symbol is represented using a rectangle?

a) Decision b) Connector

c) Input/Output d) Process

Q.8: Which one of the following is a graphical or symbolic representation of a process?

a) Algorithm b) Pseudocode

c) Flowchart d) Program



10.6 LET US SUM UP

- An *algorithm* is a precise specification of a sequence of instructions to be carried out in order to solve a given problem.
- In the context of computer programming, an *algorithm,* is defined as a well-ordered collection of unambiguous and effectively computable operations, that when executed, produces a result and halts in a finite amount of time.
- *Pseudocode* consists of English-like phrases describing an algorithm. An ideal pseudocode must be complete, describing entire logic of the algorithm, so that it can be translated straightway into a program using any programming language. It facilitates programmers to focus on the logic of the algorithm.
- A flowchart is a pictorial representation of an algorithm. It shows the logic of the algorithm and the flow of control.
- The flowchart uses symbols to represent specific actions and arrows to indicate the flow of control.
- For ***Start*** and ***End/Stop, oval*** or ***rounded rectangle*** is used.
- For ***input/output*** operation, ***parallelogram*** is used.
- For ***process*** or ***computation, rectangle*** is used.
- For ***decision***, the ***diamond*** symbol is used.
- For indicating ***flow of control, arrows*** with different heads are used.



10.7 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q. No. 1: i) True; ii) True; iii) False

Ans. to Q. No. 2: Algorithm for inter changing/swapping two values:

Step 1: Input first number as A

Step 2: Input second number as B

Step 3: Set temp = A

Step 4: Set A = B

Step 5: Set B = temp

Step 6: Display A, B

Step 7: End

Ans. to Q. No. 3: There are no such set rules, but the code should provide clear descriptions of the algorithms being outlined.

Ans. to Q. No. 4: Pseudocode is not an actual programming language. It uses short phrases to describe an algorithm before you actually create it in a specific programming language. Once you know what the program is about and how it will function, then you can use pseudocode to create statements to achieve the required results for your program.

Ans. to Q. No. 5: A flowchart is a diagrammatic or symbolic representation of an algorithm. It uses various symbols to represent the operations to be performed.

Ans. to Q. No. 6: The advantages of flowcharts are:

i) Flowcharts are helpful for better documentation of complex programs.

ii) Flowchart also enables us in tracing and detecting any logical or other errors before the programs are written.

Ans. to Q. No. 7: d) Process

Ans. to Q. No. 8: c) Flowchart



10.8 FURTHER READING

1) Goel, A. (2010): *Computer Fundamentals*; Pearson Education India.

2) Rajaraman, V. & Adabala, N. (2014): *Fundamentals of Computers*; PHI Learning Pvt. Ltd.

3) Sinha, P. K. & Sinha, P. (2010): *Computer Fundamentals* (Vol. 4); BPB publications.



10.9 MODEL QUESTION

Q.1: Define algorithm. How is it useful in the context of software development?

Q.2: What do you understand by the term pseudocode?

Q.3: Differentiate between algorithm and pseudocode.

Q.4: Write an algorithm to find the smallest of the given three numbers.

Q.5: Write the algorithm to find the average of given three values.

Q.6: Write an algorithm to find the sum of natural numbers up to N.

Q.7: Write an algorithm to find the area of a triangle.

Q.8: Write an algorithm to find the sum of a set of number.

Q.9: What is a flowchart? What is the significance of flowchart?

Q.10: With the help of an example explain the use of a flowchart.

Q.11: Draw the flowchart to find the area and circumference of a circle of radius r.

Q.12: Draw the flowchart to find the smallest of three given numbers.

Q.13: Discuss the advantages and limitations of flowchart.

Q.14: Describe the symbols used in flowchart.

*** ***** ***

UNIT 11: FILE STRUCTURE

UNIT STRUCTURE

11.1 Learning Objectives

11.2 Introduction

11.3 Data and Information

11.4 Records

11.5 Files

11.5.1 Operation on Files

11.6 Database Approach

11.6.1 Objectives of Database

11.6.2 Characteristics of Database

11.7 Let Us Sum Up

11.8 Answers to Check Your Progress

11.9 Further Reading

11.10 Model Questions

11.1 LEARNING OBJECTIVES

After going through this unit, you will be able to:

- define the term data and information
- describe the concept of files
- describe records and its types
- describe the operations on files
- describe database concepts.

11.2 INTRODUCTION

In the earlier units we have learnt about the basic components of the computer. We discussed computer classification, computer memory and buses. In the previous units we also learnt basic operating systems, computer languages and introduction to algorithms and flowchart.

This unit will help us to understand the concept of data and information. Also in this unit, we will be made familiar to records and their

types. In addition to these we will also learn about files and the operation on files. A brief introduction to database concepts is also included in this units. In the next units, we will learn about computer security.

11.3 DATA AND INFORMATION

- **Data:** Data can be random facts or unorganized statements. Data can be something simple like numbers and figures and is useless until it is organized. Imagine a scenario of an India versus England World Cup cricket match. The batting scores or bowling scores corresponding to each individual player in the match are all data. In this example the individual player's batting and bowling scores are not of much use.

  Data refers to a set of facts or statements that are stored together but not according to any criteria or structure. When data is processed, organized, structured or presented in a given context so as to make it useful, it is called information. In the above example, the outcome of the match can be gathered by using the collected scores of players together and this is information. The batting and bowling averages can also be calculated and then later analyzed to check the performance of the players.

  In a general scenario, data can be considered as raw materials and inputs and information as the produced goods and output. Examples of data can be lists of some names with numbers, or names of some places, or some numbers etc.

- **Information:** Information is the data that is useful in some way. Organized or structured data which is useful in some way is information. For example, let us assume that we have the details of temperature for the whole of India for the last 100 years. This is an example of data. But if the data is used for extracting information like whether temperatures are rising or falling over the years or if it is related to global warming in any way then the data becomes information.

  Information can be obtained from data by either extracting some parts of the data, or by analyzing the data or adding relevant facts to

the data or by using some formula or technique on the data to get some meaningful information. Information retrieval from data is important. Examples of information can be connecting the list of names and numbers as student name and student roll number.

- **Difference between Data and Information:** Data and information are often interchangeably used. But there is a difference between the two terms. Data is the raw material from which information is produced. For example, data can be a series of alphanumeric characters like AA123, BC124, XY345, LK876, which have no meaning on its own. But when we provide the context along with the numbers that these are item codes used in a shopping mall then the information can be gathered that the item with the above item codes have been selected for purchase by a particular customer.

11.4 RECORDS

A record is a collection of fields of information. An example of a field of information can be a student name. A collection of such information like student's name, student's roll number, course name, percentage obtained is an example of a record. A record can also be said to be a set of fields of information.

- **Types of Records:** The fields of information in a record can be of different data types. It can be of numeric type, character type or alphanumeric type. Different or similar data types of fields of information can make a record. Let us take the above students record example, the students name and course name will be of character type, the students roll numbers can be of alphanumeric or numeric data type, and percentage obtained will be of numeric data type.

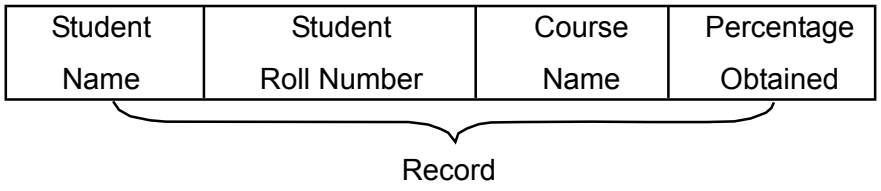


Fig. 11.1: Example of a Record

11.5 FILES

Files are collection of related records of information. The information is stored as records and a collection of these related records are stored as files. We can store several of the records together in a file. If we consider the earlier example, then a collection of different student records can be stored in a file. Let us look at the example below. Here four student's records are stored in the file.

Student Name	Student Roll Number	Course Name	Percentage Obtained
Rahul Sarma	BCA 16_01	BCA	78%
Gagan Deka	MCA 15_04	MCA	81%
Rahul Sarma	BCA 14_03	BCA	64%
Riya Gogoi	MSCIT 14_02	MSCIT	56%

Fig. 11.2: Example of Student Information File

- **Key:** A key is a unique identifier of a record. The key distinguishes each record uniquely. Suppose we need to find the marks of a particular student. Then how do we identify that particular student in a file? One way would be to check the name of the student. But, if the student file contains student records with similar names then we would require some other identifier to uniquely identify the student in the file. For the student file this unique identifier or the **key** could be the student roll number, as it is unique for each student.

  Let us now look at the above figure 11.2. Here, two students have the same name ‘‘Rahul Sarma’’ so if we want to distinguish between the two students we need some unique identifier. Roll number field is one such unique identifier to uniquely distinguish between the two students.

11.5.1 Operations on Files

The different operations that can be performed on files are basically categorized as either update operations or retrieval operations. Let us look at the different operations in detail.

- **Creation:** A file is created in the creation operation by giving the file a specific name. After it is created the file is allotted some space in the computer's memory.
- **Open:** This operation is used to open an already created file in either read mode or in write mode. In the read mode, changes are not allowed to be made to the data in the opened file. Whereas in the write mode, changes to the data are allowed.
- **Read:** A file may be opened in the read mode and the pointer here by default always points to the beginning of the file.
- **Write:** To write in a file the file is first opened and then the pointer is placed at the position where we intend to write. By default, the pointer points to the beginning of the file.
- **Repositioning within a File:** There is a file pointer called file seek, which is used to relocate the file pointer to the location where we intend to read or write.
- **Delete:** To delete a file first the file is searched using its name and then the selected file is deleted. After deletion, the memory space occupied by the file is now free for use for other files and processes.
- **Truncate:** The user may want to delete the contents of the file but not the file itself. Deletion of the file and then recreating it again wastes a considerable amount of time. Instead, we can use the truncate operation. By using this function, we can delete just the contents of the file and not the file itself. This operation will also adjust the file length to zero from its previous length.

Disadvantage of File Systems: The file system consists of a few files along with many application programs. In the beginning, files system was used to perform commercial transaction mostly and the preferred language to do so was COBOL. Many application programs were written to access data files and perform a specific task. Each of the application programs and their data files were independent of each other.

All these programs contain some amount of similar information like name or registration number. This information is common to all the files and is replicated three times for three functions. Suppose the student's names are updated and two more students are added in the file. But these changes may not be simultaneously updated in the other files. As a result, wrong information may be provided to the users. This is one of the most serious disadvantages of file systems among many.



CHECK YOUR PROGRESS

Q.1: What do you mean by data? How is data different from information?

Q.2: What are the different operations that can be done on files?

Q.3: Define record.

11.6 DATABASE APPROACH

Database is a collection of related data. Database models part of the real world called enterprise. Databases are organized by fields, records and files. Field is a single unit of information, a record is set of fields and a file is a collection of records. A database can be a collection of related files about anything. It can be a student information database of a university, an employee database of an organization or a sales information database of a commercial industry.

Database management systems (DBMS) are some computer software applications that help the users to store and analyze data. A DBMS is a collection of data, software, hardware, users and applications that help to create and manage a database. Some well-known DBMSs are MySQL, Microsoft SQL Server, and Oracle among many.

Example: Let us look at the figure below about a student information database system in a university. We have four files in the database named ‘‘STUDENT_DATABASE’’. The first is ‘‘STUDENT_INFO’’ file which keeps all the information about the students. The second is ‘‘COURSE_INFO’’ file

which keeps track of the courses offered by the university. The third is ‘‘GRADE_INFO’’ file which keeps the grade details of the students. And the fourth is ‘‘LIBRARY_INFO’’ file which keeps details of the books taken by the students.

STUDENT_DATABASE

STUDENT_INFO	
STUDENT_ID	**STUDENT_NAME**
001	ABC
002	DEF
003	GHI

COURSE_INFO	
COURSE_ID	**COURSE_NAME**
11	BBP
13	BA (EDUCATION)

GRADE_INFO			
STUDENT-ID	**COURSE-ID**	**SEMESTER**	**GRADE**
001	11	1	A
001	11	2	B
002	13	1	A
003	13	1	C

GRADE_INFO				
BOOK_ID	**STUDENT_ID**	**BOOK_NAME**	**BOOK_AUTHO**	**DUT_DATE**
00001	001	AB	XY	20-04-2015
00002	003	ER	EN	12-05-2015
00003	001	RT	JH	05-03-2015
00004	002	GH	RT	01-07-2015
00005		AS	EG	
00006	001	UI	YT	15-04-2015

Fig. 11.3: Example of a Database

11.6.1 Objectives of Database

Some of the objectives of database are:

- To provide efficient storage, management and retrieval of data
- Reduce of data redundancy
- Providing data independence
- Sharing of data
- Providing data security from unauthorized access and use
- Handling different user views of the same stored data
- Being adaptable and scalable according to user requirements

11.6.2 Characteristics of Database

The main characteristics of database are as follows:

- **Concurrent Use:** Several users are able to access a database concurrently. The database is able to retrieve information for different queries from different users using the same data. The data is centrally controlled and there is no redundancy of data. The figure below describes concurrent use of data.
- **Structured and Described Data:** The essential information about database is that it not only stores and maintains the data but also the entire description and definition of the data. These descriptions are basically details about the structure, the type and the format of all data and the relationship between the data.
- **Data Integrity:** Data integrity refers to the reliability and quality of data in a database system. It also includes the protection of data from unauthorized access and usage.
- **Transactions:** A transaction is a set of actions that are performed within a database to take from one consistent state to another. Any data in between these two states are inconsistent. A transaction can be thought of as an atomic statement, which cannot be divided any further. In a transaction, either all the actions are performed or none are performed.

- **Data Persistence:** Data persistence means that in a database all data is maintained as long as it is not deleted explicitly.
- **Data Views:** A database has many users and each of these users depending on the access rights and queries forwarded have their own individual views. These views can be of the whole data, a subset of the data or some kind of derived data.

Advantages of Database:

- Helps in controlling redundancy
- Concurrent access of data is possible
- Data integrity can be imposed
- Sharing of data is possible
- Protection from unauthorized access and usage of data
- Data recovery and backup is possible
- Time and cost needed is less
- Tools available for easy access of database
- Inconsistency can be avoided

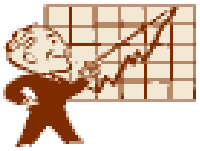
Disadvantages of Database:

- More complex than file systems
- Performance time needed for simple applications may be more
- Cost may be high depending on functionality provided



EXERCISE

1) Explain two scenarios you observe around your daily life where the use of database would be recommended. Mention why database is recommended.
2) Also explain another two scenarios where usage of file would be recommended but not database according to you. Give reasons.



CHECK YOUR PROGRESS

Q.4: What do you mean by database and DBMS?

Q.5: Mention a few characteristics of database.

Q.6: Give two applications of database.

Q.7: Give two examples of DBMS software.



11.7 LET US SUM UP

- Data can be random facts or unorganized statements. Data is the raw material from which information is produced.
- Data refers to a set of facts or statements that are stored together but not according to any criteria or structure. When data is processed, organized, structured or presented in a given context so as to make it useful, it is called information.
- A record is a collection of fields of information. The fields of information in a record can be of different data types
- A key is a unique identifier of a record. The key distinguishes each record uniquely.
- Files are collection of related records of information. The information is stored as records and a collection of these related records are stored as files.
- Database is a collection of related data. Database models part of the real world called enterprise. Databases are organized by fields, records and files. Field is a single unit of information, a record is set of fields and a file is a collection of records.
- Database management systems (DBMS) are some computer software applications that help the users to store and analyze data. A DBMS is a collection of data, software, hardware, users and applications that help to create and manage a database.

11.8 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q. No. 1: Data is the raw material from which information is produced. For example, data can be a series of alphanumeric characters like AA123, BC124, XY345, LK876, which have no meaning on its own. Organized or processed data is information. So when we provide the context along with the numbers that these are item codes used in a shopping mall then the information can be gathered that the item with the above item codes have been selected for purchase by a particular customer.

Ans. to Q. No. 2: The different operations that can be performed on files are: creating a file, opening a file, reading a file, writing a file, repositioning the file pointer within a file deleting a file and truncating a file.

Ans. to Q. No. 3: A record is a collection of fields of information.

Ans. to Q. No. 4: Database is a collection of related data. Database models part of the real world called enterprise. Databases are organized by fields, records and files. Field is a single unit of information, a record is set of fields and a file is a collection of records. Database management systems (DBMS) are some computer software applications that help the users to store and analyze data. A DBMS is a collection of data, software, hardware, users and applications that help to create and manage a database.

Ans. to Q. No. 5: A few characteristics of database are: Concurrent Use: Several users are able to access a database concurrently, Structured and Described Data: The essential information about database is that it only stores and maintains the data but also the entire description and definition of the data, Data integrity: Data integrity refers to the reliability and quality of data in a database system, Transactions: A transaction is a set of actions that are performed within a database to take from one consistent state to another, Data Persistence: Data persistence means that in a database all data is maintained as long as it is not deleted explicitly, and Data Views: A

database has many users and each of these users depending on the access rights and queries forwarded have their own individual views.

Ans. to Q. No. 6: Two applications of database are: 1.Banking: Database used for customer information, accounts, and loans, and banking transactions and 2.Airlines: Database used for reservations and schedule information.

Ans. to Q. No. 7: Two examples of DBMS software are MySQL and Oracle.



11.9 FURTHER READING

1) Data, C. J. (1975): *An Introduction to Database Systems*; Addison-Wesley.
2) Elsmari, R. & Navathe, S. (2000): *Fundamentals of Database Systems*; Pearson Education Publication.



11.10 MODEL QUESTIONS

Q.1: How is information different from data? Explain in detail.

Q.2: What is file system? Give the operations that can be performed on files.

Q.3: Explain heap file organization with an example.

Q.4: Give the advantages and disadvantages of sequential file organization.

Q.5: How is hash file organization better than heap and sequential file organization?

Q.6: What is database? What do you understand by DBMS?

Q.7: Mention some advantages and disadvantages of database.

Q.8: Give reasons why you think database is necessary.

Q.9: What are the objectives of database? Explain in brief.

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UNIT 12: COMPUTER SECURITY

UNIT STRUCTURE

12.1 Learning Objectives

12.2 Introduction

12.3 Computer Security

12.4 Malware

12.5 Computer Viruses

12.6 Worms

12.7 Other Threats

- 12.7.1 Trojan Horses
- 12.7.2 Spyware
- 12.7.3 Adware
- 12.7.4 Scareware

12.8 Counter Measures

- 12.8.1 Antiviruses
- 12.8.2 Deception Techniques
- 12.8.3 Working of an Antivirus

12.9 Let Us Sum Up

12.10 Answers to Check Your Progress

12.11 Further Reading

12.12 Model Questions

12.1 LEARNING OBJECTIVES

After going through this unit, you will be able to:

- learn about computer security and its goals
- describe different threats to computer security
- learn the classification of the threats
- counter measures of threats.

12.2 INTRODUCTION

The advancement of computer networking and information technology has been explosive in recent times. This technology has been propagated

around the world rapidly and has affected every aspect of day-to-day life. Most computer facilities continue to protect their physical machine better than their data, but in reality the value of the data is greater than the value of the hardware. Throughout this chapter, the discussion of computer security emphasizes the problem of protecting information from unauthorized disclosure, or information secrecy.

12.3 COMPUTER SECURITY

The state of being free from danger or threat is called security. So computer security means protection of the computer systems from theft or damage to its hardware or to its software or to the information it stores, as well as from disruption or misdirection of the services it provides. More precisely we can explain with the CIA triad of information security, which maintains these three security goals

- **Confidentiality:** It means protecting the information from disclosure to unauthorized parties.
- **Integrity:** It means keeping the data pure and trustworthy by protecting system data from intentional or accidental changes.
- **Availability:** It refers to ensuring that authorized parties are able to access the information when needed.

Let us describe a day-to-day example to clear this CIA triad. Suppose I own an bank account and I am not willing to share my ATM card number and its pin and the bank statements also. So me and my bank is protecting the information so its confidentiality. One day I was making a online transaction to a 3rd party of rupees 1000.00 but in the mean time somehow someone tampered the information and made the amount rupees 10000.00. I don't want to have such tampering with my confidential data. That is Integrity. I want my bank account to be accessed and manipulated only by me not by others, my bank should protect my account from unauthorized attempt of access. This is an example of Availability.

12.4 MALWARE

If we can ensure these goals for our system then we can say our system is protected and any threat to these is a threat to computer security. The threats to computer security can be in the form of unauthorized access or deception or disruption or usurpation to the services or data. Generally these violations to security are caused by some malicious software. A software is potentially malicious if it can be used to harm either the computer on which it is hosted or another computer. Software may also be considered malicious if it is designed to install itself on a computer without the permission of the owner of that computer, particularly if it does so in a way that may compromise the security of the computer. Malicious may be loosely interpreted. A piece of software may be considered malicious even though it may have been launched with the intention of providing an arguable benefit. These types of software are referred as **malware** (= **mal** icious + soft **ware**) in general.

Malware can be classified as–

- Transient– They need a host to exist (Viruses, Trapdoors)
- Resident– They can exist on their own (Worms)

Most malicious software takes advantage of the vulnerability-exploit cycle in software development if it is not managed properly. Vulnerability is a system susceptibility or flaw, and vulnerability-exploit cycle is the continuous process of identifying, classifying, remediating, and mitigating vulnerabilities as they are discovered.

In this unit our main focus will be mainly on malware and its exploiting techniques, other threats to computer security is beyond the scope of this unit.

12.5 COMPUTER VIRUSES

A computer virus is an executable program that replicates itself or attached to a file where it infects the computer when the file is executed. Sometimes it replaces an existing program also. There are many techniques used by virus to spread or replicate or attached to a file, but the self replicating

nature is the main criterion that distinguish a virus from other software. And not all viruses show harmful activities on system.

But why is such malicious software is termed with the biological term ‘‘Virus’’? This is so because most computer viruses are parasitic like biological virus i.e.: they work by attaching themselves to a carrier object (e.g.: a file). And when this carrier object is transmitted to other systems the virus is also transmitted and it is activated when the host program is executed. After activation the computer virus like its biological one search for another host and gets attached to it.

Working of a Computer Virus: A virus does not appear as an object in itself. A virus always resides hidden in some useful object and it may perform the main parts of a virus’ code which are the **Replication routine** and the **Payload Routine.** A virus is not a virus without the replication routine, but pay load routine for a virus is optional.

- **Virus replication:** The replication routine contains a code that locates suitable objects to attach the virus to and to copy the virus to these elements. There are different techniques for this purpose.

  Virus’ code can be executed when the object is executed. Viruses that infect program files may attach the virus code at the start or at the beginning of the program and patch the entry point so that when the program is run the virus code is executed first. The virus usually transfers control to the original program when it has finished its tasks. This ensures that the original program works properly and the virus avoids detection.
- **Payload Execution:** Payload routine of a virus is optional, some of the viruses may not have the payload routine which give them the efficiency to replicate more quickly. Payload part of the virus code generally contains the malicious activity such as slowing down the PC, deleting system files, making short cuts of every folder, swiping out the memory etc. The payload routine usually contains some activation criteria that must be met before the payload activates. This gives the virus some time to spread without detection. The activation criteria may be any data that can be found in computer

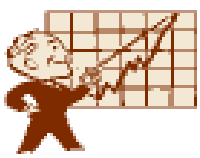
like a particular date after infection or a lapse of time period or execution of certain application etc.

From the above discussion one thing is clear: a virus always need a host to spread and it cannot spread on its own. It needs some activation criterion to be fulfilled. Then only it can be executed or it can take over the computer resources. But there are some other types of malicious software commonly mistaken as virus but unlike the viruses. But there are some other types of malicious software commonly mistaken as virus but unlike the viruses they can survive without a host. These malware are called worms.

12.6 WORMS

A **worm** is more independent than a virus. A pure worm works by itself as an independent object. The main feature that separates worms from viruses is that worms are self replicating. A worm can initiate network communication by itself and send copies to other computers. So there is no need for activation criteria or host process. As worms can spread rapidly across a network infecting every PC so they are the most notorious of malwares. There are some malicious software that resemble both viruses and worms.

One common example of this kind is mass mailing worms. They are attached to documents or other object like a virus, but uses email clients to mass mail themselves in a worm like way. This type of worm needs some kind of activation as for example, in mass mail worms can only activated when a receiver opens an attachment. It makes the worm slow but as it initiate the network by its own they are much faster transmitted than viruses. Worms and viruses are the most common wide-spread malicious software .There are some other programs also which work may not be so vicious like the virus or worm, but still they are malicious.



CHECK YOUR PROGRESS

Q.1: What are the three security goals?

Q.2: What is computer virus?

Q.3: Differentiate between worm and virus.

12.7 OTHER THREATS

In this section we will go briefly into the other malicious software other than virus and worm which may not exploit or damage the system like virus or worms do but may be a potential threat in point of view of security.

12.7.1 Trojan Horses

The term Trojan horse comes from the Trojan war described in Greek mythological epic. As the tale describes in the Trojan War the Greeks were unable to enter the city of Troy despite 10 years of long siege and finally they constructed a large wooden horse and hid some soldiers in it. The citizens of Troy thought it was just a mere wooden horse and they let it in their city and in the night the soldiers inside the horse opened the city gates, which eventually became the downfall of their city. The wooden horse is coined as Trojan horse in the epic. The Trojan horses in computer security also serve the same purpose.

Trojan horses are applications which appear to be useful, legitimate applications, but run malicious, hidden code. The application may appear to perform tasks, such as scanning for spyware, but actually steal personal data from your system. Executing Trojans may result in changing desktop wallpaper, creating popups, or even deleting files. One of their most popular uses is creating backdoors to allow malicious users to gain access to files and information. Unlike viruses or worms, Trojans cannot infect other systems.

12.7.2 Spyware

Spyware are the software that collects user sensitive information like browsing and searching habit, password, social interactions without your knowledge and uses such information to gain profit. Information collection by spyware is done using technique like key logging, browser activity monitoring. Spyware is meant to

make money by using personal information so it does not exploit the PC like other malware do. In fact, many spyware may be running in our PC without our knowledge.

12.7.3 Adware

Adware are the software that supports advertising. In general it is the entire program that downloads or displays unwanted banner advertisements in the software being used. Adware can be also used to collect user personal data and based on these data the adware shows up with classified advertisement. This type of software doesn't harm the system but collecting information and running advertisement without user knowledge is a threat.

12.7.4 Scareware

Scareware is a new type of attack, where a user is tricked into downloading a software that appears to be a useful one. After installing, it shows that the machine is infected and it can clean all the infection if you purchase the full license version of the software. These Scareware applications are malware that hold the PC hostage until people don't pay the ransom. In most of cases, these Scareware can't be uninstalled also.

12.8 COUNTER MEASURES

‘‘Prevention is better than cure’’. To detect and eliminate security threat is always tougher than to prevent it. We can say a standalone system is more secure than any other. But it is not ideal scenario that a PC will never expose to security threats. A threat to computer security may be in many forms and hence we have to deploy different technique also to encounter them. But in this unit we will mainly focus on counter measures techniques for malware.

12.8.1 Anti Viruses

Malware uses different strategies for deception and replication. Hence, for detection and elimination of different malware involved,

different techniques and tools are used which is impossible to be done manually. A special kind of software is developed for this purpose commonly known as Antivirus. So, antivirus software is a program or set of programs designed for searching, preventing, detecting and eliminating malware. The detection techniques of anti viruses are generally based on malware deception strategies. So let's go through a brief overview of different deceptions strategies used by the malware.

12.8.2 Deception Techniques

Different malicious software uses different strategies to spread or replicate them and exploit the system. Deception helps malware to stay in the system and replicate for a longer time by disguising as a part of the host program. Malware employ different kinds of deception to hide them such as :

- **Overwriting:** In this technique the virus overwrites files with their own copy. It's a primitive technique but it is simple and easy to implement. This type of viruses can be disinfected from system simply by deleting the infected files.
- **Companion Infection:** In this approach the virus disguise itself as a companion of .exe file by naming it with same base name as the targeted program, but use a .COM extension instead of .EXE, because Windows gives priority to a file with the .COM extension over a file with the .EXE extension.
- **Appending:** In this method, a jump (JMP) or Goto instruction is encoded at the start of the of the host program that will point at the end of the original host. And the starting of virus code is lies there.
- **Pre-appending:** In this strategy, the virus code has been inserted at the front of host programs. This is a simple efficient method.
- **Cavity filling:** Here the virus tries to install itself in the empty space of the host while not damaging the actual program itself. An advantage of this technique is that the virus does not increase

the length of the program but it also minimizes a number of possible hosts, cavity viruses are rare.

- **Compressing:** Generally after infection size of the affected files increase, but by using compression techniques in this method size of the affected files has reduced so that change in file become negligible.
- **Encryption:** In this scenario the virus consists of a constant decryptor or set of decryptor, followed by the encrypted virus code, after decryption of the encrypted code with different decryptor yield different virus. This type of malware is called Oligomorphic virus.
- **Boot Sector Execution:** Due to the executable nature of master boot record (MBR) and partition boot sector (PBS) if any executable code is present in these section it will execute when machine booted and hence bypass all the security measure
- **Macros:** Macros are generally targeted for Microsoft Word or similar products and damages only such documents. They are embedded in such application and while activation triggered some other application or insert unreadable character in the documents.
- **Malicious Mobile Code (MMC):** Mobile codes are lightweight programs that are downloaded from a server and executed with minimal or no user intervention on your local machine. JavaScript scripts, VB Script, and ActiveX controls are some of examples of mobile code that we encounter while browsing. These code are used to monitor browsing activities, getting unauthorized access to local file system, showing pop ups, adding unwanted browser add-ons etc. Spyware, adware, Trojan are malwares that uses MMC.

12.8.3 Working of an Antivirus

Antivirus software scans all the file system and search for virus definition in there and try to disinfect it by removing the malware

code or deleting the infected file. Virus definition of a malware is signature by which the malware can be identified. The signature is determined based on the strategy adopt by the malware to replicate themselves. These definitions are provided by the antivirus company. Antivirus program try to match the files with these definition. The basic searching methods used by the antivirus can be broadly classified into five categories. These are:

1) **Signature Based Detection:** Once a virus is detected, it is analyzed precisely and a unique sequence of bytes extracted from the virus code. This string is the signature of that virus. The antivirus engine scans the binary code of files to find these strings and if it encounters with a known pattern, it alerts detection of the matching virus. Some of commonly known signature based techniques are:
   - **String Scanning Method:** Searches for sequence of bytes (strings) that are unique to a specific virus but can't be found in other programs. In this process a know virus is analyzed precisely and a unique sequence of bytes extracted from the virus code. For example a virus Die.448 has a unique bit string like B440 B9E8 0133 D2CD 2172 1126 8955 15B4 40B9 0500 BA5A 01CD in its code by which we can detect it.
   - **Wildcards Method:** Including a wild card character like ? or * allows skipping bytes or byte ranges of code in the signature code and try to match next which will enable the antivirus engine to detect slightly modified virus. For example: presence of a wildcard character * in the malware code means that scanner will try to match the next byte in the file.
   - **Mismatches Method:** This method allows a negligible number of bytes in a signature string to be of random values, regardless of their position. For example virus X has signature string of 2A 80 4D 01 F6 and following strings contains the same signature values in different places and also mismatched by 2.

11 2A 32 01 17 80 4D 24

0A D9 1E 17 80 F6 24 AA

But using Mismatched method we can still say that these two strings contains the virus X.

- **Generic Detection Method:** This technique uses one common generic string as a signature string to detect several or all known variants of a family of viruses. When a virus has lots of its variant then the variants are analyzed to extract a common string that can identify the whole genre. This type of technique often uses the wildcard and mismatched technique to determine a common unique string.
- **Bookmarks Method:** Bookmark method can ensure more reliable detection of viruses while it is used along with string scanning by negating the false positive. The byte distance between the start of the virus code and start the signature string is vary in different viruses. So it can be used as bookmark particular viruses when string bases scanning are used.
- **Smart Scanning:** Smart scanning optimizes the signature based detection. Some new variants of viruses try to hide their signature by inserting junk code or instruction in their code which have no effect in execution. Smart scanning skip junk instructions, such as NOPs (No Operation) in the host file to obtain the actual virus body.
- **Skeleton Detection:** The scanner parses the statements of a file line by line and drops all nonessential statements like statements which are not part of the virus or any blank gaps before actual procedure start and try to find essential virus code for execution of the virus which is called skeleton of the virus. An antivirus named as Kaspersky used this particular method very efficiently to detect macro viruses.

2) **Heuristic Based Detection:** This type of detection helps in detecting new unknown or altered version of malware, but it

produces false positive often. So is used with along with signature based scanner. As the name suggest this detection mainly focus on heuristics (experimental trial and error methods) like analysis of file structure and the code organization of the virus or CPU emulation of virus code .Some common heuristic based detection methods are

- **Heuristics Analysis:** It is an expert based analysis that determines the susceptibility of a malware code by running it on virtual runtime environment and analyzing system towards particular risk using various decision rules or weighing methods. Multi Criteria analysis (MCA) is one of the means of weighing.
- **Virus Specific Detection:** There are cases when the standard algorithm of the virus scanner cannot detect a particular malware. In such cases, a new detection code must be introduced to implement a virus specific detection algorithm to detect only specific malware. This method includes :
  - **Filtering:** A virus only effects a particular type of known objects. So viruses can be classified according to its infection type. For example, executable viruses infect only programs such as .EXE and .COM,, macro viruses only attack to files or that can perform macro statements. So whenever a particular set of files are scanned we have to check only the specific virus signature that is relevant to those files. Such filtering minimize the searching time
  - **Static Decryptor Detection:** Some viruses encrypt their body to bypass string matching so they have a decryptor in the virus code. Detection of this decryptor code also result in efferent detection but it also produces false negative and false positive if not used with specific types of viruses which used that particular decryption .So this method is used after filtering of encrypted virus like Oligomorphic virus.

- **XRay scanning:** This method tries to find the weakness in encryption algorithm of viruses. It is also virus specific can be only use with encrypted viruses and give more suitable result than Static Decryptor Detection as its tries to find the encryption strategy.

3) **Behavioral Based Detection:** When a malware attach to its host or execute its code some particular behavioral pattern or dynamic signature they exhibit which is not common to other programs and therefore by observing such signature we may detect them. But as these signatures are dynamic we need a continuous process for monitoring such abnormal behavior. A malware may produce dynamic signature like–
   - Opening an executable file, with both read and write permission.
   - Reading the portion of the file header containing the executable's start address
   - Writing the same portion of the file header.
   - Seeking to the end of the file.
   - Appending to the file.

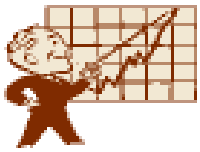
   This detection method monitors a running program's behavior in real time, watching for suspicious activity like the dynamic signature mentioned above. If any such activities are detected, it report to the antivirus engine that as a response prevents such operations from being executed or terminate the program. This detection method can only work when malware perform some malicious activity during runtime.

4) **Sandbox Detection or Emulation Detection:** This type of detection is also based on behavioral traits of the malware. Here the malware code under analysis is executed in an emulated environment or sandbox and the antivirus try to detect it during runtime based on behavioral traits. But unlike the Behavioral Based detection malware code, it is run in a virtual environment

and not in real system and hence, minimizes the risk of being affected.

5) **Data Mining Techniques:** It is the recent technology used for detecting malware which uses a data mining techniques like analyzing a very huge sets of infected data and try to find out particular behavioral pattern or try to find out a common signature strings from a large number of different variants of malware and using this signature try to detect a known malware or to classify a code for malware.

After detection, antivirus program try to remove the malware code from host ''.'' it is not possible to remove the viral code and the host program is not so significant than the antivirus delete the infected file itself. On the other hand, if the infected file is important from system point of view, then it pushes it to quarantine.



CHECK YOUR PROGRESS

Q.4: What are Trojan horses?

Q.5: Differentiate between spyware and adware.

Q.6: Define antivirus.



12.9 LET US SUM UP

- The basic goal of computer security is Confidentiality, Availability and Integrity.
- Malware is a term for all malicious programs, such as viruses, worms, Trojan horses, spyware, adware and scareware which are designed to infect and perform malicious activity on computers.
- ''Antivirus software'' is designed to protect system against malware.
- ''It is available as a standalone product and is also included in most security software packages.'' They use different static and dynamic method to identify malware and neutralize them.



12.10 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q. No. 1: The three security goals are:

- **Confidentiality:** It means protecting the information from disclosure to unauthorized parties.
- **Integrity:** It means keeping the data pure and trustworthy by protecting system data from intentional or accidental changes.
- **Availability:** It refers to ensuring that authorized parties are able to access the information when needed.

Ans. to Q. No. 2: A computer virus is an executable program that replicates itself or attached to a file where it infects the computer when the file is executed.

Ans. to Q. No. 3: A worm is more independent than a virus. A pure worm works by itself as an independent object. The main feature that separates worms from viruses is that worms are self replicating. A worm can initiate network communication by itself and send copies to other computers. So there is no need for activation criteria or host process. As worms can spread rapidly across a network infecting every PC so they are the most notorious of malwares.

Ans. to Q. No. 4: Trojan horses are applications which appear to be useful, legitimate applications, but run malicious, hidden code. The application may appear to perform tasks, such as scanning for spyware, but actually steal personal data from your system. Executing Trojans may result in changing desktop wallpaper, creating popups, or even deleting files.

Ans. to Q. No. 5: Spyware are the software that collects user sensitive information like browsing and searching habit, password, social interactions without your knowledge and uses such information to gain profit. Adware are the software that supports advertising. In general it is the entire program that downloads or displays unwanted banner advertisements in the software being used.

Ans. to Q. No. 6: Antivirus software is a program or set of programs designed for searching, preventing, detecting and eliminating malware.



12.11 FURTHER READING

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12.12 MODEL QUESTIONS

Q.1: What is computer security?

Q.2: What are the goals of computer security?

Q.3: Give an example of computer virus. Explain its working principle.

Q.4: What is the difference between computer virus and worms?

Q.5: Why is scareware considered as malware?

Q.6: Name any antivirus and explain how it works.

Q.7: Briefly describe different detection mechanism used by antivirus software.

Q.8: Why deception is needed for malware? Explain various deception strategy used by malwares.

Q.9: Is deception strategy of malware and detection method of antivirus related to each other? Explain.

Q.10: List out some of the common malware we encounter and list out whether they are viruses, worms, Trojan or any other malicious software.

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UNIT 13: BASICS OF CYBER CRIMES I

UNIT STRUCTURE

13.1 Learning Objectives

13.2 Introduction

13.3 Cybercrime

13.4 Hacking

13.5 Digital Forgery

13.6 Identity Theft

13.7 Social Engineering Attacks

13.8 Let Us Sum Up

13.9 Answers to Check Your Progress

13.10 Further Reading

13.11 Model Questions

13.1 LEARNING OBJECTIVES

After going through this unit, you will be able to:

- learn what constitutes cyber crime
- describe hacking,
- describe digital forgery,
- define identity theft and fraud
- describe different social engineering attacks

13.2 INTRODUCTION

In the previous unit you have been introduced to the concept of computer security. We have learned about different types of computer virus and worms. Different threats like malware, spyware, adware and Trojan horse were explored. Counter measures to deal with these threats like antivirus software were also explored.

In the present unit you will be introduced to the concepts of cybercrime and how cybercrimes are committed against individuals, institutions and state. Different cybercrimes like hacking, digital forgery,

identity fraud and social engineering attacks are some of the cybercrimes introduced in this unit. Cybercrimes like cyber terrorism, cyber defamation and software piracy along with the Information Technology Act, 2000 will be covered in the next unit.

13.3 CYBER CRIME

Computers have become an essential part of our life. And along with the widespread growth of computers, internet use is also expanding. Although the use of internet and technology has made the life of people easier, it has also given rise to a new type of crime - cybercrime. The term cyberspace is used to represent the electronic medium of computer networks, in which online communication takes place. This term not only represents the internet but also includes computers, computer networks, the internet, data, software etc. Cybercrime can be defined as any crime that is performed using a computer and network either as a tool or as a target. Cybercrimes are often referred to as computer crimes.

Cybercrime can also be defined as "Offences that are committed against individuals or groups of individuals with a criminal motive to intentionally harm the reputation of the victim or cause physical or mental harm, or loss, to the victim directly or indirectly, using modern telecommunication networks such as Internet (Chat rooms, emails, notice boards and groups) and mobile phones (SMS/MMS)"[1].

Some of the common cybercrimes are mentioned below:

- computer hacking
- digital forgery
- cyber stalking
- identity theft
- identity fraud
- cyber terrorism
- cyber defamation

- software piracy
- yber pornography
- cyber bullying
- unwarranted cyber surveillance
- cyber warfare

We will look at some of these cybercrimes in detail in the next few sections. Cybercrimes are generally divided into two categories depending on the use or activity of the computer. In the first category, the computer is the target of the cybercrime. Some examples of this category of cybercrime include hacking, virus attacks and denial of service attacks. In the second category, the computer is the tool used to perform the cybercrime. Some examples of this category include cyber frauds, cyber stalking and cyber terrorism.

Cybercrimes can also be divided into different categories depending on the target of the crime. The cybercrime performed can be committed against an individual, an institution or against a state. An example of cybercrime committed against an individual can be cyber stalking. Similarly, an example of cybercrime committed against an institution can be hacking their websites. And an example of cybercrime committed against a state is cyber terrorism or cyber warfare.

13.4 HACKING

Hacking is one of the most common cybercrimes. It can be defined as an illegal intrusion into a computer system or network. This is a type of crime where an individual or institution's computer is broken into so that personal or sensitive information can be accessed. The act that is committed towards breaking into a computer system or network is known as hacking.

The person who performs the act of hacking is known as a hacker. The

hacker tries to find the vulnerabilities in a person's or institutions computer system or passwords to exploit the weakness and gain access into the system. The hackers are usually highly skilled computer professions. Depending on the intent of the hackers, the hackers are classified into different groups.

The first category of hackers is ethical hackers. Ethical hackers are persons who hack into the computer system with an aim to identify the weaknesses present in the system and not for any personal gain. Because of this they are also called white hat hackers. Mostly, ethical hackers hack into computer systems on a request from the organization itself to test vulnerabilities present in the system.

The second category of hackers are crackers. Crackers are persons who hack into the computer system with an aim to gain unauthorized access to the system or network for personal gain. They aim to steal sometimes sensitive and important personal data, or corporate data or bank information. Both types of hackers use a variety of software to enter a person's computer. Most of the victims are sometimes not even aware that they had been hacked.

13.5 DIGITAL FORGERY

Digital forgery is the digitization of the process of forgery. Forgery in traditional systems is the crime of falsely and fraudulently making or altering a document and even possessing such a forged document. Digital forgery is the crime of falsely and fraudulently making or altering a documents and pictures in the digital domain. Examples of digital forgery include counterfeit currency notes, forgery of postage and revenue stamps, forgery of mark sheets etc. All of these acts of forgery are done by using computers and high quality scanners and printers.

There are different types of digital forgery. The most common types of digital forgery are mentioned below :

- **Document Forgery:** This type of forgery occurs when a legal document is forged or replicated by another person using digital means. This also includes forgery of mark sheets and revenue stamps.
- **Counterfeit Money Forgery:** This type of forgery occurs when the legal currency of a nation is forged or replicated by using digital means.
- **Digital Signature Forgery:** This type of forgery occurs when the signature of an individual is forged or replicated by another person using digital means.
- **Art Forgery:** This type of forgery occurs when a piece of art is replicated and sold as the original art piece. ‘‘Sometimes the whole painting is forged and sometimes only the signature of a famous painter is forged into the ‘‘painting and intension to get more money.’’

13.6 IDENTITY THEFT

Identity theft is one of the oldest crimes in human history. Identity theft can be defined as stealing personal information of a person and impersonating as that person. The terms identity theft and identity fraud are often used interchangeably. But they refer to different crimes. In identity theft, a criminal impersonates another person who actually exists. In identity fraud, a criminal creates a fictional person and assumes this fictional person’s identity. The criminal in identity fraud creates a whole new person, with both personal and financial details.

Identity theft is a much more common crime than identity fraud. Most of the information stolen is in identity theft is financial in nature regarding bank account or credit card details. But according to the victim’s need different personal or financial information may be stolen. For example, information

like name, address, passport number, PAN number, bank account details, bank passwords, and debit or credit card details.

While most of the identity thefts are done for financial gain, there are many identity thefts done with other intentions too. According to a non-profit Identity Theft Resource Center, identity theft can be categorized into five types depending on the intent. These categories are mentioned below:

- **Criminal Identity Theft:** In this type of identity theft, the criminal impersonates as another person as he/she is held accountable for a crime. The criminal identifies himself as another person to the state authority by using simple documents such as fake identity cards. This is usually done to get the police or court authorities off their back. The victim's of this identity theft may never come to know of these crimes done using their false impersonations.
- **Financial Identity Theft:** This is the most common type of identity theft. In this type of identity theft the criminal uses another person's identity to obtain money, loans or any other financial services using the victim's identity. These types of crimes are usually found out only the debts mount or when it is time to pay off the loan installments.
- **Identity Cloning:** In this type of identity theft, the criminal impersonates another person to conceal their own identity. The criminals are mostly persons hiding from debt collectors or who want to became someone else for personal reasons.
- **Medical Identity Theft:** This is a new type of identity theft where the criminals steal the identity of the victim's for medical benefits. The criminals pose as another person to get medical care like medical insurances and high cost drugs.

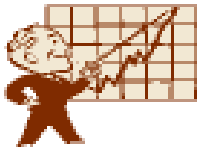
- **Child Identity Theft:** This is another type of identity theft where the criminals target minor children for their personal gain. The criminals steal the social security numbers of children and use this information for their own benefit.

13.7 SOCIAL ENGINEERING ATTACKS

Social engineering attacks involve malicious actions that involve human interactions and emotion related manipulations. The victim is generally tricked into revealing sensitive data or making mistakes by which data is revealed. This can be done by making the user click malicious links or opening malicious files by evoking emotions like sense of urgency, fear etc. There are different types of social engineering attacks like phishing, baiting, water holing, pretexting, quid pro quo and tailgating. One of the most common social engineering attack is phishing.

Phishing can be defined as a crime that occurs where a criminal tries to get the victim to disclose their personal and financial information by using emails. Vishing and smishing are two types of phishing. In **vishing**, the criminal tries to get the victim to disclose personal and confidential information by using voice calls whereas, in **smishing** the criminal tries to get the victim to disclose confidential information by using text messages from a cell phone or smartphone.

Baiting is another type of social engineering attack where physical media devices like USB are used to disperse malware to the victim's computer system. In many cases, the cybercriminals leave USB devices like pen drives as bait at noticeable places in clever ways so that employees are lured into picking and using these USB devices. When these USB devices are input into the system, they install different types of malware into the system. A common type of online baiting is in the form of advertisements where they may offer goods or services in unbelievable prices and lure the victim into clicking the links and downloading the malware into their system.



CHECK YOUR PROGRESS

Q.1. Define cybercrime.

Q.2. Differentiate between identity fraud and identity theft.

Q.3. Who are the crackers?

Q.4. What is baiting?



13.8 LET US SUM UP

- Cybercrime can be defined as any crime that is performed using a computer and network either as a tool or as a target.
- Hacking can be defined as an illegal intrusion into a computer system or network. This is a type of crime where an individual or institution's computer is broken into so that personal or sensitive information can be accessed. The person who performs the act of hacking is known as a hacker.
- Ethical hackers are persons who hack into the computer system with an aim to identify the weaknesses present in the system and not for any personal gain. Crackers are persons who hack into the computer system with an aim to gain unauthorized access to the system or network for personal gain.
- Digital forgery is the digitization of the process of forgery. Forgery in traditional systems is the crime of falsely and fraudulently making or altering a document and even possessing such a forged document. Digital forgery is the crime of falsely and fraudulently making or altering a documents and pictures in the digital domain.

- Identity theft can be defined as stealing personal information of a person and impersonating as that person. In identity theft, a criminal impersonates another person who actually exists. In identity fraud, a criminal creates a fictional person and assumes this fictional person's identity.
- Social engineering attacks involve malicious actions that involve human interactions and emotion related manipulations.
- Phishing can be defined as a crime that occurs where a criminal tries to get the victim to disclose their personal and financial information by using emails.
- Baiting is another type of social engineering attack where physical media devices like USB are used to disperse malware to the victim's computer system.



13.9 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q. No. 1: Cybercrime can be defined as any crime that is performed using a computer and network either as a tool or as a target.

Ans. to Q. No. 2: In identity theft, a criminal impersonates another person who actually exists. In identity fraud, a criminal creates a fictional person and assumes this fictional person's identity. The criminal in identity fraud creates a whole new person, with both personal and financial details whereas in identity theft, the criminal impersonates an already existing person.

Ans. to Q. No. 3: Crackers are persons who hack into the computer system with an aim to gain unauthorized access to the system or network for personal gain.

Ans. to Q. No. 4: Baiting is another type of social engineering attack where physical media devices like USB are used to disperse malware to the victim's computer system.



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13.11 MODEL QUESTIONS

Q.1. What are the different types of cybercrime?

Q.2. Define digital forgery. What are the different types of digital forgery?

Q.3. Differentiate between identity fraud and identity theft?

Q.4. Describe the different types of identity theft?

Q.5. Define hacking. How are the ethical hackers different from crackers?

Q.6. What are social engineering attacks?

Q.7. Describe different types of social engineering attacks.

Q.8. Define phishing, vishing and smishing.

Q.9. Explain how cyber criminals use baiting to attack a victim.

Q.10. Discuss the different types of cybercrimes and how we can safeguard ourselves from these attacks.

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UNIT 14: BASICS OF CYBER CRIMES II

UNIT STRUCTURE

14.1 Learning Objectives

14.2 Introduction

14.3 Cyber Stalking

14.4 Cyber Terrorism

14.5 Cyber Defamation

14.6 Software Piracy

14.7 Information Technology Act, 2000

14.7.1 Reporting of Cybercrimes

14.8 Let Us Sum Up

14.9 Answers to Check Your Progress

14.10 Further Reading

14.11 Model Questions

14.1 LEARNING OBJECTIVES

After going through this unit, you will be able to:

- describe cyber stalking
- define cyber terrorism and defamation
- explain about different types of software piracy
- describe different offences under IT Act 2000

14.2 INTRODUCTION

In the previous unit you have been introduced to the concept of cybercrimes. We have learned about different types of cybercrimes like hacking, digital forgery, social engineering attacks and identity theft. In this unit, you will be introduced to the other cybercrime like cyber stalking, cyber terrorism etc. The Information Technology Act, 2000 and its various amendments which criminalizes different cybercrimes are also included in this unit.

Let us look at some of the other cybercrimes in this unit.

14.3 CYBER STALKING

Stalking can be defined as an act of harassment targeting the victim. Stalking includes various acts such as following the victim, making harassing phone calls, vandalizing victim's property, leaving written messages or objects etc. Cyber stalking can be defined as the act of stalking done by using the means of computer systems or internet. The terms cyber stalking and cyber bullying are often used interchangeably. But there is a difference between these two terms, even though in essence both are crimes. The term **cyber bullying** is generally used when the parties involved are not adults and includes teenagers or children.

In most of the cases of cyber stalking, the victim is harassed by the criminal by sending repeated storm of online messages and emails. The criminals often harass the victims by posting messages on websites or discussion groups. The criminals often try to track every moment of the victim's daily activity using the help of social media. Cyber stalkers use social media sites like Facebook, Twitter etc. to keep track of the victim's activities and location. In most of the cyber stalking cases, the stalkers are known to the victims and they use internet to stalk the victims. Also, in many cases, if the criminals find that online stalking does not have their desired effect, they then resort to both online and offline stalking. This crime is punishable by law in India and the first conviction for cyber stalking was sent to jail for three months.

14.4 CYBER TERRORISM

Cyber terrorism can be defined as an act of terrorism that is committed using computer systems and networks. Spreading terrorism through the means of internet has become an attractive option for modern terrorists. This is due to the fact that the terrorists prefer using the internet and other advanced technology in comparison to traditional methods because these machines can be accessed remotely. Another term that frequency comes

when we speak of cyber terrorism is cyber warfare. Cyber warfare can be defined as the action by a nation or a state to penetrate another nation's computers or networks for the purpose of causing damage.

In cyber terrorism, the terrorists use the internet to conduct violent acts that may cause loss of life or bodily harm. The terrorists not only target human property and life but also try to cause deliberate failure of functioning of government services by targeting communication networks. Government services like electric and solar power plants, air and rail traffic systems, telecommunication systems, medical services, police and military services are targeted mostly to paralyze the victim country. Large scale disruptions of these services are caused by using tools like computer viruses, worms and other malicious software. Most of the government websites are brought down by performing denial-of-service (DOS) attacks. In 1998, the first cyber terrorism attack was done by ethnic Tamil guerrillas by disrupting the Sri Lankan embassies using DOS attacks. The Sri Lankan embassies were attacked by sending around 800 e-mails a day for over a two-week period.

14.5 CYBER DEFAMATION

Cyber defamation can be defined as defamation done using digital media usually through the internet. When a person publishes defamatory matter about someone on a website or sends e-mails containing defamatory information to all of that person's friends, it is termed as cyber defamation. The defamation can be done using words spoken orally or in written form or by signs or similar visible representations.

In most cases of cyber defamation when it is done with no serious grudge, it can be stopped by a cease and desist letter and by removing the messages from the digital media. But, if it is done with serious intent then the law can be used to punish the criminal. Cyber defamation not only harms the individual victim and his family, but also the individual's organization and

sometimes even the state or country of the victim. This depends on who the victim is and on what position the individual is currently working on. In such cases, the target for cyber defamation is often chosen not for personal grudge but for damaging the image of the organization or the country of the individual. The harm that is caused in defamation by using digital media is widespread and often irreparable as the information is already out over the whole internet. Some of the digital media that is used to perform cyber defamation are mention below:

- world wide web
- social networking sites
- email and messaging
- discussion groups
- bulletin boards

In India, there are two types of liability for defamation. The first category involves cases in which the liability is of the primary publishers of the defamatory content material. This category includes persons who has written the defamatory content material and then published this material in the cyber space. The second category involves cases in which the liability is of the internet service providers or bulletin board operators. This category includes persons who had authorized publication of the defamatory materials.

14.6 SOFTWARE PIRACY

Software piracy can be defined as the unauthorized copying or illegal distribution of copyrighted materials. Software piracy causes loss of revenue for the makers which in turn lads to the increased prices of software for the licensed consumers. Most of the software has an end user license agreement with the consumers. Violation of this agreement leads to software piracy.

Software piracy has been categorized into six categories. Let us look at each of these six categories.

- **Softlifting:** Softlifting or softloading is one of the most common types of software piracy. Softlifting is defined as sharing a program or software with someone who is not authorized to use that software in accordance with the licensing agreement. Most often a single licensed copy of the software is brought and but then it is loaded into multiple computer systems. Softloading is quite common in college campuses and businesses.

- **Internet piracy:** With the increasing number of internet users every year the number of persons committing internet piracy has grown tremendously. Internet piracy occurs when software is downloaded from the internet. There are a lot of websites where software is available for free unlimited download without following any licensing agreements.

- **Software Counterfeiting:** Software counterfeiting is the illegal duplication, distribution and sale of copyrighted software material. In software counterfeiting it is common to make duplicate copies of the programs, the documentation and also the licensed agreements. Microsoft products are some of the most common products to be counterfeited.

- **Hard Disk Loading:** Hark disk loading software piracy occurs when new computers are sold with unauthorized software. This is done by hardware dealers to make their products more attractive to the buyers.

- **Renting:** Renting involves the process of renting software to another person temporarily who does not have the authorized permission or license to use the software.

- **Original Equipment Manufacturer (OEM) Unbundling:** In this type of software piracy, sellers sell standalone software which are originally meant to be included with some other licensed product.

14.7 INFORMATION TECHNOLOGY ACT, 2000

The Information Technology (IT) Act, 2000 is an Act of the Indian Parliament enacted with the prime objective to create an enabling environment for commercial use of information technology. The IT Act specifies the acts which have been made punishable by law regarding cybercrime and electronic commerce in India. The IT Act has amended various sections of the Indian Penal Code (IPC) of 1860, the Indian Evidence Act of 1872, the Bankers Book of Evidence Act of 1891 and the Reverse Bank of India Act of 1934 to include cybercrimes done using new technologies. A major amendment of the IT Act was made in the year 2008 to include penalties for offensive messages, child pornography, cyber terrorism and voyeurism. In 2013, another amendment was made to include the offence of cyber stalking. Let us look at the various offenses that have been made punishable under the IT Act.

Some of the cybercrimes under the IT Act are mentioned below:

- Tampering with Computer source documents - Sec.65
- Hacking with Computer systems, Data alteration - Sec.66
- Sending any message that is offensive – Sec 66 A
- Publishing obscene information in electronic form - Sec.67
- Un-authorised access to protected system Sec.70
- Breach of Confidentiality and Privacy - Sec.72
- Publishing false digital signature certificates - Sec.73

Some of the cybercrimes under IPC are mentioned below:

- Cyber stalking – Sec 354D IPC
- Web-Hijacking - Sec. 383 IPC

- Bogus websites, cyber frauds - Sec 420 IPC
- Email spoofing - Sec 463 IPC
- Forgery - Sec 463 IPC
- Cyber defamation - Sec 499 IPC
- E-Mail Abuse - Sec.500 IPC
- Sending threatening messages by email - Sec 503 IPC

14.7.1 REPORTING OF CYBERCRIMES

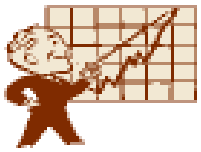
In India, cybercrimes can be reported at the website of ‘‘National Cyber Crime Reporting Portal’’ using the URL ‘‘https://cybercrime.gov.in/.’’ This portal is an initiative of Government of India to facilitate victims to report the cybercrime complaints online.



Fig 14.1: Website of National Cyber Crime Reporting Portal

Once the complaints are made, the progress made against the complaint can be traced using the website. The tracking information of the complaint can be received by giving the acknowledgement number and the OTP that is generated against that acknowledgement number. Depending on the crime, cybercrime complaints can also be made by lodging an FIR at the local police

station. In addition to this website, cybercrimes can also be lodged using a phone call to the **helpline number "1930".**



CHECK YOUR PROGRESS

Q.1. What are the different types of software piracy?

Q.2. Define cyber stalking.

Q.3. What are the different types of medium used for cyber defamation?

Q.4. What is the IT Act, 2000?



14.8 LET US SUM UP

- Cyber stalking can be defined as the act of stalking done by using the means of computer systems or internet. The term cyber bullying is generally used when the parties involved are not adults and includes teenagers or children.
- Cyber terrorism can be defined as an act of terrorism that is committed using computer systems and networks. Cyber warfare can be defined as the action by a nation or a state to penetrate another nation's computers or networks for the purpose of causing damage.
- Cyber defamation can be defined as defamation done using digital media usually through the internet. When a person publishes defamatory matter about someone on a website or sends e-mails containing defamatory information to all of that person's friends, it is termed as cyber defamation.

- Software piracy can be defined as the unauthorized copying or illegal distribution of copyrighted materials.
- The Information Technology (IT) Act, 2000 is an Act of the Indian Parliament enacted with the prime objective to create an enabling environment for commercial use of information technology. The IT Act specifies the acts which have been made punishable by law regarding cybercrime and electronic commerce in India.
- A major amendment of the IT Act was made in the year 2008 to include penalties for offensive messages, child pornography, cyber terrorism and voyeurism.
- In 2013, another amendment was made to include the offence of cyber stalking.
- Cybercrimes can be reported at the website of "National Cyber Crime Reporting Portal" using the URL “https://cybercrime.gov.in/”
- Cybercrimes can also be lodged using a phone call to the helpline number "1930".



14.9 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q. No. 1: There are six types of software piracy. They are – softloading, internet piracy, renting, software counterfeiting, hard disk loading and OEM unbundling.

Ans. to Q. No. 2: Cyber stalking can be defined as the act of stalking done by using the means of computer systems or internet. In most of the cases of cyber stalking, the victim is harassed by the criminal by sending repeated storm of online messages and emails. The criminals often harass the victims by posting messages on websites or discussion groups.

Ans. to Q. No. 3: The different types of media used for cyber defamation are world wide web, social networking sites, discussion groups, bulletin boards and using emails and messages.

Ans. to Q. No. 4: The Information Technology (IT) Act, 2000 was enacted with the prime objective to create an enabling environment for commercial use of information technology. The IT Act specifies the acts which have been made punishable by law regarding cybercrime in India.



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14.11 MODEL QUESTIONS

Q.1. Differentiate between cyber trolling and cyber bullying.

Q.2. What is cyber warfare? Give an example.

Q.3. Describe the different categories of cyber defamation.

Q.4. Define cyber stalking. How is the crime of cyber stalking performed?

Q.5. Describe the different laws related to cybercrime in India.

Q.6. What are the different ways to report cybercrimes in India?

Q.7. Describe any five cybercrimes and the laws in India that cover these cybercrimes.

*** ***** ***



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