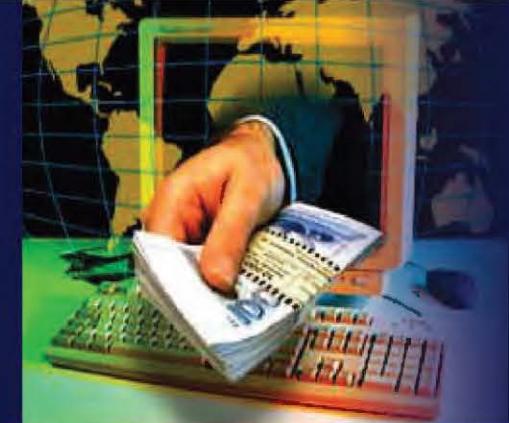


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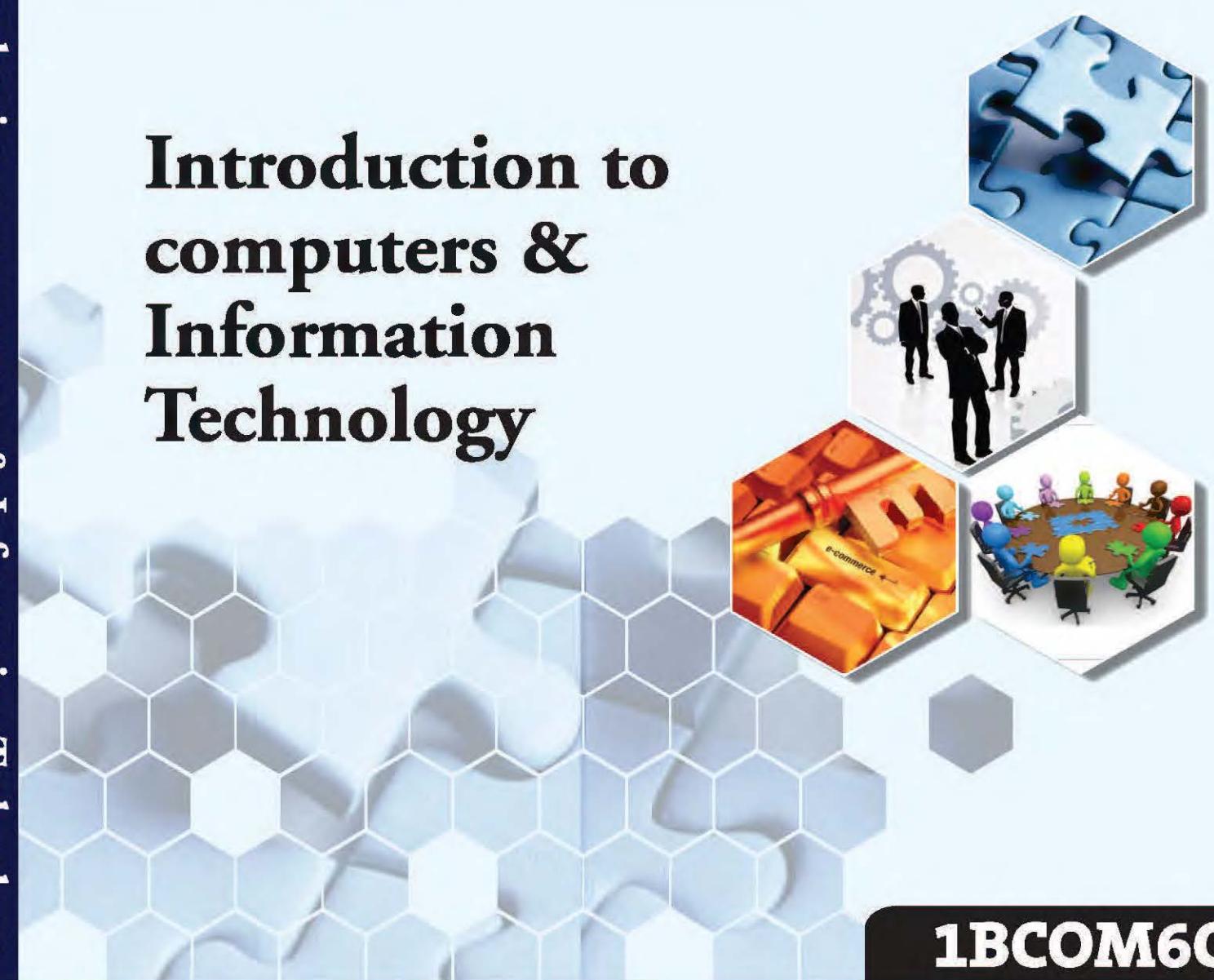


Faculty of Commerce



Introduction to computers & Information Technology

Introduction to computers & Information Technology



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A STATUTORY UNIVERSITY UNDER SECTION 2(F) OF THE UGC ACT

1 BCOM6

Introduction to Computers

&

Information Technology

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BLOCK - I

UNIT-1

KNOW THE COMPUTER

CONTENTS

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1.0 AIMS AND OBJECTIVES

After studying this lesson, you should be able to:

- Define the computer and its various parts
- Explain block structure of a computer
- Describe the various characteristics of computers
- Discuss the various uses of computers
- Explain the various types of computers
- Describe the various generations of computers

1.1 INTRODUCTION

Today's world is a world of information. The more you are informed the more you are adapting to the knowledge based global village. The computer is the only medium that has brought this change and therefore it has become a necessity for everyone to know about computers. The computer is an amazing machine. In this computer age, most of

our day-to-day activities cannot be accomplished without using computers. Sometimes knowingly and sometimes unknowingly we use computers. Whether we have to withdraw money from the ATM (Automated Teller Machines, popularly known as Any Time Money), publish a newsletter, drive a motorbike, design a building or even a new dress, visiting a grocery shop for purchasing cookies to tyres for our car — all these activities involve computer in one way or the other. The main purpose of this lesson is to introduce you about computer and its fundamentals.

1.2 WHAT DOES COMPUTER STAND FOR?

In the language of a layman, a computer is a fast calculating device that can perform arithmetic operations. Although the computer was originally invented mainly for doing high speed and accurate calculations, however it is not just a calculating device. The computer can perform any kind of work involving arithmetic and logical operations on data. It gets the data through an input device, processes it as per the instructions given and produces the information as output. We can define a computer in the following manner:

A computer is a fast electronic device that processes the input data according to the instructions given by the programmer/user and provides the desired information as output.

Table 1.1: Terminologies used In Defining a Computer

Term	Meaning
Data	A set of basic facts and entities which itself has no meaning
Information	Data which has some meaning or value
Instruction	A statement given to computer to perform a task
Input	Data and instructions given to computer
Process	Manipulation of data
Output	Information obtained after processing of data
Term	Meaning

1.3 BLOCK STRUCTURE OF A COMPUTER

The diagram of a generalized architecture of a Computer System is shown in Figure 1.1. Before discussing in details of computer architecture, let's define the computer system.

A complete computer installation including the central processing unit, the peripherals such as – hard disk drives, floppy disk drives, monitor, printer, mouse and operating system which are designed to work and interact with each other along with the user, is called a computer system.

A computer system has the following main components:

- (a) Input/Output Unit
- (b) Central Processing Unit
- (c) Memory Unit

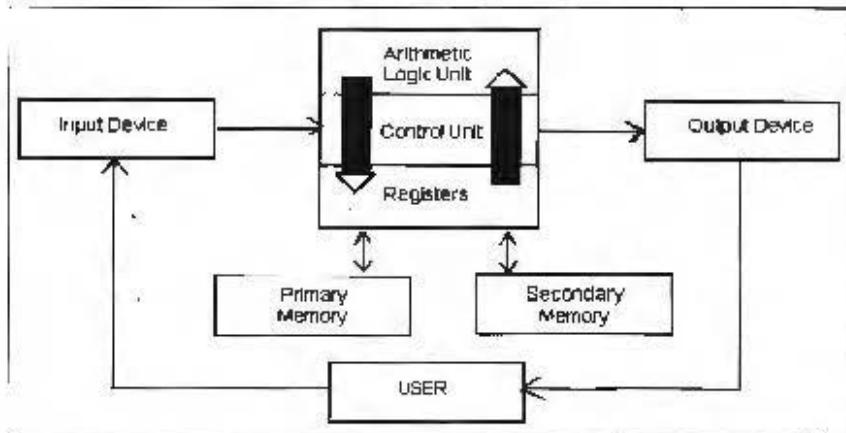


Figure 1.1: Functional Diagram of a Generalised Architecture of a Computer System

1.3.1 Input/Output Unit

We know that the computer is a machine that processes the input data according to a given set of instructions and gives the output. Before a computer does processing, it must be provided with data and instructions. After processing, the output is displayed or printed by the computer. The unit used for getting the data and instructions into the computer and displaying or printing output is known as an Input/Output Unit (I/O Unit).

The Input Unit is used to enter data and instructions into a computer. There are many peripheral devices, which are used as input/output units for the computer. The most common form of input device is known as a terminal. A terminal has an electronic typewriter like device, called keyboard along with a display screen, called Visual Display Unit (VDU) or monitor. Keyboard is the main input device while the monitor can be considered both as an input as well as an output device. There are some other common input devices like mouse, punched card, tape, joystick, scanner, modem, etc. Monitor, printer and plotter are the main peripheral devices used as output units for the computer.

1.3.2 Central Processing Unit

Central Processing Unit (CPU) is the main component or “brain” of a computer, which performs all the processing of input data. Its function is to fetch, examine and then execute the instructions stored in the main memory of a computer. In microcomputers, the CPU is built on a single chip or Integrated Circuit (IC) and is called as a Microprocessor. The CPU consists of the following distinct parts:

1. Arithmetic Logic Unit (ALU)
2. Control Unit (CU)
3. Registers
4. Buses
5. Clock

Arithmetic Logic Unit

The arithmetic and logic unit of CPU is responsible for all arithmetic operations like addition, subtraction, multiplication and division as well as logical operations such as less than, equal to and greater than. Actually, all calculations and comparisons are performed in the arithmetic logic unit.

Control Unit

The control unit is responsible for controlling the transfer of data and instructions among other units of a computer. It is considered as the "Central Nervous System" of computer, as it manages and coordinates all the units of the computer. It obtains the instructions from the memory, interprets them and directs the operation of the computer. It also performs the physical data transfer between memory and the peripheral device.

Registers

Registers are small high-speed circuits (memory locations), which are used to store data, instructions and memory addresses (memory location numbers), when ALU (Arithmetic Logic Unit) performs arithmetic and logical operations. Registers can store one word of data (1 word = 2 bytes & 1 byte = 8 bits) until it is overwritten by another word. Depending on the processor's capability, the number and type of registers vary from one CPU to another. Registers can be divided into six categories viz., General Purpose Registers, Pointer Registers, Segment Registers, Index Registers, Flags Register and Instruction Pointer Register, depending upon their functions. The detailed functions of each and every register are beyond the scope of this book.

Buses

Data is stored as a unit of eight bits (BIT stands for Binary Digit i.e., 0 or 1) in a register. Each bit is transferred from one register to another by means of a separate wire. This group of eight wires, which is used as a common way to transfer data between registers, is known as a bus. In general terms, bus is a connection between two components to transmit signal between them. Bus can be of three major types, viz. Data Bus, Control Bus and Address Bus. The data bus is used to move data, address bus to move address or memory location and control bus to send control signals to various components of a computer.

Clock

Clock is another important component of CPU, which measures and allocates a fixed time slot for processing each and every micro-operation (smallest functional operation). In simple terms, CPU is allocated one or more clock cycles to complete a micro-operation. CPU executes the instructions in synchronization with the clock pulse.

The clock speed of CPU is measured in terms of Mega Hertz (MHz) or Millions of Cycles per second. The clock speed of CPU varies from one model to another in the range 4.77 MHz (in 8088 processor) to 266 MHz (in Pentium II). CPU speed is also specified in terms of Millions of Instructions Per Second (MIPS) or Million of Floating Point Operations Per Second (MFLOPS).

1.3.3 Memory Unit

Memory Unit is that component of a computer system, which is used to store data, instructions and information before, during and after the processing by ALU. It is actually a work area (physically a collection of integrated circuits) within the computer, where the CPU stores the data and instructions. It is also known as a Main/Primary/Internal Memory. It is of the following three types:

- (a) Read Only Memory (ROM pronounced as "Ra-om")

- (b) Random Access Memory (RAM pronounced as "R-aem")
- (c) Complementary Metal Oxide Semiconductor Memory (CMOS)

Read Only Memory

Read Only Memory is an essential component of the memory unit. We know that the computer, being a machine, itself has no intelligence or memory and requires instructions, which are given by man. Whenever the computer is switched on, it searches for the required instructions. The memory, which has these essential instructions, is known as Read Only Memory (ROM). This memory is permanent and is not erased when the system is switched off. As appears with its name, it is read type of memory i.e., it can be read only and not be written by user/programmer. The memory capacity of ROM varies from 64 KB to 256 KB (1 Kilobyte = 1024 bytes) depending on the model of computer.

ROM contains a number of programs (set of instructions). The most important program of ROM is the Basic Input Output System (BIOS, pronounced as "bye-os"), which activates the hardware (physical components of computer) such as keyboard, monitor, floppy disk, etc. in communicating with the system and application software (set of instructions or programs).

Types of ROM

There are many types of ROM available for microcomputers like Mask ROM, PROM, EPROM, EEPROM and EAPROM.

- ***Mask ROM:*** Mask ROM is the basic ROM chip. In this type of ROM, the information is stored at the time of its manufacturing. So, it cannot be altered or erased later on.
- ***PROM:*** PROM stands for Programmable Read Only Memory. In this type of ROM, the information is stored by programmers after its manufacturing. It also cannot be altered or erased later on.
- ***EPROM:*** EPROM stands for Erasable Programmable Read Only Memory. It is similar to PROM, but its information can be erased later on by ultra violet light and it can be reprogrammed.
- ***EEPROM:*** EEPROM stands for Electrically Erasable Programmable Read Only Memory. It is similar to EPROM, but its information can be erased by using a high voltage current.
- ***EAPROM:*** EAPROM stands for Electrically Alterable Read Only Memory. As compared to EPROM and EEPROM, the information stored in EAPROM can be altered later.

Random Access Memory

Random Access Memory (RAM) is another important component of the Memory Unit. It is used to store data and instructions during the execution of programs. Contrary to ROM, RAM is temporary and is erased when the computer is switched off. RAM is a read/write type of memory, and thus can be read and written by the user/programmer. As it is possible to randomly use any location of this memory, therefore, this memory is known as random access memory. The memory capacity of RAM varies from 640 KB to several megabytes (1 Megabyte = 1024 KB) with different models of PC.

Types of RAM

There are two types of RAM used in PCs – Dynamic and Static RAM.

- ***Dynamic RAM (DRAM):*** The information stored in Dynamic RAM has to be refreshed after every few milliseconds, otherwise it is erased. DRAM has higher storage capacity and is cheaper than Static RAM.
- ***Static RAM (SRAM):*** The information stored in Static RAM need not be refreshed, but it remains stable as long as power supply is provided. SRAM is costlier but has higher speed than DRAM.

Complementary Metal Oxide Semiconductor Memory

Complementary Metal Oxide Semiconductor (CMOS) memory is used to store the system configuration, date, time and other important data. When the computer is switched on, BIOS matches the information of CMOS with the peripheral devices and displays error in case of mismatching.

1.4 CHARACTERISTICS OF COMPUTERS

Computers play a vital role for processing of data in an organization. Computers help in processing volumes of data efficiently and accurately within a short time. A computer has the following characteristics, which makes it so important for an organization:

- ***Fast:*** A computer is so fast that it can perform the given task (arithmetical or logical) in few seconds as compared to man who can spend many months for doing the same task. A computer can process millions of instructions per second.
- ***Accurate:*** While doing calculations, a computer is more accurate than a man. Man can make mistakes in calculations but a computer does not, if it is provided with accurate instructions.
- ***High Memory:*** A computer has much more memory or storage capacity than human beings. It can store millions of data and instructions, which can be retrieved and recalled even after a number of years. This is not possible in case of human brain.
- ***Diligence:*** A computer does not suffer from the human traits of tiredness and boredom. Man will be tired and bored while doing millions of calculations but computer, being a machine, does this job very efficiently and without any tiredness and boredom.
- ***No Intelligence:*** A computer is a machine and obviously has no intelligence of its own. Each and every instruction must be given to the computer for doing a task. Man has intelligence and it is the man who invented computer and gives it all the instructions and logic to work. The main drawback of computer is that it cannot take decisions on its own.

1.5 STRENGTHS OF COMPUTERS

- Computer can be interesting and fun.
- It caters for individual learning.
- It is interactive.
- It takes a discovery-based approach.

1.6 LIMITATIONS OF COMPUTERS

Limitations of internal computer packages are as follows:

- Many people have limited access
- Systems breakdowns
- It can be expensive to develop CD-ROMs
- Hardware is expensive

Computer cannot take over all activities simply because they are less flexible than humans.

No IQ

- A computer is a machine that has no intelligence to perform any task.
- Each instruction has to be given to computer.
- A computer cannot take any decision on its own.

Dependency

- It functions as per a user's instruction, so it is fully dependent on human beings.

Environment

- The operating environment of computer should be dust free and suitable.

No Feeling

- Computers have no feelings or emotions.
- It cannot make judgments based on feeling, taste, experience and knowledge unlike a human being.
- They have to be told what to do.
- They cannot perform anything outside the defined scope.
- If any unexpected situation arises, computer will either produce erroneous result or discard the task altogether.

1.7 FUNDAMENTAL USES OF COMPUTERS

During the last four decades, computers have revolutionized almost all disciplines of our life. Computers have made possible many scientific, industrial and commercial advances that would have been impossible otherwise. Computers are being used in many areas of application viz. business, industry, scientific research, defence, space, communications, medicine, education, etc. The utilization of computers in different fields is summarized in Table 1.2.

Table 1.2: Role of Computers in Various Fields

Application Area	Use of Computers
Scientific Research	Used to resolve complex scientific problems accurately in a very short span of time
Business	Used in banks, airports, share markets, hotels, export houses, Govt. offices and others for computerizing business applications like MIS, Payroll, Inventory, Financial Accounting, etc.
Industry	Used in electricity, steel, paper, printing, engineering & other industries for production, inventory control & related applications.

Contd...

Defense	Used in war planes, ships, radars and many advanced weapons.
Space	Used to design computerized space satellites, rockets and related technology.
Data Communication	Used to computerize geographically separated offices through networking.
Telecommunication	Used in ISDN, E-mail, Internet, Intranet, VSAT, Videoconferencing, Paging, Cellular phones, etc.
Medicine	Used in hospitals and nursing homes/clinics for maintaining medical records, prescription writing, diagnostic applications and computerized scanning (CAT Scanning).
Education	Used in development of CBT (Computer Based Teaching)/CAT (Computer Aided Teaching) programmes for education.
Law & Order	Used to record data of vehicles, criminals, finger prints, etc.
Libraries	Used to develop Library Management Systems.
Publishers	Used for Desk Top Publishing (DTP) for designing & printing of books.
Engineering	Used for CAD (Computer Aided Designing)/CAM (Computer Aided Manufacturing) by engineering companies.
Emerging Technologies	Used in Artificial Intelligence (Expert Systems, Robotics, etc.) and Virtual Reality.

1.8 DEVELOPMENT OF COMPUTERS

The earliest known device for calculation is Abacus. With 10 beads strung into the wires attached to a frame, the Abacus used to perform simple calculations. In 1642, Blaise Pascal developed the first basic calculator which would do only limited jobs. In 1690 Leibnitz developed a machine that could perform addition, subtraction, multiplication, division and calculate square roots. However, the instructions were hardcoded into the machine and could not be changed once written.

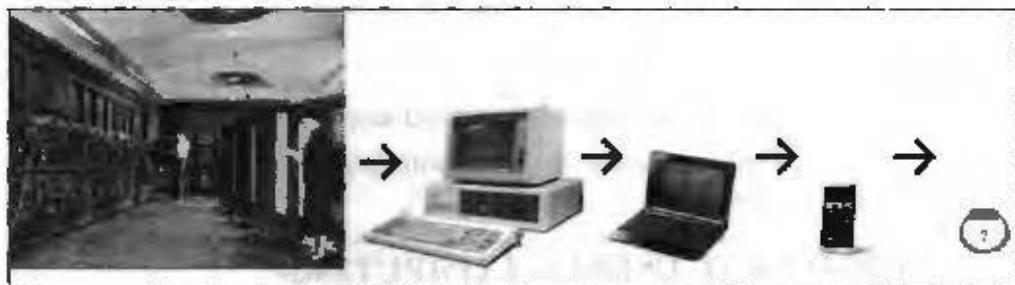


Figure 1.2: Phases in Development of Computers

Charles Babbage in 1822 designed and built a model called difference engine. His invention could perform calculations without human intervention. After that, in 1833, Babbage designed a machine called analytic engine. Technology of the analytic engine provided base for the development of modern computers. The analytic engine had an arithmetic unit to perform calculations, and mechanism to store results and instructions. Because of such contributions Babbage is known as the father of the modern day computers. During late 1940s, Jon Von Neumann found a way to encode instructions in the language. He was the force behind the development of the first stored-program computer.

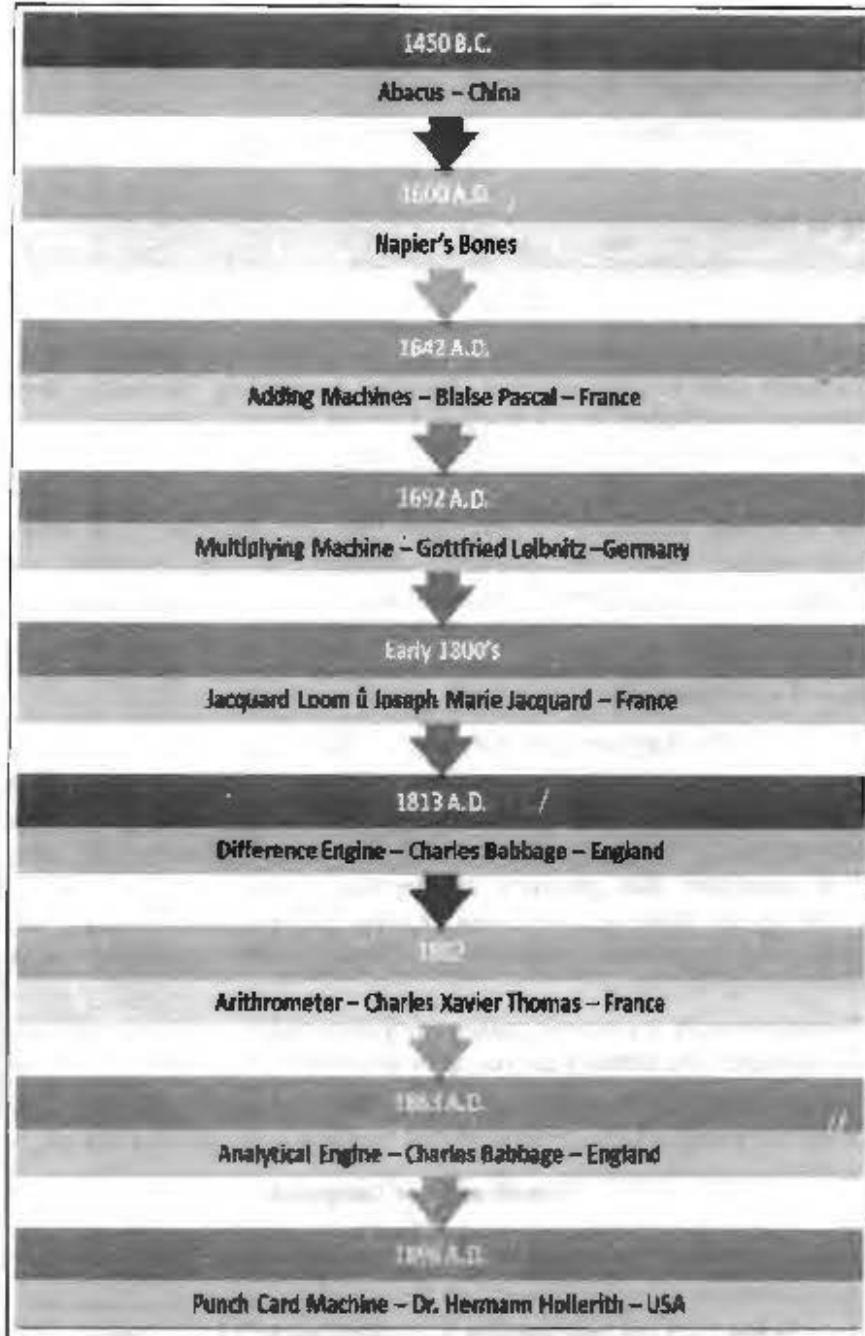


Figure 1.3: Discoveries of Computers Machines

In 1946, J. Presper Eckert and John W. Mauchly invented giant ENIAC machine at the University of Pennsylvania. ENIAC (Electrical Numerical Integrator and Calculator) was the first machine to use large number of vacuum tubes. The machinery required a big space and lot of energy to keep it cool. Further, it had punched-card input and output.

1.9 TYPES OF COMPUTERS

The classification of computers is based on the following four criteria:

- (a) According to Purpose
- (b) According to Technology Used

(c) According to Size and Storage Capacity

(d) According to Historical Advancement

Based on these criteria, the classification of computers is illustrated in Figure 1.4 and discussed below:

According to Purpose

According to the utilization of computer for different uses, computers are of the following two types:

1. **General Purpose Computers:** Computers that follow instructions for general requirements such as sales analysis, financial accounting, invoicing, inventory, management information, etc., are called General Purpose Computers. Almost all computers used in offices for commercial, educational and other applications are general purpose computers.
2. **Special Purpose Computers:** Computers that are designed from scratch to perform special tasks like scientific applications and research, weather forecasting, space applications, medical diagnostics, etc., are called Special Purpose Computers.

According to Technology Used

According to the technology used, computers are of the following three types:

1. **Analog Computers:** Analog computers are special purpose computers that represent and store data in continuously varying physical quantities such as current, voltage or frequency. These computers are programmed for measuring physical quantities like pressure, temperature, speed, etc., and to perform computations on these measurements. Analog computers are mainly used for scientific and engineering applications. Some of the examples of analog computers are given below:
 - (a) *Thermometer:* It is a simple analog computer used to measure temperature. In thermometer, the mercury moves up or down as the temperature varies.
 - (b) *Speedometer:* Car's speedometer is another example of analog computer where the position of the needle on dial represents the speed of the car.

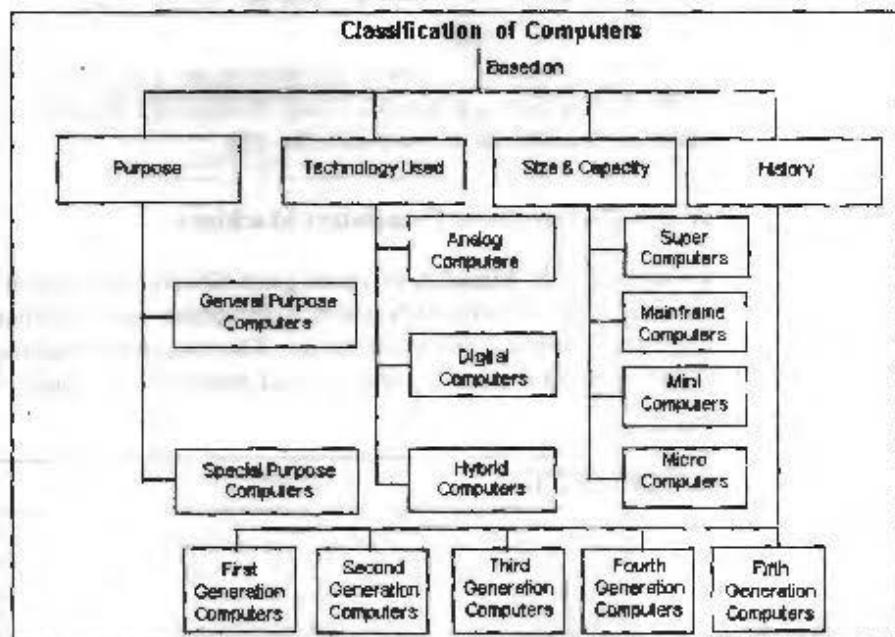


Figure 1.4: Classification of Computers Based on Different Criteria

2. **Digital Computers:** Digital computers are mainly general purpose computers that represent and store data in discrete quantities or numbers. In these computers, all processing is done in terms of numeric representation (Binary Digits) of data and information. Although the user enters data in decimal or character form, it is converted into binary digits (0's and 1's).
3. **Hybrid Computers:** Hybrid computers incorporate the technology of both analog and digital computers. These computers store and process analog signals which have been converted into discrete numbers using analog-to-digital converters. They can also convert the digital numbers into analog signals or physical properties using digital-to-analog converters. Hybrid computers are mainly used in artificial intelligence (robotics) and computer aided manufacturing (e.g. process control).

According to Size and Storage Capacity

According to the size and memory/storage capacity, computers are of the following four types:

1. **Supercomputer:** Supercomputer is the biggest and fastest computer, which is mainly designed for complex scientific applications. It has many CPUs (Central Processing Units main part of a computer), which operate in parallel to make it as a fastest computer. It is typically used for following applications:

- (a) Weather Information
- (b) Petroleum Exploration and Production
- (c) Energy Management
- (d) Defence
- (e) Nuclear Energy Research
- (f) Structural Analysis
- (g) Electronic Design
- (h) Real-time Animation
- (i) Medicine

Some of the examples of supercomputers are CRAY3, CRAY-XMP-14, NEC-500, PARAM 9000 and PARAM 10000.

2. **Mainframe Computer:** Mainframe computers are very large and fast computers but smaller and slower than supercomputers. They are used in a centralized location where many terminals (input/output devices) are connected with one CPU and thus, allow different users to share the single CPU. They have a very high memory (several hundred Megabytes) and can support thousands of users. They are mainly used for following applications:

- (a) Railway and Airline Reservations
- (b) Banking Applications
- (c) Commercial applications of large industries/companies

Some of the examples of mainframe computers are IBM 3090, IBM 4381, IBM 4300 and IBM ES-9000.

3. **Minicomputers:** Minicomputers are medium-scale, smaller and generally slower than mainframe computers. Like mainframes, they have many terminals, which are connected with one CPU and can support many users. The cost of a minicomputer is less as compared to mainframe. Therefore, it is mainly used in applications where processing can be distributed among several minicomputers rather than using a mainframe computer.

Some of the examples of minicomputers are PDP-1, DEC Micro VAX and IBM AS/400. IBM AS/400, which is actually a midicomputer (computer with performance between a mainframe and minicomputer) is becoming very popular among minicomputers.

4. **Microcomputers:** A microcomputer is the smallest digital computer, which uses a microprocessor as its CPU. Microprocessor is a single chip (integrated circuit) CPU. Microcomputer is popularly called as Personal Computer (PC). It can be used both as a stand-alone machine and a terminal in a multi-user environment. Microcomputers are becoming very popular now-a-days due to very high processing power and memory. Today, a powerful microcomputer may be used as a substitute for mini or mainframe computer.

Microcomputers are either of desktop or portable model. Portable computers can be carried from one place to another. Some of the models are called as laptops while others as notebook computers. Notebook computers are smaller, lighter and costlier than laptops. Desktop computers fit on a desktop and are used widely in offices and homes. The pictures of some of the desktop and portable computers are shown in Figure 1.5.

There are many types and models of personal computers, which are summarized in Table 1.3.



Figure 1.5: Some Desktop and Portable Computers

Table 1.3: Different Types of Microcomputers along with the Technical Specifications of CPU

CPU Model	Clock (MHz)	Data Bus	Register(BIT) (RAM)	Max.	Comments Memory
8088	8	8	16	1 MB	First 8 bit microprocessor (Original PC)
8086	8	16	16	1 MB	First 16 bit CPU on a chip (PC/XT)*
80286	20	16	16	16 MB	5 times faster than PC/XT (PC/AT)*

Contd...

80386 SX	33	16	32	16 MB	80386 with an 80286 bus
80386 DX	40	32	32	4 GB	True 32 bit CPU on a chip
80486 SX	40	32	32	4 GB	Math co-processor disabled
80486 DX2	66	32	32	4 GB	More speed with Math co-processor enabled
80486 DX4	100	32	32	4 GB	More speed than 486 DX2
Pentium Pro (P5)	200	64	32	4 GB	Superscalar architecture able to execute 2 instructions simultaneously
Pentium II (P6)	266	64	32	64 GB	Faster than Pentium Pro

*XT stands for Extended Technology and AT for Advanced Technology

1.10 GENERATIONS OF COMPUTERS

The computer evolved as a result of man's search for a fast and accurate calculating device. Abacus was the first manual calculating device, which was invented in Asia many centuries ago. In 1617, John Napier, a Scottish mathematician invented a mechanical calculator called the 'Napier's bones'. Thereafter, many kinds of computers have been designed and built during the evolution of the modern digital computer. In order to provide a framework for the growth of computer industry, the computer era has been referred in terms of generations. Computers are classified into following six types based on their historical advancement and electronic components used:

1. **Zeroth Generation Computers:** The zeroth generation of computers (1642-1946) was marked by the invention of mainly mechanical computers. Pascaline was the first mechanical device, invented by Blaise Pascal, a French mathematician in 1642. In 1822, Charles Babbage, an English mathematician, designed a machine called 'Difference Engine' to compute tables of numbers for naval navigation. Later on, in the year 1834, Babbage attempted to build a digital computer, called Analytical Engine. The analytical engine had all the parts of a modern computer i.e., it had four components – the store (memory unit), the mill (computation unit), the punched card reader (input unit) and the punched/printed output (output unit). As all basic parts of modern computers were thought out by Charles Babbage, he is known as Father of Computers. In later years, Herman Hollerith invented a machine for doing counting for 1880 US census, which was called the Tabulating Machine. In 1944, Howard A. Eiken invented first American general-purpose electro-mechanical computer, called Mark I and later on its successor, Mark II. The zeroth generation of computers or the era of mechanical computers ended in 1946, when vacuum tubes were invented.
2. **First Generation Computers:** The first generation of computers (1946-1954) was marked by the use of vacuum tubes or valves as their basic electronic component. Although these computers were faster than earlier mechanical devices, they had many disadvantages. First of all, they were very large in size. They consumed too much power and generated too much heat, when used for even short duration of time. They were very unreliable and broke down frequently. They required regular maintenance and their components had also to be assembled manually. The first generation of computers became out-dated, when in 1954, the Philco Corporation developed transistors that can be used in place of vacuum tubes.

Examples:

- ❖ **ENIAC** (Electronic Numerical Integrator and Calculator) – 1946
It was the first electronic computer using vacuum tubes.
- ❖ **EDSAC** (Electronic Delay Storage Automatic Calculator) – 1949
It was the first stored-program computer.
- ❖ **EDVAC** (Electronic Discrete Variable Automatic Computer) – 1951
It was successor of EDSAC.
- ❖ **IAS machine** (Princeton's Institute of Advanced Studies) – 1952
It was a new version of the EDVAC, built by von Neumann.

The basic design of IAS machine is now known as von Neumann machine, which had five basic parts – the memory, the arithmetic logic unit, the program control unit, the input and output unit as shown in Figure 1.6.

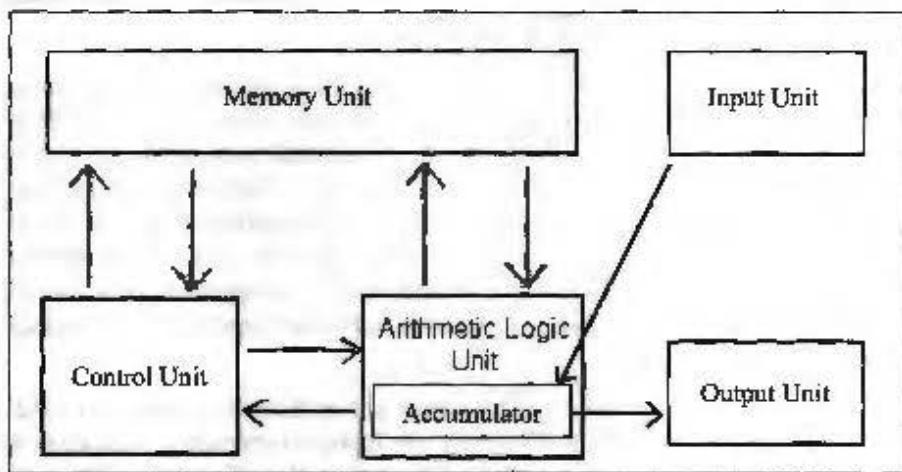


Figure 1.6: The Original von Neumann Machine

3. **Second Generation Computers:** The second generation of computers (1954-64) was marked by the use of transistors in place of vacuum tubes. Transistors had a number of advantages over the vacuum tubes. As transistors were made from pieces of silicon, so they were more compact than vacuum tubes. The second-generation computers, therefore, were smaller in size and less heat generated than first generation computers. Although they were slightly faster and more reliable than earlier computers, they also had many disadvantages. They had limited storage capacity, consumed more power and were also relatively slow in performance. Like first generation computers, they also required regular maintenance and their components had also to be assembled manually. Manual assembly of components was very expensive and later many attempts were made to reduce such manual assembly. It was in 1964, when it was discovered that a number of transistors could be sealed up into a tiny package, called an Integrated Circuit (IC) or a Chip. Second generation computers became out-dated after the invention of ICs.

Examples:

- ❖ PDP-1, developed by DEC was the first minicomputer.
- ❖ NCR 304 (National Cash Register) was first all-transistorized computer.

4. **Third Generation Computers:** The third generation of computers (1964-1980) was marked by use of Integrated Circuits (ICs) in place of transistors. As hundreds of transistors could be put on a single small circuit, so ICs were more compact than transistors. The third generation computers, therefore, removed many drawbacks of second-generation computers. The third generation computers were even smaller in size; very less heat generated and required very less power as compared to earlier two generation of computers. These computers required less human labour at the assembly stage. Although, third generation computers were also still faster and even more reliable, they also had few disadvantages. They still had less storage capacity, relatively slower performance and thus could not fulfill the requirements of the users and programmers. The third generation computers became out-dated, when it was found in around 1978, that thousands of ICs could be integrated onto a single chip, called LSI (Large Scale Integration).

Examples:

- ❖ IBM 360, developed by IBM in 1964 was the first product line designed as a family.
- ❖ PDP-8, developed by DEC in 1965 was the first mass-market minicomputer.
- ❖ PDP-11, developed by DEC in 1970 was the first highly successful minicomputer.
- ❖ CRAY-1, developed by Cray in 1974 was the first supercomputer.
- ❖ VAX, developed by DEC in 1978 was the first supermini computer.

5. **Fourth Generation Computers:** The fourth generation of computers (1978-till date) was marked by use of Large Scale Integrated (LSI) circuits in place of ICs. As thousands of ICs could be put onto a single circuit, so LSI circuits are still more compact than ICs. In 1978, it was found that millions of components could be packed onto a single circuit, known as Very Large Scale Integration (VLSI). VLSI is the latest technology of computer, that led to the development of the popular Personal Computers (PCs), also called as Microcomputers. All present day computers are fourth generation of computers. These computers are very powerful having a high memory and a fast processing speed. Today's PCs are even more powerful than mainframe computers. Although fourth generation computers offer too many advantages to users, still they have one main disadvantage. The major drawback of these computers is that they have no intelligence on their own. Scientists are now trying to remove this drawback by making computers, which would have artificial intelligence.

Examples:

- ❖ IBM PC, developed in 1981 was the first industry standard personal computer, having Intel 8088 memory chip.
- ❖ IBM PC/AT, developed in 1982 was the first advanced technology PC, having Intel 80286 memory chip.
- ❖ 386, developed in 1985, had Intel 80386 memory chip.
- ❖ CRAY-2, developed in 1985, was the fourth generation supercomputer.
- ❖ 486, developed in 1989, had Intel 80486 memory chip.
- ❖ Pentium, developed in 1995, has pentium (80586) memory chip.

6. **Fifth Generation Computers:** The fifth generation computers (Tomorrow's computers) are still under research and development stage. These computers

would on a single IC. The most important feature of fifth generation computers is that they will use intelligent software. This software will enable the user to tell computer 'What to do' and not 'How to do' by using intelligent programming and knowledge-based problem solving techniques. So, the programmers or users would not require giving each and every instruction to the computer for solving a problem. These computers will also have user interface in form of speech in natural languages have artificial intelligence. They will use USLI (Ultra Large Scale Integration) chips in place of VLSI chips. One USLI chip contains millions of components.

Example:

- ❖ Yet to develop, but ROBOTS have few features of fifth generation computers

The comparative features of various generations of computers are shown in Table 1.4.

Table 1.4: Comparative Features of Various Generations of Computers

Criteris	First Gen. Computers	Second Gen. Computers	Third Gen. Computers	Fourth Gen. Computers	Fifth Gen. Computer
Basic Electronic Component	Vacuum Tubes or Valves	Transistors Integration (VLSI)	Integrated Circuits (ICs) Integration (ULSI)	Very Large Scale	Ultra Large Scale
Speed	Slowest	Slow	Medium	Faster	Fastest
Size	Largest	Large	Medium	Smallest	Medium
Reliability	Unreliable	Less Reliable	More Reliable	Most judge	Yet to
Availability	Out-dated	Out-dated	Out-dated	Current	Yet to build

Check Your Progress

Fill in the blanks:

1. Fear of computers mainly caused by lack of knowledge is known as _____
2. _____ are large-sized, powerful multi-user computers that can support concurrent programs.
3. The four basic operations of a computer are referred to as _____
4. _____ is the first known calculating device.
5. _____ was the first electronic computer.

1.11 LET US SUM UP

- We are breathing in the computer age and gradually computer has become a necessity of our life. Now that computers have moved in our society so rapidly, one needs, at least the basic computer skills to pursue one's career goals and functions effectively and efficiently.
- Computer is an electronic device for performing arithmetic and logical operations. Computer is a programmable machine i.e., it depends on what program a computer is using for performing a particular function. There are four basic operations of computer. They are Input, Processing, Output and Storage. These operations are often referred to as IPOS cycle.

- A computer is a machine with high speed and accuracy. It is versatile and diligent. It has its own permanent memory and it has no intelligence of its own. It works on the instructions given by the human being.
- The idea of computing is as old as the civilization itself. From abacus to today's micro-computers, their evolution has changed the way, man lives and works. Charles Babbage, for his inventions of Difference Engine and Analytical Engine, is recognized as the father of computer. Dr. Herman Hollerith, started the company IBM Corp. in 1924, which is world's leading computer Industry, even today.
- The term generation was introduced to distinguish between different computer hardware technologies. The computers are divided into five generations. The first generation computers include ENIAC, which used vacuum tubes, second generation computers were characterized by the use of solid state devices (transistors), third generation computers used integrated circuits, fourth generation computers used microprocessors and fifth generation computers use the concept of 'Artificial Intelligence'.
- Computers can be classified into general purpose or special purpose; analog, digital or hybrid; Super computer, mainframe minicomputer or microcomputer on the basis of purpose, technology used, size and capacity respectively. Computers are used in various fields from education to research.

1.12 UNIT END ACTIVITY

Observe the types of computers in your office/lab/facility and distinguish them into different categories, such as mainframe computers, minicomputers, workstations or PCs, etc.

1.13 KEYWORDS

Computer: An electronic device used for performing arithmetic and logical operations.

Program: A set of instructions given to the computer to perform certain task.

Hardware: The physical components of the computer that can be seen and touched.

Software: A set of computer programs that enables the hardware to process data.

Artificial Intelligence (AI): The study of thought processes of humans and representation of those processes via machines (computers, robots, etc.).

Data: Raw facts or elementary description of things, events, activities, and transactions, that are captured, recorded, stored and classified, but not organized to convey any specific meaning.

Information: A collection of facts (data) organized in some way so that they are meaningful to a recipient.

First generation computers: Computers built between 1942 and 1955, which used vacuum tubes. Programming was in assembly language.

Second generation computers: Computers built during the period 1955-1964, which used transistors in CPU, magnetic core main memories and high level languages for programming.

Third generation computers: Computers built between 1964-1975, which used integrated circuits in CPU, high speed magnetic core main memories and powerful high level languages for programming.

SSI (Small Scale Integrated Circuit): An electronic circuit with about 20 transistors fabricated on a silicon chip.

VLSI (Very Large Scale Integrated Circuit): An electronic circuit with about 100,000 transistors fabricated on a silicon chip.

LSI (A Large Scale Integrated Circuit): An electronic circuit with about 10,000 transistors fabricated on a silicon chip.

Fourth generation computers: Computers built between 1975 and 1989. They use LSI circuits, semiconductor memories and powerful high-level languages and operating systems.

Fifth generation computers: Computers built between 1989 and now. They use large number of processors working concurrently and independently. Simpler programming languages and knowledge based system implementations are expected in this generation.

General purpose computers: Computers that follow instructions for general requirements.

Special purpose computers: Computers that are designed from scratch to perform special tasks.

Analog computers: Special purpose computers that represent and store data in continuously varying physical quantities.

Digital computers: General purpose computers that represent and store data in discrete quantities or numbers.

Hybrid computers: Computers that incorporate the technology of both analog and digital computers.

Super computer: The biggest and fastest computer designed for complex scientific applications.

Mainframe computer: Very large and fast computers used in a centralized location to allow different users to share the single CPU.

Microprocessor: A single chip CPU.

1.14 QUESTIONS FOR DISCUSSION

1. Define computer and briefly explain its main characteristics. Do you think computer is more intelligent than human beings? Discuss.
2. Which major category of computers is used in almost all offices and homes?
3. Explain the salient features of analog, digital and hybrid computers.
4. What is a supercomputer? List the various uses of supercomputers.
5. Explain the differences between mainframe computer and minicomputer.
6. What is a microcomputer? Explain the differences among various models of microcomputers.
7. Classify the following computers in different categories:

(a) IBM 3090	(b) IBM AS/400	(c) PDP-1
(d) CRAY3	(e) IBM ES-9000	(f) DEC Micro VAX
(g) NCR 304	(h) IBM 360	(i) Pentium
(j) PARAM 10000		

8. Write a short note on Zeroth Generation of Computers.
9. Why did the First Generation Computers fail? Did the Second Generation Computers become successful? Discuss with examples.
10. Discuss the differences between Third and Fourth generation of computers.
11. What are the Fifth Generation Computers? Do you think these computers would replace Fourth Generation Computers? Discuss.
12. Name the following computers:
 - (a) First Supercomputer
 - (b) First Supermini Computer
 - (c) First highly successful minicomputer
 - (d) First industry standard personal computer
13. Write the full form of following abbreviations:
 - (a) ENIAC
 - (b) EDSAC
 - (c) EDVAC
 - (d) IBM
 - (e) IAS
14. Why are IBM Compatible PCs more popular than Apple Mac PCs? Discuss.
15. Do we need computers? Explain the various uses of computers.

Check Your Progress: Model Answer

1. Cyberphobia
2. Mainframe
3. IPOS cycle
4. Abacus
5. ENIAC

1.15 REFERENCES & SUGGESTED READINGS

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UNIT-2

INTRODUCTION TO PERSONAL COMPUTER

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2.0 AIMS AND OBJECTIVES

After studying this lesson, you should be able to:

- Define personal computer, its uses and components
- Describe the evolution of personal computer
- Explain the developments of processors
- Understand the architecture of Pentium IV
- Discuss the configuration of PC

2.1 INTRODUCTION

When most people think about computers, they picture a personal computer or PC. It's designed for only one person to use at a time. Most of the computers you and your friends and family have are probably personal computers. The first general-purpose, cost-effective personal computer created by IBM was called the IBM PC or means "personal computer". It is a microprocessor technology that has been any small,

relatively inexpensive computer designed to be used by one person, at home or in an office. It is often simply called a Personal Computer (PC). The example of Personal Computer or PC is microcomputer, desktop computer, laptop computer and tablet.

2.2 MEANING OF PERSONAL COMPUTER

A personal computer is a computer small and low cost, which is intended for personal use (or for use by a small group of individuals). The term "personal computer" is used to describe desktop computers (desktops). It is often shortened to the acronym PC or microcomputer, whose meaning in English is "personal computer". It is a very common type of machines.

In its more general usage, a personal computer (PC) is a microcomputer designed for use by one person at a time. Prior to the PC, computers were designed for (and only affordable by) companies who attached terminals for multiple users to a single large computer whose resources were shared among all users. The advent of the era of the personal computer was acknowledged by Time magazine in 1982, when they broke with tradition by choosing the PC as their "Man of the Year." By the late 1980s, technology advances made it feasible to build a small computer that an individual could own and use.

Personal Computer (acronym PC) consists of a central processing unit (CPU) contains the arithmetic, logic and control circuitry on a single (IC) integrated circuit; two types of memory, main memory, such as RAM, and ROM, magnetic hard disks (HDD) and compact discs and various input/output devices, including a display screen, keyboard and mouse, modem and printer.

The term "PC" has been traditionally used to describe an "IBM-compatible" personal computer in contradistinction to an Apple Macintosh computer. The distinction is both technical and cultural and harkens back to the early years of personal computers, when IBM and Apple were the two major competitors. Originally, the "IBM-compatible" PC was one with an Intel microprocessor architecture and an operating system such as DOS or Windows that written to use that microprocessor. The Apple Macintosh uses Motorola microprocessor architecture and a proprietary operating system. The "IBM-compatible" PC was associated with business and use, while the "Mac," known for its more intuitive user interface, was associated with graphic design and desktop publishing. Although the distinctions have become less clear-cut in recent years, people often still categorize a personal computer as either a PC or a Mac.

2.3 USES OF PERSONAL COMPUTER

The personal computer was first introduced by IBM – International Business Machines – in 1981, according to the Computer History Museum. Since that time, the use of personal computers in business has spread pervasively. In 2011, almost every employee has a personal computer on their desk. Business professionals use computers for many functions, such as creating letters, calculating numbers or performing research on the Internet. Personal computers can also be used for many functions and applications for business.

- **Sending Emails:** Emails are one of the most pervasive ways to communicate in the business world. Business professionals from executives to marketing analysts use personal computers for sending emails. Secretaries use company emails to apprise other managers and employees of meetings or special functions. Managers often use email to attach and disseminate important documents, such as reports and memos. Additionally, emails can be used externally to inform customers about new products or services. Advertising professionals often send emails out to

- thousands of businesses at the click of a button to generate leads and product orders.
- ***Creating Documents:*** Business professionals frequently use personal computers to create documents, such as memos, reports, business forms, shipping invoices and order forms. Marketing research managers use personal computers to write questionnaires. These questionnaires can then be printed in mass quantities for conducting customer services. Secretaries sometimes use personal computers to print shipping labels for mailing packages. Advertising copywriters use publishing software to produce brochures or fliers on personal computers. A company can also use personal computers to design advertisements or create newsletters.
 - ***Creating Spreadsheets:*** Business professionals use personal computers to create spreadsheets. For example, a finance manager may create a personal computer spreadsheet to keep track of his company's budget. A spreadsheet is a software application that is divided into many different columns and rows. Each individual section of a spreadsheet is called a cell. The finance manager may enter department names in the rows and types of expenses various departments incur across columns of the spreadsheet. Personal computer spreadsheets are extremely useful for making calculations, as business professionals can create formulas for specific cells. Subsequently, totals will automatically be calculated each time a manager enters additional numbers to the spreadsheet.
 - ***Creating Databases:*** Companies use personal computers to create databases, which are massive lists of names or numbers. The most important consideration when creating a database is deciding what data will be used, according to Inc. magazine. Marketing managers may use personal computer databases to keep track of customers who order products. For example, the marketing manager may enter the date a customer ordered a product and how much they spent. Periodically, the marketing manager may send out brochures or coupons to customers announcing new products or sales. Entrepreneurs may use a personal computer database to track the results of an advertising campaign. That way the advertising manager can determine which ads are profitable.

2.4 COMPONENTS OF PERSONAL COMPUTER

A modern PC is both simple and complicated. It is simple in the sense that over the years, many of the components used to construct a system have become integrated with other components into fewer and fewer actual parts. It is complicated in the sense that each part in a modern system performs many more functions than did the same types of parts in older systems.

This section briefly examines all the components and peripherals in a modern PC system. Here are the components and peripherals necessary to assemble a basic modern PC system are shown in Table 2.1.

Table 2.1: Basic PC Components

Component	Description
Motherboard	The motherboard is the core of the system. It really is the PC; everything else is connected to it, and it controls everything in the system.
Processor	The processor is often thought of as the "engine" of the computer. It's also called the CPU (central processing unit).
Memory (RAM)	The system memory is often called RAM (for random access memory). This is the primary memory, which holds all the programs and data the processor is using at a given time.

Contd...

Case/chassis	The case is the frame or chassis that houses the motherboard, power supply, disk drives, adapter cards and any other physical components in the system.
Power supply	The power supply is what feeds electrical power to every single part in the PC.
Floppy drive	The floppy drive is a simple, inexpensive, low-capacity, removable-media, magnetic storage device.
Hard drive	The hard disk is the primary archival storage memory for the system.
CD-ROM/DVD-ROM	CD-ROM (compact disc read-only) and DVD-ROM (digital versatile disc read-only) drives are relatively high-capacity, removable media and optical drives.
Keyboard	The keyboard is the primary device on a PC that is used by a human to communicate with and control a system.
Mouse	Although many types of pointing devices are on the market today, the first and most popular device for this purpose is the mouse.
Video card	The video card controls the information you see on the monitor.
Monitor	Monitor is often used synonymously with "computer screen" or "display." Monitor is an output device that resembles the television screen. It may use a Cathode Ray Tube (CRT) to display information. The monitor is associated with a keyboard for manual input of characters and displays the information as it is keyed in. It also displays the program or application output. Like the television, monitors are also available in different sizes.
Sound card and Speaker(s)	It enables the PC to generate complex sounds. An expansion board that enables a computer to manipulate and output sounds. Sound cards are necessary for nearly all CD-ROMs and have become commonplace on modern personal computers. Sound cards enable the computer to output sound through speakers connected to the board, to record sound input from a microphone connected to the computer, and manipulate sound stored on a disk.
Modem	Most prebuilt PCs ship with a modem (generally an internal modem).
Trackball	A trackball is an input device used to enter motion data into computers or other electronic devices. It serves the same purpose as a mouse, but is designed with a moveable ball on the top, which can be rolled in any direction.
Touchpad	A touch pad is a device for pointing (controlling input positioning) on a computer display screen. It is an alternative to the mouse. Originally incorporated in laptop computers, touch pads are also being made for use with desktop computers. A touch pad works by sensing the user's finger movement and downward pressure.
Touch Screen	It allows the user to operate/make selections by simply touching the display screen. A display screen that is sensitive to the touch of a finger or stylus. Widely used on ATM machines, retail point-of-sale terminals, car navigation systems, medical monitors and industrial control panels.
Magnetic Ink Character Recognition (MICR)	MICR can identify character printed with a special ink that contains particles of magnetic material. This device particularly finds applications in banking industry.
Optical Mark Recognition (OMR)	Optical mark recognition, also called mark sense reader is a technology where an OMR device senses the presence or absence of a mark, such as pencil mark. OMR is widely used in tests such as aptitude test.
Bar code reader	Bar-code readers are photoelectric scanners that read the bar codes or vertical zebra strips marks, printed on product containers. These devices are generally used in super markets, bookshops, etc.
Scanner	Scanner is an input device that can read text or illustration printed on paper and translates the information into a form that the computer can use. A scanner works by digitizing an image.
Plotter	Plotters are used to print graphical output on paper. It interprets computer commands and makes line drawings on paper using multi colored automated pens. It is capable of producing graphs, drawings, charts, maps, etc.
Facsimile (FAX)	Facsimile machine, a device that can send or receive pictures and text over a telephone line. Fax machines work by digitizing an image.

2.5 EVOLUTION OF THE PERSONAL COMPUTER (1975-1984)

Personal computer history doesn't begin with IBM or Microsoft, although Microsoft was an early participant in the fledgling PC industry.

The first personal computers, introduced in 1975, came as kits: The MITS Altair 8800, followed by the IMSAI 8080, an Altair clone. (Yes, cloning has been around that long!) Both used the Intel 8080 CPU. That was also the year Zilog created the Z-80 processor and MOS Technology produced the 6502. Bill Gates and Paul Allen wrote a BASIC compiler for the Altair and formed Microsoft.



Figure 2.1: Altair

In 1976, Apple's two Steves (Jobs and Wozniak) designed the Apple I, Apple's only "kit" computer (you had to add a keyboard, power supply and enclosure to the assembled motherboard), around the 6502 processor. That was also the year that Electric Pencil, the first word processing program, and Adventure, the first text adventure for microcomputers, were released. Shugart introduced the 5.25" floppy drive; it would become a key component in the personal computing revolution.

The young industry exploded in 1977 as Apple introduced the Apple II, a color computer with expansion slots and floppy drive support; Radio Shack rolled out the TRS-80 to its stores across the nation; Commodore tapped into the pet rock craze with its PET; Digital Research released CP/M, the 8-bit operating system that provided the template for MS-DOS; and the first ComputerLand franchise store (then Computer Shack) opened.

Software took center stage in 1978 when Dan Bricklin and Bob Frankston produced VisiCalc, the first electronic spreadsheet. This turned the personal computer into a useful business tool, not just a game machine or replacement for the electric typewriter.



Figure 2.2: Electronic Spreadsheet

WordMaster, soon to become WordStar, was released and went on to dominate the word processing industry for years. Atari leveraged its video game experience and household name to enter the personal computing market, and Epson shipped the TX-80, the first low-cost dot matrix printer.

The third important software category, the database, blasted onto the scene in 1979 with Vulcan, the predecessor of dBase II and its successors. That was also the year Hayes introduced a 300 bps modem and established telecommunication as an aspect of personal computing.

Texas Instrument's poorly designed and ill-fated TI-99/4 also shipped in 1979 as the personal computer industry's first 16-bit computer. It was hobbled by an 8-bit bus for memory and peripherals, which slowed memory access significantly.



Figure 2.3: Vulcan

1980 was the year Commodore opened the floodgates of home computing with the \$299 VIC-20. Sinclair tried to one-up them with a \$199 kit computer, the ZX80, which was quite popular in Britain, but it was destined to remain a bit player in the PC industry. The same can be said of Radio Shack's fairly impressive TRS-80 Color Computer, which suffered primarily from complete incompatibility with its existing TRS-80 line.

Yet another 1980 disaster was the Apple III, which shipped with 128 KB of memory, an internal floppy drive and Apple II emulation. Alas, it just didn't work right, forcing Apple to recall them all, fix a number of problems, and rerelease the Apple III some time later with 192 KB of RAM. This was also Apple's first computer to support a hard drive, the 5 MB Profile.



Figure 2.4: Apple III

Estimates are that there were one million personal computers in the US in 1980.

In early 1981, Adam Osborne introduced the first portable computer. The Osborne 1 was about this size of a suitcase, ran CP/M, included a pair of 5.25" floppies, and had a tiny 5" display. The innovative machine was bundled with about \$1,500-2,000 worth of software, and the whole package sold for \$1,899.



Figure 2.5: The Epson HX-20

The first laptop computer also arrived in 1981, the Epson HX-20 (a.k.a. Geneva). The HX-20 was about 8.5" by 11" and maybe 1.5-2" thick and used a microcassette to store data. It displayed 4 lines of 20 characters on an LCD screen above the keyboard.



Figure 2.6: Keyboard with LCD Screen

2.5.1 The IBM PC

Of course, the most significant event of 1981 for the personal computing industry was the introduction of the IBM PC on August 12. This computer ran a 16-bit CPU on an 8-bit bus (the Intel 8088), had five expansion slots, included at least 16 KB of RAM, and had two full-height 5.25" drive bays.



Figure 2.7: IBM PC (the Intel 8088)

Buyers could get a fairly loaded machine with a floppy controller, two floppy drives, a monochrome display adapter and 720 × 350 pixel green screen monitor, a color display adapter and CGA (320 × 200 with 4 colors or 640 × 200 with 2) monitor, a parallel card, a dot matrix printer, and an operating system – with the choice of CP/M-

86, the UCSD p-System, or PC-DOS (a.k.a. MS-DOS). Pretty much everything was an option and everyone recognized that the IBM PC was based on ideas perfected in the Apple II, particularly general use expansion slots.

The second most significant event of 1981 was dependent on the first: Microsoft got IBM to agree that PC-DOS would not be an IBM exclusive. This paved the way for the clone industry, which in the end marginalized the influence of Big Blue.

Time magazine called 1982 "The Year of the Computer" as the industry grew up. By 1983, the industry estimated that 10 million PCs were in use in the United States alone.

Ever since IBM entered the market, the term PC has taken on a different meaning. Although it retains the original meaning of "personal computer", the IBM architecture has so dominated the industry that it soon came to mean IBM compatible computers to the exclusion of other machines.

VisiCalc met its match in 1983 when Lotus 1-2-3 shipped for the IBM PC. That was also the year that Microsoft Word 1.0 shipped, although it remained a small player until Windows dominated the PC world.

Apple introduced the first consumer machine with a mouse and graphical user interface, the Lisa. Of course, at \$10,000, not many consumers or businesses could afford it, but it paved the way for the Apple Macintosh of 1984. At \$2,500, it was much more affordable than the Lisa.



Figure 2.8: The Lisa (Consumer Machine with a Mouse and Graphical User Interface)

IBM took the PC beyond the 8-bit bus when it introduced the AT (for Advanced Technology), a 6 MHz 80286-based computer with a 16-bit bus, high density 5.25" floppies, and a new video standard, EGA.

2.6 DEVELOPMENT OF PROCESSORS

Today, computers are a part of our lifestyle, but the first computer that was used was developed at the University of Pennsylvania in the year 1946. It had an ENIAC (Electronic Numerical Integrator and Computer) processor. The reprogramming feature that is so extensively used today was introduced by Alan Turing and John von Neumann with their teams. The von Neumann architecture is the basis of modern computers.

From the development of the first microprocessor - Intel's 4004 to the latest ones - the microprocessors have come a long way. Here, we look into the story so far.

2.6.1 Chips Till Date

1971 - Intel 4004

- It was the first microprocessor and it was used in the Busicom 141-PF calculator.
- It was designed by Federico Faggin and Ted Hoff of Intel and Masatoshi Shima of Busicom, and it was launched on November 15, 1971.
- It consisted of 2300 transistors with pMOS technology.
- The total number of instructions was 46. The designed clock speed was 1 MHz while only 740 kHz was achieved.

1972 - Intel 8008

- For the first time it was used in personal computers, Micral and SCELBI.
- Also known as MCS-8, it was launched in April 1972.
- It was developed by Victor Poor and Harry Pyle of CTC, and Ted Hoff, Faggin, Stanley Mazor and Hal Feeney from Intel.
- It was made up of 3500 transistors. However, it was slower than its predecessor 4004.
- The clock speed was 0.5 MHz with the total number of instructions being 48.

1974 - Intel 8080

- It was used in the computers MITS Altair 8800 and IMSAI 8080. Space Invaders (arcade video game) also used 8080 as the main processor.
- Launched in April 1974, it was developed by Faggin, Mazor and Masatoshi Shima.
- The clock speed increased to 2 MHz, it was built on nMOS technology and used 6000 transistors.
- The major development was the separation of address (16-bit) and data (8-bit) bus. It also supported 256 I/Os.

1974 - Motorola 6800

- HCF is a self-test feature developed for the first time by Motorola.
- This processor developed by Motorola had no I/O ports.
- Memory-mapped input-output were used as I/Os.
- The clock speed was only 2 MHz with the instruction set consisting of 72 instructions.
- It was for the first time that HCF (Halt and Catch Fire) opcode was used, that made the processor unresponsive to any interrupts till it was reset.

1977 - Intel 8085

- The radiation-hardened version was used in NASA and ESA space expeditions.
- Unlike the other processors developed so far, this one was also used as a microcontroller working on +5V supply.
- It was the first time that von Neumann architecture was used.
- It was built with 6500 transistors and used nMOS technology.
- The instruction set consisted of 256 instructions.

1978 - Intel 8086

- This was first used in the microcomputer Mycron 2000.
- The designed clock speed was 10 MHz.
- The development team for architecture consisted of Stephen P. Morse and Bruce Ravenel. Logic was designed by Jim McKevitt, John Bayliss and William Pohlman was the project manager.

1979 - Intel 8088

- The original IBM PC was based on 8088.
- 8088 was based on the new HMOS technology and was launched on 1 July.
- It came in 40-pin DIP as well as PLCC (plastic leaded chip carrier) package.
- However, the data path was only 8-bit. The designed frequency was 10 MHz.

1987 - SPARC

- Fujitsu's K Computer is ranked number 1 in the world's fastest 500 supercomputers as per TOP500 list ratings. It used SPARC.
- This processor was developed by Sun Microsystems.
- It had a clock speed of 40 MHz.
- It was made up of 1.8 million transistors with 256 IO pins.

1991 - Am386

- The excellent performance of AMD's floating point unit made it the second best choice (after Intel) for many manufacturers.
- This AMD (Advanced Micro Devices) processor had striking resemblance to the Intel 80386 version x86 processors.
- With a clock speed of 40 MHz and 32-bit data bus, the processor was a competitor to Intel.

1993 - Pentium Processor

- It was the first superscalar x86 microarchitecture that could execute two instructions simultaneously, thus speeding up the processor and reducing computing time.
- The Pentium family started with the launch of the P5 processor.
- It came in two models - 510-pin version with 60 MHz clock speed and 567-pin version with a clock speed of 66 MHz.
- Launched on March 22, it was built with 3.1 million transistors.
- This 32-bit processor was the most advanced processor used in many computers that were manufactured at that time.

1995 - Pentium Pro

- This processor was used in ASCI Red that delivered teraFLOP (one trillion floating-point operations in one second) performance.
- This was the first processor of the Pentium II series.

- This latest entrant came in an unconventional MCM (ceramic multi-chip module) 387 pins packaging.
- With a clock speed of 200 MHz, it was built to run in quad as well as dual processor configurations.
- About 5.5 million transistors were used to build this processor.
- It did not have an MMX instruction set.

1997 - Pentium II

- Launched on 7 May, the Pentium II family had a vast range of processors to offer.
- The clock speed was increased gradually with every model launched to up to 450 MHz.
- Unlike the traditional processors, this one came in a slot or socket module. This made it easy for the computer manufacturers to use it in a limited space.
- Various processors were launched under this family:
 - ❖ Klamath (233 and 266 MHz)
 - ❖ Deschutes (333 MHz)
 - ❖ Pentium II Overdrive (300 or 333 MHz)
 - ❖ Tonga (First mobile Pentium II)
 - ❖ Dixon (Considered to be the fastest Pentium II)
- It had a removable heatsink/fan combination that reduced the problem of heat dissipation.

1999 - Pentium III

- This Pentium II successor was launched on 26 February.
- The advancement from the previous model was the addition of the SSE instruction that accelerated the floating point calculations.
- On the similar lines as Pentium II, this processor was launched in Celeron (Low-end version) and Xeon (High-end version).
- The list of processors under this family are:
 - ❖ Katmai: Clock speed of 450 MHz and uses 9.5 million transistors
 - ❖ Coppermine: Clock speed of up to 1 GHz
 - ❖ Coppermine T: Only Coppermine model with an integrated heatsink (IHS)
 - ❖ Tualatin: Clock speed up to 1.4 GHz and 0.13 μm process
- PSN (Processor Serial Number) was introduced in the manufacturing process that created the processor's unique identity, which was the first instance.

1999 - Athlon

- Enhanced 3DNow! was first introduced, which increased the speed up to 2-4 times.
- AMD launched Athlon on June 23. It was built using 37 million transistors and achieved a clock speed of about 800 MHz.
- It was packaged in a unique PGA (Pin Grid Array) 453-pin packaging.

- Athlon was a legitimate competitor to Intel Pentium III because it was faster.
- It was the first processor to reach the speed of 1 GHz.

2000 - Pentium IV

- Intel's new single core processor family in the market was the Pentium IV processor that achieved a clock speed between 1.3 GHz to 3.08 GHz.
- The 423-pin processor came in an OLGA (Organic Land Grid Array) and PPGA (Plastic Pin Grid Array) type packaging.
- The processors under this family are:
 - ❖ Willamette: Clock speed of 1.4 and 1.5 GHz and 180 nm process
 - ❖ Northwood: Clock speed up to 2.2 GHz and 130 nm die
 - ❖ Pentium 4-M: Built for Mobile use with TDP of 35 watts
 - ❖ Mobile Pentium 4: Built for laptop use with increased bus speed of 33 MHz
 - ❖ Gallatin: Die of 130 nm and an added 2 MB level 3 cache
 - ❖ Prescott: Die of 90 nm and hyper-threading that speeds up processes such as video editing
 - ❖ Prescott 2M: Clock speed of 3.8 GHz and 90 nm process
 - ❖ Cedar Mill: Die of 65 nm
- The NetBurst architecture was first used in the processors under this family.

2003 - Pentium M

- This processor was a mobile single-core processor from Intel.
- It was designed with a clock speed of 2.26 GHz.
- Two processors were developed under this family, namely:
 - ❖ Banias: Clock speed of 1.7 GHz and TDP of 24.5 watts
 - ❖ Dothan: Die of 90 nm and clock speed of 2.1 GHz; TDP is reduced to 21 watts
- This processor was used for the first time in Intel Carmel notebook under Centrino brand.

2006 - Core 2

- Intel Core 2 brand, launched on July 27, 2006, was also known as E6320.
- The clock speed was achieved up to 3.5 GHz.
- The processors launched under this family were single-core, dual-core and quad-core.
- The processor has been dropped from the price list since 2011.
- The processors under this brand for desktops are:
 - ❖ Conroe: Die of 65 nm (dual)
 - ❖ Allendale: Die of 65 nm (dual)
 - ❖ Wolfdale: Die of 45 nm (dual)
 - ❖ Conroe XE: Die of 65 nm (dual)

- ❖ Allendale XE: Die of 65 nm (quad)
- ❖ Wolfdale XE: Die of 45 nm (dual)
- ❖ Kentsfield: Die of 65 nm (quad)
- ❖ Yorkfield: Die of 45 nm (quad)
- The processors under this brand for laptops are:
 - ❖ Merom: Die of 65 nm (dual)
 - ❖ Penryn: Die of 45 nm (dual)
 - ❖ Merom XE: Die of 65 nm (dual)
 - ❖ Penryn XE: Die of 45 nm (quad and dual)
 - ❖ Merom-L: Die of 65 nm (single)
 - ❖ Penryn-L: Die of 45 nm (single)
- The processor was capable of saving battery power by lowering the clock speed.

2.6.2 The Latest

The microprocessor technology has come a long way since the launch of 4004. The chip size has reduced, the clock speed has increased and the caches have further increased. The latest processors that have achieved this are:

1. *Sandy Bridge*: This Intel microarchitecture-based products were launched in 2011. It has achieved a 32-nanometer die manufacturing. It includes Intel Quick sync that is a hardware support for video encoding and decoding. There is also an improved 256-bit/cycle ring bus connect that interconnects the different parts of the processor. The transistor count used in this processor reaches up to 2.27 billion. This is the successor to the Nehalem microarchitecture family that achieved 45 nm manufacturing. The clock speed designed is 3.6 GHz. Intel recalled 67-series motherboards that had Cougar Point Chipset due to some hardware issue. The series under this family are:

- (a) Pentium: Clock speed up to 3.0 GHz
- (b) Celeron: Clock speed up to 3.0 GHz
- (c) Core i3: Clock speed up to 2.5 GHz
- (d) Core i5: Clock speed up to 3.4 GHz
- (e) Core i7: Clock speed up to 3.3 GHz
- (f) Core i7 Extreme: Clock speed up to 3.8 GHz

It has a vPro feature that can delete the information on a hard disk and the commands for this can be sent through 3G signals, Ethernet or Internet.

2. *Ivy Bridge*: An amazing 22-nm die processor named Ivy Bridge was announced by Intel in 2011, but it was introduced in the market on April 29, 2012. Reduced die is possible due to the use of the 3D (tri-gate) transistors. The 3D transistors reduce the power consumption to almost 50% less than the 2D ones. It also includes special support for PCI Express and also better graphics with DirectX 11. The clock speed is about 3.80 GHz. They are reported to have 20 °C higher temperatures than Sandy Bridge. The desktop models under this family are:

- (a) Core i3 Series: Clock speed up to 3.4 GHz
- (b) Core i5 Series: Clock speed up to 3.8 GHz

(c) Core i7 Series: Clock speed up to 3.5 GHz

The mobile models for under this family are:

(a) Core i3 Series: TDP of 14W

(b) Core i5 Series: TDP of 14W

(c) Core i7 Series: TDP of 14W to 45W

It is one of the 'tick' versions of Sandy Bridge.

The Future

The future processors that are expected to be launched in the 2013 are very promising. Here's a sneak preview.

- Haswell is being developed with a further shrunken die of 22 nm.
- Broadwell is announced to have a 14-nm die with Multi-chip packaging design that will be used.
- Skylake processors are expected to be available by 2015 with 14 nm process.
- The latest one to join this league is Skymont that will have a die of 10 nm.
- There are also indications of development of processors with die as small as 5 nm!

From the clock frequency of 1 MHz to about 3 GHz, the processor technology has come a long way. The die has shrunken to 22 nm and the miniaturization is still on. All these signs point to a brighter future for processors, which will come to benefit everyone.

2.7 ARCHITECTURE OF PENTIUM IV

Pentium 4 was a series of single-core Central Processing Units (CPU) for desktop PCs and laptops. The series was designed by Intel and launched in November 2000. Pentium 4 clock speeds were over 2.0 GHz.

Intel shipped Pentium 4 processors until August 2008. Pentium 4 variants included code named Willamette, Northwood, Prescott and Cedar Mill with clock speeds that varied from 1.3-3.8 GHz.

The Pentium 4 processor replaced the Pentium III via an embedded seventh-generation x86 microarchitecture, known as Netburst Microarchitecture, which was the first new chip architecture launched after the P6 microarchitecture in the 1995 Pentium Pro CPU model.

The Pentium 4 architecture enhanced chip processing in the following ways:

- Performance was boosted by increased processor frequency.
- A rapid-execution engine allowed each instruction execution to occur in a half-clock cycle.
- The 400 MHz system bus had data transfer rates (DTR) of 3.2 GBps.
- Execution trace cache optimized cache memory and improved multimedia units and floating points.
- Advanced dynamic execution enabled faster processing, which was especially critical for voice recognition, video and gaming.

After May 2005, Intel produced dual-core processors as Pentium Extreme Edition and Pentium D, which was a shift toward dividing instructions among processors

(parallelism). In July 2006, Intel released the Intel Core2 line of quad, dual and single core processors.

The Pentium 4 processor is designed to deliver performance across applications where end users can truly appreciate and experience its performance. For example, it allows a much better user experience in areas such as Internet audio and streaming video, image processing, video content creation, speech recognition, 3D applications and games, multi-media and multi-tasking user environments. The Pentium 4 processor enables real-time MPEG2 video encoding and near real-time MPEG4 encoding, allowing efficient video editing and video conferencing. It delivers world-class performance on 3D applications and games, such as Quake 3¹, enabling a new level of realism and visual quality to 3D applications.

The Pentium 4 processor has 42 million transistors implemented on Intel's 0.18μ CMOS process; with six levels of aluminium interconnect. It has a die size of 217 mm² and it consumes 55 watts of power at 1.5GHz. Its 3.2 GB/second system bus helps provide the high data bandwidths needed to supply data to today's and tomorrow's demanding applications. It adds 144 new 128-bit Single Instruction Multiple Data (SIMD) instructions called SSE2 (Streaming SIMD Extension 2) that improves performance for multi-media, content creation, scientific and engineering applications.

2.7.1 Overview of the NetBurst™ Microarchitecture

A fast processor requires balancing and tuning of many microarchitectural features that compete for processor die cost and for design and validation efforts. Figure 2.9 shows the basic Intel NetBurst microarchitecture of the Pentium 4 processor. As you can see, there are four main sections: the in-order front end, the out-of-order execution engine, the integer and floating-point execution units and the memory subsystem.

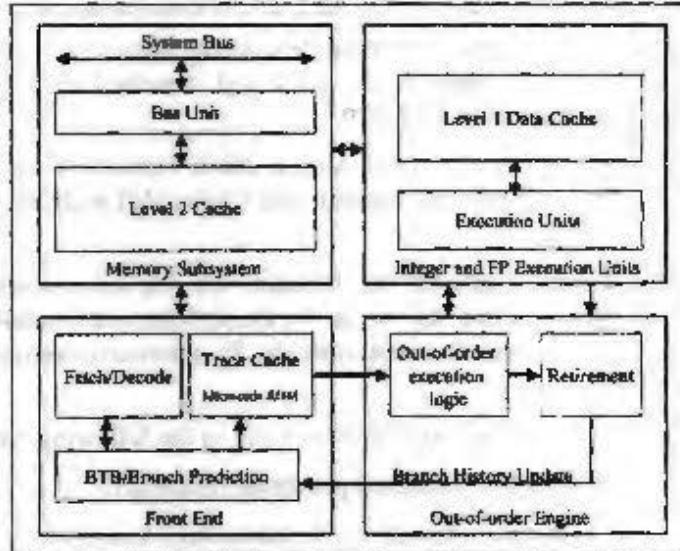


Figure 2.9: Basic Block Diagram

In-Order Front End

The in-order front end is the part of the machine that fetches the instructions to be executed next in the program and prepares them to be used later in the machine pipeline. Its job is to supply a high-bandwidth stream of decoded instructions to the out-of-order execution core, which will do the actual completion of the instructions. The front end has highly accurate branch prediction logic that uses the past history of program execution to speculate where the program is going to execute next. The

predicted instruction address, from this front-end branch prediction logic, is used to fetch instruction bytes from the Level 2 (L2) cache. These IA-32 instruction bytes are then decoded into basic operations called uops (micro-operations) that the execution core is able to execute.

The NetBurst microarchitecture has an advanced form of a Level 1 (L1) instruction cache called the Execution Trace Cache. Unlike conventional instruction caches, the Trace Cache sits between the instructions decode logic and the execution core as shown in Figure 2.9. In this location, the Trace Cache is able to store the already decoded IA-32 instructions or uops. Storing already decoded instructions removes the IA-32 decoding from the main execution loop. Typically, the instructions are decoded once and placed in the Trace Cache and then used repeatedly from there like a normal instruction cache on previous machines. The IA-32 instruction decoder is only used when the machine misses the Trace Cache and needs to go to the L2 cache to get and decode new IA-32 instruction bytes.

Out-of-Order Execution Logic

The out-of-order execution engine is where the instructions are prepared for execution. The out-of-order execution logic has several buffers that it uses to smooth and re-order the flow of instructions to optimize performance as they go down the pipeline and get scheduled for execution. Instructions are aggressively reordered to allow them to execute as quickly as their input operands are ready. This out-of-order execution allows instructions in the program following delayed instructions to proceed around them as long as they do not depend on those delayed instructions. Out-of-order execution allows the execution resources such as the ALUs and the cache to be kept as busy as possible executing independent instructions that are ready to execute.

Integer and Floating-Point Execution Units

The execution units are where the instructions are actually executed. This section includes the register files that store the integer and floating-point data operand values that the instructions need to execute. The execution units include several types of integer and floating-point execution units that compute the results and also the L1 data cache that is used for most load and store operations.

Memory Subsystem

Figure 2.9 also shows the memory subsystem. This includes the L2 cache and the system bus. The L2 cache stores both instructions and data that cannot fit in the Execution Trace Cache and the L1 data cache. The external system bus is connected to the backside of the second-level cache and is used to access main memory when the L2 cache has a cache miss, and to access the system I/O resources.

2.8 CONFIGURATION OF PERSONAL COMPUTER

The way a system is set up, or the assortment of components that make up the system. Configuration can refer to either hardware or software, or the combination of both. It means the configuration of hardware and software in your computer/laptop present. In case of a computer, it would also include the chassis of computer, the monitor, ram, graphic card, motherboard, processor, cooling system, literally anything which is attached to a PC for its basic use or use required by the user and has been attached will entail a PC configuration. It also helps to determine the power of a PC. For instance, a typical configuration for a PC consists of 32MB (megabytes) main memory, a floppy drive, a hard disk, a modem, a CD-ROM drive, a VGA monitor and the Windows operating system.

Many software products require that the computer have a certain minimum configuration. For example, the software might require a graphics display monitor and a video adapter, a particular microprocessor, and a minimum amount of main memory.

When you install a new device or program, you sometimes need to configure it, which means to set various switches and jumpers (for hardware) and to define values of parameters (for software). For example, the device or program may need to know what type of video adapter you have and what type of printer is connected to the computer. Thanks to new technologies, such as plug-and-play, much of this configuration is performed automatically.

Check Your Progress

Fill in the blanks:

1. The Apple Macintosh uses _____ microprocessor architecture and a proprietary operating system.
2. A _____ is a software application that is divided into many different columns and rows.
3. _____ is the primary memory, which holds all the programs and data the processor is using at a given time.
4. The first personal computers, introduced in _____.
5. Intel 8008 which is also known as _____ was launched in April 1972.
6. Intel's new single core processor family in the market was the _____ processor that achieved a clock speed between 1.3 GHz to 3.08 GHz.

2.9 LET US SUM UP

- The term “personal computer” is used to describe desktop computers (desktops). In its more general usage, a Personal Computer (PC) is a microcomputer designed for use by one person at a time.
- Personal computers can also be used for many functions and applications for business. Almost every employee has a personal computer on their desk. Business professionals use computers for many functions, such as creating letters, calculating numbers or performing research on the Internet.
- A modern PC is both simple and complicated. It is simple in the sense that over the years, many of the components used to construct a system have become integrated with other components into fewer and fewer actual parts.
- From the development of the first microprocessor - Intel's 4004 to the latest ones - the microprocessors have come a long way. Today, computers are a part of our lifestyle, but the first computer that was used was developed at the University of Pennsylvania in the year 1946.
- The Pentium 4 processor is designed to deliver performance across applications where end users can truly appreciate and experience its performance.

2.10 UNIT END ACTIVITY

Critically examine the use of personal computers in School and Hospital.

2.11 KEYWORDS

Personal Computer: A personal computer (PC) is a multi-purpose computer whose size, capabilities, and price make it feasible for individual use. PCs are intended to be operated directly by an end user, rather than by a computer expert or technician.

Emails: Electronic Mail (email or e-mail) is a method of exchanging messages ("mail") between people using electronic devices.

Spreadsheets: A spreadsheet is a sheet of paper that shows accounting or other data in rows and columns; a spreadsheet is also a computer application program that simulates a physical spreadsheet by capturing, displaying and manipulating data arranged in rows and columns.

Motherboard: A motherboard is one of the most essential parts of a computer system. It holds together many of the crucial components of a computer, including the central processing unit (CPU), memory and connectors for input and output devices.

Electronic Numerical Integrator and Computer: ENIAC (Electronic Numerical Integrator and Computer) was amongst the earliest electronic general-purpose computers made. It was Turing-complete, digital and able to solve "a large class of numerical problems" through reprogramming.

Pentium 4: Pentium 4 is a brand by Intel for an entire series of single-core CPUs for desktops, laptops and entry-level servers. The processors were shipped from November 20, 2000, until August 8, 2008.

Microarchitecture: Microarchitecture is the fundamental design of a microprocessor. It includes the technologies used, resources and the methods by which the processor is physically designed in order to execute a specific instruction set (ISA or instruction set architecture).

Configuration: Configuration can refer to either hardware or software, or the combination of both.

2.12 QUESTIONS FOR DISCUSSION

1. What is personal computer?
2. Highlight the uscs of personal computer.
3. Explain basic PC components.
4. How first personal computer was introduced?
5. Write short note on the IBM PC.
6. Discuss the story of the development of the first microprocessor to the latest ones.
7. How Pentium 4 architecture has enhanced chip processing?
8. Explain the NetBurst™ Microarchitecture.
9. Write short note on the configuration of personal computer.

Check Your Progress: Model Answer

- | | |
|-------------|----------------|
| 1. Motorola | 2. Spreadsheet |
| 3. RAM | 4. 1975 |
| 5. MCS-8 | 6. Pentium IV |

2.13 REFERENCES & SUGGESTED READINGS

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UNIT-3

INPUT DEVICES

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3.0 AIMS AND OBJECTIVES

After studying this lesson, you should be able to:

- Describe the commonly used keys of the keyboard
- Describe the use of mouse and trackball
- Describe joystick and its application in aviation and gaming
- Describe MIDI keyboard and video input devices
- Explain use of optical mark reader and Magnetic Ink Character Reader (MICR)

3.1 INTRODUCTION

The input unit accepts coded information from human operators or from other computers. Input to the computer is in the form of data or any other useful information that will be processed by the processor. Various types of input devices like keyboard, mouse and scanner are used to enter the input to the system. Inputs before processed will be converted into computer understandable form, called binary codes.

Examples: Keyboard, joystick, mouse, input pen, touch screen, trackball, scanner, bar code readers, microphone, floppy disks, magnetic tapes and compact disks.

3.2 CONCEPTS OF INPUT DEVICES

Input devices are used to input data, information and instructions into the RAM. We may classify these devices into the following two broad categories:

- (i) Basic Input Devices
- (ii) Special Input Devices

We are discussing below the structure and function of the common input devices of these two categories in details.

3.2.1 Basic Input Devices

The input devices, which have now-a-days become essential to operate a PC, may be called as Basic Input Devices. These devices are always required for basic input operations. These devices include Keyboard and Mouse. Today, every PC has a keyboard and mouse as the basic input devices as shown in Figure 3.1.



Figure 3.1: A Student using Basic Input Devices of a PC

3.2.2 Special Input Devices

The input devices, which are not essential to operate a PC, are called as Special Input Devices. These devices are used for various special purposes and are generally not required for basic input operations. These devices include Trackball, Light Pen, Touch Screen, Joystick, Digitizer, Scanner, OMR, OCR, Bar Code Reader, MICR and Voice Input Devices.

3.3 TYPING INPUT DEVICES

Keyboard is the main typing input device. In this section, we will discuss about keyboard.

3.3.1 Keyboard

A keyboard (similar to a typewriter) is the main input device of a computer. It contains 3 types of keys – alphanumeric keys, special keys and function keys. Alphanumeric keys are used to type all alphabets, numbers and special symbols like \$, %, @, ^, etc. Special keys such as <Shift>, <Ctrl>, <Alt>, <Home>, <Scroll Lock>, etc., are used for special functions. Function keys such as <F1>, <F2>, <F3>, etc., used to give special commands depending upon the software used. We can understand the function of each and every key actually by working on a PC. When any key is pressed, an electronic signal is produced. This signal is detected by a keyboard encoder that sends a binary code corresponding to the key pressed to the CPU. There are many types of keyboards but 101 Keys Keyboard, as shown in Figure 3.2, is the most popular one.

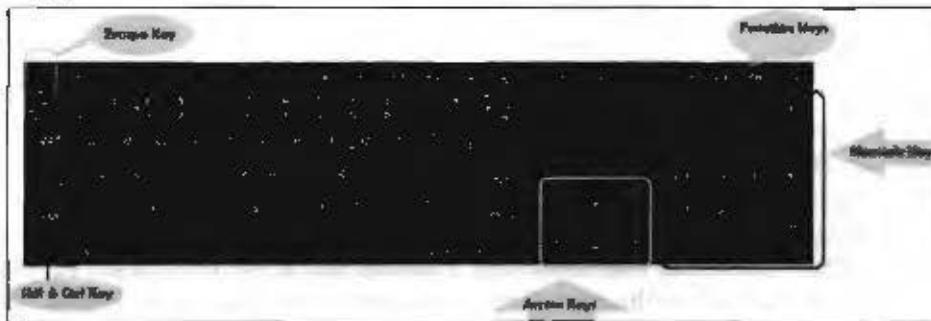


Figure 3.2: A 101 Keys Keyboard

The following is a list of commonly used keys that have special functions (keep in mind that key functions can change depending on which program you are using):

1. **Backspace:** This key deletes letters backward.
2. **Delete:** This key deletes letters forward.
3. **Shift:** This key, when pressed with another key, will perform a secondary function.
4. **Spacebar:** This key enters a space between words or letters.
5. **Tab:** This key will indent what you type, or move the text to the right. The default indent distance is usually $\frac{1}{2}$ inch.
6. **Caps Lock:** Pressing this key will make every letter you type capitalized.
7. **Control (Ctrl):** This key, when pressed with another key, performs a shortcut.
8. **Enter:** This key either gives you a new line, or executes a command (pressed in a word processing program, it begins a new line).
9. **Number Keypad:** These are exactly the same as the numbers at the top of the keyboard; some people just find them easier to use in this position.
10. **Arrow Keys:** Like the mouse, these keys are used to navigate through a document or page.

Main types of keyboards include:

- Keyer Keyboard
- Lighted Program Function Keyboard (LPFK)

3.4 POINTING INPUT DEVICES

Pointing devices are the most commonly used input devices today. A pointing device is any human interface device that allows a user to input spatial data to a computer. In the case of mouse and touchpads, this is usually achieved by detecting movement across a physical surface. Analog devices, such as 3D mice, joysticks, or pointing sticks, function by reporting their angle of deflection. Movements of the pointing device are echoed on the screen by movements of the pointer, creating a simple, intuitive way to navigate a computer's Graphical User Interface (GUI).

Types of pointing devices include:

- Mouse
- Touchpad
- Pointing stick
- Touchscreen
- Trackball
- Light pen

3.4.1 Mouse

Mouse is another important input device. It is a pointing device used to move cursor, draw sketches/diagrams, selecting a text/object/menu item, etc., on monitor screen while working on windows (graphics based operating environment of a computer). Mouse is a small, palm size box containing 3 buttons and a ball underneath as shown in Figure 3.3, which senses the movement of the mouse and sends the corresponding signals to CPU on pressing the buttons.

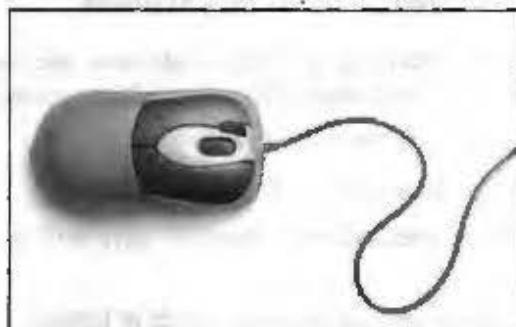


Figure 3.3: A Mouse

On the basis of buttons, mouse can be classified as:

1. Two-buttoned mouse
2. Three-buttoned mouse

Usually, the left button of the mouse is for normal selection and the right button is used for special function and central button is used for scrolling a document.

On the basis of working mechanism and its architecture, mouse can be classified as:

- **Mechanical mouse:** It contains a rubber ball and a pair of rotating wheels. When the mouse is moved on the table, the ball rotates which results in rotation of the wheels and generates electronic signal.
- **Opto-mechanical mouse:** The opto-mechanical mouse contains both mechanical and electric component.

- **Optical mouse:** Optical mouse operates using reflection of light. It is easier to use but usually less reliable than mechanical mouse.

It is also available in following types:

- **Wheel Mouse:** It contains left, right buttons and a middle scrolling button. It is used for scrolling the page up and down. It has a ball under it that rotates when a user drags over. In this way, the screen pointer is controlled.
- **Laser Mouse:** It is very similar to the wheel mouse but the difference is that it emits a laser beam of light to get through mouse pad instead of rolling ball, remaining other functions are same like wheel mouse.
- **Wireless Mouse:** Such type of mouse does not require a cable to attach. It consists of internal battery of dry cell and performs all functions using wireless technology.

Advantages of Mouse

- Easy to use
- Not very expensive
- Moves the cursor faster than the arrow keys of the keyboard

3.4.2 Touchpad

A touchpad or “trackpad” is a flat control surface used to move the cursor and perform other functions on a computer. Touchpads are commonly found on laptops and replace the functionality of a mouse. Touchpads are a common feature of laptop computers, and are also used as a substitute for a mouse where desk space is scarce. Because they vary in size, they can also be found on Personal Digital Assistants (PDAs) and some portable media players. Wireless touchpads are also available as detached accessories.



Figure 3.4; Touchpad

3.4.3 Pointing Stick

A pointing stick is an isometric joystick used as a pointing device, as with a touchpad or trackball, typically mounted in a computer keyboard. Movements of the pointing stick are echoed on the screen by movements of the pointer (or cursor) and other visual changes.

The pointing stick senses applied force by using two pairs of resistive strain gauges. A pointing stick can be used by pushing with the fingers in the general direction the user wants the cursor to move. The velocity of the pointer depends on the applied force so increasing pressure causes faster movement. The relation between pressure and cursor or pointer speed can be adjusted, similar to the way the mouse speed is adjusted.

Joystick is also a pointing device, which is used to move cursor position on a monitor screen. The lower spherical ball moves in a socket. The joystick can be moved in all four directions. The function of joystick is similar to that of a mouse. It is mainly used in Computer Aided Designing (CAD) and playing computer games.



Figure 3.5: Pointing Stick

3.4.4 Touchscreen

A touchscreen is an input and output device normally layered on the top of an electronic visual display of an information processing system. Some special VDU devices have touch sensitive screens. These screens are sensitive to human fingers and act as tactile input devices. Using touch screen, the user can point to a selection on the screen instead of pressing keys as shown in Figure 3.6. Touch screen helps the user in getting the information quickly. It is mainly used in hotels or airports to convey information to visitors.

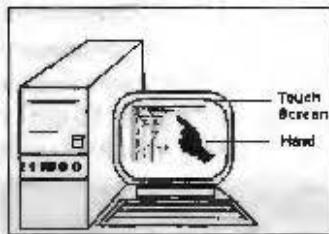


Figure 3.6: Demonstration of Touchscreen

3.4.5 Trackball

A trackball looks like a mouse, as the roller is on the top with selection buttons on the side as shown in Figure 3.7. It is also a pointing device used to move the cursor and works like a mouse. For moving the cursor in a particular direction, the user spins the ball in that direction. It is sometimes considered better than mouse, because it requires little arm movement and less desktop space. It is generally used with portable computers.



Figure 3.7: A Trackball

Differences between Trackball and Mouse

Compared with a mouse, a trackball has no limits on effective travel; at times, a mouse can reach an edge of its working area while the operator still wishes to move the screen pointer farther. With a trackball, the operator just continues rolling, whereas a mouse pointer can be lifted and re-positioned.

3.4.6 Light Pen

It is also a pointing device. We move it on the screen just like an ordinary pen but it works with electricity. It is used for drawing maps, pictures and also has no alphabetic keys. Simply it sends input to the computer when a user touches on the screen. That is why graphic designers and Engineers use it most of the time.

3.5 SCANNING INPUT DEVICES

Scanning devices translate images of text, drawings, photos, and the like into digital form. The images can then be processed by a computer, displayed on a monitor, stored on a storage device, or communicated to another computer, scanning devices include:

- Barcode readers
- Mark-and character-recognition devices
- Fax machines
- Imaging systems

3.5.1 Barcode Readers

A bar code is a machine-readable code in the form of parallel vertical lines of varying widths. It is commonly used for labeling goods that are available in super markets and numbering books in libraries. This code is sensed and read by a bar code reader using reflective light. The information recorded in the bar code reader is then fed into the computer, which recognizes the information from the thickness and spacing of the bars. The bar code readers are either hand-held or fixed-mount. Hand-held scanners are used to read bar codes on stationary items. With fixed-mount scanners, the items having bar codes pass by the scanner using hand as in retail scanning applications or by conveyor belt in many industrial applications.



Figure 3.8: Barcode Reader

Barcode data collection systems provide enormous benefits for every business with a barcode data collection solution; capturing data is faster and more accurate. A barcode scanner can record the data five to seven times faster than a skilled typist. A barcode data entry has an error rate of about one in three million. Bar coding also reduces the cost in terms of labour and revenue losses resulting from the data collection errors. The barcode readers are widely used in supermarkets, department stores, libraries and other places. You must have seen barcode on the back cover of certain books and

greeting cards. The retail and grocery stores use a bar code reader to determine the item being sold and to retrieve the price of an item from a computer system.

Types of Barcode

The printed code used for recognition by a barcode scanner (barcode reader). The “bar” in barcode comes from the ubiquitous, one-dimensional (1D) UPC barcode found on countless product packages. Several two-dimensional (2D) barcodes are also in wide use, but they are not really as bar-like as the UPC.



Figure 3.9: 1D Barcode

The 2D codes are scanned horizontally and vertically and hold considerably more data. All the 2D examples below contain the same data.

Symbol Technologies' PDF417 is a general-purpose barcode that contains up to 1,850 alphanumeric and 2,710 numeric characters. It is recognizable by patterns of vertical lines on each side.

The DataMatrix code is used to mark small parts and holds up to 2,355 alphanumeric and 3,116 numeric characters. It is recognizable by its border with two solid lines and two alternating lines.



Figure 3.10: 2D DataMatrix

The QR code is used to mark products as well as identify establishments. It is recognizable by its four squares with dots in the middle and holds up to 4,296 alphanumeric and 7,089 numeric characters.



Figure 3.11: 2D QR Code

3.5.2 Mark-and Character-Recognition Devices

There are three types of scanning devices that “read” marks or characters. They are usually referred to by their abbreviations MICR, OMR and OCR.

Magnetic Ink Character Recognition

There are two technologies in magnetic data entry. A Magnetic Ink Character Recognition (MICR) technology reads iron oxide ink preprinted or encoded on checks, deposit slips or on documents. An MICR reader electronically captures data, by first magnetizing the magnetic ink characters and then sensing the signal.

Another form of magnetic data entry is the magnetic stripe technology that makes computers read credit cards. The dark magnetic stripe on the back of credit cards is the iron oxide coating. A magnetic stripe reader reads this magnetic stripe.



Figure 3.12: MICR Reader

Optical Mark Recognition

Optical Mark Recognition (OMR) is a method of entering data into a computer system. Optical Mark Readers reads pencil or pen marks made in pre-defined positions on paper forms as responses to questions or tick list prompts. The OMR data entry system contains the information to convert the presence or absence of marks into a computer data file.



Figure 3.13: Optical Mark Reading (OMR)

The OMR technology could be used if data is to be collected from a large number of sources simultaneously, a large volume of data must be collected and processed in a short period of time, and information mainly comprises the selection of categories or "tick box" answers to multiple-choice questions.

Example of OMR based questionnaire form:

SECTION 1: WHY ARE YOU HERE?

1.1 What is your primary Orthopaedic problem today? Please choose one of the following.

- Pain Numbness Tingling Weakness Instability Swelling

1.2 Where is your primary Orthopaedic problem located? Please choose one of the following.

- Right side Left side Both sides

1.3 Are you right-handed or left-handed? Please choose one of the following.

- Right handed Left handed

Figure 3.14: OMR based Questionnaire Form

The main advantages and disadvantages of OMR technology are as follows:

Advantages

- A fast method of inputting large amounts of data - up to 10,000 forms can be read per hour depending on the quality of the machine used.
- Only one computer needed to collect and process the data.
- OMR is much more accurate than data being keyed in by a person.

Disadvantages

- If the marks don't fill the space completely, or aren't in a dark enough pencil, they may not be read correctly.
- Only suitable for recording one out of a selection of answers, not suitable for text input.

Optical Character Recognition

Optical Character Recognition (OCR) uses a device that reads special pre-printed characters and converts them into machine readable form. Examples that use OCR characters are – utility bills and price tags on department store merchandise. The wand reader is a common OCR scanning device.

3.5.3 Fax Machines

A fax machine or facsimile transmission machine scans an image and sends it as electronic signals over telephone lines to a receiving fax machine, which re-creates the image on paper.

Dedicated Fax Machines

Generally called simply “fax machines,” dedicated fax machines are specialized devices that do nothing except send and receive fax documents. They are found not only in offices and homes but also alongside regular phones in public places such as airports.

For the status conscious or those needing works from their cars, fax machines can be installed in their automobiles. The movie the player, for example, contains a scene in which the stalker of a movie studio executive faxes a threatening note. It arrives through the fax machine housed beneath the dashboard in the executive’s range rover.

The scanner in a fax machine can also be used to scan graphics and other items and then send them to a computer to be saved as an electronic file and later manipulated.



Figure 3.15: Scanner

3.5.4 Imaging Systems

An imaging system or image scanner converts text, drawings and photographs into digital form that can be stored in a computer system and then manipulated. The system scans each image with light and breaks it into light and dark dots, which are then converted to digital code.

An example of an imaging system is the type used in desktop publishing. This device scans in artwork or photos that can then be positioned within a page of text. Other systems are available for turning paper documents into electronic files so that people can reduce their paperwork.

Imaging system technology has led to a whole new art or industry called electronic imagine. Electronic imagine is the combining of separate images, using scanners, digital cameras and advances graphic computer. This technology has become an important part of multimedia.

3.6 AUDIO INPUT DEVICES

Audio input devices are used to capture sound. In some cases, an audio output device can be used as an input device, in order to capture produced sound. Audio input devices allow a user to send audio signals to a computer for processing, recording or carrying out commands. Devices such as microphones allow users to speak to the computer in order to record a voice message or navigate software. Aside from recording, audio input devices are also used with speech recognition software.

Examples of types of audio input devices include:

- Microphones
- MIDI keyboard or other digital musical instrument

3.6.1 Microphones

A microphone is an acoustic-to-electric transducer or sensor and is used to convert sound signals into electrical signals. It was originally invented by Emile Berliner in 1877, and allows you to record voices or sounds and place them onto computers, generally as a wave file.

To connect microphone, one has to insert the plug of it into the back of computer system (generally written as mic next to it). Integrated microphones can be found on laptops and some desktop monitors. These Microphones usually look like a small hole in front of the computer which when spoken into will record your voice.



Figure 3.16: Microphone

3.6.2 MIDI Keyboard

A MIDI keyboard is typically a piano-style user interface keyboard device used for sending MIDI signals or commands over a USB or MIDI cable to other devices connected and operating on the same MIDI protocol interface. This could also be a personal computer running software such as a Digital Audio Workstation (DAW) that listens to and sends MIDI information to other MIDI devices connected by cable or running internal to the personal computer system. The basic MIDI keyboard does not produce sound. Instead, MIDI information is sent to an electronic module capable of reproducing an array of digital sounds or samples that resemble traditional analog musical instruments. These samples or waveforms are also referred to as voices or timbres.



Figure 3.17: MIDI Keyboard

3.7 VIDEO INPUT DEVICES

Video input devices are used to digitize images or video from the outside world into the computer. The information can be stored in a multitude of formats depending on the user's requirement.

Types of video input devices include:

- Digital camera
- Digital camcorder
- Portable media player
- Webcam
- Microsoft Kinect Sensor
- Image scanner
- Fingerprint scanner
- 3D scanner
- Laser rangefinder
- Eye gaze tracker
- Video Cameras

Digital Camera

Digital camera is a very popular input device that is used to capture photos. These pictures can be transferred to the computer as it can be connected to a computer through USB very easily. Many cameras provide facility to edit pictures with the help of built-in functions. Pictures taken by the camera are stored in its own memory. So no need to record them on extra film.



Figure 3.18: Digital Camera

Digital Camcorder

A camcorder or camera recorder is a portable electronic recording device capable of recording live-motion video and audio for later playback. Camcorders have three major components -- a lens that gathers and focuses light, an imager that converts light into an electrical signal and a recorder that converts electrical signals into digital video and encodes them for storage.

The first camcorders recorded in one of two analog formats, VHS and Betamax formats. Recordings were stored on video tape cassettes and replayed with a video tape cassette recorder (VCR) hooked up to a monitor, typically a TV set. As technology improved, other formats such as S-VHS, 8mm, Hi-8, and digital video (DV) and high definition video (HDV) became available. These formats offered a sharper picture, better colour, more hours of recording and more efficient storage.



Figure 3.19: Digital Camcorder

Digital video camcorder formats include Digital8, MiniDV, DVD, hard disk drive, direct to disk recording and solid-state, semi-conductor flash memory. Newer analog and digital camcorders use a solid-state charge-coupled imaging device (CCD) or a CMOS imager.

Portable Media Player

The term portable media player (PMP) defines any type of portable electronic device that is capable of handling digital media. Depending on the capabilities of the device, the types of media files that can be played include: digital music, audiobooks, and video.



Figure 3.20: Portable Media Player Devices

Portable media players are often generically named as MP4 players to describe their multimedia capabilities. But, this shouldn't be confused with the idea that they are just compatible with the MP4 format. Incidentally, the term PMP also contrasts with another digital music term, *DAP* (digital audio player), which is usually used to describe MP3 players that can only handle audio.

Examples of Devices: As well as dedicated portable media players, there are other electronic devices that can also have multimedia playback facilities, thus qualifying them as PMPs. These include:

- Smartphones /cellphones.
- Satellite navigation receivers (satnavs).
- Digital cameras.
- Internet tablets.
- Smart watches.

Webcam

This is a very basic video camera used to feed live video into a computer.

The video data from a web cam is low quality compared to a full video camera. However, it is good enough for web chats (e.g., using a messenger application such as MSN Messenger or Skype). Usually a web cam is clipped to the top of a monitor, but many laptops now have web cams built into the edge of the screen.

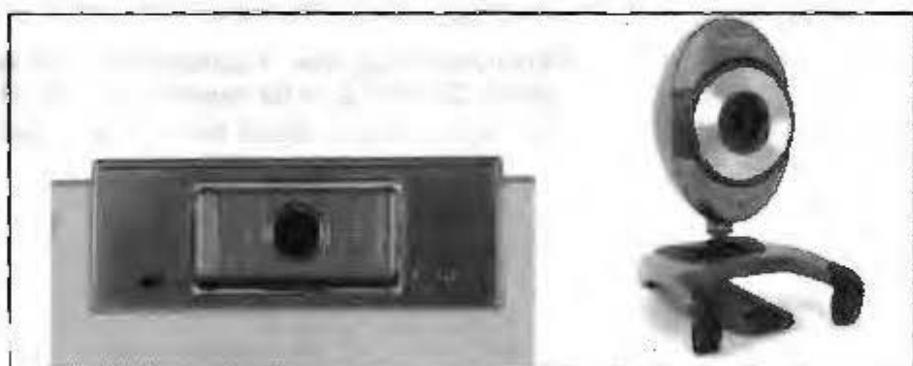


Figure 3.21: (a) Web Camera of Notebook/Laptop and (b) External Web Camera

Microsoft Kinect Sensor

Microsoft Kinect sensor is an advanced sensor to achieve high performance 3D image capture, facial recognition and voice recognition. The Kinect sensor is a popular sensor for robotics due to the advance capabilities it offers for human-robot interaction.

The Microsoft Kinect sensor is made of:

- A motorized pivot
- A RGB colour camera
- A depth sensor
- A microphone
- A set of advanced software to capture motion and gestures

The Kinect sensor provided here has a dual USB cable/plug. The USB port allows connection to the PC that is needed to process information provided by the Kinect sensor and manage the behaviour of the robot. The plug provides power to the Kinect sensor.



Figure 3.22: Kinect Sensor with a dual USB cable/plug

Image Scanner

An image scanner is a digital device used to scan images, pictures, printed text and objects and then convert them to digital images. Image scanners are used in a variety of domestic and industrial applications like design, reverse engineering, orthotics, gaming and testing. The most widely used type of scanner in offices or homes is a flatbed scanner, also known as a Xerox machine.



Figure 3.23: Image Scanner

The image scanner was introduced in 1957 by a team led by Russell Kirsch at the U.S. National Bureau of Standards now the National Institute of Standards and Technology.

When a document is placed inside a scanner, the image is first scanned and then the scanned data is processed and sent to a computer system. Scanners can read red-green-

blue colour from colour array and the depth of these colours is measured based on the array characteristics. Image resolution is measured in pixels per inch.

Fingerprint Scanner

Fingerprint Scanners is a fingerprint recognition device for computer security equipped with the fingerprint recognition module featuring with its superior performance, accuracy, durability based on unique fingerprint biometric technology.



Figure 3.24: Fingerprint Scanners

Fingerprint Reader /Scanner is very safe and convenient device for security instead of password, that is vulnerable to fraud and is hard to remember. Using USB Fingerprint Scanner / Reader with Biometrics software for authentication, identification and verification functions that let your fingerprints act like digital passwords that cannot be lost, forgotten or stolen.

3D Scanner

A 3-D scanner is an imaging device that collects distance point measurements from a real-world object and translates them into a virtual 3-D object. 3-D scanners are used for creating life-like images and animation in movies and video games. Other applications of 3-D scanning include reverse engineering, prototyping, architectural and industrial modelling, medical imaging and medical device modelling. 3-D printers can use data from 3-D scans to create physical objects.

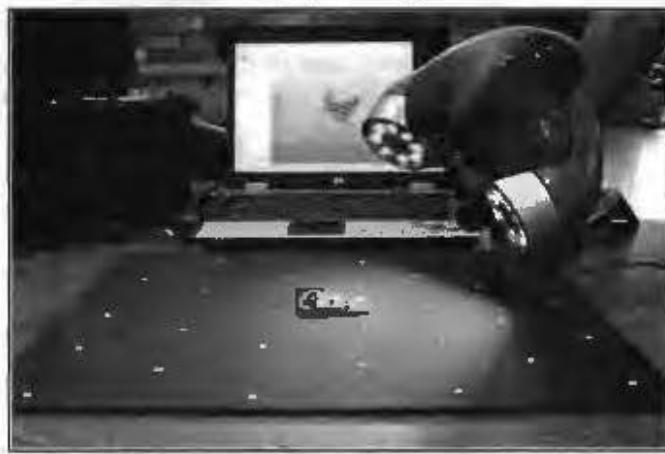


Figure 3.25: 3D Laser Scanner

- Contact-based 3-D scanners work in a number of ways. One type has a carriage system and a control flat bed on which the object rests, while arms take measurements. Another type has articulated arms, and measurements are calculated from the joint angles of those arms.

- Optical 3-D scanners use photographic, stereoscopic cameras, lasers or structured or modulated light. Optical scanning often requires many angles or sweeps.
- Laser-based methods use a low-power, eye-safe pulsing laser working in conjunction with a camera. The laser illuminates a target, and associated software calculates the time it takes for the laser to reflect back from the target to yield a 3-D image of the scanned item.
- Non-laser light-based scanners use either light that is structured into a pattern or a constantly modulated light and then record the formation the scanned object makes. Some medical tomographic scanners use X-rays to create a 3-D X-ray scan image.

Laser Rangefinder

Range finder, any of several instruments used to measure the distance from the instrument to a selected point or object. One basic type is the optical range finder modelled after a ranging device developed by the Scottish firm of Barr and Stroud in the 1880s. The optical range finder is usually classified into two kinds, coincidence and stereoscopic.



Figure 3.26: A Laser Rangefinder

The coincidence range finder, used chiefly in cameras and for surveying, consists of an arrangement of lenses and prisms set at each end of a tube with a single eyepiece at its centre. This instrument enables the user to sight an object by correcting the parallax resulting from viewing simultaneously from two slightly separated points. The object's range is determined by measuring the angles formed by a line of sight at each end of the tube; the smaller the angles produced, the greater is the distance, and vice versa. The stereoscopic range finder operates on much the same principle and resembles the coincidence type except that it has two eyepieces instead of one.

The laser range finder, like radar, measures distance by timing the interval between the transmission and reception of electromagnetic waves, but it employs visible or infrared light rather than radio pulses. Such a device can measure distances of up to 1 mile (1.61 km) to an accuracy of 0.2 inch (0.5 cm). It is especially useful in surveying rough terrain where remote points have to be located between rocks and brush.

Eye gaze Tracker

Eye tracking is the process of electronically locating the point of a person's gaze, or following and recording the movement of the point of gaze. Various technologies exist for accomplishing this task; some methods involve attachments to the eye, while others rely on images of the eye taken without any physical contact.



Figure 3.27: Eye gaze Tracker

One of the earliest applications of eye-tracking was enabling computer access for the disabled. A device that pinpoints the gaze point on a computer screen can allow a quadriplegic to operate that computer by "pointing" with the gaze and "clicking" by blinking the eyelids or staring at a certain point on the screen for a length of time, thereby obtaining the functionality of a mouse. An on-screen keyboard and numeric keypad can allow for text typing and calculations, and continuous eye-movement tracking can allow the user to draw diagrams or create graphs.

Other Potential Applications

- Providing new features for e-readers, such as displaying dictionary definitions for words that the reader stares at for a certain length of time.
- Helping paralyzed people to operate wheelchairs and other mechanical devices.
- Alerting drivers when their gaze wanders off the road.
- Allowing surgeons to control instruments without touching them.
- Controlling common household appliances such as TV sets and Hi-Fi equipment.
- Diagnosing visual disorders by detecting abnormal gaze patterns.
- Development of new gaze-based or eye-movement-controlled video games.
- Helping marketers determine which parts of an advertisement people look at the most.
- Monitoring the eye movements of pilots in flight simulators.
- Remote control of drones and guided missiles.
- Detecting abnormal eye movements in SCUBA divers that might indicate nitrogen narcosis or oxygen deprivation.

Video Cameras

It is a device that captures moving images or video. Like a digital camera, most video cameras do not directly input data into a computer ~ the captured movies are stored on video-tape or memory cards and later transferred to a computer. However, there are some situations where video cameras do feed video data directly into a



Figure 3.28: Video Camera

3.8 VOICE-INPUT DEVICES

Voice-Input Devices are the latest input devices that can recognize the human voice. They seem to be very useful but are not popular due to storage of limited vocabularies and variations in the way of pronouncing words by different persons.

Check Your Progress

Fill in the blanks:

1. _____ is an acoustic-to-electric transducer or sensor and is used to convert sound signals into electrical signals.
2. A _____ tablet is also called a graphics tablet or just a digitizer.
3. To connect _____, one has to insert the plug of it into the back of computer system.

3.9 LET US SUM UP

- A keyboard is a device used to encode data by key depression, which enters information into a system.
- The keyboard converts alphabets and numbers, and other special symbols into electrical signals that processor can understand and process. These signals are sent to the computer's CPU.
- An object used as a pointing and drawing device. The mouse usually has a ball and buttons and is connected to the system unit through serial port.
- As a mouse is rolled across the flat desktop in any direction, it locates the pointer correspondingly on the screen. Then it issues commands using the selection buttons on the mouse. Many portable microcomputers such as laptops use track balls instead of mice.
- On the basis of buttons, mouse can be classified as: Two-buttoned mouse and Three-buttoned mouse.
- On the basis of working mechanism and its architecture, mouse can be classified as Mechanical mouse, Opto-mechanical mouse and Optical mouse.

- Mechanical mouse contains a rubber ball and a pair of rotating wheels. When the mouse is moved on the table, the ball rotates which results in rotation of the wheels and generates electronic signal.
- Optical mouse operates using reflection of light. It is easier to use but usually less reliable than mechanical mouse. The opto-mechanical mouse contains both mechanical and electric component.
- This pointing device is not moved about like a mouse, instead it has a large ball that the user spins. Data about which direction the ball is spun is passed to the computer.
- It can be used to control a GUI pointer. Tracker balls are often used by people with limited movement (disabled) or by the very young since they are easier to use than a mouse.
- Joystick also known as 'Joypad'. It is used mainly for playing games. The user moves the joystick left/right, forward/back and data about these movements are sent to the computer. Small joysticks can also be found on some mobile phones.
- Joystick originated as controls for aircraft ailerons and elevators, and is first known to have been used as such on Louis Bleriot's Bleriot VIII aircraft of 1908, in combination with a foot-operated rudder bar for the yaw control surface on the tail.
- A digital joystick gives only the on-off states of a group of switches, each corresponding to a direction of applied force. The simplest form uses one switch for each of the cardinal directions, and will usually allow for the activation of adjacent pairs, providing the popular "8-directional" capability.
- A scanner is basically an input device that lets a user capture pictures and text and puts it into a digital format that can be edited and stored on a computer.
- A scanner is generally characterized by the following elements: Resolution, The format of the document, Acquisition speed, Interface and Physical characteristics.
- The types of scanner are Flatbeds, Sheet-fed Scanners, Drum Scanners, Microfilm Scanners and Slide Scanners.
- Optical Mark Reading (OMR) is a method of entering data into a computer system. Optical Mark Readers reads pencil or pen marks made in pre-defined positions on paper forms as responses to questions or tick list prompts.
- The OMR data entry system contains the information to convert the presence or absence of marks into a computer data file.
- A bar code is a machine-readable code in the form of parallel vertical lines of varying widths. It is commonly used for labeling goods that are available in super markets and numbering books in libraries.
- This code is sensed and read by a bar code reader using reflective light. The information recorded in the bar code reader is then fed into the computer, which recognizes the information from the thickness and spacing of the bars.
- A Magnetic Ink Character Recognition (MICR) technology reads iron oxide ink pre-printed or encoded on checks, deposit slips or on documents.
- An MICR reader electronically captures data, by first magnetizing the magnetic ink characters and then sensing the signal.
- Light Pen is also a pointing device. We move it on the screen just like an ordinary pen but it works with electricity.

- Many plastic cards, such as credit cards, have a strip of material that can be magnetized on the back. Data can be stored here in the form of magnetized dots.
- A microphone is an acoustic-to-electric transducer or sensor and is used to convert sound signals into electrical signals. It was originally invented by Emile Berliner in 1877, and allows you to record voices or sounds and place them onto computers, generally as a wav file.
- The video data from a web cam is low quality compared to a full video camera. However it is good enough for web chats. Usually a web cam is clipped to the top of a monitor, but many laptops now have web cams built into the edge of the screen.
- A device that captures moving images, or video. Like a digital camera, most video cameras do not directly input data into a computer – the captured movies are stored on video-tape or memory cards and later transferred to a computer.

3.10 UNIT END ACTIVITY

Make a list of application of Optical Mark Reading (OMR) and describe the application of MICR.

3.11 KEYWORDS

Accessories: The drivers and user manual are usually provided, but you must check that connection cables are also provided; if not they must be purchased separately.

Acquisition Speed: Expressed in pages per minute (ppm), the acquisition speed represents the scanner's ability to pick up a large number of pages per minute. The acquisition speed depends on the document format and the resolution chosen for the scan.

Arrow Keys: Like the mouse, these keys are used to navigate through a document or page.

Backspace: This key deletes letters backward.

Caps Lock: Pressing this key will make every letter you type capitalized.

Control (Ctrl): This key, when pressed with another key, performs a shortcut.

Delete: This key deletes letters forward.

Enter: This key either gives you a new line, or executes a command (pressed in a word processing program, it begins a new line).

Number Keypad: These are exactly the same as the numbers at the top of the keyboard; some people just find them easier to use in this position.

Resolution: It expressed in dots per inch (referred to as dpi), the resolution defines the fineness of the scan. The order of magnitude of the resolution is around 1200 per 2400 dpi.

Shift: This key, when pressed with another key, will perform a secondary function.

Spacebar: This key enters a space between words or letters.

Tab: This key will indent what you type, or move the text to the right. The default indent distance is usually $\frac{1}{2}$ inch.

3.12 QUESTIONS FOR DISCUSSION

1. What is a keyboard?
2. Describe the commonly used keys of the keyboard.
3. What is a mouse? What are the types of mouse on the basis of buttons and working mechanism?
4. What is a trackball? Write the differences between trackball and mouse.
5. What is a joystick? What are the application of joysticks in aviation and gaming?
6. What is a scanner? What are the characteristics of a scanner and types of scanner?
7. What is an Optical Mark Reader (OMR)? What are the main advantages and disadvantages of OMR technology?
8. What is a barcode and barcode reader? What are the types of barcode?
9. What are a Magnetic Ink Character Reader (MICR) and Digitizer?
10. Write short notes on the following:
 - (a) Card reader
 - (b) Voice recognition
11. Write a note on the webcam and video cameras also differentiate them.

Check Your Progress: Model Answer

1. Microphone
2. Digitizer
3. Microphone

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UNIT-4

●OUTPUT DEVICES

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4.0 AIMS AND OBJECTIVES

After studying this lesson, you should be able to:

- Explain the computer display and various characteristics
- Describe the types of VDU
- Discuss the various types of printers
- Explain the work of plotters
- Describe the role of computers output micro files
- Explain the use of multimedia projector

4.1 INTRODUCTION

Output devices of computers are types of peripheral hardware connected to the computers either using cables or over a wireless network. An output given by the computer can be in the form of a display on the screen or a printed document or a sound that is played. No matter, whether you have a desktop computer, laptop computer or supercomputer, you will require at least one output device.

4.2 CONCEPTS OF OUTPUT DEVICES

Output devices are hardware components, which are used to display or print the processed information. We are discussing below the structure, working and uses of the common output devices.

The major output devices are:

1. VDT
2. Monitors
3. Printers
4. Plotters

4.3 SOFT COPY VS. HARD COPY OUTPUT

Output device is a peripheral device that allows computer to communicate information to humans or another machine.

Output devices are mainly divided into two types:

- (a) Softcopy devices
- (b) Hardcopy devices

4.3.1 Softcopy Devices

Softcopy devices give screen displayed output which is lost when the computer is turned off. Softcopy devices enable viewing of work, which allow correction and rearrangement of materials to suit specific needs. Monitor, PC, projectors and VDT (Video Display Terminals) are the examples of softcopy devices.

4.3.2 Hardcopy Devices

Hardcopy devices give the output in a hardcopy like printed in paper. The output is permanent. Printers, plotters are the examples of hardcopy output devices because they print the output in hard paper.

4.4 MONITOR

A computer display is also called a display screen or video display terminal (VDT) (sometimes Visual Display Unit). A monitor is a screen used to display the output. Images are represented on monitors by individual dots called pixels. A pixel is the smallest unit on the screen that can be turned on and off or made different shades. The density of the dots determines the clarity of the images, the resolution.

4.4.1 Characteristics of VDU

- **Screen resolution:** This is the degree of sharpness of a displayed character or image. The screen resolution is usually expressed as the number of columns by the number rows. A 1024x768 resolution means that it has 1024 dots in a line and 768

lines. A smaller screen looks sharper on the same resolution. Another measure of display resolution is a dot pitch.

- **Interlaced/Non-interlaced:** An interlaced technique refreshes the lines of the screen by exposing all odd lines first then all even lines next. A non-interlaced technology that is developed later refreshes all the lines on the screen from top to bottom. The non-interlaced method gives more stable video display than interlaced method. It also requires, twice as much signal information, as interlaced technology.

4.4.2 Types of VDU

There are two forms of display:

1. Cathode Ray Tubes (CRTs)
2. Flat Panel Display.

Cathode Ray Tubes (CRT)

A CRT is a vacuum tube used as a display screen for a computer output device. Although the CRT means only a tube, it usually refers to all monitors. IBM and IBM compatible microcomputers operate two modes unlike Macintosh based entirely on graphics mode. They are a text mode and a graphics mode. Application programs switch computers into appropriate display mode.



Figure 4.1: CRT Display

- **Monochrome Monitors:** A monochrome monitor has two colours, one for foreground and the other for background. The colours can be white, amber or green on a dark (black) background. The monochrome monitors display both text and graphics modes.
- **Colour Monitors:** A colour monitor is a display peripheral that displays more than two colours. Colour monitors have been developed through the following paths:
 - ❖ **CGA:** This stands for Colour Graphics Adapter. It is a circuit board introduced by IBM and the first graphics standard for the IBM PC. With a CGA monitor, it is harder to read than with a monochrome monitor, because the CGA (320×200) has much fewer pixels than the monochrome monitor (640×350). It supports 4 colours.
 - ❖ **EGA:** It stands for Enhanced Graphics Adapter. EGA is a video display standard that has a resolution of 640 by 350 pixels and supports 16 colours. EGA supports previous display modes and requires a new monitor.
 - ❖ **VGA:** VGA stands for Video Graphics Array. This is a video display standard that provides medium to high resolution. In a text mode, the resolution of this

board is 720 by 400 pixels. It supports 16 colours with a higher resolution of 640 by 480 pixels and 256 colours with 320×200 pixels.

- ❖ ***Super VGA:*** This is a very high resolution standard that displays up to 65,536 colours. Super VGA can support 16.8 million colours at 800 by 600 pixels and 256 colours at 1024 by 768 pixels. A high-priced super VGA allows 1280 by 1024 pixels. Larger monitors (17" or 21" and larger) with a high resolution of 1600 by 1280 pixels are available. VESA (Video Electronics Standards Association) has set a standard for super VGA.

Flat Panel Displays

Portable computers such as a laptop uses flat panel displays, because they are more compact and consume less power than CRTs. Portable computers use several kinds of flat panel screens:



Figure 4.2: Flat Panel Display

- ***Liquid-Crystal Displays (LCDs):*** A display technology that creates characters by means of reflected light and is commonly used in digital watches and laptop computers. LCDs replaced LEDs (light emitting diodes) because LCDs use less power. LCDs are difficult to read in a strong light, because they do not emit their own light. Portable computers wanted to have brighter and easier to read displays. Backlit LCDs are now used for this purpose.
 - ❖ ***Backlit LCDs:*** This is a type of LCD display having its own light source provided from the back of the screen. The backlit makes the background brighter and clear, as a result the texts and images appear sharper. However, this still is much less clear than CRTs. Thus, better technology is needed.
 - ❖ ***Active Matrix LCDs:*** This is an LCD display technique in which every dot on the screen has a transistor to control it more accurately. This uses a transistor for each monochrome or each red, green and blue dot. It provides better contrast, speeds up screen refresh and reduces motion smearing.
- ***Light Emitting Display (LED):*** A flat panel display technology that actively emits light at each pixel when it is electronically charged. This provides a sharp, clear image and wide viewing angle. The EL display type of flat panel is better than LCD.
- ***Gas Plasma Displays:*** This is also called a gas panel or a plasma panel and is another flat screen technology. A plasma panel contains a grid of electrodes in a flat, gas filled panel. The image can persist for a long time without refreshing in this panel. The disadvantages of the gas plasma displays are that they must use AC power and cannot show sharp contrast.

4.5 PRINTERS

A printer is an output device that produces a hard copy of data. The resolution of printer output is expressed as DPI. Printers can be classified into different types in several ways.

First, the printers can be divided into three categories by the way they print.

1. **Serial Printers:** Also called a character printer. Prints a single character at a time. They are usually inexpensive and slow.
2. **Line Printers:** Print a line at a time. They are expensive and very fast. Line printers use a band, a chain, etc.
3. **Page Printers:** Also called a laser printer. Print a page at a time. They usually use a laser to produce page images. Quality is best. This is a little bit expensive, but the price of the personal laser printer is decreasing. The price range of the personal laser printer is around \$400, today.

Laser Printers

A laser printer is a printer that uses the electro-photographic method used in a copy machine. The printer uses a laser beam light source to create images on a photographic drum. Then the images on the drum are treated with a magnetically charged toner and then are transferred onto a paper. A heat source is usually applied to make the images adhere.

In 1984, Hewlett-Packard introduced the first desktop laser printer, called the LaserJet. The laser printer revolutionized personal computer printing and has spawned desktop publishing.



Figure 4.3: HP P1007 Laser Printer

The laser printer produces high-resolution letters and graphics quality images, so it is adopted in applications requiring high-quality output. Although a high-priced colour laser printer is also available in the market, a less expensive, desktop gray scale laser printer is widely used. Recently, the laser printer is gaining its market share dramatically, mainly because of price economic and the quality.

Second, printers can be classified into two forms according to the use of a hammer.

1. **Impact Printers:** Hammer hits ribbons, papers or print head. Dot-matrix and daisy-wheel printers are the example.

Dot Matrix Printers: Dot-matrix printers are printers that write characters and form graphic images uses one or two columns of tiny dots on a print head. The dot

hammer moves serially across the paper and strikes an inked-ribbon and creates images on paper.

Dot matrix printers are popular printers used with microcomputers, because the printers are highly reliable and inexpensive. They are used for tasks where a high-quality image is not essential. Many users, however, move from dot printers to laser printers, because the price of laser printers is falling down. Several kinds of dot matrix printers are available with print heads that have 7, 9, 18 or 24 pins.



Figure 4.4: Dot Matrix Printers

2. **Non-impact Printers:** They do not have the hammer and do not hit. An example is an ink-jet and laser printer.

Ink-jet Printers

Ink-jet is a printer mechanism that sprays one or more colour of ink at high speed onto the paper and produces high-quality printing. This printer also produces colour printing as well as high-quality image. That is, ink-jet printers can be used for variety of colour printing at a relatively low cost. Ink-jet printing has two methods: Continuous stream method and drop-on-demand method.



Figure 4.5: HP DESKJET 3745 Inkjet Printer

Another classification can be made by the way they form characters.

- **Bit-Mapped Printers:** Images are formed from groups of dots and can be placed anywhere on the page. They have many printing options and good printing quality. They use PostScript as a standard language for instructing a microcomputer.
- **Character-based Printers:** Printer print characters into the lines and columns of a page. These printers use predefined set of characters and are restricted in position of characters.

The pictures of some of the printers are shown in Figure 4.6.



Figure 4.6: Various Types of Printers

4.6 PLOTTER

Plotter is an important output device, used to print high quality graphics and drawings. Although the graphics can be printed on printers, the resolution of such printing is limited on printers. Plotters are generally used for printing/drawing graphical images such as charts, drawings, maps etc., of engineering and scientific applications. Some important types of plotters are shown in Figure 4.7 and are discussed below:

- (i) **Flat Bed Plotters:** These plotters print the graphical images by moving the pen on stationary flat surface material. They produce very accurate drawings.
- (ii) **Drum Plotters:** These plotters print graphical images by moving both the pen and the drum having paper. They do not produce as accurate drawings as printed by flatbed plotters.
- (iii) **Inkjet Plotters:** These plotters use inkjets in place of pens. They are faster than flatbed plotters and can print multi-coloured large drawings.

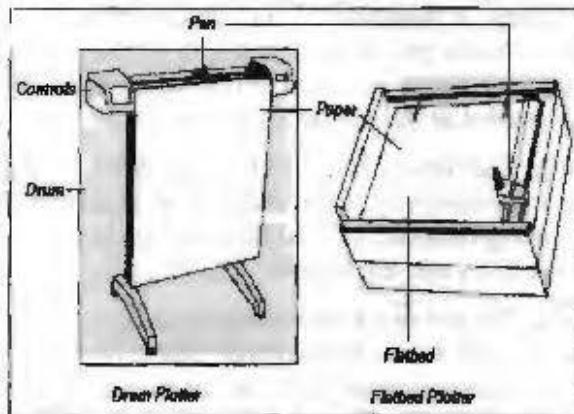


Figure 4.7: Various Types of Plotters

4.7 COMPUTER OUTPUT MICROFILM

COM consists of:

1. A high-speed recorder that transfers digital data onto microfilm using laser technology; and
2. A processor that develops the microfilm once exposed to a light source. A COM recorder can operate "on-line" or "off-line," meaning that it can be connected to a single computer, a local or wide-area network, a minicomputer, or a mainframe

computer. In addition, the recorder can operate independently as a stand-alone device that reads digital data from formatted magnetic media, such as tape.

A COM recorder generally operates with:

1. A duplicator that generates copies of microfiche; and
2. A sorter that separates duplicate microfiche cards into bins for easy, end-point distribution. Each functional unit is connected to the next, providing a linear path from creation to end-point distribution of the microfiche.

4.7.1 COM to CD Service

MIS can also arrange for Compact Disc transfer service. Data that has been transferred to COM for retention purposes can be transferred to CD-ROM for ease of access and very high storage capability.

The cost of this service varies based on the number of frames recorded to CD.

4.7.2 What are the Benefits of COM?

COM offers many advantages that assist agencies with efficient office operations and adherence to sound records management principles. Key benefits include:

1. ***Reduction of Paper:*** One of the primary objectives of providing COM is to decrease paper use as allowed by Public Law 40-1979, Section 16, which authorizes recording, copying, and reproducing records by photostatic, photographic, or micrographic process to reduce storage space. A one-cubic-foot box of paper records holds an average of only 3,000 pages. One microfiche card holds 230 documents (or images), and a one-cubic-foot records storage box holds 6,000 microfiche cards – a minimum of 1,380,000 pages. To store that many paper documents, 460 one-cubic-foot records storage boxes would be needed.
2. ***Cost Reduction:*** Using COM to store or distribute information is more economical than most electronic media, and is even less expensive than paper. The cost of printing a standard 8" x 11" page from a centralized printer is approximately three cents per sheet, versus only 0.0033 cents per sheet for COM microfiche. Other cost savings can be realized through the decrease in office and warehouse space needed to store paper documents.
3. ***Improved Quality:*** The newest COM technology provides superior image quality for improved user productivity. Such features as enhanced titling, enlarged file breaks, and bar coding make access and filing easier. Improved quality also means reader and printer copies that are legible.
4. ***Improved Service:*** The use of COM services outsourced by MIS helps reduce the risk of lost tapes and slow turn-around times from individually-contracted vendors, thereby offering agencies quick access to high-quality microfilm images. Initial transfer of information from the agency to the Micrographics lab is also simple and quick: database (ASCII or EBCDIC) or image (TIFF Group IV) files may be sent directly from your agency's computers to the Micrographics FTP site for transfer to fiche. Contact the Micrographics lab for specific file-type requirements and FTP address.
5. ***Electronic Record Retention/Archiving:*** With the proliferation of electronic records, and with few rules governing the purchase and use of imaging systems, it is vitally important that state agencies have the means to archive records from a variety of electronic sources. Using COM, electronic records can be moved from diverse, incompatible electronic storage systems to a "universal" reader. COM provides a sophisticated electronic records management tool that ensures proper

4.8 SPECIAL PURPOSE OUTPUT EQUIPMENT

The following list contains many different output devices:

- 3D Printer
- Braille embosser
- Braille reader
- Flat panel
- GPS
- Headphones
- Computer Output Microfilm (COM)
- Monitor
- Plotter
- Printer (Dot matrix printer, Inkjet printer and Laser printer)
- Projector
- Sound card
- Speakers
- Speech-generating device (SGD)
- TV
- Video card

4.8.1 Multimedia Projector

It is a hardware device with which an image and text is projected onto a flat screen. Image data is sent to the video card by the computer which is then translated into a video image and sent to the projector. A projector is often used in meetings or to make presentations as it allows the display to be visible to a larger audience. Ceiling mount projector and table mount projector are the two types of projectors available in the market today.



Figure 4.8: Projector

Technical Consideration

Criteria to evaluate suitable projector: Stationary or Mobile: It is useful to consider where the digital projector will most often be used. Will it be stationary or will it be used in different place. If the projector is to remain in one spot, a projector that best

meets the conditions of that location can be purchased. Stationary projectors are typically ceiling mounted, and connected by cable to the appropriate PC. In these situations, a power socket is needed to be available above the ceiling and close to the projector. If the projector is likely to be moved around, a portable projector that can adapt readily and cope with varying light and screen distance conditions should be purchased. A suitable robust trolley is an appropriate means of transport within the school.

1. **Luminosity (Brightness):** The luminosity of a digital projector is measured in lumens and it is the primary consideration when purchasing a digital projector. The brightness of the image displayed is also affected by the amount of light available in the room. Window blinds may be needed to regulate the amount of external daylight entering the room. Modern projectors have two luminosity settings, namely – (a) standard and (b) eco mode. In eco mode, the luminosity is set at the lower setting which coupled with lower noise is more appropriate for a regular classroom environment.
2. **Resolution:** The resolution of the data projector is another major factor. The resolution of computer screens has tended to increase in recent years. A computer screen resolution of 800×600 is referred to as SVGA, while a screen of 1024×768 is referred to as XGA. Data projectors will typically project their own native resolution, but will also compress a higher resolution. This compression will result in some loss of definition. Since most school computers will be the XGA resolution, and nearly all laptops have XGA or higher, projectors with XGA resolution are strongly recommended. A digital projector should automatically detect the resolution and type (analogue or digital) of incoming video signal (from the computer) and adjust accordingly.
3. **Contrast Ratio:** Another image quality indicator to be considered when reviewing a digital projector specification is the contrast ratio. This is denoted in proportions such as 400:1. The contrast ratio indicates differences in brightness in the unit's projection of black and white. The greater the ratio, the more colour detail the projector can show. Schools should seek a contrast ratio of 400:1 or greater, as lower ratios may create less sharp or blurred looking images.
4. **LCD vs. DLP Technologies:** There are two main projector technologies available when you are considering what type of projectors to get. LCD (Liquid Crystal Display) is the most common type of data projector available. DLP (Digital Light Processing) is a newer technology which uses thousands of tiny mirrors to create the image. It is smaller than a LCD projector filling a demand for small light weight projectors. It also produces a smoother video image. Both technologies are suitable for schools.
5. **Lamp Life:** The lamp (or bulb) inside a digital projector is key to its functionality and it is important to have information about its lifespan and cost of replacement prior to purchase. Most lamps are pre-installed and manufacturers guarantee them for 6 months or between 1,000 and 4,000 hours of use. The lamp will need to be replaced at some point, so it is worth checking the price and lifespan of individual manufacturers' bulbs. Most lamps have a lifespan of 3000 hours, but some only last 1,000 to 1,500 hours even though they are priced similarly. Some providers will offer a free spare lamp. Replacement lamps (outside of lamp warranty) will typically cost €150 - €300 depending on the model. A significant factor in how long a projector bulb will operate well is determined by the number of times it is turned on and off during its lifetime. Many projectors have recommended powering off procedures which if adhered to will prolong the life of the bulbs. Alternatively not adhering to these can significantly shorten the bulb life.

6. **Size and Weight:** If a digital projector is to remain in one location, its size and weight will not be a key consideration. However, if a school intends to move the projector between classrooms, then weight and size are of major importance. The weight of a digital projector can vary from 2kg to 5kg, and size can vary from A5 to A3. All digital projectors should come with a soft carry case, capable of holding the digital projector and all of its cables and accessories.
7. **Keystone Correction:** Keystone correction adjusts for the fact that if a projector is directed towards the screen at an angle, the projected image will be distorted; the edge furthest away from the projector will be wider than the edge closest to the projector. In other words, the image will appear in the shape of a trapezoid. The projectors keystone correction feature can correct this thus allowing the audience to view a rectangular image rather than one with a wider top or bottom.
8. **Noise level/Eco Mode/Brightness:** Low levels of projector noise are important especially in smaller classrooms or learning areas. Projector noise is typically caused by the internal fan which is used to cool the bulb. The lower the noise-level the better it is. Levels of 39dBA in normal mode or 33dBA in Eco mode are considered quite well. Switching to Eco mode can also extend the bulb life by reducing the brightness, associated heat levels, and power consumption. Use in Eco mode is recommended as the lower brightness levels may be more appropriate for regular use especially in classrooms.
9. **Maintenance and Care:** When a digital projector is purchased, it is advisable to ensure that all school staff is appropriately trained on how to operate and take care of this expensive piece of equipment. For example, it is important to know that the lamp should be allowed to cool down fully after turning off the digital projector. The internal cooling fan may run for 5 minutes after the machine has been 'switched off' and, after this period, it automatically turns itself off. The projector should not be unplugged until this has taken place.
10. **Security:** Schools should be aware that projectors may be seen as attractive target in schools. Certain models have clear labeling and markings indicating to potential thieves that the projector will not operate without a security code, such features may be useful in a school setting.

4.8.2 Audio Response Unit (ARU)

ARU permits computers to talk to people. It works in the following manner.

All the sounds needed to process the possible inquiries are provided on a storage medium. Each sound is given a code. When enquiries are received, the processor follows a set of rules to create a reply message in a coded form. This coded message is then transmitted to an audio-response device. The sounds are assembled in proper sequence. The audio message is transmitted back to the station requesting the information.

A common example of an ARU is the way messages and train schedules are narrated on railway stations having automatic enquiry system.

4.8.3 Photographic Output

It is in the form of a high resolution image on the photographic film. It is capable of storing large quantities of data in readable character form in a relatively small space. Photographic output may take two forms: micro film and micro fiche.

- Micro Film is an ordinary film in one of the standard widths, most commonly 6mm. Its density is very high. It is used to store data for future viewing.

- Micro fiche Micro fiche is a sheet of film 105mm by 148mm, containing a rectangular pattern of pages. These patterns of pages are 80 at a reduction of 25 times or 224 at a reduction of 72 times. Special viewers are available to magnify a page at a time up to readable size. Normal printouts can be photographed onto micro film or micro fiche.

Check Your Progress

Fill in the blanks:

1. There are two forms of display: Cathode-Ray Tubes (CRTs) and _____ Display.
2. Dot-matrix and daisy-wheel printers are the example of _____ printer.
3. _____ printers are printers that write characters and form graphic images using one or two columns of tiny dots on a print head.
4. A _____ printer is a printer that uses the electro-photographic method used in a copy machine.
5. Computer output microfilm (COM) is a process for copying and printing data onto _____ from electronic media found on personal, mini, or mainframe computers.
6. A _____ is often used in meetings or to make presentations as it allows the display to be visible to a larger audience.

4.9 LET US SUM UP

- A computer display is also called a display screen or video display terminal (VDT) Visual Display Unit. A monitor is a screen used to display the output.
- Images are represented on monitors by individual dots called pixels. A pixel is the smallest unit on the screen that can be turned on and off or made different shades.
- The characteristics of VDU are Screen resolution and Interlaced/Non-interlaced
- The types of VDU are Cathode-Ray Tubes (CRTs) and Flat-Panel Display.
- A CRT is a vacuum tube used as a display screen for a computer output device. Although the CRT means only a tube, it usually refers to all monitors.
- A printer is an output device that produces a hard copy of data. The resolution of printer output is expressed as DPI. Printers can be classified into different types in several ways.
- First, the printers can be divided into three categories by the way they print: Serial Printers, Line Printers and Page Printers.
- Printers can be classified into two forms according to the use of a hammer: Impact Printers and Non-impact Printers.
- Another classification can be made by the way they form characters: Bit-Mapped Printers and Character-based Printers.
- Dot-matrix printers are printers that write characters and form graphic images using one or two columns of tiny dots on a print head. The dot hammer moving serially across the paper strikes an inked-ribbon and creates images on paper.
- Ink-jet is a printer mechanism that sprays one or more colour of ink at high speed onto the paper and produces high-quality printing. This printer also produces colour printing as well as high-quality image.

- A laser printer is a printer that uses the electro-photographic method used in a copy machine. The printer uses a laser beam light source to create images on a photographic drum. Then the images on the drum are treated with a magnetically charged toner and then are transferred onto a paper. A heat source is usually applied to make the images adhere.
- Plotters, like printers, create a hard copy rendition of a digitally rendered design. The design is sent to a plotter through a graphics card and the image is created using a pen.
- In simple words, plotters basically draw an image using a series of straight lines. This device is used with engineering applications. Drum plotter uses a drum, on which the paper gets wrapped. The plotter pen moves across the drum to produce plots.
- Computer Output Microfilm (COM) is a process for copying and printing data onto microfilm from electronic media found on personal, mini, or mainframe computers.
- MIS can also arrange for Compact Disc transfer service. Data that has been transferred to COM for retention purposes can be transferred to CD-ROM for ease of access and very high storage capability.
- Key benefits of COM include: Reduction of Paper, Cost Reduction, Improved Quality, Improved Service and Electronic Record Retention/Archiving.
- A projector is often used in meetings or to make presentations as it allows the display to be visible to a larger audience. Ceiling mount projector and table mount projector are the two types of projectors available in the market today.
- Criteria to evaluate suitable projector: Luminosity (Brightness), Resolution, Contrast Ratio, LCD vs. DLP Technologies, Lamp Life, Size and Weight, Keystone Correction, Noise level/Eco Mode/Brightness, Maintenance and Care and Security.

4.10 UNIT END ACTIVITY

Make a list of output devices used in daily day life.

4.11 KEYWORDS

Screen Resolution: This is the degree of sharpness of a displayed character or image. The screen resolution is usually expressed as the number of columns by the number rows.

Interlaced/Non-interlaced: An interlaced technique refreshes the lines of the screen by exposing all odd lines first then all even lines next. A non-interlaced technology that is developed later refreshes all the lines on the screen from top to bottom. The non-interlaced method gives more stable video display than interlaced method.

CGA: This stands for Colour Graphics Adapter. With a CGA monitor, it is harder to read than with a monochrome monitor, because the CGA (320×200) has much fewer pixels than the monochrome monitor (640×350). It supports 4 colours.

EGA: It stands for Enhanced Graphics Adapter. EGA is a video display standard that has a resolution of 640 by 350 pixels and supports 16 colours. EGA supports previous display modes and requires a new monitor.

VGA: VGA stands for Video Graphics Array. This is a video display standard that provides medium to high resolution. In a text mode, the resolution of this board is 720

by 400 pixels. It supports 16 colours with a higher resolution of 640 by 480 pixels and 256 colours with 320×200 pixels.

Super VGA: This is a very high resolution standard that displays up to 65,536 colours. Super VGA can support 16.8 million colours at 800 by 600 pixels and 256 colours at 1024 by 768 pixels.

Backlit LCDs: This is a type of LCD display having its own light source provided from the back of the screen. The backlit makes the background brighter and clear, as a result the texts and images appear sharper.

Serial Printers: Also called a character printer. Print a single character at a time. They are usually inexpensive and slow.

Line Printers: Print a line at a time. They are expensive and very fast. Line printers use a band, a chain, etc.

Page Printers: Also called a laser printer. Print a page at a time. They usually use a laser to produce page images. Quality is best.

Impact Printers: Hammer hits ribbons, papers or print head. Dot-matrix and daisy-wheel printers are the example.

Non-Impact Printers: They do not have the hammer and do not hit. An example is an ink-jet and laser printer.

Bit-Mapped Printers: Images are formed from groups of dots and can be placed anywhere on the page. They have many printing options and good printing quality. They use PostScript as a standard language for instructing a microcomputer.

Character-based Printers: Printer print characters into the lines and columns of a page. These printers use predefined set of characters and are restricted in position of characters.

4.12 QUESTIONS FOR DISCUSSION

1. What is a monitor? What are the various criteria of monitor?
2. What are the types of VDU?
3. What is the roll of printer?
4. What are the classifications of printer according to different criteria?
5. How do a dot matrix printer works?
6. How do an inkjet printers works?
7. What is the work of plotter?
8. What do you mean by Computers Output Micro Files (COM)?
9. What is the roll of COM to CD Service?
10. What are the benefits of COM?
11. What is a multimedia projector? What are the various criteria to evaluate suitable projector?

Check Your Progress: Model Answer

1. Flat-Panel
2. Impact
3. Dot-matrix
4. Laser
5. Microfilm
6. Projector

4.13 REFERENCES & SUGGESTED READINGS

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BLOCK-II

UNIT-5

CENTRAL PROCESSING UNIT (CPU)

CONTENTS

- 5.0 Aims and Objectives**
- 5.1 Introduction**
- 5.2 What is Central Processing Unit?**
 - 5.2.1 Data Bus**
 - 5.2.2 Address Bus**
 - 5.2.3 Control Bus**
 - 5.2.4 Flowchart of CPU Operation**
- 5.3 Arithmetic and Logic Unit**
 - 5.3.1 How an ALU Works?**
- 5.4 Control Unit**
 - 5.4.1 Functions of the Control Unit**
- 5.5 Registers**
- 5.6 Instruction Set**
 - 5.6.1 Reduced Instruction Set Computers (RISC)**
 - 5.6.2 Complex Instruction Set Computers (CISC)**
- 5.7 Processor Speed**
 - 5.7.1 How to Choose Processor Speed?**
 - 5.7.2 What Processor Speed Means?**
 - 5.7.3 What Speeds Do not Mean?**
- 5.8 Let Us Sum Up**
- 5.9 Unit End Activity**
- 5.10 Keywords**
- 5.11 Questions for Discussion**
- 5.12 References & Suggested Readings**

5.0 AIMS AND OBJECTIVES

After studying this lesson, you should be able to:

- Explain the concept of central processing unit
- Discuss the flowchart of CPU operation
- Explain arithmetic and logic unit and how an ALU works
- Describe the functions of the control unit
- Analyse registers and instruction set
- Know about how to choose processor speed

5.1 INTRODUCTION

Computer is an advanced electronic device that takes raw data as an input from the user and processes it under the control of a set of instructions (called program), produces a result (output), and saves it for future use. This lesson explains the foundational concepts of central processing unit, arithmetic and logic unit, control unit and registers. This lesson will also explain the instruction set and processor speed.

5.2 WHAT IS CENTRAL PROCESSING UNIT?

It is the part of the computer that carries out the instructions of a computer program. It is the unit that reads and executes program instructions. Hence it is considered as the brain of the computer.

Central Processing Unit (CPU) consists of the following features:

- CPU is considered as the brain of the computer.
- CPU performs all types of data processing operations.
- It stores data, intermediate results, and instructions (program).
- It controls the operation of all parts of the computer.

CPU consists of the following three components:

1. Memory or Storage Unit
2. Control Unit
3. ALU (Arithmetic Logic Unit)

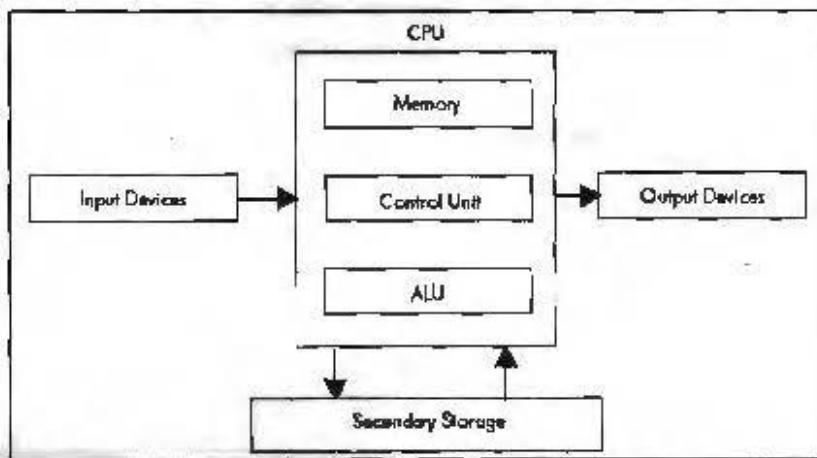


Figure 5.1: Block Diagram of a Computer

The components of CPU communicate among themselves with the help of an internal set of wires called 'Bus'. Just as buses carry people from one place to another, here these wires are used to carry data from one unit to another hence the name BUS. There are different kinds of buses for different purposes.

5.2.1 Data Bus

The data bus carries the data that is transferred from one unit to another. Generally a data bus is a bi-directional bus. This means that data can travel in both the directions. The size of a bus determines how much data can be transferred at one time. If the width of data bus is 16 then 2 bytes of data can be transferred at a time.

The need of data transfer may arise due to interaction between memory and CPU, input output unit and processor, etc.

5.2.2 Address Bus

Every information stored in the memory is identified by a unique number called an 'address'. This address needs to be supplied to this memory for accessing of data. The address bus carries the address of the data to be accessed. The number of memory locations that a CPU can address is determined by the number of address lines. If the CPU has no address lines then it can address 2^n different addresses in the memory and other I/O equipment. The address bus is un-directional – from CPU to memory or from CPU to I/O unit.

5.2.3 Control Bus

It is the most important bus of the system. It controls nearly all the operations in the CPU. The most common control bus signals are the read-write signals. To read from memory unit, the CPU places the address on the address bus, i.e., location from where data is to be read and initiates the read control signal.

The control bus is also unidirectional because control signals are initiated only by the CPU.

The central processing unit is the most important hardware component of a computer system. It is known as the CPU, the central processor or instruction processor, and the main microprocessor in a microcomputer. Data is processed and stored in a computer system through the presence or absence of electronic or magnetic signals in the computer's circuitry or the media it uses. This is called a two-state or binary representation of data, since the computer and media can exhibit only two possible states or conditions (1s and 0s).

The CPU can be divided into two major subunits which include the Arithmetic-Logic Unit (ALU) which performs the arithmetic and logic functions required in processing and the control unit which interprets computer program instructions and transmits directions to the other components of the computer system.

The primary function of the Central Processing Unit is to execute sequences of instructions representing programs, which are stored in the Main Memory.

As mentioned before, the CPU consists of the ALU and CU.

To carry out its role the CPU must be an interpreter of a set of instructions at machine language level.

Program execution is carried out as follows:

1. The CPU transfers instructions and, when necessary their input data, called operands, from the Main Memory into the registers of the CPU.
2. The CPU executes the instructions in their stored sequence (one after another) except when the execution sequence is explicitly altered by a branch instruction.
3. When necessary, the CPU transfers results from the CPU registers into the Main Memory.

Sometimes CPUs are called simply Processors.

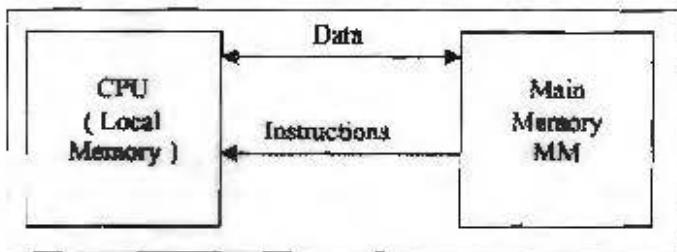


Figure 5.2: CPU and Main Memory Interrelation

CPU-Memory Communication

Consequently, there exist streams of instructions and data between the Main Memory and the set of general registers that forms the CPU's local memory.

The CPU is significantly faster than the Main Memory that it can read from or write in the CPU's registers 5 to 10 times faster than it can read from or write in the Main Memory (MM). Nowadays, VLSI technology tends to increase the CPU/Main Memory speeds disparity.

As mentioned before to remedy this drawback, the memory is organized in a hierarchical way; a new layer of memory, called Super operative Memory (SOM) is placed between the Main Memory and CPU. At present, the SOM is represented by the CACHE Memory (CM); this CM is smaller and faster than MM and can be placed wholly or in part on the same chip as CPU (the so called internal Cache Memory).

The main role of CM is to ensure a memory read or write operation in a single clock cycle, whereas a MM access (bypassing the CM memory) takes several clock cycles.

The CM and MM are seen by the CPU as forming a single memory space, because the operation of CM is totally transparent to the CPU.

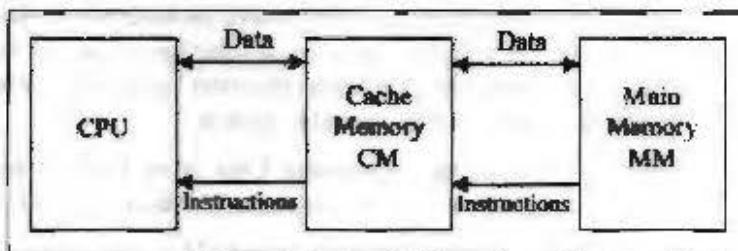


Figure 5.3: CPU-Memory Communication with a Cache

CPU communicates with I/O devices in much the same way as it communicates with the Main Memory. The I/O devices are associated with addressable registers called I/O PORTS. The CPU can store or extract a word from I/O PORTS (the OUTPUT and INPUT operations).

The programs executed by the CPU are divided into two broad groups: user programs and supervisor programs.

A user program, known also as application program, handles a specific application, whereas a supervisor program manages various routine aspects of the entire computer system on behalf of the users and it is part of the system software named the operating system. As examples of supervisor programs there are mentioned the control of transferring data between Secondary Memory and Main Memory, control of a graphic interface etc.

In a normal operation any CPU switches between user programs and supervisor programs.

5.2.4 Flowchart of CPU Operation

It is generally useful to design CPUs that can interrupt their current program in execution and pass to another needed program; such requests can be received from I/O units, the secondary memory etc, and are materialized in interrupt signals. If accepting an Interrupt Request (IR) the CPU suspends the execution of the current program and transfers execution to an appropriate interrupt – handling program (called also interrupt service routine).

As interrupts need usually a fast response, the CPU must check frequently for the presence of Interrupt Request (IR). This happens at the beginning of any Instruction Cycle.

The mechanisms of interrupting the CPU operation will be treated extensively later.

Another special mechanism of interrupting CPU is related to DMA implementation, where the DMA controller takes the control of the system bus to ensure a fast transfer of data to/from the Main Memory, without participation of the CPU.

5.3 ARITHMETIC AND LOGIC UNIT

The arithmetic unit performs a number of calculations and computations. The logic unit is used to apply logic, i.e., for comparisons uses of certain types of tests and for the purpose of taking decisions. All such types of logical operations are done in this unit. This unit has a number of registers and accumulators for short-term storage of data while doing calculations and comparisons.

5.3.1 How an ALU Works?

An ALU performs basic arithmetic and logic operations. Examples of arithmetic operations are addition, subtraction, multiplication and division. Examples of logic operations are comparisons of values such as NOT, AND and OR.

All information in a computer is stored and manipulated in the form of binary numbers, i.e., 0 and 1. Transistor switches are used to manipulate binary numbers since there are only two possible states of a switch: open or closed. An open transistor, through which there is no current, represents a 0. A closed transistor, through which there is a current, represents a 1.

Operations can be accomplished by connecting multiple transistors. One transistor can be used to control a second one - in effect, turning the transistor switch on or off depending on the state of the second transistor. This is referred to as a gate because the arrangement can be used to allow or stop a current.

The simplest type of operation is a NOT gate. This uses only a single transistor. It uses a single input and produces a single output, which is always the opposite of the input. This figure below shows the logic of the NOT gate:

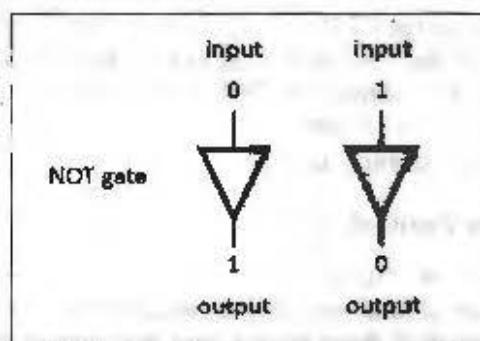


Figure 5.4: How a NOT Gate Processes Binary Data

Other gates consist of multiple transistors and use two inputs. The OR gate results in a 1 if either the first or the second input is a 1. The OR gate only results in a 0 if both inputs are 0. This figure shows the logic of the OR gate:

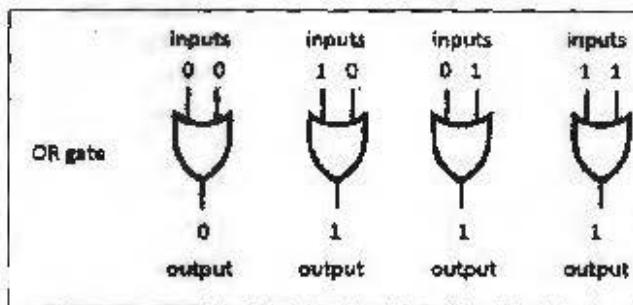


Figure 5.5: How an OR Gate Processes Binary Data

The AND gate results in a 1 only if both the first and second input are 1s. This figure shows the logic of the AND gate:

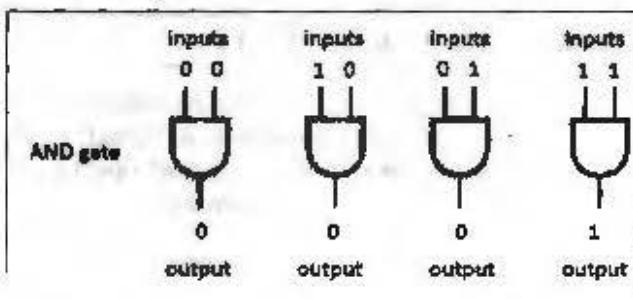


Figure 5.6: How an AND Gate Processes Binary Data

The XOR gate, also pronounced X-OR gate, results in a 0 if both the inputs are 0 or if both are 1. Otherwise, the result is a 1. This figure shows the logic of the XOR gate:

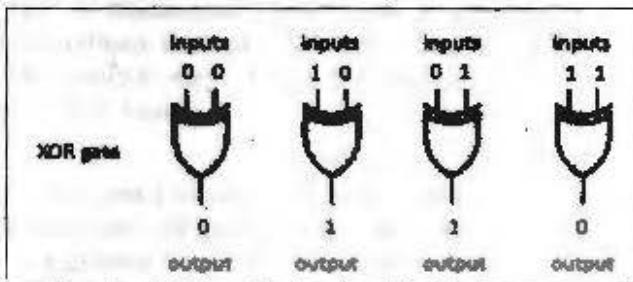


Figure 5.7: How an XOR Gate Processes Binary Data

5.4 CONTROL UNIT

It is the most critical part of the CPU. It is responsible for generating control signals to control the functioning of the CPU and other units. The control signals, generated by the CPU, are placed on the control bus. The control unit determines the sequence in which program instructions are interpreted and executed. It also controls the flow of data to and from secondary storage devices.

5.4.1 Functions of the Control Unit

The Control Unit (CU) is digital circuitry contained within the processor that coordinates the sequence of data movements into, out of, and between a processor's many sub-units. The result of these routed data movements through various digital

circuits (sub-units) within the processor produces the manipulated data expected by a software instruction (loaded earlier, likely from memory). It controls (conducts) data flow inside the processor and additionally provides several external control signals to the rest of the computer to further direct data and instructions to/from processor's external destination's (i.e., memory).

Examples of devices that require a CU are CPUs and graphics processing units (GPUs). The CU receives external instructions or commands which it converts into a sequence of control signals that the CU applies to the data path to implement a sequence of register-transfer level operations.

More precisely, the Control Unit (CU) is generally a sizable collection of complex digital circuitry interconnecting and controlling the many execution units (i.e., ALU, data buffers, registers) contained within a CPU. The CU is normally the first CPU unit to accept from an externally stored computer program, a single instruction (based on the CPU's instruction set). The CU then decodes this individual instruction into several sequential steps (fetching addresses/data from registers/memory, managing execution (i.e., data sent to the ALU or I/O), and storing the resulting data back into registers/memory) that controls and coordinates the CPU's inner works to properly manipulate the data. The design of these sequential steps are based on the needs of each instruction and can range in number of steps, the order of execution, and which units are enabled. Thus by only using a program of set instructions in memory, the CU will configure all the CPU's data flows as needed to manipulate the data correctly between instructions.

5.5 REGISTERS

The CPU consists of a set of registers, which are used for various operations during the execution of instructions. CPU needs registers for storing instructions as well as for storage and manipulation of temporary results.

Registers are the top of the memory hierarchy and are the fastest way for the system to manipulate data. Registers are normally measured by the number of bits they can hold, for example, an 8-bit register means it can store 8 bits of data or a 32-bit register means it can store 32 bit of data.

Registers are used to store data temporarily during the execution of a program. Some of the registers are accessible to the user through instructions. Data and instructions must be put into the system. So we need registers for this.

The basic computer registers with their names, size and functions are listed below:

Table 5.1: Description of the Basic Computer Registers

Register Symbol	Register Name	Number of Bits	Description
AC	Accumulator	16	Processor Register
DR	Data Register	16	Hold memory data
TR	Temporary Register	16	Holds temporary Data
IR	Instruction Register	16	Holds Instruction Code
AR	Address Register	12	Holds memory address
PC	Program Counter	12	Holds address of next instruction
INPR	Input Register	8	Holds Input data
OUTR	Output Register	8	Holds Output data

Following registers are present in a computer.

- ***Memory Data Register (DR):*** Memory Data Register is used to read the value of an operand from a memory location. It can hold up to 16 bits of data.
- ***Memory Address Register (AR):*** Memory Address Register holds the address of memory where operand is stored. By using this address, the data from the memory location is retrieved. The size of address register is 12 bits.
- ***Accumulator:*** Accumulator can contain 16 bit value. It is a general purpose processing register and used to perform arithmetic and logical operations.
- ***Instruction Register (IR):*** It generally contains 16 bits for storing the instructions. Instructions read from memory are placed here for execution.
- ***Program Counter (PC):*** It is a 12 bit register and holds the address of the instruction to be executed next. When the next instruction is read for execution, the program counter jumps to the next instruction.
- ***Temporary Register (TR):*** Temporary Register can contain 8 bits and can hold the temporary or intermediate data as well as memory locations during processing. These registers are also known as general purpose registers. There are six general purpose registers available known as BX, CX, DX, EX, HX, LX. They can be used in pairs of BC, DE and HL, to store 16 bit data.
- ***Stack Pointer (SP):*** A useful feature in CPU is a program stack, a last in first out (LIFO) list. A stack is created in the main memory and stores information in such a manner that the item stored last is the first item retrieved. It requires only an address register, which can count the current location of stack. The register that holds the address for the stack is called Stack Pointer (SP), which always points to the top item in the stack.
- ***Index Registers:*** The SI and DI registers are available for indexed addressing. The 16 bit Base Index Register (BP) facilitates the referencing parameters, which are data and address passed via stack.
- ***Flag Registers:*** They are used to indicate the current status of the machine and the results of processing. Many instructions require comparison and conditions to be evaluated based on previous results. These flag registers provide memory information to such instructions. The common flag registers are Overflow (OF), Direction (DF), Interrupt (IF), Sign (SF) and Zero (ZF).

5.6 INSTRUCTION SET

An instruction includes opcode and operand. Operation code tells about the operation to be performed over operand. Instruction set design includes opcode and operand specification, the design of instruction types to be included in the processor's instruction set.

5.6.1 Reduced Instruction Set Computers (RISC)

For faster execution of instructions, instructions should be fewer in number so that they make less use of memory. The type of computers using fewer instructions and executing them at a faster speed is called Reduced Instruction Set Computers.

RISC Characteristics

The basic concept behind designing of RISC is to reduce execution time.

It has some peculiar characteristics:

1. Hardwired rather than micro programmed control.

2. Fixed length instruction format.
3. Memory is accessed only for storing instructions and fetching them from memory on demand.
4. Few number of instructions.
5. Few addressing modes.
6. Single cycle instruction execution.
7. Relatively large number of registers in processor.
8. Instruction pipeline is efficient.

5.6.2 Complex Instruction Set Computers (CISC)

A computer with a large number of instructions is classified as a Complex Instruction Set Computer.

CISC Characteristics

1. A large number of instructions (typically from 100-250 instructions) are used with such computers.
2. Variable length instruction formats.
3. Instructions which manipulate operands in memory.
4. A large number of addressing modes.
5. Some special infrequently used instructions are provided for performing some special tasks.

5.7 PROCESSOR SPEED

No matter how fast the processor is, the processing speed depends more on the speed of the main memory and other Input/output devices. It is because of this reason that a cache memory having access time closer to the processor speed is introduced.

Most computer applications require that the computer system meets minimum requirements in order for the installation to run. One of those requirements is processor speed. Processor speed measures (in megahertz or gigahertz; MHz or GHz) the number of instructions per second the computer executes. The need for speed is most evident for schools that offer advanced computing classes including web design, animation and graphic design. The processor speed for schools that primarily utilize "normal" sized programs for word processing and introduction to computers, for example, would not require the speed to be as high.

5.7.1 How to Choose Processor Speed?

On one level, choosing a processor speed for your business' computers is simple. The faster your processor speed, the faster your computer will move, and, all things being equal, the more it will cost. However, given the high speed of modern processors, it's possible to buy one that is faster than you need. On the other hand, there are other ways to speed up a computer that can have a more meaningful impact than CPU speed.

5.7.2 What Processor Speed Means?

When you see a processor's speed in GHz, it refers to the speed of the processor's internal clock. Every time that the clock ticks, the processor can execute an instruction or read and write data. A 3.0 GHz processor has 3 billion opportunities per second to

do something, while a 3.6 GHz processor has 3.6 billion chances making it roughly 20 per cent faster.

5.7.3 What Speeds Do not Mean?

Internal clock speeds do not tell you how fast the processor can communicate with the outside world. That is defined by its external clock speed or bus speed, which is usually much slower. This means that if you cannot get enough data into the processor to keep it busy until it can communicate with the outside world again, it will sit idle. Clock speeds also do not tell you how long it takes a processor to actually do something. If a 3.0 GHz processor can do an instruction in five clock ticks while a 3.6 GHz processor takes nine, the slower processor is actually faster much like comparing a delivery person that drives slowly but never gets lost to one that drives quickly but is always lost. While processors in the same family frequently have the same instruction sets and execution times, it can be hard to compare processors of different brand or different type within the same brand because of this difference.

Many different factors determine how fast your computer gets things done. Processor speed is one factor. But what determines the processor's speed?

Processor Speed is affected by:

System clock rate = rate of an electronic pulse used to synchronize processing

(Only one action can take place between pulses.)

Measured in megahertz (MHz) where 1 MHz = 1 million cycles per second or gigahertz (GHz) where 1 GHz = 1 billion cycles per second.

This is what they are talking about if they say a computer is a 2.4 GHz machine. Its clock rate is 2.4 billion cycles per second.

Bigger number = faster processing

Higher is not Always Better

High processor speeds are not always better. You need a balanced and well-rounded PC for the processor speed to actually make a significant difference. If you have a 3.2 Ghz processor speed but weak statistics on everything else, then it isn't worth all of the money spent. Having a system with good balance is ideal. If you have a 2.66 Ghz processor speed, with 9GB of DDR3 RAM, then your computer is likely to not even utilize all of it. As games and cameras become more advanced however, it will eventually catch up.

Keep-up with Technology

Sometimes keeping up with the technology is always a better investment than buying a new computer every two years. You should try to aim for a PC that is upgradable and expandable. This means you can change your processor and RAM easily without damaging anything or buying a whole new tower. Not all computers are upgradable to high speeds, so be sure the one you buy can be expanded upon. Many have a maximum processor speed they can support.

Price is not Everything

When buying a computer with a fast processor, the price you pay isn't everything. Many computers will have faster processors than more expensive counterparts. Look for the best value that will give you what you want while still being affordable. For example, a computer with 2.66GHz and 9GB of RAM (expandable to 24GB) would cost over \$1,000. It's likely the processor would never be able to support using 24GB.

Choose one with a bit more processor power and lower RAM and you will not only have a cheaper PC but a better one.

Check Your Progress

Fill in the blanks:

1. The _____ carries the data that is transferred from one unit to another.
2. This _____ needs to be supplied to this memory for accessing of data.
3. The _____ is the most important hardware component of a computer system.
4. The logic unit is used to apply _____, i.e., used for comparisons, for certain types of tests and to take decisions.
5. The _____ determines the sequence in which program instructions are interpreted and executed.

5.8 LET US SUM UP

- Central Processing Unit is the part of the computer that carries out the instructions of a computer program.
- CPU itself has following three components: Memory or Storage Unit, Control Unit and ALU (Arithmetic Logic Unit).
- The data bus carries the data that is transferred from one unit to another. Generally a data bus is a bi-directional bus.
- The address bus carries the address of the data to be accessed. The number of memory locations that a CPU can address is determined by the number of address lines.
- The most common control bus signals are the read-write signals. To read from memory unit, the CPU places the address on the address bus, i.e., location from where data is to be read and initiates the read control signal.
- The arithmetic unit performs a number of calculations and computations. The logic unit is used to apply logic, i.e., used for comparisons, for certain types of tests and to take decisions.
- An ALU performs basic arithmetic and logic operations. Examples of arithmetic operations are addition, subtraction, multiplication and division. Examples of logic operations are comparisons of values such as NOT, AND and OR.
- The control signals, generated by the CPU, are placed on the control bus. The control unit determines the sequence in which program instructions are interpreted and executed.
- The CU receives external instructions or commands which it converts into a sequence of control signals that the CU applies to the data path to implement a sequence of register-transfer level operations.
- The CPU consists of a set of registers, which are used for various operations during the execution of instructions. CPU needs registers for storing instructions as well as for storage and manipulation of temporary results.
- All instruction includes opcode and operand. Operation code tells about the operation to be performed over operand.
- Most computer applications require that the computer system meets minimum requirements in order for the installation to run. One of those requirements is

processor speed. Processor speed measures (in megahertz or gigahertz; MHz or GHz) the number of instructions per second the computer executes.

5.9 UNIT END ACTIVITY

Make a list of registers that are present in a computer. Elaborate the stack registers.

5.10 KEYWORDS

Accumulator: It can contain 16 bit value. It is a general purpose processing register and used to perform arithmetic and logical operations.

Address Bus: It carries the address of the data to be accessed.

ALU: It performs basic arithmetic and logic operations.

CISC: It stands for Complex Instruction Set Computer based on microprogramming techniques. The hardware is controlled by instructions coded in control memory.

Control Bus: To read from memory unit, the CPU places the address on the address bus, i.e., location from where data is to be read and initiates the read control signal.

Control Unit: It determines the sequence in which program instructions are interpreted and executed.

CPU: It is the unit that reads and executes program instructions.

Data Bus: It carries the data that is transferred from one unit to another.

Instruction Set: The complete set of all the instructions in machine code that can be recognized and executed by a central processing unit.

Processor Speed: It measures (in megahertz or gigahertz; MHz or GHz) the number of instructions per second the computer executes.

Register: It is one of a small set of data holding places that are part of the computer processor.

RISC: It stands for Reduced Instruction Set Computer in which each instruction has dedicated electronic circuitry made from gates, decoders etc., to generate control signal.

5.11 QUESTIONS FOR DISCUSSION

1. What is central processing unit?
2. Differentiate data bus and address bus. What is the role of control bus in CPU?
3. Explain and draw the flowchart of CPU operation.
4. What do you understand by arithmetic and logic unit?
5. How an ALU works?
6. Explain the concept of control unit. What are the functions of the control unit?
7. What are the registers? Make a list of registers that are present in a computer.
8. Discuss reduced instruction set computers and complex instruction set computers.
9. How to choose processor speed? What does processor speed mean?
10. Describe the characteristics of CISC and RISC.

Check Your Progress: Model Answer

1. Data bus
2. Address
3. Central processing unit
4. Logic
5. Control unit

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UNIT-6

STORAGE DEVICES

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6.0 AIMS AND OBJECTIVES

After studying this lesson, you should be able to:

- Provide an overview of storage devices
- Explain about main memory
- Describe various storage evaluation criteria
- Describe memory organization and its addressing strategies, content-addressable memories, memory capacity
- Explain random access memory and read only memory
- Describe secondary storage devices, magnetic disk, floppy and hard disk
- Explain optical disks CD-R●M like compact disk, DVD, Blu-ray disk, HD-DVD and VCD
- Describe mass storages devices and differences between the primary and secondary memory

6.1 INTRODUCTION

In the last lesson, we discussed about the central processing unit of the computer. Now we will learn about storage devices.

In computing, memory refers to the physical devices used to store programs (sequences of instructions) or data (e.g., program state information) on a temporary or permanent basis for the use in a computer or other digital electronic devices. The term primary memory is used for the information in physical systems which function at high-speed (i.e., RAM); quite distinct from secondary memory; which are physical devices for program and data storage, but slow to access while offering higher memory capacity. If needed, primary memory can be stored in secondary memory, through a memory management technique called "virtual memory". An archaic synonym for memory is store.

6.2 STORAGE AND ITS NEEDS

Storage devices are the data storage devices that are used in the computers to store data. The computer has many types of data storage devices. Some of them can be classified as the removable data storage devices and the others are the non-removable data storage devices.

Computer storage devices are a must for an individual or organization to keep data and information in a reliable and permanent way. When your computer fails to work (it can happen anytime), your files will be kept safe on secondary storage devices. That is the beauty of these devices.

According to volatility, memory is classified in two categories:

1. **Non-volatile Memory:** Will retain the stored information even if it is not constantly supplied with electric power. It is suitable for long-term storage of information.
2. **Volatile Memory:** Requires constant power to maintain the stored information. Since primary storage is required to be very fast, it predominantly uses volatile memory.

According to accessibility, memory is classified in two categories:

1. **Random Access:** Any location in storage can be accessed at any moment in approximately the same amount of time. Such characteristic is well suited for primary and secondary storage. Most semiconductor memories and disk drives provide random access.
2. **Sequential Access:** The accessing of pieces of information will be in a serial order, one after the other; therefore the time to access a particular piece of information depends upon which piece of information was last accessed. Such characteristic is typical of off-line storage.

The memory is of two types:

1. Main Memory
2. Secondary Memory

There are many storage devices used with microcomputers. Some of the common storage devices are explained below and are shown in Figure 6.1.



Figure 6.1: Common Storage Devices

6.2.1 Brain vs. Memory

Storage is the more or less passive process of retaining information in the brain, whether in the sensory memory, the short-term memory or the more permanent long-term memory.

The human brain is perhaps the most complex living structure known in the universe. Although it has the same general structure as the brains of other mammals, however it is over three times larger than the brain of a typical mammal with an equivalent body size.

Memory is the faculty of the mind by which information is encoded, stored and retrieved.

Memory is vital to experience feelings and related to limbic systems. It retains information over time for the purpose of influencing future actions.

6.3 STORAGE EVALUATION UNITS

The performance of a memory system is defined by two different measures, the access time and the cycle time.

6.3.1 Access Time

Access time, also known as response time or latency, refers to how quickly the memory can respond to a read or write request. Several factors contribute to the access time of a memory system. The main factor is the physical organization of the memory chips used in the system. This time varies from about 80 ns in the chips used in personal computers to 10 ns or less for chips used in caches and buffers (small, fast memories used for temporary storage, described in more detail below). Other factors are harder to measure. They include the overhead involved in selecting the right chips (a complete memory system will have hundreds of individual chips), the time required to forward a request from the processor over the bus to the memory system, and the time spent waiting for the bus to finish a previous transaction before initiating the processor's request. The bottom line is that the response time for a memory system is usually much longer than the access time of the individual chips.

6.3.2 Memory Cycle Time

Memory cycle time refers to the minimum period between two successive requests. For various reasons, the time separating two successive requests is not always 0, i.e., a memory with a response time of 80 ns cannot satisfy a request every 80 ns. A simple, if old, example of a memory with a long cycle time relative to its access time is the magnetic core used in early mainframe computers. In order to read the value stored in memory, an electronic pulse was sent along a wire that was threaded through the core. If the core was in a given state, the pulse induced a signal on a second wire. Unfortunately the pulse also erased the information that used to be in memory, i.e., the memory had a destructive read-out. To get around these problems designers built memory systems so that each time something was read it immediately got written back. During this writing process, the memory cell is unavailable for further requests, and thus the memory had a cycle time that was roughly twice as long as its access time. Some modern semiconductor memories have destructive reads, and there may be several other reasons why the cycle time for a memory is longer than the access time.

6.3.3 Effective Access Time

Hit Ratio (h)

Hit Ratio (h) is a concept defined for any two adjacent levels of a memory hierarchy. When an information item found in M_i , it is a hit, otherwise, a miss. The hit ratio (h_i) at M_i is the probability that an information item will be found in M_i . The miss ratio at M_i is define as $1 - h_i$.

Access Frequency

The access frequency to M_i is define as

$$F_i = (1 - h_1)(1 - h_2) \dots (1 - h_n)$$

The performance of a hierarchical memory is defined by the effective access time, which is a function of the hit ratio and the relative access times between successive levels of the hierarchy.

In practice, we wish to achieve as high a hit ratio as possible at M_i . Every time a miss occurs, a penalty must be paid to access the next higher level of memory.

The T_{eff} of a memory hierarchy is given by:

$$T_{eff} = \sum_{i=1}^n f_i \times t_i \\ = h_1 t_1 + (1 - h_1)h_2 t_2 + (1 - h_1)(1 - h_2)h_3 t_3 + \dots + (1 - h_1)(1 - h_2) \dots (1 - h_{n-1})t_n$$

Effective access time = Hit rate \times Hit time + Miss rate \times Miss penalty

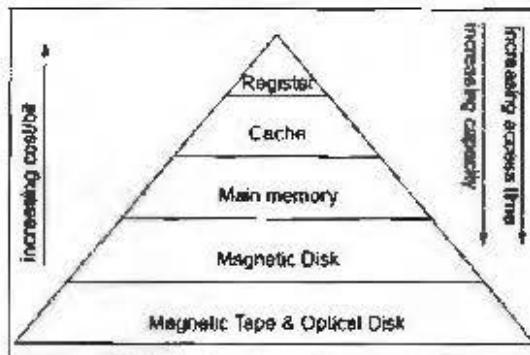


Figure 6.2: Memory Hierarchy

Example: Suppose the cache access time is 10ns, main memory access time is 100ns, and the cache hit rate is 98%. Then the average time for the processor to access an item in memory is:

$$t_{eff} = 0.98 \times t_{cache} + 0.02 \times t_{main} \\ = 11.8 \text{ ns}$$

Over a long period of time the system performs as if it had a single large memory with an 11.8ns cycle time, thus the term "effective access time". With a 98% hit rate the system performs nearly as well as if the entire memory was constructed from the fast chips used to implement the cache, i.e., the average access time is 11.8ns, even though most of the memory is built using less expensive technology that has an access time of 100ns.

6.4 MEMORY ORGANIZATION

This section discusses some of the ways in which memory units may be organized.

6.4.1 Addressing Strategies

Most memories encountered in computer systems are coordinate-addressed. This means that the memory is accessed by supplying a number (address) which is used directly to identify a particular physical storage location. Data is then copied into or out of the selected location. Coordinate addressed memories are typically constructed as a collection of individual units such as chips, each capable of storing a limited number of bits. The small-scale organization within each unit, such as 2-D, etc., is discussed in the text. Large-scale organization, putting the units together to fill a complete address space, is discussed in the next section.

A few special subsystems within some computers make use of memory that is content-addressed. This type is also called associative memory. A content-addressed memory is accessed by supplying a data value for certain portions (fields) of a storage location, rather than the physical address of that location. The memory automatically identifies any locations that match the given data, and the contents of these locations may be accessed. Content addressable memories are discussed in a later section of this document.

6.4.2 Organization of Memory Units

A basic memory unit provides the ability to store and access a fixed number of bits (anywhere from a few thousand to several million with current technology). Each bit within such a unit may be selected individually for reading and writing. Usually only one bit in a given memory unit may be accessed at a time.

The high speed requirements of data transfer throughout a computer system create a need to access storage bits simultaneously in many cases. The most obvious example arises in reading or writing a complete word of data. All the bits of the word are available or needed at once, and if possible should be transferred simultaneously. To support this parallel transfer, enough data lines are provided between the memory and the rest of the system to carry all of the bits in a word, typically 32, 64 or even more. However, for true simultaneous access each bit must be located in a different memory unit.

For this reason, memory units are usually distributed as bit slices. If a chip can store 64K bits, each chip will be used to store *one bit each* from 64K different locations, rather than a complete byte (assuming a byte-addressed architecture) from 8K different locations. The bit-slice organization is illustrated in Figure 6.3.

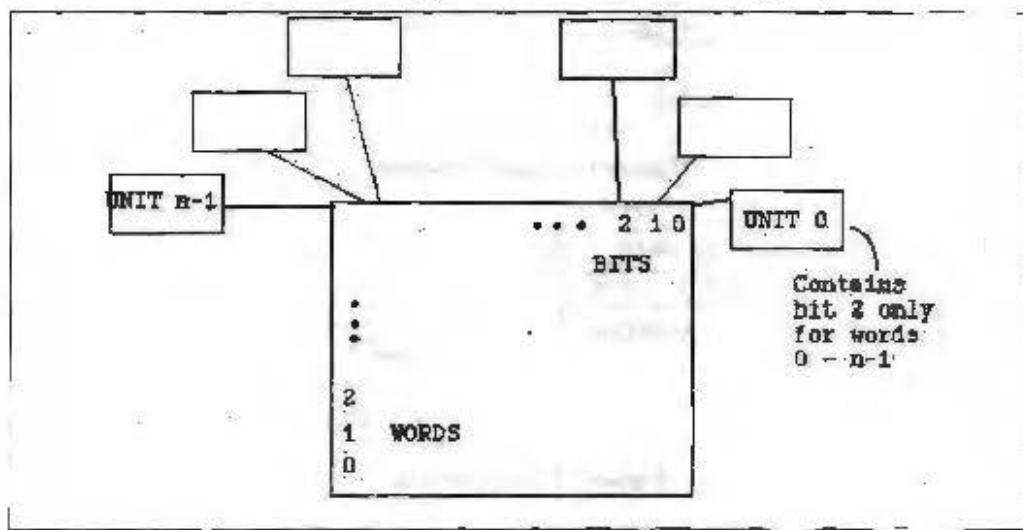


Figure 6.3: Bit Slice Memory Organization

In addition to parallel access to the individual bits of a word, newer architectures support increasing opportunities to usefully access more than one word at a time. Data may be flowing between memory and disk units while the CPU executes other instructions. Increasing use of pipelining and overlap require fetching instructions and data at the same time in some cases, or reading a sequence of instructions as fast as possible.

Since data and instructions can be read and written at the same time only if they are located in different memory units, it is often desirable to use smaller units even if larger ones are available. The complete set of words in the address space is divided among the various units. The division is designed so that a group of bits from the address select a unit (actually a set of bit-sliced units), while the remaining bits select the location within that unit.

There are two principal ways to assign memory units to the address space:

1. **Bank Addressing:** This method uses the high-order bits of the address to select units. Each unit represents a consecutive sequence of addresses. 0-4K might be unit 0, 4K-8K might be unit 1, etc. Bank switching assigns different units to parts

of memory likely to be used for different purposes. It was common in early minicomputer architectures, in part because memory units were necessarily small. Today it is useful in systems which provide distinct memories for instructions and data. If the two types of items are kept in distinct memory units, they can be accessed simultaneously.

2. **Interleaving:** This method uses the low-order bits of the address to select units. As a consequence, consecutive memory locations are assigned to different memory units. When it is desired to read a consecutive sequence at high speed, such as pipelined instruction fetching or block data transfer to disk, the transfers can be effectively overlapped since they will tend to come from independent units. High speed processors typically provide 4-way or 8-way interleaving by using 2 or 3 low-order bits for unit selection.

Bank selection is illustrated in Figure 6.4, and Interleaving is shown in Figure 6.5. Many architectures combine these two methods.

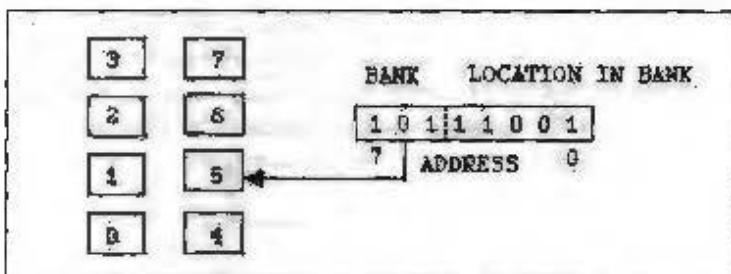


Figure 6.4: Bank Selection

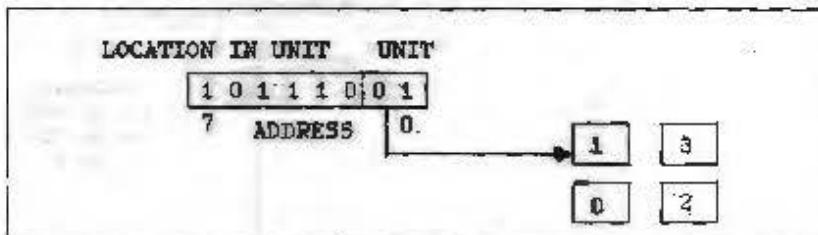


Figure 6.5: Interleaving

6.4.3 Content-Addressable Memories

A content-addressable memory, abbreviated CAM and known also as associative memory, provides an automatic parallel search capability. It has the ability to check the contents of all its locations at the same time to identify those which match a particular pattern. Each location in such a memory includes its own circuits to compare patterns. Searching with a coordinate-addressable memory is like asking each person in the class, one at a time, if they were born in June. Searching with a content-addressable memory is like asking everyone born in June to raise their hands.

Such a memory is clearly more expensive than conventional memories and most useful for special purposes. However, there are areas within high-performance architectures, such as cache and virtual memory management, where content-addressable memories play a critical role, and their cost can easily be justified.

A few experimental architectures have been based entirely on associative memories; such systems are called associative processors. These will be studied in a later part of the text. Content-addressable memory also plays a very important role in architectures specialized for database processing.

This section will describe the operation of a typical general-purpose content-addressable memory. Many actual CAMs are simpler since they are dedicated to a special purpose.

The general structure of a CAM is shown in Figure 6.6. It includes a set of words, each consisting of a number of bits. It is common for such a memory to have very large word sizes, often 100 bits or more. However, it may include only a limited number of words.

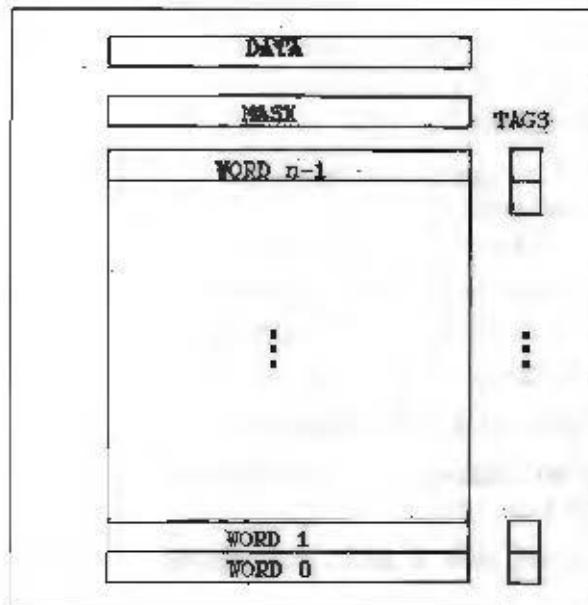


Figure 6.6: A Content-Addressable Memory

Two registers are associated with the CAM, a MASK register and a DATA register. Each is the size of one full word. In addition, each word includes some comparison logic and one or more TAG bits. Each set of tag bits forms a bit-slice register, with one bit for each word of the memory.

The most important operation on a CAM is the SEARCH operation. Its purpose is to identify words that match a particular pattern. The pattern is defined by loading the DATA and MASK registers. Usually we are searching for words having a specified value in certain fields. We then may want to find out what is in other fields of that word. The MASK register is set to 1 for each bit that is to be tested, and 0 for bits whose content should not affect the search. The DATA register is set to the desired pattern within the selected fields; its content in other fields does not matter.

Figure 6.7 shows these two registers set to search for all words that contain the pattern 1101 in bits 10 through 7, and 010 in bits 3 through 1.

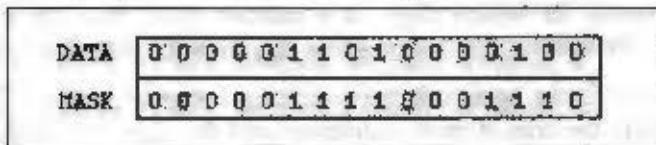


Figure 6.7: Example of Search Register Setup

When the CAM is signaled to perform a search, the logic associated with each word compares that word to the selected pattern. If a match is found, the tag bit for that word is set to one. At the end of this process, all matching words may be identified by their tag bits.

The search is often designed so that all tag bits are initially set, and the search operation clears those that do not match. This may allow several conditions to be tested, selecting only words that meet all conditions. Additional tag registers may also be used as temporary storage to support more complex operations.

Once the search completes, if exactly one word has been selected, a READ or WRITE operation may be performed to transfer data to or from the selected location. If no match is found, an error signal will be returned.

If there is more than one match, the READ operation will select one (any one), read it, and clear its tag bit. Thus successive READs will access all of the matched locations.

Other types of operations that may be possible on associative memories include:

- ***Count Matches:*** This operation indicates how many tag bits are set. Often the possible answers are restricted to zero, one, or many. It is more difficult to provide an exact count if there is more than one match.
- ***Masked Write:*** Write data from the data register into only the bits selected by the mask register (in the tagged word). Other bits remain unchanged.
- ***Multi-write:*** Write data into all tagged words at the same time.
- ***Store:*** Write a data word into any empty location, rather than a selected one.
- ***Address Operations:*** Determine the coordinate address of a tagged word, or read or write by address.
- ***Tag Operations:*** Set, clear or read a tag register, or copy among multiple tag registers.

6.5 MEMORY CAPACITY

Memory on computers is measured in bits, bytes, words, pages, sectors, megabytes and gigabytes among other units of measure.

1. ***Page:*** The address space of the PA-RISC machines is divided into units of 2048 bytes, called pages. If you need 20 bytes of memory, you get a page. HP-UX allocates main memory and file space in 2048-byte physical pages, but MPE/iX manages file system space in logical pages which are 4096 bytes: twice as large. MPE manages things this way for its own performance reasons.
2. ***Sector:*** Sectors are an archaic measure of disc space sometimes used on MPE. For example, the Listf and Listfile commands show disc space allocated to files in sectors. A sector is 256 bytes. Just remember that MPE/iX disc space is actually allocated in software pages which are equal to 16 sectors.
3. ***Byte:*** A byte is eight bits and can hold a value from 0 to 255 (2 to the 8th power, less 1). Bit stands for binary digit, or a number place that can have only two values: 0 or 1. Remember that HP numbers bits from the left, starting with zero.
4. ***Word:*** The word is the basic unit for accessing computer storage on a particular machine, usually the size of each instruction and the size of the data value which is most efficiently processed. The word on a PA-RISC machine is 32-bits (4 bytes), while a word on the Classic HP 3000 is 16-bits (2 bytes). A byte is 8 bits and 16-bits are called a half-word on PA-RISC machines. There are Machine Instructions to load and store words, half-words and bytes.
5. ***Half-word:*** The half-word is a unit of storage on PA-RISC machines, equal to 16-bits or half of a 32-bit Word.
6. ***Kilobyte (KB):*** A kilobyte (KB) is 1024 bytes, or 2 to the 10th power.

7. **Megabyte:** A megabyte (MB) is a memory space measure equal to 1,048,576 bytes (1024 times 1024), or 2 to the 20th power. A megabyte is equal to 4,096 MPE sectors, 512 PA-RISC hardware Pages, or 256 MPE/iX software pages. 1,024 megabytes is a gigabyte.
8. **Gigabyte:** A gigabyte (GB) is a measure of memory space equal to 1024 megabytes or 1,073,741,824 bytes (2 to the 30th power). A gigabyte is equal to 4,194,304 MPE sectors, 524,288 hardware PA-RISC pages or 262,144 software MPE/iX pages.

6.6 DATA ACCESS METHODS

In computing, an access method is a program or a hardware mechanism that moves data between the computer and an outlying device such as a hard disk (or other form of storage) or a display terminal. The term is sometimes used to refer to the mechanics of placing or locating specific data at a particular place on a storage medium and then writing the data or reading it. It is also used to describe the way that data is located within a larger unit of data such as a data set or file.

Two fundamental types of data access exist:

1. Sequential access (as in magnetic tape, for example)
2. Random access (as in indexed media)

6.7 PRIMARY STORAGE

Computer Memories are internal storage areas in the computer used to either temporarily or permanently store data or instructions to be processed. There are four basic types of computer memory: Cache Memory, RAM, Virtual Memory and Hard Drives. With modern CPU's running at speeds of 1 gigahertz or higher, it is hard for computer memory to keep up with the extreme amount of data being processed.

The types of primary memories are given below:

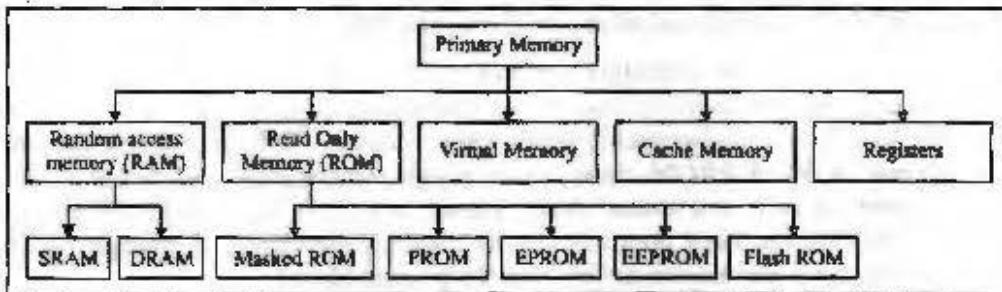


Figure 6.8: Classification of Primary Memory

6.7.1 Random Access Memory

It allows the computer to store data for immediate manipulation and to keep track of what is currently being processed. It is the place in a computer where the operating system, application programs and data in current use are kept so that they can be accessed quickly by the computer's processor. RAM is much faster to read from and write to than the other kinds of storage in a computer (like hard disk or floppy disk). However, the data in RAM stays there only as long as the computer is running. When the computer is turned off, RAM loses all its contents. When the computer is turned on again, the operating system and other files are once again loaded into RAM. When an application program is started, the computer loads it into RAM and does all the processing there. This allows the computer to run the application faster. Any new

information that is created is kept in RAM and since RAM is volatile in nature, one needs to continuously save the new information to the hard disk.

There are two types of random access memory, which are as follows:

1. **Static RAM (SRAM):** This kind of RAM retains the data as long as power is provided to the memory chip i.e., RAM is volatile memory. It need not be 'refreshed' periodically. It is very fast but much more expensive than DRAM. SRAM is often used as cache memory due to its high speed.
2. **Dynamic RAM (DRAM):** This type of RAM needs to be refreshed continuously to maintain the data. This is done by placing the memory on a refresh circuit that rewrites the data several hundred times per second. DRAM is used for most system memory because it is cheap and small.

6.7.2 Read Only Memory

Just like a human being needs instructions from the brain to perform actions in certain event, a computer also needs special instructions every time it is started. This is required because during the start-up operation, the main memory of the computer is empty due to its volatile property, so there has to be some instructions (special boot programs) stored in a special chip that could enable the computer system to perform start-up operations and transfer the control to the operating system. This special chip, where the start-up instructions are stored, is called read-only memory (ROM). It is nonvolatile in nature, that is, its contents are not lost when the power is switched off. The data and instructions stored in ROM can only be read and used, but cannot be altered thereby making ROM much safer and secure than RAM. ROM chips are used not only in the computer, but also in other electronic items like washing machine and microwave oven.

There are different types of ROMs, which are as follows:

- **Masked ROM:** The very first ROMs, known as masked ROMs, were hard-wired devices that contained a preprogrammed set of data or instructions. The contents of such ROMs had to be specified before chip production so that the actual data could be used to arrange the transistors inside the chip.
- **Programmable ROM (PROM):** Creating a ROM chip from scratch is a time-consuming and an expensive process. For this reason, developers created a type of ROM known as Programmable Read Only Memory (PROM), which can be programmed. Blank PROM chips can be bought economically and coded by the users with the help of a special device known as PROM-programmer. However, once a PROM has been programmed, its contents can never be changed. As a result, PROM is also known as One-time Programmable (OTP) device.
- **Erasable Programmable ROM (EPROM):** An EPROM is programmed in exactly the same manner as a PROM. However, unlike PROMs, an EPROM can be erased and reprogrammed repeatedly. It can be erased by simply exposing it to a strong source of Ultraviolet (UV) light for a certain amount of time. Note that an EPROM eraser is not selective. It will erase the entire EPROM. Although EPROM is more expensive than PROM.
- **Electrically Erasable Programmable ROM (EEPROM):** This type of ROM can be erased by an electrical charge and then written to by using slightly higher-than-normal voltage. EEPROM can be erased one byte at a time, rather than erasing the entire chip with UV light. Hence, the process of re-programming is flexible, but slow. In addition, changing the contents does not require any additional committed equipment. Because these chips can be changed without opening a

- **Flash ROM:** Flash ROM, also called flash BIOS or flash memory, is a type of constantly powered nonvolatile memory that can be erased and re-programmed in blocks. It is a variation of EEPROM, which, unlike flash memory, is erased and rewritten at the byte level. Flash memory is often used to hold the control code such as the BIOS in a personal computer. When BIOS needs to be changed or rewritten, the flash memory can be written in block (rather than byte) sizes, thus making it easier to update. Flash memory gets its name because the microchip is organized so that a section of memory cells are erased in a single action or 'flash'. Flash memory is used in digital cellular phones, digital cameras, LAN switches, PC cards for notebook computers, digital set-up boxes, embedded controllers and other devices.

6.7.3 Virtual Memory

An imaginary memory area supported by some operating systems for example, Windows but not DOS, in conjunction with the hardware. You can think of virtual memory as an alternate set of memory addresses. Programs use these virtual addresses rather than real addresses to store instructions and data. When the program is actually executed, the virtual addresses are converted into real memory addresses.

The purpose of virtual memory is to enlarge the address space, the set of addresses a program can utilize. For example, virtual memory might contain twice as many addresses as main memory. A program using all of virtual memory, therefore, would not be able to fit in main memory all at once. Nevertheless, the computer could execute such a program by copying into main memory those portions of the program needed at any given point during execution.

To facilitate copying virtual memory into real memory, the operating system divides virtual memory into pages, each of which contains a fixed number of addresses. Each page is stored on a disk until it is needed. When the page is needed, the operating system copies it from disk to main memory, translating the virtual addresses into real addresses.

6.7.4 Cache Memory

Cache memory is a small-sized type of volatile computer memory that provides high-speed data access to a processor and stores frequently used computer programs, applications and data. It is the fastest memory in a computer, and is typically integrated onto the motherboard and directly embedded in the processor or main random access memory (RAM).

Cache memory provides faster data storage and access by storing instances of programs and data routinely accessed by the processor. Thus, when a processor requests data that already has an instance in the cache memory; it does not need to go to the main memory or the hard disk to fetch the data.

Cache memory can be primary or secondary cache memory, with primary cache memory directly integrated into or closest to the processor. In addition to hardware-based cache, cache memory also can be a disk cache, where a reserved portion on a disk stores and provides access to frequently accessed data/applications from the disk.

6.7.5 Registers

Registers are used to quickly accept, store, and transfer data and instructions that are being used immediately by the CPU, there are various types of Registers those are used for various purposes. Among of the some mostly used Registers named as AC

or Accumulator, Data Register or DR, the AR or Address Register, program counter (PC), Memory Data Register (MDR), Index register, Memory Buffer Register.

These Registers are used for performing various operations. While we are working on the System then these Registers are used by the CPU for performing the operations. When we give some input to the system then the input will be stored into the Registers and when the system will give us the results after processing then the result will also be from the Registers. So that they are used by the CPU for processing the data which is given by the user.

6.8 SECONDARY STORAGE

The secondary memory is used to store the data permanently in a computer. Secondary memory or secondary storage is the slowest and cheapest form of memory. It cannot be processed directly by the CPU. It must be copied first into primary storage (also known as RAM).

Secondary memory devices include magnetic disks like hard drives and floppy disks; optical disks such as CDs and CDROMs; and magnetic tapes, which were the first forms of secondary memory.

Secondary memory is computer memory that is non-volatile and persistent in nature and is not directly accessed by a computer/processor. It allows a user to store data that may be instantly and easily retrieved, transported and used by applications and services.

Secondary memory is also known as secondary storage.

Secondary memory consists of all permanent or persistent storage devices, such as read-only memory (ROM), flash drives, hard disk drives (HDD), magnetic tapes and other types of internal/external storage media. In computing operations, secondary memory is accessed only by the primary or main memory and later transported to the processor.

Secondary memory is slower than primary memory but can store and retain data, even if the computer is not connected to electrical power. It also has substantial storage capacities, ranging from megabytes to several terabytes of storage space within single memory.

Its classification is shown in Figure 6.9:

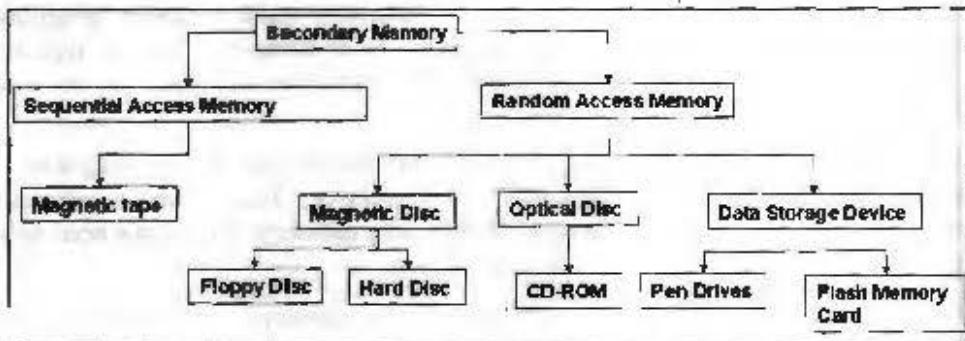


Figure 6.9: Classification of Secondary Memory

6.8.1 Sequential Access Memory

Sequential Access Memory (SAM) is a class of data storage devices that read their data in sequence. This is in contrast to random access memory (RAM) where data can

be accessed in any order. Sequential access devices are usually a form of magnetic memory.

While sequential access memory is read in sequence, accesses can still be made to arbitrary locations by "seeking" to the requested location. This operation, however, is often relatively inefficient.

Magnetic sequential access memory is typically used for secondary storage in general-purpose computers due to their higher density at lower cost compared to RAM, as well as resistance to wear and non-volatility. Examples of SAM devices still in use include hard disks, CD-ROMs and magnetic tapes. Historically, drum memory has also been used.

Magnetic Tape

Magnetic tape is a type of physical storage media for different kinds of data. It is considered an analog solution, in contrast to more recent types of storage media, such as solid state disk (SSD) drives. Magnetic tape has been a major vehicle for audio and binary data storage for several decades, and is still part of data storage for some systems.

Originally, magnetic tape was designed to record sound. In computing, it holds binary data. In recent years, magnetic tape devices have become scarcer with the emergence of digital imaging and audio-visual media storage.

Magnetic tape was used in many of the larger and less complex mainframe computers that predated today's personal computers (PC).

One use of magnetic tape that still exists is tape vaulting for the storage of physical records. In this process, technicians and other professionals back up digital data to magnetic tape to secure it in physical vaults as a redundant strategy in the event of disasters or other emergencies.

6.8.2 Random Access Memory

Random access memory (RAM) is a type of data storage used in computers that is generally located on the motherboard. This type of memory is volatile and all information that was stored in RAM is lost when the computer is turned off. Volatile memory is temporary memory while ROM (read-only memory) is non-volatile and holds data permanently when the power is turned off.

The RAM chip may be individually mounted on the motherboard or in sets of several chips on a small board connected to the motherboard. Older memory types were in the form of chips called dual in-line package (DIP). Although DIP chips are still used today, the majority of memory is in the form of a module, a narrow printed circuit board attached to a connector on the motherboard. The three main memory circuit boards types containing chips are: RIMMs (Rambus in-line memory modules), DIMMs (dual in-line memory modules) and SIMMs (single in-line memory modules).

There are two main types of RAM: dynamic random access memory (DRAM), or Dynamic RAM, and static random access memory (SRAM). The RAM in most personal computers (PC's) is Dynamic RAM. All dynamic RAM chips on DIMMs, SIMMs or RIMMs have to refresh every few milliseconds by rewriting the data to the module.

Static RAM (SRAM) is volatile memory and is often used in cache memory and registers because it is a lot faster and does not require refreshing like Dynamic RAM. SRAM retains information and is able to operate at higher speeds than DRAM. Because DRAM is a lot cheaper than SRAM, it's common to see PC manufacturers use DRAM.

Dynamic RAM is memory that needs refreshing. The refreshing is done by the memory controller which is part of the chipset on the motherboard. Static RAM (SRAM) does not need refreshing and is used in memory cache on the central processing unit (CPU); it is called L1, L2 and L3 cache. Original SRAM was stored on the motherboard; later SRAM was inside of the CPU housing or stored on both the motherboard and inside of the CPU.

Magnetic Disc

A magnetic disk is a storage device that uses a magnetization process to write, rewrite and access data. It is covered with a magnetic coating and stores data in the form of tracks, spots and sectors. Hard disks, zip disks and floppy disks are common examples of magnetic disks.

A magnetic disk primarily consists of a rotating magnetic surface and a mechanical arm that moves over it. The mechanical arm is used to read from and write to the disk. The data on a magnetic disk is read and written using a magnetization process. Data is organized on the disk in the form of tracks and sectors, where tracks are the circular divisions of the disk. Tracks are further divided into sectors that contain blocks of data. All read and write operations on the magnetic disk are performed on the sectors.

Magnetic disks have traditionally been used as primary storage in computers. With the advent of solid-state drives (SSDs), magnetic disks are no longer considered the only option, but are still commonly used.

Floppy Disc

A floppy disk drive (FDD), or floppy drive, is a hardware device that reads data storage information. It was invented in 1967 by a team at IBM and was one of the first types of hardware storage that could read/write a portable device. FDDs are used for reading and writing on removable floppy discs. Floppy disks are now outdated, and have been replaced by other storage devices such as USB and network file transfer.

A floppy disk commonly came in three sizes, 8 inches, 5.5 inches and 3.5 inches, becoming smaller as the technology advanced. The newer, 3.5-inch version used more cutting-edge technology and held more data than previous models, while the original 8-inch floppy drive was developed to load hardware-level instructions and/or data structures called microcode into the IBM System/370 mainframe. The 8-inch flexible diskette was read-only, held 80 kilobytes of memory and was referred to as a memory disk. Eight-inch floppy drives did not connect to the motherboard, but rotated on a turntable that was run by an idler wheel.

As the floppy disk advanced to a smaller 5.5- and 3.5-inch designs, the FDD changed as well. To accommodate a smaller floppy disk, an FDD had to make aggressive changes by matching the size of the floppy disk drive opening to the size of the floppy disk for compatibility. For many years, the majority of PCs and notebooks had a floppy drive. Using a floppy disk to exchange data between PCs was a standard method for many computer technicians. The floppy disk was one of the most common ways to store adequate amounts of data outside of a computer's hard drive for personal use because they were inexpensive and easy to carry.

As technology advanced, floppy disks were finally able to read and write. By this point, FDDs had four basic components:

1. Magnetic read/write heads (one or two)
2. A spindle clamping device that held the disk in place as it was spinning 300 to 360 rotations per minute
3. A frame with levers that opened and closed the device

4. A circuit board that contained all of the electronics

The read/write heads could read both sides of a disk, and the same head was used for reading and writing. A separate, wider head was used for erasing data to ensure that all data was erased without having to interfere with the data already on the adjacent track.

A floppy drive cable could house two drives. In a computer system, the drive at the end of the cable was drive A. When another drive was added, it was connected to the middle of the cable and was called drive B.

Floppy drives are mostly a hardware device of the past. Newer hardware devices have been introduced, including ZIP drives, CDs and USB. Today, floppy drives are usually not included on a PC, notebook or laptop.

Hard Disc

When you save data or install programs on your computer, the information is typically written to your hard disk. The hard disk is a spindle of magnetic disks, called platters, that record and store information. Because the data is stored magnetically, information recorded to the hard disk remains intact after you turn your computer off. This is an important distinction between the hard disk and RAM, or memory, which is reset when the computer's power is turned off.

The hard disk is housed inside the hard drive, which reads and writes data to the disk. The hard drive also transmits data back and forth between the CPU and the disk. When you save data on your hard disk, the hard drive has to write thousands, if not millions, of ones and zeros to the hard disk.

A hard drive fits inside a computer case and is firmly attached with the use of braces and screws to prevent it from being jarred as it spins. Typically it spins at 5,400 to 15,000 RPM. The disk moves at an accelerated rate, allowing data to be accessed immediately. Most hard drives operate on high speed interfaces using serial ATA (SATA) or serial attached technology. When the platters rotate, an arm with a read/write head extends across the platters. The arm writes new data to the platters and reads new data from them. Most hard drives use enhanced integrated drive electronics (EIDE) including cables and connectors to the motherboard. All data is stored magnetically, allowing information to be saved when power is shut off.

Hard drives need a read only memory (ROM) controller board to instruct the read/write heads how, when and where to move across the platters. Hard drives have disks stacked together and spin in unison. The read/write heads are controlled by an actuator, which magnetically reads from and writes to the platters. The read/write heads float on a film of air above the platters. Both sides of the platters are used to store data. Each side or surface of one disk is called a head, with each one divided into sectors and tracks. All tracks are the same distance from the centre of the disk. Collectively they comprise one cylinder. Data is written to a disk starting at the furthest track. The read/write heads move inward to the next cylinder once the first cylinder is filled.

A hard drive is divided into one or more partitions, which can be further divided into logical drives or volumes. Usually a master boot record (MBR) is found at the beginning of the hard drive and contains a table of partition information. Each logical drive contains a boot record, a file allocation table (FAT) and a root directory for the FAT file system.

Optical Disc

An optical disk is any computer disk that uses optical storage techniques and technology to read and write data. It is a computer storage disk that stores data

digitally and uses laser beams transmitted from a laser head mounted on an optical disk drive to read and write data.

An optical disk is primarily used as a portable and secondary storage device. It can store more data than the previous generation of magnetic storage media, and has a relatively longer lifespan. Compact disks (CD), digital versatile/video disks (DVD) and Blu-ray disks are currently the most commonly used forms of optical disks. These disks are generally used to:

- Distribute software to customers
- Store large amounts of data such as music, images and videos
- Transfer data to different computers or devices
- Back up data from a local machine

CD-ROM

- Pronounced see-dee-rom. Short for Compact Disc-Read-Only Memory, a type of optical disk capable of storing large amounts of data - up to 1GB, although the most common size is 650MB (megabytes). A single CD-ROM has the storage capacity of 700 floppy disks, enough memory to store about 300,000 text pages.
- CD-ROMs are stamped by the vendor, and once stamped, they cannot be erased and filled with new data. To read a CD, you need a CD-ROM player. All CD-ROMs conform to a standard size and format, so you can load any type of CD-ROM into any CD-ROM player. In addition, CD-ROM players are capable of playing audio CDs, which share the same technology.
- CD-ROMs are particularly well-suited to information that requires large storage capacity. This includes large software applications that support colour, graphics, sound, and especially video.

Data Storage Device

A storage device is any computing hardware that is used for storing, porting and extracting data files and objects. It can hold and store information both temporarily and permanently, and can be internal or external to a computer, server or any similar computing device.

A storage device may also be known as a storage medium or storage media. These are one of the core components of any computing device. They store virtually all the data and applications on a computer, except hardware firmware. They are available in different forms factors depending on the type of underlying device. For example, a standard computer has multiple storage devices including RAM, cache, and hard disk, as well as possibly having optical disk drives and externally connected USB drives.

There are two different types of storage devices:

- *Primary storage devices*: Generally smaller in size, these are designed to hold data temporarily and are internal to the computer. They have the fastest data access speed, and include RAM and cache memory.
- *Secondary storage devices*: These usually have large storage capacity, and they store data permanently. They can be either internal or external to the computer, and they include the hard disk, optical disk drive and USB storage device.

In a computer, data storage is the place where data is held in an electromagnetic or optical form for access by a computer processor.

Storage is frequently used to describe the devices and data connected to the computer through input/output (I/O) operations -- that is, hard disk and tape systems and other forms of storage that don't include computer memory and other in-computer storage. For the enterprise, the options for this kind of storage are of a much greater variety and expense than those related to memory.

Pen Drives

A pen drive, or a USB flash drive, is a portable data-storage device. Pen drives have replaced the floppy drives of old and have become the most popular data-storage devices among consumers. Micro, lightweight and handy, a pen drive can be easily carried from place to place by students, professionals, academicians and independent tech consultants. Currently available pen drives with storage capacities ranging from 8GB and 32GB can be used to store graphics-heavy documents, photos, music files and video clips.

Flash Memory Card

A flash memory card, sometimes called a storage card is a small storage device that uses nonvolatile semiconductor memory to store data on portable or remote computing devices. Such data includes text, pictures, audio and video. Most current products use flash memory, although other memory technologies are being developed, including devices that combine dynamic random access memory (DRAM) with flash memory.

There are a number of flash memory card types on the market, roughly divided between consumer devices and enterprise storage devices.

These devices include the Secure Digital card (SD card) and its smaller variant, the micro SD card; Secure Digital High Capacity (SDHC) card; CompactFlash card (CF card); Smart Media card; Memory Stick; MultiMediaCard (MMC); xD-Picture card; and USB card.

The above types of memory cards are usually associated with consumer devices, such as digital cameras, smartphones and tablets. The cards come in varying sizes, and storage capacities.

Most types of memory cards available have constantly powered, nonvolatile memory, particularly NAND flash. Nonvolatile memory safeguards data in the event of a power outage, software bug or other disruption, and also eliminates the need to periodically refresh data on the memory card. Because memory cards use solid-state media, they involve no moving parts and are less likely to suffer mechanical difficulties.

6.8.3 Differences between the Primary and Secondary Memory

The following table lists out some of the key differences between the primary and secondary memory:

Table 6.1: Differences between the Primary and Secondary Memory

S.No.	Primary memory	Secondary memory
1.	The memory devices used for primary memory are semiconductor memories	The secondary memory devices are magnetic and optical memories.
2.	The primary memory is volatile (RAM) as well as non-volatile memories (ROM).	The secondary memory is always nonvolatile.
3.	The primary memory is composed of programs and data that are presently being used by the micro-processor.	The secondary memory is enough capable to store huge amount of information.
4.	Faster as compared with the secondary memory.	Slow as compared with the primary memory.

Contd..

5.	Primary memory is known as main memory.	Secondary memory is known as additional memory or back memory.
6.	These memories are also called as internal memory.	These memories are also called as external memory.
7.	Primary memory is temporary.	The secondary memory is permanent.
8.	The currently available capacity of primary memory is 512 MB to 8 GB RAMs.	Currently the secondary memories are available from 80 GB to 4 TB Hard Disc Drive.

6.9 FLOPPY DISK DRIVES

Floppy disks are made of round plastic disks located with magnetic oxide particles. The disks are unclosed in a plastic jacket which protects the magnetic recording surface from damage. Floppy disks come in 3 sizes: 8 inch, 5½ inch and 3½ inch. All disk sizes can never be single-sided or double-sided. Single-sided disks store data on only one side of disk and double-sides disks store on both sides. Floppy disks can also be classified on the basis of data they can. This is called disks density. There are three level of floppy disk density: single density, double-density and high-density.

Construction of 5.25 inch Floppy Disk

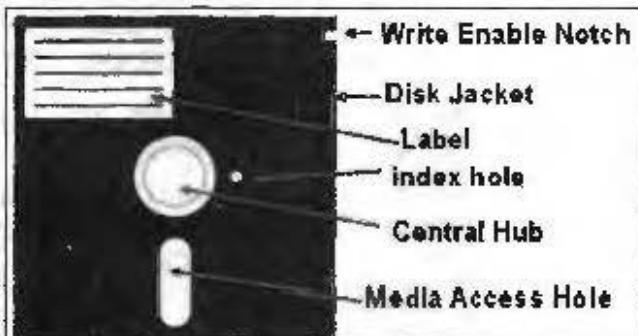


Figure 6.10: Floppy

Disk Jacket: The disk is enclosed in a plastic jacket to protect the disk surface contamination caused by dust, dirt and smoke. Stress Relief Notches on the bottom of disk jacket are two notches called stress relief notches. They help to relieve stress on the disk. Some drives also use these notches to keep the disk in proper position in the drive.

Media Access Hole: There is a Media Access hole on each side of disk. When you insert the disk in-a drive, the head is positioned over these holes to read or write on disk.

Index Hole: The index hole indicates the start of sector. Soft-sectorized disks have only 1 index hole and hard sectored disks have 8 or 9 index holes and each hole represents start of a sector.

Write Enable Notch: In order to write on a disk this notch must be present. If you want to protect the disk, from accidental loss of data then you have to cover this notch with a strip of tape.

Central Hub: In the center of the disk there is a big hole known as Central Hub Access hole. When you insert the disk in the drive, a cone shaped clamp centers the disk and clamps it to the spindle motor.

Index Hole: This hole was the computer's way of knowing where the starting point of the sector was on the diskette by physically having a hole punched in the film disc within the plastic casing.

There are many types of floppies depending upon their sizes and storage capacities as summarized in Table 6.2. The original floppy, developed by IBM, is an 8" floppy, but the most popular sizes available for present day PCs are 5 1/4" and 3 1/2". The storage capacity of floppies varies from 360 KB to 1.44 MB. The floppies can store data on both sides (Double-sided Floppies) or on single side (Single-sided Floppies) depending upon the floppy drive. Double-sided floppy drives are most frequently used in present day PCs. The latest floppy drive, that packs two high density floppy drives (5.25 & 3.5 inch) into a single package, is known as Combo Drive.

Table 6.2: Comparison among Different Types of Floppies

Type of Floppy	Size	Density	Sectors	Tracks	Storage Capacity
DSDD*	5.25 inch	Double	9	40	360 K
DSL.D*	3.5 inch	Low	9	80	720 K
DSHD* Big	5.25 inch	High	15	80	1.2 MB
DSHD Small	3.5 inch	High	18	80	1.44 MB

* DS stands for Double Sided, LD for Low Density and HD for High Density

6.10 WINCHESTER DISK

Winchester Disk is the most common storage device of present day microcomputers. It is popularly called as the Hard Disk Drive (HDD) or sometimes as Fixed Disk Drive. It is fixed inside the computer and is not easily removable. It is used for storing the software and data inside the computer. It is also known as 'Winchester Disk', probably because this drive was first made by IBM at Hursley Laboratory, located near Winchester in England.

Winchester Disk consists of one or more disk platters, an access mechanism and read/write heads which are sealed in a case as shown in Figure 6.11. Hard disk size depends upon the disk platter's diameter. There are many different platter sizes (such as 5 1/4, 3 1/2, 2 1/2 inch etc.). The 3 1/2 inch size platter is common with PCs and 2 1/2 inch with laptop/portable computers. Read/write head is used to write any information on the disk surface or to read it back.

There are different types of hard disks depending upon their storage capacities. Storage capacities of hard disks range from 10 MB to several GBs, but 1.2 GB to 4.1 GB are now-a-days a common part of Pentium computers.

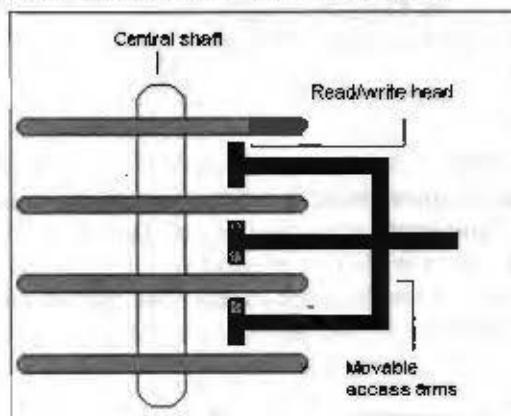


Figure 6.11: Internal Structure of a Winchester Disk

6.11 HARD DISCS

A hard disk drive is the device used to store large amounts of digital information in computers and related equipment like iPods and games consoles such as the Xbox 360 and PS3. Hard disk drives are used to store operating systems, software and working data. These are suitable for any application which requires very fast access to data for both reading and writing to. However, hard disk drives may not be suitable for applications which need portability.

Almost all computers use a fixed hard disc. Used for on-line and real time processes requiring direct access. Used in file servers for computer networks to store large amount of data.

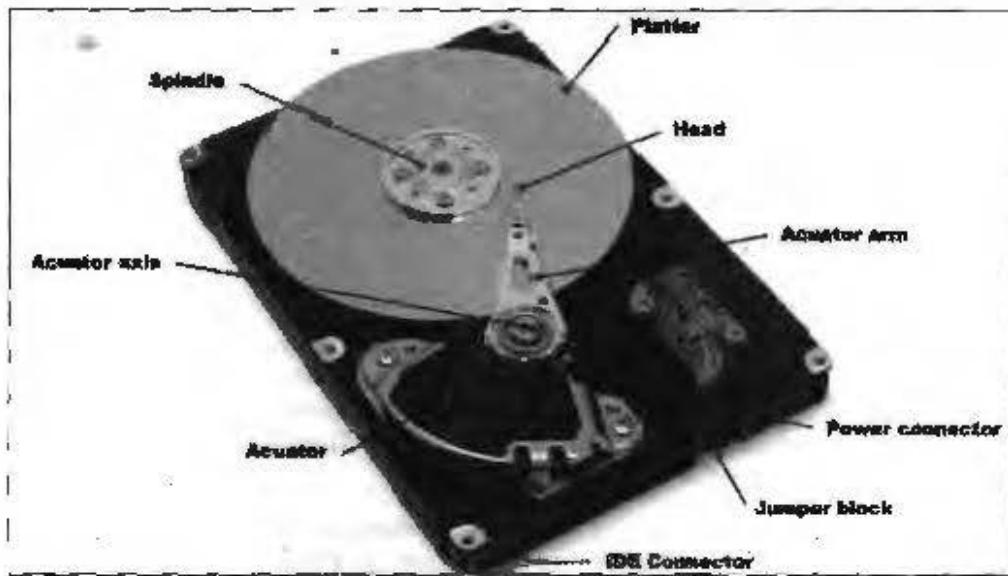


Figure 6.12: Hard Disc

6.12 OPTICAL DISKS CD-ROM

Almost all optical storage involves the use of a 5" disk from which data is read by a laser. Optical media can be read only (such as commercial software, music or movie disks), write-one, or rewritable, and currently exists in one of three basic formats. These are Compact Disk (CD), Digital Versatile Disk (DVD) and Blu-Ray disk (BD). A fourth format called High-Definition DVD (HD DVD) is no more preferred.

6.12.1 Compact Disk

Compact disk is a very mature, low-cost and reliable storage media particularly well suited for most personal computer users for incremental data archiving, as well as for the physical exchange of moderate-sized qualities of data. Writable compact disks can be either CD-R (which are a write-one media) or CD-RW (to which data can be written and erased typically a few hundred times). The storage capacity of a compact disk is up to about 700MB for CD-R and some what less for CD-RW media (and depending on the format used to write the data).

For the reliable back-up or exchange of up to 700MB of data there is still little to beat a compact disk. Problems accessing a CD-R disk are now very rare, and the cost of the disks is low if bought in bulk in "pancakes" of 25, 50 or 100 disks. The media are also physically very durable – and certainly considerably more so than an external hard disk. The only real drawbacks to compact disks for data storage are the speed of

access (even if a modern drive will write and verify a CD-R in well under five minutes) and the relatively limited capacity.

6.12.2 DVD

DVD followed compact disk into the optical storage arena, and most new computers are now equipped with an optical drive that will read and write both CD and DVD media.

DVD ROM and DVD RAM disks are optical disks having a storage capacity of 4.7 GB and 5.2 GB respectively. These disks are becoming the next generation's new standard for higher capacity removable media. They are ideal for storage of huge amount of information required for multimedia applications. One can put 133 minutes of high quality of video with digital sound on a DVD RAM Disk. The picture of DVD RAM disk is shown in Figure 6.13.



Figure 6.13: A DVD RAM Disk

DVD comes in two write-once formats (DVD-R and DVD+R), as well as two rewritable formats (DVD-RW and DVD+RW). Many older DVD writers will only write to either DVD-R or DVD-RW or to DVD+R and DVD+RW, so users need to take care of purchasing the right media. Also many DVD drives will only read one type of rewritable media, and again users need to carefully take this into account when producing disks for other people. In general, it is fairly wide-accepted that DVD+R is the most "stable" widely-readable write-once format (especially in domestic DVD video players) due to having superior error correction and burning control than DVD-R, whilst DVD+RW is the most flexible re-writable format.

To make matters a little more confusing, Panasonic also created a format called DVD RAM. This is actually a superb re-writable technology (disks can reliably be re-written tens of thousands of times, as opposed realistically to hundreds of times for DVD-RW or DVD+RW). DVD RAM disks are also starting to be widely used in domestic DVD recorders, and are available in caddy units that can be either single or double sided. For video recording purposes and stable data archiving, DVD RAM is the media of choice. The only constraint is that many DVD drives still will not read or write DVD RAM disks (although the number is rapidly growing), with even fewer drives accepting the caddied disks that offer the media the best protection from dust, and hence maximum the durability. Windows XP also has only limited support for DVD RAM.

The standard capacity for any format of DVD media is 4.7 GB. Commercial read-only disks (as used to distribute movies) double this to 8.5GB by storing the data on two layers. Yet two more formats of DVD write-one disk (DVD-R DL and DVD+R DL) also exist to copy the same trick to raise writeable DVD data storage capacity to 8.5GB. However, once again not all drives will write these media, and in terms of cost per gigabyte it remains far cheaper (if less environmentally or archive-space friendly) to write two DVD-R or DVD+R disks rather than a single double layer (DL) disk. Double-sided DVD RAM disks that physically have to be turned over to read or write the other side--have a capacity of 9.4 GB.

6.12.3 Blu-Ray Disk

Blu-Ray disk is the high-capacity successor to DVD, and the only surviving new optical disk media on the block. It was developed by the Blu-Ray Disk Association (BDA) as a higher-capacity replacement for DVD (and especially to allow for the distribution and home recording of movies in high definition). Whilst most of the attention in this area has until recently been focused on Blu-Ray's battle with HD DVD (see below), for computer users Blu-Ray already offers write-once (BD-R) and re-writable (BD-RE) disk capacities of 25GB on a single-layer disk and 50GB on a dual layer disks. Just as importantly for the format, multi-hundred GB disks are already in the lab and on the consumer horizon.

6.12.4 HD-DVD

It is worth noting for completeness that HD DVD was the contender to Blu-Ray Disk to replace DVD as the next generation optical storage media for both computer data storage and domestic video use. HD DVD disks had a 15GB capacity (lower than Blu-Ray disk at 25 or 50GB, and not that much higher than dual layer DVD-R DL or DVD+R DL disks at 8.5GB). HD DVD was created by Toshiba and NEC, and was backed by Microsoft. However, most movie studios and other computer industry players (including Sony, Panasonic, Philips, Samsung, Pioneer, Sharp, JVC, Hitachi, Mitsubishi, TDK, Thomson, LG, Apple, HP and Dell) were on the side of Blu-Ray. Indeed, it was following the defection in early 2008 of Warner Bros from HD DVD camp that Blu-Ray won the high capacity optical disk format wars.

6.12.5 VCD

Video Compact Disc (VCD) is a compact disk format based on CD-ROM XA that is specifically designed to hold MPEG-1 video data and to include interactive capabilities. VCD has a resolution similar to that of VHS, which is far short of the resolution of DVD. Each VCD disk holds 72-74 minutes of video and has a data transfer rate of 1.44 Mbps. VCDs can be played on a VCD player connected to a television set (in the same way that video cassettes can on a VCR) or computer, on a CD-i player, on some CD-ROM drives, and some DVD players.

6.13 MASS STORAGES DEVICES

Mass Storage Devices refers to various techniques and devices for storing large amounts of data. The earliest storage devices were punched paper cards, which were used as early as 1804 to control silk-weaving looms. Modern mass storage devices include all types of disk drives and tape drives. Mass storage is distinct from *memory*, which refers to temporary storage areas within the computer. Unlike main memory, mass storage devices retain data even when the computer is turned off.

The main types of mass storage are as follows:

- **Floppy disks:** Relatively slow and have a small capacity, but they are portable, inexpensive and universal.
- **Hard disks:** Very fast and with more capacity than floppy disks, but also more expensive. Some hard disk systems are portable (removable cartridges), but most are not.
- **Optical disks:** Unlike floppy and hard disks, which use electromagnetism to encode data, optical disk systems use a laser to read and write data. Optical disks have very large storage capacity, but they are not as fast as hard disks. In addition, the inexpensive optical disk drives are read-only. Read/write varieties are expensive.

- **Tapes:** Relatively inexpensive and can have very large storage capacities, but they do not permit random access of data.

Mass storage is measured in kilobytes (1,024 bytes), megabytes (1,024 kilobytes), gigabytes (1,024 megabytes) and terabytes (1,024 gigabytes). Mass storage is sometimes called auxiliary storage.

6.13.1 Zip Drive

A Zip drive is a small, portable disk drive used primarily for backing up and archiving personal computer files. The trade marked Zip drive was developed and sold by Iomega Corporation. Zip drives and disks come in two sizes. The 100 megabyte size actually holds 100,431,872 bytes of data or the equivalent of 70 floppy diskettes. There is also a 250 megabyte drive and disk. The Iomega Zip drive comes with a software utility that lets you copy the entire contents of your hard drive to one or more Zip disks.

6.13.2 Flash Drives

A flash drive is a small, ultra-portable storage device which unlike an optical drive or a traditional hard drive, has no moving parts.

Flash drives connect to computers and other devices via a built-in USB Type-a plug, making a flash drive a combination of USB device and the cable.

Flash drives are often referred to as pen drives, thumb drives, or jump drives. The terms USB drive and Solid State Drive (SSD) are also sometimes used but most of the time those refer to larger and not-so-mobile USB-based storage devices.

How to Use a Flash Drive?

To use a flash drive, just insert the drive into a free USB port on the computer.

On most computers, you will be alerted that the flash drive was inserted and the contents of the drive will appear on the screen, similar to how other drives on your computer appear when you browse for files.

Exactly what happens when you use your flash drive depends on your version of Windows or other operating system, and how you have your computer configured.

6.13.3 Memory Card

A memory card, flash card or memory cartridge is an electronic flash memory data storage device used for storing digital information. These are commonly used in portable electronic devices, such as digital cameras, mobile phones, laptop computers, tablets, PDAs, portable media players, video game consoles, synthesizers, electronic keyboards and digital pianos.

6.14 DRIVING NAMING CONVENTIONS IN A PC

In the Windows world, drives can be identified by their names (such as "Windows7_OS") and their drive letters (such as "C:"). The important thing to remember is that Windows really only cares about the drive letter. That has to be unique; you cannot have two drives labeled E: on the same computer.

The name, on the other hand, is just for convenience. Windows display it and let you edit it, but the OS does not use it when selecting which drive to access. That's why you can have two or more drives with the exact same name without confusing Windows.

Just for clarity, I'm using the word drive here to mean not a physical drive but a partition. Of course, if a physical drive has only one partition, it's effectively the same thing.

The drive letter plays an important role in telling Windows where to look. A file in C:\Users probably is not also in D:\Users. The drive letter standard, with the colon (:), dates back to before DOS.

By default, in Windows (and in DOS before it), the boot drive is C:. Other drives, whether they're internal, external, optical, or additional partitions, get other letters, usually in the order they were assigned: D:, E:, and so on.

What about drives A: and B? Their absence is a historical relic. Those letters were originally set aside for floppy drives.

Changing a drive letter can cause problems. For instance, if you've got a shortcut that points to a program installed on E:\, and you change drive E: to F:, the shortcut will not work.

Check Your Progress

Fill in the blanks:

1. _____ time, also known as response time or latency, refers to how quickly the memory can respond to a read or write request.
2. _____ time refers to the minimum period between two successive requests.
3. Mass storage is distinct from _____, which refers to temporary storage areas within the computer.
4. A gigabyte (GB) is a measure of memory space equal to 1024 _____.
5. An EPROM can be erased and reprogrammed repeatedly. It can be erased by simply exposing it to a strong source of _____ light for a certain amount of time.
6. A _____ is the device used to store large amounts of digital information in computers and related equipment like iPods and games consoles such as the Xbox 360 and PS3.

6.15 LET US SUM UP

- Storage devices are the data storage devices that are used in the computers to store the data. The computer has many types of data storage devices. Some of them can be classified as the removable data storage devices and the others as the non-removable data storage devices.
- According to volatility, memory is classified in two categories: Non-volatile Memory and Volatile Memory
- According to accessibility, memory is classified in two categories: Random Access and Sequential Access.
- The memory is of two types: Main Memory and Secondary Memory
- Computer memories are internal storage areas in the computer used to either temporarily or permanently store data or instructions to be processed.
- There are four basic types of computer memory: Cache Memory, RAM, Virtual Memory and Hard Drives.

- A basic memory unit provides the ability to store and access a fixed number of bits. Each bit within such a unit may be selected individually for reading and writing. Usually only one bit in a given memory unit may be accessed at a time.
- There are two principal ways to assign memory units to the address space: Bank Addressing and Interleaving.
- A content-addressable memory, abbreviated CAM and known also as associative memory, provides an automatic parallel search capability.
- It has the ability to check the contents of all its locations at the same time to identify those which match a particular pattern. Each location in such a memory includes its own circuits to compare patterns.
- Other types of operations that may be possible on associative memories include: Count Matches, Masked Write, Multi-write, Store, Address Operations and Tag Operations.
- Memory on computers is measured in bits, bytes, words, pages, sectors, megabytes and gigabytes, among other units of measure.
- There are two types of random access memory, which are as follows: Static RAM (SRAM) and Dynamic RAM (DRAM).
- There are different types of ROMs, which are as follows: Masked ROM, Programmable ROM (PROM), Erasable Programmable ROM (EPROM), Electrically Erasable Programmable ROM (EEPROM) and Flash ROM.
- The secondary memory is used to store the data permanently in the computer. Secondary memory is the slowest and cheapest form of memory. It cannot be processed directly by the CPU. It must first be copied into primary storage.
- Secondary memory devices include magnetic disks like hard drives and floppy disks; optical disks such as CDs and CDROMs; and magnetic tapes, which were the first forms of secondary memory.
- Magnetic Disk is Flat, circular platter with metallic coating that is rotated beneath read/write heads. It is a random access device; read/write head can be moved to any location on the platter.
- Floppy disks are made of round plastic disks located with magnetic oxide particles. Floppy disks come in 3 sizes: 8 inch, 5½ inch and 3½ inch. All disk sizes can never be single-sided or double-sided.
- A hard disk drive is the device used to store large amounts of digital information in computers and related equipment like iPods and games consoles such as the Xbox 360 and PS3. Hard disk drives are used to store operating systems, software and working data.
- Almost all computers used a fixed hard disc. Used for on-line and real time processes requiring direct access. Used in file servers for computer networks to store large amount of data.
- Optical media can be read only (such as commercial software, music or movie disks), write-one, or rewritable, and currently exists in one of three basic formats. These are Compact Disk (CD), Digital Versatile Disk (DVD) and Blu-Ray Disk (BD). A fourth format called High-Definition DVD (HD DVD) is not used now.
- It is worth noting for completeness that HD DVD was the contender to Blu-Ray Disk to replace DVD as the next generation optical storage media for both computer data storage and domestic video use.

- HD DVD disks had a 15GB capacity (lower than Blu-Ray disk at 25 or 50GB, and not that much higher than dual layer DVD-R DL or DVD+R DL disks at 8.5GB).
- Mass Storage Devices refers to various techniques and devices for storing large amounts of data. The earliest storage devices were punched paper cards, which were used as early as 1804 to control silk-weaving looms.
- The main types of mass storage are: Floppy disks, Hard disks, Optical disks and Tapes.

6.16 UNIT END ACTIVITY

Make a list of characteristics of CD, DVD, VCD and CD-ROM.

6.17 KEYWORDS

Address Operations: Determine the coordinate address of a tagged word, or read or write by address.

Byte: A byte is eight bits and can hold a value from 0 to 255 (2 to the 8th power, less 1). Bit stands for binary digit, or a number place that can have only two values: 0 or 1.

Count Matches: This operation indicates how many tag bits are set. Often the possible answers are restricted to zero, one, or many. It is more difficult to provide an exact count if there is more than one match.

Floppy Disks: Relatively slow and have a small capacity, but they are portable, inexpensive and universal.

Gigabyte: A gigabyte (GB) is a measure of memory space equal to 1024 megabytes or 1,073,741,824 bytes.

Half-word: The half-word is a unit of storage on PA-RISC machines, equal to 16-bits or half of a 32-bit Word.

Hard Disks: Very fast and with more capacity than floppy disks, but also more expensive. Some hard disk systems are portable (removable cartridges), but most are not.

Kilobyte: A kilobyte (KB) is 1024 bytes, or 2 to the 10th power.

Masked Write: Write data from the data register into only the bits selected by the mask register (in the tagged word). Other bits remain unchanged.

Megabyte: A megabyte (MB) is a memory space measures equal to 1,048,576 bytes (1024 times 1024), or 2 to the 20th power. A megabyte is equal to 4,096 MPE sectors.

Multi-write: Write data into all tagged words at the same time.

Non-volatile Memory: Will retain the stored information even if it is not constantly supplied with electric power. It is suitable for long-term storage of information.

Optical Disks: Unlike floppy and hard disks, which use electromagnetism to encode data, optical disk systems use a laser to read and write data. Optical disks have very large storage capacity, but they are not as fast as hard disks.

Page: The address space of the PA-RISC machines is divided into units of 2048 bytes, called pages.

Sector: Sectors are an archaic measure of disc space sometimes used on MPE.

Store: Write a data word into any empty location, rather than a selected one.

Tag Operation: Set, clear or read a tag register, or copy among multiple tag registers.

Tapes: Relatively inexpensive and can have very large storage capacities, but they do not permit random access of data.

Volatile Memory: Requires constant power to maintain the stored information. Since primary storage is required to be very fast, it predominantly uses volatile memory.

Word: The word is the basic unit for accessing computer storage on a particular machine, usually the size of each instruction and the size of the data value which is most efficiently processed.

6.18 QUESTIONS FOR DISCUSSION

1. What do you mean by memory and storage devices? Classify the memory according to volatility and accessibility.
2. What is a primary memory? What are the types of primary memories?
3. Explain the storage evaluation criteria. Explain all about secondary storage devices.
4. Explain the memory organization with suitable diagram. What are the addressing strategies of memory?
5. What are the two principal ways to assign memory units to the address space? Explain the content-addressable memories.
6. What are the types of operations associated with memories? How to measure memory on computers?
7. What is a random access memory? What are the types of random access memory?
8. Explain the working of magnetic disk, floppy and hard disk.
9. Explain all about the Optical Disks CD-ROM like Compact Disk (CD), Digital Versatile Disk (DVD) and Blu-Ray Disk (BD).
10. What do you mean by the mass storage devices?
11. What are the main types of mass storage? Explain the differences between the primary and secondary memory.

Check Your Progress: Model Answer

1. Access
2. Memory Cycle
3. Memory
4. Megabytes
5. Ultraviolet (UV)
6. Hard disk

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BLOCK-III

UNIT- 7

BASIS OF SOFTWARE

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7.0 AIMS AND OBJECTIVES

After studying this lesson, you should be able to:

- Know about the concept of software
- Explain the needs of software
- Describe system software
- Analyse application software

- Learn about the advantages and disadvantages of open-source software
- Explain the benefits and features of IDEs

7.1 INTRODUCTION

Software, in its most general sense, is a set of instructions or programs instructing a computer to do specific tasks. Software is a generic term used to describe computer programs. Scripts, applications, programs and a set of instructions are the terms often used to describe software. System software serves as a base for application software. System software includes device drivers, Operating Systems (OSs), compilers, disk formatters, text editors and utilities helping the computer to operate more efficiently. It is also responsible for managing hardware components and providing basic non-task specific functions. The system software is usually written in C programming language. On the other hand, application software is intended to perform certain tasks. In this lesson, we will discuss basis of software, types of software, open-source software and Integrated Development Environment (IDE).

7.2 WHAT DOES SOFTWARE STAND FOR?

Software is a set of programs, which is designed to perform a well-defined function. A program is a sequence of instructions written to solve a particular problem.

Computer software is a program that tells a computer what to do. These instructions might be internal commands, such as updating the system clock, or a response to external input received from the keyboard or mouse. Though there are many different types of software made both with open source and proprietary standards, the programming mostly comes down to a few basic rules.

7.2.1 How Software Works?

Hardware only understands the two basic concepts, on and off, which are represented as 1s and 0s in binary language. Software acts as the translator between human languages and binary, which makes it possible for the hardware to understand the instructions being fed into it. Programmers write commands called source code in programming languages that are similar to what someone might use in everyday speech. Another program called a compiler is then used to transform the source code commands into binary. The result is an executable computer program.

7.3 NEEDS OF SOFTWARE

Business in today's world need dedicated software for successful operation and growth. The easiest and most convenient way is to use project management software with online collaboration. There are various types of software to help in the business needs.

Accounting software helps in easing the financial issues and the accounting team does not get overburdened with the issues related to accounts and finances of the company. It helps the company to record and process basic accounting transactions. It also helps to manage financial relationships with different companies or customers. Over the time, it becomes a vast database storing all the important financial information and managing it becomes very easy with the dedicated accounting software.

The business can be linked to the emails of hundreds of potential clients via business management software platforms. There are many hosting companies that provide dedicated email and website domains which help in managing the client's emails and notifying them whenever needed.

Business software helps with documentation management as documents let the world know about you, your work and how do you do it. Text documents, tabular sheets, business plans, presentations are some of the examples of the types of documents. Word processing and managing software has evolved as major business software over the years.

CRM (Customer Relationship Management), as the name suggests, helps a firm to keep a track of the customers and the relationship with them. It is very helpful software when it comes to large number of clients as it not only helps to keep an eye on the number of clients that a firm has, but it also helps in managing the appointments with them. Also, it reminds about the follow ups even when the professional relationship has ended to see if your valuable (former) customers are interested for any further projects.

7.4 TYPES OF SOFTWARE

There are two types of software:

1. System Software
2. Application Software

7.4.1 System Software

The system software is a collection of programs designed to operate, control and extend the processing capabilities of the computer itself. System software is generally prepared by the computer manufacturers. These software products comprise of programs written in low-level languages, which interact with the hardware at a very basic level. System software serves as the interface between the hardware and the end users.

Some examples of system software are Operating System, Compilers, Interpreter, Assemblers, etc.



Figure 7.1: System Software

System software includes:

- ***Operating Systems:*** These are essential collections of software that manage resources and provides common services for other software that runs "on top" of them. Supervisory programs, boot loaders, shells and window systems are core parts of operating systems. In practice, an operating system comes bundled with additional software (including application software) so that a user can potentially do some work with a computer that only has one operating system.
- ***Device Drivers:*** This software operates or controls a particular type of device that is attached to a computer. Each device needs at least one corresponding device driver; because a computer typically has at least one input device and at least one output device but needs more than one device driver.

- **Utilities:** These are computer programs designed to assist users for the maintenance and care of their computers.

Here is a list of some of the most prominent features of system software:

- Close to the system
- Fast in speed
- Difficult to design
- Difficult to understand
- Less interactive
- Smaller in size
- Difficult to manipulate
- Generally written in low-level language

7.4.2 Application Software

Application software products are designed to satisfy a particular need of a particular environment. All software applications prepared in the computer lab can come under the category of application software.

Application software may consist of a single program, such as Microsoft's notepad for writing and editing a simple text. It may also consist of a collection of programs, often called a software package, which work together to accomplish a task, such as a spreadsheet package.

Examples of application software are the following:

- Payroll Software
- Student Record Software
- Inventory Management Software
- Income Tax Software
- Railways Reservation Software
- Microsoft Office Suite Software
- Microsoft Word
- Microsoft Excel
- Microsoft PowerPoint



Figure 7.2: Application Software

The features of application software are as follows:

- Close to the user
- Easy to design

- More interactive
- Slow in speed
- Generally written in high-level language
- Easy to understand
- Easy to manipulate and use
- Bigger in size and requires large storage space

7.4.3 Other Types of Software

There are many different types of software, which can be a little confusing for the uninitiated. Let's discuss a brief definition of each type, and the differences between them here.

- **Programming Software:** This is a set of tools to aid the developers to write programs. The various tools available are compilers, linkers, debuggers, interpreters and text editors.
- **Retail software:** This type is sold off the shelves of retail stores. It includes expensive packaging designed to catch the eye of shoppers and, as such, is generally more expensive. An advantage of retail software is that it comes with printed manuals and installation instructions, missing in hard-copy form from virtually every other category. However, when hard-copy manuals and instructions are not required, a download version of the Internet will be less expensive, if available.
- **OEM software:** OEM stands for "original equipment manufacturer" and refers to software that is sold to computer builders and hardware manufacturers (OEMs) in large quantities, for the purpose of bundling with computer hardware. For example, Microsoft has contracts with various companies including Dell Computers, Toshiba, Gateway and others. Microsoft sells its operating systems as OEM software at a reduced price, minus retail packaging, manuals and installation instructions. Resellers install the operating system before systems are sold and the OEM CD is supplied to the buyer. The "manual" consists of the Help menu built into the program itself. OEM software is not legal to buy unbundled from its original hardware system.
- **Shareware:** This software is downloadable from the Internet. Licenses differ, but commonly the user is allowed to try the program for free, for a period stipulated in the license, usually thirty days. At the end of the trial period, it must be purchased or uninstalled. Some shareware incorporates an internal clock that disables the program after the trial period unless a serial number is supplied. Other shareware designs continue to work with "nag" screens, encouraging the user to purchase the program.
- **Crippleware:** This software is similar to shareware except that key features will cease to work after the trial period has ended. For example, the "save" function, the print function, or some other vital feature necessary to use the program effectively may become unusable. This "cripples" the program. Other types of crippleware incorporate crippled functions throughout the trial period. A purchase is necessary to unlock the crippled features.
- **Demo software:** Demo software is not intended to be a functioning program, though it may allow partial functioning. It is mainly designed to demonstrate what a purchased version is capable of doing, and often works more like an automated tutorial. If a person wants to use the program, they must buy a fully functioning version.

- **Adware:** This is free software supported by advertisements built into the program itself. Some adware requires a live Internet feed and uses constant bandwidth to upload new advertisements. The user must view these ads in the interface of the program. Disabling the ads is against the license agreement. Adware is not particularly popular.
- **Spyware:** Spyware is normally free, but can be shareware. It clandestinely "phones home" and sends data back to the creator of the spyware, most often without the user's knowledge. For example, a multimedia player might profile what music and video files the program is called upon to play. This information can be stored with a unique identification tag associated with the specific program on a user's machine, mapping a one-to-one relationship. The concept of spyware is very unpopular, and many programs that use spyware protocols were forced to disclose this to users and offer a means to turn off reporting functions. Other spyware programs divulge the protocols in their licenses, and make acceptance of the spyware feature a condition of agreement for using the software.
- **Freeware:** Freeware is also downloadable off the Internet and free of charge. Often freeware is only free for personal use, while commercial use requires a paid license. Freeware does not contain spyware or adware. If it is found to contain either of these, it is reclassified as such.
- **Public domain software:** This is free software, but unlike freeware, it does not have a specific copyright owner or license restrictions. It is the only type that can be legally modified by the user for his or her own purposes.

People are encouraged to read licenses carefully when installing software, as they vary widely.

7.5 OPEN-SOURCE SOFTWARE

The term "open source" refers to something people can modify and share because its design is publicly accessible.

Open-source Software (OSS) is the computer software with its source code made available with a license in which the copyright holder provides the rights to study, change, and distribute the software to anyone and for any purpose. Open-source software may be developed in a collaborative public manner. According to scientists who studied it, open-source software is a prominent example of open collaboration.

7.5.1 Open-source Software Development

Development Model

In his 1997 essay *The Cathedral and the Bazaar*, open-source evangelist Eric S. Raymond suggests a model for developing OSS known as the bazaar model. Raymond likens the development of software by traditional methodologies to building a cathedral, "carefully crafted by individual wizards or small bands of mages working in splendid isolation". He suggests that all software should be developed using the bazaar style, which he described as "a great babbling bazaar of differing agendas and approaches."

In the traditional model of development, which he called the cathedral model; development takes place in a centralized way. Roles are clearly defined. Roles include people dedicated to designing (the architects), people responsible for managing the project, and people responsible for implementation. Traditional software engineering follows the cathedral model.

The bazaar model, however, is different. In this model, roles are not clearly defined. Gregorio Robles suggests that software developed using the bazaar model should exhibit the following patterns:

Users should be Treated as Co-developers

The users are treated like co-developers and so they should have access to the source code of the software. Furthermore, users are encouraged to submit additions to the software, code fixes for the software, bug reports, documentation, etc. Having more co-developers increases the rate at which the software evolves. Linus's law states, "Given enough eyeballs all bugs are shallow." This means that if many users view the source code, they will eventually find all bugs and suggest how to fix them. Note that some users have advanced programming skills, and furthermore, each user's machine provides an additional testing environment. This new testing environment offers that ability to find and fix a new bug.

Early Releases

The first version of the software should be released as early as possible so as to increase one's chances of finding co-developers early.

Frequent Integration

Code changes should be integrated (merged into a shared code base) as often as possible so as to avoid the overhead of fixing a large number of bugs at the end of the project life cycle.

Several Versions

There should be at least two versions of the software. There should be a buggy version with more features and a more stable version with fewer features. The buggy version (also called the development version) is for users who want the immediate use of the latest features, and are willing to accept the risk of using code that is not yet thoroughly tested. The users can then act as co-developers, reporting bugs and providing bug fixes.

High Modularization

The general structure of the software should be modular allowing for parallel development on independent components.

Dynamic Decision Making Structure

There is a need for a decision making structure, whether formal or informal, that makes strategic decisions depending on changing user requirements and other factors.

Data suggests, however, that OSS is not quite as democratic as the bazaar model suggests. An analysis of five billion bytes of free/open source code by 31,999 developers shows that 74% of the code was written by the most active 10% of authors. The average number of authors involved in a project was 5.1, with the median at 2.

7.5.2 Advantages and Disadvantages of Open-source Software

Open-source software is usually easier to obtain than proprietary software, often resulting in increased use. Additionally, the availability of an open source implementation of a standard can increase adoption of that standard. It has also helped to build developer loyalty as developers feel empowered and have a sense of ownership of the end product.

Moreover, lower costs of marketing and logistical services are needed for OSS. OSS also helps companies keep abreast of technology developments. It is a good tool to promote a company's image, including its commercial products. The OSS development approach has helped produce reliable, high quality software quickly and inexpensively.

Open source development offers the potential for a more flexible technology and quicker innovation. It is said to be more reliable since it typically has thousands of independent programmers testing and fixing bugs of the software. It is flexible because modular systems allow programmers to build custom interfaces, or add new abilities to it and it is innovative since open source programs are the product of collaboration among a large number of different programmers. The mix of divergent perspectives, corporate objectives, and personal goals speeds up innovation.

Moreover, free software can be developed in accord with purely technical requirements. It does not require thinking about commercial pressure that often degrades the quality of the software. Commercial pressures make traditional software developers pay more attention to customers' requirements than to security requirements, since such features are somewhat invisible to the customer.

It is sometimes said that the open source development process may not be well defined and the stages in the development process, such as system testing and documentation may be ignored. However, this is only true for small (mostly single programmer) projects. Larger, successful projects do define and enforce at least some rules as they need them to make the teamwork possible. In the most complex projects, these rules may be as strict as reviewing even minor change by two independent developers.

Not all OSS initiatives have been successful, for example SourceXchange and Eazel. Software experts and researchers who are not convinced by open source's ability to produce quality systems identify the unclear process, the late defect discovery and the lack of any empirical evidence as the most important problems (collected data concerning productivity and quality). It is also difficult to design a commercially sound business model around the open source paradigm. Consequently, only technical requirements may be satisfied and not the ones of the market. In terms of security, open source may allow hackers to know about the weaknesses or loopholes of the software more easily than closed-source software. It depends on control mechanisms in order to create effective performance of autonomous agents who participate in virtual organizations.

7.5.3 Why do People Prefer using Open-source Software?

People prefer open-source software to proprietary software for a number of reasons, including:

Control: Many people prefer open source software because they have more control over that kind of software. They can examine the code to make sure it's not doing anything they don't want it to do, and they can change parts of it they don't like. Users who aren't programmers also benefit from open source software, because they can use this software for any purpose they wish—not merely the way someone else thinks they should.

Training: Other people like open source software because it helps them become better programmers. Because open source code is publicly accessible, students can easily study it as they learn to make better software. Students can also share their work with others, inviting comment and critique, as they develop their skills. When people discover mistakes in programs' source code, they can share those mistakes with others to help them avoid making those same mistakes themselves.

Security: Some people prefer open source software because they consider it more secure and stable than proprietary software. Because anyone can view and modify open source software, someone might spot and correct errors or omissions that a program's original authors might have missed. And because so many programmers can work on a piece of open source software without asking for permission from original authors, they can fix, update and upgrade open source software more quickly than they can proprietary software.

Stability: Many users prefer open source software to proprietary software for important, long-term projects. Because programmers publicly distribute the source code for open source software, users relying on that software for critical tasks can be sure their tools won't disappear or fall into disrepair if their original creators stop working on them. Additionally, open source software tends to both incorporate and operate according to open standards.

7.6 INTEGRATED DEVELOPMENT ENVIRONMENT

An Integrated Development Environment (IDE) is a software suite that consolidates the basic tools developers need to write and test software. Typically, an IDE contains a code editor, a compiler or interpreter and a debugger that the developer accesses through a single Graphical User Interface (GUI). An IDE may be a standalone application, or it may be included as part of one or more existing and compatible applications.

7.6.1 History of IDEs

Before IDEs, developers wrote their programs in text editors. They would write and save an application in a text editor; then run the compiler, taking note of the error messages; then go back to the text editor to revise the code.

In 1983, Borland Ltd. acquired a Pascal compiler and released it as TurboPascal, which featured, for the first time, an integrated editor and compiler.

While TurboPascal launched the idea of an integrated development environment, many believe Microsoft's Visual Basic (VB), launched in 1991, was the first real IDE. Visual Basic was built on the older BASIC language, which was a popular programming language throughout the 1980s. With the emergence of Visual Basic, programming could be thought of in graphical terms, and significant productivity benefits emerged.

7.6.2 Features of IDEs

An IDE's toolbar looks much like a word processor's toolbar. The tools in the toolbar facilitate colour-coding, source-code formatting, error diagnostics, and reporting and intelligent code completion. The interface allows the developer to compile and execute code incrementally and manage changes to source code in a uniform manner. IDEs are typically designed to integrate with third-party version control libraries, like GitHub or Apache Subversion.

Increasingly, IDEs are being offered through a software-as-a-service (SaaS) delivery model. The benefits of cloud IDEs include accessibility to software development tools from anywhere in the world, from any compatible device; minimal to non-existent download and installation; and ease of collaboration among geographically dispersed developers. Popular IDE tools include NetBeans, Eclipse, IntelliJ, Visual Studio and Windows PowerShell.

Therefore, IDEs offer a central interface featuring all the tools a developer needs, including the following:

- **Code editor:** This feature is a text editor designed for writing and editing source code. Source code editors are distinguished from text editors because they enhance or simplify the writing and editing of code.
- **Compiler:** This tool transforms source code written in a human readable/writable language into a form executable by a computer.
- **Debugger:** This tool is used during testing to help debug application programs.
- **Build automation tools:** These tools automate common developer tasks.

In addition, some IDEs might also include the following:

- **Class browser:** This tool is used to examine and reference the properties of an object-oriented class hierarchy.
- **Object browser:** This feature is used to examine the objects instantiated in a running application program.
- **Class hierarchy diagram:** This tool allows the programmer to visualize the structure of object-oriented programming code.

The IDE may be a stand-alone application or may be included as part of one or more compatible applications.

7.6.3 Benefits of IDEs

The overall goal and main benefit of an integrated development environment is improved developer productivity. IDEs boost productivity by reducing setup time, increasing the speed of development tasks, keeping developers up to date and standardizing the development process.

- **Faster setup:** Without an IDE interface, developers would need to spend time configuring multiple development tools. With the application integration of an IDE, developers have the same set of capabilities in one place, without the need for constantly switching tools.
- **Faster development tasks:** Tighter integration of all development tasks improves developer productivity. For example, code can be parsed and syntax checked while being edited, providing instant feedback when syntax errors are introduced. Developers don't need to switch between applications to complete tasks. In addition, the IDE's tools and features help developers organize resources, prevent mistakes and take shortcuts.

Further, IDEs streamline development by encouraging holistic thinking. They force developers to think of their actions in terms of the entire development lifecycle, rather than as a series of discrete tasks.

- **Continual learning:** Staying up to date and educated is another benefit. For instance, the IDE's help topics are constantly being updated, as well as new samples, project templates, etc. Programmers who are continually learning and current with best practices are more likely to contribute value to the team and the enterprise, and to boost productivity.
- **Standardization:** The IDE interface standardizes the development process, which helps developers work together more smoothly and helps new hires get up to speed more quickly.

7.6.4 Languages Supported by IDEs

Some IDEs are dedicated to a specific programming language or set of languages, creating a feature set that aligns with the particulars of that language. For instance, Xcode for the Objective-C and Swift languages, Cocoa and Cocoa Touch APIs.

However, there are many multiple-language IDEs, such as Eclipse (C, C++, Python, Perl, PHP, Java, Ruby and more), Komodo (Perl, Python, TCL, PHP, Ruby, JavaScript and more) and NetBeans (Java, JavaScript, PHP, Python, Ruby, C, C++ and more).

Support for alternative languages is often provided by plugins. For example, Flycheck is a syntax checking extension for GNU Emacs 24 with support for 39 languages.

7.6.5 Different Types of IDEs

There are a variety of different IDEs, catering to the many different ways developers work and the different types of code they produce. There are IDEs that are designed to work with one specific language, cloud-based IDEs, IDEs customized for the development of mobile applications or for HTML, and IDEs meant specifically for Apple development or Microsoft development.

Multi-Language IDEs

Multi-language IDEs, such as Eclipse, NetBeans, Komodo, Aptana and Geany, support multiple programming languages.

- **Eclipse:** Supports C, C++, Python, Perl, PHP, Java, Ruby and more. This free and open source editor is the model for many development frameworks. Eclipse began as a Java development environment and has expanded through plugins. Eclipse is managed and directed by the Eclipse.org Consortium.
- **NetBeans:** Supports Java, JavaScript, PHP, Python, Ruby, C, C++ and more. This option is also free and open source. All the functions of the IDE are provided by modules that each provide a well-defined function. Support for other programming languages can be added by installing additional modules.
- **Komodo IDE:** Supports Perl, Python, Tcl, PHP, Ruby, Javascript and more. This enterprise-level tool has a higher price point.
- **Aptana:** Supports HTML, CSS, JavaScript, AJAX and others via plugins. This is a popular choice for web app development.
- **Geany:** Supports C, Java, PHP, HTML, Python, Perl, Pascal and many more. This is a highly customizable environment with a large set of plugins.

IDEs for Mobile Development

There are IDEs specifically for mobile development, including PhoneGap and Appcelerator's Titanium Mobile.

Many IDEs, especially those that are multi-language, have mobile-development plugins. For instance, Eclipse has this functionality.

HTML IDEs

Some of the most popular IDEs are those for developing HTML applications. For example, IDEs such as HomeSite, DreamWeaver or FrontPage automate many tasks involved in web site development.

Cloud-Based IDEs

Cloud-based IDEs are starting to become mainstream. The capabilities of these web-based IDEs are increasing rapidly, and most major vendors will likely need to offer one to be competitive. Cloud IDEs give developers access to their code from anywhere. For example, Nitrous is a cloud-based development environment platform that supports Ruby, Python, Node.js and more. Cloud9 IDE supports more than 40 languages, including PHP, Ruby, Python, JavaScript with Node JS, and Go. Heroku is a cloud-based development platform as a service (PaaS), supporting several programming languages.

IDEs Specific to Microsoft or Apple

These IDEs cater to those working in Microsoft or Apple environments:

- **Visual Studio:** Supports Visual C++, VB.NET, C#, F# and others. Visual Studio is Microsoft's IDE and is designed to create applications for the Microsoft platform.
- **MonoDevelop:** Supports C/C++, Visual Basic, C# and other .NET languages.
- **Xcode:** Supports the Objective-C and Swift languages, and Cocoa and Cocoa Touch APIs. This IDE is just for creating iOS and Mac applications and includes an iPhone/iPad simulator and GUI builder.
- **Espresso:** Supports HTML, CSS, XML, JavaScript and PHP. This is a tool for Mac web developers.
- **Coda:** Supports PHP, JavaScript, CSS, HTML, AppleScript and Cocoa API. Coda bills itself as "one-window development" for the Mac user.

IDEs for Specific Languages

Some IDEs cater to developers working in a single language. These include CodeLite and C-Free for C/C++, Jikes and Jcreator for Java, Idle for Python and RubyMine for Ruby/Rails.

Check Your Progress

Fill in the blanks:

1. _____ may consist of a single program, such as Microsoft's notepad for writing and editing a simple text.
2. Supervisory programs, boot loaders, shells and window systems are core parts of _____.
3. _____ is normally free, but can be shareware. It clandestinely "phones home" and sends data back to the creator of the spyware, most often without the user's knowledge.
4. _____ is generally prepared by the computer manufacturers.
5. _____ may be developed in a collaborative public manner.
6. _____ supports Java, JavaScript, PHP, Python, Ruby, C, C++ and more. This option is also free and open source.

7.7 LET US SUM UP

- Software is a set of programs, which is designed to perform a well-defined function. A program is a sequence of instructions written to solve a particular problem.
- Hardware only understands the two basic concepts, on and off, which are represented as 1s and 0s in binary language. Software acts as the translator between human languages and binary, which makes it possible for the hardware to understand the instructions being fed into it.
- Accounting software helps in easing the financial issues and the accounting team does not get over burdened with the issues related to accounts and finances of the company.
- Business software helps with documentation management as documents let the world know about you, your work and how do you do it. Text documents, tabular sheets, business plans, presentations are some of the examples of the types of documents.
- The system software is a collection of programs designed to operate, control, and extend the processing capabilities of the computer itself.
- Application software products are designed to satisfy a particular need of a particular environment. All software applications prepared in the computer lab can come under the category of Application software.
- OEM stands for “Original Equipment Manufacturer” and refers to that sold in bulk to resellers, designed to be bundled with hardware.
- Demo software is not intended to be a functioning program, though it may allow partial functioning.
- Spyware is normally free, but can be shareware. It clandestinely “phones home” and sends data back to the creator of the spyware, most often without the user’s knowledge.
- Open-source Software (OSS) is computer software with its source code made available with a license in which the copyright holder provides the rights to study, change, and distribute the software to anyone and for any purpose.
- Typically, an IDE contains a code editor, a compiler or interpreter and a debugger that the developer accesses through a single Graphical User Interface (GUI).

7.8 UNIT END ACTIVITY

Make a list of examples of system software and application software. What are the use of word processors or video games and ERP software for groups of users?

7.9 KEYWORDS

Application Software: These are designed to satisfy a particular need of a particular environment.

Freeware: It is also downloadable off the Internet and free of charge.

Integrated Development Environment (IDE): It is a software suite that consolidates the basic tools developers need to write and test software.

OEM Software: OEM stands for “Original Equipment Manufacturer” and refers to that sold in bulk to resellers, designed to be bundled with hardware.

Programming Software: This is a set of tools to aid the developers to write programs.

Shareware: This software is downloadable from the Internet. Licenses differ, but commonly the user is allowed to try the program for free, for a period stipulated in the license, usually thirty days.

System Software: It is a collection of programs designed to operate, control, and extend the processing capabilities of the computer itself.

7.10 QUESTIONS FOR DISCUSSION

1. What do you understand by software? How software works?
2. Discuss the needs of software in business world.
3. What is system software? Make a list of system software.
4. Discuss the roles of various business application software's, in computerizing the different departments of an organization.
5. What are the most prominent features of system software?
6. Explain the features of application software. Make a list of application software.
7. Make a note on the programming software and spyware.
8. Explain open-source software development in brief.
9. What are the advantages and disadvantages of open-source software?
10. What are the history and features of IDEs? Explain the languages supported by IDEs.

Check Your Progress: Model Answer

1. Application software
2. Operating systems
3. Spyware
4. System software
5. Open-source software
6. NetBeans

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UNIT-8

OPERATING SYSTEM

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8.0 AIMS AND OBJECTIVES

After studying this lesson, you should be able to:

- Know about the concept of operating system
- List out the functions of operating system
- Define the booting process
- Learn about the types of reboot
- Discuss how to boot from different operating system
- Describe the types of operating system
- Explain some prominent operating systems

8.1 INTRODUCTION

An operating system is a layer of software which takes care of technical aspects of a computer's operation. It shields the user of the machine from the low-level details of the machine's operation and provides frequently needed facilities. There is no universal definition of what an operating system consists of. You can think of it, analyzing the software already installed on a machine, before adding anything of your own. In this lesson, we will discuss booting process, types of operating system and some prominent operating system.

8.2 CONCEPT OF OPERATING SYSTEM

An operating system (sometimes abbreviated as "OS") is the program that after being initially loaded into the computer by a boot program manages all the other programs in a computer. The other programs are called applications or application programs.

The application programs make use of the operating system by making requests for services through a defined Application Program Interface (API). In addition, users can interact directly with the operating system through a user interface such as a command language or a Graphical User Interface (GUI).

Formally, we can define OS as an intermediary between users and computer hardware. It provides users an environment in which a user can execute programs conveniently and efficiently.

In technical terms, it is the software which manages hardware. An operating system controls the allocation of resources and services such as memory, processors, devices and information.

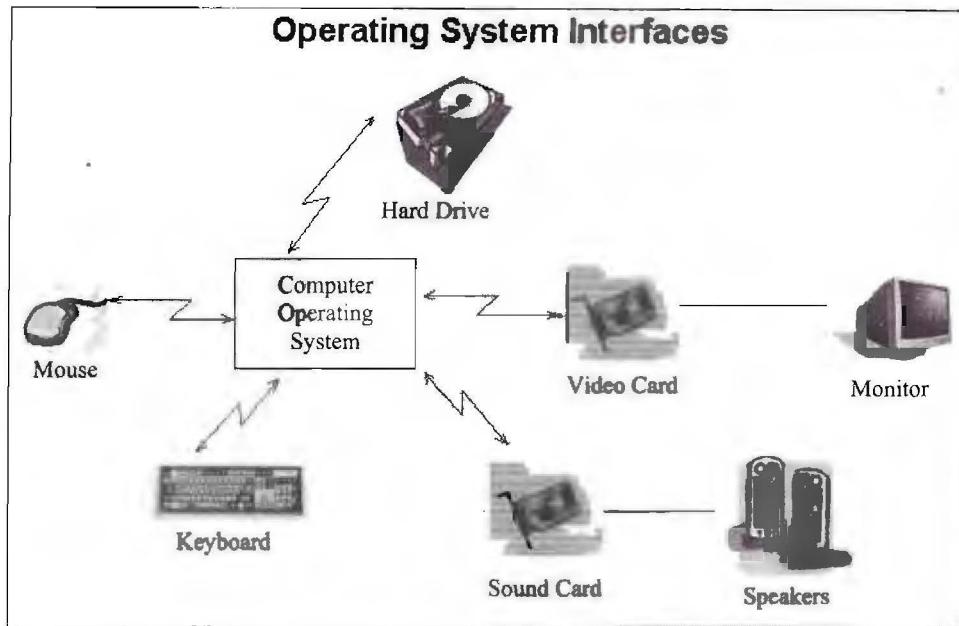


Figure 8.1: Operating System and System Components

8.2.1 Why an Operating System?

Normally, the operating system has a number of key elements:

1. A technical layer of software for driving the hardware of the computer, like disk drives, the keyboard and the screen;
2. A file system which provides a way of organizing files logically;
3. A simple command language which enables users to run their own programs and to manipulate their files in a simple way. Some operating systems also provide text editors, compilers, debuggers and a variety of other tools. Since the Operating System (OS) is in charge of a computer, all requests to use its resources and devices need to go through the operating system. An operating system therefore provides legal entry points into its code for performing basic operations like writing to devices.

8.2.2 Historical Background of Operating System

Early computers lacked any form of operating system. The user had sole use of the machine and would arrive armed with program and data, often on punched paper and tape. The program would be loaded into the machine, and the machine would be set to work until the program completed or crashed. Programs could generally be debugged via a front panel using switches and lights. It is said that Alan Turing was a master of this on the early Manchester Mark I machine, and he was already deriving the primitive conception of an operating system from the principles of the Universal Turing machine.

Later machines came with libraries of support code, which would be linked to the user's program to assist in operations such as input and output. This was the genesis of the modern-day operating system. However, machines still ran a single job at a time; at Cambridge University in England the job queue was at one time, a washing line from which tapes were hung with different coloured clothes-pegs to indicate job-priority.

As machines became more powerful, the time needed for a run of a program diminished and the time to hand off the equipment became very large by comparison.

Accounting for and paying for machine usage moved on from checking the wall clock to automatic logging by the computer. Run queues evolved from a literal queue of people at the door, to a heap of media on a jobs-waiting table, or batches of punch-cards stacked one on top of the other in the reader, until the machine itself was able to select and sequence which magnetic tape drives were online. Where program developers had originally had access to run their own jobs on the machine, they were supplanted by dedicated machine operators who looked after the well-being and maintenance of the machine and were less and less concerned with implementing tasks manually. When commercially available computer centers were faced with the implications of data lost through tampering or operational errors, equipment vendors were put under pressure to enhance the runtime libraries to prevent misuse of system resources. Automated monitoring was needed not just for CPU usage but for counting pages printed, cards punched, cards read, disk storage used and for signaling when operator intervention was required by jobs such as changing magnetic tapes. All these features were building up towards the repertoire of a fully capable operating system. Eventually, the runtime libraries became an amalgamated program that was started before the first customer job and could read in the customer job, control its execution, clean up after it, record its usage, and immediately go on to process the next job. Significantly, it became possible for programmers to use symbolic program-code instead of having to hand-encode binary images, once task-switching allowed a computer to perform translation of a program into binary form before running it. These resident background programs, capable of managing multistep processes, were often called monitors or monitor-programs before the term operating system established itself. Computer centers were faced with the implications of data lost through tampering or operational errors, equipment vendors were put under pressure to enhance the runtime libraries to prevent misuse of system resources. Automated monitoring was needed not just for CPU usage but for counting pages printed, cards punched, cards read, disk storage used and for signaling when operator intervention was required by jobs such as changing magnetic tapes.

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With the era of commercial computing, more and more "secondary" software was bundled in the operating system package, leading eventually to the perception of an operating system as a complete user-system with utilities, applications (such as text editors and file managers) and configuration tools, and having an integrated graphical user interface. The true descendant of the early operating systems is what we now call the "kernel". In technical and development circles, the old restricted sense of an operating system persists because of the continued active development of embedded operating systems for all kinds of devices with a data-processing component, from hand-held gadgets up to industrial robots and real-time control-systems, which do not run user-applications at the front-end. An embedded operating system in a device today is not so far removed as one might think from its ancestor of the 1950s.

8.3 FUNCTIONS OF OPERATING SYSTEM

An operating system performs these general services:

- Management of programs in a multitasking operating system where multiple programs can run simultaneously. The operating system determines which applications should run in what order and how much time should be allowed for each application before giving another application a turn.
- **Memory Management:** It manages the sharing of internal memory among multiple applications.
- **Device Management:** It handles input and output to and from attached hardware devices, such as hard disks, printers and dial-up ports.
- **Coordination between other software and users:** It sends messages to each application or interactive user (or to a system operator) about the status of operation and any errors that may have occurred.
- **Job accounting:** It can offload the management of what are called batch jobs (for example, printing) so that the initiating application is freed from this work.
- **Management of programs in parallel processing computer:** An operating system can manage how to divide the program so that it runs on more than one processor at a time.

Apart from the above there are few more important functions of operating system such as:

- Error detecting aids
- File management
- Disk management
- Device management
- Security
- Control over system performance

8.4 THE BOOTING PROCESS

The boot process of a modern system involves multiple phases. Here we will discuss each step, how it contributes to the boot process, what can go wrong and things you can do to diagnose problems during booting.

The heart of a modern computer is one or more Central Processing Units. A CPU gets its instructions from memory. The CPU reads instruction from the BIOS and searches for the hard disks, CD drives and other hardware. The BIOS program looks at the first sector for boot code. Devices that feed the initial CPU instructions are known as bootstrap media.

The booting is a process involving two stages:

1. Getting hardware up and running, and
2. Getting the OS and other software up and running

8.4.1 Booting a Computer

- Power up; computer runs POST
- Boot sequence governed by BIOS ROM

- ❖ BIOS parameters stored in CMOS
- ❖ BIOS ROM may be password protected
- Control passes to the MBR of the first bootable device detected
- MBR points to boot record of selected operating system
- Operating system takes control

The following components are involved in the boot process. They are each executed in this order:

- Power Supply Unit
- BIOS and CMOS
- POST Tests
- Reading the Partition Table
- The Boot-loader
- The Kernel and the Ramdisk
- OS Kernel and Init
- Runlevels
- Getty

Power Supply Unit

When the power button is pressed, an electric circuit is closed which causes the power supply unit to perform a self-test. In order for the boot process to continue, this self-test has to be completed successfully. If the power supply cannot confirm the self-test, there will be no output at all.

Most modern x86 computers, especially those using the ATX standard, will have two main connectors to the motherboard: a 4-pin connector to power the CPU, and a 24-pin connector to power other motherboard components. If the self-test passes successfully, the PSU will send a signal to the CPU on the 4-pin connector to indicate that it should power on.

Possible Failures

If the PSU is unable to perform a good self-test, the PSU may be damaged. This could be caused by a blown fuse, or other damage caused by over-/under-current on the power line. Using a UPS or a good surge protector is always recommended.

BIOS and CMOS

At its core, the Basic Input/Output System (*BIOS*) is an integrated circuit located on the computer's motherboard that can be programmed with firmware. This firmware facilitates the boot process so that an operating system can load.

Let's examine each of these in more detail:

- Firmware is the software that is programmed into Electrically Erasable Programmable Read-Only Memory (EEPROM). In this case, the firmware facilitates booting an operating system and configuring basic hardware settings.
- An integrated circuit (IC) is what you would likely think of as a stereotypical "computer chip" - a thin wafer that is packaged and has metal traces sticking out from it that can be mounted onto a printed circuit board.

Your BIOS is the lowest level interface you will get to the hardware in your computer. The BIOS also performs the Power-On Self Test, or POST.

Once the CPU has powered up, the first call made is to the BIOS. The first step then taken by the BIOS is to ensure that the minimum required hardware exists:

- CPU
- Memory
- Video card

Once the existence of the hardware has been confirmed, it must be configured.

The BIOS has its own memory storage known as the CMOS (Complementary Metal Oxide Semiconductor). The CMOS contains all of the settings the BIOS needs to save, such as the memory speed, CPU frequency multiplier, and the location and configuration of the hard drives and other devices.

The BIOS first takes the memory frequency and attempts to set that on the memory controller.

Next the BIOS multiply the memory frequency by the CPU frequency multiplier. This is the speed at which the CPU is set to run. Sometimes it is possible to “overclock” a CPU, by telling it to run at a higher multiplier than it was designed to, effectively making it run faster. There can be benefits and risks to doing this, including the potential for damaging your CPU.

POST Tests

Once the memory and CPU frequencies have been set, the BIOS begins the Power-On Self Test (POST). The POST will perform basic checks on many system components, including:

- Check that the memory is working
- Check that hard drives and other devices are all responding
- Check that the keyboard and mouse are connected (this check can usually be disabled)
- Initialize any additional BIOS which may be installed (e.g., RAID cards)

Possible Failures

In the event that a POST test fails, the BIOS will normally indicate failure through a series of beeps on the internal computer speaker. The pattern of the beeps indicates which specific test failed. A few beep codes are common across systems:

- One beep: All tests passed successfully (Have you noticed that your computer beeps once when you press the power button? This is why!)
- Three beeps: Often a memory error
- One long, two short beeps: Video card or display problem

Your BIOS manual should document what its specific beep codes mean.

Reading the Partition Table

The next major function of the BIOS is to determine which device to use to start an operating system.

Typical BIOS can read boot information from the devices below, and will boot from the first device that provides a successful response. The order of devices to scan can be set in the BIOS:

- Floppy disks
- CD-ROMs
- USB flash drives
- Hard drives
- A network

We will cover the first four options here. There's another section that deals with booting over the network.

There are two separate partition table formats: Master Boot Record (MBR) and the GUID Partition Table (GPT). We will illustrate how both store data i.e., what's on the drive, and how they are used to boot the operating system.

Master Boot Record (The Old Way)

Once the BIOS have identified which drive it should attempt to boot from, it looks at the first sector on that drive. These sectors should contain the Master Boot Record.

The MBR has two component parts:

1. The boot loader information block (448 bytes)
2. The partition table (64 bytes)

The boot loader information block is found where the first program the computer can run is stored. The partition table stores information about how the drive is logically laid out.

The MBR has been heavily limited in its design, as it can only occupy the first 512 bytes of space on the drive (which is the size of one physical sector). This limits the tasks the boot loader program is able to do. The execution of the boot loader literally starts from the first byte. As the complexity of systems grew, it became necessary to add "chain boot loading". This allows the MBR to load another program from elsewhere on the drive into memory. The new program is then executed and continues the boot process.

If you are familiar with Windows, you may have seen drives labelled as "C:" and "D:" these represent different logical "partitions" on the drive. These represent partitions defined in that 64-byte partition table.

GPT - The GUID Partition Table (The New Way)

The design of the IBM-Compatible BIOS is an old design and has limitations in today's world of hardware. To address this, the Unified Extensible Firmware Interface (UEFI) was created, along with GPT, a new partition format.

There are a few advantages to the GPT format, specifically:

- A Globally-Unique ID that references a partition, rather than a partition number. The MBR only has 64 bytes to store partition information and each partition definition is 16 bytes. This design allows for unlimited partitions.
- The ability to boot from storage devices that are greater than 2 TBs, due to a larger address space to identify sectors on the disk. The MBR simply had no way to address disks greater than 2 TB.

- A backup copy of the table that can be used in the event that the primary copy is corrupted. This copy is stored at the ‘end’ of the disk.

There is some compatibility maintained to allow standard PCs that are using old BIOS to boot from a drive that has a GPT on it.

The Bootloader

The purpose of a bootloader is to load the initial kernel and supporting modules into memory.

There are a few common bootloaders. We will discuss the GRand Unified Bootloader (GRUB), a bootloader used by many Linux distributions today.

sGRUB is a “chain bootloader,” meaning it initializes itself in stages. These stages are:

- ***Stage 1*** - This is the very tiny application that can exist in that first part of the drive. It exists to load the next, larger part of GRUB.
- ***Stage 1.5*** - Contains the drivers necessary to access the file-system with stage 2.
- ***Stage 2*** - This stage loads the menu and configuration options for GRUB.

On an MBR-formatted Drive and Standard BIOS

These stages must fit in that first 448 bytes of the boot loader information block table. Generally, Stage 1 and Stage 1.5 are small enough to exist in that first 448 bytes. They contain the appropriate logic that allows the loader to read the filesystem that Stage 2 is located on.

On a GPT-formatted Drive and UEFI

UEFI motherboards are able to read FAT32 file systems and execute code. The system firmware looks for an image file that contains the boot code for Stages 1 and 1.5, so that Stage 2 can be managed by the operating system.

The Kernel and the Ramdisk

The kernel is the main component of any operating system. The kernel acts as the lowest-level intermediary between the hardware on your computer and the applications running on your computer. The kernel abstracts away such resource management tasks as memory and processor allocation.

The kernel and other software can access peripherals such as disk drives by way of device drivers.

So what, then, is this Initial RAM Filesystem, or Ramdisk?

You can imagine there are tens of thousands of different devices in the world. Hard drives made with different connectors, video cards made by different manufacturers, network cards with special interfaces. Each of these needs its own device driver to bridge the hardware and software.

For our small and efficient little boot process, trying to keep every possible device driver in the kernel would not work very well.

This lead to the creation of the Initial RAM disk as a way to provide module support to the kernel for the boot process. It allows the kernel to load just enough drivers to read from the filesystem, where it can find other specific device drivers as needed.

With the kernel and ramdisk loaded into memory, we can attempt to access the disk drive and continue booting our Linux system.

OS Kernel and Init

The organizational scheme for determining the load order for system services during the boot process is referred to as an init system. The traditional and still most common init system in Linux is called “System V init”.

After the initial ramdisk sets the stage for the kernel to access the hard drive, we now need to execute the first process that will essentially “rule them all” - /bin/init .

The init process reads /etc/inittab to figure out what script should be run to initialize the system. This is a collection of scripts that is based on the desired “runlevel” of the system.

Runlevels

Various runlevels have been defined to bring the system up in different states. In general, the following runlevels are consistent in most Linux distributions:

- 0: Halt the system
- 1: Single User Mode
- 6: Reboot the machine

Across distributions there can be various meanings for runlevels 2-5. RedHat-based distributions use runlevel 3 for a multiuser console environment and 5 for a graphical-based environment.

Multiuser vs. Single User Runlevels

As the name implies, in some runlevels multiple users can use the machine, versus one user in single user mode. So why does single user mode exist, anyways?

In multiuser runlevels, the system boots as normal. All standard services such as SSH and HTTP daemons load in the order defined in the init system. The network interfaces, if configured, are enabled. It’s business as usual if you are booting to a multiuser runlevel.

Conversely, single user mode has the bare minimum of services enabled (notably there is no networking enabled), making it useful for troubleshooting (and not much else).

You will need (or involuntarily find yourself in) single user mode when something breaks: something you configured interferes with the boot process and you need to turn it off, or perhaps a key filesystem is corrupt and you need to run a disk check.

In single user mode, the only available access is via the console, although that need not be limited to physical presence. Remote console access by way of serial consoles and similar devices is a common management tool for data centers.

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Getty is often used to continuously spawn /bin/login, which reads the username and password of the user and, if authentication succeeds, spawn the user’s preferred shell. At this point, the boot and login process has completed.

8.5 TYPES OF REBOOT

Rebooting a computer through the menu option or the keystroke combination is sometimes referred to as a warm boot, perhaps because it is gentler than the alternative cold boot (simply pressing the computer’s power button once to turn it off and then again to turn it back on).

Let us discuss different types of reboot in this section.

8.5.1 Cold Boot

Cold boot is the process of starting a computer from shutdown or a powerless state and setting it to normal working condition. A cold boot refers to the general process of starting the hardware components of a computer, laptop or server to the point that its operating system and all startup applications and services are launched.

A cold boot is usually set in motion by pressing a computer's power button. A computer doing a cold boot is already in a shutdown state, wherein no hardware, software, network or peripheral operations are occurring. For the most part, a cold boot is done so that a computer is able to perform standard computing tasks (general use). However, sometimes cold boot is necessary after software and usually hardware troubleshooting.

For example, unlike a warm boot, cold boot flushes not only RAM contents but also clear the caches. This ensures that no traces or instances of conflicting programs or their data are left within the computer memory. Cold boot is also known as hard boot, cold start or dead start.

8.5.2 Warm Reboot

A warm reboot is the process of aborting and reloading the operating system when it is already in an operational or live mode. This closes current programs including the operating system and reinitiates the boot sequence until the operating system and all startup programs are reloaded.

A warm reboot is also known as a soft boot, warm boot or warm restart.

Warm reboot is primarily used in scenarios where it's essential to restart the computer to restore its normal working operations, resolve program errors, or initiate changes in an installed application. Typically, a warm boot is performed by pressing the CTRL-ALT-DEL key simultaneously within Windows OS or selecting the restart function from the Start menu. In warm a reboot, the computer reloads faster than the time it would take to revive it from cold or dead state.

8.5.3 Hard Reboot

A hard reboot means that the system is not shut down in an orderly manner, skipping file system synchronisation and other activities that would occur on an orderly shutdown. This can be achieved by either applying a reset, by cycling power, by issuing the halt-q command in most Unix-like systems, or by triggering a kernel panic.

8.6 BOOTING FROM DIFFERENT OPERATING SYSTEM

Most computers ship with a single operating system, but you can have multiple operating systems installed on a single PC. Having two operating systems installed—and choosing between them at boot time — is known as “dual-booting.”

Google and Microsoft ended Intel's plans for dual-boot Windows and Android PCs, but you can install Windows 8.1 alongside Windows 7, have both Linux and Windows on the same computer, or install Windows or Linux alongside Mac OS X.

8.6.1 How Dual-Boot Works?

Your computer's operating system is generally installed on its internal hard drive. When you boot your computer, the BIOS loads the boot loader from the hard drive and the boot loader boots the installed operating system.

There's no limit to the number of operating systems you installed — you are not just limited to a single one. You could put a second hard drive into your computer and install an operating system to it, choosing which hard drive to boot in your BIOS or boot menu. You could also boot an operating system — like a live Linux system or a Windows To Go USB drive — from external storage media.

Even if you only have a single hard drive, you can have multiple operating systems on that hard drive. By partitioning the drive into several different partitions, you can have one partition for one operating system and another partition for another operating system, splitting the drive between them. (In reality, many operating systems use multiple partitions. The point is you are devoting part of the drive to one operating system and part of the drive to another.)

When you install a Linux distribution, it typically installs the Grub boot loader. Grub loads instead of the Windows boot loader at boot time if Windows was already installed. That allows you to choose the operating system you want to boot. Windows also has its own boot loader, which can be used to select between different versions of Windows if you have more than one installed.

8.6.2 Switching between Operating Systems

If each operating system is installed to a separate drive, you could actually switch between both by selecting a different drive as your boot device every time you boot. This is inconvenient and you will probably have two operating systems installed on the same drive, so that's where a boot manager comes in.

Switch between your installed operating systems by rebooting your computer and selecting the installed operating system you want to use. If you have multiple operating systems installed, you should see a menu when you start your computer. This menu is typically set up when you install an additional operating system on your computer, so you will not see it if you just have Windows installed or just have Linux installed.

8.6.3 Setting up a Dual-Boot System

Setting up a dual-boot system is fairly easy. Here is a quick overview of what to expect:

- **Dual Boot Windows and Linux:** Install Windows first if there's no operating system installed on your PC. Create Linux installation media, boot into the Linux installer, and select the option to install Linux alongside Windows.
- **Dual Boot Windows and Another Windows:** Shrink your current Windows partition from inside Windows and create a new partition for the other version of Windows. Boot into the other Windows installer and select the partition you created.
- **Dual Boot Linux and Another Linux:** You should be able to dual-boot two Linux distributions by installing one first and then installing the other. Choose to install the new Linux system alongside your old Linux system. Resize your old Linux partitions in the installer and create new ones to make space if the installer will not do this automatically.
- **Dual Boot Mac OS X and Windows:** The Boot Camp utility included with Mac OS X allows you to easily set up a Windows dual-boot system on your Mac.
- **Dual Boot Mac OS X and Linux:** Boot Camp does not allow you to set up a dual-boot Linux system, so you will need to do a bit more footwork here.

You are not limited to just two operating systems on a single computer. If you wanted to, you could have three or more operating systems installed on your computer – you could have Windows, Mac OS X, and Linux all on the same computer. You are only restricted by the storage space available on your computer and the time you want to spend setting this up.

8.7 TYPES OF OPERATING SYSTEM

In this section, we are going to discuss few important types of operating systems.

8.7.1 Batch Processing Operating Systems

In a batch processing operating system, environment users submit jobs to a central place where these jobs are collected into a batch, and subsequently placed on an input queue at the computer where they will run.

In this case, the user has no interaction with the job during its processing, and the computer's response time is the turnaround time the time from submission of the job until execution is complete, and the results are ready for return to the person who submitted the job.

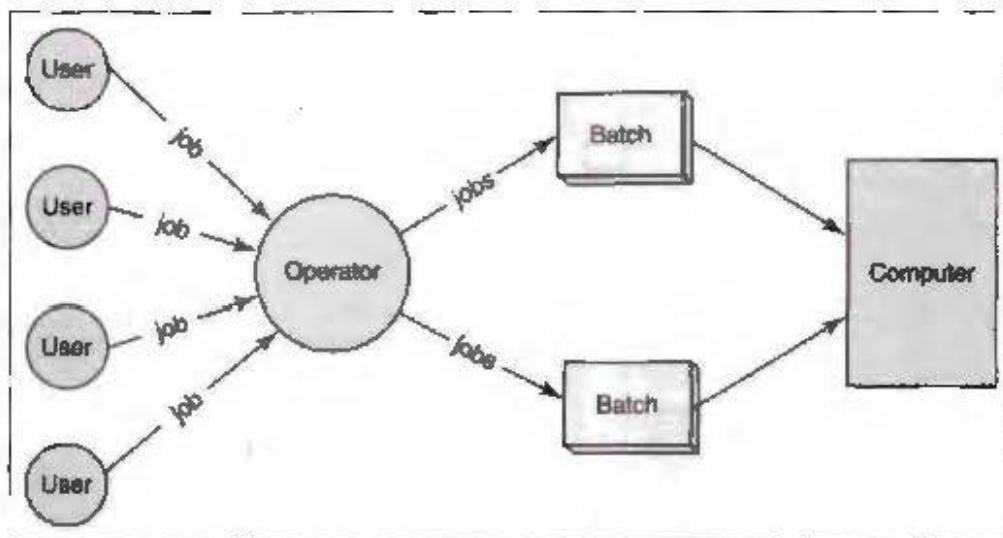


Figure 8.2: Batch Processing System

8.7.2 Time Sharing Operating Systems

Time sharing operating system provides computing services to several or many users concurrently online. Here, the various users are sharing the central processor, the memory, and other resources of the computer system in a manner facilitated, controlled, and monitored by the operating system. The user, in this environment, has nearly full interaction with the program during its execution, and the computer's response time may be expected to be no more than a few second.

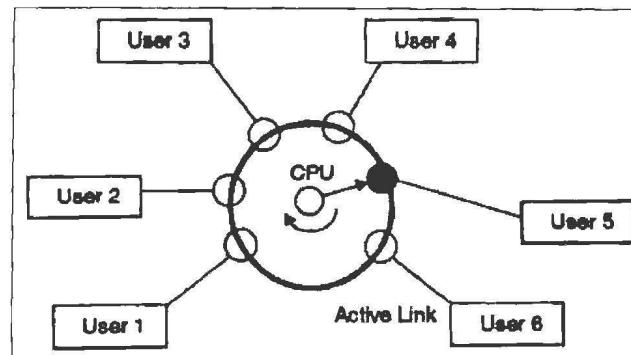


Figure 8.3: Concept of Time Sharing System

8.7.3 Mainframe Operating Systems

Through the 1960s, many major features were pioneered in the field of operating systems. The development of the IBM System/360 produced a family of mainframe computers available in widely differing capacities and price points, for which a single operating system OS/360 was planned (rather than developing ad-hoc programs for every individual model).

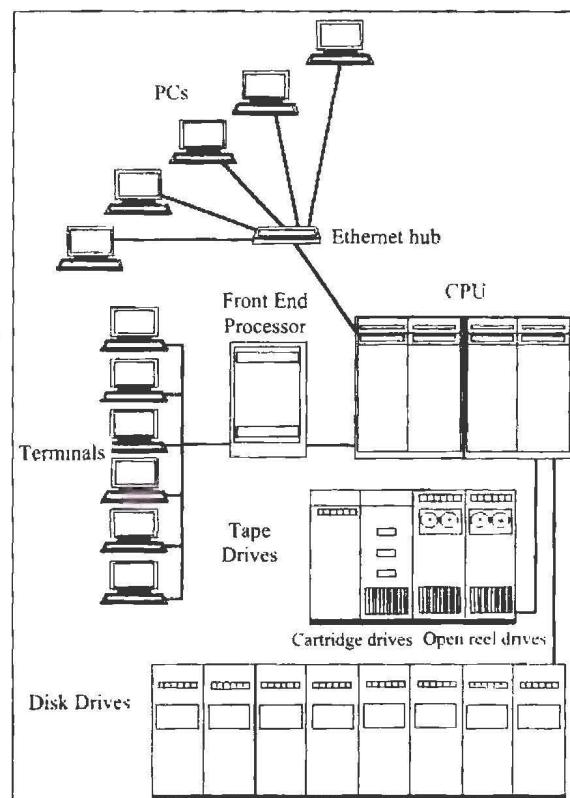


Figure 8.4: Diagrammatic Representation of Multiple Operating System

This concept of a single OS spanning an entire product line was crucial for the success of System/360 and, in fact, IBM's current mainframe operating systems are distant descendants of this original system; applications written for the OS/360 can still be run on modern machines. OS/360 also contained another important advance: the development of the hard disk permanent storage device (which IBM called DASD).

Another key development was the concept of time-sharing: the idea of sharing the resources of expensive computers amongst multiple computer users interacting in real time with the system. Time sharing allowed all of the users to have the illusion of

having exclusive access to the machine; the Multics (Multiplexed Information and Computing Service) timesharing system was the most famous of a number of new operating systems developed to take advantage of the concept.

8.7.4 Desktop Operating Systems

Modern desktop operating systems usually feature a Graphical User Interface (GUI) which uses a pointing device such as a mouse or stylus for input in addition to the keyboard. This is opposed to an older, but still popular, concept of Command Line Interface (CLI), where main user-to-OS communication happens via typing some strictly defined commands. Both models are centered around a “shell”, a program which accepts and processes commands from the user (e.g., clicking on a button, or a typed command at a prompt).

The choice of operating system may be dependent on the hardware architecture, specifically the CPU, with only Linux and BSD running on almost any CPU. Since the mid-1990s, the most commonly used operating systems have been the Microsoft Windows family, Linux, and other Unix-like operating systems, most notably Mac OS X. Mainframe computers and embedded systems use a variety of different operating systems, many with no direct connection to either Windows nor Unix. QNX and VxWorks are two common embedded operating systems, the latter being used in network infrastructure hardware equipment.

As computers have progressed and developed so have the types of operating systems. Below is a basic list of the different types of operating systems and a few examples of Operating Systems that fall into each of the categories. Many computer Operating Systems will fall into more than one of the below categories.

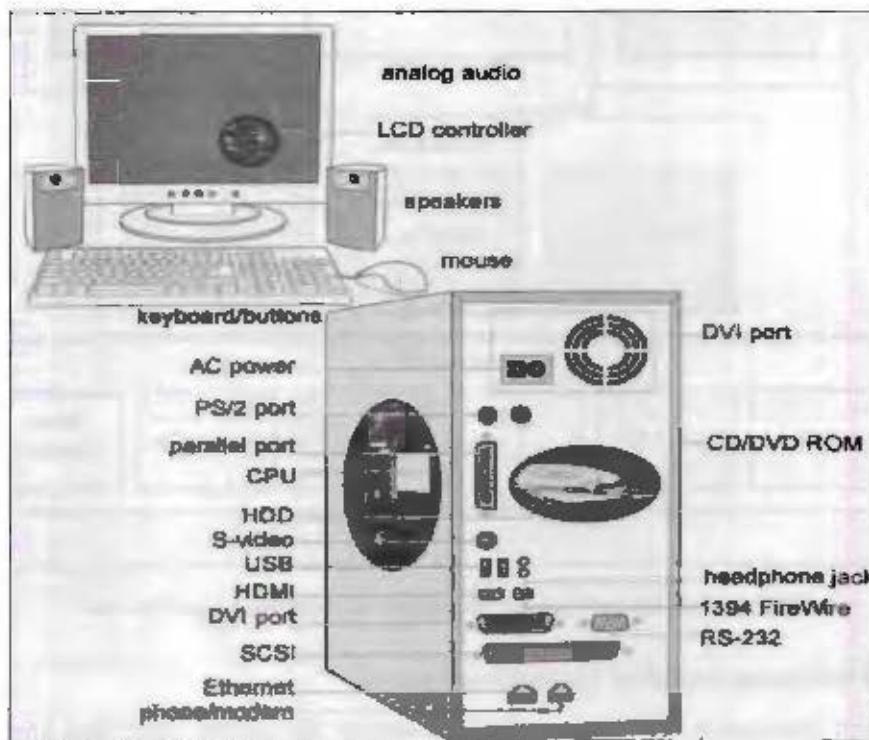


Figure 8.5: Desktop System

8.7.5 Multiprocessing Operating Systems

A multiprocessor system is simply a computer that has >1 & not ≤ 1 CPU on its motherboard. If the operating system is built to take advantage of this, it can run

different processes (or different threads belonging to the same process) on different CPUs.

Multiprocessing operating systems strive to make the most efficient use of a computer's resources. Most of this efficiency is gained by sharing the machine's resources among several tasks (multiprocessing). Such "large-grain" resource sharing is enabled by operating systems without any additional information from the applications or processes. All these processes can potentially execute concurrently, with the CPU (or CPUs) multiplexed among them. Newer operating systems provide mechanisms that enable applications to control and share machine resources at a finer grain, that is, at the threads level. Just as multiprocessing operating systems can perform more than one task concurrently by running more than a single process, a process can perform more than one task by running more than a single thread.

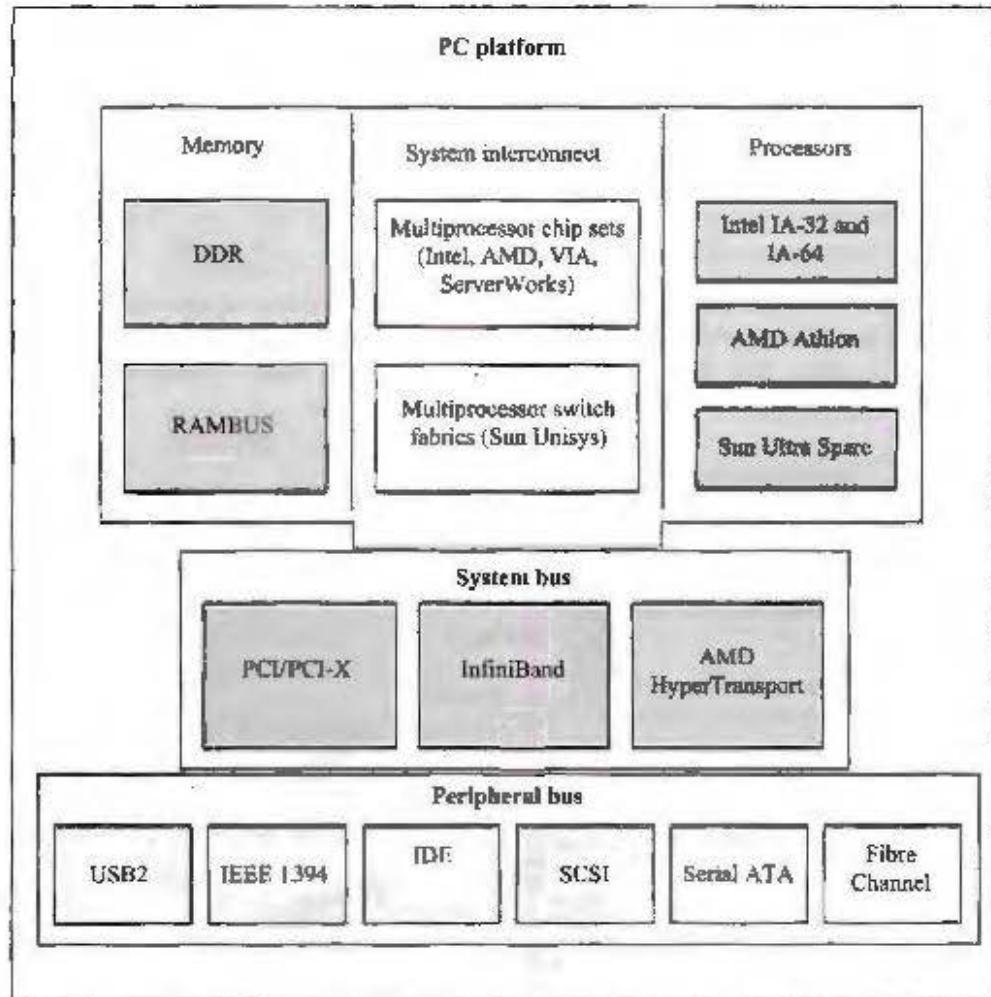


Figure 8.6: Diagrammatic Structure of Multiprocessor System

8.7.6 Multiprogramming Operating Systems

A multiprogramming operating system is a system that allows more than one active user program (or part of user program) to be stored in main memory simultaneously. Thus, it is evident that a time-sharing system is a multiprogramming system, but note that a multiprogramming system is not necessarily a time-sharing system. A batch or real time operating system could, and indeed usually does, have more than one active user program simultaneously in main storage. Another important, and all too similar, term is "multiprocessing".

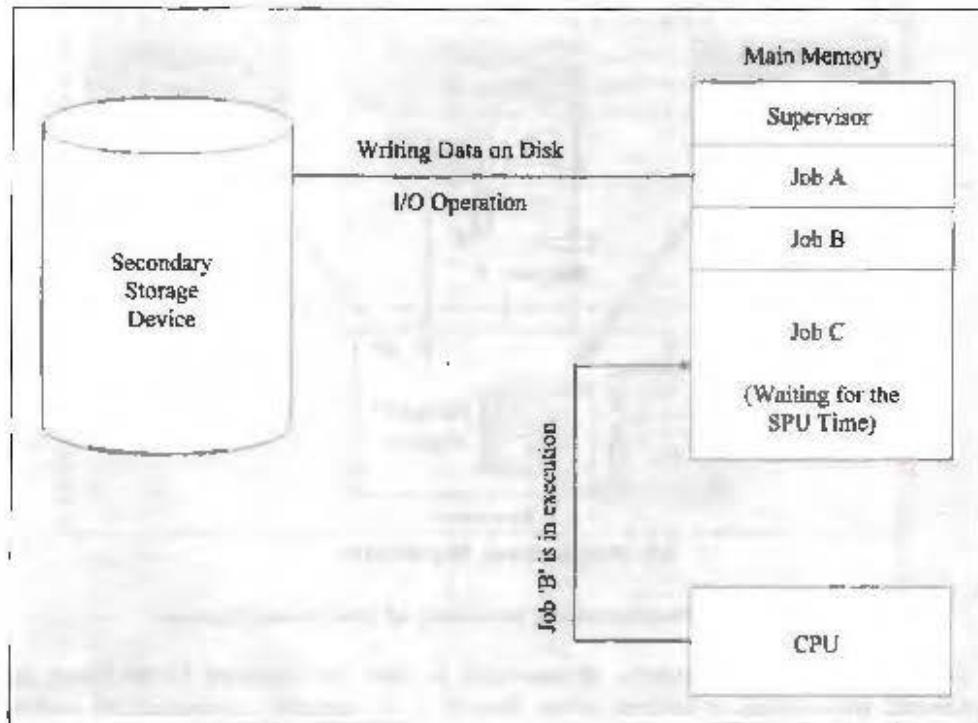


Figure 8.7: Diagrammatic Structure of Multiprogramming System

8.7.7 Distributed Operating Systems

A distributed system is a computer system in which the resources resides in separate units connected by a network, but which presents to the user a uniform computing environment. It is more than simply a network; a distributed system uses a design principle the fact that the system resources such as processors, disk storage, printers etc., exist in separate nodes of a computer network, but all of these resources can be utilized transparently by the user.

In distributed computing different parts of a program are run simultaneously on two or more computers that are communicating with each other over a network. Distributed computing is a type of segmented or parallel computing, but the latter term is most commonly used to refer to processing in which different parts of a program run simultaneously on two or more processors that are part of the same computer. While both types of processing require that a program be segmented-divided into sections that can run simultaneously, distributed computing also requires that the division of the program take into account the different environments on which the different sections of the program will be running.

Example: Two computers are likely to have different file systems and different hardware components.

Distributed computing is a natural result of using networks to enable computers to communicate efficiently. But distributed computing is distinct from computer networking or fragmented computing. The latter refers to two or more computers interacting with each other, but not, typically, sharing the processing of a single program. The World Wide Web is an example of a network, but not an example of distributed computing.

There are numerous technologies and standards used to construct distributed computations, including some which are specially designed and optimized for that purpose, such as Remote Procedure Calls (RPC) or Remote Method Invocation (RMI) or .NET Remoting.

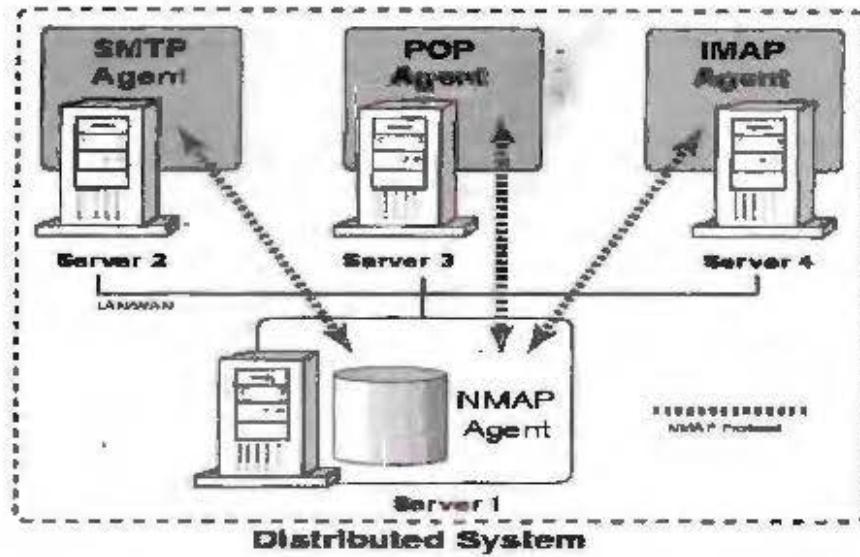


Figure 8.8: Diagrammatic Structure of Distributed System

A distributed operating system, in contrast, is one that appears to its users as a traditional uni-processor system, even though it is actually composed of multiple processors. In a true distributed system, users should not be aware of where their programs are being run or where their files are located; that should all be handled automatically and efficiently by the operating system.

True distributed operating systems require more than just adding a little code to a uniprocessor operating system, because distributed and centralized systems differ in critical ways. Distributed systems, for example, often allow program to run on several processors at the same time, thus requiring more complex processor scheduling algorithms in order to optimize the amount of parallelism achieved.

8.7.8 Clustered Systems

A clustered system is a group of loosely coupled computers that work together closely so that in many respects they can be viewed as though they are a single computer. The components of a cluster are commonly, but not always, connected to each other through fast local area networks. Clusters are usually deployed to improve performance and/or availability over that provided by a single computer, while typically being much more cost-effective than single computers of comparable speed or availability.

Clustering has been the driving force behind many of the world's most powerful scientific supercomputers for many years and is now being used increasingly as a cost-effective way to provide high-performance, high availability computing for a wide variety of commercial workloads such as business intelligence, engineering design, financial analysis, digital media and petroleum exploration.

Clustering is the practice of connecting multiple processors or servers to cooperate on complex workloads as a single, unified computing resource. Because it behaves like a single large resource, a clustered system offers many valuable benefits to a modern e-business environment.

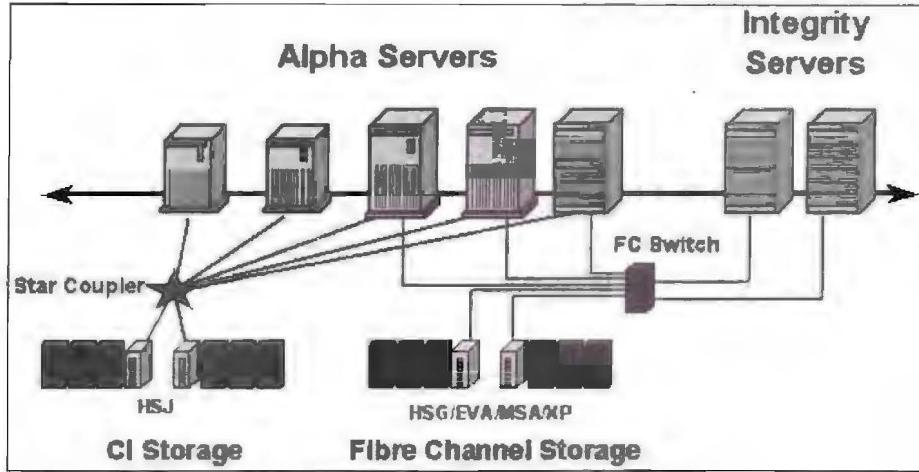


Figure 8.9: Diagram of Clustered System

8.7.9 Real Time Operating Systems

A Real-time Operating System (RTOS) is a multitasking operating system intended for real-time applications. Such applications include embedded systems (programmable thermostats, household appliance controllers, mobile telephones), industrial robots, spacecraft, industrial control and scientific research equipment.

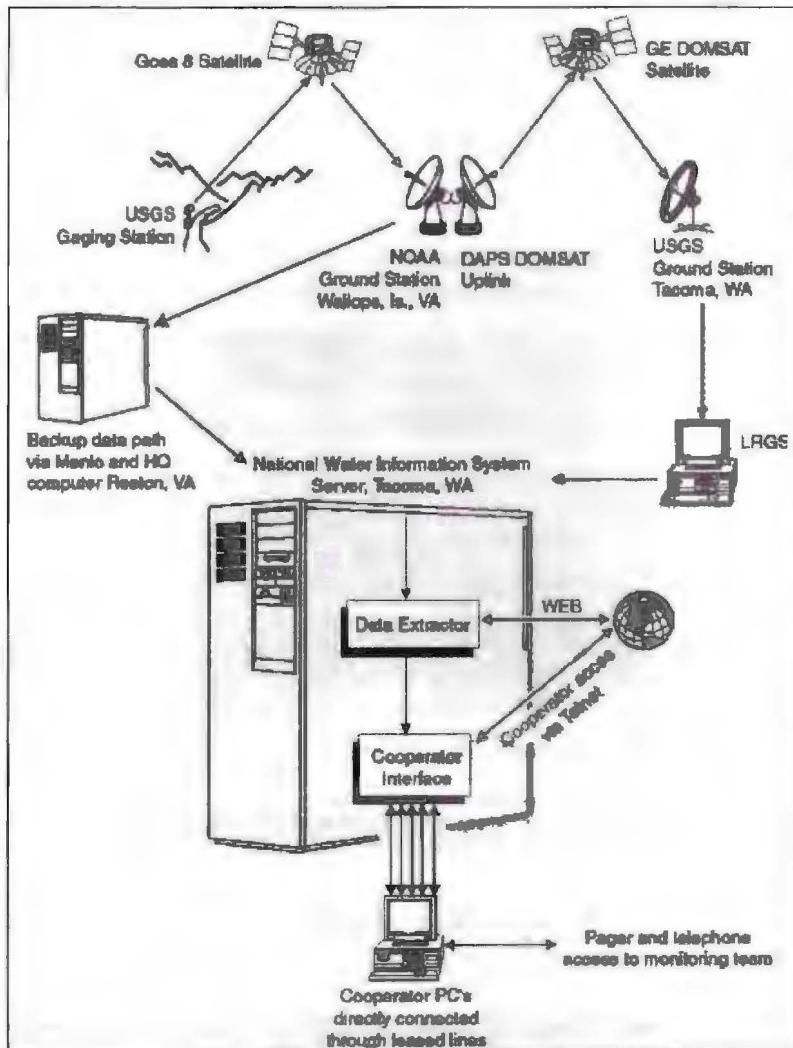


Figure 8.10: Diagram of Real Time System

An RTOS facilitates the creation of a real-time system, but does not guarantee the final result will be real-time; this requires correct development of the software. An RTOS does not necessarily have high throughput; rather, an RTOS provides facilities which, if used properly, guarantee deadlines can be met generally (soft real-time) or deterministically (hard real-time). An RTOS will typically use specialized scheduling algorithms in order to provide the real-time developer with the tools necessary to produce deterministic behaviour in the final system. An RTOS is valued more for how quickly and/or predictably it can respond to a particular event than for the given amount of work it can perform over time. Key factors in an RTOS are therefore, minimal interrupt latency and a minimal thread switching latency.

An early example of a large-scale real-time operating system was the so-called “control program” developed by American Airlines and IBM for the Sabre Airline Reservations System.

8.7.10 Operating Systems for Embedded Devices

As embedded systems (PDAs, cellphones, point-of-sale devices, VCR's, industrial robot control, or even your toaster) become more complex hardware-wise with every generation, and more features are put into them day-by-day, applications they run require more and more to run on actual operating system code in order to keep the development time reasonable. Some of the popular OS are:

- Nexus's Conix - an embedded operating system for ARM processors.
- Sun's Java OS - a standalone virtual machine not running on top of any other OS; mainly targeted at embedded systems.
- Palm Computing's Palm OS - Currently the leader OS for PDAs, has many applications and supporting companies.
- Microsoft's Windows CE and Windows NT Embedded OS.

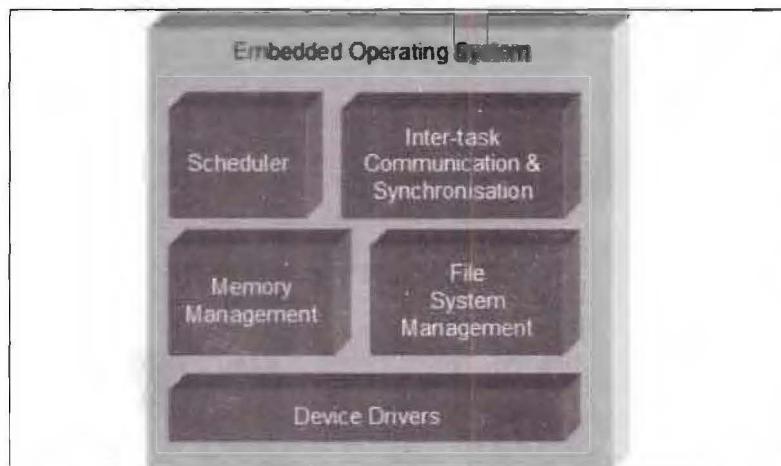


Figure 8.11: Diagrammatic Structure of Multiprogramming System

8.8 SOME PROMINENT OPERATING SYSTEMS

The operating system is the computer's most important piece of software. It manages the hardware resources, determines which programs are compatible with the system and executes those programs when the user decides to run them. Its influence on the nuts and bolts of computer operation makes it a major determining factor when it comes to the user's experience. A given operating system has not only its own functionality, but a unique look and feel that creates a specific environment. Each of

the world's major operating systems has its own passionate following, prompting endless debate on which is superior, and for what. Learning about them in the face of this shifting competitive landscape requires understanding certain basic principles.

8.8.1 Ubuntu

Ubuntu is based on a version of the Linux operating system known as Debian GNU/Linux. Its main benefit is that it's free and open source. This means users can alter the code as they see fit. Ubuntu also stands out because it is updated once in every six months, unlike other open source programs those have no strict upgrade schedule. Most Ubuntu-compatible software is also free and available in on-line software "repositories." Users can try Ubuntu on their PC using the program's "Live CD" mode. This allows you to run the system without actually installing it on your computer. Because Ubuntu programs are less ubiquitous than those for more well-known systems, users may need to do some research before finding the software solutions they need.

8.8.2 Android

Android is a "mobile" operating system maintained by the Open Handset Alliance, a group of companies and organizations that contribute to the system's development under the management of Google Inc. The system is an "open standard," meaning that an entire community of developers can alter the software, not just Google. Android comes pre-installed on smartphones and tablet PCs for which it was designed. As of the date of publication, all four major smartphone carriers – Verizon, T-Mobile, Sprint and AT&T – have Android devices available. A variety of manufacturers also make Android-compatible devices. One of the main benefits of the system's open source status is that developers can create different versions of its basic programs, allowing users greater freedom to customize their mobile devices.

8.8.3 Mac OS X

While a version of Mac OS X comes pre-installed on all Apple Macintosh computers, users must pay if they wish to use newer versions when they become available. The system is not open source, so only Apple developers have the ability to legitimately make alterations or improvements to its code. It differs from other computer operating systems in that it only works on Apple computers. Its key feature is its usability. The most recent version as of the date of publication includes a "resume" feature that re-opens applications in the same state they were in when you last closed them. It also includes a "Mission Control" feature, which allows you to see all of your open files at a glance.

8.8.4 IOS

IOS is Apple's mobile operating system. It runs on the company's iPod, iPhone and iPad devices. Like Mac OS X, it can only be used on Apple's mobile devices. One advantage of iOS is that more applications are available for it than for any other mobile operating system. As of summer 2011, it has approximately 400,000 to Android's 300,000. This increases the chances that users will find the type of app they are looking for. The system's key features include multitasking support, which allows users to run multiple apps simultaneously, and Face Time, a video chat program that comes pre-installed on iOS devices.

8.8.5 Windows

Windows is an operating system owned and operated by Microsoft. It differs from open source systems in that only Microsoft has the ability to make changes to the

code. However, it also differs from Mac OS X in that it can be installed on a variety of different computers from a host of competing manufacturers, offering the user more freedom of choice when it comes to hardware. According to Net Market Share, Windows is the most widely used operating system. The latest version as of the date of publication includes touchscreen support, which combines the usability of a touchscreen tablet with the power of a desktop computer. It also features "Play To" and "Remote Media Streaming," which allow you to play media from your computer on other devices in its vicinity and to access your media when you are away from your computer.

Check Your Progress

Fill in the blanks:

1. _____ handles input and output to and from attached hardware devices, such as hard disks, printers and dial-up ports.
2. The CPU reads instruction from the _____ and searches for the hard disks, CD drives and other hardware.
3. The Basic Input/Output System (BIOS) is an integrated circuit located on the computer's _____ that can be programmed with firmware.
4. The _____ acts as the lowest-level intermediary between the hardware on your computer and the applications running on your computer.
5. _____ is based on a version of the Linux operating system known as Debian GNU/Linux.

8.9 LET US SUM UP

- In technical terms, it is software which manages hardware. An operating system controls the allocation of resources and services such as memory, processors, devices and information.
- An operating system therefore provides legal entry points into its code for performing basic operations like writing to devices.
- Early computers lacked any form of operating system. The user had sole use of the machine and would arrive armed with program and data, often on punched paper and tape.
- Management of programs in a multitasking operating system where multiple programs can be running at the same time. The operating system determines which applications should run in what order and how much time should be allowed for each application before giving another application a turn.
- The boot process of a modern system involves multiple phases.
- When the power button is pressed, an electric circuit is closed which causes the power supply unit to perform a self test.
- In the event that a POST test fails, the BIOS will normally indicate failure through a series of beeps on the internal computer speaker.
- The purpose of a bootloader is to load the initial kernel and supporting modules into memory.
- The kernel is the main component of any operating system. The kernel acts as the lowest-level intermediary between the hardware on your computer and the applications running on your computer.

- Rebooting a computer through the menu option or the keystroke combination is sometimes referred to as a warm boot, perhaps because it is gentler than the alternative cold boot (simply pressing the computer's power button once to turn it off and then again to turn it back on).
- A hard reboot means that the system is not shut down in an orderly manner, skipping file system synchronisation and other activities that would occur on an orderly shutdown.
- In a batch processing operating system, environment users submit jobs to a central place where these jobs are collected into a batch, and subsequently placed on an input queue at the computer where they will be run.
- Time sharing operating system provides computing services to several or many users concurrently online.
- Modern desktop operating systems usually feature a Graphical User Interface (GUI) which uses a pointing device such as a mouse or stylus for input in addition to the keyboard.
- Multiprocessing operating systems strive to make the most efficient use of a computer's resources.
- A multiprogramming operating system is a system that allows more than one active user program (or part of user program) to be stored in main memory simultaneously.
- A distributed system is a computer system in which the resources resides in separate units connected by a network, but which presents to the user a uniform computing environment.
- A clustered system is a group of loosely coupled computers that work together closely so that in many respects they can be viewed as though they are a single computer.
- A Real-time Operating System (RTOS) is a multitasking operating system intended for real-time applications.
- Some prominent operating systems are Ubuntu, Android, Mac OS X, iOS and Windows.

8.10 UNIT END ACTIVITY

Write the differences between the multiprocessor operating system and distributed operating system.

8.11 KEYWORDS

Android: It is a "mobile" operating system maintained by the Open Handset Alliance, a group of companies and organizations that contribute to the system's development under the management of Google Inc.

Basic Input/Output System (BIOS): It is an integrated circuit located on the computer's motherboard that can be programmed with firmware.

Booting: Start (a computer) and put it into a state of readiness for operation.

Firmware: It is the software that is programmed into Electrically Erasable Programmable Read-Only Memory (EEPROM).

iOS: It is Apple's mobile operating system. It runs on the company's iPod, iPhone and iPad devices.

Multics: It is an influential early time-sharing operating system, based around the concept of a single-level memory.

Operating System: The low-level software that supports a computer's basic functions, such as scheduling tasks and controlling peripherals.

Ubuntu: It is based on a version of the Linux operating system known as Debian GNU/Linux.

Windows: It is an operating system owned and operated by Microsoft. It differs from open source systems in that only Microsoft has the ability to make changes to the code.

8.12 QUESTIONS FOR DISCUSSION

1. What is the historical background of operating system?
2. What do you understand by an operating system?
3. What are the main functions of operating system?
4. Describe how to boot from different operating system?
5. How dual-booting works?
6. What are the main components involved in the boot process? Examine each of these components in detail.
7. What are the different types of reboot? Differentiate cold reboot and warm reboot.
8. Explain switching between operating systems and how to set up a dual-boot system.
9. What are the different types of operating system? Explain in brief.
10. Describe the mainframe operating systems and desktop operating systems.

Check Your Progress: Model Answer

1. Device Management
2. BIOS
3. Motherboard
4. Kernel
5. Ubuntu

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DISK OPERATING SYSTEM (DOS)

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9.0 AIMS AND OBJECTIVES

After studying this lesson, you should be able to:

- Know about the concept of DOS
- Elaborate the history of DOS
- List out the examples of Disk Operating Systems
- Learn about the features of DOS
- Discuss the functions of DOS
- List out the versions of DOS
- Analyse the DOS commands
- Explain important internal commands of DOS
- Describe important external commands of DOS
- Discuss executable vs. non-executable files in DOS

9.1 INTRODUCTION

Today, most computer users are only familiar with how to navigate Microsoft Windows using the mouse. Unlike Windows, MS-DOS is a command-line and is navigated by using MS-DOS commands. For example, if you wanted to see all the files in a folder in Windows you would double-click the folder to open the folder in Windows Explorer. In MS-DOS, to view that same folder you would navigate to the folder using the `cd` command and then list the files in that folder using the `dir` command.

9.2 WHAT IS DOS?

DOS stands for Disk Operating System. It is used for abstraction and management of secondary storage devices of the computers and the information stored there.

9.2.1 History of DOS

In early days of computers, there were no disk drives; instead magnetic tapes, punched cards etc., were used. After creation of hard disks and floppy disks, the need of software for managing rapid access to block storage of sequential and other data became inevitable. So, DOS was developed.

9.2.2 Examples of Disk Operating Systems

- DOS/360 for IBM system/360 family of Mainframe computers.
- DOS for DEC PDP-II Minicomputers. The best known family of operating systems named DOS was running on IBM PC's type hardware using the INTEL CPU's or alike. The original was 86-DOS, which later became MS-DOS when Microsoft bought the license and rights.

9.2.3 Features of DOS

The primitive operating system of DOS has the following features:

- It is the primary system where the user will get an environment about the input and output devices, e.g., Monitor, Keyboard, Printers, etc.
- It is helpful in performing file management e.g., creating, editing, deleting files, etc.
- It is a single user operating system. One user can operate at one time in this operating system.
- It is Character Based interface system. We can type letters (or characters in this operating system).

9.3 FUNCTIONS OF DOS

MS-DOS (Microsoft Disk Operating System) is a single-user, single-tasking computer operating system that uses a command line interface. In spite of its very small size and relative simplicity, it is one of the most successful operating systems that have been developed to date.

The functions of DOS are as follows:

- To manage disk files.
- To allocate system resources according to the requirement.
- To provide features essential to control hardware devices such as Keyboard, Screen, Disk Devices, Printers, Modems and programs.

- It takes commands from the keyboard and interprets them.
- It shows all the files in the system.
- It creates new files and allot space for programme.
- It changes the name of a file in place of old name.
- It copies information in a floppy.
- It helps in locating a file.
- It searches where the file is located in the disk.
- If you want the information in the file to be printed, it gives printout of the information.
- It hides the files and directories so as not to be seen by others.
- It permanently removes the file.

9.4 VERSIONS OF DOS

The different versions of DOS are discussed in this section.

DOS 1.0: In July, 1981, the copyright of 86-DOS (QDOS) is bought by Microsoft, and it became the first operating system in IBM PC history. Meanwhile, Microsoft developed an exclusive edition PC-DOS for IBM PC. Except for system file names and partial kernels designed for IBM machines and external commands and utility programs, the other mobile codes in DOS and PC-DOS have small difference.

DOS 1.25: In July, 1982, it began to support double-sided floppy and correct mistakes. Not only IBM, but OEM also applied it widely.

DOS 2.0: In March, 1983, UNIX type of dendriform file system and hard disk support were added. Seen from a lower level, it is the first significant revision of DOS.

DOS 2.11: In March, 1984, the errors of edition 2.01 were amended for primary OEM edition, and international support for Non-English language and file format was added.

MS-DOS 2.25: In October, 1985, additional expanded character sets (Japanese and Korean) were added and the error of the old edition was amended.

MS-DOS 3.0: In August, 1986, PC/AT supporting for floppy of 1.2 MB was introduced and hard disk of larger capacity was added.

MS-DOS 3.1: In November, 1986, support for Microsoft network was added.

MS-DOS 3.2: In January, 1986, enhanced support for floppy was added, and the hardware EMS can be applied through driver.

MS-DOS 3.3: In August, 1987, partial internal errors were amended, external commands related to file handle were added and it began to support floppy. DOS 3.3 was the most stable and salable edition. It was the second significant revision of DOS. And the 4.0 edition released one year later was not as popular as 3.3 edition.

MS-DOS 4.0: In July, 1988, MS-DOS 4.0 was based on Code Base of IBM rather than that of Microsoft itself.

MS-DOS 4.01: In September, 1988, it amended a series of errors of the old edition.

MS-DOS 5.0: In June, 1991, it was the third revision of DOS; maybe it was the most significant one in DOS history.

MS-DOS 6.0: In March, 1993, many gaudy external commands were added.

MS-DOS 6.2: In November, 1993, DoubleSpace was renamed as DrvSpace.

MS-DOS 6.22: In June, 1994, it was the last sale edition. KC got the authorities of Microsoft and IBM and it released its own DOS 7.0 collocated with KC Chinese System.

MS-DOS 7.0: In August, 1995, the version was built in Windows 95, and it supported long file name.

MS-DOS 7.1: In August, 1996, supports for large hard disk and FAT32 partition were added.

MS-DOS 8.0: In September, 2000, it is the last edition of DOS. Partial functions were cancelled. For example, it did not support SYS commands and printer operation.

9.5 DOS COMMANDS

MS-DOS has a relatively small number of commands, and an even smaller number of commonly used ones. Moreover, these commands are generally inflexible because, in contrast to Linux and other Unix-like operating systems, they are designed to accommodate few options or arguments (i.e., values that can be passed to the commands).

DOS commands can be divided into two categories:

1. **Internal commands:** Internal commands are those commands that can be entered once the DOS prompt is available, i.e., they do not need any special files for their execution. For example

A:/> CD\DOS

is an internal command that changes the directory.

2. **External commands:** External commands are those commands that need separate files, containing their source codes, to invoke them. The external commands basically are accessories to the operating system that increase its extensibility.

A:/DOS > FORMAT C:

The above command would format the drive C:. The file FORMAT.EXE should be present in the DOS directly of drive A: for the command to be executed as desired.

Some of the most common commands are as follows (corresponding commands on Unix-like operating systems are shown in parenthesis):

CD - changes the current directory (cd)

COPY - copies a file (cp)

DEL - deletes a file (rm)

DIR - lists directory contents (ls)

EDIT - starts an editor to create or edit plain text files (vi, vim, ed, joe)

FORMAT - formats a disk to accept DOS files (mformat)

HELP - displays information about a command (man, info)

MKDIR - creates a new directory (mkdir)

RD - removes a directory (rmdir)

REN - renames a file (mv)

TYPE - displays contents of a file on the screen (more, cat)

Directories

In the DOS environment, each disk is organised into directories. Each Directory holds files. The default directory is the Root Directory and contains the minimum DOS Files. The Root Directory has no name in the DOS terminology.

The Root Directory cannot show more than 132 files in its directory listing.

Today's computing environment consists of using various computer languages and packages in order to satisfy our computing needs. If all these packages, languages and associated data, program files, etc., are kept together in the same directory, file managing and handling becomes extremely inefficient. In order to tackle this inefficiency, DOS allows users to create subdirectories within the Root Directory and within subdirectories as well.

Commands to Create a Directory

In order to create a directory named DEEP in the Root Directory, type in the following command:

C:> MD\DEEP

or type

C:>MKDIR\DEEP

Changing Your Working Directory

In order to work with files in the directory DEEP type the following command:

C:>CD\DEEP

Removing a Directory

To remove a directory, please ensure that the directory is empty and enter the command:

C:>RD\DEEP

The DIR Command

This command enables us to view the contents of a directory.

C:>DIR – This gives a complete listing of files and directories.

C:>DIR/P – This command pauses the directory listing at every screen.

C:>DIR/W – This command shows the listing width-wise on the screen.

Files

The most common requirements of a computer user are commands to manage his files. DOS has a naming convention for all files which states that:

Files can have names up to 8 characters. This can be followed by a (.) dot and an extension of up to 3 characters. However, special characters like commas, slashes, blanks, etc., are not allowed in a file name. Hence:

MYFILE is a valid file name.

MYFILE.BAK is a valid file name.

MY FILE is invalid because a blank space has been given.

MY,FILE is invalid because of the comma.

Creating a File Using Editor

DOS has an inbuilt editor which allows you to create a file. In order to create a file named ANYFILE enter the command,

C:\DOS> EDIT ANYFILE

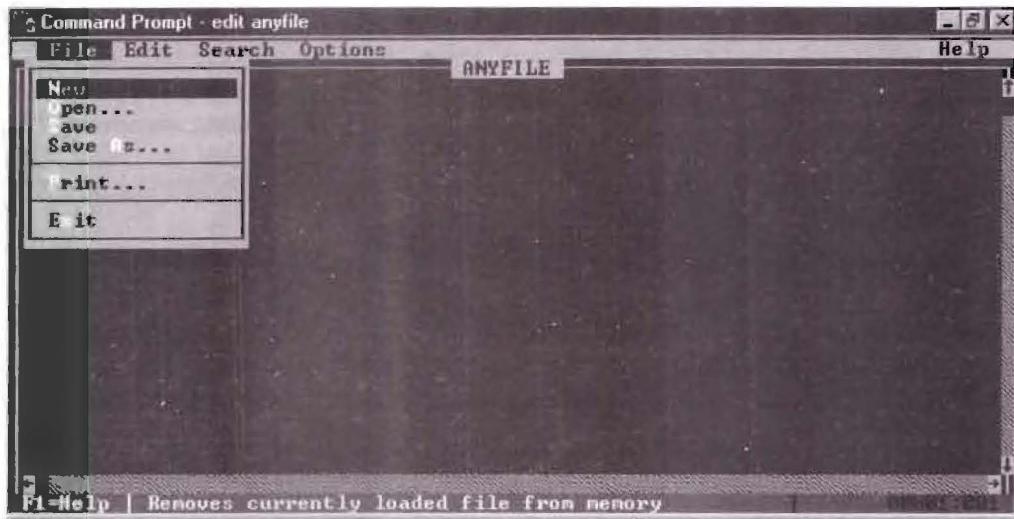


Figure 9.1: Command Prompt for Edit

DOS will present a screen as shown above. You can then enter your program or text in the box and exit out of the editor by using the ALT+F key and then press X.



C:\>COPY ANYFILE A: (This command will copy the file named ANYFILE in the Root Directory to a Floppy)

C:\>COPY ANYFILE \DEEP (This command will copy the file ANYFILE from the Root Directory to the DEEP directory.)

Wild Cards

DOS supports two wild cards ‘?’ and ‘*’, which allow you to specify whole groups of file names. The ‘?’ stands for any single character in their specified position within the file name and the ‘*’ stands for any set of characters, starting at the specified position within the name and extension and continuing till the end of the filename or extension.

For example, DIR A:??001.* will list all files having any character values in the first two position of the filename followed by 001 and any three characters in the extension.

C:\> COPY *.* A: COMMAND will copy all files in the Root Directory on to a floppy.

The ATTRIB Command

C:\> ATTRIB -R ANYFILE : This command is used for making your file ANYFILE as read and write, i.e., you can both read as well as write from and to the file.

The following notations can be used with the ATTRIB command:

+R : Makes the file read only

+H : Suppresses the file in the directory listing, i.e., makes it hidden

-H : Unhide the previously hidden file

+A : Changes file settings to Archived

- A : Changes file settings to Not archived
- +S : Marks file as DOS system file
- S : Removes DOS system file setting

Renaming a File

C:\>RENAME ANYFILE MYFILE

This command allows us to rename the file named ANYFILE to MYFILE.

Deleting a File

C:\> DEL ANYFILE

The above command will delete the file named ANYFILE.

Erase can also be used to delete files.

The DELTREE Command

If you wish to remove unwanted directories and their contents (files and subdirectories) use the DELTREE command.

C:\>DELTREE C:\deep

Printing on Screen

C:\>TYPE ANYFILE

This command will output the contents of the file ANYFILE on the screen. However, it will pause at the end of the text. As a result, you will not be able to view the total contents. In order to view screen by screen, use the Piping feature of DOS.

Piping

If you desire to reprocess the output obtained from a DOS command by another DOS command then one way to do this is to redirect the output to a disk file and then send the contents of the file as input to the next command.

However, DOS allows you a more convenient method in which you can combine multiple commands on a single line. This technique is called piping and uses the pipe character | to combine the DOS commands.

For instance, in the previous example if we wished to pause at every screen to view our output, we would enter the following command:

C:\> TYPE ANYFILE| MORE

MORE forces DOS to display output one screen at a time.

Redirection Options in DOS

Output can be redirected to various devices by using the > symbol for output and < symbol for input.

Standard target device names are as under:

- CON The screen or console
- PRN The default printing device
- LPT1 Parallel printer port
- COM1 Communication serial port 1
- COM2 Communication serial port 2

NUL Null device (Suppresses output from device)

C:\> TYPE MYFILE >PRN

The above command will redirect output of the screen to the printer.

Some Disc Commands

The Format Command

Formatting or initialising floppy or disk is the technique of creating tracks and sectors on the floppy which are ultimately used for reading and writing data from and to the floppy. The command provided by DOS for this important task is as follows:

C:\> FORMAT A: Formats the floppy in drive A.

C:\> FORMAT A:/S Formats the floppy and also transfers the systems files to the floppy.

The Scandisk Command

C:\>SCANDISK /ALL

This command available in DOS 6.2 version analyses and repairs logical and physical disk errors. If DOS version is lower than 6.2 use CHKDISK/F command instead.

The Config.sys File

This is a user defined file in DOS and contains additional information for the operating system regarding the environment in which the user desires to work. For instance a config.sys file may contain the following DOS commands:

DEVICE=\DOS\HIMEM.SYS

FILES=100

BUFFERS=40

DOS=HIGH

The device command tells DOS to look for extended memory. DOS would, by default, assume that your computer has the primary conventional memory of 640 KB only. However, HIMEM.SYS will check for extra memory,

The FILES command tells DOS that up to 100 files can be open at a given point of time. Otherwise the default of 8 files is applied by DOS.

DOS=HIGH tells DOS to load the operating system files in upper memory area leaving the conventional memory area free for applications which require more of conventional memory.

When the computer is booted, the operating system first reads the CONFIG.SYS file in order to configure the environment before bringing up the C prompt.

The AUTOEXEC.BAT File

This is also a user defined file, which contains DOS commands to be executed before the user actually starts his session on the computer. For instance, if the user desires that the computer should check for any viruses on his hard disk the following command should be written in the AUTOEXEC.BAT file.

MSAV C:

We have so far discussed some of the very common and necessary commands and files of the disk operating system which must have given you an idea of the DOS environment and which must have illustrated some important features of DOS. We shall now discuss the commands.

9.6 IMPORTANT INTERNAL COMMANDS OF DOS

A command that is stored in the system memory and loaded from the command.com is called as Internal Commands.

Directory Commands: DIR shows all the files & Directories. MD Create Directory
CD Changes Directory RD Removes a Directory here is user specified valid name

File Commands:

Copy to Copies the Source file contents to the Target file.

Del Erases the files

Type Show the contents of a file

Rename

Renames the existing file.

Given below are some of the common commands with their function and syntax.

BREAK

Type: Internal command.

Function: When the 'BREAK' command is invoked, (i.e., BREAK ON), the computer checks to see if Ctrl.C would stop the execution of the current DOS command.

Syntax: BREAK ON or OFF.

CD

Type: Internal command.

Function: The CD command is used to change the directories which may be on the same or other drives.

Syntax: CD drive:\path.

CLS

Type: Internal command

Function: The CLS command clears the screen and only the operating system prompt on the top left corner is displayed.

Syntax: CLS

COPY

Type: Internal command

Function: As the name suggests the copy command is used to copy files from one destination to another.

Syntax: COPY source_drive:\path\file(s) target_drive:\path\file(s).

CTTY

Type: Internal command

Function: The CTTY command redirects a console input or output to a distant input/output device (e.g., printer).

Syntax: CTTY device-name.

Suppose the device is the printer connected to LPT1. The appropriate command would be.

CTTY LPT1

DATE

Type: Internal command.

Function: If the DATE command is used without any parameters, DOS displays the current system date & prompts the user to enter another. If after the DATE command, the date is included, DOS changes the date.

Syntax: DATE.

DEL (ERASE)

Type: Internal command.

Function: The DEL command is used to delete files.

Syntax: DEL drive:\path\file(s)/switches

ERASE drive:\path\file(s)/switches

DIR

Type: Internal command.

Function: The DIR command displays a list of files in a directory. The DIR command without parameters displays the list of files in the currently logged drive and subdirectory.

Syntax: DIR drive:\path\file(s)/switches.

LABEL

Type: Internal Command.

Function: Every disk has the option of having a volume label which can be used for its identification. The LABEL command adds or modifies the volume label.

Syntax: LABEL target: Labelname.

MD

Type: Internal Command.

Function: The MD command is used for creating a new directory or subdirectory.

Syntax: MD drive:\path\directoryname.

MK DIR can also be used in place of MD.

MORE

Type: Internal Command.

Function: The MORE command when used displays the output one screen at a time instead of continuous scrolling. The MORE command is used to display the contents of a data file or to display the output of a program.

Syntax: MORE < drive:\path\file(s)

or

Command (parameters) MORE

For e.g.,

MORE < STUDENT.TEXT

or

TYPE STUDENT.TXT | MORE

MOVE

Type: Internal Command.

Function: The Move Command Moves files from one location to another. This command is quite identical to the copy command the only difference being that the source files remain intact in the case of the copy command while they are deleted in the case of the Move command.

Syntax: Move Source:\path\file(s) target:\path\file(s)

PATH

Type: Internal Command

Function: The path command searches in a list of subdirectories (specified in its syntax) for executable program files.

Syntax: PATH drive:\path1; drive\path2

For Example,

PATH C:\DIR1; C:\DIR2

would look for all executable files on DIR1 & DIR2 subdirectories.

PROMPT

Type: Internal Command

Function: The PROMT Command is used to change the appearance of the Dos prompt.

Syntax: PROMPT starting

The prompt may one or a combination of the following:

\$ \$ Dollar Sign (\$)

\$b Piping Symbol (|)

\$d Current date

\$g Greater than symbol (>)

\$l Less than symbol (<)

\$q Equal sign (=)

\$t Current time

\$v DOS version number

\$p Currently logged drive and directory

\$n Current drive

\$e Escape character

RD

Type: Internal Command

Function: The RD Command is used to remove directories. The directory to be removed should be empty.

Syntax: N drive:\path\country file

RMDIR can also be used in place of RD.

RENAME OR REN

Type: Internal Command.

Function: The REN command is used to change the file names.

Syntax: REN drive:\path\oldfilename drive:\path\newfilename

RENAME can be used in place of REN.

SORT

Type: Internal Command.

Function: The SORT command sorts data in character based files or sorts the output of DOS commands.

Syntax: SORT/Switches < drive:\path\file.

or

Command: SORT/Switches.

for e.g.,

VOL

Type: Internal Command.

Function: The VOL command displays the volume label of the disk.

Syntax: VOL drive

The following statement.

TYPE STUDENT.TXT > PRN directs the output to the printer.

TYPE STUDENT.TEXT : SORT

TIME

Type: Internal Command.

Function: The TIME command is used to display or change the system time.

Syntax: TIME (displays the current system time)

TIME hh:mm:ss a/p

a & p stand for a.m. or p.m.

TREE

Type: Internal Command.

Function: The TREE command displays the subdirectory structure of a drive.

Syntax: TREE drive:\path\switches.

TYPE

Type: Internal Command.

Function: The TYPE command displays the contents of a file.

Syntax: TYPE drive:\path file

Type: Internal Command.

Function: The VER command displays the version number of DOS.

Syntax: VER.

9.7 IMPORTANT EXTERNAL COMMANDS OF DOS

External commands are the commands stored separately as .Com files.

FORMAT

This is used to format a floppy disk. Normally a new floppy is used with format. Of course already used floppy may reused by taking format command.

Syntax: Format a:/s:q Format a floppy quickly and transfer system files also.

CHKDSK

This is check disk command with this a floppy is analyzed for used space, total no. of bytes remaining, sectors, tracks and if any bad sectors/tracks.com

This command mainly used to know about any virus.

Syntax :Chkdsk a:

DISKCOPY

To copy the contents of one disk to another floppy disk provided both should have same size and capacity.

DISKCOPY

SYS

This command is used to transfer the system files to a floppy disk.

Sys A

LABEL : This command is used to give name to a floppy disk

Label

CHKDSK

Type: External Command.

Function: The CHKDSK command analyses, diagnoses and optionally corrects command hard disk errors. CHKDSK can also be made to work on a specific file to check whether it is contiguous (stored in adjacent areas of the disk) or noncontiguous (scattered over separate areas of the disk).

Syntax: CHKDSK drive:\path\file\switches.

DBLSPACE

Type: External commands.

Function: The DBLSPACE command is used to compress the data files. It can also be used to compress the entire drive. The DBLSPACE has very vast applications which are beyond the scope of this book.

Syntax: DBLSPACE/Switches drive:

DEFRAG

Type: External command.

Function: The DEFrag command is used to arrange the files in contiguous sectors. Files become fragmented over a period of time. Hence, the DEFrag command should be periodically used to increase the performance of the system

Syntax: DEFrag drive:/switches.

DELTREE

Type: External command.

Function: The DELTREE command is used to remove an unwanted directory, plus all files on it, and all subdirectories nested below it, in a single command.

Syntax: DELTREE/switch drive:\path.

DISKCOMP

Type: External command

Function: The DISKCOMP command compares the contents of two floppy disks on a track to track basis, reporting which track numbers are not identical.

Syntax: DISKCOMP source; target:/switches.

DISCOPY

Type: External command

Function: The DISCOPY command copies the contents of one floppy disk to another on a track to track basis.

Syntax: DISCOPY source; target:/switches.

DOSHELP

Type: External command

Function: The DOSHELP command provides instant help to the user when invoked.

Syntax: DOSHELP Command

or

Command /?

When executed instant help is provided on the 'Command Name' entered.

DOSKEY

Type: External Command.

Function: Once invoked the DOSKEY command introduces a special buffer space in which the DOS commands being entered are stored. Each time a command is entered it is added to the DOSKEY's Command buffer. These commands can be recalled.

Syntax: DOSKEY.

EDIT

Type: External Command.

Function: The EDIT command provides a text editor for the editing of text files or batch files.

Syntax: EDIT drive:\path\file/switches.

Type: External command

Function: The FC command matches the contents of two files or sets of files and reports the differences between them.

Syntax: FC/switches drive:\path\file(s) drive:\path\file(s)

FDISK

Type: External Command.

Function: The FDISK command is used to partition the hard disk. This command should be used on a formatted hard disk, otherwise it may erase or overwrite the existing files.

Syntax: FDISK/switch.

FIND

Type: External Command.

Function: The FIND command is used to find all occurrences of a specified character string in a file. This command is case-sensitive, i.e., it distinguishes between upper case and lowercase letters.

Syntax: FIND/switches "string" drive:\path\file.

FORMAT

Type: External Command.

Function: The FORMAT command prepares a blank disk for storing, or creates a new blank disk from a used one. In other words, the disk is formatted.

Syntax: FORMAT targetdrive:/switches.

HELP

Type: External Command.

Function: The HELP command is synonymous to the DOSHELP command. It displays the syntax summary of the command name entered.

Syntax: HELP Command.

KEYB

Type: External Command.

Function: This command when invoked loads a non-standard keyboard configuration into memory.

Syntax: KEYB keyboard codepage drive:\path\library file.

The Library file usually is KEYBOARD.SYS

MEM

Type: External Command.

Function: The MEM command displays the information on the allocation of the random access memory.

Syntax: MEM/switches.

MSAV

Type: External Command.

Function: The MSAV (Microsoft anti-virus) command scans the memory for the presence of computer viruses.

Syntax: MSAV drive:\path\switches

NLSFUNC

Type: External Command

Function: The NLSFUNC command when invoked loads national language support functions which allow the user to switch to international character set tables in RAM.

Syntax: NLSFUNC drive:\path\country file

REPLACE

Type: External Command.

Function: The REPLACE command is used to replace files with new files of the same name. This command is used update data files.

Syntax: REPLACE source:\path\file(s) target:\path\switches.

The above statement replaces the files in the target directory with that of the source directory.

UNDELETE

Type: External Command.

Function: As the name suggests the UNDELETE command is used to UNDELETE files that have previously, not always successful in recovering the deleted files. A file may be undeleted if the disk area it occupied has not been overwritten by another file.

Syntax: UNDELETE drive:\path\file(s)/Switches

UNFORMATED

Type: External Command.

Function: The UNFORMAT command is used to recover files which were lost when the disk was formatted.

Syntax: UNFORMAT drive:/switches.

9.8 EXECUTABLE VS. NON-EXECUTABLE FILES IN DOS

An executable file is a file that is used to perform various functions or operations on a computer. Unlike a data file, an executable file cannot be read because it has been compiled. On an IBM compatible computer, common executable files are .BAT, .COM, .EXE, and .BIN. On an Apple mac computer running macOS the .DMG and .APP files are executable files. Depending on the operating system and its setup, there can also be other executable files.

9.8.1 How to Run an Executable File?

- To execute a file in Microsoft Windows, double-click the file.
- To execute a file in other GUI operating systems, a single or double-click will execute the file.

- To execute a file in MS-DOS and numerous other command line operating systems, type the name of the executable file and press enter. For example, the file myfile.exe is executed by typing “myfile” at the command prompt.
- Other command line operating systems such as Linux or Unix may require the user to type a period and a forward slash in front of the file name. For example,./myfile would execute the file named myfile.

Non-executable Files

Non-executable files contain only the data that we produce. It cannot execute them. It needs application program to run.

Programming command is not run or executed when being read by the computer. A commonly used non-executable statement is a remark (REM) used in batch files and other Microsoft Windows and DOS programs.

Below is a listing of other text used to remark, comment, or cause the line to be skipped.

Table 9.1: List of Symbol and Remark

#	The pound symbol is used to comment a line in programming languages such as Perl. This symbol is only required once at the beginning of what you want ignored.
;	The semicolon is used to remark a line in an INI file and in AutoHotkey. This symbol is only required once at the beginning of the line. Note that it must be at the beginning of the line in an INI file.
!	The exclamation mark is used in scripting programs to comment a line. This symbol is commonly required at the beginning of the line.
/* */	Used to add a comment to a line in the C, PHP and other programming languages. The comment must begin with “/*” and end with “*/”. Below is an example of how this may look /* Computer Hope comment */
<!-- -->	Used in HTML and some other scripting languages. Begin the comment with “<!--” and end it with “-->” Below is an example of how this may look in the HTML code. <!-- Computer Hope comment -->
'	In Microsoft QBasic starting a line with single quote is a way of creating a non-executable line.

Check Your Progress

Fill in the blanks:

1. _____ has a relatively small number of commands, and an even smaller number of commonly used ones.
2. _____ are those commands that can be entered once the DOS prompt is available, i.e., they do not need any special files for their execution.
3. External commands are those commands that need _____ files, containing their source codes, to invoke them.
4. _____ command is used for making your file ANYFILE as read and write, i.e., you can both read as well as write from and to the file.

9.9 LET US SUM UP

- DOS stands for Disk Operating System. It is used for abstraction and management of secondary storage devices of the computers and the information stored there.
- DOS for DEC PDP-II Minicomputers. The best known family of operating systems named DOS was that running on IBM PC's type hardware using the INTEL CPU's or alike.
- MS-DOS (Microsoft Disk Operating System) is a single-user, single-tasking computer operating system that uses a command line interface. In spite of its very small size and relative simplicity, it is one of the most successful operating systems that have been developed to date.
- September, 2000 version was the last edition of DOS. Partial functions were cancelled. For example, it did not support SYS commands and printer operation.
- MS-DOS has a relatively small number of commands, and an even smaller number of commonly used ones.
- Internal commands are those commands that can be entered once the DOS prompt is available, i.e., they do not need any special files for their execution.
- External commands are those commands that need separate files, containing their source codes, to invoke them.
- In the DOS environment, each disk is organised into directories. Each Directory holds files.
- Today's computing environment consists of using various computer languages and packages in order to satisfy our computing needs.
- Files can have names up to 8 characters. This can be followed by a(.)dot and an extension of up to 3 characters.
- C:\> ATTRIB -R ANYFILE: This command is used for making your file ANYFILE as read and write, i.e., you can both read as well as write from and to the file.
- If you desire to reprocess the output obtained from a DOS command by another DOS command then one way to do this is to redirect the output to a disk file and then send the contents of the file as input to the next command.
- *Directory Commands:* DIR shows all the files & Directories. MD Create Directory
CD Changes Directory RD Removes a Directory here is user specified valid name.

9.10 UNIT END ACTIVITY

Make a list of DOS commands. Which of the following commands is correct if we wish to copy a file named ANYFILE in the root directory to a directory named MYDIRECT?

9.11 KEYWORDS

Directory: It is a list of file which is itself a file stored in the computer's memory so that users can reference it as it is required.

Label Command: It is used to check the label of the disk that you have been currently working.

EDIT Command: It is used to edit the files in MS DOS. It provides a different full screen Editor window with a few menu options.

Command: It is a set of instructions used to perform a specific work.

9.12 QUESTIONS FOR DISCUSSION

1. What is the concept of disk operating system?
2. What is the history of DOS?
3. List out the examples of disk operating systems.
4. What are the main features of DOS?
5. What are the key functions of disk operating system?
6. Define the versions of DOS in Microsoft.
7. What are the key DOS commands?
8. What are the important internal commands of DOS?
9. Discuss important external commands of DOS.
10. Describe executable vs. non-executable files in DOS.

Check Your Progress: Model Answer

1. MS-DOS
2. Internal commands
3. separate
4. C:\> ATTRIB -R ANYFILE

9.13 REFERENCES & SUGGESTED READINGS

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PROGRAMMING LANGUAGES

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10.0 AIMS AND OBJECTIVES

After studying this lesson, you should be able to:

- Describe computer programming languages
- Explain various generations of programming languages
- Classify various programming languages
- Understand the concept of program and programming
- Discuss various fourth generation languages
- Describe various high level languages

10.1 INTRODUCTION

Language is the main tool of communication among people. Languages like English, Hindi, Punjabi, Marathi, etc., which we use to communicate with each other are known as general languages in India. Each language uses its own constructs and rules for word formation known as semantic rules. Words themselves cannot communicate the full meaning until joined together to form sentences or statements under certain syntax rules. Similarly, in order to communicate with the computer, we use programming languages. These programming languages are used to communicate instructions and commands of a user-written program to the computer to accomplish the tasks assigned by the program. Learning a programming language means learning the syntactic and semantic rules and other various constructs and structures of the language.

In this lesson, we will study about the evolution and generation of languages, why we need to learn different languages, how the programs are interpreted and implemented in the computer, etc. In this lesson, data, information and knowledge, comparison between human language and computer language, programming concepts, algorithm, program flowcharts and Pseudocode will be studied. We will also learn programming approaches, programming paradigms, programming development cycle, generations of programming languages and classification of programming languages. This knowledge will help us in selecting the languages according to our work and choice.

10.2 DATA, INFORMATION AND KNOWLEDGE

Let us discuss data, information and knowledge in detail.

10.2.1 Data

Data is unprocessed facts and figures without any added interpretation or analysis. For example, “The price of crude oil is \$ 80 per barrel.”

10.2.2 Information

Information is data that has been interpreted so that it has meaning for the user. “The price of crude oil has risen from \$70 to \$80 per barrel” gives meaning to the data and

is said to be information provided to someone who tracks oil prices. The Infogineering Model (below) explains how these interact.

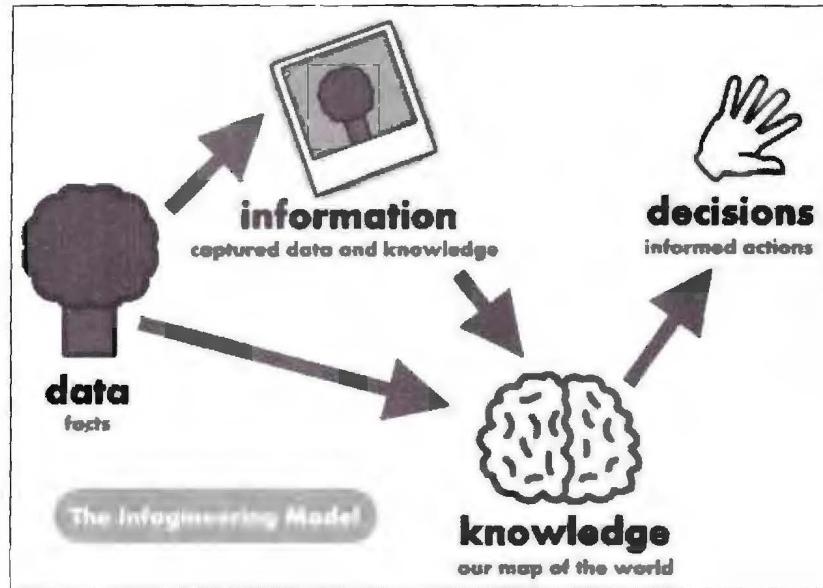


Figure 10.1: Infogineering Model of Data, Information and Knowledge

Characteristics of Information

Good information is that which is used and which creates value. Experience and research shows that good information has numerous qualities.

Good information is relevant for its purpose, sufficiently accurate for its purpose, completes enough for the problem, reliable and targeted to the right person. It is also communicated in time for its purpose, contains the right level of detail and is communicated by an appropriate channel, i.e., one that is understandable to the user.

Further details of these characteristics related to organisational information for decision-making follows:

- Availability/accessibility
- Accuracy
- Reliability or objectivity
- Relevance/appropriateness
- Completeness
- Level of detail/conciseness
- Presentation
- Timing
- Value of information
- Cost of information

10.2.3 Knowledge

Knowledge is a combination of information, experience and insight that may benefit the individual or the organisation. “When crude oil prices go up by \$10 per barrel, it's likely that petrol prices will rise by 2p per litre” is knowledge.

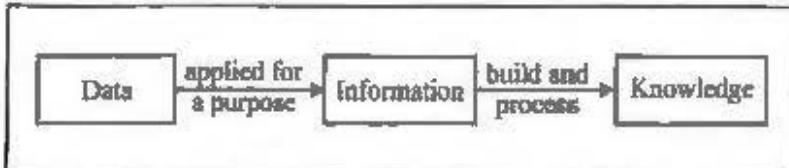


Figure 10.2: From Data to Information to Knowledge

The boundaries between the three terms are not always clear. What is data to one person is information to someone else. To a commodities trader for example, slight changes in the sea of numbers on a computer screen convey messages which act as information that enables a trader to take action. To almost anyone else they would look like raw data. What matters are the concepts and your ability to use data to build meaningful information and knowledge.

10.3 COMPARISON BETWEEN HUMAN LANGUAGE AND COMPUTER LANGUAGE

Programming languages are (designed to be) easily used by machines, but not people. While natural languages (like English) are easily used by humans, but not machines.

Programming languages are unambiguous, while natural languages are often multiply ambiguous and require interpretation in context to be fully understood (also why it's so hard to get machines to understand them). Natural languages are also creative and allow poetry, metaphor and other interpretations. Programming does allow some variation in style, but the meaning is not flexible.

Natural languages consist of sentences, usually declarative sentences expressing information in a sequence. Programming languages typically are not declarative but procedural, giving instructions to the machine to do something (like commands in natural languages). Rarely, programming languages are declarative, such as Prolog, where statements are given to the computer, then the evaluation consists of finding possible solutions that match those statements (generate a list of words based on possible combinations of letters as defined just by letter-combining rules, for example).

The vocabulary of natural languages is filled with conceptual terms. The vocabulary of programming languages is generally only 'grammatical'/functional 'words' like basic commands, plus various custom-named things like variables and functions. There are no words like you'd look up in a dictionary to express something like 'love' or 'happy' or 'sing'.

The grammatical structures also vary in so many ways, not possible to list all. But some of the most obvious factors are that words do not have separable parts in programming languages (like English cat-s to form a plural), and that via brackets, line breaks or other markers, embedding tends to be overtly and clearly marked on both sides for the parser in programming languages, whereas spoken languages usually only have one word (like "that") linking embedded sentences, and sometimes no word at all. This is another reason that parsing human languages is so hard on a computer.

10.4 BASICS OF PROGRAM

In computing, a program is a specific set of ordered operations for a computer to perform. John von Neumann outlined in 1945, the program contains a one-at-a-time sequence of instructions that the computer follows. Typically, the program is put into a storage area accessible to the computer. The computer gets one instruction and

performs it and then gets the next instruction. The storage area or memory can also contain the data that the instruction operates on.

Programs can be characterized as interactive or batch in terms of what drives them and how continuously they run. An interactive program receives data from an interactive user (or possibly from another program that simulates an interactive user). A batch program runs and does its work, and then stops. Batch programs can be started by interactive users who request their interactive program to run the batch program. A command interpreter or a Web browser is an example of an interactive program. A program that computes and prints out a company payroll is an example of a batch program. Print jobs are also batch programs.

A program is a set of instructions that are arranged in a sequence to guide the computer in what steps should be taken and how they can be computed in order to solve a problem. Writing programs is known as programming.

10.4.1 Why We Learn About Programming Language?

There are hundreds of programming languages available but we use only a few languages because it is a very tedious task to learn all of them. But in most cases, programmers are supposed to know at least about the features of many different programming languages and then decide which language suits them the most for their work. The reasons why programming languages are studied:

- To improve the ability to develop the effective algorithms and making use of programming language features. Improper use of the programming language can cause logical errors. Solving these errors is a very time-consuming and difficult task because syntax errors can be detected by compilers but not logical errors.
- Improve programming capabilities by being able to select more suitable languages.
- It is easier to learn a new programming language, if we know the basic construct and features of different programming languages.

10.4.2 Programming Concepts

As we all know that programs are a sequence of instructions which tell a computer what to do and how to do it. Making programs for complex problems is a very tedious task and requires expertise and deep knowledge of the programming language with some basic concept of programming technique. Programming is a step-by-step process which involves:

- Study of the problem.
- Breaking big and complex problems into small and easily understandable forms.
- Define inputs for each problem.
- Define outputs required for each problem.
- Define processes that are required to get desired output
- Define the steps involved in each process.
- Develop algorithms for each process.
- Draw flow charts using algorithms.
- Write the program and subroutines according to the flow charts.

10.4.3 Algorithm

An algorithm is a procedure or formula for solving a problem, based on conducting a sequence of specified actions. A computer program can be viewed as an elaborate algorithm. In mathematics and computer science, an algorithm usually means a small procedure that solves a recurrent problem.

Algorithms are widely used throughout all areas of IT (information technology). A search engine algorithm, for example, takes search strings of keywords and operators as input, searches its associated database for relevant web pages and returns results.

An encryption algorithm transforms data according to specified actions to protect it. A secret key algorithm such as the U.S. Department of Defence's Data Encryption Standard (DES), for example, uses the same key to encrypt and decrypt data. As long as the algorithm is sufficiently sophisticated, no one lacking the key can decrypt the data.

10.4.4 Program Flowcharts

Program flowchart is a diagram which uses a set of standard graphic symbols to represent the sequence of coded instructions fed into a computer, enabling it to perform specified logical and arithmetical operations. It is a great tool to improve work efficiency. There are four basic symbols in program flowchart, start, process, decision and end. Each symbol represents a piece of the code written for the program.

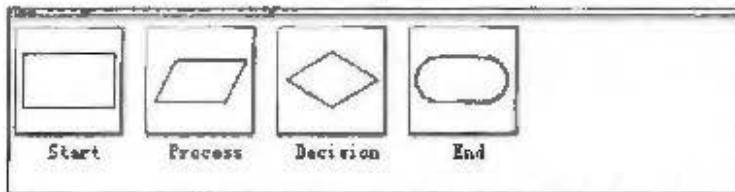


Figure 10.3: Program Flowchart Shapes

- **Start** event symbol signals the first step of a process.
- **Process** is a series of actions or steps taken in order to achieve a particular end.
- **Decision** is the action or process of deciding something or of resolving a question.
- **End** event symbol stands for the result of a process.

Steps to Create Program Flowcharts

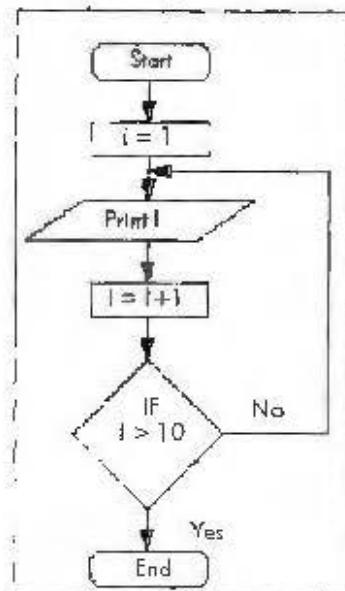
Use program flowchart maker, you can create program flowchart in minutes.

- Drag relevant symbols of program flowchart and drop them on the page.

The purpose of program chart is making complex program easy and readable, which means you should confirm your core topic and state it simply with several steps.

- Drag relevant vector symbols and drop them on the page. Each symbol has its own function within the program; flowchart will not work if there is a wrong symbol.
- Text information into right symbols. Single key words or short phrases will make flowchart much clear and concise.
- Connect the steps with arrow according to their correct order. You can connect the shapes one by one or click the floating button which saves a lot of time.
- Complete and check the programming flowchart. After completing the program flowchart, check it before carrying it out to find if there is any bug.

For example, the flow chart of printing 1 to 10 numbers can be represented as:



10.4.5 Pseudocode

Pseudocode is a detailed yet readable description of what a computer program or algorithm must do, expressed in a formally-styled natural language rather than in a programming language. Pseudocode is sometimes used as a detailed step in the process of developing a program. It allows designers or lead programmers to express the design in great detail and provides programmers a detailed template for the next step of writing code in a specific programming language.

Because pseudocode is detailed yet readable, it can be inspected by the team of designers and programmers as a way to ensure that actual programming is likely to match design specifications. Catching errors at the pseudocode stage is less costly than catching them later in the development process. Once the pseudocode is accepted, it is rewritten using the vocabulary and syntax of a programming language. Pseudocode is sometimes used in conjunction with computer-aided software engineering-based methodologies.

It is possible to write programs that will convert a given pseudocode language into a given programming language.

10.4.6 Programming Approaches

Here are some approaches:

- Structural Programming
- Modular Designing
- Top Down Designing
- Bottom Up Designing
- Object Oriented Programming

The objective of program design are given below:

1. **Replace old system:** The new system is used to replace old system because maintenance cost is high in old system and efficiency level is low.
2. **Demand of Organization:** The new system is developed and installed on the demand of organization and working groups.

3. **Productivity:** The new system is installed to increase productivity of company or organization.
4. **Competition:** The new system is a matter of status also. In the age of roaring competition, if organization can not cope with modern technology they are bound to fail and will not be able to face competitions.
5. **Maintenance:** The new system is needed to maintain organization status.

Structured Programming

This is the first programming approach used widely in the beginning. Professor Edsger Wybe Dijkstra (1960) coined the term Structural Programming. Italian computer scientist C. Bohm and G. Jacopini (1966) provided the basic principles which supported this approach. The structured programming movement started in 1970, and much has been written about it since then. It is often regarded as “*goto-less*” programming, because it is usually avoided by programmers.

The program is divided into several basic structures. These structures are called building blocks.

These are following:

- (a) **Sequence Structure:** This module contains program statements one after another. This is a very simple module of structured programming.

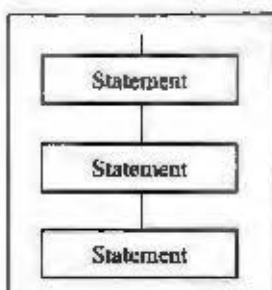


Figure 10.4: Sequence Structure

- (b) **Selection or Conditional Structure:** The program has many conditions from which correct condition is selected to solve problems. These are: (a) if-else, (b) else-if, and (c) switch-case.

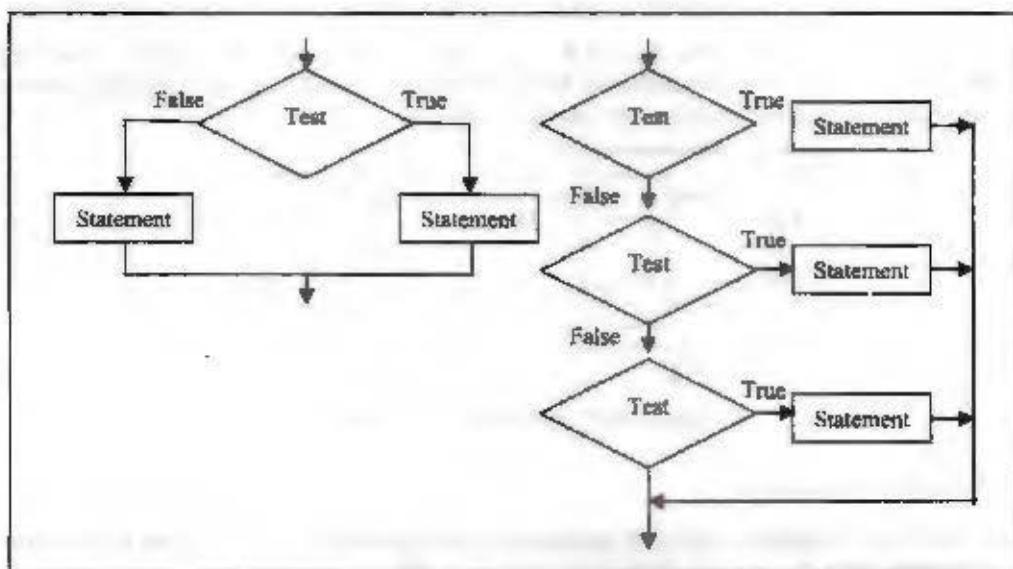


Figure 10.5: Conditional Structure

- (c) **Repetition or Loop Structure:** The process of repetition or iteration repeats statements blocks several times when condition is matched, if condition is not matched, looping process is terminated. In C, (a) goto, (b) for (), (c) do and (d) do – while are used for this purpose.

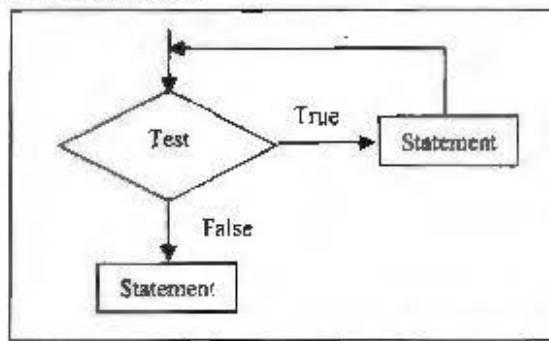


Figure 10.6: Loop Structure

Modular Programming

When we study educational philosophy, the concept of modulation can be clear without any ambiguity. Rene Descartes (1596-1650) of France has given concept to reconstruct our knowledge piece by piece. The piece is nothing, but it is a module of modern programming context.

In modular approach, large program is divided into many small discrete components called Modules. In programming language, different names are used for it.

For example:

Q-basic, Fortran	Subroutine
Pascal	Procedure or Function
C, C+, C#, Java	Function

It is logically separable part of program. Modules are independent and easily manageable. Generally modules of 20 to 50 lines considered as good modules when lines are increased, the controlling of module become complex.

Modules are debugged and tested separately and combined to build system. The top module is called root or boss modules which charges control over all sub-modules from top to bottom. The control flows from top to bottom, but not from bottom to top.

The evaluation of modeling is called coupling and cohesion. The module coupling denotes number of interconnections between modules and module cohesion shows relationship among data or elements within a module.

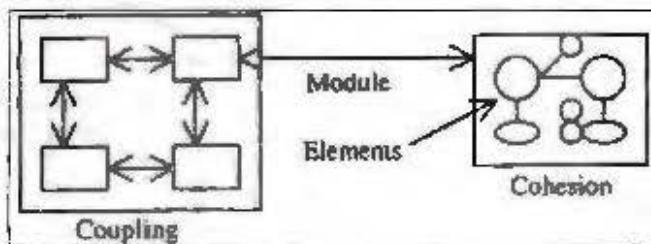


Figure 10.7: Modular Programming

Top Down Approach

- (a) The large program is divided into many small module or subprogram or function or procedure from top to bottom.

- (b) At first supervisor program is identified to control other sub modules. Main modules are divided into sub modules, sub-modules into sub-sub modules. The decomposition of modules continues until desired module level is not obtained.
- (c) Top module is tested first, and then sub-modules are combined one by one and tested.

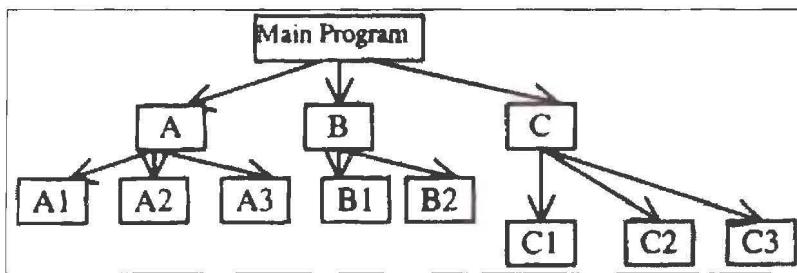


Figure 10.8: Top Down Approach

Example: The main program is divided into sub-program A, B, and C. The A is divided into subprogram A1, A2 and A3. The B is into B1, and B2. Just like these subprograms, C is also divided into three subprograms C1, C2 and C3. The solution of Main program is obtained from sub program A, B and C.

Bottom up Approach

- In this approach, designing is started from bottom and advanced stepwise to top. So, this approach is called Bottom up approach.
- At first bottom layer modules are designed and tested, second layer modules are designed and combined with bottom layer and combined modules are tested. In this way, designing and testing progressed from bottom to top.
- In software designing, only pure top down or bottom up approach is not used. The hybrid type of approach is recommended by many designers in which top down and bottom up, both approaches are utilized.

Object-oriented Programming

In the object-oriented programming, program is divided into a set of objects. The emphasis is given on objects not on procedures. All the programming activities revolve around objects. An object is a real world entity. It may be airplane, ship, car, house, horse, customer, bank account, loan, petrol, fee, courses, registration number, etc. Objects are tied with functions. Objects are not free for walk without leg of functions. One object talks with other through earphone of functions. Object is a boss but captive of functions.

Features of Object-oriented Language

- The program is decomposed into several objects. In this language, emphasis is given to the objects and objects are central points of programming. All the activities are object centered.
- Objects occupy spaces in memory and have memory address like as records in PASCAL and structure in C language.
- Data and its functions are encapsulated into a single entity.
- **Reusability:** In C++, we create classes and these classes have power of reusability. Other programmers can use these classes.
- It supports bottom up approach of programming. In this approach, designing is started from bottom and advanced stepwise to top.

10.4.7 Programming Paradigms

Programming paradigms are a way to classify programming languages based on their features. Languages can be classified into multiple paradigms.

Some paradigms are concerned mainly with implications for the execution model of the language, such as allowing side effects, or whether the sequence of operations is defined by the execution model. Other paradigms are concerned mainly with the way that code is organized, such as grouping a code into units along with the state that is modified by the code. Yet others are concerned mainly with the style of syntax and grammar.

Common programming paradigms include:

- imperative which allows side effects,
- functional which disallows side effects,
- declarative which does not state the order in which operations execute,
- object-oriented which groups code together with the state the code modifies,
- procedural which groups code into functions,
- logic which has a particular style of execution model coupled to a particular style of syntax and grammar, and
- symbolic programming which has a particular style of syntax and grammar.

For example, languages that fall into the imperative paradigm have two main features: they state the order in which operations occur, with constructs that explicitly control that order, and they allow side effects, in which state can be modified at one point in time, within one unit of code, and then later read at a different point in time inside a different unit of code. The communication between the units of code is not explicit. Meanwhile, in object-oriented programming, code is organized into objects that contain state that is only modified by the code that is part of the object. Most object-oriented languages are also imperative languages. In contrast, languages that fit the declarative paradigm do not state the order in which to execute operations. Instead, they supply a number of operations that are available in the system, along with the conditions under which each is allowed to execute. The implementation of the language's execution model tracks those operations which are free to execute and chooses the order on its own.

10.5 WHAT IS A PROGRAMMING LANGUAGE?

A computer, being an electronic device, cannot understand instructions if provided in a general language. Therefore, a special language is used to provide instructions to a computer system. This language is known as computer programming language. It consists of a set of symbols and characters, words and grammar rules that permit the user to construct instructions in the format that can be understood and acted upon by the computer system. A major goal of computer scientists is to develop computer system which can accept instructions in normal human language – known as Natural Language Processor.

10.6 PROGRAMMING DEVELOPMENT CYCLE

The programming development cycle is a process of steps, used by programmers to more efficiently manage their time in designing error-free programs that produce the desired output.

The program development cycle correlates to the Software Development Life Cycle, as the Program Development Cycle defines each stage and different Software Development Life Cycle models have specific methods of using each stage.

Each step in the Program Development Cycle is utilized dependent on the programmers chosen Software Development Life Cycle method. In the Agile Software Development Life Cycle, less time is spent in the design phase, and more time is spent in the coding phase, and the process is not a step by step process; but rather, the process is iterative in which specific components are designed to meet output requirements. The Waterfall Software Development Life Cycle more closely aligns itself with the step by step process defined in the program development cycle, as each phase is completed before sequentially moving on to the next stage.

Analyze Define the problem.

You must have a clear idea of what data (or input) is given and the relationship between the input and the desired output.

Design – Plan the solution to the problem.

Find a logical sequence of precise steps that solve the problem (aka the algorithm). The logical plan may include flowcharts, pseudocode, and top-down charts.

Design the interface – Select objects (text boxes, buttons, etc.).

Determine how to obtain input and how the output will be displayed. Objects are created to receive input and display output. Appropriate menus, buttons, etc., are created to allow user to control the program.

Code – Translate algorithm into a programming language.

During this stage the program is written.

Test and debug – Locate and remove errors in program.

Testing is the process for finding errors. Debugging is the process for correcting errors.

Complete the documentation – Organize all materials that describe the program.

Documentation is necessary to allow another programmer or non-programmer to understand the program. Internal documentation, known as comments, is created to assist a programmer. An instruction manual is created for the non-programmer. Documentation should be done during the coding stage.

10.7 GENERATIONS OF PROGRAMMING LANGUAGES

The term 'generation' of computer languages is used to categorize the generic enhancements in various computer languages. It shows the step-by-step evolution of programming languages. Each generation indicates significant progress towards making computers easier to use. Computer languages by generation are classified as follows:

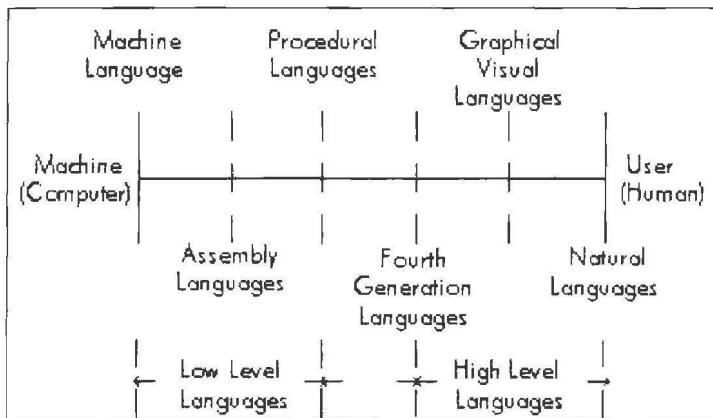
- First Generation (late 1940s)
e.g., machine language
- Second Generation (early 1950s)
e.g., assembly language
- Third Generation (late 1950s through 1970s)
e.g., high level language

- Fourth Generation (late 1970 onwards)
includes a whole range of query languages and other tools.

10.8 CLASSIFICATION OF PROGRAMMING LANGUAGES

Computer programming languages can be classified into two major categories:

1. Low Level
2. High Level



10.8.1 Low Level Languages

The languages, which use only primitive operations of the computer, are known as low level languages. In these languages, programs are written by means of the memory and registers available on the computer. As we all know that the architecture of computer differs from one machine to another, so for each type of computer there is a separate low level programming language. In the other words, programs written in one low level language of one machine cannot be ported on any other machine due to architectural changes. Because of this, low level languages are known as machine dependent languages. Examples are Machine Language and Assembly Language.

Machine Language

In machine language programs, the computation is based on binary numbers. All the instructions including operations, registers, data and memory locations are given in their binary equivalent.

The machine directly understands this language by virtue of its circuitry design so these programs are directly executable on the computer without any translations. This makes the program execution very fast. Machine languages are also known as first generation languages. A typical low level instruction consists essentially of two parts:

1. **An Operation Part:** Specifies operation to be performed by the computer, also known as Opcode.
2. **An Address Part:** Specifies location of the data on which operation is to be performed.

Machine Language Instruction

There are several types of machine instructions for performing a variety of tasks. For example, one group of machine language instructions known as "RX" type, are designed to perform operations on two operands or variables. First is stored in one of the CPU registers and the other is stored in the internal memory.

4 Byte or 32 Bit Length										Description
Opcode	R1	X2	B2	D2	31 Bits					Machine code
0101 1010	0011	0000	0101	0000 0001 0000	0	7	8	11	12	Add from Storage to Register
					15	16	19	20		
										31 Bits
										Machine code
										Add from Storage to Register
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										Add from Storage to Register

1. A name or label field
2. An operation code (Opcode)
3. An operand
4. A comment field (separated by; (semicolon) from the executable part of the instruction).

A name or label field is optional. It is used to mark a place in a program to which computer control can be transferred. An operation code specifies to the control unit what processing tasks to perform and the operand field identifies the location of data item in primary memory. The comment field enables a programmer to write relevant notes and thereby improve the program documentation. This field is optional. In assembly language, symbols are used rather than absolute addresses, to represent memory locations e.g., hexadecimal value can be used to represent the memory location of the data in a statement. For example, 2AH for hexadecimal where 2A represents some memory location. Similarly BX and CX can be used to represent B register and C register of the computer's ALU respectively. Mnemonics are used for operation code i.e., short abbreviations that help programmers remember what the codes represent.

Advantages

Assembly languages provide optimal use of computer resources like registers and memory because of direct use of these resources within the programs. Assembly language is easier to use than machine language because there is no need to remember or calculate the binary equivalents for opcode and registers. An assembler is useful for detecting programming errors. Assembly language encourages modular programming which provides the facility of reusable code, using macro.

Drawbacks

Assembly language programs are not directly executable due to the need of translation. Also, these languages are machine dependent and, therefore, not portable from one machine to another. Programming in assembly language requires a high level of programming skills and knowledge of computer architecture of the particular machine.

10.8.2 High Level Languages (HLL)

All high level languages are procedure-oriented languages and are intended to be machine independent. Programs are written in statements akin to English language, a great advancement over mnemonics of assembly language. That is, the high level languages use natural language like structures. These languages require translators (compilers and interpreters) for translating high level language programs into machine language programs for execution. The programs written in a high level language can be ported on any computer that is why they are known as machine independent. The early high level languages come in third generation of languages e.g., COBOL, FORTRAN, PASCAL, BASIC, APL, etc.

These languages enable the programmer to write instructions using English words and familiar mathematical symbols which makes it easier for programmers to concentrate on the logic of problem-solving rather than technical details of the computer. It makes the programs more readable too.

Procedures

Procedures are the reusable code which can be called at any point of the program. Each procedure is defined by a name and set of instructions accomplishing a particular

task. The procedure can be called by its name with the list of required parameters which should pass to that procedure.

Advantages

These languages are easier to learn than assembly languages and less time is required to write programs in HLL. They also provide better documentation and have an extensive vocabulary. Libraries of subroutines can be incorporated and used in many other programs, saving time and effort. Programs written in high level languages are easier to debug because translators display all the errors with proper error messages at the time of translation. Due to the use of natural language like structure and procedures, the programs of HLL are more readable. Also, these programs are largely machine independent. Therefore, programs developed on one computer can run on other computers, with minimum or no modifications at all.

10.8.3 Compiler Based and Interpreter Based Language

A program written in HLL (source program) needs to be translated into its equivalent machine code (object program) before it runs. Depending upon the relationship between the language translation process and its execution, HLL can be characterized as:

- Compiler-oriented Language
- Interpreter-oriented Language

Compiler-oriented language is one in which the entire source program is analyzed and translated into equivalent machine code before it is executed. Whereas interpreter-oriented language is one in which as soon as one source code instruction is translated into its equivalent machine code, the instruction is immediately executed. Thus the language translation software, whether compiler or interpreter, takes as its input, source program written in HLL and produces equivalent machine code or object program as output.

Translator

Programs which convert a source code in any other language, 'mostly machine code' are called translator programs. Every high level language and assembly language uses a translator to translate its program. Translated programs are directly executable because they are in machine language (i.e., binary language) which is directly understandable by any computer.

"A translator is a program that takes as input a program written in one programming language (e.g., a high level language), known as source language and produces as output a program in another language (machine language) known as target language."

Compiler

Compilers are programs which translate the high level procedural language programs into machine instructions. Compiler goes through a series of steps to examine and modify source code during the compilation process. Each source code instruction typically gives a list to several machine code instructions.



Figure 10.9: Compilation Process

"Compiler is a program which takes as input a program of a high level language and produces object program in machine code".

The steps taken by a compiler to compile a high level program into machine language are:

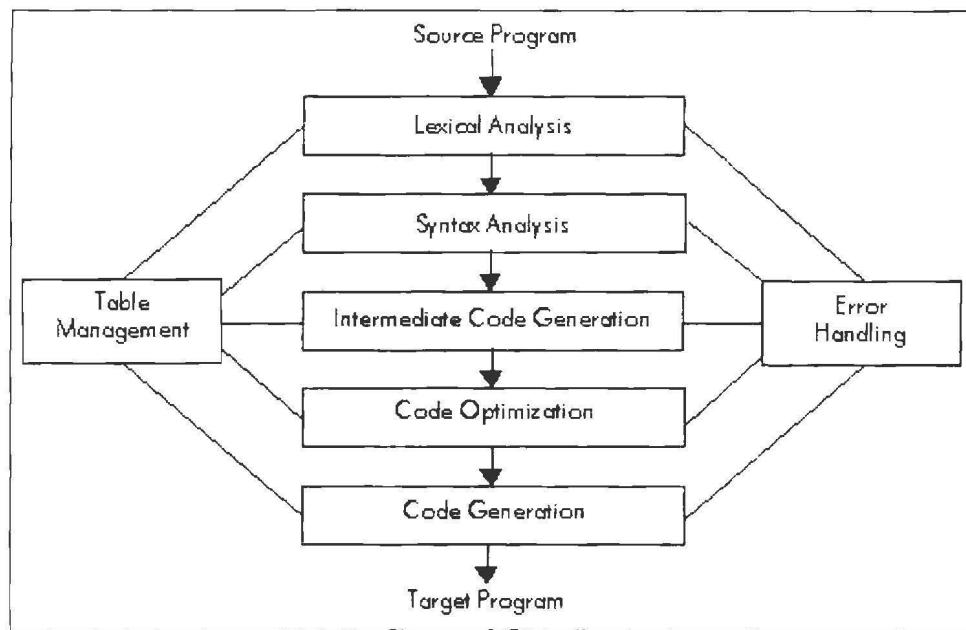
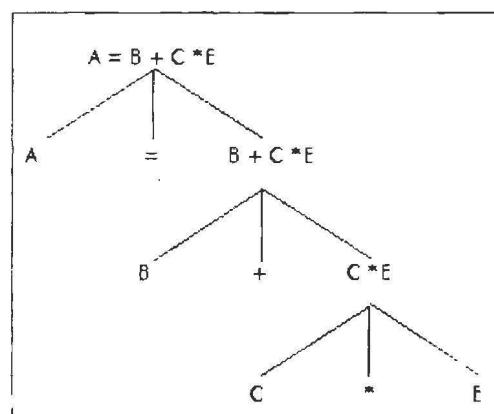


Figure 10.10: Phases of Compiler

Lexical Analyzer: Lexical analyzer reads source program characters by character and returns the tokens of the source program. The character groups, called as tokens can be a keyword, variable name, operator such as +, -, >, etc., punctuation marks like (,), ", Comma (,), etc., which in isolation provide very little meaning. For example, the plus (+) symbol shows addition but does not show the addition of what.

The output of lexical analyzer is a stream of these tokens which are just like the words of a language. This phase, checks for error in token formation and if found any, passes it to the error handling section and then, passes the token stream to the next phase of the syntax analysis.

Syntax Analyze: The syntax analyzer groups tokens together to form a set of expressions based on the grammatical rules of the programming language. Expressions can be used further to form a statement. The syntactic structure can be represented, as a tree whose leaves are tokens. The upper levels of the tree represent strings of tokens logically being together to form expressions and top of the tree (root) represents the statement.



Here A, =, B, +, C, *, E represent the leaves, C* E and B+C*E represents expressions and A = B+C*E represents a statement.

If any syntax problem occurs according to the grammar rules of the language, it is sent to the error handling phase. Then the code is passed to the next phase which is intermediate code generation.

Intermediate Code Generation: This phase uses the structures provided by the syntax analyzer and breaks them into simple instructions which can further be easily translated into machine language program. These instructions are further transferred to the code optimization or to the code generation phase if the code optimization phase is not present.

Code Optimization: Code optimization is an optional phase. It provides the facility to improve the intermediate code in such form that it provides for fast execution of the program and takes less space. The output of this phase is another intermediate code which is passed to the code generation phase.

Code Generation: This phase takes responsibility of converting the intermediate code generated by the previous phase into the machine language code known as object program or target program.

Table Management: Table management phase collects all the information of each phase, for example; what variables and intermediate variable it uses; what types of each variable and what data structures are used. All this information is stored for further use in a data structure known as ‘symbol table’.

Error Handling: Error handling is invoked when a flaw in the source program is detected. It collects information of each error in every phase and warns the programmer by issuing error code and error information by diagnosing them. The compilation should be completed on the entire program so that maximum possible errors can be detected in one compilation. It is also supposed to see that, if an error occurs due to the error in a previous line, it should be suspended. Table management and error handling phases interact with all the compilation phases.

Interpreter

An interpreter is the language translator for the third generation programming languages. Rather than generating object code for the entire source code, this class of translators examines and executes source code on a line by line basis. Each line of source code is scanned, parsed, translated and executed before moving on to the next line.

“Interpreter is smaller than compiler and facilitates the implementation of complex programming language construct by translating, interpreting and executing each line one by one.”

Assembler

Computer hardware is capable of executing an instruction only when it is presented to it in machine language. Therefore, any instruction to the computer in any language other than machine language has to be first translated into machine language instruction before it can be executed. A program written in assembly language has to be first converted into its corresponding machine code before it can be executed. The translation or code conversion is performed by the computer itself using specialized software called Assembler.

An assembler takes a program written in assembly language as input (known as source program) and generates its equivalent machine language code (known as object program) as output. During the process of translation, if any grammatical or logical errors are detected, these are suggested to user so that correction can take place before the final code conversion.

10.8.4 Some High Level Languages

FORTRAN: Formula Translation

FORTRAN was developed by IBM in 1957. It is very suitable for expressing formulae, solving equations and performing iterative calculations. FORTRAN is oriented toward solving problems of a mathematical nature and has been designed as an algebra-based programming language. It is one of the oldest and most widely used high level languages.

- FORTRAN I (1957)
- FORTRAN II & III (1958)
- FORTRAN IV (1962)
- FORTRAN 77 (1977)

It is mostly used by scientists and engineers because this language has huge libraries of engineering and scientific functions.

COBOL: Common Business-oriented Language

COBOL was designed specifically for business data processing so that the processed output could have the appearance and structure of a business report written in English. Thus it is constructed from sentences, paragraphs, sections and divisions.

All COBOL programs must have four divisions, namely, the Identification Division, the Environment Division, the Data Division and the Procedure Division. It is not oriented to real-time data processing. It takes inputs, stores them in a file and produces the output as a separate module.

BASIC: Beginner's All-Purpose Symbolic Instruction Code

BASIC was developed by John Kemeny and Thomas Kothy at Dartmouth College, USA. Interpreter is used to translate BASIC instructions into machine language code. It is a very simple and versatile language and can be used for different types of tasks like data file handling, graphics, games, etc. The various versions of BASIC language are:

- MS-BASIC
- QBASIC
- BASICA
- GW BASIC

Advantages

- Widely known and accepted programming language and easy to use.
- Uses English sentence like structures for instructions.
- Almost always coded in a real-time, conversational mode.
- Good error diagnostics.

- Minimal language standards. As a result of this there are many versions of basic language.
- Not self-structuring or self-documenting.

Pascal

PASCAL was Developed in 1968 by a Swiss named Niklaus Wirth and named after the French inventor Blaise Pascal. PASCAL was the first structured programming language which was designed to force us to look at a problem in a logical way. It was used for both scientific and file processing applications and was standardized by ANSI in 1983.

ALGOL: Algorithmic Language

ALGOL is an algebraic, high-level language similar to FORTRAN. It was designed by an international group of mathematicians and was first introduced in 1958. It is a modular language that is well suited for use in structured programming settings. It was primarily designed as a way of expressing algorithms.

PL/I: Programming Language/I

PL/I is a very versatile and powerful language developed by IBM. It was oriented towards applications which require both complex calculations and processing of large amount of data.

RPG: Report Program Generator

RPG was developed by IBM in 1969. It is an important business oriented programming language and primarily used for preparing written reports.

Advantages

- Problem oriented
- Limited programming skills required
- Easy to learn and use

APL: A Programming Language

APL was developed by Dr Kenneth Inversion at IBM. It is a convenient, interactive programming language suitable for expressing complex, mathematical expressions in compact formats. It is a real-time language developed primarily for scientific purpose. It requires a special terminal for use and is usually used in an interpretive and interactive manner.

LOGO

It was developed in late 1960s by Seymour Papert at MIT and used in Universities for serious scientific work. LOGO is also used as the first educational language that children can use to achieve intellectual growth and develop problem-solving skills. It has easy-to-learn graphics feature.

LISP: List Processing

LISP was developed in 1960 by Professor John Mc. Karthy. It is suitable for non-numeric applications and widely used in artificial intelligence projects. It is a functional language, i.e., each instruction is defined in LISP as a function.

PROLOG: Programming in Logic

PROLOG was designed for handling complex logical operations. The language is being used to design intelligent computer systems. LISP and PROLOG are the primary languages used in artificial intelligence research and applications for simulation of games.

10.8.5 Network Programming Languages

Networking programming languages are the languages which are used to write programs and can be downloaded and executed on different computers of a network. These languages are generally ‘platform independent’ languages. This means that the programs written in these languages can be executed on any operating system and on any computer. The common examples of such languages are Java, perl, etc.

10.8.6 Hypertext Mark-up Language (HTML)

HTML is the language for creating web pages which can be seen by using any web browser like Internet Explorer, Netscape Navigator, etc. This language provides formal rules for marking text which governs its display as part of the web page. It could be used, for example, to mark text so that it appears in boldface or italics. It also provides the facility to create links to the other sites and pages shown in the form of highlighted items known as hyperlinks.

10.8.7 Java as Platform Independent Language

JAVA is an object-oriented programming language developed by Sun Microsystems for writing programs for running on the internet. The programs written using JAVA can be distributed on World Wide Web (WWW) and executed on a variety of computers. Programs written in JAVA are translated by the JAVA compiler in a format called byte codes which can be executed on any computer. Programs can be developed in JAVA and the executable code can be distributed on the Internet. Anyone with a program to interpret the code can download and use the program. This feature of JAVA is known as “Architecture-Neutrality”. Web pages include small application programs written in JAVA, called APPLETS, which can perform a variety of tasks like animations, sound generation, video playback and perhaps most importantly, interaction between users.

10.8.8 Visual Languages

Development of visual programming languages is one more step in the direction of making it easier for non-computer professionals to make use of computers for solving their problems. Use of visual representation makes man-computer interface more user-friendly and easy to use. The term “visual programming” has been used to imply the use of graphic tools and techniques in connection with programming.

A visual programming language can be defined as a language which uses some visual representations (in addition to or in place of words and numbers like buttons, check boxes, list boxes, etc.) to accomplish what would otherwise have to be written in a traditional linear programming language. Visual programming languages utilize visual representation of two things:

1. Programming constructs and various ways of combining these basic constructs to develop complex problem-solving logic, are visually presented.
2. Various objects to be dealt with as part of the problem-solving process, including traditional data types such as arrays, stacks, queues, and application-oriented data types, etc., are also presented visually.

- Computer Graphics
- User Interface Design
- Database Interface
- Forms Management
- Computer-aided Design

Listed below are some of the well-known visual programming languages:

1. Pygmalion
2. The Xerox Star
3. Programming by Rehearsal
4. Pict
5. Vennlisp
6. State Transition Diagram Language
7. Pascal-HSD
8. Programming with Interactive Graphical Support (PIGS)
9. Formal
10. Query-by-Example (QBE)
11. Visual Basic (VB)
12. Visual C++ (VC++)
13. Visual Java (VJ++)

Visual Basic and Visual C++ are the most widely used visual languages in the current world but the usage of Visual Java is also growing very rapidly and it is becoming very popular due to platform independence. It is used in Internet as Network Programming Language.

10.8.9 Visual C++

Visual C++ is a highly Integrated Development Environment (IDE) that allows you to create, build and debug Windows applications faster than ever before. It also serves as a fully functional vehicle for cross platform applications development. There are two major features which account for growing popularity of C++.

1. The Visual C++ environment itself runs in Windows so that the full set of Windows based tools become available to create and manage projects and applications in Windows.
2. The Visual C++ uses visual user interface to facilitate the task of developing new applications.

The core of the Visual C++ environment is built around three basic components.

1. The C/C++ Compiler and Linker
2. The Developer Studio
3. The Microsoft Foundation Class Library (MFC)

10.8.10 VJ++

Visual Java is one of the most powerful Internet products. VJ++ is a programming environment based on GUI rather than CUI. It provides integrated and workable Java tools to develop the application programs. It simplifies the process of creating Java applets and applications and adds the power of Microsoft Wizard to speed up Java application development. It is useful in both Internet application developments as well as in stand-alone application.

10.8.11 Visual Basic

Visual Basic is a full-featured, very high level programming language. Visual refers to the way in which you develop an application's user interface. You "draw" windows, buttons, text boxes, scroll bars and other components of the user interface. Basic refers to the type of programming code you write; the familiar BASIC language code.

Visual BASIC is the software development environment that enables you to develop Windows applications quickly and easily. Using Visual Basic, you develop "event-driven", rather than "procedural" programs.

In a procedural program, the program itself determines which portions of the code are to be executed and when. In an event-driven program, events (i.e., user actions such as a mouse click, or system events such as the passage of a specified amount of time) determine which portions of the code are to be executed and when. Program execution depends on which and when events occur.

Advantages of Visual Languages

In general, people prefer pictures over words as they are a more powerful means of communication -they convey large information more concisely and more clearly. Pictures are easily understood by people regardless of what language they speak. It facilitates and encourages end user participation in system development.

10.9 FOURTH GENERATION LANGUAGES (4GLS)

Fourth Generation Languages are a class of software designed to simplify the task of developing a new application by making the user interface similar to natural languages. These are very easy to use languages. Some 4GLs are designed to improve the productivity of programming professionals while others are designed to be used directly by the end user.

Fourth-generation programming languages are high-level languages built around database systems. They are generally used in commercial environments.

- ABAP
- CorVision
- CSC's GraphTalk
- Easytrieve report generator (now CA-Easytrieve Plus)
- FOCUS
- IBM Informix-4GL/Aubit-4GL
- LINC 4GL
- MAPPER (Unisys/Sperry) - now part of BIS
- MARK-IV (Sterling/Informatics) now VISION:BUILDER of CA
- Progress 4GL

- LiveCode (not based on a database; still, the goal is to work at a higher level of abstraction than 3GLs)
- SAS
- Ubercode (VHLL, or Very High Level Language)
- Uniface
- Visual DataFlex
- Visual FoxPro
- xBase

4GLs are designed more for specification of what tasks to be accomplished as compared to third generation procedural languages which focus on how to solve a problem. These languages are developed for the purpose of making database management more efficient and are also known as database management systems. Database Management System (DBMS) is a concept to construct, organize and manipulate a large set of data in a best possible way.

In 4GLs the task could be accomplished by giving a single instruction as follows:

Display all for employee name = "David" from employee master file.

Many fourth generation languages either incorporate a query language or support a standard query language like SQL, which can be used to interact with the database.

e.g.: SQL statement for the above illustration will be:

[Select * from employee_master where emp_name = "David".]

NOTE * means all the fields of record.

Advantages

- Easy to use; little or no computer knowledge is required.
- Machine independent.
- Enhanced programming productivity.
- Ease of modification and maintenance of data.
- Good documentation.

Disadvantages

- 4GL programs are less efficient from the computer resource utilization point of view.
- Programmers become less skilled over a period of time.
- Security standards are difficult to enforce in 4GL environment.

10.9.1 Popular 4GLs

The organization storage and management of ever-increasing quantity of information is a major problem facing modern organizations. A number of 4GL tools have been developed to address this problem efficiently. Using popular 4GL packages, users can store vast quantities of data on the computer which can be retrieved easily either individually or organized in the form of various reports. In this section, we are going to highlight major features of some of the most widely used 4GLs.

dBase

Dbase (or later versions) is a database management system designed for use on microcomputers in DOS operating system environment. It has been developed by Ashton-Tate Inc. (USA). A maximum of 15 files can be used at a time. In dbase five types of data fields are permissible.

Field type	Code	Size	
1. Character	(C)	255	
2. Numeric	(N)	19	in which last 9 digits are for fractions
3. Date	(D)		8 it is taken by system automatically
4. Memo	(M)		
5. Logical	(Y/N) OR (T/F)	1	

It has a series of English-like commands using which data stored in the database can be manipulated.

e.g.: Create, Append, Display, List, Edit, Browse, Replace, Delete, Sort, etc.

Following operations can be performed in dbase:

- Creation of database.
- Editing of data in the database.
- Selective access and retrieval of data from the database.
- Manipulation of data using arithmetic and logical operators.
- Programming using its command language.

Foxbase

It is a database management system similar to but more powerful than dbaseIII+. It is developed by Fox Software Inc. (USA). Foxbase is completely source code compatible with dbase, i.e., files created in dbase can run with Foxbase without any modifications. It is significantly faster than dbase in execution, also it can run on a variety of hardware and operating systems environments including DOS and UNIX.

FoxPro

FoxPro is one of the leading DBMS for PCs. It is an updated and enhanced version of the Foxbase software and very simple and easy to use. It helps you design database files as per user requirements and user specified formats and helps you in creating and managing database effectively through simple built-in commands. The retrieved information can be displayed on the screen or printed as per the desired report format. Flexibility is one of the key features of FoxPro i.e., contents and the structure of foxPro file can be changed any number of times with ease.

Focus

Focus was one of the largest selling 4GL DBMS tool, at one time, but now it is not used widely due to a very complex structure and slow performance. The command structure of Focus was also very typical.

Fill in the blanks:

1. _____ is sometimes used as a detailed step in the process of developing a program.
2. In modular approach, large program is divided into many small discrete components called _____.
3. _____ are a way to classify programming languages based on their features.
4. The _____ is a process of steps, used by programmers to more efficiently manage their time in designing error-free programs that produce the desired output.

10.10 LET US SUM UP

- Language is the main tool of communication among people. A computer understands a special language called machine language. Writing a machine language program involves clerical chores. To alleviate this, assembly languages were developed. The assembly language for a computer uses mnemonics to represent operation codes and symbolic addresses instead of absolute numerical addresses.
- Knowledge is a combination of information, experience and insight that may benefit the individual or the organisation.
- Good information is relevant for its purpose, sufficiently accurate for its purpose, completes enough for the problem, reliable and targeted to the right person.
- Programs can be characterized as interactive or batch in terms of what drives them and how continuously they run.
- Programming languages are unambiguous, while natural languages are often multiply ambiguous and require interpretation in context to be fully understood (also why it's so hard to get machines to understand them).
- High-level languages were developed to allow application programs to be run on a variety of computers. These languages are machine independent and procedure oriented. One statement in a high-level language would be translated into many statements in its machine language equivalent. Every high level language has precise rules of syntax and semantics. The most commonly used high level languages are FORTRAN, COBOL, BASIC, PASCAL, C, C++, Java, RPG, LISP, and SNOBOL.
- Object oriented programming is becoming popular as it allows reuse of old code and program generalization. C++ is an object oriented language.
- Programming languages are unambiguous, while natural languages are often multiply ambiguous and require interpretation in context to be fully understood (also why it's so hard to get machines to understand them).
- An algorithm is a procedure or formula for solving a problem, based on conducting a sequence of specified actions.
- Program flowchart is a diagram which uses a set of standard graphic symbols to represent the sequence of coded instructions fed into a computer, enabling it to perform specified logical and arithmetical operations.

- Non-procedural languages concentrate on precisely defining specifications rather than detailed procedure to realize specifications. PROLOG is an important non-procedural language. A good programming language should be easy to learn and understand, should be user-friendly, easy to debugs, its subprograms should be reusable, should be portable, secure and take less execution time.
- 4GLs are designed for specification of what tasks to be accomplished as compared to third generation procedural languages which focuses on how to solve a problem. Some popular 4GLs include Foxpro, dBase, Foxbase and iFocus.
- Visual programming languages uses some visual representations to accomplish what would otherwise have to be written in a traditional linear programming language. Some of such languages are Visual C++, VJ++, Visual Basic, etc.

10.11 UNIT END ACTIVITY

Make a list of network programming language and high level languages.

10.12 KEYWORDS

Assembler: System software that translates assembly language into machine language.

Assembly Language: A lower-level programming language that is slightly more user-friendly than machine language; represent the second generation of programming language.

Compiler: A software program that translates a high-level language program to object code.

Data: Facts, a description of the World.

High Level Language: Computer language in which each statement is translated into many machine language statements.

Information: Captured Data and Knowledge.

Interpreter: A compiler that translates and executes one source program statement at a time.

Knowledge: Our personal map/model of the World.

Linker: Software that converts the object code into a load module that can be placed in memory and run by assigning memory address to various parts of the program.

Loader: Software used to bypass the step of creating a loadable module and places the object module directly into memory for execution.

Machine Language: The lowest level programming language, using binary digits, which is the only language the CPU understands; represents the first generation of programming language.

Object-oriented Language: Programming language that encapsulates a small amount of data along with instructions about how to manipulate that data; inheritance and reusability features provide functional benefits.

Procedures: The strategies, policies, methods and rules for using an information system.

Sub-program: Part of a program which can be created and executed independently.

10.13 QUESTIONS FOR DISCUSSION

1. What do you understand by programming? Describe the features of programming languages.
2. Write down the classification and generation of programming languages with examples.
3. What is a low level language? Describe in detail.
4. Write down the programming concepts of procedural languages.
5. Differentiate between:
 - (a) Compiler and Interpreter
 - (b) Low Level Language and High Level Language
 - (c) Assembler and Compiler
 - (d) Linker and Loader
 - (e) 4th Generation and 2nd Generation Languages
6. Write short notes on:

(a) Syntax analyzer	(b) Code optimization
(c) Code generation	(d) Table management
(e) Visual programming languages	(f) Visual basic
7. What is compiler based and interpreter based language?
8. Make a list of 4th Generation language and explain Visual C++ language.
9. What do you understand by Pseudocode, algorithm, program and flowcharts?
10. Explain the programming development cycle in detail.

Check Your Progress: Model Answer

1. Pseudocode
2. Modules
3. Programming paradigms
4. Programming development cycle

10.14 REFERENCES & SUGGESTED READINGS

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BLOCK-IV

UNIT-11

COMPUTER VIRUS'S

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11.0 AIMS AND OBJECTIVES

After studying this lesson, you should be able to:

- Know about the basics of computer virus
- Discuss the activation of virus
- Explain the history of virus
- Learn about how damages are caused by virus
- Discuss the mechanism of virus
- Describe how a virus spreads
- Elaborate how is virus named

- List out the types of computer virus
 - Know about antivirus programs
 - Analyse Norton AntiVirus (NAV)
 - Understand execution of Norton AntiVirus
-

11.1 INTRODUCTION

A computer virus, much like a flu virus, is designed to spread from host to host and has the ability to replicate itself. Similarly, in the same way as viruses cannot reproduce without a host cell, computer viruses cannot reproduce and spread without programming such as a file or document. In this lesson, we will discuss basics of computer virus, activation of virus and history of virus.

Damages caused by virus, mechanism of virus, how a virus spreads, how is virus named will be discussed in this lesson. Lastly, we will elaborate types of computer viruses, antivirus programs, Norton AntiVirus (NAV) and execution of Norton AntiVirus.

11.2 BASICS OF COMPUTER VIRUS

A computer virus is a program, script, or macro designed to cause damage, steal personal information, modify data, send e-mail, display messages or some combination of these actions.

When the virus is executed, it spreads by copying itself into or over data files, programs, or boot sector of a computer's hard drive, or potentially anything else writable. To help spread an infection the virus writers use detailed knowledge of security vulnerabilities, zero days, or social engineering to gain access to a host's computer.

A computer virus resides on a host computer and can replicate itself when executed. Virus can steal user data, delete or modify files and documents, records keystrokes and web sessions of a user. It can also steal or damage hard disk space, it can slowdown CPU processing.

11.2.1 Activation of Virus

When the computer virus starts working, it is called the activation of virus. A virus normally runs all the time in the computer. Different viruses are activated in different ways. Many viruses are activated on a certain date. For example, a popular virus "Friday, the 13th" is activated only if the date is 13 and the day is Friday.

11.2.2 Damages Caused by Virus

Computer virus cannot damage computer hardware. IT may cause many damages to a computer system. A virus can:

- Damage data or software on the computer.
- Delete some or all files on the computer system.
- Destroy all the data by formatting hard drive.
- Display a politically wrong or false message.

11.3 HISTORY OF VIRUS

Computers and computer users are under assault by hackers like never before, but computer viruses are almost as old as electronic computers themselves. Most people use the term "computer virus" to refer to all malicious software, which we call malware. Computer Viruses are actually just one type of malware, self-replicating programs designed to spread itself from computer to computer. A virus is, in fact, the earliest known malware invented.

The following is a history of some of the most famous viruses and malwares ever:

- **1949–1966 – Self-Reproducing Automata:** Self-replicating programs were established in 1949, to produce a large number of viruses, John von Neumann, whose known to be the "Father of Cybernetics", wrote an article on the "Theory of Self-Reproducing Automata" that was published in 1966.
- **1959 – Core Wars:** A computer game was programmed in Bell Laboratory by Victor Vaysotsky, H. Douglas McIlroy and Robert P Morris. They named it Core Wars. In this game, infectious programs named organisms competed with the processing time of PC.
- **1971 – The Creeper:** Bob Thomas developed an experimental self-replicating program. It accessed through ARPANET (The Advanced Research Projects Agency Network) and copied to remote host systems with TENEX operating system. A message displayed that, "I'm the creeper, catch me if you can!". Another program named Reaper was created to delete the existing harmful program the Creeper.
- **1974 – Wabbit (Rabbit):** This infectious program was developed to make multiple copies of itself on a computer clogging the system reducing the performance of the computer.
- **1974 – 1975 – ANIMAL:** John Walker developed a program called ANIMAL for the UNIVAC 1108. This was said to be a non-malicious Trojan that is known to spread through shared tapes.
- **1981 – Elk Cloner:** A program called the "Elk Cloner" was developed by Richard Skrenta for the Apple II Systems. This was created to infect Apple DOS 3.3. These programs started to spread through files and folders that are transferred to other computers by floppy disk.
- **1983 –** This was the year when the term "Virus" was coined by Frederick Cohen for the computer programs that are infectious as it has the tendency to replicate.
- **1986 – Brain:** This is a virus also known as the "Brain boot sector", that is compatible with IBM PC was programmed and developed by two Pakistani programmers Basit Farooq Alvi, and his brother, Amjad Famoq Alvi.
- **1987 – Lehigh:** This virus was programmed to infect command.com files from Yale University.
- **Cascade:** This virus is a self-encrypted file virus which was the outcome of IBM's own antivirus product.
- **Jerusalem Virus:** This type of virus was first detected in the city of Jerusalem. This was developed to destroy all files in infected computers on the thirteenth day that falls on a Friday.
- **1988 – The Morris Worm:** This type of worm was created by Robert Tappan Morris to infect DEC VAX and Sun machines running BSD UNIX through the

Internet. This is best known for exploiting the computers that are prone to buffer overflow vulnerabilities.

- **1990 – Symantec** launched one of the first antivirus programs called the Norton Antivirus, to fight against the infectious viruses. The first family of polymorphic virus called the Chameleon was developed by Ralf Burger.
- **1995 – Concept:** This virus name concept was created to spread and attack Microsoft Word documents.
- **1996 – A macro virus** known as Laroux was developed to infect Microsoft Excel Documents. A virus named Baza was developed to infect Windows 95 and Virus named Staog was created to infect Linux.
- **1998 – CIH Virus:** The first version of CIH viruses was developed by Chen Ing Hau from Taiwan.
- **1999 – Happy99:** This type of worm was developed to attach itself to e-mails with a message Happy New Year. Outlook Express and Internet Explorer on Windows 95 and 98 were affected.
- **2000 – ILOVEYOU:** The virus is capable of deleting files in JPGGs, MP2 or MP3 formats.
- **2001 – Anna Kournikova:** This virus was spread by e-mails to the contacts in the compromised address book of Microsoft Outlook. The emails purported to contain pictures of the very attractive female tennis player, but in fact hid a malicious virus.
- **2002 – LFM-926:** This virus was developed to infect Shockware Flash files.
- **Beast or RAT:** This is backdoor Trojan horse and is capable of infecting all versions of Windows OS.
- **2004 – MyDoom:** This infectious worm also called the Novang. This was developed to share files and permitted hackers to access to infected computers. It is known as the fastest mailer worm.
- **2005 – Samy XX4:** This type of virus was developed to spread faster and it is known to infect the Windows family.
- **2006 – OSX/Leap-A:** This was the first ever known malware discovered against Mac OS X.
- **Nyxem:** This type of worm was created to spread by mass-mailing, destroying Microsoft Office files.
- **2007 – Storm Worm:** This was a fast spreading e-mail spamming threat against Microsoft systems that compromised millions of systems.
- **Zeus:** This is a type of Trojan that infects used capture login credentials from banking web sites and commits financial fraud.
- **2008 – Koobface:** This virus was developed and created to target Facebook and MySpace users.
- **2010 – Kenzero:** It is a virus that spreads online between sites through browsing history.
- **2013 – Cryptolocker:** This is Trojan horse encrypts the files infected machine and demands a ransom to unlock the files.
- **2014 – Backoff:** Malware designed to compromise Point-of-Sale (POS) systems to steal credit card data.

The operations and functions of computer virus are given here.

11.4.1 Parts

A viable computer virus must contain a search routine, which locates new files or new disks which targets infection. Secondly, every computer virus must contain a routine to copy itself into the program which the search routine locates. The three main virus parts are as follows:

1. **Infection Mechanism:** Infection mechanism (also called ‘infection vector’), is how the virus spreads or propagates. A virus typically has a search routine, which locates new files or new disks for infection.
2. **Trigger:** The trigger, which is also known as logic bomb, is the compiled version that could be activated any time an executable file with the virus is run that determines the event or condition for the malicious “payload” to be activated or delivered such as a particular date, a particular time, particular presence of another program, capacity of the disk exceeding some limit, or a double-click that opens a particular file.
3. **Payload:** The “payload” is the actual body or data that perform the actual malicious purpose of the virus. Payload activity might be noticeable (e.g., because it causes the system to slow down or “freeze”), as most of the time the “payload” itself is the harmful activity, or sometimes non-destructive but distributive, which is called Virus hoax.

11.4.2 Phases

Virus phases are the life cycle of the computer virus, described by using an analogy to biology. This life cycle can be divided into four phases:

1. **Dormant Phase:** The virus program is idle during this stage. The virus program has managed to access the target user’s computer or software, but during this stage, the virus does not take any action. The virus will eventually be activated by the “trigger” which states which event will execute the virus, such as a date, the presence of another program or file, the capacity of the disk exceeding some limit or the user taking a certain action (e.g., double-clicking on a certain icon, opening an e-mail, etc.). Not all viruses have this stage.
2. **Propagation Phase:** The virus places an identical copy of itself into other programs or into certain system areas on the disk. Each infected program will now contain a clone of the virus, which will itself enter a propagation phase. A virus will typically not propagate to another infected program.

The virus starts propagating, that is multiplying and replicating itself. The virus places a copy of itself into other programs or into certain system areas on the disk. The copy may not be identical to the propagating version; viruses often “morph” or change to evade detection by IT professionals and anti-virus software. Each infected program will now contain a clone of the virus, which will itself enter a propagation phase.

3. **Triggering Phase:** The virus is activated to perform the function for which it was intended. This can be caused by a variety of system events. A dormant virus moves into this phase when it is activated, and will now perform the function for which it was intended. The triggering phase can be caused by a variety of system

events, including a count of the number of times that this copy of the virus has made copies of itself.

4. **Execution Phase:** This is the actual work of the virus, where the “payload” will be released. It can be destructive such as deleting files on disk, crashing the system, or corrupting files or relatively harmless such as popping up humorous or political messages on screen.

11.5 HOW A VIRUS SPREADS?

The following are the main causes of a computer virus:

Infected Flash Drives or Disks

Flash drives and disks are the main cause of spreading viruses. Flash drives and disks are used to transfer data from one computer to other. A virus can also be copied from one computer to other when the user copies infected files using flash drives and disks.

Email Attachments

Most of the viruses spread through e-mails. E-mail attachment is a file that is sent along with an e-mail. An e-mail may contain an infected file attachment. Virus can spread if the users open and download an e-mail attachment. It may harm the computer when it is activated. It may destroy files on the hard disk or may send the virus automatically to all e-mail addresses saved in the address book.

Infected/Pornography Websites

Thousands of insecure websites can infect computer with viruses. Most of the websites with pornographic materials are infected, so by visiting these websites the user's computer also gets infected by virus. These websites are developed to spread viruses or other unethical material. The virus is transferred to the user's computer when this material is downloaded. These websites may access the computer automatically when the users visit them.

Networks

Virus can spread if an infected computer is connected to a network. The internet is an example of such network. When a user downloads a file infected with virus from the Internet, the virus is copied to the computer. It may infect the files stored on the computer.

Pirated Software

An illegal copy of software is called pirated software. Virus can spread if user installs pirated software that contains a virus. A variety of pirated software is available in CDs and from the Internet. Some companies intentionally add virus in the software. The virus is automatically activated if the user uses the software without purchasing license.

11.6 HOW IS VIRUS NAMED?

Heartbleed, Melissa, Klez, Nimda, and Sasser—all of these innocent sounding words could ruin your computer, steal your information and impact your digital life forever. These computer viruses and system vulnerabilities are the best at what they do: breaking stuff. But how did these terrors get their names?

There is not one standardized way to name viruses. These are not hurricanes, there's no master list to turn to, and no authority that watches over them to regulate them.

Instead, there are three main avenues for virus naming: when the name is given to the virus as part of its programming; when the vector by which the virus is spread determines the name; and when vulnerability is found and then named after the fact, usually by its discoverer.

When viruses got around mainly through the forwarding of e-mails, the name of the threat would be based on the file name of the attachment. One of the worst viruses ever seen was called "ILOVEYOU." It spread like wildfire because of the pleasant sounding e-mail subject and attachment (Love-letter-for-you.txt). The happy attachment turned out to be malicious code that overwrote existing files with copies of itself.

Koobface and Vundo were named after the method by which they were spread. Koobface, an anagram of Facebook, was a worm that spread through the social media site. Vundo was a combination of Virtual and Mundo ("world" in Spanish), and it spread through virtual communities.

Then, there are vulnerabilities like Heartbleed. Heartbleed was a bug found in the OpenSSL encryption service. The line of code that contained the glitch was CVE-2014-0160 — not exactly the most memorable name. Ossi Herrala, a system administrator at Codenomicon (the company which found the bug) came up with the name. Vocativ reported that Herrala, "thought it was fitting to call it Heartbleed because it was bleeding out the important information from the memory." Because Heartbleed was such a terrible bug — security expert Bruce Schneier ranked it an 11 on a scale of 1 to 10 — it needed solid branding to get the attention it deserved. The catchy named Heartbleed, linked with the bleeding heart logo and a user-friendly website, was the perfection combination of marketing. It received the attention it needed, causing thousands of affected websites to construct patches and users to change passwords in record time.

As for some of the kookier named viruses, there's always a story behind it, usually as unique as the program itself. Melissa, one of the fastest-spreading viruses ever, was named after a stripper programmer David Smith. The Michelangelo virus would only activate on March 6th, the artist's birthday. Many have taken on the name of the celebrity who you are promised naked pictures of if only you click on a suspicious link. Some virus names are just glorification for their developer: Samy Kumar named the Samy Worm after himself, and the CIH virus is the initials of its developer, Chen Ing Hau.

Regardless of how delightful the name is, be sure to run virus screenings regularly, and backup your data. I LOVE YOU affected over 50 million users and cost the U.S. \$15 billion to remove.

11.7 TYPES OF COMPUTER VIRUS

The following are a few prominent viruses:

CryptoLocker

When it comes to malware, ransomware is the new kid on the block. While most people can rattle off names like 'Trojan', 'viruses' and 'spyware', they're often not too familiar with ransomware.

Ransomware is a kind of malware that takes your files hostage. You know in heist movies when the bad guy grabs someone and threatens them in return for money? Ransomware works much like that, except your computer is taken hostage by a faceless bad guy.

Released in September 2013, CryptoLocker spread through e-mail attachments and encrypted the user's files so that they could not access them.

The hackers then sent a decryption key in return for a sum of money, usually somewhere from a few hundred pounds up to a couple of grand.

ILOVEYOU

While ILOVEYOU sounds like a cheerful bon mot you might find printed on the inside of a Valentine's Day card, it's actually far, far more sinister than that. ILOVEYOU is one of the most well-known and destructive viruses of all time.

It's been 15 years since ILOVEYOU was let loose on the Internet. By today's standards it's a pretty tame virus, but in 2000 it was the most damaging malware event of all time. Likely, ILOVEYOU inspired many hackers to wield their keyboard as a weapon.

MyDoom

MyDoom is considered to be the most damaging virus ever released—and with a name like MyDoom would you expect anything less?

MyDoom, like ILOVEYOU, is a record-holder and was the fastest-spreading e-mail-based worm ever. MyDoom was an odd one, as it hit tech companies like SCO, Microsoft, and Google with a Distributed Denial of Service attack.

A version of the virus allegedly hit the SCO website with a boatload of traffic in an attempt to crash its servers.

Storm Worm

Storm Worm was a particularly vicious virus that made the rounds in 2006 with a subject line of '230 dead as storm batters Europe'. Intrigued, people would open the email and click on a link to the news story and that's when the problems started.

Storm Worm was a Trojan horse that infected computers, sometimes turning them into zombies or bots to continue the spread of the virus and to send a huge amount of spam mail.

Anna Kournikova

Anna Kournikova was one of the most searched terms on the Internet. People were just very into tennis.

Jan De Wit, a 20-year-old Dutch man, wrote the virus as 'a joke'. The subject was "Here you have, ;)" with an attached file called AnnaKournikova.jpg.vbs. Anna was pretty harmless and did not do much actual damage, though De Wit turned himself into police anyway.

CodeRed

It is a worm that infects a computer running Microsoft IIS server. This virus launched DOS attack on White House's website. It allows the hacker to access the infected computer remotely.

Nimba

It is a worm that spreads itself using different methods. IT damages computer in different ways. It modified files, alters security settings and degrades performance.

While most of the malware on this list strictly hit computers, Slammer was created with broader ambitions. Slammer is the kind of virus that makes it into films, as only a few minutes after infecting its first victim, it was doubling itself every few seconds. 15 minutes in and Slammer had infected half of the servers that essentially ran the Internet.

The Bank of America's ATM service crashed, 911 services went down, and flights had to be cancelled because of online errors. Slammer, quite aptly, caused a huge panic as it had effectively managed to crash the Internet in 15 quick minutes.

Stuxnet

Stuxnet is easily the scariest virus on the list as it was built by government engineers in the US with the intention of obstructing nukes from being built in Iran. Stuxnet is the first real venture into cyberwar and it definitely asks the question as to what will come next.

SirCam

It is distributed as an email attachment. It may delete files, degrade performance and send the files to anyone.

Melisa

It is a virus that is distributed as an email attachment. It disables different safeguards in MS Word. It sends itself to 50 people if Microsoft Outlook is installed.

Ripper

It corrupts data from the hard disk.

MDMA

It is transferred from one MS Word file to other if both files are in memory.

Concept

It is also transferred as an email attachment. It saves the file in template directory instead of its original location.

One_Half

It encrypts hard disk so only the virus may read the data. It displays One_Half on the screen when the encryption is half completed.

11.8 ANTIVIRUS PROGRAMS

Antivirus programs are designed to provide ultimate protection against potential hazards a person might face while browsing the Internet. These programs work by identifying dangerous security threats that could compromise the performance of a computer. Antivirus software is also aimed at preventing security issues that often arise while using a computer, including the prevalent threat of identity theft.

Every day, there are growing concerns to address regarding computer security. Ensuring computer security in the workplace and in the home has become a priority of individuals and businesses. This is primarily due to the continuous threat of new computer viruses and malicious software, or malware that emerge on a daily basis.

An antivirus program works by maintaining a type of surveillance within a network. The virus program with antispyware will continuously check for threats from malware. The computer user has the option of running a quick virus scan, thus eradicating the most common low-risk problems found.

There are several steps involved in the process an antivirus program employs to identify a potential threat to a computer. Considering there are new viruses, worms and spyware threats surfacing on the Internet regularly, subscribing to an antivirus program does not necessarily mean protection is complete. That is why, it is believed crucial to maintain regular updates for continuous protection.

Other possible features of an antivirus program might include the addition of firewall protection. The antivirus software and firewall work in conjunction to form a barrier of protection, keeping intruders and hackers from gaining access to personal information. A antivirus program with complete protection can protect computer users against becoming victims of identity theft.

After the antivirus program is installed, the user will need to register the product. When set-up is complete, the software will begin to work instantaneously. A good program will carefully monitor the computer and ultimately eliminate any viruses, spyware and threats that are found. Virus detection found on the antivirus program will typically be isolated at first. The user will then have the option of removing the danger or keeping the infected file in isolation.

It's important to note that an antivirus program should specifically inform the consumer which operating systems are compatible with the software. Many older operating systems might not be compatible with the latest programs on the market. Typically, this information is available for consumer knowledge before downloading the antivirus software.

11.9 NORTON ANTIVIRUS (NAV)

Norton Antivirus is anti-malware software developed and distributed by Symantec Corporation since 1991 as part of its Norton family of computer security products. It uses signatures and heuristics to identify viruses. Other features included in it are e-mail spam filtering and phishing protection.

Symantec distributes the product as a download, a box copy, and as OEM software. Norton AntiVirus and Norton Internet Security, a related product, held a 61% US retail market share for security. Competitors, in terms of market share in this study, include antivirus products from CA, Trend Micro, and Kaspersky Lab.

Norton AntiVirus runs on Microsoft Windows and macOS. Windows 7 support was in development for versions 2006 through 2008. Version 2009 has Windows 7 supported update already. Versions 2010, 2011, and 2012 all natively support Windows 7, without needing an update. Version 12 is the only version fully compatible with Mac OS X Lion. With the 2015 series of products, Symantec made changes in its portfolio and briefly discontinued Norton AntiVirus. This action was later reversed with the introduction of Norton AntiVirus Basic.

11.9.1 Origin of Norton AntiVirus

In May 1989, Symantec launched Symantec Antivirus for the Macintosh (SAM). SAM 2.0, released March 1990, incorporated technology allowing users to easily update SAM to intercept and eliminate new viruses, including many that did not exist at the time of the program's release.

In August 1990 Symantec acquired Peter Norton Computing from Peter Norton. Norton and his company developed various DOS utilities including the Norton

Utilities, which did not include antivirus features. Symantec continued the development of acquired technologies. The technologies are marketed under the name of "Norton", with the tagline "from Symantec". Norton's crossed-arm pose, a registered U.S. trademark, was traditionally featured on Norton product packaging. However, his pose was later moved to the spine of the packaging, and eventually dropped altogether.

By early 1991, U.S. computers were invaded by hundreds of foreign virus strains and corporate PC infection was becoming a serious problem. Symantec's Norton Group launched Norton AntiVirus 1.0 (NAV) for PC and compatible computers. Ads for the product, with suggested retail \$129, featured Norton in his crossed-arm pose, wearing a pink shirt and surgical mask covering his nose and mouth.

With the 1998 version 5.0 update, SAM was renamed Norton AntiVirus (NAV) for Macintosh.

11.10 EXECUTION OF NORTON ANTIVIRUS

Since a successful exploit of this issue allows malicious code to execute in web clients, consider disabling support for script code and active content within the client browser. Note that this mitigation tactic might adversely affect legitimate websites that rely on the execution of browser-based script code.

11.10.1 How to Run Norton AntiVirus from the Command Prompt?

Certain malware applications consume valuable resources that critical services and applications need to operate. Worms, for example, can cause a spike in central processing unit and RAM usage, slowing your computer to a crawl. Rather than perform a virus scan in Norton AntiVirus, which requires significant available resources partly because of its graphical user interface, run a Quick Scan or Full System Scan from the command prompt using the Nav32.exe application. You can also initiate the scan in CMD if you are running resource-intensive software and do not want Norton AntiVirus to interfere or cause decreased PC performance.

1. Press "Windows-E" to open File Explorer. Browse through "C:\Program Files\Norton Antivirus\Engine\[X]\," where "[X]" represents the version of Norton AntiVirus, such as 18.5.0.125 or 19.2.0.10.
2. Select the address bar and then press "Ctrl-C" to copy the folder path to the clipboard. Press "Windows-R" to open Run.
3. Type "cmd:" (without the quotes here and throughout) into the input field and click "OK" to launch Command Prompt.
4. Type "C:" into the console and press "Enter" to go to the C: drive.
5. Type "cd" and right-click inside the console. Select "Paste" from the context menu and press "Enter."
6. Type "navw32.exe" and press the "Spacebar." Type "/A" to scan all drives, "/L" to scan the local drive, "/BOOT" to scan the boot records, or "/QUICK" to perform a Quick Scan. For example, type: navw32.exe /L
7. Press "Enter" to perform the virus scan in CMD.

Check Your Progress

Fill in the blanks:

1. _____ is a file that is sent along with an email. An email may contain an infected file attachment.
2. Virus phases are the life cycle of the _____, described by using an analogy to biology.
3. When the computer virus starts working, it is called the _____ of virus. A virus normally runs all the time in the computer.
4. Computer Viruses are actually just one type of _____, self-replicating programs designed to spread itself from computer to computer.

11.11 LET US SUM UP

- A computer virus is a program, script, or macro designed to cause damage, steal personal information, modify data, send e-mail, display messages or some combination of these actions.
- When the computer virus starts working, it is called the activation of virus. A virus normally runs all the time in the computer.
- Computer Viruses are actually just one type of malware, self-replicating programs designed to spread itself from computer to computer.
- 1983 – This was the year when the term “Virus” was coined by Frederick Cohen for the computer programs that are infectious as it has the tendency to replicate.
- 2014 – Backoff: Malware designed to compromise Point-of-Sale (POS) systems to steal credit card data.
- A viable computer virus must contain a search routine, which locates new files or new disks which are worthwhile targets for infection.
- Virus phases are the life cycle of the computer virus, described by using an analogy to biology.
- Flash drives and disks are the main cause of spreading viruses. Flash drives and disks are used to transfer data from one computer to other.
- Email attachment is a file that is sent along with an email. An email may contain an infected file attachment.
- Released in September 2013, CryptoLocker spread through email attachments and encrypted the user’s files so that they could not access them.
- MyDoom is considered to be the most damaging virus ever released.
- Antivirus programs are designed to provide ultimate protection against potential hazards a person might face while browsing the Internet.
- Norton AntiVirus is anti-malware software developed and distributed by Symantec Corporation since 1991 as part of its Norton family of computer security products.
- Certain malware applications consume valuable resources that critical services and applications need to operate.

11.12 UNIT END ACTIVITY

Make a list of computer virus. Why should you not open email messages from unknown or untrusted individuals?

11.13 KEYWORDS

Anna Kournikova: This virus was spread by emails to the contacts in the compromised address book of Microsoft Outlook.

Antivirus Programs: These are designed to provide ultimate protection against potential hazards a person might face while browsing the Internet.

Backoff: Malware designed to compromise Point-of-Sale (POS) systems to steal credit card data.

CIH Virus: The release of the first version of CIH viruses developed by Chen Ing Hau from Taiwan.

ILOVEYOU: The virus is capable of deleting files in JPEGs, MP2, or MP3 formats.

Infection Mechanism: It is how the virus spreads or propagates.

MyDoom: This infectious worm also called the Novang. This was developed to share files and permits hackers to access to infected computers. It is known as the fastest mailer worm.

Norton AntiVirus: It is anti-malware software developed and distributed by Symantec Corporation since 1991 as part of its Norton family of computer security products.

Payload: It is the actual body or data that perform the actual malicious purpose of the virus.

Virus: It can steal user data, delete or modify files & documents, records keystrokes & web sessions of a user.

Wabbit (Rabbit): This infectious program was developed to make multiple copies of itself on a computer clogging the system reducing the performance of the computer.

11.14 QUESTIONS FOR DISCUSSION

1. What is the name of the viruses that fool a user into downloading and/or executing them by pretending to be useful applications?
2. How do you update your antivirus program?
3. What is a computer virus? Explain the history of virus in brief.
4. What software can be used against viruses and how does it function?
5. How do you explain the activation of virus?
6. What are the main damages caused by virus? What are the main types of computer virus?
7. Explain the mechanism of virus and also define parts and phase of mechanism of virus.
8. Explain how a virus spreads. How is virus named?
9. What do you understand by antivirus programs? Explain Norton AntiVirus (NAV).
10. Describe execution of Norton AntiVirus. How do you run Norton AntiVirus from the command prompt?

Check Your Progress: Model Answer

1. Email attachment
2. Computer virus
3. Activation
4. Malware

11.15 REFERENCES & SUGGESTED READING

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COMMUNICATION AND IT

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12.0 AIMS AND OBJECTIVES

After studying this lesson, you should be able to:

- Learn about computer network
- Discuss the characteristics of a computer network
- Know about communication process
- Explain communication types
- Describe transmission media
- Explain communication channels/media
- List out the characteristics of a modem
- Learn about the types of modem

12.1 INTRODUCTION

A network is an arrangement in which two or more computers are connected in such a way, so that they are able to communicate with each other. With a network, computers can receive electronic mail (e-mail); send files and instant messages to each other. In a network, the computers are connected by network cables through which data is transferred in the form of signals. Today, communication between computers is not restricted to physical cables. Wireless networks allow computers to exchange information by radio signals. In this lesson, we will discuss computer network, characteristics of a computer network and communication process. We will also learn communication types, transmission media and communication channels/media. Lastly, we will explain modem, characteristics of a modem and types of modem.

12.2 COMPUTER NETWORK

A computer network is a system in which multiple computers are connected to each other to share information and resources.

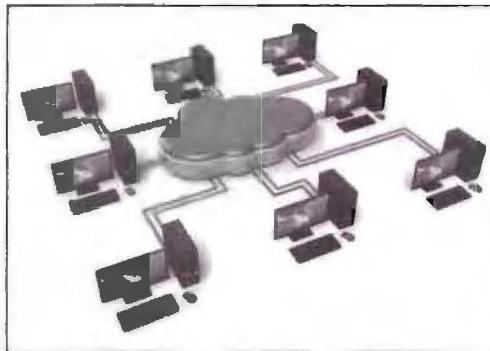


Figure 12.1: Computer Network

12.2.1 Characteristics of a Computer Network

- Share resources from one computer to another.
- Create files and store them in one computer, access those files from the other computer(s) connected over the network.
- Connect a printer, scanner or a fax machine to one computer within the network and let other computers of the network use the machines available over the network.

12.3 COMMUNICATION PROCESS

The goal of communication is to convey information—and the understanding of that information—from one person or group to another person or group.

Seven major elements of communication process are: (1) Sender, (2) Ideas, (3) Encoding, (4) Communication channel, (5) Receiver, (6) Decoding and (7) Feedback.

Communication may be defined as a process concerning exchange of facts or ideas between persons holding different positions in an organisation to achieve mutual harmony. The communication process is dynamic in nature rather than a static phenomenon.

Communication process as such must be considered a continuous and dynamic interaction, both affecting and being affected by many variables.

1. **Sender:** The person who intends to convey the message with the intention of passing information and ideas to others is known as sender or communicator.
2. **Ideas:** This is the subject matter of the communication. This may be an opinion, attitude, feelings, views, orders or suggestions.
3. **Encoding:** Since the subject matter of communication is theoretical and intangible, its further passing requires use of certain symbols such as words, actions or pictures, etc. Conversion of subject matter into these symbols is the process of encoding.
4. **Communication Channel:** The person who is interested in communicating has to choose a channel for sending the required information, ideas, etc. This information is transmitted to the receiver through certain channels which may be either formal or informal.
5. **Receiver:** Receiver is the person who receives the message or for whom the message is meant for. It is the receiver who tries to understand the message in the best possible manner in achieving the desired objectives.
6. **Decoding:** The person who receives the message or symbol from the communicator tries to convert the same in such a way so that he may extract its meaning to his complete understanding.
7. **Feedback:** Feedback is the process of ensuring that the receiver has received the message and understood in the same sense as sender meant it.

12.4 COMMUNICATION TYPES

Computer networks can be classified based on interconnected computers by scale-LAN, MAN and WAN.

Local Area Network (LAN)

This technology connects people and machines within a site. A Local Area Network (LAN) is a network that is confined to a relatively small area. Local Area Networks (LANs) are most often described as privately owned networks that offer reliable high speed communication channels optimized for connecting information processing equipment in a limited geographical area.

Metropolitan Area Network (MAN)

It may include cities or school districts. By interconnecting smaller networks within a large geographic area, information is easily disseminated throughout the network.

Wide Area Network (WAN)

You must understand that this technology connects sites that are in diverse locations. Wide Area Networks (WANs) may connect larger geographic areas such as New Delhi, India or the world.

12.5 TRANSMISSION MEDIA

This section will help you understand the concept of transmission of media. You can define data transmission as the movement of data in the form of bits among two or more digital devices. This transmission of data occurs through some form of transmission media. The transmission medium, in a data transmission system, is the physical path between transmitter and receiver. In case of guided media, the electromagnetic waves are guided along a solid medium, like copper twisted pair,

copper coaxial cable and optical fibre. In case of unguided media, wireless transmission takes place via the atmosphere, water, etc.

12.5.1 Guided Transmission Media

It is important for you to note that guided transmission media or bounded media or wired transmission systems employ physical media, which are tangible. Also known as conducted systems, wired media generally employ a metallic or glass conductor which serves to conduct some form of electromagnetic energy.

Example: Twisted pair and coaxial cable systems conduct electrical energy, employing a copper medium. Fibre optic systems conduct light or optical energy, generally using a glass conductor.

The term 'bounded or guided media' refers to the fact that the signal is contained within an enclosed physical path. Finally, bounded media refers to the fact that some form of shield, cladding, and/or insulation is employed to bind the signal within the core medium, thereby improving signal strength over a distance and enhancing the performance of the transmission system in the process. Twisted pair (both unshielded and shielded), coaxial and fibre optic cable systems fall into this category.

Twisted Pair (Copper Conductors)

As you can see in Figure 12.2, a twisted pair is a pair of copper wires, with diameters of 0.4–0.8 mm, twisted together and wrapped with a plastic coating. The twisting increases the electrical noise immunity, and reduces the error rate of the data transmission. Each conductor is separately insulated by some low-smoke and fire retardant substance. Polyethylene, polyvinyl chloride, fluoropolymer resin and Teflon are the substances that are used for insulation purposes.



Figure 12.2: Two Wires Open Lines

This twisting process serves to improve the performance of the medium by containing the electromagnetic field within the pair. Thereby, the radiation of electromagnetic energy is reduced and the strength of the signal within the wire is improved over a distance. Clearly, this reduction of radiated energy also serves to minimise the impact on adjacent pairs in a multiple cable configuration. This is especially important in high-bandwidth applications, as higher frequency signals tend to lose power more rapidly over distance. Additionally, the radiated electromagnetic field tends to be greater at higher frequencies, impacting adjacent pairs to a greater extent. Generally speaking, the more twists per foot, the better the performance of the wire.

These are popular for telephone network. The energy flow is in guided media. Metallic wires were used almost exclusively in telecommunications networks for the last 80 years, until the development of microwave and satellite radio communications systems. Use of copper wire is now a mature technology, rugged and inexpensive. In certain applications, copper-covered steel, copper alloy, nickel- and/or gold-plated copper and even aluminium metallic conductors are employed. The maximum transmission speed is limited in this case.

The copper conductor that carries analogue data can be used to carry digital data also in association with Modem. Modem is a device to convert digital signal into analogue signal and vice versa. The data rate in this category is limited to around 28 Kbps. The introduction of the Integrated Services Digital Network (ISDN) led to the use of

improved modulation and coding schemes and data rate up to 128 Kbps. Local Area Networks (LANs) also use twisted pairs. These networks also upgraded to support for high bit rate real time multimedia.

A recent development is Asymmetric Digital Subscriber Lines (ADSL) technology which is aimed at using two wire copper loops at data rates of 1.544 Mbps in the network to user direction and about 600 Kbps from the user to network.

The twisted pair cable may be defined in two categories based upon the shielding and without shielding. You will now understand the concept of these categories:

- **Unshielded Twisted Pair (UTP):** UTP as depicted in Figure 12.3 is the copper media, inherited from telephony, which is being used for increasingly higher data rates, and is rapidly becoming the *de facto* standard for horizontal wiring. Horizontal wiring specifies the connection between, and including, the outlet and the termination in the communication closet. The horizontal is limited to a maximum of 90 meters. This is independent of the media type so that the communication closet is common to all media and all applications operating over the media. In addition, there is an allowance for 3 meters in the work area and 6 meters for cross connecting in the closet for a total of 99 meters.

The recommended media and connectors for the horizontal are:

- ❖ 100-ohm unshielded twisted pair – 4 pairs, 8-pin modular connector (ISDN).
- ❖ 150-ohm shielded twisted pair – 2 pairs (IBM connector or RJ45).
- ❖ 50-ohm coax (thin) – IEEE 10BASE2, standard BNC connector.
- ❖ 62.5/125 multi-mode fibre.

You must understand that a UTP cable contains from 2 to 4200 twisted pairs. The advantages of UTP are the flexibility, low cost media, and can be used for either voice or data communications. Its greatest disadvantage is the limited bandwidth, which restricts long distance transmission with low error rates.

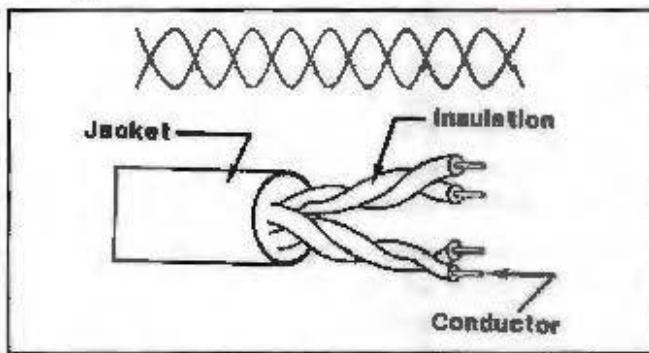


Figure 12.3: Unshielded Twisted Pair (UTP)

- **Shielded Copper or STP:** Shielded Twisted Pair (STP) differs from UTP in that a metallic shield or screen surrounds the pairs, which may or may not be twisted. As you can see in Figure 12.4, the pairs can be individually shielded. A single shield can surround a cable containing multiple pairs or both techniques can be employed in tandem. The shield itself is made of aluminium, steel or copper. This is in the form of a metallic foil or woven meshes and is electrically grounded. Although less effective, the shield sometimes is in the form of nickel and/or gold plating of the individual conductors.

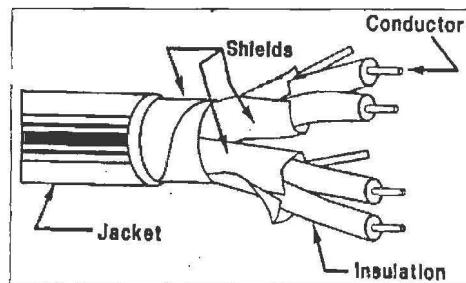


Figure 12.4: Shielded Twisted Pair (STP) Configuration

Shielded copper offers the advantage of enhanced performance for reasons of reduced emissions and reduction of electromagnetic interference. Reduction of emissions offers the advantage of maintaining the strength of the signal through the confinement of the electromagnetic field within the conductor. In other words, signal loss is reduced. An additional benefit of this reduction of emissions is that high-frequency signals do not cause interference in adjacent pairs or cables. Immunity from interference is realized through the shielding process, which reflects electromagnetic noise from outside sources, such as electric motors, other cables and wires, and radio systems.

Shielded twisted pair, on the other hand, has several disadvantages. Firstly, the raw cost of acquisition is greater as the medium is more expensive to produce. Secondly, the cost of deployment is greater as the additional weight of the shield makes it more difficult to deploy. Additionally, the electrical grounding of the shield requires more time and effort.

The general properties of twisted pair are as follows:

1. **Gauge:** Gauge is a measure of the thickness of the conductor. The thicker the wire, the less the resistance, the stronger the signal over a given distance, and the better the performance of the medium. Thicker wires also offer the advantage of greater break strength. The gauge numbers are retrogressive. In other words, the larger is the number, the smaller is the conductor.
2. **Configuration:** In a single pair configuration, the pair of wires is enclosed in a sheath or jacket, made of polyethylene, polyvinyl chloride or Teflon. Usually, multiple pairs are so bundled in order to minimize deployment costs associated with connecting multiple devices (e.g., electronic PBX or KTS telephone sets, data terminals and modems) at a single workstation.
3. **Bandwidth:** The effective capacity of twisted pair cable depends on several factors, including the gauge of the conductor, the length of the circuit and the spacing of the amplifiers/repeaters. One must also recognize that a high-bandwidth (high frequency) application may cause interference with other signals on other pairs in close proximity.
4. **Error Performance:** Signal quality is always important, especially relative to data transmission. Twisted pair is especially susceptible to the impacts of outside interference, as the lightly insulated wire act as antennae and, thereby, absorbs such errant signals. Potential sources of Electro Magnetic Interference (EMI) include electric motors, radio transmissions and fluorescent light boxes. As transmission frequency increases, the error performance of copper degrades significantly with signal attenuation increasing approximately as the square root of frequency.

5. **Distance:** Twisted pair is distance limited. As distance between network elements increases, attenuation (signal loss) increases and quality decreases at a given frequency. As bandwidth increases, the carrier frequency increases, attenuation becomes more of an issue, and amplifiers/repeaters must be spaced more closely.
6. **Security:** Twisted pair is inherently an insecure transmission medium. It is relatively simple to place physical taps on UTP. Additionally, the radiated energy is easily intercepted through the use of antennae or inductive coils, without the requirement for placement of a physical tap.
7. **Cost:** The acquisition, deployment and rearrangement costs of UTP are very low, at least in inside wire applications. In high-capacity, long distance applications, such as inter-office trunking, however, the relative cost is very high, due to the requirements for trenching or boring, conduit placement, and splicing of large, multi-pair cables. Additionally, there are finite limits to the capacity and other performance characteristics of UTP, regardless of the inventiveness of technologists. Hence, the popularity of alternatives such as microwave and fibre-optic cable.
8. **Applications:** UTP's low cost including recently developed methods of improving its performance has increased its application in short-haul distribution systems or inside wire applications. Current and continuing applications include the local loop, inside wire and cable, and terminal-to-LAN. Generally speaking, UTP no longer is deployed in long haul or outside the premises transmission systems.

The additional cost of shielded copper limits its application to inside wire applications. Specifically, it is generally limited to application in high-noise environments. It also is deployed where high frequency signals are transmitted and there is concern about either distance performance or interference with adjacent pairs.

Example: LANs and image transmission.

Optical Fibre

It is important to note that the geometry of coaxial cable significantly reduces the various limiting effects, the maximum signal frequency, and hence the information rate that can be transmitted using a solid conductor, although very high, is limited. This is also the case for twisted lines. Optical fibre differs from both these transmission media in that it carries the transmitted information in the form of a fluctuating beam of light in a glass fibre rather than as an electrical signal on a wire. This type of transmission has become strong support for digital network owing to its high capacity and other factors favourable for digital communication.

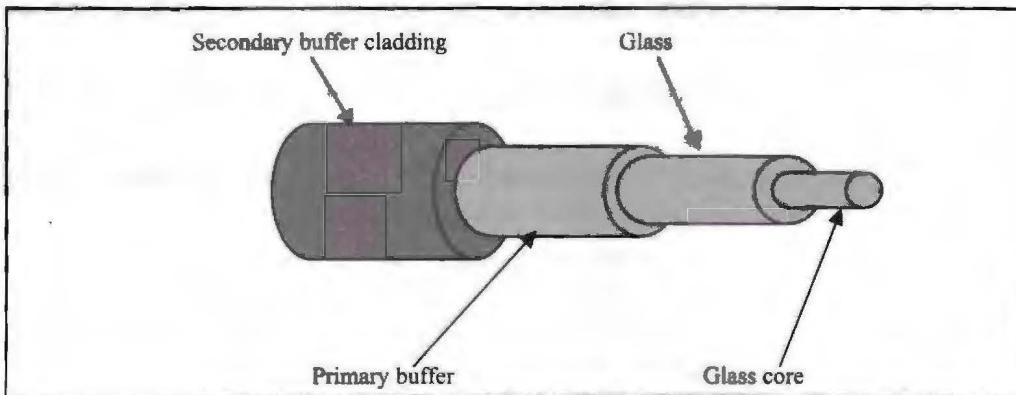


Figure 12.5: Fibre Optic Cables – General View

Fibre optic transmission systems are opto-electric in nature. In other words, a combination of optical and electrical electromagnetic energy is involved. The signal originates as an electrical signal, which is translated into an optical signal, which subsequently is reconverted into an electrical signal at the receiving end. Thin glass fibre as shown in Figure 12.5 is very clear and designed to reflect light internally for efficient transmission carries light with encoded data. Plastic jacket allows fibre to bend (some!) without breaking. Light Emitting Diode (LED) or laser injects light into fibre for transmission. Light sensitive receiver at other end translates light back into data.

The optical fibre consists of a number of substructures as shown in Figure 12.6. In this case, a core made of glass, which carries most of the light is surrounded by a cladding made of glass with lower refractive index. This bends the light and confines it to the core. The core is surrounded by a substrate layer (in some fibres) of glass, which does not carry light, but adds to the diameter and strength of the fibre. A primary buffer coating and a secondary buffer coating to provide mechanical protection cover all these.

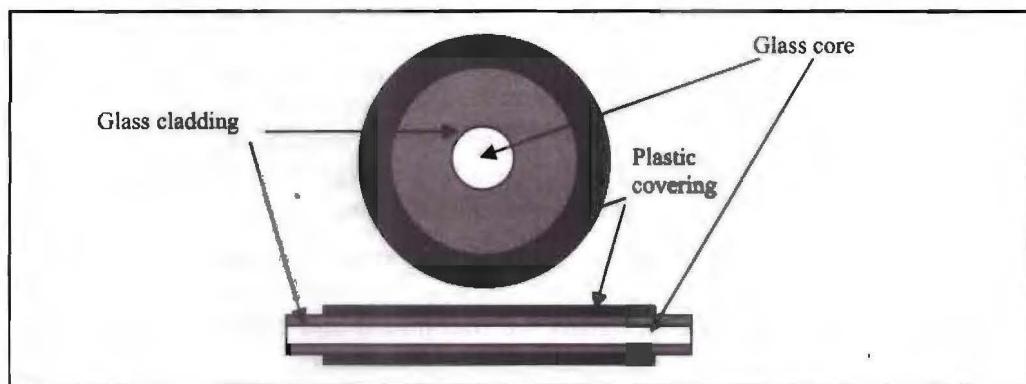


Figure 12.6: Glass Fibre Optic Cable, Side View and Cross Section

The light pulse travels down the centre core of the glass fibre. Surrounding the inner core is a layer of glass cladding, with a slightly different refractive index. The cladding serves to reflect the light waves back into the inner core. Surrounding the cladding is a layer of protective plastic coating that seals the cable and provides mechanical protection. This is shown in Figure 12.6.

Examples:

- Fibre-optic cables are used in the telephone system, the cable TV system or the Internet. Fibre-optic cables are basically the strands of optically pure glass that carry long distances digital information. Optical cables appear to be as thin as human hair.
- Optical fibres are also used in mechanical engineering inspection and medical inspection.

Light propagates along the optical fibre core in one of the following ways as given below depending on the type and width of core material used.

- **Multimode Fibre:** In the case of a multimode fibre, the core diameter is relatively large compared to a wavelength of light. Core diameter ranges from 50 micrometres (μm) to 1,000 μm , compared to the wavelength of light of about 1 μm . This means that light can propagate through the fibre in many different ray paths, or modes, hence the name multimode.

Multimode fibre is less expensive to produce and inferior in performance because of the larger diameter of the inner core. When the light rays travel down the fibre,

they spread out due to a phenomenon known as modal dispersion. Although reflected back into the inner core by the cladding, they travel different distances and, therefore, arrive at different times. The received signal thus has a wider pulse width than the input signal with a corresponding decrease in the speed of transmission. Consequently, multimode fibre is relegated to applications involving relatively short distances and lower speeds of transmission, for example, LANs and campus environments.

You must keep in mind the two basic types of multimode fibres exist. The simpler and older type is a "step index" fibre, where the index of refraction (the ability of a material to bend light) is the same all across the core of the fibre.

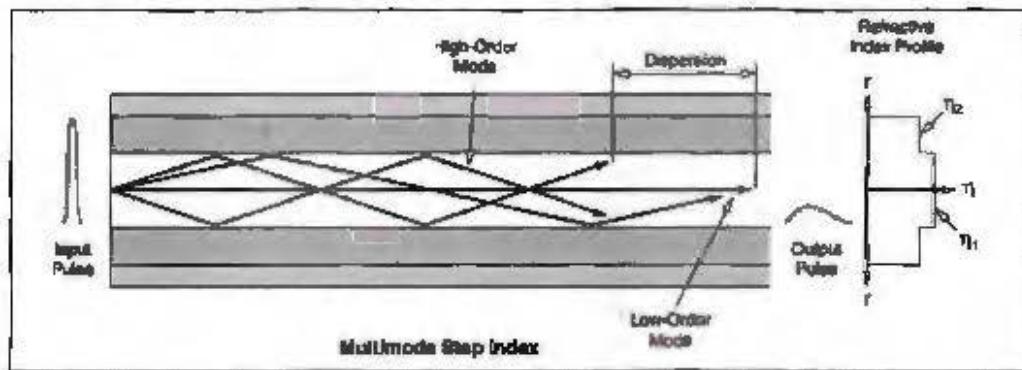


Figure 12.7: Multimode Step Index Fibre

- ❖ **Step Index Multimode Fibre:** This is shown to you in Figure 12.7. With all these different ray paths or modes of propagation, different rays travel different distances, and take different amounts of time to transit the length of a fibre. This being the case, if a short pulse of light is injected into a fibre, the various rays emanating from that pulse will arrive at the other end of the fibre at different times, and the output pulse will be of longer duration than the input pulse. This phenomenon is called "modal dispersion" (pulse spreading), and limits the number of pulses per second that can be transmitted down a fibre and still be recognisable as separate pulses at the other end. This, therefore, limits the bit rate or bandwidth of a multimode fibre. For step index fibres, wherein no effort is made to compensate for modal dispersion, the bandwidth is typically 20 to 30 MHz over a length of one kilometre of fibre, expressed as "MHz - km".
- ❖ **Graded Index Multimode Fibre:** In the case of a graded index multimode fibre, the index of refraction across the core is gradually changed from a maximum at the centre to a minimum near the edges, hence the name graded index. This design takes advantage of the phenomenon that light travels faster in a low-index-of-refraction material than a high-index material. If a short pulse of light is launched into the graded index fibre, it may spread some during its transit of the fibre, but much less than in the case of a step index fibre. Therefore, dispersion can be reduced using a core material that has a variable refractive index. In such multimode graded index fibre light is refracted by an increasing amount as it moves away from the core as shown in Figure 12.8. This has the effect of narrowing the pulse width of the received signal compared with stepped index fibre, allowing a corresponding increase in the speed of transmission. They therefore can support a much higher bit rate or bandwidth.

It will be important for you to know typical bandwidths of graded index fibres range from 100 MHz-km to well over 1GHz-km. The actual bandwidth

depends on how well a particular fibre's index profile minimises modal dispersion, and on the wavelength of light launched into the fibre.

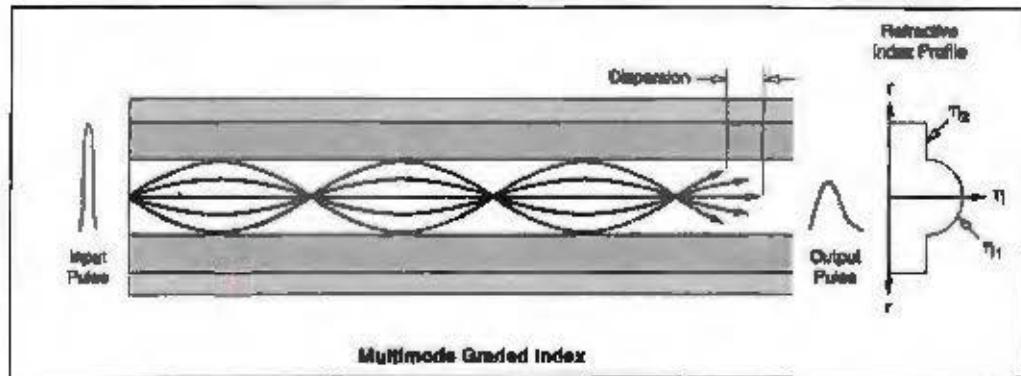


Figure 12.8: Light Propagation in Multimode Graded Index Fibre

- **Monomode/Single-mode fibre:** This has a thinner inner core. In this case, the core diameter of about $9 \mu\text{m}$ is much closer in size to the wavelength of light being propagated, about $1.3 \mu\text{m}$. This limits the light transmission to a single ray or mode of light to propagate down the core of the fibre as shown in Figure 12.9. All the multiple-mode or multimode effects described above are eliminated. However, one pulse-spreading mechanism remains. Just as in the multimode fibres, different wavelengths of light travel at different speeds, causing short pulses of light injected into the fibre to spread as they travel. This phenomenon is called "chromatic dispersion".

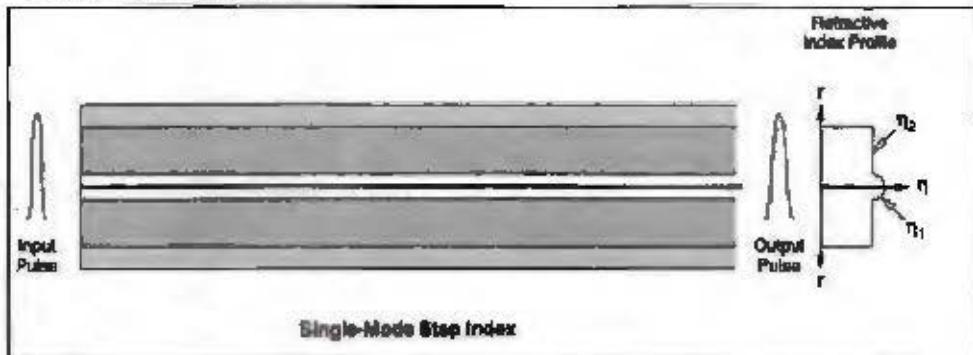


Figure 12.9: Light Propagation in Single Mode Step Index Fibre

It performs better than does multimode fibre over longer distances at higher transmission rates. Due to reduced core diameter all the emitted light propagates along a single path. Consequently the received signal is of a comparable width to the input signal. Although more costly, monomode fibre is used to advantage in long haul, and especially in high bandwidth, applications.

Single-mode fibres have the very broadest bandwidth, lowest cost and lowest attenuation of any available optical fibre. Therefore, they are universally used in long-distance telephony and cable television applications.

The advantages of optical fibres are as under:

- Immunity to electromagnetic interference and crosstalk
- No electrical ground loop or short circuit problems
- Small size and light-weight
- Large bandwidth for size and weight
- Safe in combustible areas (no arcing)

- Immunity to lightning and electrical discharges
- Longer cable runs between repeaters
- Flexibility and high strength
- Potential high temperature operation
- Secure against signal leakage and interference
- No electrical hazard when cut or damaged.

The general properties of optical fibre are as follows:

- **Configuration:** Fibre optic systems consist of light sources, cables and light detectors, as depicted in Figure 12.10. In a simple configuration, one of each is used. In a more complex configuration over longer distances, many such sets of elements are employed. Much as is the case in other transmission systems, long haul optical communications involves a number of regenerative repeaters. In a fibre optic system, repeaters are opto-electric devices. On the incoming side of the repeater, a light detector receives the optical signal, converts it into an electrical signal, boosts it, converts it into an optical signal, and places it onto a fibre, and so on. There may be many such optical repeaters in a long haul transmission system, although typically far fewer than would be required using other transmission media.

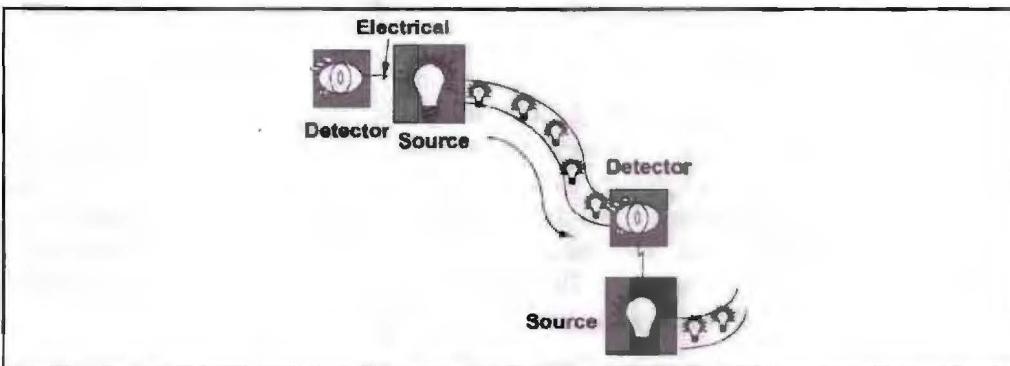


Figure 12.10: Fibre Optic System

- **Bandwidth:** Fibre offers by far the greatest bandwidth of any transmission system, often in excess of 2 Gbps in long haul carrier networks. Systems with 40 Gbps have been tested successfully on numerous occasions. The theoretical capacity of fibre is in the terabit (Tbps) range, with current monomode fibre capacity being expandable to that level.
- **Error Performance:** Fibre being a dielectric (a non-conductor of direct electric current), it is not susceptible to Electro Magnetic Interference/Radio Frequency Interference (EMI/RFI). This also does not emit EMI/RFI. The light signal will suffer from attenuation, although less so than other media. Scattering of the optical signal, bending in the fibre cable, translation of light energy to heat, and splices in the cable system can cause such optical attenuation.
- **Distance:** Monomode fibre optic systems are capable of transmitting signals over distances in excess of 325 km. Therefore, relatively few optical repeaters are required in a long-haul system. This will reduce costs, and eliminating points of potential failure.
- **Security:** Fibre is intrinsically secure, as it is virtually impossible to place a physical tap without detection because no light is radiated outside the cable. Therefore, interception of signal is almost impossible. Additionally, the fibre

system supports such a high volume of traffic that it is difficult to intercept and distinguish a single transmission from the tens of thousands of other transmissions that might ride the same cable system. The digital nature of most fibres, coupled with encryption techniques frequently are used to protect transmission from interception, make fibres highly secure.

- **Cost:** While the acquisition, deployment, and rearrangement costs of fibre are relatively high, the immense bandwidth can outweigh that cost in bandwidth-intensive applications. At Gbps speeds, a single set of fibres can carry huge volumes of digital transmissions over longer distances than alternative systems, thereby lowering the transport cost per bit and cost per conversation to fractions of a penny per minute.
- **Applications:** Applications for fibre optic transmission systems are bandwidth intensive. Such applications include backbone carrier networks, international submarine cables, backbone LANs (FDDI), interoffice trunking, computer-to-computer distribution networks (CATV and Information Superhighway) and fibre to the desktop (Computer Aided Design).

12.5.2 Unguided or Wireless Transmission

You must understand that wireless transmission systems do not make use of a physical conductor, or guide, to bind the signal. In this case, data are transmitted using electromagnetic waves. Therefore, they are also known as unguided or unbounded systems. Energy travels through the air rather than copper or glass. Hence the term radiated often is applied to wireless transmission. Finally, such systems employ electromagnetic energy in the form of radio or light waves that are transmitted and received across space, and are referred to as airwave systems. The transmission systems addressed under this category include microwave, satellite and infrared. There are different techniques to convert the data suitable for this mode of communication. Conceptually similar to radio, TV, cellular phones, radio waves can travel through walls and through an entire building. They can travel for long distance using satellite communication or short distance using wireless communication.

Use of this technology for delivery of real time applications like multimedia material should be treated carefully, because radio links are susceptible to fading, interference, random delays, etc.

Non-real time use of this technology is likely to perform as well as current Ethernet LANs.

Radio Transmission

It is a method where data is transmitted through radio waves and energy travels through the air instead of copper or glass ware. Conceptually, radio, TV, cellular phones, etc., use radio transmission in one type or another. The radio waves will travel through walls and through a complete building. Relying upon the frequency, they will travel long distance or short distance.

Example: Satellite relay is the one example of long distance communication.

Therefore, you must keep in mind that each frequency range is divided into different bands, which has a specific range of frequencies in the Radio Frequency (RF) spectrum. The RF is divided in different ranges starting from Very Low Frequencies (VLF) to Extremely High Frequencies (EHF). Figure 12.11 shows each band with a defined upper and lower frequency limit.

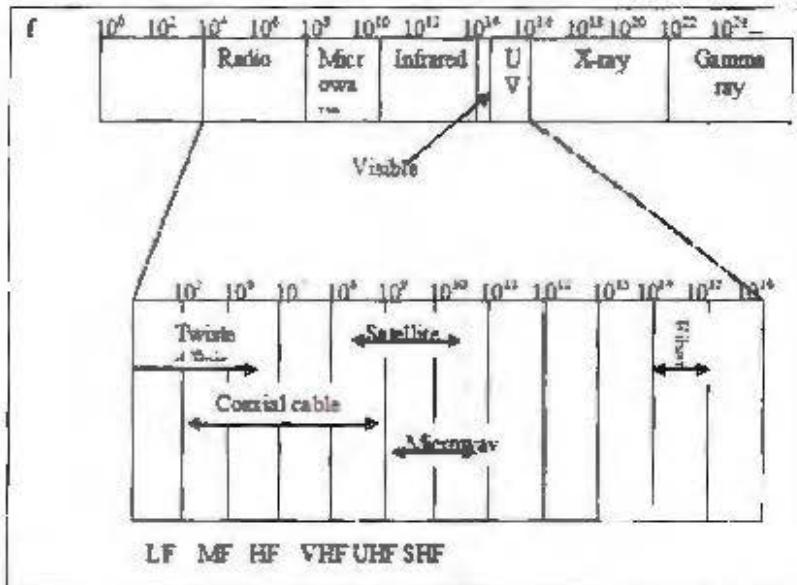


Figure 12.11: Radio Frequency Range and Types of Transmission Media

You must also note that two transmitters cannot share the same frequency band because of mutual interference and therefore band usage is regulated. International use of the radio spectrum is regulated by the International Telecommunication Union (ITU). Domestic use of the radio spectrum is regulated by national agencies such as Wireless Planning and Coordination (WPC) in India. WPC assigns each transmission source a band of operation, a transmitter radiation pattern, and a maximum transmitter power. Omni directional or directional antennas are used to broadcast radio waves depending upon band. The transceiver unit, which is consisted of transmitter and receiver along with the antenna, determines the power of RF signal. Other characteristics of radio waves are that in vacuum all electromagnetic waves or radio waves travel at the same speed i.e. at the speed of light which is equal to 3×10^8 meter per seconds. In any medium, this speed gets reduced and also becomes frequency dependent. In case of copper, the speed of light becomes approximately two thirds of the speed of light.

Examples:

- **Audio:** AM radio uses amplitude modulation, i.e., AM radio is processed through radio waves. FM radio sends music and voice with higher fidelity than AM radio.
- **Telephony:** Mobile phones transmit to a local cell site (transmitter/receiver) which leads to the working of mobiles in the network area only. Its working is done through optic fibre or microwave radio and other network elements.
- **Video:** Television sends the picture as AM and the sound as AM or FM.
- **Heating:** Heating of objects is basically processed by the radio-frequency energy generated for it. Microwave ovens use radio waves to heat food.

The basic features of the radio waves are given below:

- They are easy to generate.
- They have same velocity in vacuum.
- They may traverse long distances.
- They are omni-directional.
- They can penetrate building easily so they find extensive use in communication both indoor and outdoor.

- They are frequency dependent. At low frequency, they can pass through obstacles well but the power falls off sharply with distance from the source, as power is inversely proportional to cube of the distance from the source. At HF, they travel in straight lines and bounce off obstacles.

Microwave Transmission

It is essential for you to know that microwave radio, a form of radio transmission that uses ultra-high frequencies, developed out of experiments with radar (radio detecting and ranging) during the period preceding World War II. There are several frequency ranges assigned to microwave systems, all of which are in the Giga Hertz (GHz) range and the wavelength in the millimetre range. This very short wavelength gives rise to the term microwave. Such high frequency signals are especially susceptible to attenuation and, therefore must be amplified or repeated after a particular distance.

In order to maximise the strength of such a high frequency signal and, therefore, to increase the distance of transmission at acceptable levels, the radio beams are highly focused. The transmit antenna is centred in a concave, reflective metal dish which serves to focus the radio beam with maximum effect on the receiving antenna, as illustrated in Figure 12.12. The receiving antenna, similarly, is centred in a concave metal dish, which serves to collect the maximum amount of incoming signal.

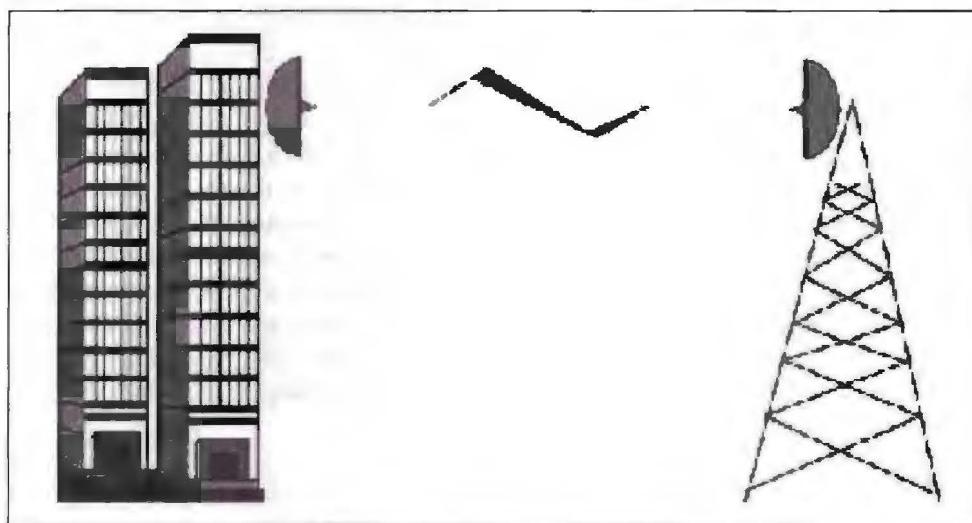


Figure 12.12: Point-to-point Microwave

It is a point-to-point, rather than a broadcast, transmission system. Additionally, each antenna must be within line of sight of the next antenna. Given the curvature of the earth, and the obvious problems of transmitting through it, microwave hops generally are limited to 50 miles (80 km). If the frequencies are higher within the microwave band given in Table 12.1. This impact is more than lower frequencies in the same band.

Table 12.1: Microwave Frequency Bands

Frequency Bands	Maximum Antenna Separation	Analogue/Digital
4–6 GHz	32–48 Km	Analogue
10–12 GHz	16–24 Km	Digital
18–23 GHz	8–11 Km	Digital

The general properties of microwave transmission are as under:

- **Configuration:** Microwave radio consists of antennae centred within reflective dishes that are attached to structures such as towers or buildings. Cables connect the antennae to the actual transmit/receive equipment.
- **Bandwidth:** Microwave offers substantial bandwidth, often in excess of 6 Gbps.
- **Error Performance:** Microwave, especially digital microwave, performs well in this regard, assuming proper design. However, such high frequency radio is particularly susceptible to environmental interference e.g., precipitation, haze, smog, and smoke. Generally speaking, however, microwave performs well in this regard.
- **Distance:** Microwave clearly is distance limited, especially at the higher frequencies. This limitation can be mitigated through special and more complex arrays of antennae incorporating spatial diversity in order to collect more signals.
- **Security:** As is the case with all radio systems, microwave is inherently not secure. Security must be imposed through encryption (scrambling) of the signal.
- **Cost:** The acquisition, deployment and rearrangement costs of microwave can be high. However, it often compares very favourably with cabled systems, which require right-of-way, trenching, conduit, splicing, etc.
- **Applications:** Microwave originally was used for long haul voice and data communications. Competing long distance carriers, microwave was found a most attractive alternative to cabled systems, due to the speed and low cost of deployment where feasible, however, fibre optic technology is currently used in this regard. Contemporary applications include private networks, interconnection of cellular radio switches, and as an alternative to cabled systems in consideration of difficult terrain.

Satellite Communication

You must understand that satellite radio, quite simply, is a non-terrestrial microwave transmission system utilising a space relay station. Satellites have proved invaluable in extending the reach of voice, data, and video communications around the globe and into the most remote regions of the world. Exotic applications such as the Global Positioning System (GPS) would have been unthinkable without the benefit of satellites.

Geostationary Satellite

It is important to note that contemporary satellite communications systems involve a satellite relay station that is launched into a geostationary, geosynchronous, or geostatic orbit. Such satellites are called geostationary satellite. Such an orbit is approximately 36,000 km above the equator as depicted in Figure 12.13. At that altitude and in an equatorial orbital slot, the satellite revolves around the earth with the same speed as of that the speed of revolution of earth and maintains its relative position over the same spot of the earth's surface. Consequently, transmit and receive earth stations can be pointed reliably at the satellite for communications purposes.

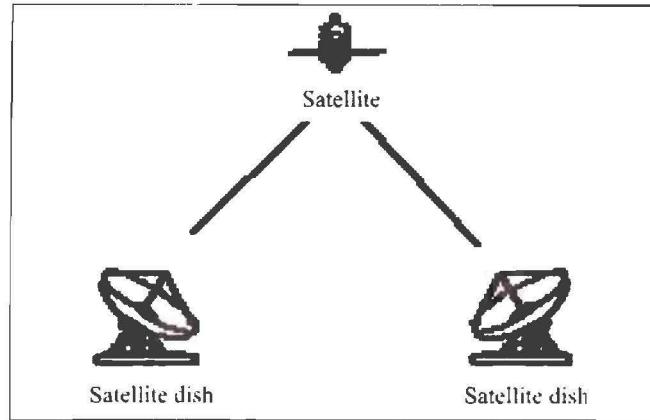


Figure 12.13: Satellites in Geostationary Earth Orbit

You must understand that the popularity of satellite communications has placed great demands on the international regulators to manage and allocate available frequencies, as well as the limited number of orbital slots available for satellite positioning are managed at national, regional and international levels. Generally speaking, geostationary satellites are positioned approximately 2° apart in order to minimize interference from adjacent satellites using overlapping frequencies.

Such high frequency signals are especially susceptible to attenuation in the atmosphere. Therefore, in case of satellite communication two different frequencies are used as carrier frequencies to avoid interference between incoming and outgoing signals. These are given below:

- **Uplink frequency:** It is the frequency accustomed transmit signal from earth station to satellite. Table 12.2 shows the upper of the two frequencies is employed for the transmission. The uplink signal will be tailored stronger and thus better handle atmospherical distortion. The antenna at sending side is centred during a concave, reflective dish that serves to focus the signal, with impact result, on the receiving satellite antenna. The receiving antenna, similarly, is centred during a concave metal dish, that serves to gather the maximum quantity of incoming signal.

Table 12.2: Example Uplink/Downlink Satellite Frequencies

Frequency Band	Uplink/Downlink Frequency Range	Example
C-band	6 GHz/4 GHz	TV, Voice, Videoconferencing
Ku-band	14 GHz/11 GHz	TV, Direct Broadcast Satellite /DSS
Ka-band	30 GHz/20 GHz	Mobile Voice

- **Downlink frequency:** It is the frequency used to transmit the signal from satellite to earth station. In other words, the downlink transmission is focused on a particular footprint or area of coverage. The lower frequency, used for the downlink, can better penetrate the earth's atmosphere and electromagnetic field, which can act to bend the incoming signal much as light bends when entering a pool of water.
- **Broadcast:** The wide footprint of a satellite radio system allows a signal to be broadcast over a wide area. Thereby any number (theoretically an infinite number) of terrestrial antennae can receive the signal, more or less simultaneously. In this manner, satellites can serve a point-to-multipoint network requirement through a single uplink station and multiple downlink stations.

Recently, satellites have been developed which can serve a mesh network requirement, whereby each terrestrial site can communicate directly with any

other site. Previously, all such communications were required to travel through a centralised site, known as a head end. Such a mesh network, of course, imposes an additional level of difficulty on the network in terms of management of the flow and direction of traffic.

The general properties of satellite communication are discussed below:

- **Configuration:** Satellite communication systems consist of antennae and reflective dishes, much as in terrestrial microwave. The dish serves to focus the signal from a transmitting antenna to a receiving antenna. The send/receive dishes that make up the earth segment are of varying sizes, depending on power levels and frequency bands. They generally are mounted on a tripod or other type of brace, which is anchored to the earth, pad or roof, or attached to a structure such as building. Cables connect the antennae to the actual transmit/receive equipment. The terrestrial antennae support a single frequency band.

It is important to note that the higher the frequency bands the smaller the possible size of the dish. Therefore, while C-band TV dishes tend to be rather large, Ku-band DBS (Direct Broadcast Satellite) TV dishes tend to be very small. The space segment dishes are mounted on a satellite, of course. The satellite can support multiple transmit/receive dishes, depending on the various frequencies, which it employs to support various applications, and depending on whether it covers an entire footprint or divides the footprint into smaller areas of coverage through the use of more tightly focused spot beams. Satellite repeaters are in the form of number of transponders. The transponders accept the weak incoming signals, boost them, shift from the uplink to the downlink frequencies, and transmit the information to the earth stations.

- **Bandwidth:** Satellites can support multiple transponders and, therefore, substantial bandwidth, with each transponder generally providing increments in bandwidth.
- **Error Performance:** Satellite transmission is susceptible to environmental interference, particularly at frequencies above 20 GHz. Sunspots and other types of electromagnetic interference affect satellite and microwave transmission. Additionally, some satellite frequency bands, for example, C-band needs careful frequency management. As a result of these factors, satellite transmission often requires rather extensive error detection and correction capabilities.
- **Distance:** Satellite is not considered to be distance limited as the signal largely travels through the vacuum of space. Further each signal travels approximately 36,000 km in each direction.
- **Propagation Delay:** Geostationary satellites, by virtue of their high orbital altitude, impose rather significant propagation delay on the signal. Hence, highly interactive voice, data, and video applications are not effectively supported via two-way satellite communications.
- **Security:** As is the case with all microwave and other radio systems, satellite transmission is inherently not secure. Satellite transmission is especially vulnerable to interception, as the signal is broadcast over the entire area of the footprint. Therefore, the unauthorized user must know only the satellite and associated frequency range being employed. Security must be imposed through encryption (scrambling) of the signal.
- **Cost:** The acquisition, deployment, and rearrangement costs of the space segment of satellite systems can be quite high in several millions dollars. However, the satellite can be shared by a large number of users, with each user perhaps

connecting a large number of sites. Consequently, satellite networks often compare very favourably with cabled systems or microwave systems for many point-to-multipoint applications.

- **Applications:** Satellite applications are many and increasing rapidly as the traditional voice and data services have been augmented. Traditional international voice and data services have been supplanted to a considerable extent by submarine fibre optic cable system.

Traditionally, you may say applications include international voice and data, remote voice and data, television and radio broadcast, maritime navigation, videoconferencing, inventory management and control through VSATs, disaster recovery and paging. More recent and emerging applications include air navigation, Global Positioning Systems (GPS), mobile voice and data because of Low Earth Orbit Satellites (LEOs), Advanced Traffic Management Systems (ATMS), Direct Broadcast Satellite (DBS) TV, Integrated Digital Services Network (ISDN), interactive television and interactive multimedia.

Infrared Transmission: Light from a Laser

Infrared light transmissions have existed for many years and their use having been limited to TV remote controls and wireless slide projector remote controls. However, they now are assuming a position of some, if still limited, importance. Infrared systems use the infrared light spectrum to send a focused light beam to a receiver, much as would a microwave system, although no reflective dish is used. Rather, pair of lenses is used, with a focused lens employed in the transmitting device and a collective lens in the receiving device as shown in Figure 12.14. Infrared is an airwave, rather than a conducted transmission system. Although generally used in short-haul transmission, they do offer substantial bandwidth, but with risks of interference.

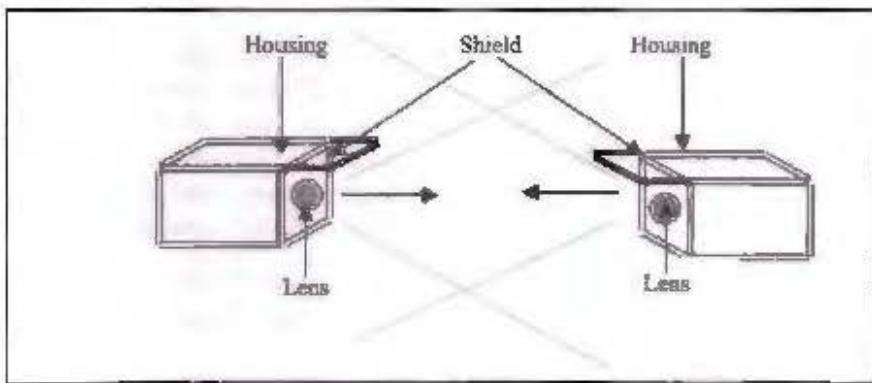


Figure 12.14: Infrared Transmission Systems

You may already be aware of the advantages that include rapid deployment, especially as there are no licensing requirements as typically is the case with microwave. Additionally, infrared offers fairly substantial bandwidth at relatively low cost. However, infrared systems require line-of-sight and suffer from environmental interference, as do microwave systems. Error performance is also satisfactory. Additionally, infrared is distance limited. However, infrared often is an attractive alternative to leased lines or private cabled systems for building-to-building connectivity in a campus environment. Infrared transmission also is used in certain wireless LAN systems and is incorporated into some PDAs (Personal Digital Assistants).

The fibre optic communication enables us to use enhanced bandwidth. The Wavelength-Division Multiplexing (WDM) technology is used in fibre optic

communication to multiplex multiple optical carrier signals on a single optical fibre by using different wavelengths of laser light to carry different signals.

12.6 COMMUNICATION CHANNELS/MEDIA

Communication media are the physical channels through which information is transmitted between computers in a network. Media may be classified as bounded (i.e., wires, cables and optical fibres) or unbounded (i.e., ether or airwaves through which radio, Transmitted data can move along simplex, half-duplex or full-duplex lines depending on the needs and protocols involved.

12.6.1 Bound Media

Twisted-pair of wires are inexpensive media used in voice grade telephone lines. They are used for low speed transmission of signals of the order of 1200 bps. Coaxial cables can be used for high-speed data transmission over distance of several kms. Coaxial cables have wide bandwidth of the order of 400 MHz. They may be used in LAN at transmission rates of about 1 Mega bps. Fibre Optics cables are glass fibres that provide high quality transmission of signals at very high speeds of nearly 1000 Megabits per second (Mbps) for distances up to 25 miles.

12.6.2 Unbound Media

Radio wave in the Very High Frequency band (VHF) at about 300 MHz is used for communication between computers in inaccessible locations or for short-range communications. Micro-waves are used for wide bandwidth line-of-sight communication. Rates of transmission up to 20 Giga bps are possible with this media. Communication satellite acts as microwave relay station in the sky. Transponders on the satellite are used to receive, amplify and retransmit signals sent from an earth station. The main advantage of satellite is its wide coverage of a large area and thus it may be used from inaccessible location. A transponder has a very large capacity and can handle about 400 channels, each channel having 64 kbps speed.

12.7 MODEM

A MODEM is a MODulation-DEModulation device that converts the discrete stream of digital "on-off" electric pulses used by computers into the analog wave patterns used for transmission of the human voice. Demodulator (recovers) the digital data from the transmitted signal. A special type of MODEM called an acoustic coupler is often used in libraries and information units with portable machines, but internal and external direct-connect MODEMs are generally used at permanent stations.

12.7.1 Characteristics of a Modem

The characteristics of a modem are as follows:

Speed

The speed at which the modem can send data in bps (bits per second). Typically modem speeds are: 300, 600, 1200, 2400, 4800, 9600, 14.4K, 19.2K, 28.8K bps

Auto Dial /Redial

Smart Modems can dial the phone number and auto redial if a busy signal is received.

Auto Answer

Most modems can automatically answer the phone when an incoming call comes in. They have Ring Detect capability.

Self-testing

New modems have **self-testing** features. They can test the digital connection to the terminal/computer and the analog connection to a remote modem. They can also check the modem's internal electronics.

Voice Over Data

Voice over data modems allows a voice conversation to take place while data is being transmitted. This requires both the source and destination modems to have this feature.

Synchronous or Asynchronous Transmission

Newer modems allow a choice of synchronous or asynchronous transmission of data. Normally, modem transmission is asynchronous. We send individual characters with just start and stop bits. Synchronous transmission or packet transmission is used in specific applications.

12.7.2 Types of Modem

Modems can be of several types and they can be categorized in a number of ways.

Categorization is usually based on the following basic modem features:

1. **Directional capacity:** half duplex modem and full duplex modem.
2. **Connection to the line:** 2-wire modem and 4-wire modem.
3. **Transmission mode:** asynchronous modem and synchronous modem.

Half Duplex Modem

- A half-duplex modem permits transmission in one direction at a time.
- If a carrier is detected on the line by the modem, it gives an indication of the incoming carrier to the DTE through a control signal of its digital interface.
- As long as they camel IS being received; the modem does not give permission to the DTE to transmit data.

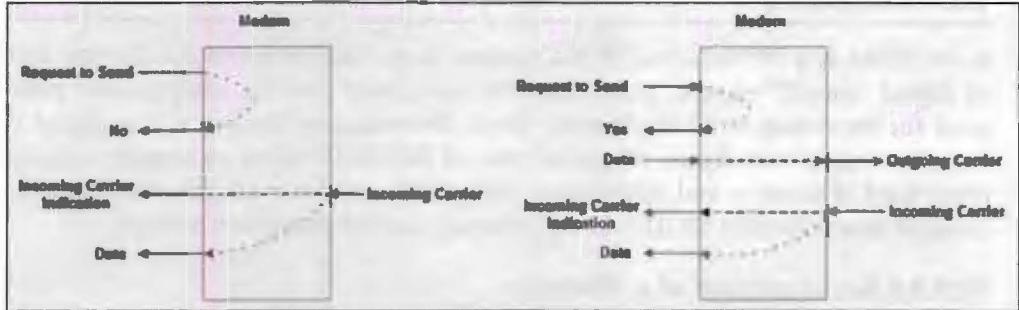


Figure 12.15: Half Duplex Modem and Full Duplex Modem

Full Duplex Modem

- A full duplex modem allows simultaneous transmission in both directions.
- Therefore, there are two carriers on the line, one outgoing and the other incoming.
- The line interface of the modem can have a 2-wire or a 4-wire connection to transmission medium.
- In a 4-wire connection, one pair of wires is used for the outgoing carrier and the other pair is used for incoming carrier.

- Full duplex and half duplex modes of data transmission are possible on a 4-wire connection.
- As the physical transmission path for each direction is separate, the same carrier frequency can be used for both the directions.

2-Wire Modem

- 2-wire modems use the same pair of wires for outgoing and incoming carriers.
- A leased 2-wire connection is usually cheaper than a 4-wire connection as only one pair of wires is extended to the subscriber's premises.
- The data connection established through telephone exchange is also a 2-wire connection.
- In 2-wire modems, half duplex mode of transmission that uses the same frequency for the incoming and outgoing carriers can be easily implemented.
- For full duplex mode of operation, it is necessary to have two transmission channels, one for transmit direction and the other for receive direction.
- This is achieved by frequency division multiplexing of two different carrier frequencies. These carriers are placed within the bandwidth of the speech channel.

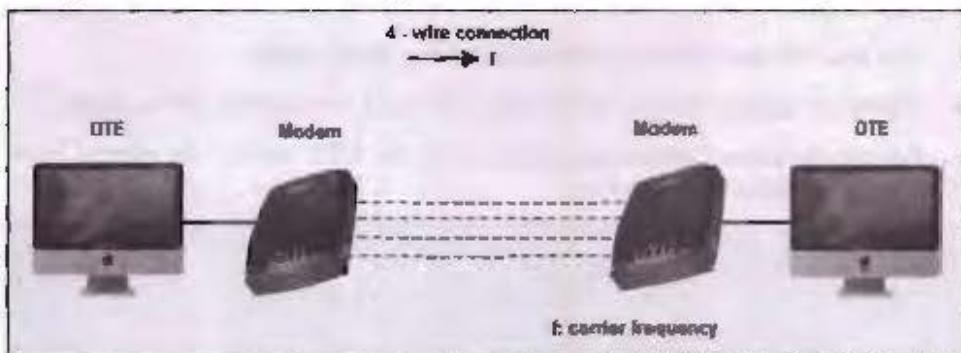


Figure 12.16: Half Duplex 4-Wire Connection

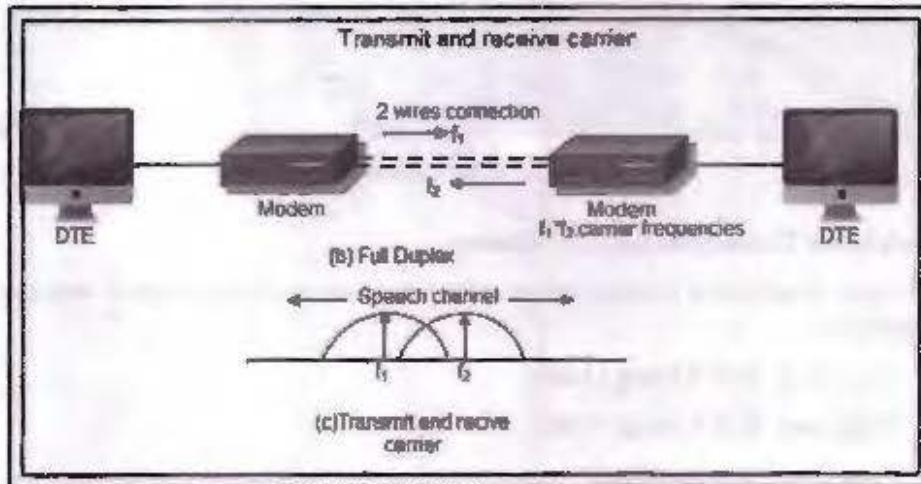


Figure 12.17: Transmit and Receiver Carrier

Asynchronous & Synchronous Modems

Asynchronous Modem

- Asynchronous modems can handle data bytes with start and stop bits.

- There is no separate timing signal or clock between the modem and the DTE.
- The internal timing pulses are synchronized repeatedly to the leading edge of the start pulse.

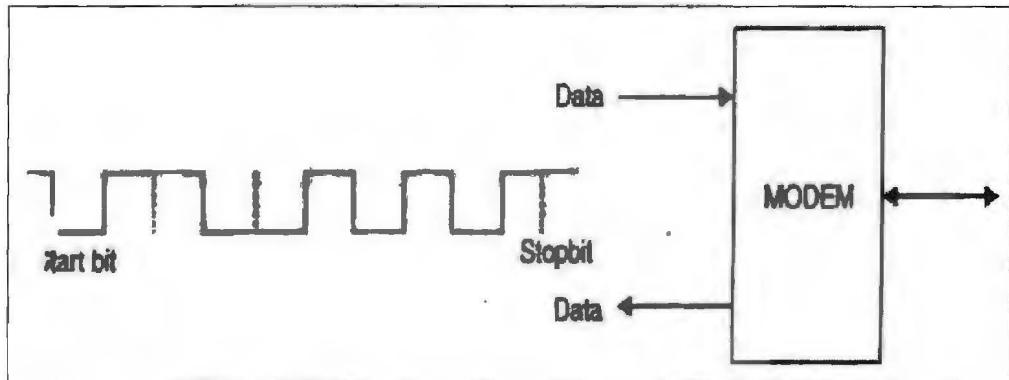


Figure 12.18: Asynchronous Modem

Synchronous Modem

- Synchronous modems can handle a continuous stream of data bits but requires a clock signal.
- The data bits are always synchronized to the clock signal.
- There are separate clocks for the data bits being transmitted and received.
- For synchronous transmission of data bits, the DTE can use its internal clock and supply the same to the modem.

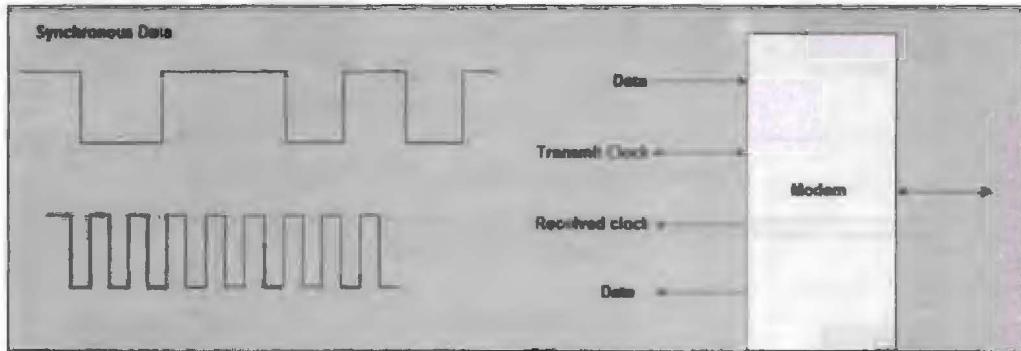


Figure 12.19: Synchronous Modem

Modulation Techniques used for Modem

The basic modulation techniques used by a modem to convert digital data to analog signals are:

- Amplitude Shift Keying (ASK)
- Frequency Shift Keying (FSK)
- Phase Shift Keying (PSK)
- Differential PSK (DPSK)

These techniques are known as the binary Continuous Wave (CW) modulation.

Modems are always used in pairs. Any system whether simplex, half duplex or full duplex requires a modem at the transmitting as well as the receiving end.

Check Your Progress

Fill in the blanks:

1. _____ share resources from one computer to another.
2. In case of _____, the electromagnetic waves are guided along a solid medium, like copper twisted pair, copper coaxial cable and optical fibre.
3. A LAN is a form of local (limited distance), shared _____ for computer communications.
4. The _____, in a data transmission system, is the physical path between transmitter and receiver.

12.8 LET US SUM UP

- A computer network is a system in which multiple computers are connected to each other to share information and resources.
- Seven major elements of communication process are: (1) Sender, (2) Ideas, (3) Encoding, (4) Communication channel, (5) Receiver, (6) Decoding and (7) Feedback.
- Feedback is the process of ensuring that the receiver has received the message and understood in the same sense as sender meant it.
- Computer networks can be classified based on interconnected computers by scale-LAN, MAN and WAN.
- A LAN is a form of local (limited distance), shared packet network for computer communications.
- The transmission medium, in a data transmission system, is the physical path between transmitter and receiver. In case of guided media, the electromagnetic waves are guided along a solid medium, like copper twisted pair, copper coaxial cable and optical fibre.
- It is important for you to note that guided transmission media or bounded media or wired transmission systems employ physical media, which are tangible.
- You must understand that wireless transmission systems do not make use of a physical conductor, or guide, to bind the signal. In this case, data are transmitted using electromagnetic waves. Therefore, they are also known as unguided or unbounded systems.
- A MODEM is a MODulation-DEModulation device that converts the discrete stream of digital "on-off" electric pulses used by computers into the analog wave patterns used for transmission of the human voice.
- The characteristics of a modem are as follows: speed, auto dial/redial, auto answer, self-testing, voice over data and synchronous or asynchronous transmission.

12.9 UNIT END ACTIVITY

Elaborate the characteristics of guided and unguided wireless transmission media.

12.10 KEYWORDS

Computer Network: It is a system in which multiple computers are connected to each other to share information and resources.

Transmission Medium: In a data transmission system, the physical path is between transmitter and receiver.

MODEM: It is a MODulation-DEModulation device that converts the discrete stream of digital "on-off" electric pulses used by computers into the analog wave patterns used for transmission of the human voice.

Guided Media: It is the transmission media, in which signals are confined to a specific path using wire or cable.

12.11 QUESTIONS FOR DISCUSSION

1. What do you understand by computer network?
2. Describe the characteristics of a computer network.
3. What are the seven major elements of communication process?
4. Explain main communication types in detail.
5. What are the characteristics of transmission technology and LAN topology?
6. What do you understand by guided transmission media?
7. Describe the general properties of twisted pair.
8. What is the unguided or wireless transmission? Discuss the features of the radio waves.
9. Explain communication channels/media. Differentiate bound media and unbound media.
10. What are the characteristics of a modem? Explain the types of modem in detail.

Check Your Progress: Model Answer

1. Computer Network
2. Guided media
3. Packet network
4. Transmission medium

12.11 REFERENCES & SUGGESTED READING

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NETWORKS

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13.0 AIMS AND OBJECTIVES

After studying this lesson, you should be able to:

- Define network
- Learn about Internet vs. Intranet
- Describe various network topologies

- Know about the types of connectivity
- Explain various network communication devices

13.1 INTRODUCTION

Information transfer between people situated on different sites on a real time basis is an age-old requirement. During the last many years, people have used different ways to communicate with each other using humans and even pigeons as messengers. In the nineteenth century, telephone, the first communication device was developed which is the most common communication device even today.

In the 1960s, it was decided to develop computer network for the purpose of fast and real time data transfer for scientific research data, where data was in a very large quantity. The first useful network, ARPANET, was commissioned in the late 1960s. Since then, networking technology has been evolving continuously at a very rapid pace.

In this lesson, we will study the various network techniques, equipment used in networking and the various topologies used in network connections. We will also cover up different types of network and connectivity of in computer network.

13.2 DEFINITION OF NETWORK

A group of computers and associated peripheral devices connected by a communication channel, capable of sharing files and other resources between several users is known as network. A network can range from a peer to peer network connecting a small number of users in an office to LAN connecting many users over permanently installed cables and dial up lines to a Metropolitan Area Network (MAN) or WAN connecting users on several different networks spread over a wide geographic area.

13.2.1 Objectives of Networking

Networking provides us with the facility to share distant resources such as database, processor or software. It provides high reliability by having alternate resources for providing distribution of processing so that load sharing can be achieved.

Networks are used to save money because using a network of computers is cheaper than using a single mainframe, which costs several times more. A mainframe can be 100 times faster than a personal computer but the cost of mainframe can be thousand times more than that. Networking also provides cheaper expendability in terms of connecting new machines in a network; if we require more nodes, we can attach a new machine very easily at any point of a network communication medium. It provides such a communication medium that persons sitting at geographically separate locations can exchange information, very easily.

13.2.2 Networking Considerations

Cost

Cost of the network involves installation of hardware and software facilities. The hardware includes the computers, peripherals, communication medium, etc., and software includes operating system and network environment. Software also provides network constructs and rules (protocols).

Beginners are first supposed to receive training covering basic computer operations and network facility and usage. This should be followed by training, covering the applications and procedures they use in their jobs and how the network supports their work.

Housekeeping Operations

Housekeeping operations have to be performed for a network to manage resources properly and with better efficiency.

Routine Daily Tasks

- Cleaning up the file server hard disk drive.
- Installing software upgrades.
- Making back-ups.
- Restoring damaged or lost files.
- Monitoring traffic.
- Collecting accounting data.
- Generating reports for management.

Routine Weekly Tasks

- Monitoring and evaluating network performance.
- Managing and documenting the network configuration.
- Exploring and appraising new hardware and software technology.

Security

- Being a multiuser system, security maintenance is a necessary task.

13.2.3 Advantages of Network Applications

Networks may prove to be very effective in the area of electronic-mail. Remote databases can be accessed very easily and quickly, e.g., steel inventory in plants and warehouses of Steel Authority of India Ltd. (SAIL). Financial transactions can be done through the network e.g., Electronic Fund Transfer (EFT) in global banks. Network is also used very effectively in the areas of device sharing, e.g., hard disks, printers, scanners, etc., and can also be of vital help at homes by providing stock market figures, business data, educational material, etc. The users of a network can also read a magazine or some important news by connecting the home television to some network. Networks provide an effective tool for communicating through the use of e-mail and other work group software. Messages can be sent instantaneously throughout the network, work plans can be updated as changes occur and meetings can be scheduled. Use of work group software reduces the need for face-to-face meeting and other time-consuming methods of distributing information. It allows increased interaction among workers from their workstations. Networking can also enhance the effect of communication, as people tend to put more thought into written communication than into informal conversation.

13.3 INTERNET VS. INTRANET

In this lesson, we will see what is Internet and Intranet, as well as discuss the similarities and differences between the two.

13.3.1 Internet

It is a worldwide/global system of interconnected computer networks. It uses the standard Internet Protocol (TCP/IP). Every computer in Internet is identified by a unique IP address. IP Address is a unique set of numbers (such as 110.22.33.114) which identifies a computer's location.

A special computer DNS (Domain Name Server) is used to provide a name to the IP Address so that the user can locate a computer by a name.

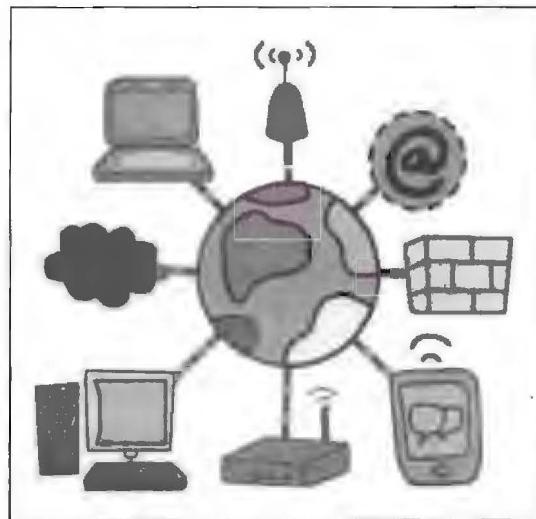


Figure 13.1: Internet Connected with Computer

Internet is accessible to every user all over the world.

13.3.2 Intranet

Intranet is the system in which multiple PCs are connected to each other. PCs in intranet are not available to the world outside the intranet. Usually each organization has its own Intranet network and members/employees of that organization can access the computers in their intranet.

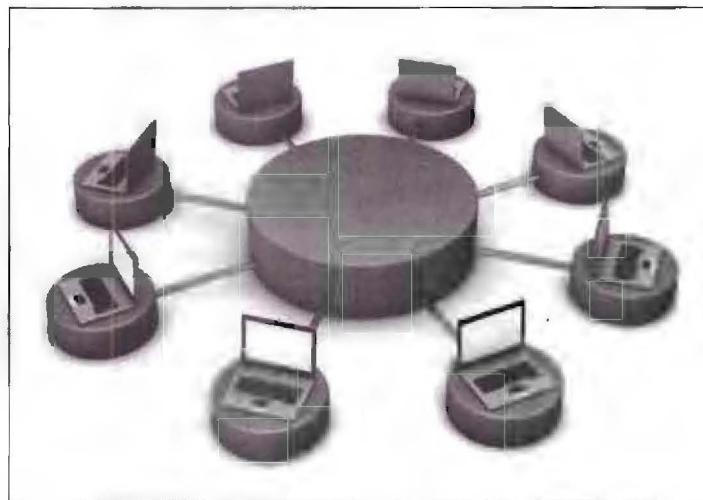


Figure 13.2: Intranet

Intranet is also identified by an IP Address which is unique among the computers in that Intranet.

13.3.3 Similarities between Internet and Intranet

- Intranet uses the internet protocols such as TCP/IP and FTP.
- Intranet sites are accessible via the web browser in a similar way as websites in the internet. However, only members of Intranet network can access intranet hosted sites.
- In Intranet, own instant messengers can be used as similar to yahoo messenger/gtalk over the internet.

13.3.4 Differences between Internet and Intranet

- Internet is general to PCs all over the world whereas Intranet is specific to few PCs.
- Internet provides a wider and better access to websites to a large population, whereas Intranet is restricted.
- Internet is not as safe as Intranet. Intranet can be safely privatized as per the need.

13.4 TYPES OF NETWORK

Used for everything from accessing the internet or printing a document to downloading an attachment from an email, networks are the backbone of business today. They can refer to a small handful of devices within a single room to millions of devices spread across the entire globe, and can be defined based on purpose and/or size. In this section, we will the types of networks in use today, and what they are used for.

Personal Area Network

A personal area network or PAN, is a computer network organized around an individual person within a single building. This could be inside a small office or residence. A typical PAN would include one or more computers, telephones, peripheral devices, video game consoles and other personal entertainment devices.

If multiple individuals use the same network within a residence, the network is sometimes referred to as a home area network, or HAN. In a very typical setup, a residence will have a single wired Internet connection connected to a modem. This modem then provides both wired and wireless connections for multiple devices. The network is typically managed from a single computer but can be accessed from any device.

Peer-to-Peer Network

These networks are used for a small range of computers. In this network, all machines have their own resources and can also have sharable resources for other machines. It means that the resources of machines available for the network are controlled by different computers, so we can call it a network of decentralized resources. This type of network can be developed very easily using Windows' 95.

Local Area Network (LAN)

LAN is a group of computers and associated peripheral devices connected by a communication channel, capable of sharing files and other resources between several users. Using LAN, we can get high speed connections among computers but have to sacrifice the ability to cover large distances.

Example: Network in an organization, buildings, schools or campus can be a LAN.

A LAN is a form of local (limited distance), shared packet network for computer communications. LANs interconnect computers and peripherals over a common medium in order that users might share access to host computers, databases, files, applications and peripherals. They can also provide a connection to other networks either through a computer, which is attached to both networks, or through a dedicated device called a gateway.

The components used by LANs can be divided into cabling standards, hardware, and protocols. Various LAN protocols are Ethernet, Token Ring, TCP/IP, SMB, NetBIOS and NetBeui, IPX/SPX, Distributed Fiber Data Interchange (FDDI) and Asynchronous Transfer Mode (ATM).

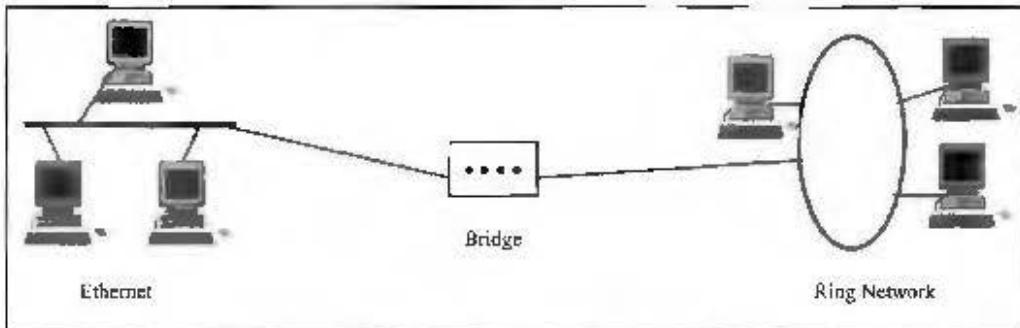


Figure 13.3: Local Area Network

Briefly, based on size, transmission technology and topology LAN is characterised as below:

- **Size:** LAN has usually a span of not more than a few kilometres.
- **Transmission technology:** LAN uses a shared cable running at speeds of 10 to 100 Mbps (and even higher), with delay of tens of microseconds and few errors.
- **Topology:** It may have topologies as bus (e.g., Ethernet), ring (e.g., IBM token ring), etc.
- **Allocation of the shared channel:** Each computer is statically allocated a time slot to transmit, and gets its turn by round robin. To avoid waiting time in case of an idle computer, dynamic allocation of time is done where each computer is dynamically allocated a time slot on demand.

LAN can operate between 10 mbps (mega bit per second) to 2gbps. Due to the shorter area coverage, the LAN offers lower delays than WAN and MAN; delays on a LAN can be calculated in milliseconds. For the communication purpose, usually computers on LAN have a network interface device that connects the machine directly to the network medium.

The main features of LAN are:

- A common communication medium over which all user terminals can share information, programs and hardware devices.
- A high transmission rate intended to accommodate the needs of both users and equipment.
- A low error rate in data transfer.

Advantages

- Provides a cost-effective multiuser computer environment.
- Easy physical connection of devices to the media.

- Network data transmission rates are independent of the rates used by the attached devices, making it easier for device of one speed to send information to device operating at another speed.
- It provides data integrity.

Metropolitan Area Network (MAN)

MAN is a public, high speed network, operating at 100 mbps or faster, capable of voice and data transmission over a distance of up to 50 Kms. A MAN is smaller than a WAN but larger than a LAN. The metropolitan area network standards are sponsored by IEEE (Institution of Electrical and Electronic Engineers), AT&T (American Telegraphy and Telephony) and The Regional Bell Operating Companies (RBOCs). IEEE 802.6 set of standards are dedicated to MAN.

A MAN is designed with two unidirectional buses, each bus is independent of the other in the transfer of traffic. The topology can be designed as an open bus or a closed bus configuration. MAN may cover an entire city. It may also utilize the Cable Television Networks (CATV) to connect computers together.

Example: Local libraries and government agencies often use a MAN to connect to citizens and industries.

It may also connect LANs together within a greater area than a LAN. The geographical limit of a MAN may span a city. As you can see in Figure 13.4, it depicts how a MAN may be available within a city.

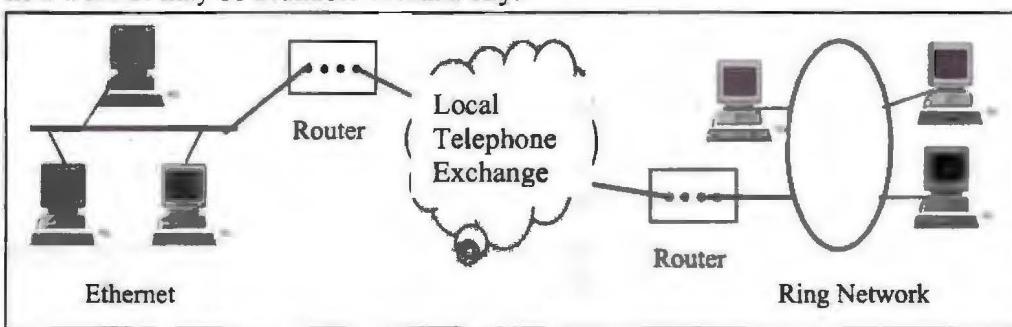


Figure 13.4: Metropolitan Area Network

In MAN, different LANs are connected through a local telephone exchange using one or two cables but not switching elements. Some of the widely used protocols for MAN are RS-232, X.25, Frame Relay, Asynchronous Transfer Mode (ATM), ISDN (Integrated Services Digital Network), OC-3 lines (155 Mbps), ADSL (Asymmetrical Digital Subscriber Line) etc. These protocols are quite different from those used for LANs.

Wide Area Network (WAN)

A network that connects users across larger distances, often crossing the geographical boundaries of cities, states or countries is known as Wide Area Network. WANs normally use public telephone network and satellite links for data transmission. Data transmission rates are below 1 mbps (megabits per second) for WAN. It is normally owned by multiple organizations. The transmission time is more for WAN because of longer distances and different transmission mediums used.

WANs have the following advantages:

- They tend to enhance reliability.
- They are used for remote data collection.
- They allow work groups to be spread across geographical boundaries.

Example: The main example of WAN network system in our daily life is telecom system. Also, Internet is a good example of a WAN.

WAN has no geographical limits. Dedicated transoceanic cabling or satellite up links may be used to connect this type of network. Hence, a WAN may be defined as a data communications network that covers a relatively broad geographic area to connect LANs together between different cities with the help of transmission facilities provided by common carriers, such as telephone companies.

A WAN involves many cables or telephone lines, each one connecting a pair of routers. When a packet is transmitted from one router to another, it is received at each intermediate router in its entirety, stored there until the required output line is free, and then forwarded. A network using this principle is referred to as point-to-point, store-and-forward or packet-switched subnet.

Figure 13.5 illustrates the system of WAN, which connects many LANs together. It also uses switching technology offered by local exchange and long distance carrier.

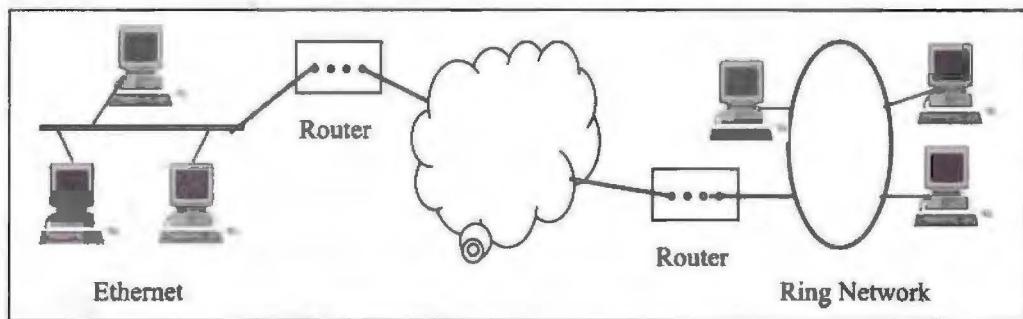


Figure 13.5: Wide Area Network

Packet switching technologies are used to implement WAN along with statistical multiplexing to enable devices to share these circuits.

Examples of Packet switching technologies include Asynchronous Transfer Mode (ATM), Frame Relay, Switched Multimegabit Data Service (SMDS) and X.25.

A WAN has host computers for running user programs and they are connected to subnet, whose job is to carry messages from host to host. The subnet has transmission lines (circuits, channels or trunks) that move bits between hosts to host. Routers as switching elements are used to connect two or more transmission lines.

You must observe the difference between MAN and WAN may be understood only from the services being used by them. WAN uses both the local and long distance carrier while MAN uses only a local carrier. Hardware and protocols are same as in case of MAN.

The answer to the confusion between LAN and WAN technologies lies in how data is switched. It is the integration of LAN/and WAN integration that makes the network work. After all, people and machines not only need to be accessible locally, but from different sites as well.

Private Networks

One of the benefits of networks like PAN and LAN is that they can be kept entirely private by restricting some communications to the connections within the network. This means that those communications never go over the Internet.

Storage Area Network

A type of network that specializes in files sharing and other matters in storing various software within a group of computers.

Enterprise Private Network

This is a software network that's often used in businesses so that they can have privacy over files and interactions between computers.

Virtual Private Network

This software is capable of setting up a network where everyone registered in the network using a credential will be able to access each other through other registered computers.

System Area Network

This term is fairly new within the past two decades. It is used to explain a relatively local network that is designed to provide high-speed connection in server-to-server applications (cluster environments), storage area networks (called "SANs" as well) and processor-to-processor applications. The computers connected on a SAN operate as a single system at very high speeds.

Passive Optical Local Area Network (POLAN)

As an alternative to traditional switch-based Ethernet LANs, POLAN technology can be integrated into structured cabling to overcome concerns about supporting traditional Ethernet protocols and network applications such as PoE (Power over Ethernet). A point-to-multipoint LAN architecture, POLAN uses optical splitters to split an optical signal from one strand of single mode optical fiber into multiple signals to serve users and devices.

Enterprise Private Network (EPN)

These types of networks are built and owned by businesses that want to securely connect its various locations to share computer resources.

13.4.1 Homogeneous and Heterogeneous Networks

Homogeneous Network

A network that consists of only one type of workstation, server, operating system and network interface card is known as a homogenous network.

It uses a standard network interface card that plugs into a personal computer or server and works with the network. All nodes use the same protocol and the same control procedures in this type of network.

Heterogeneous Network

A network that consists of workstations, servers, network interface cards, operating systems and applications from many different vendors, all working together as a single unit is known as Heterogeneous network. These networks may also use different media and different protocols over different network links.

13.5 TOPOLOGY

Network topology can be defined as the way of physical interconnection between computers to form a computer network. Computers are connected to each other

through some interconnection medium known as communication medium. Some important network topologies are discussed below:

13.5.1 Star Topology

In star configuration, a central controller provides the hardware/software resources and interface required for connecting different computers in the network. The individual computers are not linked directly to each other and can communicate only via the central controlling computer.

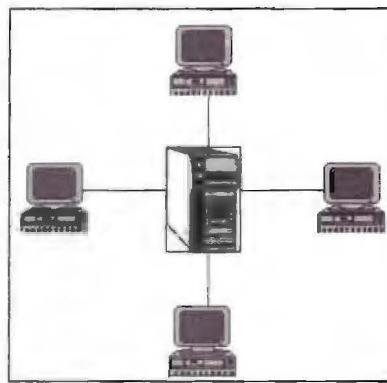


Figure 13.6: Star Topology

The disadvantage of such a configuration is that there are a lot of cables and interfaces which are probably never used at the same time. This topology is not reliable because if the central computer crashes, then there is no way for other computers to communicate with each other and the complete network becomes inoperative. Connecting a new computer in this topology is very difficult because the central computer should have a communication port available. We can't install new hardware in star topology if the communication port cannot be installed on central computer.

13.5.2 Ring Topology

Ring configuration is a collection of individual point-to-point links that happen to form a circle. The computers are connected through these links. Control of the network is exercised by all connected computers by following common protocols, known as ring protocols. Ring network is not a broadcast network. The data from the sender station is propagated to its intended receiver station through the intermediate stations in the ring network path. Each station monitors the communication link and accepts the packets addressed to it only.

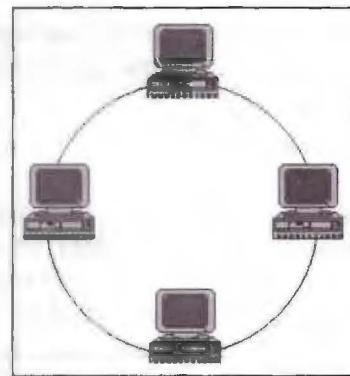


Figure 13.7: Ring Topology

Connection of new station in a ring is easy because it needs only two cables to get connected to its preceding and succeeding neighbour in the ring.

The major disadvantage of this configuration is that in the event of a collapse of one point-to-point link in the ring or one station, the whole network collapses. Ring maintenance and fault diagnosis is a little more complicated than in star topology because of the collapse of the entire network, if one station fails.

13.5.3 Bus Topology

In this topology, a common communication channel is shared by all the computers on the network. This network is also known as broadcast network because of the fact that when a data packet is sent out, it propagates throughout the medium and is received by all the stations. Each work station continuously monitors the communication channel and accepts only those packets that are addressed to it.

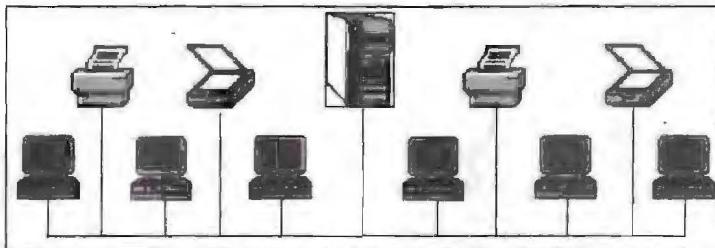


Figure 13.8: Bus Topology

The advantage of bus topology is that the cable runs are shorter than in other topologies and also, additional nodes can be connected to an existing bus network at any point along its length. The disadvantages are that, the fault diagnosis and isolation of computer from broadcast is difficult. The whole system is more reliable because of the fact that failure of any station does not affect operations of other stations.

13.6 TYPES OF CONNECTIVITY

Network connectivity describes the extensive process of connecting various parts of a network to one another, for example, through the use of routers, switches and gateways, and how that process works.

The two different computer network connection types are:

1. Point-to-Point Connection
2. Multipoint Connection

13.6.1 Point-to-Point Connection

A point-to-point connection is a direct link between two devices such as a computer and a printer. It uses dedicated link between the devices. The entire capacity of the link is used for the transmission between those two devices. Most of today's point-to-point connections are associated with modems and PSTN (Public Switched Telephone Network) communications. In point-to-point networks, there exist many connections between individual pairs of machines.

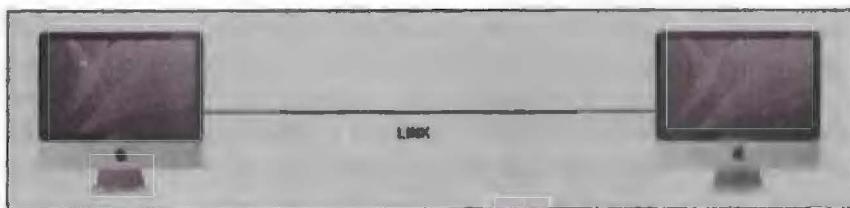


Figure 13.9: Point-to-Point Configuration

To move from sources to destination, a packet (short message) may follow different routes. In networking, the Point-to-Point Protocol (PPP) is a data link protocol commonly used in establishing a direct connection between two networking nodes. It can provide connection authentication, transmission encryption, and compression. PPP is used over many types of physical networks including serial cable, phone line, trunk line, cellular telephone, specialized radio links, and fibre optic links such as SONET. PPP is also used over Internet access connections (now marketed as "broadband").

Internet service providers (ISPs) have used PPP for customer dial-up access to the Internet, since IP packets cannot be transmitted over a modem line on their own, without some data link protocol. Two encapsulated forms of PPP, Point-to-Point Protocol over Ethernet (PPPoE) and Point-to-Point Protocol over ATM (PPPoA), are used most commonly by Internet Service Providers (ISPs) to establish a Digital Subscriber Line (DSL) Internet service connection with customers.

PPP is commonly used as a data link layer protocol for connection over synchronous and asynchronous circuits, where it has largely superseded the older Serial Line Internet Protocol (SLIP) and telephone company mandated standards (such as Link Access Protocol, Balanced (LAPB) in the X.25 protocol suite). PPP was designed to work with numerous network layer protocols, including Internet Protocol (IP), TRILL, Novell's Internetwork Packet Exchange (IPX), NBF and AppleTalk.

13.6.2 Multipoint Connection

A multipoint connection is a link between three or more devices. It is also known as Multi-drop configuration. The networks having multipoint configuration is called Broadcast Networks. In broadcast network, a message or a packet sent by any machine is received by all other machines in a network. The packet contains address field that specifies the receiver. Upon receiving a packet, every machine checks the address field of the packet. If the transmitted packet is for that particular machine, it processes it; otherwise it just ignores the packet.

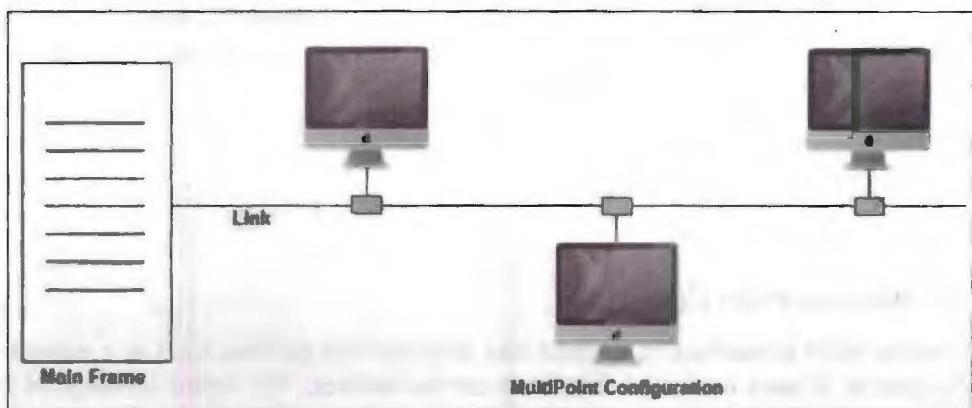


Figure 13.10: Multipoint Configuration

Broadcast network provides the provision for broadcasting and multicasting. Broadcasting is the process in which a single packet is received and processed by all the machines in the network. It is made possible by using a special code in the address field of the packet. When a packet is sent to a subset of the machines i.e., only a few machines in the network it is known as multicasting. Historically, multipoint connections were used to attach central CPs to distributed dumb terminals. In today's LAN environments, multipoint connections link many network devices in various configurations.

13.7 NETWORK DEVICES

Following is the list of network devices required to set up a computer network.

- Hub
- Switches
- Bridges
- Gateways
- ISDN (Integrated Services Digital Network)
- Network Protocols
- Network Cables
- Distributors
- Routers
- Network Cards
- Universal Serial Bus (USB)

Hub

Hub is one of the basic icons of networking devices which works at physical layer and hence connect networking devices physically together. Hubs are fundamentally used in networks that use twisted pair cabling to connect devices. They are designed to transmit the packets to the other appended devices without altering any of the transmitted packets received. They act as pathways to direct electrical signals to travel along. They transmit the information regardless of the fact if data packet is destined for the device connected or not.

Switches

Switches are the linkage points of an Ethernet network. Just as in hub, devices in switches are connected to them through twisted pair cabling. But the difference shows up in the manner both the devices; hub and a switch treat the data they receive. Hub works by sending the data to all the ports on the device whereas a switch transfers it only to that port which is connected to the destination device. A switch does so by having an in-built learning of the MAC address of the devices connected to it. Since the transmission of data signals are well defined in a switch hence the network performance is consequently enhanced. Switches operate in full-duplex mode where devices can send and receive data from the switch at the simultaneously unlike in half-duplex mode. The transmission speed in switches is double than in Ethernet hub transferring a 20Mbps connection into 30Mbps and a 200Mbps connection to become 300Mbps. Performance improvements are observed in networking with the extensive usage of switches in the modern days.

Bridges

A bridge is a computer networking device that builds the connection with the other bridge networks which use the same protocol. It works at the Data Link layer of the OSI Model and connects the different networks together and develops communication between them. It connects two local-area networks; two physical LANs into larger logical LAN or two segments of the same LAN that use the same protocol.

Gateways

Gateway is a device which is used to connect multiple networks and passes packets from one packet to the other network. Acting as the 'gateway' between different

networking systems or computer programs, a gateway is a device which forms a link between them. It allows the computer programs, either on the same computer or on different computers to share information across the network through protocols. A router is also a gateway, since it interprets data from one network protocol to another.

Network Protocols

Network protocols define a language of instructions and conventions for communication between the network devices. It is essential that a networked computer must have one or more protocol drivers. Usually, for two computers to interconnect on a network, they must use identical protocols. At times, a computer is designed to use multiple protocols. Network protocols like HTTP, TCP/IP offer a basis on which much of the Internet stands.

ISDN (Integrated Services Digital Network)

ISDN are used to send over graphic or audio data files. It is a WAN technology that can be used in place of a dial up link. The accessibility of ISDN depends upon the provision of the service by the service provider, the quality of the line set up to your area. It surely provides higher speed than a modem and has the capability to pick up the line and drop it considerably at a faster rate.

ISDN can create numerous communication routes on a single line. Nowadays with faster and cheaper technologies, ISDN has found its way in the realm of technology.

Network Cables

Network cables are used to connect computers. The most commonly used cable is Category 5 cable RJ-45.

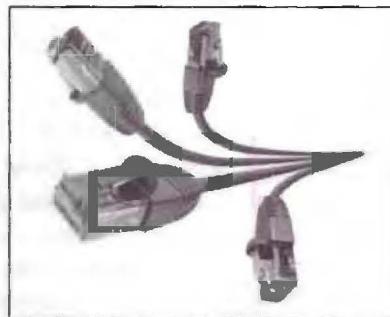


Figure 13.11: Network Cables

Distributors

A computer can be connected to another one via a serial port but if we need to connect many computers to produce a network, this serial connection will not work.

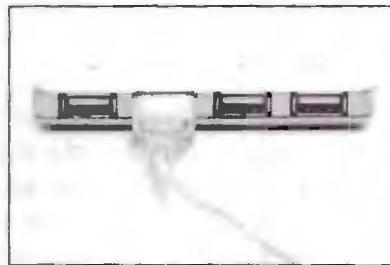


Figure 13.12: Distributors

The solution is to use a central body to which other computers, printers, scanners, etc. can be connected and then this body will manage or distribute network traffic.

Router

A router is a type of device which acts as the central point among computers and other devices that are a part of the network. It is equipped with holes called ports. Computers and other devices are connected to a router using network cables. Now-a-days router comes in wireless modes using which computers can be connected without any physical cable.



Figure 13.13: Router

Network Card

Network card is a necessary component of a computer without which a computer cannot be connected over a network. It is also known as the network adapter or Network Interface Card (NIC). Most branded computers have network card pre-installed. Network cards are of two types: Internal and External Network Cards.

Internal Network Cards

Motherboard has a slot for internal network card where it is to be inserted. Internal network cards are of two types in which the first type uses Peripheral Component Interconnect (PCI) connection, while the second type uses Industry Standard Architecture (ISA). Network cables are required to provide network access.

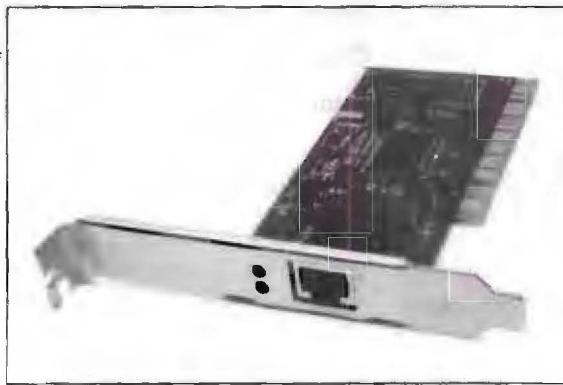


Figure 13.14: Internal Network Cards

External Network Cards

External network cards are of two types: Wireless and USB based. Wireless network card needs to be inserted into the motherboard; however no network cable is required to connect to the network.

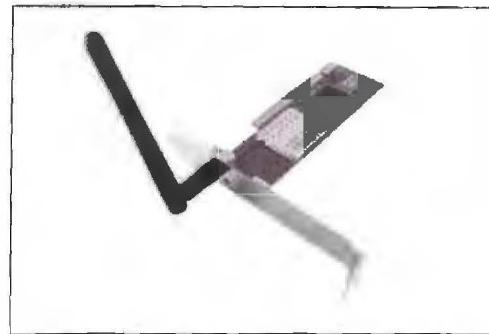


Figure 13.15: External Network Cards

Universal Serial Bus (USB)

USB card is easy to use and connects via USB port. Computers automatically detect USB card and can install the drivers required to support the USB network card automatically.



Figure 13.16: Universal Serial Bus (USB)

Check Your Progress

Fill in the blanks:

1. _____ provides us with the facility to share distant resources such as database, processor or software.
2. It is a worldwide/global system of interconnected computer networks. It uses the _____
3. _____ is the system in which multiple PCs are connected to each other.
4. A network that connects users across larger distances, often crossing the geographical boundaries of cities, states or countries is known as _____
5. _____ can be defined as the way of physical interconnection between computers to form a computer network.

13.8 LET US SUM UP

- A network is a collection of interlinked computers by means of a communication system. The networks facilitate resource sharing, increased reliability, reduced costs, increased and fast communication.
- The pattern of interconnection of nodes in a network is called topology. Most popular topologies are star, bus, ring, graph and mesh.
- On the basis of geographical spread, networks can be classified into LAN, MAN and WAN. Small computer networks that are confined to a localized area e.g., an office, a building etc., are called LANs. MANs are the networks spread over a city. A WAN is a group of computers that are separated by large distances and tied together. It can even be a group of LANs that are spread across several locations and connected together to look like a big LAN.
- Ethernet is a LAN architecture developed by Xerox Corp along with DEC and Intel. It uses either a bus or star topology and supports data transfer rates of up to 10 Mbps.
- Network connectivity describes the extensive process of connecting various parts of a network to one another, for example, through the use of routers, switches and gateways, and how that process works.
- The two different computer network connection types are: point-to-point connection and multipoint connection.
- Several network communication devices are used for efficient transmission of data between and within networks. Some of them are bridges, gateways, routers, modem, decoders, encoders, multiplexers, hubs and switches.
- The communication links are established using various types of transmission media such as twisted pair cables, co-axial cables, microwave links, radio waves, fibre optic cables and satellite links.

13.9 UNIT END ACTIVITY

Make a list of advantages of network applications and various types of network topologies.

13.10 KEYWORDS

Bridge: A network device that connects two networks following the same set of protocols.

Ethernet: A LAN architecture developed by Xerox corp along with DEC and Intel. It uses either a bus or star topology and supports data transfer rates of up to 10 mbps.

Gateway: A network device that connects multiple networks using different protocols and routes packets among them.

Heterogeneous Network: A network that consists of workstations, servers, network interface cards, operating systems and applications from many different vendors, all working together as a single unit.

Homogeneous Network: A network that consists of only one type of workstation, Server, Operating system and Network interface card.

Hub: A hardware device used to connect several computers together.

LAN (Local Area Networks): Small computer networks that are confined to a localized area e.g., an office, a building etc.

MANs (Metropolitan Area Networks): Networks spread over a city.

Network Protocols: A collection of designated practices, policies and procedures often unwritten but agreed upon between its users that facilitates electronic communication between them.

Network Topology: The way of physical interconnection between computers to form a computer network.

Network: A collection of interlinked computers by means of a communication system.

Peer-to-Peer Network: Networks used for a small range of computers with all machines having their own resources and can also have shareable resources for other machines.

WANs (Wide Area Networks): A group of computers separated by large distances and tied together. It can even be a group of LANs that are spread across several locations and connected together to look like a big LAN.

13.11 QUESTIONS FOR DISCUSSION

1. What do you mean by "Network"? Write short notes on:
 - (a) Passive Optical Local Area Network (POLAN)
 - (b) LAN
 - (c) WAN
 - (d) MAN
2. Define the network 'topologies' with examples.
3. Describe the storage area network and virtual private network.
4. What is the idea of network device in your mind? Define the following:
 - (a) Bridges (b) Gateways
 - (c) Hub (d) Routers
5. Explain the similarities between Internet and Intranet.
6. What do you know about protocols? Describe with examples.
7. When do you think ring topology becomes the best choice for a network?
8. What are the types of connectivity used in computer network?
9. Differentiate Internet and Intranet.
10. What is bandwidth? How is it measured?
11. What is difference between LAN and WAN?

Check Your Progress: Model Answer

1. Networking
2. Standard Internet Protocol (TCP/IP)
3. Intranet
4. Wide Area Network
5. Network topology

13.12 REFERENCES & SUGGESTED READINGS

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UNIT-14

INTERNET

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14.0 AIMS AND OBJECTIVES

After studying this lesson, you should be able to:

- Define Internet
- Discuss the growth of Internet
- Explain owner of the Internet

14.1 INTRODUCTION

Today's world is an information-rich world and it has become a necessity for everyone to know about the store house of all information e.g., Internet applications. This lesson will provide an introduction to the various terms like web pages, web server, browser, etc. You might have come across these terms while surfing the Internet. It will provide an easy but a comprehensive explanation of what web pages are and how they are created. It will give you an idea of how communication takes place between web clients and a web server and how web pages are transferred from the web server to the web clients.

14.2 WHAT IS INTERNET ACTUALLY?

The Internet, sometimes called as, "the Net," is a worldwide system of computer networks - a network of networks. Users at any one computer can (if they have permission) get information from any other computer (and sometimes talk directly to users at other computers). This idea was conceived by the Advanced Research Projects Agency (ARPA) of the U.S. Government in 1969 and was first known as the ARPANet. The original aim was to create a network that would allow users of a research computer at one University to "talk to" research computers at other Universities. A side benefit of ARPANet's design was that, messages could be routed or rerouted in more than one direction. The network could continue to function even if parts of it were destroyed. Today, the Internet is a public, cooperative and self-sustaining facility accessible to hundreds of millions of people worldwide. Physically, the Internet uses a portion of the total resources of the currently existing public telecommunication networks. Technically, what distinguishes Internet is its use of protocols called TCP/IP (for Transmission Control Protocol/Internet Protocol). Two recent adaptations of Internet technology, the intranet and the extranet, also make use of the TCP/IP protocol.

For most Internet users, electronic mail (email) practically replaced the postal services. People communicate over the Internet in a number of other ways including Internet Relay Chat (IRC), Internet telephony, instant messaging, video chat and social media.

The most widely used part of the Internet is the World Wide Web (often abbreviated "WWW" or called "the Web"). Its outstanding feature is hypertext, a method of instant cross-referencing. In most Web sites, certain words or phrases appear in text of a different colour than the rest; often this text is also underlined. When you select one of these words or phrases, you will be transferred to the site or page that is relevant to this word or phrase. Sometimes there are buttons, images, or portions of images that are "clickable." If you move the pointer over a spot on a Website and the pointer changes into a hand, this indicates that you can click but will be transferred to another site.

Using the Web, you can access billions of pages of information. Web browsing is done with a Web browser, the most popular of which are Chrome, Firefox and Internet Explorer. The appearance of a particular Website may vary slightly depending on the browser you use. Also, later versions of a particular browser are able to render more "bells and whistles" such as animation, virtual reality, sound, and music files, than earlier versions.

The Internet has continued to grow and evolve over the years of its existence. IPv6, for example, was designed to anticipate enormous future expansion in the number of available IP addresses. In a related development, the Internet of Things (IoT) is the

burgeoning environment in which almost any entity or object can be provided with a unique identifier and the ability to transfer data automatically over the Internet.

14.2.1 Growth of Internet

Today the Internet continues to grow day by day making McLuhan's Global Village a reality. The following table shows the incredibly fast evolution of the Internet from 1995 till the present time:

Table 14.1: Number of Users

Date	Number of Users	% World Population	Information Source
December, 1995	16 millions	0.4 %	IDC
December, 1996	36 millions	0.9 %	IDC
December, 1997	70 millions	1.7 %	IDC
December, 1998	147 millions	3.6 %	C.I. Almanac
December, 1999	248 millions	4.1 %	Nua Ltd.
March, 2000	304 millions	5.0 %	Nua Ltd.
July, 2000	359 millions	5.9 %	Nua Ltd.
December, 2000	361 millions	5.8 %	Internet World Stats
March, 2001	458 millions	7.6 %	Nua Ltd.
June, 2001	479 millions	7.9 %	Nua Ltd.
August, 2001	513 millions	8.6 %	Nua Ltd.
April, 2002	558 millions	8.6 %	Internet World Stats
July, 2002	569 millions	9.1 %	Internet World Stats
September, 2002	587 millions	9.4 %	Internet World Stats
March, 2003	608 millions	9.7 %	Internet World Stats
September, 2003	677 millions	10.6 %	Internet World Stats
October, 2003	682 millions	10.7 %	Internet World Stats
December, 2003	719 millions	11.1 %	Internet World Stats
February, 2004	745 millions	11.5 %	Internet World Stats
May, 2004	757 millions	11.7 %	Internet World Stats
October, 2004	812 millions	12.7 %	Internet World Stats
December, 2004	817 millions	12.7 %	Internet World Stats
March, 2005	888 millions	13.9 %	Internet World Stats
June, 2005	938 millions	14.6 %	Internet World Stats
September, 2005	957 millions	14.9 %	Internet World Stats
November, 2005	972 millions	15.2 %	Internet World Stats
December, 2005	1,018 millions	15.7 %	Internet World Stats
March, 2006	1,023 millions	15.7 %	Internet World Stats
June, 2006	1,043 millions	16.0 %	Internet World Stats
Sept, 2006	1,086 millions	16.7 %	Internet World Stats
Dec, 2006	1,093 millions	16.7 %	Internet World Stats
Mar, 2007	1,129 millions	17.2 %	Internet World Stats
June, 2007	1,173 millions	17.8 %	Internet World Stats
Sept, 2007	1,245 millions	18.9 %	Internet World Stats
Dec, 2007	1,319 millions	20.0 %	Internet World Stats
Mar, 2008	1,407 millions	21.1 %	Internet World Stats

Contd...

June, 2008	1,463 millions	21.9 %	Internet World Stats
Sept, 2008	1,504 millions	22.5 %	Internet World Stats
Dec, 2008	1,574 millions	23.5 %	Internet World Stats
Mar, 2009	1,596 millions	23.8 %	Internet World Stats
June, 2009	1,669 millions	24.7 %	Internet World Stats
Sept, 2009	1,734 millions	25.6 %	Internet World Stats
Dec, 2009	1,802 millions	26.6 %	Internet World Stats
June, 2010	1,966 millions	28.7 %	Internet World Stats
Sept, 2010	1,971 millions	28.8 %	Internet World Stats
Mar, 2011	2,095 millions	30.2 %	Internet World Stats
Jun, 2011	2,110 millions	30.4 %	Internet World Stats
Sept, 2011	2,180 millions	31.5 %	Internet World Stats
Dec, 2011	2,267 millions	32.7 %	Internet World Stats
Mar, 2012	2,336 millions	33.3 %	Internet World Stats
June, 2012	2,405 millions	34.3 %	Internet World Stats
Sept, 2012	2,439 millions	34.8 %	Internet World Stats
Dec, 2012	2,497 millions	35.7 %	I.T.U.
Dec, 2013	2,802 millions	39.0 %	Internet World Stats
June, 2014	3,035 millions	42.3 %	Internet World Stats
Dec, 2014	3,079 millions	42.4 %	Internet World Stats
June, 2015	3,270 millions	45.0 %	Internet World Stats
Dec, 2015	3,366 millions	46.4 %	Internet World Stats
Jun. 2016	3,631 millions	49.5 %	Internet World Stats
Dec. 2016	3,696 millions	49.5 %	Internet World Stats
Mar. 2017	3,739 millions	49.6 %	Internet World Stats
June 2017	3,885 millions	51.7 %	Internet World Stats

14.2.2 Owner of the Internet

Who actually owns the Internet? There are two answers to this question:

1. Nobody
2. Lots of people

If you think of the Internet as a unified, single entity, then no one owns it. There are organizations that determine the Internet's structure and how it works, but they do not have any ownership over the Internet itself. No government can lay claim to owning the Internet, nor can any company. The Internet is like the telephone system no one owns the whole thing.

From another point of view, thousands of people and organizations own the Internet. The Internet consists of lots of different bits and pieces, each of which has an owner. Some of these owners can control the quality and level of access you have to the Internet. They might not own the entire system, but they can impact your Internet experience.

The physical network that carries Internet traffic between different computer systems is the Internet backbone. In the early days of the Internet, ARPANET served as the system's backbone. Today, several large corporations provide the routers that serve as the Internet backbone. These companies are upstream Internet Service Providers