PREFACE

COMPUTER SCIENCE for GRADE - 11 is developed according to the National Curriculum 2009 and National Style Guide. It is presented under the supervision of textbook development, principles and guidelines with new design and layout.

Computers have impacts almost on every aspect of modern daily life and will continue to do so in the future as more advanced technologies are developing and implementing. In the present world, it is practically impossible to find any facet of life that is not influenced by computers in one way or another. Computer plays a vital roll and it is backbone of the infrastructure of modern civilization, controlling everything including bank accounts, the stock markets, medical records, the power grid stations, utilities, nuclear weapons, and much more. Computers have ushered a new era of automation that has increased productivity and efficiency. Tasks that used to take hours or days to complete can now be finished in the blink of an eye with the help of modern computers. To be successful, computer literacy is now a need of an hour.

Computer Science for Grade - 11 is designed according to the needs of present day students. Care has been taken to ensure that all new topics in the syllabus are adequately covered. Throughout the book, there is an emphasis on the practical work rather than theory.

Our efforts are to make textbooks teachable with quality, i.e. maintaining of standards. It is a continuous effort and we will get feedback of the yearly feasibility reports and redesign the textbook every year.

Like before, the National Book Foundation has made specific endeavours to publish the text and illustrations in much effective pedagogical form. The meticulous effort of the team is acknowledged.

Quality of Standards and Actualization of Style is our motto. With these elaborations, this series of new development is presented for use. As their is always room for improvement, criticism and suggestions are always welcome to make the subsequent editions of the textbook more interesting, informative and useful for the students. After necessary changes pointed out by FBISE, the book is being published again.

National Book Foundation

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1

OVERVIEW OF COMPUTER SYSTEM

After completing this lesson, you will be able to:

- Identify computing devices.
- Define the term computer and its basic operations.
- Define and classify types of computers (micro, mini, mainframe, supercomputer and mobile computing).
- Differentiate between hardware, software and firmware.
- Describe application software and system software.
- Define the terms licensed software, open source software, shareware and freeware.
- Define various input/output devices and understand their working principles.
- Differentiate between hardcopy and softcopy.

Reading

UNIT INTRODUCTION

Computer systems are now common place in every part of our life. This unit introduces the basic components that make up these computer systems. There are two parts of all the computer systems; the hardware and the software. Hardware is the collective name given to all the devices that make up a computer system. Software is the term used for the actual programs that allow the hardware to do a useful job. Software is made up of a series of instructions that tell the computer what to do.

Teacher Point

1. Before starting the chapter, the students could be encouraged to explain what they understand about computer system.
2. Teacher should explain the importance of computer in daily life.

1.1 INTRODUCTION TO COMPUTERS

A computer is an electronic device that accepts data (as Input), performs operations (as Processing) on data at very high speed and produces the results (as Output). It is a programmable machine that executes a programmed list of instructions that it is provided.

Computers are composed of the central processing unit (CPU), input devices, output devices, secondary storage, and communication devices. The CPU is the main component of a computer that interprets and executes instructions.

A digital computer is a machine that can solve problems for people by carrying out instructions given to it. A digital computer consists of an interconnected system of processors, memories and input/output devices. A simple computer system is shown in Fig.1.1.

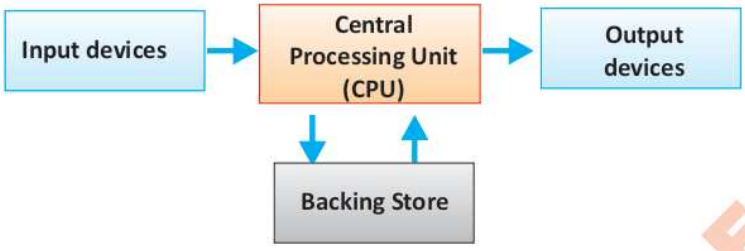


Fig.1.1 A simple computer system

TECHNOLOGY FACT!

Although we normally think of computers as the ones we use in our everyday lives to surf the web, write documents etc., small computers are also embedded into other things such as mobile phones, toys, microwaves and MP3 players. We use computers all the time, often without even knowing it!

1.1.1 COMPUTING DEVICES

All machines, components or devices that contain embedded, specialised computers are called computing devices. For example ATM machine, digital alarm clock, digital washing machine, microwave oven, toys, cell phones, CD player, etc. are computing devices. All these

Fig.1.2 Computing Devices

devices contain embedded computer chips which allow these devices to do special computing tasks, for example the computer of ATM machine gives banking transaction facilities, the computer of digital alarm clock sets the time for alarm and manages calendar, and the computer of digital washing machine can be programmed to wash clothes. Some important computing devices are shown in Fig 1.2.

1.1.2 BASIC OPERATIONS OF A COMPUTER

Any computer system, regardless of its size, is capable of performing the following basic operations which are shown in Fig.1.3.

Input operation: Accepting data for processing from an input device.

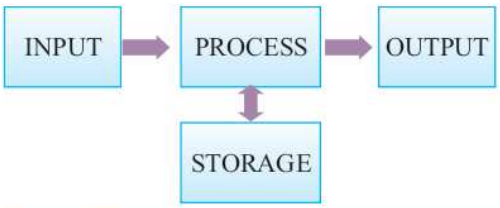


Fig.1.3 Basic operations of a computer

Processing operations: Performing arithmetic and logical operations. Arithmetic operations include addition, subtraction, multiplication and division while logical operations include comparison of different values and decision making.

Output operation: Sending results to an output device.

Storage operation: Writing data to a storage device such as hard disk or USB flash drive.

The purpose of a computer system is to accept data, process it and as a result of processing, produce output in the form of useful information. The input unit of computer presents data to the processor for processing. The results of processing of the data are displayed on the monitor screen, printed on paper or sent to any other output or storage device.

1.1.3 CLASSIFICATION OF DIGITAL COMPUTERS

There are several factors that make computers different from each other. These factors are physical size, cost, speed, etc. Based on these factors, computers are classified into four categories.

- Supercomputer
- Mainframe computer
- Minicomputer
- Microcomputer

DO YOU KNOW?

The first electro-mechanical computer was developed in 1939.
(Get more info from the Internet)

Supercomputer

Fig.1.4 Modern Supercomputer

Supercomputers are the largest, the most expensive and powerful computers. They are used to process complex calculations as well as designing and controlling of complicated machines, such as rockets and fighter planes. Supercomputers are also used in nuclear research and weather forecasting which requires huge amount of calculations to be performed at high speed. The best known supercomputers are built by Cray Inc. an American supercomputers manufacturers and IBM. In Pakistan supercomputers are used in many organizations, like Atomic Energy Research Centre. A supercomputer is shown in Fig.1.4.

Mainframe computer

These are larger, more expensive and more powerful computers compared to minicomputer but less powerful than supercomputer. They are used in large corporations, banks, universities and scientific laboratories. Mainframes usually fill a large room because they include many types of peripheral devices.

Fig. 1.5 Mainframe computer

A typical mainframe can execute about trillion instructions per second (TIPS) and can support thousands of users.

Some examples of mainframe are IBM's zEnterprize EC12, EC 196 and HP 16500 Series.

A mainframe is shown in Fig.1.5.

Minicomputer

These computers are larger and more expensive than microcomputers. Minicomputer and its peripheral equipment can usually fill a small room.

Minicomputers can support hundreds of users at a time. Minicomputers are faster than microcomputers. They can execute billions of instructions per second (BIPS). These computers can process more data than microcomputers.

Fig.1.6 Minicomputer

Minicomputers are widely used in industrial process control, scientific research and small business applications.

Due to advancement of technology, the difference between the performance of microcomputer and minicomputer is gradually decreasing. As a result, modern microcomputers are replacing the more expensive minicomputers.

Examples of minicomputer are IBM System/36, DEC PDP, VAX Series, HP 3000, etc. A minicomputer is shown in Fig.1.6.

Microcomputers

Microcomputer, shown in Fig.1.6, is the smallest and least expensive computer. Its small size is a result of LSI (Large Scale Integration) and VLSI (Very large Scale Integration) technologies. A modern microcomputer can execute millions of instructions per second (MIPS). Although, this is very fast but it is much slower than minicomputers and mainframes.

Fig.1.7 Microcomputer

A typical microcomputer (as shown in Fig.1.7) consists of a Keyboard, a Mouse, a Monitor and System Unit. Microcomputers are used at home for personal use as well as

for business applications. A large variety of software is available for use on microcomputers. A microcomputer can easily fit on a desktop or in a briefcase in the form of laptop computer.

Some examples of microcomputer are IBM Thinkpad, Toshiba Satellite series, Dell XPS, HP Envy series and Apple series.

1.1.4 MODERN USE OF COMPUTERS IN TODAY'S LIFE

Mobile Computing

Fig.1.8 Tablet PC and PDA

It refers to a variety of small portable devices such as shown in Fig.1.8 that allow people to access data and information from anywhere in a wireless network system. Mobile computing devices run on batteries and have limited functionality as compared to laptops. Popular mobile computing devices are tablet PCs, PDAs (Personal Digital Assistants) and smartphones.

Internet of Things (IoT)

Internet of Things (IoT) is the interconnection between computer network and physical devices to collect and exchange data. Devices used in daily life can be equipped with wireless connectivity, and embedded with software, sensors, actuators, cameras, microphones and other instruments that enable them to collect and share data. All kinds of household items can be modified to work in an Internet of Things system. These devices are known as smart devices and they are designed in such a way that they can interact with human beings through wireless connection.

Smart home is a popular application of IoT. In future, IoT will allow us to switch on air conditioning before reaching home or switch off lights after leaving home. There are homes equipped with various types of electronic devices that can be controlled remotely with smart phone or computer through IoT system.

Cloud Computing

Cloud computing means instead of buying and installing your own computer system and software at your workplace, you can get it as a service provided and managed by another company. You can perform your computing tasks through access to service over the Internet. It does not matter where the hardware and software is located. It is just somewhere in the "cloud". It is a way of outsourcing your computing requirements.

The advantage of cloud computing is that you don't have to buy and maintain a complex computer system. This cuts cost of buying computers and peripherals. Besides, you are not worried about equipment going out of date and other problems related with system security and reliability.

The disadvantage of cloud computing is that it requires a reliable high speed broadband connection functioning the whole time you are working. Another disadvantage of cloud computing is the privacy and security risk of having valuable data on someone else's system in an unknown location. Companies those offer Cloud Computing services are: Google, Microsoft, Ctrix Systems, Joyent and Amazon, etc.

Data Centers

Data center is a centralized location for collecting, storing, processing and distribution of vast amount of data. It consists of servers, routers, switches and backup equipment. A data center facility usually requires air conditioning, fire suppression, smoke detection and security entry. It may be housed in a room, an entire building or a group of buildings. Organizations such as government agencies, banks, educational institution, telecommunication companies and social networking services use large amount of data and thus have requirement for data center. Many companies are moving their data centers to cloud services to cut the cost of running their own computing networks and servers.

1.1.5 COMPUTER HARDWARE AND SOFTWARE

A computer system consists of hardware and software.

Hardware

All the physical components of computer system, such as monitor, keyboard, hard disk, printer, along with the circuitry connecting them are known as computer hardware. Computer hardware is what you can physically touch and see. In simple words all tangible parts of computer system are referred as hardware.

Software

Software is any set of instructions, also called programs, which are given to the computer to perform any task or to do any activity. It tells the computer what to do and how to do. Programming languages are used to prepare software.

A computer cannot do anything on its own. It must be instructed to do a desired job. Hence, it is necessary to specify a sequence of instructions, which a computer must perform to solve a problem. For example, word-processing software, spreadsheet software and database management software may contain many programs for creating, editing, formatting and printing different types of documents.

1.2 TYPES OF COMPUTER SOFTWARE

Computer software can be classified into the following types.

- System Software
- Application Software
- Internet Applications
- Licensed Software, Open Source Software, Shareware and Freeware

1.2.1 SYSTEM SOFTWARE

System software is a collection of system programs that control and coordinate the activities of a computer system. System software consists of a collection of operative programs

Teacher Point

Students may be taken to some organizations like electric supply companies, sui gas companies, airlines, etc., to show the working of different types of computer systems.

required to control computer hardware and also to execute application software. The purpose of system software is to make the use of computer more effective and efficient. A computer without some kind of system software would be ineffective and impossible to operate. Some examples of system software are:

- Operating system
- Device Drivers
- Utility Software
- Language Processors/Translators

Operating System

Operating system manages the hardware and software resources of a computer system, such as CPU, storage devices and all the input/output devices. Some commonly used operating systems are Windows, Linux, Mac OS and Android.

Operating system performs the following tasks.

- Allocates system resources
- Manages files by maintaining a proper file and folder system
- Loads and executes application software
- Controls the operation of all the input/output and storage devices
- Maintains security
- Controls network operations
- Provides user interface

Device Drivers

Device drivers are system software that control the operation of hardware devices. When we attach any type of device, such as printer, scanner, network card, or digital camera to a computer, it will not work without a device driver. We have to first install the driver of a device in our computer before using it. Device drivers are provided by device manufacturers. Some devices like Mouse, Keyboard, Monitor, USB Flash drive, etc. are "***Plug n Play***" devices. Their software is preinstalled with Windows. When attached, the computer system automatically recognize them.

Utility Software

Utility software (or simply utilities) provides additional facilities to carry out tasks which are beyond the capabilities of the operating system. A few important utilities are disk defragmenter, disk cleaner, file compression utilities, antivirus utility, file manager, network utilities and utilities to configure hardware devices.

Teacher Point

Teacher should explain the important software for computer.

Language Processors/Translators

The computer can only understand machine language which consists of 0s and 1s. Therefore, any program written in assembly language or high level language must be translated to machine language before execution by the computer. Language processors are used to translate computer programs into machine language. The types of language processors are assembler, compiler and interpreter.

Assembler is software that translates assembly language program into machine language. Assembly language consists of symbolic abbreviations called mnemonics which must be translated into machine language before execution by the computer. Each computer has its own assembly language.

Compiler is software that translates a program written in a high level language into machine language. It converts the entire program into machine language before execution by the computer.

Interpreter is software that translates high level language into machine language but it translates one instruction at a time and executes it immediately before translating the next instruction.

1.2.2 APPLICATION SOFTWARE

Application software is a set of programs designed to perform a specific task. For example, application software for payroll processing produces pay slips and application software for processing examination results produces mark sheets along with some other statistical reports.

Some examples of application software are:

- Productivity Software
- Business Software
- Entertainment Software
- Educational Software

Productivity Software

Productivity software is used to improve the way people do their work. It speeds up the daily routine tasks performed by individuals and teams by eliminating the repetitive tasks. Productivity software includes word-processing, spreadsheet, database management and graphics software.

Business Software

Business software is used to run business activities. It helps in efficiently running business functions of a company. Examples of business software are payroll, accounting, inventory and retail software.

Entertainment Software

Entertainment software is used to entertain people. It includes games, audio video player, etc.

Educational Software

Educational software is used for learning purpose. Examples of educational software are programs that teach about human body, working of an engine, solar system, typing, foreign language, music and subjects like Mathematics, Physics, Chemistry, etc.

1.2.3 INTERNET APPLICATIONS

- Web Applications
- Cloud Computing Applications
- Social Media Network Applications

Web Applications

A Web application is a program that runs on a remote server while its users interact with it through a Web browser. Some common Web applications include web-based email programs (such as Gmail, Hotmail), online ticketing service, on line banking service, online auction, online retail sales, instant messaging services, etc.

Cloud Computing Applications

Cloud application is a program that supports cloud computing. A cloud application is entirely stored on a remote server and is delivered over the Internet through a Web browser. Users of a cloud application need a computer with a high speed Internet connection.

Social Media Network Applications

Social media is an Internet-based communication system that allows the creation and exchange of information, ideas, common interests and other forms of expression. Social media websites connect users with their friends, family and colleagues through the use of Internet. Some popular examples of social media are Facebook, Twitter and WhatsApp.

Facebook : Facebook is one of the fastest growing free social networking services used by millions of people all over the world. It allows registered users to create profile and exchange messages, photos, videos and links with other users. It helps users stay updated with what is happening around the world. It provides a platform by which users can create groups and pages based on their common interests and share views and ideas.

Twitter : Twitter is an online news and social networking service which allows subscribers to broadcast short messages to other subscribers of the service. The short messages known as "tweets" are restricted to 140 characters. It is free to join service. It is totally different from email and more like a news broadcast. Users of Twitter service type short statements about what is going on in their life, what they are doing and what their thoughts and opinions are on specific topics or current affairs. People all over the world are continually broadcasting tweets which can be viewed by anyone.

WhatsApp : WhatsApp is a free instant messaging service for smartphone users to exchange text, photos, videos and audio messages through Internet. It has become the largest messaging service around the world. WhatsApp is very popular among teenagers because of features like group chatting, voice messages and location sharing. It was started for Android mobile devices but now it is available for iPhone, BlackBerry, Windows Phone and Nokia smartphone also.

1.2.4 LICENSED SOFTWARE, OPEN SOURCE SOFTWARE, SHAREWARE AND FREEWARE

Licensed Software

A software license is a legal agreement that specifies the terms of use for a computer program. It defines the rights of the software developer and the user. When a person purchases software, he is allowed to use the software, which means he is not the owner of the software. Generally all the system software and application software is licensed.

The software license deals with the Copyright Law. Copyright law prevents illegal copying of computer software. It allows creators of computer software to benefit financially from their software and to retain some control over how it is used.

When the software is given away free, it makes it difficult for the software creators to stay in business. This makes it improper to make copies of software and sell it. Software that is copied and sold without the permission of the owner is known as pirated software and it is violation of copyright.

Examples of licensed software are Microsoft Windows and Microsoft Office.

Open Source Software

It is computer software that is available in the form of source code that allows users to study, change and improve it. Open source software is free for inspection, modification and distribution. It allows certain rights which are normally protected by Copyright Law. Linux operating system is an open source software.

Shareware/Trial-ware

Shareware is given to people free of charge for a limited time period. After the expiry time, this software should be purchased for further usage. Shareware is a trial version and its functionality is limited. There are some types of shareware which are available as full version but they stop working at the end of trial period. The trial period is usually 30 or 60 days. Some shareware can be downloaded from Internet. For example some Antivirus software are shareware.

Freeware

Freeware is available for use, free of cost. It is usually full version of the software for an unlimited period of time. This software may have restrictions in term of use. For example, it may be allowed for personal or academic use only or for non-profit use. Some examples of freeware are Skype, Viber and Mozilla Web browser.

1.2.5 FIRMWARE

Firmware is an intermediate form between hardware and software. It consists of software embedded in electronic devices during their manufacturing. Firmware is used when the programs are rarely or never expected to be changed, for example, in toys, appliances and ROM. Firmware is also used when the programs must not be lost when the power is off.

1.2.6 INTERNET APPLICATION SECURITY

Internet application security refers to preventive measures against threats that can harm the Internet applications. Internet applications are available 24/7 and offer access to many people leading to high risk of intrusion. Internet applications are venerable to a wide variety of threats. Hackers can steal, modify or delete sensitive data. To ensure application security, it is essential to continuously monitor the activity of server on which the application is running and block hackers trying to obtain sensitive data. Internet application security system consists of firewalls, anti-virus programs, spyware detection and removal programs and encryption/decryption programs.

1.3 COMPUTER HARDWARE

A computer system consists of hardware and software. The physical components of a computer that we can see, touch and feel are called hardware. Computer hardware consists of input devices, output devices, memory devices, processing devices, communication devices and the electronic circuitry that links these devices for communication between them. In this section only input and output devices are discussed. Other devices will be covered in the coming units.

1.3.1 INPUT DEVICES

The input devices are used to communicate with the computer. They consist of devices that accept data and convert it into machine readable form. These devices are often referred to as peripherals because they are physically separated from the system unit. Some input devices are keyboard, mouse, joystick, microphone and image scanners.

Keyboard

Keyboard is the primary input device for the input of data to a computer, though voice input devices may ultimately supersede it. It operates by converting key presses to electronic signals in digital form. Keyboard has the standard character keys together with numeric keys and special keys.

Pointing Input Devices

Pointing devices are used to control the movement of the pointer (cursor) to select items on a screen or open computer programs or files.

DO YOU KNOW?

The First Computer Mouse was invented by Doug Engelbart in around 1964 and was made of wood.

Fig.1.9 Mouse

Commonly used pointing devices are mouse, trackball, joystick, touch screen, light pen and touch pad.

- **Mouse**

Mouse is a hand-held pointing input device that detects multi-dimensional motion relative to a surface. This motion is typically translated into the motion of a pointer on a display screen, which

allows a smooth control of the objects on the screen. Mouse originally used a ball rolling on a surface to detect motion, but modern mouse has optical sensors that have no moving parts. In addition to moving a cursor, mouse has one or more buttons to allow operations such as selection, scrolling, dragging, etc. Mouse is an essential part of the computer system to run/use Windows and other application software. A mouse is shown in Fig.1.9.

- **Trackball**

Trackball remains stationary on the surface. The ball, at the top, is rolled with fingers. It has buttons that are used to perform operations similar to those performed by a mouse. A trackball is shown in Fig.1.10.

Fig.1.10 Trackball

- **Joystick**

Joystick is commonly used for playing computer games. It is fixed on the table and it has a stick in the centre that can be tilted in any direction. The stick is held by hand and when it is tilted in any direction, the movement is translated into the movement of an object on the screen. The buttons are used to perform actions such as firing guns and lasers. A joystick is shown in Fig.1.11.

Fig.1.11 Joystick

- **Touch Screen**

A touch screen is a computer display screen. It is an input as well as output device. The screen is sensitive to pressure. User interacts with the computer by touching pictures or words on the screen as shown in Fig.1.12. Instead of using a pointing device user can use finger to point directly to objects on the screen. Touch screens are generally attached to computers but they are also popular in other devices such as mobile phones, satellite navigators and Personal Digital Assistants (PDAs).

Fig.1.12 Touch Screen Monitor

- **Light Pen**

It looks like a pen with a photocell at its tip as shown in Fig.1.13. It is used to point to an object or draw on the screen. It gives more accuracy than pointing with our finger on the touch screen. It is mainly used in engineering for designing purpose.

Fig.1.13 Light Pen

Fig.1.14 Touch Pad

- **Touch Pad**

Touch pad is used in laptop computers as shown in Fig.1.14. It is a pointing device that can sense the movement and position of finger on the pad. They are commonly used as an alternate to computer mouse in a laptop computer. There are two buttons located above or below the pad and their function is the same as the buttons on the mouse.

Fig.1.15 Microphone

Microphone

Microphone is used to convert the spoken words to digital signals for computer input. It converts audio signals to electrical waves and these are converted by electronic circuitry in the computer to digital form. A microphone is shown in Fig.1.15.

Fig.1.16 Digital Camera

Digital Camera

It is a camera that captures pictures and stores them in digital form. Pictures taken by a digital camera can be downloaded to a computer for viewing and editing.

Digital cameras have a LCD for viewing both images in the viewfinder and those in the camera's memory. It is an input as well as output device. A digital camera is shown in Fig.1.16.

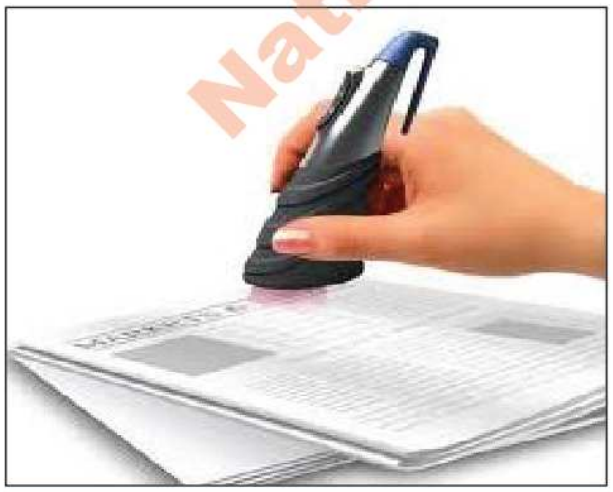


Fig.1.17 Hand-held Scanner

Scanners

Scanner is an optical input device that optically scans printed or handwritten text and images and stores them in computer memory in digital form. Nowadays, scanners are widely used to get drawings, diagrams and photographs into computer systems for incorporation into documents and books which are made up electronically prior to printing.

There are different types of scanners like hand-held scanner, flatbed scanner and barcode reader.

- **Hand-held Scanner**

To scan an image, the hand-held scanner is dragged over the image to be scanned. The hand-held scanner should be moved carefully with uniform speed because uneven scanning rate would produce distorted image. Hand-held scanners are very useful for scanning articles from magazine, newspapers and books. A hand-held scanner is shown is Fig.1.17

Fig.1.18 Flatbed Scanner

- **Flatbed Scanner**

In a flatbed scanner, the image to be scanned is placed face down on the glass and a cover is lowered over it to exclude light. The camera moves across glass pane, reading the entire area. A flatbed scanner is shown in Fig.1.18.

- **Barcode Reader**

Barcode reader is also a type of scanner which is used to scan barcode, also called ***UPC*** (Universal Product Code), available on various products. These barcodes contain information about the product, like name of the product, company, manufacturing date, expiry date, etc. This information is provided to the computer for further processing like generating bills at check outs in shopping malls. Prices are normally not included in barcodes because prices are not constant and may change frequently. A Barcode with reader is shown in Fig 1.19.

Fig.1.19 Barcode with Reader

Magnetic Stripe Card Reader

A magnetic stripe card reader is an input device that reads the information encoded in the magnetic stripe located on the back of a plastic card. Data is stored in the magnetic stripe in the form of tiny magnetized particles. The information on the card is read by swiping the card past a magnetic reading head. Examples of these cards include credit cards, ATM cards, VISA and MasterCard, driver's license and membership cards. A magnetic stripe card reader is shown is Fig.1.20.

Fig.1.20 Magnetic Stripe Card Reader

Teacher Point

Teacher may also use presentations or animations, or videos to explain the working of I/O devices.

1.3.2 OUTPUT DEVICES

Output devices consist of computer components such as monitor, printer, speaker and plotter that transfer information from computer memory to the outside world. They display or print text, graphics or pictures. The output generated on paper by an output device such as printer or plotter is called ***Hardcopy*** output. The output in the form of data or information stored on a storage device or displayed on a monitor is called ***Softcopy*** output.

Monitors

Fig.1.21 CRT Monitor

A monitor, sometimes called a VDU (Visual Display Unit), is an electronic output device for computers. It displays the results of the user activities. The output produced by monitors is called softcopy output. There are different types and sizes of monitors, each can be distinguished on the basis of the following features:

Size: The size of the monitor is measured diagonally. Standard size of monitor is from 15 to 21 inches.

Color: The monitor can be either black and white or color.

Pixel: Pixel is a small/tiny dot on the monitor which forms the image.

Resolution: The number of pixels (or dots) per square inch is called the resolution of the monitor.

Dot Pitch: The distance between the pixels on the monitor is called dot pitch. The lesser the dot pitch more will be resolution of the monitor.

CRT (Cathode Ray Tube), LCD (Liquid Crystal Display) and LED (Light Emitting Diodes) are the common types of monitors.

- **Cathode Ray Tubes (CRT) Monitors**

CRT monitors are similar to the standard television sets because they contain Cathode Ray Tube. The Cathode Ray Tube (CRT) is a vacuum tube containing an electron gun and a phosphors coated screen. The electron gun, fires a beam of electrons which falls repeatedly on the phosphors coated screen and it glows for a fraction of a second. In color CRT monitors there are three electron guns while the phosphors atoms are in three different colors i.e. Red, Green, Blue (RGB). Other colors are produced by the combinations of these three colors.

Fig.1.22 LCD Monitor

- **Liquid crystal display (LCD) Monitors**

Liquid Crystal Display (LCD) is a thin and light weight monitor. It contains a substance called liquid crystal between two sheets. The molecules of this substance are lined up in such a way that the light behind the screen is blocked or allowed to create an image on the screen. LCDs provide a sharper image than CRT monitors and emit less radiation. They are used in a wide range of

applications, including computer monitors, televisions, and clocks. They are usually more compact, lightweight, portable, less expensive, more reliable, and easier on the eyes than CRT monitors.

- **Light Emitting Diodes (LED) Monitors**

LED monitor is a light-weight flat panel display unit, which uses LEDs (light-emitting diodes) as pixels for display. In contrast to LCDs these monitors produce bright images and emit less radiations. LEDs run at lower temperatures and consume less power as compared to LCDs. Their lifespan is also longer than other types of monitors. The only drawback is that these monitors are expensive than other types of monitors.

Printers

Printers are used to produce hardcopy of output. In the past, printers were connected to the computer through parallel port but now they are connected through USB port.

Printers vary in their capabilities based on the following characteristics.

- The quality of output
- The ability to print graphics
- The printing speed

There are two main categories of printers.

- Impact printers
- Non-impact printers

- **Impact Printers**

Impact printers are those printers which work like typewriters. Impact printers use electro-mechanical mechanism, which causes the character shape to strike against the paper and leave an image of character on the paper. Examples of impact printers are dot matrix and chain printers. Their print quality is low and they produce noise.

Dot matrix printers have 9 or 24 pins arranged in a matrix to print shapes of characters. A dot matrix printer is shown in Fig.1.23.

Fig.1.23 Dot Matrix Printer

Fig. 1.24 IBM 1403 Chain Printer

Chain printer is very old type of line printer. It contains characters in a chain. The chain moves rapidly by two geared pulleys while printing. IBM 1403 Chain printer is shown in Fig.1.24.

- **Non-impact Printers**

Fig.1.25 Inkjet Printer

Non-impact printers produce a printed image without striking the paper. The printing quality and speed of these printers is better than impact printers. These printers produce very little noise while printing. Commonly used non-impact printers are inkjet and laser printers. Inkjet printers are character printers. They form characters and all kinds of images by spraying small drops of ink on the paper. Inkjet printers are cheap, quiet in operations and can print in multicolour but the printing quality and speed is slower than laser printers. An inkjet printer is shown in Fig.1.25.

Fig.1.26 Laser Jet Printer.

Laser printers are page printers, meaning that they print an entire page at a time. Their printing technology is very similar to photocopiers. They are very fast and silent in operation. The print quality of laser printer is very high and they can print graphics in multicolour. A laser printer is shown in Fig.1.26.

Plotters

Plotters are output device used to produce large size hardcopy output. Plotters are used for a variety of applications, which include drawing graphs, making maps, plotting civil engineering drawings/machine components and producing large size panaflexes. Plotters are of two types i.e. flatbed and drum.

- **Flatbed Plotter**

Flatbed plotter plots on paper that is spread and fixed over a rectangular flatbed as shown in Fig.1.27. Pens of different colours are mounted in the pen holding mechanism that moves on the surface to draw the image.

Fig.1.27 Flatbed plotter

Fig.1.28 Drum Plotter

- **Drum Plotter**

In drum plotter, paper/sheet is fed from one side and drum of the plotter rotates to move the paper to the other side. These plotters are used to print large size drawings and panaflexes as shown in Fig.1.28.

- **Speakers**

Speakers are audio output devices that are attached to the sound card on motherboard. Speakers produce softcopy output in the form of voice. Speakers are available in different shapes and sizes as shown in Fig.1.29.

Fig. 1.29 Speakers

Key Points

- A computer is a device which takes instructions and data in the form of input, performs computations according to the given instructions and provides output as a result.
- All machines, components or devices that mediate in the processing of a computer system are called computer devices.
- Computers are classified into Microcomputer, Minicomputer, Mainframe and Supercomputer. Microcomputers are the smallest and the least expensive computers whereas Supercomputers are the largest, the most expensive and powerful computers.
- The physical components of a computer such as monitor, keyboard and hard disk are known as hardware.
- System software is a collection of programs to make the use of computer easy, efficient and effective.
- Application software is a set of programs designed to perform a particular task.
- Firmware is an intermediate form between hardware and software which consists of software embedded in electronic devices during their manufacture.
- Input devices are used to communicate with the computer. They accept data and instructions from the user and convert them into machine readable form before storing in the computer memory.
- Output devices consist of peripheral devices that transfer information from the main memory to the outside world in human readable form.
- Hardcopy is the output generated on paper by an output device such as printer or plotter.
- Softcopy is data or information stored on a storage device or displayed on a monitor.

Exercise

Q1. Select the best answer for the following MCQs.

i. _____ of the following is the smallest computer.
   A. Mainframe
   B. Minicomputer
   C. Microcomputer
   D. Supercomputer

ii. How many instructions per second a minicomputer can execute?
   A. Thousands of instructions
   B. Millions of instructions
   C. Billions of instructions
   D. Above trillion instructions

iii. What type of software MS Word is?
   A. System software
   B. Application software
   C. Utility software
   D. Language processor

iv. _____ is most suitable for playing games.
   A. Mouse
   B. Keyboard
   C. Joystick
   D. Light pen

v. Which of the following is an impact printer?
   A. Dot matrix printer
   B. Laser printer
   B. Ink jet printer
   D. Plotter

vi. _____ software controls the operation of a hardware device.
   A. Utility software
   B. Language processor
   C. Application software
   D. Device driver

vii. Which of the following devices is used to print large size hardcopy?
   A. Plotter
   B. Inkjet printer
   C. Laser printer
   D. Chain printer

viii. Which of the following devices converts spoken words into electrical form?
   A. Touch pad
   B. Microphone
   C. Scanner
   D. Digital camera

ix. _____ software converts computer programs to machine language.
   A. Utility program
   B. Device driver
   C. Language processor
   D. Application software

x. Which of the following is productivity software?
   A. Spreadsheet software
   B. Utility software
   C. Windows 7
   D. Compiler

Q2. Answer the following questions briefly.

i. Write important characteristics of computers.
ii. Compare microcomputer with mainframe computer.
iii. Give few application areas of supercomputers.
iv. Name few organizations of Pakistan where supercomputers are used.
v. How barcode system works in a shopping mall?
vi. Differentiate between computer hardware and software.

vii. Differentiate between system software and application software.
viii. Define licensed software.
ix. Differentiate between shareware and freeware.
x. Briefly describe magnetic stripe card.
xi. Give any five advantages of using LCD monitor over CRT monitor?
xii. Why LED monitors are better choice than LCDs? Give three reasons to support your answer.
xiii. Why dot-matrix printers are becoming obsolete?
xiv. What are the advantages of using laser printer over dot matrix printer?
xv. Give any three uses of plotters.

Q3. Answers the following questions.

i. Describe the types of system software.
ii. Why scanners are used? Describe their types.
iii. What are output devices? Explain its types.
iv. Why plotters are used? Briefly explain their types.
v. What is non-impact printer? Describe its types.

Lab Activities

Following lab activities are to be carried out during the practical periods.

1. The assembling and disassembling of the computer system should be demonstrated to the student. (Practically or through some video/animation)
2. Students should be shown microprocessor, motherboard and power supply unit and the function of these should be explained through video/animation.
3. All the input/output devices covered in this unit should be shown to the students and their operations should be demonstrated.
4. The concept of "Plug n Play" devices should be demonstrated/explained practically by attaching such devices.
5. Hardcopies of various printers and plotters should be shown to the students for comparing print quality.
6. Students may be taken to the places/organizations where super, mainframe and mini computers are used.
7. Teacher may ask the students to use the website www.howstuffworks.com for learning purpose.

2

COMPUTER MEMORY

After completing this lesson, you will be able to:

- Define bit, byte, memory word and memory units
- Differentiate between main memory and secondary memory
- Explain the difference between chip memory and magnetic memory
- Differentiate between volatile and non-volatile memory
- Describe internal processor memory, RAM and ROM
- Differentiate between sequential access and direct access memory
- Describe magnetic tapes, magnetic disks and optical disks
- Describe flash memory and memory cards

Reading

UNIT INTRODUCTION

Computer memory is one of the important and compulsory components of every computer system. This unit describes memory and memory devices used to store data and programs on a temporary or permanent basis for use in digital computers. The two main types of computer memories i.e. primary and secondary memories are discussed thoroughly.

2.1 INTRODUCTION TO COMPUTER MEMORY

In computing ***memory*** refers to the physical devices used to store programs (sequence of instructions) or data on a temporary or permanent basis for use in a computer or other digital/computing device. Memory in a digital computer contains the main part of operating system and all the application programs and related data that is being used.

Memory that communicates directly with the CPU as shown in Fig.2.1 is called ***main memory*** or primary

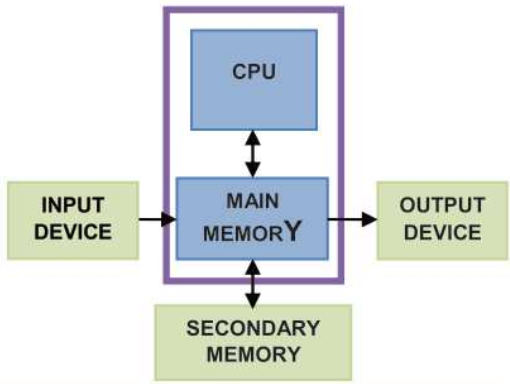


Fig. 2.1 Block diagram of a computer with memory unit

Teacher Point

Before starting the chapter, the students could be encouraged to explain what they understand about Computer Memory.

memory. Devices that provide backup storage are called ***secondary memory*** or mass storage devices. All the information is stored in secondary memory and it is transferred to main memory on a demand basis.

2.1.1 Memory characteristics

The important characteristics of any memory device are its access mode, access time, transfer rate, capacity and cost.

- ***Access mode:*** Memory has two major access modes, sequential and random. In sequential access mode memory can be accessed only in serial order i.e. if we have to access 4th memory location then we first would have to move to first three locations and skip them and only then we can access the 4th location. It is also called serial access mode. In random access mode memory location can be accessed at random i.e. if we have to access 4th location then we can directly go to 4th location and access it. It is also called direct access mode.
- ***Access time:*** It is the time taken to retrieve data from memory. Access time in sequential access memory devices is more than the random access memory devices.
- ***Data transfer rate:*** It is the time taken to transfer data from one memory device to the other. For example time taken to transfer data from Hard disk to the main memory (RAM).
- ***Capacity:*** The memory capacity is the amount of space that a memory device has to store data or the amount of memory required for a program to run.
- ***Cost:*** It is the price that computer users have to pay as per capacity of the memory device.

2.1.2 Memory Terminology

The following are some important terms related to memory.

Bit

The smallest unit of memory in digital computer is a bit, which stands for binary digit 0 or 1. The memory of a computer consists of millions of memory (or electronic) cells. Each cell contains one bit of information. The memory cell has two states, ON and OFF. The ON state represents a binary 1 and OFF state a binary 0.

Byte

Byte is the basic unit of computer memory and it is the minimum piece of data to be processed by a computer. A group of 8 bits is known as one byte. One byte of memory is required to store one character in the computer, for example ‘A’, ‘a’, ‘b’, ‘*’, etc. A byte is generally used to express the memory size of a computer. Computer memory is measured in terms of bytes. The higher units are Kilobyte (KB), Megabyte (MB), Gigabyte (GB) and Terabyte (TB). In future, memories will also be available in Petabyte (PB) and Exabyte (EB) as indicated in red colour in Table 2.1. The relationship between the memory units is shown in Table 2.1.

MEMORY UNIT	EQUIVALENT TO
1 Byte	8 Bits
1 Kilobyte (KB)	2^{10} Bytes = 1024 Bytes
1 Megabyte (MB)	2^{20} Bytes = 1024 KB
1 Gigabyte (GB)	2^{30} Bytes = 1024 MB
1 Terabyte (TB)	2^{40} Bytes = 1024 GB
1 Petabyte (PB)	2^{50} Bytes = 1024 TB
1 Exabyte	2^{60} Bytes = 1024 PB

Table 2.1 Memory Units and their Equivalents

Memory Word

In computing, the smallest chunk or size of data that a computer can process is called memory word. It is a fixed-sized piece of data handled as a unit by the processor. The number of bits in a word is called the word size. Word size in modern computers typically ranges from 16 to 64 bits, depending on the size of the computer. A computer that has a bigger word size can transfer more bits into the microprocessor at a time for processing and this improves the processing speed of the computer.

The main indication of the word size is how much memory the processor can address. A 32-bit processor is limited to 2^{32} memory addresses. This is a group of bits (cells) in a memory that represents information or data of some type.

2.1.3 Memory Built-up and Retention power

All types of computer memories, as far as their built-up or manufacturing is concerned, are divided into Chip memory, Magnetic memory and Optical memory. And as far as their retention power is concerned these memories are divided into Volatile memory and Non-Volatile memory.

Fig.2.2: Chip Memory devices

Chip Memory

Chip is a small piece of semi-conducting material (usually silicon). A small circuit called IC (Integrated Circuit) is embedded on it. A typical chip contains millions of electronic components (transistors).

Chip memories are very fast as compared to other memories as there are no mechanical moving parts in them but on the other hand chips rely on electric currents.

Examples of chip memory are main memory (RAM, ROM and Cache), Flash memory drives, memory cards and registers. Many special-purpose chips, known as application-specific integrated circuits, are also being made today for

automobiles, home appliances, telephones, and other devices. Different types of chip memory devices are shown in Fig.2.2.

Magnetic Memory

One of the most widely used types of digital data storage is magnetic memory/storage. This refers to any type of data storage using a magnetized medium. Magnetic tapes and disks are examples of magnetic memory devices. A thin layer of magnetic material is coated on the surface of magnetic tape and magnetic disks. Binary information is stored in the form of tiny magnetized and non-magnetized spots on the surface of magnetic tape or disk. A magnetized spot represents a binary 1 and a non-magnetized spot a binary 0. A read-write head moves very close to the magnetic surface. The head is able to detect and modify the magnetization of the material. Magnetic storage is widely used because it is relatively cheap in comparison with other storage technologies. The storage capacity is also very large, making it attractive for storing very large amounts of data. The major limitation of magnetic storage is that accessing the data can be quite slow. Hard disk is the common example of magnetic memory as shown in Fig 2.3.

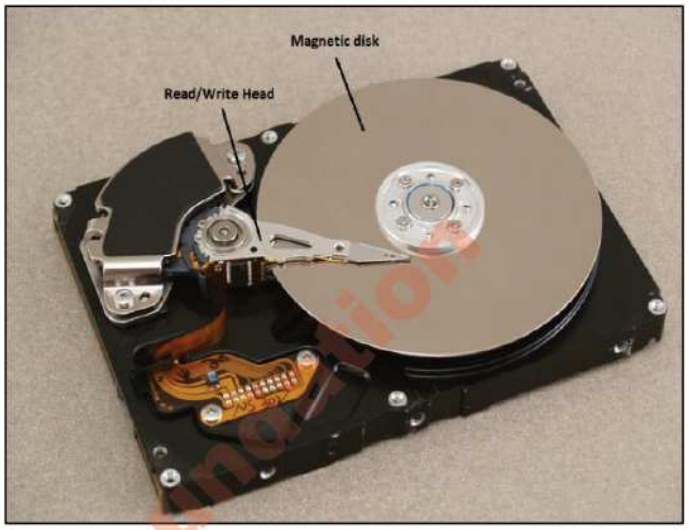


Fig.2.3: Magnetic disk with read/write head

Optical Memory

In optical-storage technology, a laser beam encodes digital data onto an optical disk in the form of tiny pits and lands arranged in concentric tracks on the disk's surface as shown in Fig. 2.4. A low-power laser scanner is used to "read" data or information from these pits and lands, and converts it to digital form.

Optical storage provides cheaper and greater memory capacity than magnetic storage. An entire set of encyclopedias, for example, can be stored on a standard 12-centimetre (4.72-inch) optical disk.

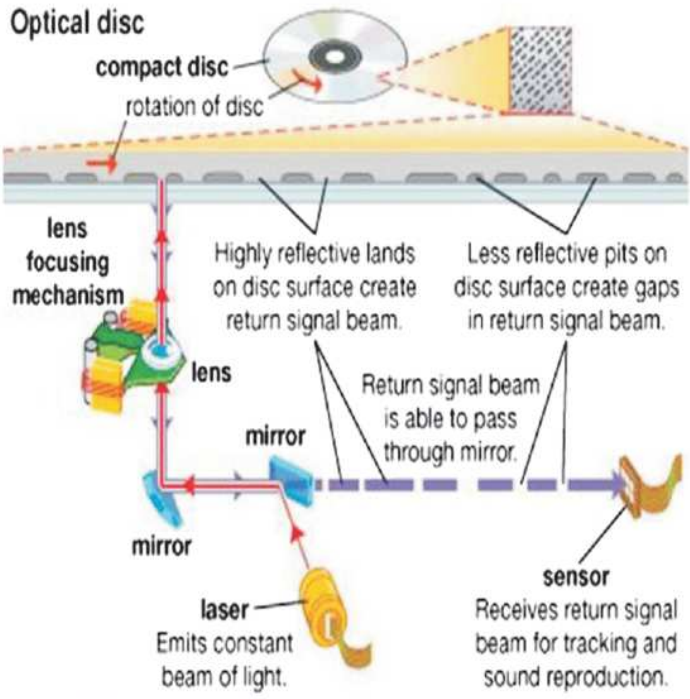


Fig.2.4: Optical Memory technology

Volatile and Non-Volatile Memory

Memory, on the basis of retention power, can be divided into two types i.e. volatile and non-volatile memory.

Volatile memory

Volatile memory is computer memory that requires power (electricity) to maintain the stored information. Volatile memory retains the information as long as power supply is on, but when power supply is off or interrupted the stored memory is lost. It is also known as temporary memory. Examples of such memory are RAM (Random access memory), Cache memory and Registers.

Non-Volatile memory

Non-volatile memory is a permanent memory that can retain the stored information even when not powered. Examples of non-volatile memory include ROM (Read-only memory), flash memory, magnetic storage devices (e.g. hard disks and magnetic tape), optical disks, and blue-ray disk. Non-volatile memory is typically used as secondary storage for long-term or future use.

2.1.4 TYPES OF COMPUTER MEMORY

Computer memory can be classified into two main types as shown in Fig. 2.5.

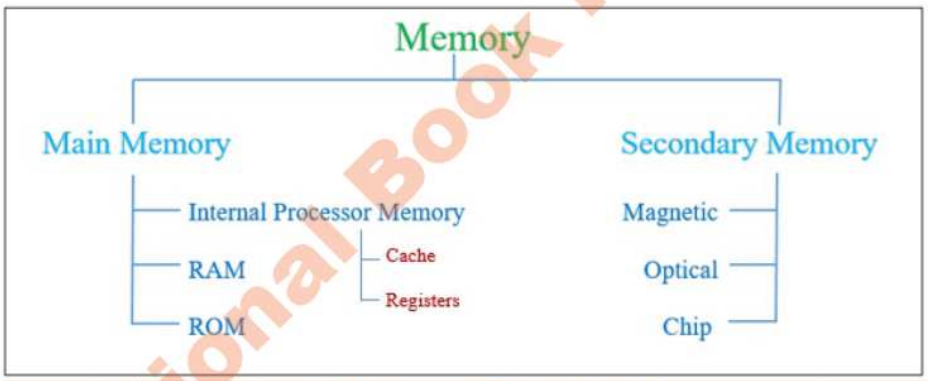


Fig. 2.5 Memory Classification

2.2 MAIN MEMORY

Main memory, also called primary or internal memory is the part of the computer system that holds data and instructions for processing. It is mainly used to store data that is used by the system at startup and to run various types of programs such as the operating system and other programs. Typically, main memory is contained on microchips that are either attached or connected to the computer's motherboard. Computer memory can range from a couple of megabytes (MBs) to several gigabytes (GBs). When users load software from a storage medium, it is first loaded in the main memory and then executed or processed.

Types of Main Memory

Main memory is divided into the following three types.

- Internal Processor Memory

- RAM
- ROM

2.2.1 Internal Processor Memory

These memories are directly accessible to the CPU. Cache memory and processor registers are the examples of such memories. These are extremely fast memories.

Cache Memory

Cache memory is small amount of high-speed semiconductor memory which exists inside the microprocessor or on the motherboard of the computer. This memory stores some active portion of main memory. It lies between the RAM and the CPU. When any information is required by the CPU, first it will look up in the cache memory, and if it is not available in the cache then it will fetch it from the RAM.

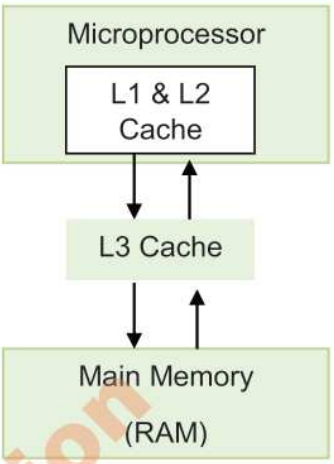


Fig.2.6 L1, L2 and L3 Cache Memory

There are three types of cache memories, Level 1(L1), Level 2(L2) and Level 3(L3) as shown is Fig.2.6.

L1 and L2 cache memories are built inside the microprocessor chip. These have the fastest access time.

L3 cache memory is available as separate chip on the motherboard. It can be accessed more quickly than the RAM.

Processor Registers

Registers are small memory units. There are a large number of registers inside the processor. There function is to temporarily store binary information and pass it on to the other parts of the processor or main memory during the execution of program instructions. Some commonly used registers inside the microprocessors are Accumulator (AC), Instruction Register (IR), Data Register (DR), Program Counter (PC) and Memory Address Register (MAR).

2.2.2 RAM (Random Access Memory)

DO YOU KNOW?
Robert H. Dennard invented first dynamic random-access memory (DRAM) in 1968.

RAM stands for Random Access Memory. When the term RAM is used with semiconductor memories, it is usually taken to mean READ/WRITE memory. It is used in computers for the storage of active programs and data. The contents of RAM change continually as the computer executes a program. RAM plays very important role in the processing speed of the computer. Large RAM size provides larger amount of information to a computer for processing and hence increases the processing speed. The major disadvantage of RAM is that it is volatile and will lose all stored information if power is turned off.

Teacher Point

Teacher should explain the difference between memory and storage.

The following are the types of RAM

- Dynamic RAM (D-RAM)
- Static RAM (S-RAM)

Dynamic RAM (D-RAM)

Dynamic RAM (D-RAM) is the most common type of RAM in the computer. Each dynamic RAM chip contains millions of memory cells. A memory cell is an electronic switch, having two states, ON and OFF, representing a binary 1 and a 0 respectively. These memory cells are made up of a transistor and a capacitor. Each memory cell can store one bit of information. A small amount of power is put into the cell to store one bit of information. This energy leaks out quickly. Therefore, computer must recharge all the cells in the memory chip many times per second otherwise the information will be lost. It is used in computers as temporary memory (RAM). Normal RAM used in computers is D-RAM.

Static RAM (S-RAM)

Static RAM (S-RAM) works in a different way. Each memory cell of static RAM is like an electronic switch having two states, ON and OFF. ON state represents a binary 1 and OFF state a binary 0. It does not need to be recharged but it requires more transistors than dynamic RAM. It is faster than dynamic RAM and more expensive. Static RAM is used as cache memory in computers. S-RAM does not need to be periodically refreshed. It operates at higher speed than D-RAM. S-RAM is expensive than D-RAM.

2.2.3 ROM (Read Only Memory)

ROM stands for Read Only Memory. The process of entering data in ROM is called programming the ROM. Some ROMs cannot have their data changed once they have been programmed; others can be erased and reprogrammed as often as required by the manufacturers. ROMs are used to store programs that are frequently required and are not to change during the operation of the computer. All ROMs are non-volatile because programs stored in them are not lost when the computer is turned off.

There are three types of ROM.

- PROM
- EPROM
- EEPROM

PROM

PROM stands for Programmable ROM. A PROM is a semiconductor chip that is obtained from the manufacturer in an un-programmed state and the user programs it according to his requirements. It can be programmed only once. PROM is used in electronic machine that require some information to be stored in it permanently.

EPROM

EPROM stands for Erasable PROM. This type of ROM can have its contents erased by ultraviolet light using special circuitry outside the computer and then reprogrammed. This procedure can be carried out many times. However, the constant erasing and rewriting will eventually make the chip useless. EPROMs are generally used for programs designed for repeated use such as the BIOS (Basic Input Output Setup) and can also be upgraded with a latest version of the program.

EEPROM

EEPROM stands for Electrically Erasable PROM. EEPROM is also being used for ROM applications. The EEPROM can be altered while being used in a logic board by using special power circuits and write pulse generators. The EEPROM can work like a read/write semiconductor memory while retaining the non-volatile nature of ROMs and PROMs. This type of ROM works in a similar way to flash memory. It is used to store a computer system's BIOS and can be updated without removing it from the circuit board.

2.3 SECONDARY MEMORY

Secondary memory is also known as backing storage, auxiliary storage or mass storage. It stores large amount of information permanently. Some examples of secondary storage devices are Hard Disk drive, CD, DVD, Blue Ray Disk, Flash memory and Memory cards.

2.3.1 SECONDARY STORAGE DEVICES

Secondary storage devices are used to store information even when the computer is turned off. All the secondary storage devices are non-volatile memory. The types of secondary storage devices used in modern computers are hard disks, CDs, DVDs, USB flash drives and memory cards. An internal hard disk is almost compulsory part of every computer system. Other secondary storage devices are portable.

2.3.2 SEQUENTIAL ACCESS AND DIRECT ACCESS MEMORY DEVICES

Memory devices are classified into sequential access memory and direct access memory devices, based on the access mode.

Sequential Access Memory

It is a type of memory in which data is accessed sequentially one after the other. A particular stored data is found by sequencing through all locations until the desired data is reached. This produces access times, which are much longer than those of direct access memories. Examples of sequential access memory devices include magnetic tapes and audio/video tapes.

Teacher Point

Teacher may also use presentations or animations or videos to explain the working of memory devices.

Direct Access Memory

In this type of memory the data is accessed directly or randomly. Semiconductor memories, disk memories and optical memories are direct access memories. Direct access memory is also known as random access memory. Hard disk, compact disk and flash memory are examples of direct access memory.

2.3.3 TYPES OF SECONDARY STORAGE DEVICES

Secondary storage devices are classified into the following types.

- Magnetic Tape
- Magnetic Disks
- Optical Disks
- Chip Memory

Magnetic Tape

Magnetic tape is a plastic strip with a magnetic coated material. Bits are recorded as magnetic spots on the tape along several tracks. Usually 7 or 9 bits are recorded simultaneously to form a character. Read/write heads are mounted one in each track so that data can be recorded and read as a sequence of characters. Magnetic tape is either in the form of cassette or big reels as shown in Fig.2.7.

Fig.2.7 Magnetic Tape Cassette and Reel

Magnetic tape is slow in operation as it has sequential access to data but it is a cheap storage device. Magnetic tape drive is used to write data to and read data from a magnetic tape. Tapes are used for storing large amount of data. Modern tapes can store data up to 5 TB. It is used with minicomputers and mainframes for backups and archives.

Magnetic Disks

A magnetic disk is a flat disk coated with a magnetic material on which data/information is stored in digital form. Data/Information is stored in digital form as tiny magnetized spots called bits. Hard disk is the common type of magnetic disk in use today. Some other types of magnetic disks were also used in the past like Floppy disks and Zip disks. These disks are obsolete and not in use nowadays. These disks have been replaced by optical disks and USB flash drives which are more reliable and have more storage capacity.

The only magnetic disk used nowadays is the Hard disk.

Hard Disk

Hard disk contains one or many platters (disks) coated with magnetic material on both sides. The platters are attached to a spindle holding them in parallel with equal gap. All the platters rotate together at high speed. Bits are stored on the magnetic surface in spots along concentric circles called tracks. Hard disks contain thousands of tracks. Track is divided into sections called sectors. Each platter has two read/write heads for writing data to and reading data from both surfaces of the platter.

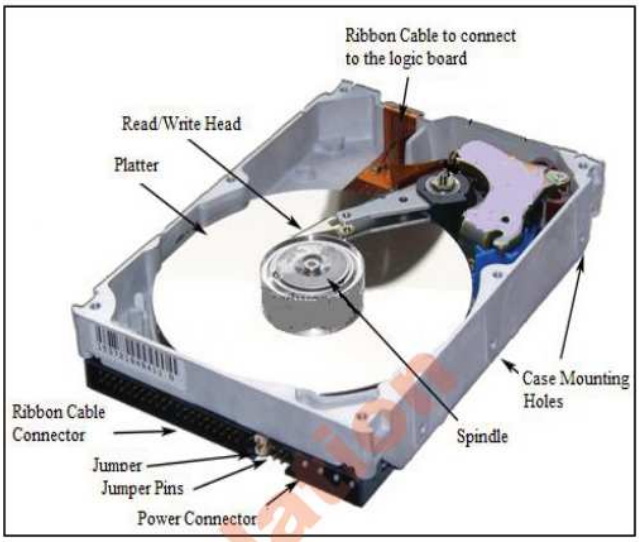


Fig.2.8 Hard Disk

Hard disks are manufactured in very clean environment. They must be kept dust free. Dust particles can create scratches on the surface of the platters and damage the data stored in it. The storage capacity of modern hard disks is in Tera bytes. A hard disk is shown in Fig.2.8.

Portable Hard Drive

A portable hard drive is a compact magnetic disk drive that plugs into a USB port on a computer. It is used as portable secondary or backup storage device. Its common storage capacity may range from 500GB to 4TB. It consists of one or more platters which are air-sealed inside a casing and connected to and powered by USB port of computer. It is used for storing data, programs, photos, music, videos and documents. New models are using USB 3.0 technology which provides fast file transfer rate. Some portable hard drives contain built-in wireless functionality to communicate with the computer through Wi-Fi connection. A portable hard drive is shown in Fig.2.9.

Fig.2.9 Portable Hard Drive

Optical Disks

Optical disk is a plastic-coated disk that can store digital data. Data is stored in optical disk in digital form by laser technology as tiny bumps etched on the surface.

The following are types of optical disks.

- CDs
- DVDs
- Blu-ray Disk

DO YOU KNOW?

In September 1956 IBM launched the 305 RAMAC, the first 'SUPER' computer with a hard disk drive (HDD). The HDD weighed over a ton and stored 5 MB of data.

Compact Disks (CDs)

It is an optical disk used for storing digital data. It was originally developed for storing and playback of sound recording but later on its use expanded to computer data storage. A CD is 1.2 millimeters thick with a diameter of 120 millimeters. It is made up of polycarbonate plastic and weighs 15 to 20 grams. The storage capacity of CDs ranges from 350 MB to 800MB.

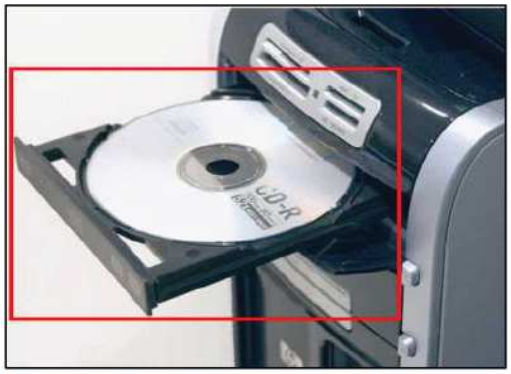


Fig.2.10 A CD inside a CD Player

CDs are popular for storing data, application programs, device drivers, Windows operating system, images and videos. A CD has a single spiral track that spirals (rotates) from the center to the outside edge. Information is stored on a CD in the form of lands and bumps. A binary 0 is represented by a bump and a 1 by a land.

A CD drive/player is used for reading the data stored on the CD as shown in Fig.2.10. The job of CD player is to focus the laser on the track of bumps. The laser beam passes through the polycarbonate layer, reflects off the aluminium layer and hits the censor that detects changes in light. The bump scatters the light and the land reflects it into the censor. The change in reflectivity is transmitted as 0s and 1s into the memory of the computer.

Digital Video/Versatile Disks (DVDs)

DVD is very similar to CD but has larger data storage capacity. Its data storage capacity is about seven times more than CD. It has replaced the video tapes that were used in the past for storing movies. A DVD writer or player is used to read the data stored on a DVD. DVD players are compatible with CD which means they can play CDs also.

Fig.2.11 Blu-ray Disk

DVDs have the same diameter and thickness as CDs and are made of the same material and manufacturing methods. Data is also stored just like a CD on a spiral track in the form of lands and bumps. The storage capacity of DVDs ranges from 2GB to 16 GB. The MPEG (Moving Picture Experts Group) format is used for storing movies in a compressed form on the DVDs.

Teacher Point

Teacher should give some home assignments to the students at the end of the chapter.

Blu-ray Disk (BD)

Blu-ray is a new type of optical storage device. Its main advantage over CD and DVD is that it has storage capacity up to 300GB and it is also faster. The bumps on the surface of Blu-ray that represent digital information are much smaller and very densely packed compared to DVD. This increased the storage capacity of Blu-ray. Blu-ray disks are better storage devices for storing movies because they require a lot more storage. Another advantage of Blu-ray disk is their durability. They have a special coating that helps prevent scratches and marks. A Blu-ray disk is shown in Fig.2.11.

FLASH MEMORY/CHIP MEMORY

Flash memory or Chip memory is a type of EEPROM. It is solid-state storage device which means that there are no moving parts in it. Everything inside the flash or chip memory is in electronic form. It got its name "Flash" from the fact that it can store chunks of data and also erase large chunks of data in a flash because it is a semiconductor IC chip memory.

Flash memory comes in two forms, that is, in the form of flash drive and memory cards.

Flash Drive

Flash drives are also called USB flash drives. They are small and portable drives that are connected to computers through USB ports. The storage capacity of flash memory ranges from 2GB to 256GB. Flash drive is shown in Fig.2.12.

Fig.2.12 Flash Drive (USB Drive)

Flash Memory Cards

Memory cards are used with laptop computers and other electronic devices such as digital cameras, mobile phones and video games. They come in various sizes and with different storage capacity. Flash memory cards are shown in Fig.2.13.

Advantages of using Flash/Chip memory

- It allows fast read/write operations.
- It is non-volatile semiconductor memory.
- It is very light and very small in size.
- It is very reliable.
- Its operation is noiseless since it has no moving part.

Fig.2.13 Flash Memory Cards

Key Points

- Computer memory is a storage device that holds instructions, data and the results produced after processing by the computer.
- Main memory is high-speed IC chip memory that stores programs and data that the computer is currently executing.

- Cache memory is small amount of high-speed semiconductor memory which exists inside the microprocessor and it is faster than main memory.
- Registers are small memory units inside the processor, used to temporarily store binary information and pass it on to the other parts of the processor or main memory during execution of instructions.
- ROM is Read Only Memory used to store small programs that are frequently required and are not to change during the operation of the computer.
- Secondary memory, also known as backing storage, has huge storage capacity and stores information permanently.
- Optical disk is a plastic-coated disk that can store data in digital form using laser technology as tiny bumps etched on the surface.
- Flash memory is a type of EEPROM. It is solid-state storage device having no moving parts and it is used as hard disk.

Exercise

Q1. Select the best answer for the following MCQs.

i. Which of the following is the fastest memory?
   A. RAM B. ROM
   C. Cache memory D. USB flash drive

ii. How much is 1MB memory equal to?
   A. 1024 Bytes B. 1024 TB
   C. 1024 KB D. 1024 GB

iii. Which of the following is volatile memory?
   A. RAM B. ROM
   C. PROM D. EEPROM

iv. Which of the following has highest storage capacity?
   A. DVD B. Blu-ray Disk
   C. CD D. Floppy Disk

v. USB flash drive is what type of memory?
   A. Magnetic memory B. Optical memory
   C. Solid State memory D. Primary memory

vi. Which of the following memory devices has the smallest storage capacity?
   A. RAM B. Cache memory
   C. CD D. Memory card

vii. Which of the following storage device is obsolete now days?
   A. Hard disk B. CD
   C. Memory card D. Floppy disk

viii. Which memory communicates directly with the CPU?
   A. Main memory B. Secondary memory
   C. Hard disk D. USB flash drive

ix. Which of the following memory devices has sequential access to data?

A. Magnetic disk
B. Optical memory
C. Magnetic tape
D. Chip memory

x. Where are the registers located?

A. Inside hard disk
B. Inside DVD
C. Inside RAM
D. Inside Microprocessor

Q2. Write short answers of the following questions.

i. State three differences between primary and secondary memory.
ii. Differentiate between sequential access and direct access memory.
iii. Why data access time in sequential access devices is more than the random access devices?
iv. If cache memory is removed from a computer, what will happen to it?
v. Define memory word.
vi. Differentiate between RAM and ROM.
vii. What is the purpose of secondary memory?
viii. Give few advantages of using flash memory?
ix. How the size of RAM affects the processing speed of a computer system?

Q3. Write long answers of the following questions.

i. What is Internal processor memory? Explain different types of internal processor memories used in computers.
ii. Explain magnetic tape and hard disk.
iii. What is optical disk? Describe its types.
iv. What is Flash or Chip memory? Explain its types.

Lab Activities

Following lab activities are to be carried out during the practical periods.

1. Different types of IC chips (like RAM chip) should be shown to the students. Students should know where these are fixed on the motherboard and their functions should also be explained.
2. Magnetic tape in cassette or reel form should be shown to the students and they should know how information is stored on it.
3. Internal and external hard disk should be shown and their operations should be explained.
4. Students should practically use different types of optical disks in the computer.
5. Working of USB flash drive and various types of memory cards is to be demonstrated to the students.
6. Teacher may ask the students to use the website www.howstuffworks.com for learning purpose.

3

CENTRAL PROCESSING UNIT

After completing this lesson, you will be able to:

- Define CPU and its components (ALU, CU, Register, Cache and Internal Buses)
- Describe the functions of general purpose and special purpose registers
- Define bus and explain data bus, address bus and control bus
- Define instructions and its types
- Explain instruction formats
- Describe instruction cycle (Fetch, Decode and Execute)
- Describe CISC and RISC architecture
- Differentiate between Intel Pentium IV and AMD Athlon processors

Reading

UNIT INTRODUCTION

Central Processing Unit (CPU) is the main part of any computer system. This unit explains central processing unit and the components inside it. It describes instruction formats and their execution by the control unit. It describes how control unit cycles through fetch, decode and execute operations to carry out program instructions stored in main memory. It also discusses the role of registers and buses in programs' execution.

3.1 INSIDE CPU

Fig.3.1 Intel Core i7 Microprocessor

Computers have the capabilities to store and process a large amount of information at extremely high speed and produce accurate results. Computers can work for many hours uninterruptedly and can do the same jobs repeatedly that would be impossible without them.

The Central Processing Unit (CPU) is the main part of the computer which performs all its activities. It is also called the processor or microprocessor

DO YOU KNOW?

The Intel 4004, a 4.bit central processing unit (CPU) was released by Intel Corporation in 1971. It was the first microprocessor.

Teacher Point

Before starting the chapter, the students could be encouraged to explain what they understand about Central Processing Unit (CPU).

and is truly the "brain" of the computer system. It combines the circuitry that generates all the control signals needed to execute instructions. A latest CPU or microprocessor is shown in Fig.3.1.

3.1.1 COMPONENTS OF CPU

The following are main components of CPU.

- ALU
- CU
- Registers
- Cache Memory
- Internal Buses

Arithmetic Logic Unit (ALU)

Arithmetic logic unit (ALU) is the part of the CPU where the actual processing takes place. ALU is capable of performing arithmetic, logical and data manipulation operations on data.

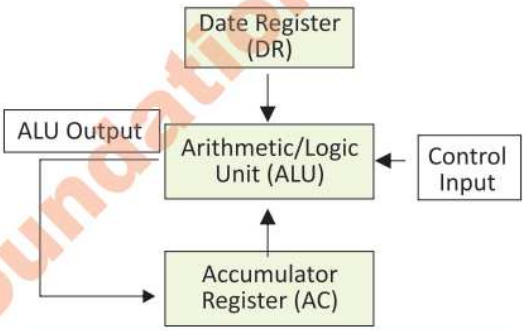


Fig.3.2 Arithmetic Logic Unit

The ALU consists of logic circuitry that performs operations such as addition, subtraction, multiplication, division, exponentials, data manipulations (for example, shifting), comparisons and logical operations such as AND, OR. NOT, etc. on the data contained in the registers. An ALU is shown in Fig.3.2 with its associated registers.

How ALU works?

Suppose we want to add two numbers 30 and 45. The ALU will perform the following steps to do this addition.

- The first number, 30 will be stored in the Accumulator Register (AC).
- The second number, 45 will be stored in the Data Register (DR).
- Control unit (CU) will send the command to add the numbers through the control input.
- Two numbers, 30 and 45 will be added by the circuitry in the ALU.
- The result 75 will appear at the ALU output and will be transferred to AC.
- Finally, the result 75 will be sent to the main memory from AC.

Control Unit (CU)

Control unit directs and coordinates the activities of the entire computer system. It controls the working of all the input/output devices, all the primary and secondary storage devices and the calculations performed by the ALU. Control unit controls the operations of computer system based on the instructions in the program by executing them in a proper order.

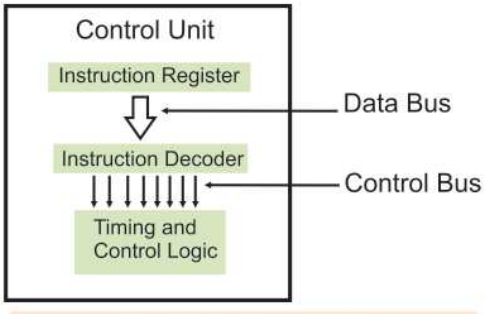


Fig.3.3 Control Unit

Control Unit consists of three main components, Instruction Register, Instruction Decoder and Timing and Control Logic as shown in Fig.3.3. Instruction register stores the instruction while it is being executed. Instruction decoder decodes (translates) it and timing and control logic generates the signals to execute it.

Registers

Registers are small memory devices whose function is to temporarily store data/ information and pass it on to the other parts of the processor or main memory during the processing. CPU contains several registers that are used to store various kinds of information needed by the microprocessor as it performs its functions. Some commonly found registers inside the CPU are Instruction Register (IR), Accumulator (AC), Data Register (DR), Program Counter (PC) and Memory Address Register (MAR).

Cache Memory

Cache memory is a small amount of memory inside as well as outside the microprocessor as shown in Fig.3.4. It is faster than main memory but it is very expensive. It stores some active portion of main memory which is frequently required by the CPU.

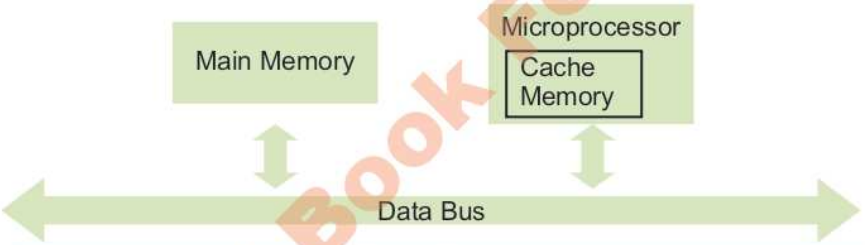


Fig.3.4: Cache Memory

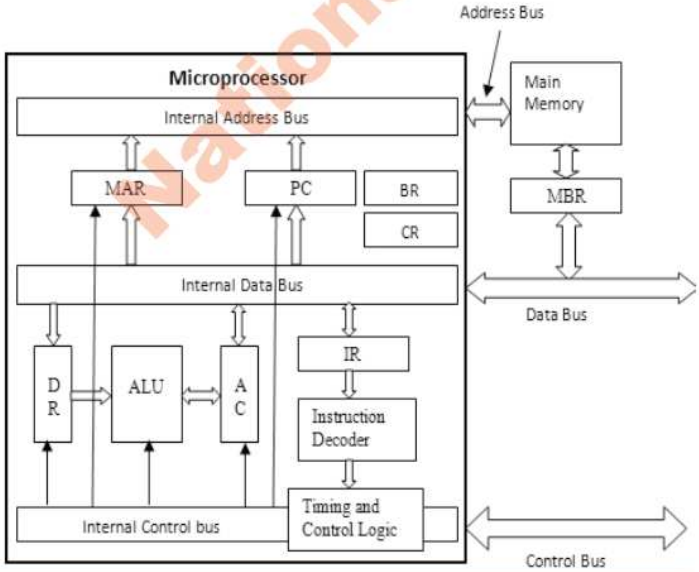


Fig.3.5 Microprocessor bus architecture with associated registers

Internal Buses

A bus is a group of parallel wires used for transmitting data/information from one part of the computer to another. In other words, it provides a path-way for transmitting data/information among various components of a computer. The buses that are found inside the CPU are known as internal buses. There are three types of buses inside the microprocessor which are address bus, data bus and control bus as shown in Fig.3.5.

3.1.2 REGISTERS

Registers are used to quickly accept, store, and transfer data and instructions that are being used immediately by the CPU. Registers used in the computer are divided into two types, general purpose registers and special purpose registers. These registers are shown in Fig.3.5.

General Purpose Registers

General purpose registers are used to store data as well as addresses. These registers are used for arithmetic data movement. Typically these are 8 to 32 bit registers. Following are the commonly used general purpose registers.

- **Accumulator Register (AC) and Data Register (DR)**

These two registers hold the operands (values) that the ALU operates on during the execution of an instruction. Operands are values on which operations such as addition or multiplication is to be performed. Operands are loaded into these registers from memory. After performing the operation, the results of ALU are transferred to the accumulator (AC). Both the accumulator and the data registers can receive data from memory over the data bus but only the accumulator can send data/information back to the memory.

- **Base Register (BR)**

It is used to hold a number that can be added to (or, in some cases, subtracted from) the address portion of a computer instruction to form an effective address. It is also known as Index register.

- **Counter Register (CR)**

It contains the address (location) of the instruction being executed at the current time. As each instruction gets fetched, the counter register increases its stored value by 1. After each instruction is fetched, it points to the next instruction in the sequence. When the computer restarts or is reset, it normally reverts to 0.

Special Purpose Registers

These registers hold the state of a program. They include program counter, instruction register, memory address register and memory buffer registers. These are used by Control Unit to control the operations of CPU and by the Operating System programs to control the execution of the programs. Following are the special purpose registers.

Teacher Point

Teacher should explain different parts of CPU with the help of diagram.

- **Instruction Register (IR)**

Instruction register holds program instructions that are fetched from the memory for execution. It holds the instruction while the instruction decoder circuit decodes it. After decoding, the timing and control logic generates the proper sequence of control signals to complete the execution of the instruction.

- **Memory Address Register (MAR)**

Memory address register hold the address of memory location from where a memory word is to be fetched or where data is to be stored.

- **Memory Buffer Register (MBR)**

A memory word that is to be stored in or to be fetched from memory must first be transferred into MBR. MBR acts as a buffer (a small temporary memory) allowing the microprocessor and memory unit to act independently without being affected by minor differences in operation.

- **Program Counter (PC)**

It controls the sequence in which instructions are fetched from memory. At any given instant, the contents of PC indicate the address in memory from which the next instruction is to be fetched. Contents of PC are loaded into MAR to fetch an instruction from memory. After fetching an instruction from memory, the PC is incremented by one to point to the next instruction to be fetched.

3.1.3 BUSES

A bus is an electrical pathway inside the computer system over which data/information is transferred from one part to the other. It connects the CPU to the main memory on the motherboard. There are three types of buses, that is, address bus, data bus and control bus as shown in Fig.3.6.

Address Bus

The address bus is used by the CPU to select a memory word for a read or write operation. It is unidirectional bus because information flows in only one direction. Address bus width is from 16 to 32 bits. A system with a 32-bit address bus can address 2^{32} (4,294,967,296) memory locations.

Data Bus

The data bus is a bidirectional bus over which data can be sent from the microprocessor to memory (Write operation) or from the memory to the microprocessor (Read operation). Although, it is called data bus, the information carried on this will not always be data, it will often be instruction codes fetched by the microprocessor. Data bus width is from 32 to 64 bits.

Control Bus

The control bus is a group of wires that sends timing and control signals to all the parts of computer needed to carry out the instructions. Some of the control lines are outputs from the microprocessor and others are inputs to the microprocessor from I/O devices. Control bus width is in the range of 8 to 16 bits.

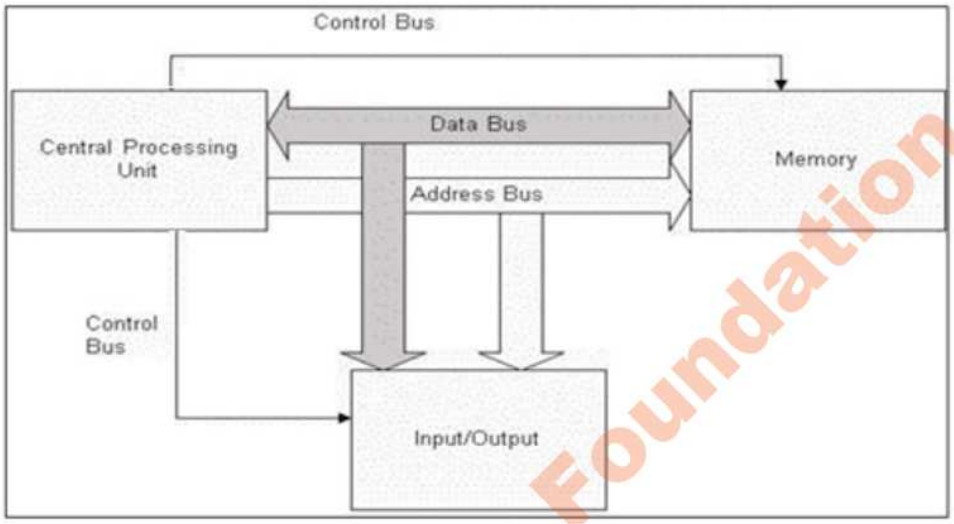


Fig.3.6 System Buses

3.2 CPU OPERATIONS

CPU is the main component of a computer system which carries out the instructions by performing the basic arithmetical, logical, and input/output operations of the system. The fundamental operation of most CPUs is to execute a sequence of stored instructions called a program. The program is represented by a series of instructions that are kept in some kind of computer memory. There are four steps that CPUs use in their operation, these are fetch, decode, execute and store.

3.2.1 INSTRUCTIONS

An instruction (or instruction code) is a group of bits that tells the computer to perform a specific operation. Instructions are stored in the main memory, waiting to be processed by the processor. An instruction has two fields:

- **Operation code**, which represents the action that the processor executes.
- **Operand code**, which defines the parameters of the action. The operand code depends on the operation. It can be data or a memory address.

Operation code	Operand code

Modern computers support many types of instructions. The following are some general types of instructions used in computers.

- Data Transfer Instructions
- Data Processing Instructions
- Program Control Instructions

Data Transfer Instructions

These instructions transfer data from one location in the computer to another location without changing the data content. The most common transfers are between:

- registers and memory,
- registers and I/O,
- registers to registers.

Examples of some common data transfer instructions are MOV, LOAD and STORE.

- **MOV (MOVE)** instruction transfers data from a memory location to a register, register to memory and register to register. This instruction is also used to store the result of a computation.

  Example: MOV A, B (Move the contents of register A to B)

- **LD (LOAD)** instruction loads particular register contents from memory.

  Example: LD A (Load the data to register A from memory)

- **STO (STORE)** instruction stores information from register to memory location.

Data Processing Instructions

These instructions are related to the arithmetic and logic operations. The arithmetic or logic operations are performed on the values of two registers and the result is also placed in a register. Data manipulation instructions can be divided into three basic types, i.e. arithmetic, logical and shift instructions.

Arithmetic Instructions

These instructions are used to perform arithmetic operations. The four basic arithmetic instructions are ADD (Addition), SUB (Subtraction), MUL (Multiplication) and DIV (Division).

Logical Instructions

These instructions are used to perform logical operations like AND, OR, NOT, etc. on binary data stored in registers.

Shift Instructions

Shift instruction is used for transfer of bits either to the left or to the right of an operand.

Teacher Point

Teacher may also use presentations or animations or videos to explain the working of CPU.

Program Control Instructions

Program control or transfer of control is a way of altering the order in which statements are executed. There are a number of instructions used for this purpose like JMP (Jump) and LOOP.

- The ***JMP*** instruction jumps to begin the execution at another location.
- The ***LOOP*** instruction is used when number of statements are to be repeated.

3.2.2 INSTRUCTION FORMATS

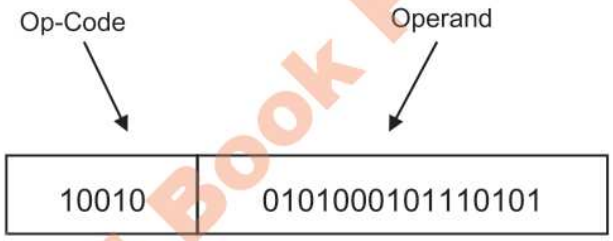
An instruction format defines the layout of the instruction. It consists of two parts, an Op-code (Operation-Code) and Operand.

- Op-Code
- Operand

Op-Code is a group of bits that define various processor operations such as LOAD, STORE, ADD, and SHIFT to be performed on some data stored in registers or memory.

Operand can be data, or can refer to data – i.e. address of data.

Example:



The **Op-code** (10010) specifies the code for **ADD** operation to be performed on the operand at the address specified in **Operand** part.

Some common instruction formats are discussed as follows.

- Zero-Address Instruction
- One-Address Instruction
- Two-Address Instruction

Zero Address Instruction

The Zero Address instruction format requires only op-code, having no operand to work with. Example of the Zero Address instruction format is HALT, STOP, which do not have any address.

Example: STOP

One Address Instruction

One Address instruction format requires one op-code and one Operand. Example of the one address instruction format is LDA (Load Accumulator), JMP (Jump) etc. These instructions require one address to do the operation. Like JMP requires one address in order to jump to that specific address location.

Op-Code	Operand

Example: JMP AX

Two Address Instruction

Two Address instruction format requires one op-code and two operands. Example of such instruction format is the MOV (Move), which moves data from the memory location to the register and from register to the memory location.

Op-Code	Operand	Operand

Example: ADD A, B

3.2.3 INSTRUCTION CYCLE

Instruction cycle is the basic operation cycle of a computer to execute various instructions. It is the process by which a computer retrieves an instruction from its memory, determines what actions the instruction requires, and carries out those actions. The following are the three instruction cycle steps.

- Fetch operations
- Decode operation
- Execute operation
- *Fetch Operation*

In this operation the control unit fetches an instruction from main memory by sending an address through the address bus and a read command through the control bus. The fetch operation places the instruction into the instruction register (IR) inside the microprocessor.

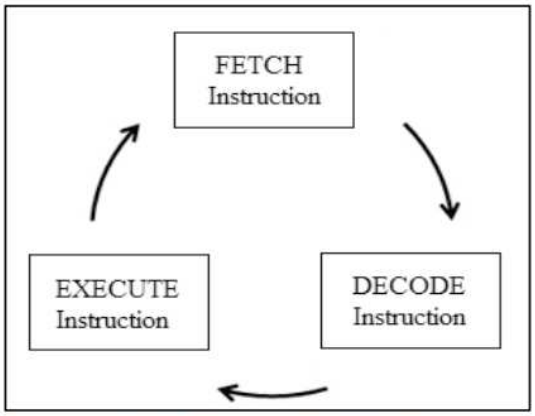


Fig.3.7 Instruction Cycle

- *Decode Operation*

In this step the instruction decoder decodes the instruction to determine what the instruction is intended to do.

Teacher Point

CPU Instruction Cycle should be demonstrated through videos available on net (youtube.com).

- ***Execute Operation***

Once the instruction has been decoded, it can be executed. In this operation the timing and control logic circuitry in the control unit generates signals needed to execute the instruction. The instruction may perform arithmetic, make a decision, simply move data from one memory location to another, etc.

3.2.4 CISC AND RISC ARCHITECTURE

RISC and CISC are two different computing philosophies in designing modern computer architecture.

CISC Architecture

CISC stands for Complex Instruction Set Computer. It is traditional architecture of CPU that supports a large variety of instructions. These instructions may have different length and use all addressing modes and require complex circuitry to decode them. CISC architecture is complex because of the instructions used at the hardware level. Examples of CISC processors are the Intel 486 series and Pentium series.

RISC Architecture

RISC stands for Reduced Instruction Set Computer. It is considered new architecture of CPUs. RISC architecture of CPU supports same size of instructions and it does not use indirect addressing mode. The instructions of a CPU that uses RISC architecture are very simple and are executed very fast. RISC CPUs require fewer transistors, which makes them cheaper to design and easy to manufacture. Examples of RISC processor are IBM PowerPC, Sun SPARC, mobiles phones and tablet PCs.

The following are few differences between CISC and RISC architectures.

- CISC instructions utilize more cycles than RISC.
- CISC has way more complex instructions than RISC.
- CISC typically has fewer instructions than RISC.
- CISC implementations tend to be slower than RISC implementations.
- Computers typically use CISC while tablets, smartphones and other devices use RISC.

3.2.5 INTEL AND AMD PROCESSORS

Intel and AMD (Advanced Micro Devices) are the primary manufacturers of processors. They make processors for desktop computers, laptops, notebooks and mobile devices. Different types of processors perform different functions at different speeds, depending on what kind of system they run. Each type of processor has different functionality, but similarities do exist among various types. Both Intel and AMD make processors for a variety of systems. Core,

Teacher Point

Teacher should give some home assignments to the students at the end of the chapter.

Pentium and Celeron families of processors belong to Intel while Phenom, Athlon and Sempron processors belong to AMD.

Intel Pentium IV Processor

Intel Pentium IV processors have 20 steps execution process. They have high clock speed and perform fewer operations per clock. Pentium processors generally use 478 pin sockets and use Mega Hertz (MHz) to specify processor speed.

AMD Athlon Processor

AMD Athlon processors have 10 steps execution process. These processors generally use 462 pin sockets. AMD processors do not use Mega Hertz (MHz) to specify processor speed. This is due to the instruction set handling that AMD uses.

The following is the comparison between Pentium IV and AMD Athlon processors.

Intel Pentium IV Processor		AMD Athlon Processor
Clock Speed	1.7 to 3.0 GHz.	1.4 to 2.33 GHz.
Bus width	32/64 bits	32/64 bits
Cache	256 KB to 1 MB	256/512 KB
Architecture	CISC/RISC	RISC

Key Points

- Central Processing Unit (CPU) is a single unit that consists of ALU and Control Unit. It is the "brain" of a computer.
- Arithmetic Logic Unit (ALU) is the part of the computer where actual processing takes place.
- Control Unit directs and coordinates the activities of the entire computer system. It controls the working of all the input/output devices, storage devices and the calculations performed by the ALU.
- A bus is a group of parallel wires used for transmitting binary information from one part of computer to another. There are three types of buses, address bus, data bus and control bus.
- The general types of instructions used in computers are data movement, operation, shift, comparison, branch and input/output instructions.
- Instruction code is a group of bits that tells the computer to perform a specific operation.

- Control Unit repeatedly cycles through the FETCH, DECODE and EXECUTE steps till the last instruction of the program is executed.
- CISC stands for Complex Instruction Set Computer that supports a large variety of instructions which may be as many as three hundred.
- RISC stands for Reduced Instruction Set Computer that supports very simple limited number of instruction.

Exercise

Q1. Select the best answer for the following MCQs.

i. Which part of computer performs Fetch, Decode and Execute cycle?

A. ALU
B. Control Unit
C. Output Unit
D. Registers

ii. Where are the results of ALU operations transferred?

A. Counter register
B. Base register
C. Data register
D. Accumulator register

iii. Which of these buses selects a memory word for a read or write operation?

A. Data bus
B. Control bus
C. Address bus
D. System bus

iv. Which of these registers controls the sequence in which instructions are fetched from memory for execution?

A. Program counter
B. Memory buffer register
C. Data register
D. Counter register

v. A memory word that is to be stored in or fetched from memory must first be transferred into which register?

A. Accumulator
B. Data register
C. Memory buffer register
D. Program counter

vi. Which instruction causes transfer of instruction execution to a specified address?

A. Comparison instruction
B. Branch instruction
C. Shift instruction
D. Data movement instruction

vii. Which of these instructions will perform addition of two numbers?

A. Operation instruction
B. Shift instruction
C. Comparison instruction
D. Data movement instruction

viii. Through which bus, instructions are transferred from main memory to instruction register?

A. Control bus
B. Address bus
C. Instruction bus
D. Data bus

ix. How many distinct operations can be performed if op-code of a microprocessor consists of 4 bits?

A. 4
B. 8
C. 16
D. 32

x. Which part of computer decodes instructions?

A. ALU
B. Main memory
C. Program counter
D. Control unit

Q2. Write short answers of the following questions.

i. What is a microprocessor?
ii. What is the function of ALU in the computer?
iii. What is the function of control unit in the computer?
iv. Define bus.
v. Define register.
vi. Define cache memory.
vii. What is meant by instruction code?
viii. What is operation code?
ix. What is the advantage of using address mode in an instruction?
x. Differentiate between CISC and RISC architecture.

Q3. Write long answers of the following questions.

i. Describe general purpose and special purpose registers.
ii. Explain the types of buses used in computers.
iii. Describe the types of CPU instructions.
iv. Explain different types of instruction formats with examples.
v. Explain CPU instruction cycle.

Lab Activities

Following lab activities are to be carried out during the practical periods.

1. Components on the motherboard including microprocessor, RAM and ROM should be shown to the students.
2. Installation of microprocessor on the motherboard along with the cooling fan should be demonstrated.
3. Students should be explained how data bus, control bus and address bus circuits are designed on the motherboard and they should have a clear understanding about their functions.
4. Students should be explained how programs are loaded into the RAM memory and executed by the microprocessor.
5. All the above activities should also be demonstrated through videos or animations.
6. Micro Processor Instruction Cycle should be demonstrated through videos available on net (youtube.com)
7. "How does an ALU work?" Teachers should demonstrate through videos available on net (youtube.com)

4

INSIDE SYSTEM UNIT

After completing this lesson, you will be able to:

- Differentiate between CPU and system unit
- Identify computer casing and its types
- Define power supply and describe the components found on motherboard (BIOS, ports, expansion slots, type of cables, memory slot, disk controller, cooling system and buses)
- Describe the ports (serial, parallel, PS/2, USB and fire wire ports)
- Identify sound, video, modem and network cards
- Describe SIMM, DIMM, SDRAM and DDR

Reading

UNIT INTRODUCTION

This unit presents information about the components of computer that exist inside the system unit. It describes the purpose of expansion cards that are installed on expansion slots on the motherboard or integrated on it. It also explains memory chips, cables used inside the system unit and ports that are found at the back of the system unit for connecting input/output devices.

4.1 COMPUTER CASING AND SYSTEM UNIT

Computer casing is a box or an enclosure that contains most of the components of a computer system. It protects and organizes all the components that make up a computer. Without casing, each of the components within the computer would be vulnerable to dirt, foreign objects and electrical interference. Casing also reduces the overall noise produced by computer fan and drives.

Teacher Point

Before starting the chapter, the students could be encouraged to explain what they understand about the System Unit.

4.1.1 CPU AND SYSTEM UNIT

Computer casing with all the components installed inside it is called system unit or main unit of the computer system. Usually people incorrectly use the word CPU for system unit. Microprocessor is the CPU of the computer that is installed on the motherboard whereas system unit contains motherboard, hard disk, DVD writer, RAM etc. System unit and microprocessor are shown in Fig.4.1.

Fig.4.1 System Unit (left) and Microprocessor (right)

4.1.2 COMPUTER CASINGS

Computer casing is a box or enclosure that contains most of the components of computer system. Computer casings are of two types, tower and desktop as shown in Fig.4.2. Tower casing is the most commonly used one. Desktop casing is designed to keep on the desk and usually monitor is kept over it.

Fig. 4.2 Tower (left) and Desktop (right) computer casings

4.1.3 EXPLORING THE SYSTEM UNIT

System unit contains the following main components.

- Casing
- Power supply
- Motherboard

Power Supply

The purpose of power supply in a computer is to convert alternating current (AC) to low-voltage direct current (DC) for operation of components of the computer. A power supply is already fixed in the casing when it is purchased. A power supply is shown if Fig.4.3

Fig.4.3 Power Supply

Motherboard

Motherboard is also known as main board or system board. A motherboard is shown in Fig.4.4. It is a circuit board that connects all the components of the computer system through ports, cables or expansion slots.

Some Important Components/Parts of Motherboard

The following are some important components or parts of a motherboard.

CPU Socket: CPU Socket is used to mount the CPU or Processor on the motherboard. The CPU socket is the connector on the motherboard that houses a CPU and forms the electrical interface and contact with the CPU.

BIOS : It stands for Basic Input Output System. It is a non-volatile ROM chip. It is a firmware in

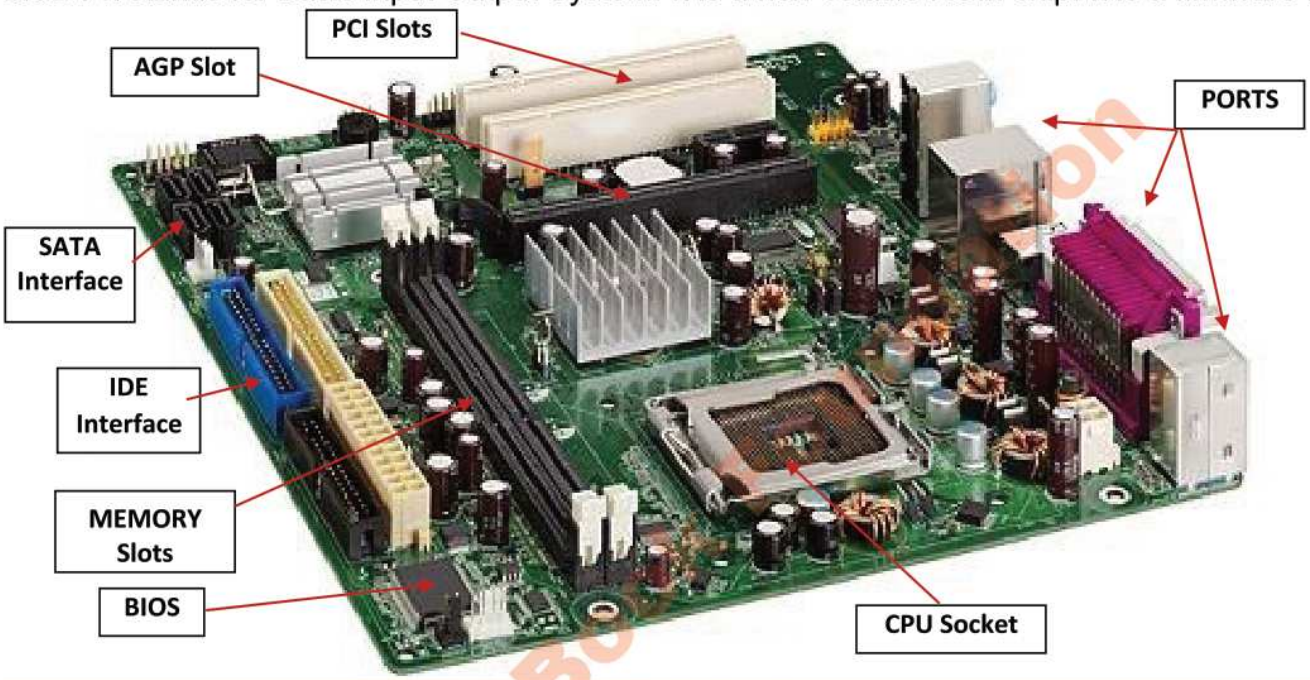


Fig.4.4 Motherboard

which system programs are permanently stored by the manufacturer. These programs have two purposes. When the computer is turned on, it initializes the computer devices such as keyboard, mouse, Hard disk, etc., and then loads the operating system from the hard disk into the RAM and makes the computer ready for operation. Secondly, it controls the basic input/output operations of all the peripheral devices attached to the computer. BIOS also has a Setup utility that allows us to configure the computer hardware, select boot device, set password, set the clock and enable or disable computer components.

Ports : A port is an interface at the back of the computer to connect external devices. There are various types of ports on the motherboard which are used for connecting input/output devices via cable.

Expansion Slots : An expansion slot is a long narrow socket on the motherboard on which circuit boards (expansion cards) are inserted to add new capabilities to the computer. There are

Teacher Point

Teacher should explain the difference between System unit and the CPU.

different types of expansion slots on the motherboard in which various types of cards are fixed. These include video display, sound, modem and network cards. In modern computers, the circuitry of many of these cards is integrated in the motherboard itself to reduce size and cost. Expansion slot standards include, AGP, PCI and PCI express. Expansion slots are shown in Fig.4.5.

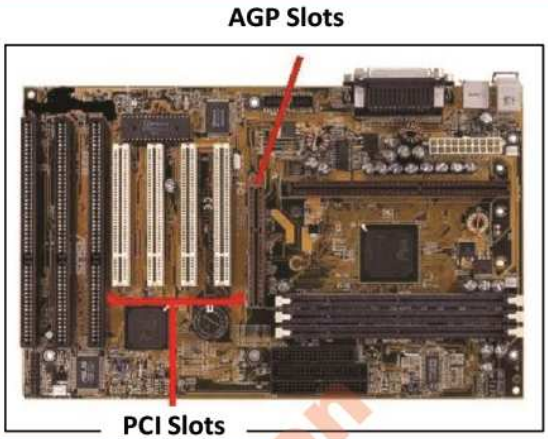


Fig.4.5 Expansion slots on motherboard

AGP: It stands for Accelerated Graphics Port. It provides a high-speed channel for attaching video card to a motherboard. It provided a dedicated path-way between the processor and the graphics card. Its bus width is 32 bits.

PCI: It is used to attach different expansion cards to the computer. It is still used in some computers but is superseded by PCI Express. PCI Express was designed to replace PCI and AGP standards. PCI Express has a bus width of 32 bits. It is the latest standard expansion slot used in micro and laptop computers. The main advantage of PCI Express is that it provides high speed serial communication.

Ribbon Cable **:** It has several parallel wires in the same flat plane that looks like a piece of ribbon which is why it is called ribbon cable. It was used in the past for transmitting information between motherboard and devices such as floppy drive, hard disk and CD-ROM drive.

Following are the different three types of ribbon cable interfaces.

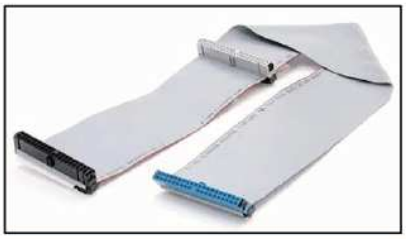


Fig.4.6 IDE Interface Cable

IDE Interface and Cable: Integrated Drive Electronics (IDE) interface was developed by Western Digital for attaching hard drives to motherboard. The first hard drive that used IDE interface appeared in Compaq PCs in 1986.Hard drives that had IDE interface had drive controller integrated into the drive itself rather than having a separate controller on the motherboard. Western Digital introduced new hard drives in 1994 with enhancements to IDE interface and named it Enhanced IDE (EIDE). An IDE interface cable is shown in Fig.4.6.

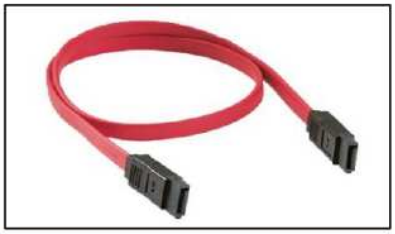


Fig.4.7 SATA Interface Cable

SATA Interface and Cable: Serial Advanced Technology Attachment (SATA) is a new computer interface bus for connecting drives to computer. It was designed to replace EIDE bus interface. SATA bus interface is used in all the modern laptop and desktop computers. SATA drives communicate via high-speed serial cable. SATA bus interface has many advantages over the older EIDE standard. These include faster and more

Teacher Point

Teacher should explain different parts of motherboard with the help of diagram.

efficient data transfer rate and reduced cable size and cost. SATA 1, SATA 2 and SATA 3 interfaces provide communications at rates of 1.5 GB/Sec, 3 GB/Sec and 6 GB/Sec respectively. A SATA interface cable is shown in Fig.4.7.

Memory Slots: These are slots on the motherboard that connect RAM with the CPU. Generally, there are two memory slots. RAM cards are inserted in these slots. RAM card is a printed circuit board having a series of RAM chips mounted on it.

Disk Controller *:* It is a circuit that allows communication between CPU and any type of drive such as floppy drive, hard drive or CD-ROM drive. Old disk controllers were implemented on a separate controller card. Modern disk controllers are integrated into the disk drive itself. For example, EIDE and SATA hard drives have their disk controller circuit inside the drives.

Fig.4.8 Fan for Cooling Microprocessor

Cooling System: Cooling system is required to maintain proper operating temperature inside the system unit. Computer components installed inside the system unit produce heat when the computer is on. If the temperature inside the system unit reaches a certain point, it can damage the parts. A fan is fixed on top of the microprocessor to cool it down. Heat sinks are also used to dissipate the surface area. Many computers are designed to turn themselves off if the temperature exceeds certain level. A fan for cooling microprocessor is shown in Fig.4.8.

Buses *:* A bus is a set of parallel wires that provides electrical path between various components of computer. There are three types of buses, data bus, address bus and control bus, printed on the motherboard. Data bus connects the CPU, memory and the other hardware devices on the motherboard. Address bus connects the CPU and RAM. Control bus is used to send control signals to all the components of the computer.

4.2 PORTS, EXPANSION CARDS AND MEMORY CHIPS

4.2.1 PORTS AND THEIR TYPES

Various types of ports exist on the motherboard and they protrude at the back of the system unit for connecting devices.

The following are different types of ports

- Serial port
- Parallel port
- PS/2 port
- USB port
- Fire wire port
- HDMI port

Serial Port

Serial ports transmit one bit of data at a time. In old computers, serial ports had 9 or 25 pins in which one pin was used for transmitting data and the rest transmitted signals and these were called COM1, COM2 and COM3. Generally modems were connected to these ports. These ports have been replaced with USB ports. A serial port is shown in Fig.4.9.

Fig.4.9 Serial Port

Parallel Port

Parallel ports can transmit multiple bits over several wires at a time. These ports had 25 pins in which 8 pins transmitted one byte of information and the others were used for transmitting control signals. Parallel ports were named as LPT1, LPT2 and LPT3. These ports have been replaced with USB ports. A parallel port is shown in Fig.4.10.

Fig.4.10 Parallel Port

PS/2 Port

PS/2 stands for IBM's Personal System 2 microcomputer. PS/2 system introduced a new type of port for connecting keyboard and mouse which are still used in many computers. It is a round shaped serial port. A PS/2 Port is shown in Fig.4.11.

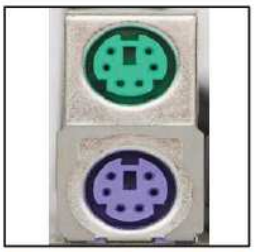


Fig.4.11 PS/2 Port

USB Port

USB stands for Universal Serial Bus. It provides very fast serial transmission. It is the most commonly used port in modern computers for connecting a large variety of devices to the computer such as printers, scanners, cameras, mouse, keyboard and USB flash drives. A computer has many USB ports and these are plug-and-play ports. Plug-and-play ports automatically detect and determine what type of device is attached to the computer. When a computer detects a plug-and-play device it automatically installs the driver for it or prompts the user to install it. A USB port is shown in Fig.4.12.

Fig.4.12 USB Port

Fire Wire Port

It is a rectangular shaped port, generally used for connecting video devices such as camcorder to the computer. Fire wire port has four or six pins. In a six pin connection, 2 extra pins are used to provide electric power. Laptop computers have 4.pin fire wire port because they do not provide electric power to devices connected to it. A fire wire port is shown in Fig.4.13.

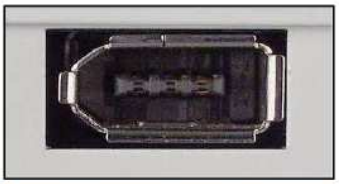


Fig.4.13 Fire Wire Port

Fig.4.14 HDMI Port

HDMI Port

HDMI stands for High Definition Multimedia Interface. HDMI technology provides audio-video interface for transmitting digital data. All the high definition equipment including PCs, laptops, camcorders, digital cameras, TV, DVR, disk players and set-top box sold today have at least one HDMI port. HDMI port transmits high quality audio-video data in totally digital form through a single cable. HDMI port is shown in Fig.4.14.

4.2.2 TYPES OF EXPANSION CARDS

Expansion card is a printed circuit board that is inserted onto an expansion slot on the motherboard. It is also known as add-on card, interface card or just card. It gives new ability to computer such as connecting to another computer using a network cable.

Four types of expansion cards are commonly used in computers. These are sound card, video graphics card, modem card and network interface card.

Sound Card

The purpose of sound card is to facilitate transmission of sound in computer. In the past, beeps were the only sound that could be produced on the computer. With the invention of sound cards in the 1980s, we can store human voice in the computer and hear it through the speakers.

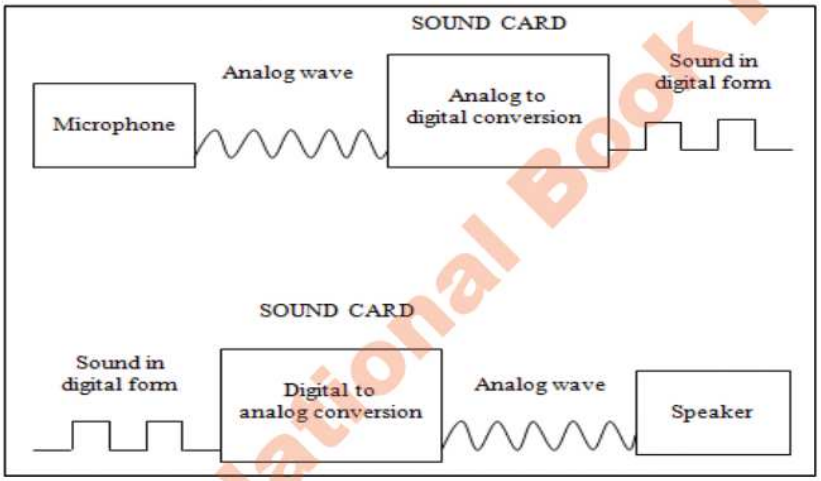


Fig. 4.15 Working of Sound Card

Sounds are analog waves whereas computers communicate using electrical pulses that represent 0s and 1s. Sound card translates analog voice input from a microphone into digital form or it outputs the digital sound stored in the computer through the speakers. In other words, it provides analog to digital and digital to analog conversion as shown in Fig.4.15.

It will not be possible to play DVDs, CDs and run multimedia applications on a computer without the sound card. Early sound cards were installed in expansion slots on the motherboard. Motherboards of modern computers are manufactured with integrated sound cards.

Video Graphics Card

The purpose of a video graphics card is to display text, graphics and images on the screen. In the past, video cards were installed in expansion slots but in modern computers, video hardware is integrated on the motherboard. Video hardware that is integrated on the motherboard is known as integrated graphics or on-board graphics. Integrated graphics uses some of the computer's RAM and reduces the total RAM capacity. These motherboards have

an AGP, PCI or PCI Express slot for adding a high performance graphics card in place of the integrated graphics. These high performance 3D graphics cards have their own dedicated memory which is generally between 256MB to 1GB. Special high performance 3D graphics cards are required for running some video games. A video graphics card is shown in Fig.4.16

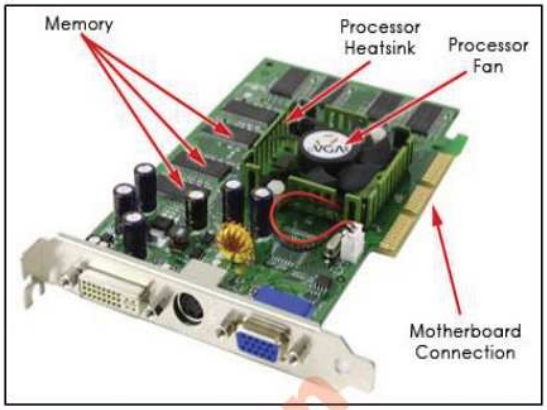


Fig. 4.16 Video Graphics Card

Modem Card

A modem is a communication device that makes possible the transmission of data between computers via telephone line or other communication lines. It is abbreviation of MOdulator-DEModulator. Modems are generally used for dial-up connection to Internet. Modem cards are fixed in expansion slot or modem hardware is integrated on the motherboard.

There are three types of modems.

- Dial-up modem
- ISDN modem
- DSL modem

Dial -up modems use telephone lines and they can provide transmission speed up to 56 Kbps (Kilobits per second) which is very slow. Therefore, there use is gradually declining. It has the advantage of providing Internet connection from any location in the world and it is the cheapest Internet connection.

ISDN modem is used with Integrated Services Digital Network. Here, "Integrated" means combining of voice and data services over the same wire. It uses the same phone lines that dial-up modems use. It can provide Internet connection speed up to 128 Kbps.

DSL (Digital Subscriber Line) modem is used with DSL connection to the Internet. These modems are more advanced compared to dial-up and ISDN modems. They provide extremely fast Internet speed depending upon the package and services of Internet Service Provider (ISP). Dial-up and ISDN modems are gradually replaced by DSL modems for high-speed Internet connection using digital subscriber line. It also uses phone lines. DSL Internet connection is more expensive than dial-up and ISDN connections.

Network Interface Card

Network Interface Card (NIC), commonly known as network card or LAN card, is an expansion card that provides interface to a network. Modern computers have network interface integrated into the motherboard, just like the sound and graphics cards. Network card allows computer users to connect to each other either by using cables or wirelessly. It provides

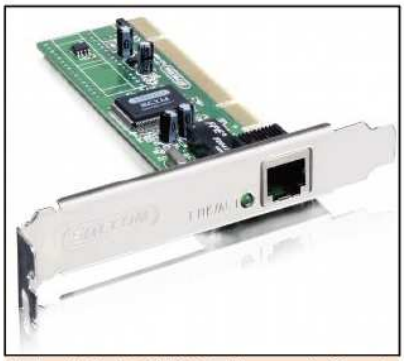


Fig.4.17 10/100 Ethernet Card

communication between computers in LAN and WAN. Following are the types of commonly used network cards.

Fig.4.18 Gigabit Card

10/100 Ethernet cards are used in home and small offices. Their data transfer rate is 10 to 100 Mbps (Mega bits per second). They are usually attached to PCI or PCIe slots. A 10/100 Ethernet card is shown in Fig.4.17

Gigabit card

Gigabit cards have data transfer rate of up to one Gbps (Giga bits per second). These cards are attached to computers using PCIe slot. A Gigabit card is shown in Fig.4.18.

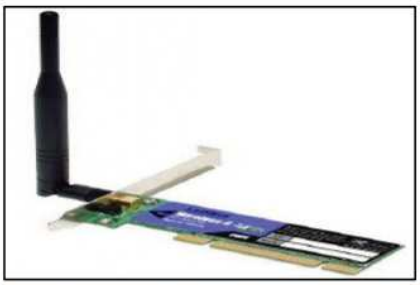


Fig.4.19 Wireless Network Card

Wireless network card

Wireless network cards are used for wireless networking. Their data transmission speed is generally less than wired cards. They are attached to PCIe slot or USB port. A wireless network card is shown in Fig.4.19

4.2.3 MEMORY CHIPS

Memory chips can be classified into four categories, SIMM, DIMM, SDRAM and DDR SDRAM.

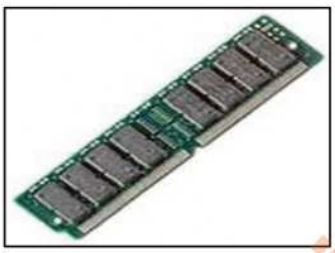


Fig.4.20 SIMM Memory

SIMM

SIMM stands for “Single In-line Memory Module”. It is a small circuit board with a bunch of memory chips on it as shown in Fig.4.20. SIMM is plugged-in into particular socket on the motherboard. It is used to add memory to computer and is referred as Random Access Memory. SIMMs typically use up to 32.bit bus. They have storage capacity ranging from 256KB up to about 32MB. SIMMs were used in early computers of 80s and 90s.

DIMM

DIMM stands for “Dual In-line Memory Module”. It is a type of computer memory. A DIMM is a small circuit board that holds memory chip. It uses a 64.bit bus to the memory, whereas single in-line memory module (SIMM) only has a 32.bit path. This allows DIMMs to transfer more data at once. DIMMs have replaced SIMMs because they have faster data transfer rates and better capabilities than DIMMs. Memory capacities of DIMMs range from 64MB up to 512MB.

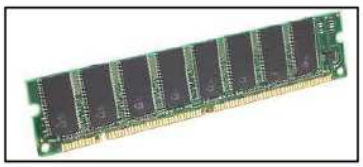


Fig.4.21 DIMM Memory

Teacher Point

Teacher should give some home assignments to the students at the end of the chapter.

SDRAM

SDRAM stands for "Synchronous Dynamic Random Access Memory". SDRAM is an improvement to standard DRAM because it retrieves data alternatively between two sets of memory. This eliminates the delay caused when one bank of memory addresses is shut down while another is prepared for reading. It is called "Synchronous" DRAM because the memory is synchronized with the clock speed that the computer's CPU bus speed is optimized for. The faster is the bus speed, the faster will be the SDRAM.

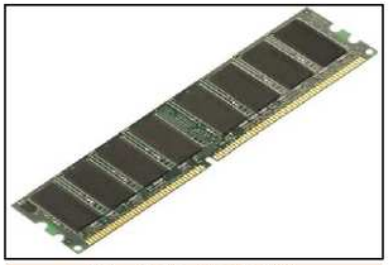


Fig.4.22 SD RAM

DDR SDRAM

DDR SDRAM (Double Data Rate SDRAM) is synchronous dynamic RAM that has improved memory clock speed as compared to simple SDRAM. It reads or writes two consecutive words per clock cycle. New type of SDRAMs, known as DDR 2 and DDR 3 have also come which are used in latest microcomputers. DDR 2 reads or writes 4 words of data per clock cycle whereas DDR3 reads or writes 8 data words per clock cycle.

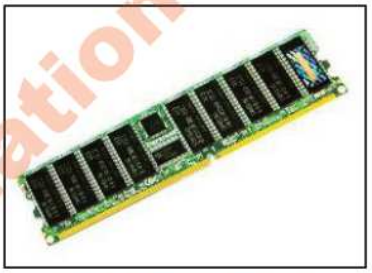


Fig.4.23 DDR SDRAM

Key Points

- Computer casing is a box that contains most of the components of a computer.
- Computer casing with all the components installed inside it is called system unit or main unit of computer.
- Power supply is used in computer to convert alternating current (AC) to low-voltage direct current (DC) for operation of components of the computer.
- Motherboard or main board is a circuit board that connects all the components of computer system through ports, cables or expansion slots.
- Disk Controller is a circuit on the motherboard that allows communication between CPU and any type of drive such as hard drive or CD drive.
- Computers have various types of ports on the motherboard that protrude at the back of the system unit for connecting devices.
- Serial ports transmit one bit of data at a time over a single wire whereas parallel ports transfer multiple bits over several wires at the same time.
- Expansion card is a printed circuit board that is inserted onto an expansion slot on the motherboard. It is also known as add-on card, interface card or just card. Commonly used expansion cards are sound card, modem card, network interface card and graphics card. In modern computers these card are integrated on the motherboard.
- SIMM stands for Single In-line Memory Module. It is a small circuit board on which RAM chips are wired together.
- DIMM stands for Dual In-line Memory Module. It is also a small circuit board like SIMM but it provides wider data bus and has more storage capacity.

Exercise

Q1. Select the best answer for the following MCQs.

i. Which port is generally used to connect video devices to the computer?
   A. Fire wire port
   B. USB port
   C. PS/2 port
   D. Parallel port

ii. What is computer casing with all the components installed inside it called?
   A. Computer System
   B. CPU
   C. Motherboard
   D. System unit

iii. What is the interface that provides connection to external devices called?
   A. Expansion slot
   B. Memory slot
   C. Disk controller
   D. Port

iv. Which of the following provides interface to network?
   A. NIC
   B. Modem
   C. Parallel port
   D. BIOS

v. Which part of computer protects and organizes all the main parts of a computer?
   A. Power supply
   B. Motherboard
   C. Casing
   D. Expansion slots

vi. What is the purpose of power supply in the computer?
   A. to convert low-voltage to high-voltage
   B. to convert DC to AC
   C. to convert AC to low-voltage DC
   D. to generate power

vii. Which circuit board connects all the components of computer?
   A. Motherboard
   B. Ports
   C. Network card
   D. Cables

viii. What is BIOS?
   A. Programs in RAM
   B. Port
   C. Interface
   D. Non-volatile ROM chip

ix. Which of these provides high-speed channel for attaching video card to motherboard?
   A. IDE interface
   B. AGP
   C. Disk controller
   D. Memory slot

x. Which card displays text, graphics and images on the screen?
   A. Network card
   B. Gigabit card
   C. Modem card
   D. Video graphics card

Q2. Write short answers of the following questions.

i. Define computer casing and describe its types.
ii. Differentiate between computer casing and system unit.

iii. What is the function of power supply in the computer?
iv. Define motherboard.
v. What is the function of BIOS in the computer?
vi. What is the function of disk controller in the computer?
vii. Define port and expansion slot.
viii. Write a brief note on cooling system used in the computer.
ix. Differentiate between SIMM and DIMM.
x. Give one advantage and two disadvantages of using wireless network card.

Q3. Write long answers of the following questions.

i. Explain IDE and SATA interfaces.
ii. Describe the following types of ports.
    a. Serial port
    b. Parallel port
    c. PS/2 port
    d. USB port
    e. Fire wire port
iii. What are the functions of following expansion cards?
    a. Sound card
    b. Video display card
    c. Modem card
    d. Network Interface Card (NIC)
iv. Explain different types of Modems.
v. Describe commonly used Network Interface Cards (NICs).

Lab Activities

Following lab activities are to be carried out during the practical periods.

1. Students should be shown the components found inside the system unit such as CPU Socket, BIOS, ports, expansion slots/cards, types of cable interfaces and cables used, memory slots and microprocessor and their functions should be explained.
2. Fixing of all the components inside the computer casing (on the motherboard) should be demonstrated so that the students understand how system unit is assembled.
3. The mounting and dismounting of CPU should be demonstrated to the students.
4. All the above activities should also be demonstrated through videos or animations.

5

NETWORK COMMUNICATION AND PROTOCOLS

After completing this lesson, you will be able to:

- Define basic network components (Sender, Receiver and Medium)
- Describe modes of communication (simples, half-duplex and full-duplex)
- Describe communication media (Guided and Un-guided)
- Identify communication devices (Switch, Router and Gateway)
- Understand network architecture (Client/Server and Peer-to-Peer)
- Identify network types (LAN, MAN, WAN and VPN)
- Identify network topologies (Star, Ring, Bus and Mesh)
- Identify the purpose of communication standards
- Understand OSI Model and concepts of its layers
- Provide examples of protocols and devices at each layer of OSI Model
- Describe TCP/IP protocol suite used for communication over the Internet
- Compare the TCP suite with OSI Model
- Differentiate between circuit switching and packet switching
- Understand IP addressing schemes (Classes, Masks and Subnets)

Reading

UNIT INTRODUCTION

A network is a collection of computers or other devices called nodes that communicate with each other on a shared network medium. This unit is dedicated to data communication over computer networks and the protocols that make it possible. It describes how computer networks are created and what their advantages are. It introduces different types of computer networks and network devices. It describes the purpose of having communication standards and discusses OSI model that allows computers of different manufacturers to communicate with each other. The last section of this unit explains how IP addressing schemes identify a computer on Internet.

Teacher Point

Before starting the chapter, the students could be encouraged to explain what they understand about the Computer Networks.

5.1 NETWORK COMMUNICATION

People use computer networks almost daily to conduct personal and professional business. This trend is accelerating as more people discover the power of computers and communication networks both for businesses and for homes. The day-to-day transactions at departmental stores, banks, reservation counters and other businesses are all dependent upon computer networks.

A computer network is an interconnection between two or more computers and/or other network devices so that they can communicate with each other to share network resources (both hardware and software). A network is made up of collection of computers and other network devices that allow information exchange to take place. While most networks connect computers using some form of cable, the connections can also be wireless, for example radio or microwave communication. A simple communication network having wired and wireless connections is shown in Fig.5.1.

Fig.5.1 A Communication Network

5.1.1 BASIC NETWORK COMMUNICATION COMPONENTS

Data communication is the process of transferring information from one point to another in a networking environment. Network communication consists of five basic components, as shown is Fig.5.2.

- Sender
- Message
- Medium
- Protocol
- Receiver

Sender

Sender, also called transmitter is a computer/device that sends the message (data or information) from source to destination in a communication network. It may be a computer, workstation, cell phone or camera. The sender device converts the electrical signal into a form that is suitable for transmission over the communication network.

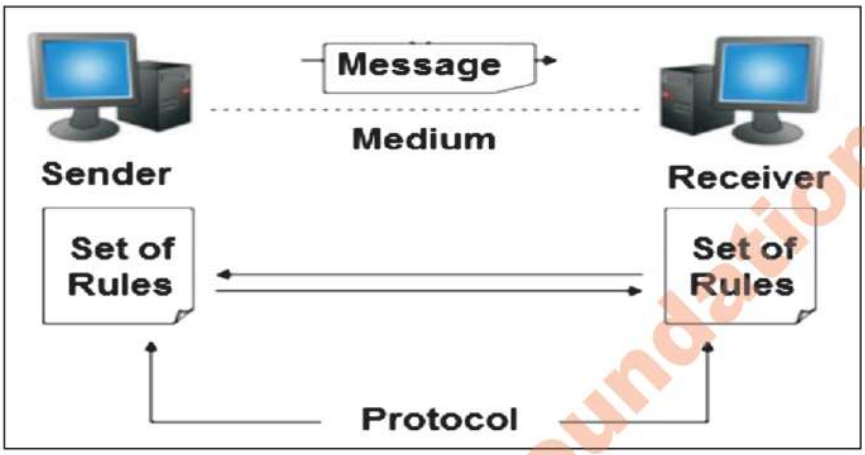


Fig.5.2 Components of Network Communication

Message

Message is the data or information that is to be transmitted. Message can be in the form of text, audio, video, or any combination of these.

Medium

Medium is the path through which message travels from source to destination. Medium can be wired, for example telephone cable, coaxial cable and fibre optics. It can also be wireless for example Bluetooth, Wi-Fi, microwave, radio wave and satellite.

Receiver

Receiver is the device which receives transmitted message. It can be a computer, workstation, telephone handset or television set. The data received from the transmission medium may not be in proper form to be accepted by the receiver and it must be converted to appropriate form before it is received.

Protocol

A protocol is a set of rules that governs data communications. It represents an agreement between the communicating devices. Without a protocol, two connected devices may not be able to communicate with each other.

Teacher Point

Teacher should explain some advantages of computer network over standalone computers.

5.1.2 MODES OF NETWORK COMMUNICATION

Modes of network communication refer to the methods or the ways information is transmitted from one place to another.

The following are different modes of data communication

- Simplex, Half-duplex and Full-duplex
- Synchronous and Asynchronous

Simplex, Half-duplex and Full-duplex communication modes

Simplex mode

In Simplex mode, the communication takes place in only one direction. In this mode communication is unidirectional, i.e. the communication can only take place in one direction and it is not possible for the receiver to send data back. For example data being sent to an electronic notice board found in train stations and Airports.

Radio and television broadcastings are also examples of simplex transmission. Transmission of information from a computer to a printer is also in one direction, as shown in Fig. 5.3.

Fig.5.3 Simplex mode of data Communication

Half-duplex mode

In half-duplex mode, the communication takes place in both the directions but not at the same time. The signal can only be sent or received at one time. A common example of this type of communication is the use of walkie-talkies, where each of the persons communicating must indicate when they have finished speaking. Half-duplex transmission is used also in transaction-oriented systems, for example communication between a computer and credit card machine as shown in the Fig.5.4.

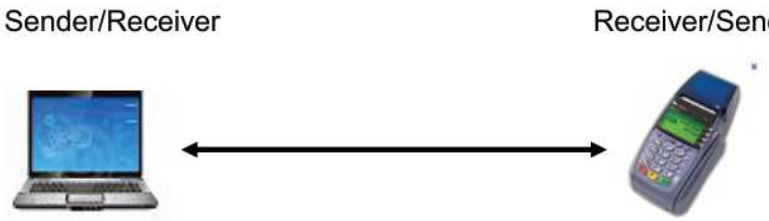


Fig.5.4 Half-duplex mode of data communication

Full-duplex mode

In full-duplex mode, the communication takes place in both the directions at the same time. In this mode, both sender and receiver can send and receive the data simultaneously, for example two or more computers connected to a network device such as a switch that provides full duplex activity. It is the fastest bi-directional mode of communication. The full-duplex mode is like a two way street, with traffic flowing in both directions at the same time.

One common example of full-duplex communication is the telephone network. When two people are communicating by a telephone line, both can talk and listen at the same time. Also full-duplex mode is the most suitable for data communication between computers as shown on Fig. 5.5.

Fig.5.5 Full-duplex mode of data communication

Asynchronous and Synchronous Transmission

Asynchronous and Synchronous Transmissions are the two different methods which are used for transmitting characters between devices within a computer or from computer to other devices such as printer, modem, etc.

Asynchronous Transmission

In asynchronous transmission, the time interval between two characters is variable and not fixed as shown in Fig.5.6. The computer devices can exchange information at their own rate, slow or fast. Start and Stop bits are used in asynchronous transmission. These bits provide timing (synchronization) for the connection betsween the sender and the receiver. The start bit tells the receiver that a character is coming and stop bit indicates that the transmission of character has ended. This type of transmission is ideal for slow-speed communication when gaps may occur during transmission. Example of asynchronous transmission is keyboard data transmission.

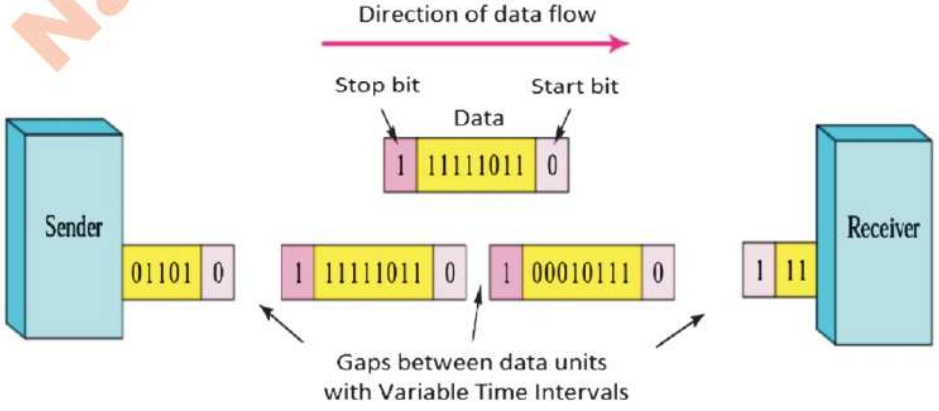


Fig.5.6 Asynchronous transmission

Synchronous Transmission

In synchronous transmission, the time interval between two characters is always the same as shown in Fig.5.7. In this method two communicating devices are synchronized and they continue to send characters in order to remain synchronized, even if there is no data to be transmitted. A special "idle" character is sent when there is no data for transmission. It does not require transmission of start and stop bits. It sends data as one long bit stream or block of data and each bit is sent one after the other. The receiver counts the bits and reconstructs the sent information in bytes. It is essential that timing is maintained as there are no start and stop bits and no gaps. Accuracy is dependent on the receiver keeping an accurate count of the bits as they come in.

Synchronous transmission is faster than asynchronous because fewer bits have to be transmitted; i.e. only data bits and no extra control bits are sent. The best example of synchronous transmission is the data transmission between devices in network communications links.

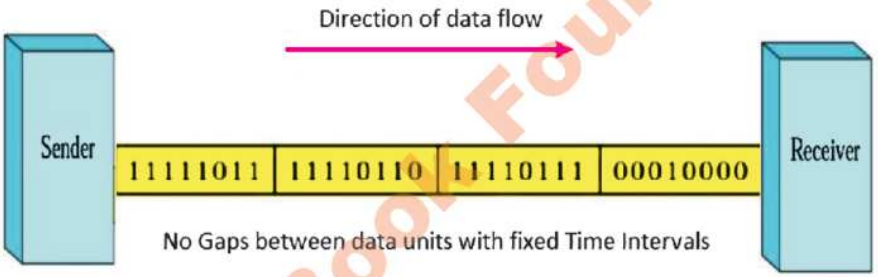


Fig.5.7 Synchronous transmission

5.1.3 COMMUNICATION MEDIA

In network communication system, communication media are the links that provide paths for communicating devices. Communication media is used to transmit data from one network device (also called a node) to another. There are two main categories of communication media.

- Guided Communication Media
- Unguided Communication Media

Guided Communication Media

It is also called physical or bounded or wired communication media. In this type of media signals pass through a physical path. It uses cables that guide the data signals along a specific path. The following are some important guided media.

- Telephone Cable
- Twisted Pair Cable
- Coaxial Cable
- Fibre Optic Cable

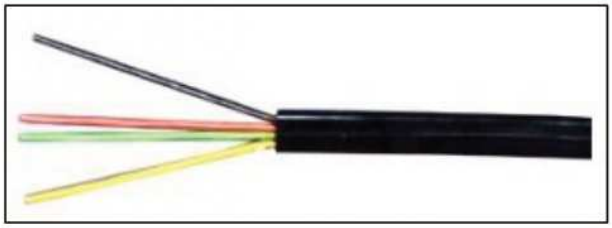


Fig.5.8 Telephone Line

Telephone Cable

Standard telephone cable is widely used as communication lines. Telephone lines are particularly useful to the user of data communication because the complex network of lines that has already been established allows data to be transmitted to any location in the world. The disadvantage of telephone line is that transmission speed is very slow. Therefore, its use for data communication is slowly declining. A telephone line is shown in Fig.5.8 with four cables.

Coaxial Cable

It is mainly used for long distance transmission. It can transmit data at much higher rate of 10 to 100 megabits per second. They are also used by telephone companies to transmit data over long distance.

Fig.5.9 Coaxial cable

Coaxial cables are packed into a very large cable that can handle hundreds of thousands of telephone calls at the same time. Coaxial cable provides high quality data transmission without distortion or loss of signal. Coaxial cables have been laid under the ocean. A coaxial cable is shown in Fig.5.9. Both telephone line and coaxial cables are made up of copper.

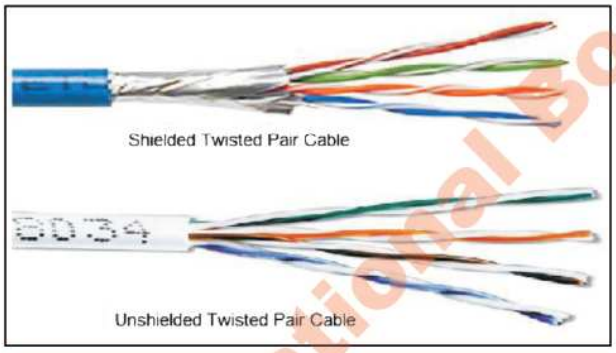


Fig. 5.10 Shielded and Unshielded Twisted Pair Cables

Twisted Pair Cables

Twisted pair cables are twisted together in pairs. It provides shielding from outside interference. Cables with a shield are called Shielded Twisted Pair (STP) cables. Cables without shields are called Unshielded Twisted Pair (UTP) cables. These cables are shown in Fig.5.10.

Fibre Optic Cable

It is new technology that is replacing the conventional cable in communication systems. Fibre optic cable is smooth hair-thin strands of transparent material that transmits signals with light waves at very high speed. Fibre optic cables are shown in Fig.5.11.

The main advantage of fibre optic cable over wire cables includes weight and size reduction and increased speed of transmission. Fibre optic cable is not affected by electromagnetic interference. Therefore, noise and distortion are reduced. Fibre optic cable can transmit both voice and digital data.

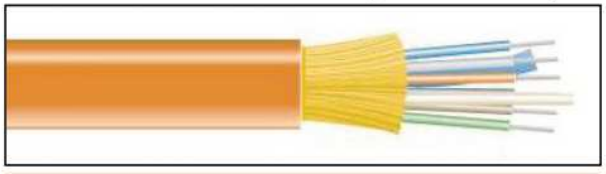


Fig.5.11 Fibre optic cables

Unguided Media

It is also called unbound or wireless media. In this type of communication media transmission takes place through open air. They are not guided through any specific path. The following are important unguided media.

Microwave Transmission

Microwave transmission signals travel through open space much like radio signals as shown in Fig.5.12. Microwave systems transmit information with transmitters which are normally installed on high buildings, mountains tops or high towers. Long distance microwave channels consist of a series of relay stations (boosters) spaced approximately 30 miles apart. Two stations must be within sight of one another. For transmitting information long distances, signals are amplified and retransmitted from station to station.

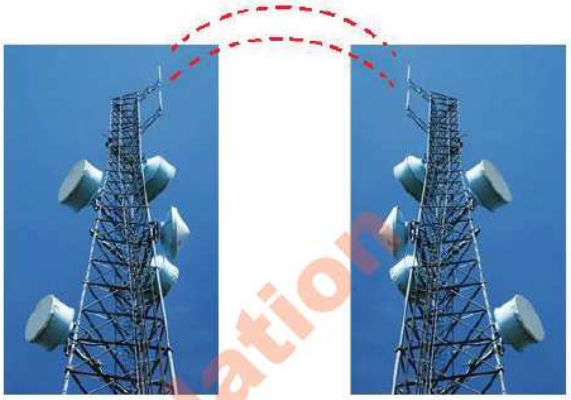


Fig.5.12 Microwave Transmission

Communication Satellites

Satellite is a relay station positioned approximately 22,000 miles above the earth. It orbits around the earth with exactly the same speed as the rotation speed of earth. Earth stations beam signals to the satellite as shown in Fig.5.13. The satellite amplifies and retransmits the signals to another earth station which can be located thousands of miles away.

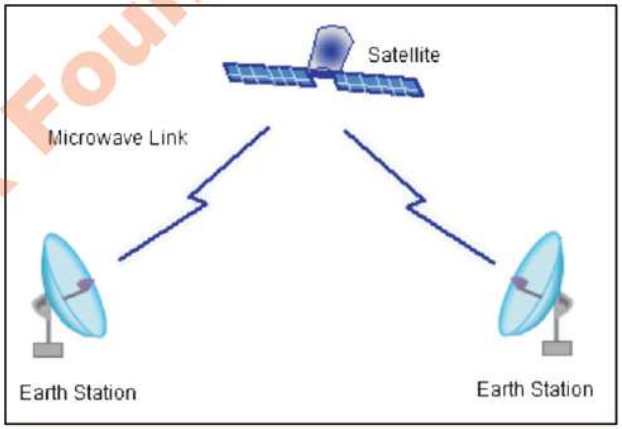


Fig.5.13 Satellite communication

Satellite communication is ideal for long distance communication. Transmission by satellite allows large amount of data to be sent long distance at rapid speeds. Its use has increased dramatically in recent years. However, a major drawback of satellite communication has been the high cost of placing the satellite into its orbit. These satellites are launched either by rockets or by space shuttles

5.1.4 COMMUNICATION DEVICES

A device that is used in telecommunication systems for transmitting data from one location to another is known as communication device.

Commonly used communication devices are: Hub, Switch, Router and Gateway.

Teacher Point

Teacher should explain different types of networks with diagrams.

Hub

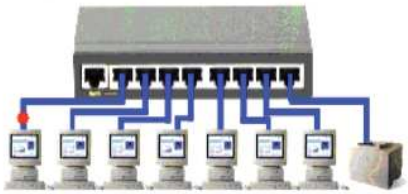


Fig.5.14 a 8 Hub

Hub is a connectivity device used in LAN. It connects multiple LAN devices on one network and makes them act together as a single network. A hub is non-intelligent device and sends output to all the devices on the network. A hub has multiple input/output (I/O) ports, in which an input in one port results in it being an output in all the other ports, except the port where it was input. In layman's terms, a hub connects many networks into one, where a data packet that is sent by one networks, is copied and passed to all network ports, making it so that every port can see that data packet.

Switch

Fig.5.14 b 8 Port Switch

Switch is a networking device that performs the same job as the hub but are considered as a more intelligent hub as it gathers information about the data packets it receives and forwards it to only the network that it was intended for. A switch inspects data packets as they are received, determines the source and destination device of each packet and forwards them appropriately. A packet is a basic unit of communication over a computer network. When data is transmitted, it is broken down into packets which are reassembled to the original form once they reach the destination.

Router

Fig.5.15 Wireless Router

Router is a communication device which is used to connect two or more networks. Today, most of the networks are connected to Internet. When the computer is sending data to another computer on the Internet, router receives the data packets, looks for the remote computer address and forwards it to a computer that is closer to the remote computer. It forwards the data packets by selecting the best path-way based on network traffic. Many routers take part in transmitting the data packets from one location to another. A wireless router is shown in Fig.5.15.

Gateway

Fig.5.16 Gateway Device

Gateway is a device that is used to connect a network to another network that uses different protocols. If we have to link different kinds of networks, such as a network of IBM mainframe computers and a network of PCs, we might have to use a gateway. Gateways change the format of the data packets but not the contents of the message, to make it conform to the application program of the remote computer.

5.1.5 NETWORK ARCHITECTURE

Network architecture is the design of a communication system. It includes hardware devices (such as routers and switches), cabling, network topology and physical and wireless connections. Computer networks consist of server computers and client computers.

Server Computer *:* A computer on the network that shares resources for others to use is called a server computer or simply server. Shared resources include information, software, printer, plotter, Internet connection, hard disk, etc.

Client Computer *:* A computer on the network that accesses resources that are shared by other computers is known as client computer or simply client.

The two commonly used network architectures are:

- Client/Server Network
- Peer-to-Peer Network

Client/Server Networks

A computer network in which each computer on the network acts as either a server or a client is called client/server or dedicated server network. Each server computer on the network is called a dedicated server. Servers are not used as client computers. Fig.5.17 illustrates how a dedicated server network may be designed. The computer at the top of the figure is the dedicated server, sharing files and applications. The remaining computers in the illustration are clients that access resources shared by the server. Similarly, in a dedicated server network, client computers never act as servers.

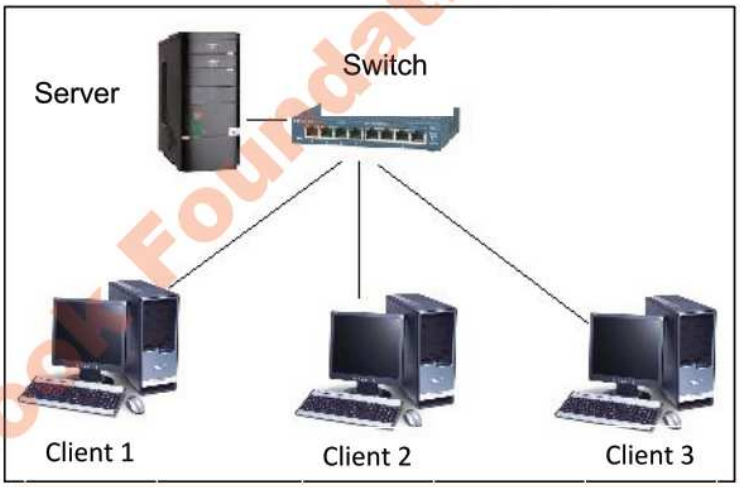


Fig.5.17 Client/Server Network

Client/Server network includes one or more computers that are dedicated to acting as servers. The servers are optimized to provide quick access to shared network resources. Servers also provide centralized security to ensure that resources are not accessed by unauthorized users.

Because the client/server approach centralizes control of data and other shared resources, one person or group is typically responsible for administering the network.

Peer-to-Peer Networks

In Peer-to-Peer networks, every computer is capable of playing the role of client, server or both at the same time. In this network each computer on the network is referred to as peer. In a peer-to-peer network, a peer computer can act as both a server and a client at the same time. A peer computer on your desktop can share files and printers with other computers

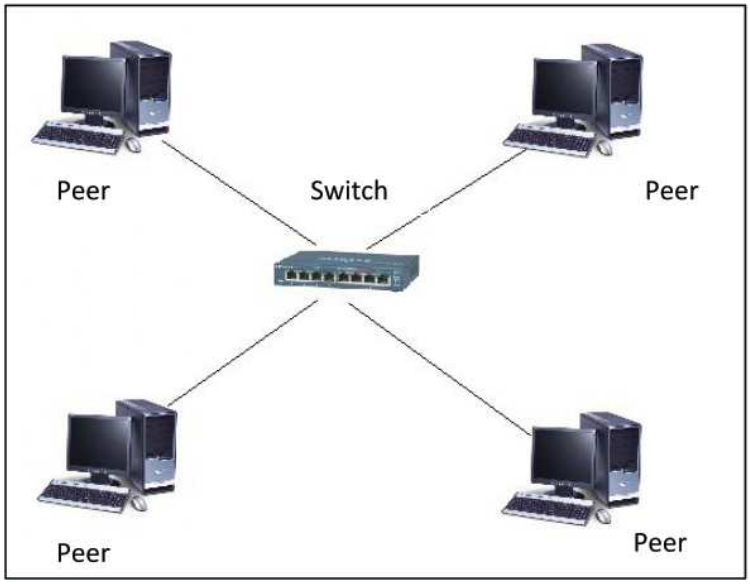


Fig.5.18 Peer-to-Peer Network

and it can simultaneously access other shared resources on the network. A conceptual view of a peer-to-peer network is shown in Fig.5.18.

Peer-to-peer networks tend to be relatively small. Most of these networks fall to range between two and ten computers. Large peer-to-peer networks become difficult to manage, because so many network administrators control sharing and maintaining shared resources.

5.1.6 TYPES OF NETWORKS

The following are different types of networks based on the size and physical area they cover.

Local Area Networks

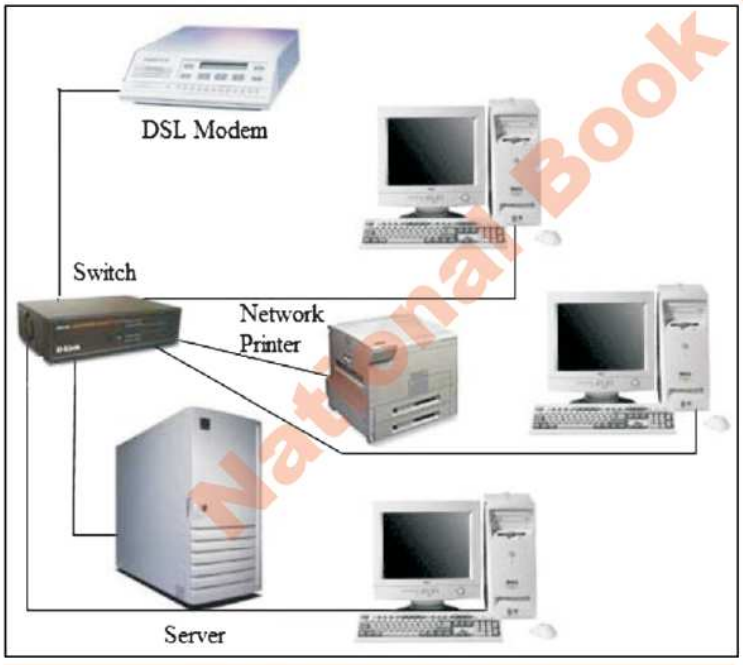


Fig.5.19 Local Area Network

A Local Area Network (LAN) spans a limited physical area. It is confined to a single building or a group of nearby buildings. LANs are used for sharing applications, printers, group scheduling, e-mail, project tracking and other tasks. A LAN is shown in Fig.5.19.

Characteristics of LAN

i. Spans a small physical area.

ii. Uses high-speed wired/wireless connections between computers.

iii. It is a very reliable network. Communication errors are very rare.

iv. It consists of a limited number of computers.

Wide Area Networks

A Wide Area Network (WAN) spans a large physical area, connecting several sites of an organization across cities, countries and continents. Because of the longer distances involved, WANs are sometimes referred to as long-haul networks.

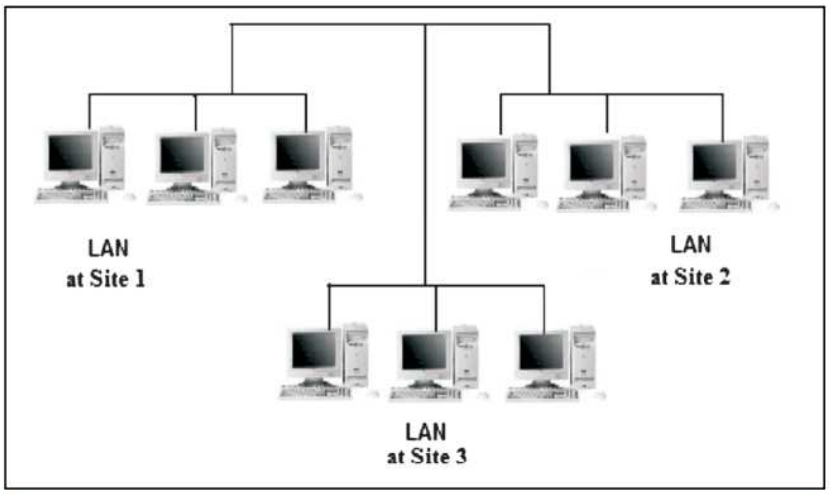


Fig.5.20 A Wide Area Network

A WAN is often made up of two or more LANs connected together as shown in Fig.5.20. For example, you might have a LAN at each site of your organization and each of those LANs might be connected together to form a WAN.

Characteristics of WAN

- Spans a large physical area. It can be worldwide like Internet.
- Communication speed is slow compared to LAN.
- Connects computers through public networks, leased lines or satellites.
- Connects multiple LANs.
- Sometimes communication errors occur due to its complexity.

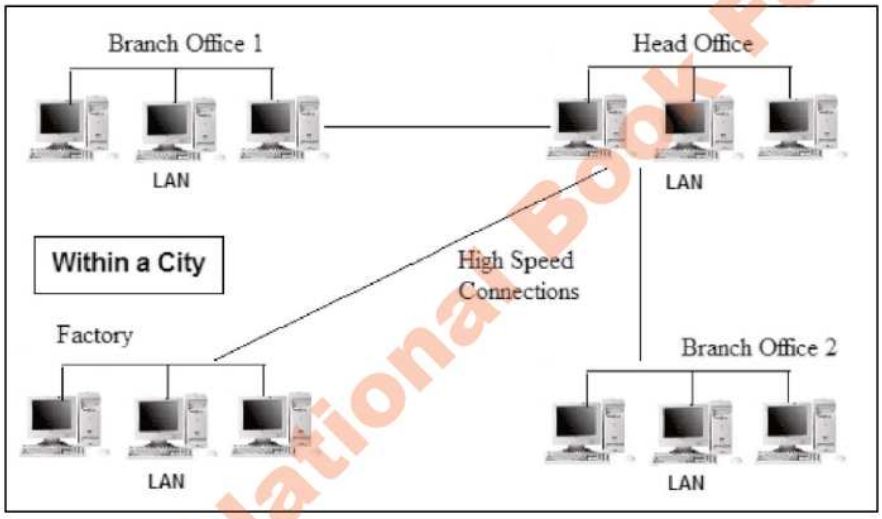


Fig.5.21 Metropolitan Area Network

Metropolitan Area Network

Metropolitan Area Network (MAN) can span from several buildings or a large campus to entire cities. MAN is used by many organizations. It also connects a number of local area networks with high-speed communication lines.

Characteristics of MAN

- It is larger than a LAN and smaller than a WAN. Covers an area of between 5 to 50 km diameter.
- Uses fiber optic cable or microwave transmission.
- Provides high-speed communication.
- Used by telephone companies, Internet Service Providers and cable TV companies.

Virtual Private Network

Virtual Private Network (VPN) is a computer network that provides remote access to individuals and offices to their organization's networks. It provides cheap communication by using public telecommunication infrastructure such as Internet instead of expensive leased lines.

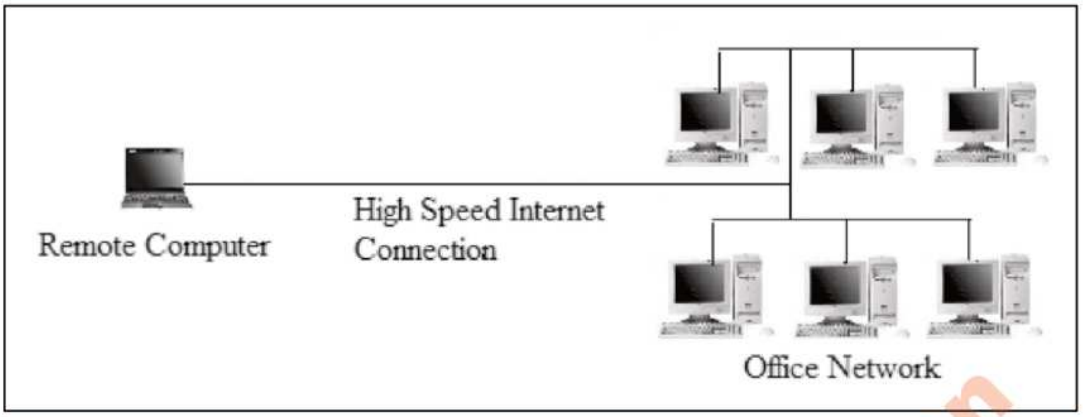


Fig.5.22 Virtual Private Network

It allows employees at home or on trip to connect their laptops into the computer at office through public telecommunication networks and do their work.

Characteristics of VPN

- It uses public networks such as Internet to connect computers.
- Provides secure remote access.
- Enables files sharing, video conferencing and similar network services.
- Provides cheap communication over long distance.

5.1.7 NETWORK TOPOLOGIES

The arrangement of network nodes (any devices which are part of network) and connections between them is called the network's topology. A node represents any device on the network. Topology is simply a map of the layout of nodes and connections in the network. Four network topologies are popular today, namely, Bus, Star, Ring, and Mesh.

Bus Topology

Bus network topology connects each node to the network along a single piece of cable, called a bus. Bus network topology is shown in Fig.5.23.

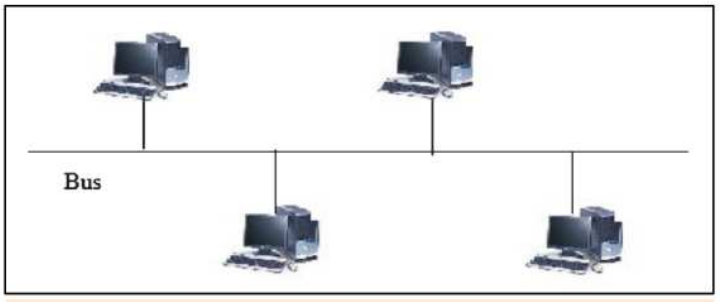


Fig.5.23 Bus network topology

Features of Bus Topology

- Suitable for a small network.
- Easy to connect a computer or a peripheral device to the network.
- Requires less cable to implement.
- Terminator is installed at each end of the cable to prevent signals from reflecting back onto the bus and cause errors. Terminator is a device that is attached to ground.

Teacher Point

Teacher may also use presentations or animations or videos for explanation.

Limitations of Bus Topology

- If the single cable is damaged or broken at any point, the entire network can go down.
- Difficult to identify the problem if the entire network goes down.
- Not suitable for large network.

Star Topology

In a star network topology, each network node is connected to a central device called a hub. Large networks can require many hubs and hubs can be connected to each other to create a single large network. Star network topology is shown in Fig.5.24.

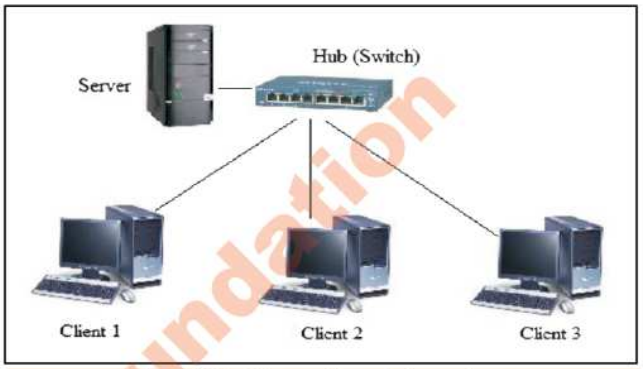


Fig. 5.24 Star network topology

Features of Star Topology

- It is suitable for both small and large networks.
- Easy to install and wire.
- Easy to detect and remove faults.
- Failure of cable does not stop functioning of the entire network.

Limitations of Star Topology

- Failure of the hub causes the entire network to go down.
- Expensive topology to implement. Lengthy cable with a hub is required to install star topology

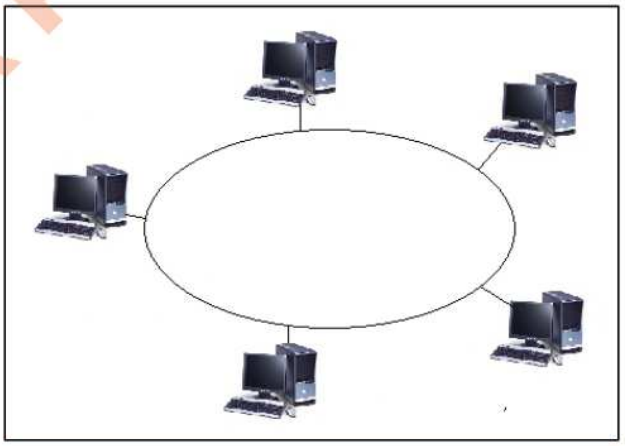


Fig.5.25 Ring network topology

Ring Topology

Ring topology is shaped just like a ring. It is made up of an unbroken circle of network nodes. Ring network topology is shown in Fig.5.25.

Features of Ring Topology

- Each node is directly connected to the ring.
- Easy to install and wire.
- Data on the network flows in one direction.
- Not costly to implement.

Limitations of Ring Topology

- If the ring is broken at any point, the entire network stops functioning.
- Slower than other network topologies.

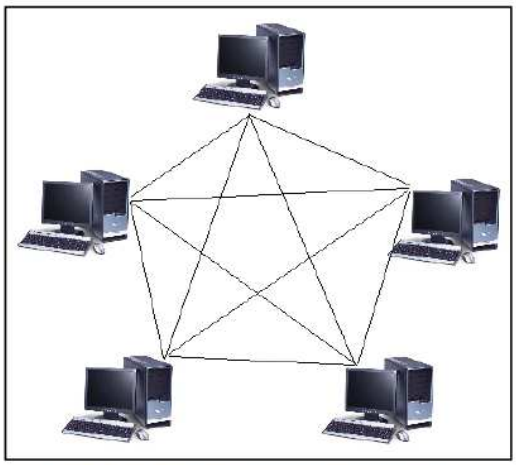


Fig.5.26 Mesh network topology

Mesh Topology

In mesh topology, each node is directly connected to all the nodes as shown in Fig.5.26.

Features of Mesh Topology

- Most reliable network topology.
- Data can be routed around failed computers or busy ones.
- Can manage high traffic.

Limitations of Mesh Topology

- Most expensive topology to implement.
- Setup and maintenance is very difficult.

5.2 DATA COMMUNICATION STANDARDS

Data communication standards refer to hardware and software specifications that make communication between different computer systems possible.

5.2.1 PURPOSE OF COMMUNICATION STANDARDS

Any computer or device in the network can communicate with any other computer or device by following some rules. These rules are called communication standards. Communication standards are needed so that different computer networks can communicate with each other.

5.2.2 OSI MODEL

The International Standards Organization (ISO) based in Geneva, developed standards for international and national data communications. In the early 1970s, ISO developed a standard model of a data communication system and called it the Open Systems Interconnection (OSI) model.

The OSI model consists of seven layers. Each layer performs a specific task during data communication.

In OSI model, control is passed from one layer to the next, starting at the application layer in one station and proceeding to the bottom layer (the physical layer), over the physical link to the next station and back up to the application layer. This process is in shown in Fig.5.27.

The seven layers of OSI model are described below.

Layer 7 – Application Layer

Application Layer provides services to end-user. It interacts with the operating system or application software whenever the user wants to send files, read messages or perform other network related activities.

Layer 6 – Presentation Layer

Presentation Layer takes the data provided by the Application Layer and converts it into a standard format that the other layers can understand. At the receiving end it also formats the information so that it looks the way the user can understand.

Layer 5 – Session Layer

Session Layer performs functions that enable two applications or two pieces of the same application to communicate across the network. It performs security, name recognition, logging and other similar functions. It also establishes, maintains and ends communication with the receiving computer.

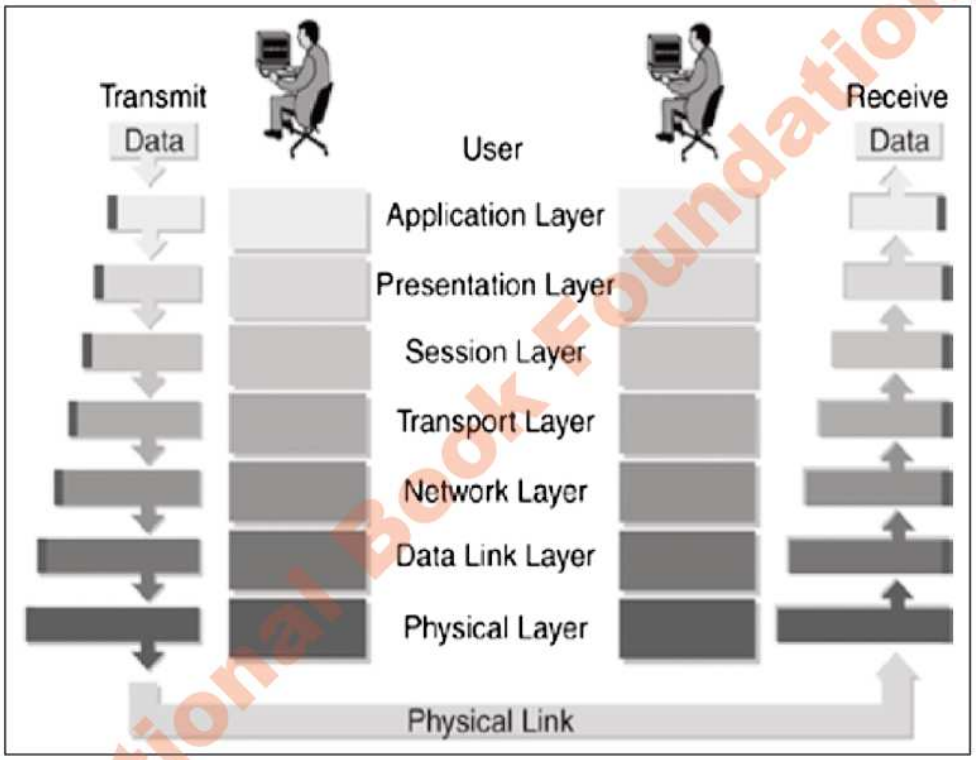


Fig.5.27 Layers of OSI Model

Layer 4 – Transport Layer

Transport Layer establishes connections between two computers on the network. It handles quality control by making sure that the data received is in the right format and the right order.

Layer 3 – Network Layer

Network Layer decides which physical path-way the data should take to reach the destination. The communication device **Router** works in network layer.

Layer 2 – Data Link Layer

Data Link Layer defines the format of data on the network. This layer converts the data into packets and checks them before putting them on the path-way. The communication device Switch works in this layer.

Layer 1 – Physical Layer

Physical Layer defines cables and signalling. It provides hardware means such as cables and connectors for sending and receiving data. Cables, hubs and repeaters work in this layer.

5.2.3 PROTOCOLS AND DEVICES USED AT VARIOUS LAYERS OF OSI MODEL

A **protocol** is a set of rules and conventions that govern how computers exchange information over a network medium. A protocol implements the functions of one or more of the OSI layers as shown in Table 5.1.

Layers of OSI Model	Protocol Name	Protocol Function	Device Used
Physical Layer	X.25 & IEEE 802	Provides hardware such as cables and connectors for sending and receiving data.	Cables and Connectors
Data Link Layer	X.25 & IEEE 802	Places data packets on to the path-way for transmission.	Switches & NICs
Network Layer	Internet Protocol	Controls routing and forwarding of data between the source and destination.	Router
Transport Layer	TCP	Transfers data between source and destination and is responsible for error recovery and flow control.	Router and Gateway
Session Layer	NetBIOS	Starts and stops communication sessions between applications.	Gateway
Presentation Layer	Windows O.S.	Converts data into a format that can be carried by the lower layer or converts data into a form that the application layer can understand at the receiving end.	Gateway
Application Layer	HTTP	Provides interaction between the end user and software	Gateway

Table 5.1 Protocols and devices of OSI Model

5.3 TCP/IP

Communication between computers on a network is done through protocol suite. TCP/IP is the most widely used protocol suite for communication. TCP/IP was developed by US Department of Defense (DoD) in 1969. The most important capability of TCP/IP is that it provides communication between two or more computer systems used for communication over the Internet.

5.3.1 TCP/IP PROTOCOL

Protocol Suite is a set of communication protocols used on Internet and many other computer networks. It is commonly known as TCP/IP protocol because its most important protocols are Transmission Control Protocol (TCP) and Internet Protocol (IP).

The architecture of TCP/IP protocol describes the function of its each layer during communication between computers on the Internet. Every computer on Internet has a unique number assigned to it called the IP address. The IP address recognizes a particular computer out of millions of computers connected to the Internet.

TCP/IP Architecture

TCP/IP protocol architecture has four layers that transmit information from one computer to another over the Internet. These layers pass information from the application layer to the physical network layer. The four layers of TCP/IP protocol architecture are:

- Application Layer
- Transport Layer
- Network Layer
- Network Access Layer

TCP/IP Ports and Applications

When an application on the computer sends or receives data over the Internet, it sends data to an IP address and a specific port on the remote computer and also receives the data on a port on the receiving computer. There are a total number of 65,535 TCP/IP ports. The Internet Assigned Numbers Authority (IANA) is a global organization that is responsible for registration of port numbers for common Internet services.

5.3.2 TCP/IP AND OSI MODEL COMPARISON

The following chart clears the difference between the two models.

	TCP/IP MODEL	OSI MODEL
1	TCP/IP stands for Transmission Control Protocol/ Internet Protocol	OSI stands for Open system Interconnect
2	TCP/IP consists of 4 Layers	OSI Model consists of 7 Layers
3	It was developed by US Department of Defense (DoD)	It was developed by ISO (International Standard Organization)
4	It is a client server model used for transmission of data over the Internet	It is a theoretical model which is used for computing system
5	TCP/IP is an implementation of OSI model	OSI is a reference model
6	The TCP/IP suite is based on protocols	OSI model is layer based model

Comparison between TCP/IP Model and OSI Model is also shown in Fig.5.28.

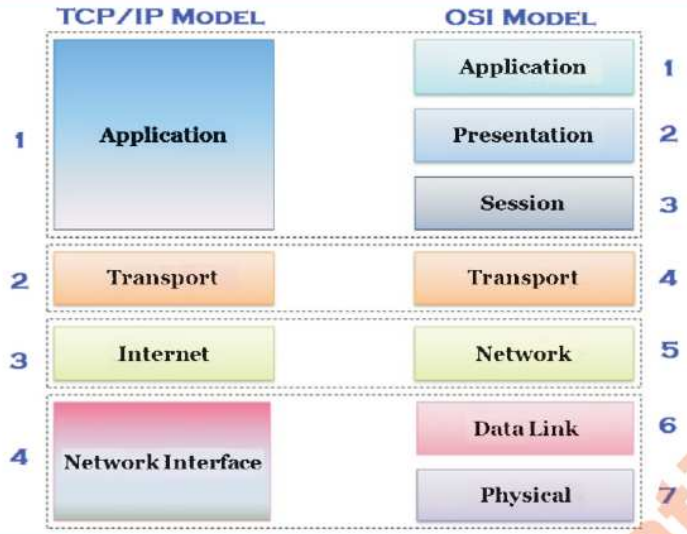


Fig.5.28 Comparison between TCP/IP and OSI Models

5.3.3 CIRCUIT SWITCHING AND PACKET SWITCHING NETWORKS

Circuit Switching Network

In circuit switching network, a physical connection must be established through the network. The data is transmitted through several switches. When transmitting data over a circuit switched network, a connection is established and kept open for the duration of communication. The circuit switched networks require dedicated point-to-point connection between the subscribers and no other network traffic can use the communication line. It provides a fixed data rate for both transmission and reception. An example of circuit switched network is the telephone network.

Packet Switching Network

In packet switching network no physical connection is established between the two subscribers like circuit switching network. All the data that is to be transmitted is broken down into small blocks called packets. These packets include both the source and destination address. They are passed by the source computer to its local Packet Switching Exchange (PSE). On receipt of each packet, the PSE first stores the packet and then inspects the destination address it contains. Each PSE contains a routing directory specifying the outgoing links' transmission paths to be used for each network address. The PSE forwards the packet on the appropriate link. When received, packets are reassembled in the proper sequence to make up the message.

5.3.4 IP ADDRESSING SCHEMES

An IP address is a 32-bit number that uniquely identifies a host (computer or other device, such as a printer or router) on a TCP/IP network. IP addresses have two parts. The first part identifies the network to which the computers are connected and the second part identifies the computers or hosts on the given network.

Network Number	Computer/Host Number

All the computers on a given network share the same network number but must have a unique computer/host number. Similarly, any two computers on different networks must have different network number but may have the same computer/host number.

An IP address is made up of 32 bits. The 32 bits are broken down into four octets. One octet is equal to 8 bits. Each octet is converted to decimal and separated by a dot. Therefore, an IP address is expressed in dotted-decimal format. For example, Fig.5.29 shows an IP address with equivalent dotted-decimal notation.

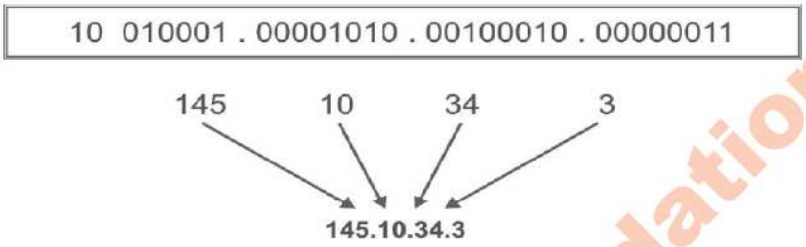


Fig. 5.29 An IP Address expressed in decimal-dotted notation

Subnet Mask

The second item, which is required for TCP/IP to work, is the subnet mask. The subnet mask is used by the TCP/IP protocol to determine whether a computer/host is on the local subnet or on a remote network. This information is supplied in another 32-bit number called a subnet mask. In this example, the subnet mask is 255.255.255.0. It is not obvious what this number means unless you know that 255 in binary notation equals 11111111; so, the subnet mask is:

11111111.11111111.11111111.0000000

Lining up the IP address and the Subnet mask together, the network and host portions of the address can be separated:

11000000.10101000.01111011.10000100 – IP address (192.168.123.132)

11111111.11111111.11111111.00000000 – Subnet mask (255.255.255.0)

The first 24 bits (the number of ones in the subnet mask) are identified as the network address, with the last 8 bits (the number of remaining zeros in the subnet mask) identified as the host address.

Network Classes

All networks in use have different sizes. For example, a company that will have 50 computers, will not need a network of 5000 computers, And on the contrary, a company that needs 5000 computers does not need a network that can only hold 50 computers.

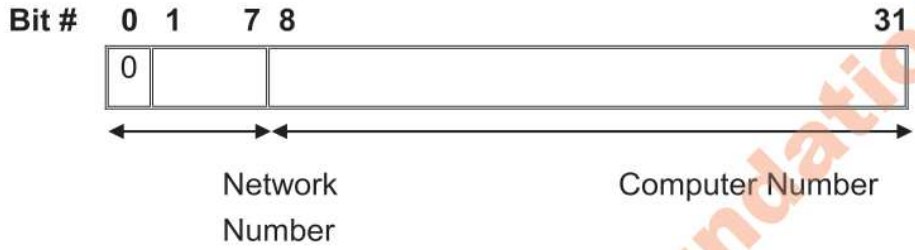
This is the main reason that engineers decided that IP address space should be divided in different classes in order to meet different size requirements of networks.

TCP/IP defines five classes of IP addresses: class A, B, C, D, and E. Each class has a range of valid IP addresses. The value of the first octet determines the class. IP addresses from the first three classes (A, B and C) can be used for host addresses. The other two classes are used for other purposes (class D for multicast and class E for experimental purposes).

Class	1st Octet Decimal Range	1st Octet High Order Bits	Network/Host ID (N=Network, H=Host)	Default Subnet Mask
A	1 – 126*	0	N.H.H.H	255.0.0.0
B	128 – 191	10	N.N.H.H	255.255.0.0
C	192 – 223	110	N.N.N.H	255.255.255.0
D	224 – 239	1110	Reserved for Multicasting	
E	240 – 254	1111	Experimental; used for research	

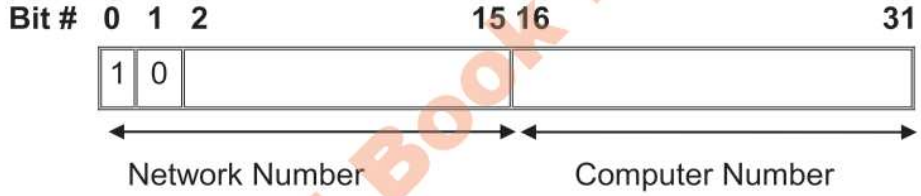
***Note:** Class A addresses 127.0.0.0 to 127.255.255.255 cannot be used and is reserved for loopback and diagnostic functions.

Class A Address



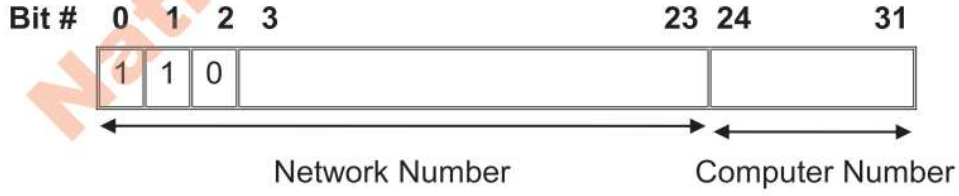
Class A networks use a default subnet mask of 255.0.0.0 and have 0-126 as their first octet. The address **10.52.36.11** is a class A address. Its first octet is 10, which is between 1 and 126, inclusive.

Class B Address



Class B networks use a default subnet mask of 255.255.0.0 and have 128-191 as their first octet. The address **172.16.52.63** is a class B address. Its first octet is 172, which is between 128 and 191, inclusive.

Class C address



Class C networks use a default subnet mask of 255.255.255.0 and have 192-223 as their first octet. The address **192.168.123.132** is a class C address. Its first octet is 192, which is between 192 and 223, inclusive.

Teacher Point

OSI model layers should be demonstrated through videos available on Internet (youtube.com). Teacher should give some home assignments to the students at the end of the chapter.

Key Points

- A computer network is an interconnection between two or more computers so that they can communicate with each other.
- Data communication consists of three basic components which are Sender, Medium and Receiver.
- Modes of data communication refer to the method or way information is transmitted from one place to another. There are three types of data communication modes which are simplex, half-duplex and full-duplex.
- In asynchronous transmission, the time interval between two characters is not fixed whereas in synchronous transmission it is fixed.
- Guided transmission media uses cables that guide the data signals along a specific path.
- Unguided transmission media transmits data signals through open air.
- A communication satellite is a relay station in the space that receives signals from ground antennas, amplifies them and then retransmits to another earth station which can be thousands of miles away.
- A Switch is a small device that connects multiple computers together in a LAN.
- A Router is a device that receives data packets and forwards them to a closer computer to the remote computer by selecting the best path-way based on network traffic.
- A Gateway is a device that is used to connect a network to another network that uses different protocols.
- A computer network in which each computer on the network acts as either a server or a client is called Client/Server Network.
- A computer network in which every computer is capable of playing the role of client, server or both at the same time is called Peer-to-Peer Network.
- A network that spans a limited physical area such as a building or a group of buildings is called Local Area Network (LAN).
- A network that spans large physical area, connecting several sites of an organization across cities, countries and continents is called Wide Area Network (WAN).
- A network that spans from several building or a large campus to entire city is called Metropolitan Area Network (MAN).
- A network that provides remote access to individuals and offices to their organization's network using public telecommunication infrastructure such as Internet is called Virtual Private Network (VPN).
- The arrangement of network nodes and connections between them is called network topology.
- The OSI Model was designed to facilitate creating system in which equipment from different venders can communicate with each other.

- TCP/IP was developed by Department of Defense, USA, to implement Transmission Control Protocol and Internet Protocol. It provides communication between two or more different computer systems.
- In a circuit switched network, a physical connection is established through the network for transmitting data.
- In a packet switched network, all the data that is to be transmitted is broken down into small blocks called packets. These packets are passed from the source computer to the destination computer through several Packet Switching Exchanges.
- IP addressing schemes are used in computer networks to identify a computer for communication.

Exercise

Q1. Select the best answer for the following MCQs.

i. In which communication mode data can be sent and received in both directions but not simultaneously?
   A. Simplex mode
   B. Half-duplex mode
   C. Full-duplex mode
   D. Synchronous transmission

ii. Which of the following network devices connects a network to another network that uses different protocol?
   A. Switch
   B. Gateway
   C. Router
   D. Modem

iii. Which of the following networks provides remote access to individuals and offices to their organization's network?
   A. LAN
   B. WAN
   C. MAN
   D. VPN

iv. In which topology a hub (switch) is used?
   A. Star topology
   B. Ring topology
   C. Bus topology
   D. Mesh topology

v. Which topology is most expensive to implement?
   A. Star topology
   B. Ring topology
   C. Bus topology
   D. Mesh topology

vi. Which layer of OSI Model decides which physical path-way the data should take to reach the destination?
   A. Data link layer
   B. Network layer
   C. Transport layer
   D. Session layer

vii. Which network layer performs security, name recognition, logging and similar functions?
   A. Transport layer
   B. Network layer
   C. Presentation layer
   D. Session layer

viii. Which of these cables transmits data using light waves?
   A. Twisted pair cable
   B. Coaxial cable
   C. Fibre optic cable
   D. Telephone line

ix. Which of these uses a start/stop bit for data transmission?

A. Asynchronous transmission B. Synchronous transmission
C. Half-duplex transmission D. Full-duplex transmission

x. Which bits are used at the start of a Class B IP address?

A. 0 B. 10
C. 101 D. 110

Q2. Write short answers of the following questions.

i. Define computer network.
ii. Define network communication and its basic components.
iii. Briefly describe the modes of network communication.
iv. Differentiate between asynchronous and synchronous network transmissions.
v. Differentiate between server and client computers.
vi. Differentiate between LAN and WAN.
vii. What is OSI Model?
viii. Compare TCP/IP Model with OSI Model.
ix. Differentiate between circuit switched and packet switched networks.
x. Briefly describe IP Addressing.

Q3. Write long answers of the following questions.

i. Explain different types of guided media.
ii. Explain microwave and satellite communications.
iii. Write notes on switch, router and gateway.
iv. Explain in detail Client/Server and Peer-to-Peer networks.
v. Define network topology and explain its types.
vi. Describe briefly the seven layers of OSI Model.
vii. Describe the four layers of TCP/IP Model.

Lab Activities

Following lab activities are to be carried out during the practical periods.

1. Clint-Server and Peer – to – Peer networks should be demonstrated through video/animation.
2. Sharing of files/folders, printers and Internet connection should be demonstrated.
3. Use of switch and router is to be demonstrated.
4. Use of TCP/IP protocol and IP addressing is to be demonstrated through video/animation.