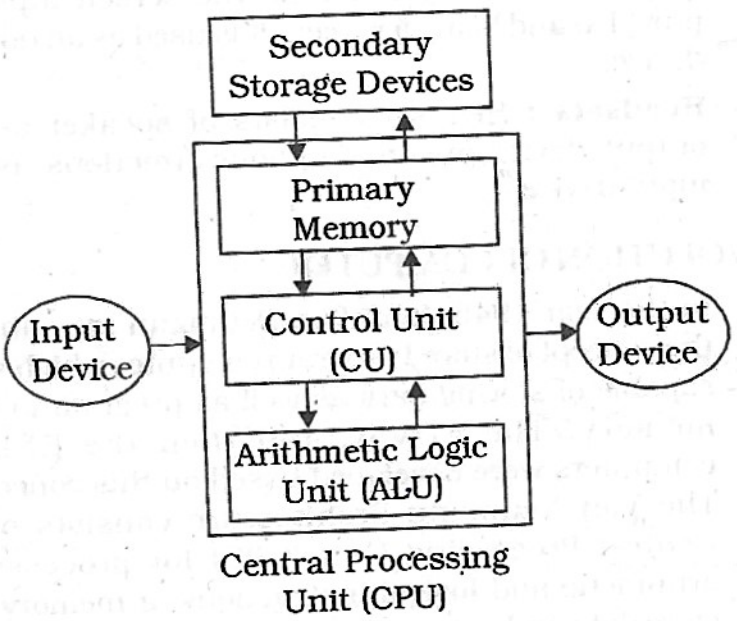
1 COMPUTER SYSTEM
(NCERT CLASS 11)

INTRODUCTION TO COMPUTER SYSTEM

- A computer is an electronic device, under the control of instructions stored in its memory that can accept data (input), process the data according to specified rules(Program) on processor & produces information (output), and store the information for future use.
- A computer along with additional hardware and software together is called a computer system.
- A computer system primarily comprises a central processing unit (CPU), memory, input/output devices and storage devices and all these components function together as a single unit to deliver the desired output.
- Following figure shows the block diagram of a computer system.The directed lines represent the flow of data and signal between the components.



- **Central processing unit (CPU) :** It is the electronic circuitry of a computer which carriesout the actual processing and usually referred as the brain of the computer. It is commonly called processor also. Physically, a CPU can be placed on one or more microchips called integrated circuits (IC). The Ics comprise semiconductor materials.CPU is also popularly known as microprocessor.
- The CPU receive instructions and data through programs and then the CPU fetches the program and data from the memory and performs arithmetic and logic operations as per the given instructions and stores the result back to memory.
- At the time of processing, the CPU stores the data as wellas instructions in its local memory which is known as registers. Registers are part of the CPU chip and they are limited in size and number. Different registers are used for storing data, instructions or intermediate results.
- The CPU has two main components other than register— Arithmetic Logic Unit (ALU) and Control Unit (CU).
- Arithmetic Logic Unit performs basic arithmetic operations such as addition and subtraction Performs logical operations such as AND, OR, and NOT. Most modern ALUs have a small amount of special storage units called registers that can be accessed faster than main memory.
- Control unit organizes the computer to work computer as single unit & generates control signals for various devices regarding read/write or execute operation. Or, we can say that Control Unit controls sequential instruction execution, interprets instructions and guides data flow through the computer's memory, ALU and input or output devices.
- **Input Devices :** In a simple word, it is a device through which data and programs from the outside world enter the computer system.Or we can say, it is the devices through which control signals are sent to a computer.

Input devices convert the input data into a digital form which is acceptable by the computer system. Data entered through input device is temporarilystored in the main memory (also called RAM) of the computer system. For permanent storage and future use, the data as well as instructions are stored permanently in additional storage locations called secondary memory.

Specially designed braille keyboards is used to help the visually impaired people for entering data into a computer. Besides that, we can also now enter data through voice, for example, we can use Google voice search to search the web where we can input the search string through our voice.

Examples of input devices are :

- **Keyboard :** It is an input device which sends data in to the computer. The data send depends on the key pressed by the user.
- **Mouse:** A mouse is a small handheld input device which controls a cursor in a graphical user interface. It can move and select text, files, folders etc. on our computer according to the user input.
- **Scanner:** Scanner optically reads and document, file or image and then changes it into digital signal and sends to the computer.

- **OMR** : Optical mark recognition/ reader, is used to read marks on a document and send them to computer.
- **OCR** : OCR stands for optical character Recognition, is an input device which reads printed text and sends that to computer.
- **MICR :** Magnetic Ink Character Reader is an input device which generally finds application is banks to process cheques.
- **Microphone :** It receives audio generated by some input source and sends it to a computer.
- **Webcam** : It sends the captured images to a computer.
- **Graphics Tablets** : This input device is used to draw using hand.
- **Trackballs :** An upside down mouse,encased within a socket. It is a cursor control device.
- **Barcode reader :** It is used to read the barcode of various items and feed the same to computer.
- **Gamepad** : Also known as joy pad is the input controller for video games.
- **Joystick** : these input devices are used to control video games.
- **Output Devices :** A device through which results stored in the computer memory are made available outside the computer system. Or we can say, it is the device that receives data from a computer system for display, physical production, etc.

  Output devices converts digital information into humanunderstandable form. A printer is the most commonly used device to get output in physical (hardcopy) form. Three types of commonly used printers are inkjet, laserjet and dot matrix. Now-a-days, there is a new type of printer called 3D-printer, which is used to build physical replica of a digital 3D design. These printers are being used in manufacturing industries to create prototypes of products. Their usage is also being explored in the medical field, particularly for developing body organs.

  A braille display monitor is useful for a visually challenged person to understand the textual output generated by computers.Example of output devices are:-
- **Monitor :** A monitor is an output device that is responsible for receiving data from a computer and displaying that information as text or images for users to see.
- **Speakers :** Receives sound signal from a computer and then plays that sound signal and thus we hear songs or music or any other audio.
- **Projector :** Gets data from a computer and displays or projects the same information onto a screen or a wall. Projector cannot directly accept data from a user and send that data to another device.
- **Both Input / Output Devices :** An input/output device is capable of receiving data from users or another devices and also sending data to another devices or computers. That means a devices which can be used as both input device and output device are called Input / Output (I/O) devices. Some examples of input/output devices are as:
- **USB drive :** Also known as pen drive or flash stick works as both input device to computer and as an output device. USB drives receive or save data from a computer as an input and it can also send data to a computer or another device.
- **Facsimile** : Facsimile or FAX machine has a scanner which is an input device and a small printer to provide output.
- **Modems :** It is used to transmit and receive data from one computer to another computer or other devices using telephone lines.
- CD-RW drives and DVD-RW drives: Receives data from a computer as input to copy onto and save into writable CD or DVD. We also use CDs or DVDs to transfer data to a computer.
- **Touch Screen :** Touch screen is both input and output device. By touching the screen input is provided and being a screen, it is used as an output device.
- **Headsets** : Headset consists of speaker as an output device and microphone functions as an input device

EVOLUTION OF COMPUTER

- In the year 1945 John Von Neumann introduced the concept of stored program computer which was capable of storing data as well as program in the memory. The EDVAC and then the ENIAC computers were developed based on this concept. The Von Neumann architecture consists of a Central Processing Unit (CPU) for processing arithmetic and logical instructions, a memory to store data and programs, input and output devices and communication channels to send or receive the output data. Electronic Numerical Integrator and Computer (ENIAC) is the first binary programmable computer based on Von Neumann architecture.
- During the 1970s, Large Scale Integration (LSI) ofelectronic circuits allowed integration of complete CPU on a single chip, called microprocessor. Moore's Law predicted exponential growth in the number of transistors that could be assembled in a single microchip.
- In 1980s, the processing power of computers increased exponentially by integrating around 3 million components on a small-sized chip termed as Very Large Scale Integration (VLSI). Further advancement in technology has made it feasible

to fabricate high density of transistors and other components (approx 106 components) on a single IC called Super Large Scale Integration (SLSI).

- IBM introduced its first personal computer (PC) for the home user in 1981 and Apple introduced Macintosh machines in 1984.
- By the introduction of Graphical User Interface (GUI) based operating systems by Microsoft and others in place of computers with only command line interface, like UNIX or DOS increases the popularity of the personal computer.
- Around 1990s, the growth of WorldWide Web (WWW) further accelerated mass usage of computers.Further, with the introduction of laptops, personal computing was made portable to a great extent. This was followed by smartphones, tablets and other personal digital assistants. These devices have leveraged the technological advancements in processor miniaturisation, faster memory, high speed data and connectivity mechanisms.
- The next wave of computing devices includes the wearable gadgets, such as smart watch, lenses, headbands, headphones, etc. Further, smart appliances are becoming a part of the Internet of Things (IoT), by leveraging the power of Artificial Intelligence (AI).

COMPUTER MEMORY

- Memory is used to store the data and instructions for processing in a computer system.
- **Units of Memory :** Bytes are grouped together to make bigger chunks or units of memory.Computer system uses binary numbers to store and process data. The binary digits 0 and 1, which are the basic units of memory, are called bits. These bits are grouped together to form words. A 4-bit word is called a Nibble. Examples of nibble are 1001, 1010, 0010, etc. A two nibble word, i.e., 8-bit word is called a byte, for example, 01000110, 01111100, 10000001, etc.
- **Types of Memory :** Computers have two types of memory — primary and secondary.

  Primary memory : It is an essential component of a computer system as program and data are loaded into the primary memory before processing. The CPU interacts directly with the primary memory to perform read or write operation. It is of two types viz. (I) Random Access Memory (RAM) and (II) Read Only Memory (ROM).

(I) **Random Access Memory (RAM)** – It is a type of volatile memory that is stores information on an integrated circuit which hold the data mainly when the program is being executed by the CPU. As it is volatile in nature so it can't store data permanently. RAM is usually referred to as main memory and it is faster than the secondary memory or storage devices.

(II) **Read Only Memory (ROM)** – It is a non-volatile memory chip in which data are stored permanently, and can not be altered by the programmerwhichmeans its contents are not lost even when the power is turned off. For example, the startup program (boot loader) that loads the operating system into primary memory, is stored in ROM.

Cache Memory: It is a small high speed memory, which is used to increase the speed of processing by making current programs and data available to the CPU at a rapid rate.It is the volatile computer memory which is very nearest to the CPU,so also called CPU memory, and is between CPU and RAM all the Recent Instructions are Stored into the Cache Memory. It is the fastest memory that provides high-speed data access to a computer microprocessor.

Secondary Memory : It is a storage, which suppliments the main memory of a computer. Often refferred to as secondary storage, this section of computer's memory is nonvolatile and has low cost per bit stored, but it generally has an operating speed far slower than that of the primary storage.Examples of secondarymemory devices include Hard Disk Drive (HDD), CD/DVD, Memory Card, etc.

DATA TRANSFER BETWEEN MEMORY AND CPU

- Data are transferred between different components of a computer system using physical wires called bus. Bus is of three types :-

  (I) **Data bus :** Used to transfer data between different components.

  (II) **Address bus :** Used to transfer addresses between CPU and main memory.The address of the memory location that the CPU wants to read or write from is specified in the address bus.

  (iii) **Control bus :** Used to communicate control signals between different components of a computer.

  All these three buses collectively make the system bus.
- CPU interacts directly with main memory therefore any data entered from input device or the data to be accessed from hard disk needs to be placed in the main memory for further processing. The data is then transferred between CPU and main memory using bus.
- CPU may require to read data from main memory or write data to main memory, a data bus is bidirectional. But the control bus and address bus are unidirectional. To write data into memory, the CPU places the data on the data bus, which is then written to the specific address provided through the address bus.

- In case of read operation, the CPU specifies the address, and the data is placed on the data bus by a dedicated hardware, called memory controller. The memory controller manages the flow of data into and out of the computer's main memory.

MICROPROCESSORS

- A processor (CPU) which is implemented on a single microchip is called microprocessor. Microprocessor is a small-sized electronic component inside a computer that carries out various tasks involved in data processing as well as arithmetic and logical operations. These days, a microprocessor is built over an integrated circuit comprising millions of small components like resistors, transistors and diodes.
- **Microprocessor Specifications :**
  (I) **Word Size :** Word size is the maximum number of bits that a microprocessor can process at a time. At present, the minimum word size is 16 bits and maximum word size is 64 bits.
  (II) **Memory Size :** Depending upon the word size, the size of RAM varies.Initially, As word size increased to 64 bits, it has become feasible to use RAM of size upto 16 Exabytes (EB).
  (III) **Clock Speed :** Computers have an internal clock that generates pulses (signals) at regular intervals of time. Clock speed simply means the number of pulses generated per second by the clock inside a computer. The clock speed indicates the speed at which the computer can execute instructions. Earlier, it was measured in Hertz (Hz) and Kilohertz (kHz). But with advancement in technology and chip density, it is now measured in Gigahertz (GHz), i.e., billions of pulses per second.
  (IV) **Cores :** Core is a basic computation unit of the CPU. CPU with two, four, and eight cores is called dual-core, quad-core and octa-core processor, respectively.
- **Microcontrollers :** It is a small computing device which has a CPU, a fixed amount of RAM, ROM and other peripherals all embedded on a single chip as compared to microprocessor that has only a CPU on the chip. Examples of microcontrollers are Keyboard, mouse, washing machine, digital camera, pendrive, remote controller, microwave etc. The simple use of microcontroller has permitted repetitive execution of tedious tasks automatically without any human intervention, thereby saving precious time.

DATA AND INFORMATION

- Data are raw numbers or other findings which, by themselves, are of limited value. Information is data that has been converted into a meaningful and useful context.
- **Data and Its Types :** A computer system has many input devices, which provide it with raw data in the form of facts, concepts, instructions, etc., Internally everything is stored in binary form (0 and 1), but externally, data can be input to a computer in the text form consisting of English alphabets A–Z, a–z, numerals 0 – 9, and special symbols like @, #, etc.Primarily, there are three types of data.
  (I) **Structured Data :** Data which follows a strict record structure and is easyto comprehend is called structured data. Such data with pre-specified tabular format may be stored in a data file to access in the future.
  (II) **Unstructured Data :** Data which are not organised in a pre-defined record format is called unstructured data. Examples include audio and video files, graphics, text documents, social media posts, satellite images, etc. Such data are unstructured as they consist of textual contents as well as graphics, which do not follow a specific format.
  (III) **Semi-structured Data :** Data which have no well-defined structure but maintains internal tags or markings to separate data elements are called semi-structured data. Examples include email document, HTML page, comma separated values (csv file), etc.
- **Data Capturing :** It involves the process of gathering data from different sources in the digital form. This capturing may vary from simple instruments like keyboard, barcode readers used at shopping outlets, comments or posts over social media, remote sensors on an earth orbiting satellite, etc.
- **Data Storage :** It is the process of storing the captured data for processing later. Now-a-days data is being produced at a very high rate, and therefore data storage has become a challenging task.
- **Data Retrieval :** It involves fetching data from the storage devices, for its processing as per the user requirement. As databases grow, the challenges involved in search and retrieval of the data in acceptable time, also increase. Minimising data access time is crucial for faster data processing.
- **Data Deletion and Recovery :** Deleting digitally stored data means changing the details of data at bit level, which can be very timeconsuming. Therefore, when any data is simply deleted, its address entry is marked as free, and that much space is shown as empty to the user, without actually deleting the data.

  In case data gets deleted accidentally or corrupted, there arises a need to recover the data. Recovery of the data is possible only if the contents or memory space marked as deleted have not been overwritten by some other data. Data recovery is a process of retrieving deleted, corrupted and lost data from secondary storage devices.

There are usually two security concerns associated with data:-

(I) Its deletion by some unauthorised person or software.

(II) unwanted recovery of data by unauthorised user or software.

SOFTWARE

- Software is a generic term for organized collections of computer data and instructions,often broken into two major categories: system software thatprovides the basic nontaskspecific functions of the computer, and application software which is used by users to accomplish specific tasks.

  Hardware : Computer hardware is the collection of physical elements/parts that constitutes a computer system,such as the monitor, mouse, keyboard, computer data storage, hard drive disk (HDD), system unit (graphic cards, sound cards, memory, motherboard and chips), etc. all of which are physical objects & can be touched.

- **Need of Software :** Purpose of a software is to make the computer hardware useful and operational. A software knows how to make different hardware components of a computer work and communicate with each other as well as with the end-user. Software acts as an interface between human users and the hardware.

  Depending on the mode of interaction with hardware and functions to be performed, the software can be broadly classified into three categories viz:-

(I) **System software :** The software that provides the basic functionality to operate a computer by interacting directly with its constituent hardware is termed as system software.A system software knows how to operate and use different hardware components of a computer. It provides services directly to the end user, or to some other software. Examples of system software include operating systems, system utilities, device drivers, etc.

(a) Operating system is a system software that operates the computer. An operating system is the most basic system software, without which other software cannot work. The operating system manages other application programs and provides access and security to the users of the system. Some of the popular operating systems are Windows, Linux, Macintosh, Ubuntu, Fedora, Android, iOS, etc.

(b) **System Utilities :** Software used for maintenance and configuration of the computer system is called system utility. Some system utilities are shipped with the operating system for example disk defragmentation tool, formatting utility, system restore utility, etc. Another set of utilities are those which are not shipped with the operating system but are required to improve the performance of the system, for example, anti-virus software, disk cleaner tool, disk compression software, etc.

(c) **Device Drivers :** As the name signifies, the purpose of a device driver is to ensure proper functioning of a particular device. When it comes to the overall working of a computer system, the operating system does the work. The device driver acts as an interface between the device and the operating system. It provides required services by hiding the details of operations performed at the hardware level of the device. Just like a language translator, a device driver acts as a mediator between the operating system and the attached device.

(II) **Programming tools :** A programming language is a vocabulary and set of grammatical rules for instructing a computer or computing device to perform specific tasks. In order to get some work done by the computer, we need to give instructions which are applied on the input data to get the desired outcome.

(a) **Classification of Programming Languages :** Two major categories of computer programming languages are low-level languages and high-level languages.

Low-level languages are machine dependent languages and include machine language and assembly language. Machine language uses 1s and 0s to write instructions which are directly understood and executed by the computer.

High level languages are machine independent and are simpler to write code into. Instructions are using English like sentences and each high level language follows a set of rules, similar to natural languages. However, these languages are not directly understood by the computer. Hence, translators are needed to translate high-level language codes into machine language. Examples of high level language include C++, Java, Python, etc.

(b) **Language Translators :** The language translators are used to convert high-level language programs into low-level language programs. They are classified into three catgories:

Assembler: Assembler is used to convert assembly language programs to machine language. The program written in the assembly or high-level language is known as source code. The assembles convert this code into machine language that can be read by the machine. The assembler can understand the microprocessor commands written in the program.

Compiler: Compiler converts high-level language program into machine language. It translates the source code into machine code and creates an object file. Once the code is translated, it brings the information from the object file. It compiles the whole program once and then reports the errors.

Interpreter: The interpreter executes the source code line by line. It stops the program if any error is reported then and there only. It accesses the source code every time when you run the program.

(c) Programming development tools are used to write programs, design interfaces, and deploy a program using high-level programming languages. As we are aware that the computer doesn't know or understand our language. So these programming language tools help to convert the program into machine language through language translators.

The IDE (Integrated Development Environment) tools provide the facility to write the source code, design the interface, and debugging. It is an integrated package of code editor, drag and drop tools to design interface and debugger. So these types of software allow to write code, design the software and debug the program for errors.

(III) **Application software :** The application software provides specific requirements for the end-users. This software runs on top of the system software. There are two broad categories of application software:

(a) **General Purpose Application Software :** General purpose application software is used to perform general-purpose tasks like documentation, spreadsheet-based tasks, presentation, graphics, or photo editing. Examples are MS word, MS Excel, MS Powerpoint, Adobe Photoshop, etc.

(b) **Customized Application Software :** Customized application software is tailormade application software designed to meet the specific requirements of the organization or an individual. This software is made as per the need of the organization and individual. For example ERP (Enterprise Resource Planning) software, accounting software, school management system software etc.

- Proprietary or Free and Open Source Software:- The developers of some application software provide their source code as well as the software freely to the public, with an aim to develop and improve further with each other's help. Such software is known as Free and Open Source Software (FOSS). For example, the source code of operating system Ubuntu is freely accessible for anyone with the required knowledge to improve or add 'new functionality. More examples of FOSS include Python, Libreoffice, Openoffice, Mozilla Firefox, etc. Sometimes, software are freely available for use but source code may not be available. Such software are called freeware. Examples of freeware are Skype, Adobe Reader, etc.

OPERATING SYSTEM

Operating System mainly operated the entire computer system. Without an operating system, the computer system cannot work. It manages and controls other application programs, provides access and security to the users of computers. Some examples are Windows, Linux, Macintosh, Ubuntu, Fedora, Android, iOS etc.

In other words, an operating system can be considered as a resource manager that manages all the resources of a computer like CPU, RAM, Disk, Network, and other input-output devices. Along with this, it is also responsible to control various application software and device drivers manage system security and users as well.

- **OS User Interface :** There are various user interface of operating system each of which provides a different functionality.

(I) **Command Based User Interface or Character User Interface (CUI) :** In this type of OS, the user enters a command to do a task and no graphics or images are supported. The only keyboard can be used as an input device. The user must remember the command to do the task. For example, UNIX, DOC etc.

(II) **Graphical User Interface (GUI) :** This type of OS supports a graphical interface. Users need not remember any command to perform any task. The keyboard and mouse can be used as an input device. For Example, Windows.

(III) **Touch-based user interface :** This type of OS mostly operated on mobiles, tables, or touch screen laptops. For Example iOS, Android etc.

(IV) **Voice-based user interface :** It accepts inputs by voice and performs the tasks. This type of OS can be used by only those users who cannot use the keyboard, mouse, etc. Some iOS devices supported Siri is an example of this type of OS.

(V) **Gesture-based interface :** Some operating supports gestures like waiving, tilting, eye motion, and shaking for operating mobile.

- Functions of Operating System:-The functions of the operating system are as follows:

(I) **Process Management :** process management concerns the management of multiple processes, allocation of required resources, and exchange of information among processes.

(II) **Memory Management :** memory management concerns with management of main memory so that maximum memoryis occupied or utilised by large number of processes while keeping track of each and every location within the memory as free or occupied.

(III) **File Management :** File management system manages secondary memory, while memory management system handles the main memory of a computer system.

(IV) **Device Management :** Just like files, devices also need security measures and their access to different devices must be restricted by the operating system to the authorised users, software and other hardware only. ❐❐❐

22 COMPUTER NETWORK
(NCERT CLASS 12)

INTRODUCTION

We often need peripheral devices and data to be shared among various computers. In fact, in your school'scomputer lab, you must have seen one printer which is connected to only one computer, serving to the needs of all the computers in the lab. How does this happen? This happens because all your lab's computers and peripherals are forming a network. They are interconnected with each other enabling you to send and receive data from one computer to another. Hence it can be said that two computers are interconnected if they are able to exchange information.

A network is any collection of independent computers that communicate with one another over ashared network medium. In simple terms, a computer network is a collection of two or more computers linked together for the purpose of sharing information and resources. When these computers are joined in a network, people can share files and peripherals such as modems, printers, backup drives, or CD-ROM drives. Each computer on the network is called a node and hence, a network is a series of points or nodes interconnected by communication paths (transmission media). A network can be as small and simple as two computers that share a printer or as complex as the world's largest network, the Internet. When networks at multiple locations are connected using services available from phone companies, people can send e-mail, share links to the global Internet, or conduct video conferences in real time with other remote users. As companies rely on applications like electronic mail and database management for core business operations, computer networking becomes increasingly more important.

NEED FOR NETWORKING

Why has networking evolved as an indispensible part of technology today? To find answer to thisquestion, let us have a look at the advantages of networking:

- Resource sharing - files and peripherals:-

i) Sharing of files and software

A network enables users to share data files with each other. For e.g. different departments of an organization may be seperated physically, being at distant places, but their data could be stored on a central computer which can be accessed by computers located in different departments. In this way latest data can be made available at all times to all users. Files and folders can be backed up to local or remote shares. Software can be installed centrally rather than on each machine which proves to be much cheaper than buying licenses for every machine:

ii) Sharing Peripherals

Laser printers and large storage media are quite expensive. Networks enable us to share such resources and hence reduce the operational cost of any organization. For e.g. a company with about fifty computers can share resources such as printers, scanners, hard disks etc, thereby reducing the cost considerably. Even fax systems can be integrated within a network. Audio and video content can also be streamed to multiple devices.

iii) Sharing storage

On a network, one can access data from any machine. Hence storage can be distributed and thus database load can be shared on the network. This even proves to be cost effective. A file can even have copies on two or three machines.

- **Improving communication**

A computer network can provide a powerful, fast and reliable communication medium among the users of various computers on the network. Using a network, it is easy for two or more people, of saydifferent departments or different branches to prepare a presentation together in spite of being located in different cities. In fact the best example in this context can be of the use of internet (discussed later in the chapter). With the help of internet we can communicate efficiently and easily via email, instant messaging, chat rooms, telephone, video telephone calls, and video conferencing.

- **Access to remote database:-**

This is another major use of network. It is easy for an average person to access any remote database, say for example airline reservations and thereby book tickets. Likewise databases of trains, online universities, hotels etc can be accessed as per the requirement. Remote-control/access programs can be used to troubleshoot problems or show new users how to perform a task.

Like two sides of a coin, networking also has some disadvantages associated with it. The disadvantages are as follows:

(I) Threat to data

A computer network may be used by unauthorized users to steal or corrupt the data and even to deploy computer viruses or computer worms on the network. File security has to be taken care of especially if connected to WANs.

(II) Difficult to set up

The systems on a network are more sophisticated and complex to run. Sometimes setting up a network, especially larger networks may turn out to be a difficult task. If systems are badly managed services can become unusable. In addition to this, larger networks may also be very costly to set up and maintain. Often a specialist may be needed to run and maintain the network.

EVOLUTION OF NETWORKING

Networking started way back in 1969 with the development of the first network called the ARPANET. The U.S. department of defence sponsored a project named ARPANET (Advanced Research Projects Agency Network) whose goal was to connect computers at different universities and U.S. defence. Soon engineers, scientists, students and researchers who were part of this system began exchanging data and messages on it. Gradually they could play long distance games and also socialize with people. Hence ARPANET expanded rapidly. In mid 80s, the National Science Foundation created a new high capacity network called NSFnet which allowed only academic research on its network. So many private companies built their own networks, which were later interconnected along with ARPANET and NSFnet to form Internet - a network formed by linking two or more networks.

TYPES OF NETWORKS

A network may be a small group of interlinked computers to a chain of a few hundred computers ofdifferent types (for example personal computers, minicomputers , mainframes etc.). These computers may be localised or spread around the world. Thus networks vary in terms of their size and complexity. Various types of networks are discussed below:

PAN (Personal Area Network)

A Personal Area Network is a computer network organized around an individual person. Personal area networks typically involve a mobile computer, a cell phone and/or a handheld computing device such as a PDA. You can use these networks to transfer files including email and calendar appointments, digital photos and music. Personal area networks can be constructed with cables or be wireless. USB and FireWire technologies often link together a wired PAN, while wireless PANs typically use bluetooth or sometimes infrared connections. Bluetooth PANs generally cover a range of less than 10 meters (about 30 feet). PANs can be viewed as a special type (or subset) of local area network (LAN) that supports one person instead of a group.

LAN (Local Area Network)

In a LAN, network devices are connected over a relatively short distance. They are generally privately owned networks within a single building or campus, of up to a few kilometres in size. LANs can be small, linking as few as three computers, but often link hundreds of computers used by thousands of people. This means that many users can share expensive devices, such as laser printers, as well as data on the LAN. Users can also use the LAN to communicate with each other, by sending mails or engaging in chat sessions.

Nowadays we also have WLAN (Wireless LAN) which is based on wireless network. One LAN can even be connected to other LANs over any distance via telephone lines and radio waves. However there is also a limit on the number of computers that can be attached to a single LAN. The development of standard networking protocols and media has resulted in worldwide proliferation of LANs throughout business and educational organizations.

MAN (Metropolitan Area Network)

This is basically a bigger version of LAN and normally uses similar technology. It might cover fewbuildings in a city and might either be private or public. This is a network which spans a physical area (in the range of 5 and 50 km diameter) that is larger than a LAN but smaller than a WAN. MANs are usually characterized by very high-speed connections using optical fibres or other digital media and provides uplink services to wide area networks (WANs) and the Internet. For example in a city, a MAN, which can support both data and voice might even be related to local cable television network.

The MAN, its communications links and equipment are generally owned by either a consortium of users or by a single network provider who sells the service to the users. Since MAN adopts technologies from both LAN and WAN to serve its purpose, it is also frequently used to provide a shared connection to other networks using a link to a WAN.

WAN (Wide Area Network)

As the term implies, WAN spans a large geographical area, often a country or a continent and uses various commercial and private communication lines toconnect computers. Typically, a WAN combines multiple LANs that are geographically separated. This is accomplished by connecting the different LANs using services such as dedicated leased phone lines, dial-up phone lines, satellite links, high speed fibre optic cables and data packet carrier services. Wide area networking can be as simple as a modem and remote access server for employees to dial into, or it can be as complex as hundreds of branch offices globally linked using special routing protocols and filters to minimize the expense of sending data sent over vast distances.

Let us take an example of your local telephone exchange which is a part of WAN. The computers at

each telephone exchange connect to other exchanges to allow you to talk to people all over the world. The internet is the largest WAN , spanning the entire earth.

NETWORK DEVICES

To communicate data through different transmission media and to configure networks with different functionality, we require different devices like Modem, Hub, Switch, Repeater, Router, Gateway, etc.

- **Modem** : Modem stands for 'MOdulator DEModulator'. It refers to a device used for conversion between analog signals and digital bits. We know computers store and process data in terms of 0s and 1s. However, to transmit data from a sender to a receiver, or while browsing the internet, digital data are converted to an analog signal and the medium (be it free-space or a physical media) carries the signal to the receiver. There are modems connected to both the source and destination nodes. The modem at the sender's end acts as a modulator that converts the digital data into analog signals. The modem at the receiver's end acts as a demodulator that converts the analog signals into digital data for the destination node to understand.
- **Ethernet Card :** Ethernet card, also known as Network Interface Card (NIC card in short) is a network adapter used to set up a wired network. It acts as an interface between computer and the network. It is a circuit board mounted on the motherboard of a computer. The Ethernet cable connects the computer to the network through NIC. Ethernet cards can support data transfer between 10 Mbps and 1 Gbps (1000 Mbps). Each NIC has a MAC address, which helps in uniquely identifying the computer on the network.
- **RJ45 :** RJ 45 or Registered Jack-45 is an eight-pin connector that is used exclusively with Ethernet cables for networking. It is a standard networking interface that can be seen at the end of all network cables. Basically, it is a small plastic plug that fits into RJ-45 jacks of the Ethernet cards present in various computing devices.
- **Repeater :** Data are carried in the form of signals over the cable. These signals can travel a specified distance (usually about 100 m). Signals lose their strength beyond this limit and become weak. In such conditions, original signals need to be regenerated.

A repeater is an analog device that works with signals on the cables to which it is connected. The weakened signal appearing on the cable is regenerated and put back on the cable by a repeater.

- **Hub :** An Ethernet hub is a network device used to connect different devices through wires. Data arriving on any of the lines are sent out on all the others. The limitation of Hub is that if data from two devices come at the same time, they will collide.
- **Switch :** A switch is a networking device that plays a central role in a Local Area Network (LAN). Like a hub, a network switch is used to connect multiple computers or communicating devices. When data arrives, the switch extracts the destination address from the data packet and looks it up in a table to see where to send the packet. Thus, it sends signals to only selected devices instead of sending to all. It can forward multiple packets at the same time. A switch does not forward the signals which are noisy or corrupted. It drops such signals and asks the sender to resend it.

Ethernet switches are common in homes/offices to connect multiple devices thus creating LANs or to access the Internet.

- **Router :** A router is a network device that can receive the data, analyse it and transmit it to other networks. A router connects a local area network to the internet. Compared to a hub or a switch, a router has advanced capabilities as it can analyse the data being carried over a network, decide/alter how it is packaged, and send it to another network of a different type. For example, data has been divided into packets of a certain size. Suppose these packets are to be carried over a different type of network which cannot handle bigger packets. In such a case, the data is to be repackaged as smaller packets and then sent over the network by a router.

A router can be wired or wireless. A wireless router can provide Wi-Fi access to smartphones and other devices. Usually, such routers also contain some ports to provide wired Internet access. These days, home Wi-Fi routers perform the dual task of a router and a modem/ switch. These routers connect to incoming broadband lines, from ISP (Internet Service Provider), and convert them to digital data for computing devices to process.

- **Gateway :** As the term "Gateway" suggests, it is a key access point that acts as a "gate" between an organisation's network and the outside world of the Internet. Gateway serves as the entry and exit point of a network, as all data coming in or going out of a network must first pass through the gateway in order to use routing paths. Besides routing data packets, gateways also maintain information about the host network's internal connection paths and the identified paths of other remote networks. If a node from one network wants to communicate with a node of a foreign network, it will pass the data packet to the gateway, which then routes it to the destination using the best possible route.

For simple Internet connectivity at homes, the gateway is usually the Internet Service Provider that provides access to the entire Internet. Generally, a router is configured to work as a gateway device in

computer networks. But a gateway can be implemented completely in software, hardware, or a combination of both. Because a network gateway is placed at the edge of a network, the firewall is usually integrated with it.

NETWORK TOPOLOGIES

The arrangement of computers and other peripherals in a network is called its topology. Common network topologies are Mesh, Ring, Bus, Star and Tree.

- **Mesh Topology :** In this networking topology, each communicating device is connected with every other device in the network. Such a network can handle large amounts of traffic since multiple nodes can transmit data simultaneously. Also, such networks are more reliable in the sense that even if a node gets down, it does not cause any break in the transmission of data between other nodes. This topology is also more secure as compared to other topologies because each cable between two nodes carries different data. However, wiring is complex and cabling cost is high in creating such networks and there are many redundant or unutilised connections.
- **Ring Topology :** In ring topology each node is connected to two other devices, one each on either side, as shown in Figure 10.16. The nodes connected with each other thus forms a ring. The link in a ring topology is unidirectional. Thus, data can be transmitted in one direction only (clockwise or counterclockwise).
- **Bus Topology :** In bus topology, each communicating device connects to a transmission medium, known as bus. Data sent from a node are passed on to the bus and hence are transmitted to the length of the bus in both directions. That means, data can be received by any of the nodes connected to the bus.

In this topology, a single backbone wire called bus is shared among the nodes, which makes it cheaper and easier to maintain. Both ring and bus topologies are considered to be less secure and less reliable.

- **Star Topology :** In star topology, each communicating device is connected to a central node, which is a networking device like a hub or a switch.

Star topology is considered very effective, efficient and fast as each device is directly connected with the central device. Although disturbance in one device will not affect the rest of the network, any failure in a central networking device may lead to the failure of complete network.

The central node can be either a broadcasting device means data will be transmitted to all the nodes in the network, or a unicast device means the node can identify the destination and forward data to that node only.

- **Tree or Hybrid Topology :** It is a hierarchical topology, in which there are multiple branches and each branch can have one or more basic topologies like star, ring and bus. Such topologies are usually realised in WANs where multiple LANs are connected. Those LANs may be in the form of a ring, bus or star.

In this type of network, data transmitted from source first reaches the centralised device and from there the data passes through every branch where each branch can have links for more nodes.

IDENTIFYING NODES IN A NETWORKED COMMUNICATION

Each node in a network should be uniquely identified so that a network device can identify the sender and receiver and decide a routing path to transmit data. Let us explore further and know how each node is distinguished in a network.

- **MAC Address :** MAC stands for Media Access Control. The MAC address, also known as the physical or hardware address, is a unique value associated with a network adapter called a NIC. The MAC address is engraved on NIC at the time of manufacturing and thus it is a permanent address and cannot be changed under any circumstances. The machine on which the NIC is attached, can be physically identified on the network using its MAC address.

Each MAC address is a 12-digit hexadecimal numbers (48 bits in length), of which the first six digits (24 bits) contain the manufacturer's ID called Organisational Unique Identifier (OUI) and the later six digits (24 bits) represents the serial number assigned to the card by the manufacturer.

- **IP Address :** IP address, also known as Internet Protocol address, is also a unique address that can be used to uniquely identify each node in a network. The IP addresses are assigned to each node in a network that uses the Internet Protocol for communication. Thus, if we know a computer's IP address, we can communicate with that computer from anywhere in the world. However, unlike MAC address, IP address can change if a node is removed from one network and connected to another network.

The initial IP Address called version 4 (IPV4 in short), is a 32 bit numeric address, written as four numbers separated by periods, where each number is the decimal (base-10) representation for an 8-bit binary (base-2) number and each can take any value from 0 - 255.

With more and more devices getting connected to the Internet, it was realised that the 32-bit IP address will not be sufficient as it offers just under 4.3 billion unique addresses. Thus, a 128 bits IP address, called IP version 6 (IPV6 in short) was proposed. An IPv6 address is represented by eight groups of hexadecimal (base-16) numbers separated by colons.

INTERNET, WEB AND THE INTERNET OF THINGS

The Internet is a system of linked networks that are worldwide in scope and facilitate data communicationservices such as remote login, file transfer, electronic mail, the World Wide Web and news groups. The Internet is made up of many networks each run by a different companies and are interconnected atpeering points. It is really a network of networks spread across the globe, all of which are connected to each other.This super network is a glorified WAN in many respects. It connects many smaller networks together and allows all the computers to exchange information with each other through a common set of rules for communication. These rules are called protocols and the internet uses Transmission Control Protocol/Internet Protocol (TCP/IP). Programs such as web browsers, File Transfer Protocol (FTP) clients, and email clients are some of the most common ways through which the users work on the Internet.

With the meteoric rise in demand for connectivity, the Internet has become a communications highway for millions of users. The Internet was initially restricted to military and academic institutions, but now it is a full-fledged conduit for any and all forms of information and commerce. Internet websites now provide personal, educational, political and economic resources to every corner of the planet.

- **The World Wide Web (WWW) :** The World Wide Web (WWW) or web in short, is an ocean of information, stored in the form of trillions of interlinked web pages and web resources. The resources on the web can be shared or accessed through the Internet.

Sir Tim Berners-Lee — a British computer scientist invented the revolutionary World Wide Web in 1990 by defining three fundamental technologies that lead to creation of web:

(I) **HTML** – HyperText Markup Language. It is a language which is used to design standardised Web Pages so that the Web contents can be read and understood from any computer. Basic structure of every webpage is designed using HTML.

(II) **URI** – Uniform Resource Identifier. It is a unique address or path for each resource located on the web. It is also known as Uniform Resource Locator (URL). Every page on the web has a unique URL. Examples are: https://www.mhrd.gov.in,http://www.ncert.nic.in,http://www.airindia.in, etc. URL is sometimes also called web address. However, a URL is not only the domain name. It contains other information that completes a web address.

(III) **HTTP** – The HyperText Transfer Protocol is a set of rules which is used to retrieve linked web pages across the web. The more secure and advanced version is HTTPS.

Many people confuse the web with the Internet. The Internet as we know is the huge global network of interconnected computers, which may or may not have any file or webpage to share with the world. The web on the other hand is the interlinking of collection of Webpages on these computers which are accessible over the Internet.

DOMAIN NAME SYSTEM

(I) DNS stands for Domain Name System.

(II) DNS is a directory service that provides a mapping between the name of a host on the network and its numerical address.

(III) DNS is required for the functioning of the internet.

(IV) Each node in a tree has a domain name, and a full domain name is a sequence of symbols specified by dots.

(V) DNS is a service that translates the domain name into IP addresses. This allows the users of networks to utilize user-friendly names when looking for other hosts instead of remembering the IP addresses.

(VI) For example, suppose the FTP site at EduSoft had an IP address of 132.147.165.50, most people would reach this site by specifying ftp.ABCSoft.com. Therefore, the domain name is more reliable than IP address.

- **DNS Server :** Instead of remembering IP addresses, we assign a domain name to each IP. But, to access a web resource, a browser needs to find out the IP address corresponding to the domain name entered. Conversion of the domain name of each web server to its corresponding IP address is called domain name resolution. It is done through a server called DNS server. Thus, when we enter a URL on a web browser, the HTTP protocol approaches a computer server called DNS server to obtain the IP address corresponding to that domain name. After getting the IP address, the HTTP protocol retrieves the information and loads it in our browser.

A DNS server maintains a database of domain names and their corresponding IP addresses. To understand how the domain name resolution works, we have to understand how and where the DNS servers are kept. The DNS servers are placed in hierarchical order. At the top level, there are 13 servers called root servers. Then below the root servers there are other DNS servers at different levels. A DNS server may contain the IP address corresponding to a domain or it will contain the IP address of other DNS servers, where this domain entry can be searched.

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23 DATA COMMUNICATION (NCERT CLASS 12)

CONCEPT OF COMMUNICATION

The term "Data Communication" comprises two words: Data and Communication. Data can be any text, image, audio, video, and multimedia files. Communication is an act of sending or receiving data. Thus, data communication refers to the exchange of data between two or more networked or connected devices. These devices must be capable of sending and receiving data over a communication medium. Examples of such devices include personal computers, mobile phones, laptops, etc.

COMPONENTS OF DATA COMMUNICATION

The communication media is also called transmission media.

(I) **Sender :** A sender is a computer or any such device which is capable of sending data over a network. It can be a computer, mobile phone, smartwatch, walkie-talkie, video recording device, etc.

(II) **Receiver :** A receiver is a computer or any such device which is capable of receiving data from the network. It can be any computer, printer, laptop, mobile phone, television, etc. In computer communication, the sender and receiver are known as nodes in a network.

(III) **Message :** It is the data or information that needs to be exchanged between the sender and the receiver. Messages can be in the form of text, number, image, audio, video, multimedia, etc.

(IV) **Communication media :** It is the path through which the message travels between source and destination. It is also called medium or link which is either wired or wireless. For example, a television cable, telephone cable, ethernet cable, satellite link, microwaves, etc.

(V) **Protocols :** It is a set of rules that need to be followed by the communicating parties in order to have successful and reliable data communication. You have already come across protocols such as Ethernet and HTTP.

MEASURING CAPACITY OFCOMMUNICATION MEDIA

In data communication, the transmission medium is also known as channel. The capacity of a channel is the maximum amount of signals or traffic that a channel can carry. It is measured in terms of bandwidth and data transfer rate as described below:

(I) **Bandwidth :** Bandwidth of a channel is the range of frequencies available for transmission of data through that channel. Higher the bandwidth, higher the data transfer rate. Normally, bandwidth is the difference of maximum and minimum frequency contained in the composite signals. Bandwidth is measured in Hertz (Hz).

$$1\ KHz = 1000\ Hz$$

$$1\ MHz = 1000\ KHz = 1000000\ Hz$$

(II) **Data Transfer Rate :** Data travels in the form of signals over a channel. One signal carries one or more bits over the channel. Data transfer rate is the number of bits transmitted between source and destination in one second. It is also known as bit rate. It is measured in terms of bits per second (bps). The higher units for data transfer rates are:

$$1\ Kbps = 210\ bps = 1024\ bps$$

$$1\ Mbps = 220\ bps = 1024\ Kbps$$

$$1\ Gbps = 230\ bps = 1024\ Mbps$$

$$1\ Tbps = 240\ bps = 1024\ Gbps$$

TYPES OF DATA COMMUNICATION

Data communication happens in the form of signals between two or more computing devices or nodes. The transfer of data happens over a point-to-pointor multipoint communication channel. Data communication between different devices are broadly categorised into 3 types: Simplex communication, Half-duplex communication, and Full-duplex communication.

(I) **SIMPLEX COMMUNICATION :**It is a one way or unidirectional communication between two devices in which one device is sender and other one is receiver. For example, data entered through a keyboard or audio sent to a speaker are one way communications.With the advent of IoT, controlling home appliances is another example of simplex communication.

(II) **Half-duplex Communication :** It is two way or bidirectional communication between two devices in which both the devices can send and receive data or control signals in both directions, but not at the same time.While one device is sending data, the other one will receive and vice-versa.

Basically, it is a simplex channel where the direction of transmission can be switched. Application of such type of communication can be found in walkie-talkie where one can press the push-to-talk button and talk. This enables the transmitter and turns off the receiver in that device and others can only listen.

(III) **Full-duplex Communication :** It is two way or bidirectional communication in which both devices can send and receive data simultaneously.

This type of communication channel is employed to allow simultaneous communication, for example, in our mobile phones and landline telephones. The capacity of the transmission link is shared between the signals going in both directions. This can be done either by using two physically separate simplex lines — one for sending and other for receiving, or the capacity of the single channel is shared between the signals travelling in different directions.

SWITCHING TECHNIQUE

Switching techniques are used to efficiently transmit data across the network. The two types of switchingtechniques are employed nowadays to providecommunication between two computers on a network are:Circuit Switching and Packet Switching.

(I) **Circuit Switching :** Circuit switching is a technique in which a dedicated and complete physical connection is establishedbetween two nodes and through this dedicated communication channel, the nodes may communicate. The circuit guarantees the full bandwidth of the channel and remains connected for the duration of the communication session. Even if no communication is taking place in a dedicated circuit, that channel still remains unavailable to other users (idle channels).

The defining example of a circuit-switched network is the early analogue telephone network. When a call is made from one telephone to another, switches within the telephone exchange create a continuous wire circuit between the two telephones, for as long as the call lasts.

(II) **Packet Switching :** Packet switching is a switching technique in which packets (discrete blocks of data of fixed size and of anycontent, type or structure) are routed between nodes over data links shared with other traffic. The term "packets" refers to the fact that the data stream from your computer is broken up into packets of about 200 bytes (on average), which are then sent out onto the network. Each packet contains a "header" with information necessary for routing the packet from source to destination. Each packet in a data stream is independent.

The main advantage of packet-switching is that the packets from many different sources can share a line, allowing for very efficient use of the communication medium. With current technology, packets are generally accepted onto the network on a first-come, first-served basis.

If the network becomes overloaded, packets are delayed or discarded ("dropped"). This method of data transmission became the fundamental networking technology behind the internet and most Local Area Networks.

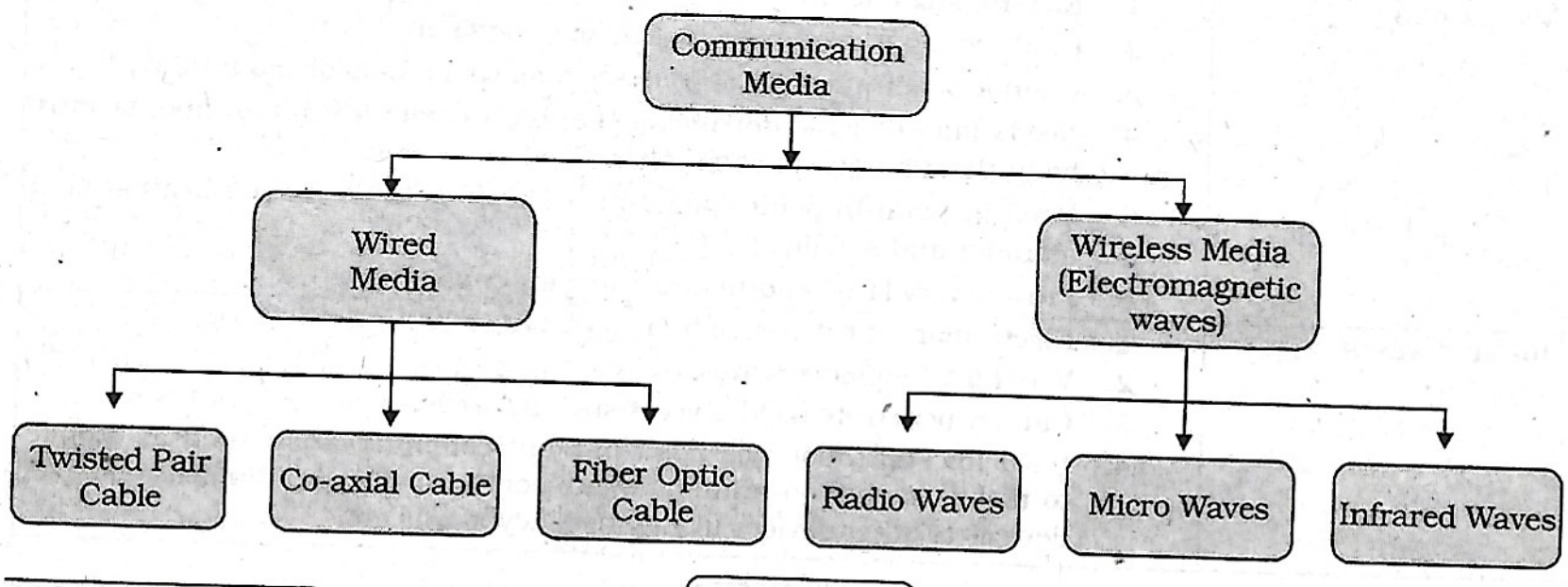
TRANSMISSION MEDIA :

A transmission medium can be anything that can carry signals or data between the source (transmitter) and destination (receiver). For example, as we switch on a ceiling fan or a light bulb, the electric wire is the medium that carries electric current from switch to the fan or bulb.

In data communication, transmission media are the links that carry messages between two or more communicating devices. Transmission can be classified as guided or unguided.

In guided transmission, there is a physical link made of wire/cable through which data in terms of signals are propagated between the nodes. These are usually metallic cable, fiber-optic cable, etc. They are also known as wired media.

In unguided transmission, data travels in air in terms of electromagnetic waves using an antenna. They are also known as wireless media.



Dish-shaped antennas are used for sending and receiving data at longer distances. These antennas are mounted on taller buildings so that it would be in line-of-sight. Waves gradually become weaker and weaker after travelling a certain distance through the air. Therefore repeaters are installed to regenerate the signals of the same energy.

- **Wired Transmission Media :** Any physical link that can carry data in the form of signals belongs to the category of wired transmission media. Three commonly used guided/wired media for data transmission are, twisted pair, coaxial cable, and fiber optic cable. Twisted-pair and coaxial cable carry the electric signals whereas the optical fiber cable carries the light signals.
- **Twisted Pair Cable :** A twisted-pair consists of two copper wires twisted like a DNA helical structure. Both the copper wires are insulated with plastic covers. Usually, a number of such pairs are combined together and covered with a protective outer wrapping.

Each of the twisted pairs act as a single communication link. The use of twisted configuration minimises the effect of electrical interference from similar pairs close by. Twisted pairs are less expensive and most commonly used in telephone lines and LANs. These cables are of two types: Unshielded twisted-pair (UTP) and Shielded twisted-pair (STP).

- **Coaxial cable :** Coxial cable is another type of data transmission medium. It is better shielded and has more bandwidth than a twisted pair. It has a copper wire at the core of the cable which is surrounded with insulating material. The insulator is further surrounded with an outer conductor (usually a copper mesh). This outer conductor is wrapped in a plastic cover. The key to success of coaxial cable is its shielded design that allows the cable's copper core to transmit data quickly, without interference of environmental factors. These types of cables are used to carry signals of higher frequencies to a longer distance.
- **Optical Fibre :** The optical fiber cable carries data as light, which travels inside a thin fiber of glass. Optic fiber uses refraction to direct the light through the media. A thin transparent strand of glass at the centre is covered with a layer of less dense glass called cladding. This whole arrangement is covered with an outer jacket made of PVC or Teflon. Such types of cables are usually used in backbone networks. These cables are of light weight and have higher bandwidth which means higher data transfer rate. Signals can travel longer distances and electromagnetic noise cannot affect the cable. However, optic fibers are expensive and unidirectional. Two cables are required for full duplex communication.
- **Wireless Transmission Media :** In wireless communication technology, information In wireless communication technology, information travels in the form of electromagnetic signals through air. Electromagnetic spectrum of frequency ranging from 3 KHz to 900 THz is available for wireless communication.

Classification of transmission waves and their properties :-

Transmission Waves	Properties
Radio Waves	1. Waves of frequency range 3 KHz - 1 GHz 2. Omni-directional, these waves can move in all directions 3. Radio waves of frequency 300KHz-30MHz can travel long distance 4. Susceptible to interference 5. Radio waves of frequency 3-300KHz can penetrate walls 6. These waves are used in AM and FM radio, television, cordless phones.
Microwaves	1. Electromagnetic waves of frequency range 1GHz - 300GHz. 2. Unidirectional, can move in only one direction. 3. Cannot penetrate solid objects such as walls, hills or mountains. 4. Needs line-of-sight propagation i.e. both communicating antenna must be in the direction of each other. 5. Used in point-to-point communication or unicast communication such as radar and satellite. 6. Provide very large information-carrying capacity.
Infrared waves	1. Electromagnetic waves of frequency range 300GHz - 400THz. 2. Very high frequency waves. 3. Cannot penetrate solid objects such as walls. 4. Used for short-distance point-to-point communication such as mobile-to-mobile, mobile-to-printer, remote-control-to-TV, and Bluetooth-enabled devices to other devices like mouse, keyboards etc.

Wireless technologies allow communication between two or more devices in short to long distance without requiring any physical media. There are many types of wireless communication technologies such as Bluetooth, WiFi, WiMax etc.

The electromagnetic spectrum range (3KHz to 900THz) can be divided into 4 categories - Radio waves, Microwaves, Infrared waves and Visible or Light waves, according to their frequency ranges.

- **Wireless Technologies :**

(I) **Bluetooth :** Bluetooth is a short-range wireless technology that can be used to connect mobile-phones, mouse, headphones, keyboards, computers, etc. wirelessly over a short distance. One can print documents with bluetoothenabled printers without a physical connection. All these bluetooth-enabled devices have a low cost transceiver chip. This chip uses the unlicensed frequency band of 2.4 GHz to transmit and receive data. These devices can send data within a range of 10 meters with a speed of 1 - 2 Mbps.

In Bluetooth technology, the communicating devices within a range of 10 meters build a personal area network called piconet. The devices in a piconet work in a master-slave configuration. A master device can communicate with up to 7 active slave devices at the same time.

Bluetooth technology allows up to 255 devices to build a network. Out of them, 8 devices can communicate at the same time and remaining devices can be inactive, waiting for a response command from the master device.

(II) Wireless LAN:- This is another way of wireless communication. Wireless LAN is a local area network (LAN), and it is a popular way to connect to the Internet. The international organisation IEEE assigns numbers to each different standards of LAN. The wireless LAN is number as 802.11, and it is popularly known as Wi-Fi.

These networks consist of communicating devices such as laptops and mobile phones, as well as the network device called APs (access points) which is installed in buildings or floors.

An access point is a device that is used to create a wireless local area network, by connecting to a wired router, switch, or hub. The APs are connected to a wired network, and all the devices communicate or access the Internet through an access point.

Wi-Fi gives users the flexibility to move around within the network area while being connected to the network. Following are some of the benefits of WLAN:

(i) Wireless connections can be used to extend or replace an existing wired infrastructure.

(ii) Resulted in increased access for mobile devices.

(iii) Provides easy access to the Internet in public places.

MOBILE TELECOMMUNICATION TECHNOLOGIES

Today the mobile phone network is the most used network in the world. The ability to be connected to the network on-the-go makes it very convenient to communicate with people via call or instant messages. It is also handy to access the Internet using the mobile phone network through wireless connection. Besides, the Internet of Things (IoT) is letting us control and communicate with other smart devices as well.

The architecture of the mobile network has rapidly evolved over the last few decades. The different landmark achievements in mobile communication technologies are classified as different generations. They are identified as 1G, 2G, 3G, 4G, and 5G.

The first generation (1G) mobile network system came around 1982. It was used to transmit only voice calls. The analog signals were used to carry voices between the caller and receiver.

The second generation (2G) mobile network system came around 1991. Instead of analog signals, voice calls were transmitted in digital form thus providing improved call quality. This increased capacity allowed more people to talk simultaneously, and led to improved security as the signals could be encrypted. It also enabled an additional service to send SMS and MMS (Multimedia messages).

The third generation (3G) mobile network technology was developed during late 90s, but it was introduced commercially around 2001. It offered both digital voice and data services. 3G provided Internet access via the same radio towers that provide voice service to the mobile phone. It facilitated greater voice and data capacity. Therefore, more simultaneous calls could happen in the same frequency range and also a significantly faster data transfer speed.

Demand for faster data is always increasing and thus 4G mobile networks were developed and now 5G networks have also come into being. 4G is much faster than 3G and this has revolutionised the field of telecommunication by bringing the wireless experience to a new level altogether. 4G systems support interactive multimedia, voice, video, wireless internet and other broadband services. Technologically, 4G is very different compared to 3G.

The fifth generation or 5G is currently under development. It is expected to be a milestone development for the success of IoT and Machine to Machine (M2M) communications. Machine to machine (M2M) is direct communication between devices — wired and wireless. 5G is expected to allow data transfer in Gbps, which is much faster than 4G. It is expected to be able to support all the devices of the future such as connected vehicles and the Internet of Things.

PROTOCOL

In communication, Protocol is a set of standard rules that the communicating parties — the sender, the receiver, and all other intermediate devices need to follow. We know that the sender and receiver can be

parts of different networks, placed at different geographic locations. Besides, the data transfer rates in different networks can vary, requiring data to be sent in different formats.

- **Need for Protocols :** We need protocols for different reasons such as flow control, access control, addressing, etc. Flow control is required when the sender and receiver have different speeds of sending and receiving the data.

Access control is required to decide which nodes in a communication channel will access the link shared among them at a particular instant of time. Otherwise, the transmitted data packets will collide if computers are sending data simultaneously through the same link resulting in the loss or corruption of data.

Protocols also define :

(I) how computers identify one another on a network.

(II) the form to which the data should be converted for transit.

(III) how to decide whether the data received is for that node or to be forwarded to another node.

(IV) ensuring that all the data have reached the destination without any loss.

(V) how to rearrange the packets and process them at the destination.

- **HyperText Transfer Protocol (HTTP) :** HTTP stands for HyperText Transfer Protocol. It is the primary protocol used to access the World Wide Web. Tim Berners-Lee led the development of HTTP at CERN in 1989 in collaboration with Internet Engineering Task Force (IETF) and the World Wide Web Consortium (W3C).

HTTP is a request-response (also called client-server) protocol that runs over TCP. The common use of HTTP is between a web browser (client) and a web server (server). HTTP facilitates access of hypertext from the World Wide Web by defining how information are formatted and transmitted, and how the Web servers and browsers should respond to various commands.

A web page is written using a markup language like HTML and is stored on a web server for access via its URL. Once a user opens a web browser and types in the URL of the intended web page, a logical communication link between the user machine (client) and the web server is created using HTTP.

- **File Transfer Protocol (FTP) :** File Transfer Protocol (FTP) is the protocol used for transferring files from one machine to another. Like HTTP, FTP also works on a client-server model.

File transfer between two systems seems simple and straightforward because FTP takes care of issues between two communicating devices, such as:

(i) use of different conventions while naming files.

(ii) representation of text and data in different formats.

(iii) having different directory structure

- **Point to Point Protocol (PPP) :** PPP is a communication protocol which establishes a dedicated and direct connection between two communicating devices. This protocol defines how two devices will authenticate each other and establish a direct link between them to exchange data. For example, two routers with direct connection communicate using PPP. The Internet users who connect their home computers to the server of an Internet Service Provider (ISP) through a modem also use PPP.

The communicating devices should have duplex modes for using this protocol. This protocol maintains data integrity ensuring that the packets arrive in order. It intimates the sender about damage or lost packets and asks to resend it.

- **Simple Mail Transfer Protocol (SMTP) :** SMTP is a protocol used for email services. It uses information written on the message header (like an envelope on a letter sent by post), and is not concerned with the content of the email message. Each email header contains email addresses of recipients. The email containing header and body are entered into a queue of outgoing mails.

The SMTP sender program takes mails from the outgoing queue and transmits them to the destination(s). When the SMTP sender successfully delivers a particular mail to one or more destinations, it removes the corresponding receiver's email address from the mail's destination list. When that mail is delivered to all the recipients, it is removed from the outgoing queue. The SMTP receiver program accepts each mail that has arrived and places it in the appropriate user mailbox.

- **Transmission Control Protocol (TCP)/ Internet Protocol (IP) :**

TCP/IP stands for Transmission Control Protocol/ Internet Protocol. It is a set of standardised rules that uses a client-server model of communication in which a user or machine (a client) requests a service by a server in the network.

The IP protocol ensures that each computer or node connected to the Internet is assigned an IP address, which is used to identify each node independently. It can be considered to be the adhesive that holds the whole Internet together.

TCP ensures that the message or data is broken into smaller chunks, called IP packets. Each of these packets are routed (transmitted) through the Internet, along a path from one router to the next, until it reaches the specified destination. TCP guarantees the delivery of packets on the designated IP address.It is also responsible for ordering the packets so that they are delivered in sequence.

There are many redundant connection paths in the Internet, with backbones and ISPs connecting to each other in multiple locations. So, there are manypossible paths between two hosts. Hence, two packets of the same message can take two different routes depending on congestion and other factors in different possible routes. When all the packets finally reach the destination machine, they are reassembled into the original message at the receiver's end. □□□

25 PROJECT BASED LEARNING (NCERT CLASS 12)

INTRODUCTION

Through project based learning, students learn to organise their project and use their time effectively for successful completion of the project.

APPROACHES FOR SOLVING PROJECTS

The approach followed for the development and completion of a project plays a pivotal role in project based learning. There are several approaches to execute a project such as modular approach, top down approach and bottom up approach. A structured or a modular approach to a project means that a project is divided into various manageable modules and each of the modules has a well-defined task to be performed with a set of inputs. This would lead to a set of outputs which when integrated leads to the desired outcome.

Different steps involved in project based learning are :

(I) **Identification of a project :** The project idea may come through any real-life situation. For example, one could think of doing a project for organising a seminar. One needs to understand the usefulness of the project and its impact. Students must be encouraged to undertake interdisciplinary projects.

(II) **Defining a plan :** Normally for any kind of project, there are several project members involved in it. One project leader has to be identified. The roles of project leader and each project member have to be clearly defined. Students who are performing a project must be assigned with specific activities. The various tools for executing these activities must be known. To obtain a better solution, one should always think of the extreme situations.

(III) **Fixing of a time frame and processing :** Every project is a time relevance project. A student must understand the importance of time frame for completion of the project. All the activities which are performed in the projects require a certain amount of time. Every project must be well structured and at the same time it must be flexible in its time frame.

(IV) **Providing guidance and monitoring a project :** Many times, the participants in the project get stuck up with a particular process and it becomes impossible to proceed further. In such a case, they need guidance, which can be obtained from various resources such as books, websites and experts in the field. While it is essential that the project leader should ensure monitoring of the project, the guide teacher also helps in monitoring the project.

(V) **Outcome of a project :** One needs to understand thoroughly the outcome of a project. The outcome can be single, or it can be multiple. The output of a project can be peer reviewed and can be modified as per the feedback from the guide teacher or other users.

TEAMWORK

Many real-life tasks are very complex and require a lot of individuals to contribute in achieving them. Efforts made by individuals collectively to accomplish a task is called teamwork.

Following are the components of teamwork :

(I) **Communicate with Others :** When a group of individuals perform one job, it is necessary to have effective communication between the members of the team. Such communication can be done via e-mails, telephones or by arranging group meetings. This helps the team members to understand each other and sort out their problems to achieve the goal effectively.

(II) **Listen to Others :** It is necessary to understand the ideas of others while executing a job together. This can be achieved when the team members listen to each other in group meetings and follow steps that are agreed upon.

(III) **Share with Others :** Ideas, images and tools need to be shared with each other in order to perform a job. Sharing is an important component of teamwork. Any member of the team who is well versed in a certain area should share the expertise and experience with others to effectively achieve the goal within the time frame.

(IV) **Respect for Others :** Every member of the team must be treated respectfully. All the thoughts and ideas that are put forth in the group meetings may be respected and duly considered. Not respecting the views of a particular member may cause problems and that particular team member may not give his best.

(V) **Help Others :** A helping hand from every member is a key to success. Sometimes help from people who are not a part of the team is also obtained in order to accomplish a job.

(VI) **Participate :** All the team members must be encouraged by each other to participate in completing the project and also in discussions in group meetings. Also, every member should take an active participation so that they feel their importance in the team.

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