**Network:** To interconnect more than one point/nodes each other.

**Computer Network:** To interconnect more than one computer/nodes each other.

Why do we use Network?

We use network for data communication and sharing resources and information.

**Data Communication:** To send data and information from one place to another place/point.

**Types of Transmission Media:** In data communication terminology, a transmission medium is a physical path between the transmitter and the receiver i.e it is the channel through which data is sent from one place to another. Transmission Media is broadly classified into the following types:

1. **Guided Media:** It is also referred to as Wired or Bounded transmission media. Signals being transmitted are directed and confined in a narrow pathway by using physical links. Features:

● High Speed

● Secure

● Used for comparatively shorter distances

There are 3 major types of Guided Media:

(i) **Twisted Pair Cable** – It consists of 2 separately insulated conductor wires wound about each other. Generally, several such pairs are bundled together in a protective sheath. They are the most widely used Transmission Media. Twisted Pair is of two types:

1. **Unshielded Twisted Pair (UTP):** This type of cable has the ability to block interference and does not depend on a physical shield for this purpose. It is used for telephonic applications.

**Advantages:**

○ Least expensive

○ Easy to install

○ High-speed capacity

○ Susceptible to external interference

○ Lower capacity and performance in comparison to STP

○ Short distance transmission due to attenuation

2. **Shielded Twisted Pair (STP):** This type of cable consists of a special jacket to block external interference. It is used in fast-data-rate Ethernet and in voice and data channels of telephone lines.

**Advantages:**

○ Better performance at a higher data rate in comparison to UTP

○ Eliminates crosstalk

○ Comparatively faster

○ Comparatively difficult to install and manufacture

**(ii) Coaxial Cable** – It has an outer plastic covering containing 2 parallel conductors each having a separate insulated protection cover. The coaxial cable transmits information in two modes: Baseband mode(dedicated cable bandwidth) and Broadband mode(cable bandwidth is split into separate ranges). Cable TVs and analog television networks widely use Coaxial cables.

**Advantages:**

● High Bandwidth

● Better noise Immunity

● Easy to install and expand

● Inexpensive

**(iii) Optical Fibre Cable** – It uses the concept of reflection of light through a core made up of glass or plastic. The core is surrounded by a less dense glass or plastic covering called the cladding. It is used for the transmission of large volumes of data. The cable can be unidirectional or bidirectional. The WDM (Wavelength Division Multiplexer) supports two modes, namely unidirectional and bidirectional mode.

**Advantages:**

● Increased capacity and bandwidth

● Lightweight

● Less signal attenuation

● Immunity to electromagnetic interference

● Resistance to corrosive materials

2**. Unguided Media:** It is also referred to as Wireless or Unbounded transmission media.No physical medium is required for the transmission of electromagnetic signals.

**Features:**

● The signal is broadcasted through air

● Less Secure

● Used for larger distances

There are 3 types of Signals transmitted through unguided media:

1. **Radiowaves** – These are easy to generate and can penetrate through buildings. The sending and receiving antennas need not be aligned. Frequency Range:3KHz – 1GHz. AM and FM radios and cordless phones use Radiowaves for transmission. Further Categorized as (i) Terrestrial and (ii) Satellite.
2. **Microwaves** – It is a line of sight transmission i.e. the sending and receiving antennas need to be properly aligned with each other. The distance covered by the signal is directly proportional to the height of the antenna. Frequency Range:1GHz – 300GHz. These are majorly used for mobile phone communication and television distribution.
3. **Infrared** – Infrared waves are used for very short distance communication. They cannot penetrate through obstacles. This prevents interference between systems. Frequency Range:300GHz – 400THz. It is used in TV remotes, wireless mouse, keyboard, printer, etc.

**Types of Transmission:** Transmission mode means transferring of data between two devices. It is also known as communication mode. Buses and networks are designed to allow communication to occur between individual devices that are interconnected. There are three types of transmission mode:-

1. **Simplex Mode** – In Simplex mode, the communication is unidirectional, as on a one-way street. Only one of the two devices on a link can transmit, the other can only receive. The simplex mode can use the entire capacity of the channel to send data in one direction. Example: Keyboard and traditional monitors. The keyboard can only introduce input, the monitor can only give the output.
2. **Half-Duplex Mode:** In half-duplex mode, each station can both transmit and receive, but not at the same time. When one device is sending, the other can only receive, and vice versa. The half-duplex mode is used in cases where there is no need for communication in both direction at the same time. The entire capacity of the channel can be utilized for each direction. Example: Walkie- talkie in which message is sent one at a time and messages are sent in both the directions.
3. **Full-Duplex Mode** – In full-duplex mode, both stations can transmit and receive simultaneously. In full\_duplex mode, signals going in one direction share the capacity of the link with signals going in other direction, this sharing can occur in two ways:

● Either the link must contain two physically separate transmission paths, one for sending and other for receiving.

● Or the capacity is divided between signals travelling in both directions.

Full-duplex mode is used when communication in both direction is required all the time. The capacity of the channel, however must be divided between the two directions.

Example: Telephone Network in which there is communication between two persons by a telephone line, through which both can talk and listen at the same time.

**OSI Ref Model:** OSI stands for Open Systems Interconnection. It has been developed by ISO – ‘International Organization of Standardization‘, in the year 1984. It is a 7 layer architecture with each layer having specific functionality to perform. All these 7 layers work collaboratively to transmit the data from one person to another across the globe.

1. **Physical Layer (Layer 1) :** The lowest layer of the OSI reference model is the physical layer. It is responsible for the actual physical connection between the devices. The physical layer contains information in the form of bits. It is responsible for transmitting individual bits from one node to the next. When receiving data, this layer will get the signal received and convert it into 0s and 1s and send them to the Data Link layer, which will put the frame back together.
2. **Data Link Layer (DLL) (Layer 2) :** The data link layer is responsible for the node to node delivery of the message. The main function of this layer is to make sure data transfer is error-free from one node to another, over the physical layer. When a packet arrives in a network, it is the responsibility of DLL to transmit it to the Host using its MAC address. 3. **Network Layer (Layer 3) :** Network layer works for the transmission of data from one host to the other located in different networks. It also takes care of packet routing i.e. selection of the shortest path to transmit the packet, from the number of routes available. The sender & receiver’s IP address are placed in the header by the network layer. The functions of the Network layer are :

1. **Routing:** The network layer protocols determine which route is suitable from source to destination. This function of network layer is known as routing.

2. **Logical Addressing:** In order to identify each device on internetwork uniquely, network layer defines an addressing scheme. The sender & receiver’s IP address are placed in the header by network layer. Such an address distinguishes each device uniquely and universally.

4. **Transport Layer (Layer 4) :** Transport layer provides services to application layer and takes services from network layer. The data in the transport layer is referred to as Segments. It is responsible for the End to End Delivery of the complete message. The transport layer also provides the acknowledgement of the successful data transmission and re-transmits the data if an error is found.

5. **Session Layer (Layer 5) :** This layer is responsible for establishment of connection, maintenance of sessions, authentication and also ensures security. The functions of the session layer are :

1. Session establishment, maintenance and termination: The layer allows the two processes to establish, use and terminate a connection.

2. **Synchronization :** This layer allows a process to add checkpoints which are considered as synchronization points into the data. These synchronization point help to identify the error so that the data is re-synchronized properly, and ends of the messages are not cut prematurely and data loss is avoided.

6. **Presentation Layer (Layer 6) :** Presentation layer is also called the Translation layer.The data from the application layer is extracted here and manipulated as per the required format to transmit over the network. The functions of the presentation layer are :

1. **Translation :** For example, ASCII to EBCDIC.

2. **Encryption/ Decryption :** Data encryption translates the data into another form or code. The encrypted data is known as the cipher text and the decrypted data is known as plain text. A key value is used for encrypting as well as decrypting data.

3. **Compression:** Reduces the number of bits that need to be transmitted on the network.

7. **Application Layer (Layer 7):** At the very top of the OSI Reference Model stack of layers, we find Application layer which is implemented by the network applications. These applications produce the data, which has to be transferred over the network. This layer also serves as a window for the application services to access the network and for displaying the received information to the user. Ex: Application – Browsers, Skype Messenger etc.

**TCP/IP Model:**

The OSI Model we just looked at is just a reference/logical model. It was designed to describe the functions of the communication system by dividing the communication procedure into smaller and simpler components. But when we talk about the TCP/IP model, it was designed and developed by Department of Defense (DoD) in 1960s and is based on standard protocols. It stands for Transmission Control Protocol/Internet Protocol. The TCP/IP model is a concise version of the OSI model. It contains four layers, unlike seven layers in the OSI model. The layers are:

1. Process/Application Layer

2. Host-to-Host/Transport Layer

3. Internet Layer

4. Network Access/Link Layer

1. **Network Access Layer** – This layer corresponds to the combination of Data Link Layer and Physical Layer of the OSI model. It looks out for hardware addressing and the protocols present in this layer allows for the physical transmission of data. We just talked about ARP being a protocol of Internet layer, but there is a conflict about declaring it as a protocol of Internet Layer or Network access layer. It is described as residing in layer 3, being encapsulated by layer 2 protocols.
2. **Internet Layer** – This layer parallels the functions of OSI’s Network layer. It defines the protocols which are responsible for logical transmission of data over the entire network. The main protocols residing at this layer are :

1. **IP** – stands for Internet Protocol and it is responsible for delivering packets from the source host to the destination host by looking at the IP addresses in the packet headers. IP has 2 versions: IPv4 and IPv6. IPv4 is the one that most of the websites are using currently. But IPv6 is growing as the number of IPv4 addresses are limited in number when compared to the number of users.

2. **ICMP** – stands for Internet Control Message Protocol. It is encapsulated within IP datagrams and is responsible for providing hosts with information about network problems. 3. ARP – stands for Address Resolution Protocol. Its job is to find the hardware address of a host from a known IP address. ARP has several types: Reverse ARP, Proxy ARP, Gratuitous ARP and Inverse ARP.

3**. Host-to-Host Layer** – This layer is analogous to the transport layer of the OSI model. It is responsible for end-to-end communication and error-free delivery of data. It shields the upper-layer applications from the complexities of data. The two main protocols present in this layer are :

1. **Transmission Control Protocol (TCP**) – It is known to provide reliable and error-free communication between end systems. It performs sequencing and segmentation of data. It also has acknowledgment feature and controls the flow of the data through flow control mechanism. It is a very effective protocol but has a lot of overhead due to such features. Increased overhead leads to increased cost.

2. **User Datagram Protocol (UDP)** – On the other hand does not provide any such features. It is the go-to protocol if your application does not require reliable transport as it is very cost-effective. Unlike TCP, which is connection-oriented protocol, UDP is connectionless.

4. **Application Layer** – This layer performs the functions of top three layers of the OSI model: Application, Presentation and Session Layer. It is responsible for node-to-node communication and controls user-interface specifications. Some of the protocols present in this layer are: HTTP, HTTPS, FTP, TFTP, Telnet, SSH, SMTP, SNMP, NTP, DNS, DHCP, NFS, X Window, LPD.

**ARP:** ARP stands for Address Resolution Protocol. It is used to convert an IP address to its corresponding physical address(i.e., MAC Address). ARP is used by the Data Link Layer to identify the MAC address of the Receiver’s machine.

**RARP:** RARP stands for Reverse Address Resolution Protocol. As the name suggests, it provides the IP address of the device given a physical address as input. But RARP has become obsolete since the time DHCP has come into the picture.

**TCP/IP Model**

● The TCP/IP model was developed prior to the OSI model.

● The TCP/IP model is not exactly similar to the OSI model.

● The TCP/IP model consists of five layers: the application layer, transport layer, network layer, data link layer and physical layer.

● The first four layers provide physical standards, network interface, internetworking, and transport functions that correspond to the first four layers of the OSI model and these four layers are represented in TCP/IP model by a single layer called the application layer.

● TCP/IP is a hierarchical protocol made up of interactive modules, and each of them provides specific functionality

**Connectivity devices:**

**Hub:** Hubs connect multiple computer networking devices together. A hub also acts as a repeater in that it amplifies signals that deteriorate after traveling long distances over connecting cables. A hub is the simplest in the family of network connecting devices because it connects LAN components with identical protocols.

**Switch:** Switches generally have a more intelligent role than hubs. A switch is a multiport device that improves network efficiency. The switch maintains limited routing information about nodes in the internal network, and it allows connections to systems like hubs or routers. Strands of LANs are usually connected using switches. Generally, switches can read the hardware addresses of incoming packets to transmit them to the appropriate destination.

**Router:**  A router is a device like a switch that routes data packets based on their IP addresses. The router is mainly a Network Layer device. Routers normally connect LANs and WANs together and have a dynamically updating routing table based on which they make decisions on routing the data packets. Router divide broadcast domains of hosts connected through it.

**Bridge:** A bridge operates at the data link layer. A bridge is a repeater, with add on the functionality of filtering content by reading the MAC addresses of source and destination. It is also used for interconnecting two LANs working on the same protocol. It has a single input and single output port, thus making it a 2 port device.

**Gateway:** A gateway, as the name suggests, is a passage to connect two networks together that may work upon different networking models. They basically work as the messenger agents that take data from one system, interpret it, and transfer it to another system. Gateways are also called protocol converters and can operate at any network layer. Gateways are generally more complex than switches or routers. Gateway is also called a protocol converter.

**Repeater:** A repeater is an electronic device that amplifies the signal it receives. You can think of repeater as a device which receives a signal and retransmits it at a higher level or higher power so that the signal can cover longer distances, more than 100 meters for standard LAN cables. Repeaters work on the Physical layer.

**Topology:** Topology defines the structure of the network of how all the components are interconnected to each other. There are two types of topology: physical and logical topology.

Physical topology is the geometric representation of all the nodes in a network.

## Bus Topology

* The bus topology is designed in such a way that all the stations are connected through a single cable known as a backbone cable.
* Each node is either connected to the backbone cable by drop cable or directly connected to the backbone cable.
* When a node wants to send a message over the network, it puts a message over the network. All the stations available in the network will receive the message whether it has been addressed or not.
* The bus topology is mainly used in 802.3 (ethernet) and 802.4 standard networks

**Ring Topology**

* Ring topology is like a bus topology, but with connected ends.
* The node that receives the message from the previous computer will retransmit to the next node.
* The data flows in one direction, i.e., it is unidirectional.
* The data flows in a single loop continuously known as an endless loop.
* It has no terminated ends, i.e., each node is connected to other node and having no termination point.
* The data in a ring topology flow in a clockwise direction.

## Star Topology

* Star topology is an arrangement of the network in which every node is connected to the central hub, switch or a central computer.
* The central computer is known as a **server**, and the peripheral devices attached to the server are known as **clients**.
* Coaxial cable or RJ-45 cables are used to connect the computers.
* Hubs or Switches are mainly used as connection devices in a **physical star topology**.

## Mesh topology

* Mesh technology is an arrangement of the network in which computers are interconnected with each other through various redundant connections.
* There are multiple paths from one computer to another computer.
* It does not contain the switch, hub or any central computer which acts as a central point of communication.
* The Internet is an example of the mesh topology.
* Mesh topology is mainly used for WAN implementations where communication failures are a critical concern.

# **Electromagnetic Spectrum**

The electromagnetic spectrum is the entire range of electromagnetic radiation according to the wavelength or frequencies. It has a range of frequencies from 1Hz to Hz. The waves in order of increasing frequencies are radio waves, microwaves, infrared rays, visible light, UV rays, X-rays and gamma rays.Among these range, the frequencies between Hz to Hz are used for communication.

**Radio Waves**

* The rapid travel of charged particles across conducting wires causes these waves.
* Radio, television, and telecom signals are transmitted through them.
* These waves have a frequency range of around 3kHz to 300MHz.
* In the ultrahigh-frequency (UHF) band, cellular phones employ radio waves to convey voice communication.

**Microwaves**

* Microwaves are a type of electromagnetic radiation that has a frequency of a few gigahertz (GHz).
* Klystrons, magnetrons, and Gunn diodes are unique vacuum tubes that produce them.
* Microwaves are commonly utilised in aviation navigation due to their short wavelengths.

**X-Rays**

* This electromagnetic radiation is found outside of the ultraviolet (UV) region of the electromagnetic spectrum and is extremely valuable in the medical field.
* The wavelength range of X-ray radiation is 1nm–10–3nm.
* By blasting a metal target with high-energy electrons, X-rays can be produced.
* At the airport checkpoint, security agents utilise it to search through passengers’ luggage. X-rays are also emitted by the universe’s heated gases.

**Gamma-Rays**

* The universe is the largest gamma-ray generator.
* These rays are in the electromagnetic spectrum’s higher frequency region.
* Gamma rays have wavelengths ranging from 10–12m to 10–14m.
* Radioactive nuclei release high-frequency radiations, which are also created during nuclear processes.

**Dynamic routing:** It is a networking technique that provides *optimal* data routing. Unlike static routing, dynamic routing enables routers to select paths according to real-time logical network layout changes.

Dynamic routing uses multiple algorithms and protocols. The most popular are Routing Information Protocol (RIP) and Open Shortest Path First (OSPF).Dynamic routing protocols allow routers to share information about the network with other routers to allow them to select the best path to reach a destination.

### **Distance Vector Routing:** Distance Vector Routing protocols determine the best path to a given destination based on distance. The distance metric is usually measured in hops, but it could also be delay, packet loss, or something else. If the distance metric is hop, a hop is traversed each time a packet passes through a router. The route to a given network with the fewest hops is the best route to that network.

The direction of that specific network is shown by the vector. Directly connected neighbours receive the entire routing table sent by distance vector protocols. RIP (Routing Information Protocol) and IGRP (Internal Gateway Routing Protocol) are two examples of distance vector protocols.

### **Link State Routing:** Shortest-path-first protocols are another name for Link State protocols. Protocols that use link state routing have a complete picture of the network topology. As a result, they have a better understanding of the entire network than any distance vector protocol.

Each router with link state routing creates three separate tables. One table stores information about directly connected neighbors, another stores the topology of the entire internetwork, and the third stores the actual routing table.

All routers in the network receive information about directly connected links via link state protocols. OSPF (Open Shortest Path First) and IS-IS (Intermediate System to Intermediate System) are two examples of Link State Routing Protocols.

Difference between Hub, Switch and Router

|  |  |  |
| --- | --- | --- |
| Hub | Switch | Router |
| 1. It broadcast to all. | 1. It is a smart device. | 1. It is an Inter Network Connectivity device. |
| 1. Security issues. | 1. One time broadcast to learn devices. | 1. It generates routing table. |
| 1. Network connectivity device. | 1. It generates the CAM table. | 1. OSI layer 3 device. |
| 1. OSI layer 1 device. | 1. It is unicast/multicast. | 1. It works on IP Address. |
| 1. More chances of collision. | 1. OSI layer 2 device. | 1. Router needs at least two networks to connect. |
| 1. Half duplex | 1. Framing. | 1. Full Duplex |
| 1. They can be used to increase the network distance. | 1. MAC address. | 1. The router is generally located at gateways, the places where two or more networks connect. |
| 1. At least single network is required to connect. | 1. Network connectivity device. | 1. In a word, router forwards data packets along with networks. |
| 1. Hub is cheaper as compared to switch and router. | 1. ARP and RARP works on this. | 1. It is very intelligent device. |

Characteristics of network according to area:

## PAN (Personal Area Network): ****PAN**** (Personal Area Network) is a computer network formed around a person. It generally consists of a computer, mobile, or personal digital assistant. PAN can be used for establishing communication among these personal devices for connecting to a digital network and the internet.

## 

## LAN (Local Area Network): A ****Local Area Network**** (LAN) is a group of computer and peripheral devices which are connected in a limited area such as school, laboratory, home, and office building. It is a widely useful network for sharing resources like files, printers, games, and other application. The simplest type of LAN network is to connect computers and a printer in someone’s home or office. In general, LAN will be used as one type of transmission medium. It is a network which consists of less than 5000 interconnected devices across several buildings.

## 

## WAN (Wide Area Network): ****WAN**** (Wide Area Network) is another important computer network that which is spread across a large geographical area. WAN network system could be a connection of a LAN which connects with other LAN’s using telephone lines and radio waves. It is mostly limited to an enterprise or an organization.

## 

## MAN (Metropolitan Area Network): A ****Metropolitan Area Network**** or MAN is consisting of a computer network across an entire city, college campus, or a small region. This type of network is large than a LAN, which is mostly limited to a single building or site. Depending upon the type of configuration, this type of network allows you to cover an area from several miles to tens of miles.

