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.

TCP/IP it stands for Transmission Control Protocol/Internet Protocol. The TCP/IP model is a concise version of the OSI model.

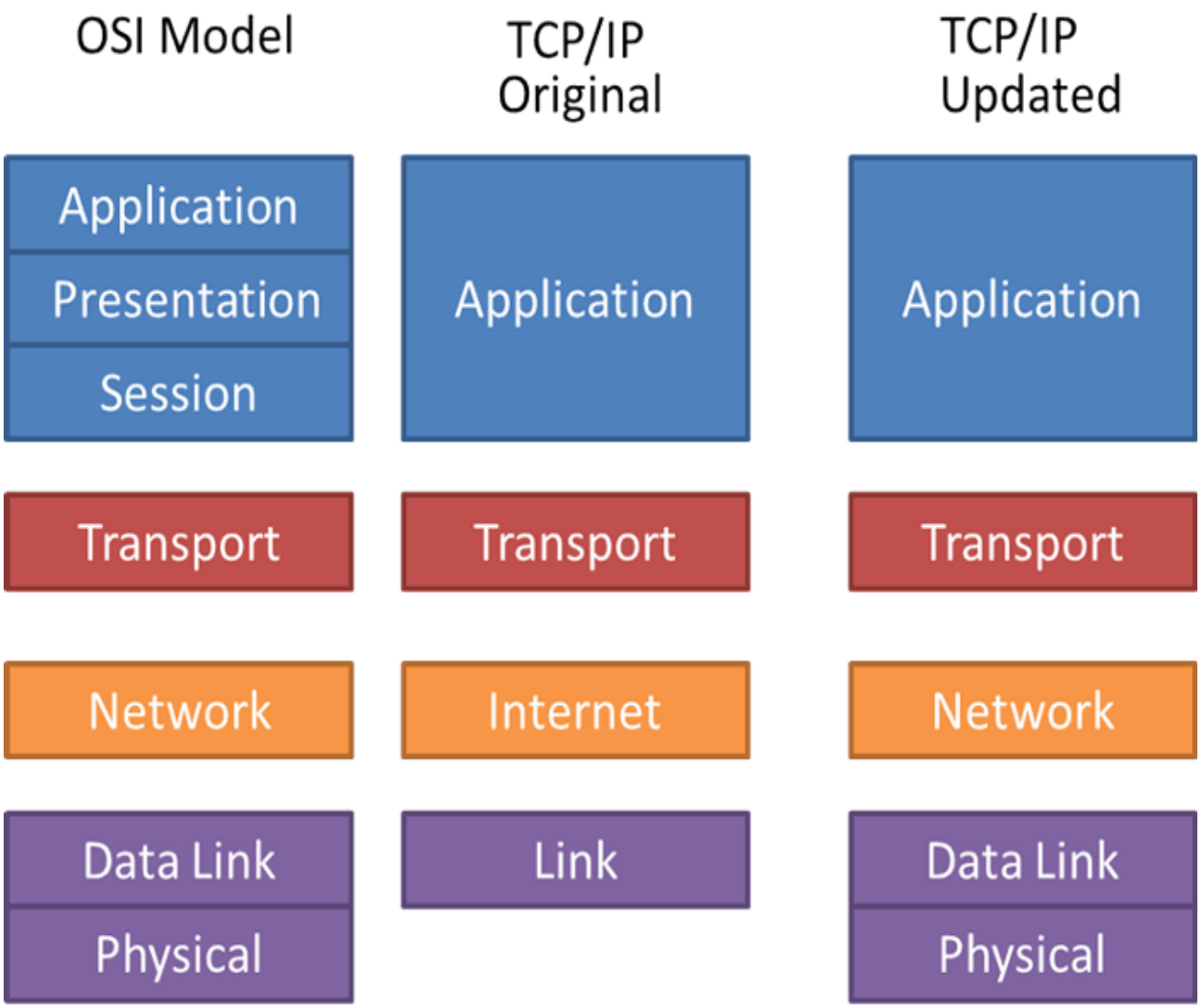
Original TCP/IP model and the updated TCP/IP model

The TCP/IP model which we use nowadays is slightly different from the original TCP/IP model. The original TCP/IP model has four layers while the updated TCP/IP model has five layers.

The original version uses a single layer (Link layer) to define the functionalities and components that are responsible for data transmission. The updated version uses two layers (Data Link and Physical) for the same.

It defines the functions that are directly related to the data transmission in the Physical layer and defines the functions that are indirectly related to the data transmission in the Data-link layer.

In the updated version, the name of the Internet layer is changed to the Network layer.


OSI Model
TCP/IP Original
TCP/IP Updated
Application
Presentation
Session
Application
Application
Transport
Transport
Transport
Network
Internet
Network
Data Link
Physical
Link
Data Link
Physical

TCP/IP

The main work of TCP/IP is to transfer the data of a computer from one device to another. The main condition of this process is to make data reliable and accurate so that the receiver will receive the same information which is sent by the sender. To ensure that, each message reaches its final destination accurately, the TCP/IP model divides its data into packets and combines them at the other end.

Difference between TCP and IP

TCP and IP are different protocols of Computer Networks. The basic difference between TCP (Transmission Control Protocol) and IP (Internet Protocol) is in the transmission of data. In simple words, IP finds the destination of the mail and TCP has the work to send and receive the mail.

Layers of TCP/IP Model

1. Application Layer
2. Transport Layer
3. Network/Internet Layer
4. Data Link Layer
5. Physical Layer

TCP/IP is a hierarchical protocol made up of interactive modules, and each of them provides specific functionality. Here, hierarchical means that each upper-layer protocol is supported by two or more lower-level protocols.

1. Physical Layer

It is a group of applications requiring network communications. This layer is responsible for generating the data and requesting connections. It acts on behalf of the sender and the Network Access layer on the behalf of the receiver.

2. Data Link Layer

TCP/IP does not define any specific protocol for the data link layer either. It supports all of the standard and proprietary protocols. At this level, the communication is also between two hops or nodes. The unit of communication however, is a packet called a frame. A frame is a packet that encapsulates the data received from the network layer with an added header and sometimes a trailer.

It is responsible for the node-to-node delivery of data. Its major role is to ensure error-free transmission of information. DLL is also responsible to encode, decode and organize the outgoing and incoming data.

Sub-layers of Data Link Layer:

The data link layer is further divided into two sub-layers, which are as follows:

Logical Link Control (LLC):

This sublayer of the data link layer deals with multiplexing, the flow of data among applications and other services, and LLC is responsible for providing error messages and acknowledgments as well.

Media Access Control (MAC):

MAC sublayer manages the device's interaction, responsible for addressing frames, and also controls physical media access.

3. Internet Layer

This layer parallels the functions of OSI's Network layer. It defines the protocols which are responsible for the logical transmission of data over the entire network. The main protocols residing at this layer are as follows:

IP Protocol: IP protocol is used in this layer, and it is the most significant part of the entire TCP/IP suite.

Following are the responsibilities of this protocol:

IP Addressing: This protocol implements logical host addresses known as IP addresses. The IP addresses are used by the internet and higher layers to identify the device and to provide internetwork routing.

Host-to-host communication: It determines the path through which the data is to be transmitted.

Data Encapsulation and Formatting: An IP protocol accepts the data from the transport layer protocol. An IP protocol ensures that the data is sent and received securely, it encapsulates the data into message known as IP datagram.

Fragmentation and Reassembly: The limit imposed on the size of the IP datagram by data link layer protocol is known as Maximum Transmission unit (MTU). If the size of IP datagram is greater than the MTU unit, then the IP protocol splits the datagram into smaller units so that they can travel over the local network. Fragmentation can be done by the sender or intermediate router. At the receiver side, all the fragments are reassembled to form an original message.

Routing: When IP datagram is sent over the same local network such as LAN, MAN, WAN, it is known as direct delivery. When source and destination are on the distant network, then the IP datagram is sent indirectly. This can be accomplished by routing the IP datagram through various devices such as routers.

Example: Imagine that you are using a computer to send an email to a friend. When you click “send,” the email is broken down into smaller packets of data, which are then sent to the Internet Layer for routing. The Internet Layer assigns an IP address to each packet and uses routing tables to determine the best route for the packet to take to reach its destination. The packet is then forwarded to the next hop on its route until it reaches its destination. When all of the packets have been delivered, your friend’s computer can reassemble them into the original email message.

In this example, the Internet Layer plays a crucial role in delivering the email from your computer to your friend's computer. It uses IP addresses and routing tables to determine the best route for the packets to take, and it ensures that the packets are delivered to the correct destination. Without the Internet Layer, it would not be possible to send data across the Internet.

4. Transport Layer

The transport layer is responsible for the reliability, flow control, and correction of data which is being sent over the network.

The two protocols used in the transport layer are User Datagram protocol and Transmission control protocol.

User Datagram Protocol (UDP)

It provides connectionless service and end-to-end delivery of transmission.

It is an unreliable protocol as it discovers the errors but not specify the error.

User Datagram Protocol discovers the error, and ICMP protocol reports the error to the sender that user datagram has been damaged.

UDP consists of the following fields:

Source port address: The source port address is the address of the application program that has created the message.

Destination port address: The destination port address is the address of the application program that receives the message.

Total length: It defines the total number of bytes of the user datagram in bytes.

Checksum: The checksum is a 16-bit field used in error detection.

UDP does not specify which packet is lost. UDP contains only checksum; it does not contain any ID of a data segment.

Transmission Control Protocol (TCP)

It provides a full transport layer services to applications.

It creates a virtual circuit between the sender and receiver, and it is active for the duration of the transmission.

TCP is a reliable protocol as it detects the error and retransmits the damaged frames. Therefore, it ensures all the segments must be received and acknowledged before the transmission is considered to be completed and a virtual circuit is discarded.

At the sending end, TCP divides the whole message into smaller units known as segment, and each segment contains a sequence number which is required for reordering the frames to form an original message.

At the receiving end, TCP collects all the segments and reorders them based on sequence numbers.

Application Layer

An application layer is the topmost layer in the TCP/IP model.

It is responsible for handling high-level protocols, issues of representation.

This layer allows the user to interact with the application.

When one application layer protocol wants to communicate with another application layer, it forwards its data to the transport layer.

There is an ambiguity occurs in the application layer. Every application cannot be placed inside the application layer except those who interact with the communication system. For example: text editor cannot be considered in application layer while web browser using HTTP protocol to interact with the network where HTTP protocol is an application layer protocol.

Design Issues for the Layers of Computer Networks

A number of design issues exist for the layer to layer approach of computer networks. Some of the main design issues are as follows −

Reliability

Network channels and components may be unreliable, resulting in loss of bits while data transfer. So, an important design issue is to make sure that the information transferred is not distorted.

Scalability

Networks are continuously evolving. The sizes are continually increasing leading to congestion. Also, when new technologies are applied to the added components, it may lead to incompatibility issues. Hence, the design should be done so that the networks are scalable and can accommodate such additions and alterations.

Addressing

At a particular time, innumerable messages are being transferred between large numbers of computers. So, a naming or addressing system should exist so that each layer can identify the sender and receivers of each message.

Error Control

Unreliable channels introduce a number of errors in the data streams that are communicated. So, the layers need to agree upon common error detection and error correction methods so as to protect data packets while they are transferred.

Flow Control

If the rate at which data is produced by the sender is higher than the rate at which data is received by the receiver, there are chances of overflowing the receiver. So, a proper flow control mechanism needs to be implemented.

Resource Allocation

Computer networks provide services in the form of network resources to the end users. The main design issue is to allocate and deallocate resources to processes. The allocation/deallocation should occur so that minimal interference among the hosts occurs and there is optimal usage of the resources.

Statistical Multiplexing

It is not feasible to allocate a dedicated path for each message while it is being transferred from the source to the destination. So, the data channel needs to be multiplexed, so as to allocate a fraction of the bandwidth or time to each host.

Routing

There may be multiple paths from the source to the destination. Routing involves choosing an optimal path among all possible paths, in terms of cost and time. There are several routing algorithms that are used in network systems.

Security

A major factor of data communication is to defend it against threats like eavesdropping and surreptitious alteration of messages. So, there should be adequate mechanisms to prevent unauthorized access to data through authentication and cryptography.

Transmission media

- Transmission media is a communication channel that carries the information from the sender to the receiver. Data is transmitted through the electromagnetic signals.
- The main functionality of the transmission media is to carry the information in the form of bits through LAN(Local Area Network).
- It is a physical path between transmitter and receiver in data communication.
- In a copper-based network, the bits in the form of electrical signals.
- In a fibre based network, the bits in the form of light pulses.
- The electrical signals can be sent through the copper wire, fibre optics, atmosphere, water, and vacuum.
- The characteristics and quality of data transmission are determined by the characteristics of medium and signal.
- Transmission media is of two types are wired media and wireless media. In wired media, medium characteristics are more important whereas, in wireless media, signal characteristics are more important.
- Different transmission media have different properties such as bandwidth, delay, cost and ease of installation and maintenance.
- The transmission media is available in the lowest layer of the OSI reference model, i.e., Physical layer.

Bandwidth: All the factors are remaining constant, the greater the bandwidth of a medium, the higher the data transmission rate of a signal.

Interference: An interference is defined as the process of disrupting a signal when it travels over a communication medium on the addition of some unwanted signal.

Transmission Impairments: The signal received may differ from the signal transmitted. The effect will degrade the signal quality for analog signals and introduce bit errors for digital signals. There are three types of transmission impairments: attenuation, delay distortion, and noise.

Attenuation: Attenuation means the loss of energy, i.e., the strength of the signal decreases with increasing the distance which causes the loss of energy.

Distortion: Distortion occurs when there is a change in the shape of the signal. This type of distortion is examined from different signals having different frequencies. Each frequency component has its own propagation speed, so they reach at a different time which leads to the delay distortion.

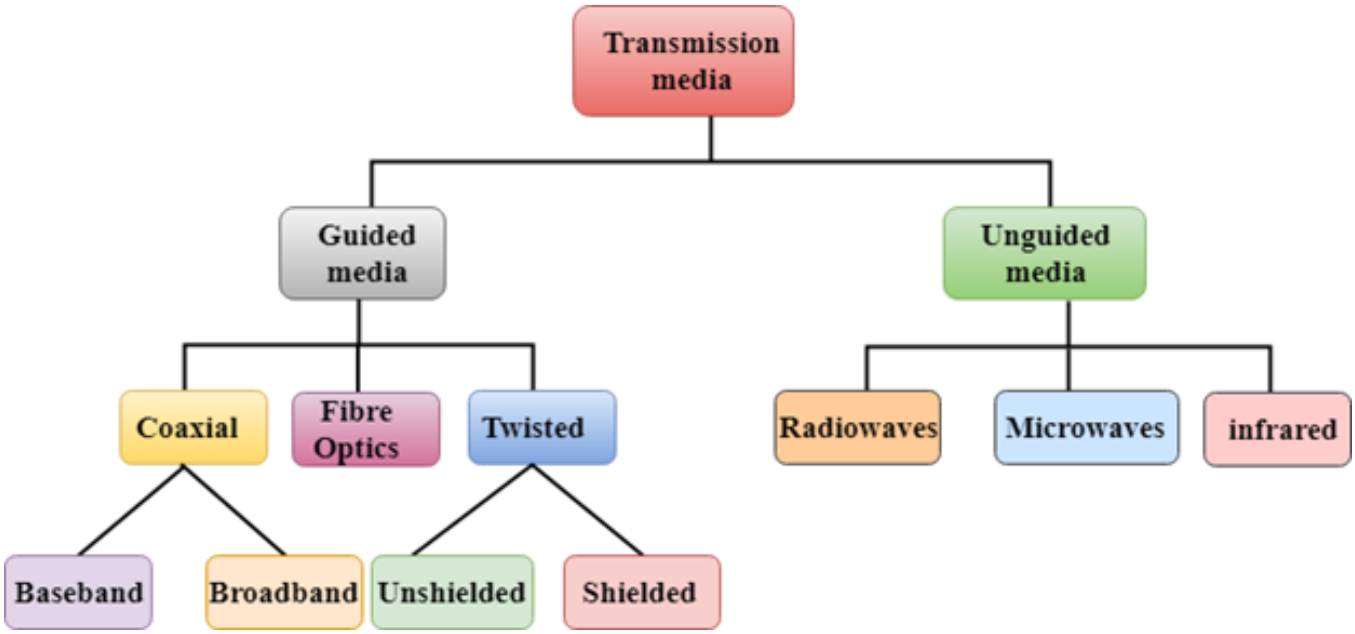
Noise: When data is travelled over a transmission medium, some unwanted signal is added to it which creates the noise.

Transmission Media:

Transmission media is defined as the total path through which data goes from sender to receiver. All the physical channels and cables that help data to go from one point to another point are transmission media.

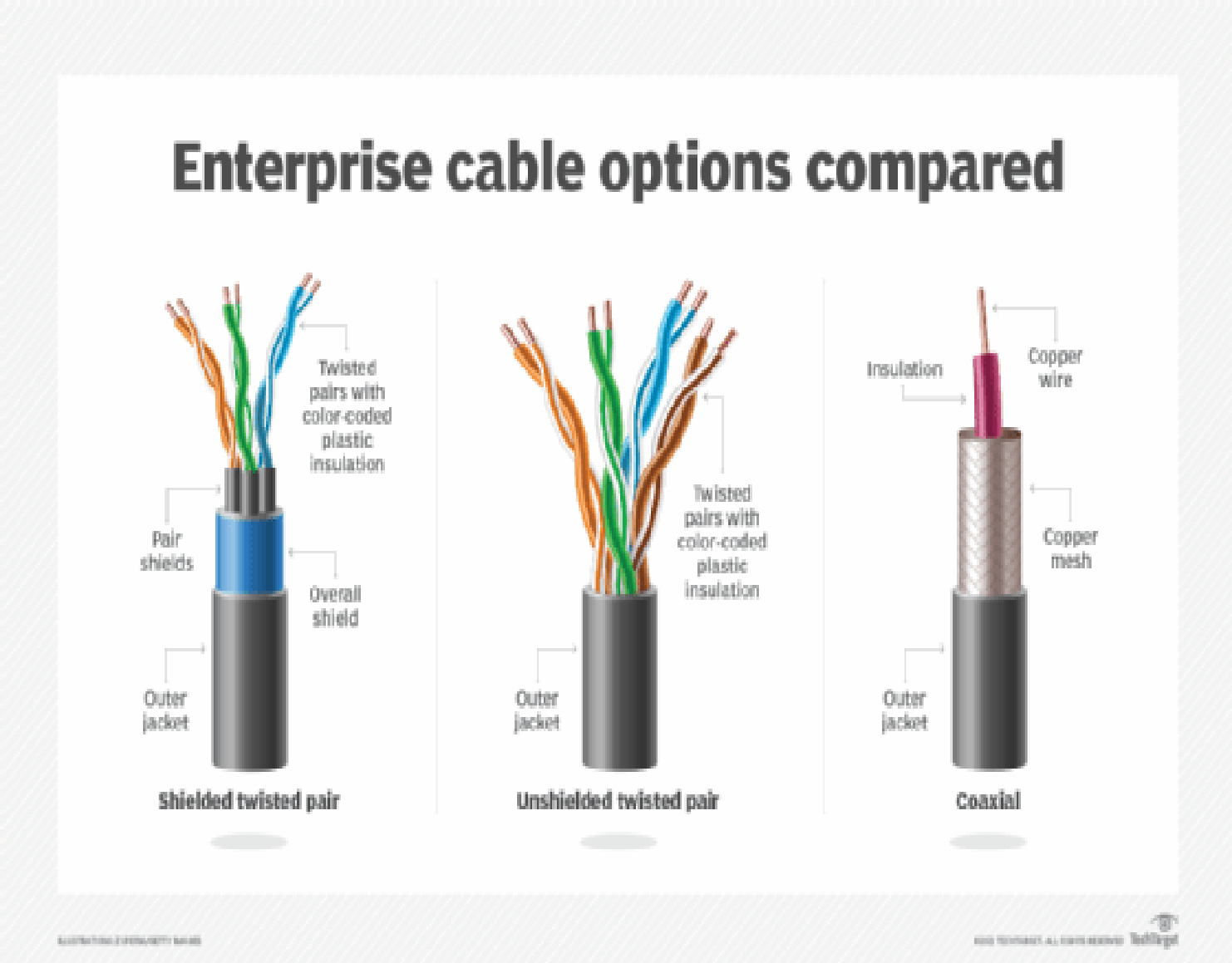
In other words, when data is transmitted via electromagnetic waves Transmission media acts as a medium to transfer information from one part to the other and is defined as the communication channel to carry the data in a process. For better transmission media, there are some factors that should be taken care of as the bandwidth of the transmission media should be greater in order to have a stronger transmission media. The other factor is Interference whenever data communication flow takes place then chances of unwanted noise signals are there so to disrupt those signals interference is used.

Classification of Transmission Media:



Wired Communication Media

Wired communication media are also known as Guided media and are a type of Transmission media. This type of communication is the most stable which is why it is considered better than wireless. These connections are less prone to other outer interferences. In wired communication media, wire is used to transfer data from source to destination. Wired communication media is not better for public use but can be used for professional purposes as it more relies on wires and ports which is not the case with wireless networks, data can be accessed from anywhere. Also, the connection speed of wired media is more as compared to wireless. The whole setup of wired media is also expensive as the larger the distances more no. of cables and ports would be required and fiber optic cables are usually expensive.



Twisted pair cable:

As the name suggests these are two twisted pairs of cables or wires made up of insulated copper. These are twisted together in such a way that they run parallelly one wire is used for the transmission of data and the other wire is used for ground. Usually, these wires or cables are 1mm in diameter. The twisted-pair cable is made up of 2 copper wires (insulated) arranged in a spiral pattern. Noise interference is more often the problem in these cables but it can be handled by increasing the number of turns per foot of twisted pair cable.

Working of twisted-pair cables: The twisted-pair cable has an outer jacket that keeps the wires together, a shield for the protection of the cable, color-coded plastic insulation to uniquely identify each conductor, and twisting of wires to cancel the electromagnetic waves that create noise interferences during the transmission of data. When current flows through the cable then a small circular magnetic field is created around the wire. For the connection between two devices connectors are needed at both ends like RJ45 for computer connection.

Types of Twisted pair cables are:-

1. **Unshielded Twisted pair (UTP)**
2. **Shielded Twisted pair (STP)**

Unshielded Twisted pair (UTP)

UTP cables are the most common twisted pair cables that are used in computer networks as well as in telecommunication. These cables are made up of 4 color-coded copper wires twisted together to cancel the disturbances from outer sources and electromagnetic interference. There are different categories of UTP cables used for telecommunication and other purposes. For example, some are used for telephone line services with good speed and some offer 4mbps to 16mbps speed some provide 20mbps speed and it is enough for communication for longer distances.

Connectors: The most common UTP connector is RJ45 (Here, RJ stands for registered jack), (There are two types of RJ45 male and RJ45 female cable). RJ45 is a keyed connector, which means that the connector can be connected in only one way. Its cables are mostly used on an ethernet connection. For example, Computers, Modems, Printers, and various network storage devices.

Merits

These cables are cheaper.

The maintenance cost is low.

Demerits

The transmission rate of data is slow.

Noise is high in these cables.

Shielded Twisted pair cables (STP)

In comparison, UTP's Shielded twisted pair cables are costlier and consist of metal foil sometimes made up of insulated conductors. Metal foils help to improve the quality of the wire which otherwise will be affected by noise. These cables are used to reduce crosstalk and the interference caused due to electromagnetic waves. The company that first introduced these STP cables was IBM. These cables are used for both Analog and digital transmissions.

Merits

The transmission rate of data is fast.

Noise is slow in these cables.

Demerits

These cables are costlier.

The maintenance cost is higher.

It requires ground wire.

Applications

Some applications of Twisted pair cables:

Telephone systems: To provide voice and data channels.

LANs use twisted-pair cables.

The DSL lines used by telephone companies also use unshielded twisted pair cables to provide extremely high data rate connections.

Co-axial cable

The most common type of transmission media that is used in various applications like tv wires and ethernet connection setup also. This is a form of transmission media that consists of two conductors kept parallel to each other. It has a central core conductor of a solid copper wire enclosed in an insulating sheet and the middle core conductor is made up of copper mesh and lastly an outer metallic wrap that helps in noise cancellation. The whole cable is covered and protected by a plastic cover.

It is considered better than twisted-pair cables because of the higher frequency range. Coaxial cables are best suited for shorter distances as there are higher chances of data loss in more distances for fiber optic cables are best as fibers are capable of higher data transfer and with greater speed as compared to coaxial cables. Cost and maintenance are also less, unlike fiber optic cables. And the durability of these cables is more.

The various types of coaxial cables:

Triaxial Coaxial Cable

RG-49Coaxial Cable

RG-11 Coaxial Cable

RG-6Coaxial Cable

Hardline cable

Rigid Coaxial Cable

Semi-Rigid Coaxial Cable

Formable Coaxial Cable

Flexible Coaxial Cable

Working of Coaxial Cables: Coaxial cables are made up of copper wires for carrying higher frequency signals this wire is covered with an insulated foil cover whenever current flows it maintains a constant distance between the conductor and the next layer and then a shielded wire that prevents the interference of noise in between the transmission and at last the plastic cover that protects the whole cable from any outer disturbances. Hence, a coaxial cable carries a signal in a way that when the current enters the center copper wire as well as the metal shield. The metal conductors at that point generate a magnetic field. The insulators help the signals not to come in contact with each other, they also the signal from outside magnetic fields. In this way, the signal is carried over larger distances without much loss.

Coaxial Cable Standards: These cables are categorized by their radio government (RG) ratings and each RG number denotes a unique set of physical specifications.

Example,

RG-59	75 ohm	Cable TV
RG-58	50 ohm	Thin Ethernet

Application

Some applications of Coaxial cables:

- Digital telephone networks
- Analog telephone networks
- Cable TV networks
- Ethernet LANs

Merits

- The cost of coaxial cables is less as compared to fiber optic cables.
- It has a higher data transmission rate.
- It can be used in both analog and digital transmissions.
- Higher-frequency applications can use coaxial cables for better performance.

Demerits

- For long distances, the cost of these cables will be higher.
- The size of these cables is usually bulky because of various layers of metal as well as copper and plastic.
- The data transmission over long distances is poor.

Fiber-optic cables

Also known as optic fiber cables are highly efficient and advanced data transmission cables that allow the transfer of data in a very large volume. Fiber optic cables allow data transmission with the help of electrical signals. These are thin pipes made up of glass or plastic known as optic fibers and data or information flows via light in these cables. With higher bandwidth and high-quality performance optic fiber cables are best suited for long-distance data transfer and communication.

Types of Fibre-Optic Cables;

Single-mode Fibres: It is capable of one-way transmission with a rate of almost 50 times more than multimode fibers. Used in small-scale companies and in local area networks also.

Multimode Fibres: It has higher bandwidth and cable of two-way transmission capable of higher data transmission. Used in local area networks, corporate sectors, and private networks also.

Working of fiber-optic cable: Fiber optic cables carry information via light so at the transmitting side the light source is first encoded with data or information and then the data starts flowing in the core of the fiber optic cable in a completely bouncing manner with a complete internal reflection then there is cladding that helps the light to remain inside the cable after reaching the receiver side the data is then decoded like the original. So basically fiber optic is a form of transmission media for the transfer of data via light with higher bandwidth and a higher rate of transmission.

It consists of five major parts named core, Cladding, Coating, Strengthening, and Outer jacket.

Here, the Core is a thin part of the glass of the optic fiber cable and cladding is the insulation around the core coating is the protective layer for the optical fiber

the strengthening part allows protection to the core and at last outer jacket for the whole optic fiber tube.

Some applications of Fibre-optic cables.

One of the most popular and important uses of Fibre -optic cables is the INTERNET.

Television broadcasting These cables are very much suitable for transmitting signals for high-definition televisions because of their greater bandwidth and speed.

In surgical operations in medicine, these cables are used in various fields of medicine and research purposes as their cost is low as compared to other cables.

It is used in industries and in defense services also these cables are of great use.

Merits

Long durability: These have long durability of almost 100 years.

Low cost: Due to the cheaper cost these cables are in high demand usually of more use.

Greater bandwidth and speed: Higher speed and great bandwidth help in faster and even smoother data transmission.

Light signals: In the same fiber cable light signals of one fiber and the other do not interfere with each other which is not the case with other cables.

Demerits

Delicacy: Fibre-optic cables are more delicate as compared with copper wires. If bent too much these cables can be damaged easily.

Installation Cost: The installation process is cost-effective as it requires machines and a specialist team for the setup of the fiber cables.

Low power: Since data flows via light in these cables power supply is limited, and for high-power emitters cost would be more.