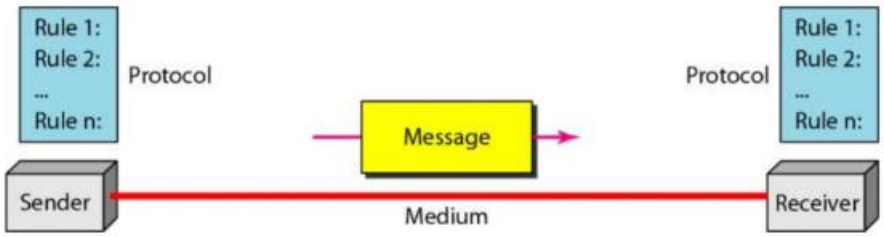
Module-1

Important Notes

1) Data Communication

- **Telecommunication** term telecommunication, which includes telephony, telegraphy, and television, means communication at a distance (tele is Greek for "far").
- The word **data** refers to information presented in whatever form is agreed upon by the parties creating and using the data.
- **Data communications** are the exchange of data between two devices via some form of transmission medium such as a wire cable.
- The effectiveness of a data communications system depends on four fundamental characteristics: **delivery, accuracy, timeliness, and jitter.**
- Delivery. The system must deliver data to the correct destination.
- Accuracy. The system must deliver the data accurately.
- Timeliness. The system must deliver data on time. Data delivered late are useless.
- Jitter. Jitter refers to the variation in the packet arrival time. It is the uneven delay in the delivery of audio or video packets.
- ***Five components of data communication***



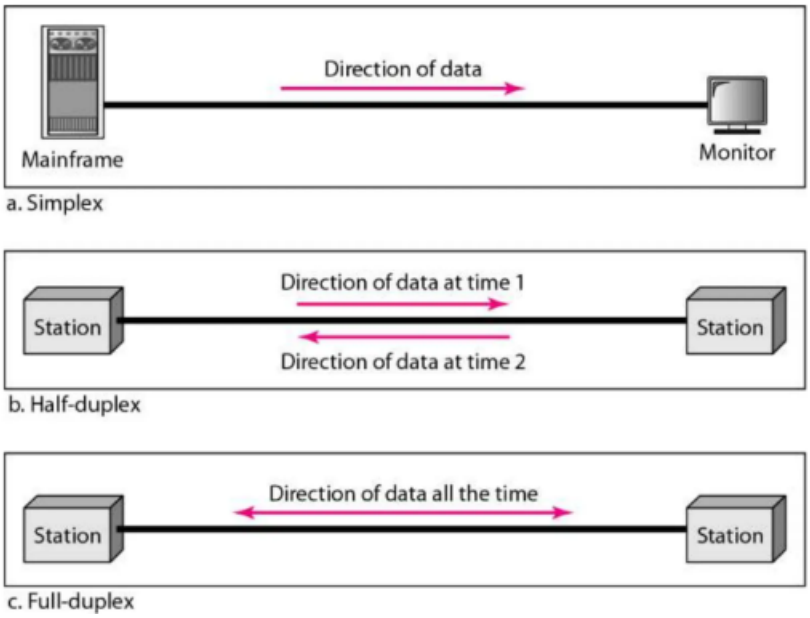
1. **Message.** The message is the information (data) to be communicated.
2. **Sender.** The sender is the device that sends the data message.
3. **Receiver**. The receiver is the device that receives the message.
4. **Transmission medium**. The transmission medium is the physical path by which a message travels from sender to receiver. Examples- twisted-pair wire, coaxial cable, etc
5. **Protocol.** A protocol is a set of rules that govern data communications. It represents an agreement between the communicating devices.

Data Representation

- Information today comes in different forms such as text, numbers, images, audio, and video.

Data Flow(Transmission Modes/Mode od)

- Communication between two devices can be simplex, half-duplex, or full-duplex



The communication is unidirectional in ***simplex mode***, as on a one-way street. Only one of the two devices on a link can transmit; the other can only receive (see Figure 1.2a). Keyboards and traditional monitors are examples of simplex devices.

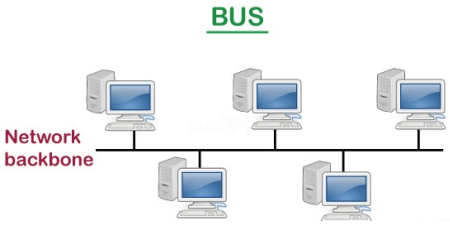
In ***half-duplex mode***, each station can both transmit and receive, but not at the same time. : When one device is sending, the other can only receive, and vice versa Examples-Walkie-talkies

In ***full-duplex*** (also called duplex), both stations can transmit and receive simultaneously example-telephone network

2) **Physical Structures of a Network**
   - Type of Connection- Line Configuration-There are two possible types of connections: ***point-to-point and multipoint.***
   - **Point-to-Point** -A point-to-point connection provides a dedicated link between two devices. The entire capacity of the link is reserved for transmission between those two devices. When you change television channels by infrared remote control, you are establishing a point-to-point connection between the remote control and the television's control system
   - **Multipoint** -A multipoint (also called multidrop) connection is one in which more than two specific devices share a single link
3) **Physical Topology**
   - The topology of a network is the geometric representation of the relationship of all the links and linking devices (usually called nodes) to one another. There are four basic topologies possible: mesh, star, bus, and ring

Multipoint configurations are: Bus and Ring. A bus topology consists of a single cable connecting all devices in the network. Same goes for a ring topology, where a single ring connection is used to connect all devices together. The devices communicate via the shared cable.

Bus



- 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.
- **Advantages**-Low-cost cable, Moderate data speeds,easy installation
- Disadvantages-**Signal interference:** If two nodes send the messages simultaneously, then the signals of both the nodes collide with each other., **Reconfiguration difficult:** Adding new devices to the network would slow down the network.,**Attenuation:**

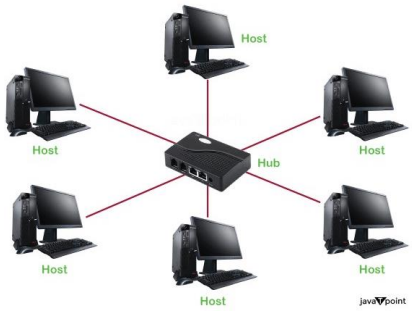
Ring

- 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.

Point-to-point configuration are: Mesh and Star. A mesh topology consists of a network of devices all connected to each other individually. Same goes for a star topology. Each device is connected to almost every other device in this network.

Star

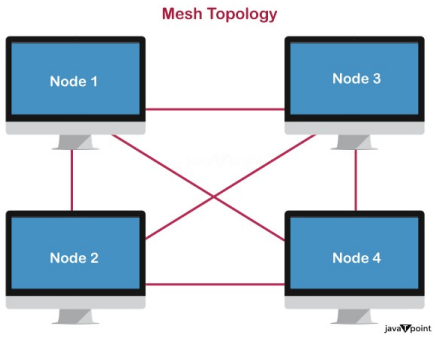
- Star topology is an arrangement of the network in which every node is connected to the central hub, switch or a central computer.
- The central computer is known as a **server**, and the peripheral devices attached to the server are known as **clients**.
- Hubs or Switches are mainly used as connection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



Mesh

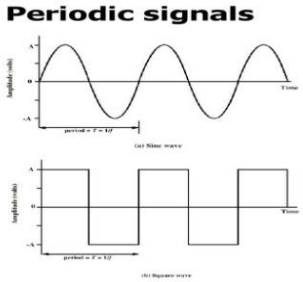
- Mesh technology is an arrangement of the network in which computers are interconnected with each other through various redundant connections.
- There are multiple paths from one computer to another computer.
- It does not contain the switch, hub or any central computer which acts as a central point 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.
- Mesh topology is mainly used for wireless networks.
- Mesh topology can be formed by using the formula: Number of cables = (n*(n-1))/2; Where n is the number of nodes that represents the network.



Data and Signals

- **Data can be of 2 types**- Analog data- continuous data that take continuous values. -Digital Data-Discrete data
- **Signals can be of 2 types-** Analog signals – continuous waves that change over a time period -Digital Signals- Discrete waves that carry binary information.
- **A periodic signal** completes a pattern within a measurable time frame, called a period, and repeats that pattern over subsequent identical periods. The completion of one full pattern is called a cycle.



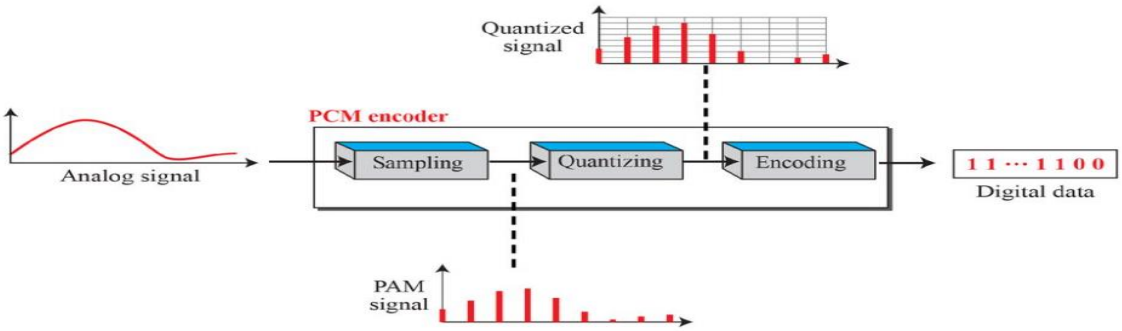
Analog to Digital Conversion

- Analog signals such as one created by a microphone or camera.
- **Need**
  - ✓ **Compatibility with Digital Devices**
  - ✓ **Noise Resistance**: Digital signals are less prone to noise
  - ✓ **Data Storage and Compression**: Digital signals can be easily stored and compressed
  - ✓ **Error Detection and Correction**: Digital data can be equipped with error detection and correction mechanisms
- to change an analog signal to digital data- 2 techniques are there-

- ✓ Pulse code modulation and
- ✓ Delta modulation

PCM

- ✓ The most common technique to change an analog signal to digital data (digitization) is called pulse code modulation (PCM).
- ✓ **Components of PCM encoder**



- ✓ **3 main steps**
  1. The analog signal is sampled.
  2. The sampled signal is quantized.
  3. The quantized values are encoded as streams of bits.
- ✓ **Step-1 -Sampling**
  - Also called Pulse Amplitude Modulation (PAM).
  - The analog signal is sampled every Ts second, where Ts is the sample interval or period.
  - By sampling we are converting an **analog signal into a discrete signal in terms of time. That is -Sampling is time discretization**
  - **Sampling Rate/Sampling Frequency -The rate at which we sample our analog signal or we can no: of samples in per unit of time**
  - The result of sampling is a series of pulses with amplitude values between the maximum and minimum amplitudes of the signal.
- ✓ **Step-2 -Quantization**
  - Result from sampling is then passed for quantization
  - **Quantization is amplitude discretization-** We discrete our signals based on amplitude.
  - It is done by **rounding off to a predetermined level**
  - **Quantization levels -**n = number of bits used to represent the sample, Then, q = number of quantization levels , which can be found using $q= 2^n$
  - **Step Size/Level Size/Delta Value in Quantization**-we divide each level with a height of step size Formula to find Step size or delta is

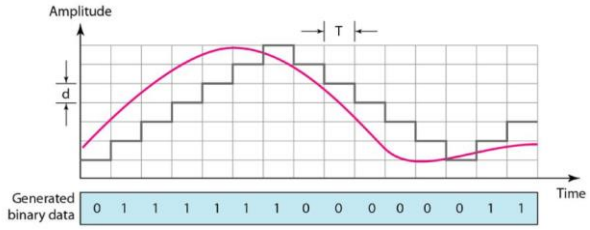
$S = V_{MAX} - V_{MIN} / L$ ie $S = V_{MAX} - V_{MIN} / 2^n$
where,

V_{MAX} it can be also denoted as Vh(maximum voltage)
V_{MIN} it can be also denoted as Vl(minimum voltage)

- ✓ **Step-3-Encoding**
  - After quantization number of bits per sample is decided, and each sample can be changed to an n-bit code word.

DELTA MODULATION(DM)

- PCM is a very complex technique; to reduce complexity we introduce delta modulation
- DM finds the change from the previous sample.
- Modulator in DM records the small positive or negative changes, called delta -If it is a positive change, it records 1 otherwise 0.



- **The modulator builds a second signal that resembles a staircase.**

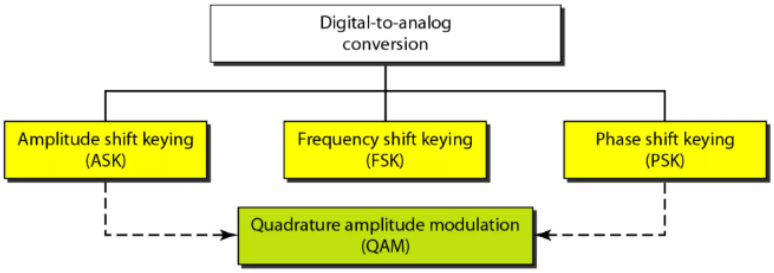
A **low pass channel** allows signals with frequencies below a certain cutoff frequency to pass through while attenuating (reducing) higher frequencies.
Applications: Transmission of voice signals in telephone systems.

A **band pass channel** allows signals within a specific **range of frequencies** (called the passband) to pass through, while attenuating signals outside this range. Like Medical devices (like EEG or ECG) that need to focus on specific frequency ranges for diagnosis.

Digital to Analog Conversion

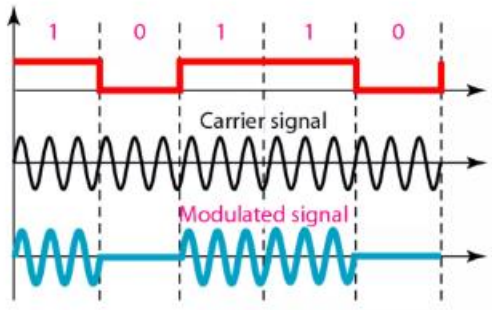
- **Converting digital data to a bandpass analog signal.is called digital to-analog conversion**
- **Process of changing one of the characteristics(Amplitude, Frequency, Phase)of an analog signal based on the information in digital data.**
- **Shift keying** refers to a type of modulation technique used in digital communication systems
- Digital data (in the form of binary bits, 0s and 1s) is transmitted over a carrier signal by altering or "shifting" one or more properties of the carrier signal.

- The carrier signal is usually a sine wave, and its characteristics (such as amplitude, frequency, or phase) are modified in discrete steps corresponding to the digital data**.**



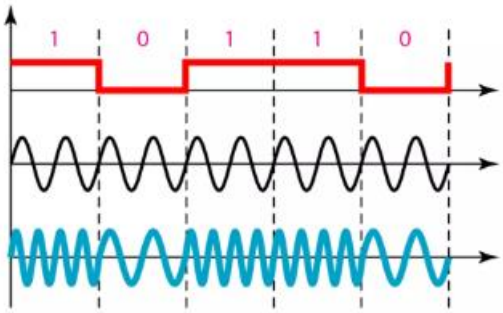
Amplitude Shift Keying

- In amplitude shift keying, the amplitude of the carrier signal is varied to create signal elements. Both frequency and phase remain constant while the amplitude changes.
- Binary amplitude shift keying or on-off keying (OOK)-normally implemented using only two levels.



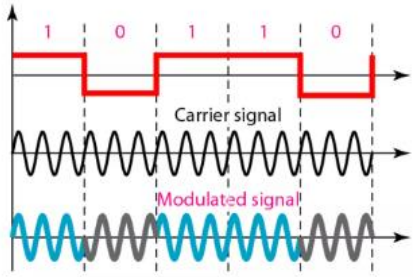
Frequency Shift Keying

- In frequency shift keying, the frequency of the carrier signal is varied to represent data.
- The frequency of the modulated signal is constant for the duration of one signal element, but changes for the next signal element if the data element changes.
- Both peak amplitude and phase remain constant for all signal elements.
- One way to think about binary FSK (or BFSK) is to consider two carrier frequencies.



Phase Shift Keying

- In phase shift keying, the phase of the carrier is varied to represent two or more different signal elements.
- Both peak amplitude and frequency remain constant as the phase changes



Quadrature Amplitude Modulation

- combination of ASK and PSK
- It modulates both the amplitude and the phase of the carrier signal to transmit more bits
- commonly used in modern communication systems like Wi-Fi and cable TV.
- **Advantages**: Highly efficient in terms of bandwidth.
- **Disadvantages**: More complex and susceptible to noise.

Analog to Analog Conversion

✓ Also called Analog modulation

Need

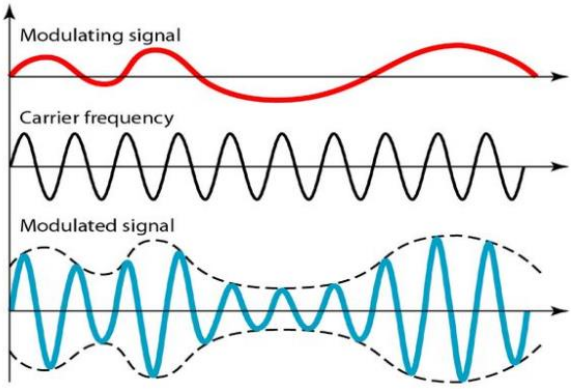
✓ An example is radio. The government assigns a narrow bandwidth to each radio station. The analog signal produced by each station is a low-pass signal, all in the same range. To be able to listen to different stations, the low-pass signals need to be shifted, each to a different range.

✓ Analog-to-analog conversion can be accomplished in three ways: amplitude modulation (AM), frequency modulation (FM), and phase modulation (PM).

Amplitude Modulation

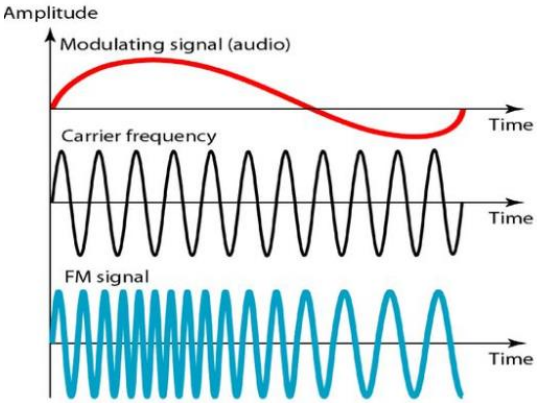
✓ In AM transmission, the carrier signal is modulated so that its amplitude varies with the changing amplitudes of the modulating signal.

✓ The frequency and phase of the carrier remain the same; only the amplitude changes to follow variations in the information.



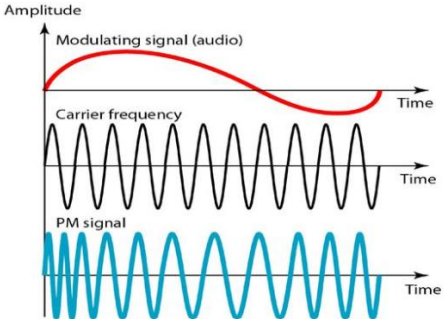
Frequency Modulation

- ✓ In FM transmission, the frequency of the carrier signal is modulated to follow the changing voltage level (amplitude) of the modulating signal.
- ✓ The peak amplitude and phase of the carrier signal remain constant.
- ✓ But as the amplitude of the information signal changes, the frequency of the carrier changes correspondingly.



Phase Moduiation

- ✓ In PM transmission, the phase of the carrier signal is modulated to follow the changing voltage level (amplitude) of the modulating signal.
- ✓ The peak amplitude and frequency of the carrier signal remain constant, but as the amplitude of the information signal changes, the phase of the carrier changes correspondingly.



- ✓

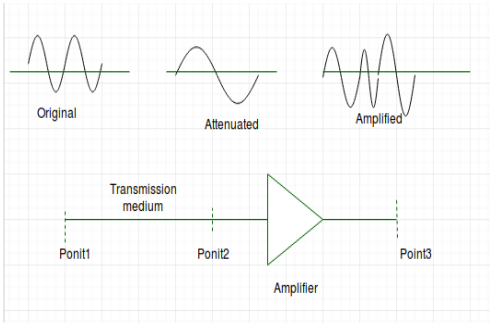
Protocols

A protocol is a set of rules that govern data communications. It defines what is communicated, how it is communicated, and when it is communicated. The key elements of a protocol are syntax, semantics, and timing

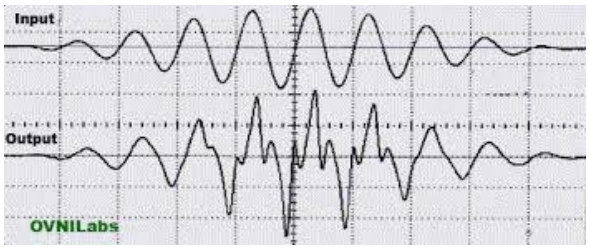
- **Syntax** refers to the structure or format of the data, meaning the order in which they are presented.
- **Semantics** refers to the meaning of each section of bits. How is a particular pattern to be interpreted
- **Timing** refers to two characteristics: when data should be sent and how fast they can be sent.

Transmission Impairments

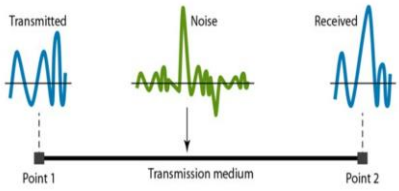
- Signals travel through transmission media, which are not perfect. The imperfection causes signal impairment. This means that the signal at the beginning of the medium is not the same as the signal at the end of the medium.
- **3 Causes** of transmission impairments are -**Attenuation, Distortion, Noise**
- **Attenuation** means a loss of energy. When a signal, travels through a medium, it loses some of its energy in overcoming the resistance of the medium. To compensate for this loss, amplifiers are used to amplify the signal. Attenuation is measured in decibels(dB). It measures the relative strengths of two signals or one signal at two different point



- **Distortion** means that the signal changes its form or shape. Distortion can occur in a composite signal made of different frequencies and frequency components that have their propagation speed traveling through a medium. Every component arrives at a different time which leads to distortion.



- The random or unwanted signal that mixes up with the original signal is called **Noise**
- Thermal noise is the random motion of electrons in a wire which creates an extra signal not originally sent by the transmitter
- Induced noise comes from sources such as motors and appliances.
- Crosstalk is the effect of one wire on the other
- Impulse noise is a spike (a signal with high energy in a very short time) that comes from power lines, lightning, and so on

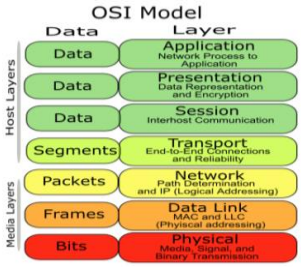


Network Models

- Network models refer to the structured representation of how different devices communicate and interact with each other within a network. These models help in organizing and streamlining the flow of data, ensuring efficient communication and resource sharing.There are two computer network models i.e. OSI Model and TCP/IP Model on which the whole data communication process relies.

Organization of Layers

1) The **Open Systems Interconnection (OSI)** model is a conceptual framework that organizes computer networks into seven layers



- Layers 1, 2, and 3 physical, data link, and network-are the network support layers; - deal with the physical aspects of moving data from one device to another
- Layers 5, 6, and 7-session, presentation, and application can be thought of as the user support layers- interoperability among unrelated software systems
- Layer 4, the transport layer, links the two subgroups

Physical Layer: Responsible for the transmission of raw binary data over physical media (cables, radio waves, etc.). It deals with the hardware components like cables, switches, and electrical signals.

Data Link Layer: Ensures reliable data transfer across a single physical link by handling error detection, frame synchronization, and flow control. It includes protocols like Ethernet and defines MAC (Media Access Control) addresses.

Network Layer: Manages data routing, forwarding, and addressing across multiple networks. It's responsible for determining the best path for data to travel, using IP addresses.

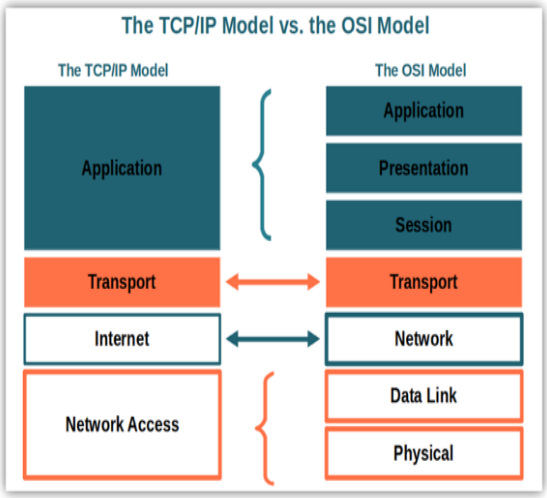
Transport Layer: Ensures complete data transfer by providing end-to-end communication, error recovery, and flow control. Protocols like TCP and UDP operate here.

Session Layer: Manages sessions between two devices, handling setup, coordination, and termination of communication sessions.

Presentation Layer: Translates data between the application layer and the network, ensuring data is in a usable format. It handles data encryption, compression, and encoding.

Application Layer: Provides network services directly to user applications (e.g., HTTP, FTP, SMTP), allowing access to network resources like web browsing and email.

2) **The TCP/IP model**, also known as the Internet Protocol Suite, has a more simplified structure compared to the OSI model. It consists of 4 layers, organized as follows:



Application layer

The top layer, which provides standardized data exchange for applications. Protocols in this layer include HTTP, FTP, and DNS.

Transport layer

Responsible for maintaining reliable data connections between devices. TCP handles communications between hosts and provides flow control, multiplexing, and reliability.

Internet layer

Also known as the network layer, this layer controls the flow and routing of traffic to ensure data is sent speedily and accurately. Protocols in this layer include IP and Internet Control Message Protocol.

Network interface layer

Also known as the network link layer or data link layer, this layer consists of protocols that operate only on a link. Protocols in this layer include Ethernet for local area networks and Address Resolution Protocol