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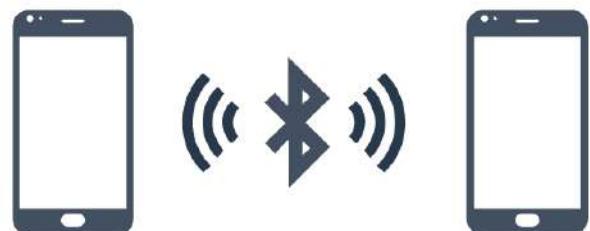
Computer Networks



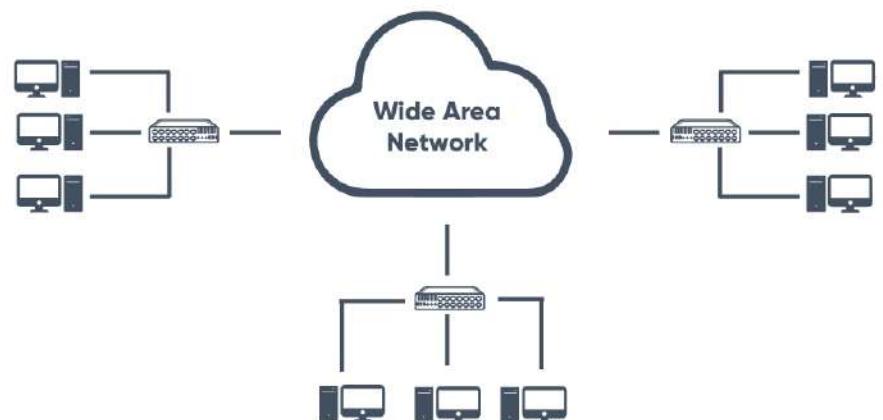
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COMPUTER NETWORK #1 Computer Network Types

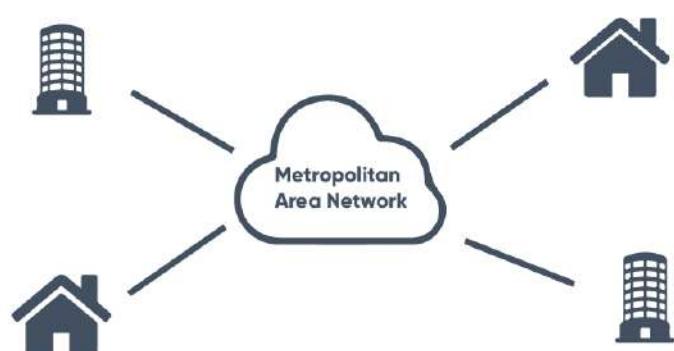
Personal Area Network



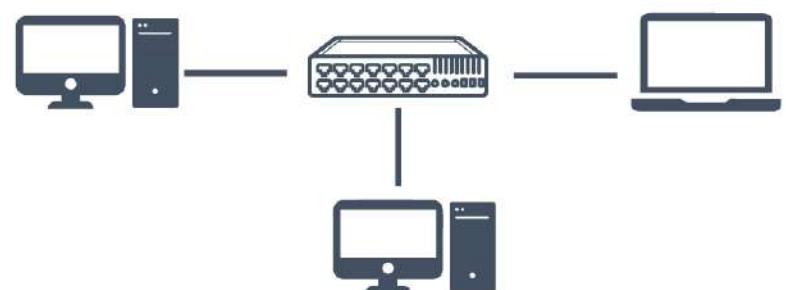
Wide Area Network



Metropolitan Area Network



Local Area Network



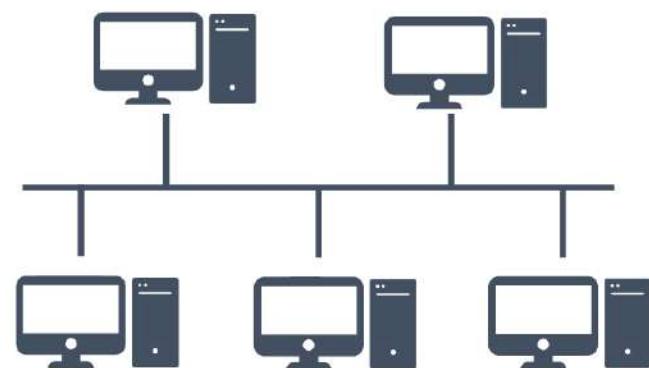
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COMPUTER NETWORK #2 CN Topologies

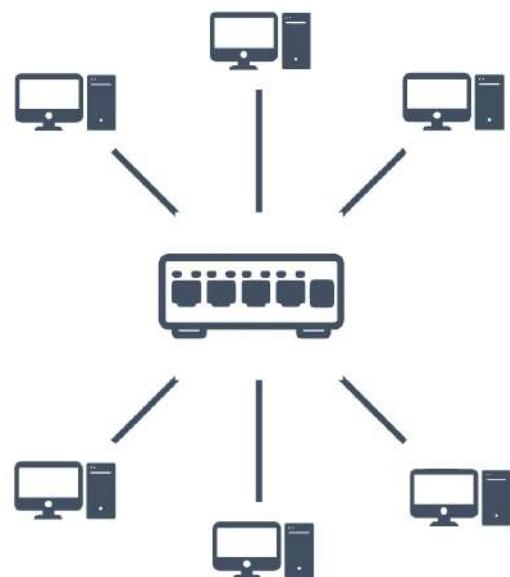
Point-to-Point



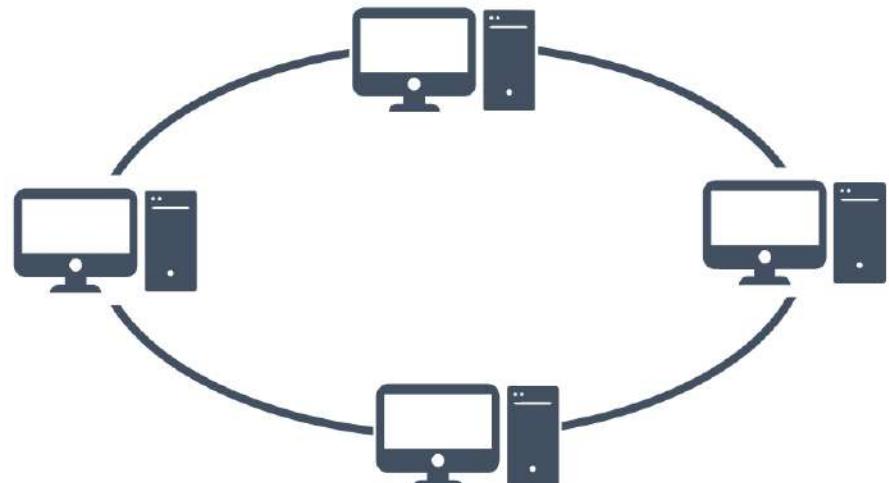
Bus Topology



Star Topology



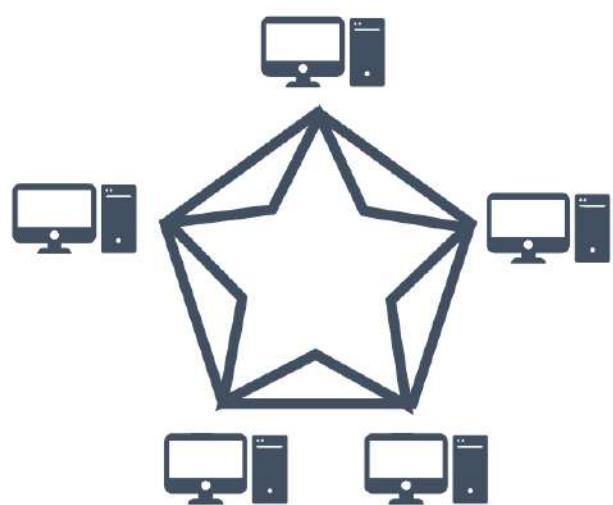
Ring Topology



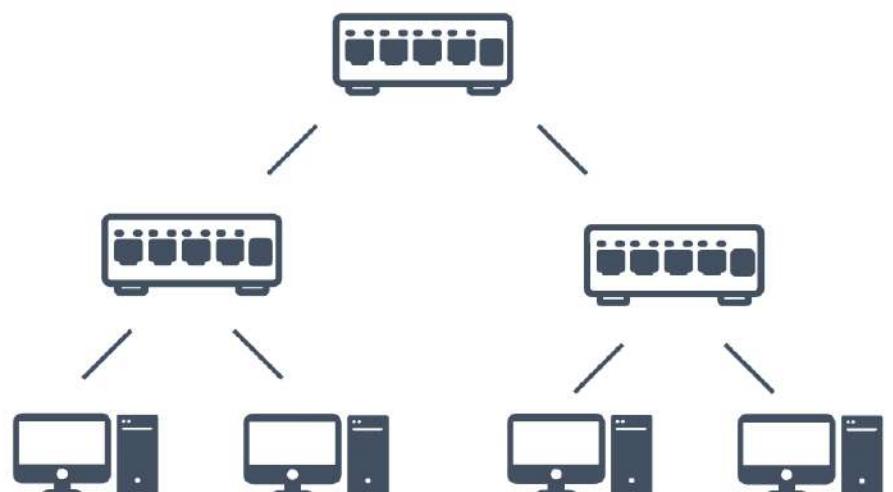
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COMPUTER NETWORK #3 CN Topologies

Mesh Topology



Tree Topology



Daisy Chain

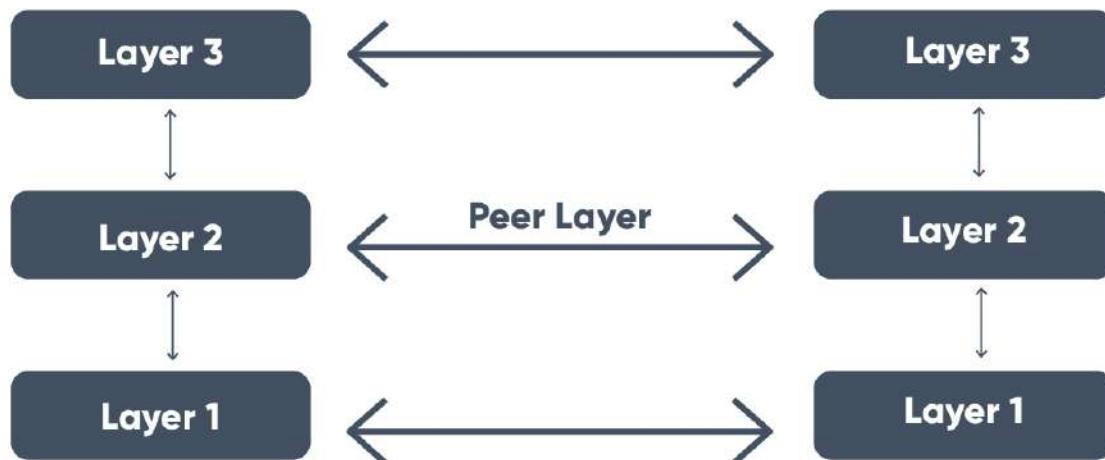


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COMPUTER NETWORK #4 CN Models

1. Layered Tasks :

- In layered architecture, one whole network process is divided into small tasks and each task is then assigned to a particular layer which works dedicatedly to process the task only.
- One layer of a host deals with the task done by or to be done by its peer layer at the same level.
- The task is either initiated by layer at the lowest level or at the top most level.



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COMPUTER NETWORK #5 CN Models

2. OSI Model :

- Open System Interconnect is an open standard for all communication systems. This model has 7 Layers.
- **Application Layer:** It is responsible for providing interface to the application user.
- **Presentation Layer:** It is responsible for how data in the native format of remote host should be presented.
- **Session Layer:** It maintains sessions between remote hosts.
- **Transport Layer:** It is responsible for end-to-end delivery between hosts.
- **Network Layer:** This layer is responsible for address assignment and uniquely addressing hosts in a network.
- **Data Link Layer:** It is responsible for reading and writing data.
- **Physical Layer:** This layer defines the hardware, cabling wiring, power output, pulse rate etc.

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COMPUTER NETWORK #6 CN Models

3. Internet Model :

- OSI Model is general communication model but Internet Model is what the internet uses for all its communication. This model has the following layers:
- **Application Layer:** This layer defines the protocol which enables user to interact with the network.
- **Transport Layer:** This layer defines how data should flow between hosts. Major protocol at this layer is Transmission Control Protocol (TCP).
- **Internet Layer:** This layer facilitates host addressing and recognition. Internet Protocol (IP) works on this layer.
- **Link Layer:** This layer provides mechanism of sending and receiving actual data.

COMPUTER SCIENCE FUNDAMENTALS

COMPUTER NETWORK #7 CN Security

All security threats are intentional i.e. they occur only if intentionally triggered.

Security threats can be divided into the following categories:

- **Interruption:** Interruption is a security threat in which availability of resources is attacked.
- **Privacy-Breach:** In this threat, the privacy of a user is compromised.
- **Integrity:** This type of threat includes any alteration or modification in the original context of communication.
- **Authenticity:** This threat occurs when a security violator, poses as a genuine person and accesses the resources or communicates with other genuine users.



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COMPUTER NETWORK #8

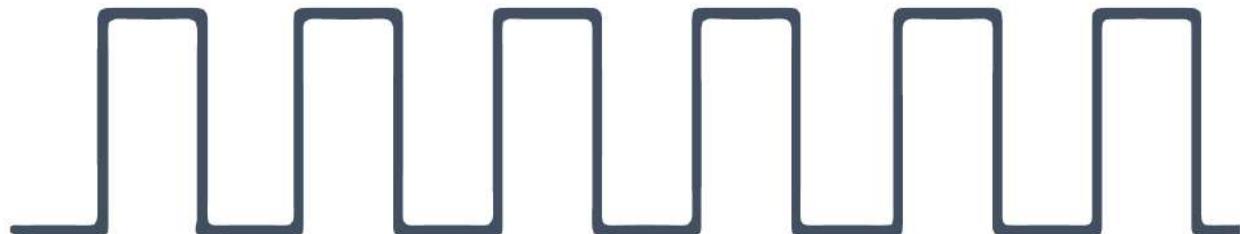
Physical Layer

Physical layer in the OSI model plays the role of interacting with actual hardware and signaling mechanism.

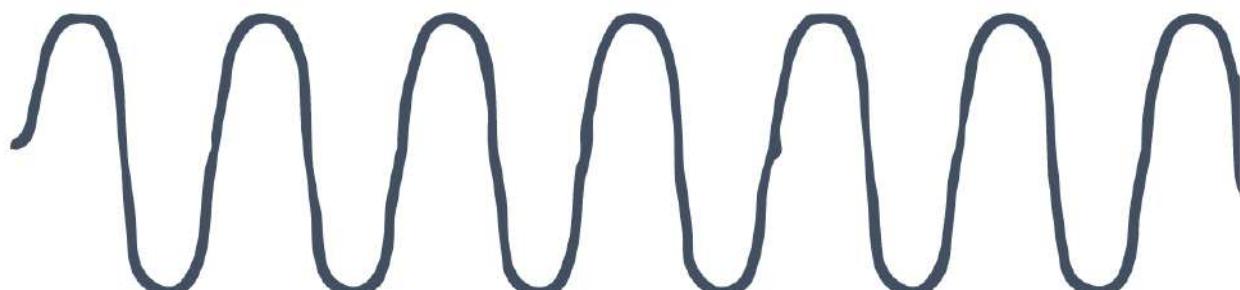
Signal:

When data is sent over physical medium, it needs to be first converted into electromagnetic signals. It is divided into 2 forms:

- **Digital Signal:** Digital signals are discrete in nature and represent sequence of voltage pulses.



- **Analog Signals:** Analog signals are in continuous wave form in nature and represented by continuous electromagnetic waves.



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COMPUTER NETWORK #8

Physical Layer

Transmission Impairment:

When signals travel through the medium they tend to deteriorate. This can be due to:

- **Attenuation:** When the signal passes through the medium, it tends to get weaker.
- **Dispersion:** As signal travels through the media, it tends to spread and overlaps. It depends upon the frequency used.
- **Delay distortion:** Signals are sent over media with pre-defined speed and frequency. If they do not match distortion occurs.
- **Noise:** Random disturbance or fluctuation in analog or digital signal is said to be Noise in signal.

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Physical Layer

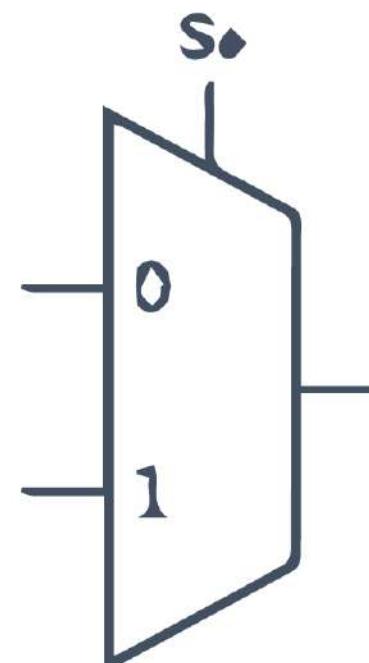
Channel Capacity:

The speed of transmission of information is said to be the channel capacity. It depends on following factors:

- **Bandwidth:** The physical limitation of underlying media.
- **Error-rate:** Incorrect reception of information because of noise.
- **Encoding:** The number of levels used for signaling.

Multiplexing:

Multiplexing is a technique to mix and send multiple data streams over a single medium. This can be achieved using a device called as Multiplexer (MUX).



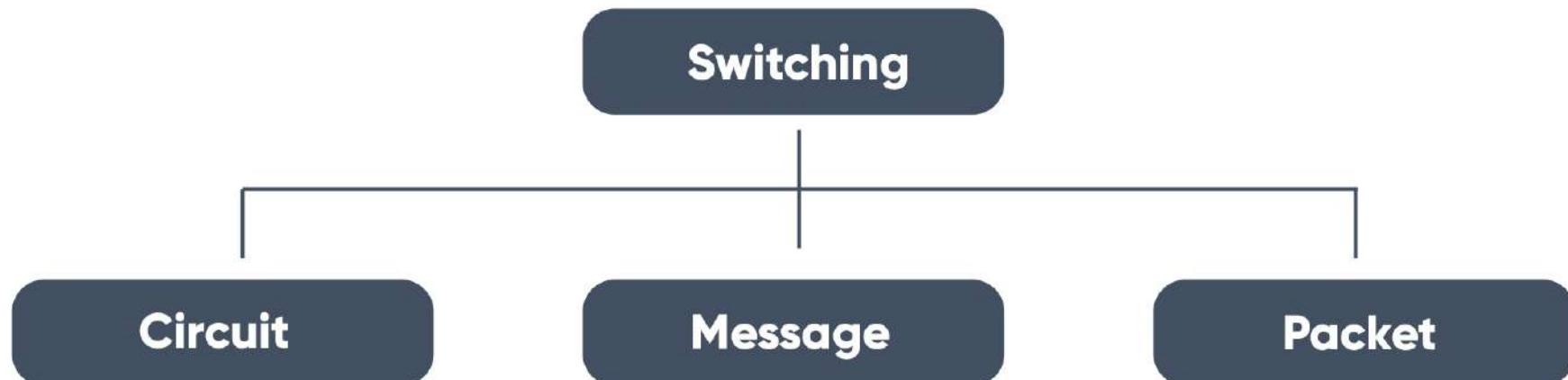
COMPUTER SCIENCE FUNDAMENTALS

COMPUTER NETWORK #10

Physical Layer

Switching:

Switching is a mechanism by which data/information sent from source towards destination which are not directly connected.



Transmission Media:

The media over which the information between two computer systems is sent, called transmission media.

- **Guided Media:** All communication wires/cables.
- **Unguided Media:** Wireless or open air space is said to be unguided media.

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COMPUTER NETWORK #11

Digital Transmission

Digital-to-Digital Conversion:

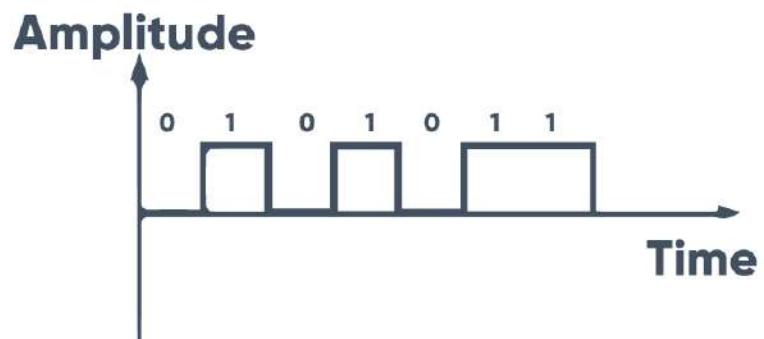
It can be carried out in two ways:

1. Line Coding :

The process for converting digital data into digital signal is said to be Line Coding. It is of 3 types:

- **Uni-polar Encoding :**

Unipolar encoding schemes use single voltage level to represent data.

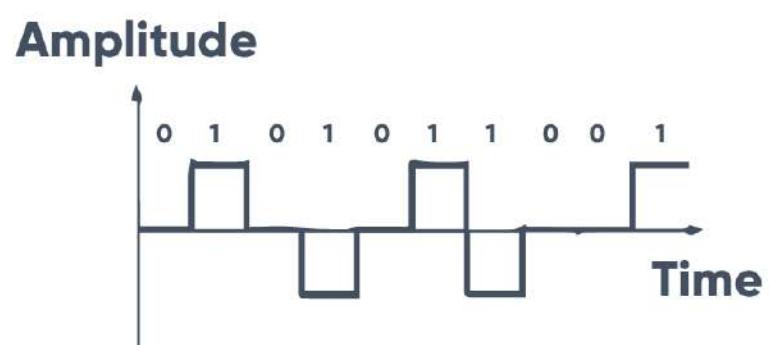


- **Polar Encoding :**

Polar encoding scheme uses multiple voltage levels to represent binary values.

- **Bipolar Encoding :**

Bipolar encoding uses three voltage levels, positive, negative and zero.



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COMPUTER NETWORK #12

Digital Transmission

2. Block Coding :

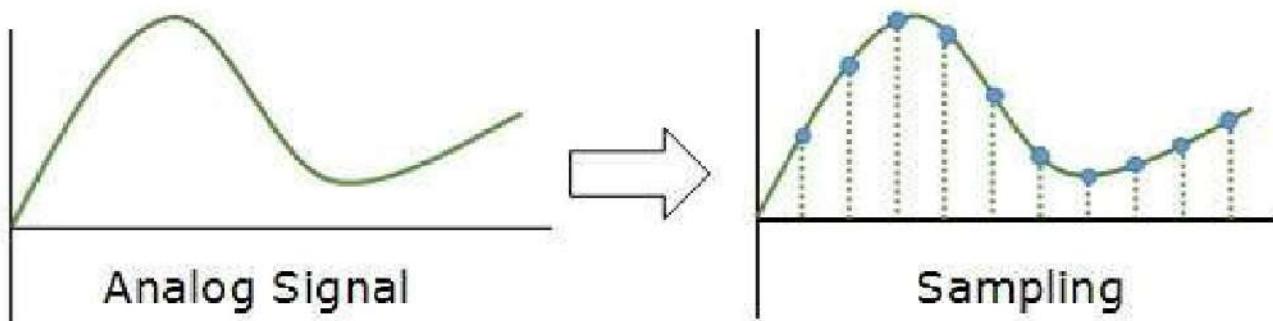
- In order to ensure accuracy of the received data frame redundant bits are used.
- Block coding is represented by slash notation.
- After block coding is done, it is line coded for transmission.

Analog-to-Digital Conversion :

PCM is one of the most common method for AtoD Conversion. It involves three steps:

1. Sampling :

According to Nyquist Theorem, the sampling rate must be at least two times of the highest frequency of the signal.



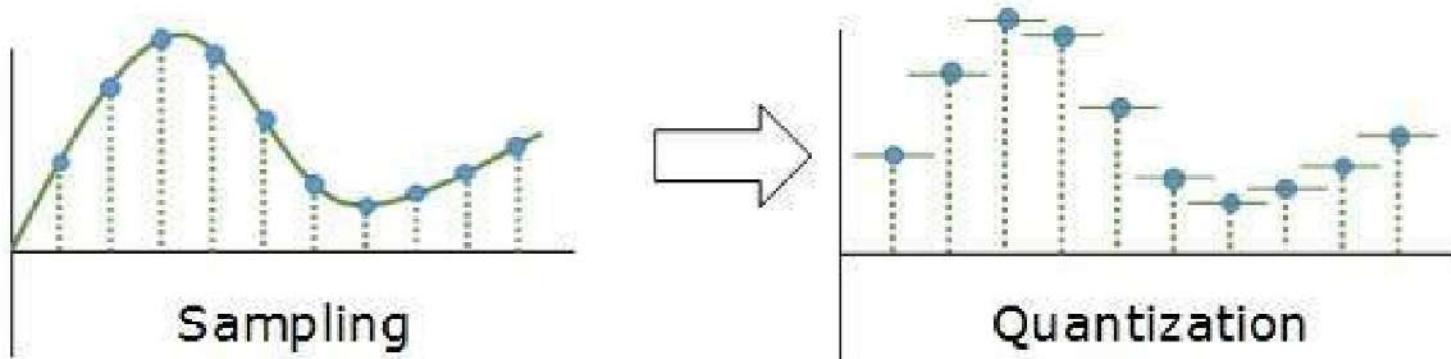
COMPUTER SCIENCE FUNDAMENTALS

COMPUTER NETWORK #13

Digital Transmission

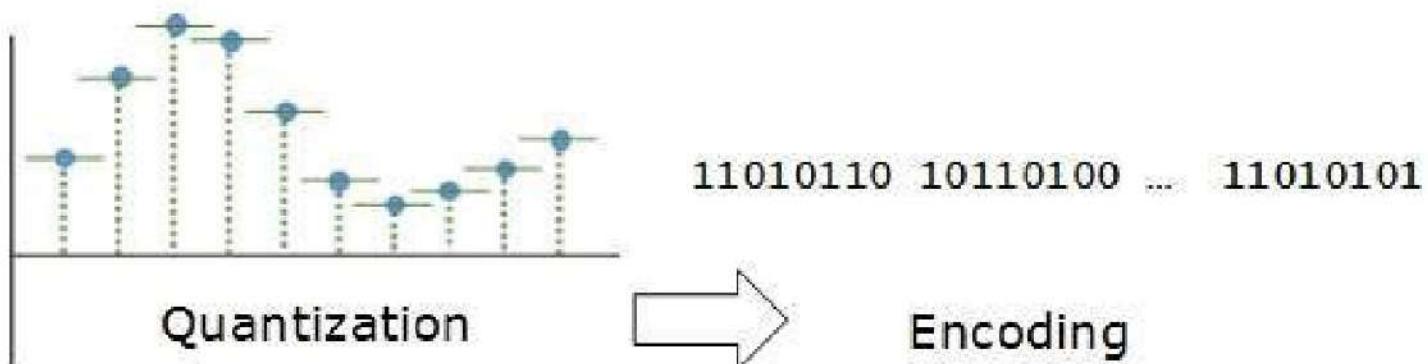
2. Quantization :

Quantization is approximation of the instantaneous analog value.



3. Encoding :

In encoding, each approximated value is then converted into binary format.



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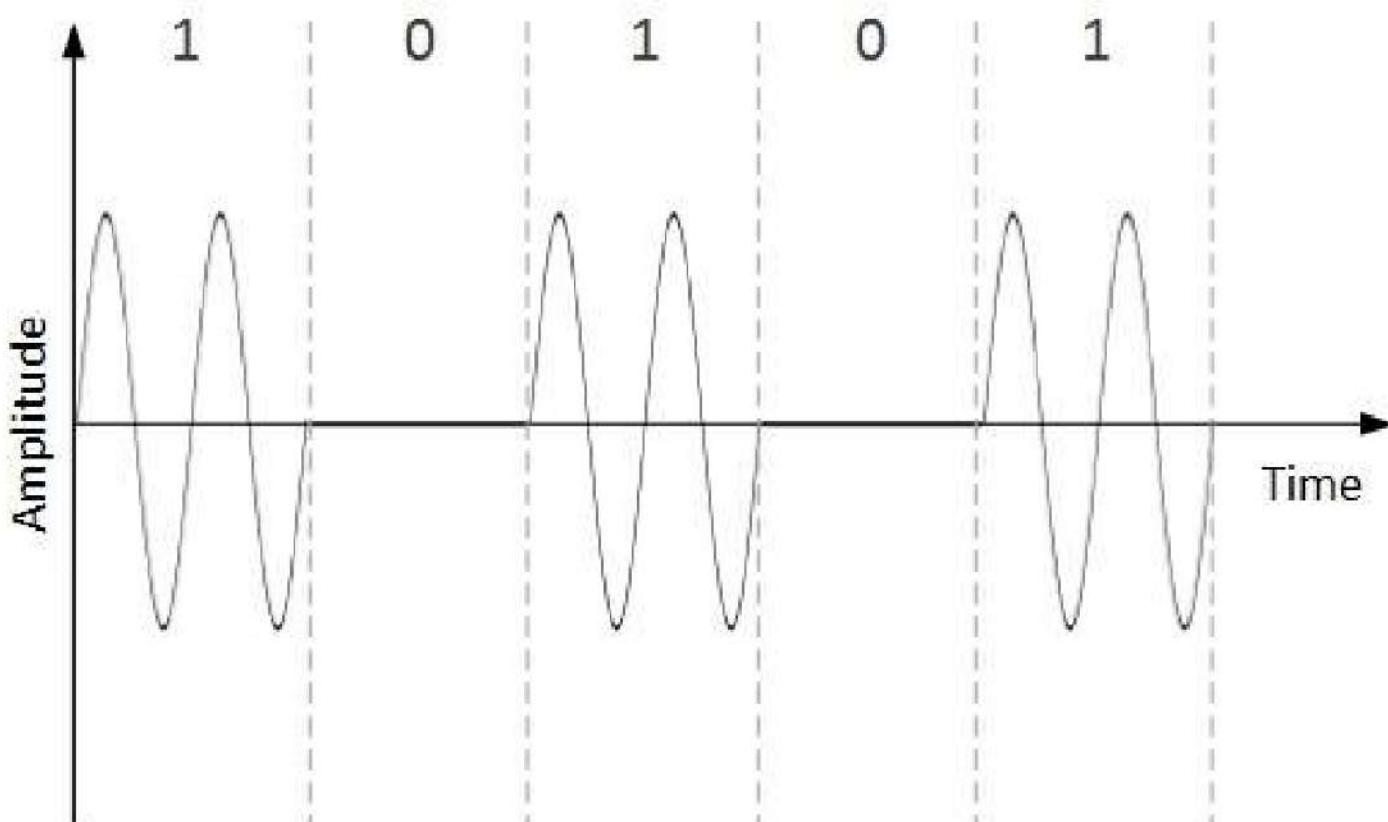
COMPUTER NETWORK #14 Analog Transmission

Digital-to-Analog Conversion :

There are three kinds of digital-to-analog conversions:

1. Amplitude Shift Keying :

In this technique, the amplitude of analog carrier signal is modified to reflect binary data.

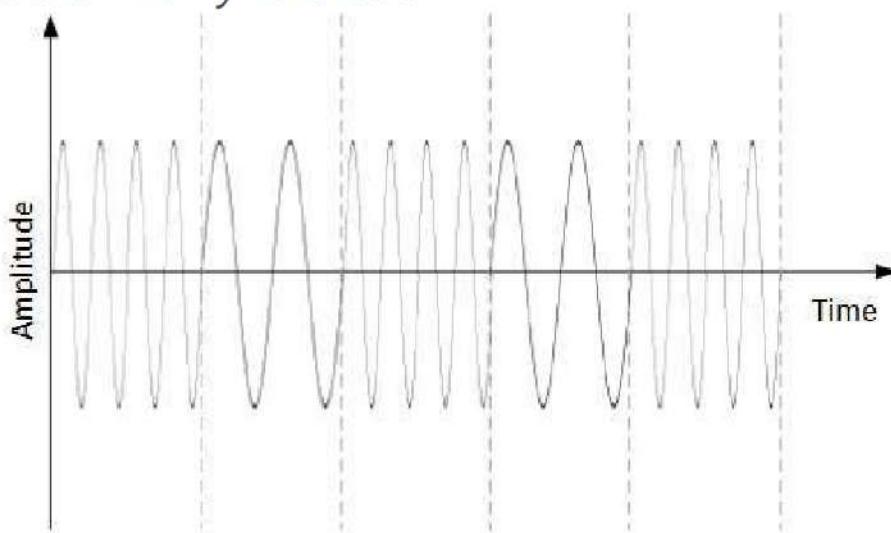


COMPUTER SCIENCE FUNDAMENTALS

COMPUTER NETWORK #15 Analog Transmission

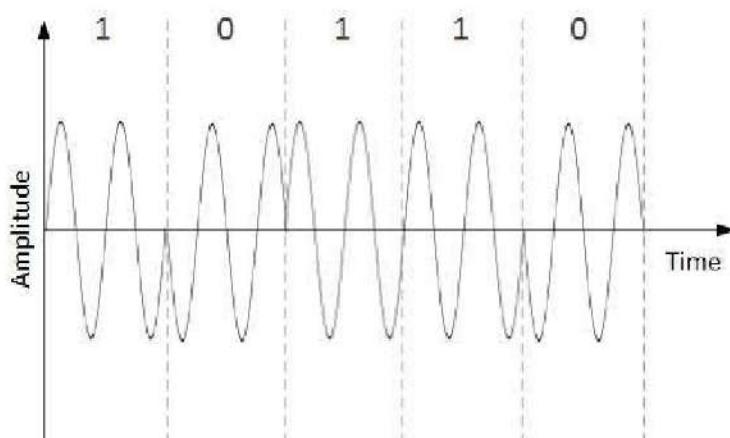
2. Frequency Shift Keying :

In this technique, the frequency of the analog carrier signal is modified to reflect binary data.



3. Phase Shift Keying :

In this technique, the phase of the original carrier signal is altered to reflect the binary data..



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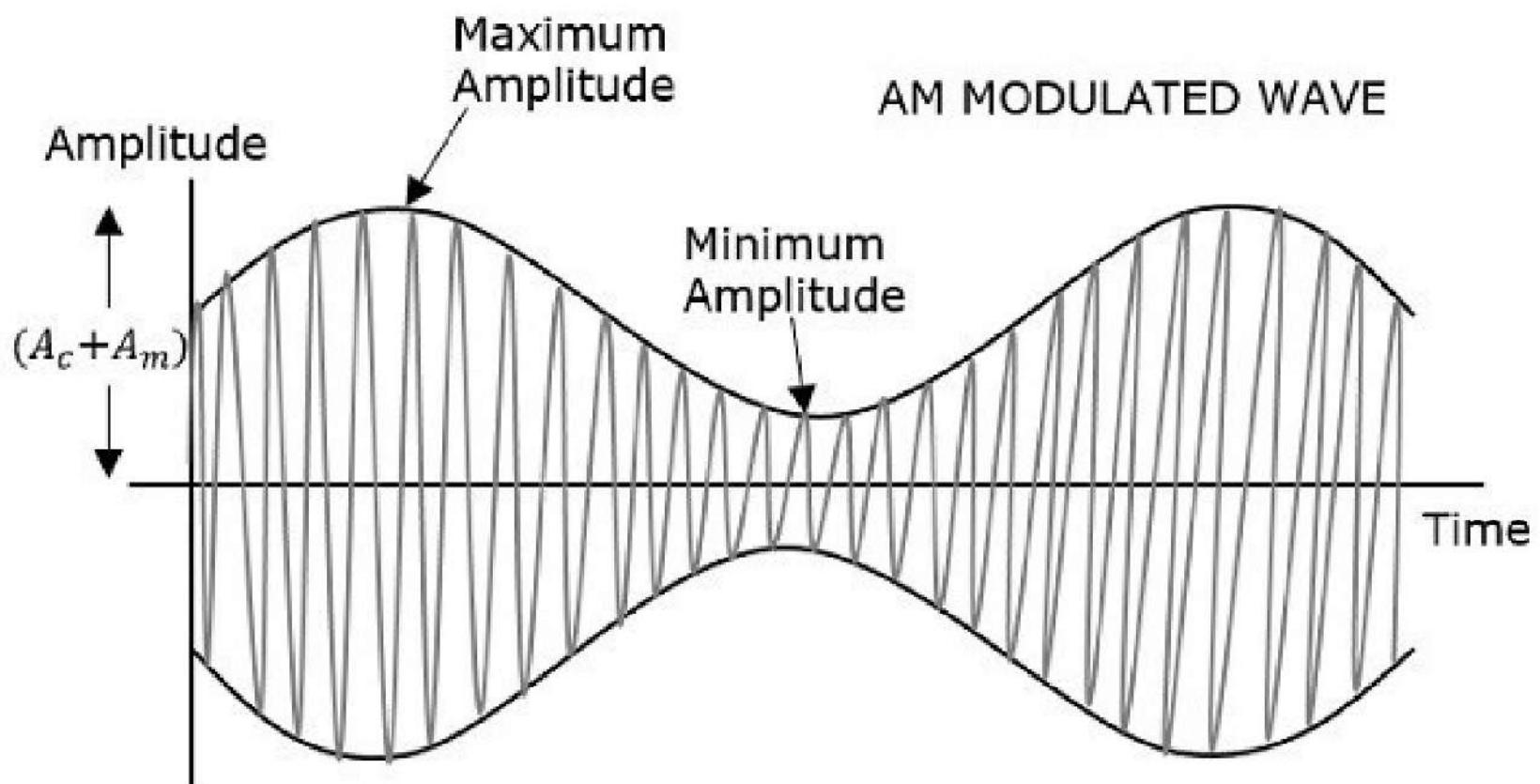
COMPUTER NETWORK #16 Analog Transmission

Analog-to-Analog Conversion :

Analog signals are modified to represent analog data. Analog to analog conversion can be done in three ways:

1. Amplitude Modulation :

In this modulation, the amplitude of the carrier signal is modified to reflect the analog data.

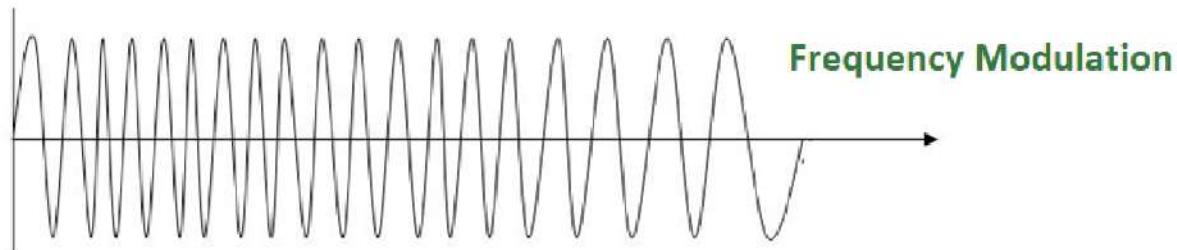


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COMPUTER NETWORK #17 Analog Transmission

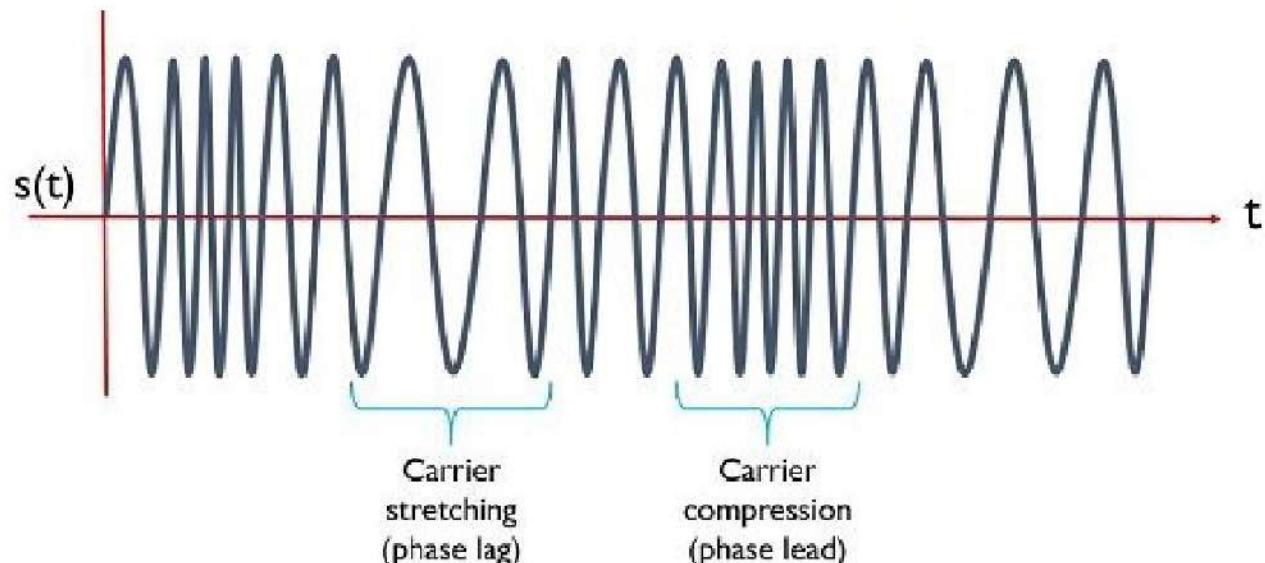
2. Frequency Modulation :

In this modulation, the frequency of the carrier signal is modified to reflect the change in the voltage levels of the modulating signal



3. Frequency Modulation :

In the technique, the phase of carrier signal is modulated in order to reflect the change in voltage of analog data signal.



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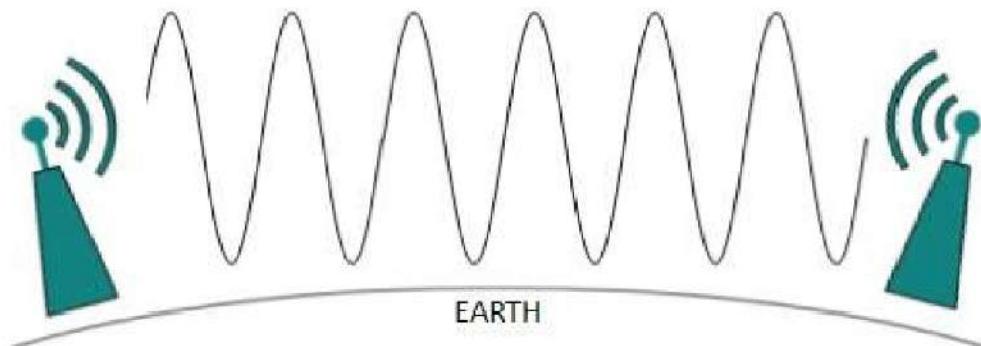
COMPUTER NETWORK #18

Wireless Transmission

Radio Transmission :

Radio frequency is easier to generate and because of its large wavelength it can penetrate through walls and structures.

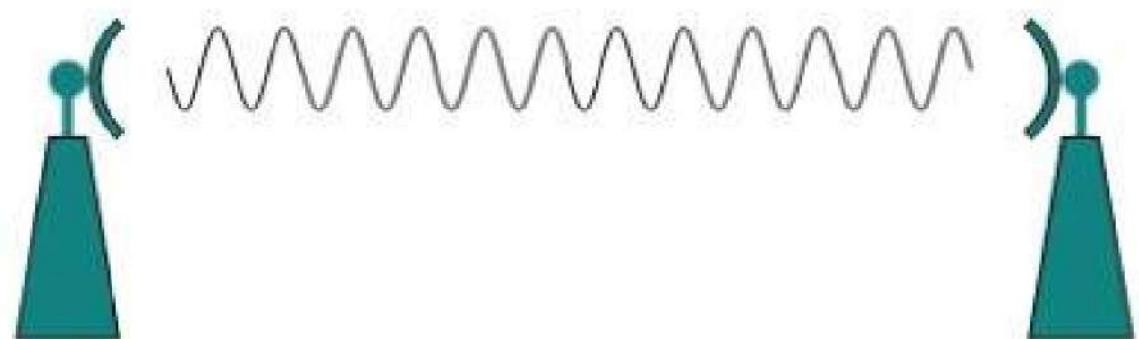
Wavelength: 1 mm to 100,000 km **Frequency:** 3 Hz to 300 GHz



Microwave Transmission :

Microwaves travel in straight lines, both sender and receiver must be aligned to be strictly in line-of-sight.

Wavelength: 1 mm – 1 meter **Frequency:** 300 MHz to 300 GHz



COMPUTER SCIENCE FUNDAMENTALS

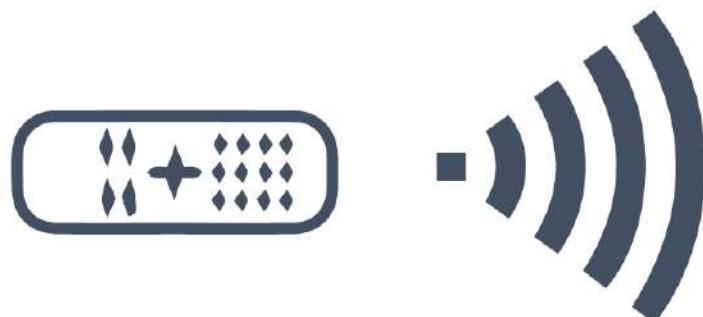
COMPUTER NETWORK #19

Wireless Transmission

Infrared Transmission :

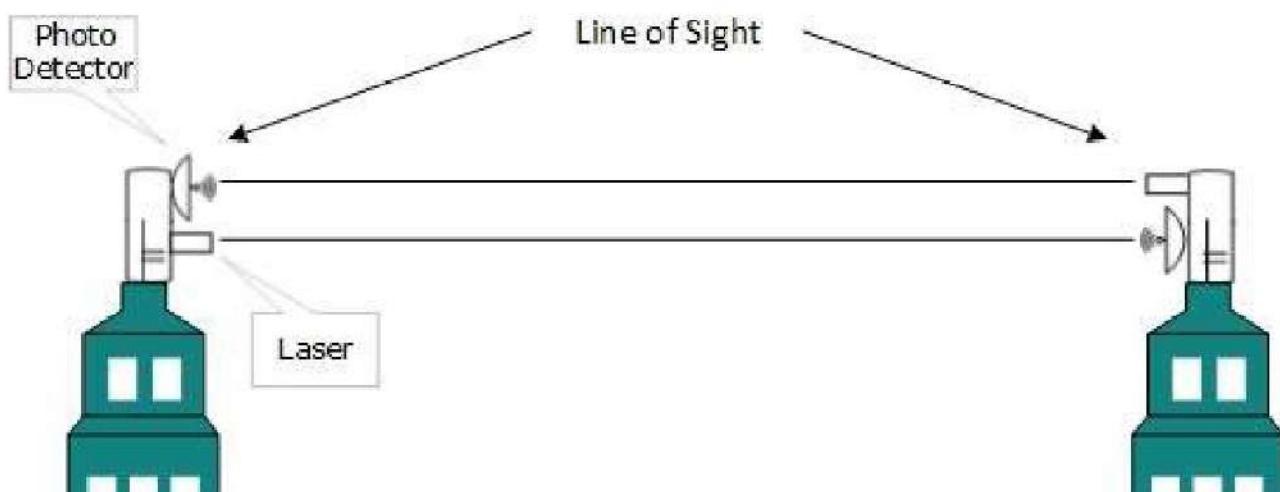
Infrared wave lies in between visible light spectrum and microwaves.

Wavelength: 700nm to 1mm **Frequency:** 300 GHz to 430 THz.



Light Transmission :

It is the highest most electromagnetic spectrum which can be used for data transmission is light or optical signaling.



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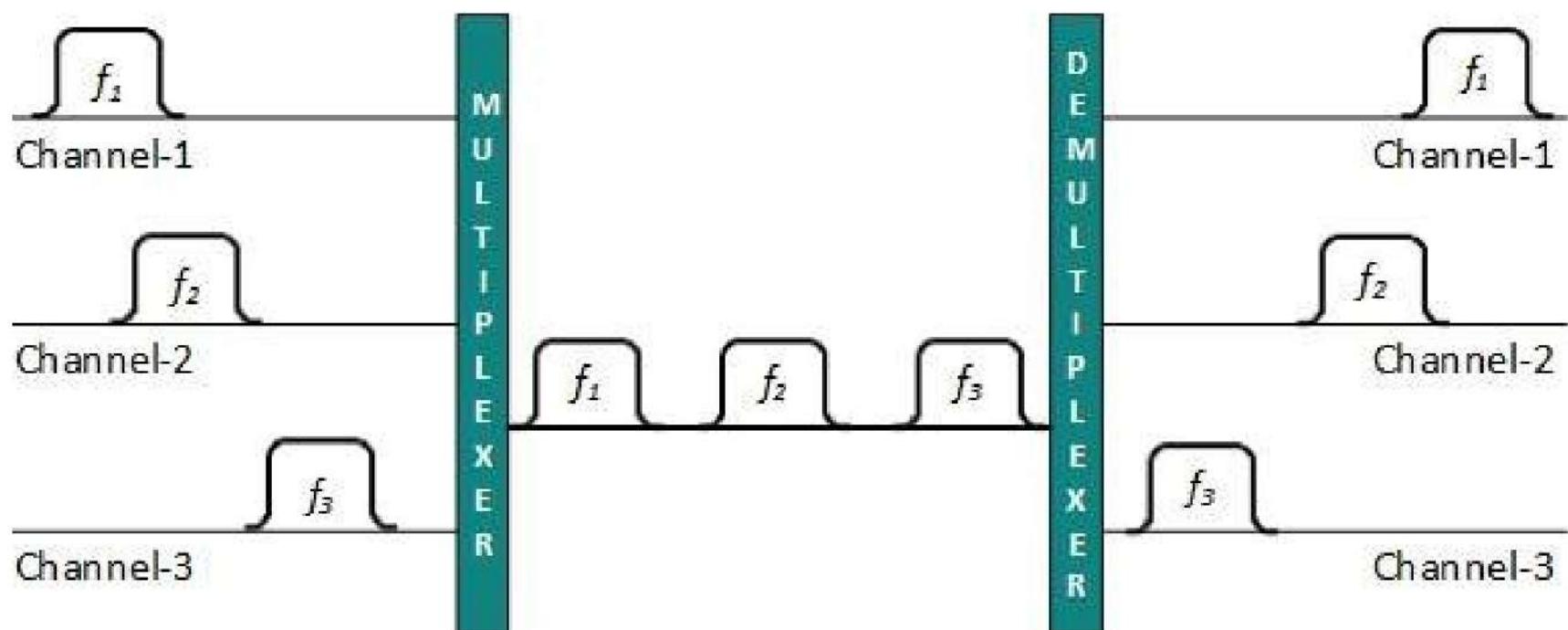
COMPUTER NETWORK #20

Multiplexing

Multiplexing divides the high capacity medium into low capacity logical medium which is then shared by different streams. It is further divided into 3 types:

1. Frequency Division Multiplexing :

It is an analog technology which divides the spectrum or carrier bandwidth in logical channels and allocates one user to each channel.



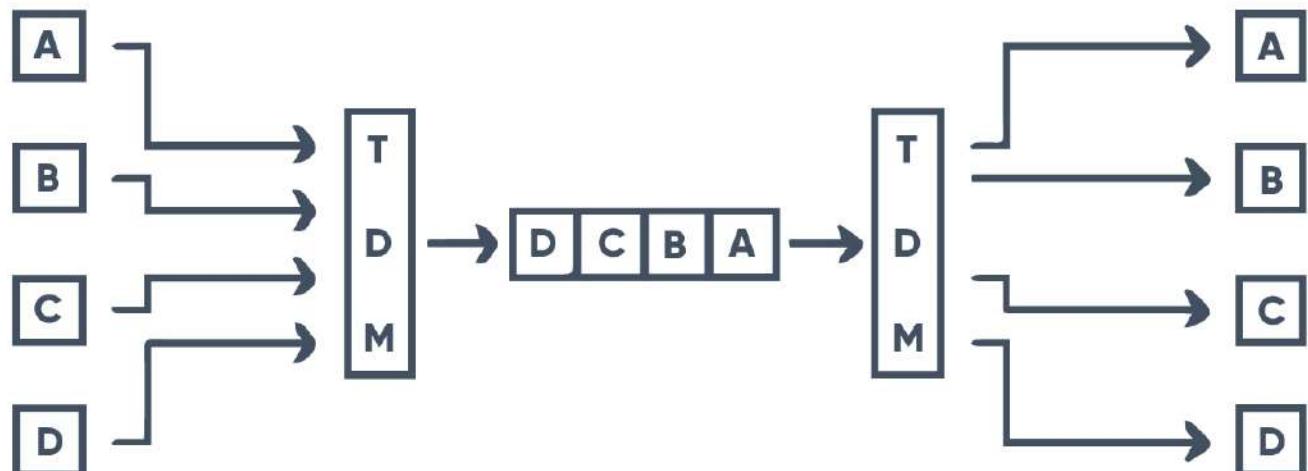
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COMPUTER NETWORK #20

Multiplexing

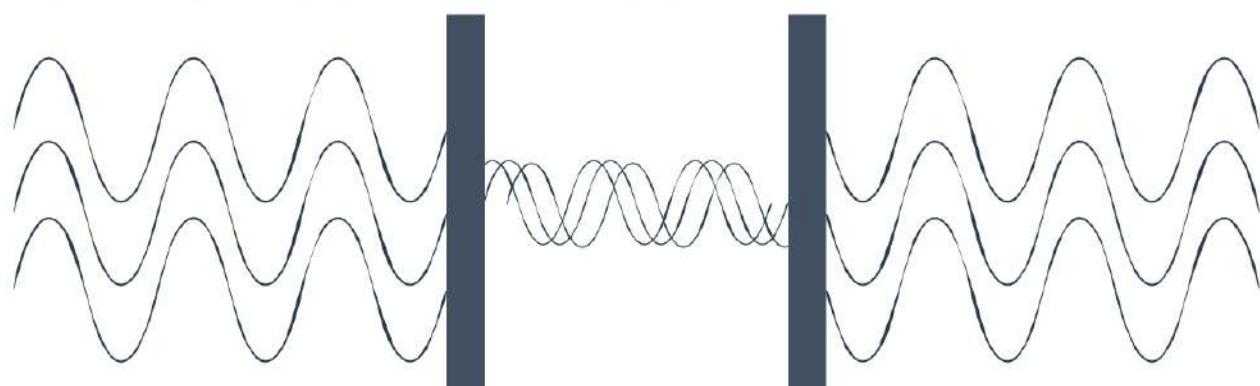
2. Time Division Multiplexing :

In Time Division Multiplexing the shared channel is divided among its user by means of time slot.



3. Wavelength Division Multiplexing :

In Wavelength Division Multiplexing the shared channel is divided among its user by means of wavelength.



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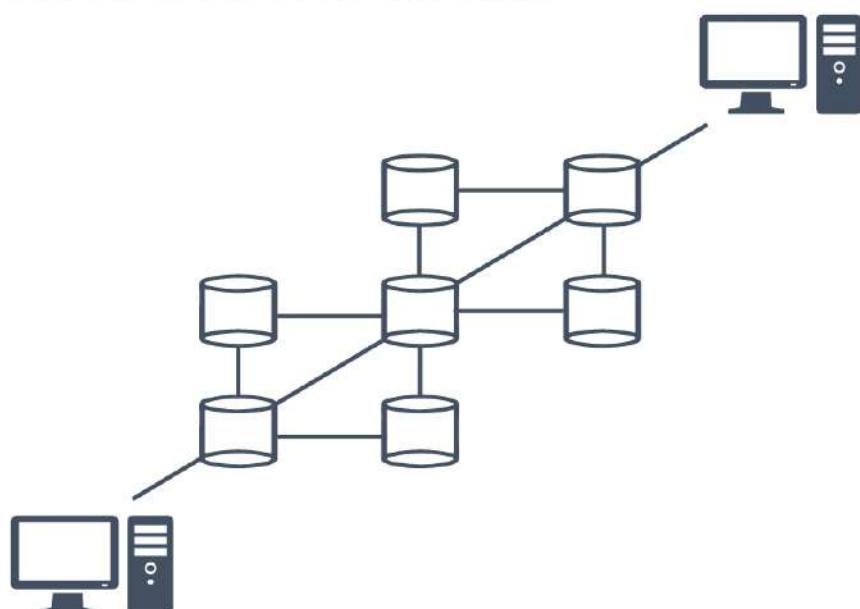
COMPUTER NETWORK #22

Network Switching

Switching is process to forward packets coming in from one port to a port leading towards the destination.

1. Circuit Switching :

- When two nodes communicate with each other over a dedicated communication path, it is called circuit switching.
- Applications which use circuit switching may have to go through three phases:
 - Establish a circuit
 - Transfer the data
 - Disconnect the circuit



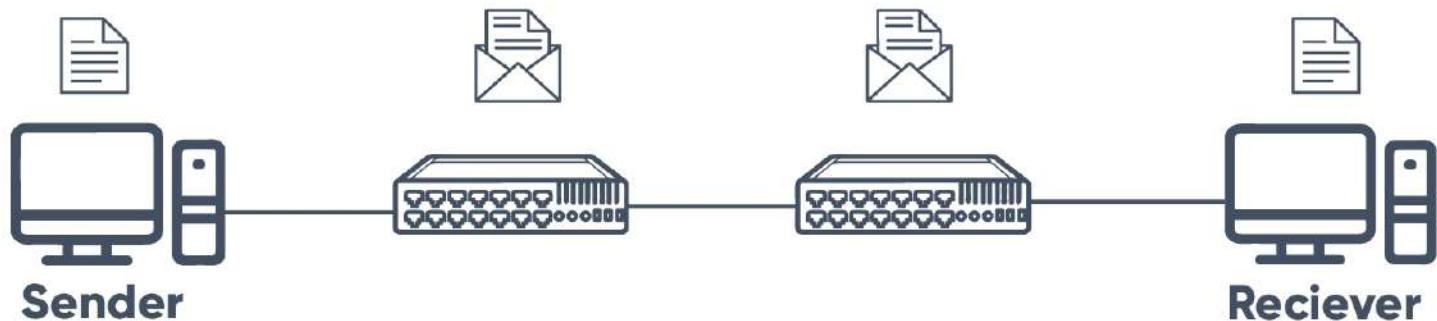
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COMPUTER NETWORK #23

Network Switching

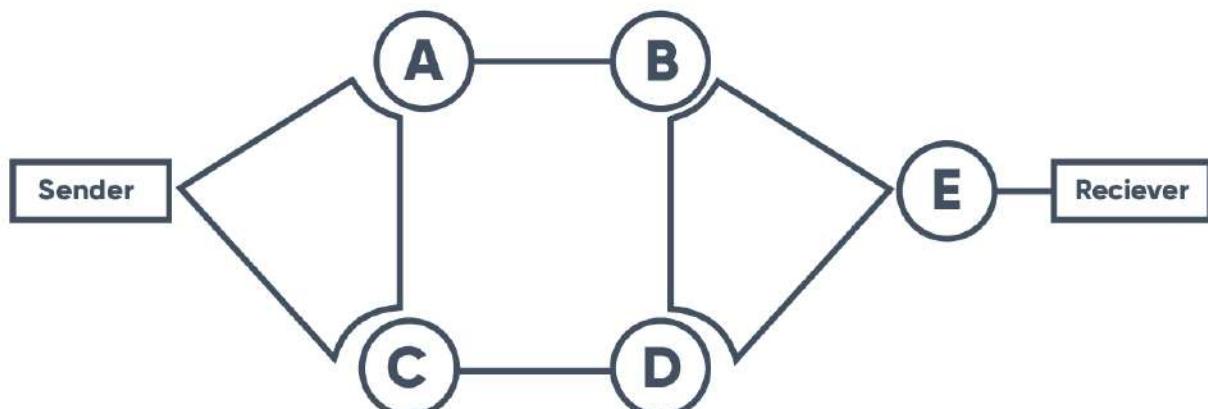
2. Message Switching :

- In message switching, the whole message is treated as a data unit and is switching / transferred in its entirety.



3. Packet Switching :

- The entire message is broken down into smaller chunks called packets. Each packet is transferred independent of other.



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COMPUTER NETWORK #24

Data-link Layer

Data Link Layer is one of the most complicated layers and has complex functionalities and liabilities.

Functionality of Data-link Layer:

- **Framing:** Data-link layer takes packets from Network Layer and encapsulates them into Frames
- **Addressing:** Data-link layer provides layer-2 hardware addressing mechanism.
- **Synchronization:** When data frames are sent on the link, it must be synchronized in order to transfer to take place.
- **Error Control:** Sometimes signals may have encountered problem in transition and the bits are flipped.
- **Flow Control:** Data-link layer ensures flow control that enables both machine to exchange data on same speed.

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COMPUTER NETWORK #25

Error Detection

Data-link layer uses some error control mechanism to ensure that frames are transmitted with certain level of accuracy.

Types of Error :

- **Single bit error:** In a frame, there is only one bit, anywhere though which is corrupt.



- **Multiple bits error:** Frame is received with more than one bits in corrupted state.



- **Burst error:** Frame contains more than 1 consecutive bits corrupted.



COMPUTER SCIENCE FUNDAMENTALS

COMPUTER NETWORK #25

Error Detection

Errors in the received frames are detected by :

Parity Check :

- One extra bit is sent along with the original bits to make number of 1s either even in case of even parity, or odd in case of odd parity.



Cyclic Redundancy Check (CRC) :

- CRC is a different approach to detect if the received frame contains valid data. This technique involves binary division of the data bits being sent.

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COMPUTER NETWORK #26

Error Correction

Errors Correction can be done in two ways :

Backward Error Correction :

- When the receiver detects an error in the data received, it requests back the sender to retransmit the data unit.
- It is a simple and can only be efficiently used where retransmitting is not expensive. Example: Optic Fiber

Forward Error Correction :

- When the receiver detects some error in the data received, it executes error correcting code, which helps it to auto-recover and to correct some kinds of errors.
- In case of wireless transmission retransmitting may cost too much, so Forward error correction is used.

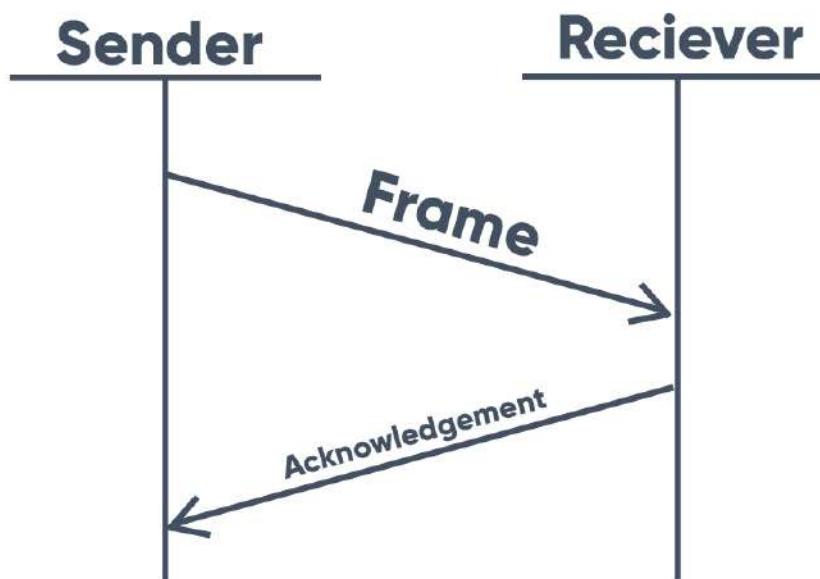
COMPUTER SCIENCE FUNDAMENTALS

COMPUTER NETWORK #27

Data-link Control & Protocols

Flow Control :

- Two types of mechanisms can be deployed to control the flow:
- **Stop and Wait** : This flow control mechanism forces the sender after transmitting a data frame to stop and wait until the acknowledgement of the data-frame sent is received.



- **Sliding Window** : This flow control mechanism, both sender and receiver agree on the number of data-frames after which the acknowledgement should be sent.

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COMPUTER NETWORK #28

Data-link Control & Protocols

Error Control :

- When data-frame is transmitted, there is a probability that data-frame may be lost in the transit or it is received corrupted.
- **Error detection :** The sender and receiver, either both or any, must ascertain that there is some error in the transit.
- **Positive ACK:** When the receiver receives a correct frame, it should acknowledge it.
- **Negative ACK:** When the receiver receives a damaged frame or a duplicate frame, it sends a NACK back to the sender.
- **Retransmission:** If an acknowledgement of a data-frame previously transmitted does not arrive before the timeout the sender retransmits the frame again.

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COMPUTER NETWORK #29

Network Layer

Network layer manages options pertaining to host and network addressing, managing sub-networks, and internetworking.

Network Layer Features:

- Quality of service management.
- Load balancing and link management.
- Security.
- Interrelation of different protocols and subnets with different schema.
- Different logical network design over the physical network design.
- Layer3 VPN and tunnels can be used to provide end to end dedicated connectivity.

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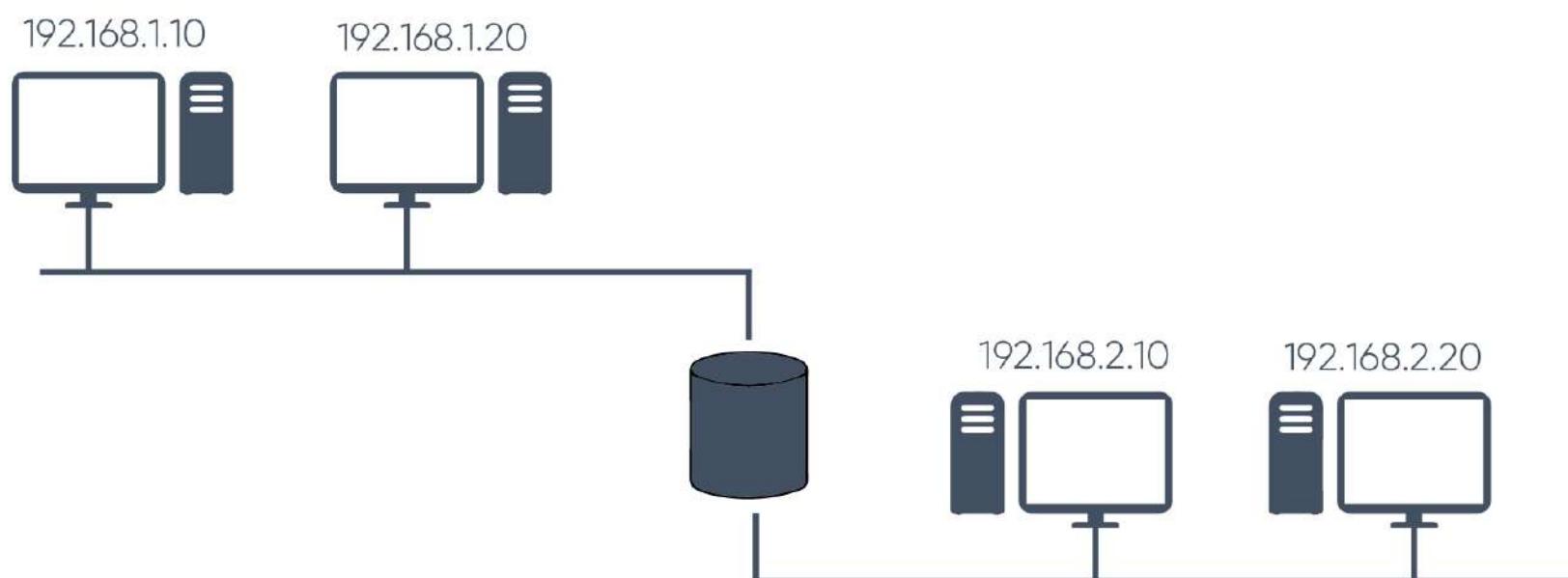
COMPUTER NETWORK #30

Network Addressing

Network Addresses are always logical i.e. these are software based addresses which can be changed by appropriate configurations.

There are different kinds of network addresses in existence:

- IP
- IPX
- AppleTalk



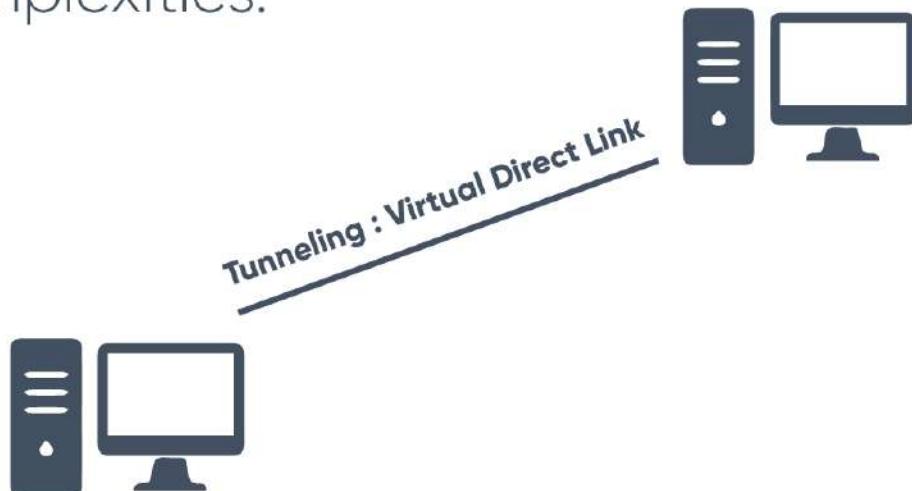
COMPUTER SCIENCE FUNDAMENTALS

COMPUTER NETWORK #32

Internetworking

Tunneling :

- Tunneling is a mechanism by which two or more same networks communicate with each other, by passing intermediate networking complexities.



Packet Fragmentation :

- A data packet can have more or less packet length depending upon the application.
- Devices in the transit path also have their hardware and software capabilities which tell what amount of data that device can handle and what size of packet it can process.

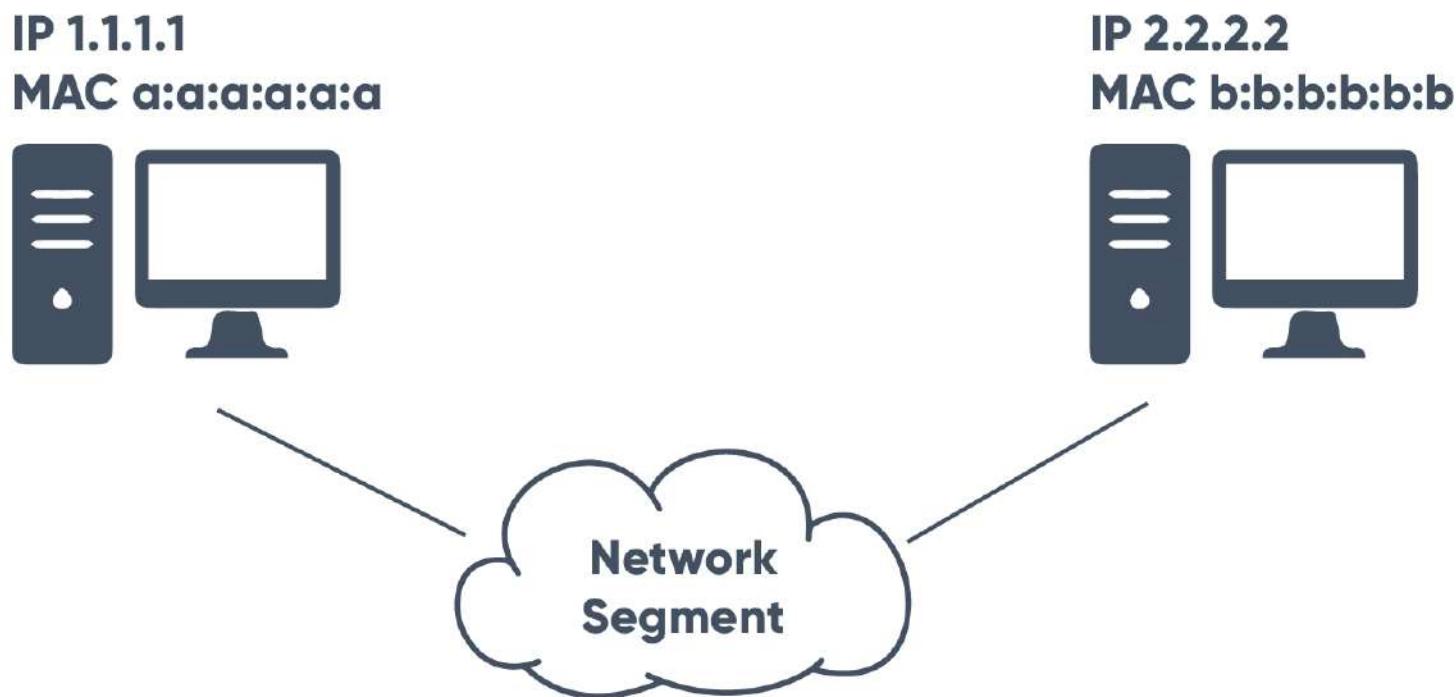
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COMPUTER NETWORK #33

Network Layer Protocols

Address Resolution Protocol (ARP) :

- ARP is a protocol that connects an ever-changing IP address to a fixed physical machine address, also known as a media access control (MAC) address.



Internet Control Message Protocol (ICMP) :

- ICMP is network diagnostic and error reporting protocol. It belongs to IP protocol suite and uses IP as carrier protocol.

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COMPUTER NETWORK #34 Network Layer Protocols

Internet Protocol Version 4 (IPv4) :

IPv4 is 32-bit addressing scheme used as TCP/IP host addressing mechanism. It is divided into:

- **Class A** : it uses first octet for network addresses and last three octets for host addressing
- **Class B** : it uses first two octets for network addresses and last two for host addressing
- **Class C** : it uses first three octets for network addresses and last one for host addressing
- **Class D** : it provides flat IP addressing scheme in contrast to hierarchical structure for above three.
- **Class E** : It is used as experimental.

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COMPUTER NETWORK #35

Transport Layer

Transport layer offers peer-to-peer and end-to-end connection between two processes on remote hosts.

Functions :

- This Layer is the first one which breaks the information data, supplied by Application layer in to smaller units called segments.
- This layer ensures that data must be received in the same sequence in which it was sent.
- This layer provides end-to-end delivery of data between hosts which may or may not belong to the same subnet.

Types of Transport Protocol :

- **Transmission Control Protocol** : It provides reliable communication between two hosts.
- **User Datagram Protocol** : It provides unreliable communication between two hosts.

COMPUTER SCIENCE FUNDAMENTALS

COMPUTER NETWORK #36

Transmission Control Protocol

TCP is used for data transmission in communication network such as internet.

Features :

- TCP provides error-checking and recovery mechanism.
- TCP provides end-to-end communication.
- TCP operates in Client/Server point-to-point mode.
- TCP provides flow control and quality of service.

Addressing :

TCP communication between two remote hosts is done by means of port numbers ranges from 0 – 65535.

- System Ports (**0 – 1023**)
- User Ports (**1024 – 49151**)
- Private/Dynamic Ports (**49152 – 65535**)

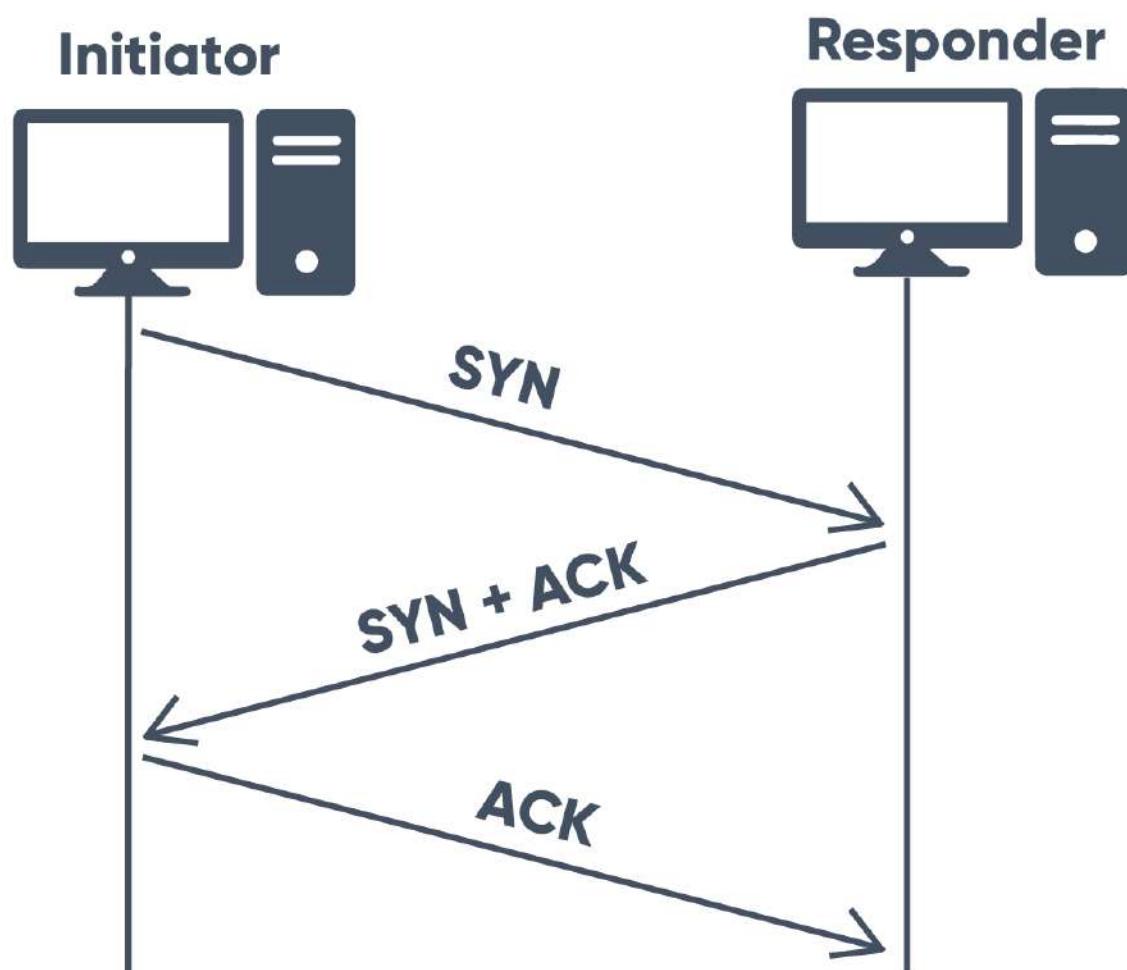
COMPUTER SCIENCE FUNDAMENTALS

COMPUTER NETWORK #37

Transmission Control Protocol

Connection Management :

- TCP communication works in Server/Client model.
- The client initiates the connection and the server either accepts or rejects it.



COMPUTER SCIENCE FUNDAMENTALS

COMPUTER NETWORK #38

Transmission Control Protocol

Bandwidth Management :

- TCP uses the concept of window size to accommodate the need of Bandwidth management.
- TCP uses slow start phase by using window size 1 and increases the window size exponentially after each successful communication.

Error & Flow Control :

- TCP uses port numbers to know what application process it needs to handover the data segment.
- The Sender knows which last data segment was received by the Receiver when it gets ACK.
- The Receiver knows about the last segment sent by the Sender by referring to the sequence number of recently received packet.

COMPUTER SCIENCE FUNDAMENTALS

COMPUTER NETWORK #39

User Datagram Protocol

The User Datagram Protocol (UDP) is simplest Transport Layer communication protocol available of the TCP/IP protocol suite.

Features :

- UDP is used when acknowledgement of data does not hold any significance.
- UDP is simple and suitable for query based communications.
- UDP is suitable protocol for streaming applications such as VoIP, multimedia streaming.

UDP application :

- Domain Name Services
- Simple Network Management Protocol
- Trivial File Transfer Protocol
- Routing Information Protocol
- Kerberos

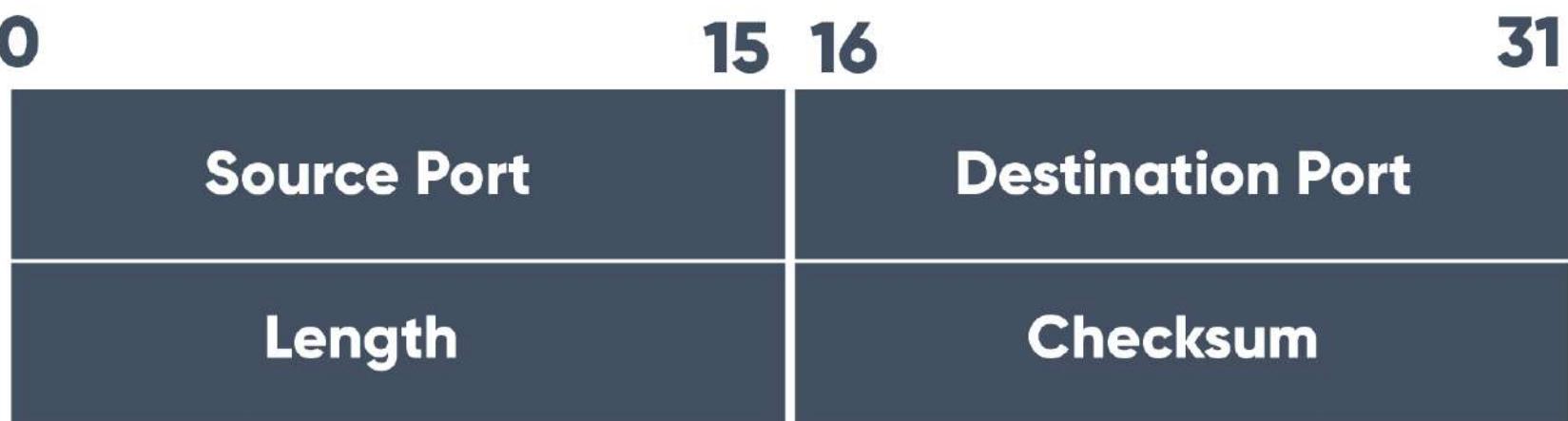
COMPUTER SCIENCE FUNDAMENTALS

COMPUTER NETWORK #40

User Datagram Protocol

UDP Header :

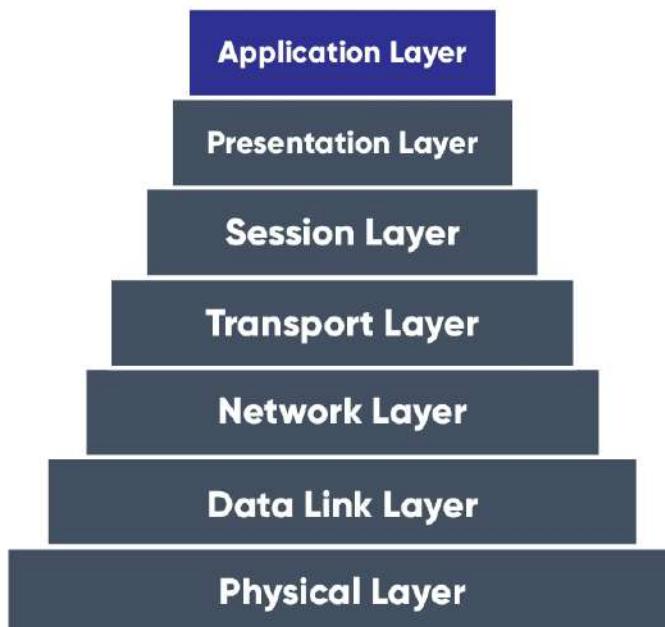
- **Source Port** - This 16 bits information is used to identify the source port of the packet.
- **Destination Port** - This 16 bits information, is used identify application level service on destination machine.
- **Length** - Length field specifies the entire length of UDP packet.
- **Checksum** - This field stores the checksum value generated by the sender before sending.



COMPUTER SCIENCE FUNDAMENTALS

COMPUTER NETWORK #41 Application Layer

- Application layer is the top most layer in OSI and TCP/IP layered model.
- This layer is for applications which are involved in communication system.
- This layer is on the top of the layer stack, it does not serve any other layers.
- Application layer takes the help of Transport and all layers below it to communicate or transfer its data to the remote host.

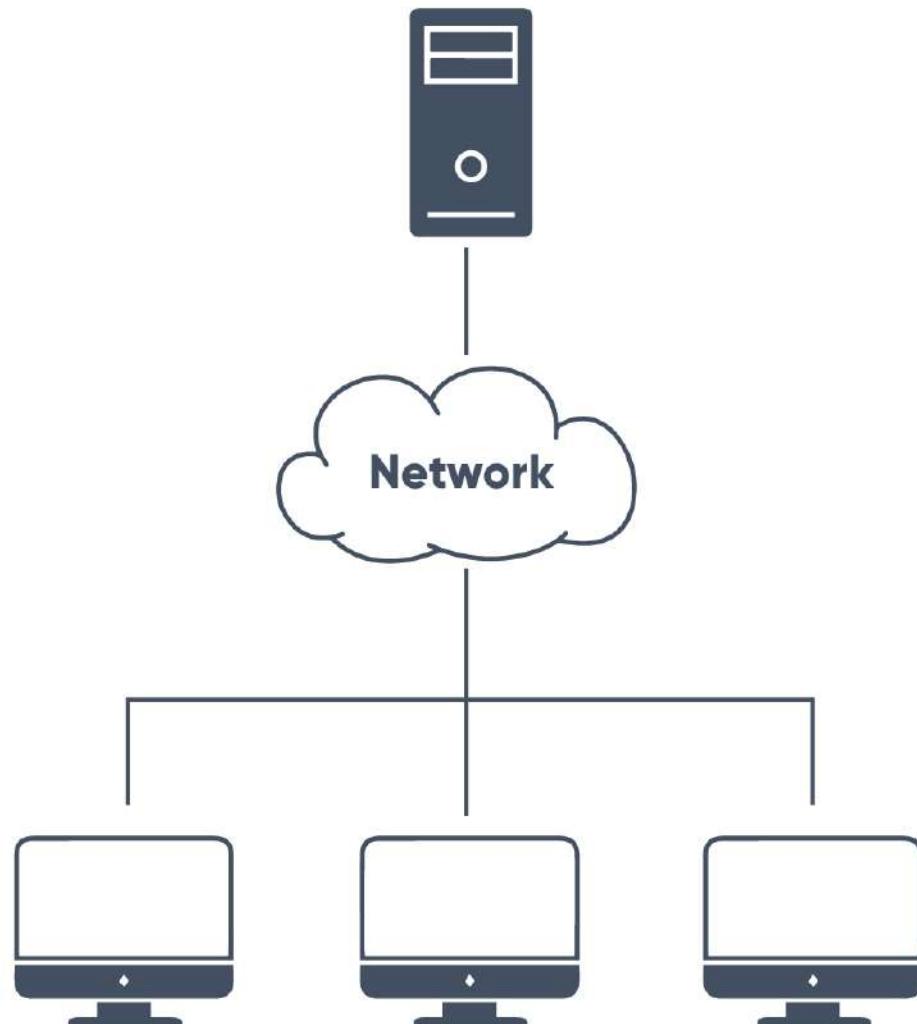


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COMPUTER NETWORK #42

Client Server Model

- **Peer-to-peer:** Both remote processes are executing at same level and they exchange data using some shared resource.
- **Client-Server:** One remote process acts as a Client and requests some resource from another application process acting as Server.



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COMPUTER NETWORK #43

Application Protocols

Domain Name System :

- The DNS works on Client Server model and It uses UDP protocol for transport layer communication.
- The DNS server is configured with Fully Qualified Domain Names (FQDN) and email addresses mapped with their respective IP addresses.

Simple Mail Transfer Protocol :

- The SMTP is used to transfer electronic mail from one user to another.
- While SMTP is used by end user to only send the emails, the Servers normally use SMTP to send as well as receive emails.
- SMTP uses TCP port number 25 and 587.

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COMPUTER NETWORK #44

Application Protocols

File Transfer Protocol :

- The FTP is the most widely used protocol for file transfer over the network.
- FTP works on Client/Server Model where a client requests file from Server and server sends requested resource back to the client.

Post Office Protocol (POP) :

- The POP 3 is a simple mail retrieval protocol used by User Agents to retrieve mails from mail server.

Hyper Text Transfer Protocol (HTTP) :

- When a user wants to access any HTTP page on the internet, the client machine at user end initiates a TCP connection to server on port 80.
- The Hyper Text Transfer Protocol (HTTP) is the foundation of World Wide Web.

COMPUTER SCIENCE FUNDAMENTALS

COMPUTER NETWORK #45

Network Services

Directory Services :

- **Accounting:** Directory Services provide means of storing this information in cryptic form and make available when requested.
- **Authentication:** User credentials are checked to authenticate a user at the time of login and/or periodically.
- **Domain Name Services:** DNS is widely used and one of the essential services on which internet works.

File Services :

- **File Sharing:** File sharing enables its users to share their data with other users. User can upload the file to a specific server.
- **File Transfer:** Network enables its user to locate other users in the network and transfers files.

COMPUTER SCIENCE FUNDAMENTALS

COMPUTER NETWORK #46

Network Services

Communication Services :

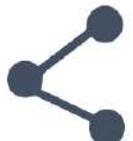
- **Email:** Electronic mail is a communication method and something a computer user cannot work without.
- **Social Networking:** The computer savvy peoples, can find other known peoples, can connect with them, and can share thoughts, pictures, and videos.
- **Internet Chat:** Internet chat provides instant text transfer services between two hosts
- **Discussion Boards:** Discussion boards provide a mechanism to connect multiple peoples with same interests.
- **Remote Access:** This service enables user to access the data residing on the remote computer.

COMPUTER SCIENCE FUNDAMENTALS

COMPUTER NETWORK #47

Network Services

Application Services :



Resource Sharing: To use resources efficiently and economically, network provides a mean to share them.



Databases: This application service is one of the most important services. It stores data and information, processes it.



Web Services: World Wide Web has become the synonym for internet. It is used to connect to the internet, and access files and information services provided by the internet servers.



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