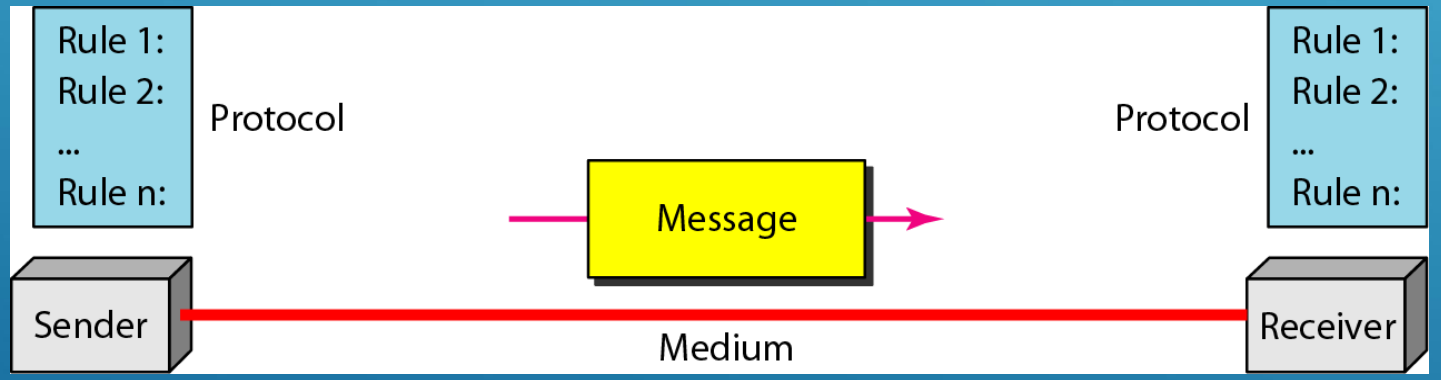
Subject Name : DATA COMMUNICATION
Subject Code : 28554
Semester : 5th
Department : Computer Science & Engineering
Institute : Sherpur Polytechnic Institute

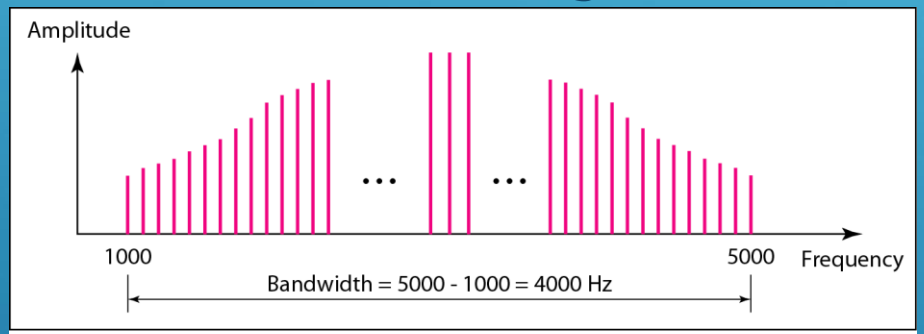
FIVE COMPONENTS OF DATA COMMUNICATION

- Message: Information(data) to be communicated
- Sender
- Receiver
- Transmission medium: Physical path by which a message travels
- Protocol: A set of rules that govern data communication

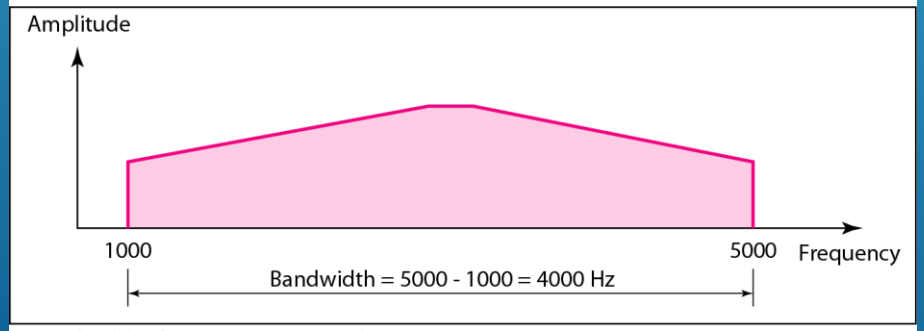


BANDWIDTH

- The bandwidth of a composite signal is the difference between the highest and the lowest frequencies contained in that signal



a. Bandwidth of a periodic signal

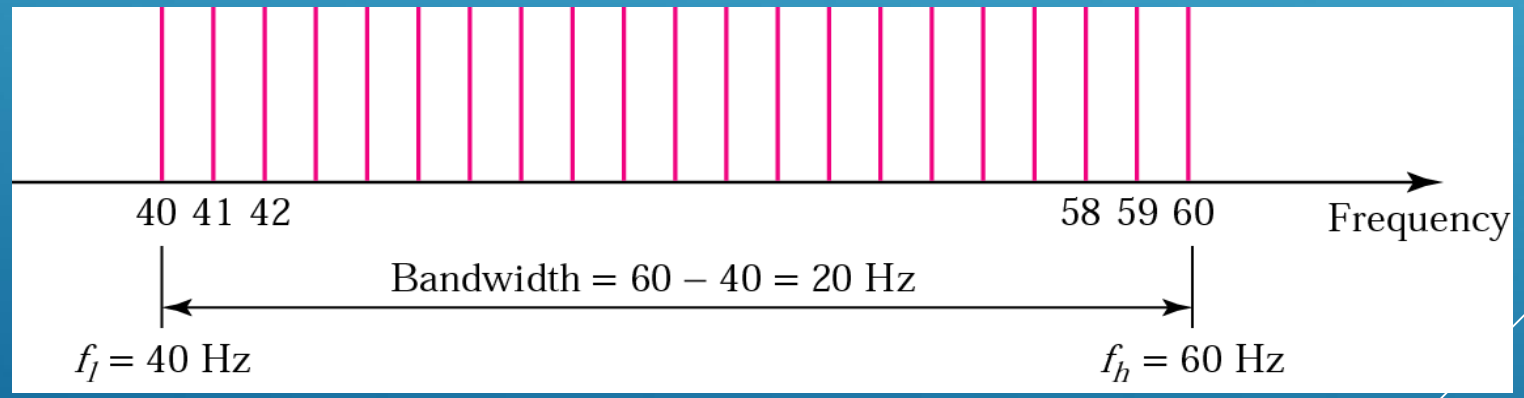


b. Bandwidth of a nonperiodic signal

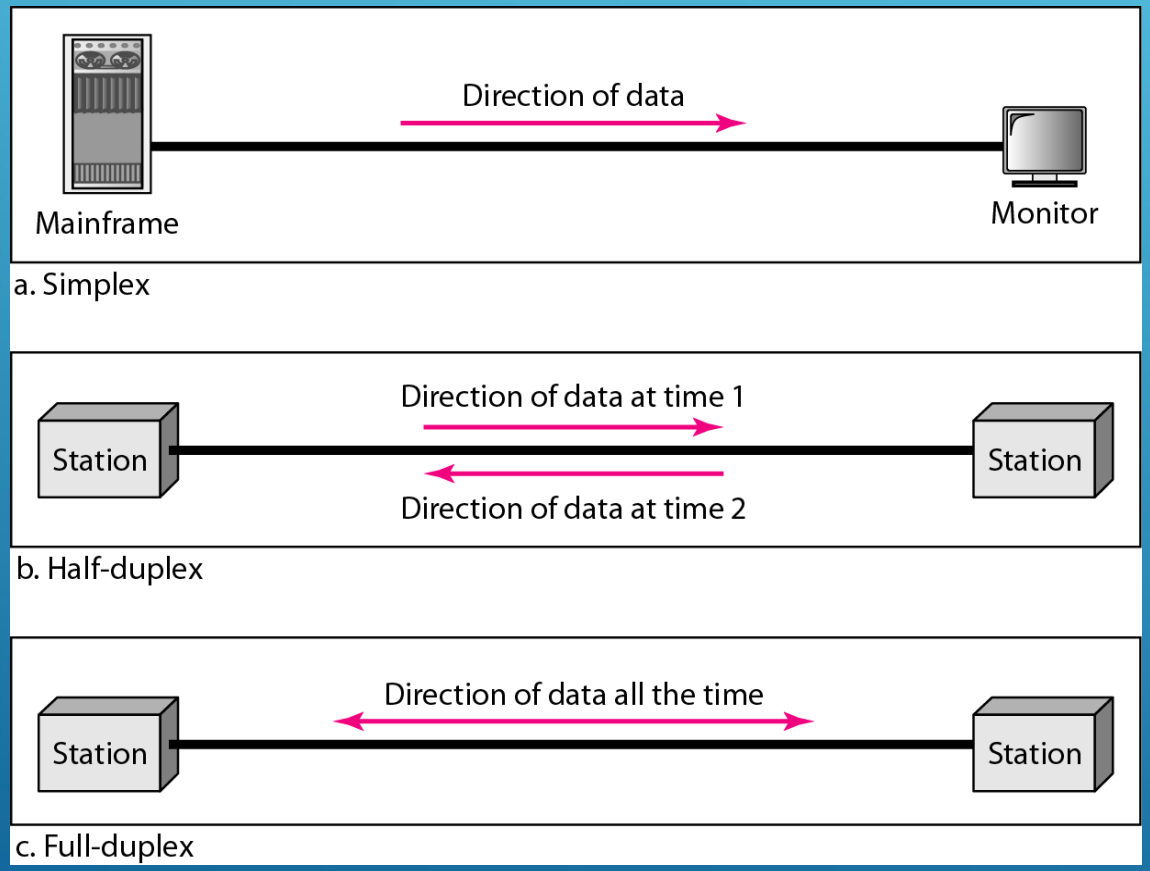
EXAMPLE 3.11

- A signal has a bandwidth of 20 Hz. The highest frequency is 60 Hz. What is the lowest frequency? Draw the spectrum if the signal contains all integral frequencies of the same amplitude

$$B = f_h - f_l, \quad 20 = 60 - f_l, \quad f_l = 60 - 20 = 40 \text{ Hz}$$



DIRECTION OF DATA FLOW

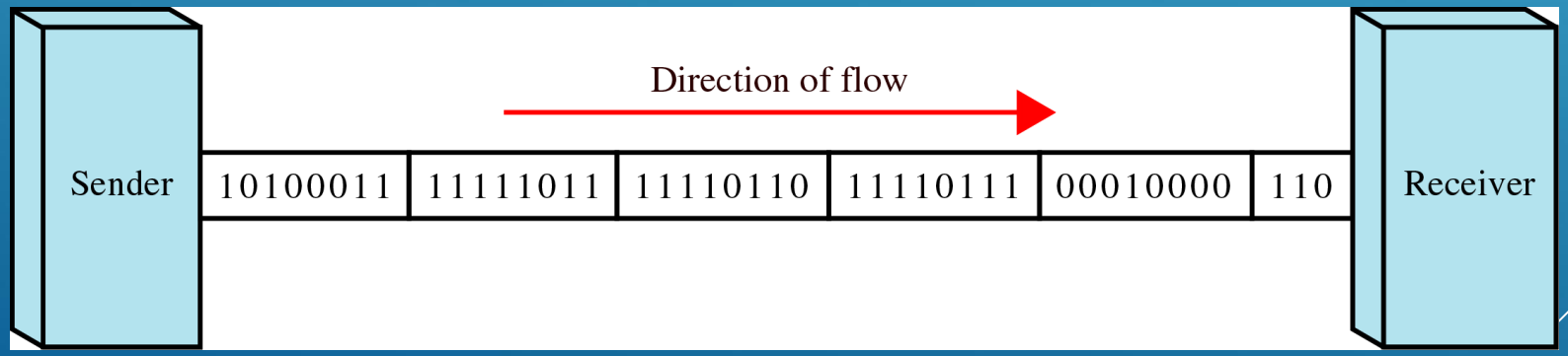


DATA FLOW

- Simplex
  - Unidirectional
  - As on a one-way street
- Half-duplex
  - Both transmit and receive possible, but not at the same time
  - Like a one-lane road with two-directional traffic
  - Walkie-talkie, CB radio
- Full-duplex
  - Transmit and receive simultaneously
  - Like a two-way street, telephone network
  - Channel capacity must be divided between two directions

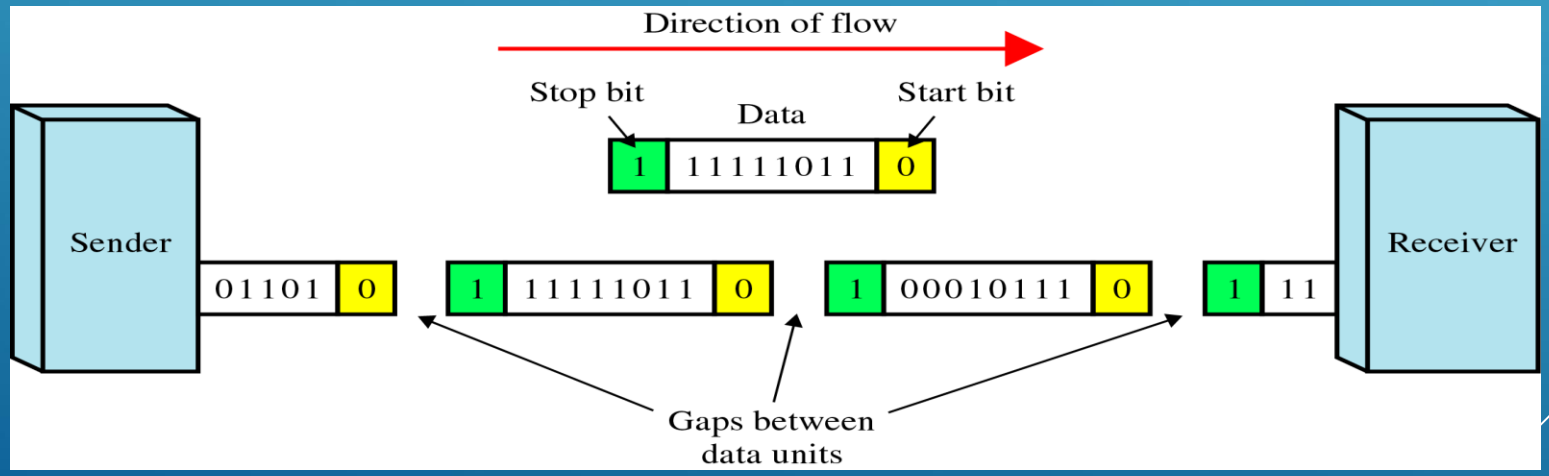
SYNCHRONOUS TRANSMISSION

- Bit stream is combined into "frames"
- Special sequence of 1/0 between frames: No gap
- Timing is important in midstream
- Byte synchronization in the data link layer
- Advantage: speed ⇒ high-speed transmission



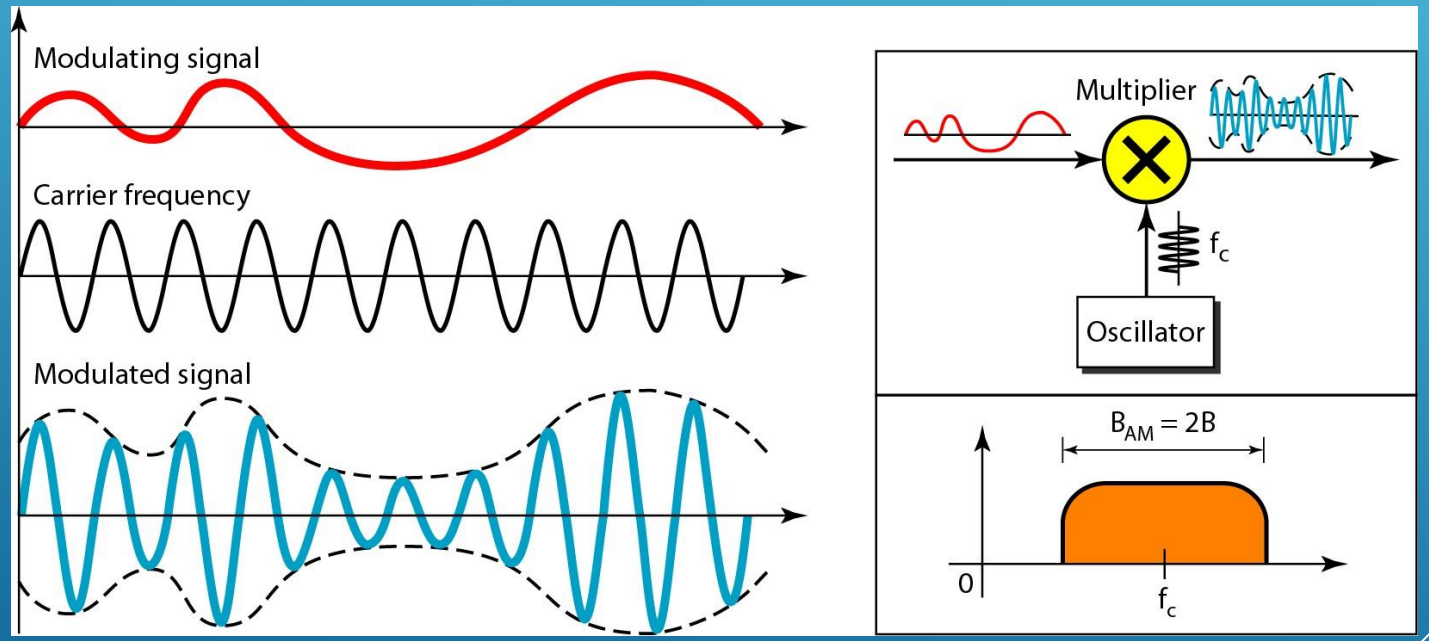
ASYNCHRONOUS TRANSMISSION

- Use *start bit* (0) and *stop bits* (1s)
- A gap between two bytes: idle state or stop bits
- It means asynchronous at byte level
- Must still be synchronized at bit level
- Good for low-speed communications (terminal)



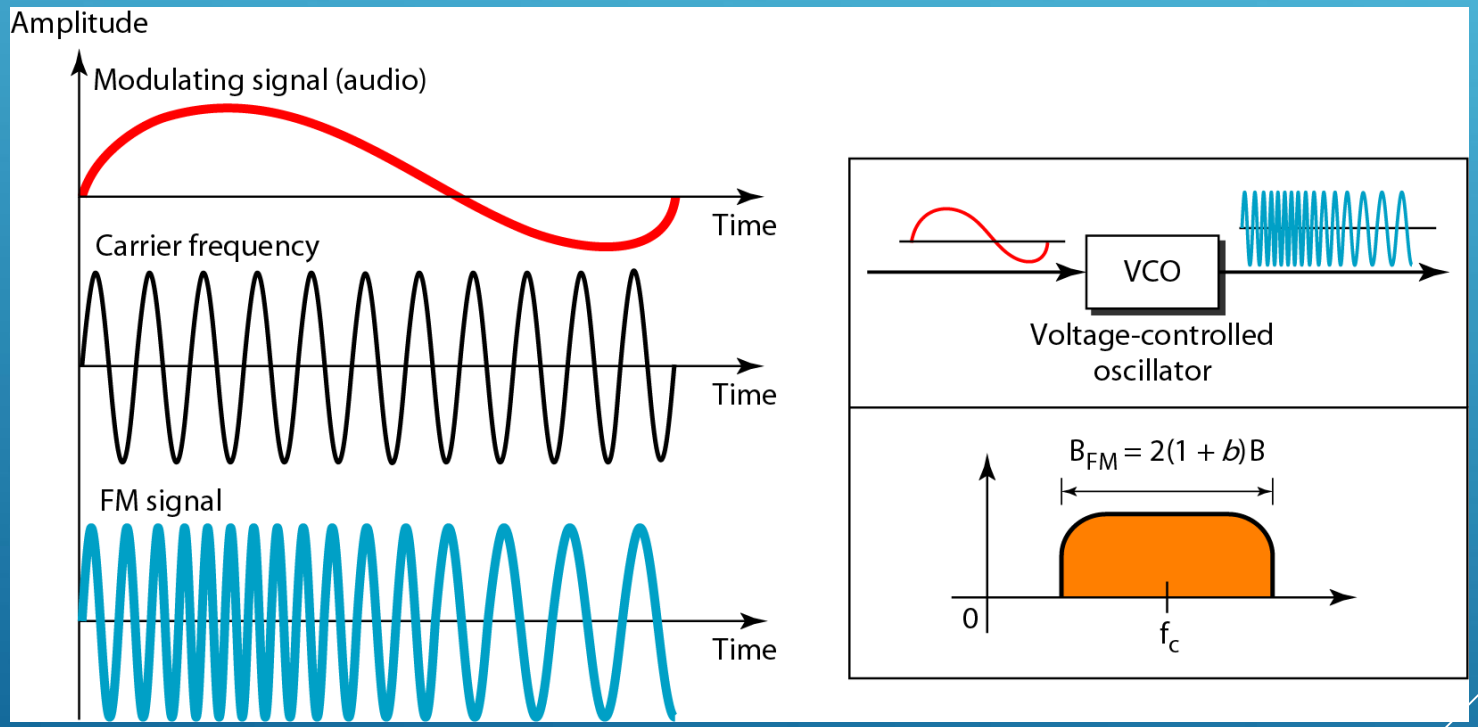
AMPLITUDE MODULATION

- The total bandwidth required for AM can be determined from the bandwidth of the audio signal: $B_{AM} = 2B$.



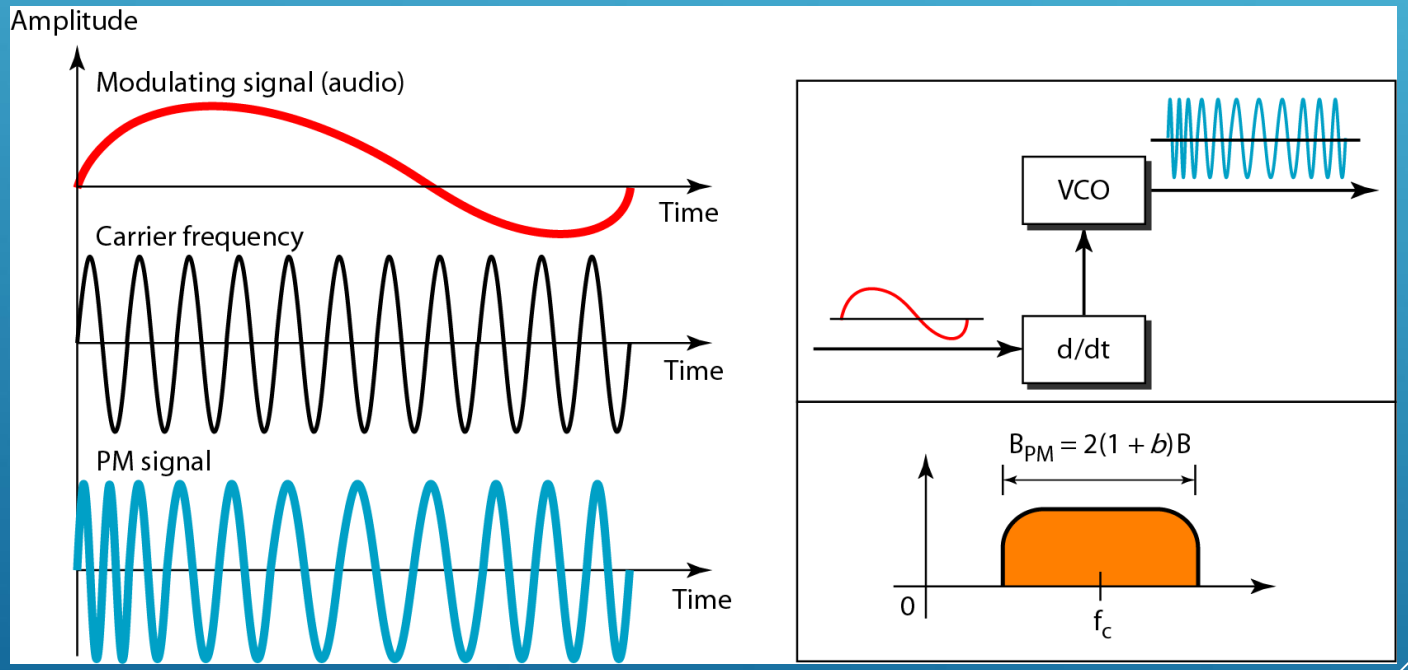
FREQUENCY MODULATION

- The total bandwidth required for FM can be determined from the bandwidth of the audio signal: $B_{FM} = 2(1 + \beta)B$.



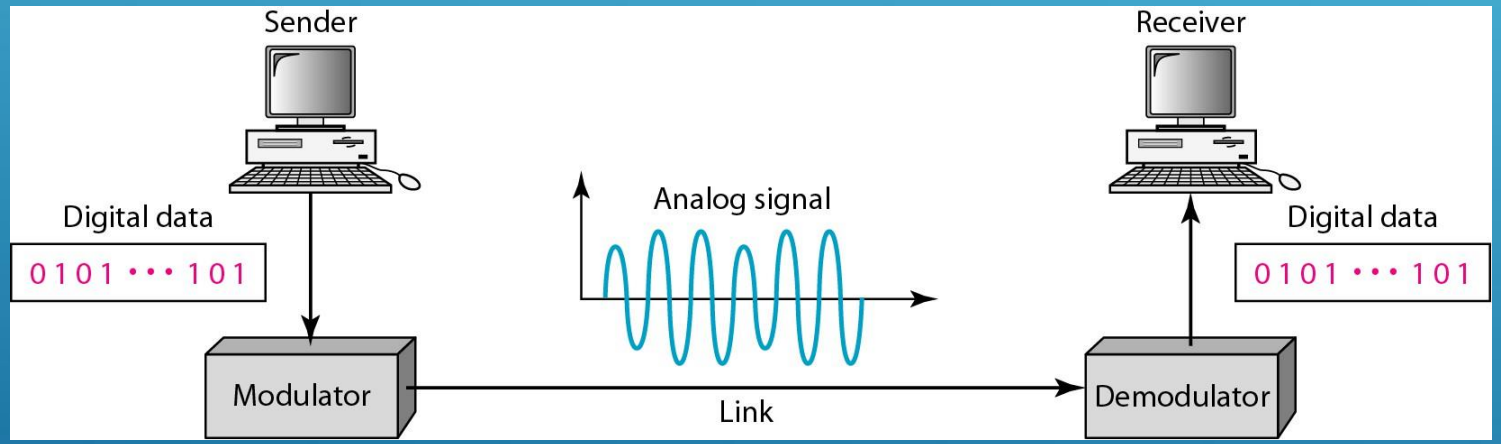
PHASE MODULATION

- The total bandwidth required for PM can be determined from the bandwidth and maximum amplitude of the modulating signal: $B_{PM} = 2(1 + \beta)B$.

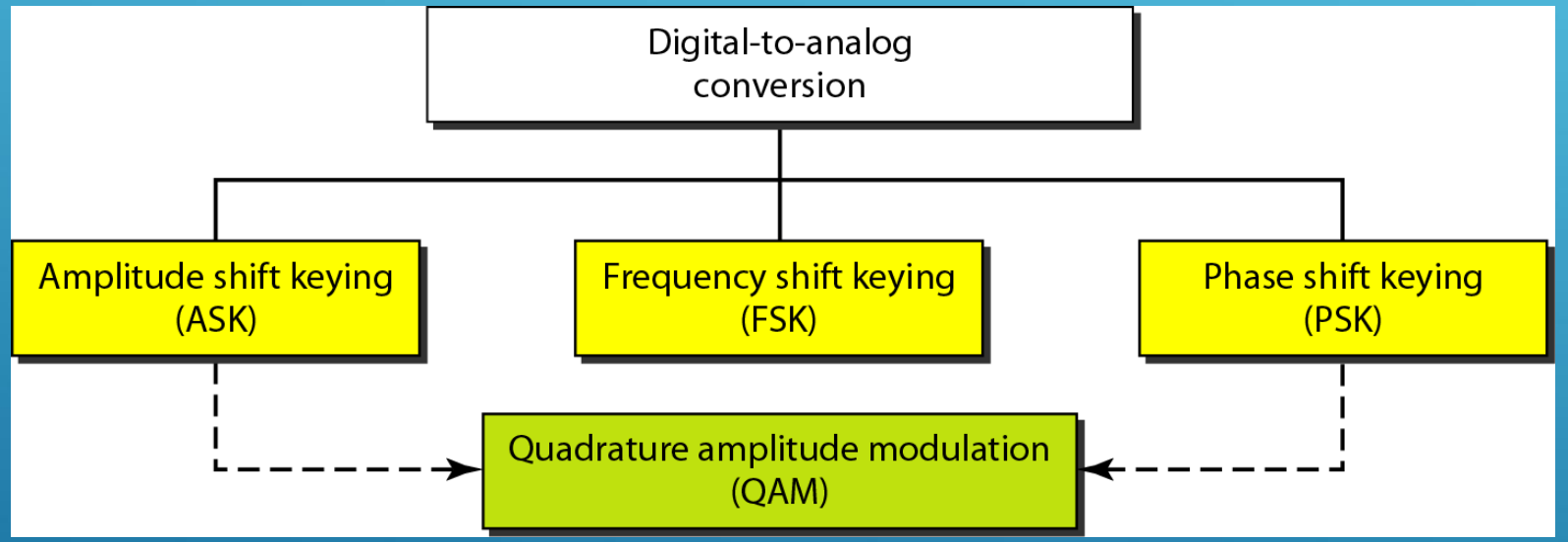


DIGITAL-TO-ANALOG CONVERSION

- Digital-to-analog conversion is the process of changing one of the characteristics of an analog signal based on the information in digital data

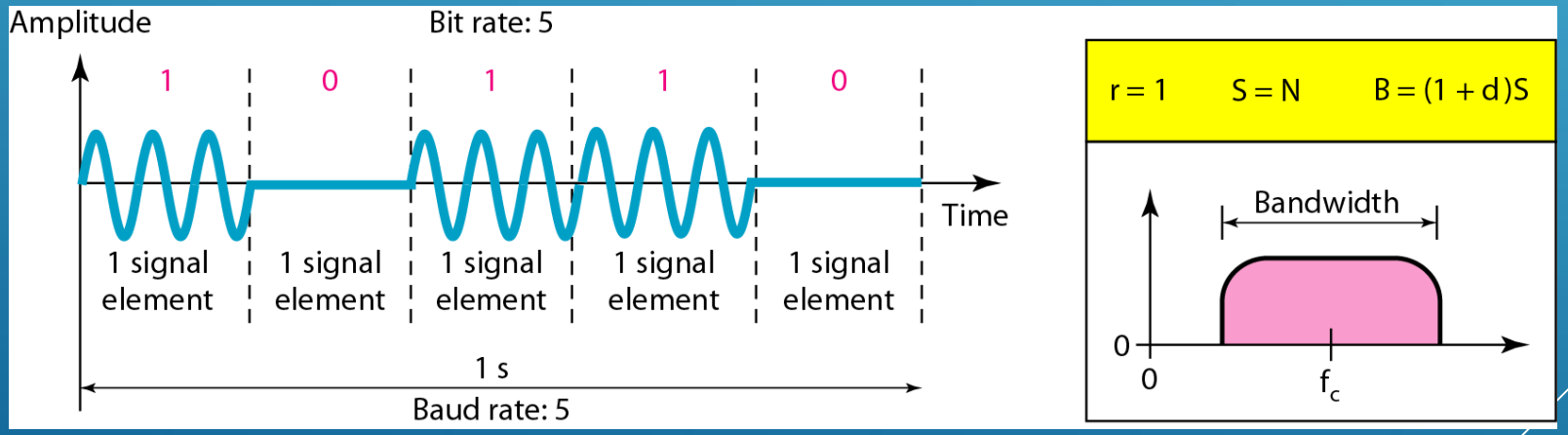


TYPES OF DIGITAL-TO-ANALOG MODULATION

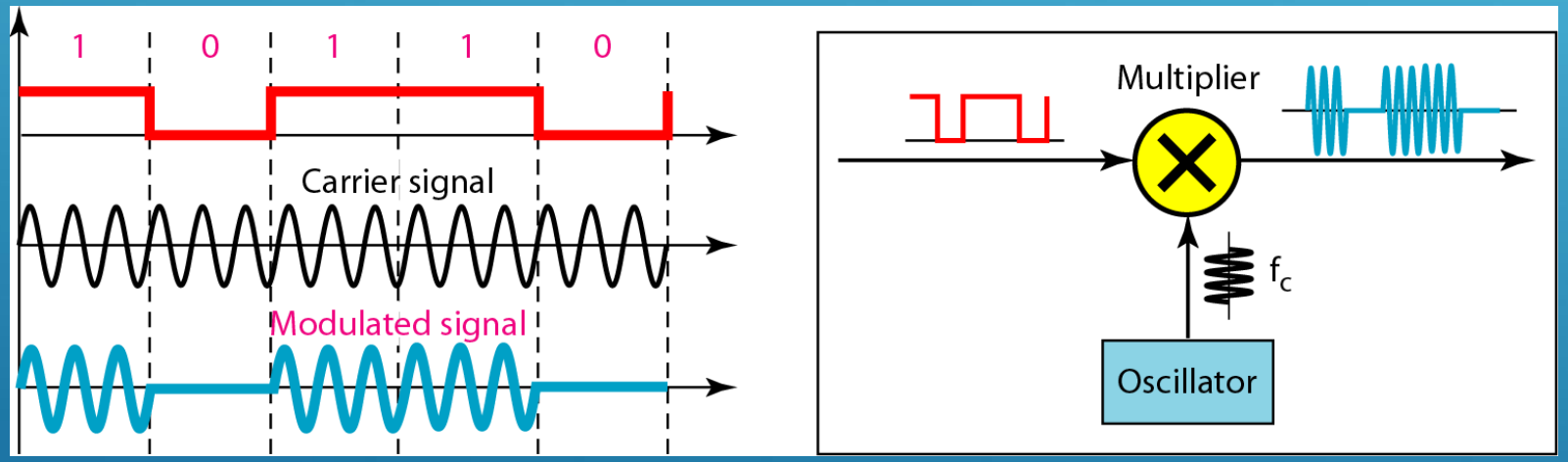


ASK : BINARY ASK

- BASK or OOK (on-off keying)
- Bandwidth for ASK: B = (1 + d) x S

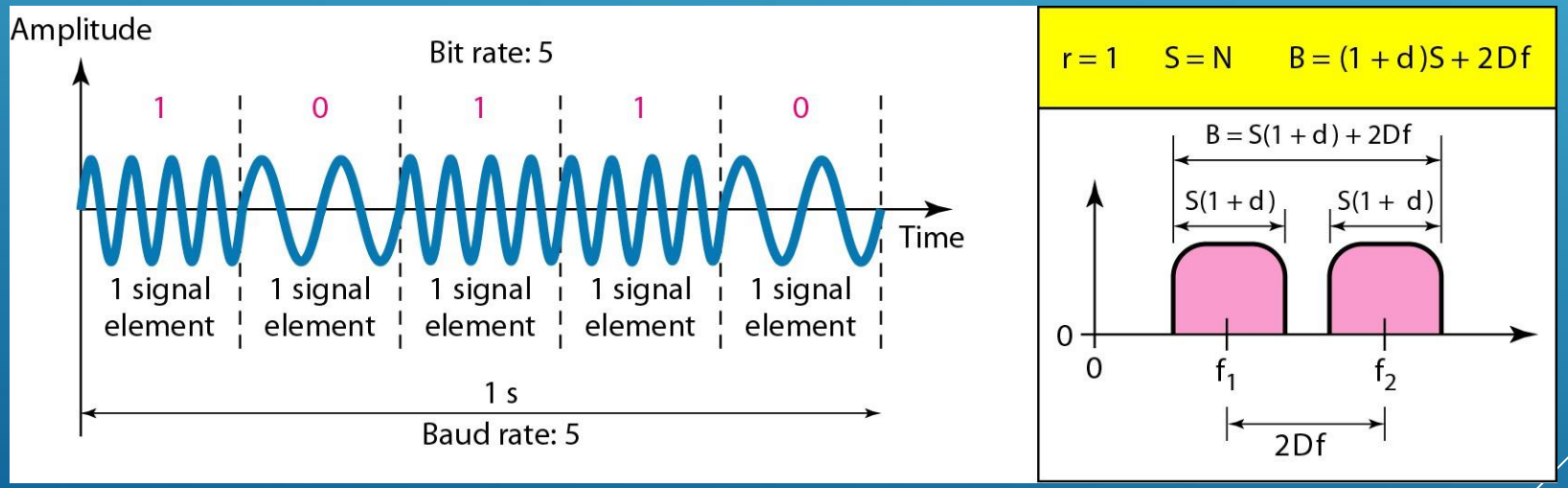


IMPLEMENTATION OF BINARY ASK

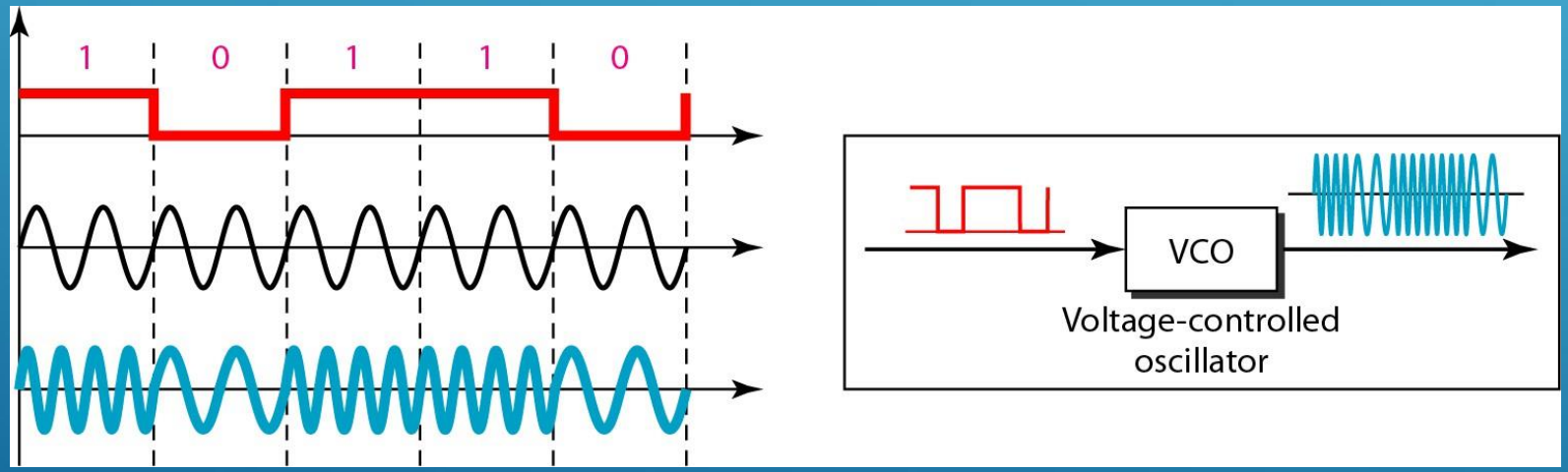


FSK: BINARY FSK

- Bandwidth for ASK: $B = (1 + d) \times S + 2\Delta f$

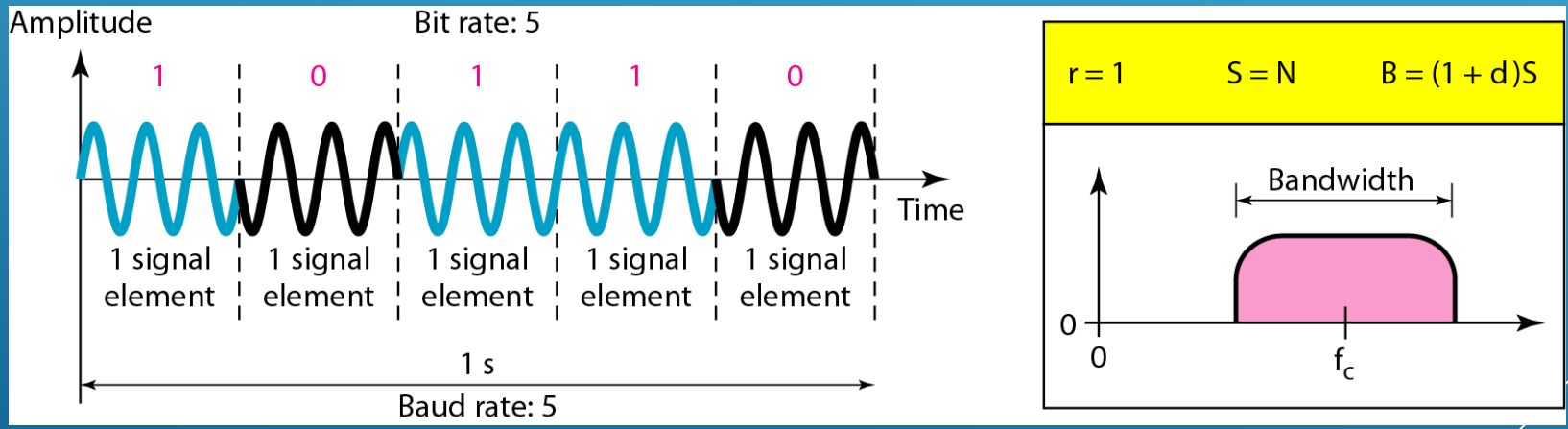


IMPLEMENTATION OF BINARY FSK

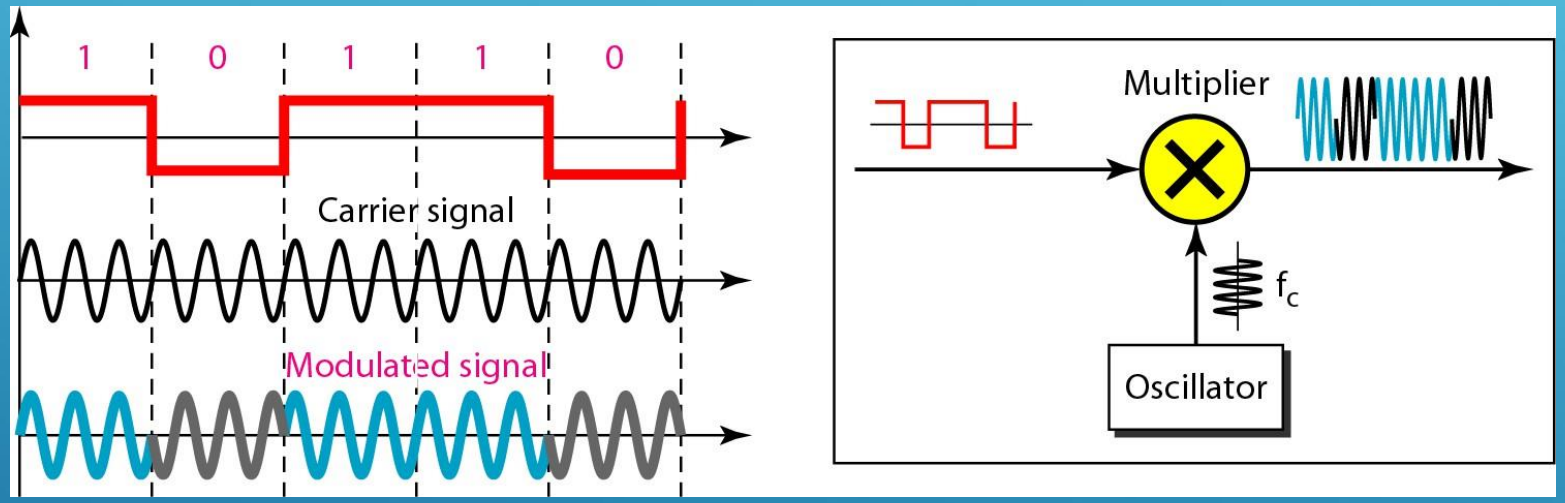


PSK: BINARY PSK

- Bandwidth : the same as BASK, B = (1 + d) x S
- Less than that for BFSK

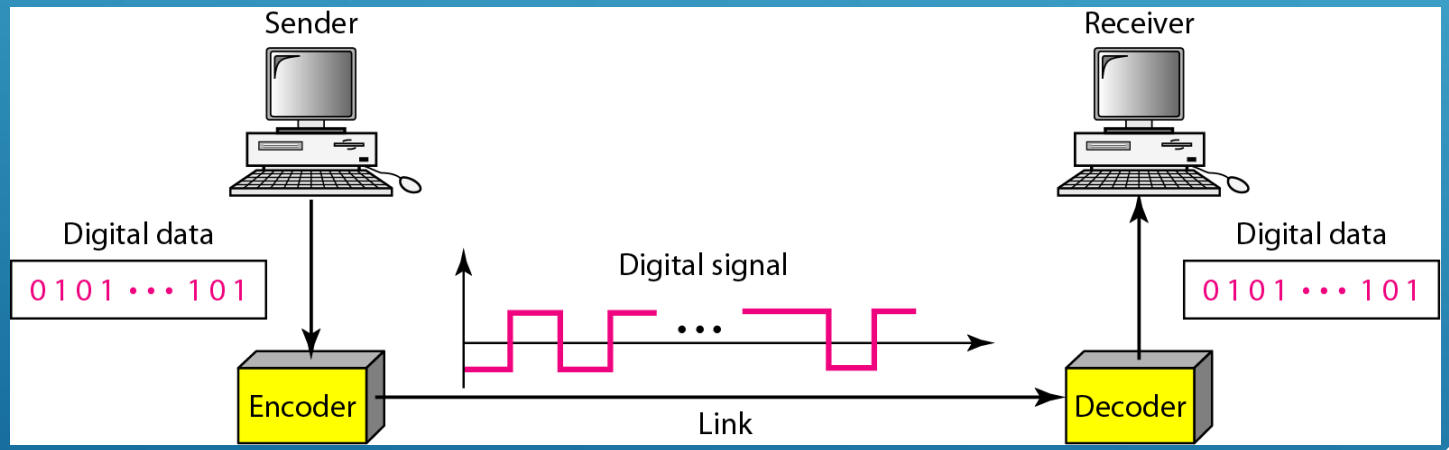


IMPLEMENTATION OF BINARY PSK

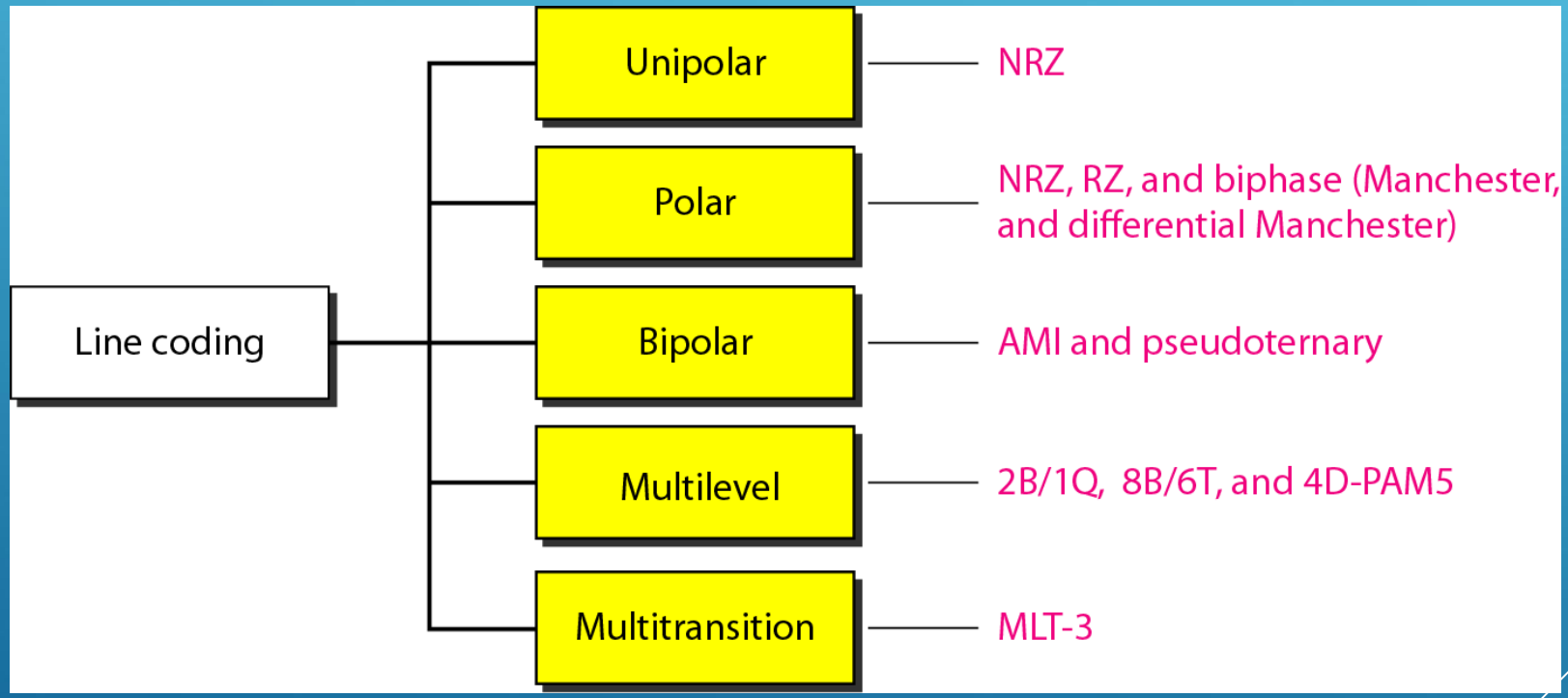


DIGITAL-TO-DIGITAL CONVERSION

- Involves three techniques:
  - Line coding (always needed), block coding, and scrambling
- Line coding: the process of converting digital data to digital signals

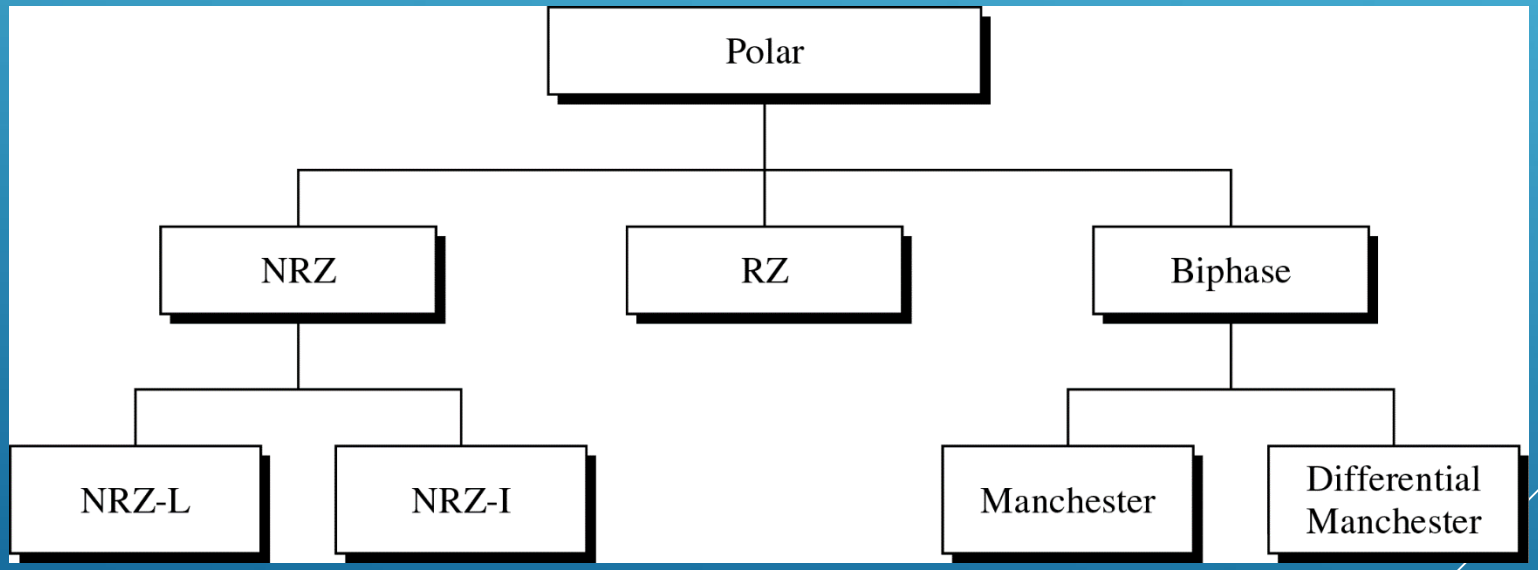


LINE CODING SCHEMES



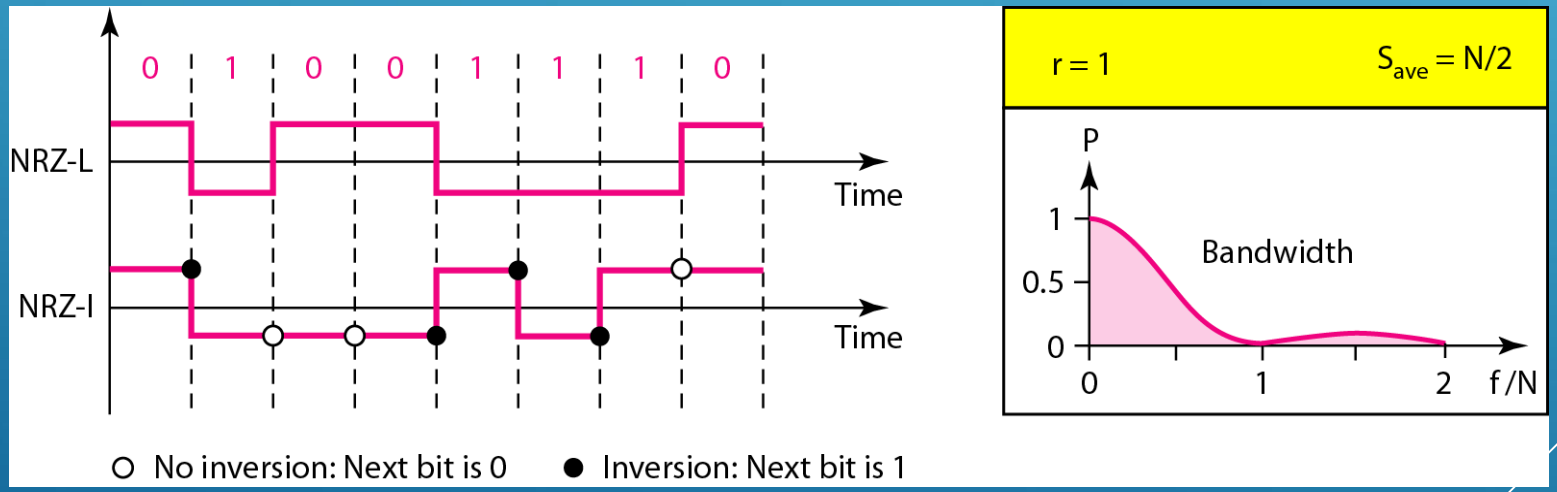
POLAR SCHEME

- Two polarity: two levels of voltage
- Problem of DC component is alleviated (NRZ,RZ) or eliminated (Biphaze)



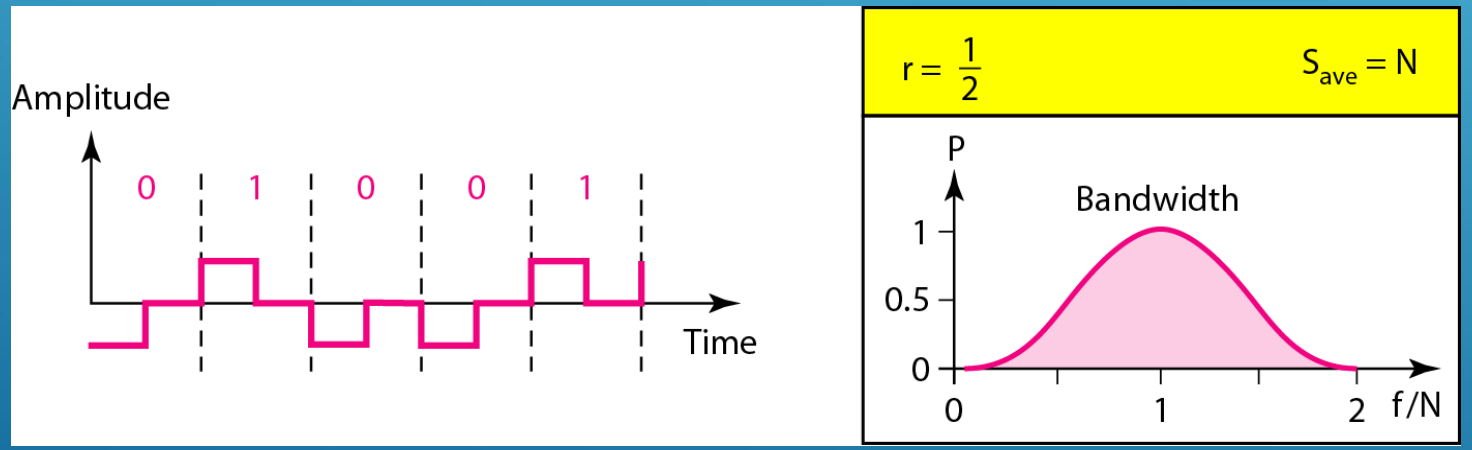
POLAR NRZ

- NRZ-L (Non Return to Zero-Level)
  - Level of the voltage determines the value of the bit
- NRZ-I (Non Return to Zero-Invert)
  - Inversion or the lack of inversion determines the value of the bit



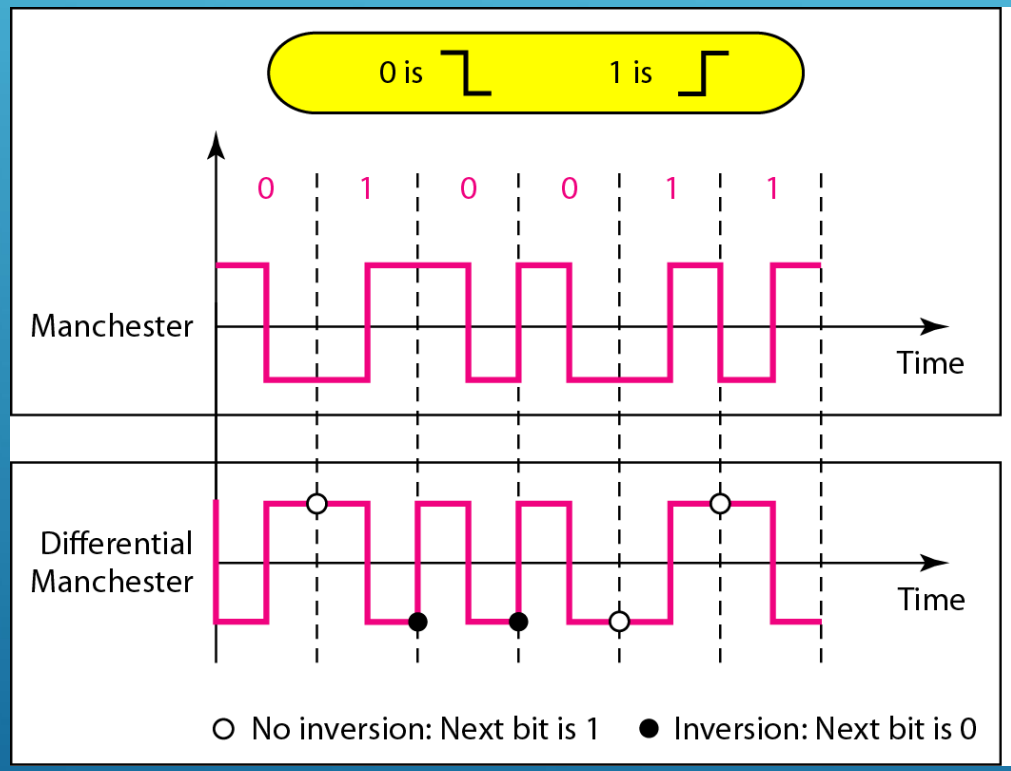
RZ

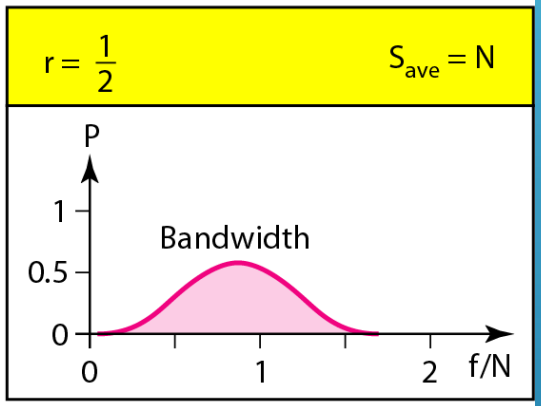
- Provides synchronization for consecutive 0s/1s
- Signal changes during each bit
- Three values (+, -, 0) are used
  - Bit 1: positive-to-zero transition, bit 0: negative-to-zero transition



POLAR BIPHASE

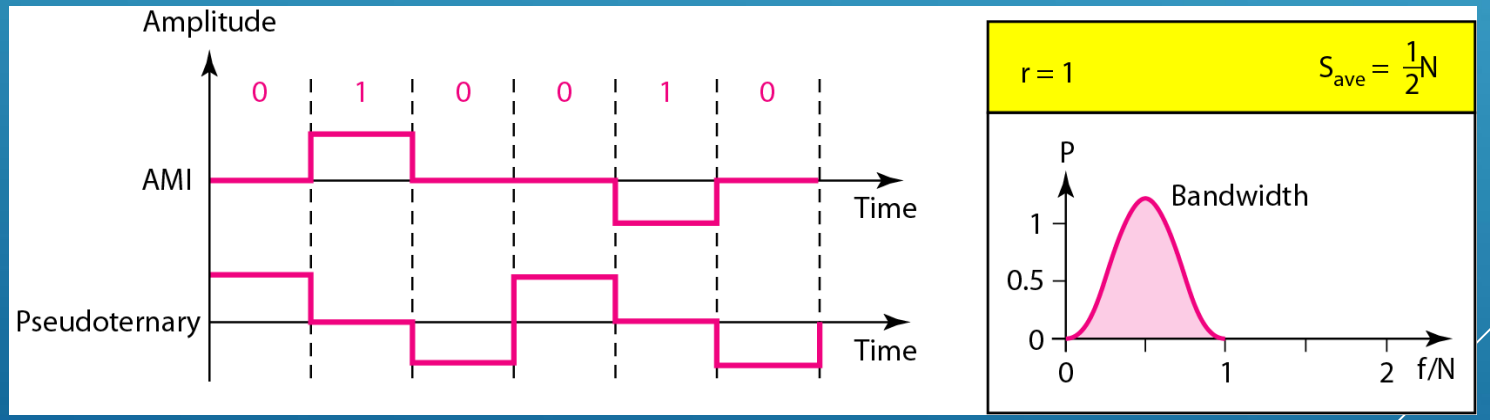
- Minimum bandwidth is 2 times that of NRZ





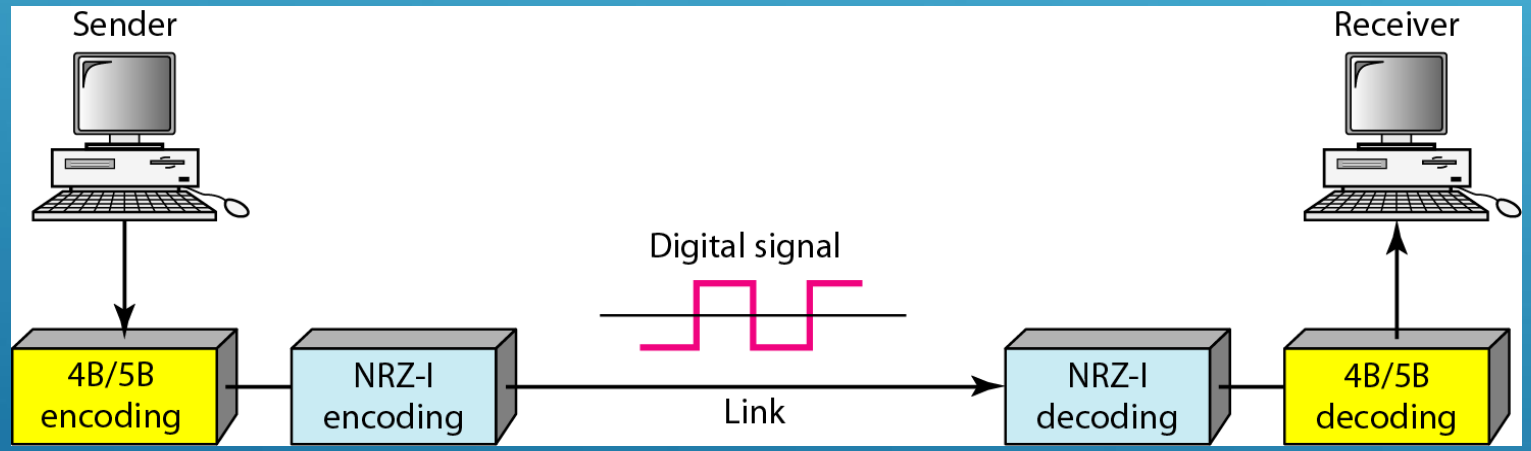
BIPOLAR SCHEME

- Three levels of voltage, called "multilevel binary"
- Bit 0: zero voltage, bit 1: alternating +1/-1
  - (Note) In RZ, zero voltage has no meaning
- AMI (Alternate Mark Inversion) and pseudoternary
  - Alternative to NRZ with the same signal rate and no DC component problem

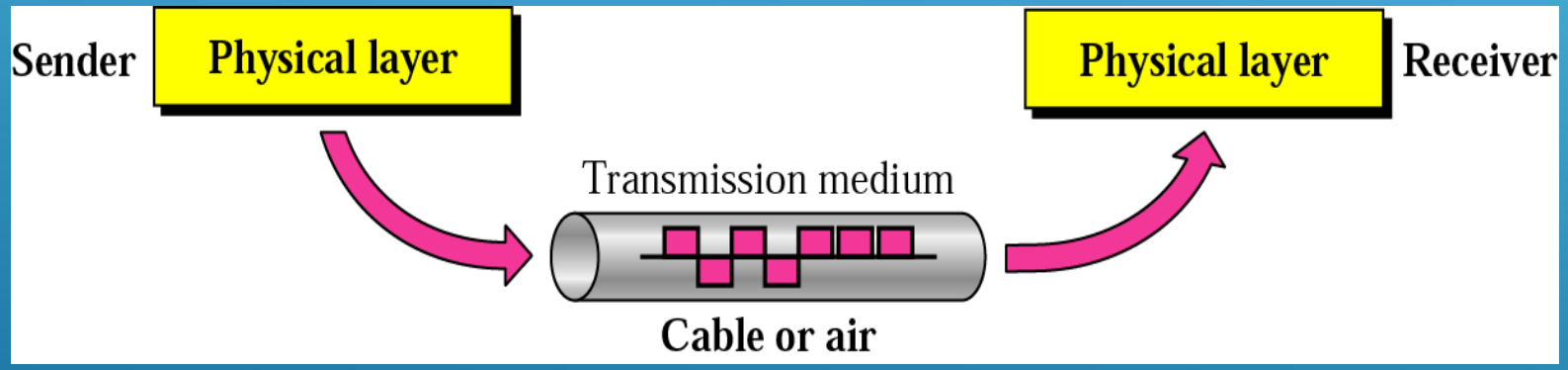


4B/5B

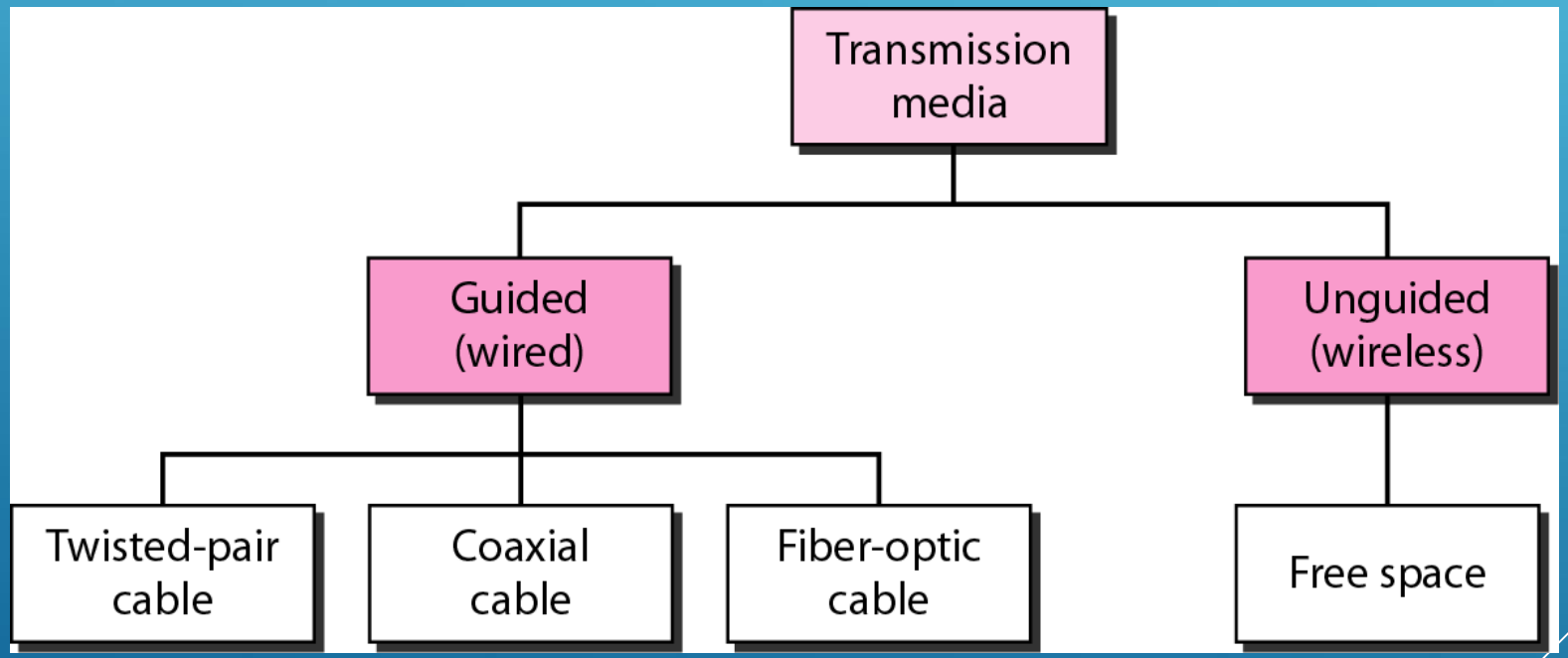
- Solve the synchronization problem of NRZ-I
- 20% increase the signal rate of NRZ-I (Biphase scheme has the signal rate of 2 times that of NRZ-I
- Still DC component problem



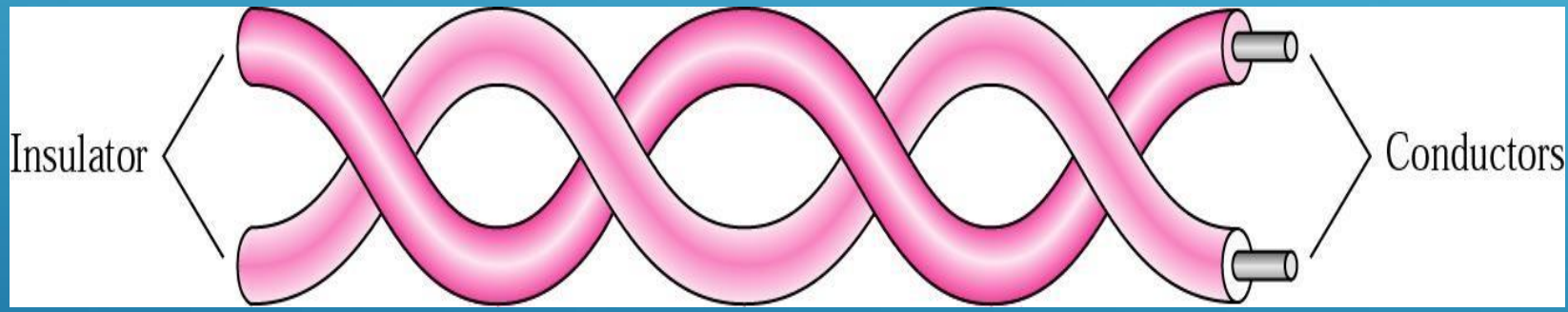
TRANSMISSION MEDIUM & PHYSICAL LAYER



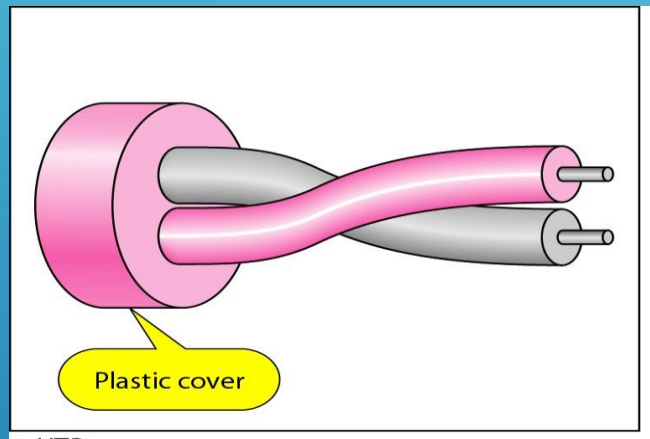
CLASSES OF TRANSMISSION MEDIA



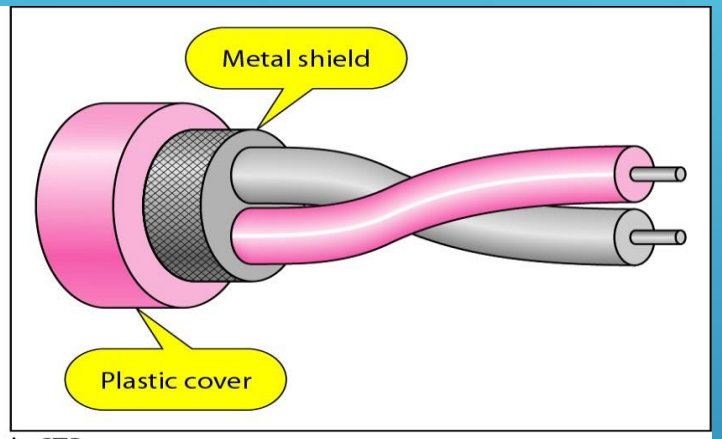
TWISTED-PAIR CABLE



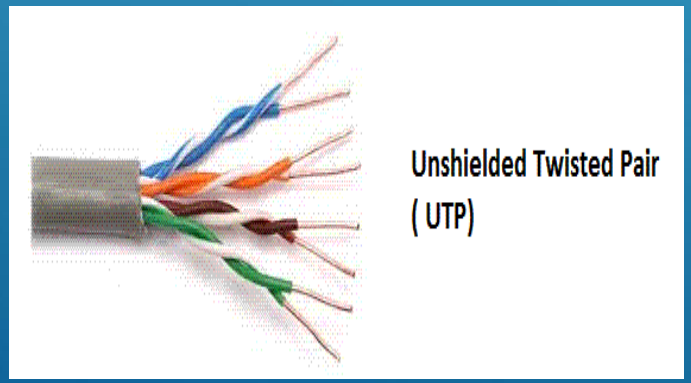
UNSHIELDED TWISTED PAIR(UTP) AND **SHIELDED TWISTED PAIR (**STP) CABLES

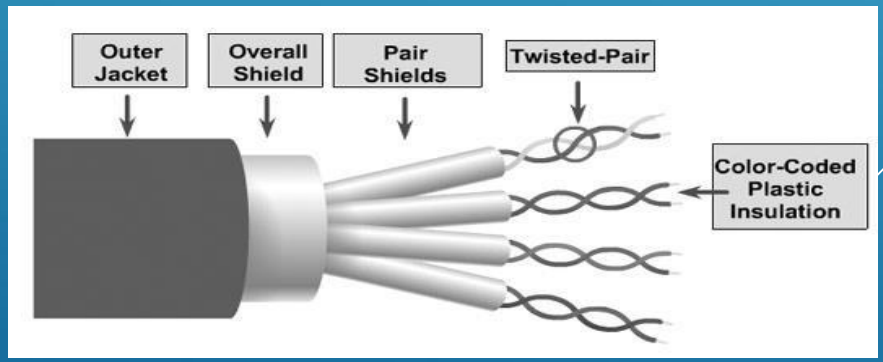


a. UTP



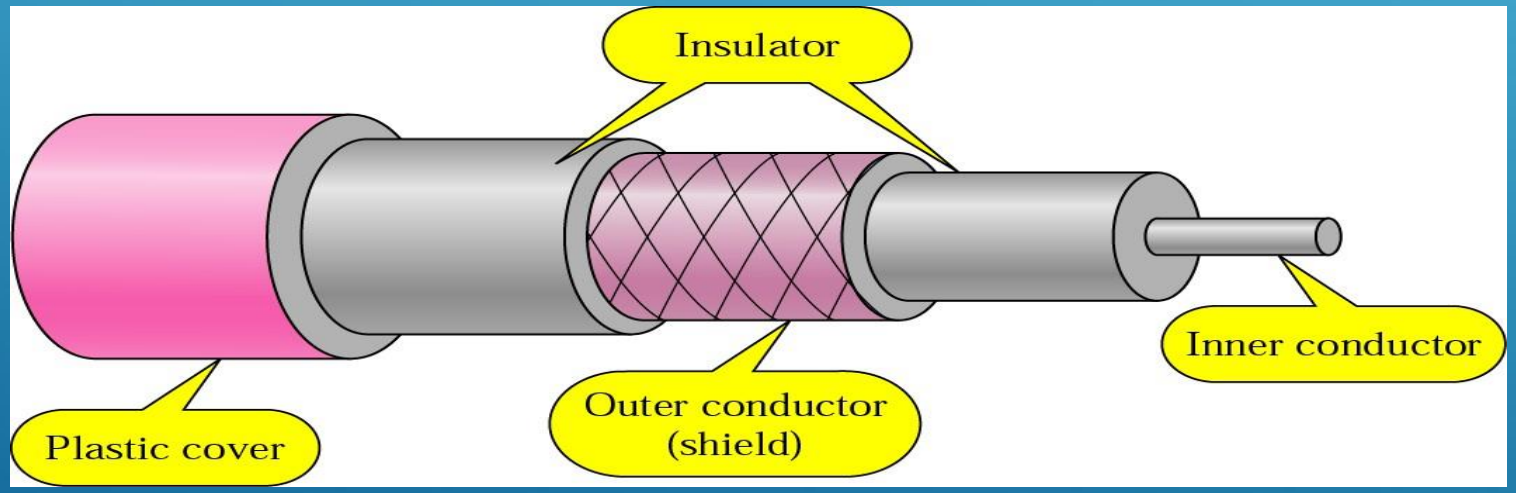
b. STP



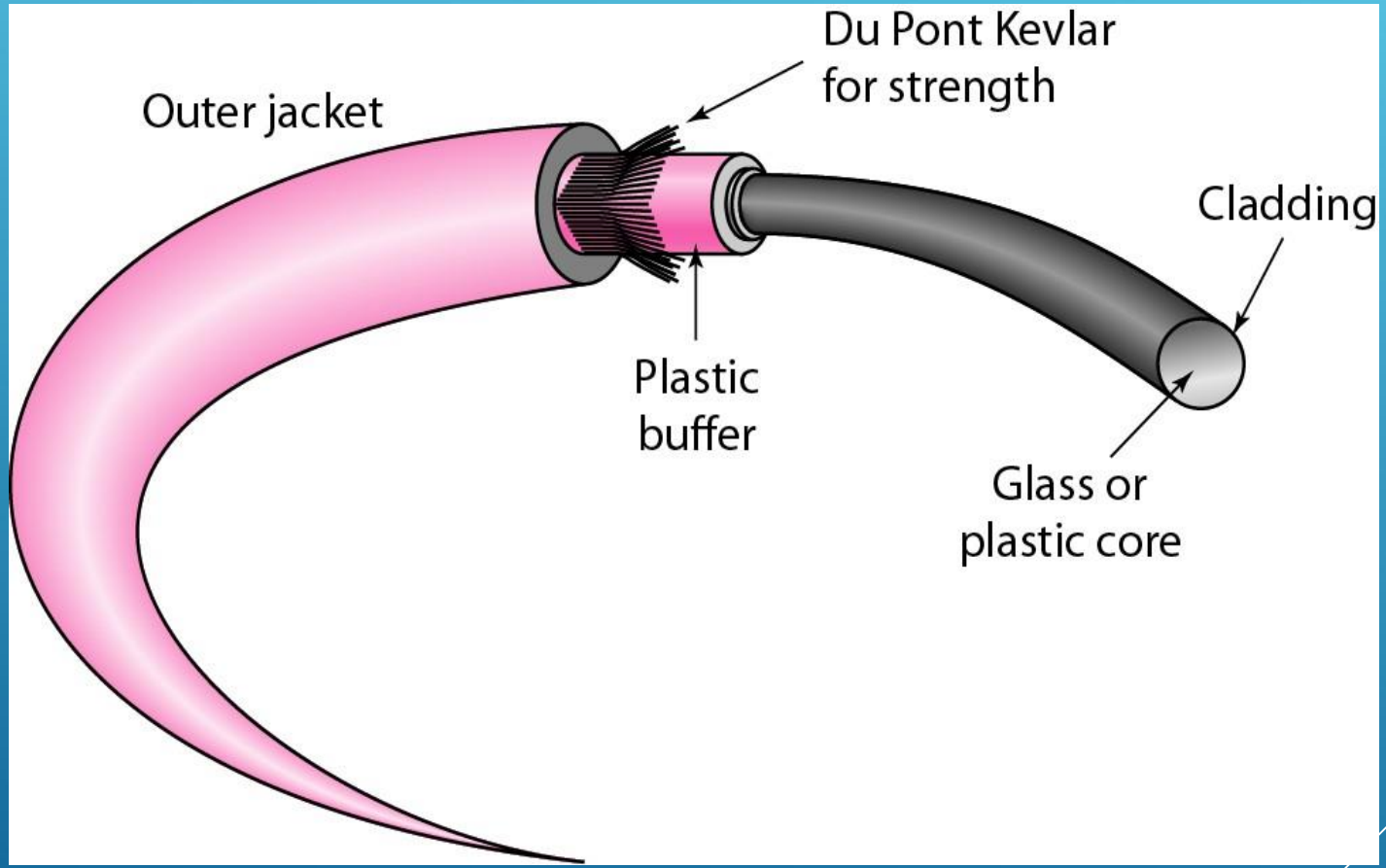


COAXIAL CABLE

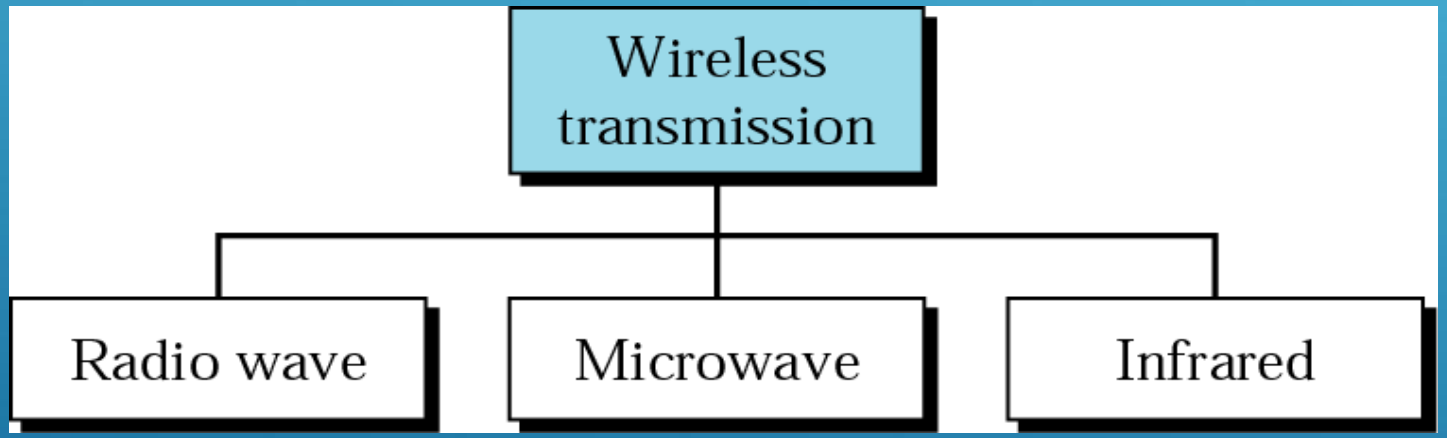
- Carries signals of higher frequency ranges than those in twisted-pair cable



FIBER CONSTRUCTION

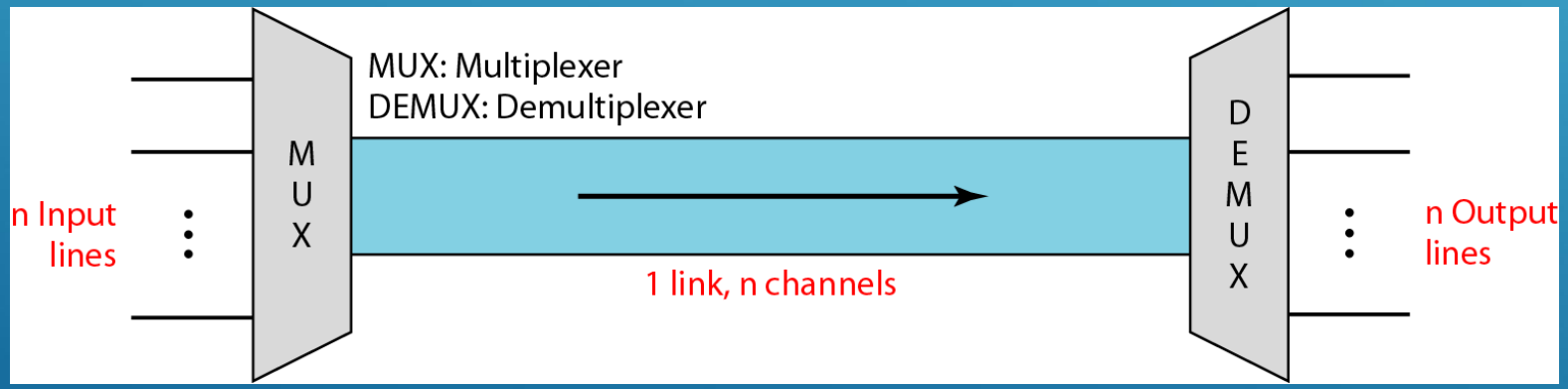


WIRELESS TRANSMISSION WAVES

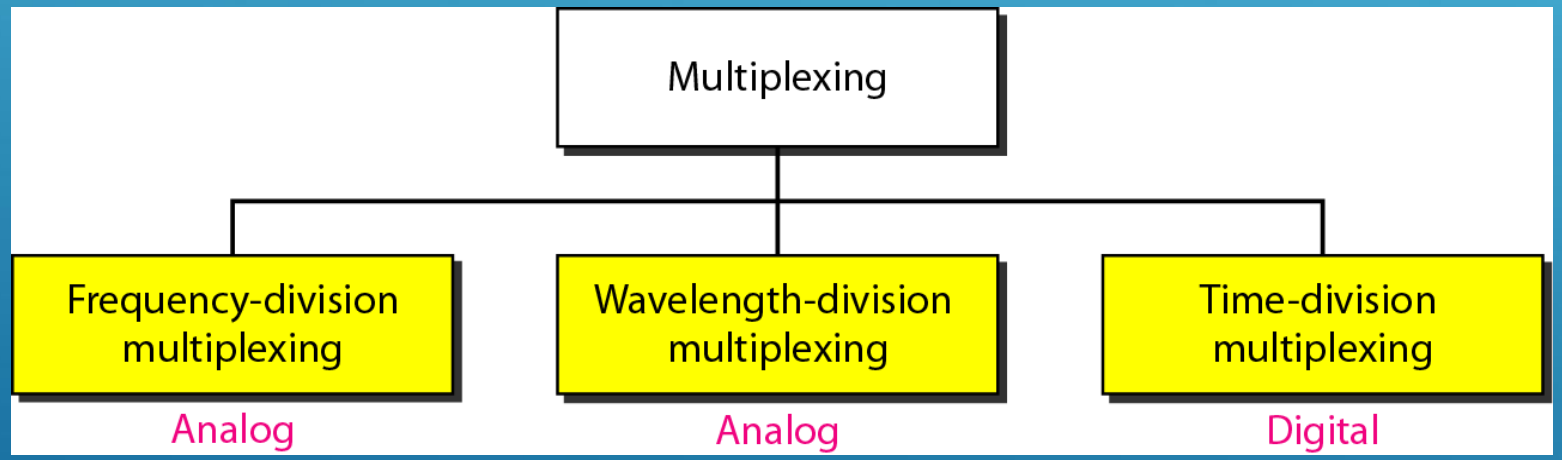


MULTIPLEXING

- Whenever the bandwidth of a medium linking two devices is greater than the bandwidth needs of the devices, the link can be shared.
- Multiplexing is the set of techniques that allows the simultaneous transmission of multiple signals across a single data link.

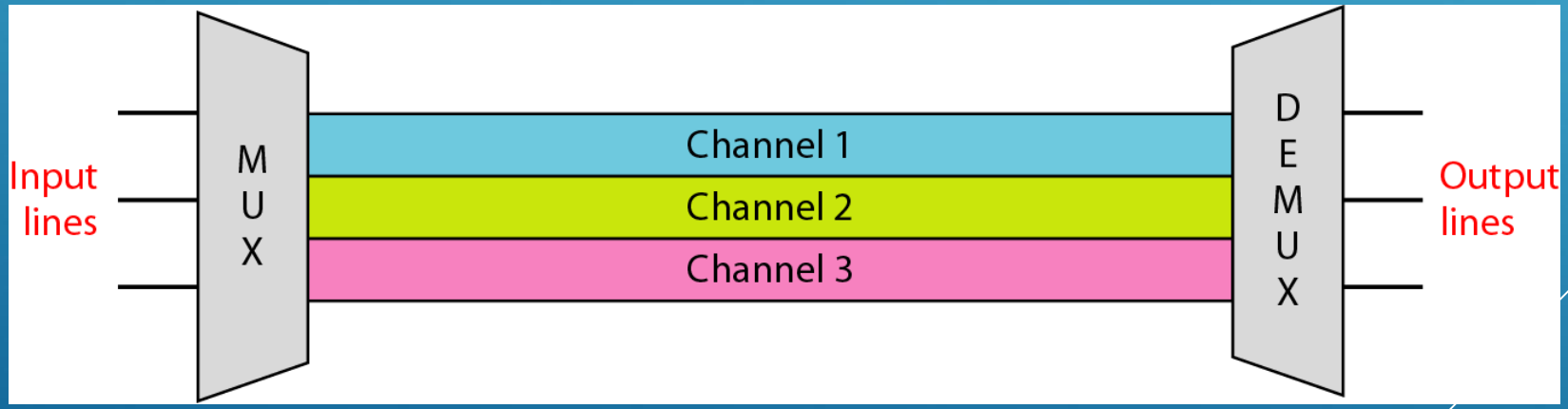


CATEGORIES OF MULTIPLEXING

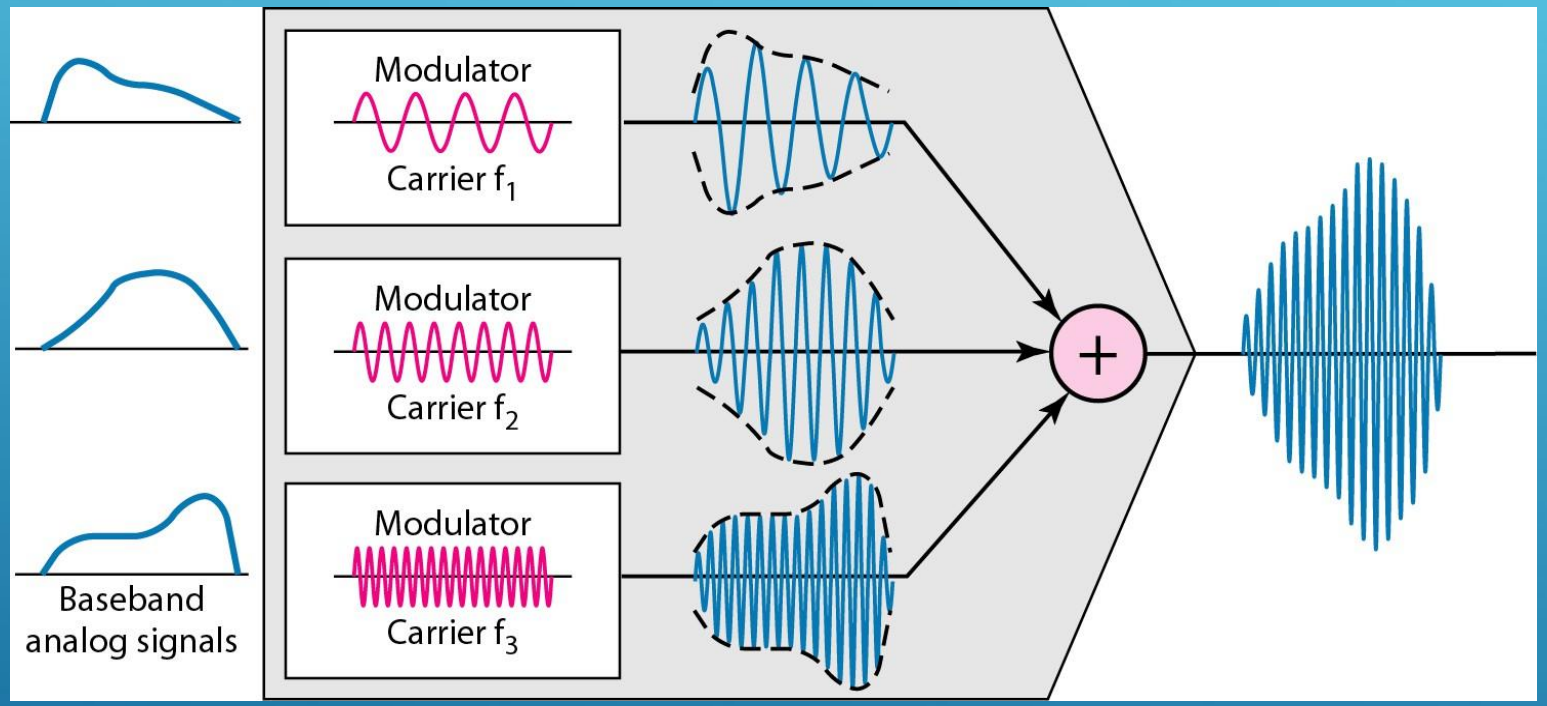


FREQUENCY DIVISION MULTIPLEXING

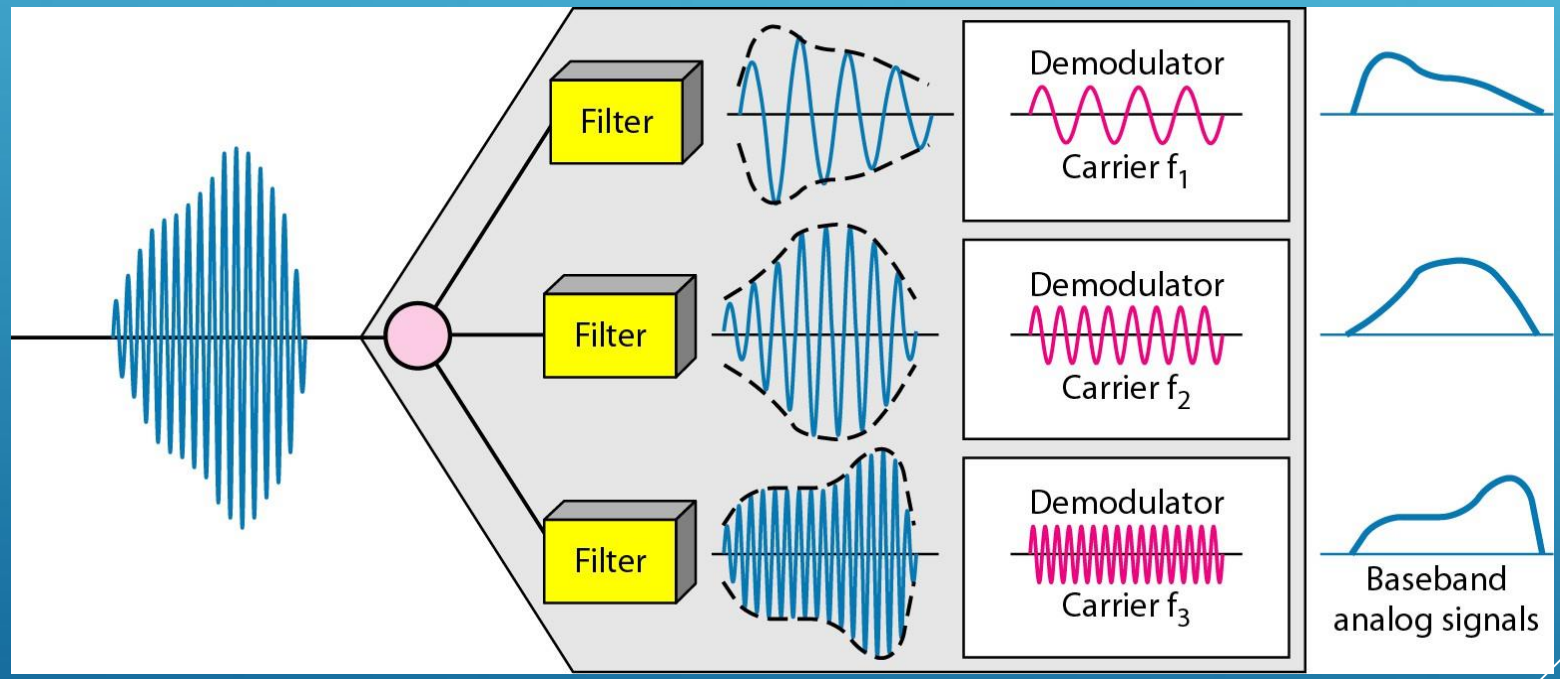
- FDM is an analog multiplexing technique that combines analog signals
- Signals modulate different carrier frequencies
- Modulated signals are combined into a composite signal
- ***Channel*** - Bandwidth range to accommodate a modulated signal
- Channels can be separated by strips of unused bandwidth (***guard band***) to prevent overlapping



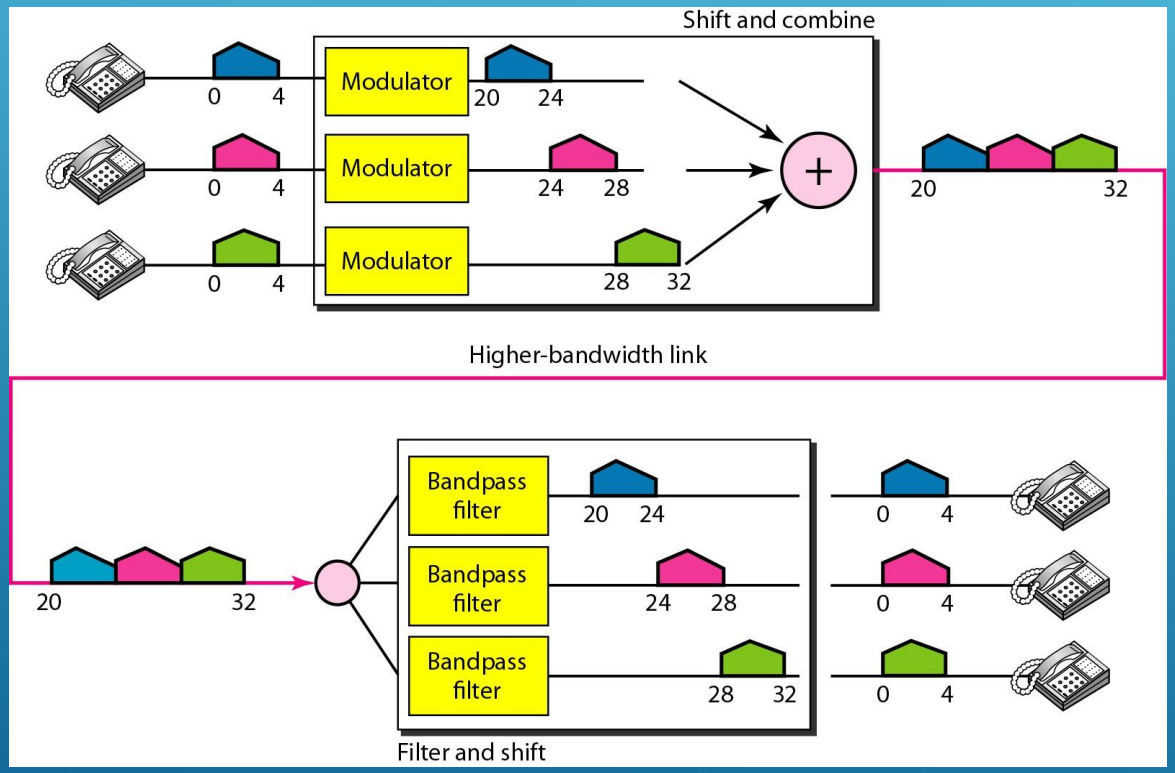
FDM PROCESS


Modulator
Carrier f_1
Modulator
Carrier f_2
Modulator
Carrier f_3
Baseband
analog signals
+

FDM DEMULTIPLEXING EXAMPLE

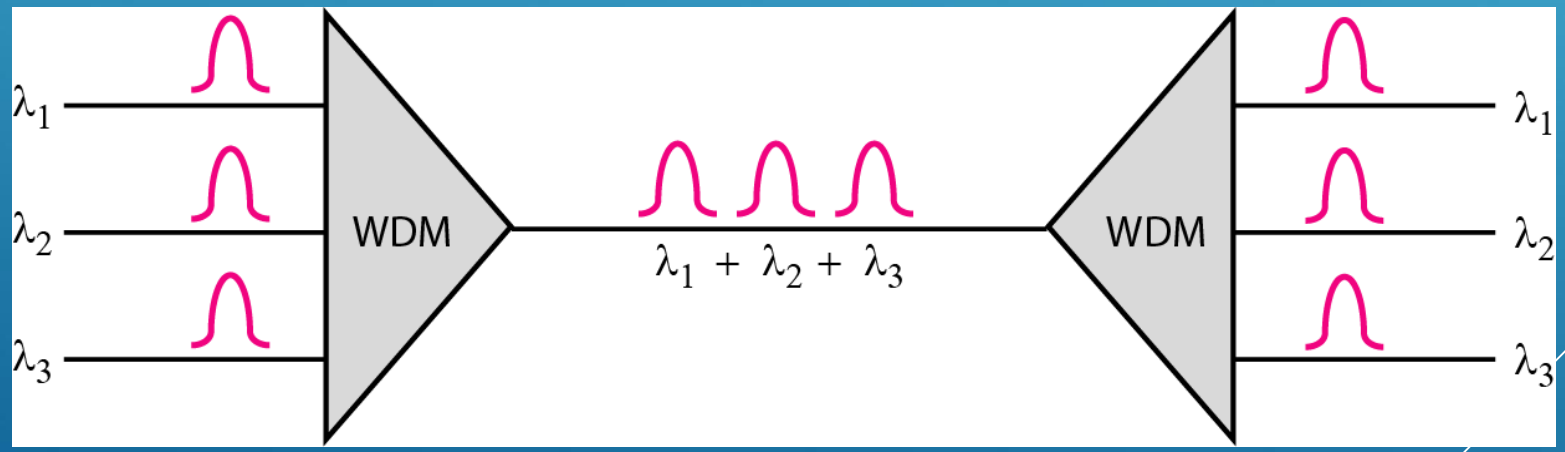


FDM: EXAMPLE 1



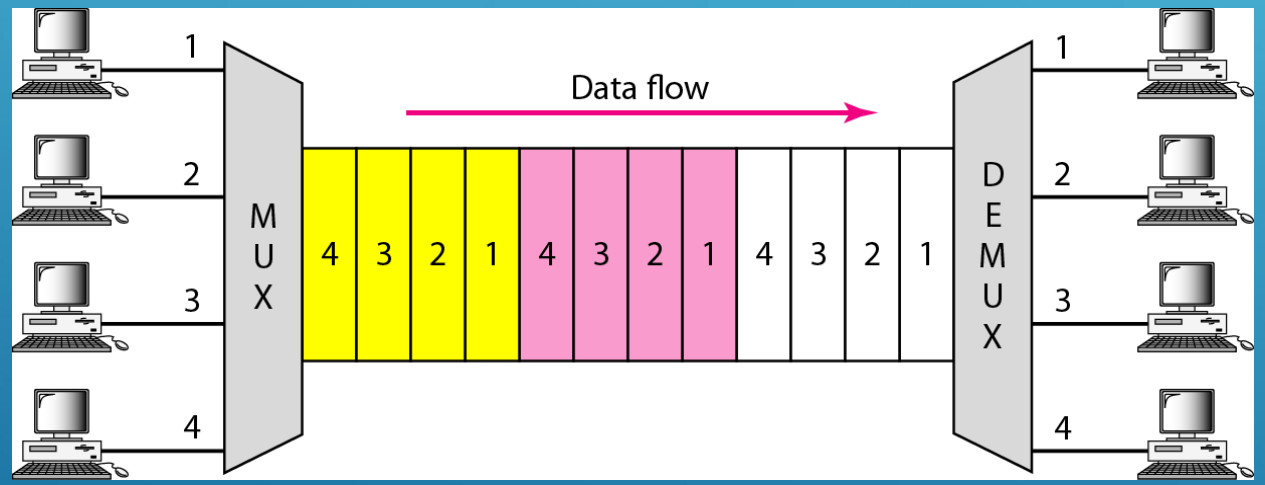
WAVE DIVISION MULTIPLEXING

- Analog multiplexing technique to combine optical signals
- Conceptually the same as FDM
- Light signals transmitted through fiber optic channels
- Combining different signals of different frequencies (wavelengths)



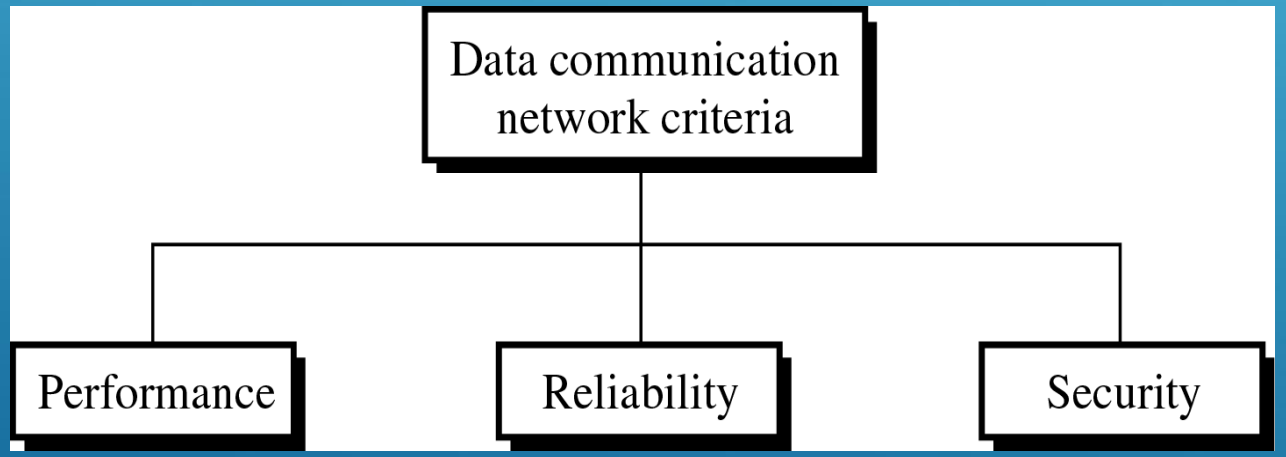
TIME DIVISION MULTIPLEXING

- Digital multiplexing technique for combining several low-rate channels into one high-rate one

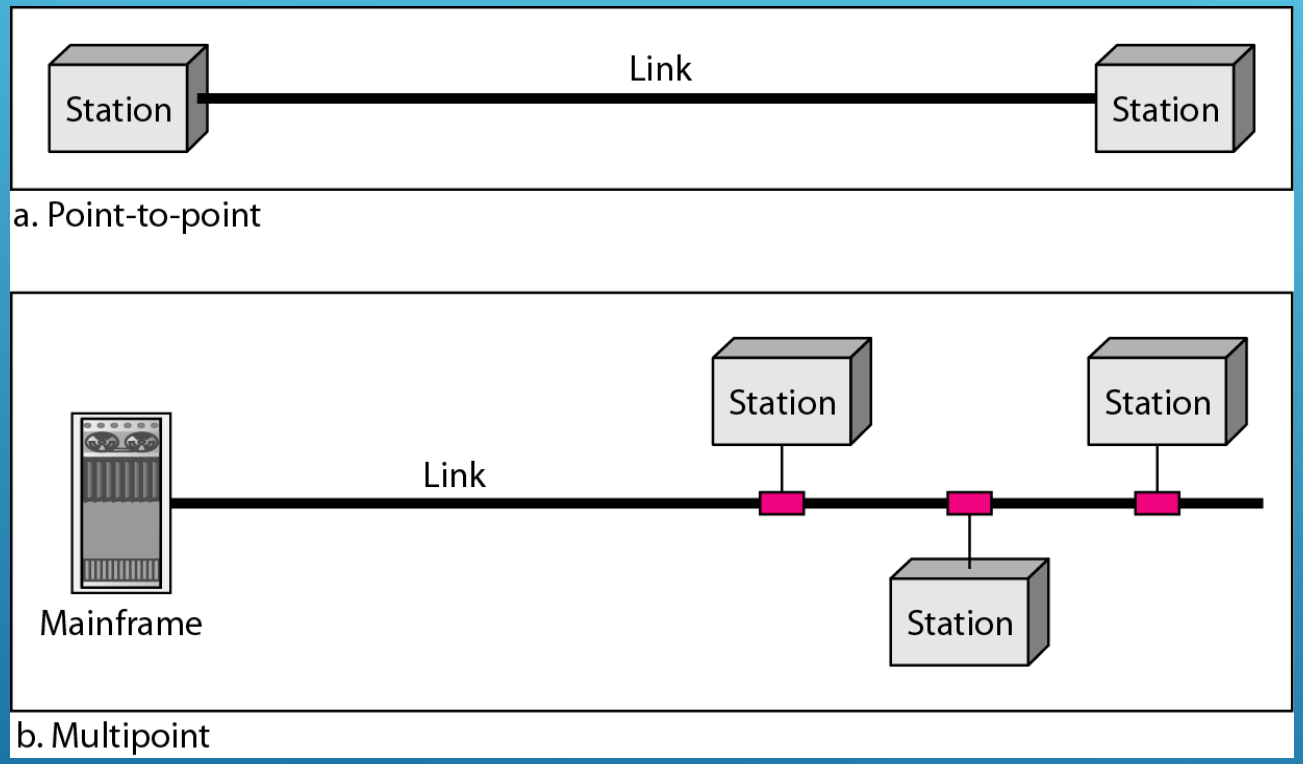


NETWORK

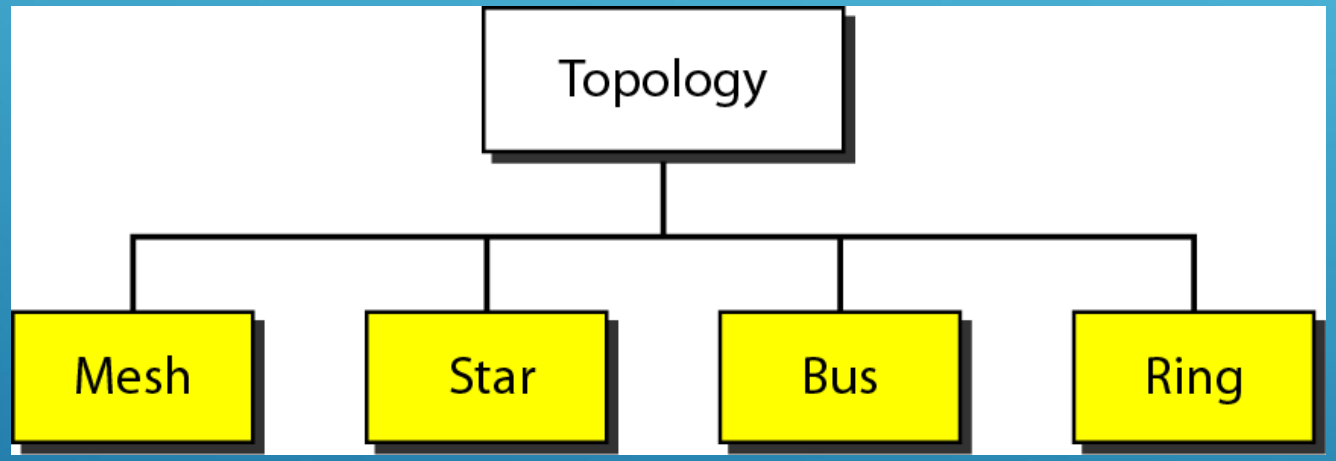
- Network: A set of devices (nodes) connected by communication links
- Node: Computer, printer, or any device capable of sending and/or receiving data
- To be considered effective and efficient, a network must meet a number of criteria



TYPE OF CONNECTION

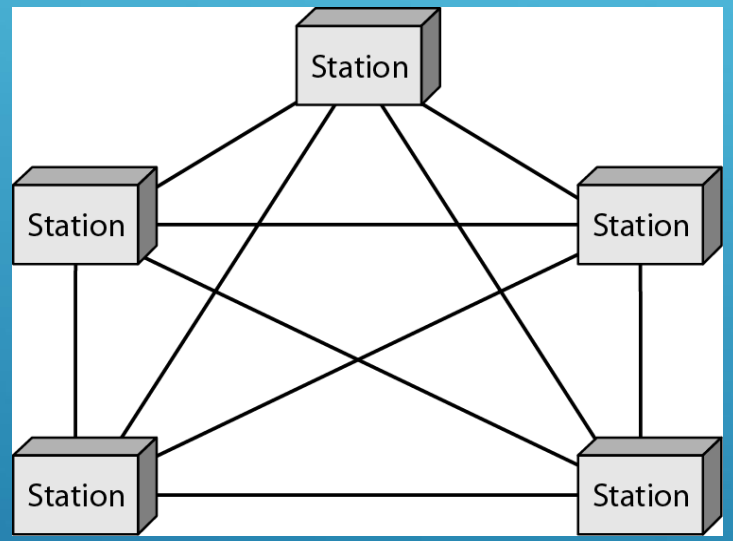


PHYSICAL TOPOLOGY



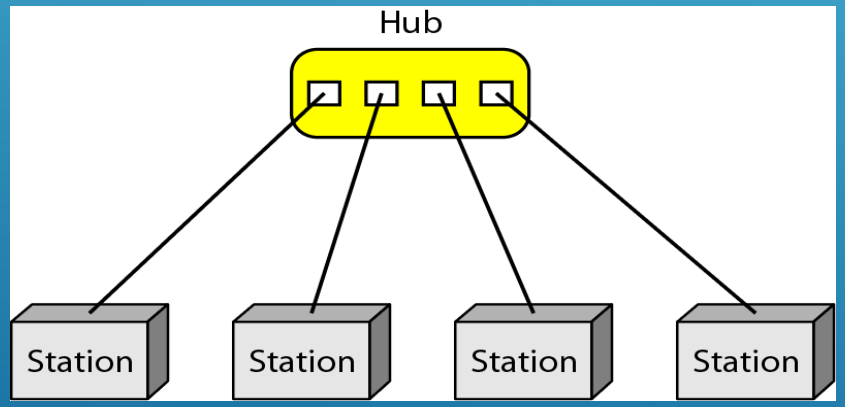
MESH TOPOLOGY

- Dedicated point-to-point link to every other nodes
- A mesh network with *n* nodes has *n(n-1)/2* links. A node has *n-1* I/O ports (links)
- Advantages: No traffic problems, robust, security, easy fault identification & isolation
- Disadvantages: Difficult installation/reconfiguration, space, cost



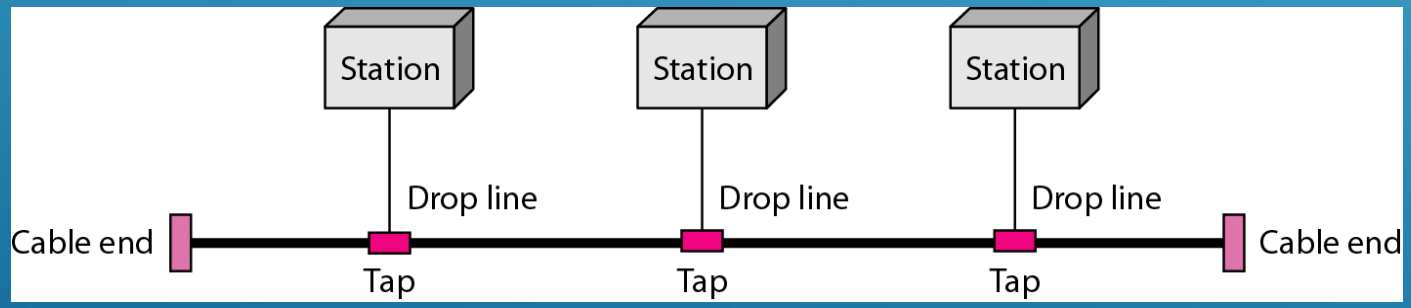
STAR TOPOLOGY

- Dedicated point-to-point link *only to* a central controller, called a ***hub***
- Hub acts as an exchange: No direct traffic between devices
- Advantages: Less expensive, robust
- Disadvantages: dependency of the whole on one single point, the hub



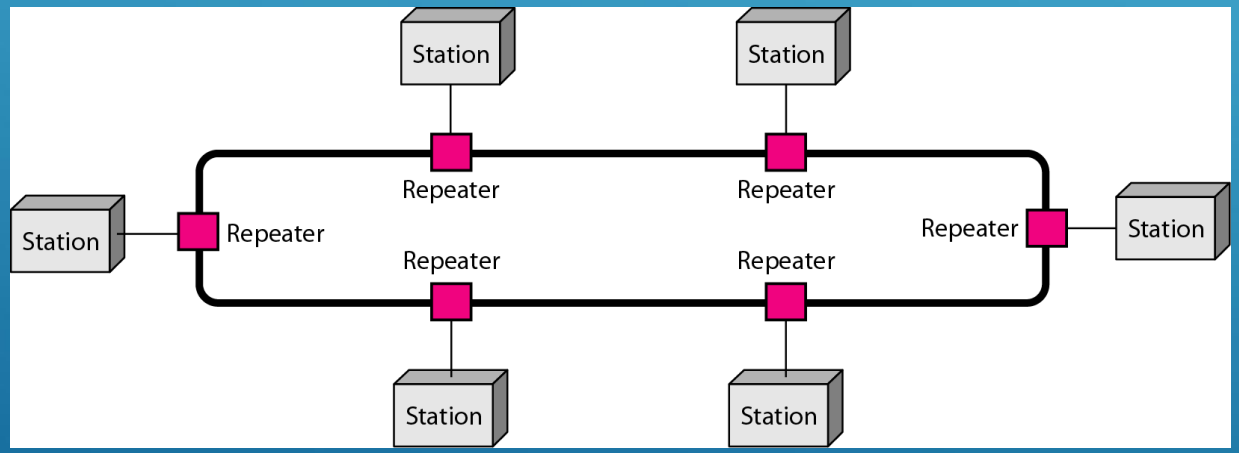
BUS TOPOLOGY

- One long cable that links all nodes
- tap, drop line, cable end
- limit on the # of devices, distance between nodes
- Advantages: Easy installation, cheap
- Disadvantages: Difficult reconfiguration, no fault isolation, a fault or break in the bus stops all transmission



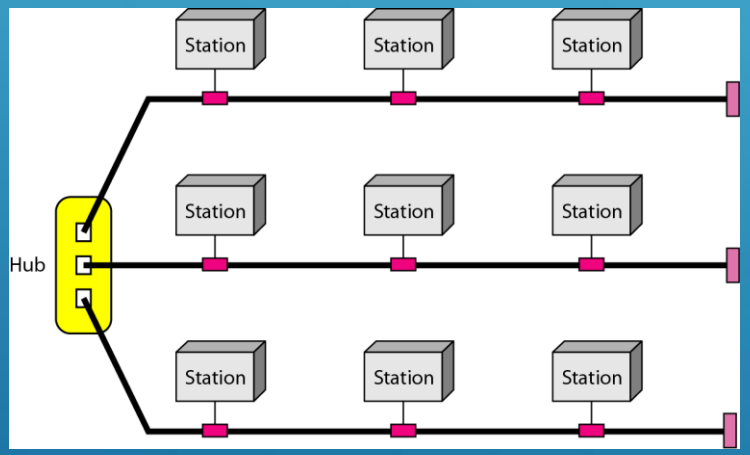
RING TOPOLOGY

- Dedicated point-to-point link only with the two nodes on each sides
- One direction, repeater
- Advantages: Easy reconfiguration, fault isolation
- Disadvantage: Unidirectional traffic, a break in the ring cab disable the entire network

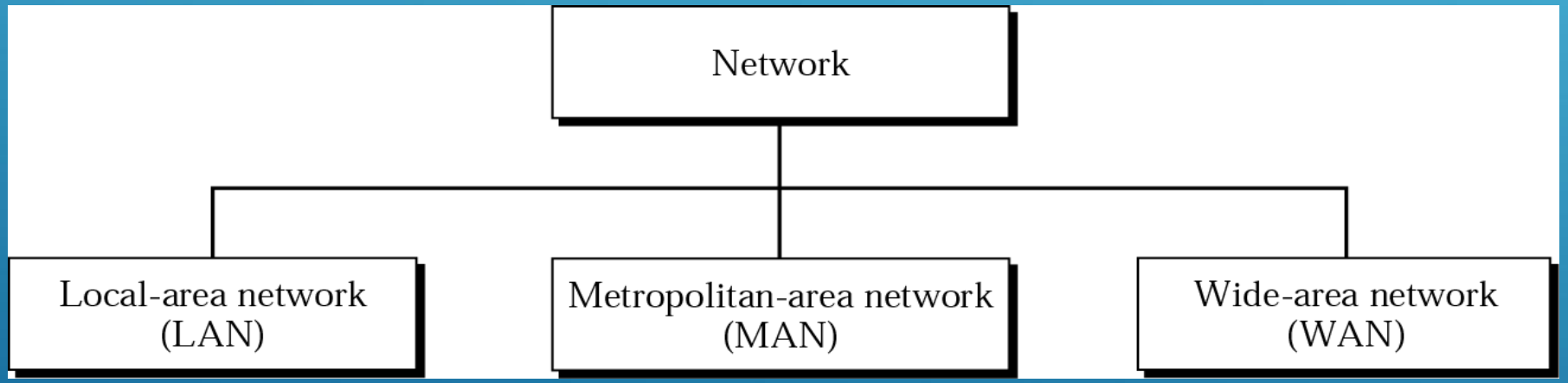


HYBRID TOPOLOGY

- Example: Main star topology with each branch connecting several stations in a bus topology
- To share the advantages from various topologies

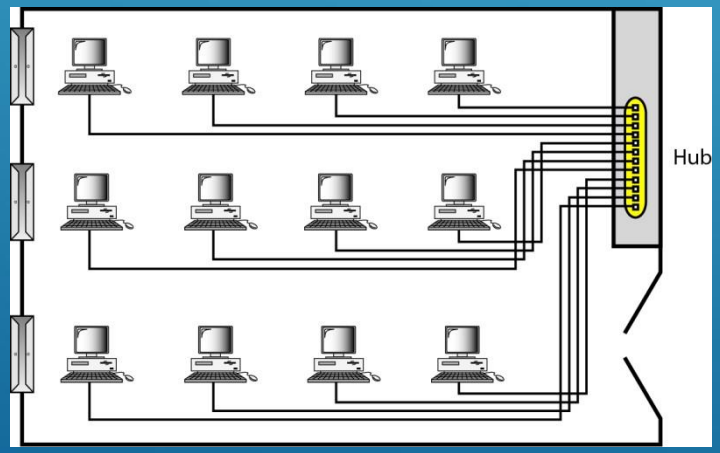


CATEGORIES OF NETWORKS



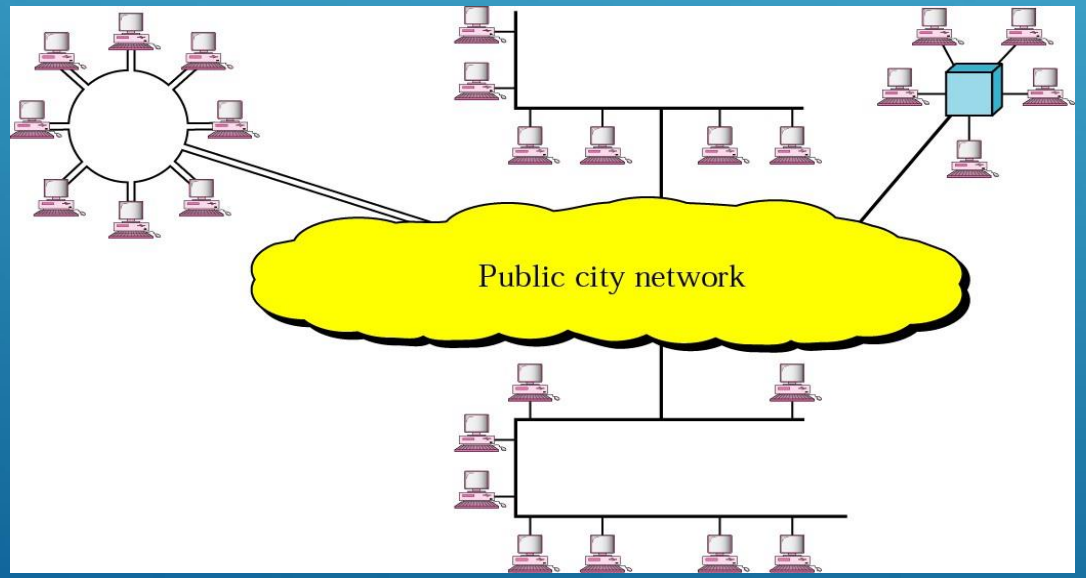
LAN

- Usually privately owned
- A network for a single office, building, or campus ≤ a few Km
- Common LAN topologies: bus, ring, star
- An isolated LAN connecting 12 computers to a hub in a closet



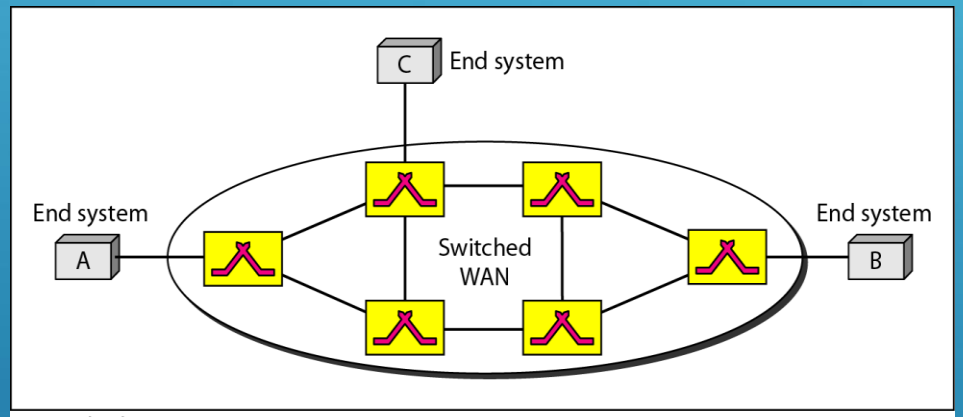
MAN

- Designed to extend to an entire city
- Cable TV network, a company's connected LANs
- Owned by a private or a public company



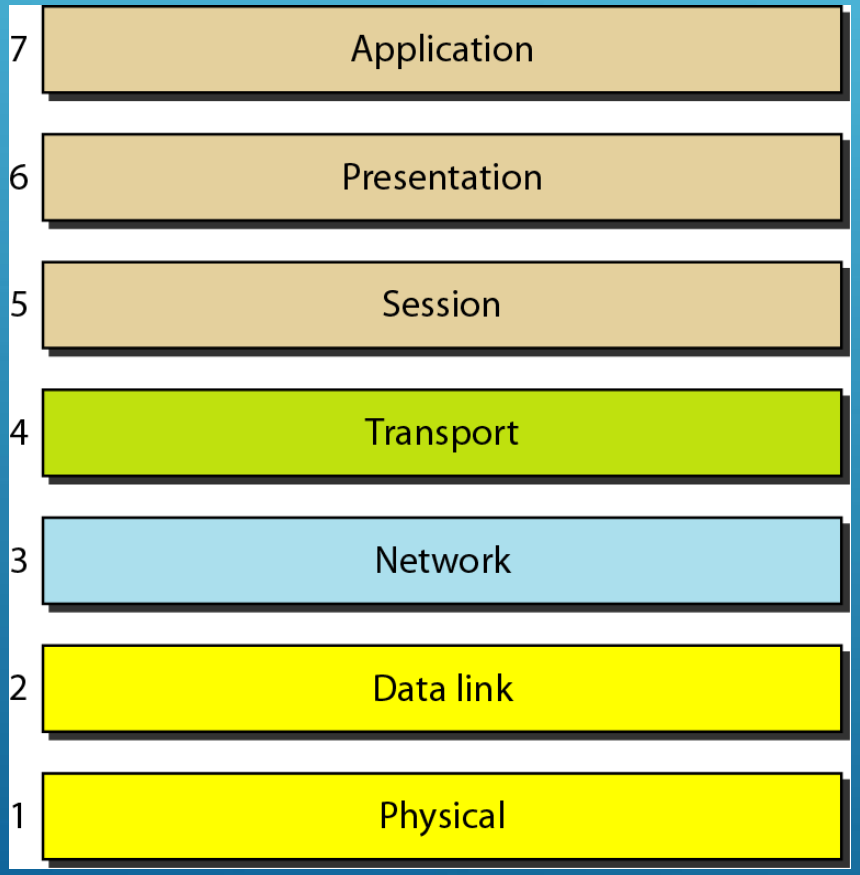
WAN

- Long distance transmission, e.g., a country, a continent, the world
- Enterprise network: A WAN that is owned and used by one company



OSI MODEL

- ISO is the organization. OSI is the model



END

Loving