Physical Layer

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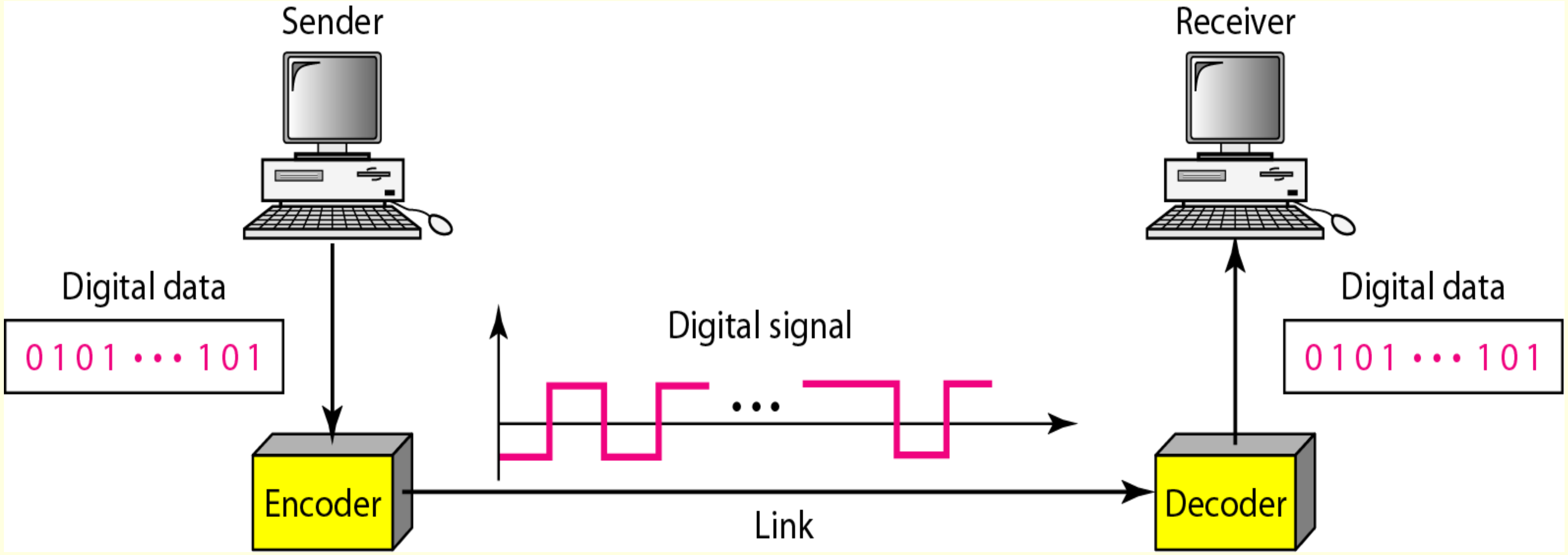
Functions of Physical layer

- Following are the various functions performed by the Physical layer

1. **Representation of Bits: Data in this layer consists of stream of bits. The bits must be encoded into signals for transmission. It defines the type of encoding i.e. how 0's and 1's are changed to signal.**

- We assume data in the form of text, numbers, graphical images, audio or video are stored in the computer memory as sequences of bits.
- You know computer is a digital Device so data is always in the form of binary (0,1)
- **Line Coding** converts a sequence of bits to a Digital Signal.
- At the sender Digital data are encoded into a Digital Signal. So at the receiver you need to decode the signal to retrieve the digital data.

Functions of Physical layer



Functions of Physical layer

Signal Element Versus Data Element

- In data communications, our goal is to send data elements.
- A data element is the smallest entity that can represent a piece of information: this is the bit.
- In digital data communications, a signal element carries data elements.
- A signal element is the shortest unit (time wise) of a digital signal.
- In other words, data elements are what we need to send: signal elements are what we can send.
- Data elements are being carried; signal elements are the carrier.

Functions of Physical layer

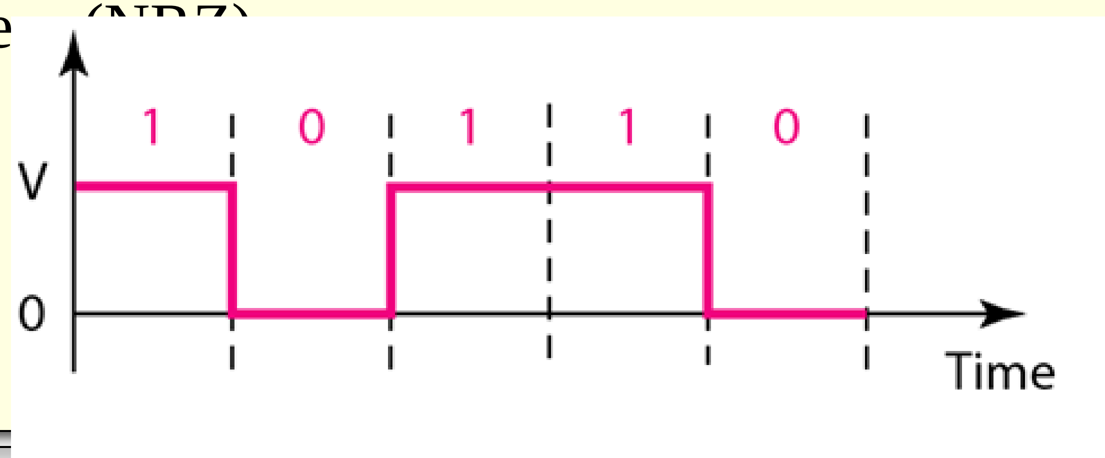
Line Coding schemes

1. Unipolar
2. Polar

1. Unipolar

All signal levels are on one side of the time axis – either above or below

Eg: Non return to ze (NRZ)



Functions of Physical layer

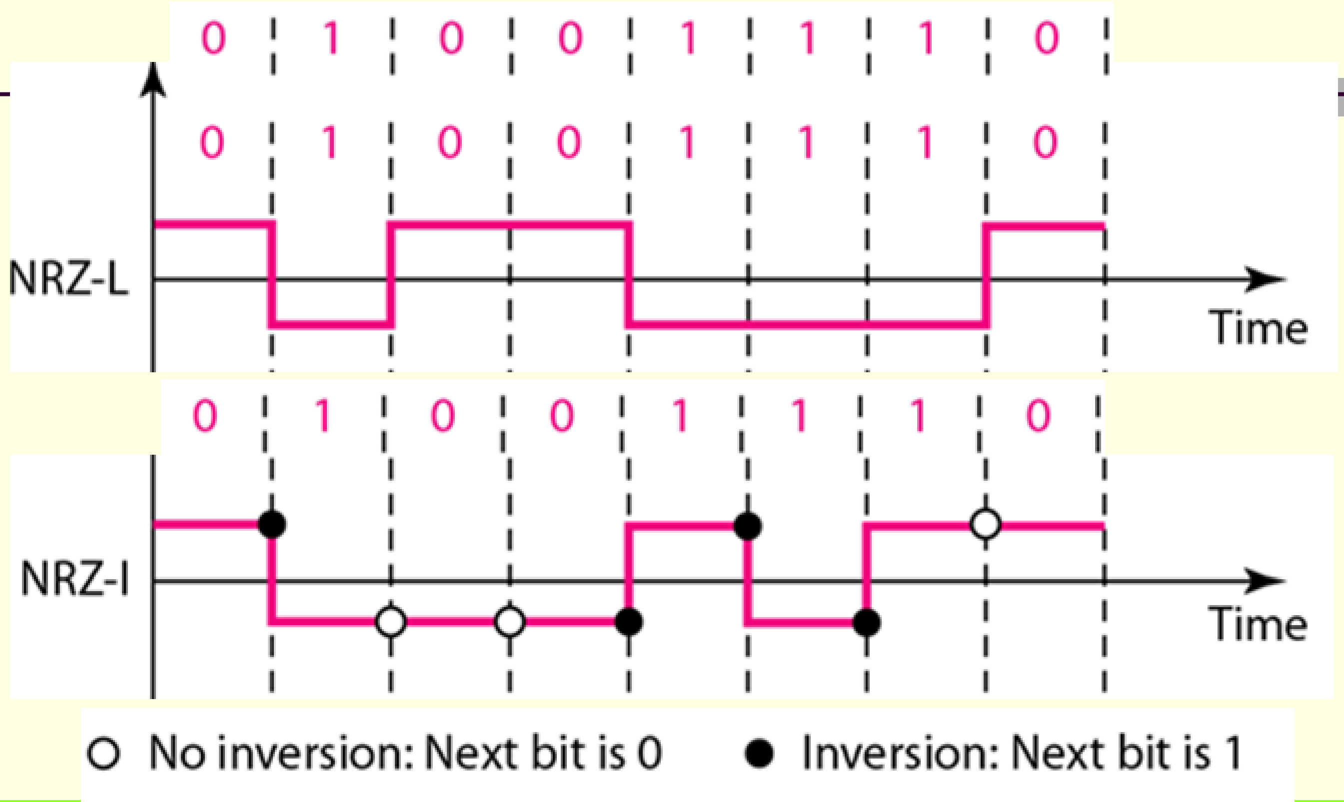
2. Polar Coding

- The voltages are on both sides of the time axis.
- Types

  1. NRZ (Non return to zero)

     - NRZ - Level (NRZ-L) - positive voltage for one symbol and negative for the other
     - NRZ - Inversion (NRZ-I) - the change or lack of change in polarity determines the value of a symbol. E.g. a “1” symbol inverts the polarity a “0” does not.

Functions of Physical layer



In NRZ-L the level of the voltage determines the value of the bit.
In NRZ-I the inversion
or the lack of inversion
determines the value of the bit.

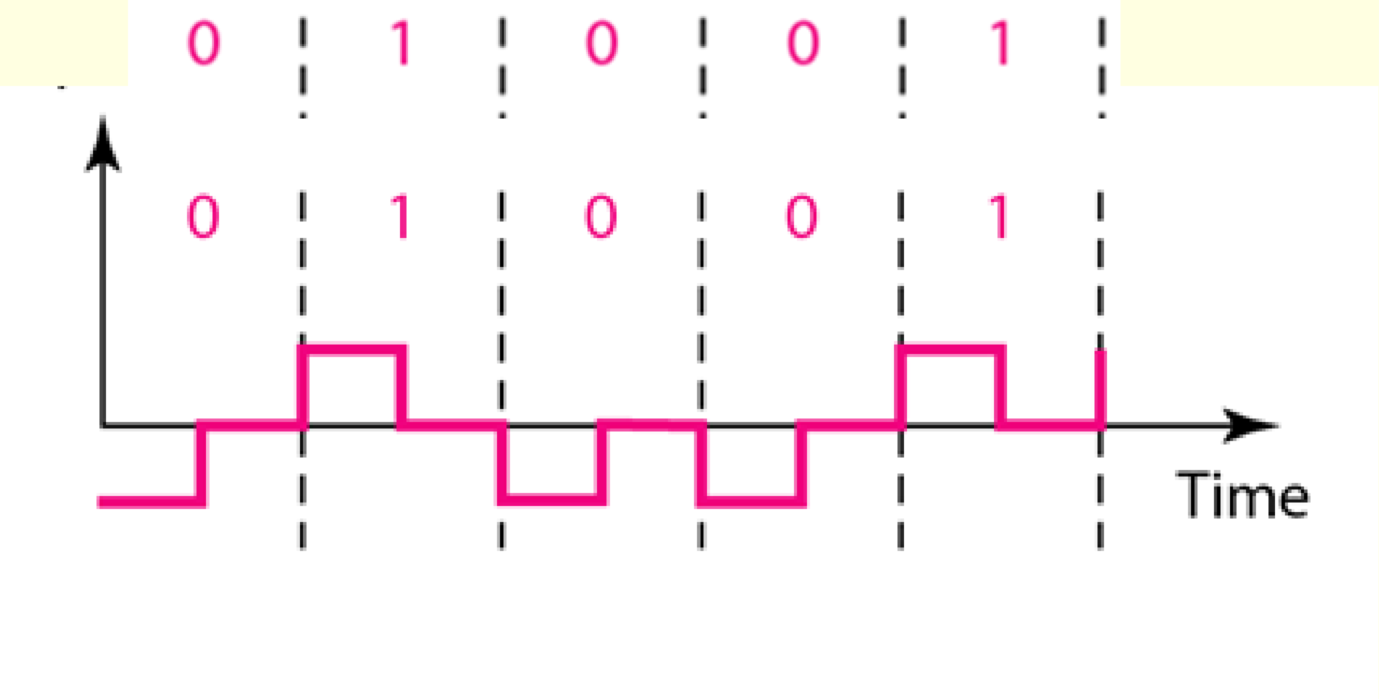
Functions of Physical layer

2. Return to zero (RZ)

- The Return to Zero (RZ) scheme uses three voltage values. +, 0, -.
- Each symbol has a transition in the middle. Either from high to zero or from low to zero.
- The signal returns to a resting state (called zero) during the second half of each bit.
- This scheme has more signal transitions (two per symbol) and therefore requires a wider bandwidth.

Functions of Physical layer

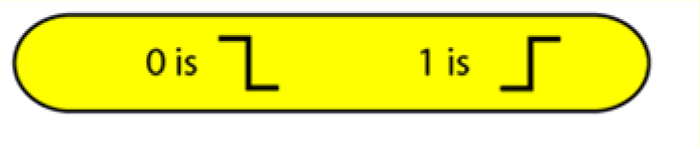
- Polar RZ

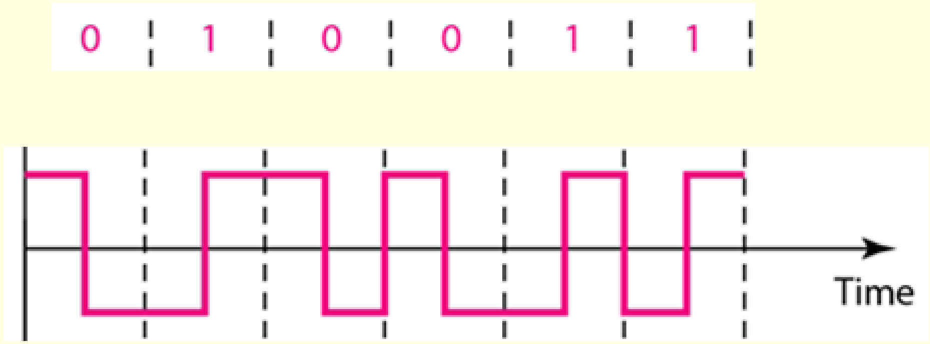


Functions of Physical layer

3. Manchester Encoding

- Every symbol has a level transition in the middle: from high to low or low to high. Uses only two voltage levels.

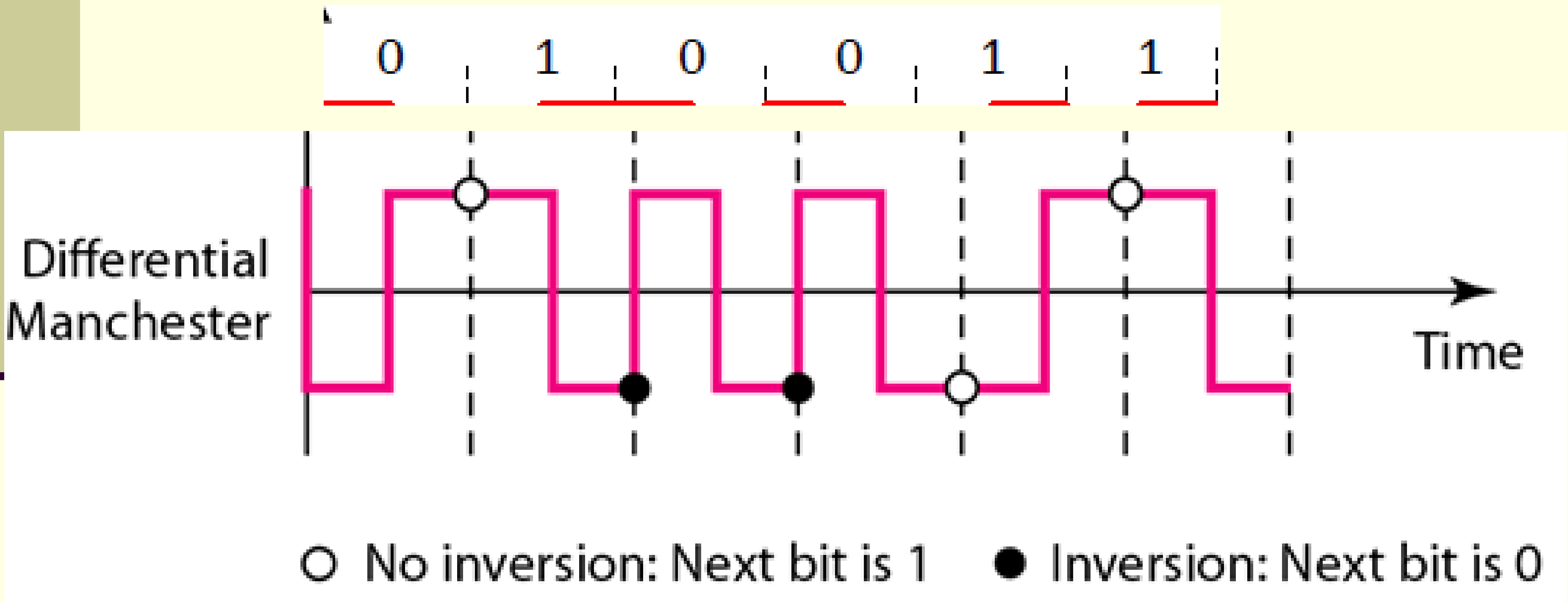




Functions of Physical layer

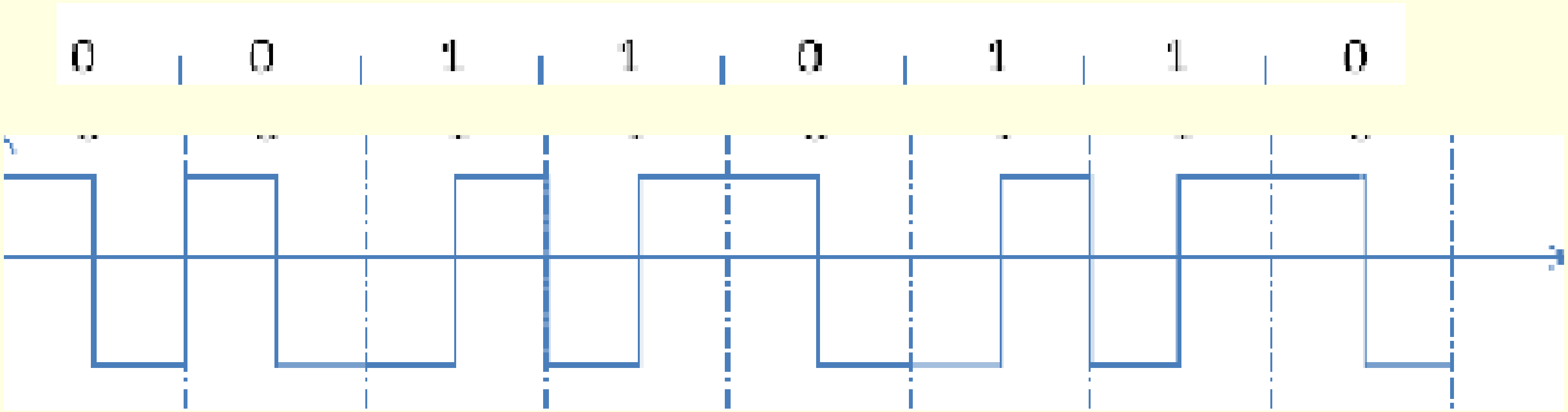
4. Differential Manchester Encoding

- Transition at start of a bit period represents zero
- No transition at start of a bit period represents one

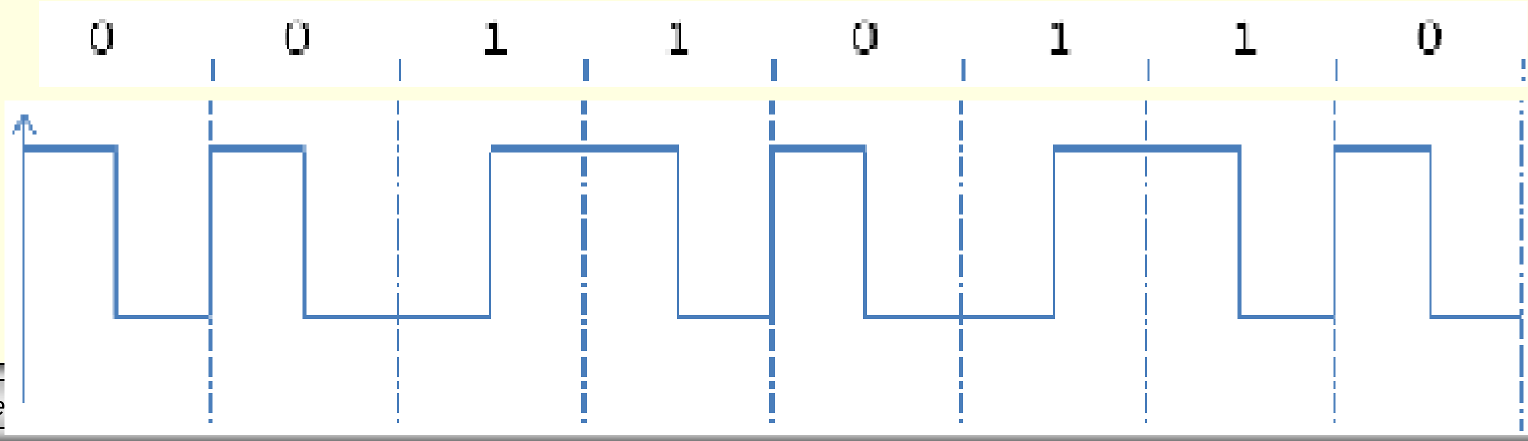


Functions of Physical layer

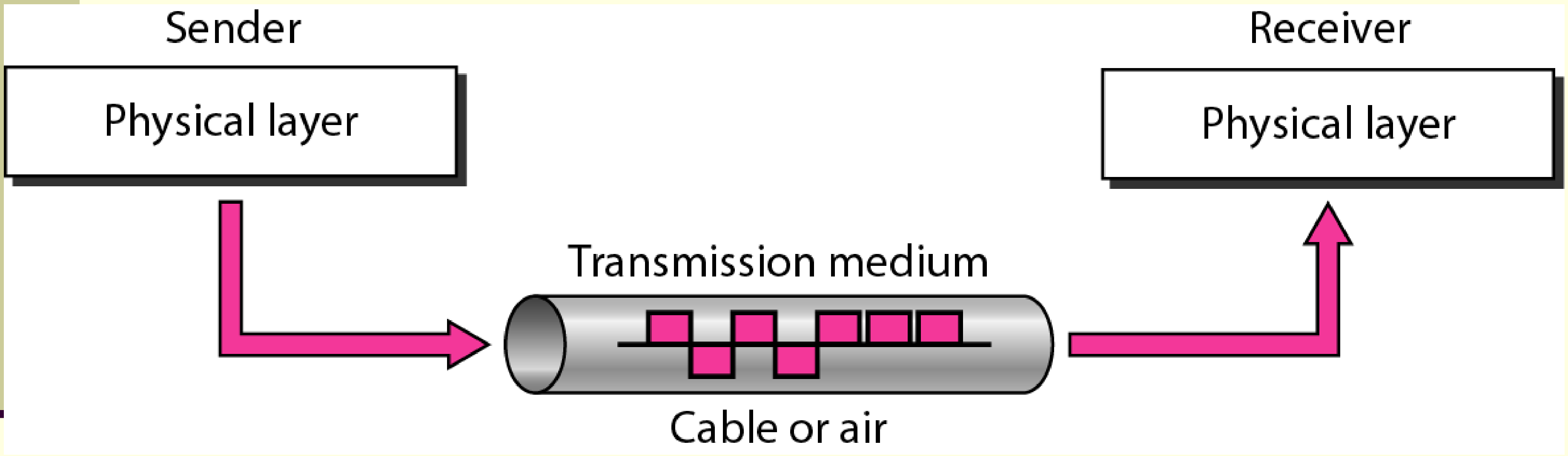
Manchester Encoding



Differential Manchester Encoding



Transmission medium



Transmission Media

Transmission medium:

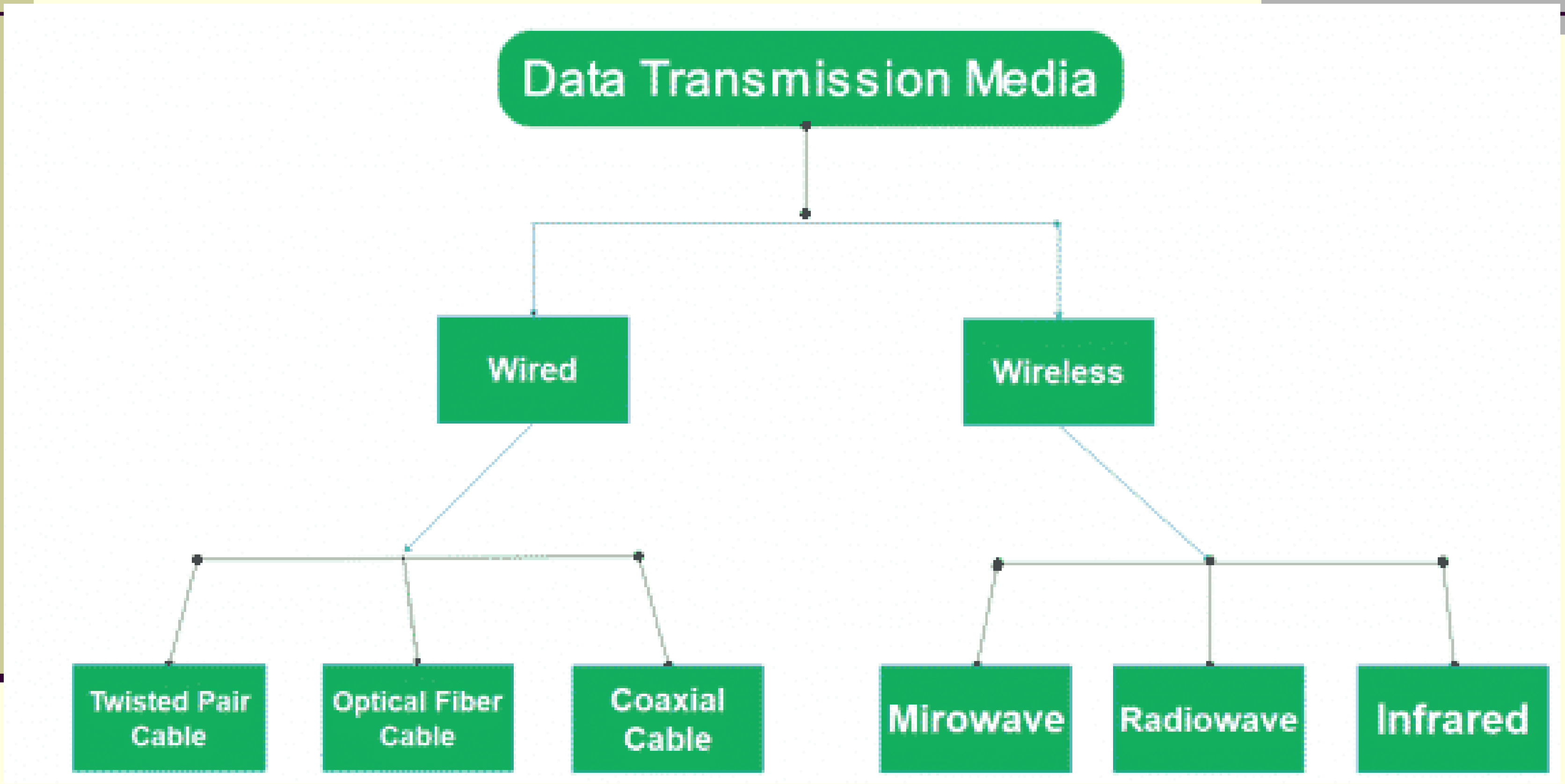
The physical path between transmitter and receiver.

- Communication of electromagnetic waves is *guided* or *unguided.*

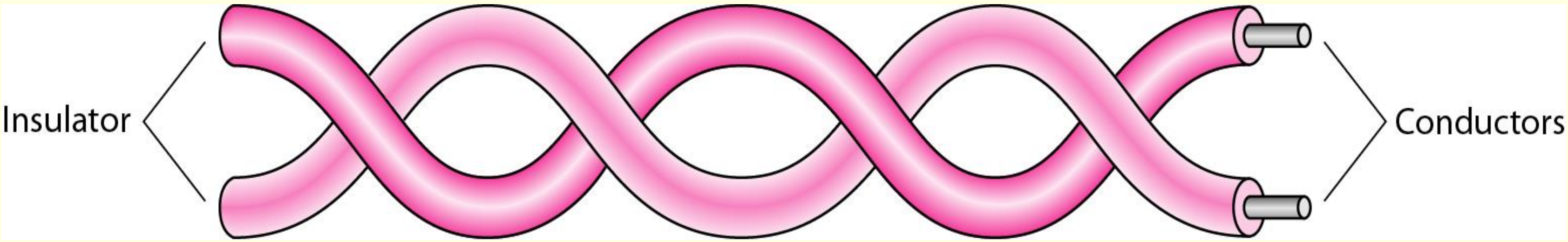
Guided media :: waves are guided along a physical path (e.g, twisted pair, coaxial cable and optical fiber).

Unguided media:: means for transmitting but not guiding electromagnetic waves (e.g., the atmosphere and outer space).

Classes of transmission media

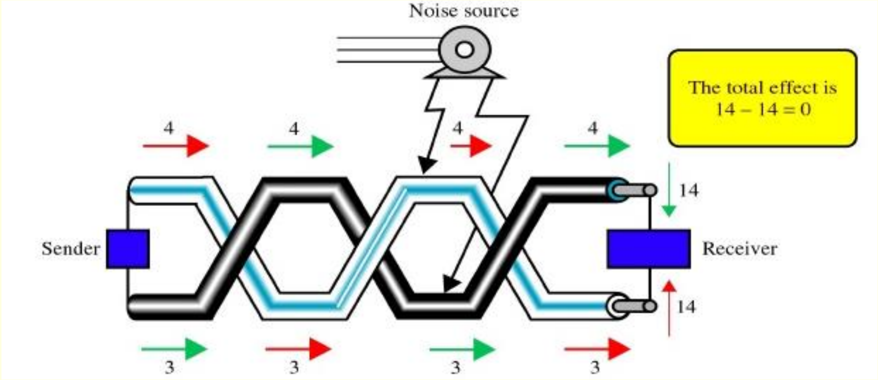


Twisted-pair cable



Twisted Pair

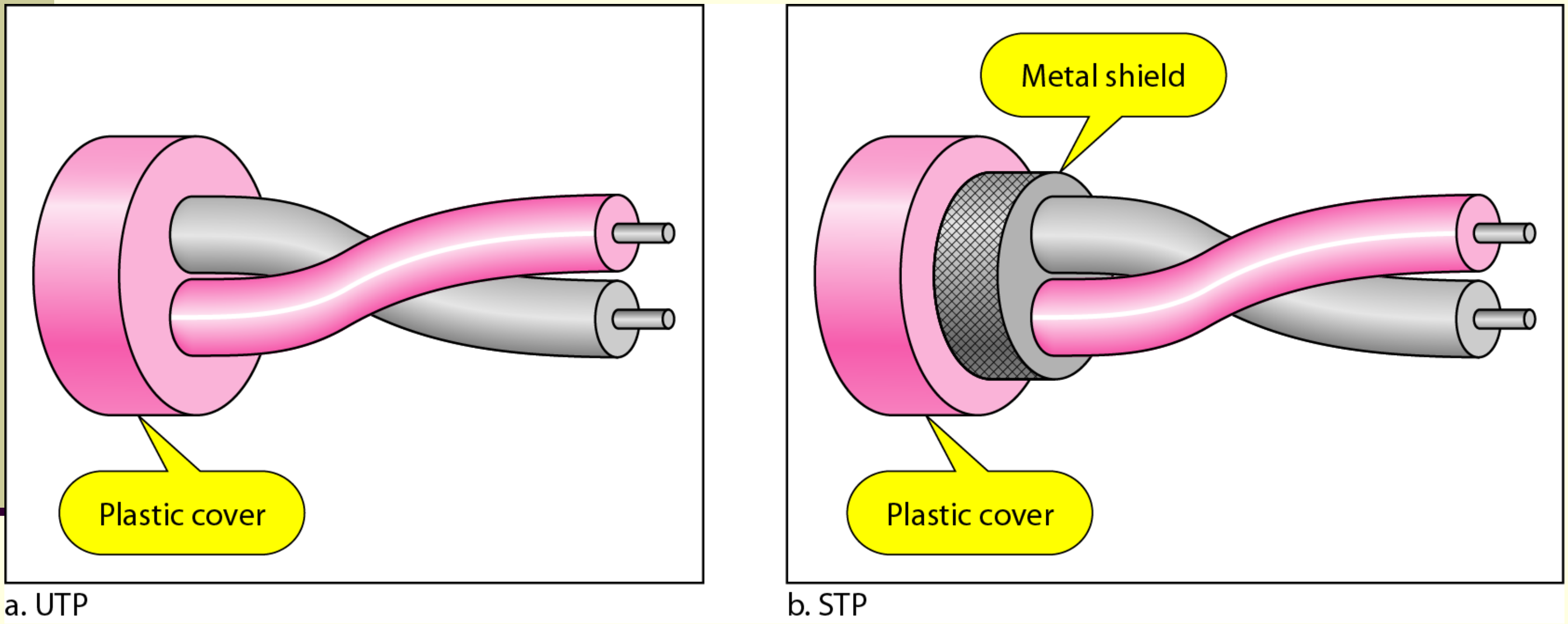
- Consists of 2 copper conductors each having it's own plastic insulation.
- Two wires are twisted around each other.
- One wire carries electrical signal and the other is the ground.
- Typically twisted pair is installed in building telephone wiring.
- Twisting is done to reduce the effect of noise on the pair. Each wire is closer to the noise source for half time and farther for the other half.



- Types: 1. Unshielded twisted pair

  2. Shielded twisted pair

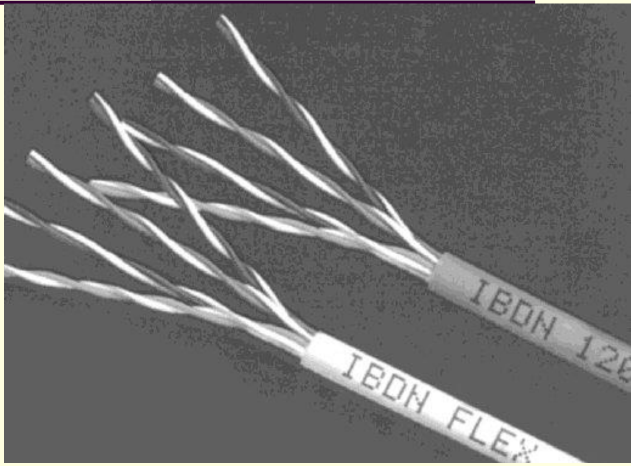
UTP(Unshielded twisted pair) and STP(Shielded twisted pair) cables



Unshielded Twisted Pair (UTP)

UTP

- Consists of 4 pairs (8 wires) of insulated copper wires typically about 1 mm thick.
- The wires are twisted together in a helical form.
- Flexible and cheap cable.
- CAT 3, CAT 4, CAT 5, Enhanced CAT 5 and now CAT 6.

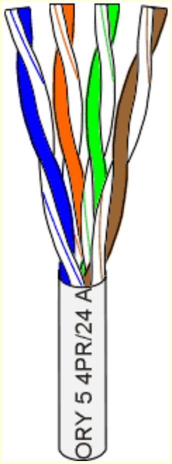


•UTP comes in several categories that are based on the number of twists in the wires, the diameter of the wires and the material used in the wires.

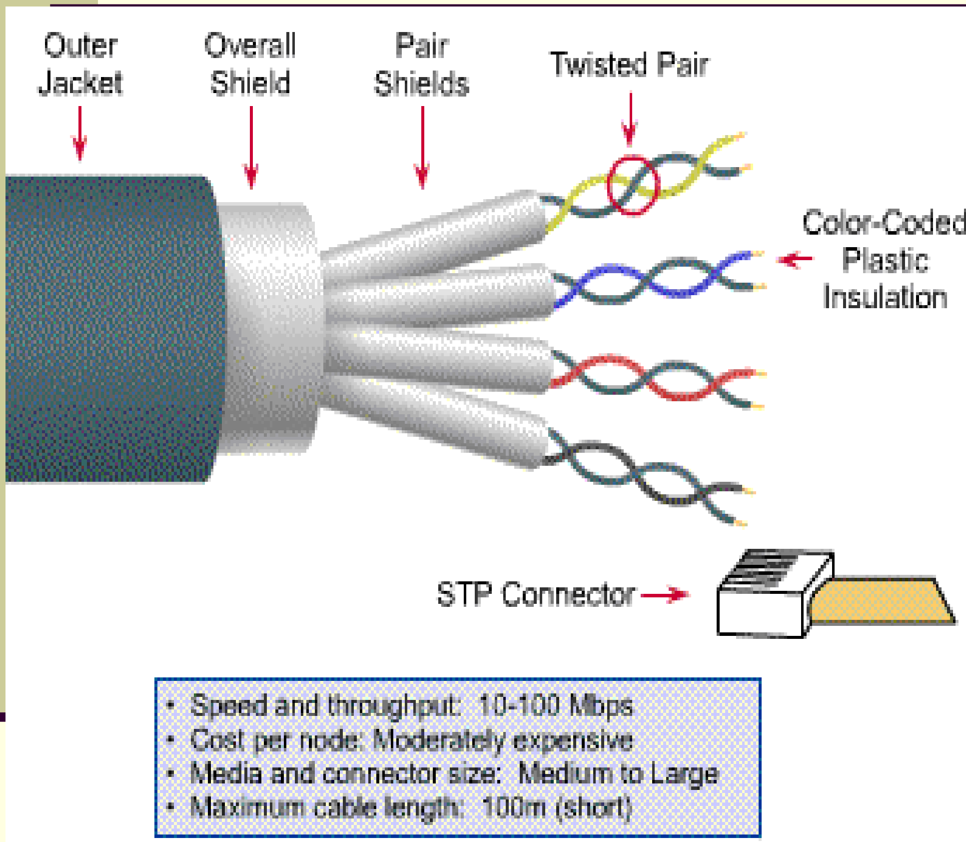
•Category 3 is the wiring used primarily for telephone connections.

•Category 4 and 5 currently the most common Ethernet cables used.

•Category 5e and 6 used in Fast Ethernet (100 Mbps), Gigabit Ethernet (1000 Mbps)



Shielded Twisted Pair



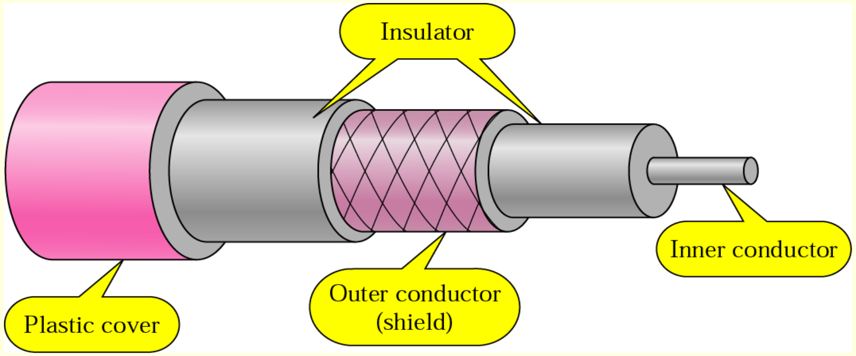
•STP cable has a metal foil or braided-mesh covering that enhances each pair of insulated conductors.

•The metal casing prevents the penetration of electromagnetic noise.

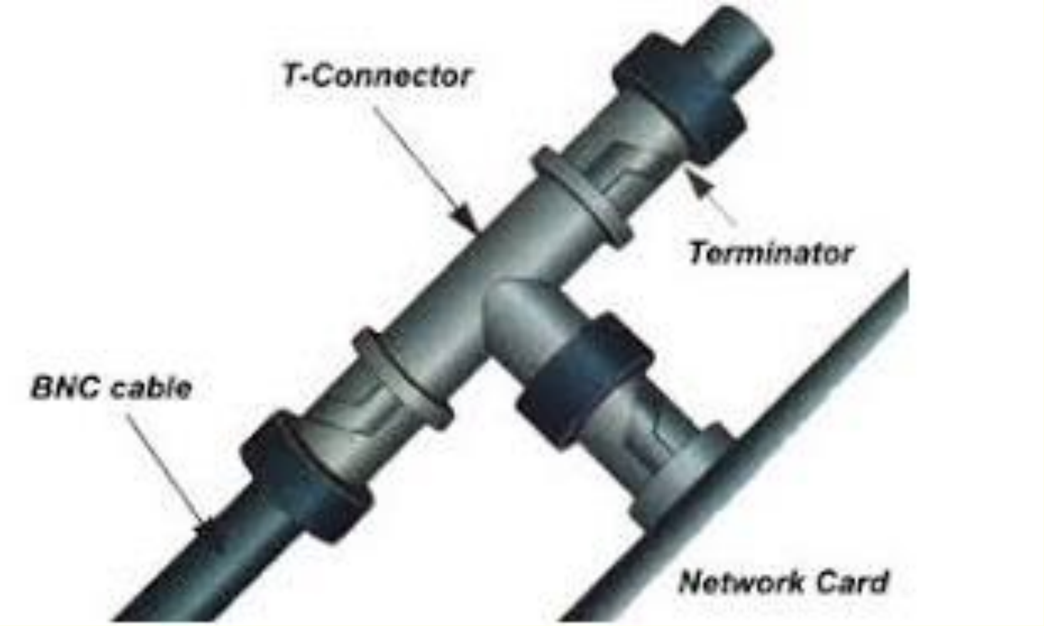
•Materials and manufacturing requirements make STP more expensive than UTP but less susceptible to noise

Coaxial cable

- Coaxial cable is a copper-cored cable surrounded by a heavy shielding and is used to connect computers in a network.
- Outer conductor shields the inner conductor from picking up stray signal from the air.
- High bandwidth but lossy channel.
- Repeater is used to regenerate the weakened signals.



- To connect coaxial cable to devices, it is necessary to use coaxial connectors.
- The most common type of connector is the Bayone-Neill-Concelman, or BNC connectors.



Fiber Optics

- Made of glass, transmits signals in the form of light
- Light pulse can be used to signal a 1-bit and the absence of a pulse a 0 bit.
- Optical transmission has 3 components:

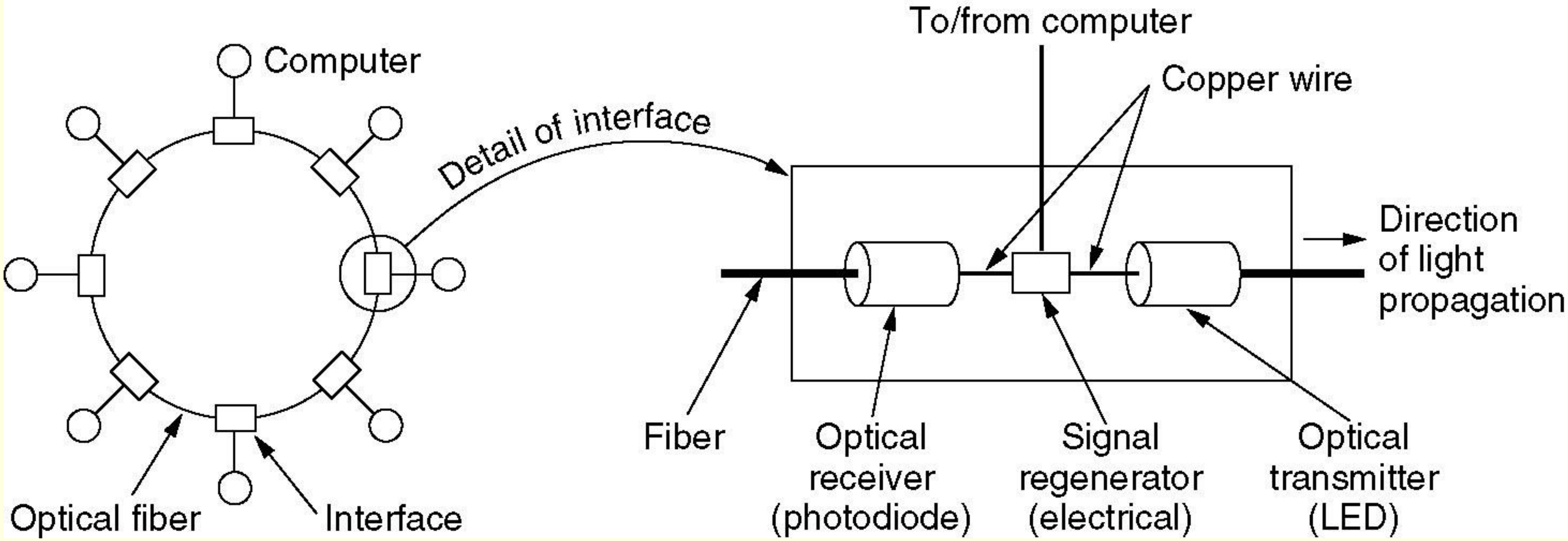
1. Transmission media(ultra thin glass fiber)
2. Light source(LED/laser diode) both emit light pulses when an electric current is applied.
3. Detector(Photodiode) : Generates an electric pulse when light falls on it.

- By attaching an LED/laser to one end of the optical fiber and a photodiode to the other, we can create a unidirectional data transmission system that-----→

1. Accepts an electrical signal, converts it to light pulses and transmits these light pulses.
2. Reconverts the output to an electrical signal at the receiving end.

Fiber Optic Networks

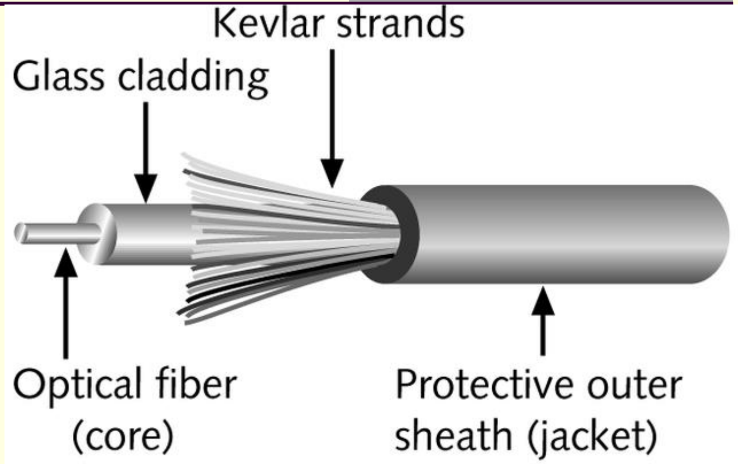
A fiber optic ring(unidrectional) with active repeaters.



Fiber Optics

Structure

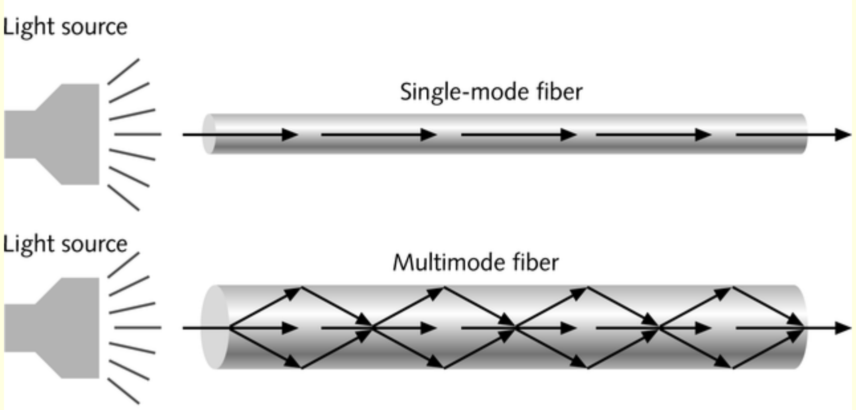
- Contains one or several glass fibers at its core
- Surrounding the fibers is a layer called cladding



Fiber Optics

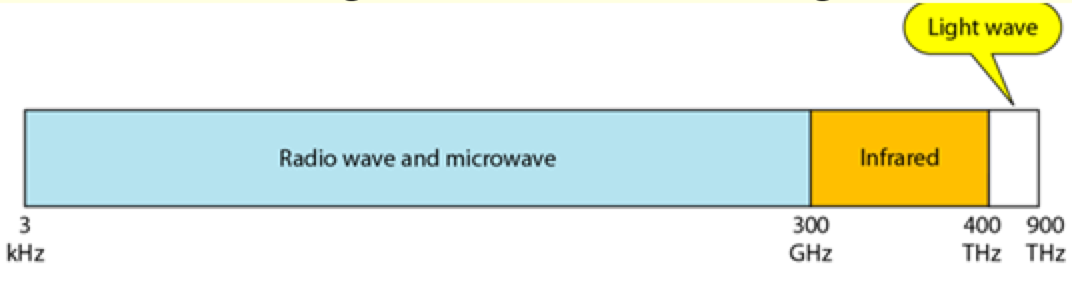
Types of fiber Optics

- **Single-mode fiber**
  - Carries light pulses along single path
  - Uses Laser Light Source
- **Multimode fiber**
  - Many pulses of light generated by LED travel at different angles



Unguided media(Wireless Transmission)

- Drawback of Guided media:
  Acceptable for short distance but expensive for long distance.
- Unguided media(or wireless communication)transport electromagnetic waves without using a physical conductor.
- Signals are broadcast through air (or, in a few cases, water), and thus are available to anyone who has a device capable of receiving them.
- How to generate electromagnetic waves- Inducing current in transmitting antenna.



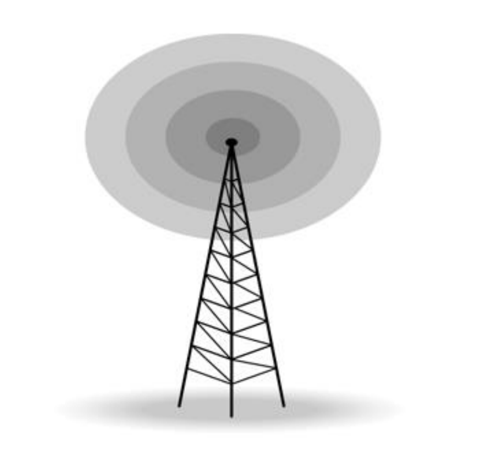
- 3kHz-1 Ghz-Radio Waves
- 1 GHz-300 Ghz-Microwaves

Radio Waves

- Electromagnetic waves ranging in frequencies between 3 KHz and 1 GHz are normally called radio waves.
- Radio waves are omnidirectional. When an antenna transmits radio waves, they are propagated in all directions. This means that the sending and receiving antennas do not have to be aligned. A sending antenna send waves that can be received by any receiving antenna.

Omnidirectional Antenna for Radio Waves

- Radio waves use omnidirectional antennas that send out signals in all directions. They follow the curvature of the earth.



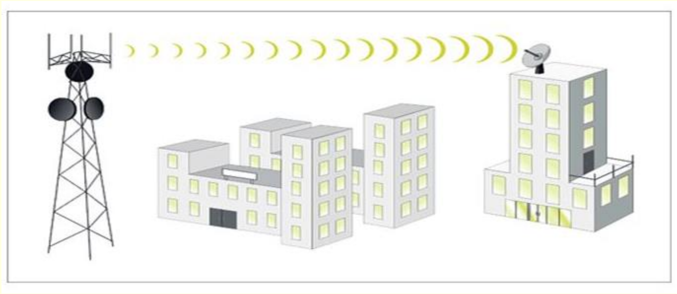
Radio Waves

Applications of Radio Waves

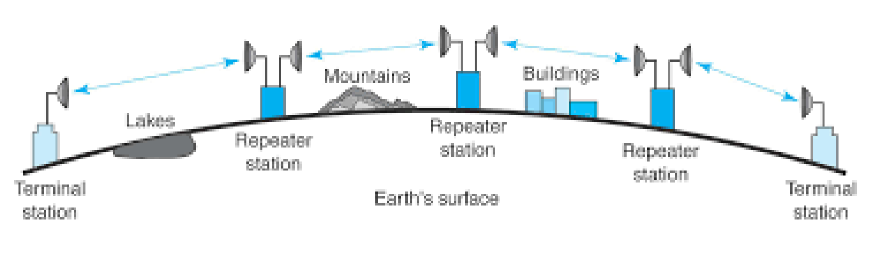
- The omnidirectional characteristics of radio waves make them useful for multicasting in which there is one sender but many receivers.
- AM(Amplitude modulation) and FM(Frequency modulation) radio, television, maritime radio, cordless phones, and paging are examples of multicasting.

Microwaves

- Microwave transmissions do not follow the curvature of the earth.
- Requires line of sight transmission and reception equipment.
- Transmission/reception equipment if at a height of 100 m, distance between them can be max 82km.



To increase the distance----→system of repeaters can be used



Applications

Cellular telephones, satellite communication and wireless LANs

Infrared

- Infrared waves, with frequencies from 300 GHz to 400 THz, can be used for short-range communication.
- Infrared waves, having high frequencies, cannot penetrate walls.
- This advantageous characteristic prevents interference between one system and another, a short-range communication system in on room cannot be affected by another system in the next room.
- When we use infrared remote control, we do not interfere with the use of the remote by our neighbours.
- However, this same characteristic makes infrared signals useless for long-range communication.
- In addition, we cannot use infrared waves outside a building because the sun's rays contain infrared waves that can interfere with the communication.

Infrared

Applications of Infrared Waves

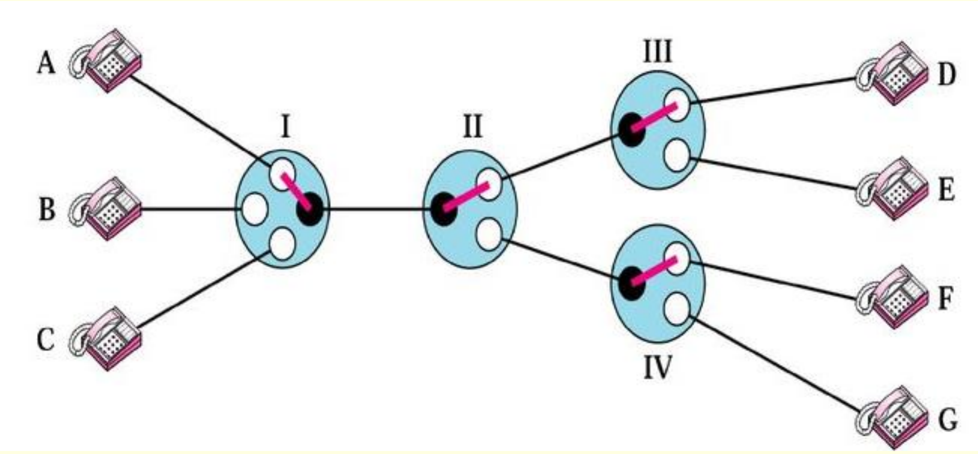
- The infrared band, almost 400 THz, has an excellent potential for data transmission. Such a wide bandwidth can be used to transmit digital data with a very high data rate.

Switching

- A switched network consists of a series of inter-linked nodes, called switches.
- Switches are hardware and/or software devices capable of creating temporary connections between two or more devices linked to the switch but not to each other.
- Methods of switching :
  - Circuit switching,
  - packet switching

Circuit Switching

- Circuit switching creates a direct physical connection between two devices such as phones or computers. We can use switches to reduce the number and length of links.
- A circuit switch is a device with n inputs and m outputs that creates a temporary connection between an input link and an output link. The number of inputs does not have to match the number of outputs.



Circuit Switching

- Creates a circuit/connection on demand.
- Terminated once no longer required(temporary)
- Eg Telephone network

Packet switching

- Problem of circuit switching
  - designed for voice service
  - Resources dedicated to a particular call
  - For data transmission, much of the time the connection is idle (say, web browsing)

Packet switching

Packet switching

- **Data are transmitted in short packets**
  - Typically at the order of 1000 bytes
  - Longer messages are split into series of packets
  - Each packet contains a portion of user data plus some control info
- **Control info contains at least**
  - Routing (addressing) info, so as to be routed to the intended destination
- **store and forward**
  - On each switching node, packets are received, stored briefly (buffered) and passed on to the next node.

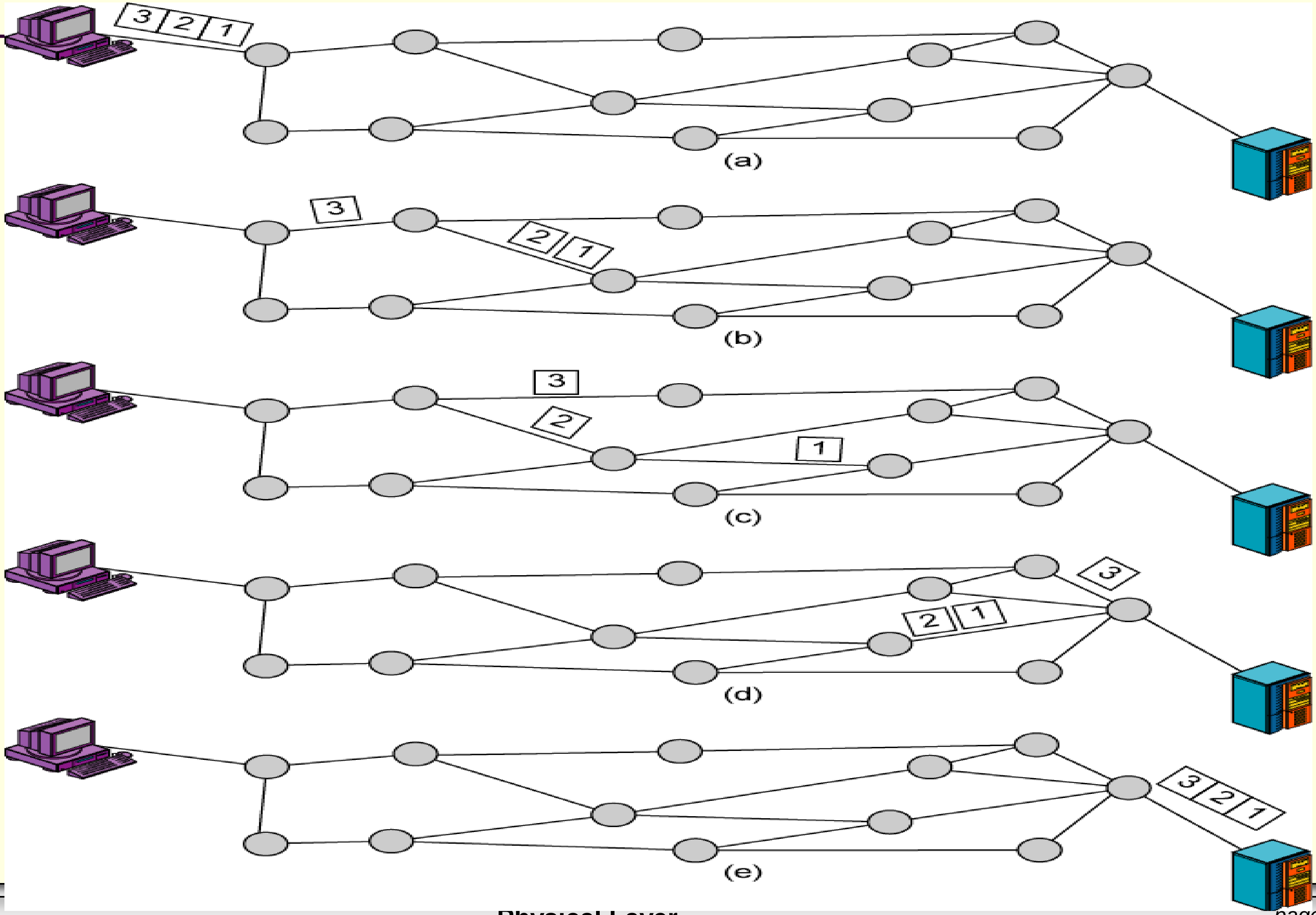
Packet switching

- A station breaks long message into packets
- Packets are sent out to the network sequentially, one at a time
- How will the network handle this stream of packets as it attempts to route them through the network and deliver them to the intended destination?
  - Two approaches
    - **Datagram** approach
    - **Virtual circuit** approach

Datagram Approach

- Each packet is treated independently, with no reference to packets that have gone before.
  - Each node chooses the next node on a packet's path.
- Packets can take any possible route.
- Packets may arrive at the receiver out of order.
- Packets may go missing.
- It is up to the receiver to re-order packets and recover from missing packets.
- Example: Internet

Datagram



Virtual Circuit

- In virtual circuit, a preplanned route is established before any packets are sent, then all packets follow the same route.
- Each packet contains a **virtual circuit identifier** instead of destination address, and each node on the pre established route knows where to forward such packets.
  - The node need not make a routing decision for each packet.
- Example: X.25, Frame Relay, ATM