COMPUTER NETWORKS MODULE I

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Topics

- Network Software
- The OSI reference model
- Services in the OSI model
- TCP/ IP reference model

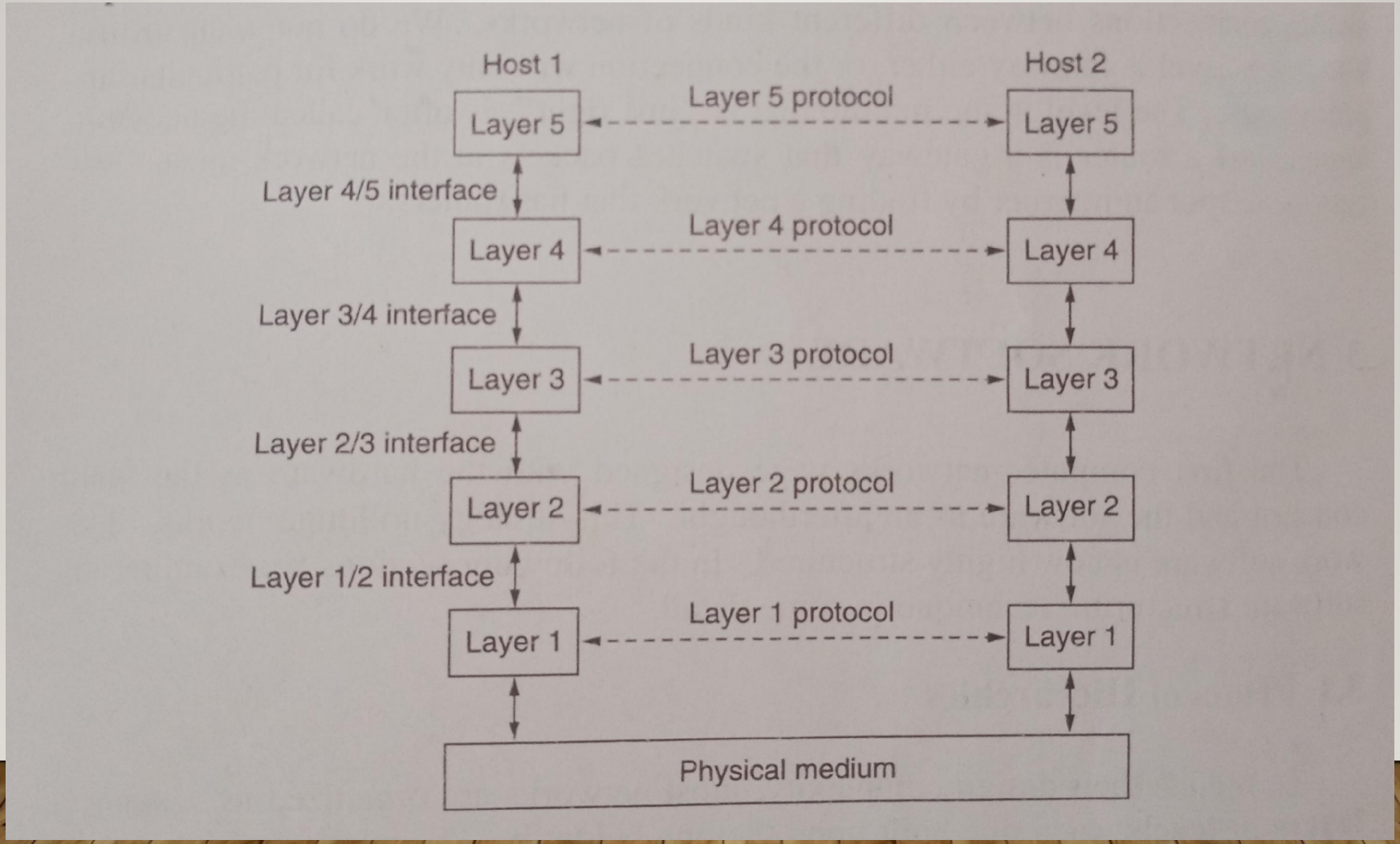
Network Software- Protocol Hierarchies

- Layered approach: stack of layers or levels.
- The number of layers, name of the layer, functions of each layer differ from network to network.
- Offer services to the higher layers.
- Protocol: agreement between the communicating parties on how the communication is to proceed.
- Data and control information are passed to the lower layers.

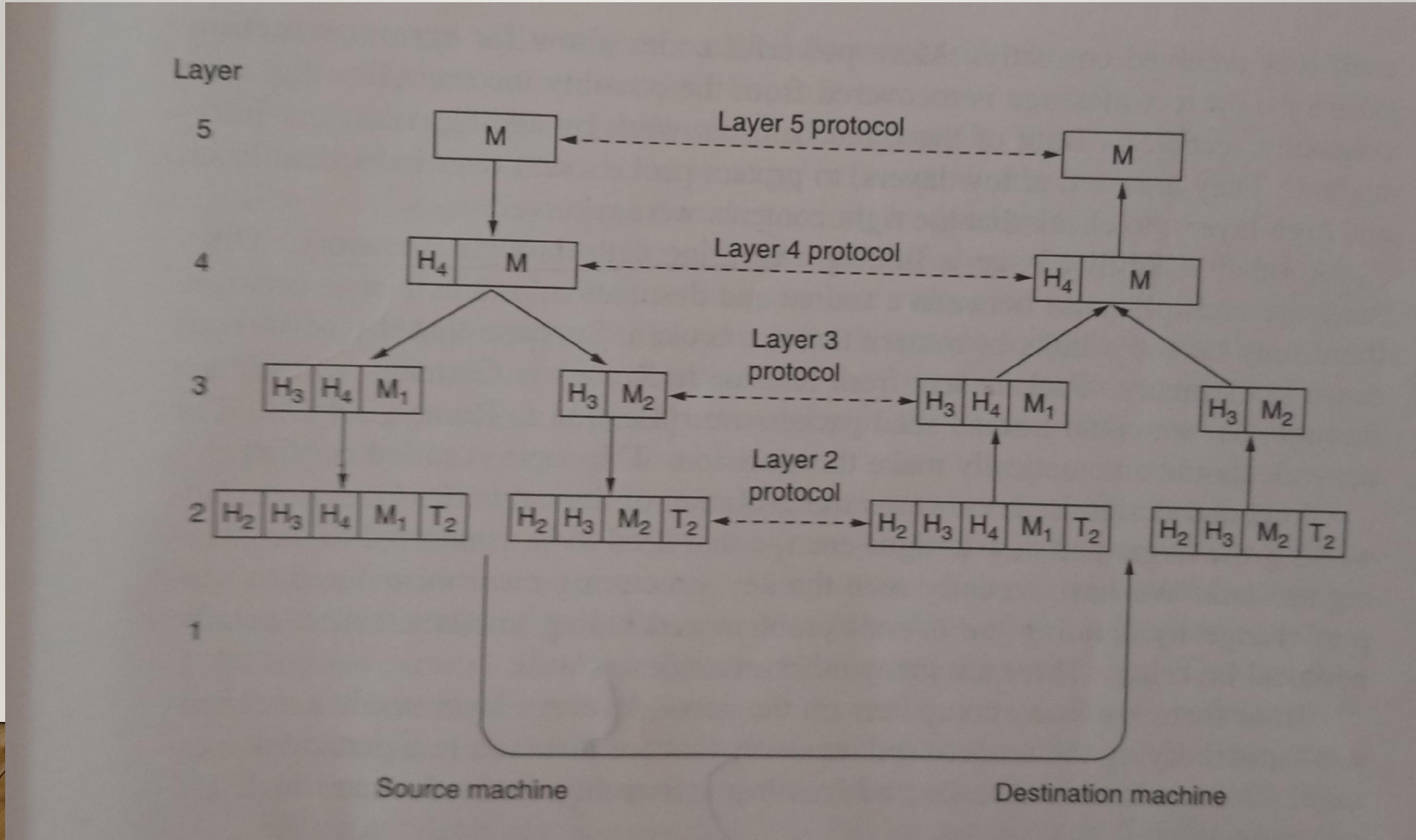
Network Software- Protocol Hierarchies

- **Interfaces**: the primitive operations and services the lower layers make available to the upper layers
- **Network architecture**: a set of layers and protocols.
- **Protocol stack**: a list of protocols used by a certain system, one protocol per layer.

Network Software- Protocol Hierarchies



Network Software- Protocol Hierarchies



Network Software- Design issues for the layers

1. Reliability:
   - Design an error free network.
   - Error detection and error correction mechanisms.
   - Routing
2. Addressing
   - Identify the sender's and receiver's address.
   - Scalability issue.

Network Software- Design issues for the layers

3. Resource Allocation:
   - Allocate the resources available.
   - Chances of congestion
4. Security
   - Secure the network against threats
   - Ensure confidentiality and authentication.

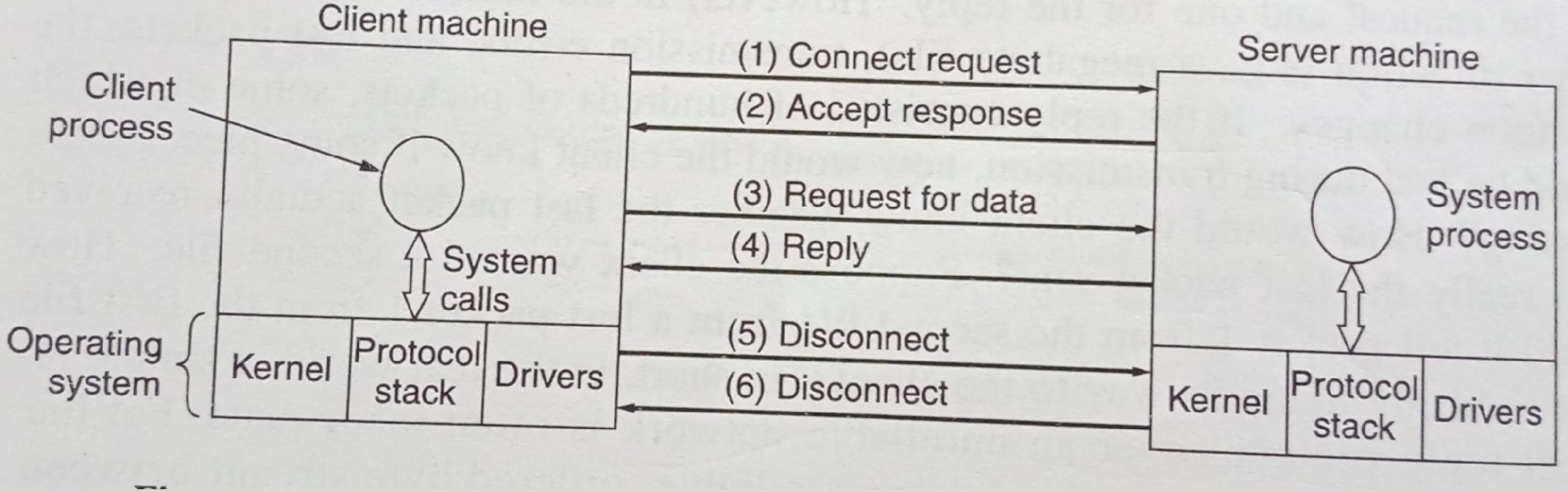
Network Software- Types of Services

Connection Oriented service	Connectionless Service
Connection-oriented service is related to the telephone system.	Connectionless service is related to the postal system.
Three phase process: a) Connection establishment b) Data transfer c) Termination	Single phase process: Data transfer
Reliable and secure	No guarantee of reliability and security
Packets follow the same route	Packets does not follow the same route
Requires authentication	Does not require authentication
E.g. TCP (Transmission Control Protocol	UDP (User Datagram Protocol)

Network Software- Service Primitives

- Service = set of primitives provided by one layer to layer above.
- Service defines what layer can do (but not how it does it).
- Primitives for connection oriented service are different from those of connectionless service.

Network Software- Service Primitives



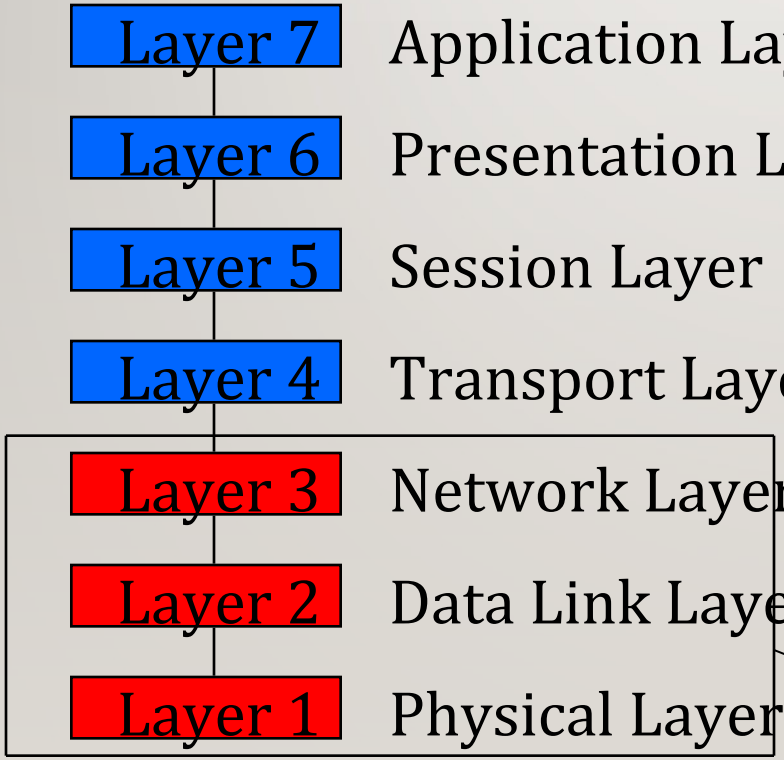
Network Software- Relationship of Service to protocols

- Service = set of primitives provided by one layer to layer above.
- Service defines what layer can do (but not how it does it).
- Protocol defines set of rules governing the format and meaning of the packets.

OSI Reference Model

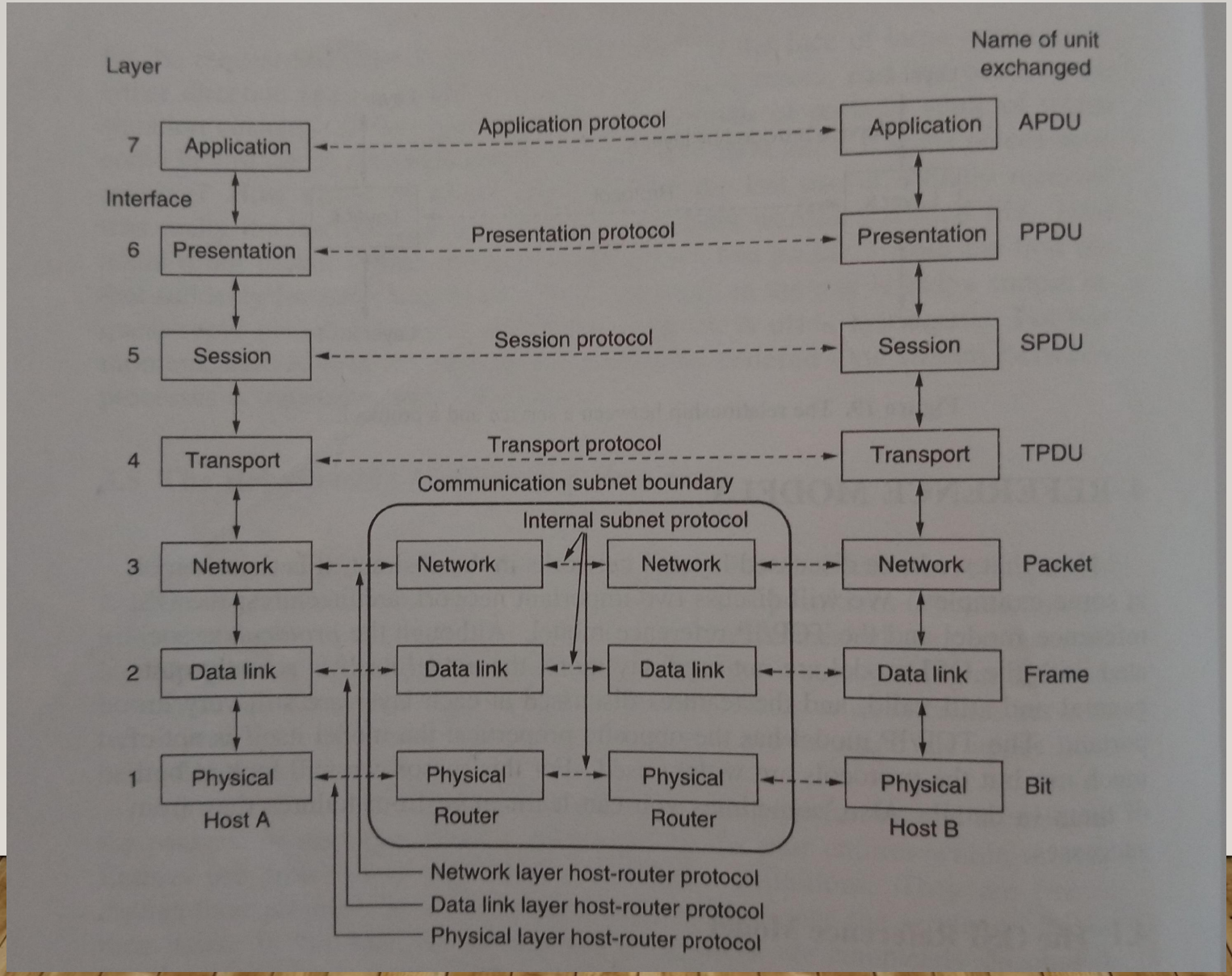
- OSI Reference Model - internationally standardised network architecture.
- OSI = *Open Systems Interconnection*: deals with *open systems*, i.e. systems open for communications with other systems.
- Developed by International Standards Organization.
- Model has 7 layers.
- Each layer has specific functionality to perform.

7-Layer OSI Model



- Layers 1-4 relate to communications technology.
- Layers 5-7 relate to user applications.

7-Layer OSI Model



Layer 1: Physical Layer

- Responsible for actual physical connection between the devices.
- Transmits bits from one computer to another.
- Regulates the transmission of a stream of bits over a physical medium.
- Defines how the cable is attached to the network adapter and what transmission technique is used to send data over the cable.

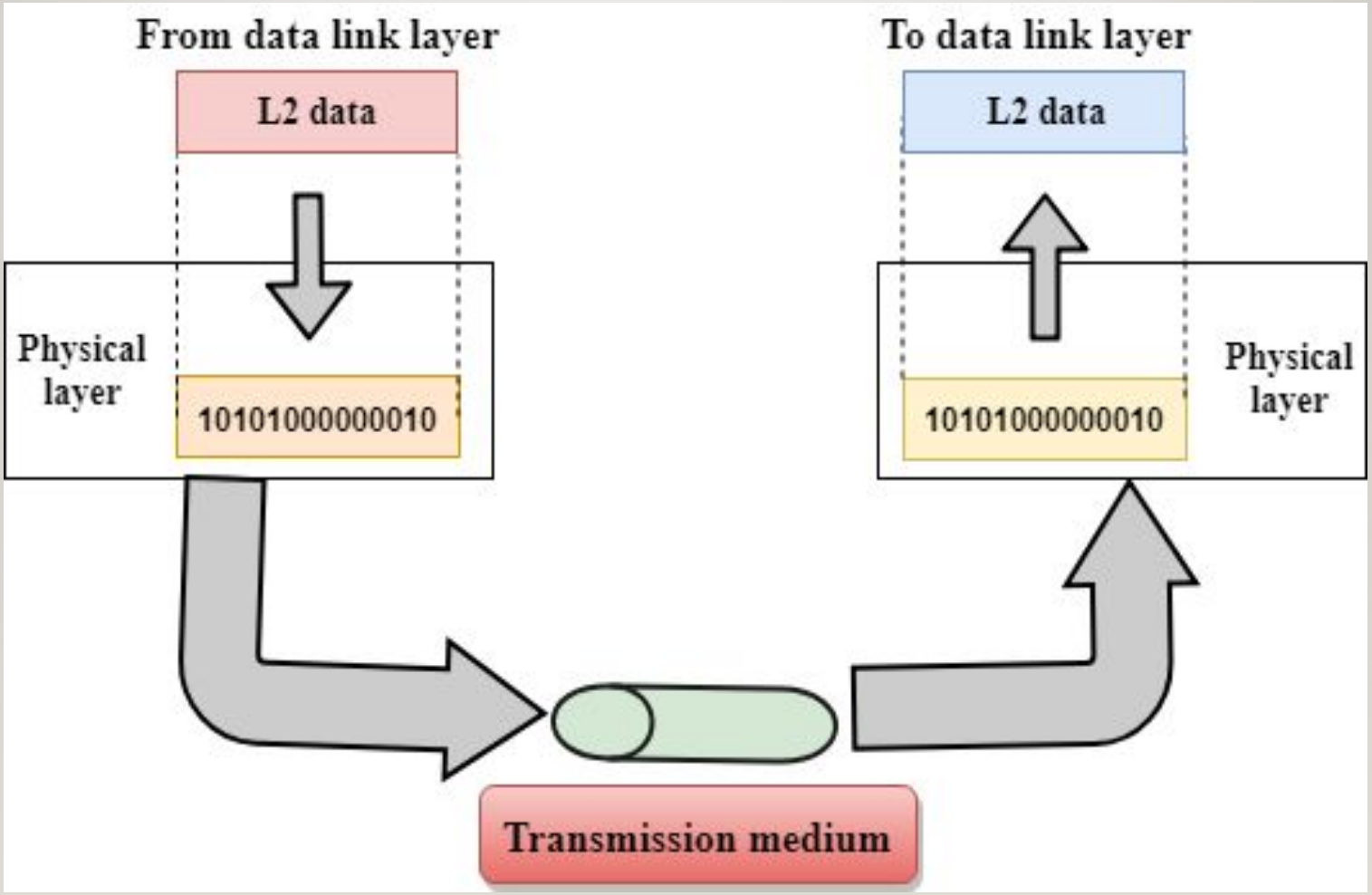
Layer 1: Physical Layer

- Deals with issues like
  - The definition of 0 and 1, e.g. how many volts represents a 1, and how long a bit lasts?
  - Whether the channel is simplex or duplex?
  - How many pins a connector has, and what the function of each pin is?

Layer 1: Physical Layer- Functions

- Bit Synchronization:
  - Use of clock that controls both sender and receiver.
- Bit rate control
  - Number of bits sent per second
- Physical topologies:
  - The way in which different nodes are arranged in a network.
- Transmission mode:
  - Simplex / Half Duplex / Duplex

Layer 1: Physical Layer- Functions



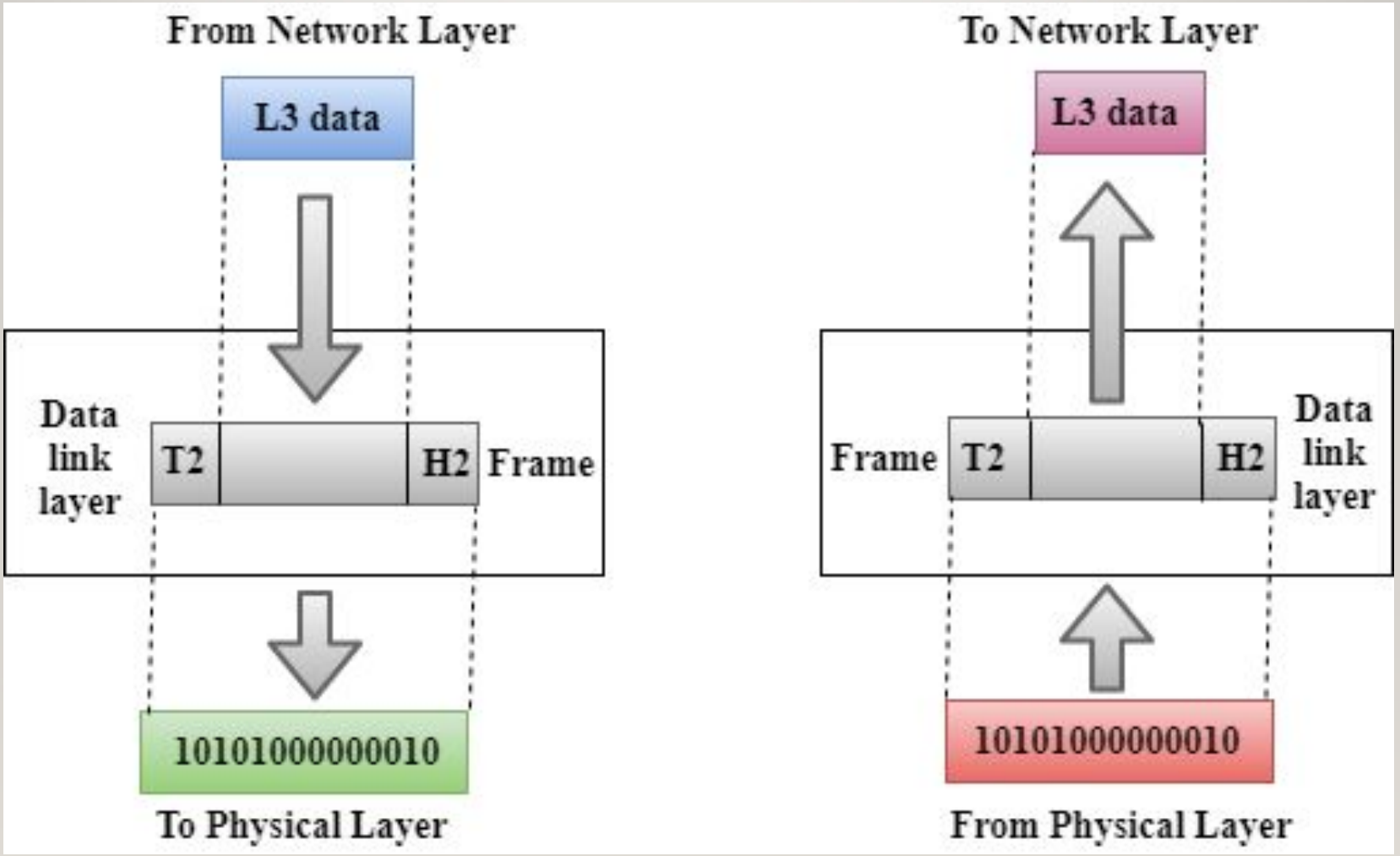
Layer 2: Data Link Layer- Functions

- Framing:
  - Transmit a set of bits that are meaningful to the receiver.
  - Attach special bit patterns to the beginning and end of the frame.
- Physical addressing:
  - Add the physical address of the sender and receiver in the header of each frame.

Layer 2: Data Link Layer- Functions

- Error Control:
  - Mechanism of error control: detect errors and retransmit damaged or lost frames.
- Flow Control:
  - Data rate must be constant at both the sides.
  - Coordinates the amount of data that can be sent before receiving acknowledgement.

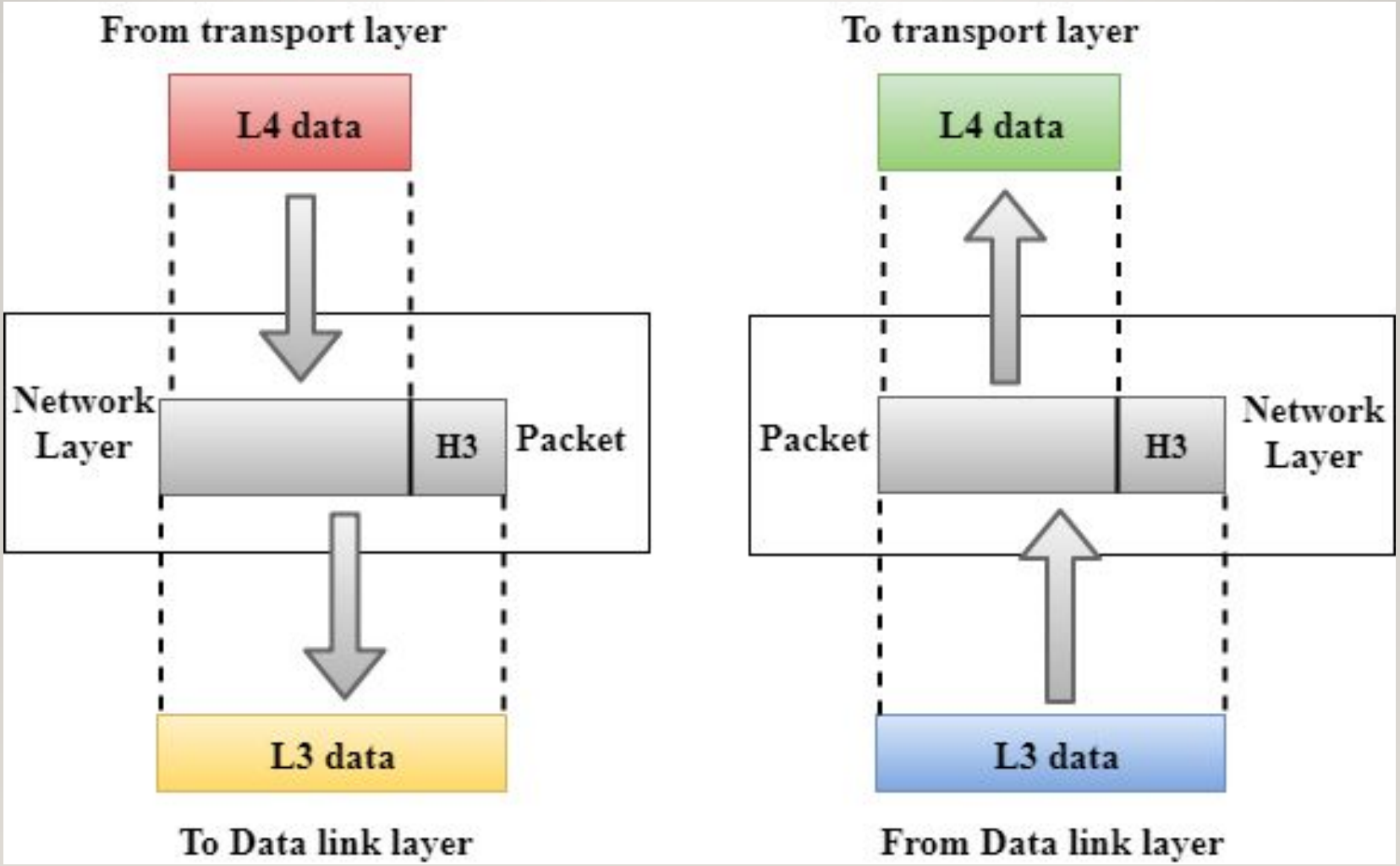
Layer 2: Data Link Layer- Functions



Layer 3: Network Layer

- Track the location of the devices on the network.
- Transmission of data from one host to the other located in different networks.
- Packet routing: selection of the shortest path to transmit the packet.
- Logical Addressing: The IP address of the sender and receiver are placed in the header.
- Manages traffic problems and controlling the congestion of data packets.

Layer 3: Network Layer- Functions



Layer 4: Transport Layer

- Heart of the OSI model.
- Manages transmission packets
  - Repackages long messages into small packets for transmission.
  - Reassembles packets in correct order to get the original message.
- Handles error recognition and recovery.
  - Provides acknowledgement of successful data transmission.
  - Resends missing packets.

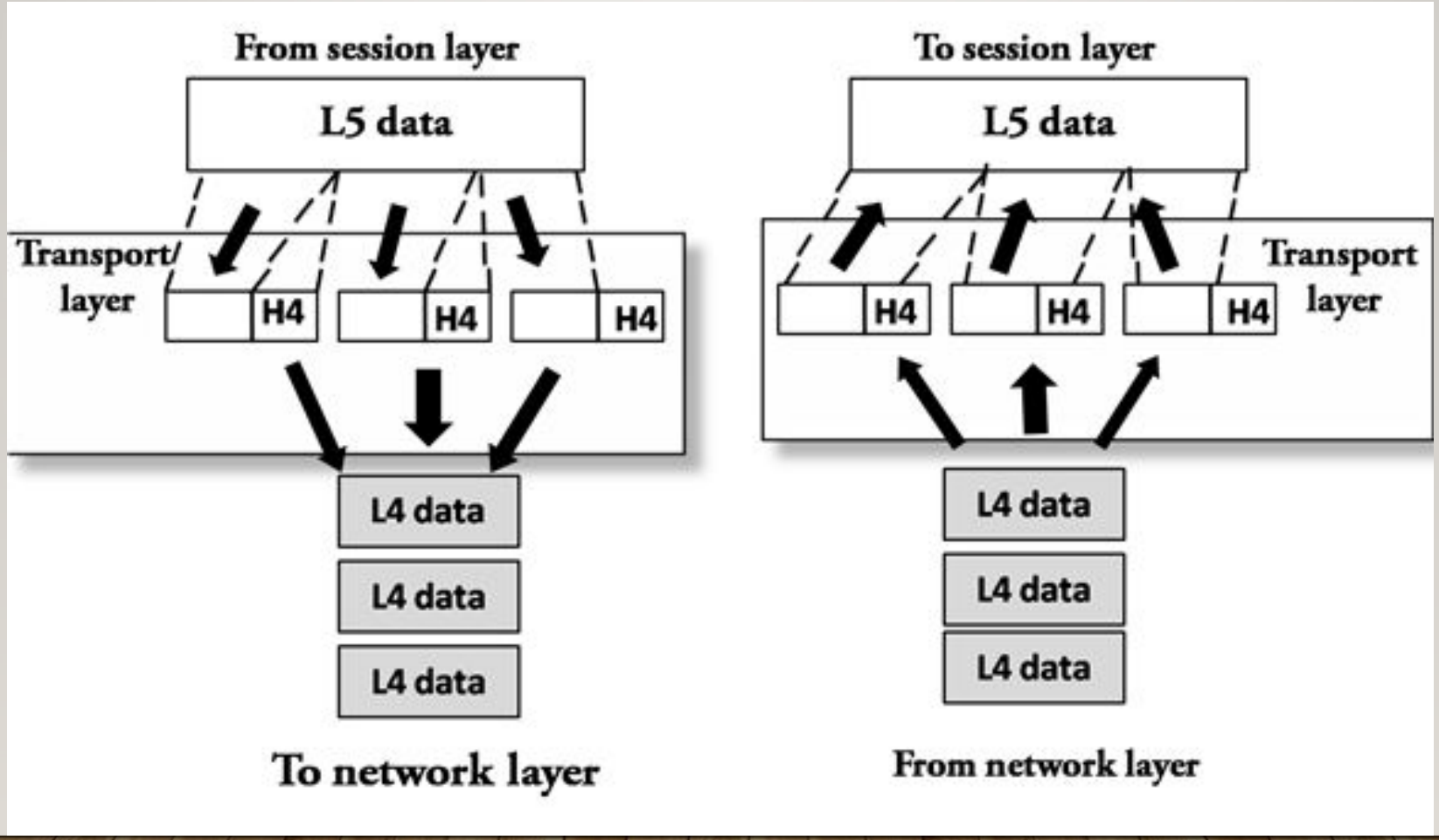
Layer 4: Transport Layer-Functions

- Segmentation and Reassembly:
  - Accepts the message from the upper layer and breaks the message into smaller units.
  - Each segment has a header.
- Service point addressing:
  - Includes service point address or port address.
- Flow and error control

Services provided by transport layer

- Connection oriented service
  - Three phase process: connection establishment, data transfer, disconnection.
  - Reliable and secure.
  - Acknowledgement by the receiver.
- Connectionless service
  - One phase process: data transfer.
  - No acknowledgement receipt of a packet.

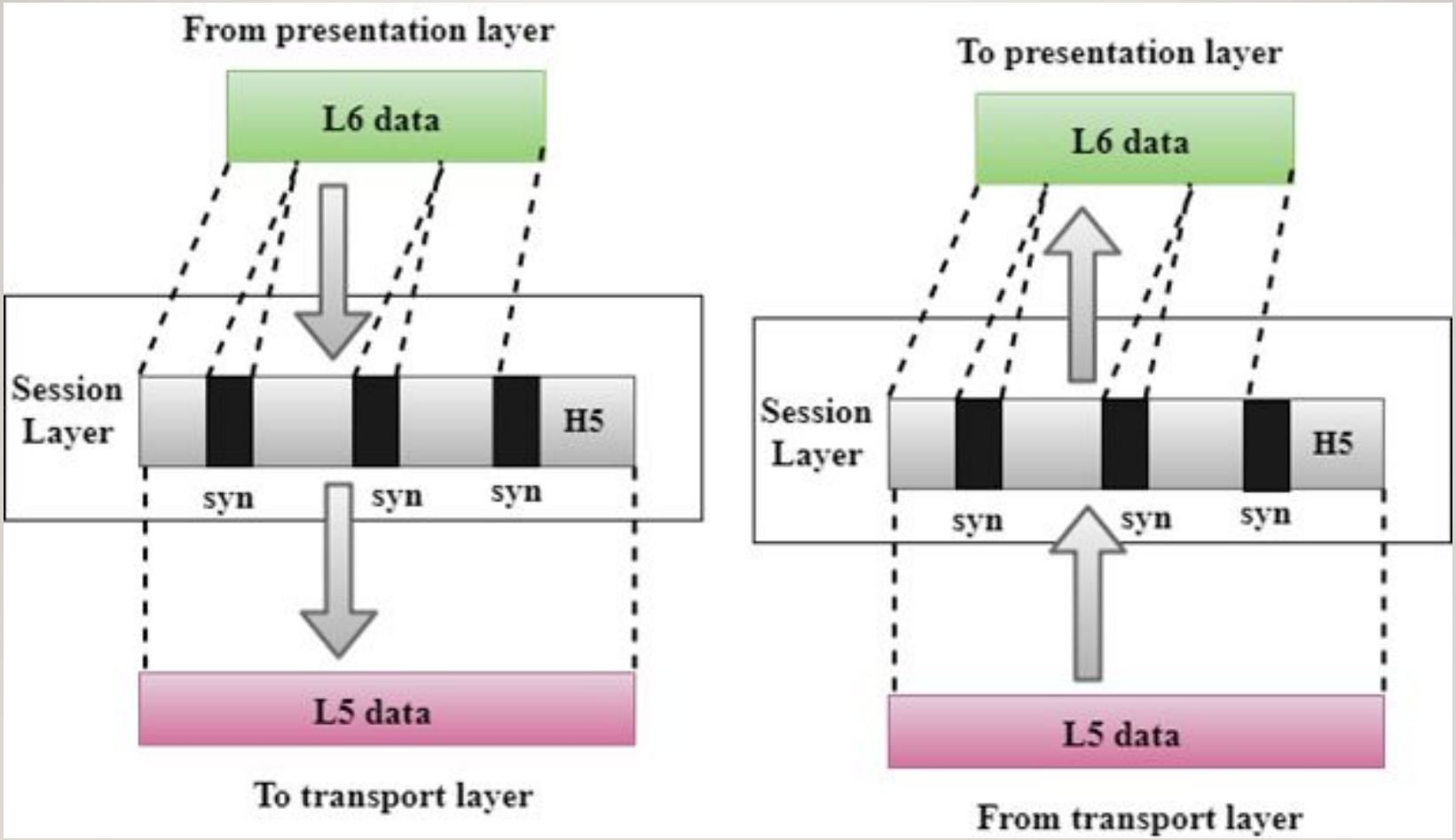
Layer 4: Transport Layer



Layer 5: Session Layer

- Allows two applications on different computers to establish, use, and end a session.
- Establishes dialog control
  - Keep track of whose turn it is to transmit.
- Performs synchronization
  - Add check points for long transmissions to identify the error and subsequent recovery.
  - Retransmission starts from the check point.

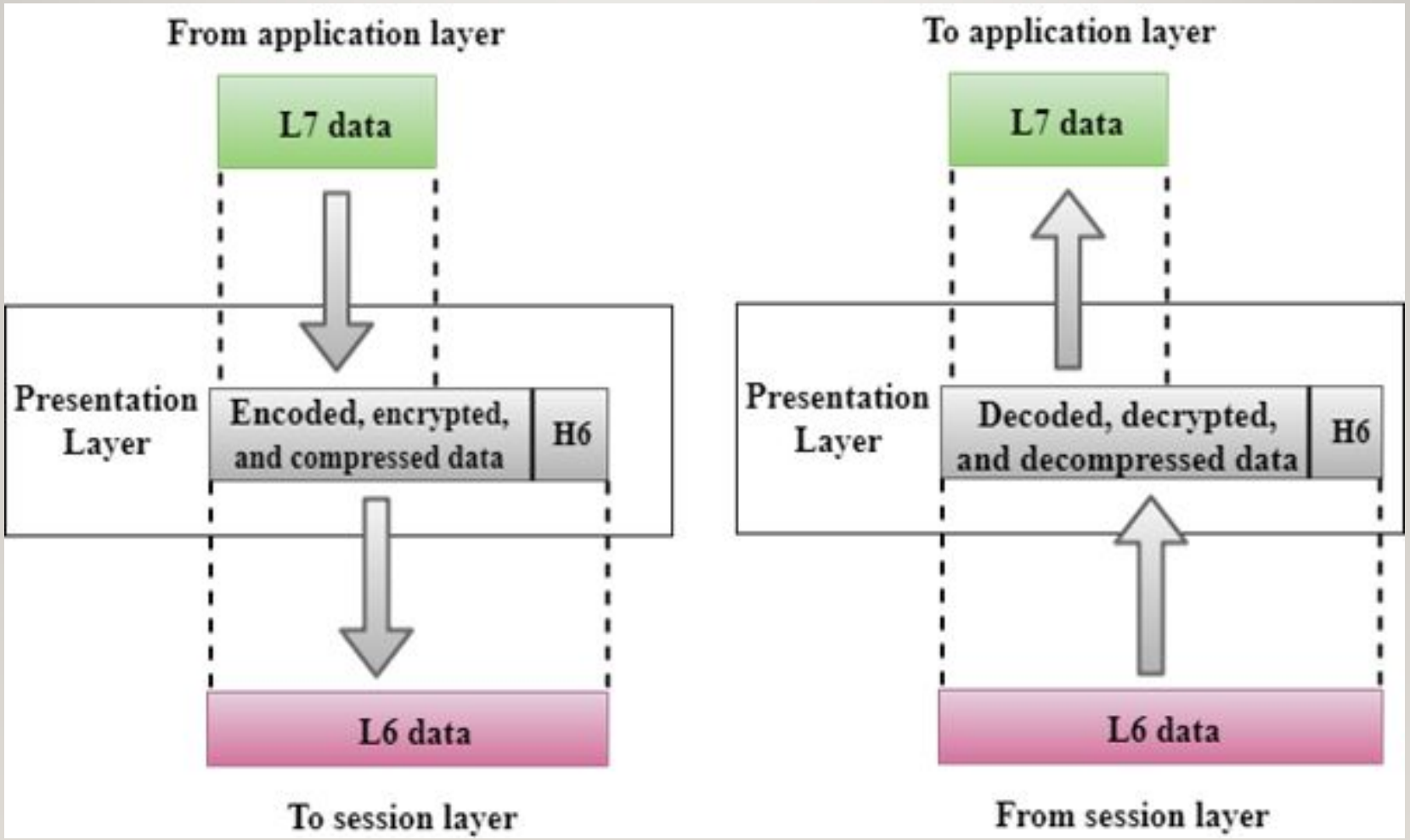
Layer 5: Session Layer



Layer 6: Presentation Layer

- Also known as translation layer.
- Translation
  - Translates different data representations from the Application layer into uniform standard format.
- Providing services for secure efficient data transmission
  - Encryption to maintain privacy.
- Compression
  - Reduce the number of bits to be transmitted.

Layer 6: Presentation Layer

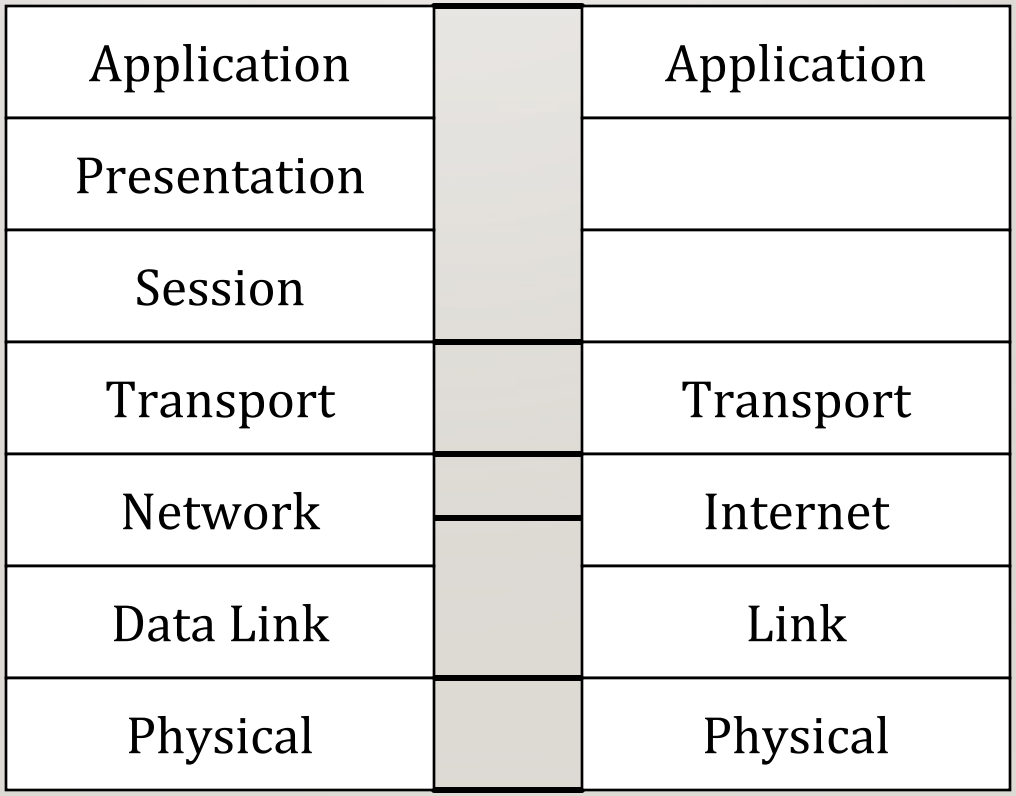


Layer 7: Application Layer

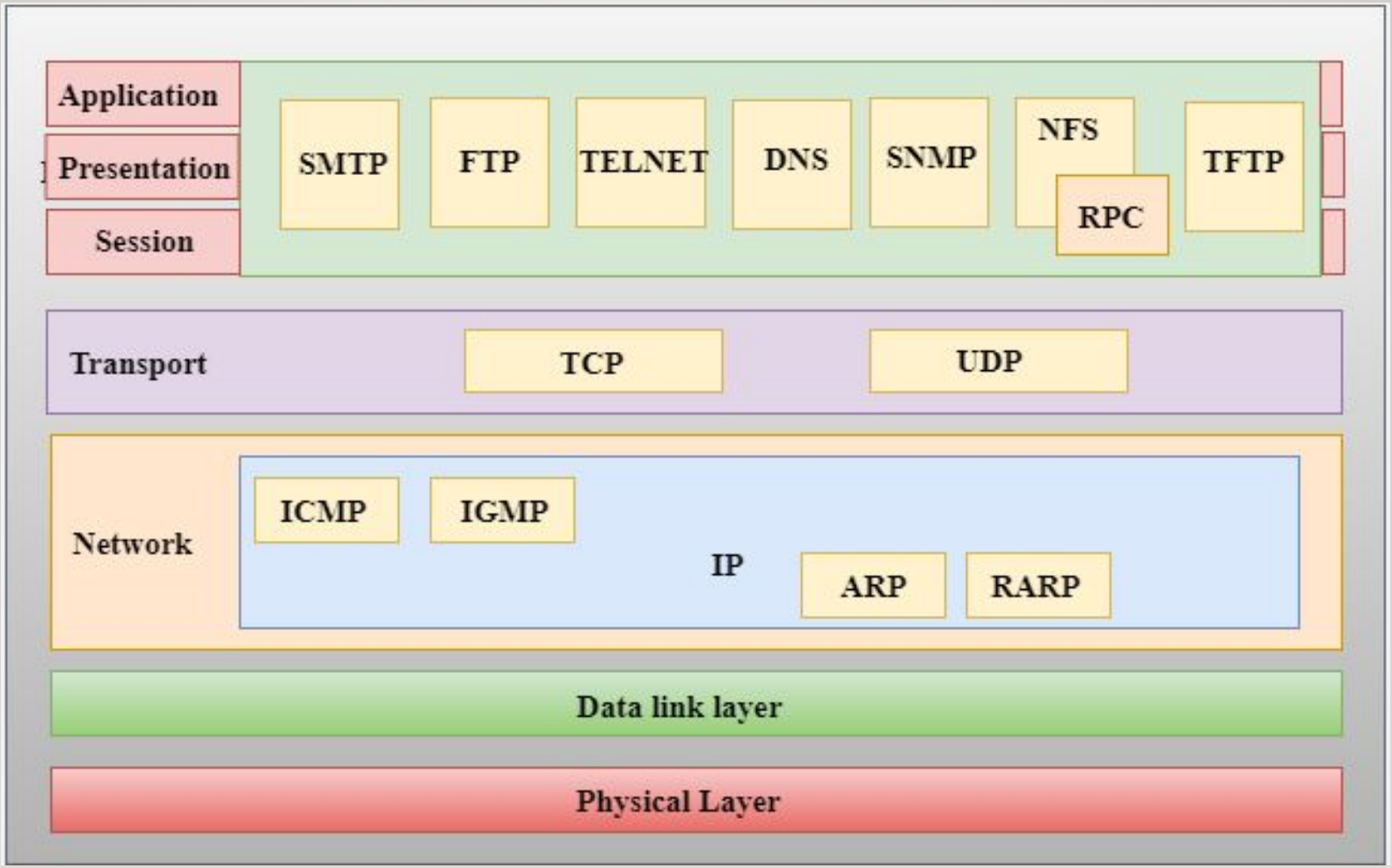
- Window for users and application processes to access the network service.
- File transfer, access and management:
  - Allows user to access files in a remote computer.
- Mail service
  - Facility for email forwarding and storage.

TCP/IP Reference Model

TCP/ IP Reference Model



TCP/ IP Reference Model



Comparison between OSI and TCP/ IP Reference Model

OSI	TCP / IP
OSI represents **Open System Interconnection.**	TCP/IP model represents the Transmission Control Protocol / Internet Protocol.
OSI is a generic, protocol independent standard.	TCP/IP model depends on standard protocols about which the computer network has created
The OSI model was developed first, and then protocols were created to fit the network architecture's needs.	The protocols were created first and then built the TCP/IP model.

Comparison between OSI and TCP/ IP Reference Model

OSI	TCP / IP
It provides both connection and connectionless oriented transmission in the network layer; however, only connection-oriented transmission in the transport layer.	It provides connectionless transmission in the network layer and supports connecting and connectionless-oriented transmission in the transport layer.
The smallest size of the OSI header is 5 bytes.	The smallest size of the TCP/IP header is 20 bytes.
7 layered architecture	5- layered architecture

COMPUTER NETWORKS MODULE I

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Topics

- Physical Layer
  - Modes of Communication
  - Physical Topologies
  - Signal Encoding
  - Repeaters and Hub
  - Transmission media
  - Performance indicators

Physical Layer-Data and Signals

- Data:
  - Analog: continuous information
  - Digital: discrete information
- Signal:
  - Analog: infinite levels of intensity over a period of time.
  - Digital: limited number of defined values.
  - Periodic: completes a pattern within a measurable time frame (period) and it repeats.
  - Non periodic: changes without a pattern.

Physical Layer-Data and Signals

- Cycle:
  - Completion of one full pattern.
- Period:
  - Amount of time, a signal needs to complete one cycle.
- Frequency:
  - The number of periods in 1 second.
  - $f = \frac{1}{T}$
  - Expressed in Hertz.

Physical Layer-Data and Signals

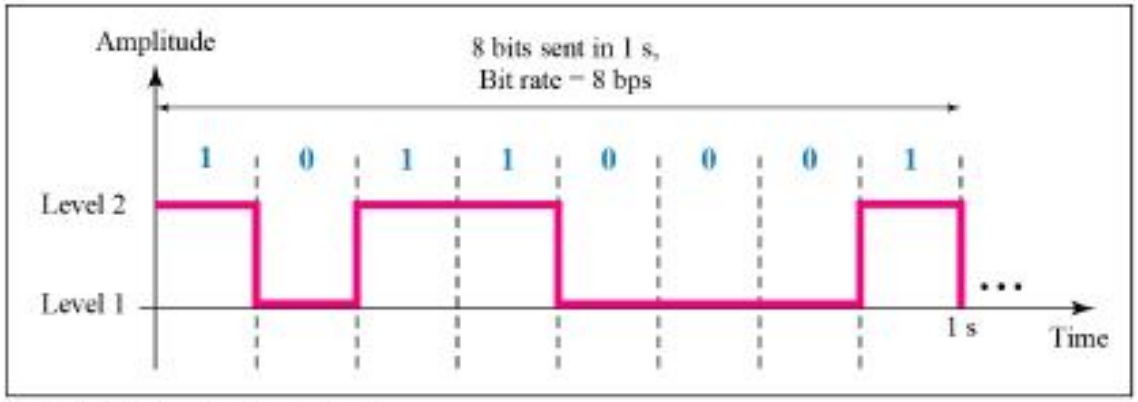
- Q1. The power at home has a frequency of 60Hz. Determine the period of the wave.

- Q2. The period of a signal is 100ms. What is its frequency in KHz?

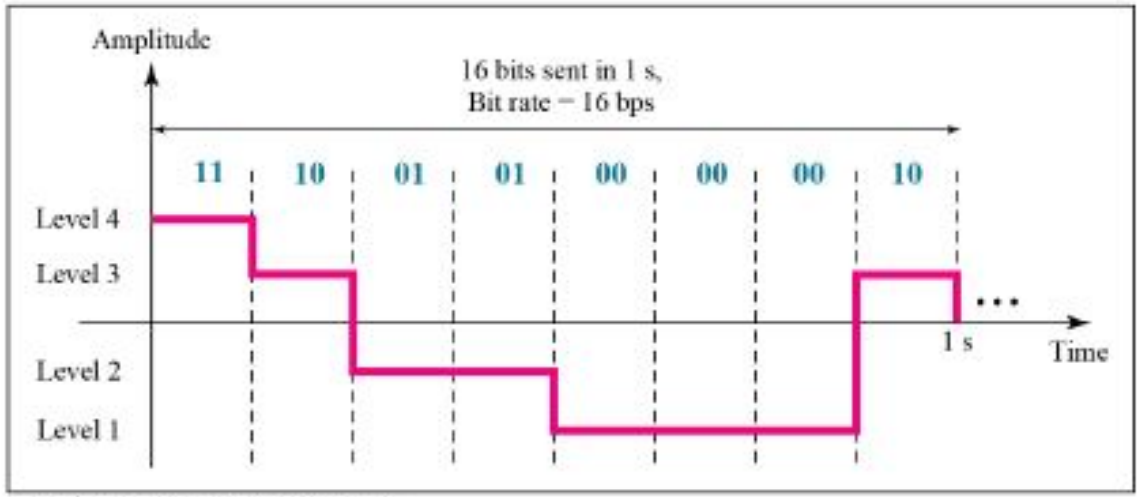
Physical Layer-Sampling & Quantization

- For converting analog signal to digital.
- **Sampling:**
  - Process of recording an analog signal at regular discrete moments of time.
- **Quantization**
  - the process of mapping continuous amplitude (analog) signal into discrete amplitude (digital) signal

Physical Layer-Digital Signals



a. A digital signal with two levels



b. A digital signal with four levels

Physical Layer-Digital Signals

- Cycle:
  - Completion of one full pattern.
- Period:
  - Amount of time, a signal needs to complete one cycle.
- Frequency:
  - The number of periods in 1 second.
  - $f = \frac{1}{T}$
  - Expressed in Hertz.

Physical Layer-Digital Signals

- **Bit Rate:**
  - The number of bits sent in 1 sec.
  - Expressed as bits per second (bps).
- Q1. What is the required bit rate of the channel to download text documents at the rate 100 pages per sec?
  - Assume a page is an average of 25 lines with 80 characters in each line. Assume 8 bits per character.
  - Ans:1600000bps=1.6Mbps

Physical Layer-Digital Signals

- Q2. A digitized voice channel is made by digitizing a 4-kHz bandwidth analog voice signal. Sample the signal at twice the highest frequency (two samples per Hertz). Assume that each sample requires 8 bits. What is the required bit rate in Kbps?
  - Ans: 64000bps =64Kbps

Physical Layer-Digital Signals

- Q2. A video signal transmission system transmits 625 frames per second. Each frame consists of 200x200 pixel grid with 64 intensity levels per pixel. Find the data rate in bps?
  - Ans: 150Mbps
  - n□ no. of pixels (200*200)
  - No. of bits for intensity levels, ($\log_2$ levels= 6)
  - Rate of transmission of frames (625frames).

Physical Layer-Digital Signals

- Cycle:
  - Completion of one full pattern.
- Period:
  - Amount of time, a signal needs to complete one cycle.
- Frequency:
  - The number of periods in 1 second.
  - $f = \frac{1}{T}$
  - Expressed in Hertz.

Physical Layer-Digital Signals

- Cycle:
  - Completion of one full pattern.
- Period:
  - Amount of time, a signal needs to complete one cycle.
- Frequency:
  - The number of periods in 1 second.
  - $f = \frac{1}{T}$
  - Expressed in Hertz.

Physical Layer-Digital Signals

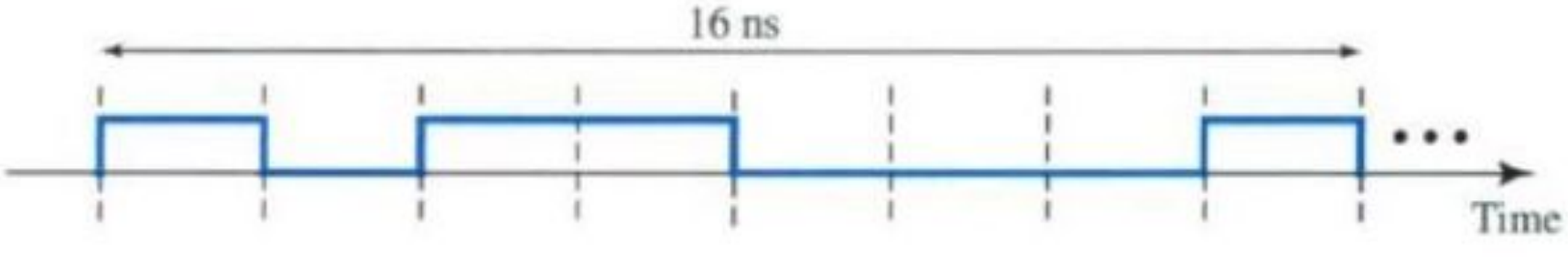
- Q3. What is the bit rate of
  - A) a signal in which 1 bit lasts 0.001 s ?
    - Ans: 1000 bps =1Kbps
  - B) a signal in which 1 bit lasts 2ms?
    - Ans: 500bps
  - C) a signal in which 10 bits lasts 20μs?
    - Ans: 500 Kbps

Physical Layer-Digital Signals

- Q4. A device is sending out data at the rate of 1000 bps.
  A) How long does it take to send out 10 bits?
  - Ans: 0.01s
- B) How long does it take to send out a single character (8 bits)?
  - Ans: 8ms

Physical Layer-Digital Signals

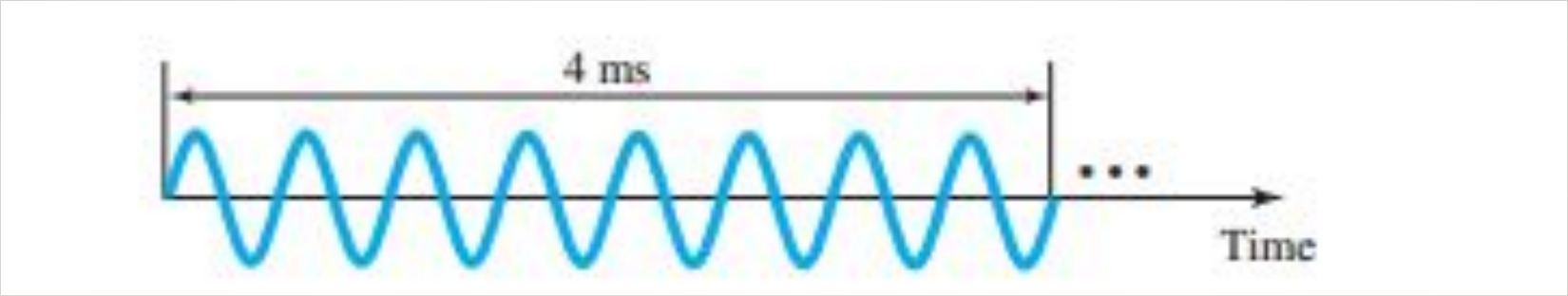
- Q5. What is the bit rate for the signal?



- Ans: 500 Mbps

Physical Layer-Digital Signals

- Q5. What is the frequency of the signal?



- Ans: 2 KHz

Physical Layer-Digital Signals

- Q5. A file contains 2 million bytes. How long does it take to download this file using a 56-Kbps channel?

  - Ans: 286 sec

Transmission Modes

- **Simplex**:
  - Unidirectional data transfer.
  - Use the entire capacity of the channel to send data in one direction.
  - E.g. Keyboards, traditional monitors
- **Half-Duplex**:
  - Bidirectional data transfer; not simultaneously.
  - E.g. Walkie- talkie
  - Channel capacity= bandwidth * propagation delay

Transmission Modes

- **Duplex**:
  - Bidirectional data transfer; simultaneous transmission possible.
  - E.g. Telephone networks
  - Channel capacity= 2*bandwidth * propagation delay

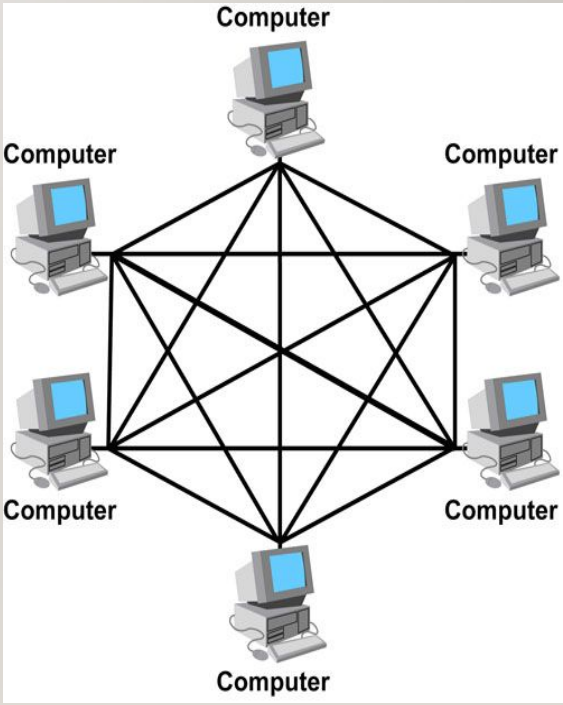
Physical Topologies

- The way in which a network is laid out physically.
- 2 or more links form a topology.
- Define the layout, virtual shape or structure of network.
- Four types.

Physical Topologies-Types

I. Mesh

- Dedicated point to point link to every other device.
- No. of physical links in a fully connected mesh = n*(n-1).
- No. of physical links (if duplex) = n*(n-1)/2.
- E.g. connection of a telephone regional offices in which every regional office needs to be connected to every other regional offices.



Physical Topologies-Types

Mesh Topology- **Advantages**

- Use of dedicated links eliminates traffic problems.
- Robust
- Advantage of privacy or security
- The network can be expanded without disruption to current uses.
- Point to point links make fault identification and fault isolation easy.

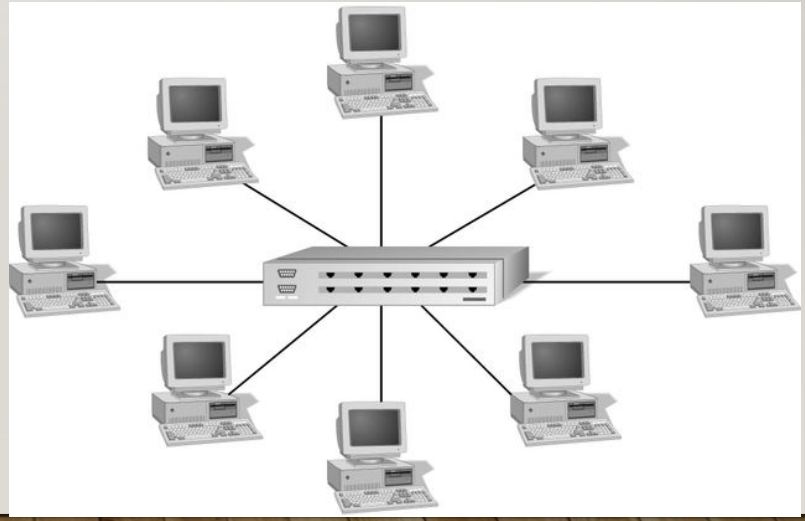
Physical Topologies-Types

Mesh Topology – **Disadvantages**

- Requires more cable than the other LAN topologies
- Complicated implementation
- Expensive Hardware.

Physical Topologies-Types

2. Star
   - Each device has a dedicated point-to-point link only to a central controller, called a hub.
   - The devices are not directly linked to one another.
   - No direct traffic between devices.
   - The controller acts as an exchange.



Physical Topologies-Types

Star Topology - **Advantages**

- Less expensive than a mesh topology.
- Robust.
- Easy fault identification and fault isolation.
- Easy to install and reconfigure.

Star Topology - **Disadvantages**

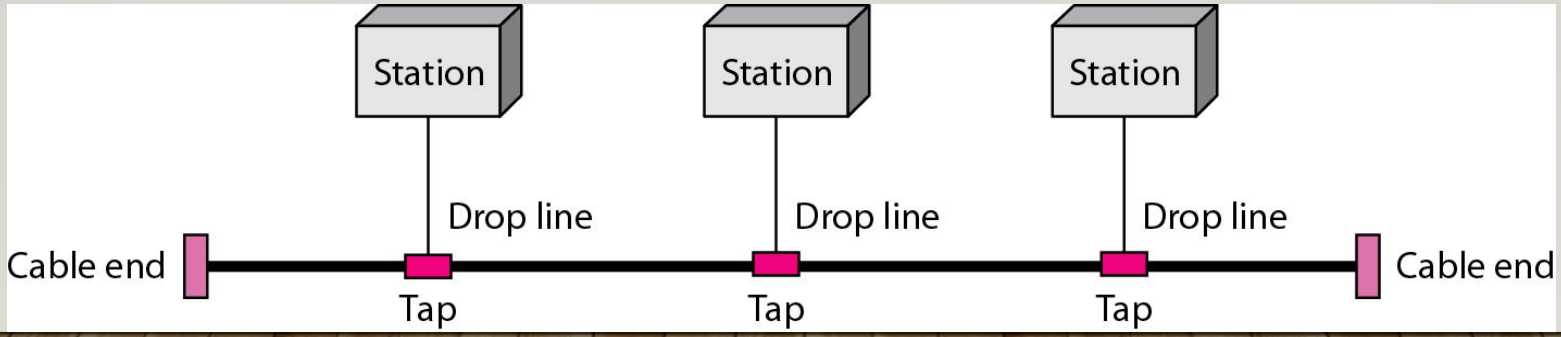
- Dependency of the whole topology on the central hub.
- More cabling is required than ring and bus topology.

Physical Topologies-Types

3. Bus Topology
   - Multipoint connection.
   - One long cable acts as a backbone to link all the devices in a network.
   - Nodes are connected to the bus cable by drop lines and taps.
   - A drop line is a connection running between the device and the main cable.

Physical Topologies-Types

3. Bus Topology
   - A drop line is a connection running between the device and the main cable.
   - A tap is a connector that either splices into the main cable or punctures the sheathing of a cable to create a contact with the metallic core.



Physical Topologies-Types

Bus Topology- **Advantages**

- Works well for small networks.
- Ease of installation.
- Requires less cabling than mesh or star topologies.

Bus Topology – **Disadvantages**

- Fault or break in the bus cable stops all transmission.
- Difficult to add new devices.

Physical Topologies-Types

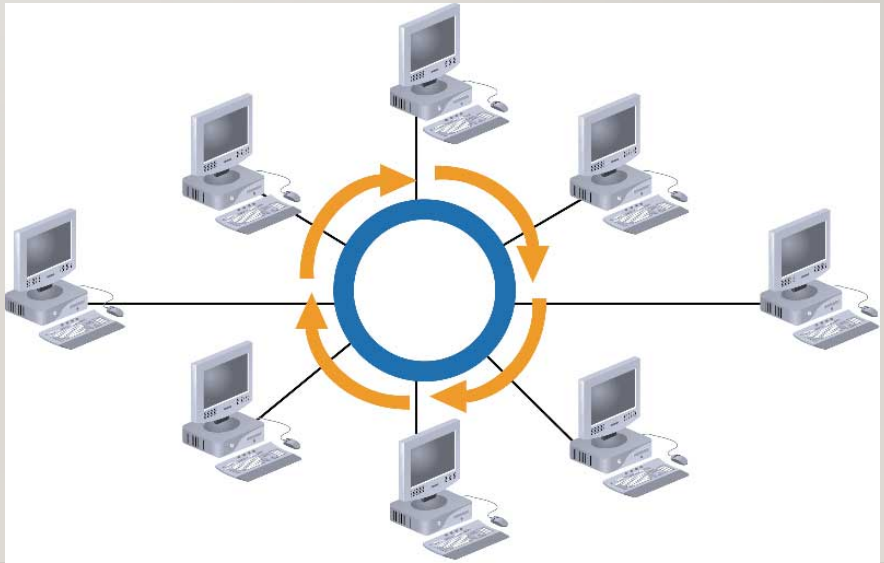
4. Ring Topology

- Each device has a dedicated point-to-point connection with only the two devices on either side of it.
- A signal is passed along the ring in one direction, from device to device, until it reaches its destination.
- Each device in the ring incorporates a repeater.

Physical Topologies-Types

4. Ring Topology

- When a device receives a signal intended for another device, its repeater regenerates the bits and passes them along.



Physical Topologies-Types

Ring Topology- **Advantages**

- Cable faults are easily located, making troubleshooting easier.
- Ring networks are moderately easy to install

Ring Topology – **Disadvantages**

- Unidirectional traffic. A single break in the cable can disrupt the entire network.
- Expansion to the network can cause network disruption.

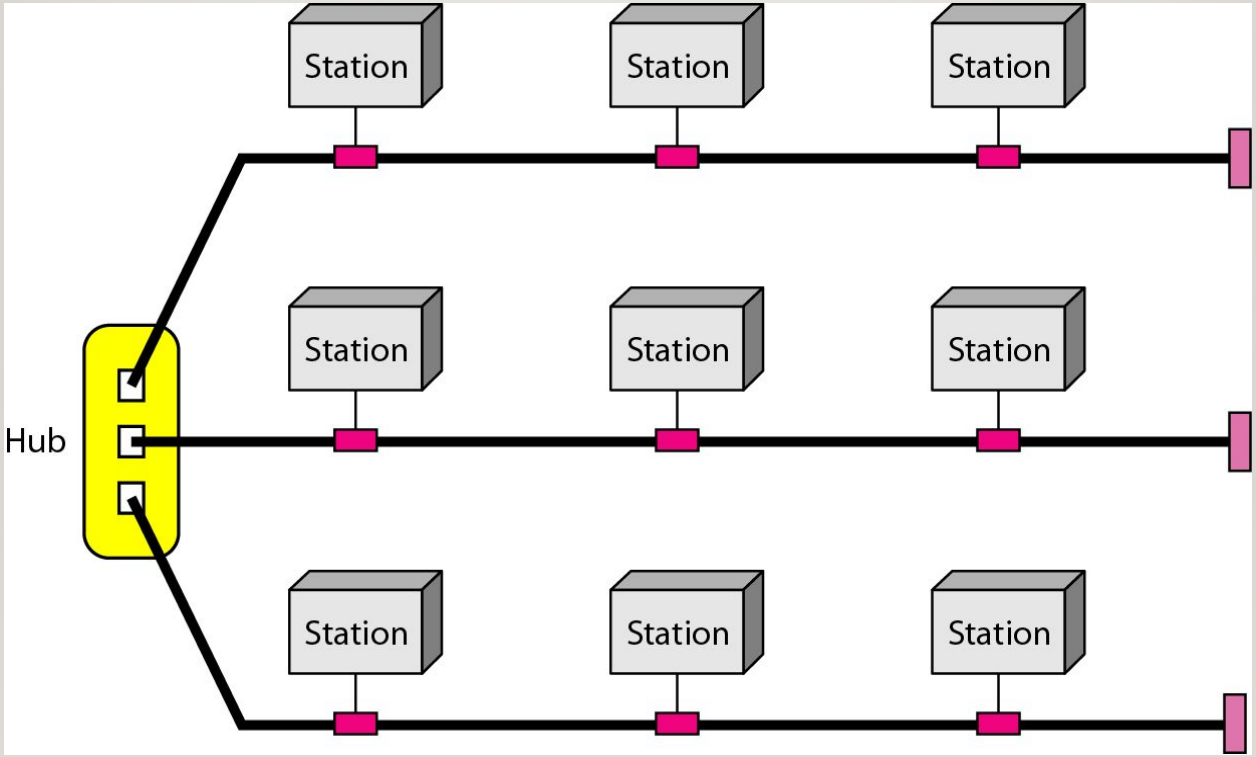
Physical Topologies-Types

Hybrid Topology

- One example of Hybrid Topology is Tree topology
- Tree topology is a combination of Bus and Star topology.
- It consists of groups of star-configured workstations connected to a linear bus backbone cable.
- If the backbone line breaks, the entire segment goes down
- An example of this network could be cable TV technology

Physical Topologies-Types

Hybrid Topology



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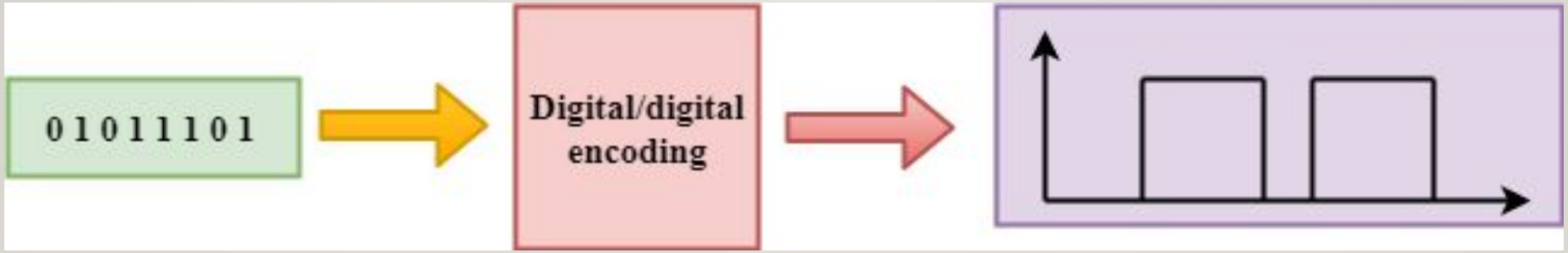
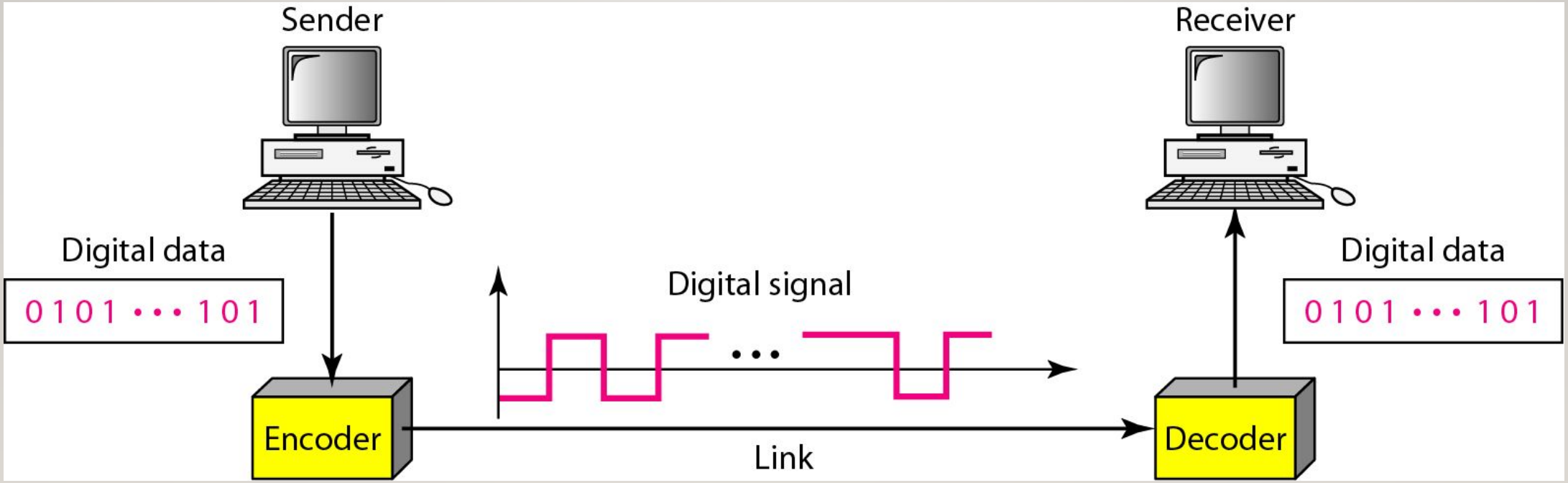
Digital to Digital Conversion

- Digital-to-digital encoding is the representation of digital information by a digital signal



Digital to Digital Conversion

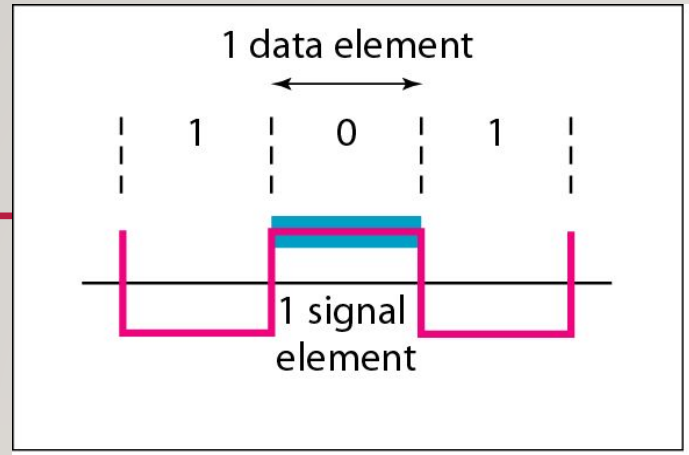


Data symbols to signals

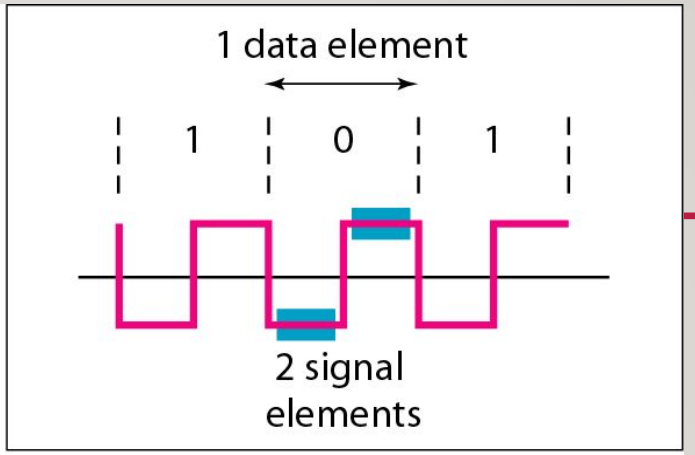
- A data symbol (or element) can consist of a number of data bits:
  - 1 , 0 or
  - 11, 10, 01, ……
- A data symbol can be coded into a single signal element or multiple signal elements
  - 1 -> +V, 0 -> -V
  - 1 -> +V and -V, 0 -> -V and +V
- The ratio ‘r’ is the number of data elements carried by a signal element.

Data Rate, Signal RateZ

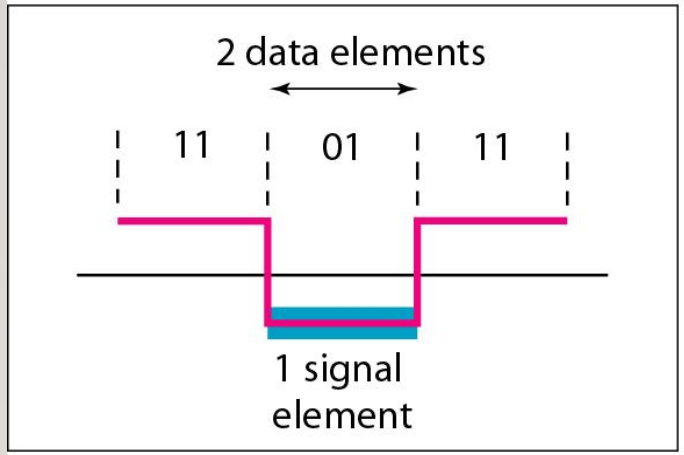
- The data rate defines the number of bits sent per sec - bps.
- It is often referred to the bit rate.
- The signal rate is the number of signal elements sent in a second and is measured in bauds.
- It is also referred to as the modulation rate (baud rate).
- Goal is to increase the data rate whilst reducing the baud rate.



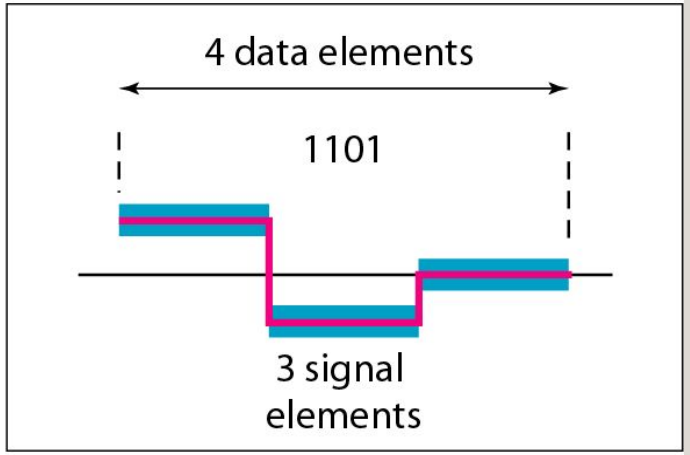
a. One data element per one signal element (r = 1)



b. One data element per two signal elements $\left(r = \frac{1}{2}\right)$



c. Two data elements per one signal element (r = 2)



d. Four data elements per three signal elements $\left(r = \frac{4}{3}\right)$

Baud Rate

- The baud or signal rate can be expressed as:

S = c x N x 1/r bauds

where N is data rate

c is the case factor (worst, best & avg)

r is the ratio between data element & signal element

Questions

- A signal is carrying data in which one data element is encoded as one signal element (r = 1). If the bit rate is 100 Kbps, what is the average value of the baud rate if c is between 0 and 1?
  - Assume c=1/2.

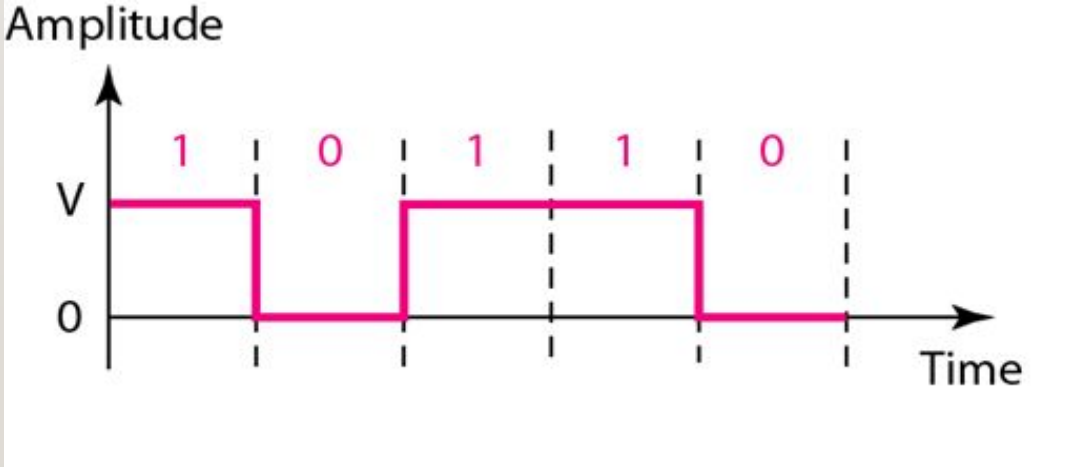
$$S = c \times N \times \frac{1}{r} = \frac{1}{2} \times 100{,}000 \times \frac{1}{1} = 50{,}000 = 50 \text{ kbaud}$$

Signal Encoding Schemes

- Unipolar
  - '1' is considered as a high voltage and '0' is considered as a zero voltage.
- Polar
  - uses two voltage levels: one is positive, and another is negative.
- Bipolar
  - represents three voltage levels: positive, negative, and zero.
  - zero level represents binary 0, and binary 1 is represented by alternating positive and negative voltages.

Unipolar- NRZ

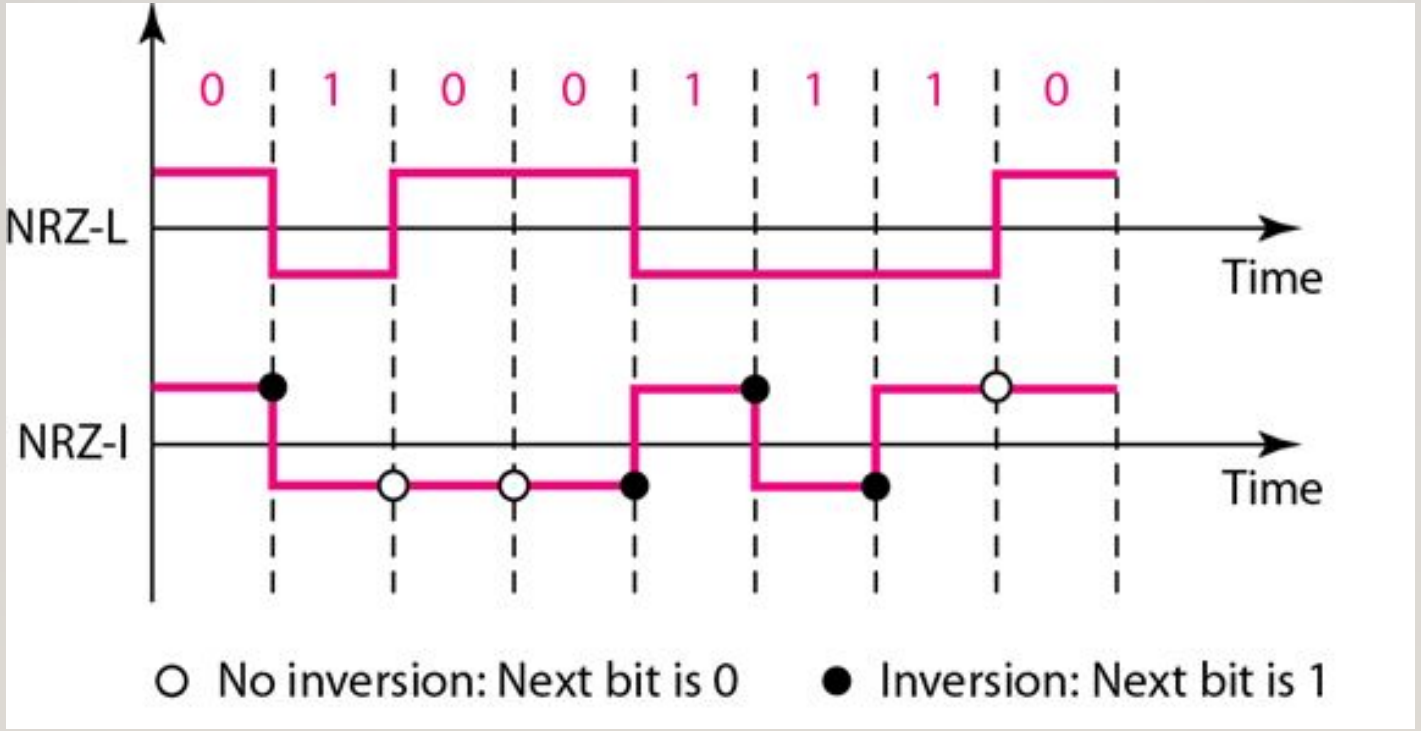
- Non-Return-to-Zero (NRZ).
- Positive voltage defines bit 1 and the zero voltage defines bit 0.
- It is called NRZ because the signal does not return to zero at the middle of the bit.



Polar- NRZ

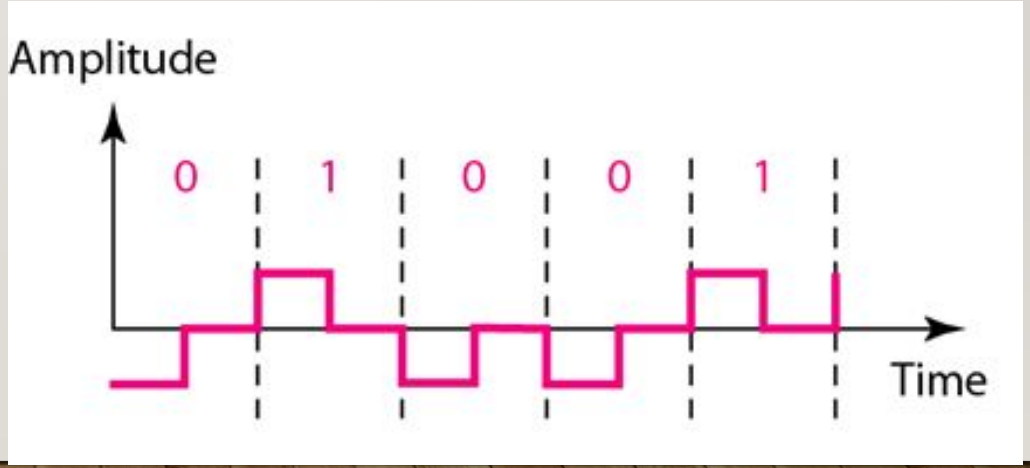
- The voltages are on both sides of the time axis.
- Polar NRZ scheme can be implemented with two voltages.
- E. g. +V for 0 and -V for 1.
- There are two versions:
  - NRZ - Level (NRZ-L) - positive voltage for one symbol and negative for the other.
  - NRZ - Inversion (NRZ-I) - the change or lack of change in polarity determines the value of a symbol. E. g. a “1” symbol inverts the polarity a “0” does not.

Polar- NRZ



Polar- RZ

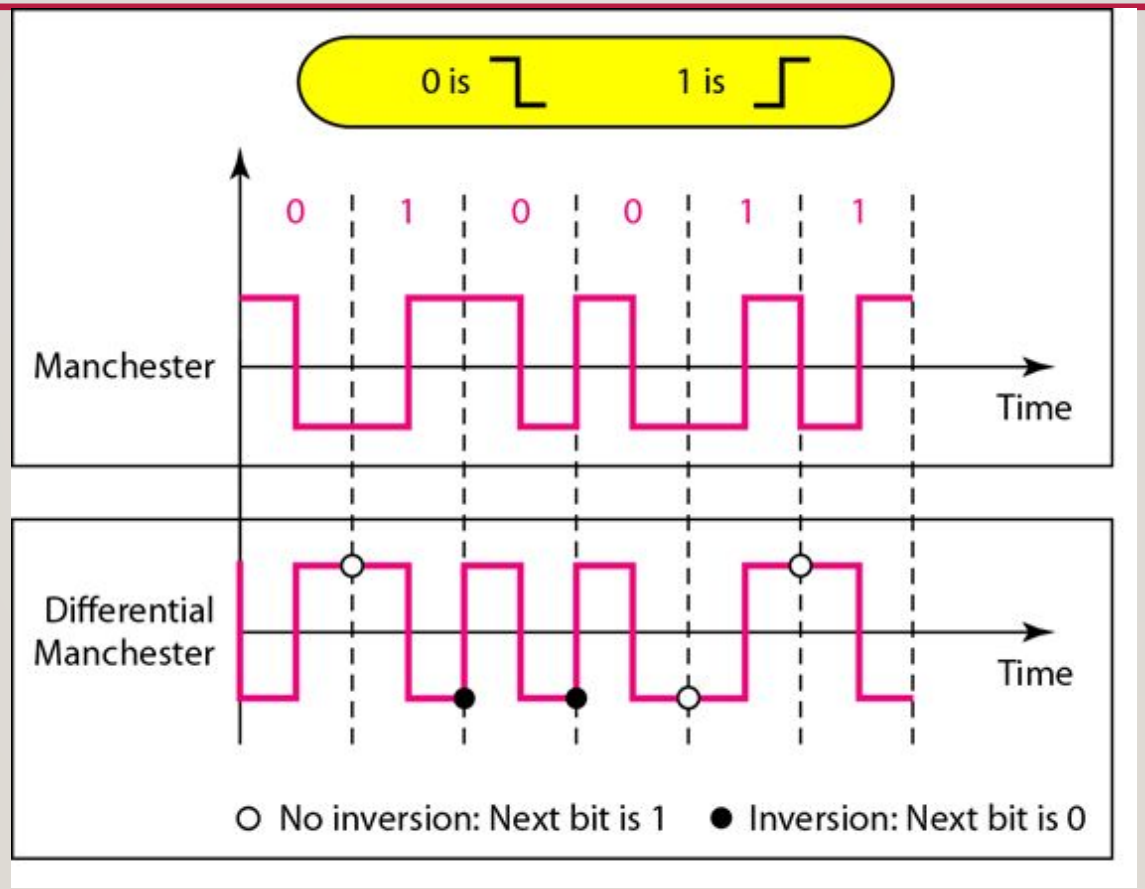
- The Return to Zero (RZ) scheme uses three voltage values. +, 0, -.
- Each symbol has a transition in the middle. Either from high to zero (bit 1) or from low to zero (bit 0).
- This scheme has more signal transitions (two per symbol) and therefore requires a wider bandwidth.



Polar- Biphase

- Manchester Encoding
  - consists of combining the NRZ-L and RZ schemes.
  - Every symbol has a level transition in the middle: from high to low or low to high.
  - Uses only two voltage levels.
- Differential Manchester Encoding
  - consists of combining the NRZ-I and RZ schemes.
  - Always a transition at the middle of the bit.
  - Bit values are determined at the beginning of the bit.

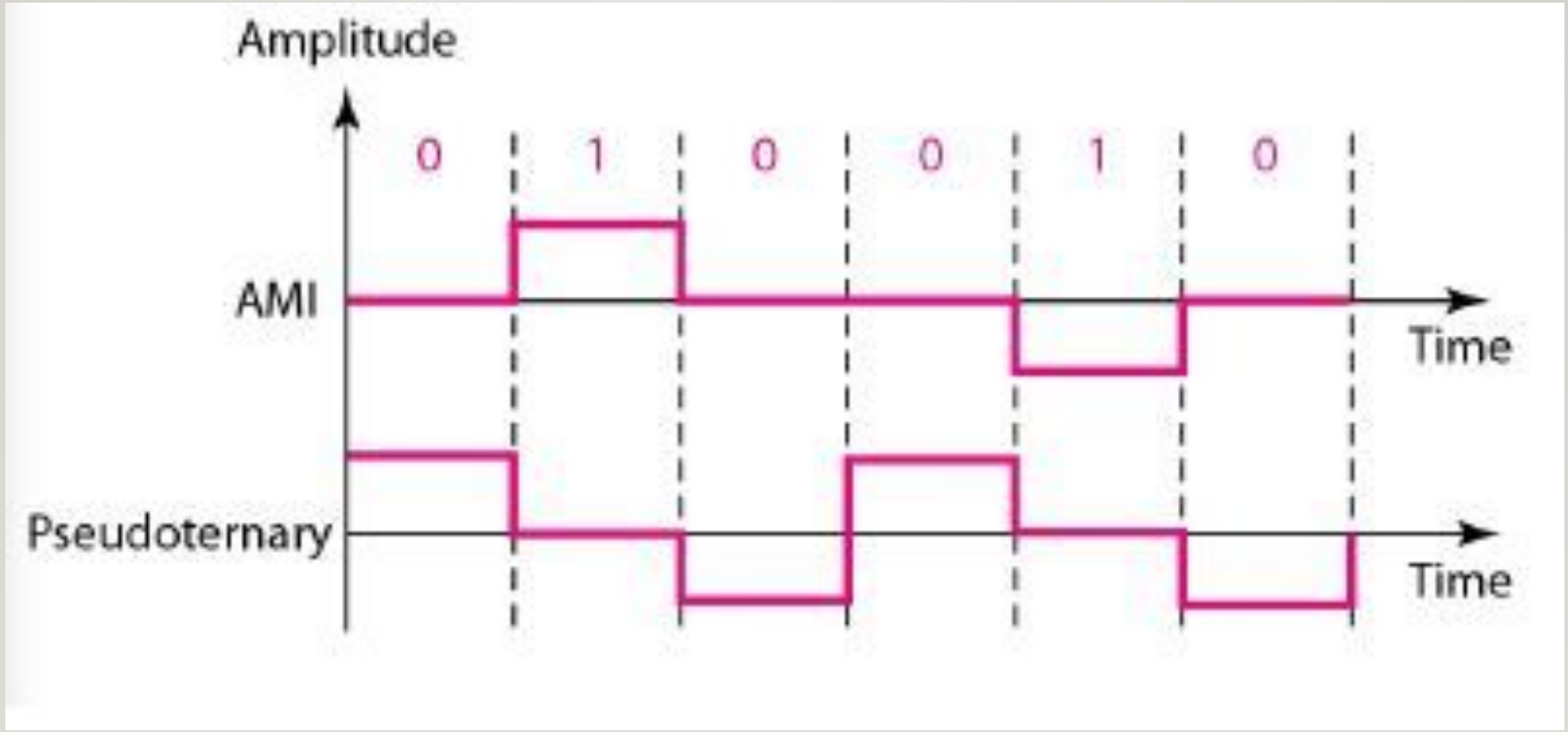
Polar- Biphase



Bipolar

- Alternate Mark Inversion (AMI)
  - Mark means '1'.
  - Zero voltage represents bit 0.
  - Binary 1's are represented by alternating positive and negative voltages.
- Pseudoternary
  - Zero voltage represents bit 1.
  - Binary 0's are represented by alternating positive and negative voltages.

Bipolar



Questions

Q1. Sketch the waveform in Manchester and Differential Manchester encoding for the bitstream 11000110010.

Q2. Sketch the waveform in Manchester and Differential Manchester encoding for the bitstream 10100111001.

Performance Indicators

- How good is the performance of the network?
- Measure of service quality of a network.
- Some general performance indicators are:
  - Bandwidth
  - Throughput
  - Latency or delay
  - Bandwidth-delay product
  - Jitter

Bandwidth

- Measure of data that can be transmitted in a fixed measure of time.
- For digital devices: bits per second (bps): no. of bits a network can transmit in a second.
- E. g: bandwidth of a Fast Ethernet network is a maximum of 100 Mbps.
- For analog devices: cycles per second or Hertz (Hz).
- An increase in bandwidth in hertz means an increase in bandwidth in bits per second.

Throughput

- Number of messages successfully transmitted per unit time.
- Measured in bits per second (bps).
- The bandwidth is a potential measurement of a link; the throughput is an actual measurement of how fast we can send data.
- A link may have a bandwidth of '*B*' bps, but '*T*' bps can be send through this link with $T < B$.
- Throughput may be affected by
  - Hindrance of the underlying physical medium.
  - Available processing power of the system components.

Throughput

Q1. A network with bandwidth of 10Mbps can pass only an average of 12000 frames per minute where each frame carries an average of 10000 bits. What will be the throughput for this network?

Ans: 2Mbps

Latency (Delay)

- Total time taken for a complete message to arrive at the destination.
- It starts with the time when first bit is sent out from the sender and ends with the time when the last bit of the message is delivered.
- Low latency networks and High latency networks.
- Measured in milliseconds.

Latency = propagation time + transmission time + queuing time + processing delay

Latency- Propagation Time

- Time required for a bit to travel from source to destination.
- $Propagation\ Time = \frac{Distance}{Propagation\ speed}$

- Q1. What is the propagation time when the distance between two points is 12000km? Assume the propagation speed to be 2.4*10^8 m/s.

Ans: 50ms

Latency- Transmission Time

- The time required for transmission of a message depends on the size of the message and the bandwidth of the channel.
  - $Transmission\ Time = \frac{Message\ Size}{Bandwidth}$
- Q1. What will be the transmission time for a 2.5KB message when the bandwidth of the network is 1Gbps?

  Ans: 0.0204ms

Latency- Queuing Time

- The time needed for each intermediate or end device to hold the message before it can be processed.
- The packet will be in a queue.
- The more the traffic, the more likely a packet is stuck in the queue.

Latency- Processing Delay

- Delay based on how long it takes the router to figure out where to send the packet.
- As soon as the router finds it out, it will queue the packet for transmission.

Latency

- Q1. What is the total delay (latency) for a frame of size 5 million bits that is being sent on a link with 10 routers each having a queuing time of 2 μs and a processing time of 1 μs. The length of the link is 2000 Km. The speed of light inside the link is 2 x 108 mls. The link has a bandwidth of 5 Mbps.

Ans: 1.0100003 s

Bandwidth Delay Product

- Signifies how many bits the sender can send before the first bit reaches the receiver.
- $Bandwidth\ Delay\ Product = Total\ available\ bandwidth\ (bps)\ * Round\ trip\ time(\text{sec})$
- RTT is the sum of the time taken for a signal to be transmitted from the sender to the receiver and the time taken for its acknowledgement to reach the sender from the receiver.
- Unit is bits or bytes.

Bandwidth Delay Product

Q1. Consider that link capacity of a channel is 512Kbps and round-trip time is 1000ms.

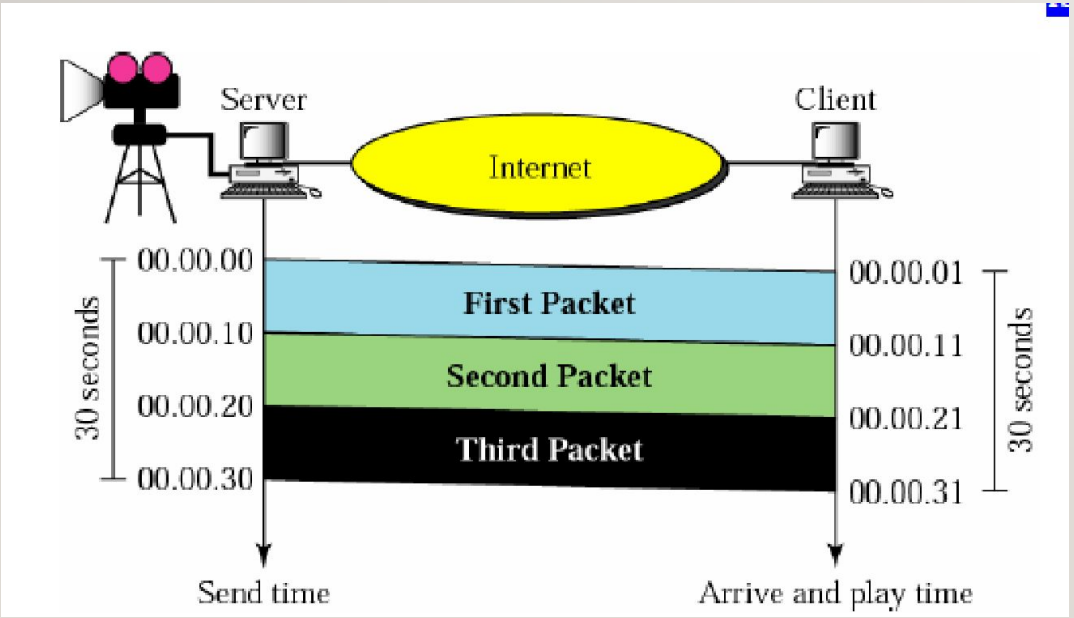
Ans: 64000 bytes

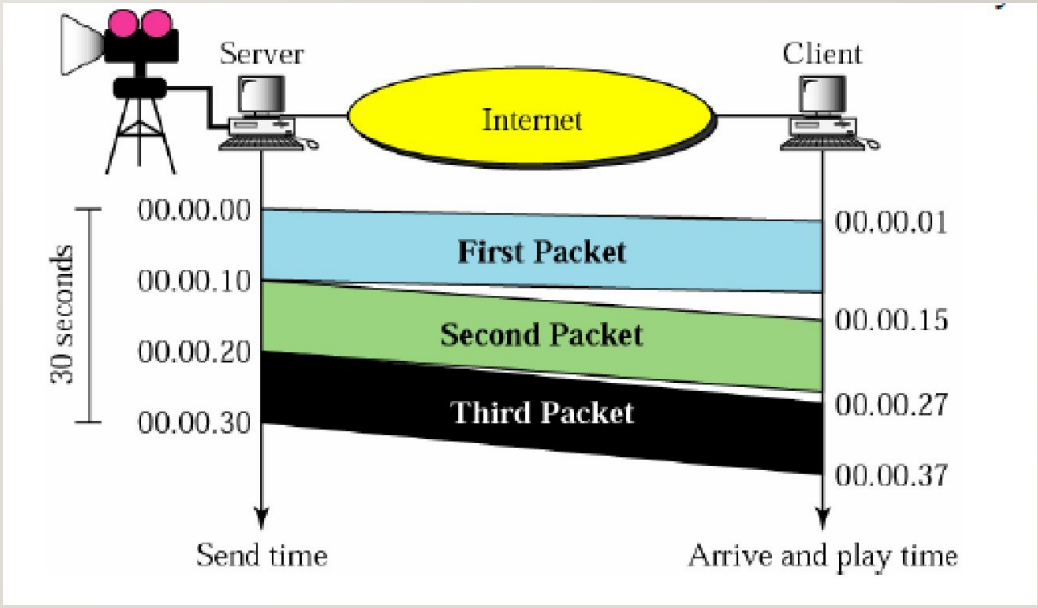
Jitter

- Jitter is any deviation in the signal pulses in a high-frequency digital signal.
- Jitter can cause a display monitor to flicker, introduce undesired effects in audio signals, and lead to loss of transmitted data between network devices.
- degrade the quality of communications.
- It is a problem if different packets of data encounter different delays.

Jitter

- Send a digitized and packetized video.
- Assume, three packets in total; each holds 10 seconds of video information, 1 sec delay for each packet to reach the destination.





COMPUTER NETWORKS MODULE 1

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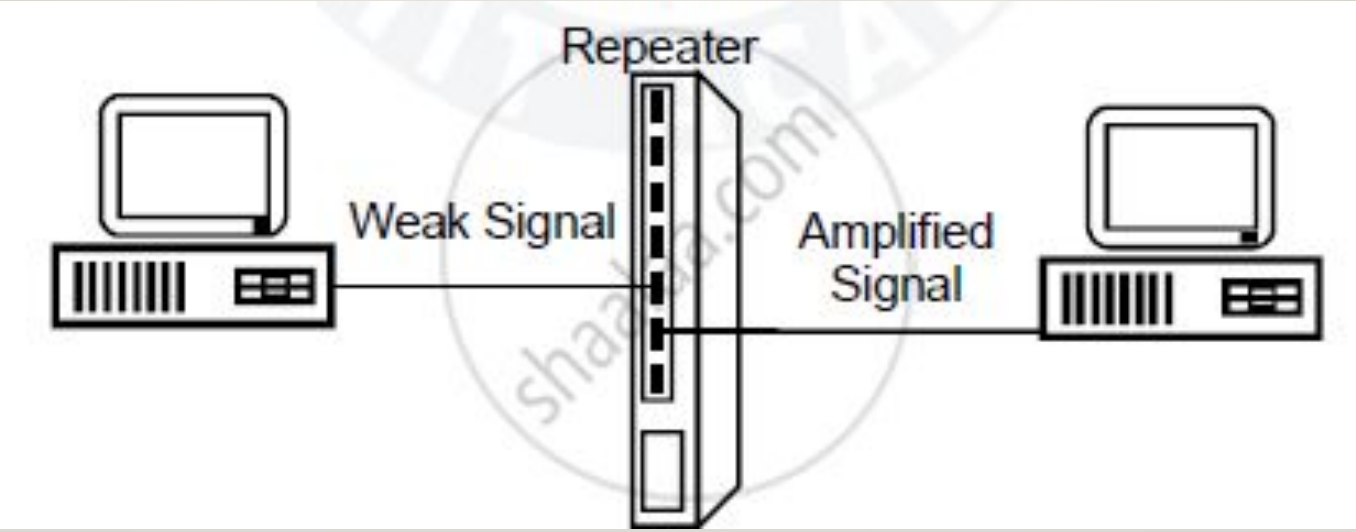
Asst. Professor- CSE

RSET

Physical Layer Devices- Repeater

- A repeater is a device that operates only in the physical layer.
- Signals that carry information within a network can travel a fixed distance before attenuation endangers the integrity of the data.
- A repeater receives a signal and, before it becomes too weak or corrupted, regenerates the original bit pattern.
- The repeater then sends the refreshed signal.

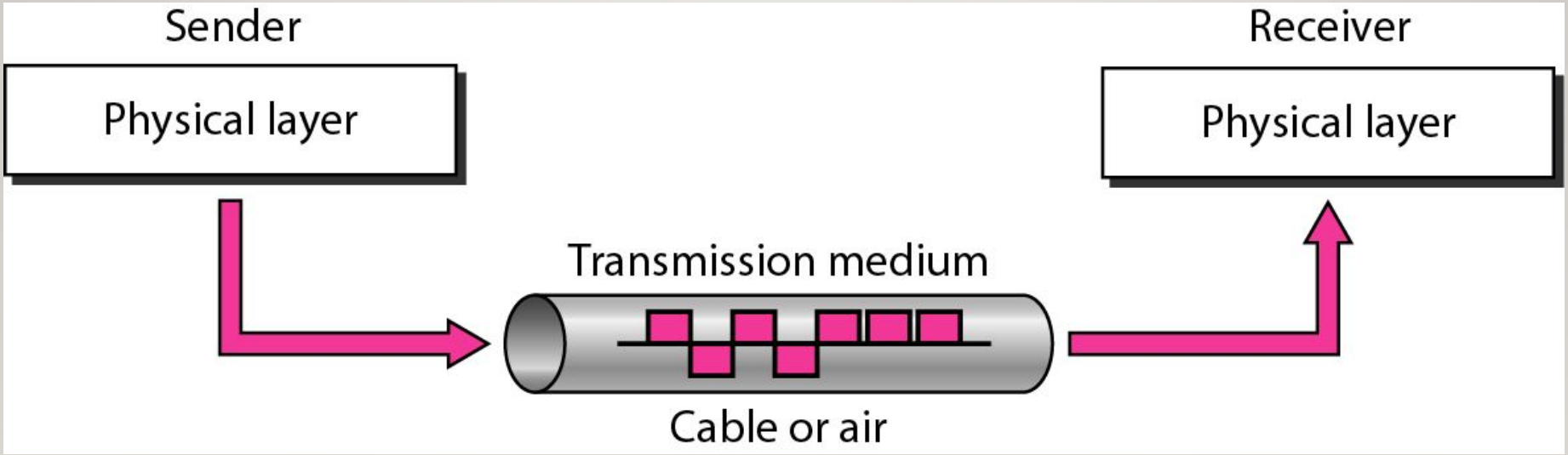
Physical Layer Devices- Repeater



Physical Layer Devices- Hub

- A hub is just a connector.
- It connects the wires coming from different branches.
- In a star-topology, a passive hub is just a point where the signals coming from different stations collide; the hub is the collision point.

Transmission Medium & Physical Layer



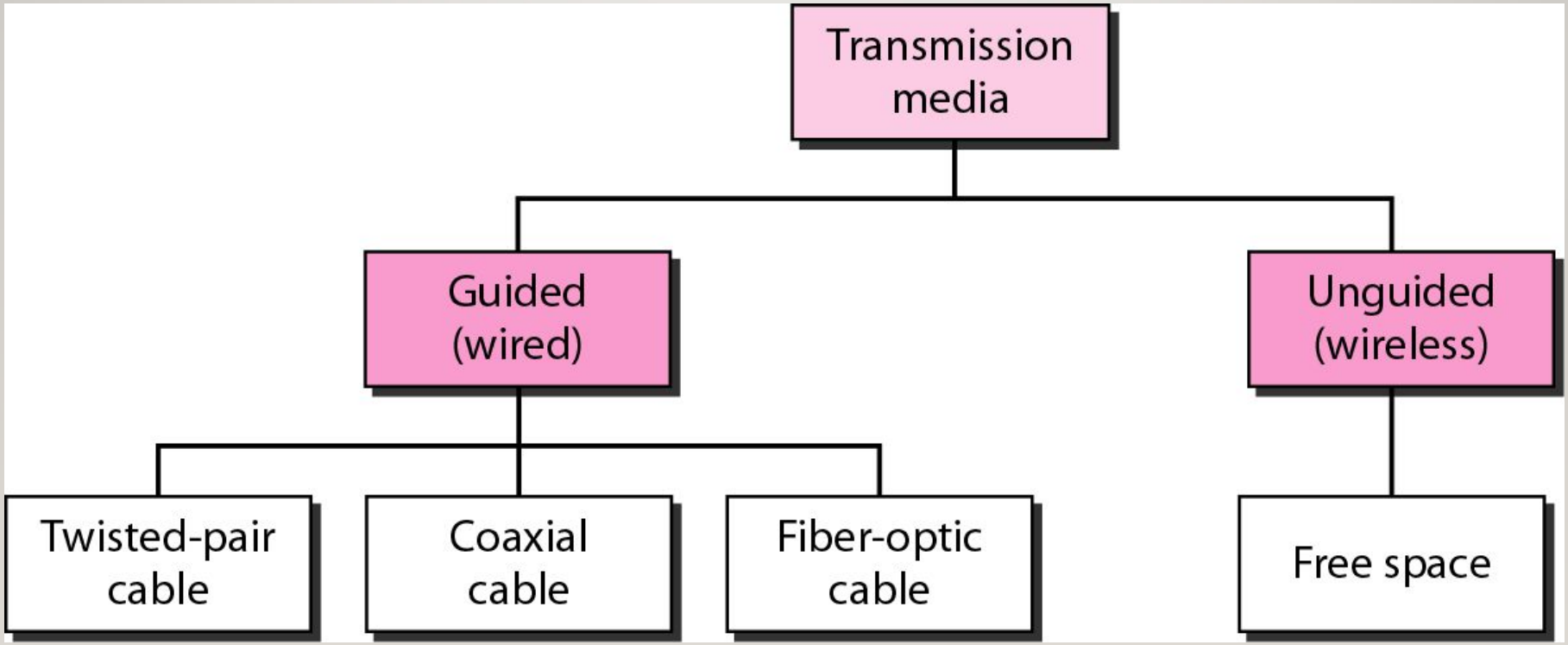
Transmission Media

- Communicating channel to carry information.
- Copper based network bits in the form of electromagnetic signals.
- Fiber based network, bits in the light pulses.
- The quality of the data transmission is determined by the characteristics of the medium and signal.

Transmission Media- Factors to be considered

1. Bandwidth
   - Bandwidth and data rate are directly proportional.
2. Transmission Impairment
   - Received signal ≠ transmitted signal.
   1. Attenuation: loss of energy (signal strength decreases with increasing distance)
   2. Distortion: change in the shape of the signal.
   3. Noise: unwanted external signal gets added to the transmitted signal.
4. Interference
   - Process of disrupting a signal by adding unwanted signals.

Classes of Transmission Medium



Guided Media

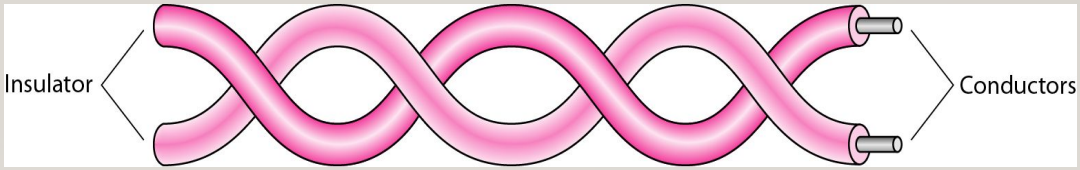
- Provide a channel from one device to another.
- Medium characteristics are important.
- Main features: high speed, covers small distances.
- Include twisted-pair cable, coaxial cable, and fiber-optic cable.

Guided Media

- Twisted-pair and coaxial cable use metallic (copper) conductors that accept and transport signals in the form of electric current.
- Optical fiber is a cable that accepts and transports signals in the form of light.

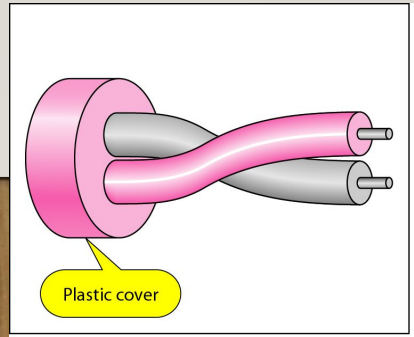
Guided Media

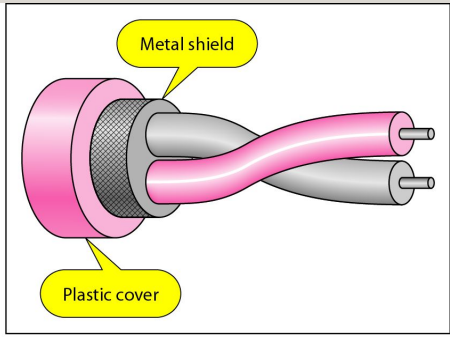
- **Twisted Pair**
  - A twisted pair consists of two conductors, each with its own plastic insulation, twisted together.
  - One of the wires is used to carry signals to the receiver, and the other is used only as a ground reference.
  - In addition to the signal sent by the sender on one of the wires, interference (noise) and crosstalk may affect both wires and create unwanted signals.



Guided Media

- **Twisted Pair- UTP and STP**
  - The most common twisted-pair cable: unshielded twisted-pair (UTP).
  - IBM has also produced a version of twisted-pair cable for its use called shielded twisted-pair (STP).
  - STP cable has a metal foil or braided mesh covering that encases each pair of insulated conductors.





Guided Media

- **Twisted Pair- UTP and STP**
  - Unshielded twisted-pair (UTP):
    - Low cost
    - Simple to install
    - High speed
    - Used in telephonic applications.

Guided Media

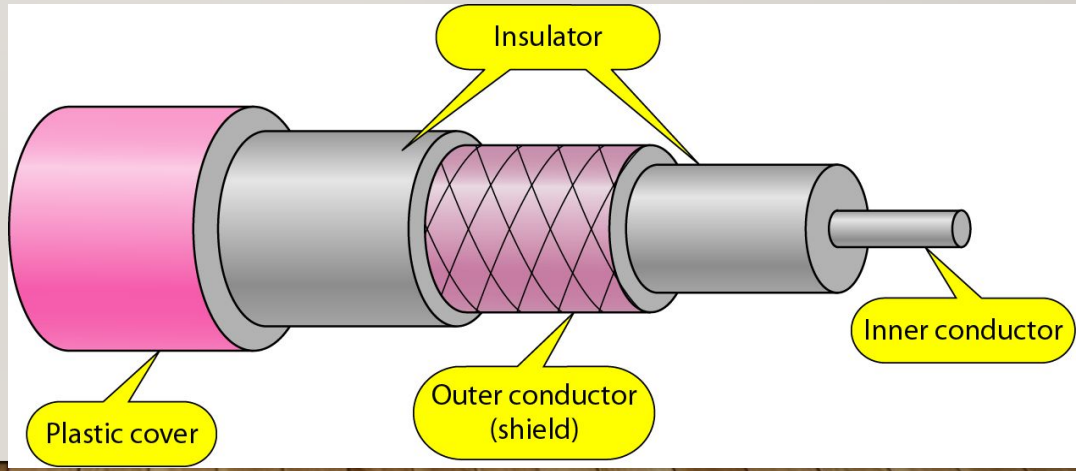
- **Twisted Pair- UTP and STP**
  - Shielded twisted-pair (STP):
    - Removes crosstalk.
    - Good speed.
    - Expensive.
    - Difficult to manufacture and install.
    - Used in voice and data channels of telephone lines.

Guided Media

- **Coaxial Cable**
  - Coaxial cable (or *coax)* carries signals of higher frequency ranges than those in twisted pair cable.
  - Coax has a central core conductor of solid or stranded wire enclosed in an insulating sheath, which is, in turn, encased in an outer conductor of metal foil, braid, or a combination of the two.
  - The outer metallic wrapping serves both as a shield against noise and as the second conductor, which completes the circuit.

Guided Media

- **Coaxial Cable**
  - This outer conductor is also enclosed in an insulating sheath, and the whole cable is protected by a plastic cover.
  - Uses – Ethernet LANs, cable TV



Guided Media

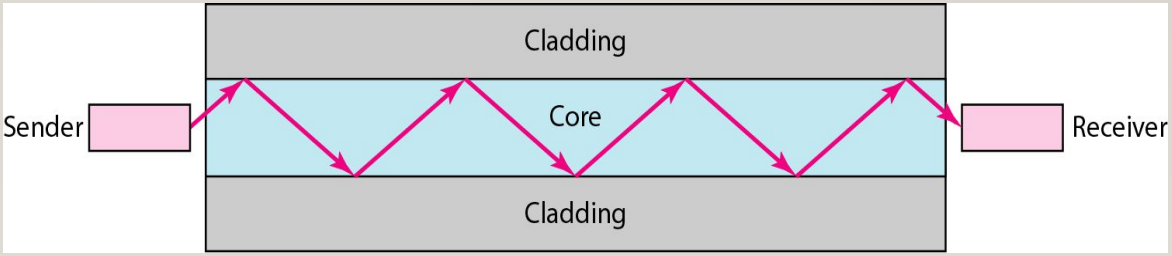
- **Coaxial Cable**
  - High bandwidth
  - Good noise immunity
  - Low cost
  - Simple to install.
  - Failure of cable can disturb whole network.

Guided Media

- **Fiber Optics Cable**
  - A fiber-optic cable is made of glass or plastic and transmits signals in the form of light.
  - Optical fibers use reflection to guide light through a channel.
  - A glass or plastic core is surrounded by a cladding of less dense glass or plastic.
  - The cladding causes light to be confined to the core of the fibre.

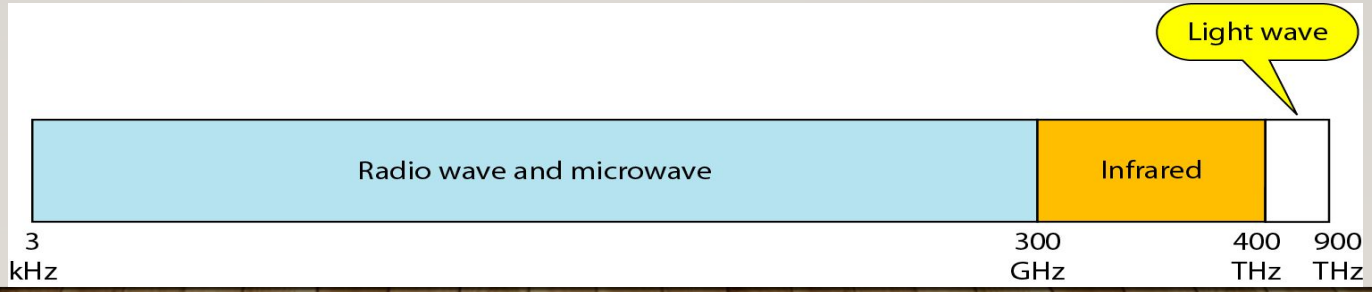
Guided Media

- **Fiber Optics Cable**
  - Light weight.
  - Increased bandwidth.
  - Less signal attenuation
  - Industry standard for high-speed networking.
  - Installation and maintenance is difficult.
  - Cost

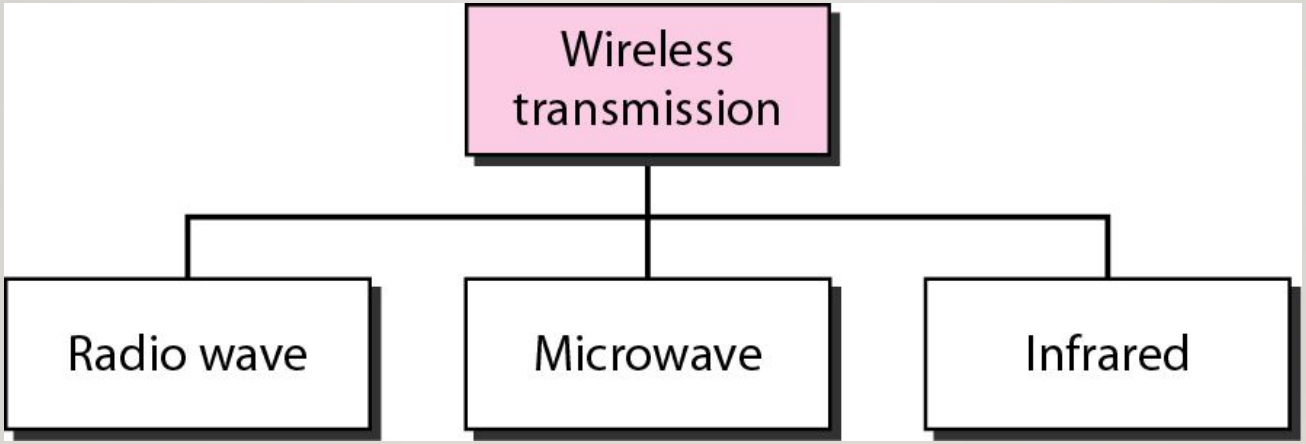


Unguided Media

- Unguided media transport electromagnetic waves without using a physical conductor.
- This type of communication is often referred to as **wireless communication.**
- Signals are normally broadcast through free space and thus are available to anyone who has a device capable of receiving them.



Classes of Wireless transmission



Wireless Transmission Waves

I. Radio waves:

- used for multicast communications, such as radio and television, and paging systems.
- can penetrate through walls.
- Frequency ranges from 3KHz to 1 GHz.
- Used in AM and FM radios

Wireless Transmission Waves

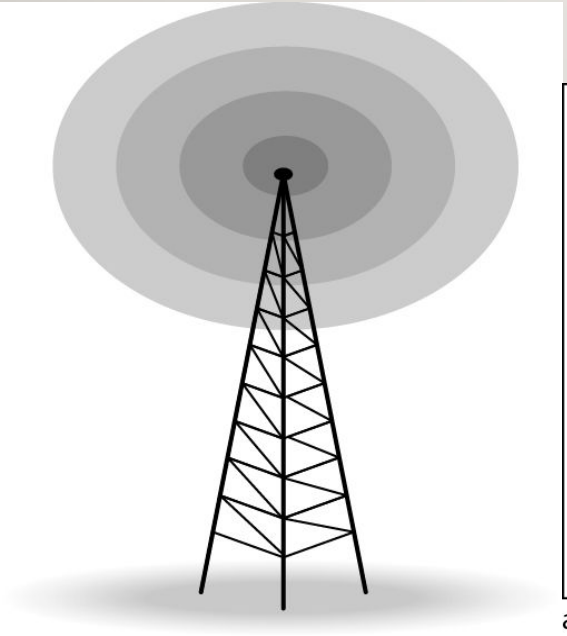
2. Microwaves:
   - used for unicast communication such as cellular telephones, satellite networks, and wireless LANs.
   - Frequency ranges from 1GHz to 300GHz.
   - Distance covered is directly proportional to antenna's height.

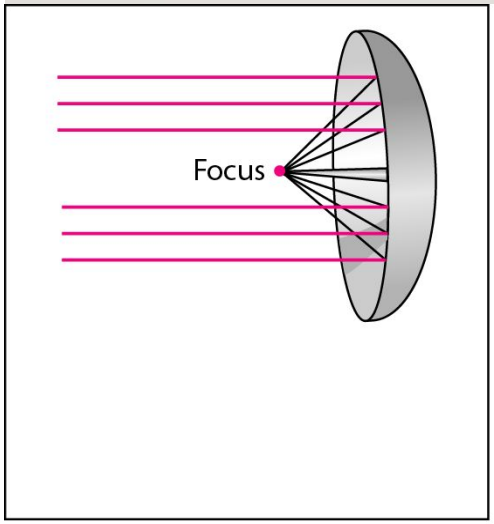
Wireless Transmission Waves

3. Infrared signals:

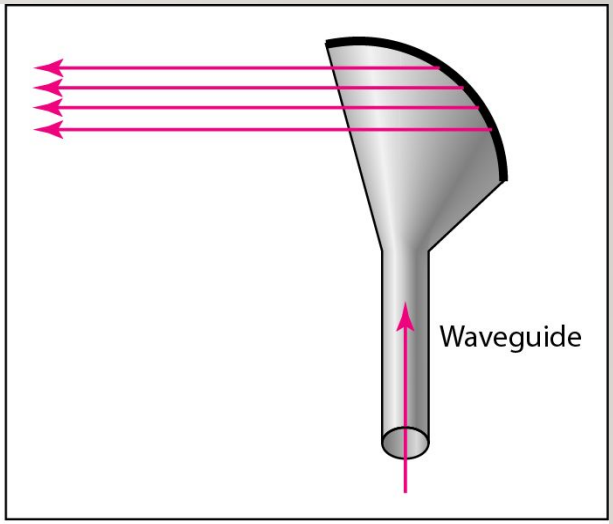
- can be used for short-range communication in a closed area (TV remote operation).
- Cannot go through obstacles.
- High bandwidth, high data rate, minimum interference.
- Unreliable outside the building because the sun rays will interfere with the infrared waves.
- Frequency ranges from 300 GHz to 400 THz.

ANTENNAS





a. Dish antenna



b. Horn antenna