Data Communication and Networking : Basics

Outline

- Goal
  - Basic Terminologies
  - Understanding the components and models of the network

- Data Communications
- Components
- Network
- Physical Structure of Network
- Protocols
- OSI Layers
- TCP/IP
- Summary

Data Communications

- Data communications: Transfer of data from one device to another via some form of transmission medium.
- The effectiveness of a data communications system depends on four fundamental characteristics: **Delivery, Accuracy, Timeliness, and Jitter.**
  - **Delivery:** The system must deliver data to the correct destination.
  - **Accuracy:** The system must deliver the data accurately.
  - **Timeliness:** The system must deliver data in a timely manner. Data delivered late are useless.
  - **Jitter**: Jitter refers to the variation in the data arrival time (Uneven delay in the arrival of the packet).

Communication Components

- The Five Components of Data Communication are:
  - **Sender**: The device that ***sends*** the message.
  - **Receiver**: The device that ***receives*** the message.
  - **Message**: The information (data) to be communicated
  - **Transmission Medium**: the ***medium*** by which a message travels from sender to receiver
  - **Protocol**: Set of ***rules*** that govern data communications

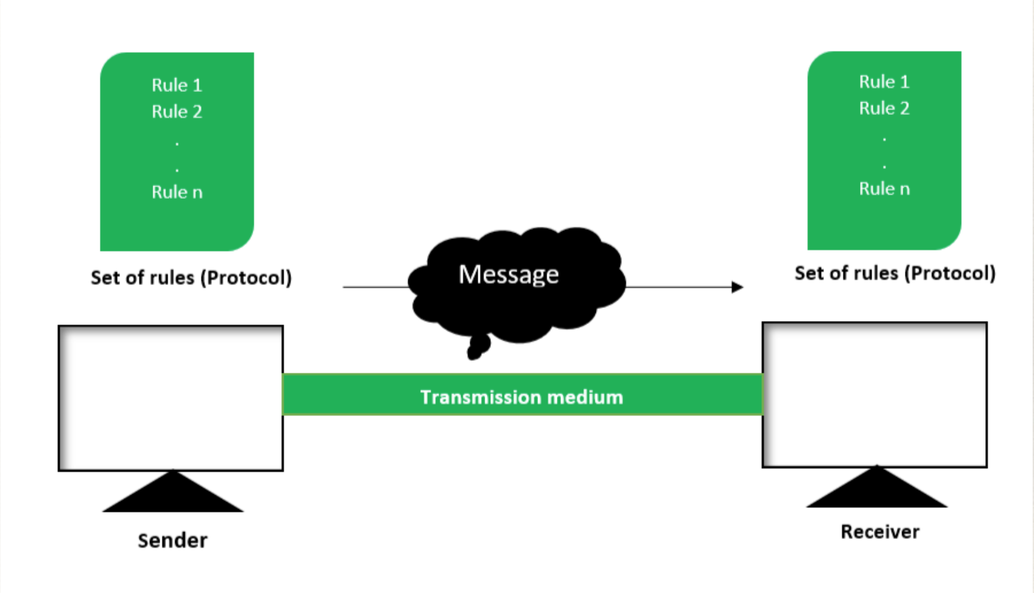


Fig. 1: Components of Data Communication (Source: Internet)

Transmission Modes

- The Communication between the two devices can be: Simplex, Half-duplex and Full-duplex.
  - **Simplex:** The communication is ***unidirectional***, Only one device can send. Eg. Keyboards and traditional monitors
  - **Half-duplex:** Both station ***can transmit and receive, but not at the same time***. Eg. Walkie-talkies and CB (citizens band) radios.
  - **Full-duplex:** Both stations can ***transmit and receive simultaneously***. Eg. telephone network

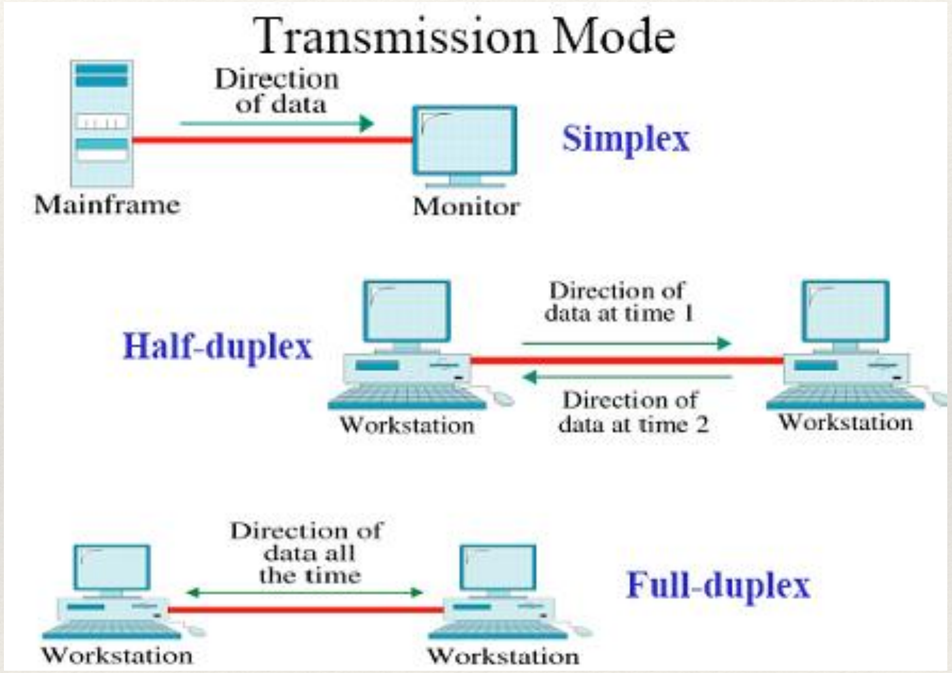


Fig 2: Transmission Modes (Source: Internet)

Networks

- **Network**: Two or more devices (Nodes) connected through the communication links.
  - A N**ode** can be a computer, printer, or any other device capable of sending and/or receiving data generated by other nodes on the network.
  - A **link** can be a cable, air, optical fiber, or any medium which can transport a signal carrying information
- **Network Criteria:** The network must be able to meet certain criteria such as: ***performance, reliability, and security*****.**
  - **Performance:** measured using various terms such as transmission time, response time, throughput, delay.
  - **Reliability:** Network's robustness in a catastrophe. Network reliability is measured by the *frequency of failure*.
  - **Security**: Network Security includes protecting data from ***unauthorized access***, protecting data from damage.

Physical Structure of Network

- The Physical Structure of the network is defined by two components:
  - *Type of Connection*
  - *Topology*
- **Type of Connection:** Defines how the devices are connected in the network. The two types of connections are Point-to-Point and Multi-Point.
  - **Point-to-point:** A point-to-point connection provides a dedicated link between two devices.
    - The entire capacity of the link is reserved for transmission between those two devices.
  - **Multi-point:** In multi-point more than two specific devices share a single link.
    - The capacity of the channel is shared, either spatially or temporally

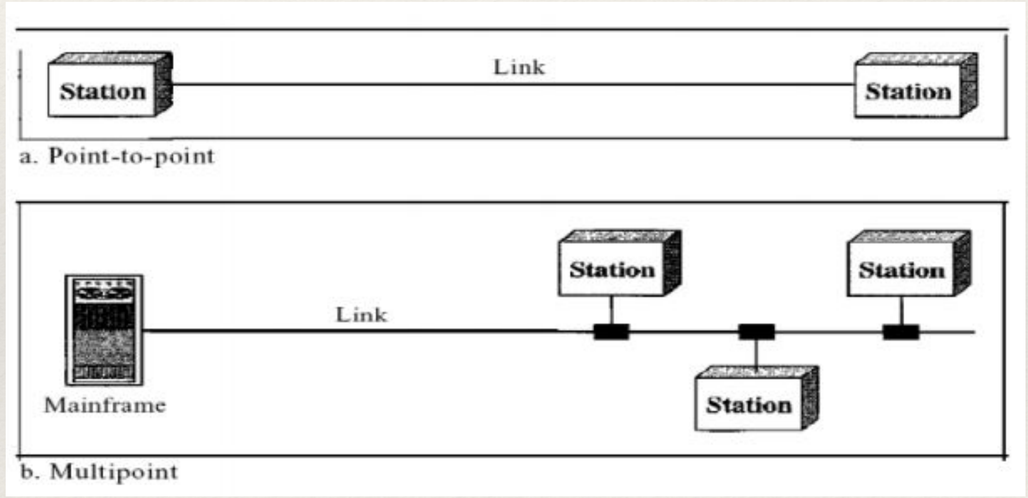


Fig 3: Type of Connection (Source: Data Communication Text book)

Network Topology

- The topology refers to the way in which ***devices in network is laid out physically***.
- Different categories of topology are:

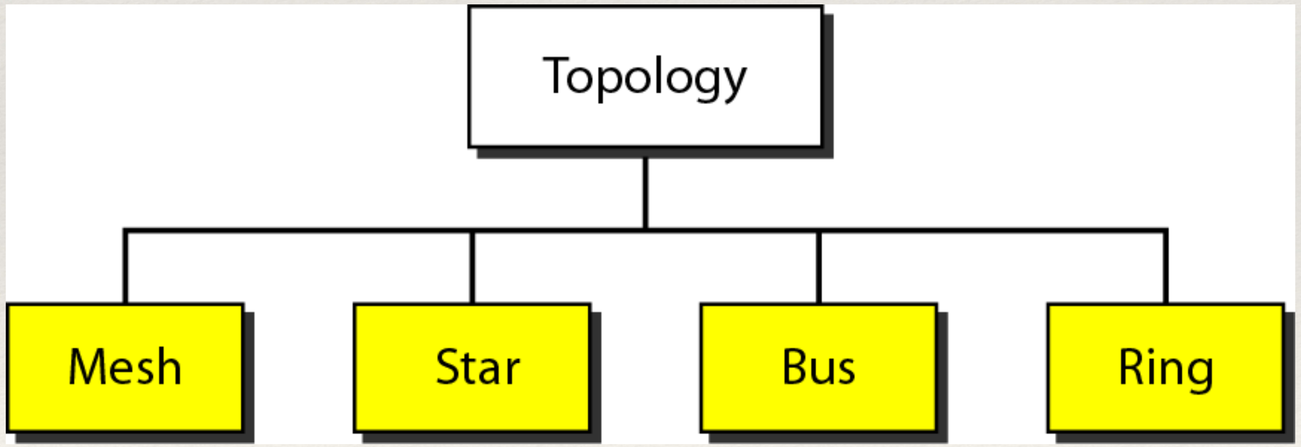


Fig 4: Topology Types

Mesh Topology

- Every device has a ***dedicated point-to-point link*** to every other device.
- Dedicated link means it carries traffic only between the two devices it connects.
- The number of links (duplex mode) required to connect the N devices in a network is given by $N(N-1)/2$.
  - Advantages:
    - It guarantees that each connection can carry its own data load.
    - Topology is Robust.
    - Fault identification and isolation is easy in point-to-point link connection.
  - Disadvantages:
    - Number of link and ports are high and also consume more physical space.

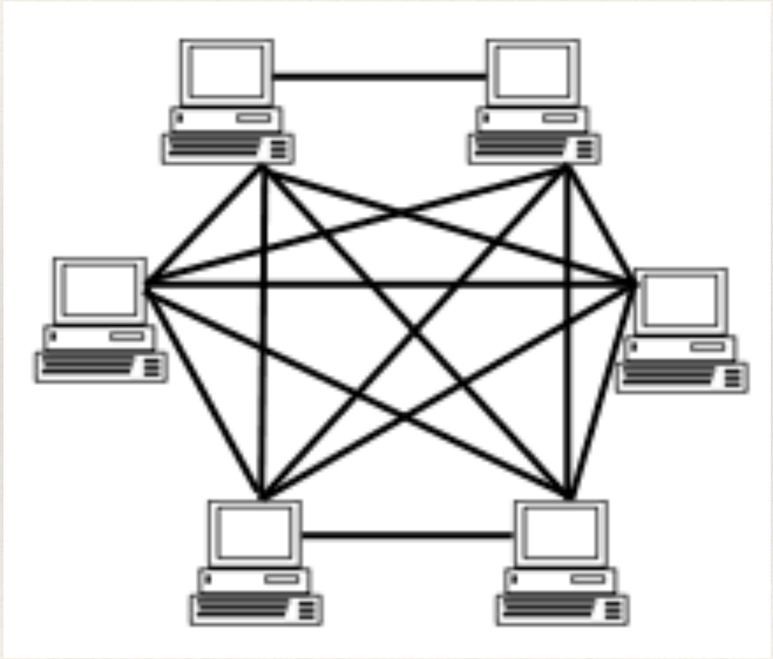


Fig 5: Mesh Topology (Source: Internet)

Star Topology

- In a star topology, each device has a ***dedicated point-to-point link*** to a central controller called as ***hub***.
- Star topology does not allow direct traffic between devices, ***data transfer happens via central hub***.
- Advantages:
  - Less Expensive compare to mesh.
  - Fault identification and isolation is easier.
- Disadvantages:
  - Depends only on centralised hub, if it fails whole topology goes down.

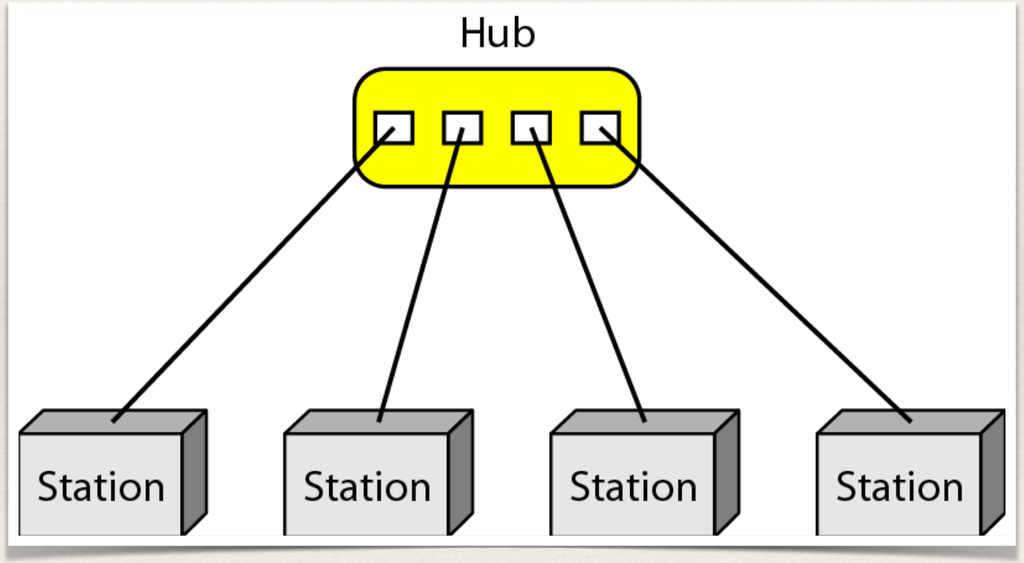


Fig 6: Star Topology (Source: Data Communication Text book)

Bus Topology

- A bus topology is a ***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.
  - 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.
- Advantages:
  - Installation is easy
  - Less expensive
- Disadvantages:
  - Fault identification, reconnection and isolation is difficult.
  - Signal reflection at the taps can cause degradation in quality

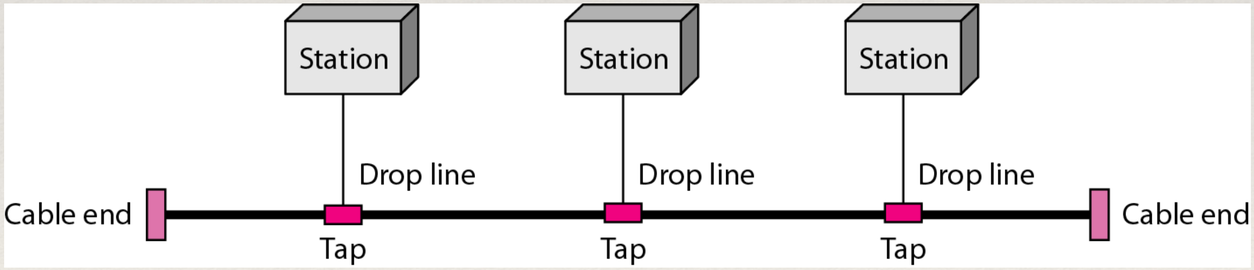


Fig 7: Bus Topology (Source: Data Communication Text book)

Ring Topology

- In a ring topology, each device has ***a dedicated point-to-point connection*** with only the two devices on either side of it.
- A message 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***
- Advantages:
  - A ring is relatively easy to install and reconfigure.
- Disadvantages:
  - unidirectional traffic can be a disadvantage.
  - A break in the ring (such as a disabled station) can disable the entire network

Ring Topology

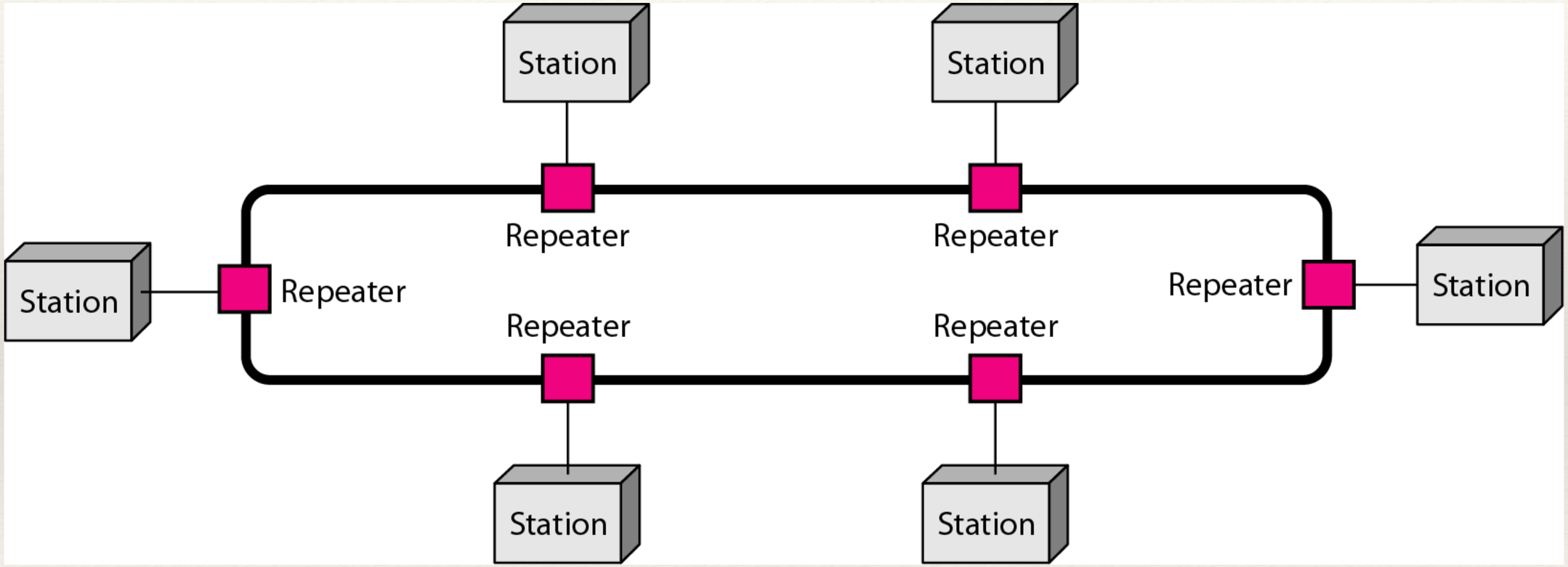


Fig. 8: Ring Topology (Source: Data Communication Text Book)

Hybrid Topology

- A network can be hybrid.
- For example, we can have a main star topology with each branch connecting several stations in a bus topology.

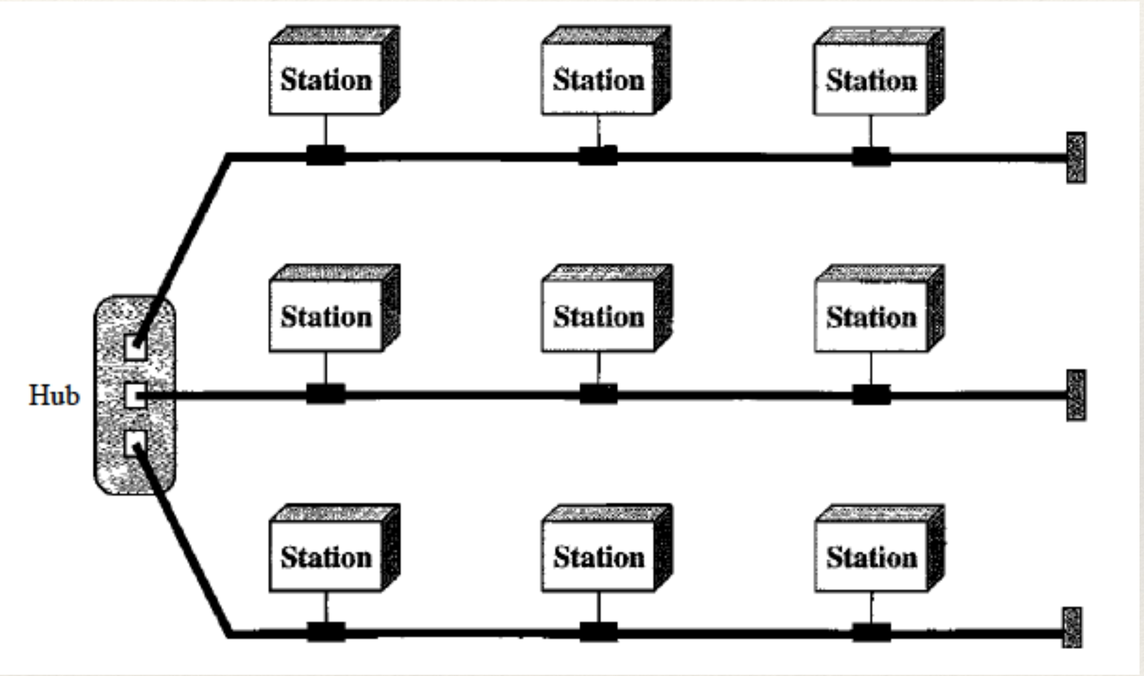


Fig. 9: Hybrid Topology (Source: Computer Networks Textbook)

Categories of Network

- Local Area Networks (LANs)
  - Short distances
  - Designed to provide local interconnectivity
- Wide Area Networks (WANs)
  - Long distances
  - Provide connectivity over large areas
- Metropolitan Area Networks (MANs)
  - Provide connectivity over areas such as a city, a campus

Protocols

- A **Protocol:** ***set of rules*** that govern data communications.
- A protocol in data communications defines what is communicated, how it is communicated, and when it is communicated.
- The key elements of a protocol are syntax, semantics, and timing.
  - **Syntax**
    - ***Structure or format of the data*** (order in which they are presented).
    - Indicates how to read the bits - field delineation
  - **Semantics**
    - The word semantics refers to the ***meaning of each section of bits***.
    - Knows which fields define what action
  - **Timing**
    - ***when data should be sent***
    - ***how fast they can be sent.***

Network Models

- Layered Model

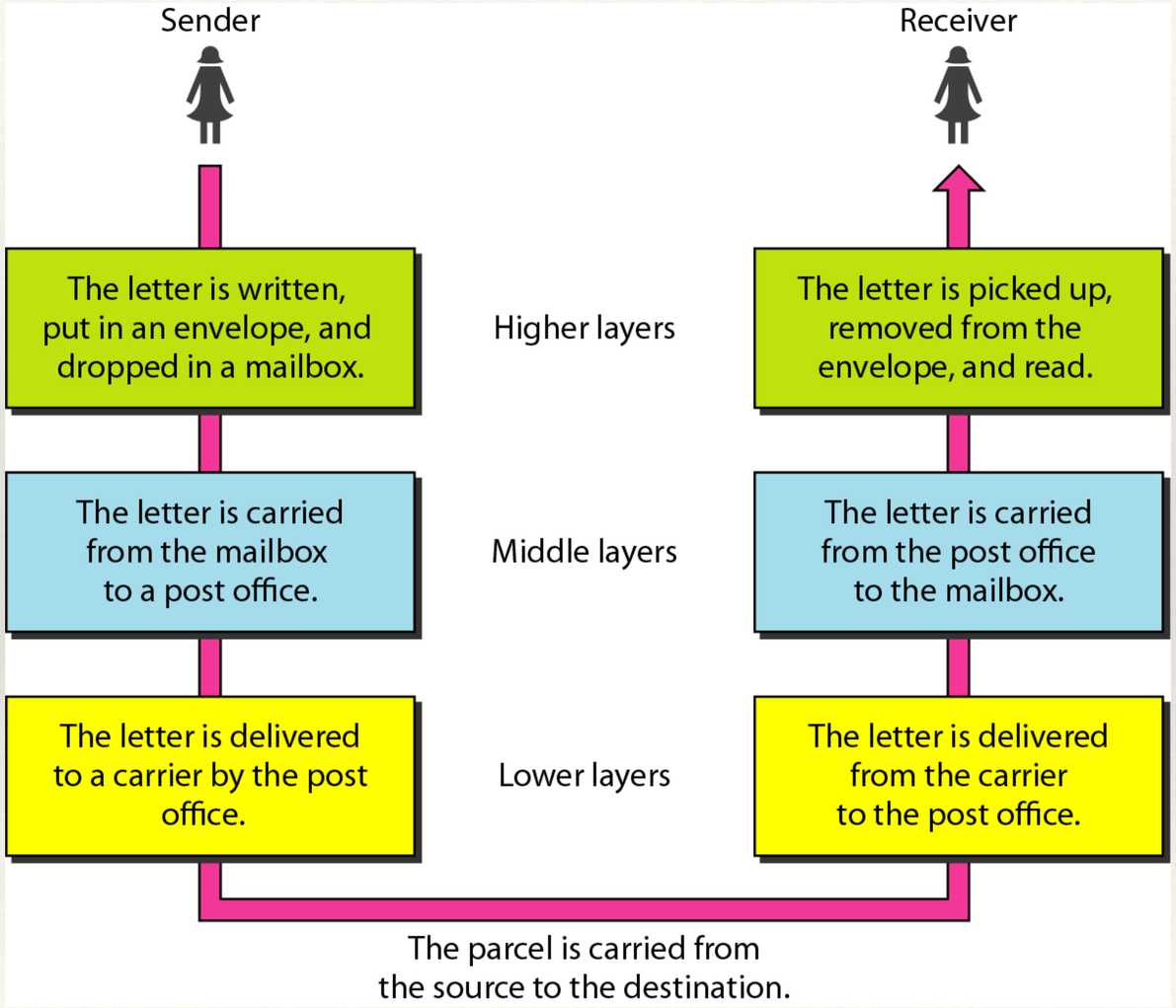


Fig 10: Tasks involved in sending a letter

OSI- Model

- Established in 1947
- International Standards Organization (ISO) is a multinational body dedicated to worldwide agreement on international standards.
- An ISO standard that covers all aspects of network communications is the Open Systems Interconnection (OSI) model.
- It was first introduced in the late 1970s.

Open System: allows any two different System to Communicate

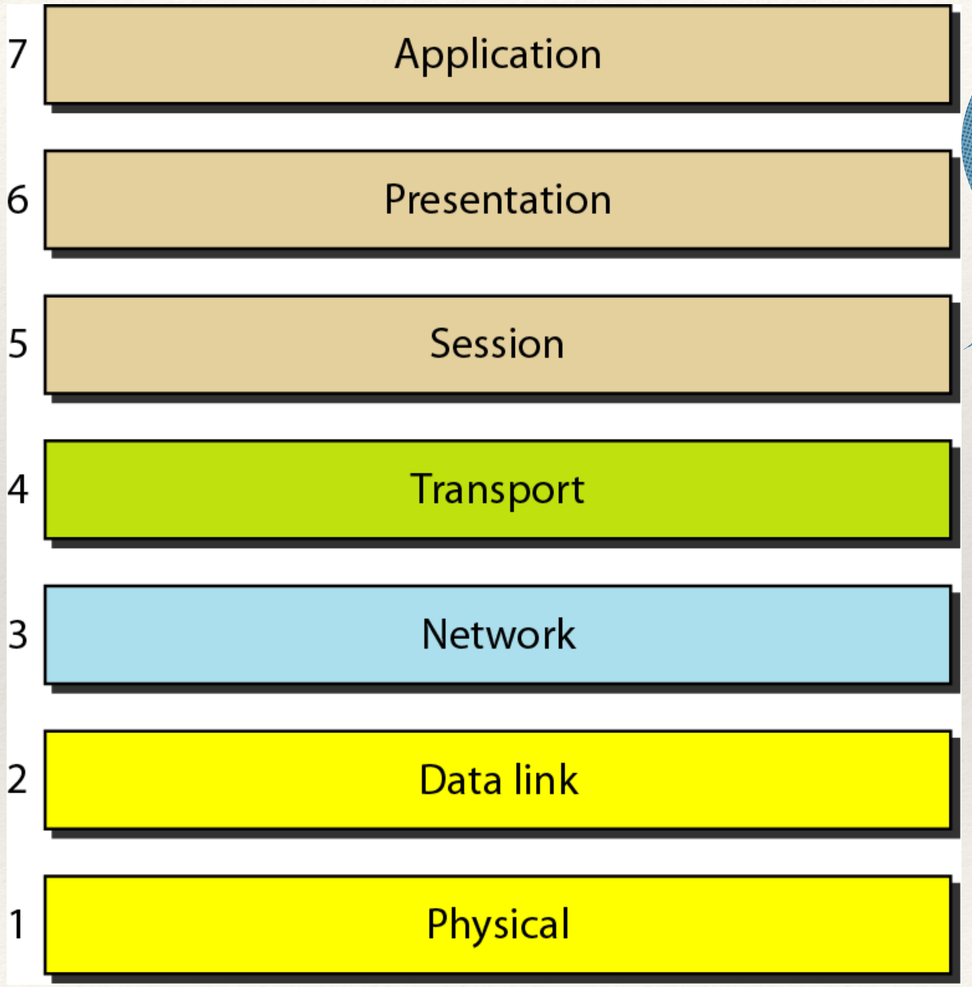
model for understanding and designing a network architecture that is flexible, robust and interoperable

Note: ISO is the organization.

&

OSI is the model.

OSI-Layers



Links the two subgroups

Layers 5,6 & 7 are called as user support layers

Layers 1,2 &3 are called as network support layers

Fig. 11: Seven Layers of the OSI Model

OSI-layer

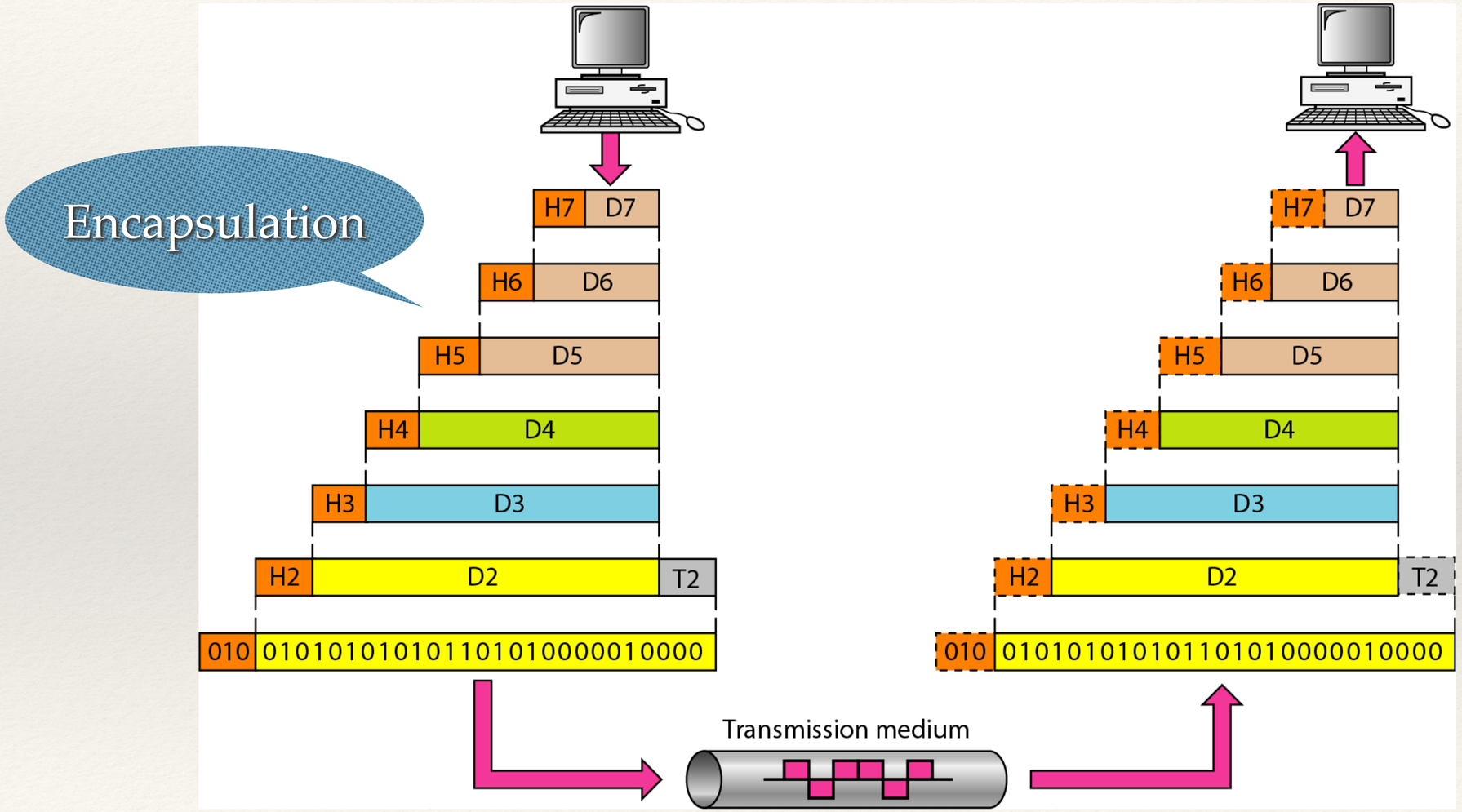


Fig 12: An exchange using the OSI model

Physical Layer

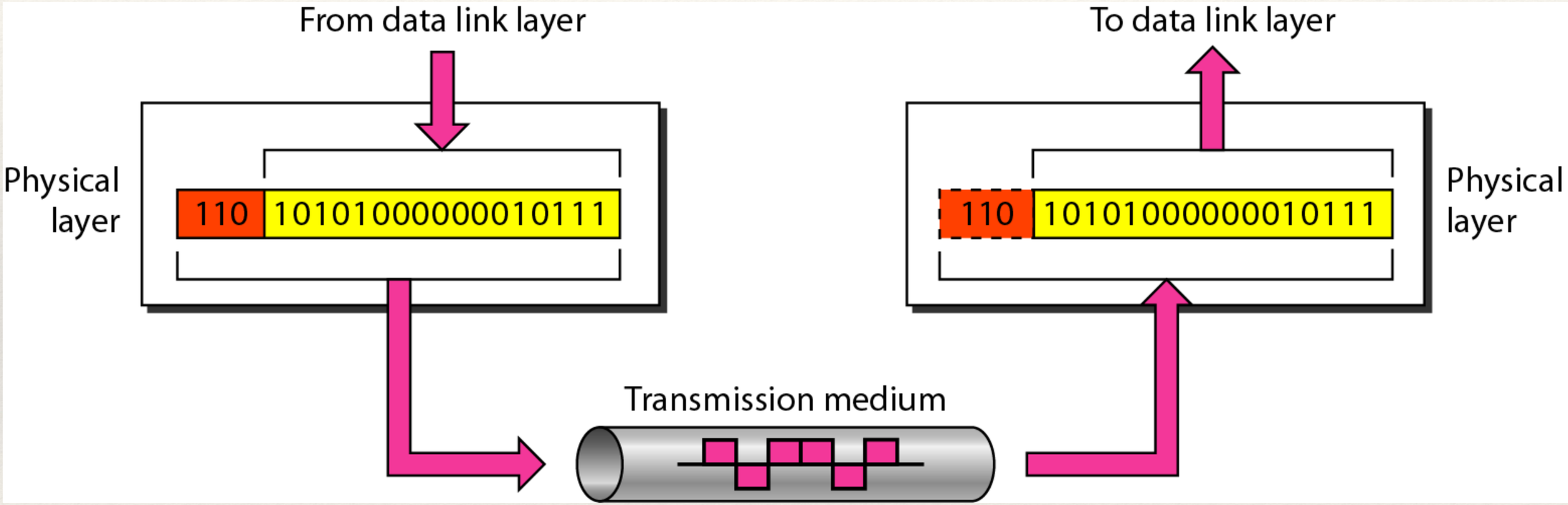


Fig 13: Physical Layer

- Responsible for movements of individual bits from one hop (node) to the next

Physical Layer

- Other responsibilities of Physical Layer
  - Physical characteristics of **interfaces** and **medium** and defines the type of the medium.
  - Representation of **bits** (Stream of bits/sequence of 0s or 1s)
  - Defines the type of **encoding**
  - **Data rate**: The transmission rate-the **number of bits sent each second**
  - **Synchronization** of bits: Sender and receiver clocks must be synchronised.
  - Line configuration (Connection Type: Point-to-point/Multi-point)
  - Physical topology
  - Type of **Transmission Modes**

Data Link Layer

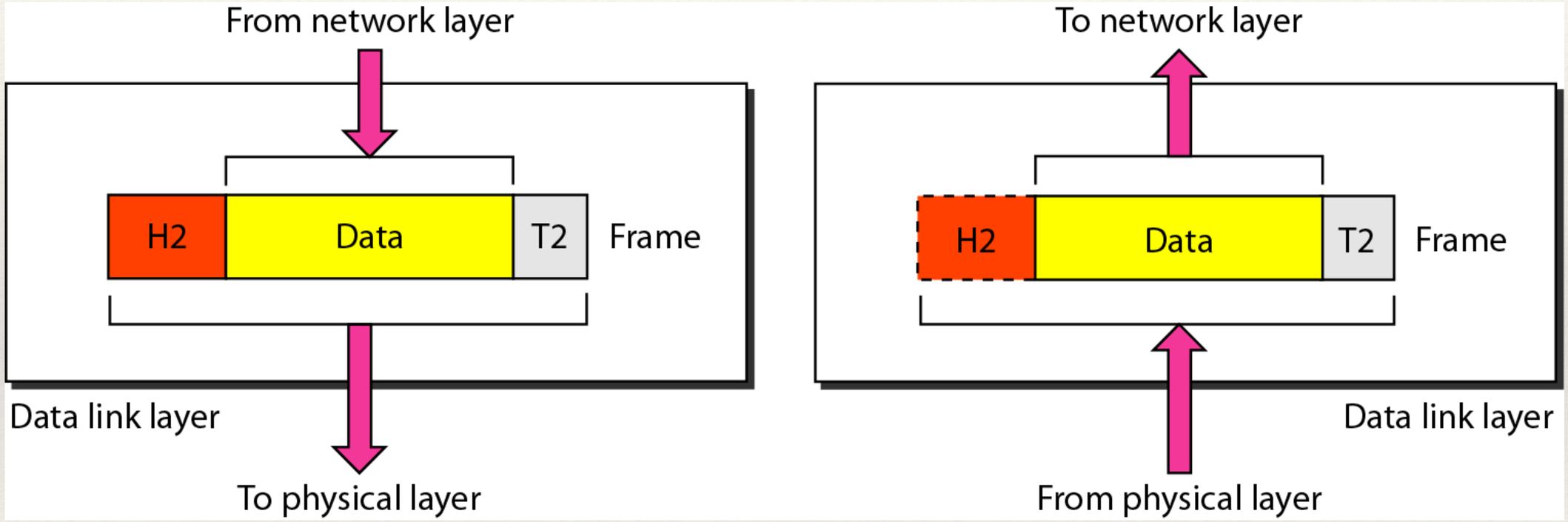


Fig 14: Data Link Layer

- Responsible for moving frames from one hop (node) to the next (Hop-to-Hop)

Data Link Layer

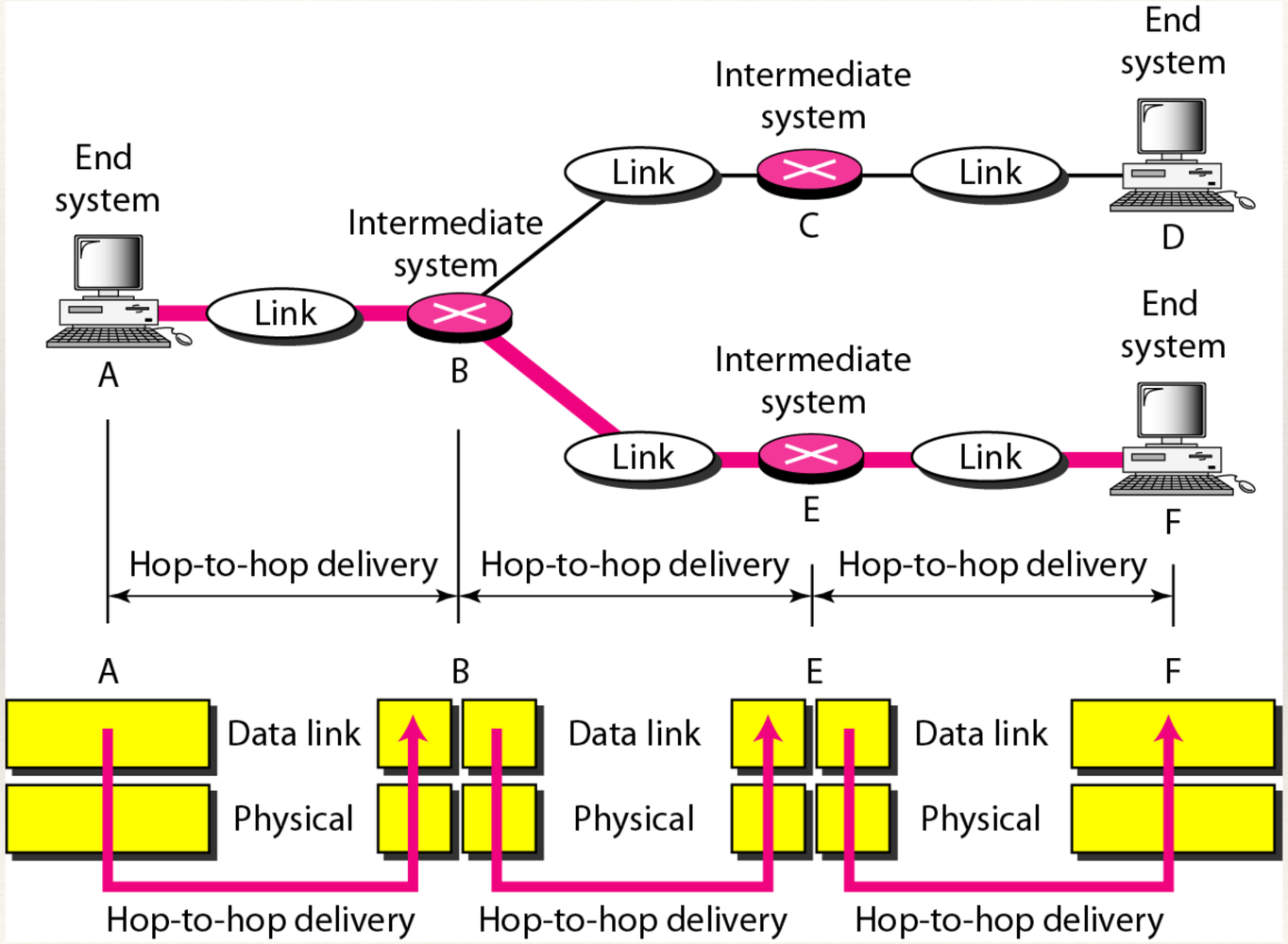


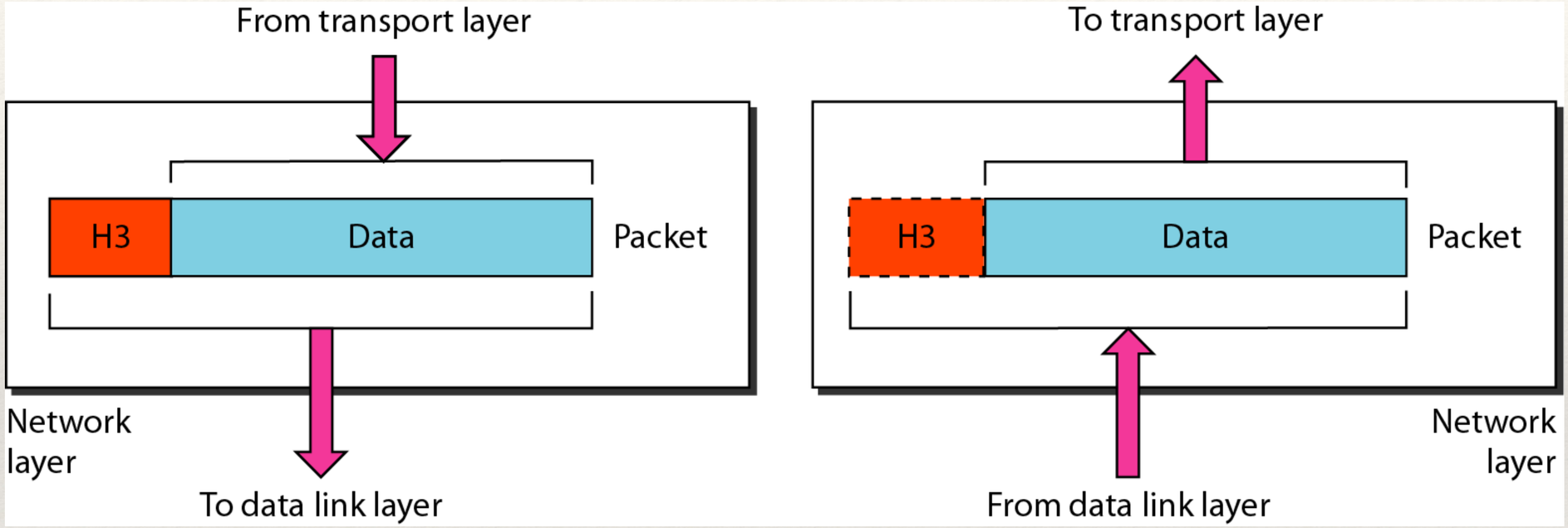
Fig 15: Hop-to-hop delivery

Data Link Layer

Other responsibilities of Data Link Layer:

- **Framing**. The data link layer divides the stream of bits received from the network layer into manageable data units called frames.
- **Physical addressing**.
- **Flow control**
- **Error control: M**echanisms to detect and retransmit damaged or lost frames
  - Uses a mechanism to recognize duplicate frames.
- **Access control:** Data link layer protocols are necessary to determine which device has control over the link.

Network Layer



- Delivery of individual packets from the source host to the destination host

Network Layer

- Other Responsibilities
  - Logical addressing
  - Routing

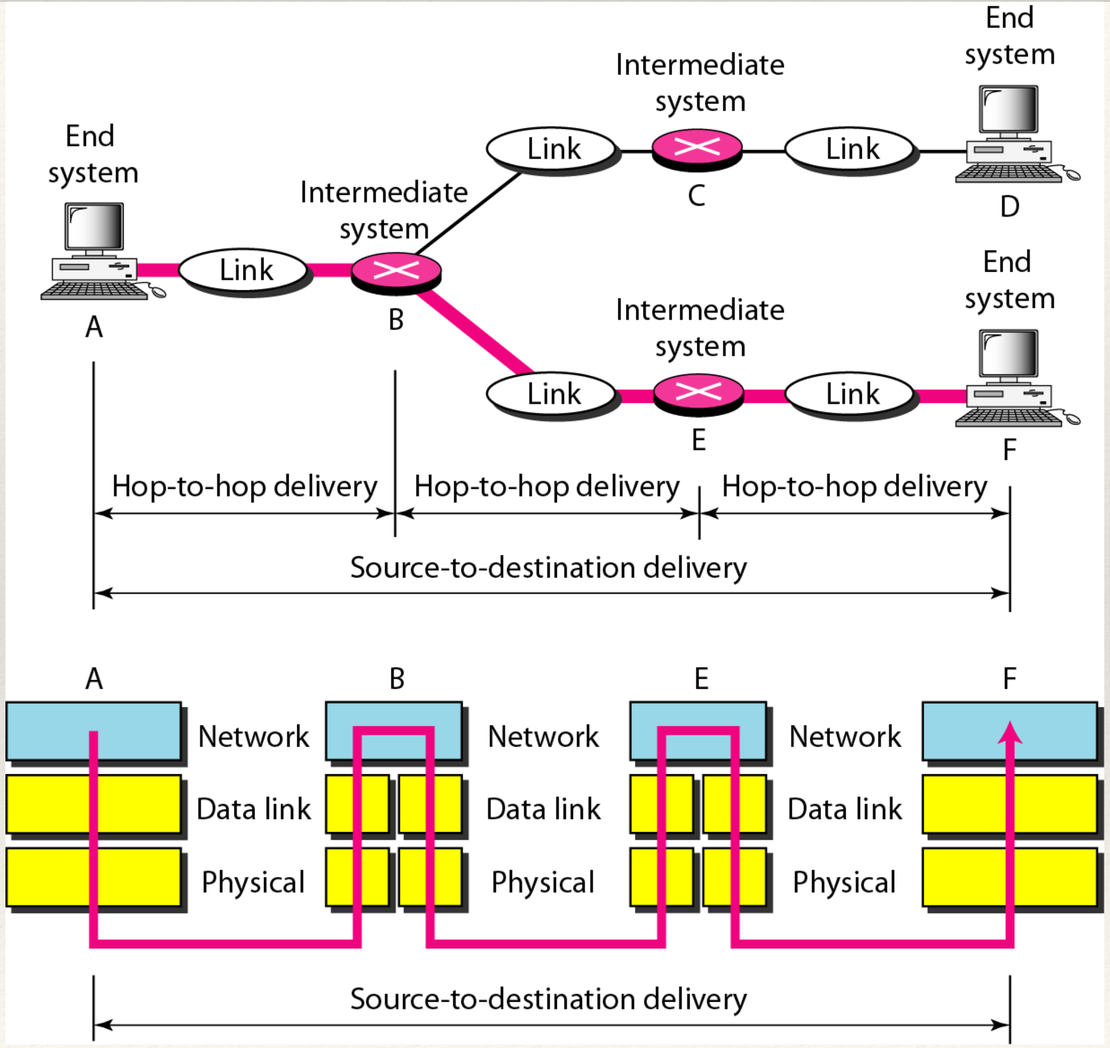
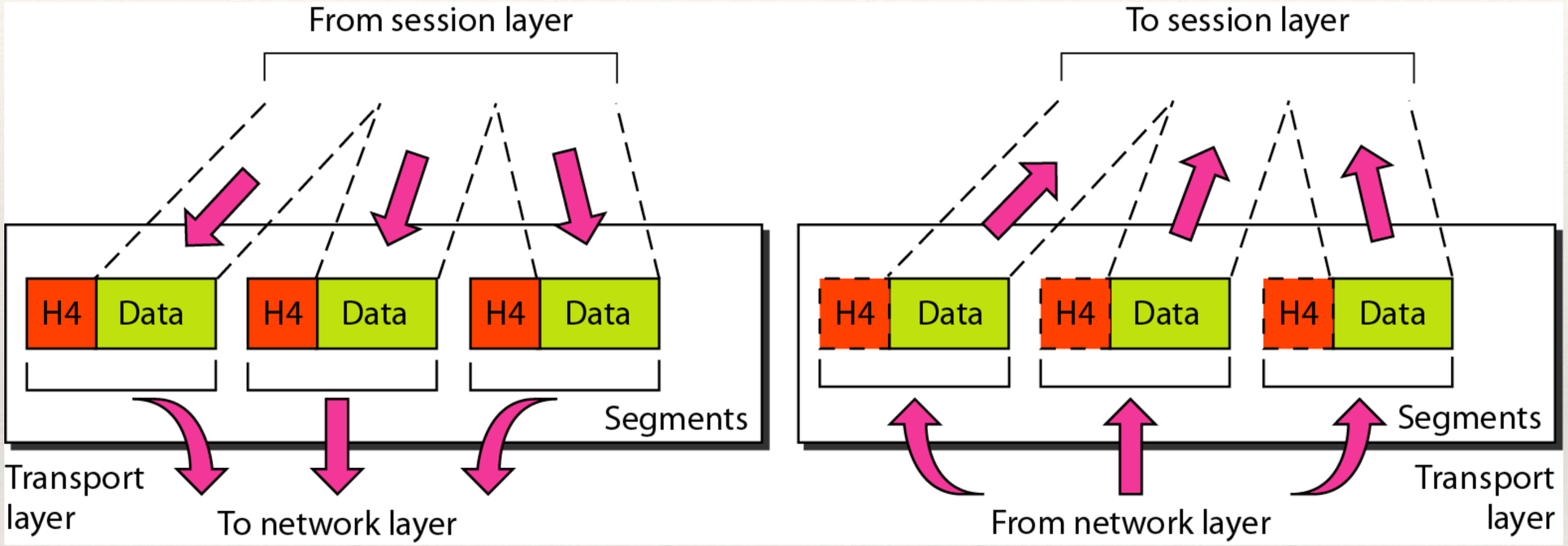


Fig 16: Source-to-destination Delivery

Transport Layer



- Responsible for the delivery of a message from one process to another

Transport Layer

Other Responsibilities

- **Service-point addressing:** Network layer gets each packet to the correct computer; the transport layer gets the entire message to the correct process (using Port Address)
- **Segmentation and reassembly:** A message is divided into transmittable segments,with each segment containing a sequence number.
- **Connection control**
- **Flow control**
- **Error control**

Transport Layer

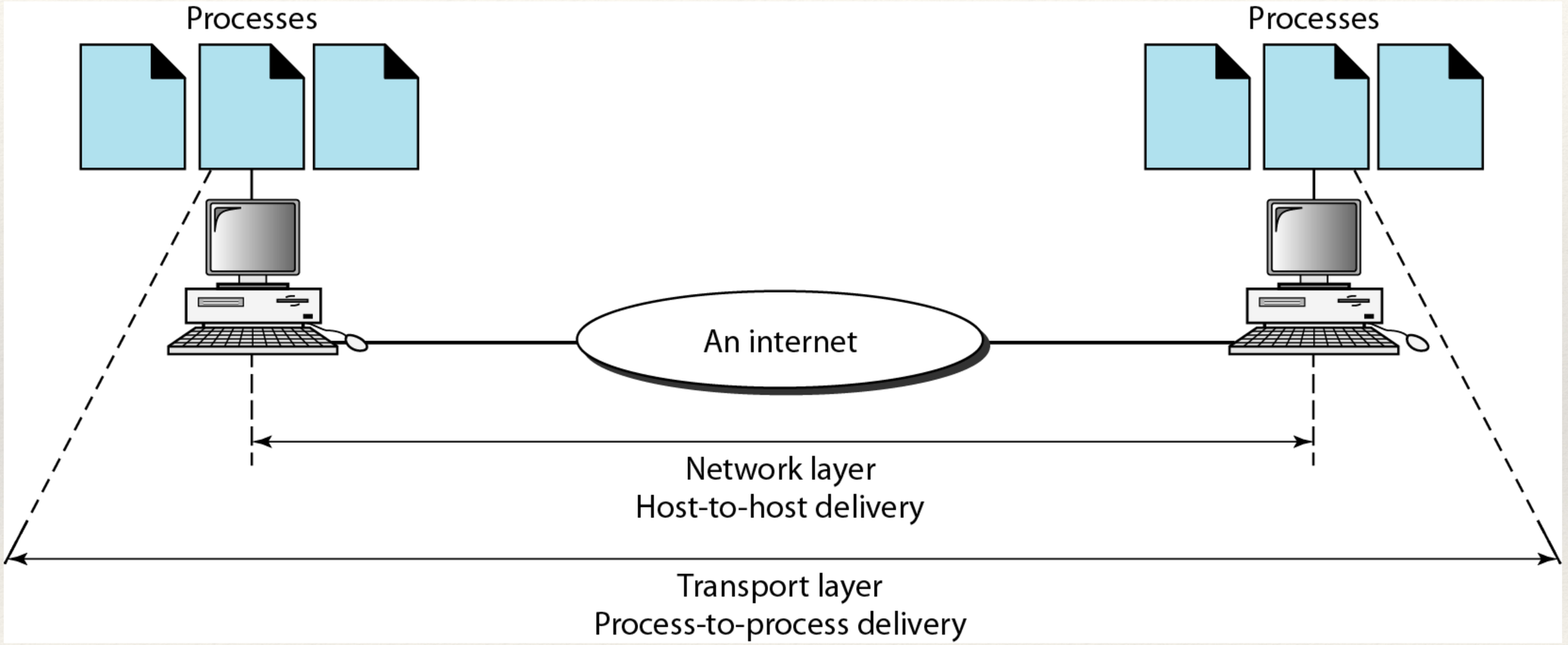


Fig 17: Reliable process-to-process delivery of a message

Session Layer

- It establishes, maintains and synchronises the interaction among the devices.
- **Dialog control:** It allows the communication between two processes to take place.
  - half-duplex (one way at a time)
  - full-duplex (two ways at a time) mode
- **Synchronization**

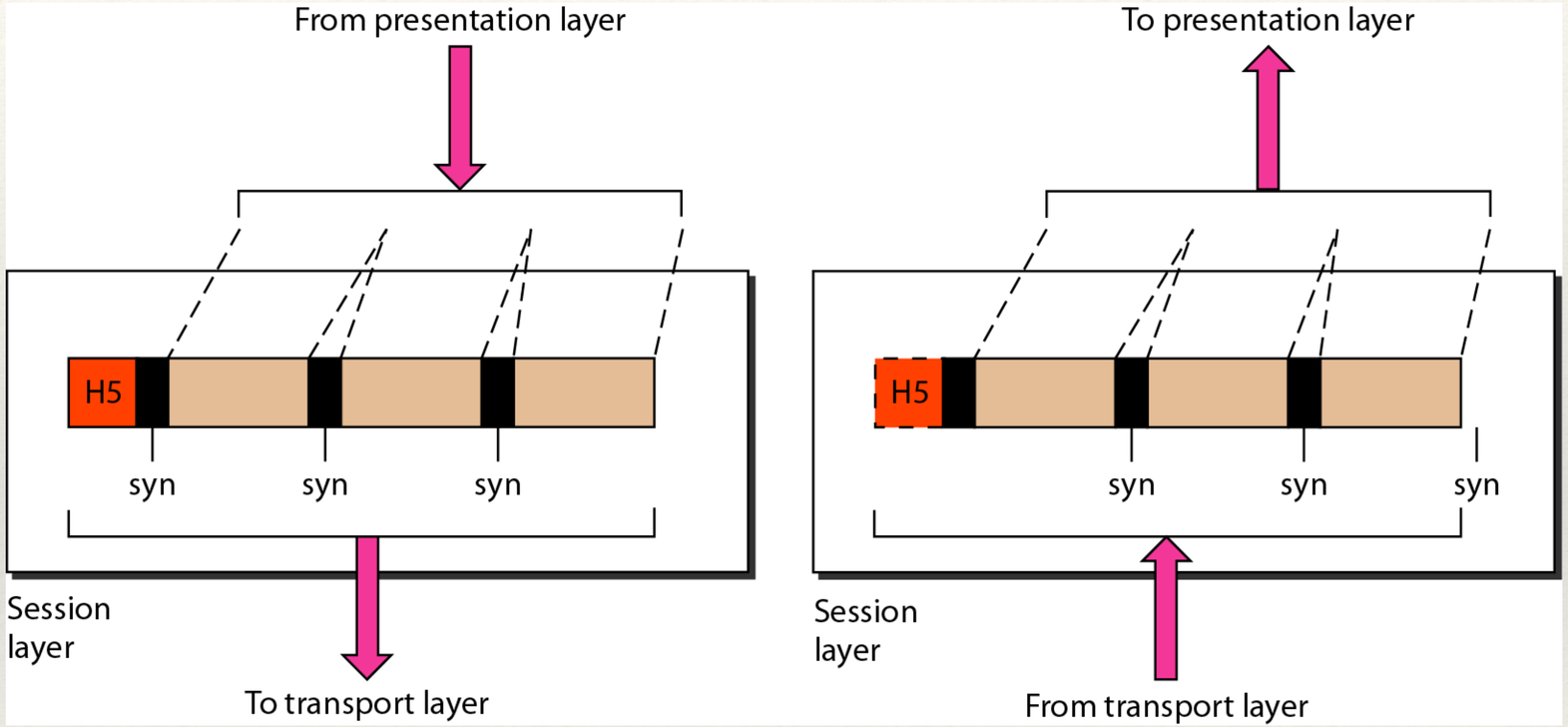


Fig 18: Session layer

- Responsible for dialog control and synchronization

Presentation Layer

- Presentation layer concerned with the syntax and semantics of the information.
- **Translation**: changes the information from its sender-dependent format into a common format
- **Compression**: reduces the number of bits contained in the information
- **Encryption**: Transform the original information

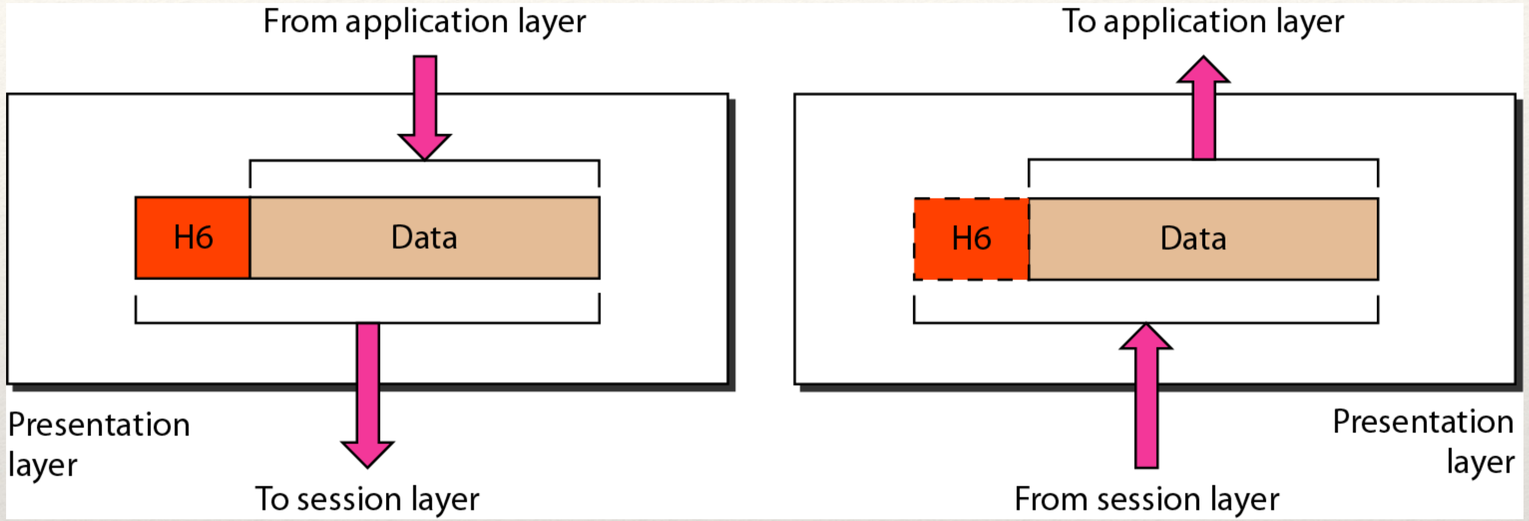


Fig 19: Presentation Layer

- Responsible for translation, compression, and encryption

Application Layer

- Other Responsibilities
  - **Network virtual terminal**: allows a user to log on to a remote host
  - File transfer, access, and management
  - **Mail services**
  - **Directory services:** access for global information about various objects and services

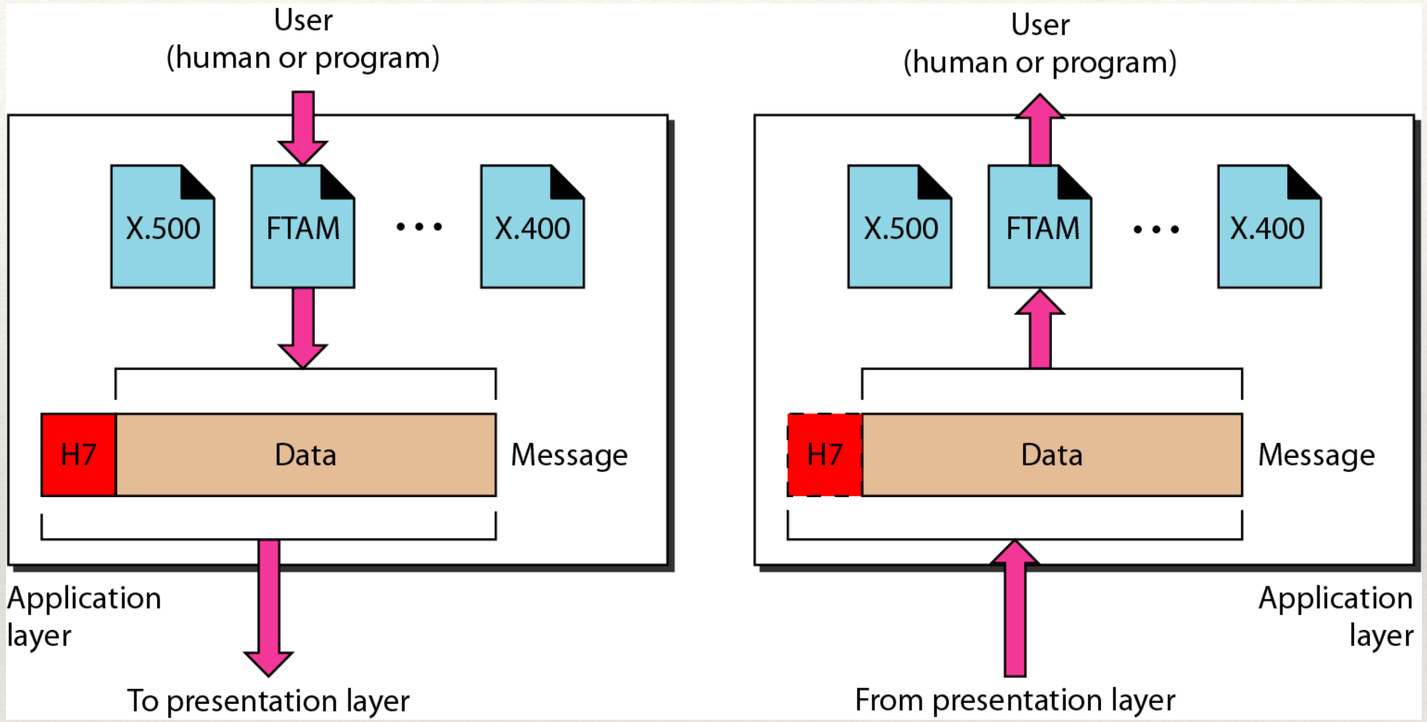


Fig 20: Application Layer

- Responsible for providing services to the user

Summary of OSI Layer Model

Away

Pizzas

Sausage

Throw

Not

Do

Please

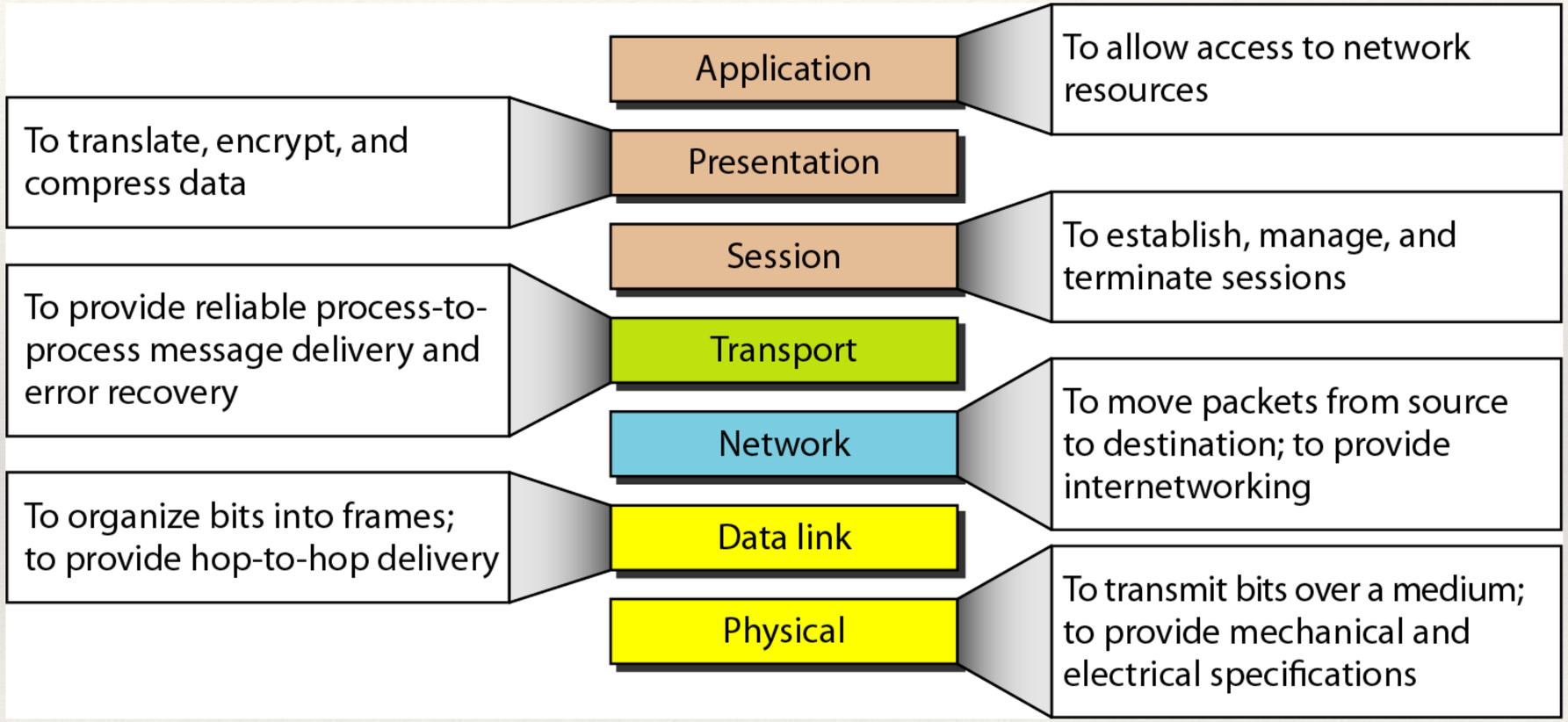


Fig 21: Summary of OSI Layers Responsibilities

TCP/IP Model

- The original TCP/IP protocol suite was defined as having four layers: host-to-network, internet, transport, and application.
- However, when TCP/IP is compared to OSI, we can say that the TCP/IP protocol suite is made of five layers: physical, data link, network, transport, and application.

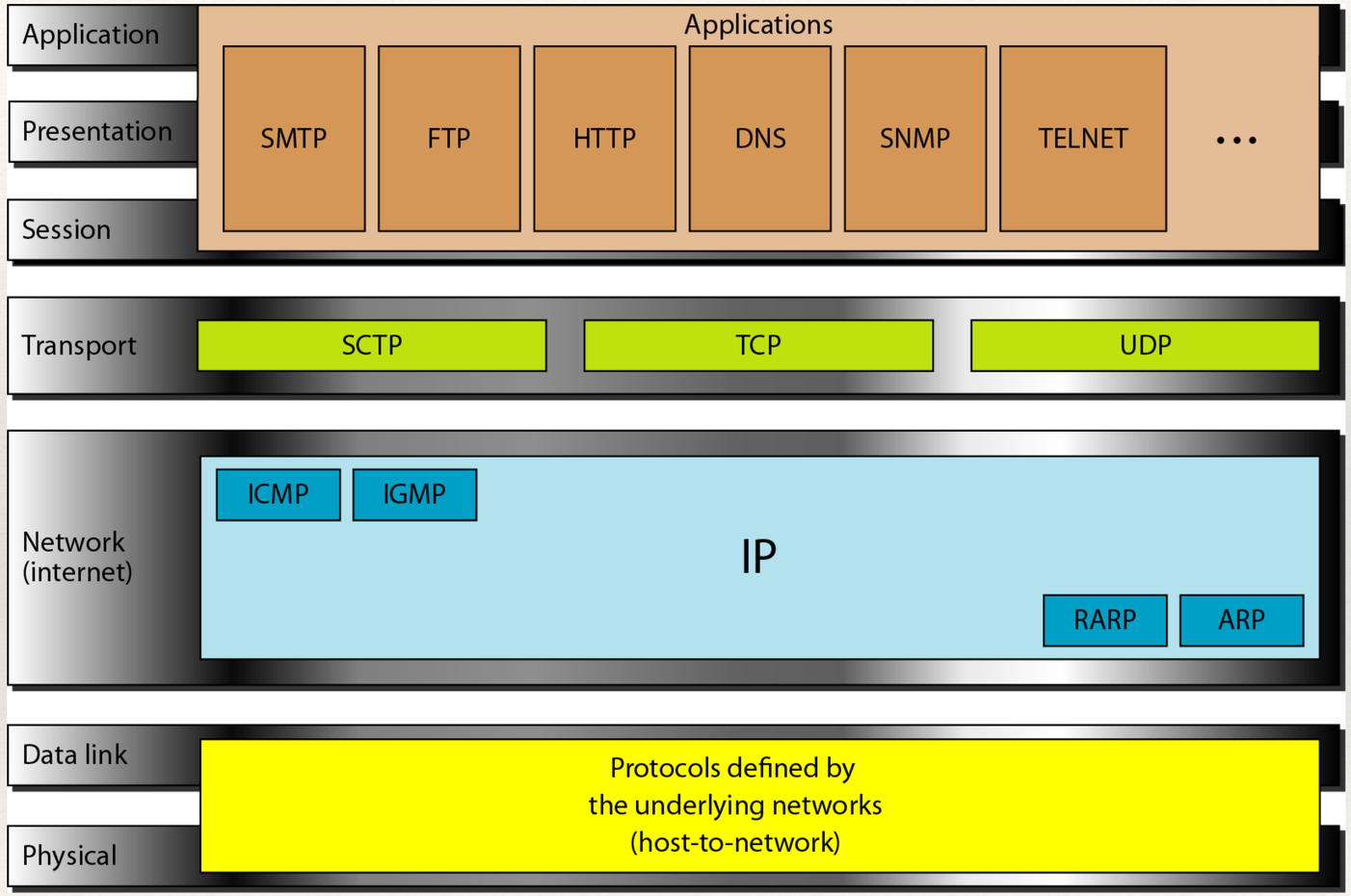
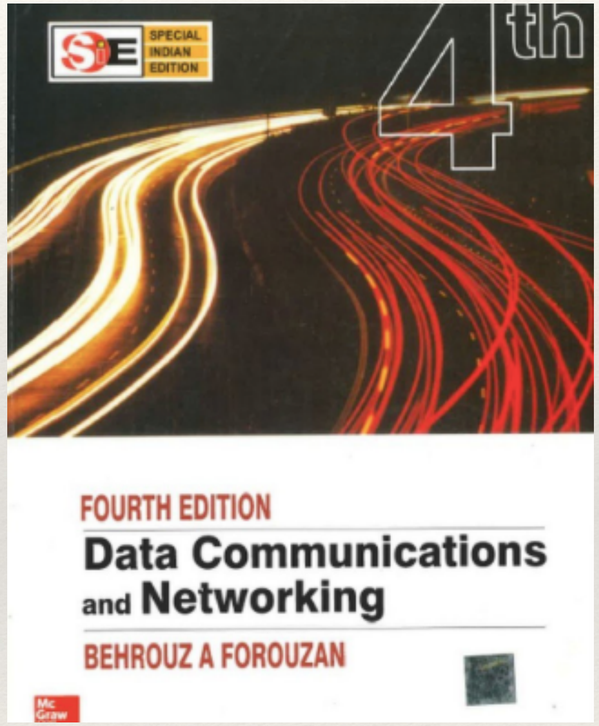


Fig. 22: TCP/IP and OSI Model

Summary

- Basic terms of Computer Networks and Data Communication.
- The computer communications components.
- Different Network Topologies.
- OSI Layers and Responsibilities
- TCP/IP Model



Note: Refer Chapter 1 (Except 1.3) and Chapter 2 (textbook Data Communication and Networking by Behrouz A Forouzan).