1985

جامعة محمد بوضياف - المسيلة

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Computer Networks

Lecture 1 : Introduction to Networking

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Chapter Layout

- Definitions & Key Terminologies
- History
- Network types
- Network Topologies
- Network standards
  - OSI
  - TCP/IP
- Network devices

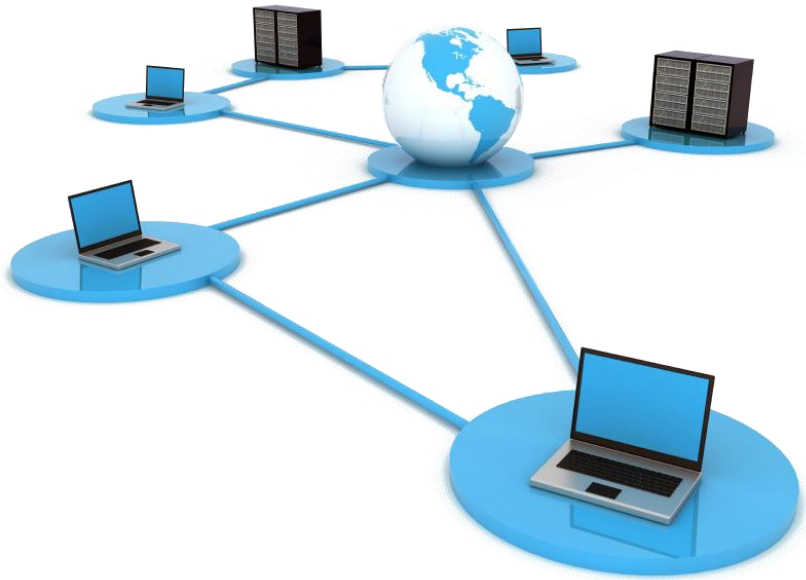
Definitions & Key terminologies

- **Networking terminology can be confusing, especially for those who are new to computer networking. Here are some basic terms and their definitions to help you understand the fundamentals of networking:**

Definitions & Key terminologies

- If things are connected together, are referred to as a **NETWORK**.

- A network can be of many types
  - Telephone network,
  - television network,
  - computer network,
  - Social network,
  - or even a people network.

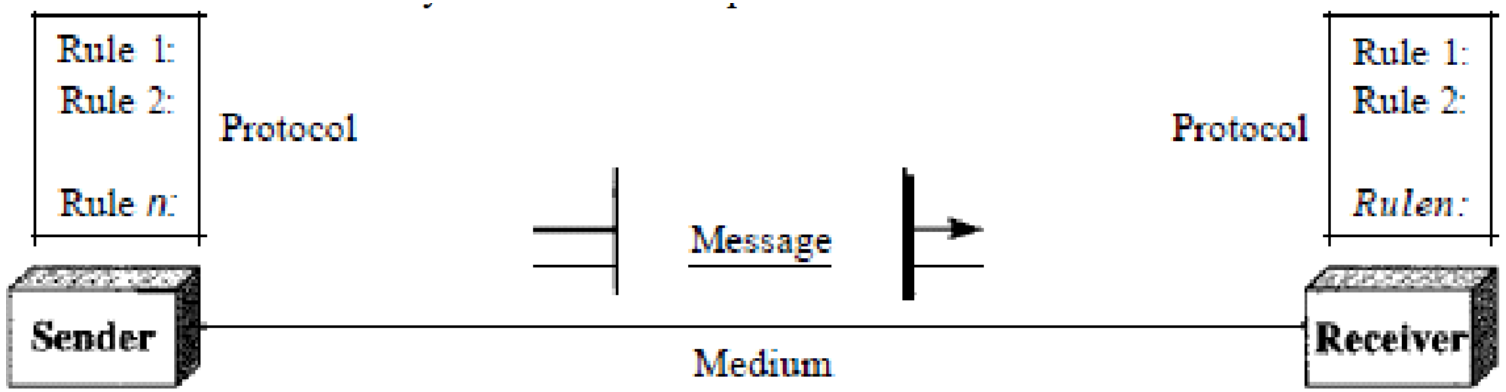


Definitions & Key terminologies

- **COMPUTER NETWORK** is a collection of interconnected devices, such as computers, printers, and servers, that communicate with each other to share a range of services and information in the form of :
  - **e-mails and messages**,
  - **databases**, **documents**,
  - **websites**,
  - **audios and videos**,
  - **telephone calls**,
  - **and video conferences**, etc. among them.
  - …

Definitions & Key terminologies

- Components of data communication:
  - At least two hosts
    - A Sender
    - A Receiver



  - Transmission medium
    - Wired
    - Wireless
  - Protocols or rules that govern the communication
  - A Message

Definitions & Key terminologies

- **Host** is :
  - any device (such as a computer, smartphone, server, or IoT device)
  - connected to a network that sends or receives information,
  - holds a unique network IP address,
  - and runs application software.
  - Hosts function as end systems, differentiating themselves from intermediate network infrastructure devices (like routers or switches)
- **Node (or device):** Any device connected to a network (host or intermediate), such as a computer, printer, or router.
- **IP Address:** A unique numerical identifier assigned to each device on a network, used to identify and communicate with other devices.

Definitions & Key terminologies

- **Transmission medium** is :
  - the physical path or channel—either wired (guided) or wireless (unguided)—
  - that connects a transmitter and receiver,
  - allowing data signals to propagate between network devices.

- **Types of transmission medium**:
  - Wired (Guided media) : twisted-pair cables (phone/LANs), coaxial cables (CATV), and fiber-optic cables (high-speed data).
  - Wireless (Unguided media) : like Bluetooth, WiFi…

Definitions & Key terminologies : Network protocols

- **Protocol:** A set of rules and standards that define how devices on a network communicate with each other.
- To facilitates **End to End** communication, a number of protocols work together to form **Protocol Suites or Stacks or reference models**.
- Some common network protocols
  - Transmission Control Protocol (TCP)
  - Internet Protocol version 6 (IPv6)
  - Dynamic Host Configuration Protocol (DHCP)
  - Domain Name System (DNS)
  - Simple Mail Transfer Protocol (SMTP)
- Importance of protocols:
  - Interoperability
  - Standardization
  - Reliable communication

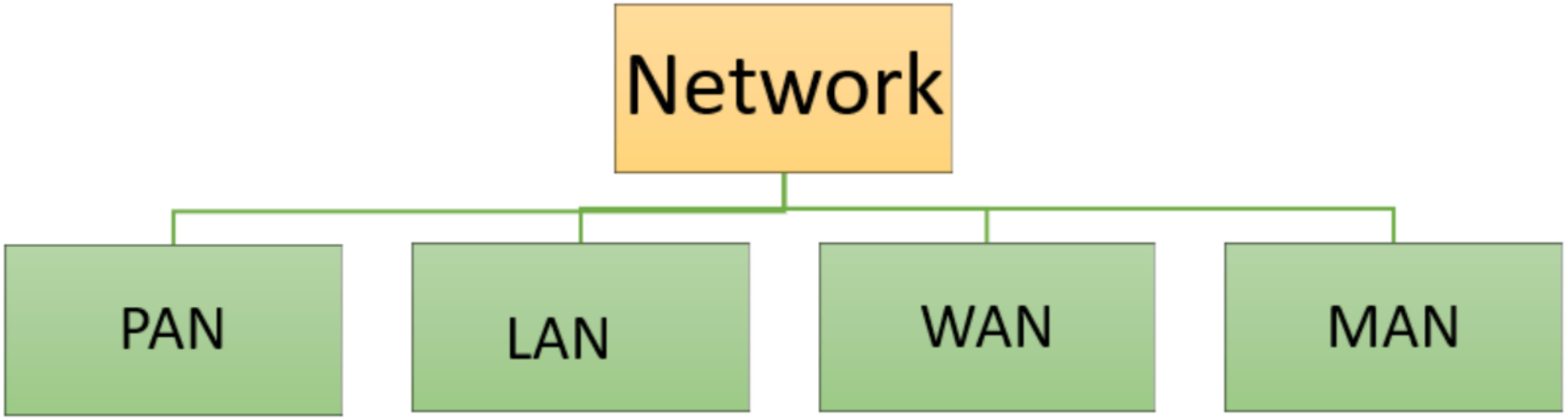
History

History

- Before 1957 : Computers only worked on one task at a time.
- 1957:
  - Remote connection to a computer
  - Processing power sharing between multiple users
- February 1958 : The USA founded DARPA
  - The first computer network called ARPANET in 1969
    - Four nodes of the ARPANET were connected using 50 kbit/s circuits between the University of California at Los Angeles, the Stanford Research Institute, the University of California at Santa Barbara, and the University of Utah.
  - Foundations of our modern Internet
- 1980s : TCP/IP
- February 28, 1990 :
  - The ARPANET hardeware was removed
  - WWW and Internet

Network types

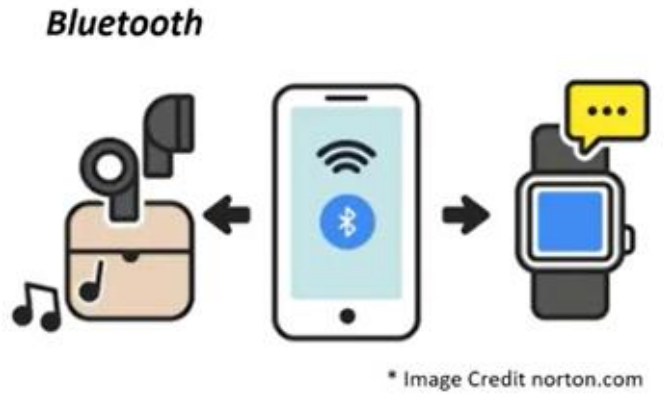
Network types



- PAN (Personal Area Network)
- LAN (Local Area Network)
- MAN (Metropolitan Area Network)
- WAN (Wide Area Network)

Network types :
Personal Area Network PAN

- It is a computer network formed around a person.
- Data is exchanged between devices and a user in a small area.
- The size of a PAN ranges from a few centimeters to a few meters.
- One of the most common real-world examples of a PAN is the connection between a Bluetooth earpiece and a smartphone.
- PANs can also connect laptops, tablets, printers, keyboards, and other computerized devices.



* Image Credit norton.com

Network types :
Local Area Network LAN

- A local area network (LAN) is a network contained within a small geographic area, usually within the same building.
- Home WiFi networks and small business networks are common examples of LANs.
- It is less costly as it is built with inexpensive hardware such as hubs, network adapters, and ethernet cables.
- The data is transferred at an extremely faster rate in Local Area Network.

Network types :
Metropolitan Area Network MAN

- A metropolitan area network (MAN) is a computer network that connects computers within a metropolitan area, which could be
  - a single large city,
  - multiple cities and towns,
  - or any given large area with multiple buildings.
- A MAN is larger than a local area network (LAN) but smaller than a wide area network (WAN).
- MAN is used in
  - communication between the banks in a city.
  - Airline Reservation.
  - college within a city.
  - communication in the military.

Network types :
Wide Area Network WAN

- A Wide Area Network is a network that extends over a large geographical area such as states or countries.
- A Wide Area Network is not limited to a single location, but it spans over a large geographical area through a telephone line, fibre optic cable or satellite links.
- The internet is one of the biggest WAN in the world.
- **Examples Of Wide Area Network:**
  - **Mobile Broadband:** A 4G network is widely used across a region or country.
  - **Last mile:** A telecom company is used to provide the internet services to the customers in hundreds of cities.

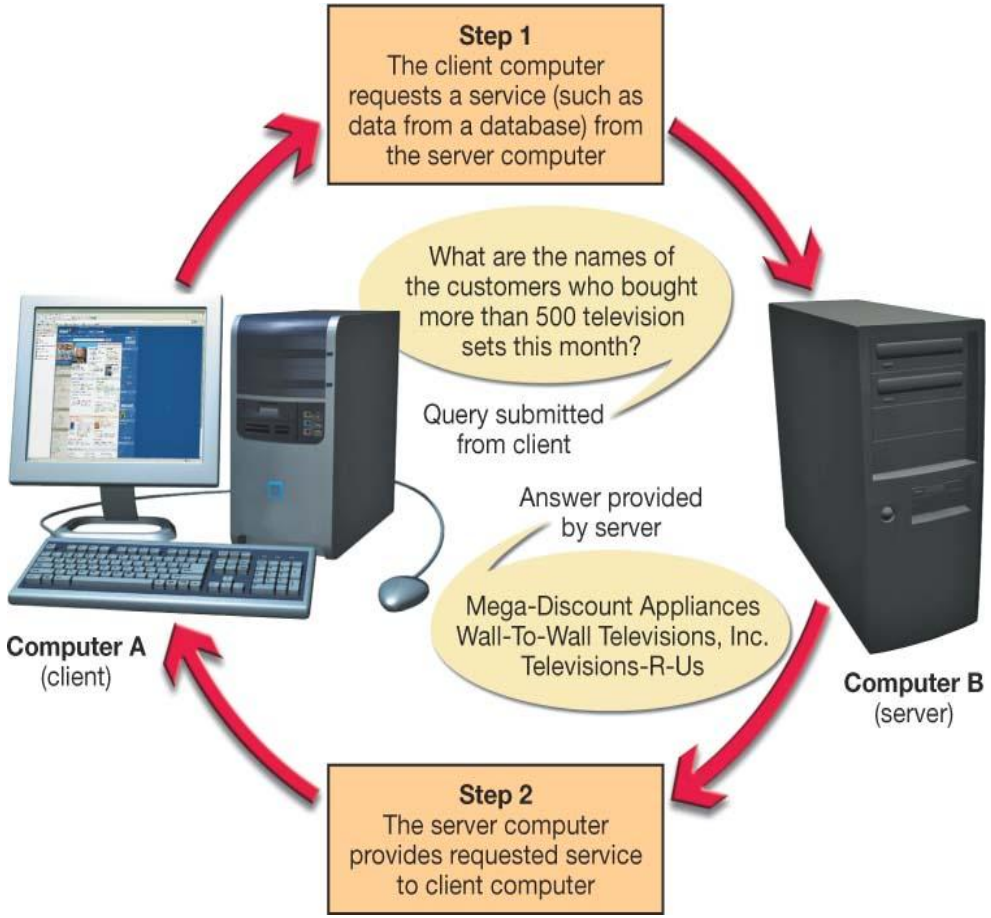
Network models

Network models

- 2 network models
  - Client / Server network
  - Peer-to-peer network

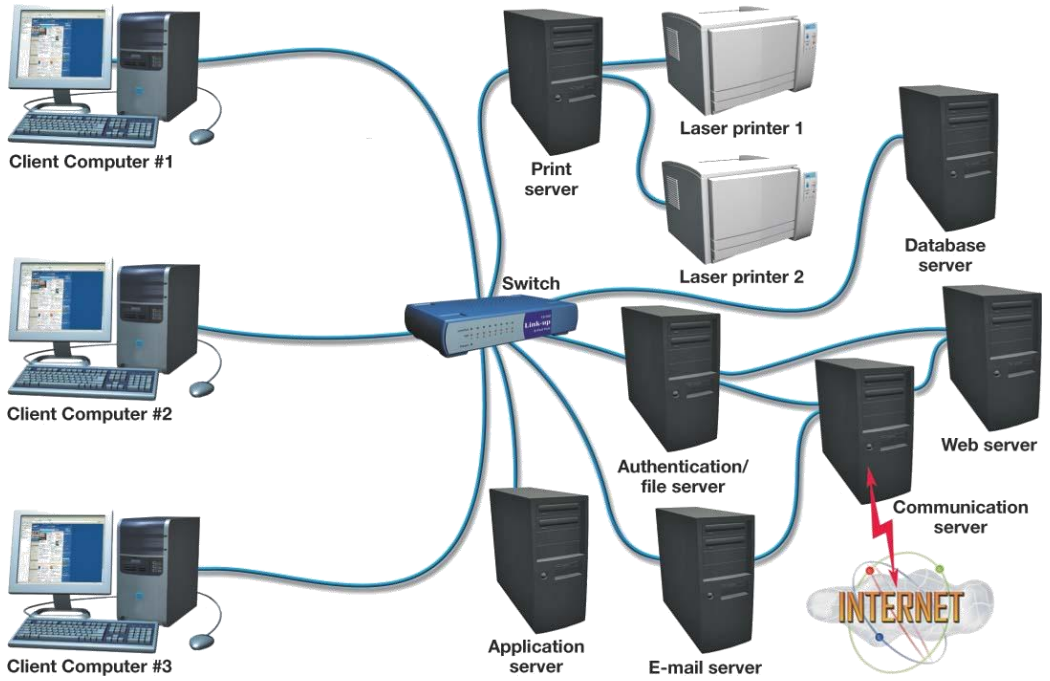
Client/Server Networks

- Server-based network
  - Clients and servers
- Data flows efficiently
- Servers respond to requests from clients
- Servers perform specific tasks
- Scalable network
- Centralized



Servers

- Number and type of servers depend on network size and workload
- Dedicated server
  - Performs one specific function
- Authentication server
  - Keeps track of network logins and services available
- File server
  - Stores and manages files



Dedicated Servers

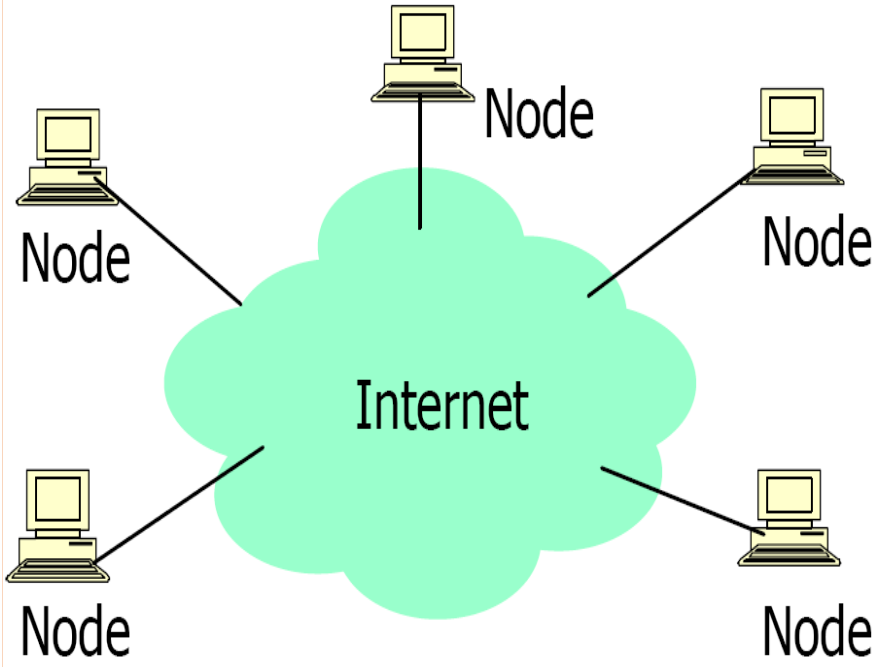
- Print server
  - Manages client-requested printing jobs
  - Creates print queue (prioritizes print jobs)
- Applications server
  - Acts as a storage area for application software
- Database server
  - Provides clients with access to database information
- E-mail server
  - Processes and delivers in-coming and outgoing e-mail
- Web server
  - Hosts a Web site available through the Internet

P2P Networking/Computing

- P2P computing is the sharing of computer resources and services by direct exchange between systems.
- These resources and services include the exchange of information, processing cycles, cache storage, and disk storage for files.
- P2P computing takes advantage of existing computing power, computer storage and networking connectivity, allowing users to leverage their collective power to the “benefit” of all.

P2P Architecture

- What is P2P?
  - A distributed system architecture
  - No centralized control
  - Typically many nodes, but unreliable and heterogeneous
  - Nodes are symmetric in function
- All nodes are both clients and servers
  - Provide and consume data
  - Any node can initiate a connection
- No centralized data source
  - "The ultimate form of democracy on the Internet"
  - "The ultimate threat to copy-right protection on the Internet



P2P vs. Client/Server

- Pure P2P:
  - No central server
  - For certain requests any peer can function as a client, as a router, or as a server
  - The information is not located in a central location but is distributed among all peers
  - A peer may need to communicate with multiple peers to locate a piece of information

As more peers are added, both demand and capacity of the network increases !

Difference between Client-Server and Peer-to-Peer Network

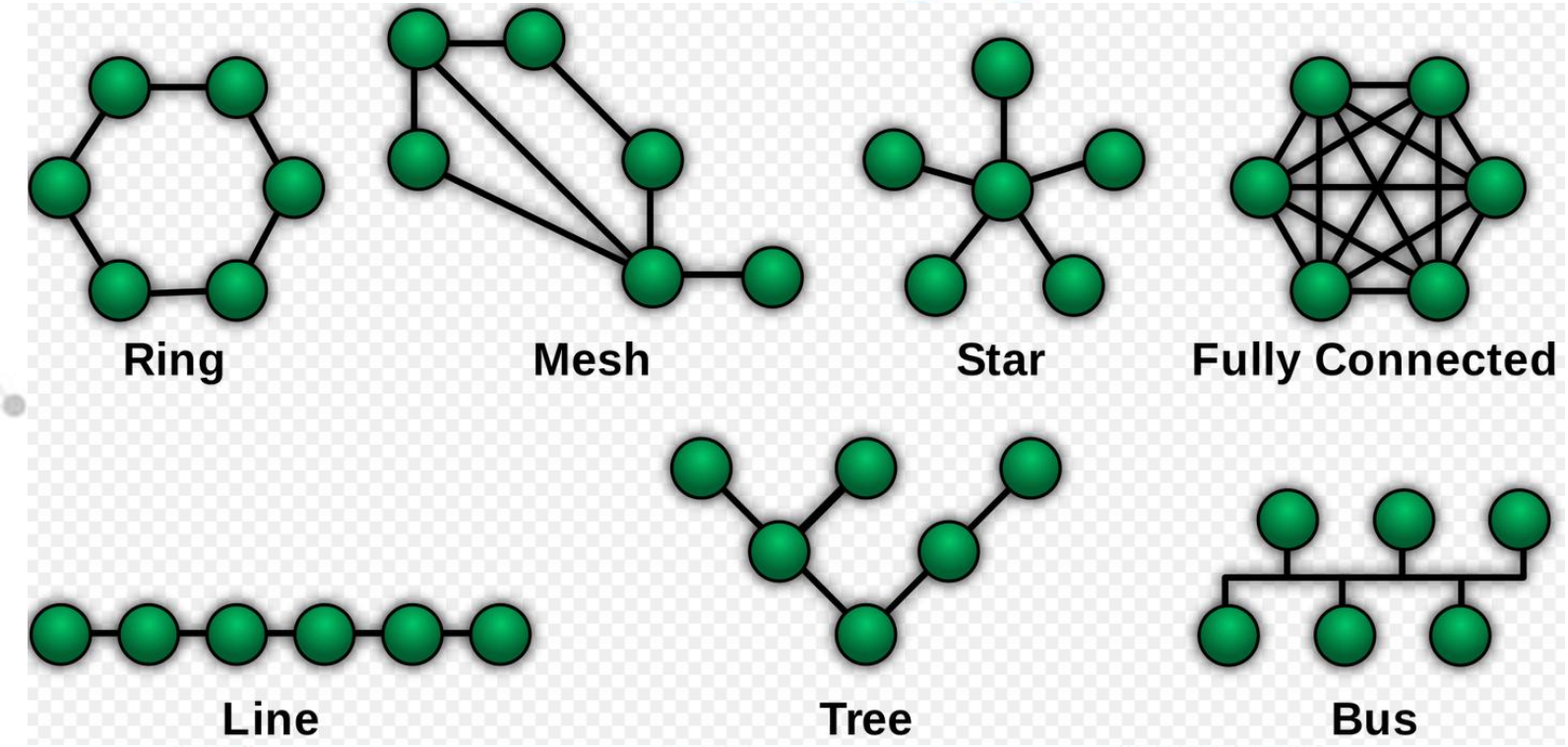
S.NO	CLIENT-SERVER NETWORK	PEER-TO-PEER NETWORK
1.	In Client-Server Network, Clients and server are differentiated, Specific server and clients are present.	In Peer-to-Peer Network, Clients and server are not differentiated.
2.	Client-Server Network focuses on information sharing.	While Peer-to-Peer Network focuses on connectivity.
3.	In Client-Server Network, Centralized server is used to store the data.	While in Peer-to-Peer Network, Each peer has its own data.
4.	In Client-Server Network, Server respond the services which is request by Client.	While in Peer-to-Peer Network, Each and every node can do both request and respond for the services.
5.	Client-Server Network are costlier than Peer-to-Peer Network.	While Peer-to-Peer Network are less costlier than Client-Server Network.
6.	Client-Server Network are more stable than Peer-to-Peer Network.	While Peer-to-Peer Network are less stable if number of peer is increase.
7.	Client-Server Network is used for both small and large networks.	While Peer-to-Peer Network is generally suited for small networks with fewer than 10 computers

Type of network topologies

What is a Network Topology?

- A network topology refers to the arrangement of elements or components in a computer network.
- The arrangement determines how information flows between devices.

Types of Network Topologies



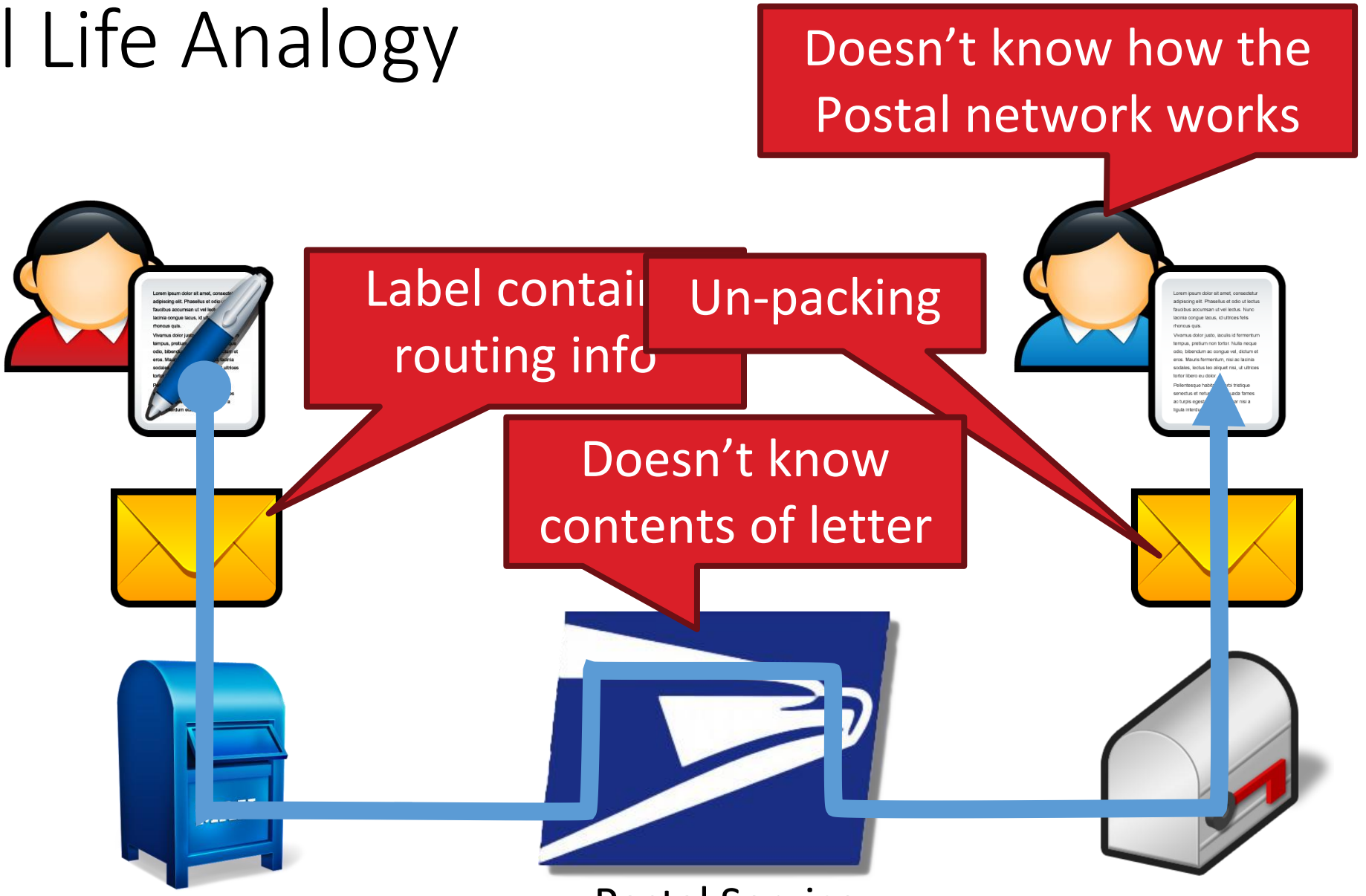
Considerations for Choosing Topologies

When selecting a network topology, there are several factors to consider:

- Scalability
- Cost
- Reliability
- Performance

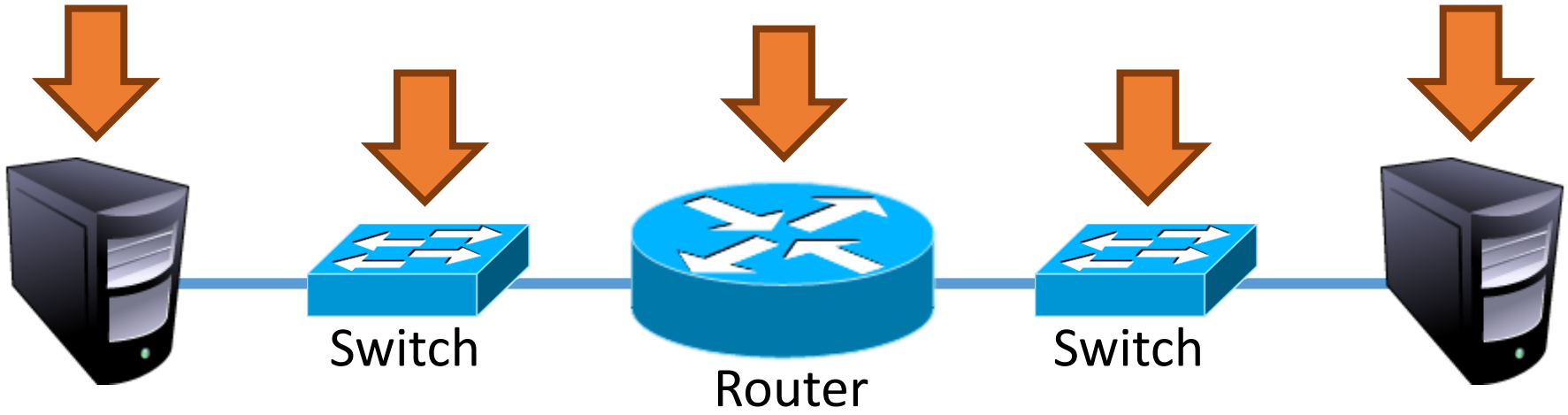
Network Standards

Real Life Analogy



Key Questions

- How do we divide functionality into layers?
  - Routing
  - Congestion control
  - Error checking
  - Security
  - Fairness
  - And many more…
- How do we distribute functionality across devices?
  - Example: who is responsible for security?



Network Standards

- 2 main standards :
  - OSI (Open System interconnection) : reference model
  - TCP/IP : practical (Internet)

THE OSI MODEL

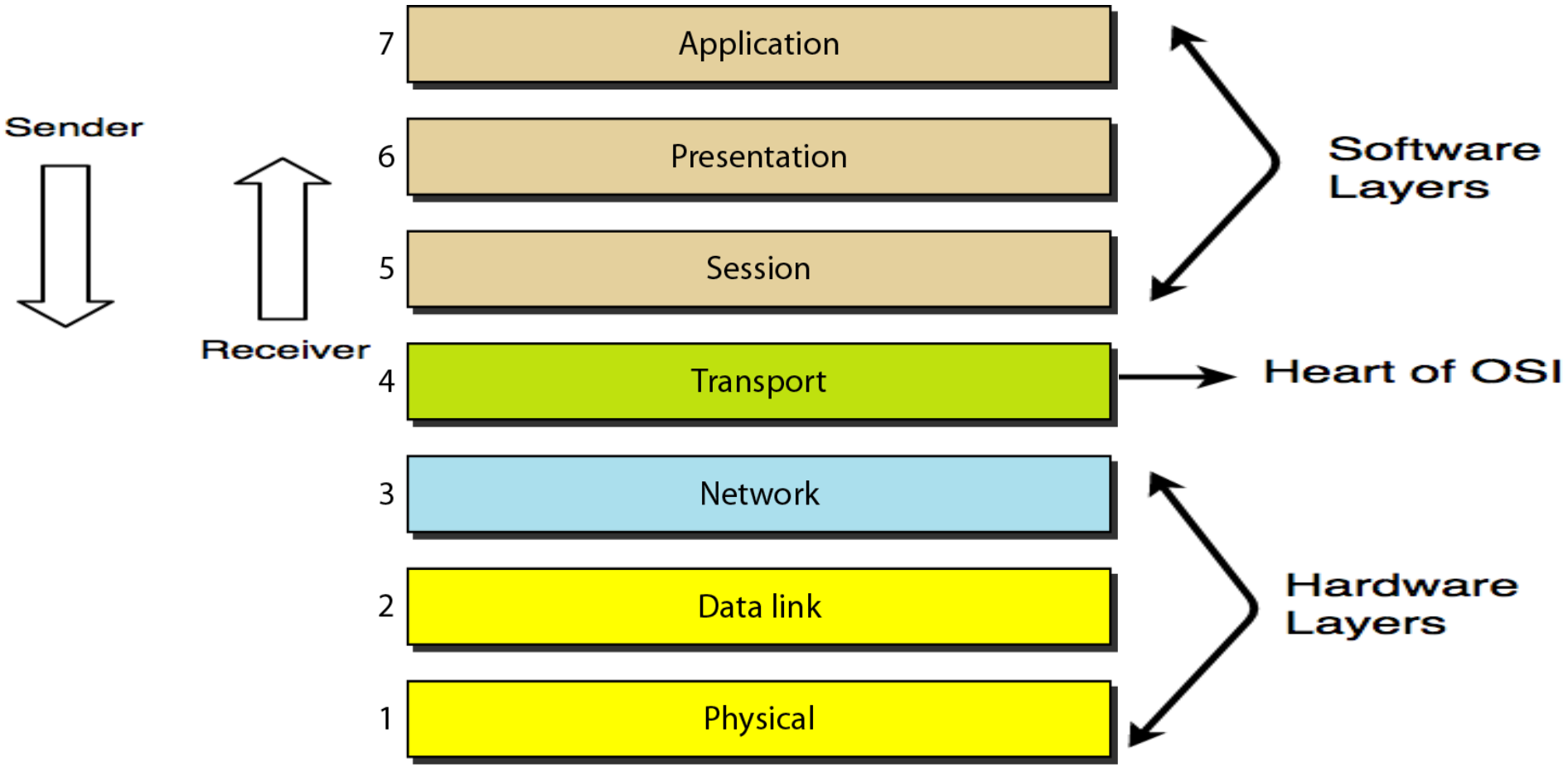
- *ISO : Established in 1947, the International Standards Organization (ISO) is a multinational body dedicated to worldwide agreement on international standards.*
- *OSI : An ISO standard that covers all aspects of network communications is the Open Systems Interconnection (OSI) model. It was first introduced in 1984.*
- *Topics discussed in this section:*
- Layered Architecture
- Peer-to-Peer Processes
- Encapsulation

Note

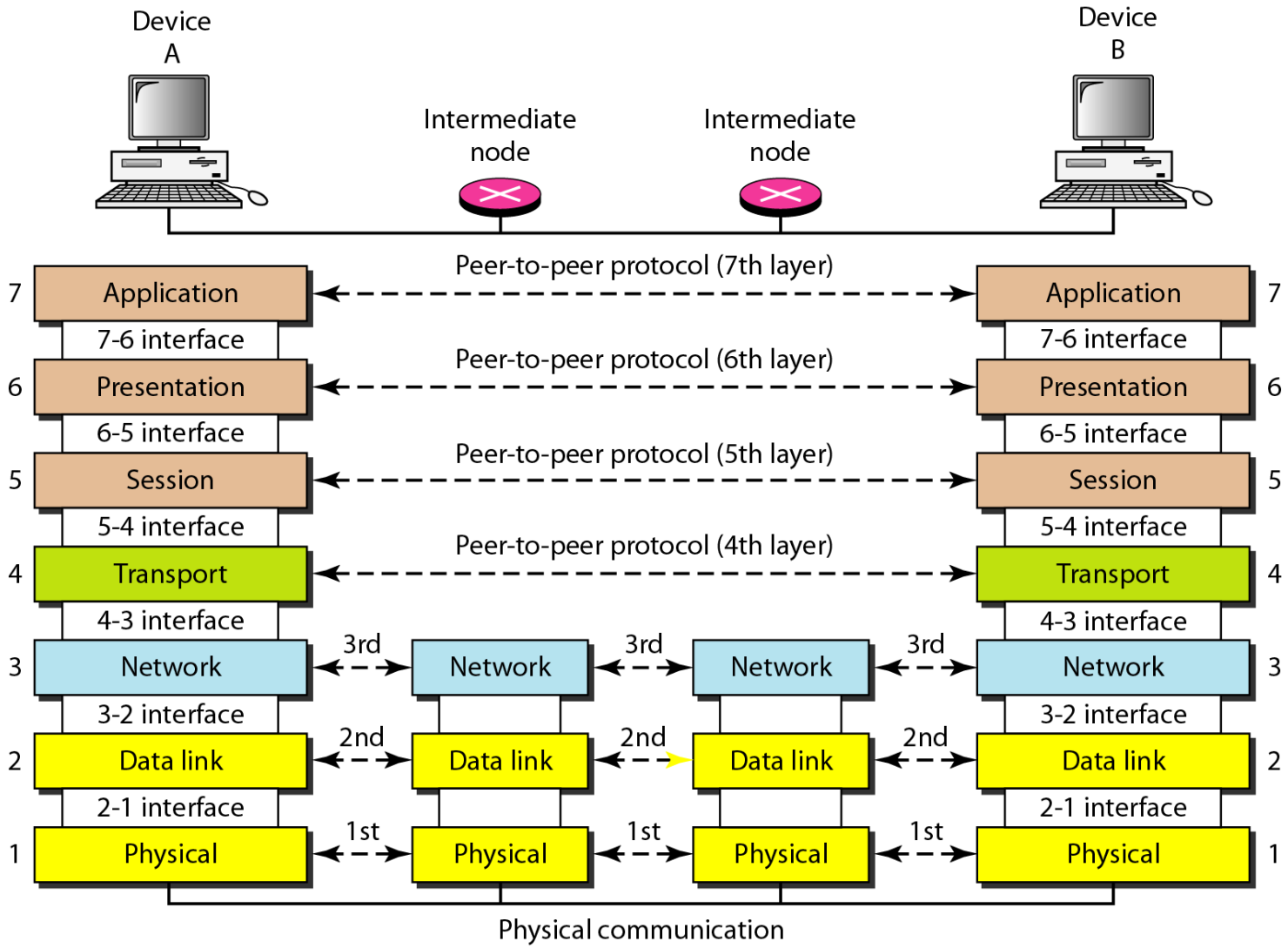
ISO is the organization.
OSI is the model.

various-layers-of-the-osi-model.webp

Seven layers of the *OSI model*

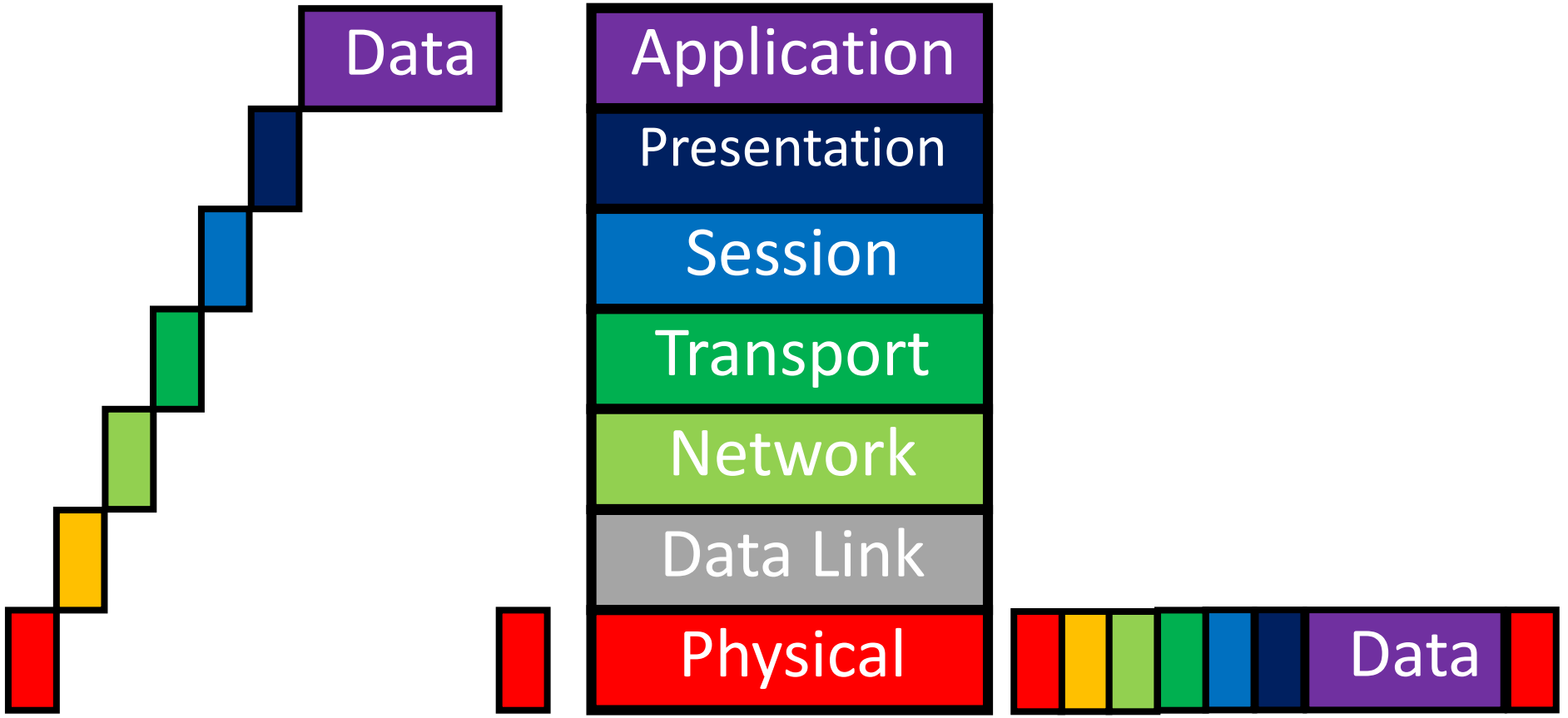


The interaction between layers in the OSI model

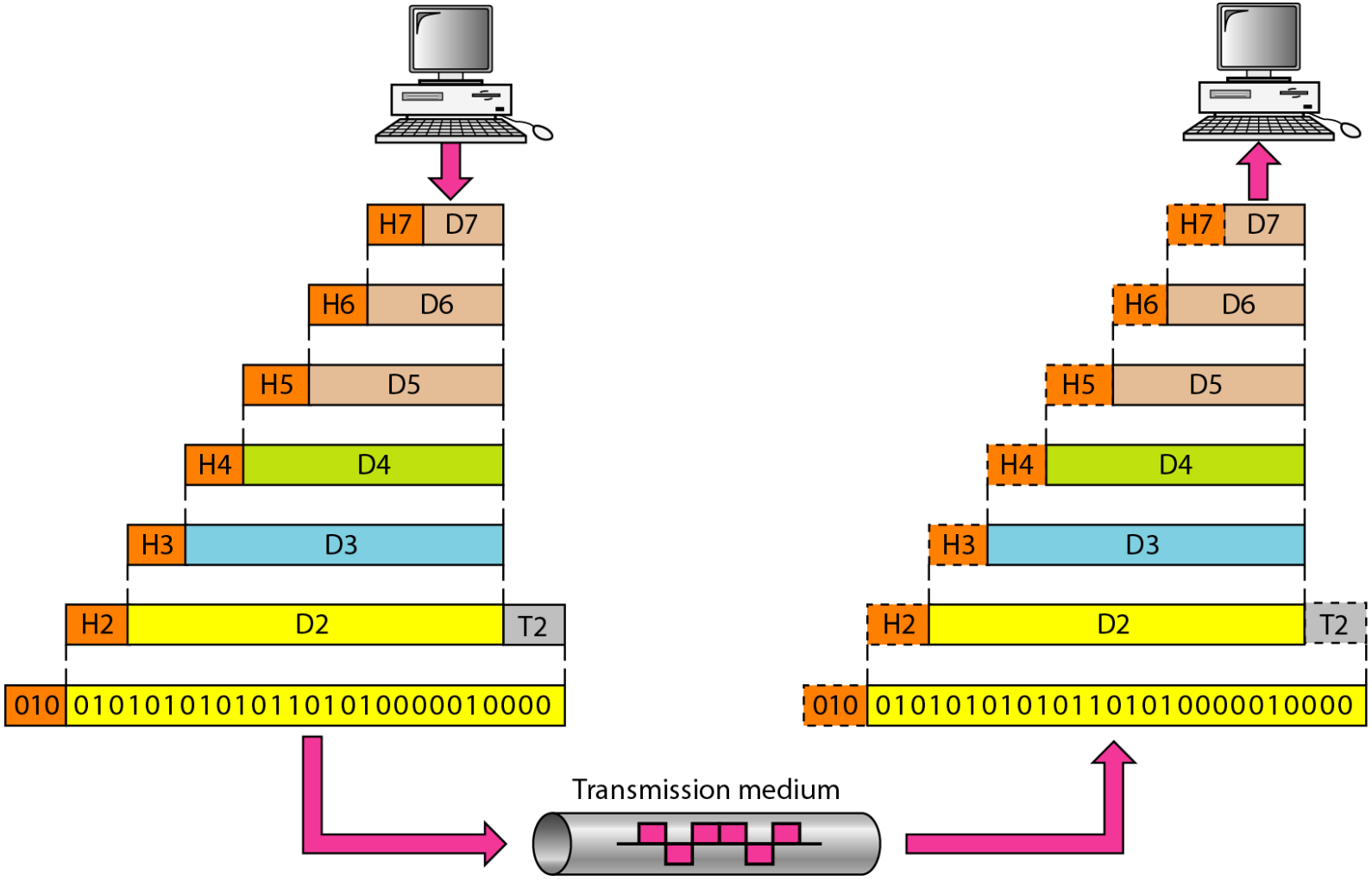


Encapsulation

How does data move through the layers?



An exchange using the OSI model



7 Application

6 Presentation

5 Session

4 Transport

3 Network

2 Data Link

1 Physical

OSI REFERENCE MODEL

7. Application Layer

a) Data or PDU (Protocol Data Unit) : Message

b) Functions :

- Providing services to the users..
- application layer is not an application, but it performs the application layer functions.

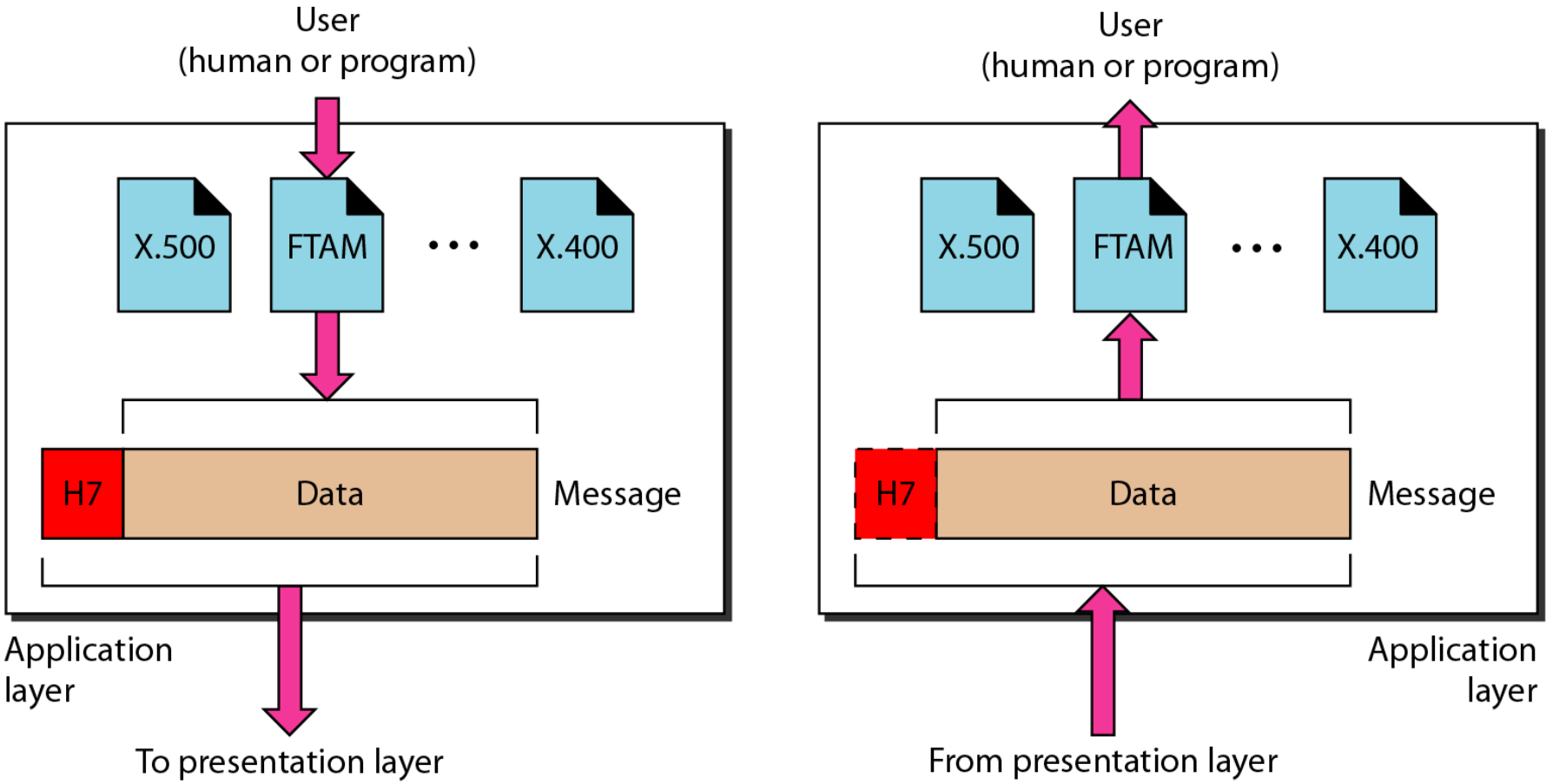
c) Protocols :

- DNS (Domain Name System),
- SMTP (Simple Mail Transfer Protocol),
- FTP (File Transfer Protocol),
- POP (Post Office Protocol),
- HTTP (HyperText Transfer Protocol),
- Telnet, etc.

d) Devices :

- PC's (Personal Computer), Phones, Servers, Printers, …

Application layer



Note

The application layer is responsible for providing services to the user.

7 Application

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1 Physical

OSI REFERENCE MODEL

6. Presentation Layer

a) Data or PDU (Protocol Data Unit) : Message

b) Functions :

- Data Translation (ASCII).
- Data Encryption/Decryption (if needed).
- Data Compression and decompression.

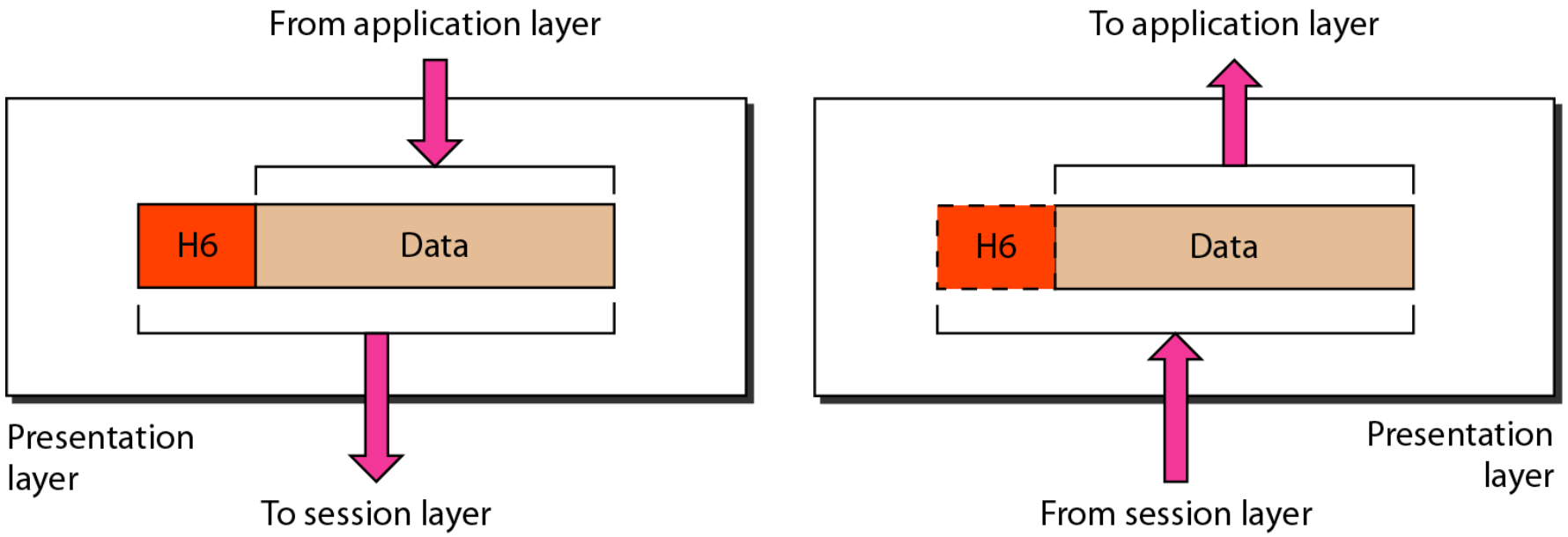
c) Protocols :

- AFP (Apple Filing Protocol),
- ICA (Independent Computing Architecture),
- LPP (Lightweight Presentation Protocol),
- NCP (NetWare Core Protocol),
- NDR (Network Data Representation),
- JPEG, MPEG, etc.

d) Devices :

- .

Presentation layer



Note

The presentation layer is responsible for translation, compression, and encryption.

7 Application

6 Presentation

5 Session

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3 Network

2 Data Link

1 Physical

OSI REFERENCE MODEL

5. Session Layer

a) Data or PDU (Protocol Data Unit) : Message

b) Functions :

- Dialog control.
- Synchronization.

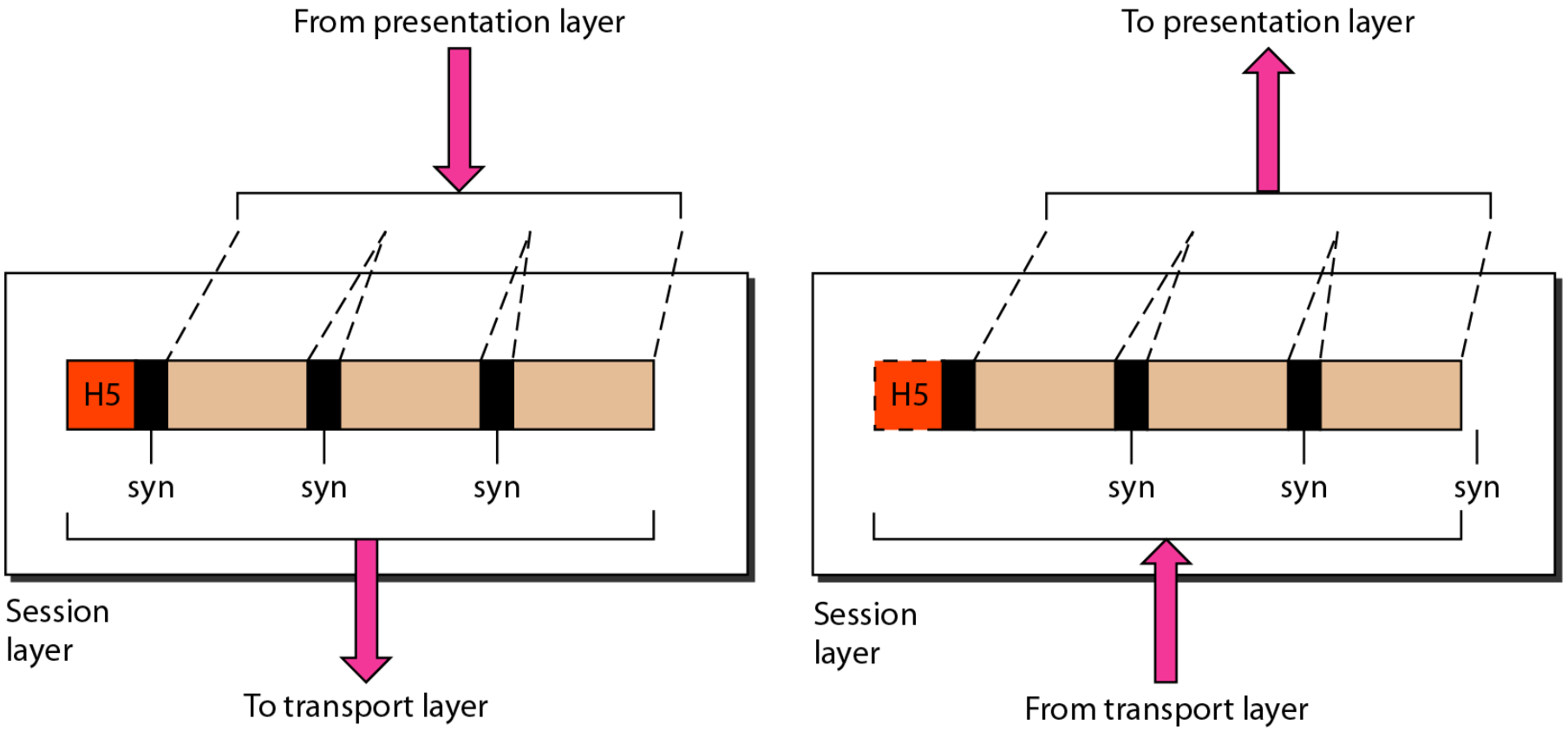
c) Protocols :

- PAP (Password Authentication Protocol)
- PPTP (Point-to-Point Tunneling Protocol)
- RPC (Remote Procedure Call Protocol)
- RTCP (Real-time Transport Control Protocol), etc.

d) Devices :

- Gateway, etc.

Session layer



Note

The session layer is responsible for dialog control and synchronization.

7 Application

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5 Session

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3 Network

2 Data Link

1 Physical

OSI REFERENCE MODEL

4. Transport Layer

a) Data or PDU (Protocol Data Unit) : Segments

b) Functions :

- Service-point addressing : Adds port number of the service/App
- Segmentation and reassembly.
- Connection control.
- Flow control.
- Error control.

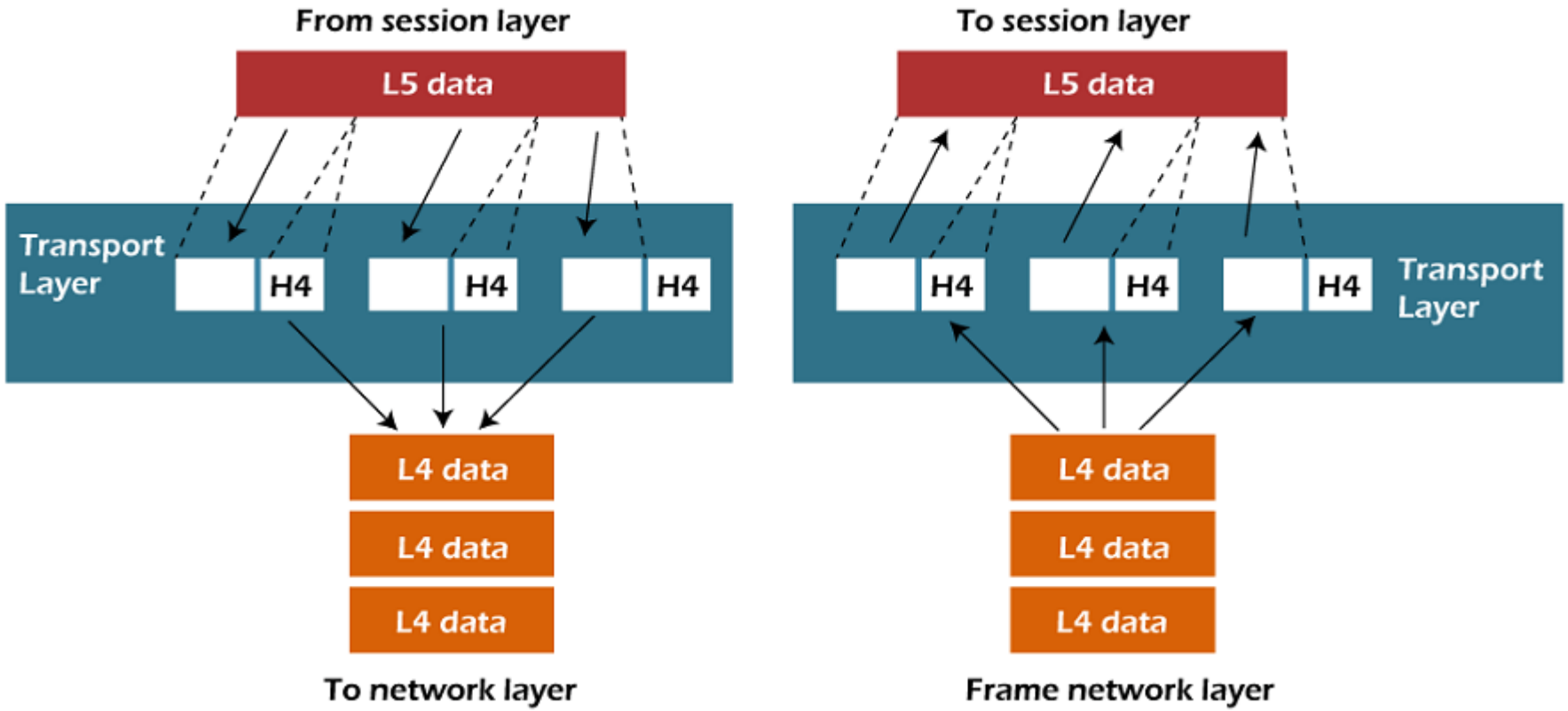
c) Protocols :

- TCP (Transmission Control Protocol) : Connection-oriented
- UDP (User Datagram Protocol) : Connectionless

d) Devices :

- Load Balancers/Firewalls, etc.

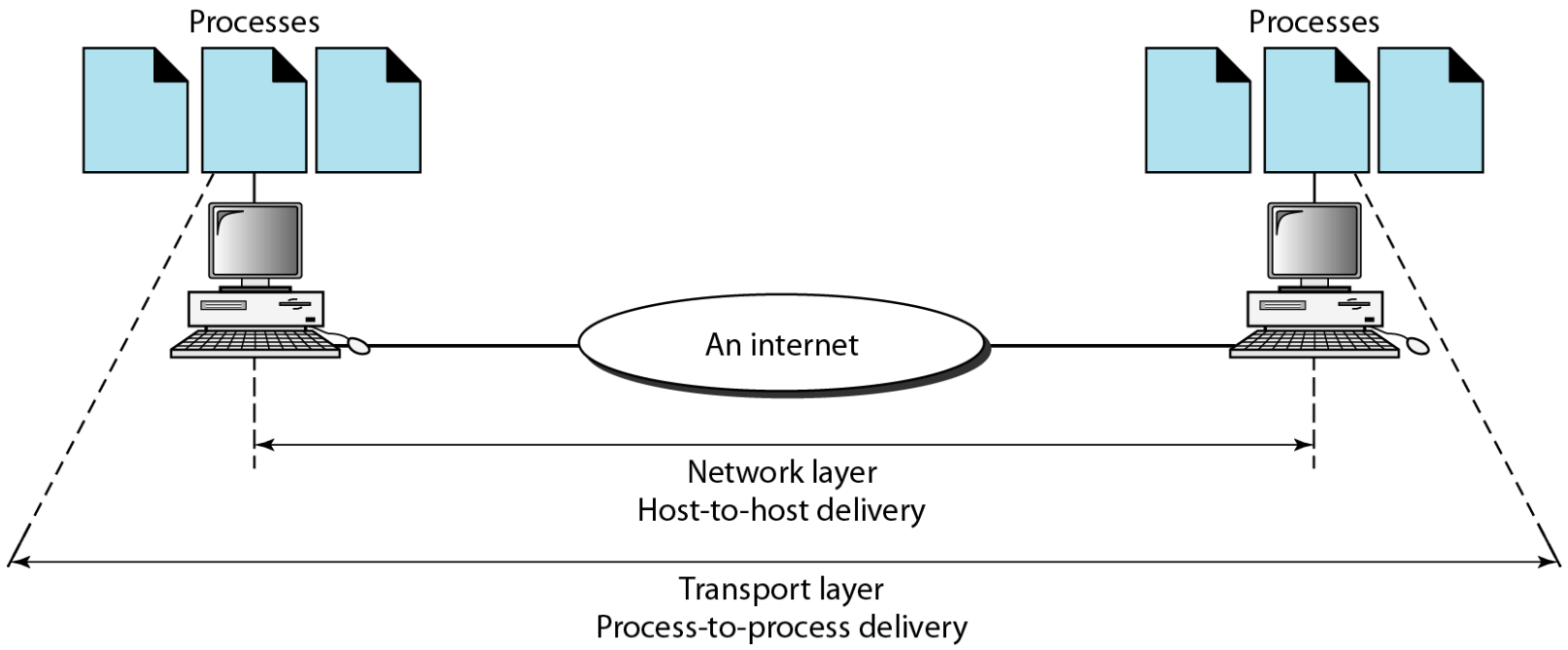
Transport layer



Note

Transport layer is operated by the Operating System. It is a part of the OS and communicates with the Application Layer by making system calls.

Reliable process-to-process delivery of a message



7 Application

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3 Network

2 Data Link

1 Physical

OSI REFERENCE MODEL

3. Network Layer

a) Data or PDU (Protocol Data Unit) : Packets

b) Functions :

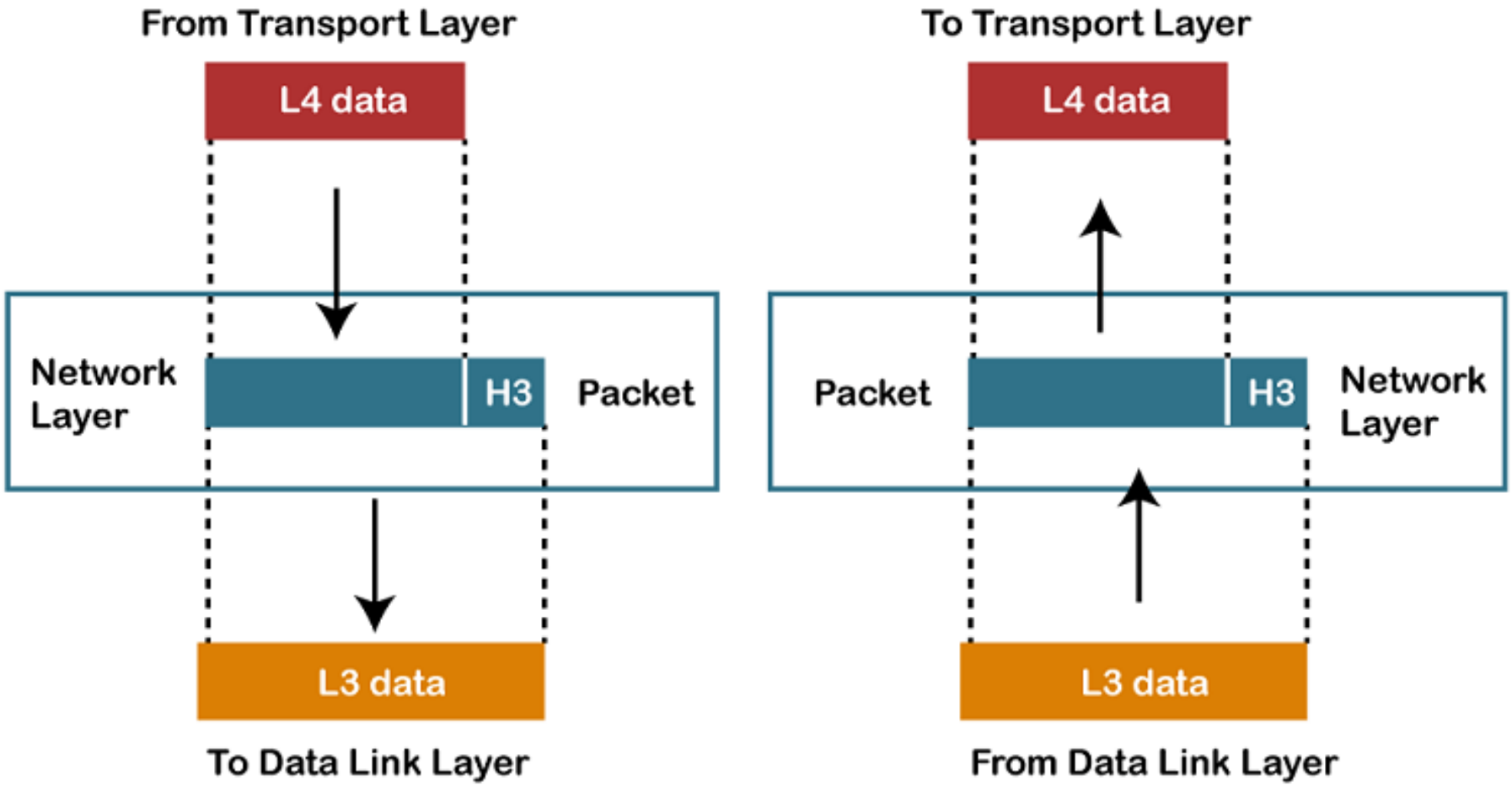
- Internetworking : Controls the operation of the subnet.
- Routing packets from source to destination.
- Logical addressing.

c) Protocols :

- IPv4 (Internet Protocol version 4).
- IPv6 (Internet Protocol version 6).
- ICMP (Internet Control Message Protocol), etc

d) Devices :

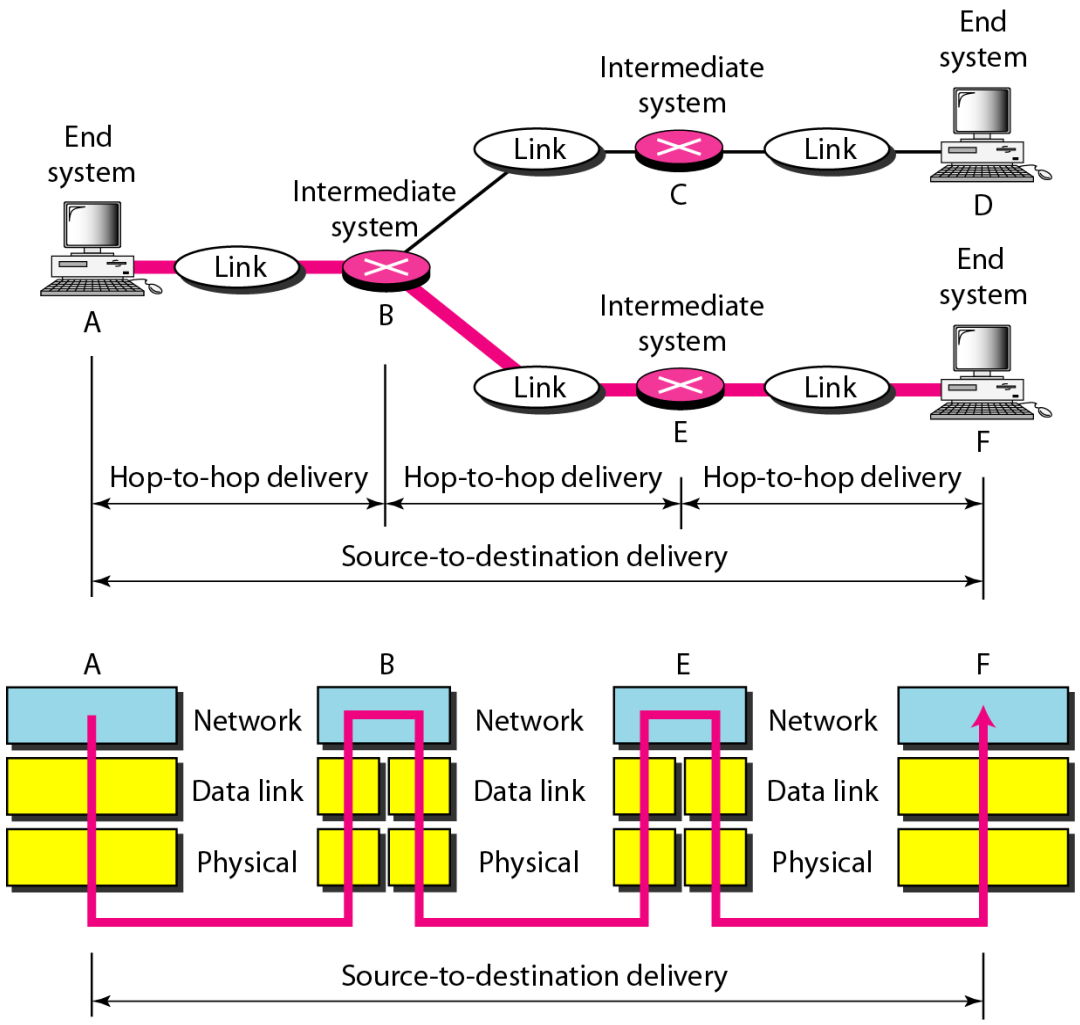
- Routers.


From Transport Layer
L4 data
Network Layer
H3
Packet
L3 data
To Data Link Layer
To Transport Layer
L4 data
Packet
H3
Network Layer
L3 data
From Data Link Layer

Note

The network layer is responsible for the delivery of individual packets from the source host to the destination host.

Source-to-destination delivery



7 Application

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3 Network

2 Data Link

1 Physical

OSI REFERENCE MODEL

2. Data Link Layer

a) Data or PDU (Protocol Data Unit) : Frames

b) Functions :

- Framing.
- Physical addressing.
- Flow control.
- Error detection and correction.
- Access control.

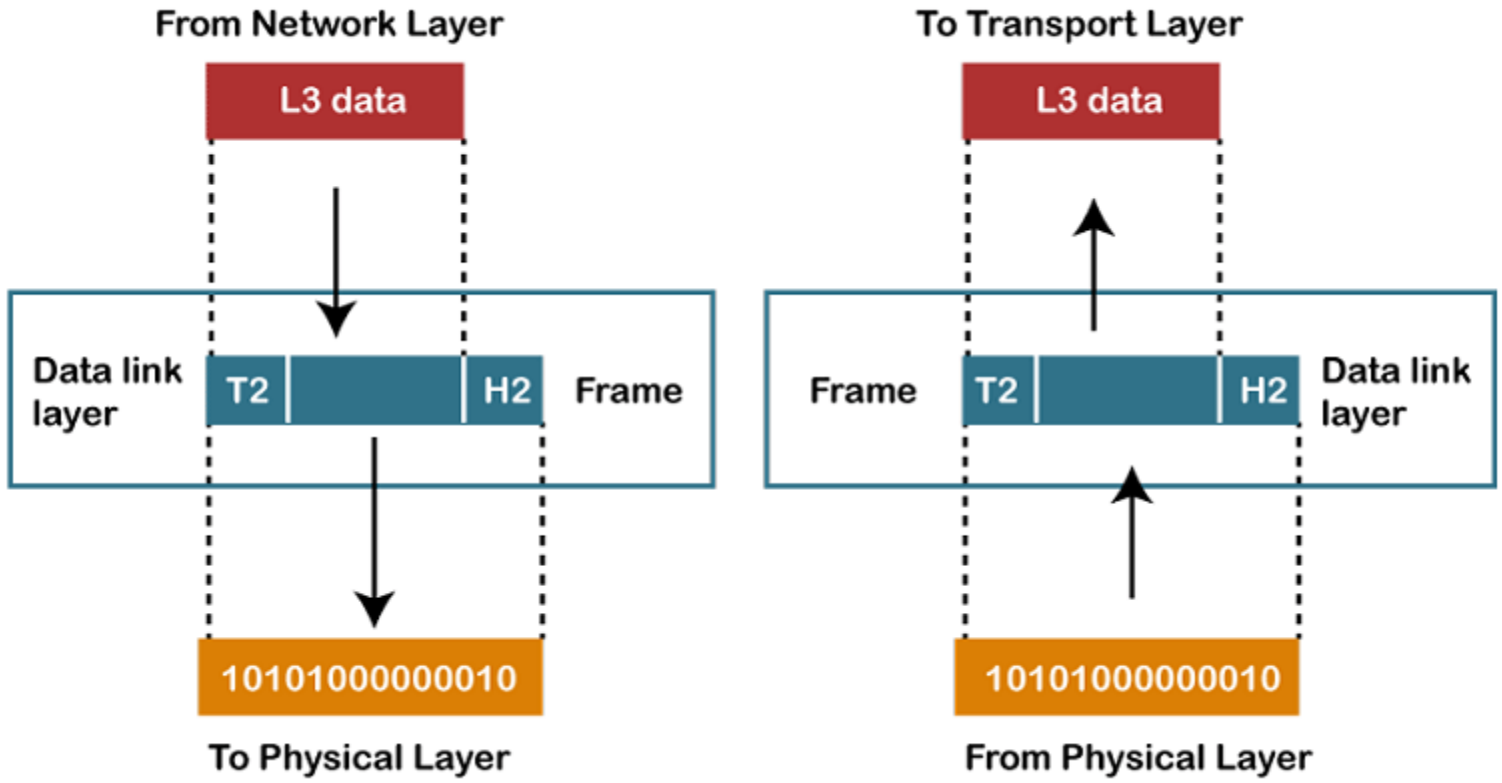
c) Protocols :

- ARP (Address Resolution Protocol)
- PPP (Point-to-Point Protocol),
- Frame Relay,
- ATM (The asynchronous transfer mode protocol), etc.

d) Devices :

- Bridges,
- Switches,
- NIC cards (Network Interface Cards), etc.

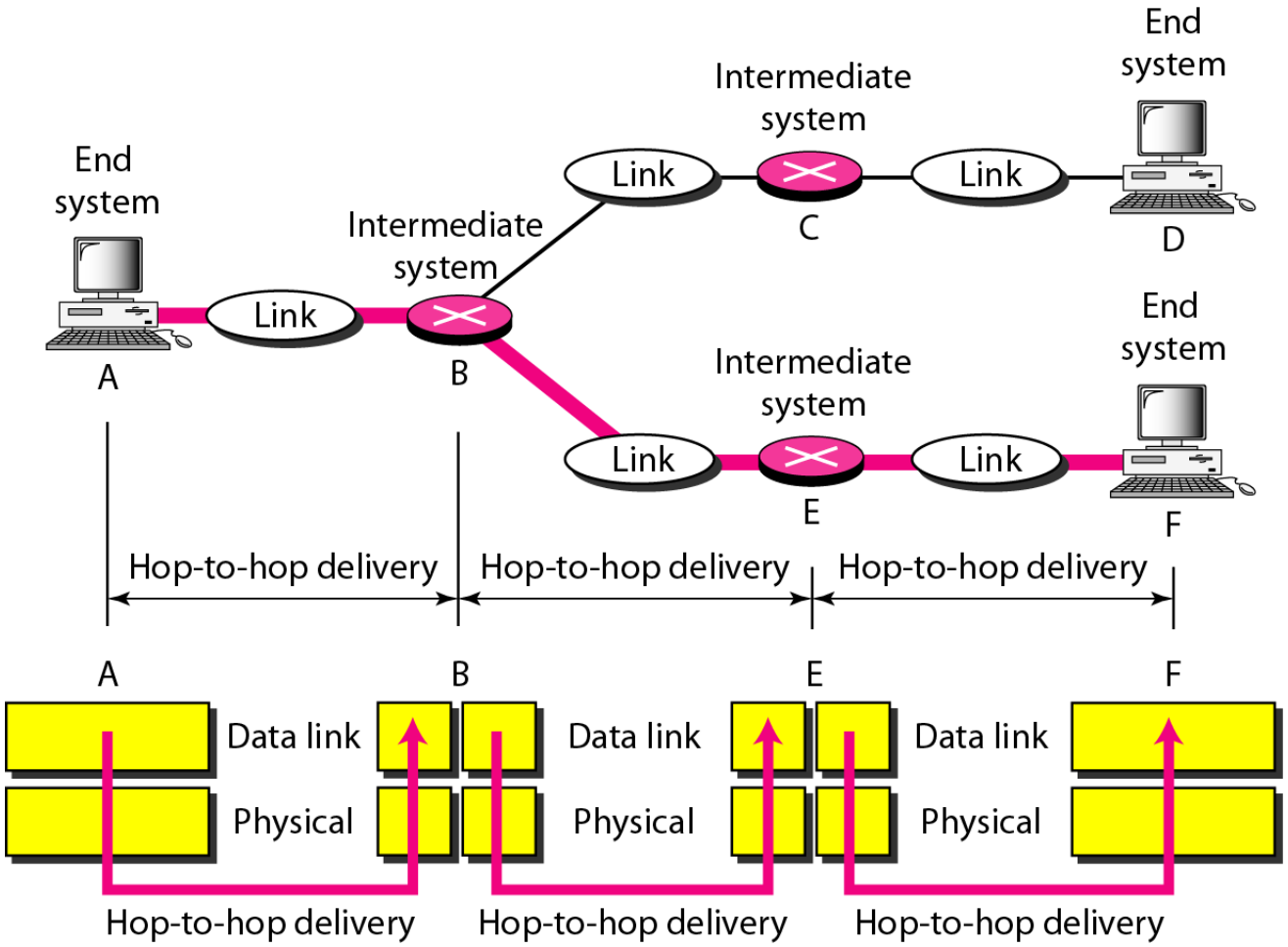
Data link layer



Note

The data link layer is responsible for moving frames from one hop (node) to the next.

Hop-to-hop delivery



OSI REFERENCE MODEL

7 Application

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2 Data Link

1 Physical

1. Physical Layer

a) Data : Stream (sequence) of bits 0 and 1

b) Functions :

- Encoding / Decoding : Converts the logical 1's and 0's (layer 2) into signals.
- Clock synchronization.
- Defining the network topology.
- Defining the direction and type of transmission (half-duplex, full duplex, …)
- Transmission of the electrical signals over a communication channel.

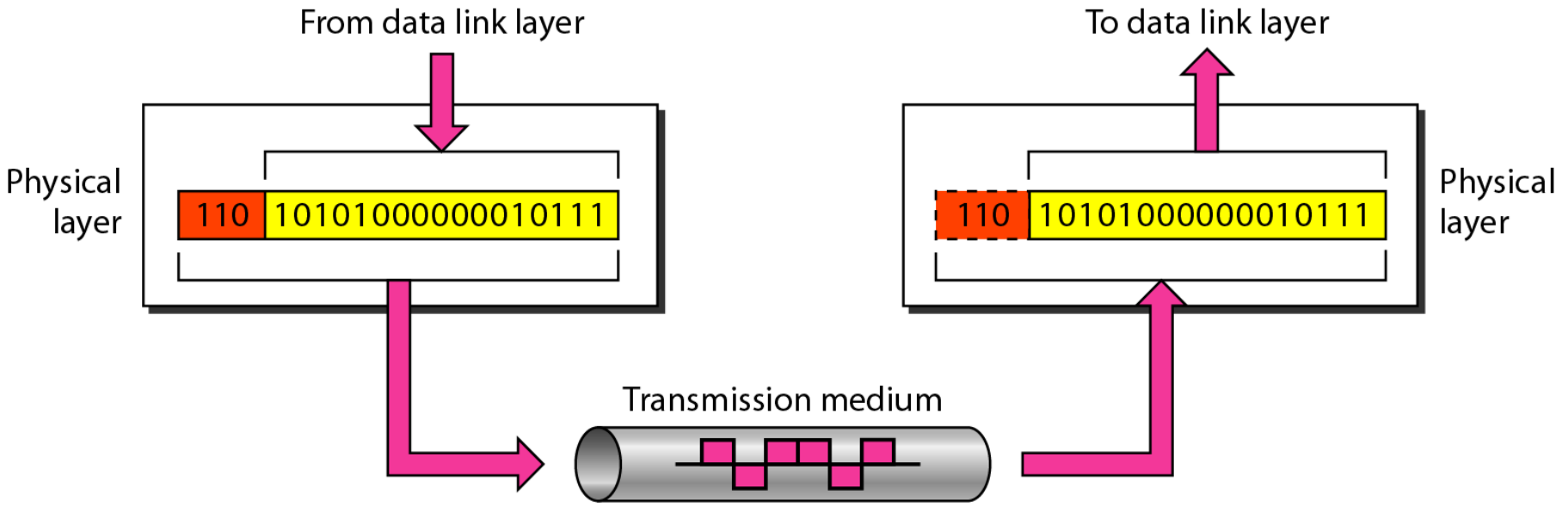
c) Protocols :

- Digital Subscriber Line.
- Integrated Services Digital Network.
- Ethernet, etc.

d) Devices :

- Repeaters,
- Hubs (multi-port repeater),
- Modem,
- Cables, etc.

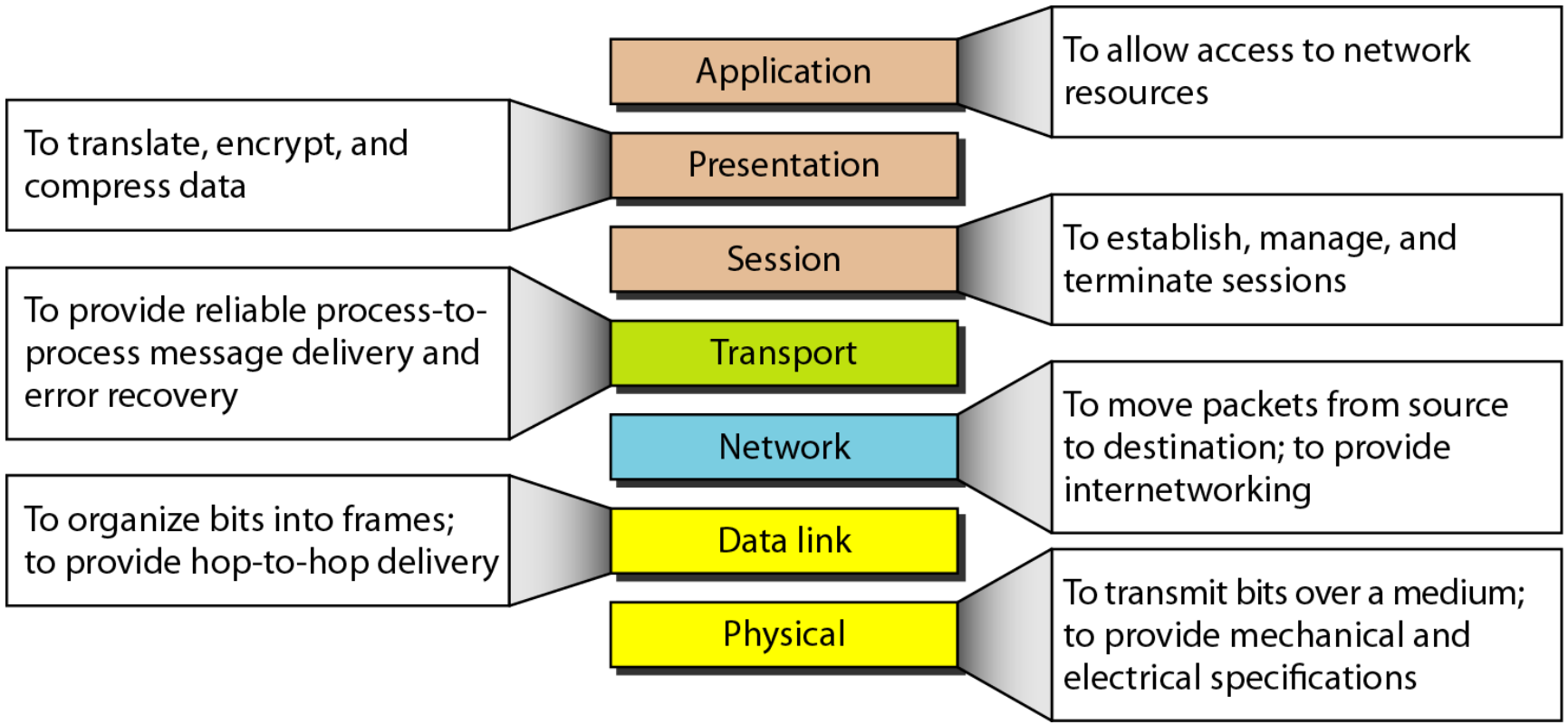
Physical layer



Note

The physical layer is responsible for movements of individual bits from one hop (node) to the next.

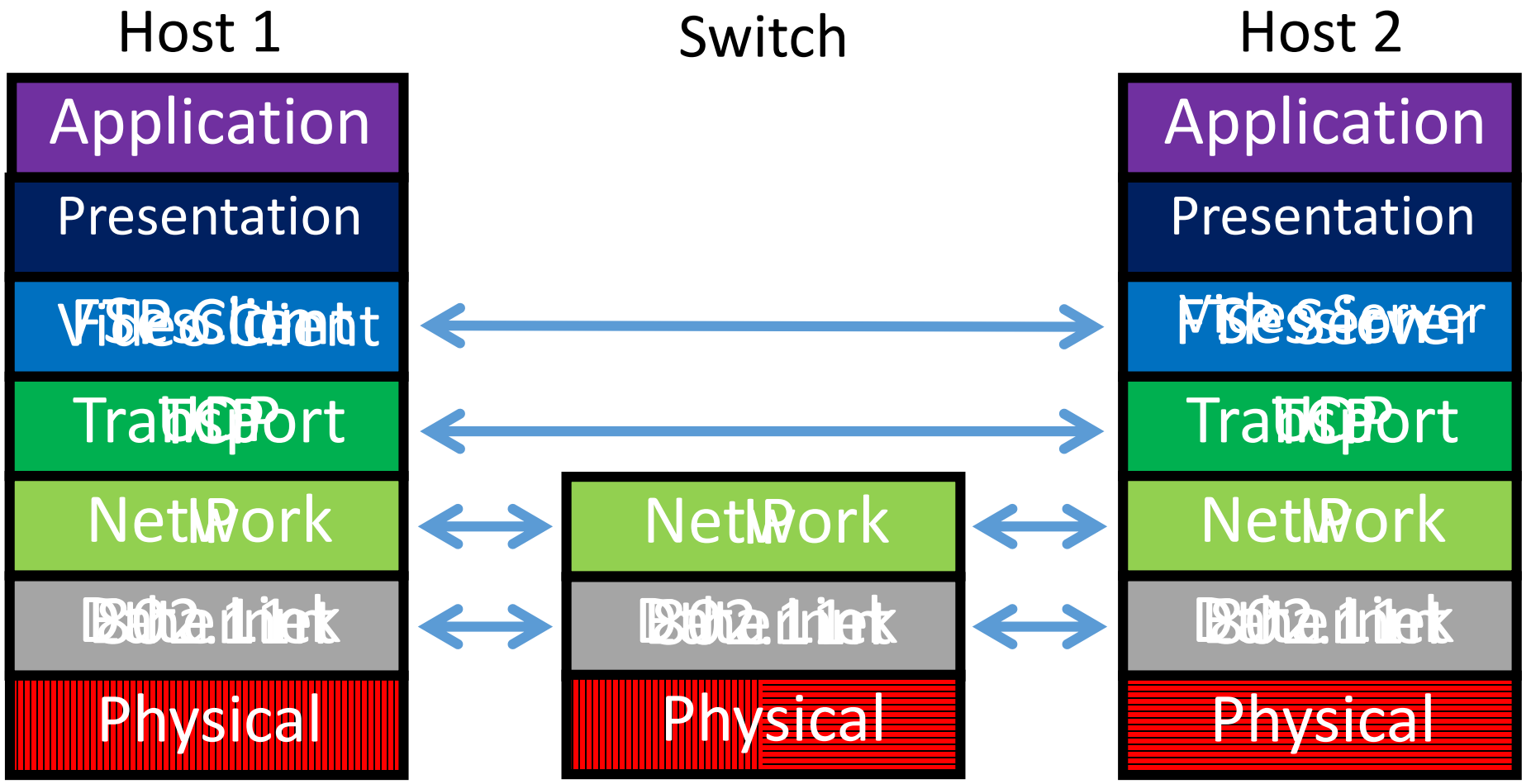
Summary of layers



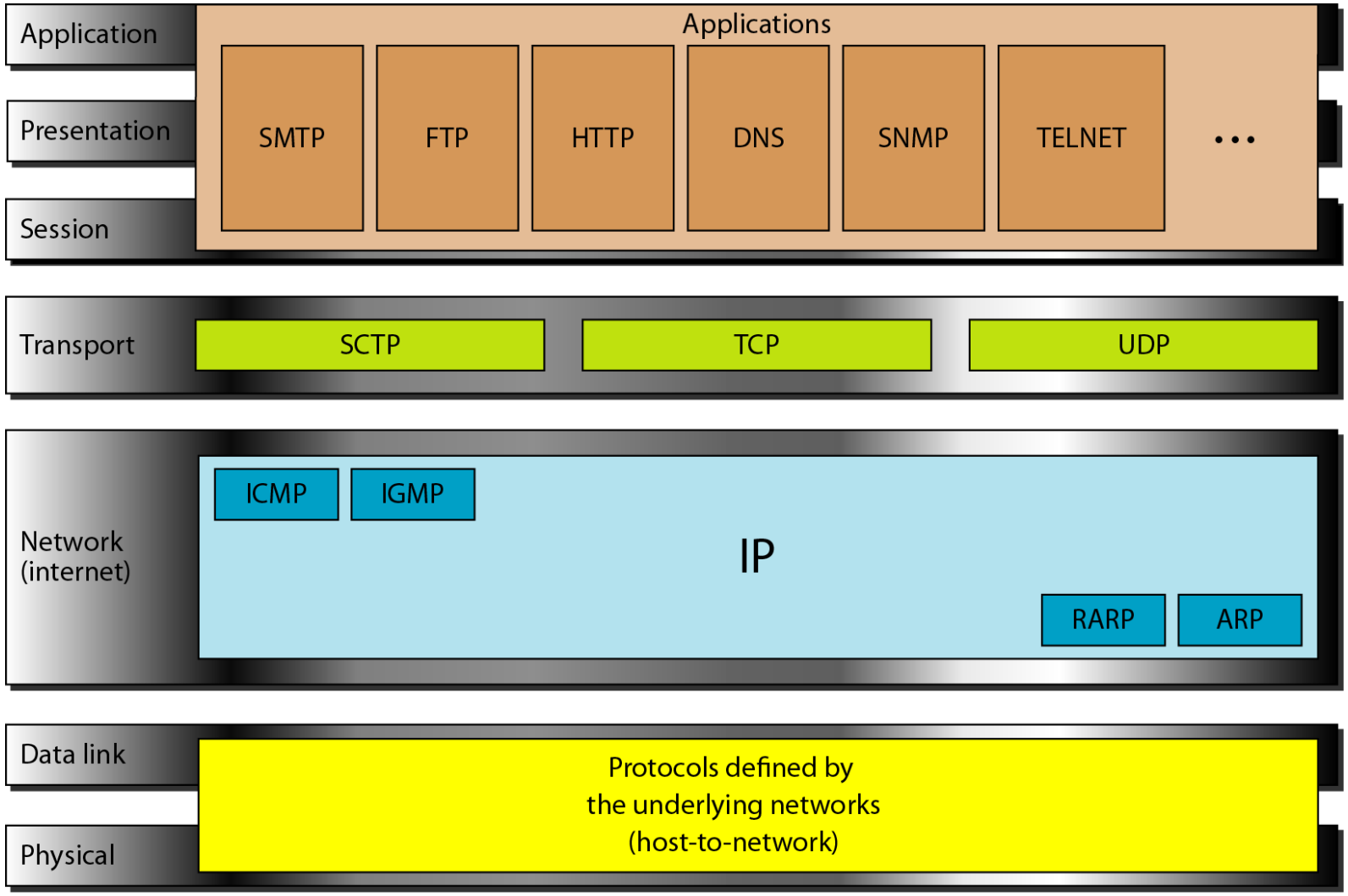
TCP/IP PROTOCOL SUITE

- *The layers in the TCP/IP protocol suite do not exactly match those in the OSI 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.*
- *Topics discussed in this section:*
  - Physical and Data Link Layers
  - Network Layer
  - Transport Layer
  - Application Layer

Network Stack in Practice



TCP/IP and OSI model

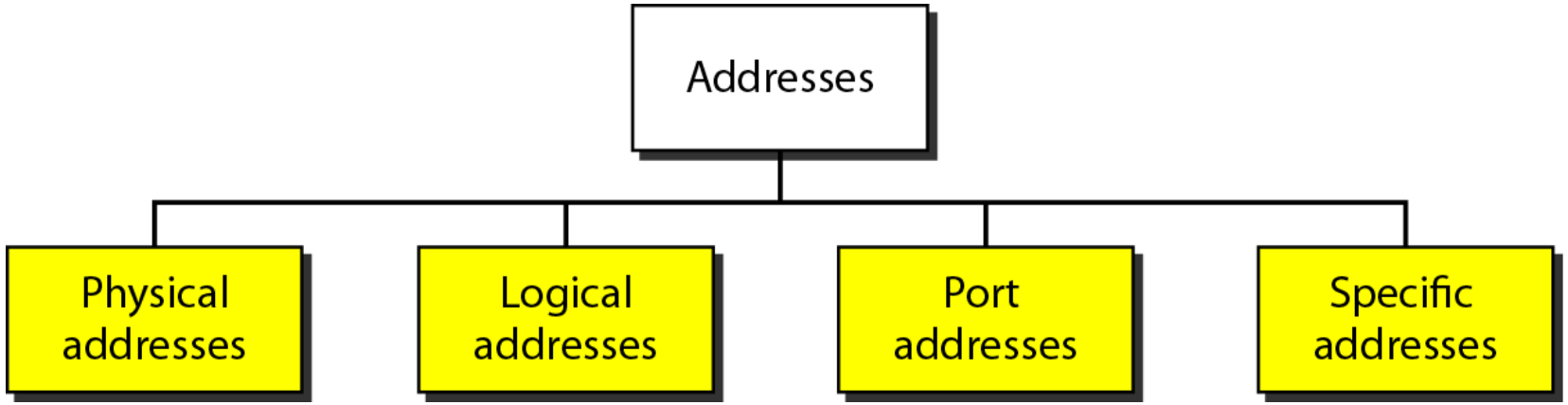


ADDRESSING

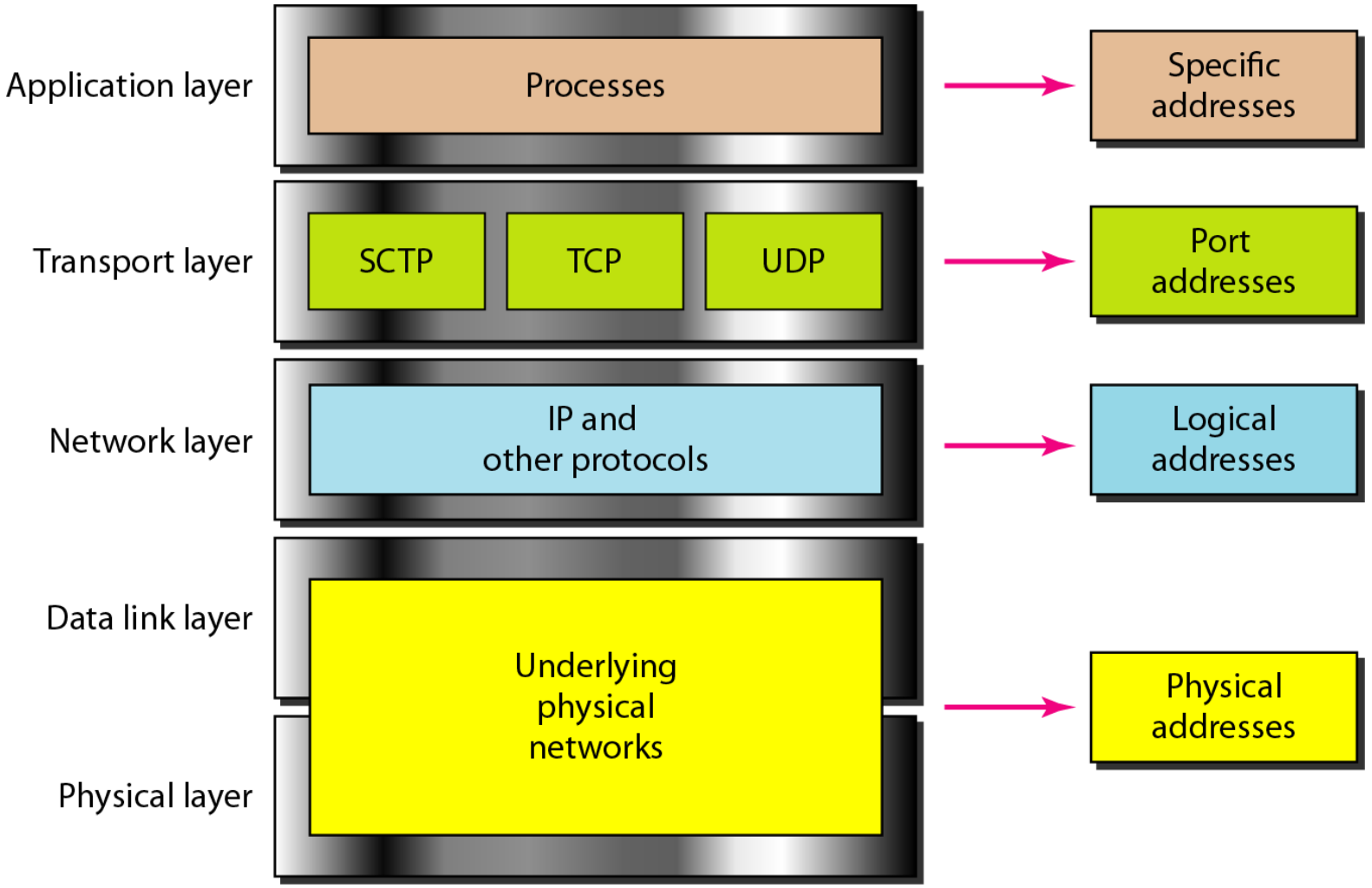
- *Four levels of addresses are used in an internet employing the TCP/IP protocols: physical, logical, port, and specific.*

- *Topics discussed in this section:*
  - Physical Addresses
  - Logical Addresses
  - Port Addresses
  - Specific Addresses

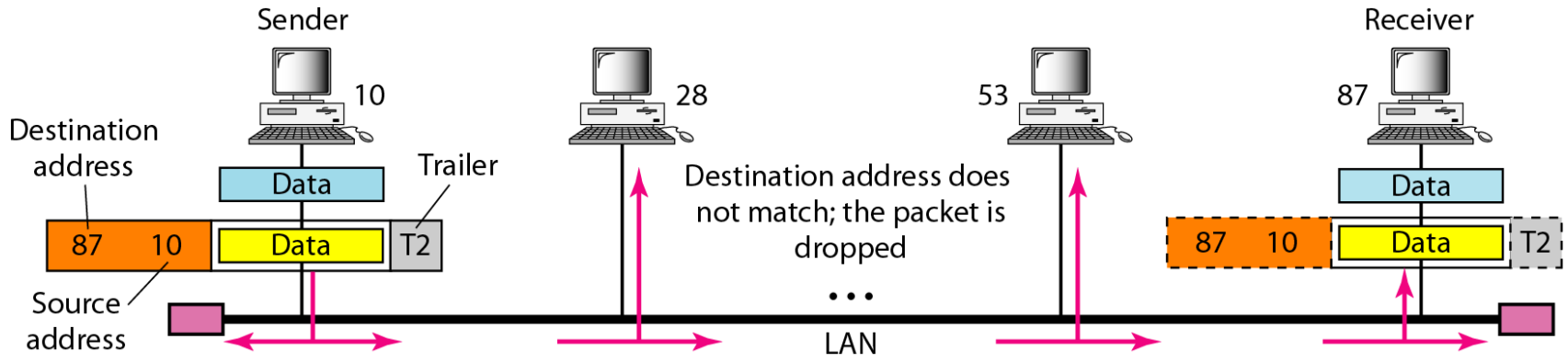
Addresses in TCP/IP



Relationship of layers and addresses in TCP/IP



Physical addresses : Example



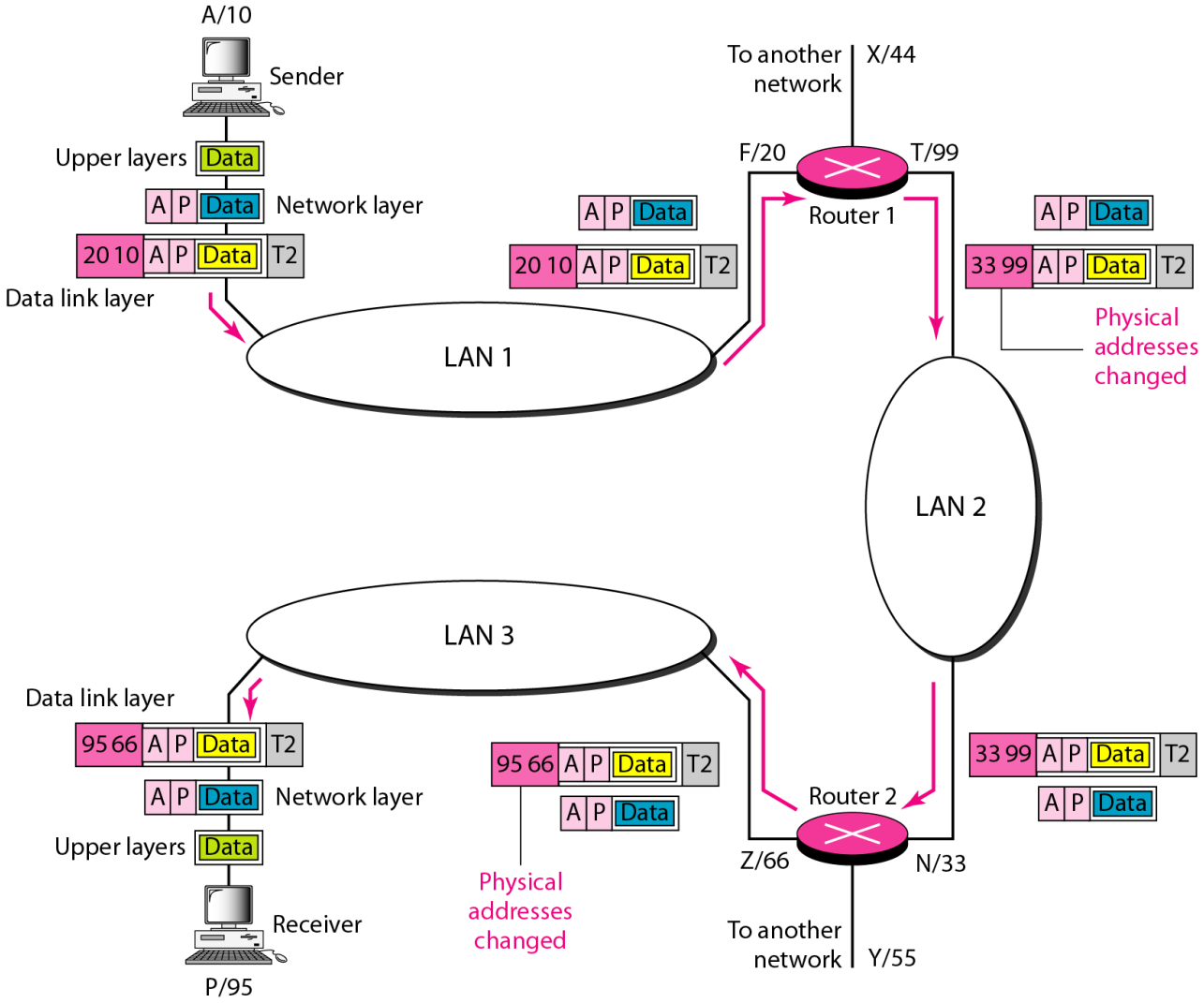
Example

Most local-area networks use a 48-bit (6-byte) physical address written as 12 hexadecimal digits; every byte (2 hexadecimal digits) is separated by a colon, as shown below:

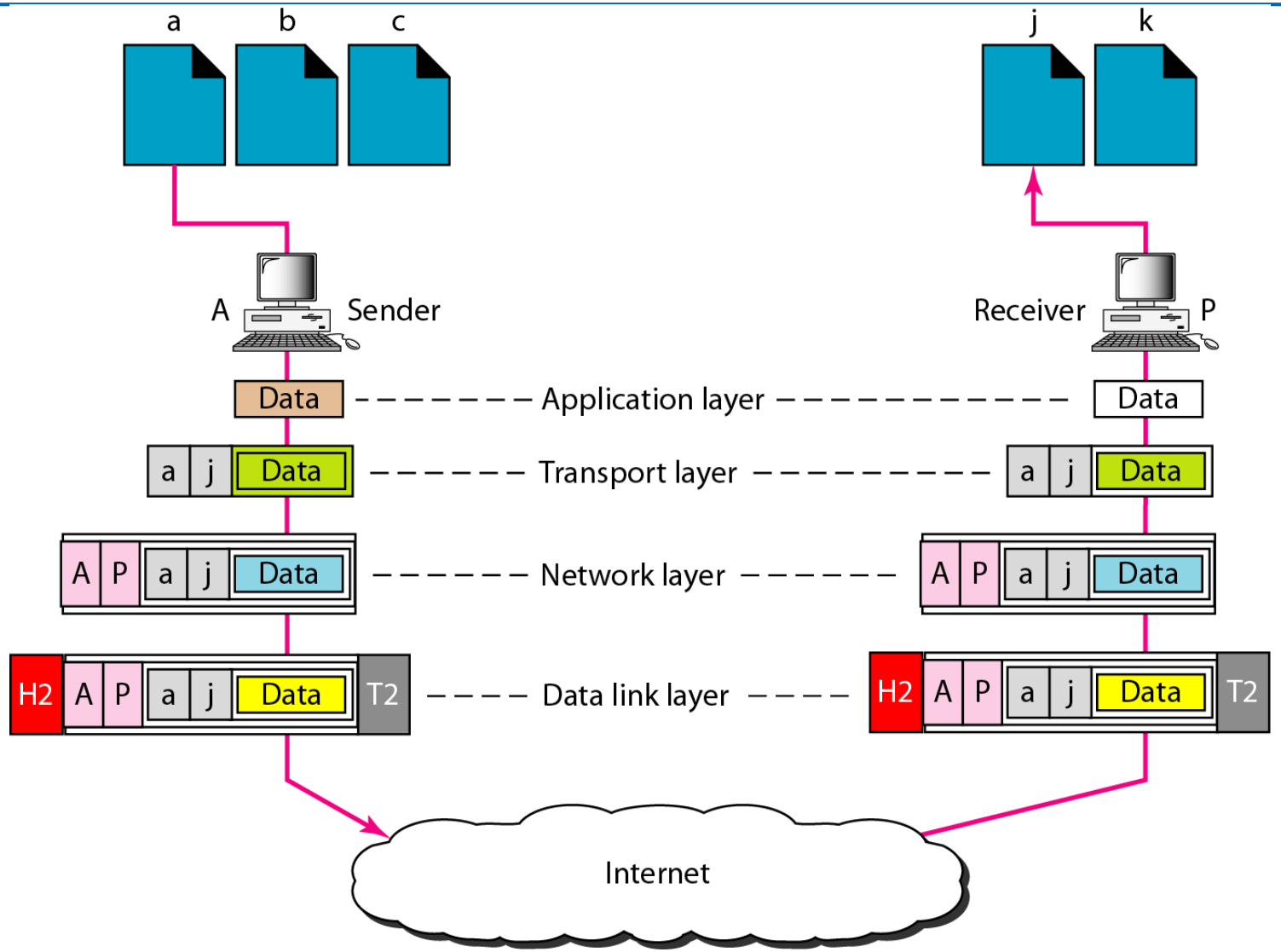
07:01:02:01:2C:4B

A 6-byte (12 hexadecimal digits) physical address.

IP addresses



Port addresses



Example

A port address is a 16-bit address represented by one decimal number as shown.

753

A 16-bit port address represented
as one single number.

Network devices

Network Devices

01. **Routers**

Connect multiple networks together

02. **Switches**

Connect devices within a network

03. **Servers**

Provide services or resources to other computers over a network

04. **Firewalls**

Monitor and control incoming and outgoing network traffic

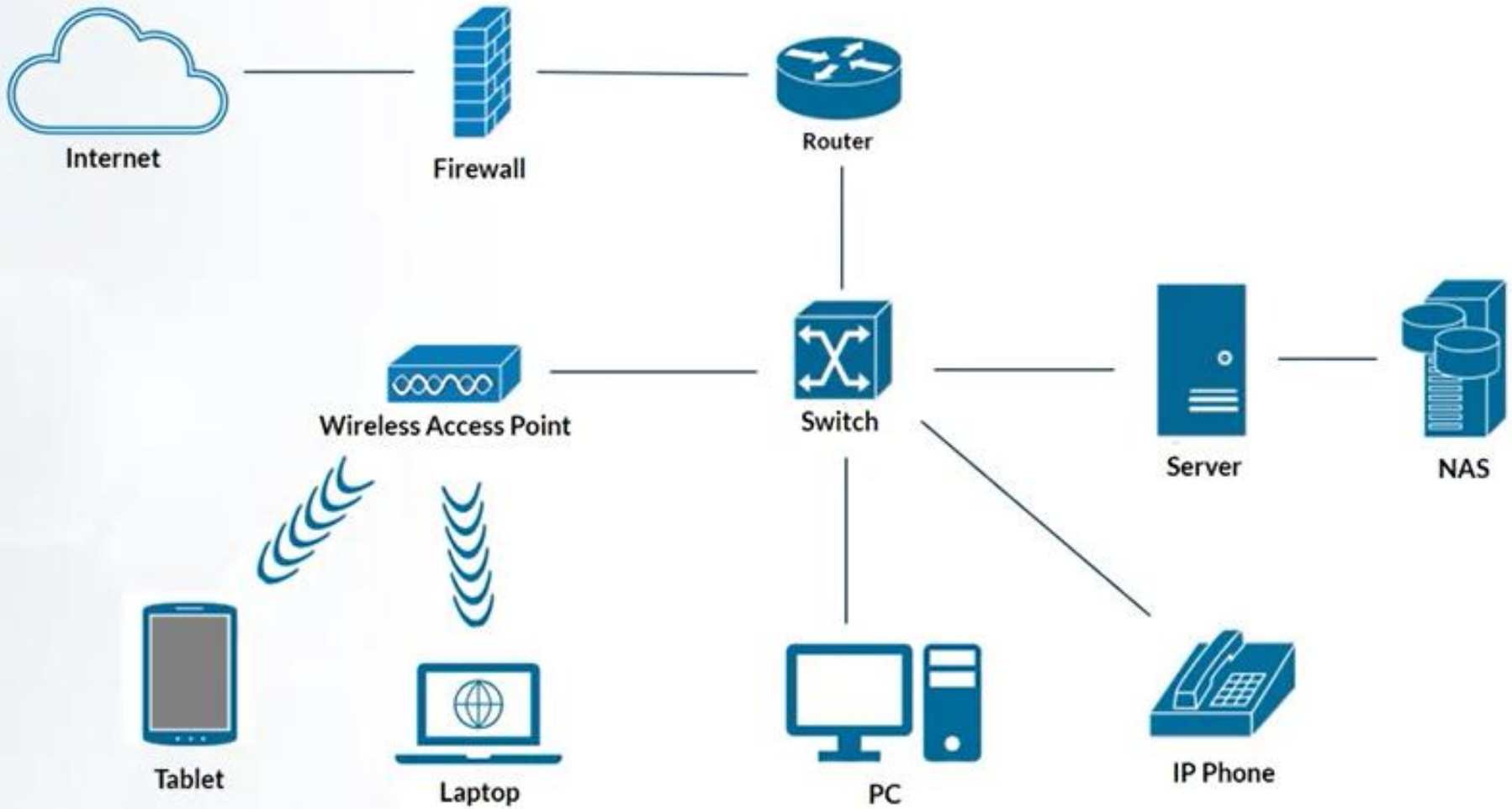
05. **Access Points (APs)**

Enable wireless devices to connect to a wired network

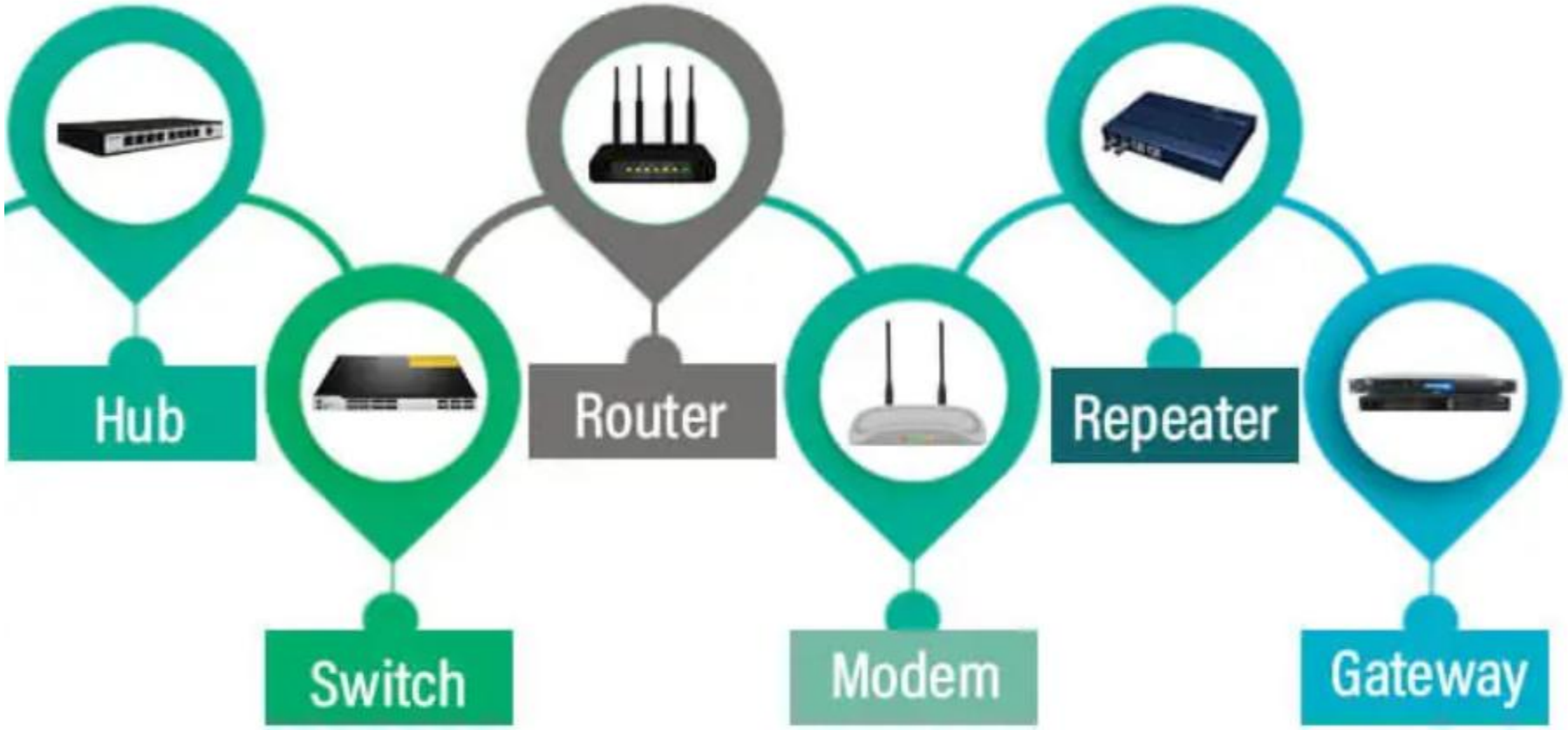
06. **Network Attached Storage (NAS)**

Provide a centralized storage for network users

Visual Representation of Network Devices

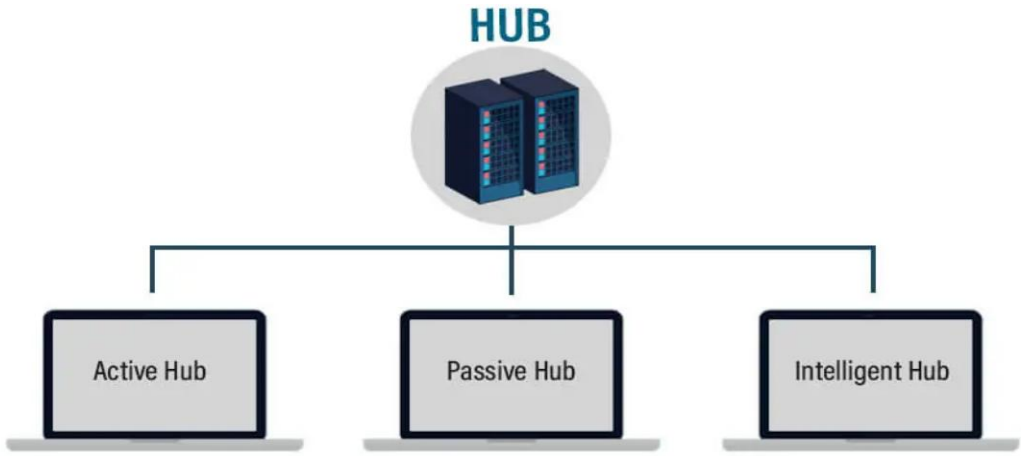


Network devices



Hub

- A network segment is formed by attaching network cables to a connectivity device. And this connectivity device is called a Hub. Hubs generally don’t filter information; instead, they conduct incoming information frames or packets to any or all the elements. Nowadays, a central switch or Hub is used by all the networks to which computers are connected.
- **Types of Hub:**



Hub :
Active Hub (Repeater)

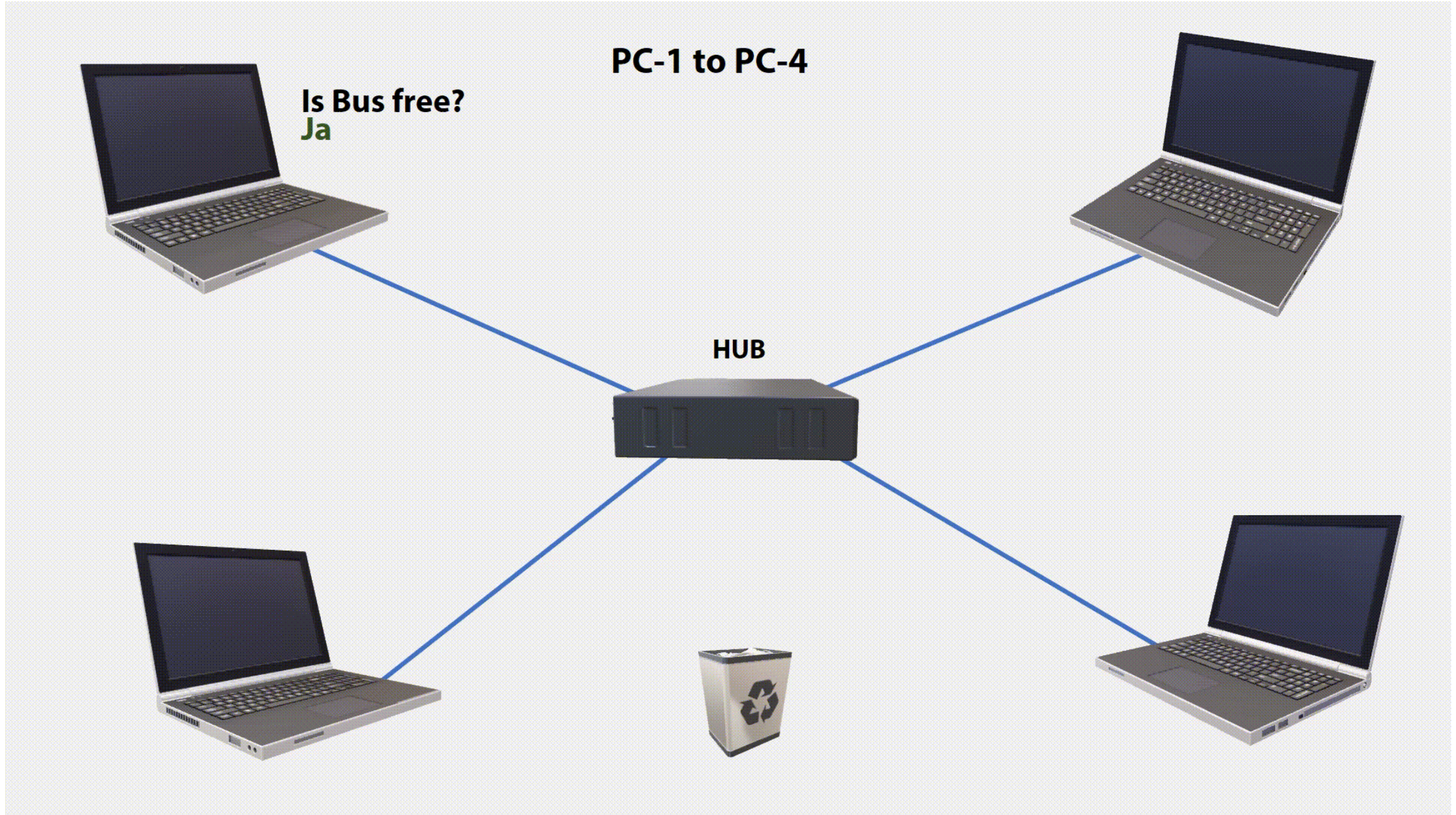
- i) **Active Hub (Repeater)**
- They can boost, relay, and clean the signals along with the network
- They don’t need power from the outside, as they have their own
- They serve each as a repeater and further as a wiring center.
- It helps to extend the maximum distance between them

Hub :
Passive Hub

- ii) **Passive Hub**
- They collect wiring from the nodes.
- An active hub is the source of the power supply
- They do not help to extend the distance between nodes

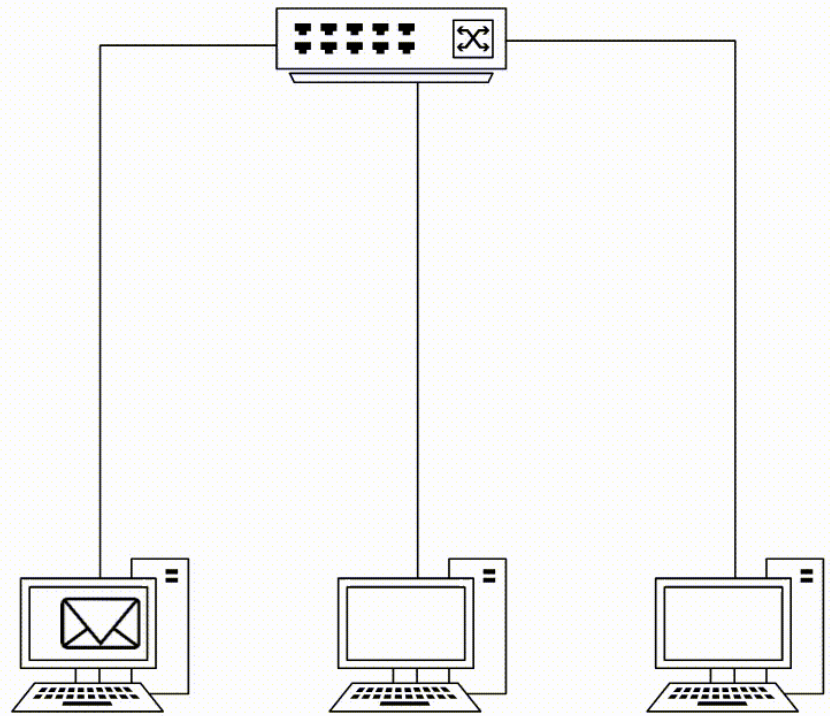
Hub :
Intelligent Hub (Switching Hub)

- iii) **Intelligent Hub**
- they provide some additional functionality over active and passive hubs.
- They analyze data packets and make decisions based on MAC address and they are operated on DLL(Data Link Layer).
- Help the controller to compose each port in the Hub and look into the traffic passing through the Hub

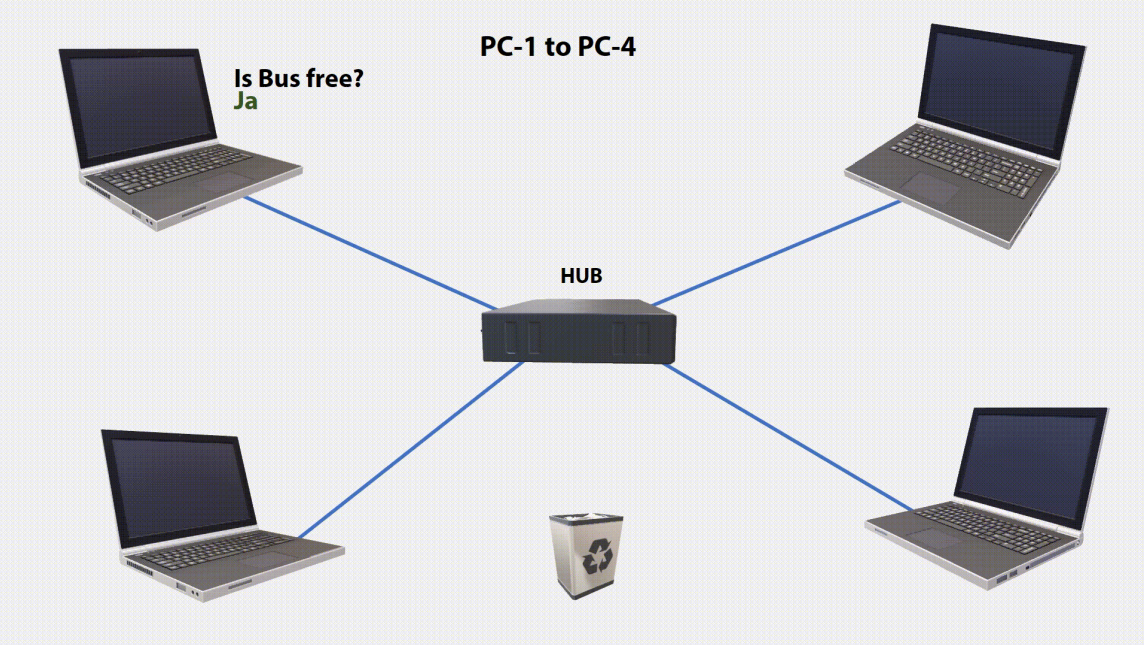

PC-1 to PC-4
Is Bus free?
Ja
HUB

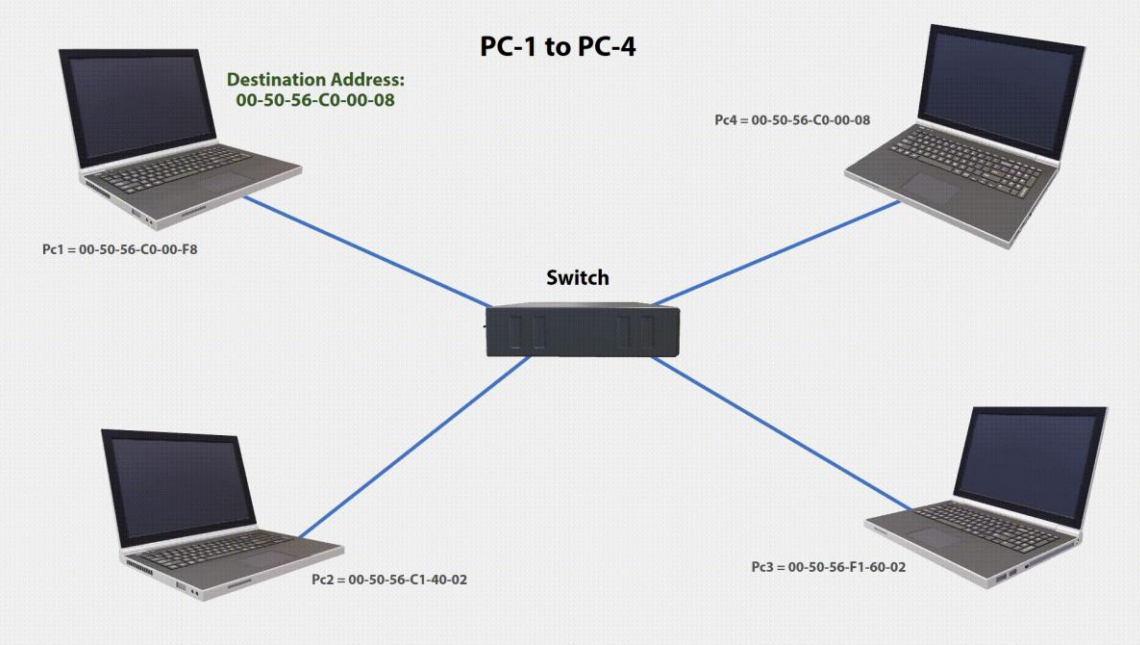
Switch

- The **switch** is designed in such a way that it can boost its productivity.
- It is designed with a buffer.
- It is a multi-port bridge device.
- It forwards data, but before doing that, it checks errors. This makes it more efficient and improves its performance, as it only forwards the excellent and efficient packet to the correct port, which doesn't have errors.
- It is simply a better version of a hub. As with a hub, with a switch also, the computer device is connected through one line, but the switch works smartly about where it sends the data that is coming through one of its ports.



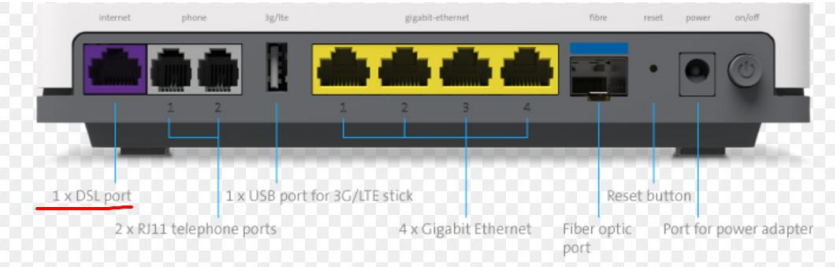
Switch vs Hub

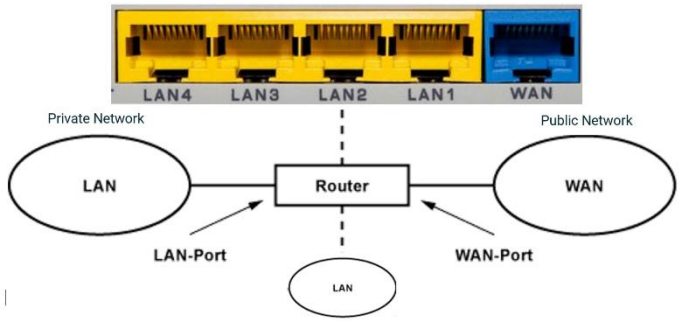




Router

- A router is a device that connects two or more packet-switched networks or subnetworks.
- It serves two primary functions:
  - managing traffic between these networks by forwarding data packets to their intended IP addresses (logical address),
  - and allowing multiple devices to use the same Internet connection.





Modem

- A **Modem** is somewhat of an additional attention-grabbing network device in our lifestyle. Thus if you have been noticed, you get an internet connection through a wire (different types of cables) to your house. This wire is employed to hold our internet data outside the internet world.
- However, binary data, in varieties of 0s and 1s, is generated by our computer. On the other hand, an analog signal is carried by a wire, and that's where a modem comes in.
- A modem works as a Modulator and Demodulator both; that is, it modulates and demodulates the signal between the binary data or digital data of a computer and, therefore, the analog signal of a telephone line.

Repeater

- A device that, on receiving the signals, amplifies it is called a repeater. In other words, it can be said that a repeater is a device that, on receiving a signal, retransmits it at a higher level so that the signal can cover longer distances.
- For Example, within a university field, the hostels may be isolated from most school areas wherever the ISP line comes in. If the university authority desires to tug a wire between the hostels and the main field, they'll need to use repeaters if space is more; thus, differing types of cables have limitations in terms of the distances they will carry the information.
- When these network devices take a selected configured form on a network, their configuration gets a chosen name, and this whole formation is termed Network topology. Ensure circumstances, once we add **some additional network devices** to a Network topology, it is known as Daisy chaining.

Gateway

- By the name only, we can get the meaning of it. It is a passage between the networks, connecting them so that this connection works upon completely **different networking protocols**. They primarily work as the middleman who takes information from a system, translates it, and then transfers it to another system.
- They are also protocol converters that may be operated at different networking layers. They are usually additionally complicated than switches and routers.

Access Point

- While a wired or wireless link is technological in an AP, it usually means a wireless device. An AP operates on the second OSI layer, **the data link layer**, and can either act as a bridge that connects a standard wireless network to wireless devices or as a router that transmits data to another access point. Wireless connectivity points (WAPs) are a device used to generate a wireless LAN (WLAN) transmitter and receiver. Access points are usually separate networked machines with an integrated antenna, transmitter, and adapter.

Questions

Identify each type of device in this network