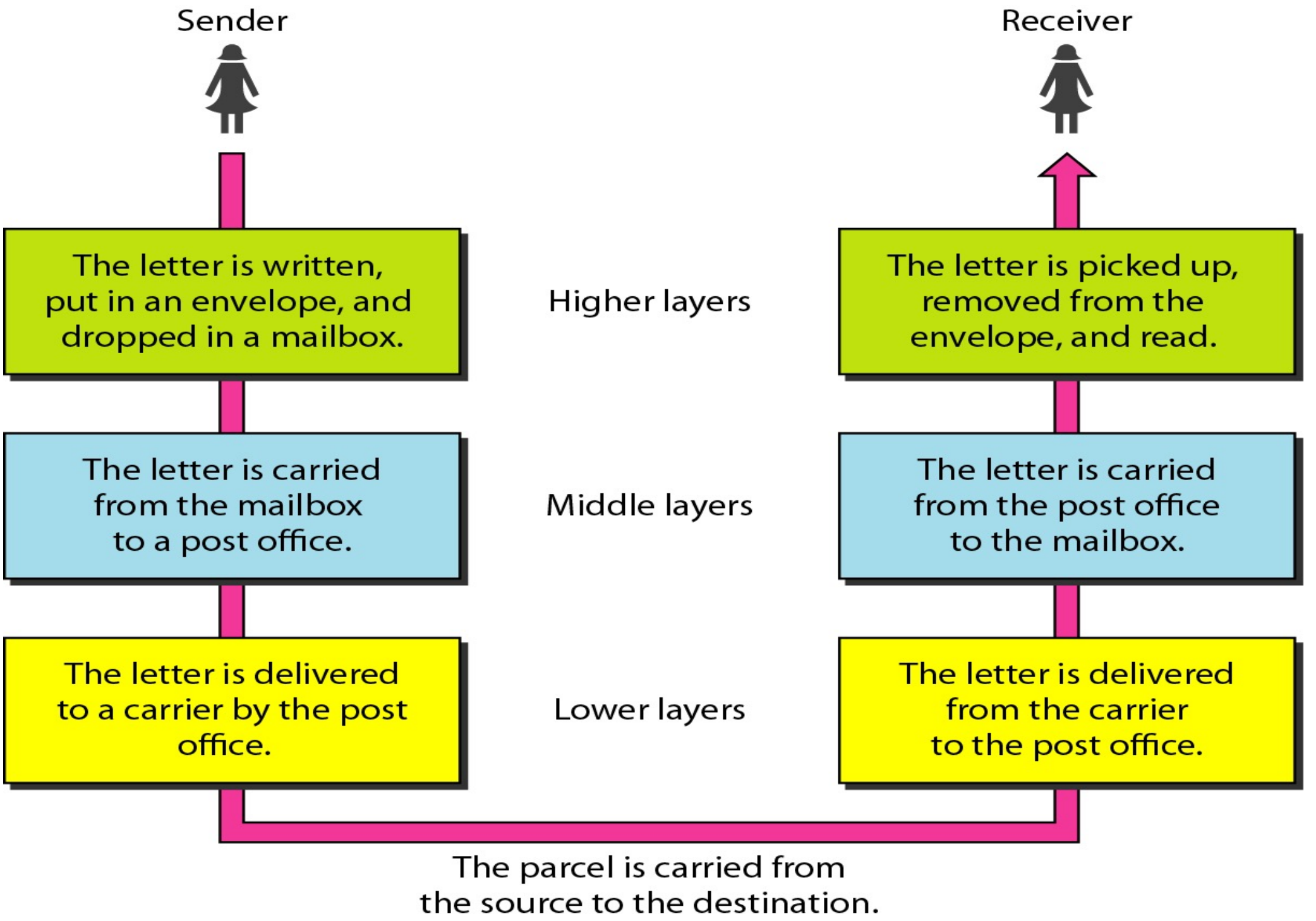
Network Models

Layered Tasks

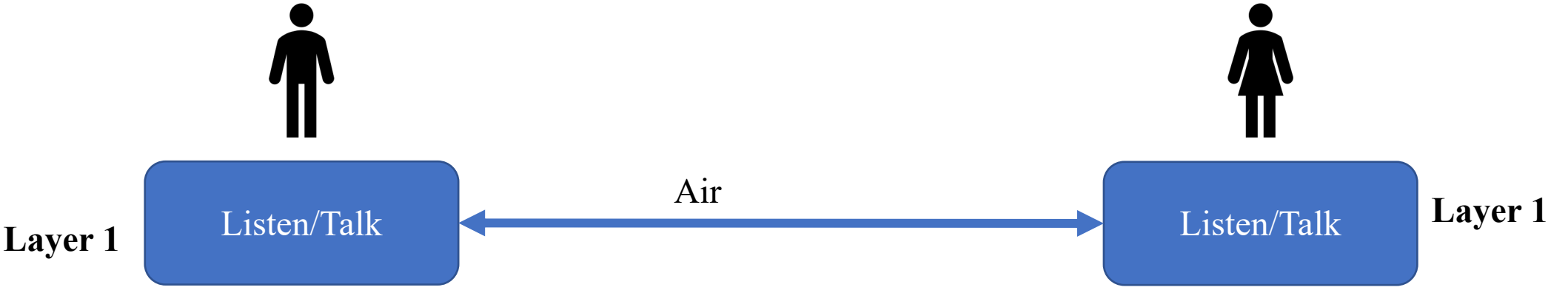
- We use the concept of layers in our daily life.
  - As an example, let us consider two friends who communicate through postal mail.
  - The process of sending a letter to a friend would be complex if there were no services available from the post office.

Tasks involved in sending a letter



Need for Protocol Layering

Scenario 1: Single Layer Protocol

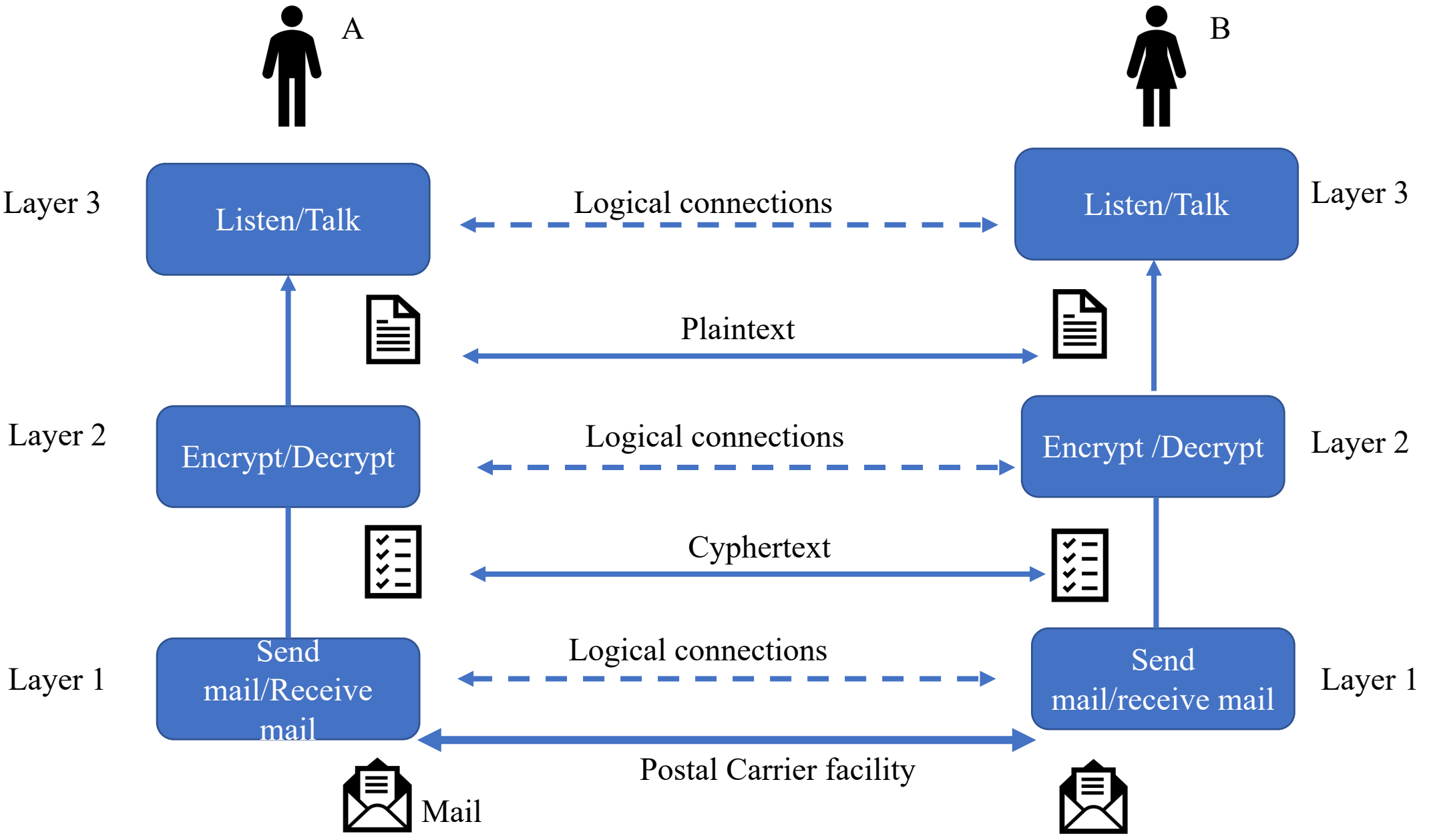


Rules:

- They greet each other when they met
- Confined their vocabulary to their level of friendship
- One is refrain in speaking when other is talking
- Conversation should have a dialogue, not a monolog
  - Both should have the opportunity to talk about the issue.
- Should exchange nice words when they end conversation

Need for Protocol Layering

Scenario 2: Three Layer Protocol



Advantages

- Divides the complex task into several smaller and simpler tasks
- Modular approach can be followed so that if any module is to be replaced then only that part requires modification
- A layer needs to be able to receive a set of services from the lower layer and give the services to the upper layer.
  - Don’t care about the implementation of the other layer

Network Protocol Standards

- **OSI (ISO)**
- **TCP/IP (Department of Defense in USA)**
- **IPX/SPX (Novell)**
- **Appletalk (Apple)**
- **Netbios (Microsoft)**

The OSI Model

- Established in 1947, the International Standards Organization (ISO) is a multinational body dedicated to worldwide agreement on international standards.

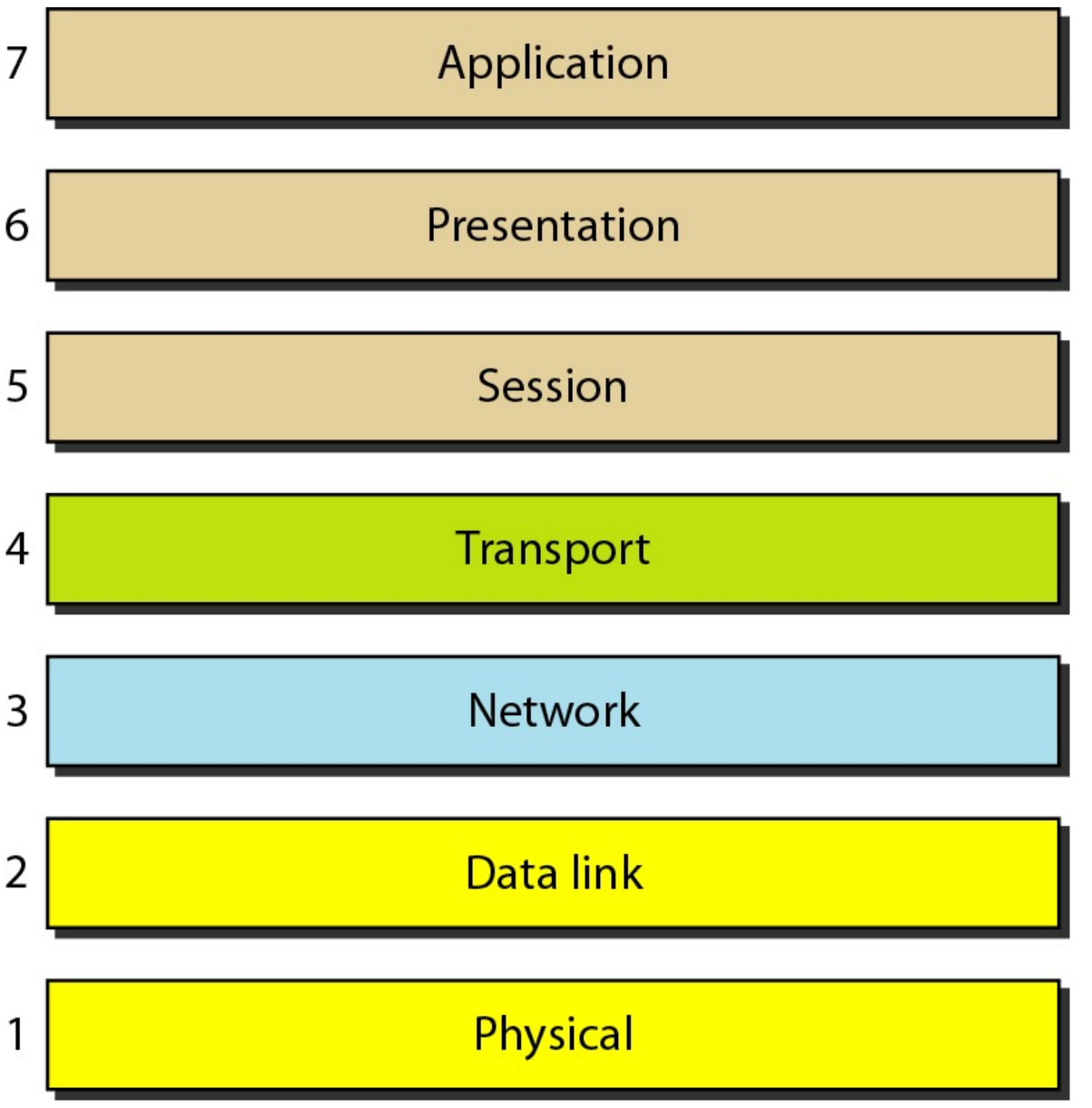
- An ISO standard that covers all aspects of network communications is the *Open Systems Interconnection* (OSI) model.
- It was first introduced in the late 1970s.

Note

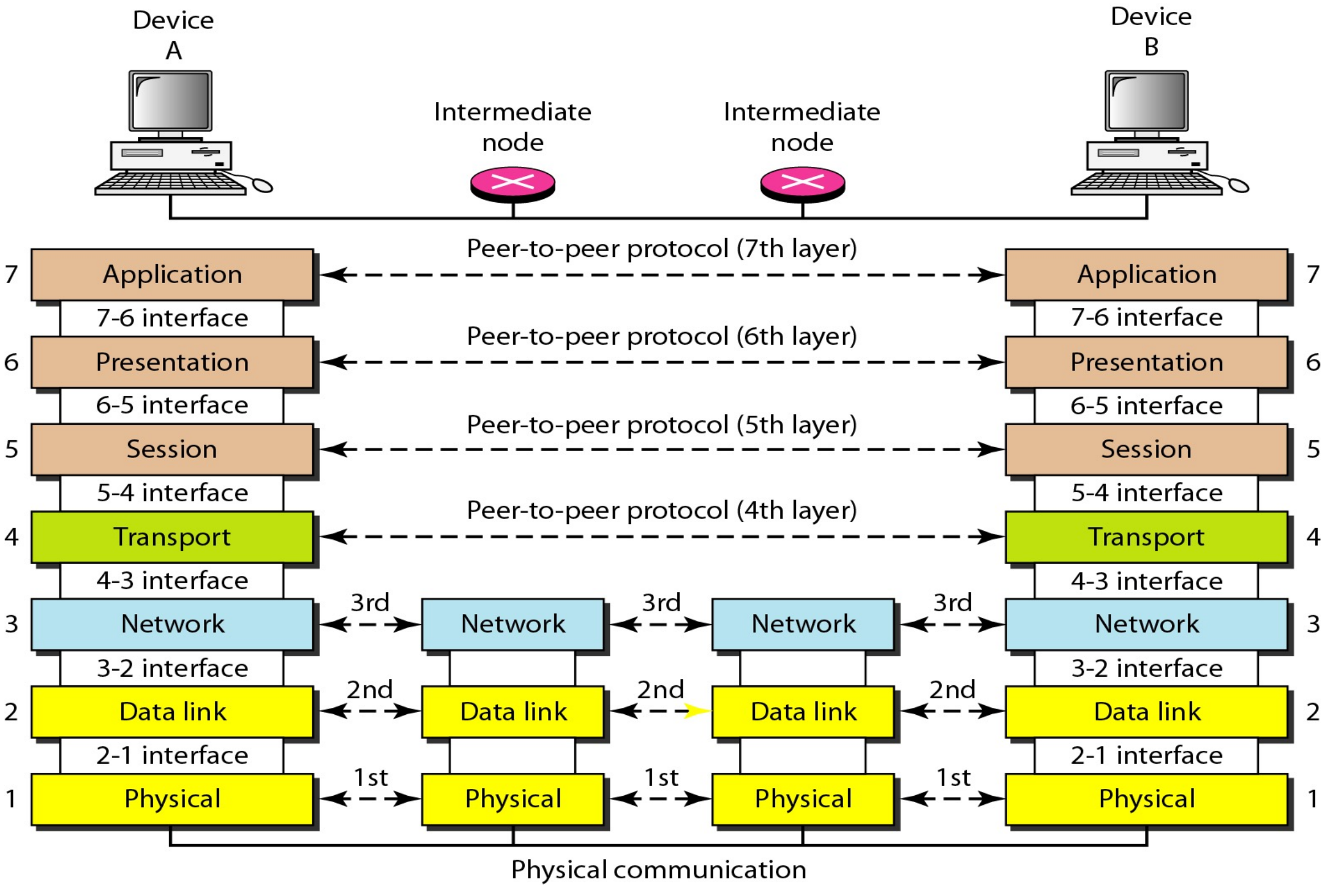
ISO is the organization.

OSI is the model.

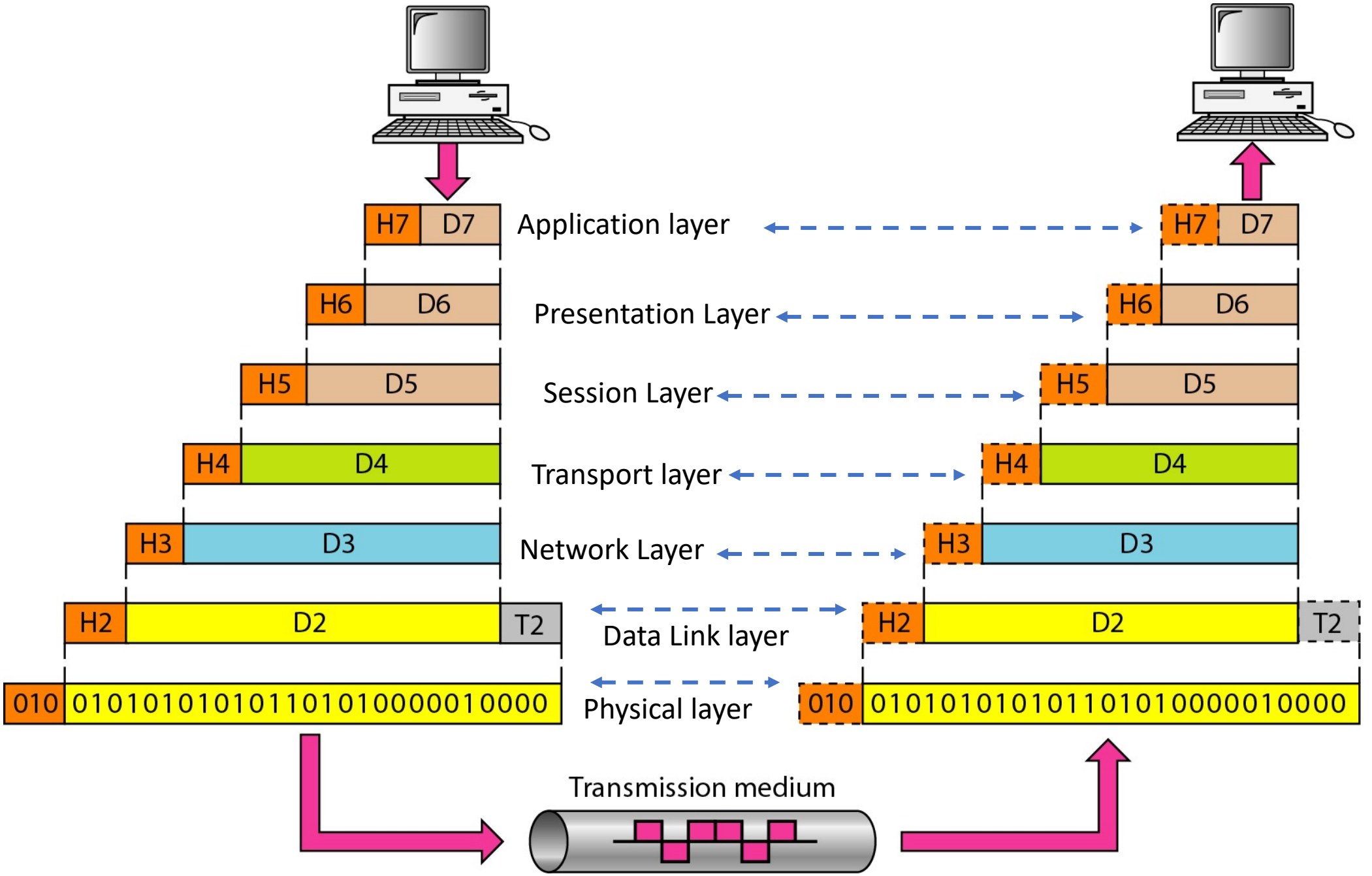
Seven layers of the OSI model



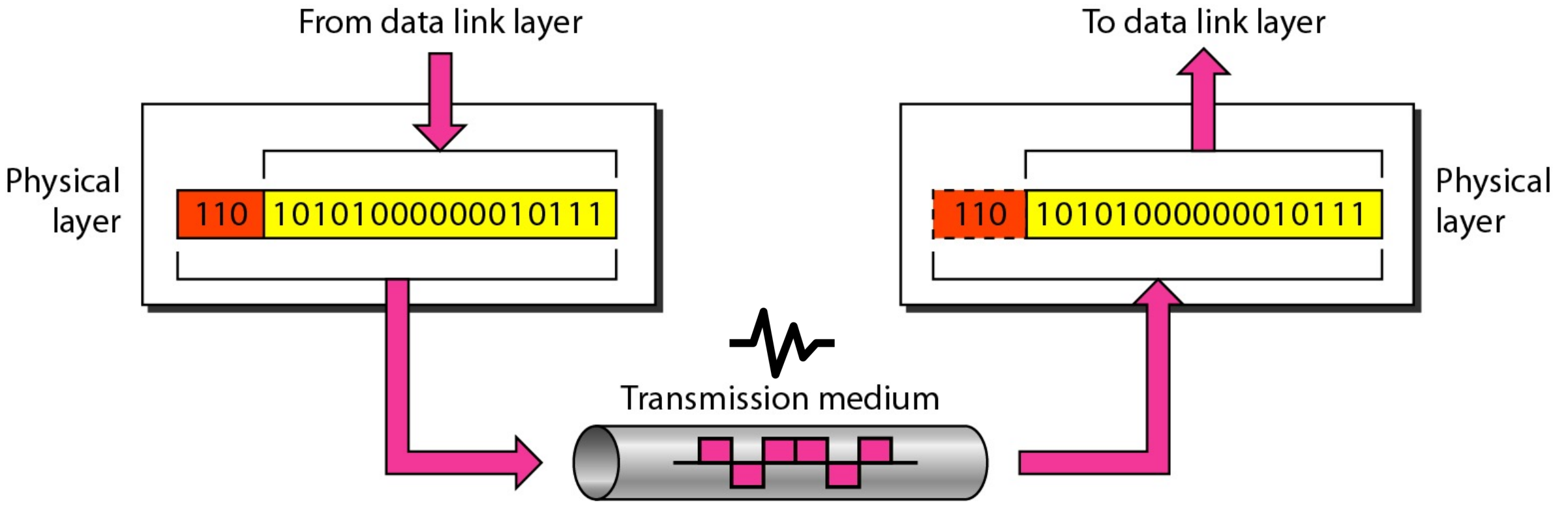
The interaction between layers in the OSI model



An exchange using the OSI model



Physical layer



- Responsible for carrying individual bits in a frame across the link
- Although the physical layer is at the lowest level, it can be considered still as a logical communication
  - One hidden layer exists called the transmission media
- Coordinates the functions required to carry a bit stream over a physical medium

Physical layer

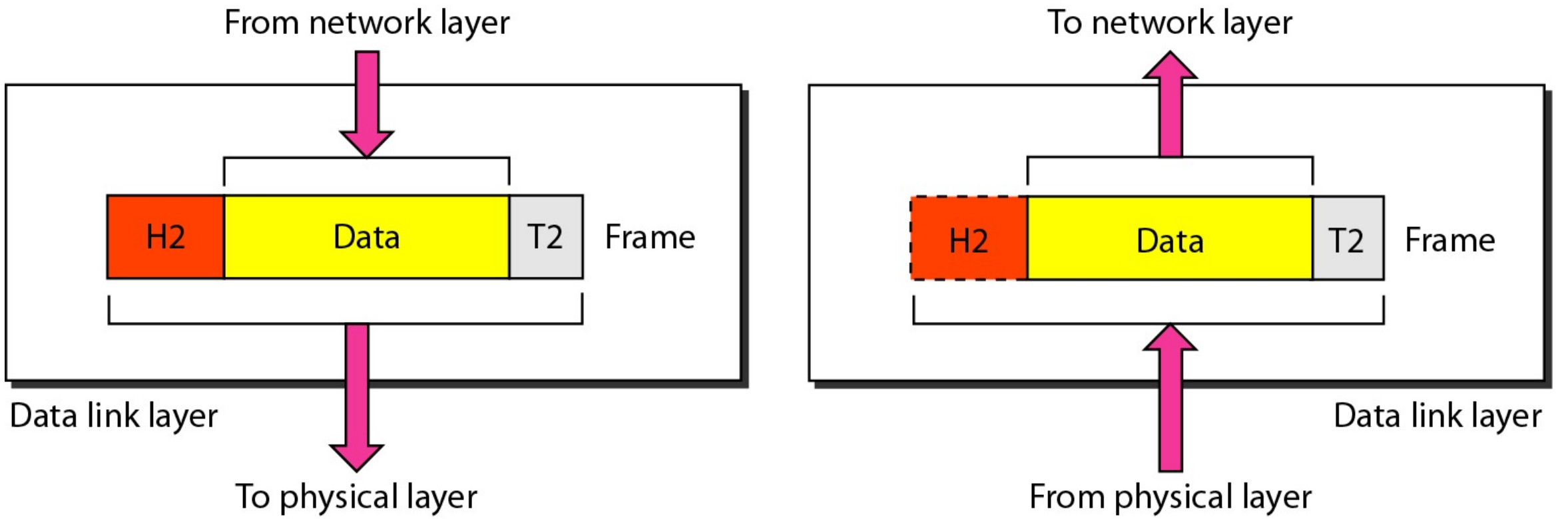
Concerned with the following:

- Physical characteristics of interfaces and medium.
- Representation of bits. Defines types of encoding
- Data rate
- Synchronization of bits
- Line configuration
- Physical topology
- Transmission mode

Note

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

Data link layer



- The data link layer transforms the physical layer, a raw transmission facility, to a reliable link
- It makes the the physical layer appear error-free to the upper layer (network layer)

Data link layer

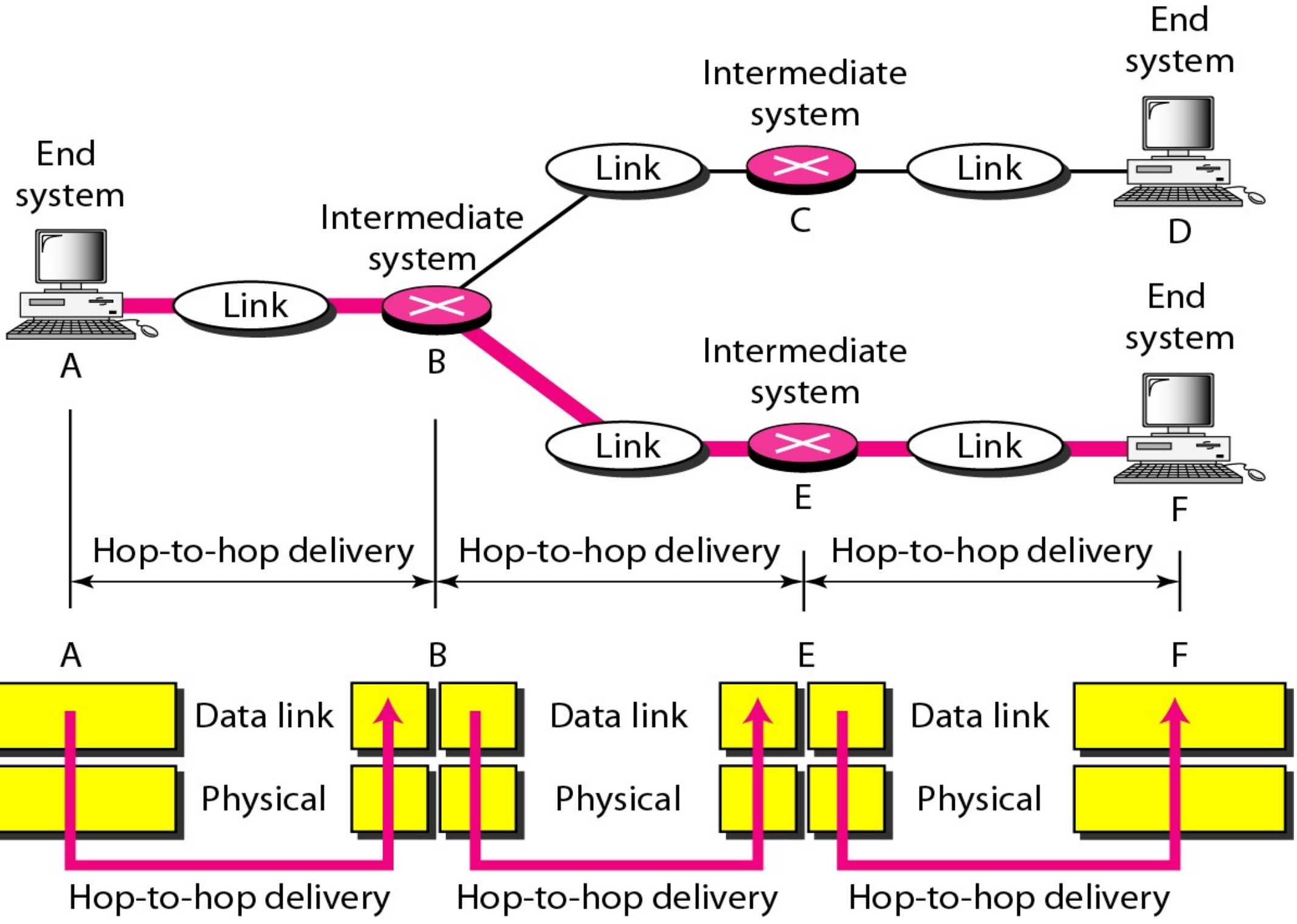
Major responsibilities

- **Framing:** Divides the stream of bits received from the network layer into manageable data units called frames.
- **Physical Addressing:** Data link layer adds a header to the frame to define the sender and/or receiver of the frame.
- **Flow Control**
- **Error control :** Adds reliability to the physical layer by adding mechanisms to detect and retransmit damaged or lost frames
- **Access Control:** Determine which device has control over the link at any given time shared by more than one devices.

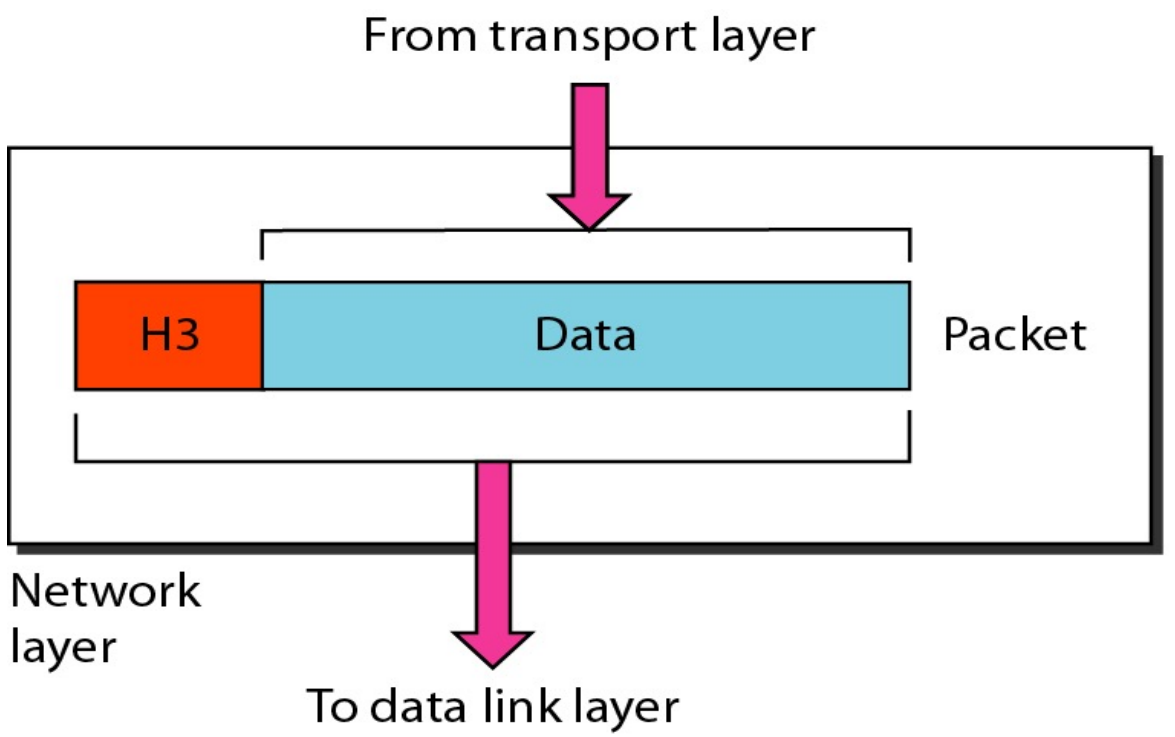
Note

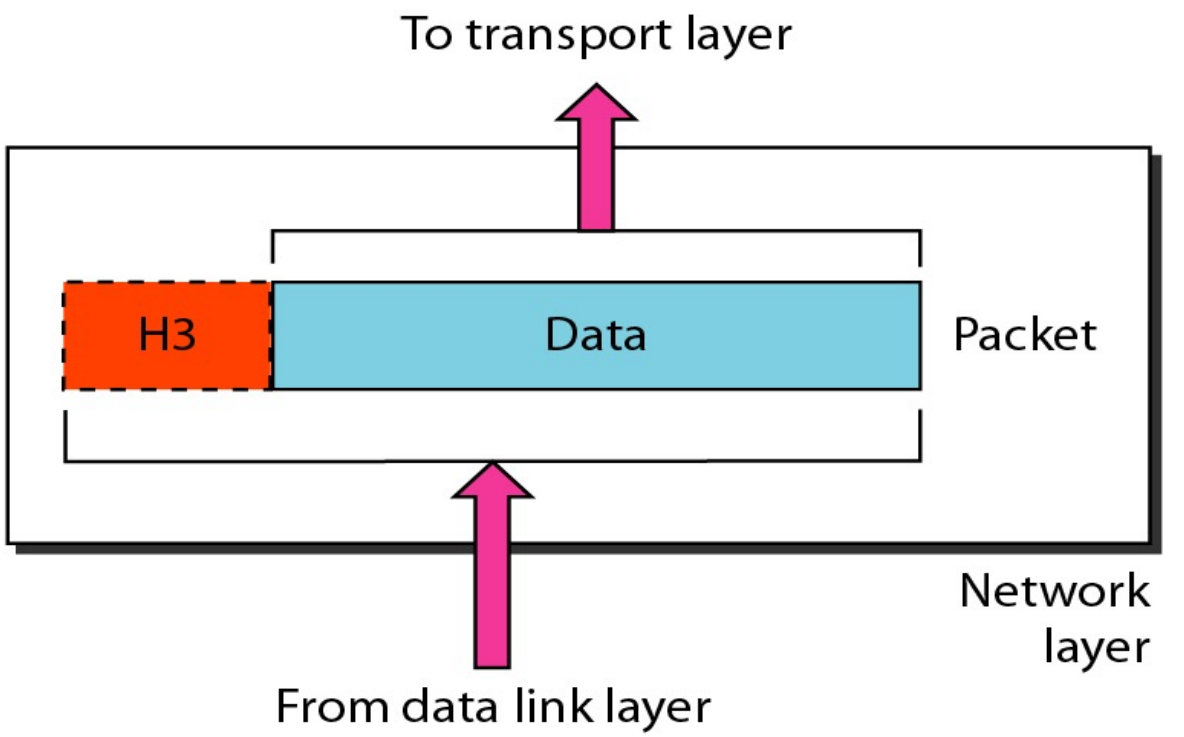
The data link layer is responsible for moving frames from one hop (node) to the next.

Hop-to-hop delivery



Network layer





- Responsible for the source-to-destination delivery of a packet, possibly across multiple networks (links)
- If two systems are connected to the same link, there is usually no need for a network layer.
- if the two systems are attached to different networks (links) with connecting devices between the networks (links), there is often a need for the network layer to accomplish source-to-destination delivery.

Network layer

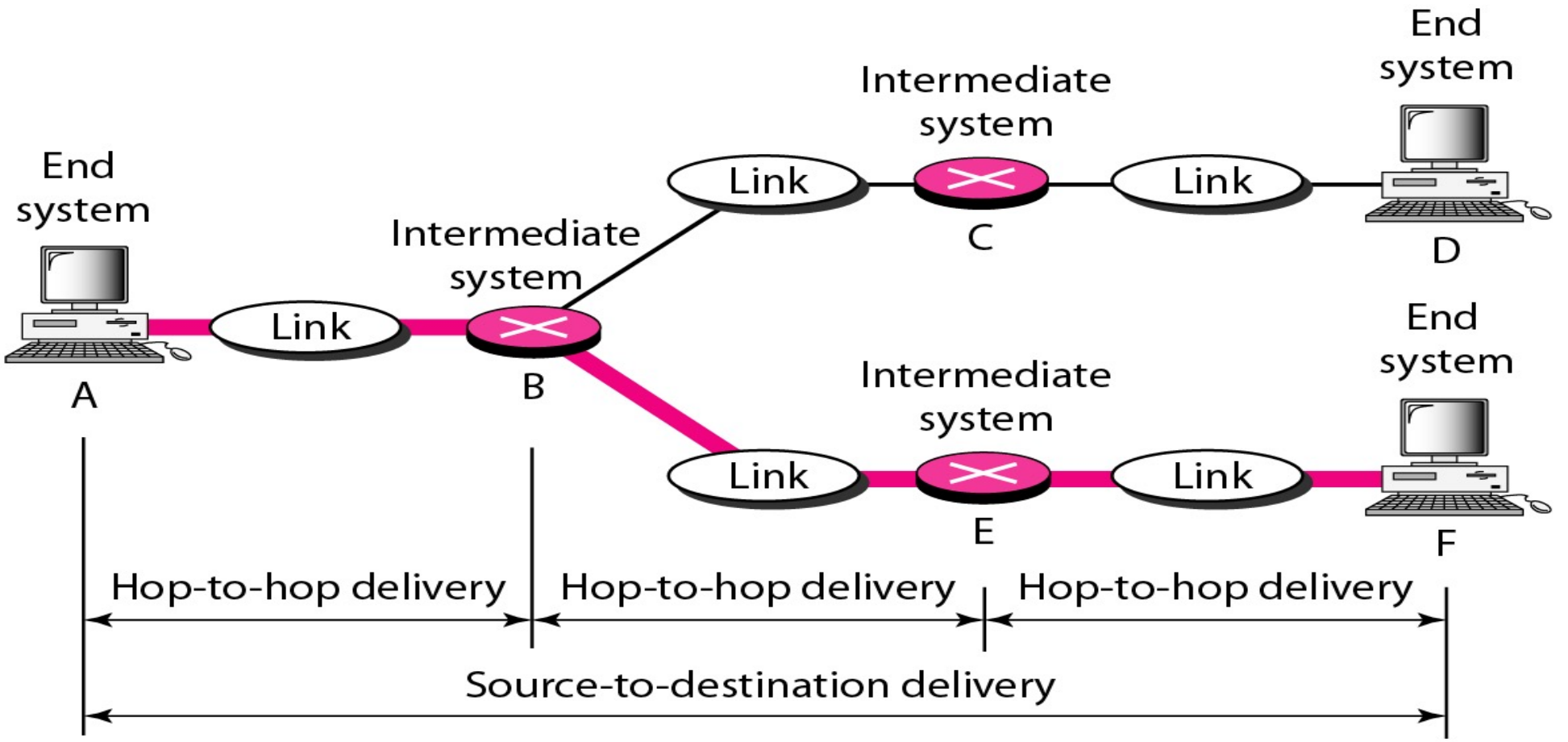
- **Logical addressing:** Helps to distinguish the source and destination systems. includes the logical addresses of the sender and receiver

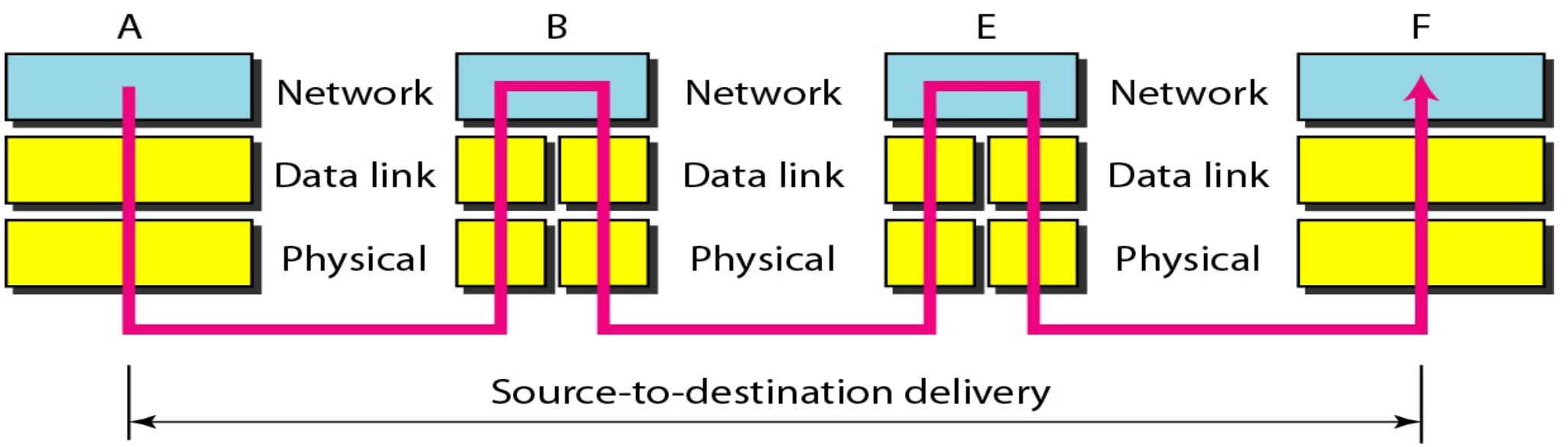
- **Routing:** When independent networks or links are connected to create *internetworks* (network of networks) or a large network, the connecting devices (called *routers* or *switches)* route or switch the packets to their final destination.
  - One of the functions of the network layer is to provide this mechanism.

Note

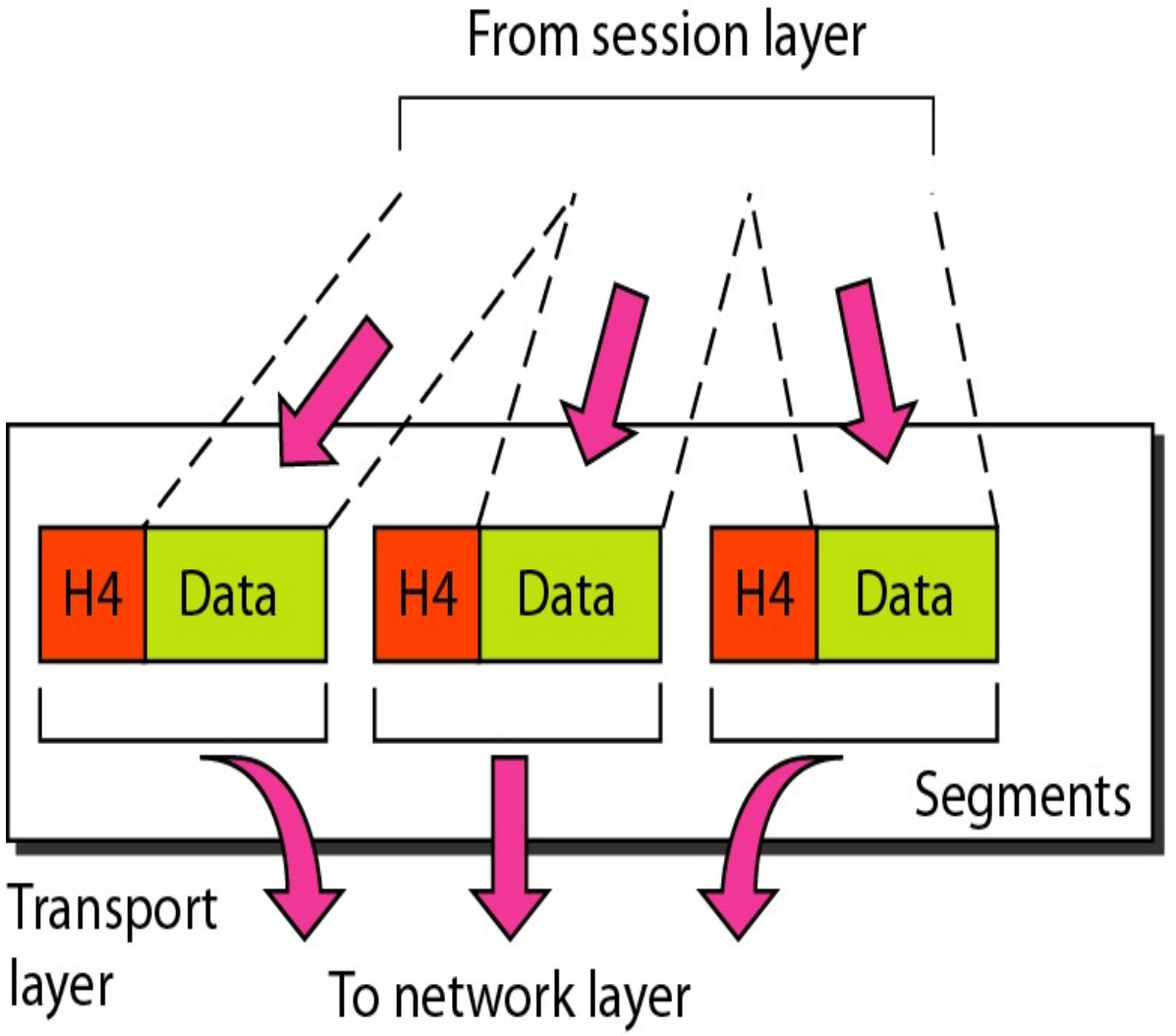
The network layer is responsible for the delivery of individual packets from the source host to the destination host.

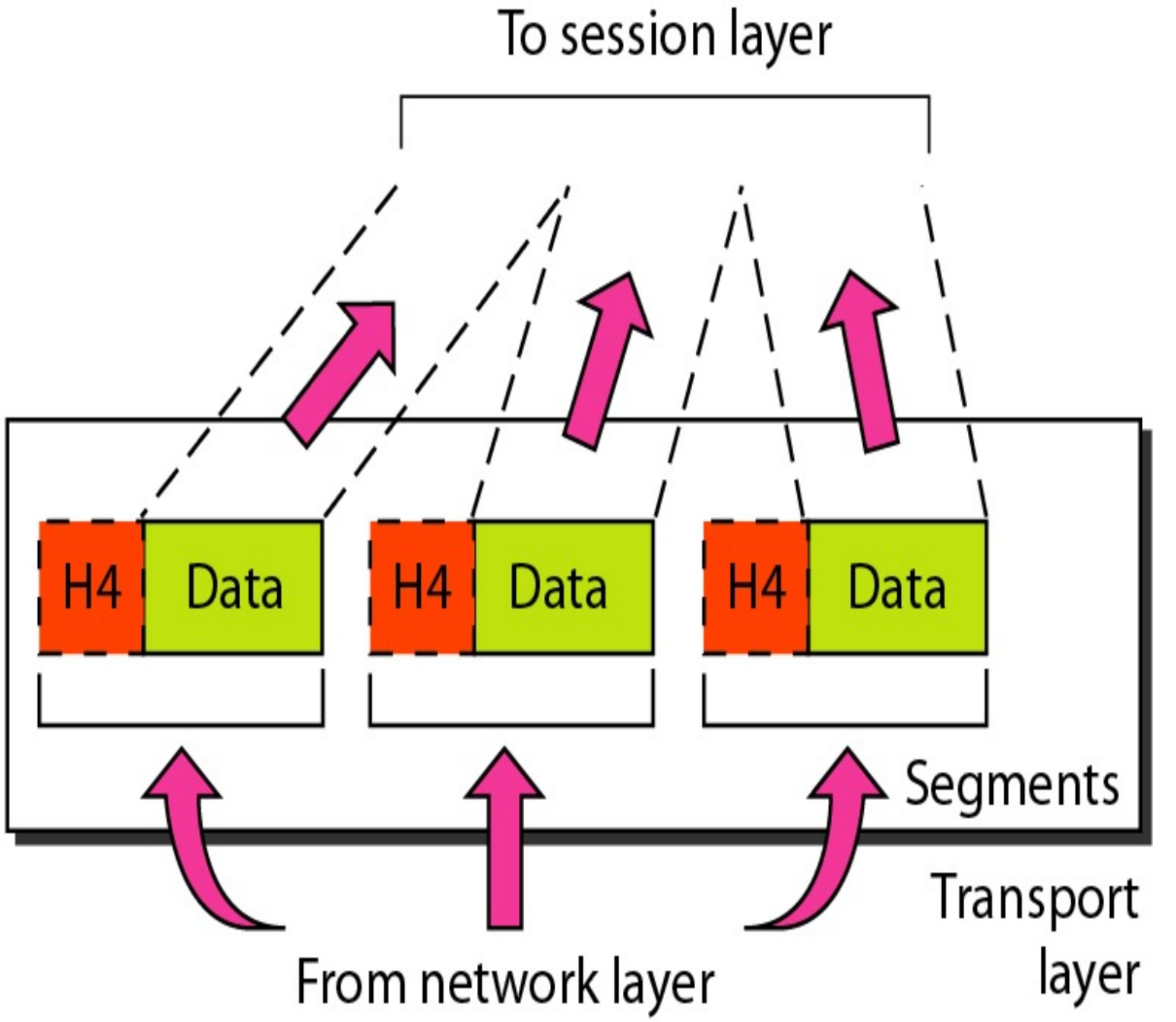
Source-to-destination delivery





Transport layer





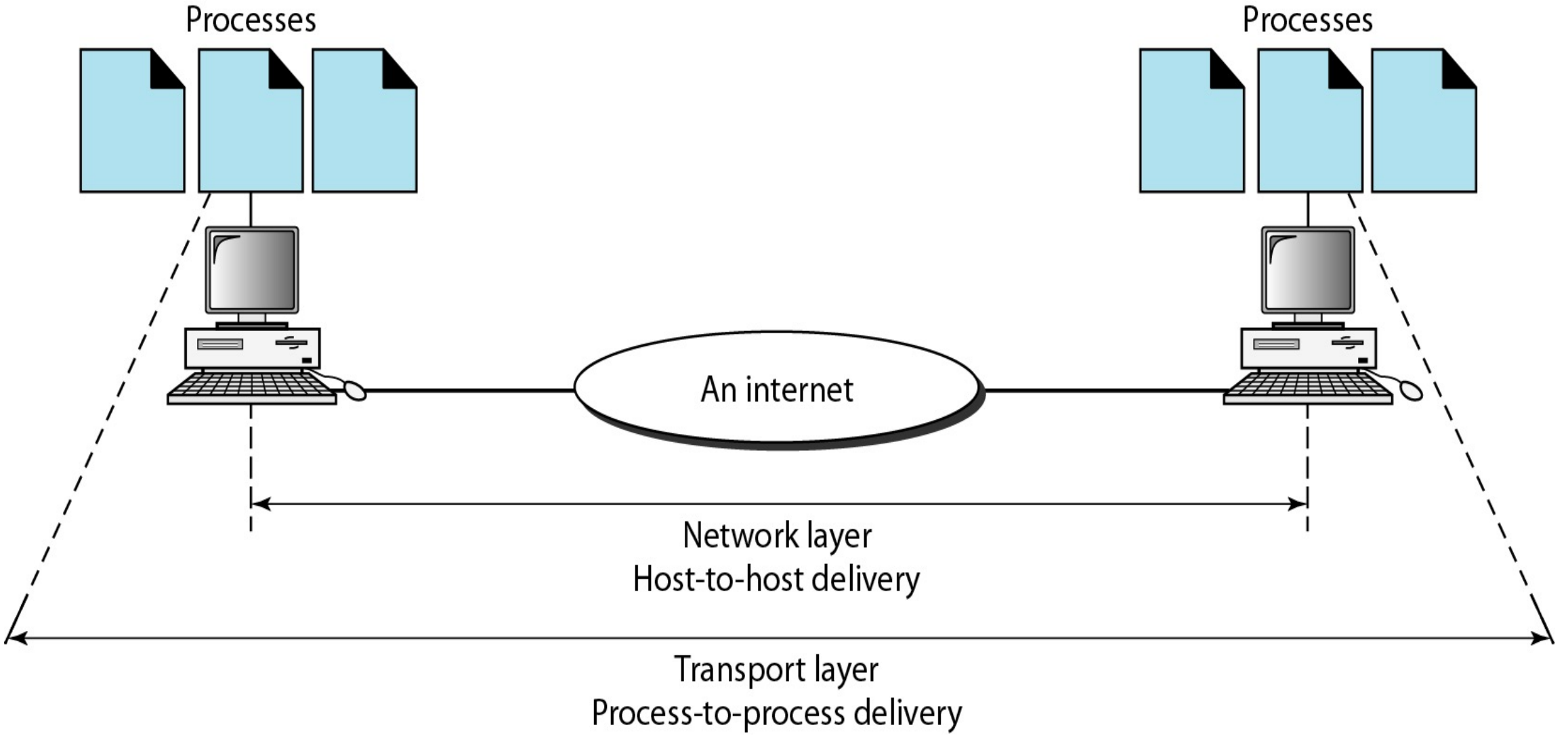
Transport layer

- Responsible for process-to-process delivery of the entire message.
- Does the following responsibilities
  - **Service-point addressing**
  - **Segmentation and reassembly :** Use sequence number for ordering and to track loss of packets
  - **Connection control :** The transport layer can be either connectionless or connection- oriented
  - **Flow control**
  - **Error control :** error control at this layer is performed process-to- process rather than across a single link.

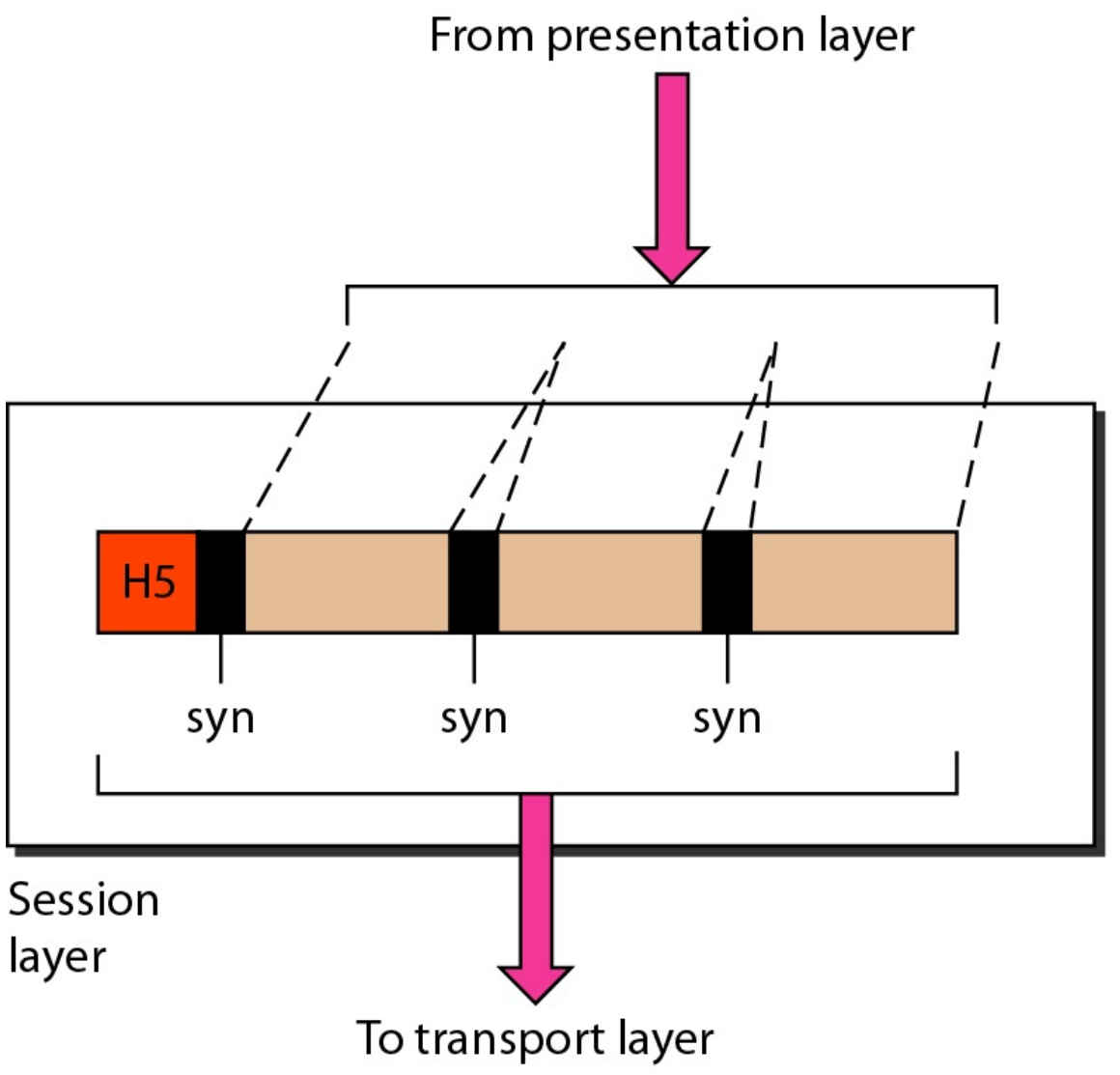
Note

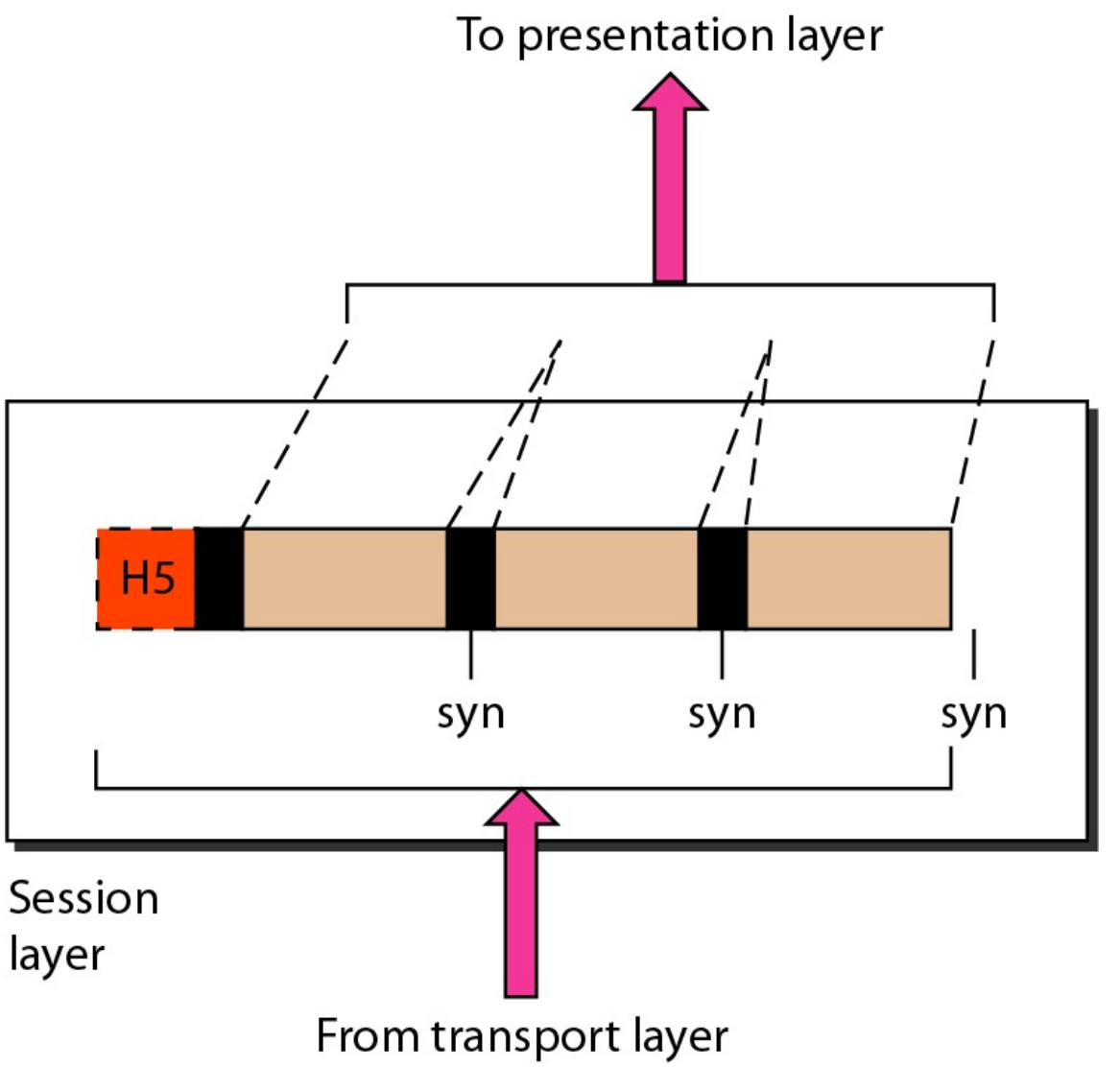
The transport layer is responsible for the delivery of a message from one process to another.

Reliable process-to-process delivery of a message



Session layer





Session layer

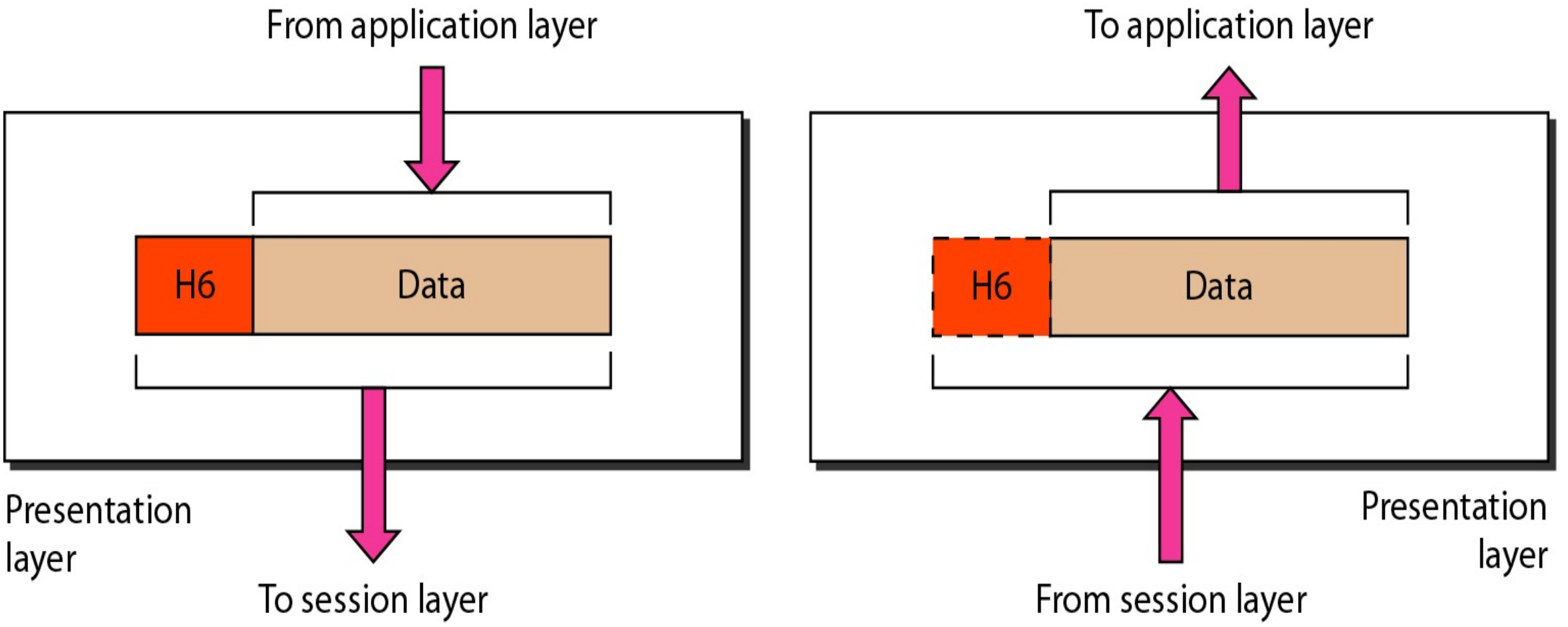
Specific responsibilities of the session layer:

- **Dialog control :** It allows the communication between two processes to take place in either half- duplex (one way at a time) or full-duplex (two ways at a time) mode.
- **Synchronization :** Allows a process to add checkpoints, or synchronization points, to a stream of data.
  - **Example:** A file of size 100 MB to be sent. But crash happens after sending of 30MB data of that file. So checkpoint helps to send only the remaining data

Note

The session layer is responsible for dialog control and synchronization.

Presentation layer



Presentation layer

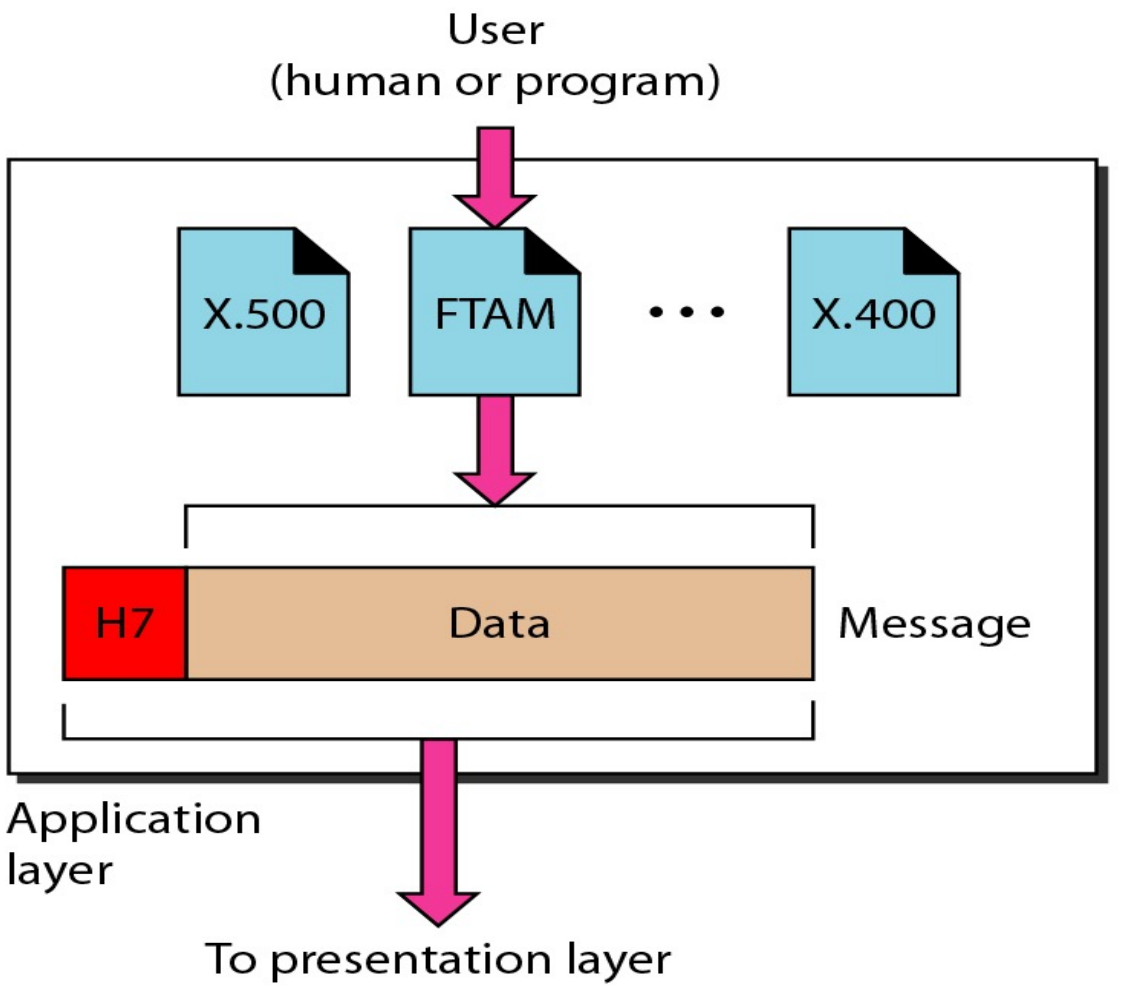
- Concerned with the syntax and semantics of the information exchanged between two systems

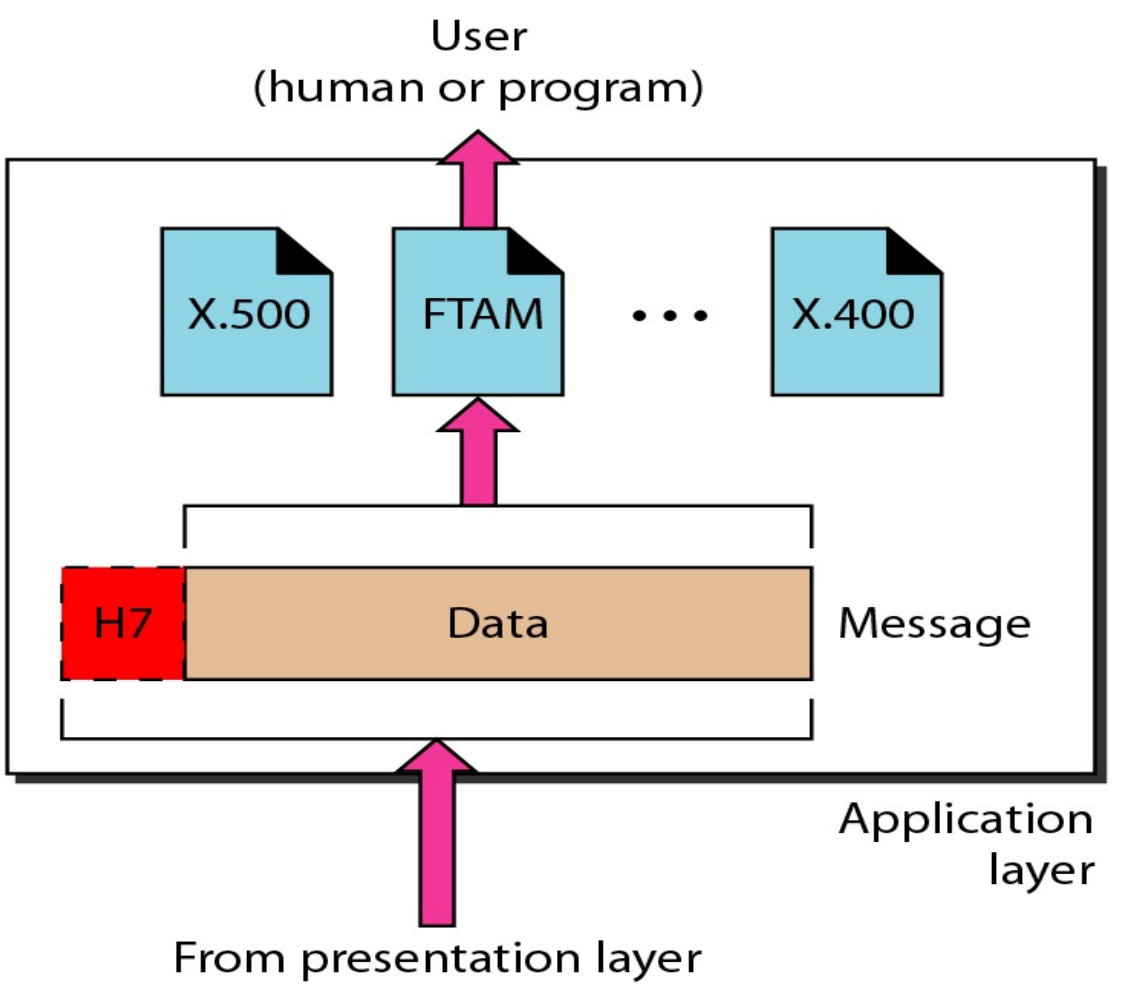
- **Specific responsibilities:**
- **Translation:**
  - The presentation layer at the sender/receiver changes the information from its sender/receiver-dependent format into a common format or vice versa.
- **Encryption/Decryption**
- **Compression:** Important for multimedia data

Note

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

Application layer



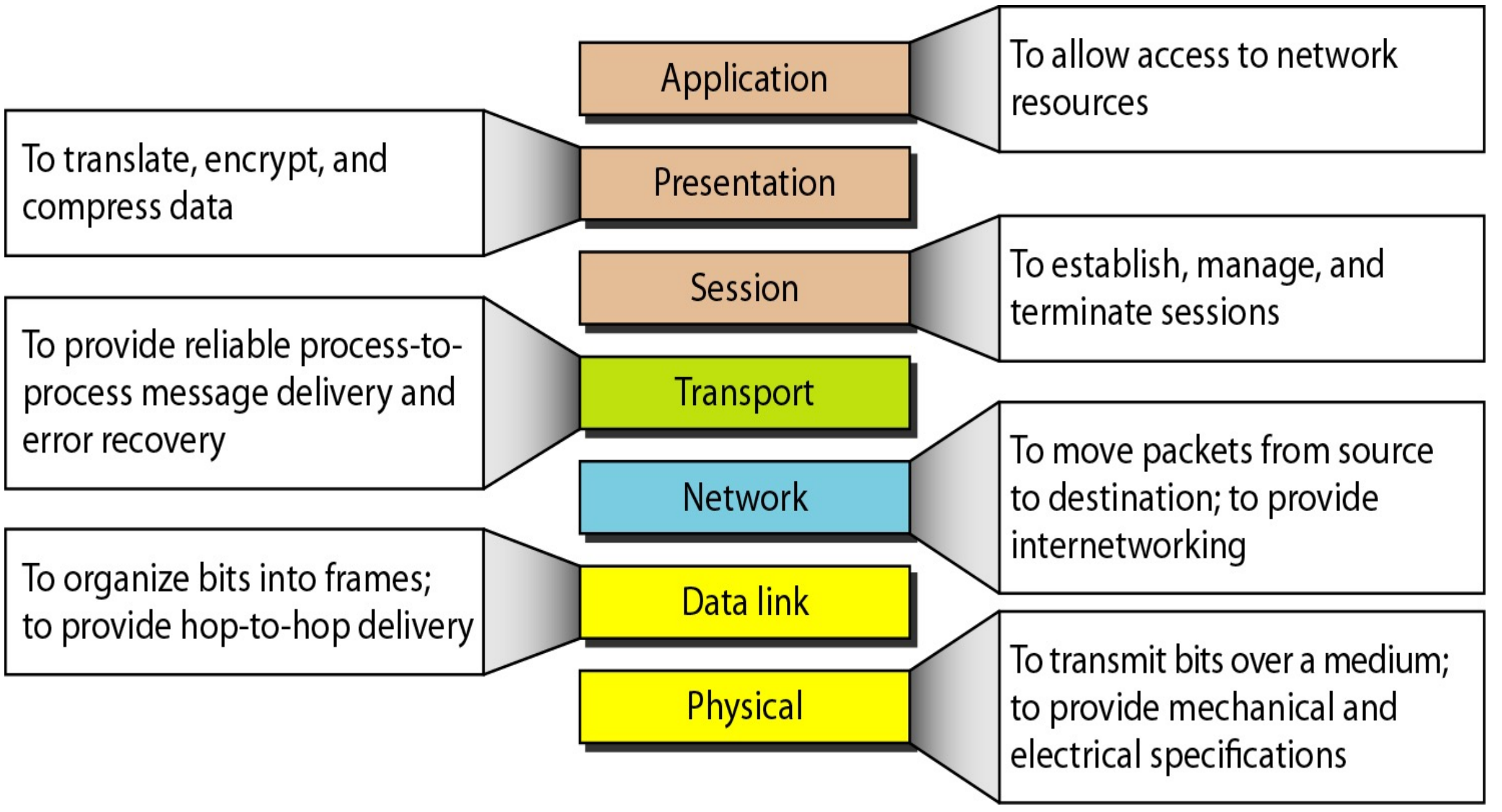


- **Enables the user, whether human or software, to access the net- work.**
- **It provides user interfaces and support for services**
  - **Ex:** Email, remote file access and transfer etc.

Note

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

Summary of layers



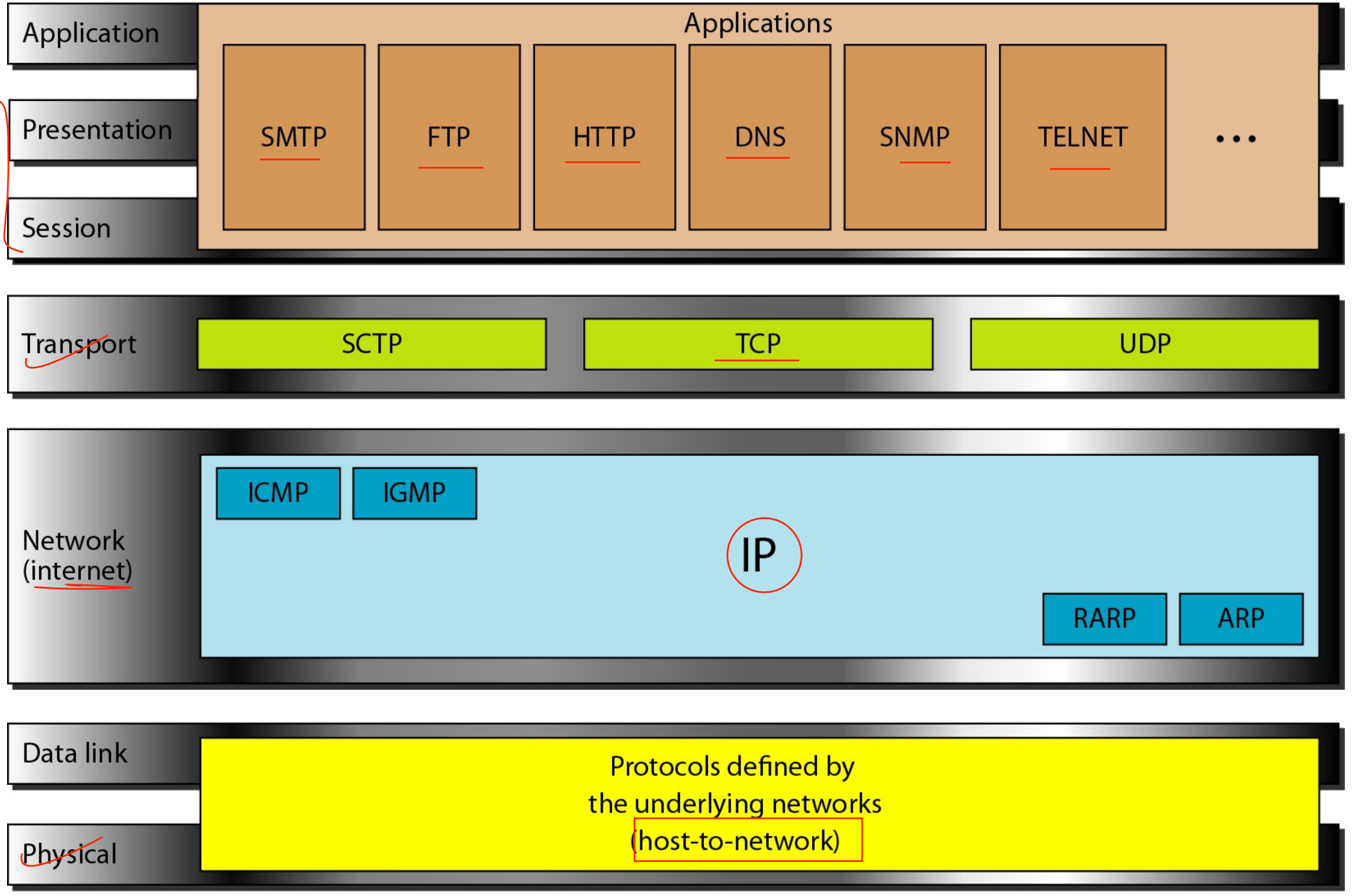
TCP/IP Protocol Suits

- 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.

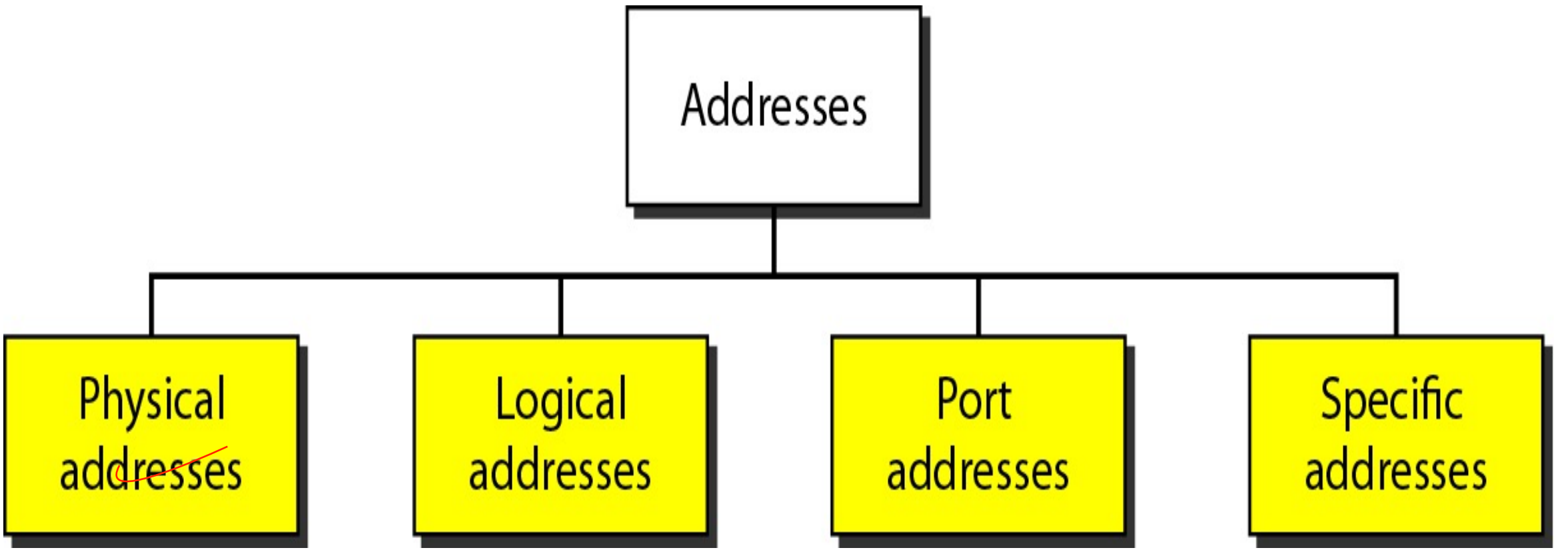
TCP/IP and OSI model



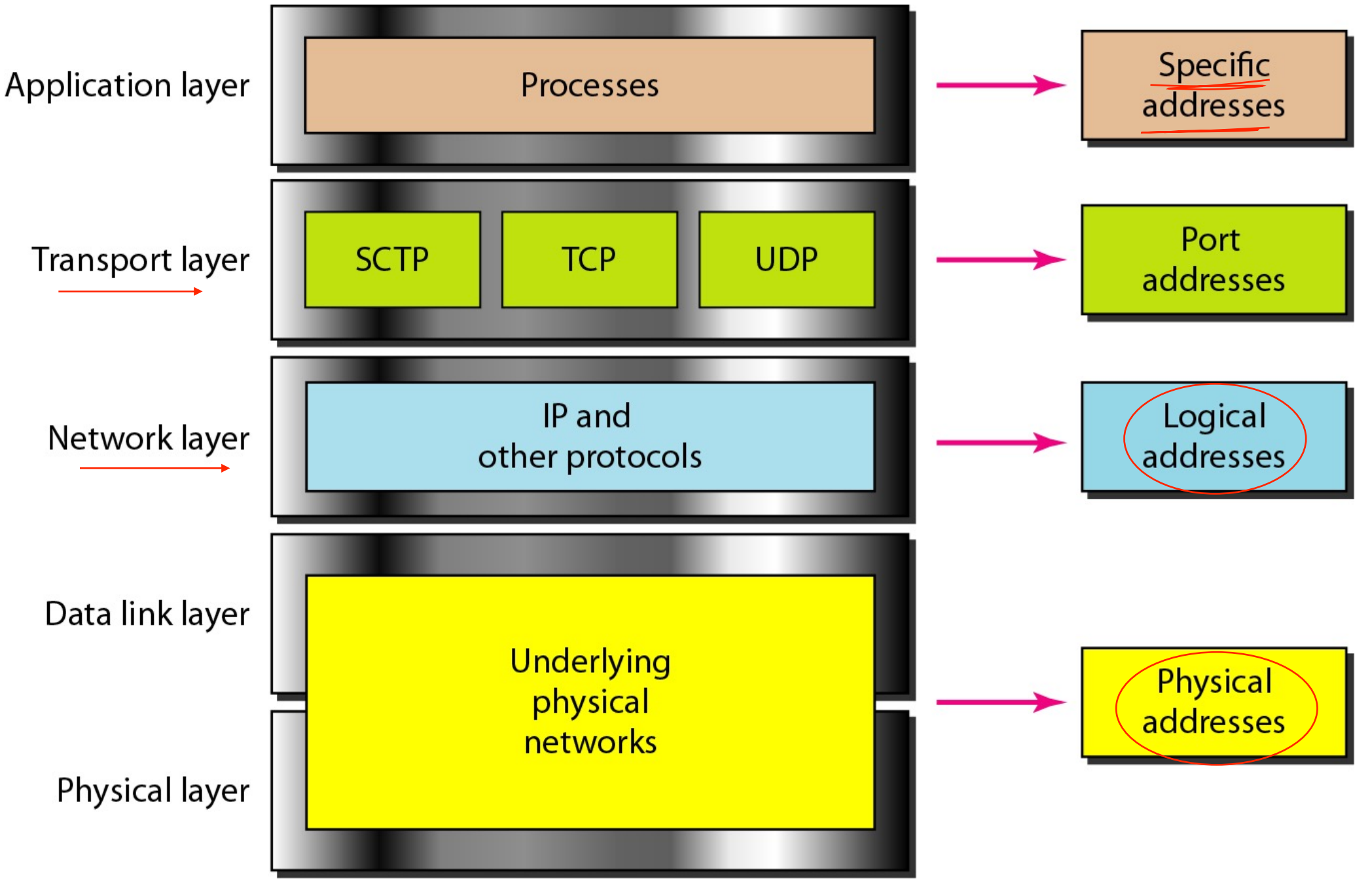
Addressing

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

Addresses in TCP/IP



Relationship of layers and addresses in TCP/IP



Application-Specific Addresses

- Some applications have user-friendly addresses that are designed for that specific application.
  - Examples: e-mail address (chandan@it.iiests.ac.in) and the Universal Resource Locator (URL) (www.iiests.ac.in).

Port Addresses

- There are many application running on the computer. Each application run with a port no.(logically) on the computer.
- A port number is part of the addressing information used to identify the senders and receivers of messages.
- Port numbers are most commonly used with TCP/IP connections.
- These port numbers allow different applications on the same computer to share network resources simultaneously.
- The physical addresses change from hop to hop, but the logical and port addresses usually remain the same.
  - Example: a port address is a 16-bit address represented by one decimal number **753**

Logical Addresses

- Logical addresses are used by networking software to allow packets to be independent of the physical connection of the network, that is, to work with different network topologies and types of media.
- A logical address in the Internet is currently a 32-bit address that can uniquely define a host connected to the Internet. An internet address in IPv4 in decimal numbers **132.24.75.9**
- No two publicly addressed and visible hosts on the Internet can have the same IP address.
- The physical addresses will change from hop to hop, but the logical addresses remain the same.
- The logical addresses can be either unicast (one single recipient), multicast (a group of recipients), or broadcast (all systems in the network). There are limitations on broadcast addresses.

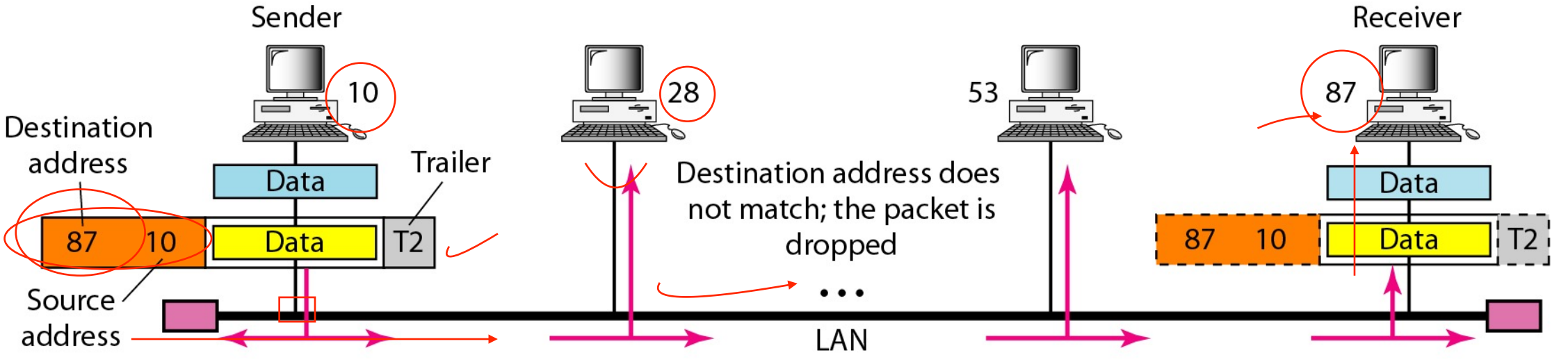
Physical Addresses

- The physical address, also known as the link address, is the address of a node as defined by its LAN or WAN.
- The size and format of these addresses vary depending on the network.
  - ***For example**, Ethernet uses a 6-byte (48-bit) physical address.*
- Physical addresses can be either unicast (one single recipient), multicast (a group of recipients), or broadcast (to be received by all systems in the network.
  - **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: A 6-byte (12 hexadecimal digits) physical address **07:01:02:01:2C:4B**

In a summary…

- **Address at Application layer:**
  - We use normally the names to define the site that provides services usch as xyz@pp.com (an email) or abc.org (web address) etc.
- **Address at Transport layer:**
  - Addresses are called port numbers and these defines the application-layer programs at the source and destination
  - Port numbers are local addresses that distinguish between several programs running at the same time.
- **Address at Network layer:**
  - Addresses are global, with the whole Internet as a scope.
  - Uniquely defines the connection of a device to the Internet
- **Address at Link-Layer:**
  - Called MAC-address, are locally defined addresses, each of which defines a specific host or router in a network (LAN or WAN)

Example 1: Physical addresses



- Here a node with physical address 10 sends a frame to a node with physical address 87.

- The two nodes are connected by a link (bus topology LAN).

- As the figure shows, the computer with physical address 10 is the sender, and the computer with physical address 87 is the receiver.

Most local-area networks use a 48-bit (6-byte) physical address (**called MAC address)**

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

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

Example 2: Logical Address

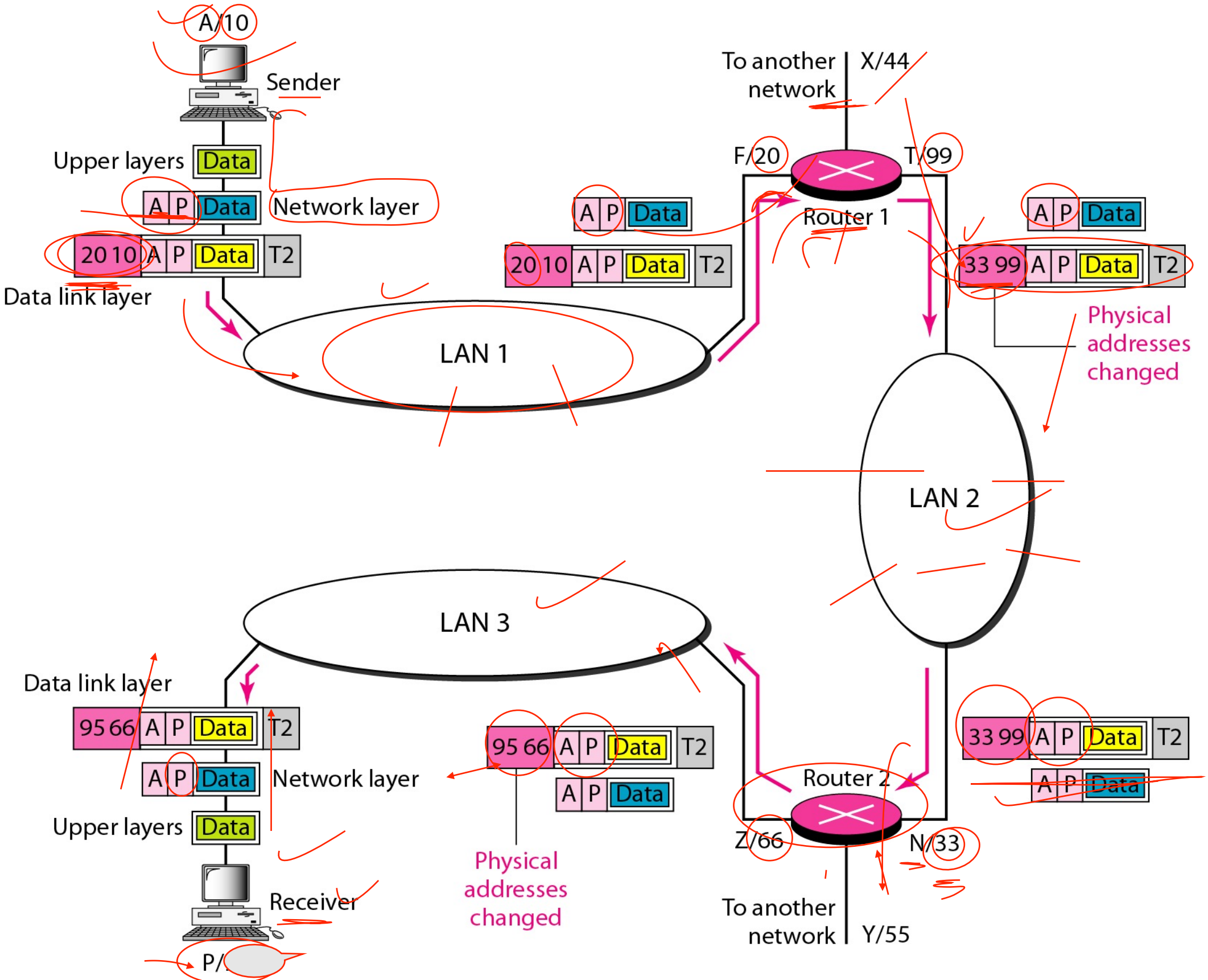
- Following figure shows a part of an internet with two routers connecting three LANs.

- Each device (computer or router) has a pair of addresses (logical and physical) for each connection.

- In this case, each computer is connected to only one link and therefore has only one pair of addresses.

- Each router, however, is connected to three networks (only two are shown in the figure). So each router has three pairs of addresses, one for each connection.

Figure : Logical Addresses



Note

The physical addresses will change from hop to hop, but the logical addresses usually remain the same.

Example 3 : Port Address

- Following figure shows two computers communicating via the Internet.

- The sending computer is running three processes at this time with port addresses a, b, and c.

- The receiving computer is running two processes at this time with port addresses j and k.

- Process a in the sending computer needs to communicate with process j in the receiving computer.

- Note that although physical addresses change from hop to hop, logical and port addresses remain the same from the source to destination.

Figure : *Port addresses*