Outline

- A preliminary overview
- Propagation characteristics
- **ISO-OSI Model**
- Physical layer: modulation
- MAC layer:
  - Fixed resource assignment
  - Random access
    - Ethernet (CSMA/CD)
    - WiFi (CSMA/CA)
- Personal Area Networks
  - Bluetooth
  - Zigbee
- Cellular network dimensioning
- Cellular networks
  - From GSM (2G) to UMTS (3G)
  - LTE (4G)

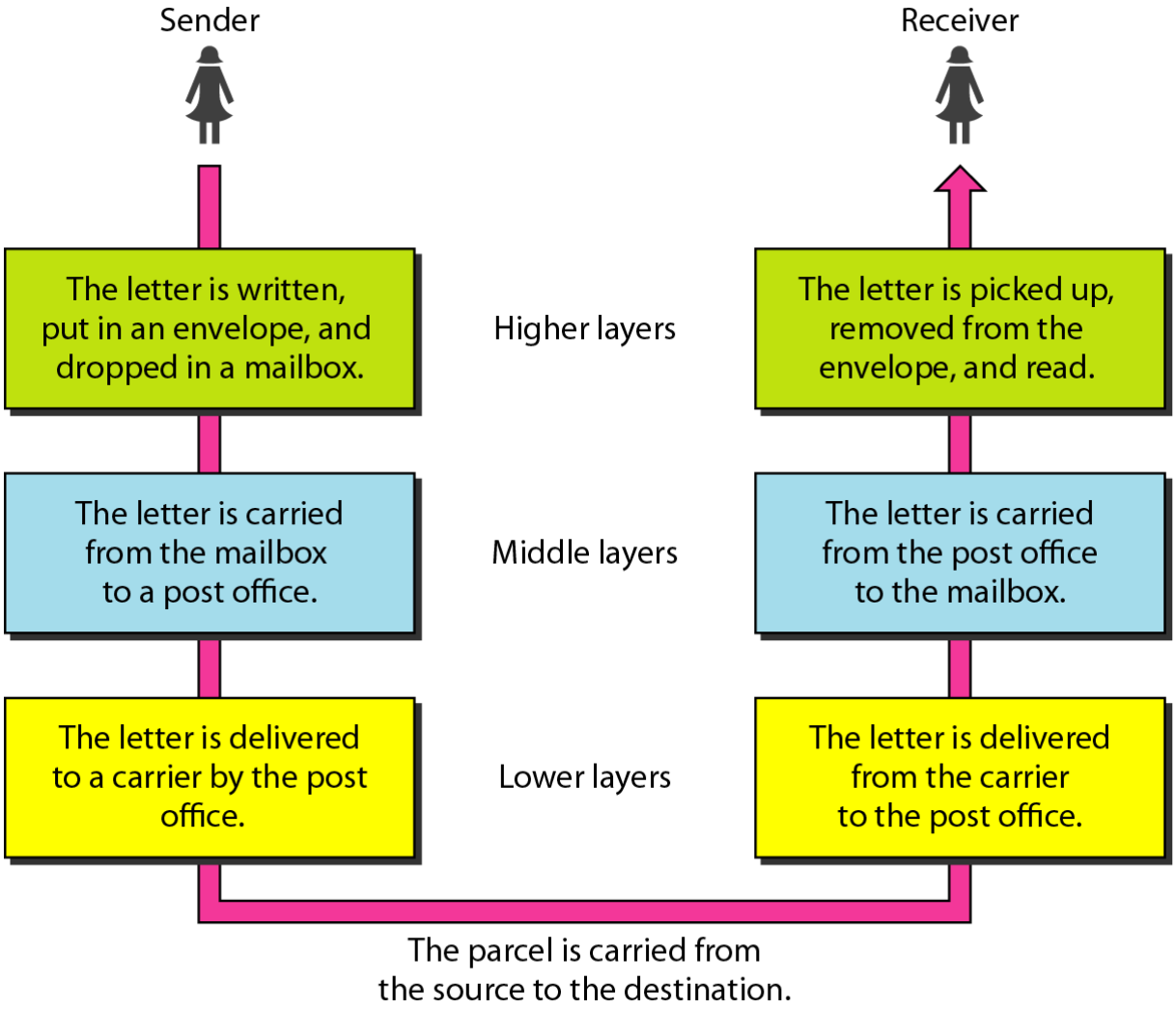
Layered Tasks

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.

Main concepts:

- Sender, receiver, and carrier
- Hierarchy

Tasks involved in sending a letter



The OSI Model

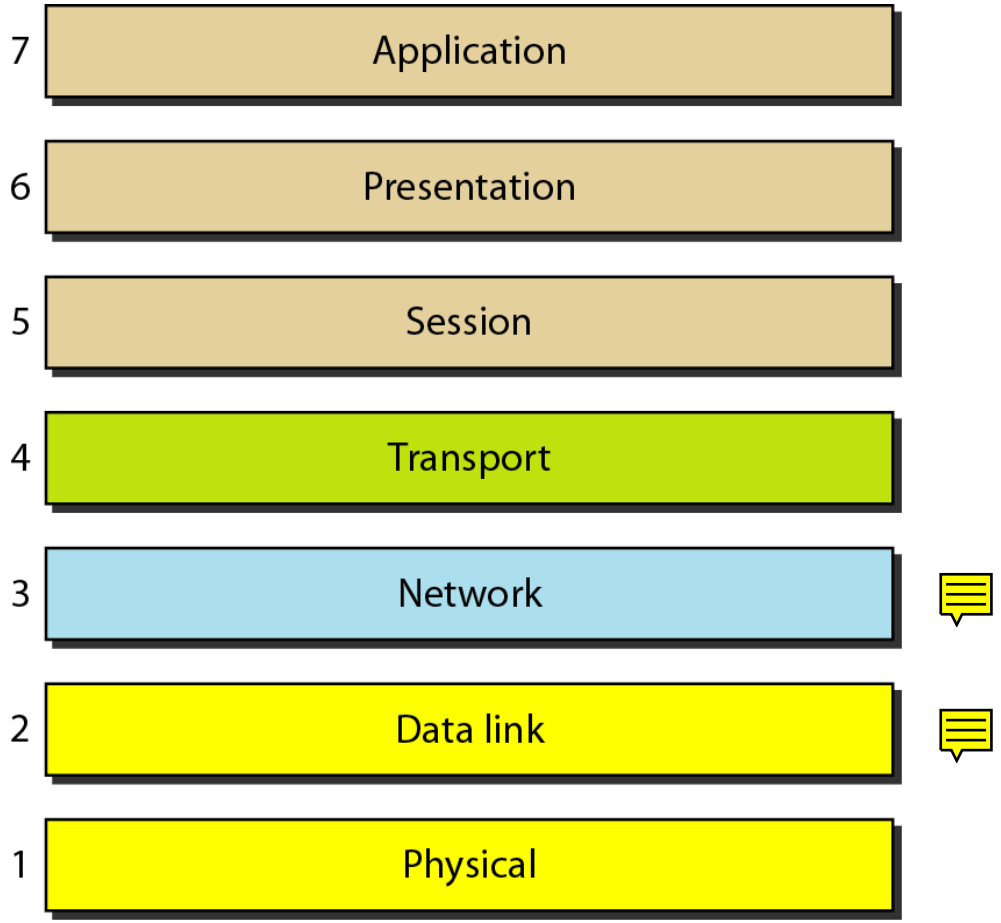
Established in 1947, the International Standards Organization (ISO) is a multinational body dedicated to worldwide agreement on international standards. An ISO standard that covers all aspects of network communications is the Open Systems Interconnection (OSI) model. It was first introduced in the late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

ISO is the organization.
OSI is the model.

Main concepts:

- Layered architecture
- Peer-to-peer processes
- Encapsulation

The Seven Layers of the OSI Model



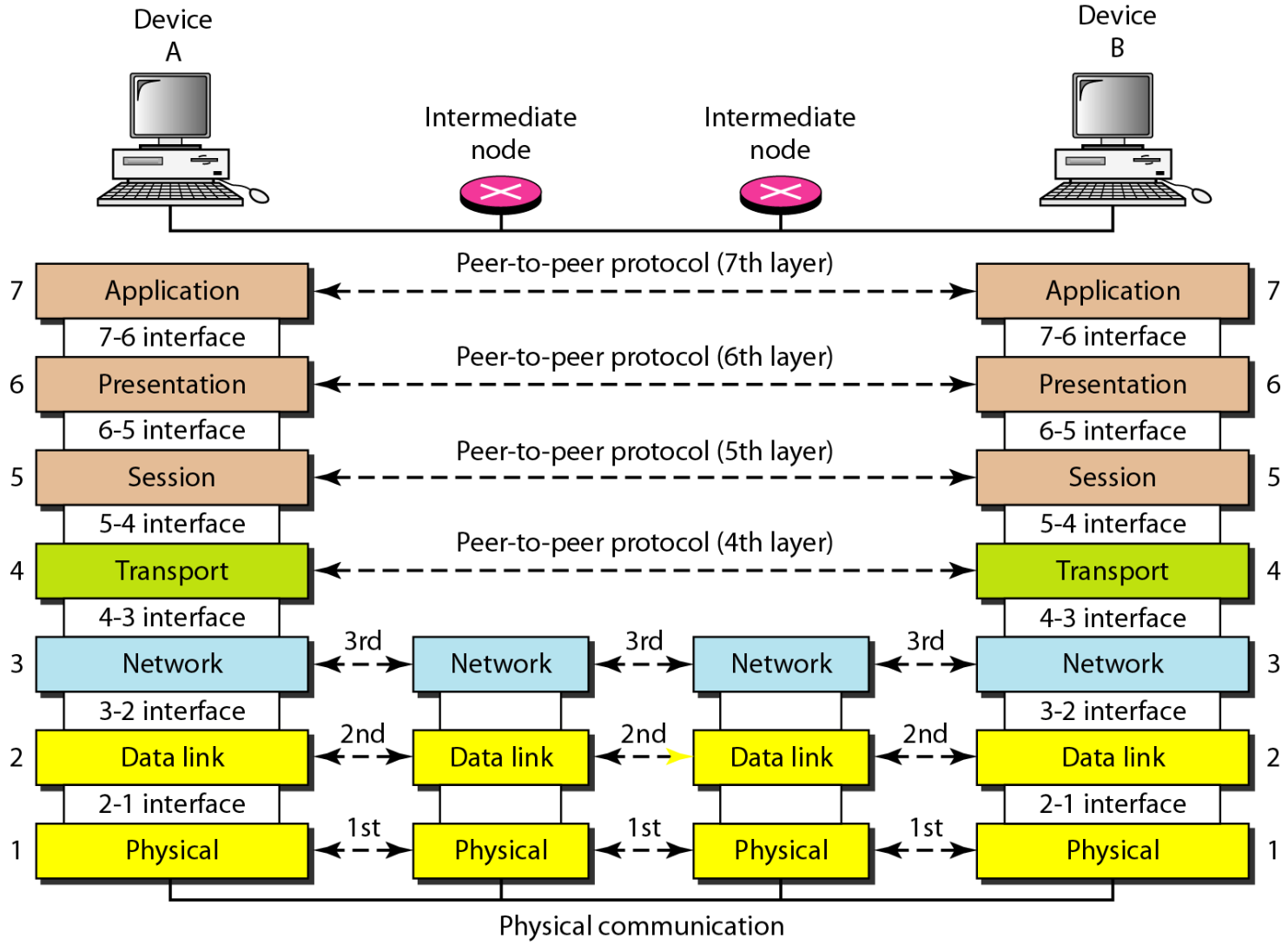
The Seven Layers of the OSI Model (ctd)

Layer	Responsible For:
7.) Application	Provides Services to User Apps
6.) Presentation	Data Representation
5.) Session	Communication Between Hosts
4.) Transport	Flow Ctrl, Error Detection/Correction
3.) Network	End to End Delivery, Logical Addr
2.) Data Link	Media Access Ctrl, Physical Addr
1.) Physical	Medium, Interfaces, Puts Bits on Med.

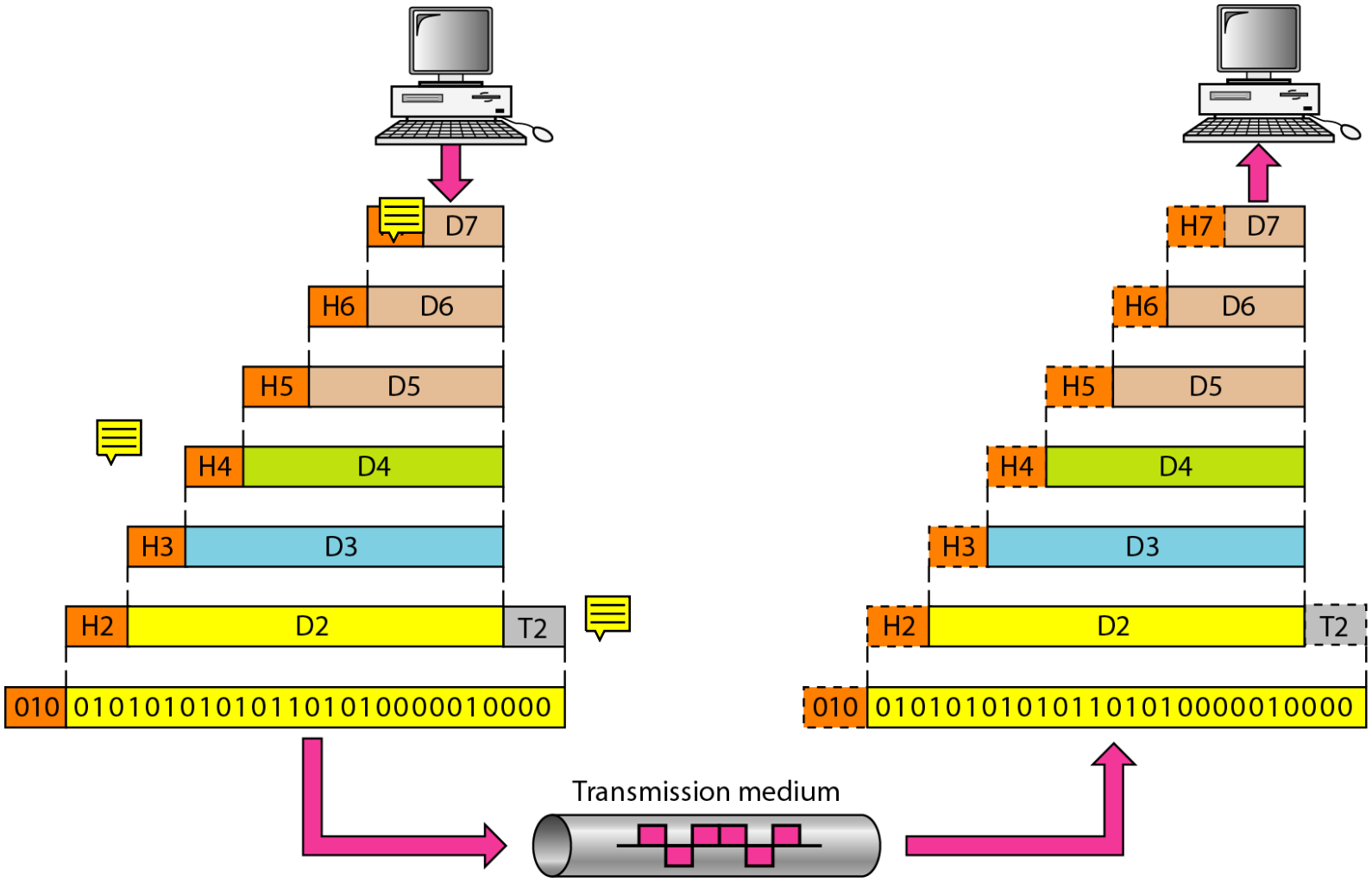
Examples

Layer	Example
7.) Application	HTTP, FTP, SMTP
6.) Presentation	ASCII, JPEG, PGP
5.) Session	BOOTP, NetBIOS, DHCP, DNS
4.) Transport	TCP, UDP, SPX
3.) Network	IP, IPX, ICMP
2.) Data Link	Ethernet, Token Ring, Frame Relay
1.) Physical	Bits, Interfaces, Hubs

The interaction between layers in the OSI Model



An exchange using the OSI model

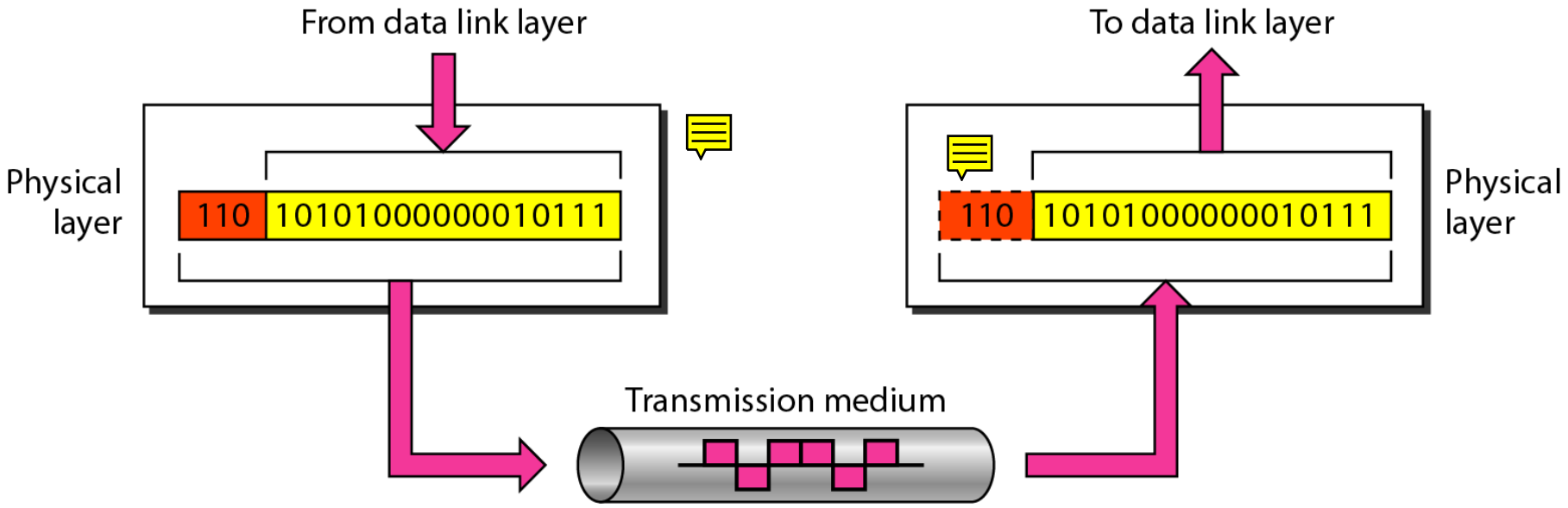


Layers in the OSI model

In this section we briefly describe the functions of each layer in the OSI model

- Physical Layer
  Data Link Layer
- Network Layer
- Transport Layer
- Session Layer
- Presentation Layer
- Application Layer

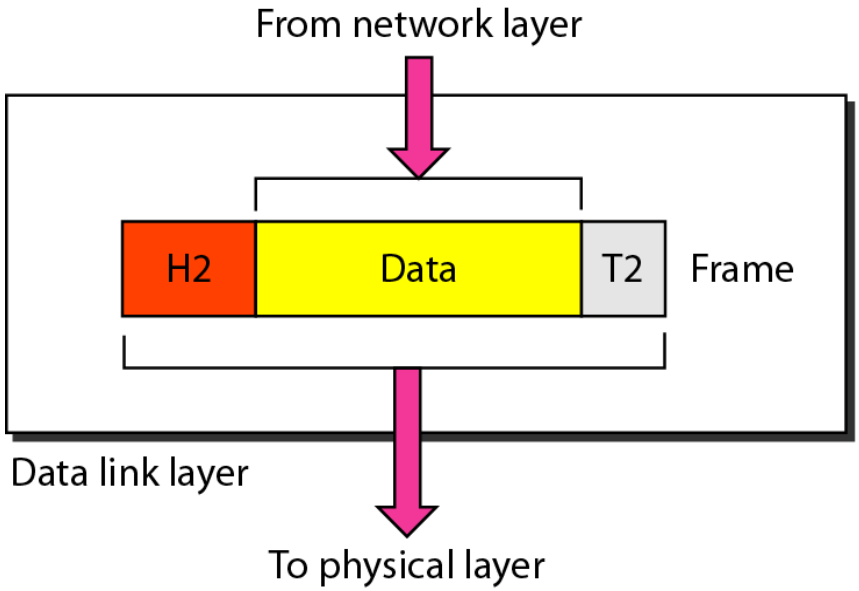
Physical Layer

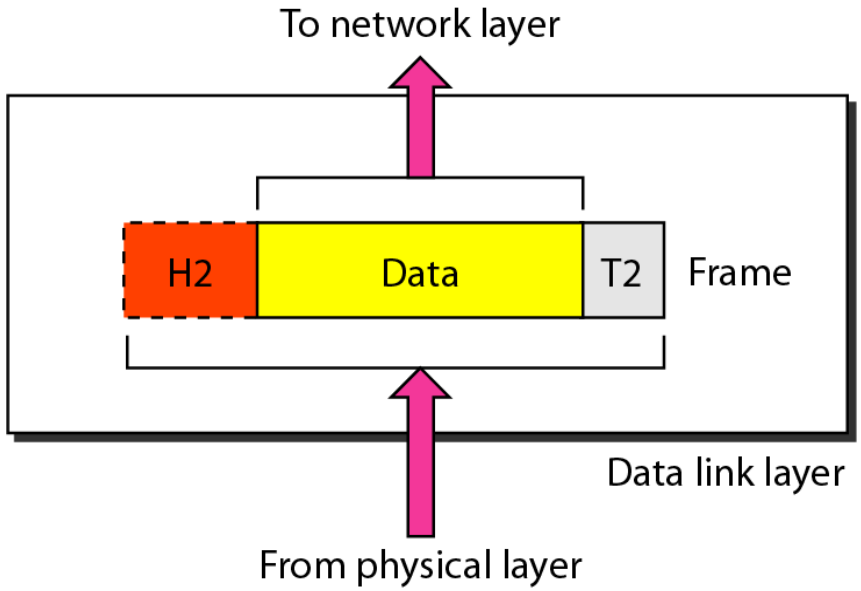


Physical Layer (ctd)

- The physical layer is responsible for movements of individual bits from one hop (node) to the next.
- Defines physical medium and interfaces
- Determines how bits are represented
- Controls transmission rate & bit synchronization
- Controls transmission mode: simplex, half-duplex, & full duplex
- PDU: Bits
- Devices: hubs, cables, connectors, etc…

Data Link Layer

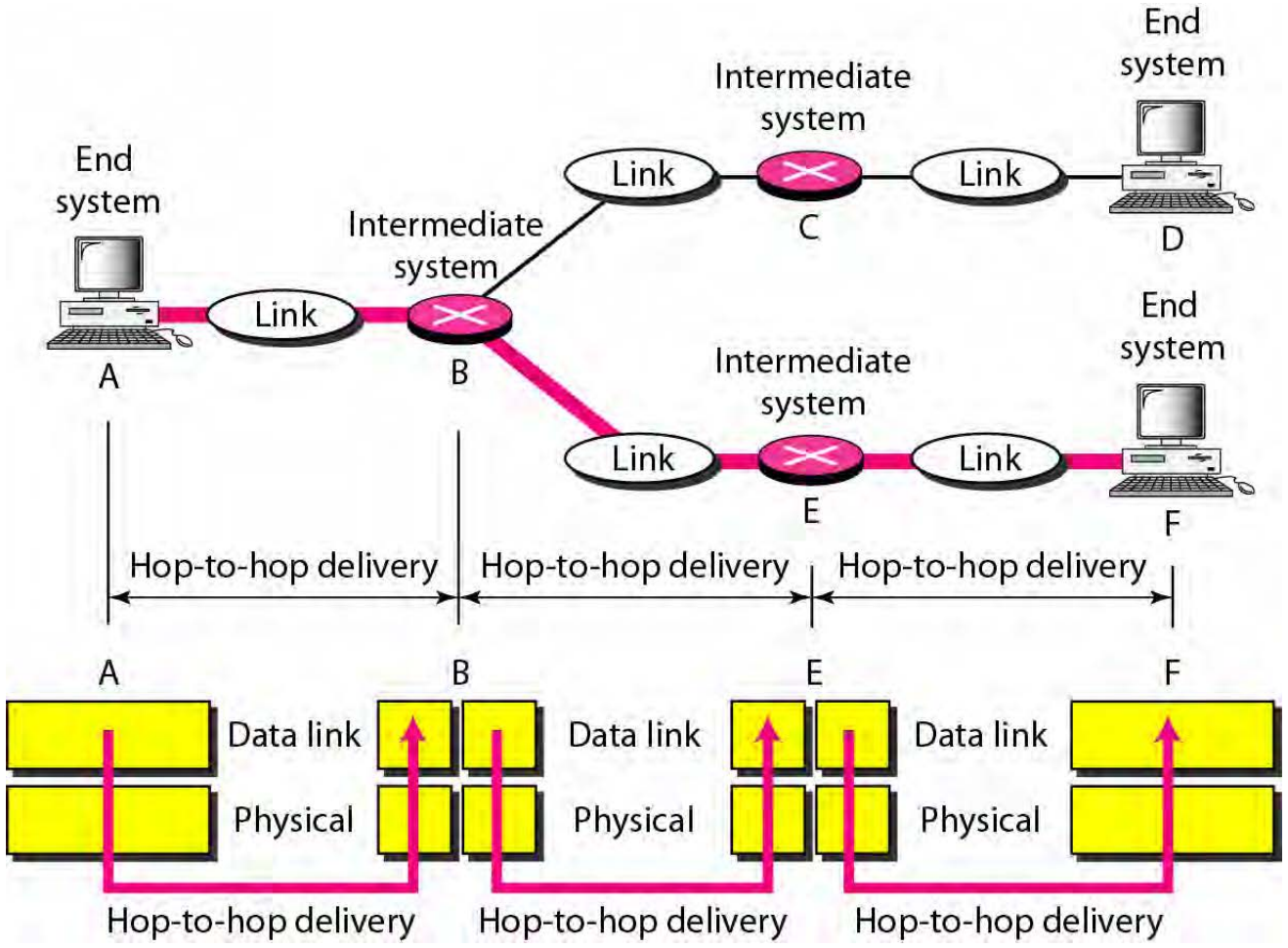




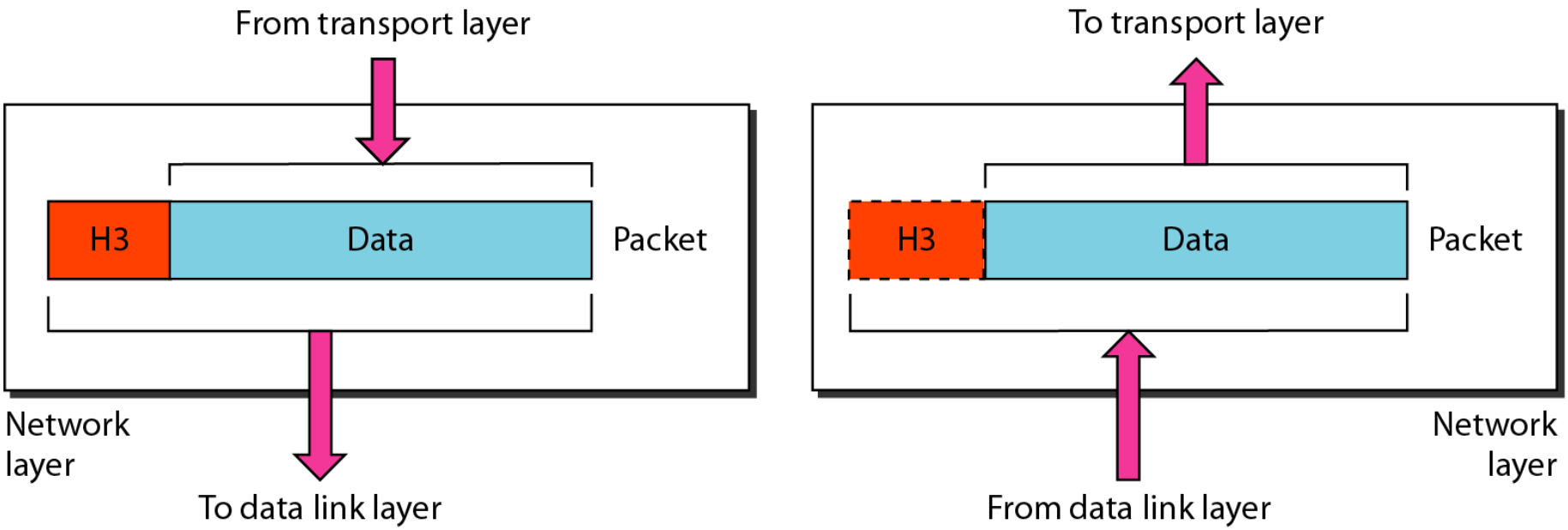
Data Link Layer (ctd)

- The data link layer is responsible for moving frames from one hop (node) to the next.
- PDU: Frames
- Keeps Link alive & provides connection for upper layer protocols
- Based on physical (flat) address space
- Physical addresses are fixed and don't change when the node is moved
- Medium/media access control
- Flow control and error detection/correction at the frame level. Think collisions…
- Topology
- Ex: Ethernet, Token Ring, ISDN
- Sublayers: MAC (framing, addressing, & MAC) & LLC (logical link control – gives error control & flow control)
- Devices: switches, bridges, NIC's

Hop-to-hop delivery



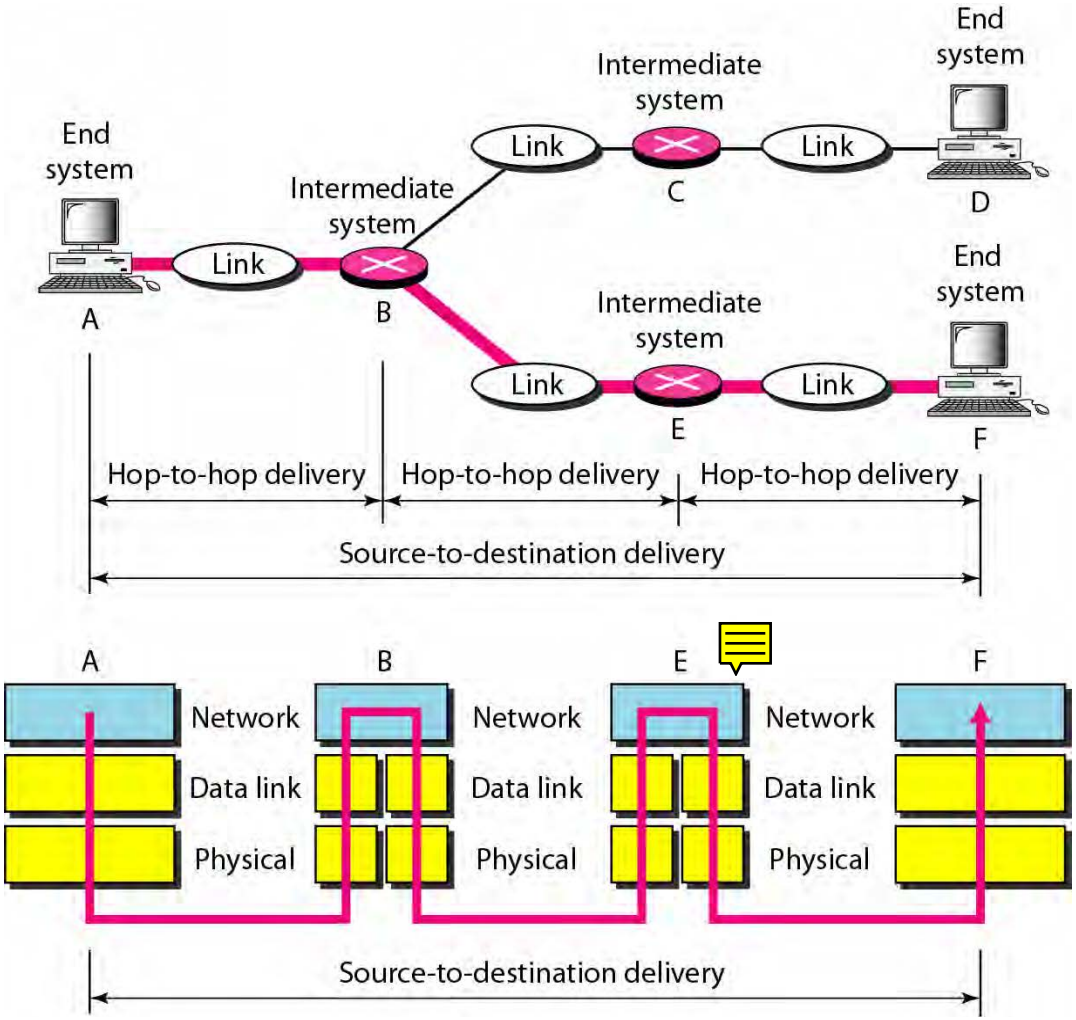
Network Layer



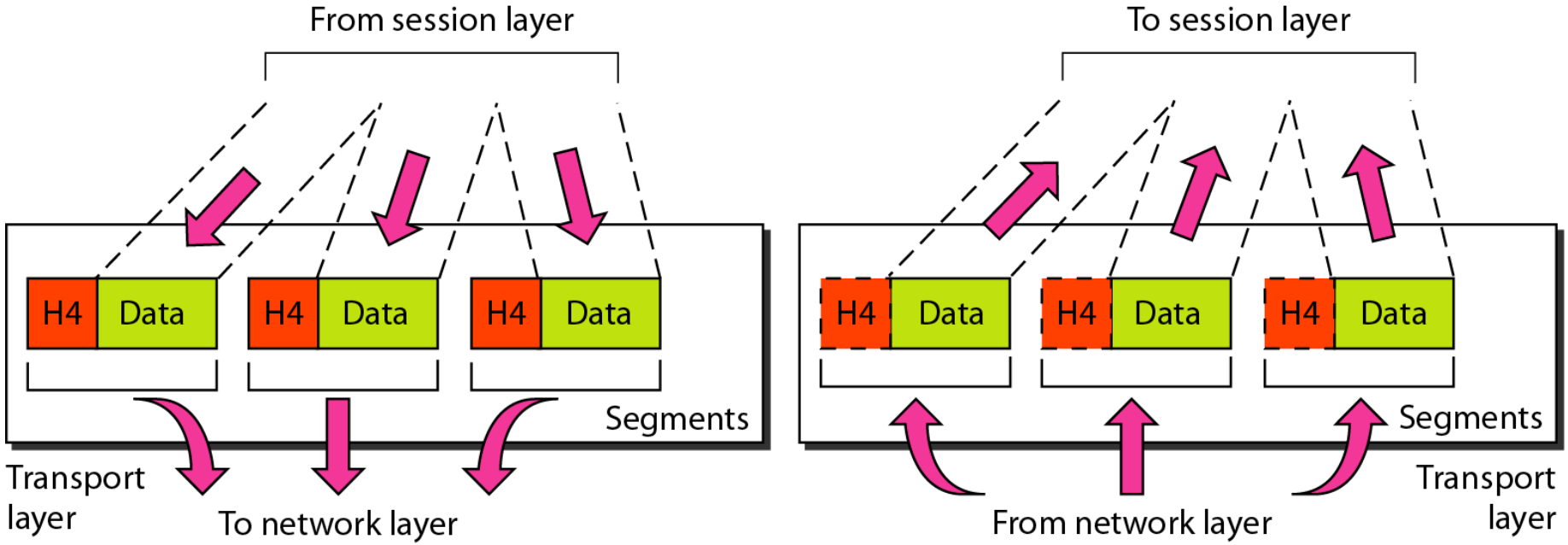
Network Layer (ctd)

- The network layer is responsible for the delivery of individual packets from the source host to the destination host
- PDU: Packet
- End to end delivery of packets
- Creates logical paths
- Path determination (routing)
- Hides the lower layers making things hardware independent
- Uses logical hierarchical addresses
- Logical hierarchical addresses do change when a node is moved to a new subnet
- Devices: routers, firewalls

Source-to-destination delivery



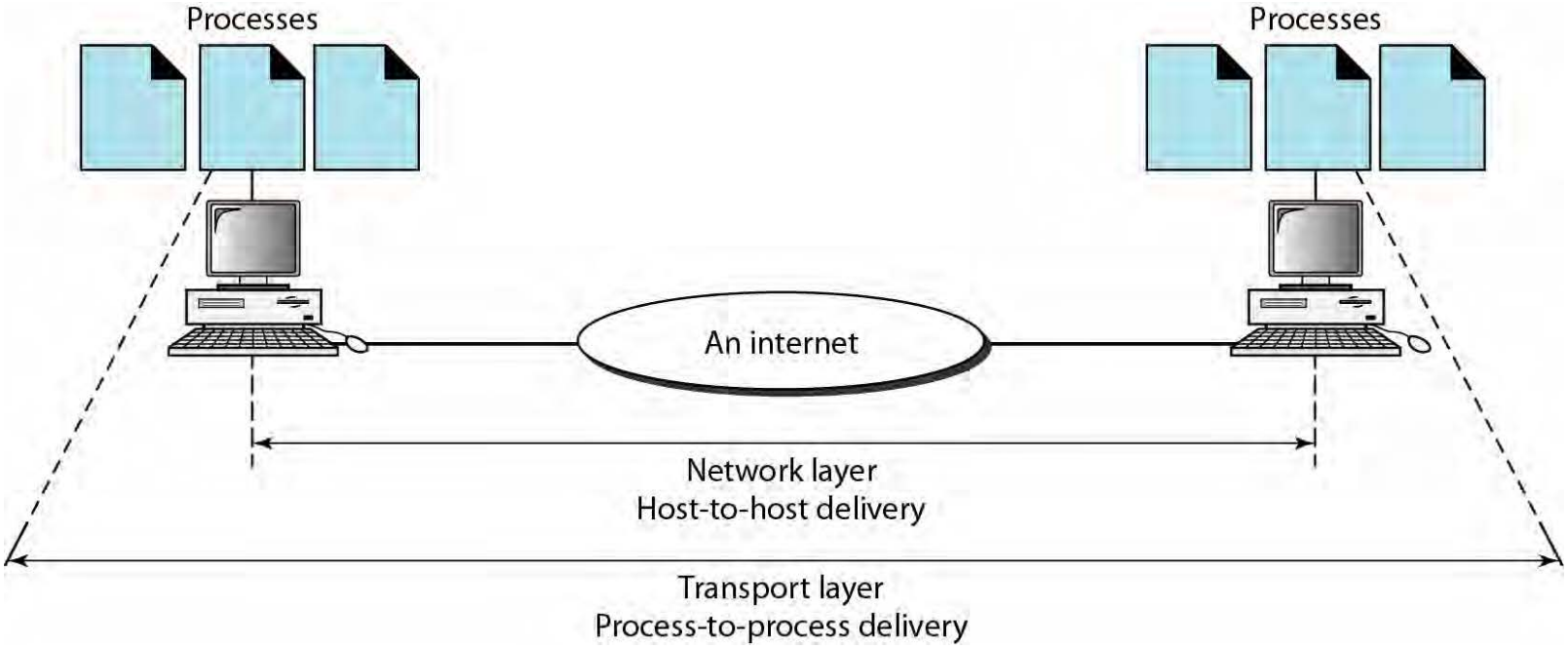
Transport Layer



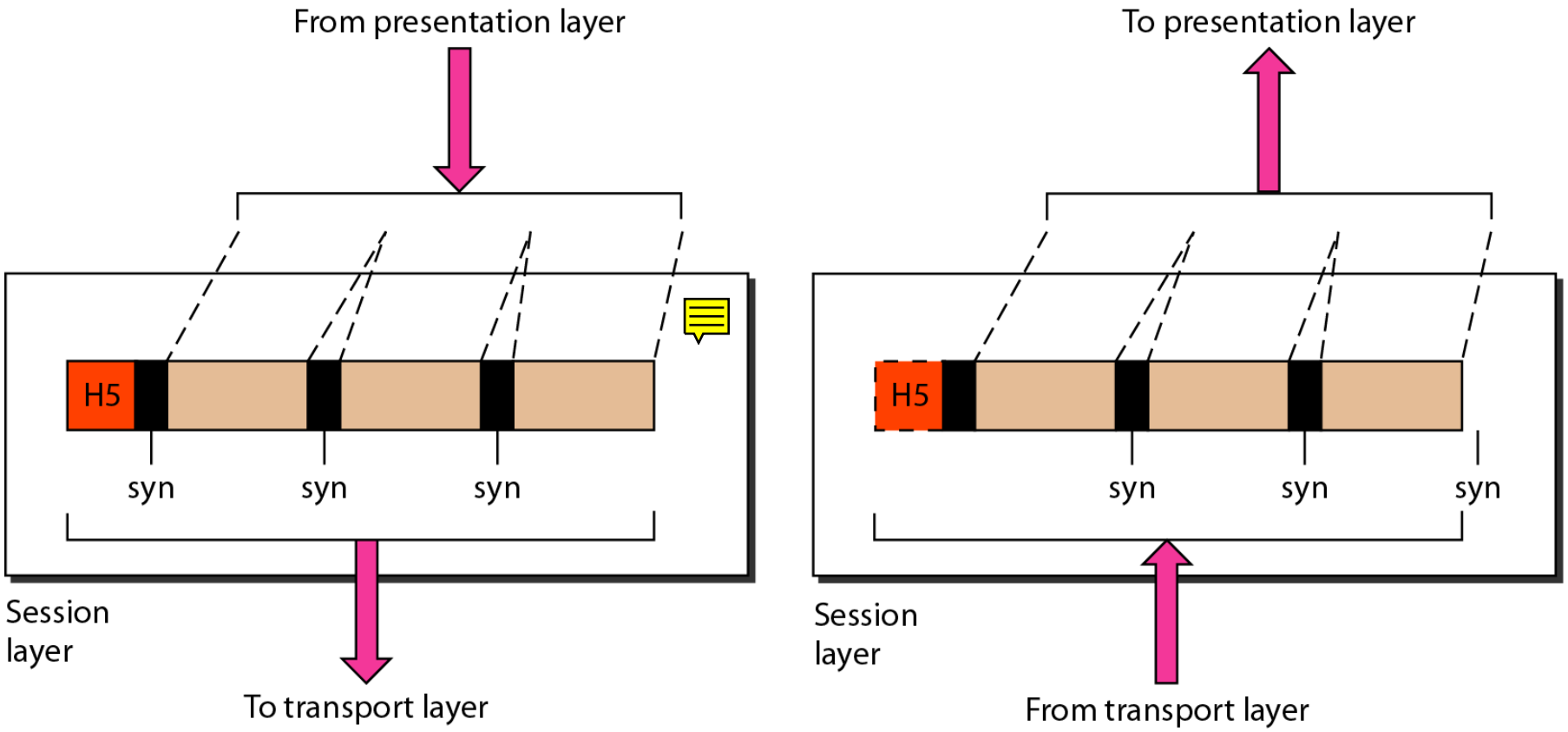
Transport Layer (ctd)

- The transport layer is responsible for the delivery of a message from one process to another
- PDU: Segment
- Service Point Address (more often called a port) used to track multiple sessions between the same systems. SPA's are used to allow a node to offer more than one service (i.e. it could offer both mail and web services)
- This layer is why you have to specify TCP or UDP when dealing with TCP/IP
- Must reassemble segments into data using sequence numbers
- Can use either connectionless or connection oriented sessions
- Connectionless sessions rely on upper layer protocols for error control and are often used for faster less reliable links
- Ex: UDP (used by things like NFS & DNS)
- Connection oriented sessions require the sender to first request a connection, the receiver to acknowledge the connection, and that they negotiate how much data can be sent/received before its reception is acknowledged
- Uses acknowledgements & retransmission for error correction
- Example: TCP (used by things like telnet, http)

Reliable process-to-process delivery of a message



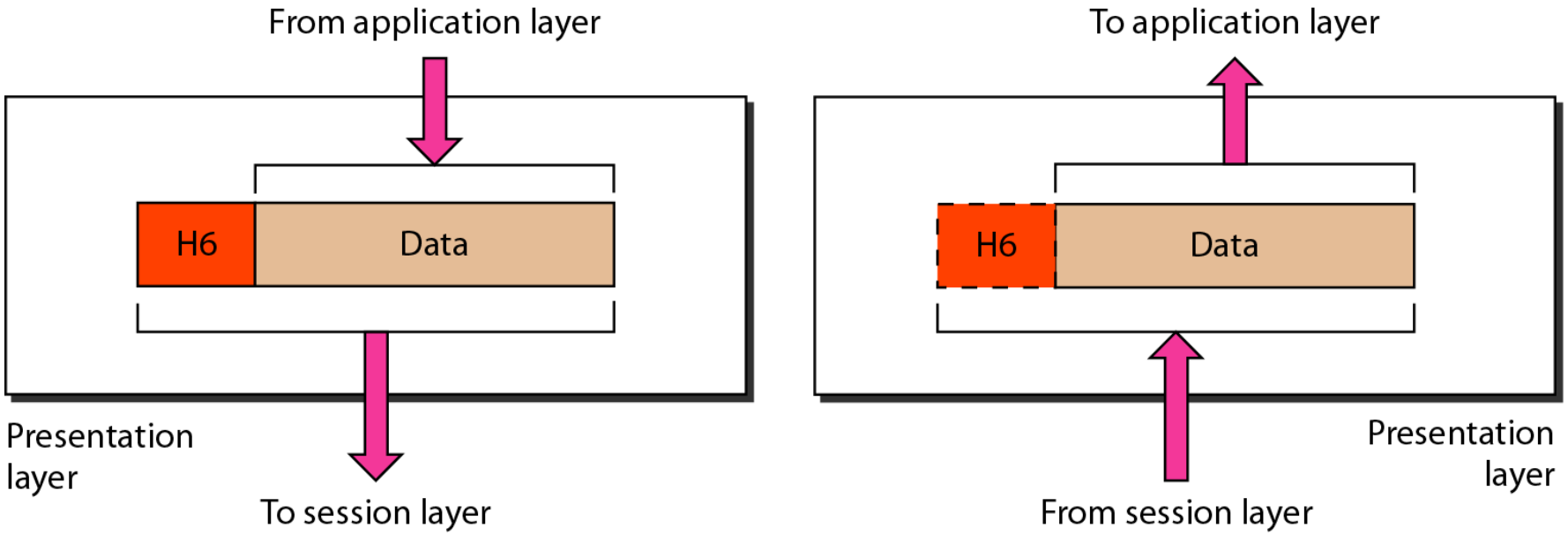
Session layer



Session layer (ctd)

- The session layer is responsible for dialog control and synchronization
- PDU: Data (from here on up)
- Sometimes called the dialog controller, this layer establishes, maintains, and terminates sessions between applications
- Sets duplex between applications
- Defines checkpoints for acknowledgements during sessions between applications
- Provides atomization – Multiple connections can be treated as one virtual session. If one fails or is terminated, all should be terminated.
- Identifies raw data as either application data or session control information
- Uses fields provided by layers 3 & 4 to track dialogs between applications / services
- Provides translations for naming services
- Ex: RPC, X-Windows, LDAP, NFS

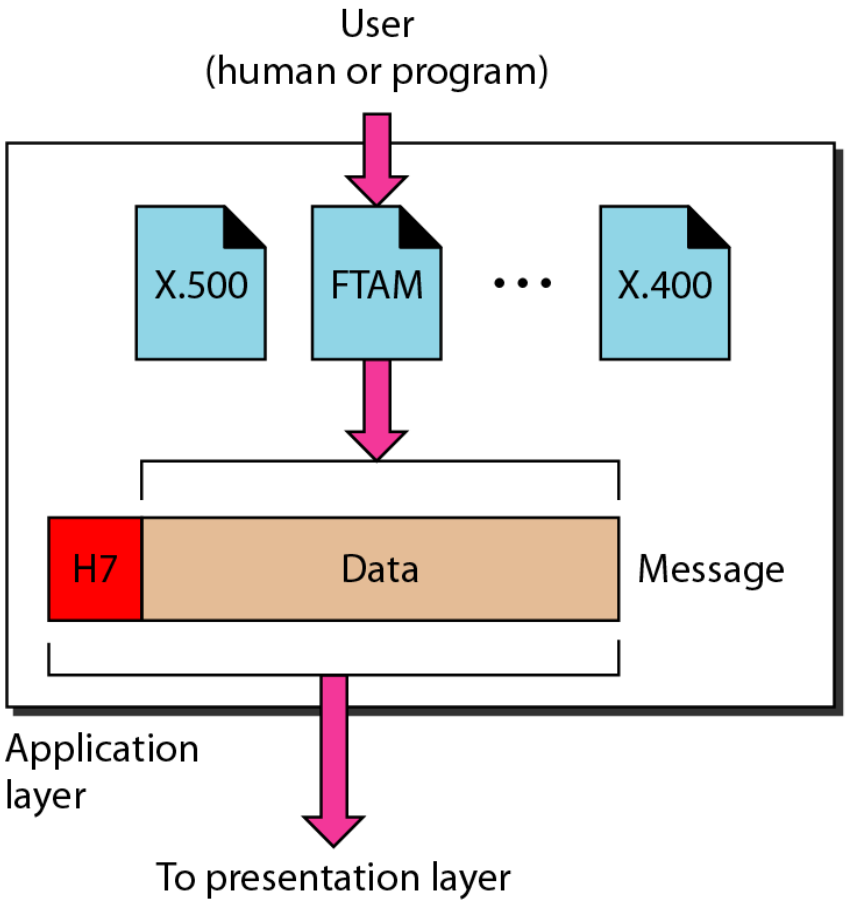
Presentation layer

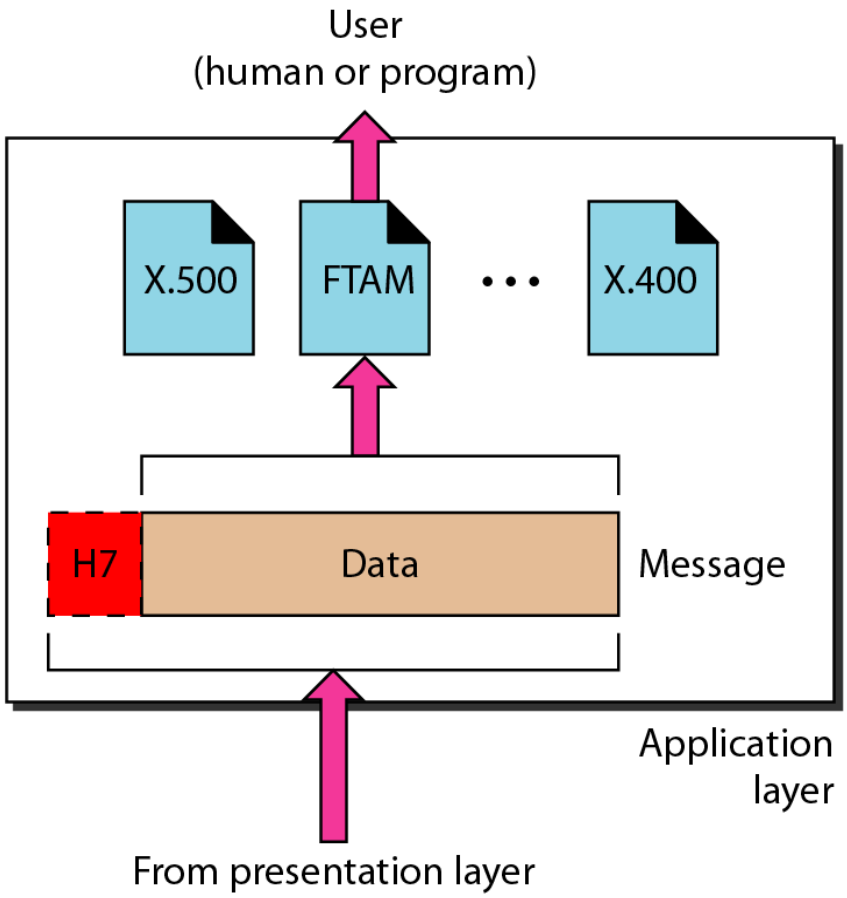


Presentation layer (ctd)

- The presentation layer is responsible for translation, compression, and encryption
- Data formatting, translation, encryption, and compression
- Ex: ASCII, EBCDIC, HTML, JPEG

Application layer

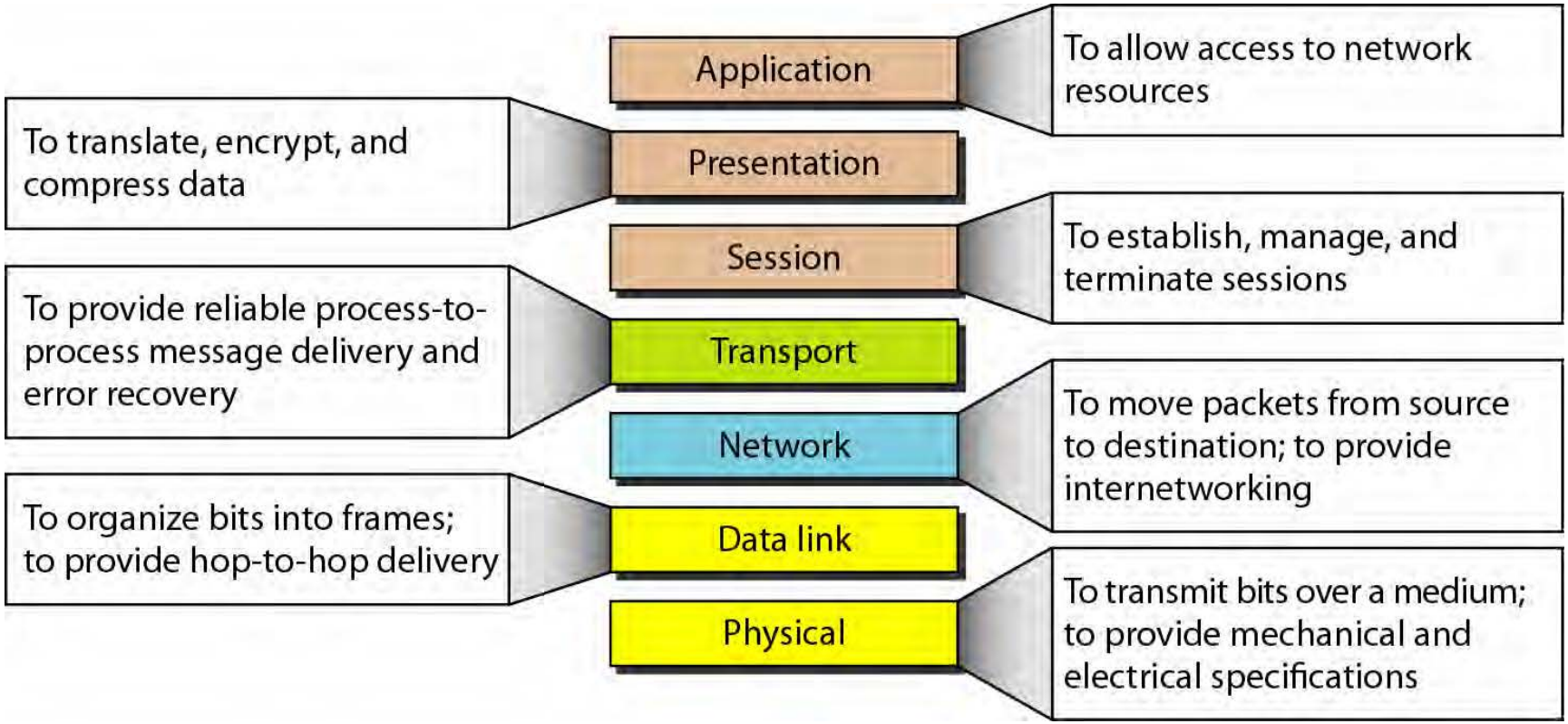




Application layer (ctd)

- The application layer is responsible for providing services to the user
- Provides communication services to applications
- Ex: HTTP, FTP, SMTP

Summary of layers

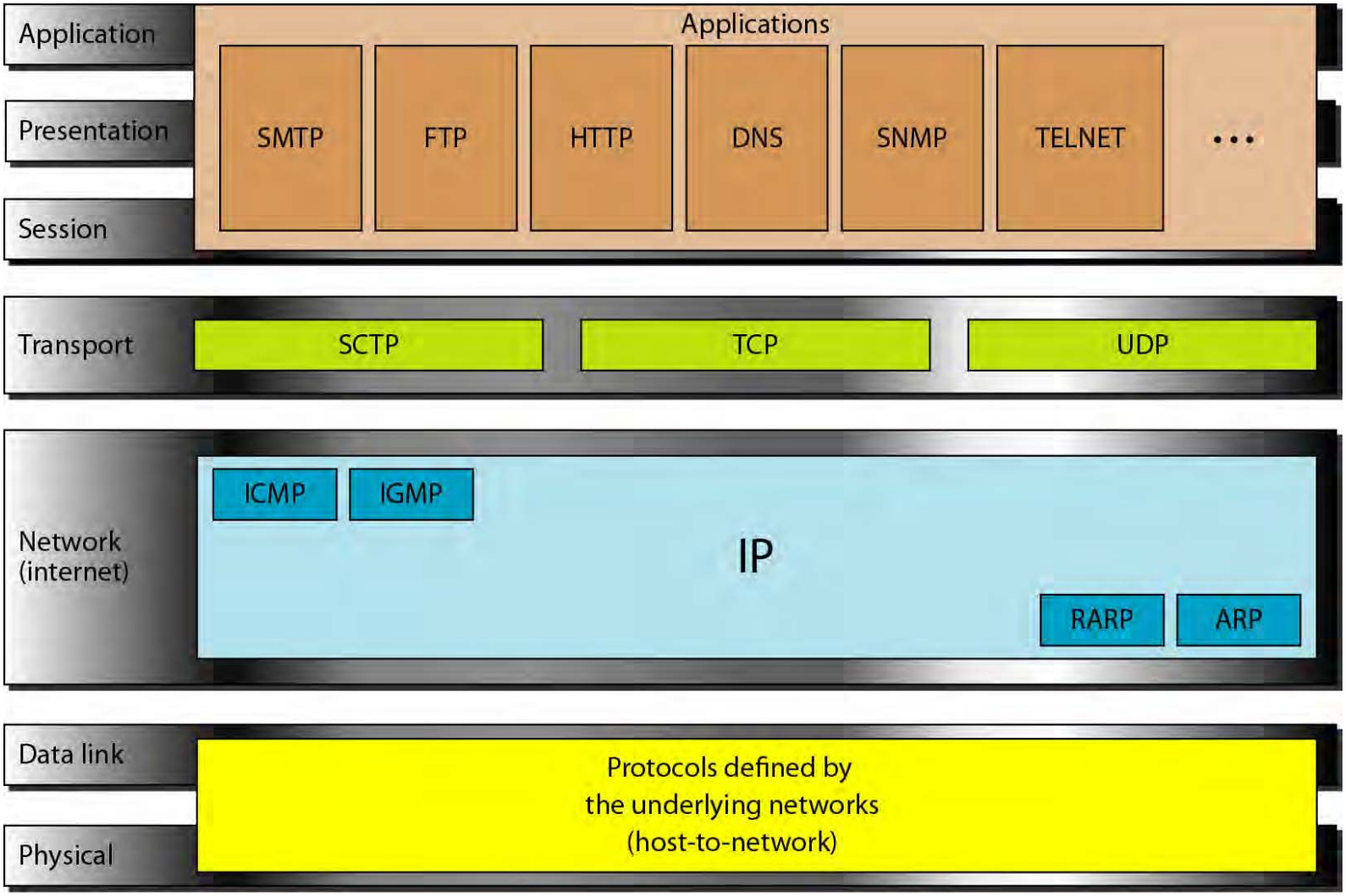


TCP/IP Protocol Suite

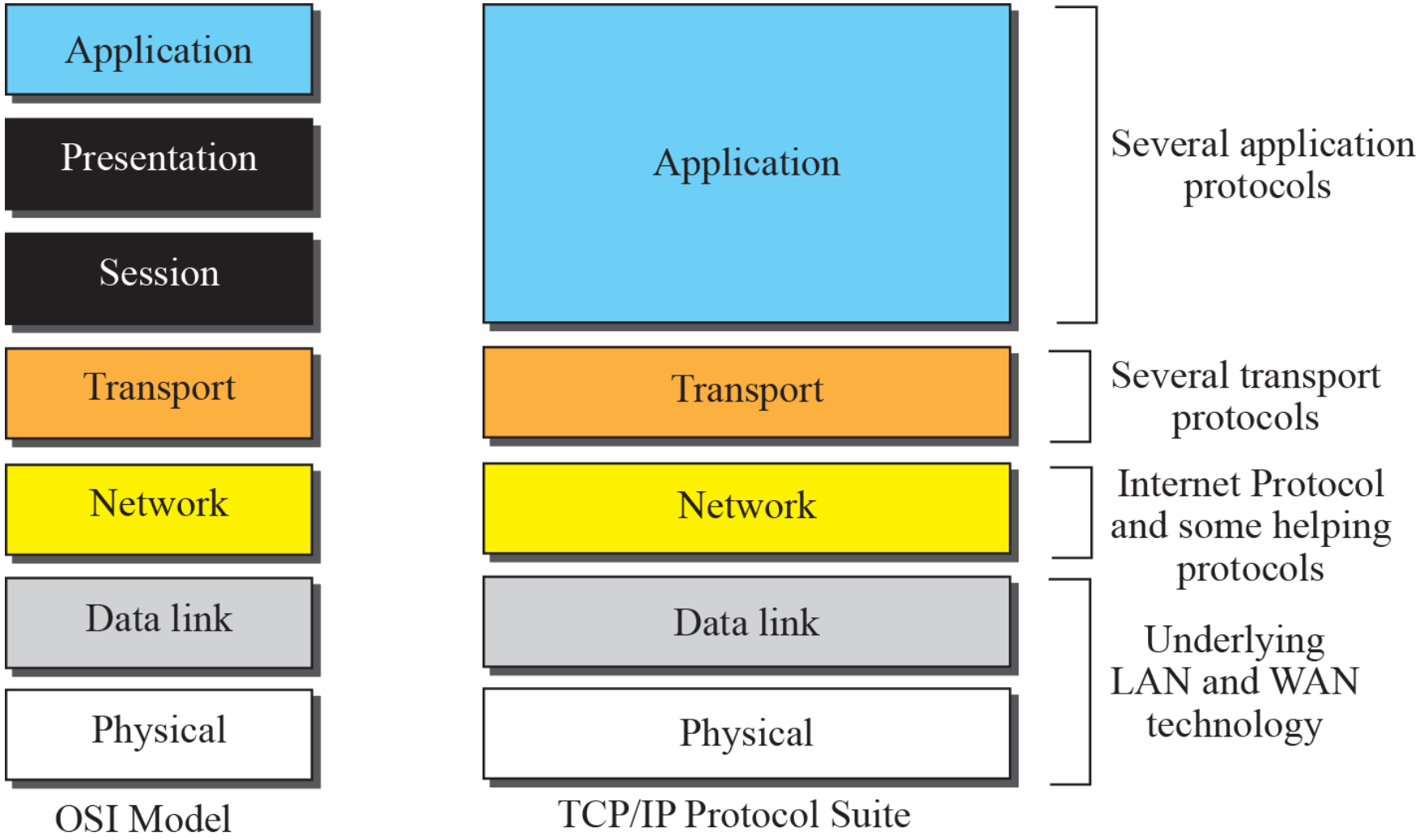
The layers in the TCP/IP protocol suite do not exactly match those in the OSI model. The original TCP/IP protocol suite was defined as having four layers: host-to-network, internet, transport, and application. However, when TCP/IP is compared to OSI, we can say that the TCP/IP protocol suite is made of five layers:

- Application
- Transport
- Network
- Data link
- Physical

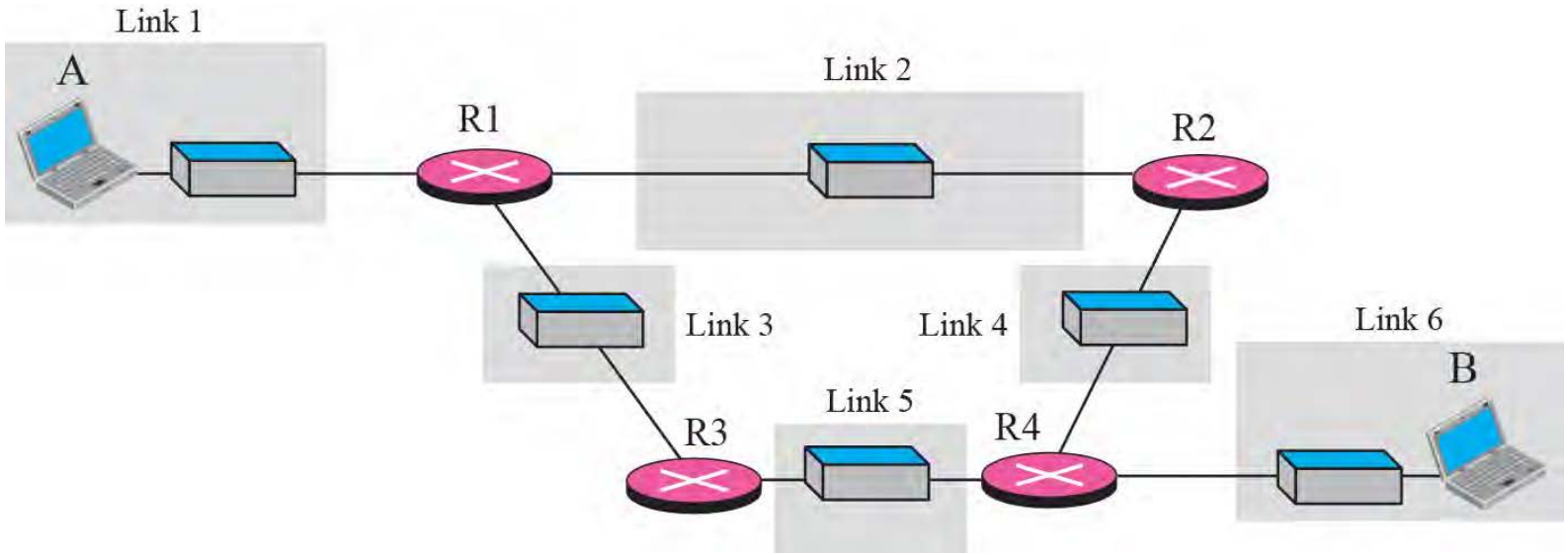
TCP/IP and OSI model



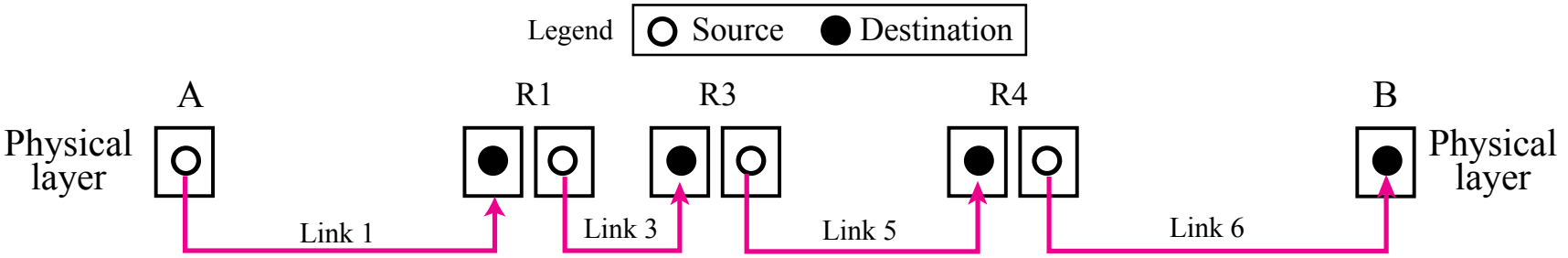
TCP/IP and OSI model

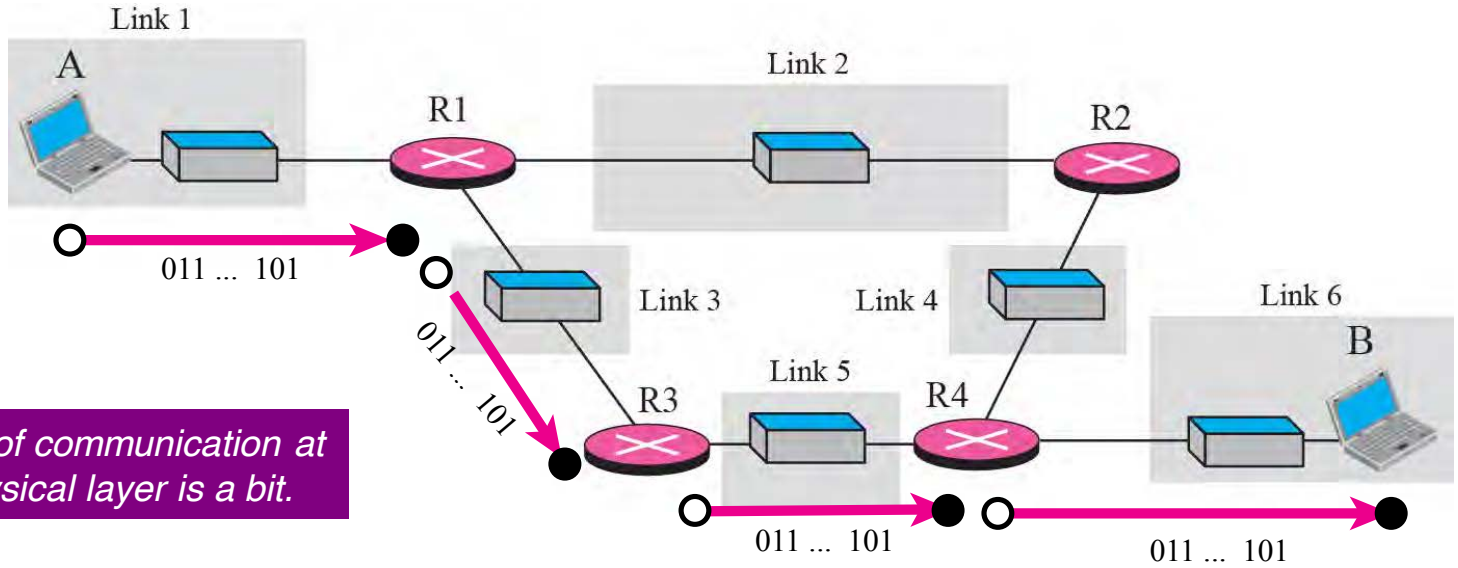


A private internet



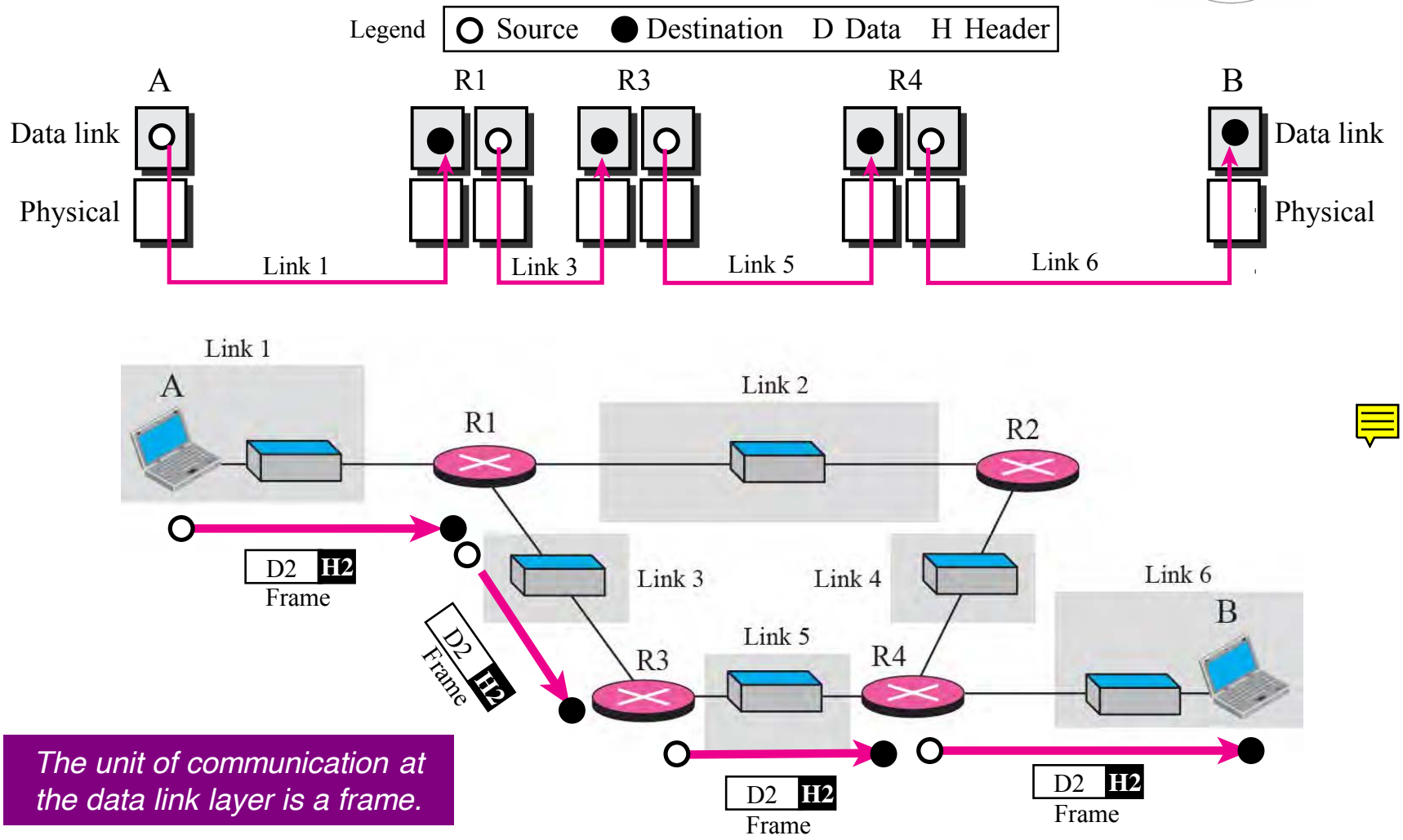
Communication at the physical layer





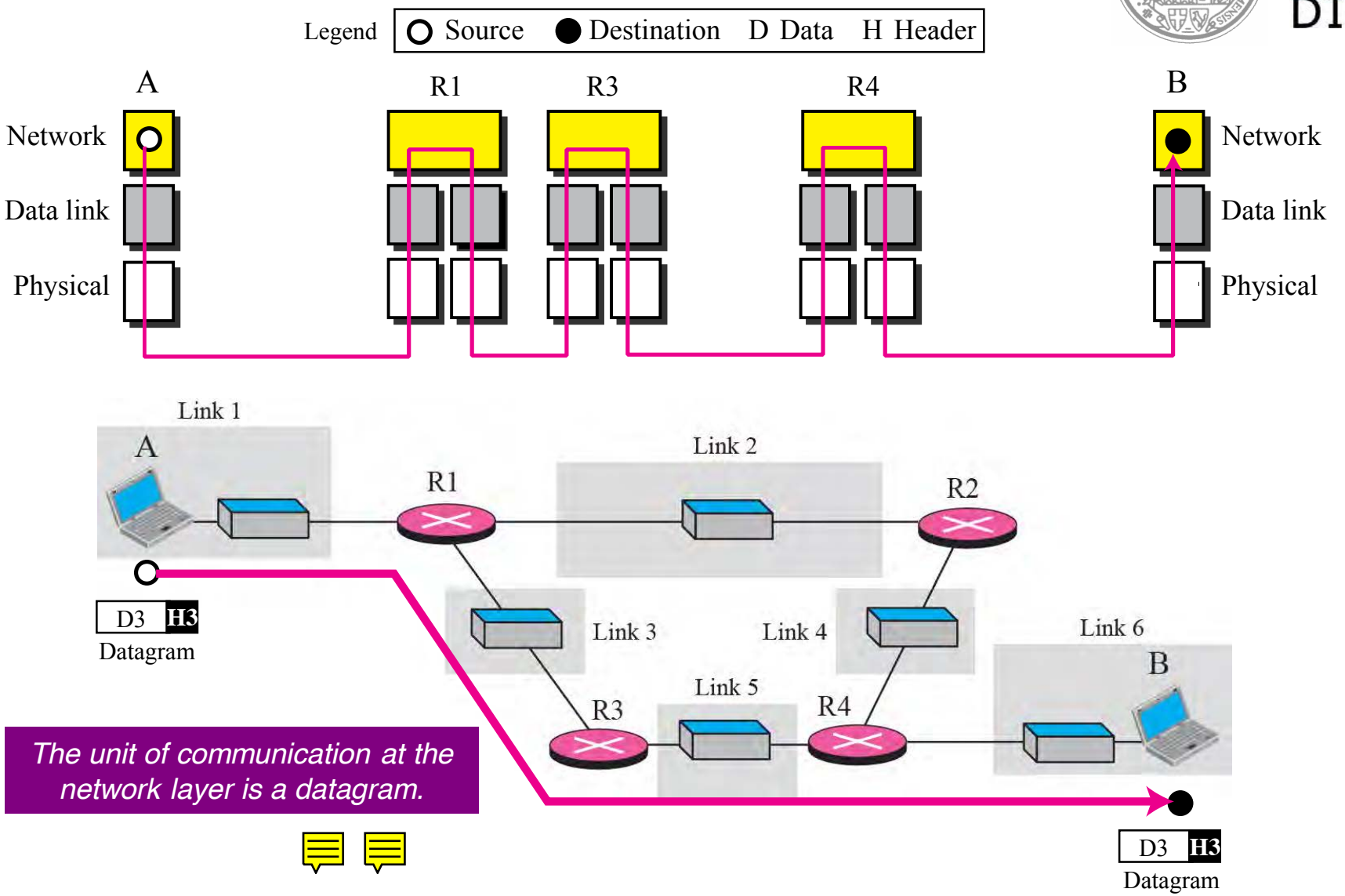
The unit of communication at the physical layer is a bit.

Communication at the data link layer



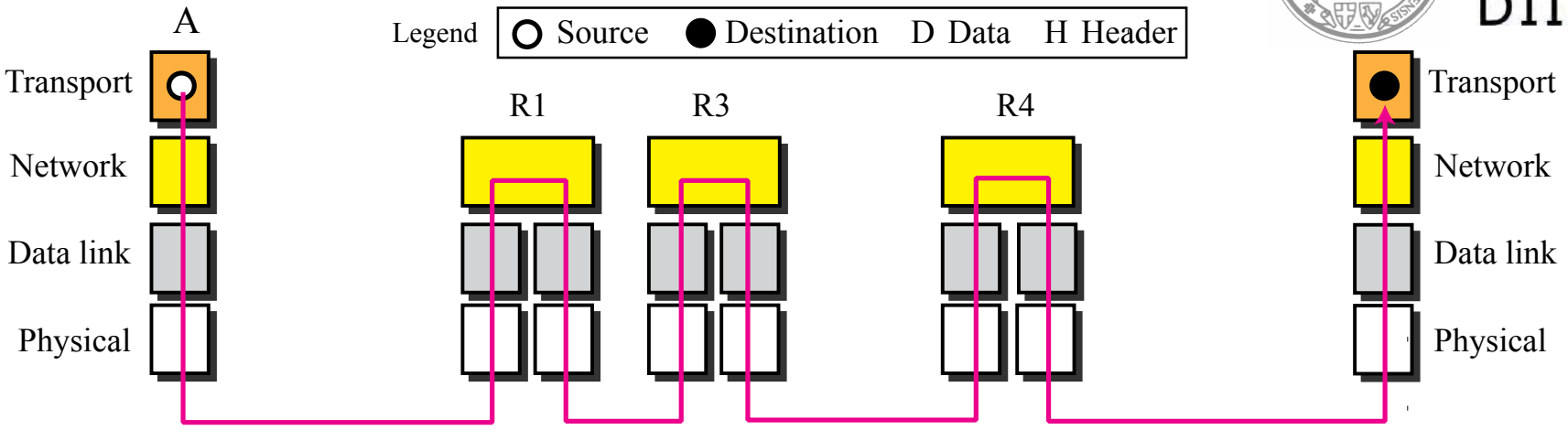
The unit of communication at the data link layer is a frame.

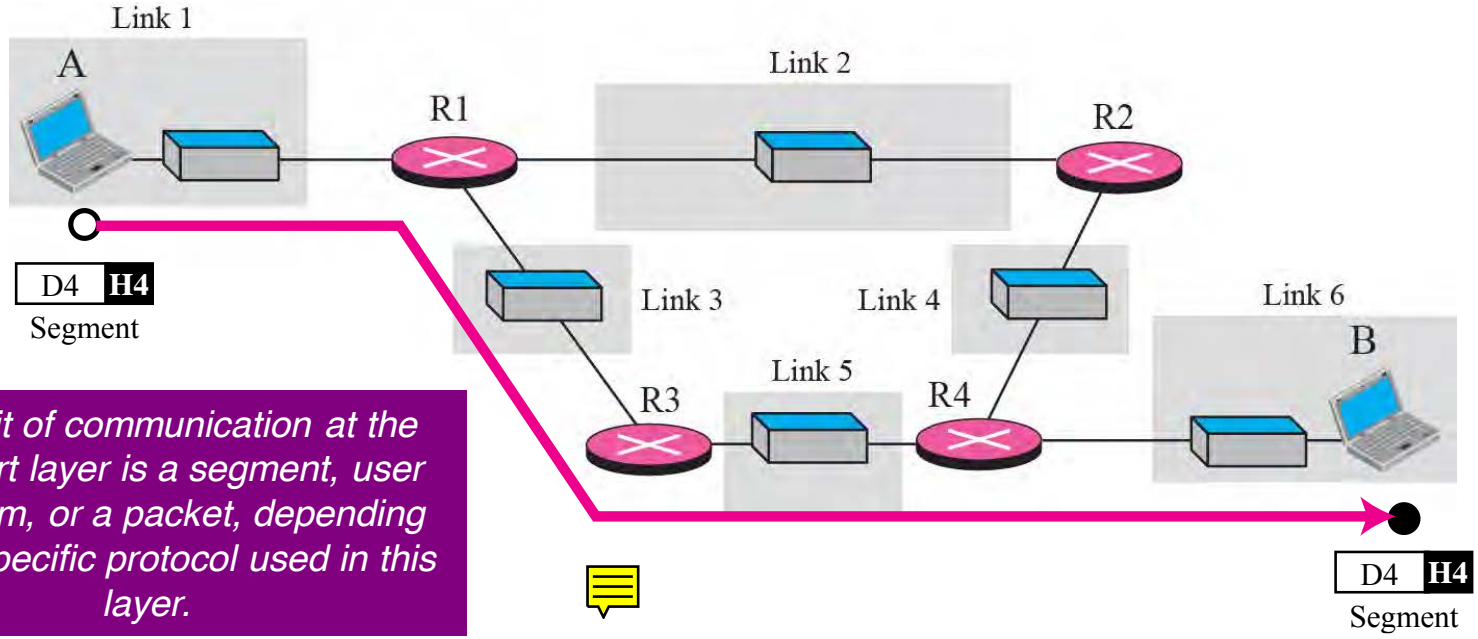
Communication at the network layer



The unit of communication at the network layer is a datagram.

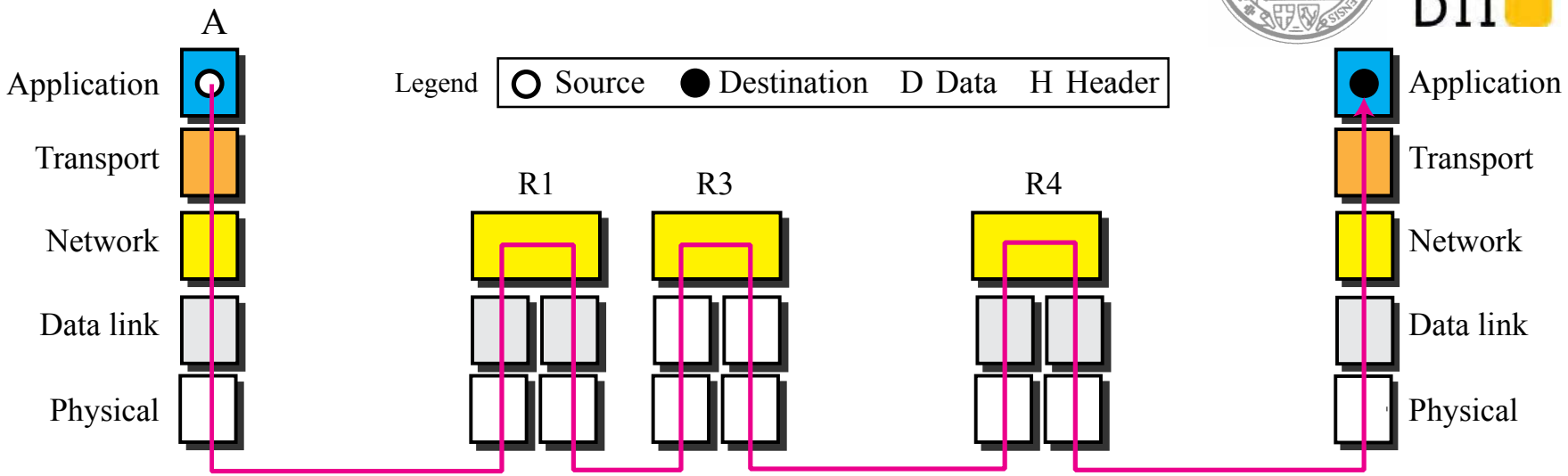
Communication at transport layer

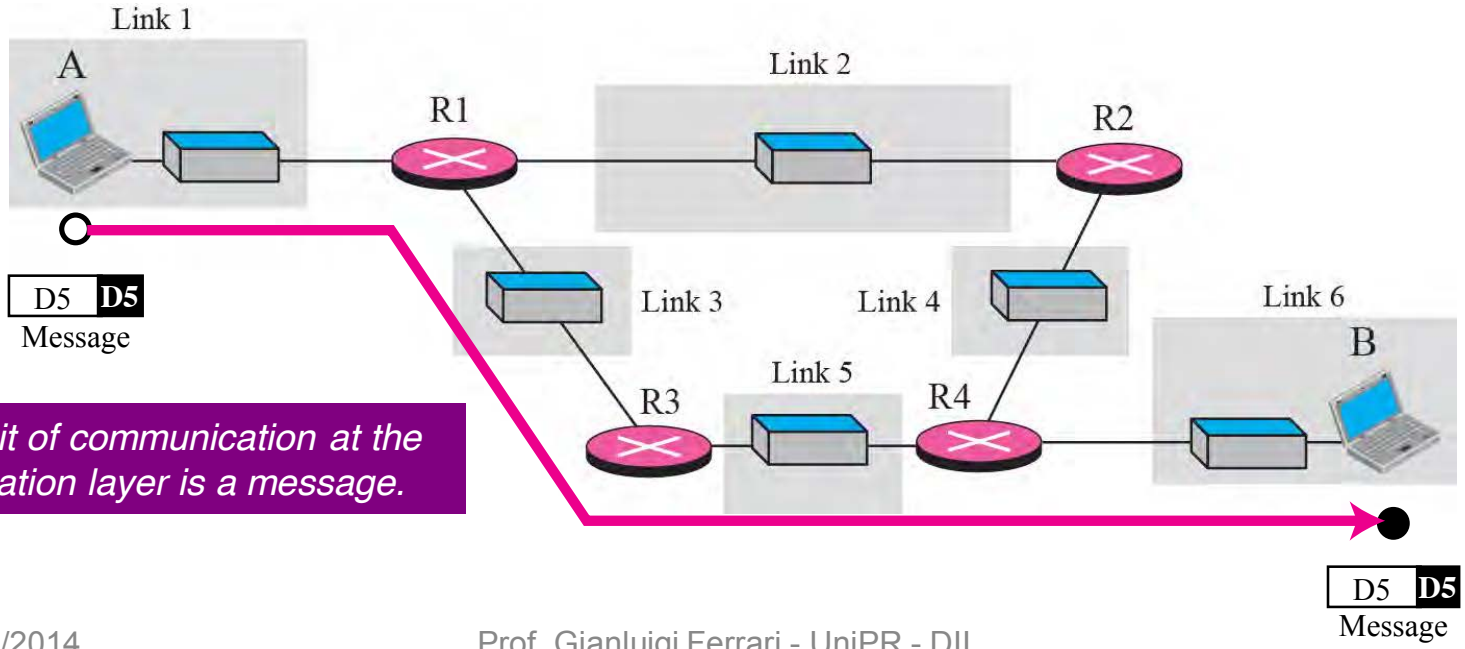




The unit of communication at the transport layer is a segment, user datagram, or a packet, depending on the specific protocol used in this layer.

Communication at application layer





The unit of communication at the application layer is a message.

Addressing

Four levels of addresses are used in an internet employing the TCP/IP protocols: physical address, logical address, port address, and application-specific address. Each address is related to a one layer in the TCP/IP architecture, as shown in Figure 2.15.

- ✓ Physical Addresses
- ✓ Logical Addresses
- ✓ Port Addresses
- ✓ Application-Specific Addresses

Addresses in the TCP/IP protocol suite