Ch. 8 - Communication Models

Sec 1 - Open Systems Interconnection (OSI) Model

COMPSCI 147

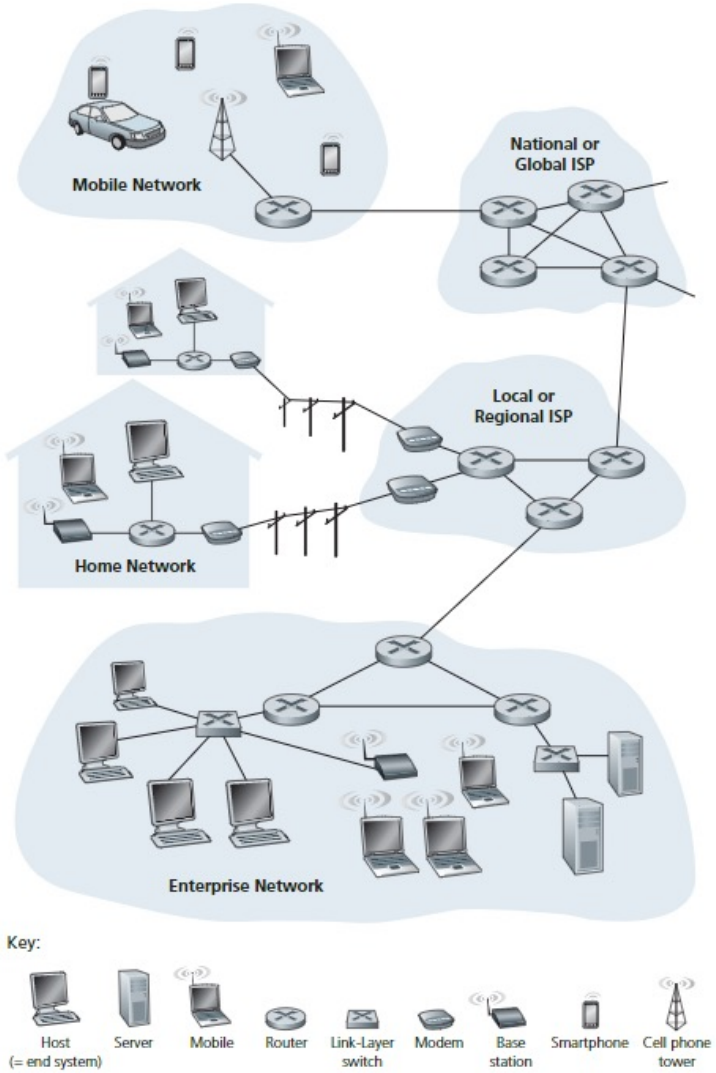
Internet-of-Things; Software and Systems

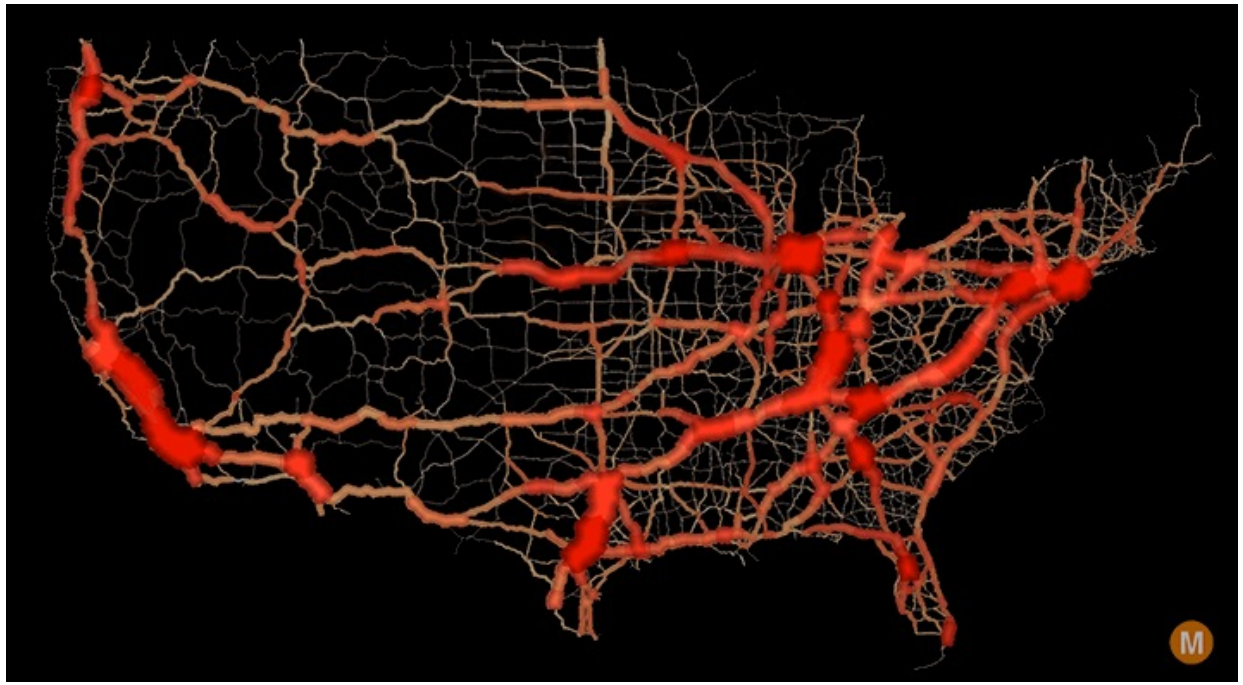
Book Chapter 2: The Internet in IoT

Internet

- One of the largest engineered system ever created by mankind.
- Hundreds of millions of connected computers, communication links, and switches; with billions of users who connect via laptops, tablets, and smartphones.
- Tens of billions of Internet-connected devices such as sensors, web cams, game consoles, picture frames, and even washing machines.
- In Internet jargon, all of these devices are called hosts or end systems.

Some pieces of the internet

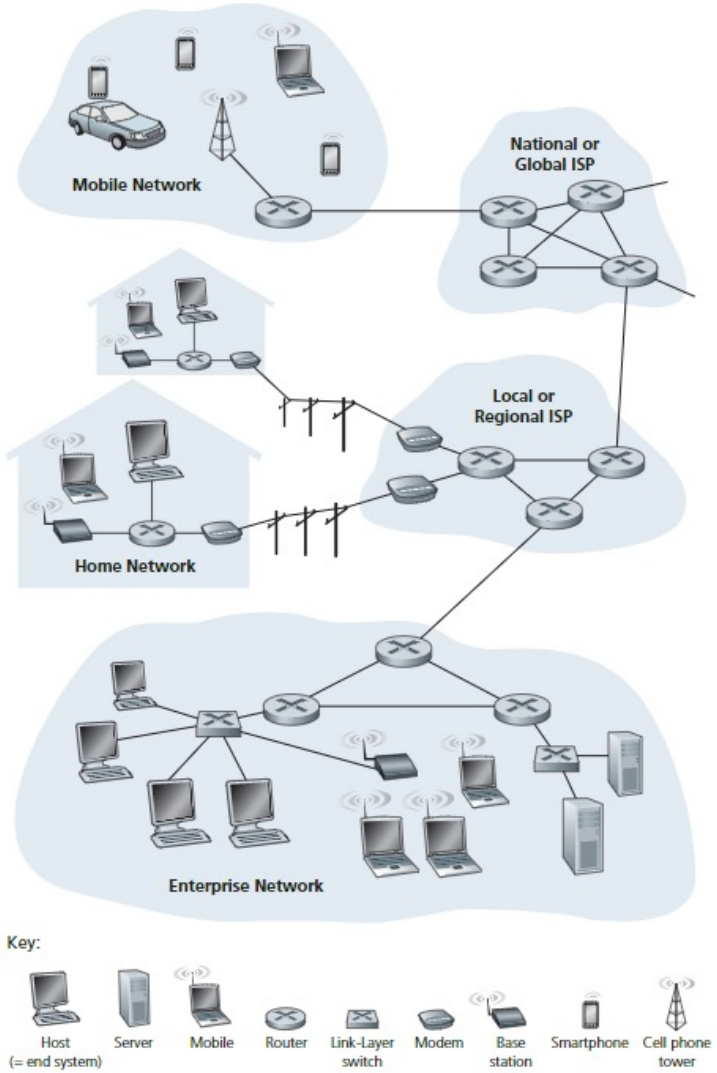




The flow of traffic through U.S. highways

http://metrocosm.com/traffic-flow-maps/

Some pieces of the internet



- End systems are connected together by a network of communication links and packet switches.

- Communication links:

  There are many types of communication links, which are made up of different types of physical media, including coaxial cable, copper wire, optical fiber, and radio spectrum.

  When one end system has data to send to another end system, the sending end system segments the data and adds header bytes to each segment.

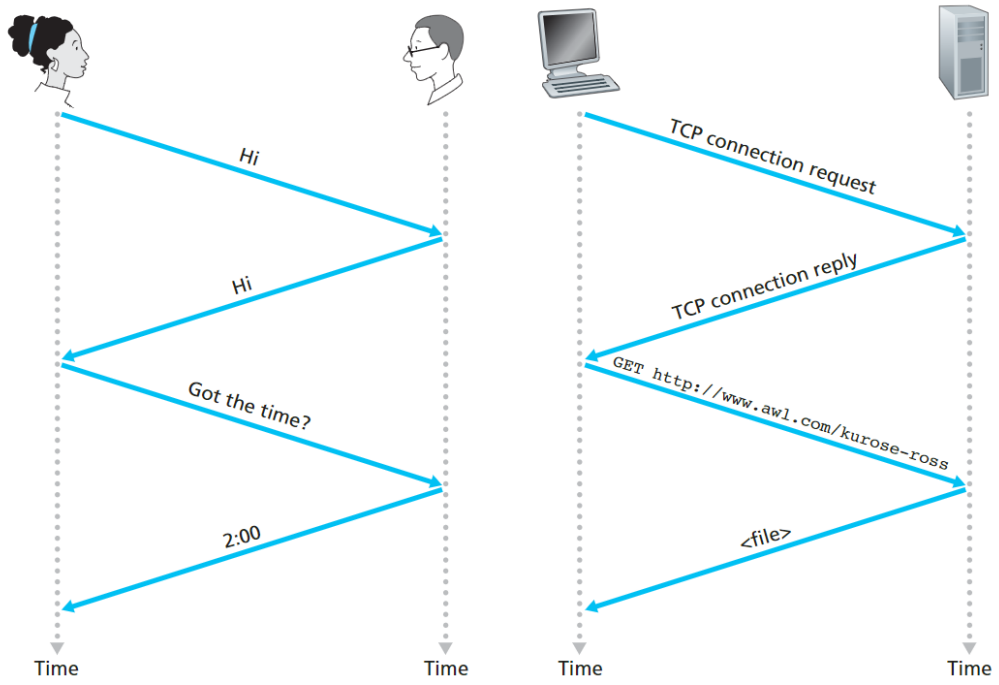
- The resulting packages of information, known as packets in the jargon of computer networks, are then sent through the network to the destination end system, where they are reassembled into the original data

- Packet switches:

  A packet switch takes a packet arriving on one of its incoming communication links and forwards that packet on one of its outgoing communication links.

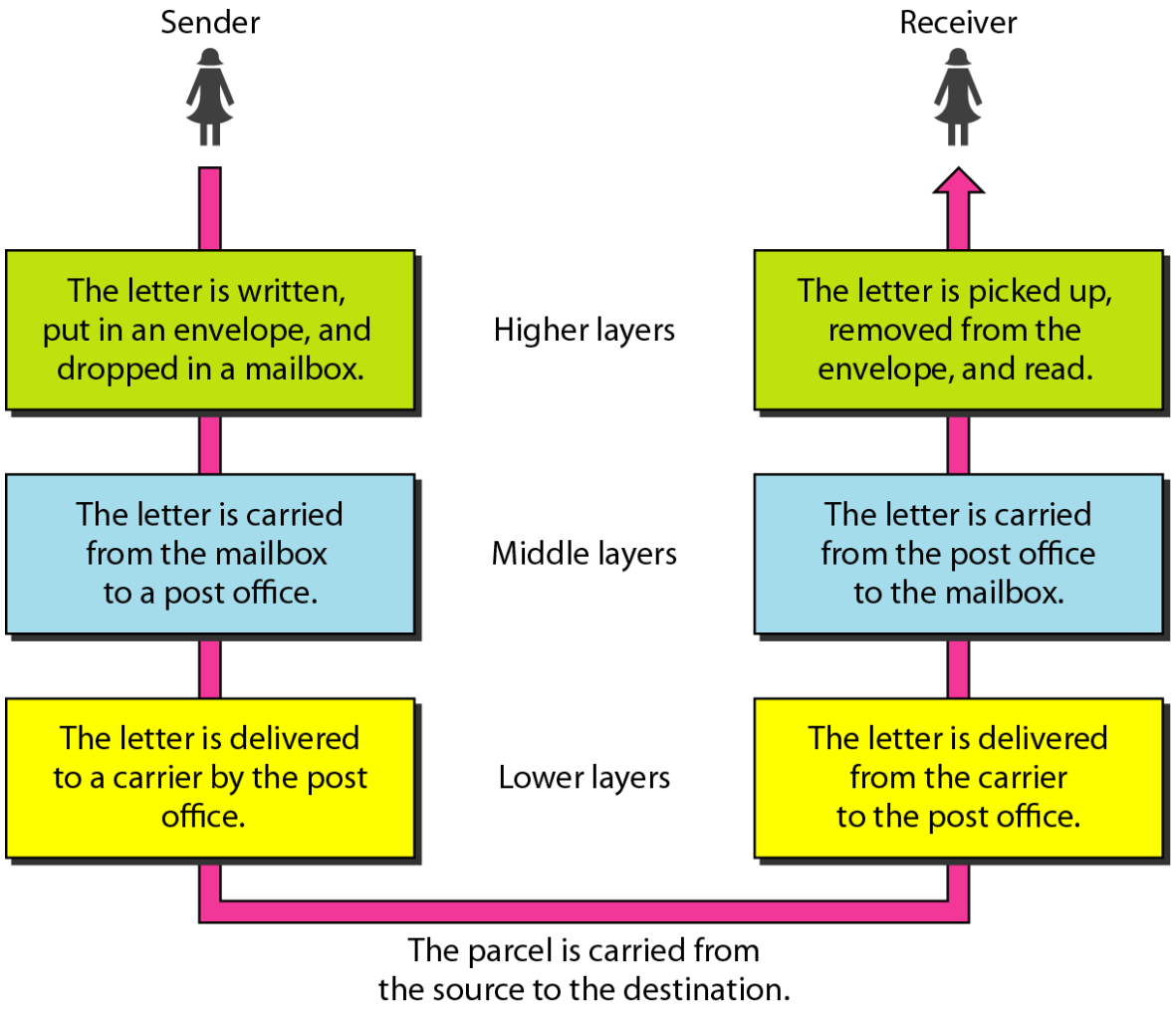
Protocols

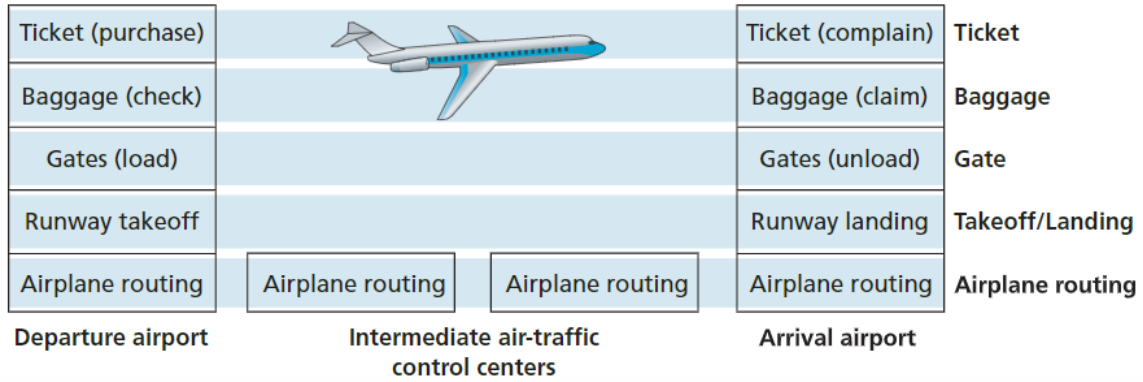
- Human protocol:
  There are specific messages we send, and specific actions we take in response to the received reply messages or other events(such as no reply within some given amount of time.
- We already saw some protocols: i2c, SPI.
  However, they cannot meet the scalability requirements of the internet.
- A network protocol is similar to a human protocol, except that the entities exchanging messages and taking actions are hardware or software components of some device.
- A protocol defines the format and the order of messages exchanged between two or more communicating entities, as well as the actions taken on the transmission and/or receipt of a message or other event.



Human protocol and a computer network protocol

LAYERED TASKS, EXAMPLE





Taking an airplane trip

Layered Protocol

- Network designers organize protocols in layers to provide structure: called protocol stack.
- Each protocol belongs to one of the layers.
- We are interested in the services that a layer offers (not so much in the implementation).
- A protocol can be implemented in hardware or software or combination of the two.

Back in the late 1970s

- The International Organization for Standardization (ISO) proposed that computer networks be organized around seven layers, called the Open Systems Interconnection (OSI) model.

- Internet protocols were in their infancy and several others were under development. (e.g., 4-layer DoD model by DARPA). Many training and university courses picked up on the ISO mandate and organized courses around the seven-layer model: hence it is still popular..

- Inventors of the original OSI model probably did not have the modern-day Internet in mind when creating it. It was intended to describe and standardize the main communication functions of any telecommunication or computing system without regard to their underlying internal structure and technology.

- Goal: Interoperability of diverse communication systems with standard protocols.

INTRODUCTION TO OSI

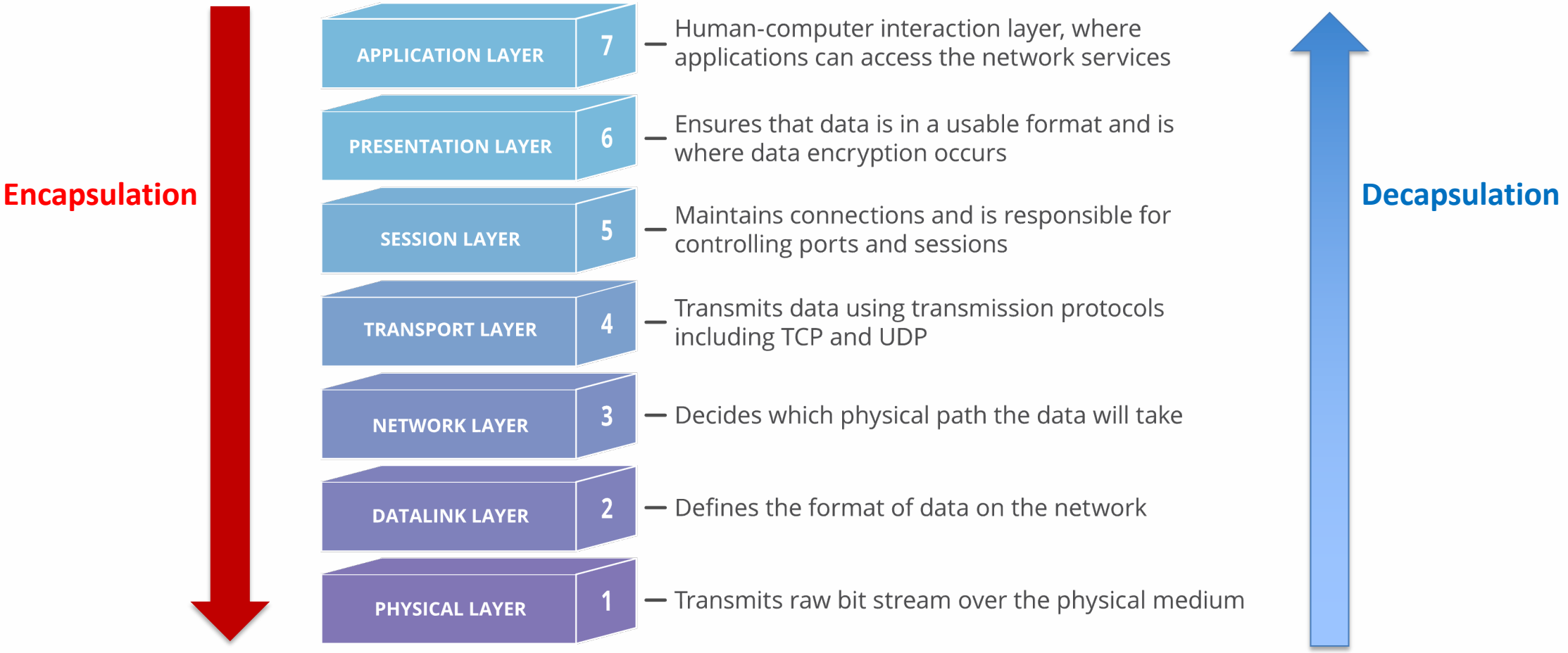
- The OSI Model (Open Systems Interconnection Model) is a conceptual framework used to describe the functions of a networking system

- "Divide and conquer" concept to virtually break down network communication responsibilities into smaller functions (layers) so they are easier to learn and develop.

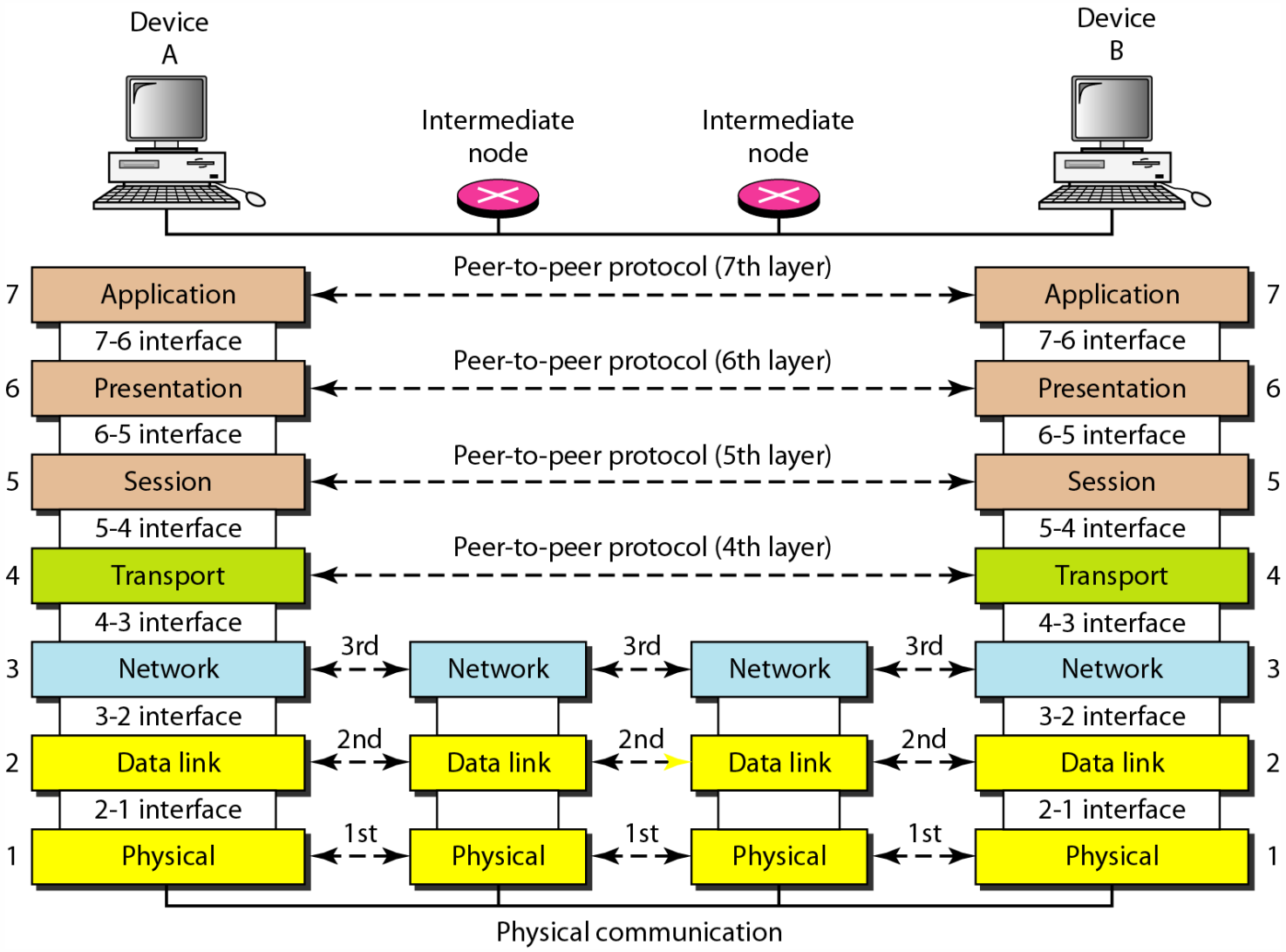
- Additional Resources:
  - Understanding the **OSI Reference Model**: Cisco Router Training 101
    - https://www.youtube.com/watch?v=sVDwG2RdJho
  - https://www.cloudflare.com/learning/ddos/glossary/open-systems-interconnection-model-osi/

THE OSI MODEL

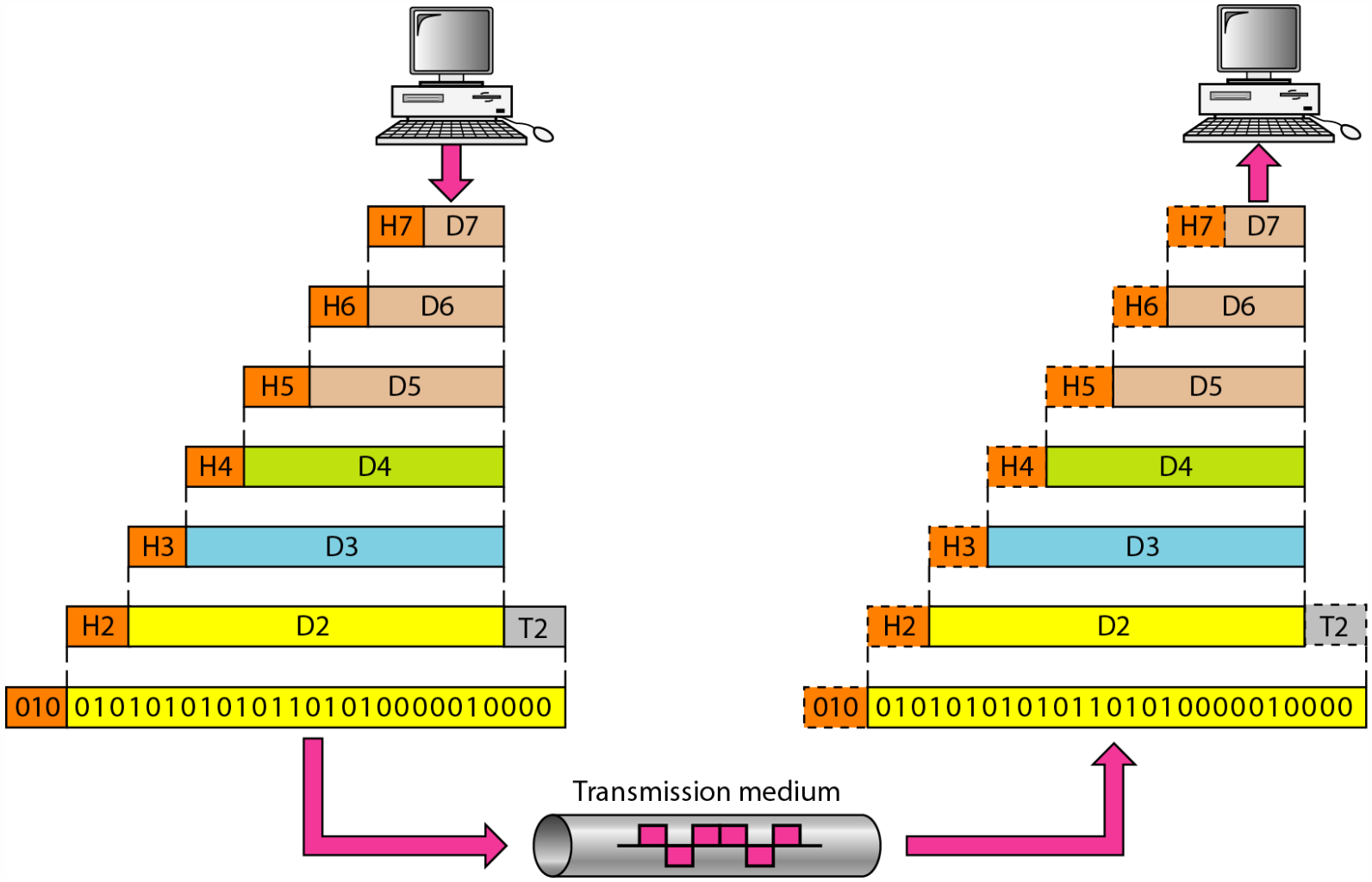
- Seven layers described by the Open Systems Interconnection model (OSI) model



OSI MODEL: INTERFACES BETWEEN LAYERS



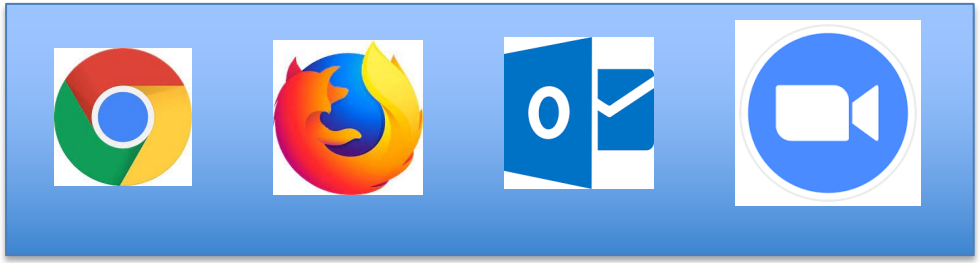
EXCHANGE USING THE OSI MODEL



Datagrams Names
Upper Layer data
Segments
Packet
Frame
Bits

OSI LAYER 7: APPLICATION LAYER

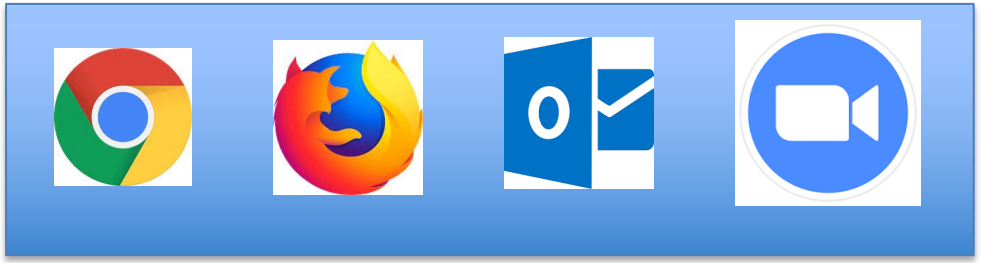
- Network applications vs application layer protocols



Network applications

OSI LAYER 7: APPLICATION LAYER

- Network applications vs application layer protocols



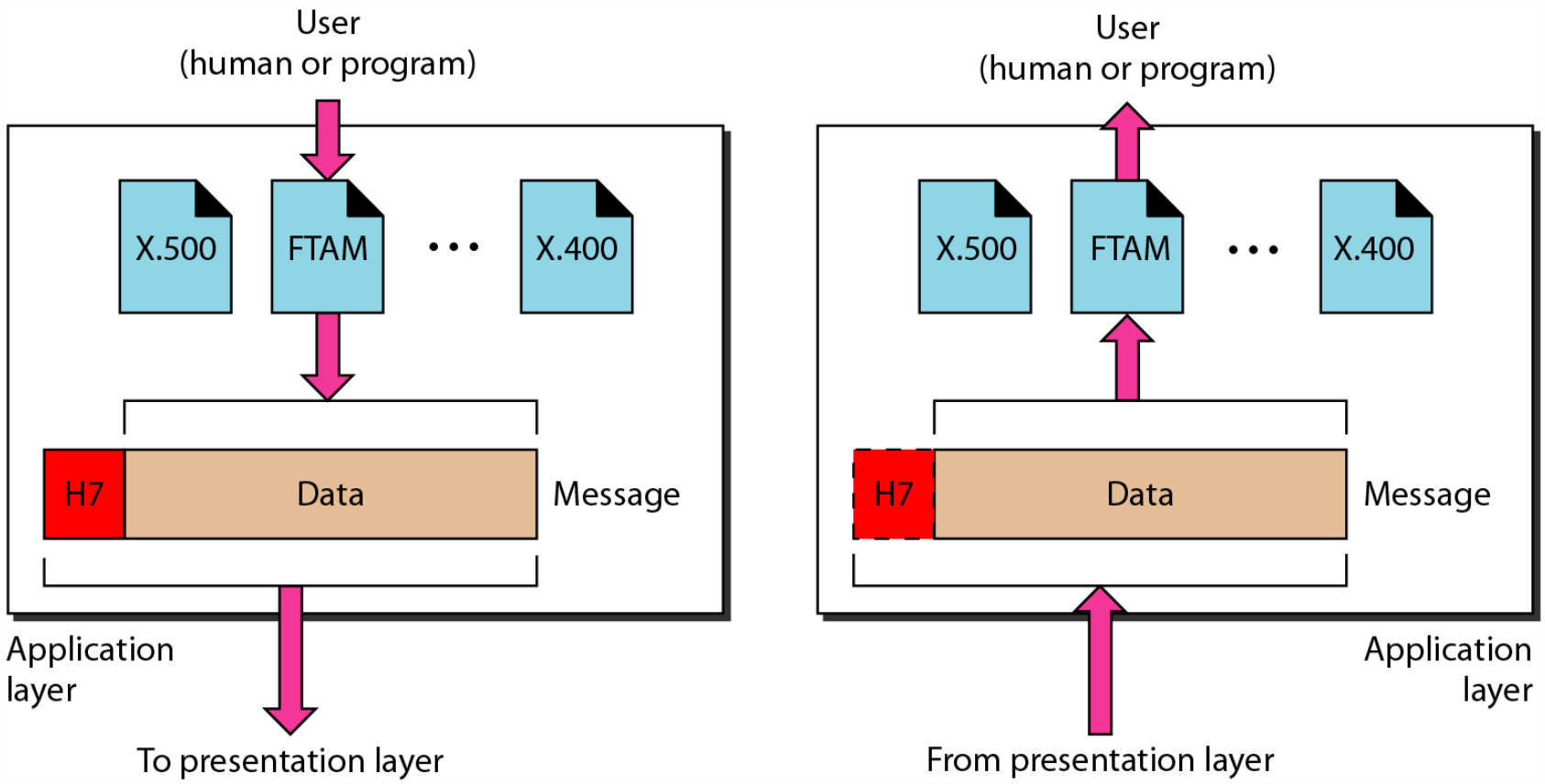
Network applications

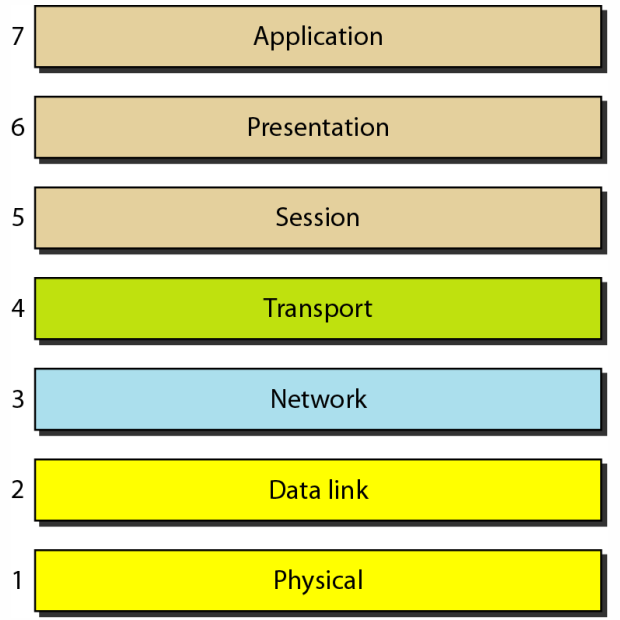
Application	Description
DHCP	Dynamic Host Configuration Protocol assigns IP addresses
DNS	Domain Name System translates website names to IP addresses
HTTP	Hypertext Transfer Protocol used to transfer web pages
NBNS	NetBIOS Name Service translates local host names to IP addresses
SMTP	Simple Mail Transfer Protocol sends email messages
SNMP	Simple Network Management Protocol manages network devices
SNTP	Simple Network Time Protocol provides time of day
Telnet	Bi-directional text communication via a terminal application
TFTP	Trivial File Transfer Protocol used to transfer small amounts of data

Application layer protocols

OSI LAYER 7: APPLICATION LAYER

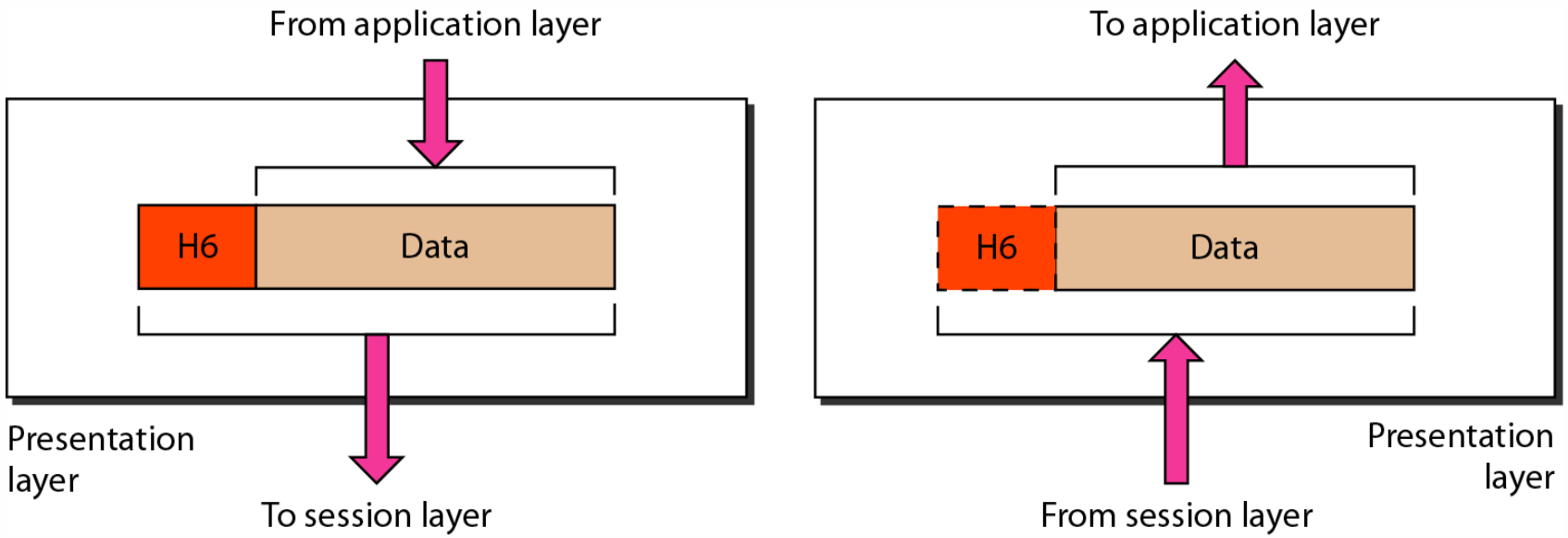
- The application layer is responsible for **providing services to the user**.

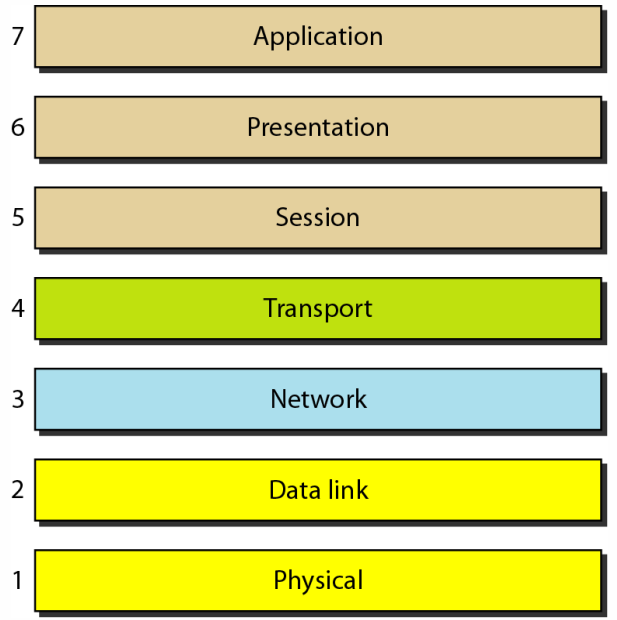




OSI LAYER 6: PRESENTATION LAYER

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





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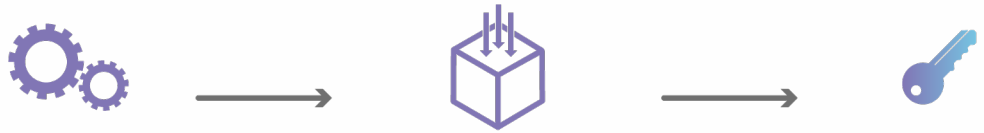


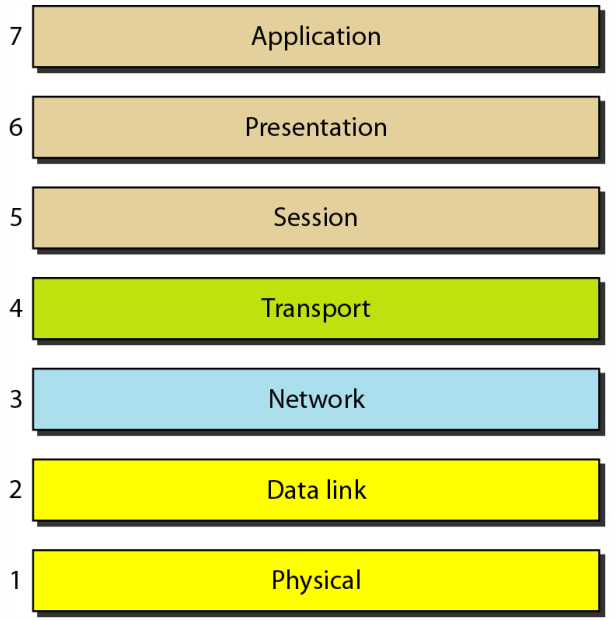
- Translation frees the applications from having to worry about the internal format in which data are represented/stored—formats that may differ from one computer to another). E.g, ASCII to EBCDIC code

- Compression reduces the number of bits required to represent the data. Can be lossy or lossless. Smaller files can be transferred faster.

- Encryption: Enhances the security of sensitive data.
(e.g., Secure Sockets Layer (SSL) protocol is used in https)

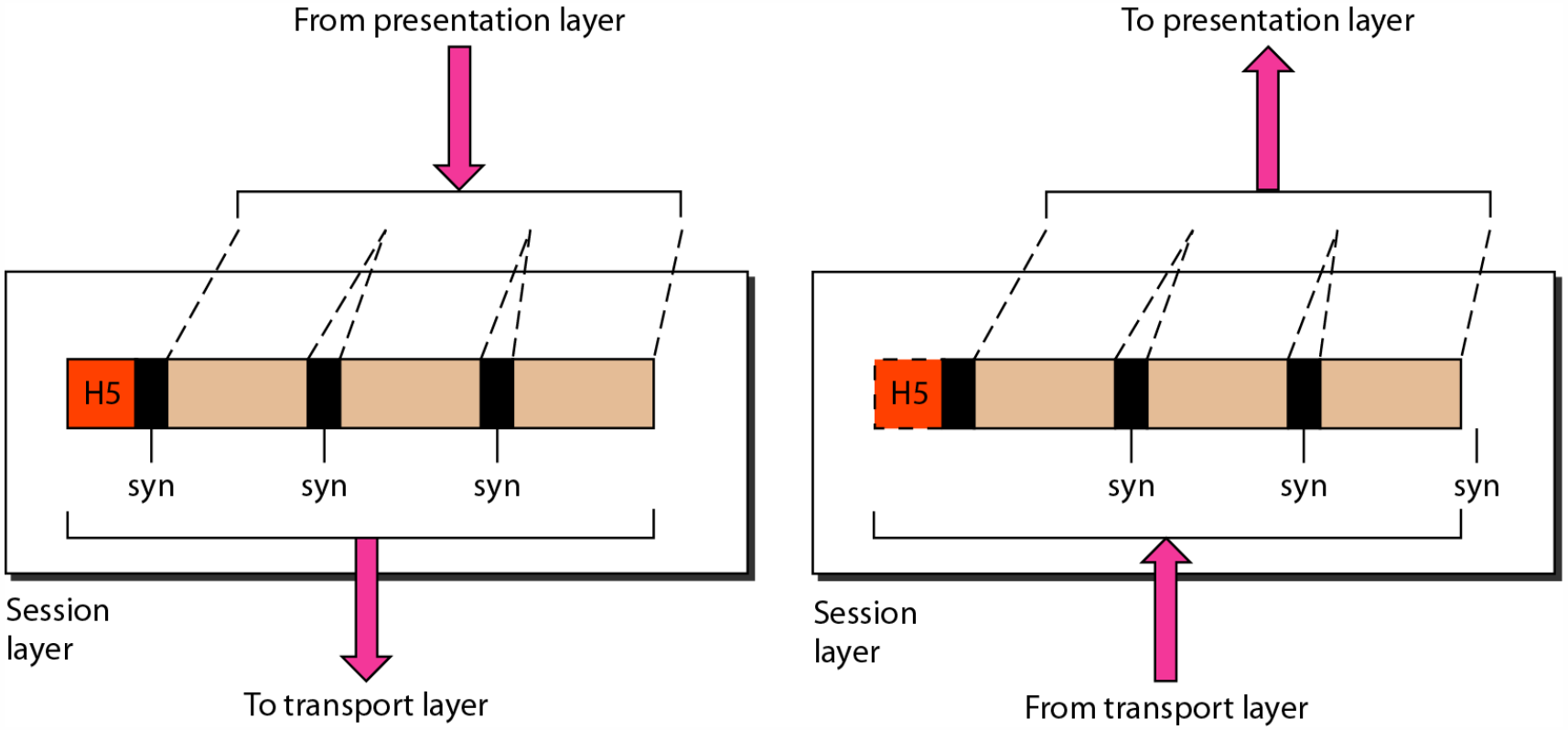
OSI LAYER 5: SESSION LAYER

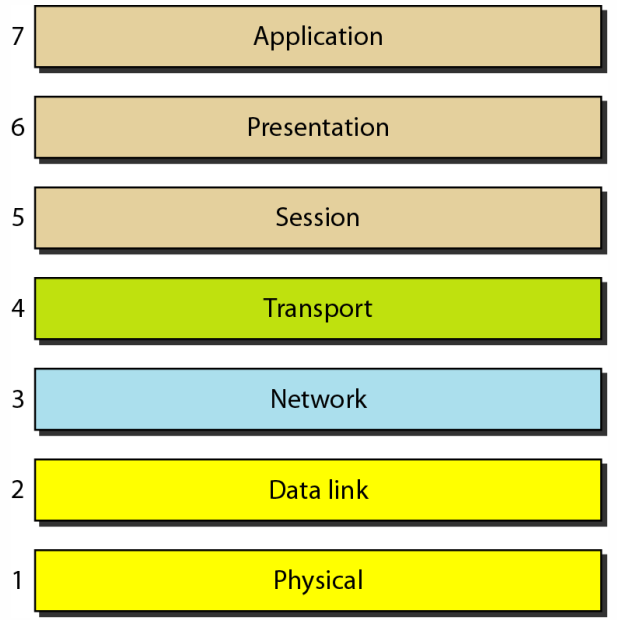
- This is the layer responsible for opening and closing communication between the two devices.
- The time between when the communication is opened and closed is known as the session.
- The session layer ensures that the session stays open long enough to transfer all the data being exchanged, and then promptly closes the session in order to avoid wasting resources.



OSI LAYER 5: SESSION LAYER

- The session layer is responsible for **dialog control** and **synchronization**.





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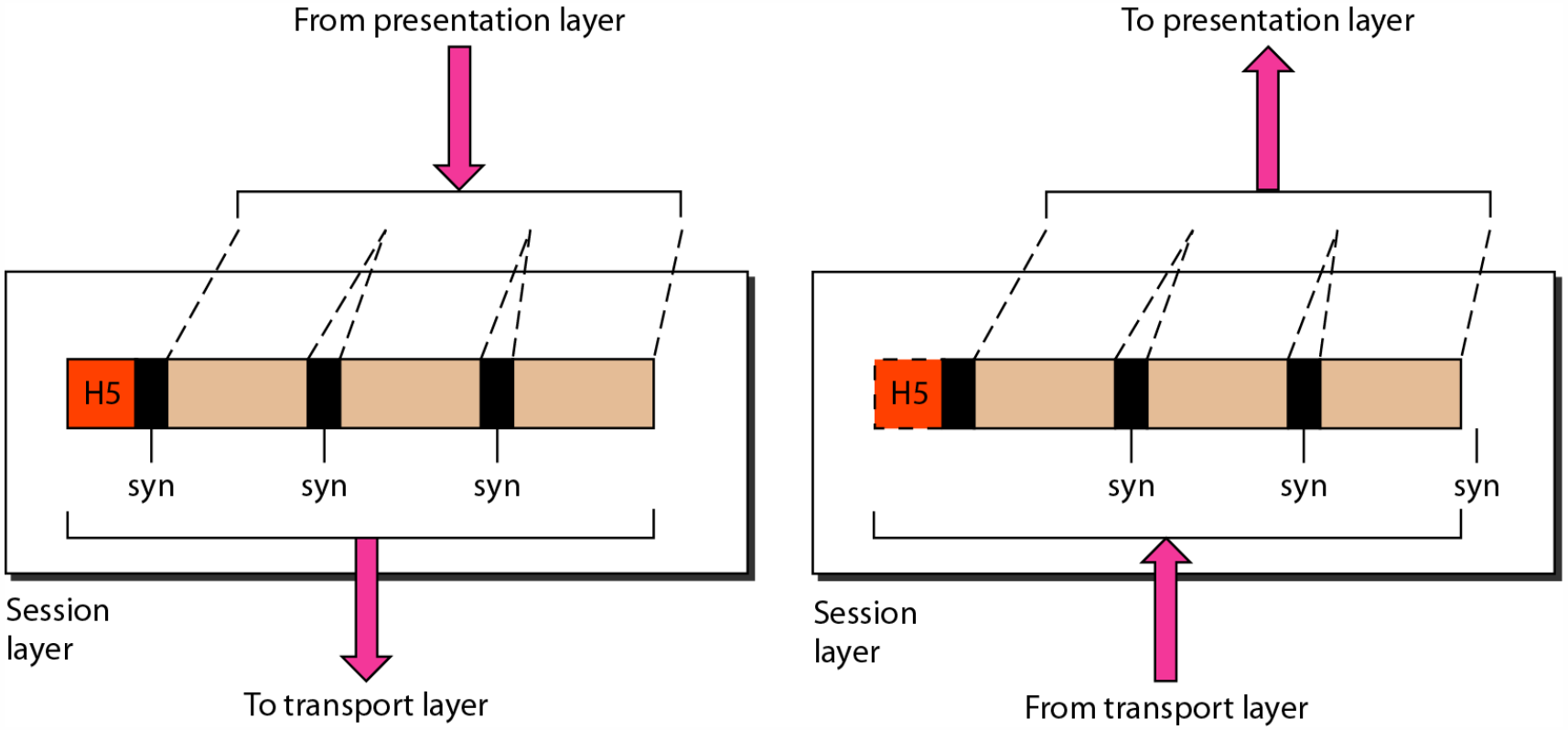
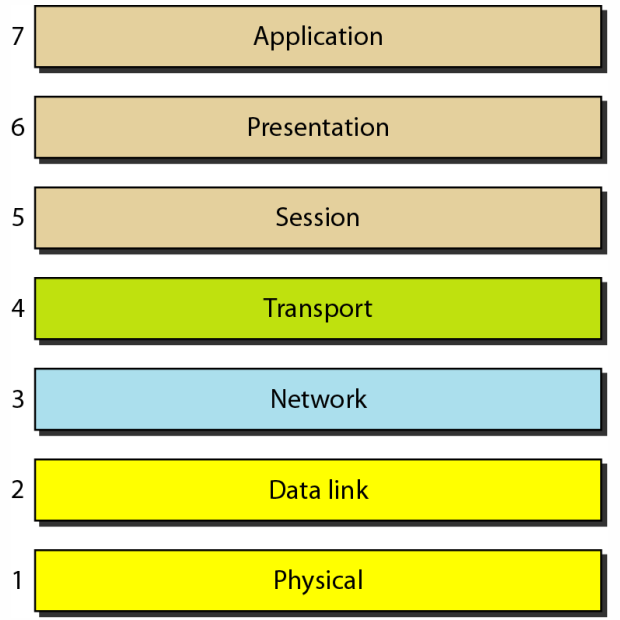




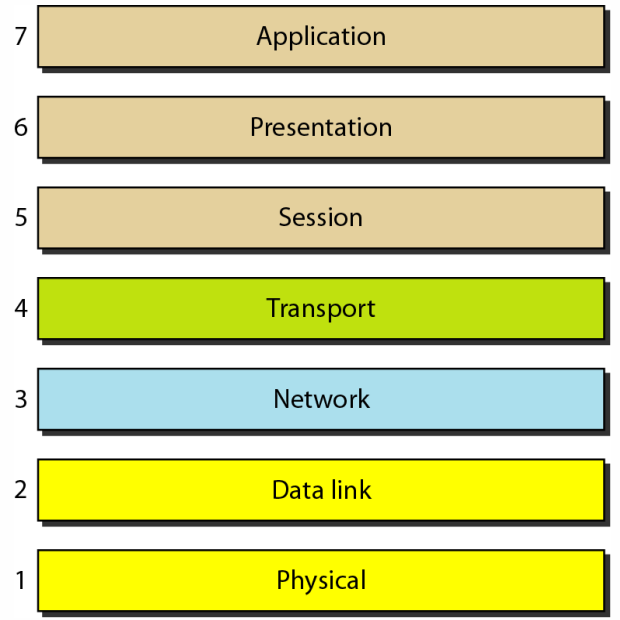
- Also responsible for **authentication** and **authorization**.

Example: Web browser

Performs all functions of

- Application
- Presentation and
- Session

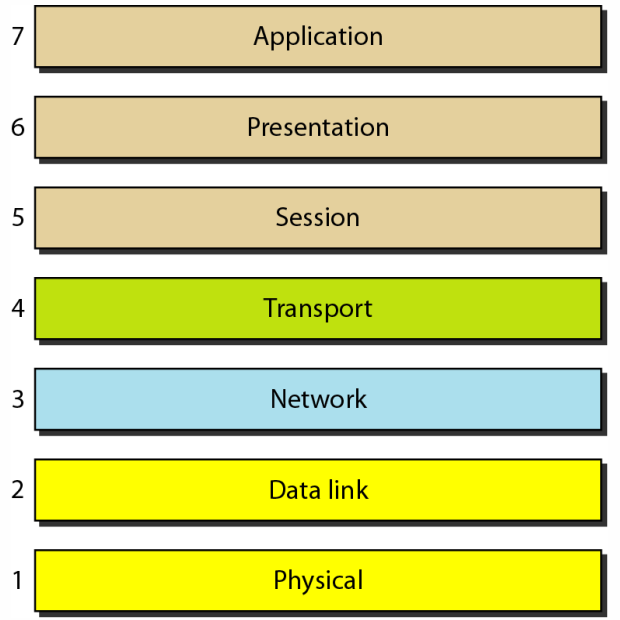
layers



OSI LAYER 4: TRANSPORT LAYER

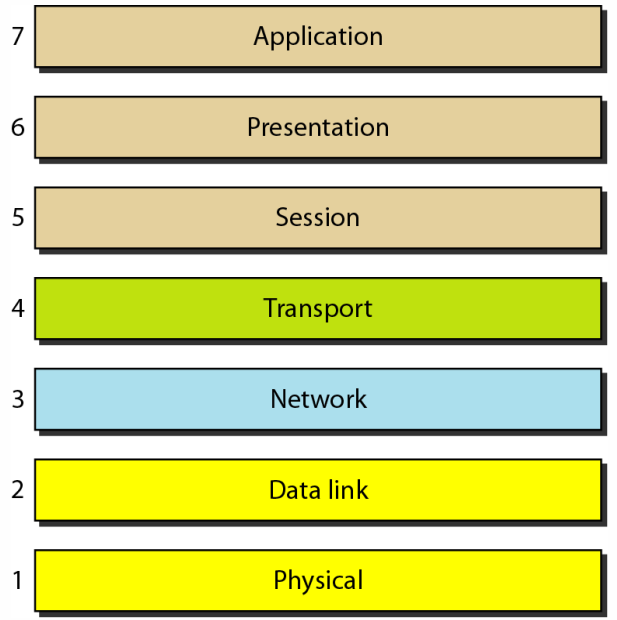
- A transport-layer protocol provides for logical communication between application processes running on different hosts.

- Application layer application-layer messages <-> transport-layer segments

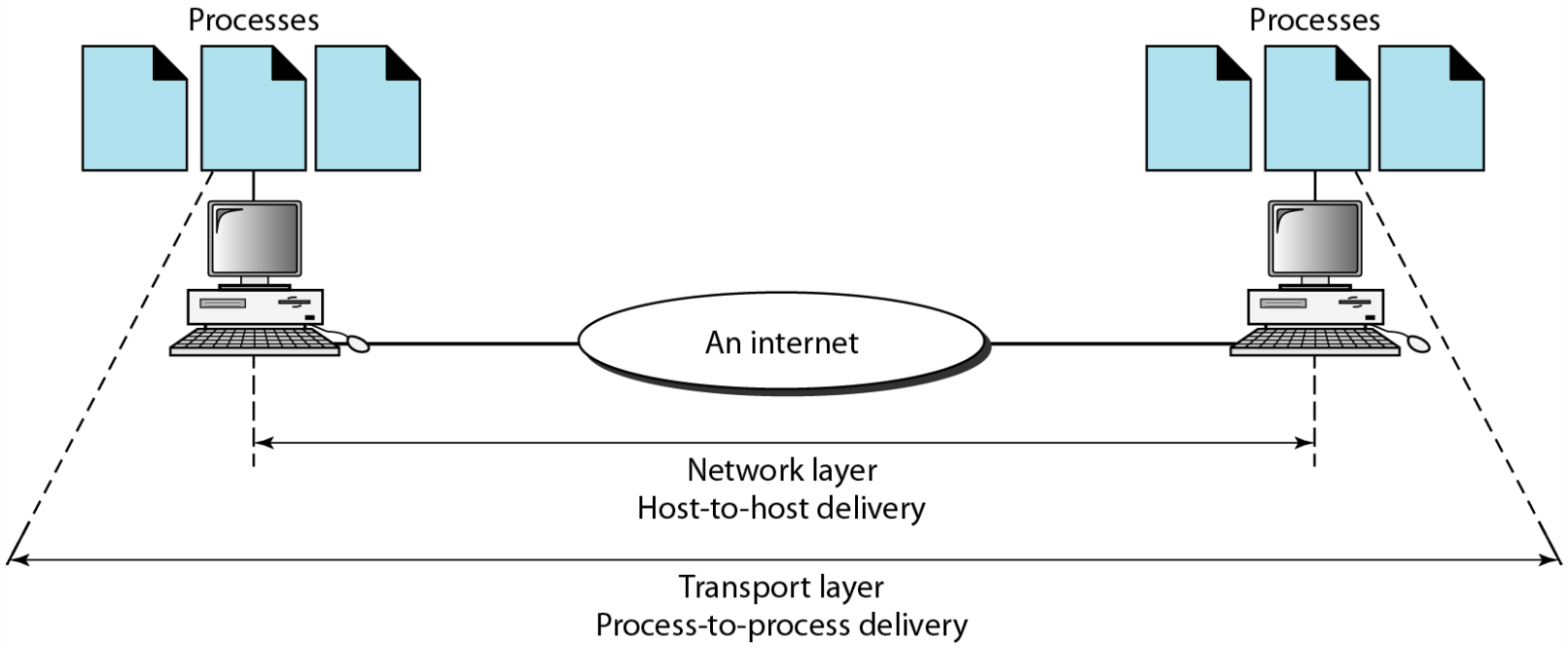


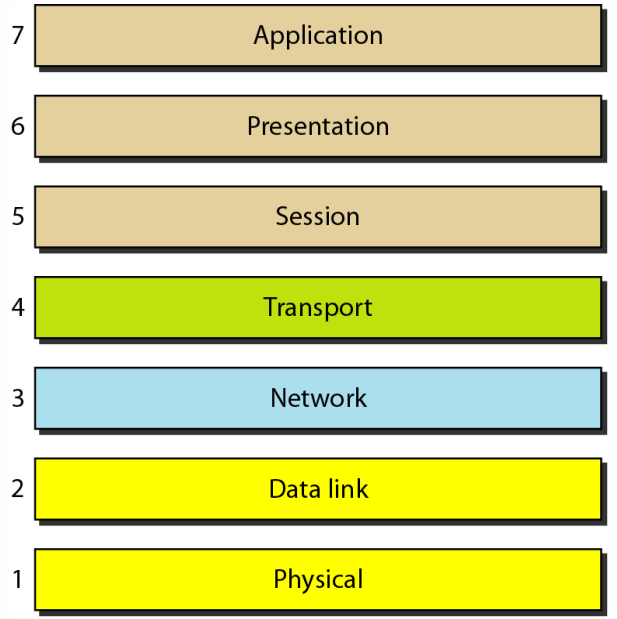
OSI LAYER 4: TRANSPORT LAYER

- A transport-layer protocol provides for logical communication between application processes running on different hosts.
- Application layer application-layer messages <-> transport-layer segments
- The transport layer is responsible for the **delivery** of a message from one process to another.
  - Service-point addressing
  - Segmentation and reassembly
  - Connection control
  - Flow control
  - Error control

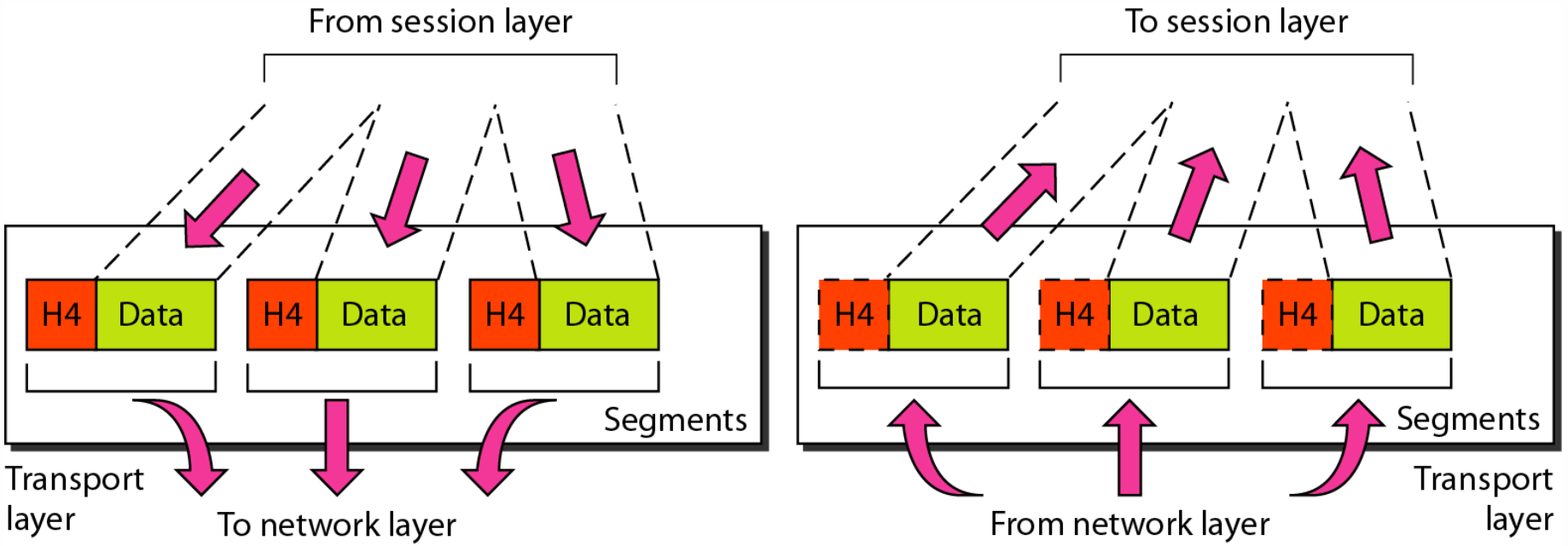


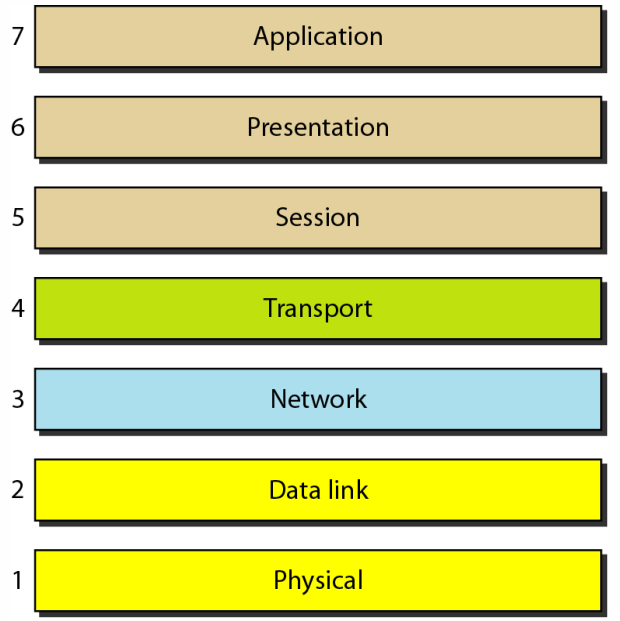
TRANSPORT LAYER: RELIABLE PROCESS-TO-PROCESS DELIVERY OF A MESSAGE





TRANSPORT LAYER: SEGMENTATION AND REASSEMBLY





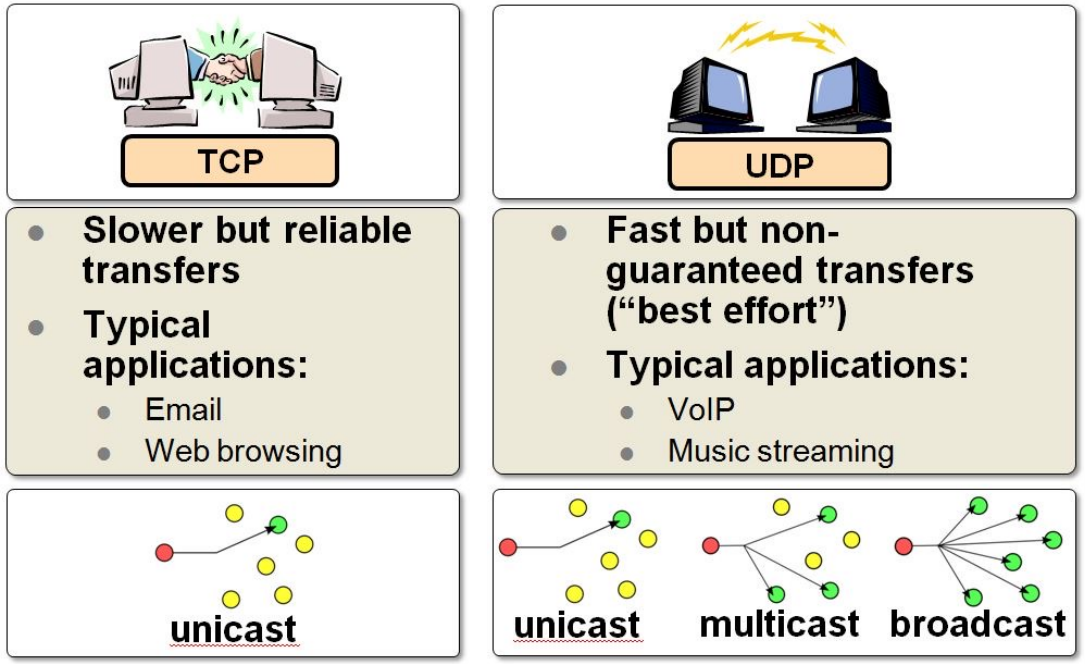
Information included in header:

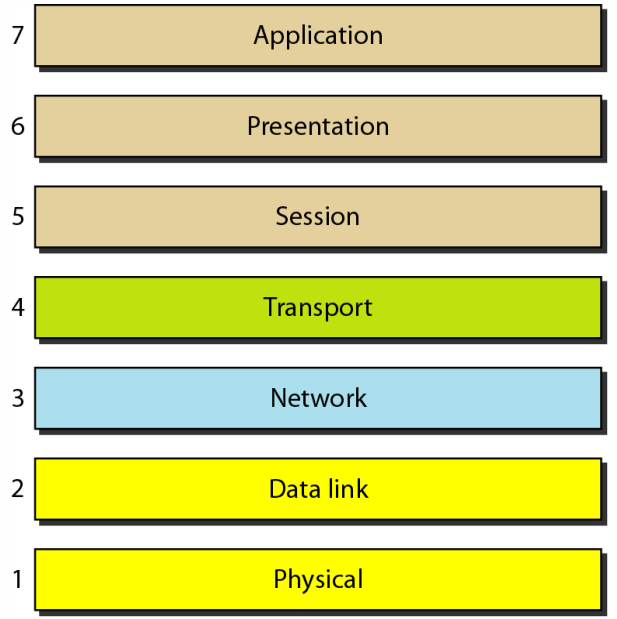
- Source/Destination Port: Determines which application
- Checksum
- Length

- Sequence number
- Acknowledgement number

TRANSPORT LAYER PROTOCOLS

Services	Protocols
Connection-oriented Transmission	Transport Control Protocol (TCP)
Connectionless Transmission	User Datagram Protocol (UDP)

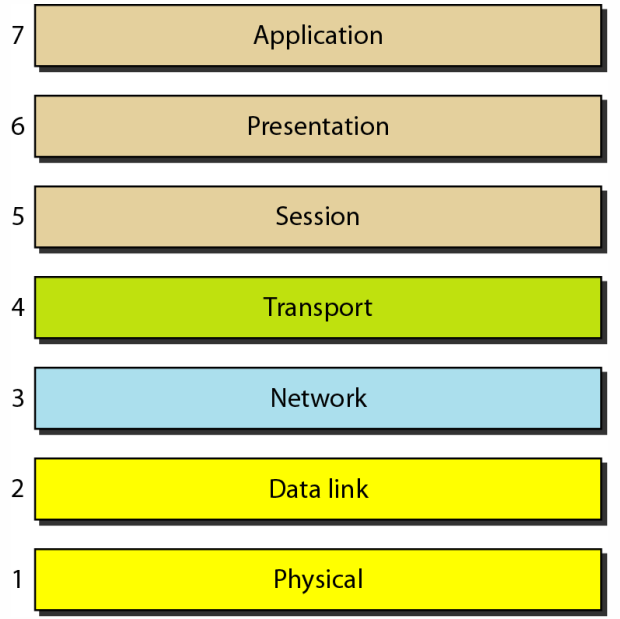




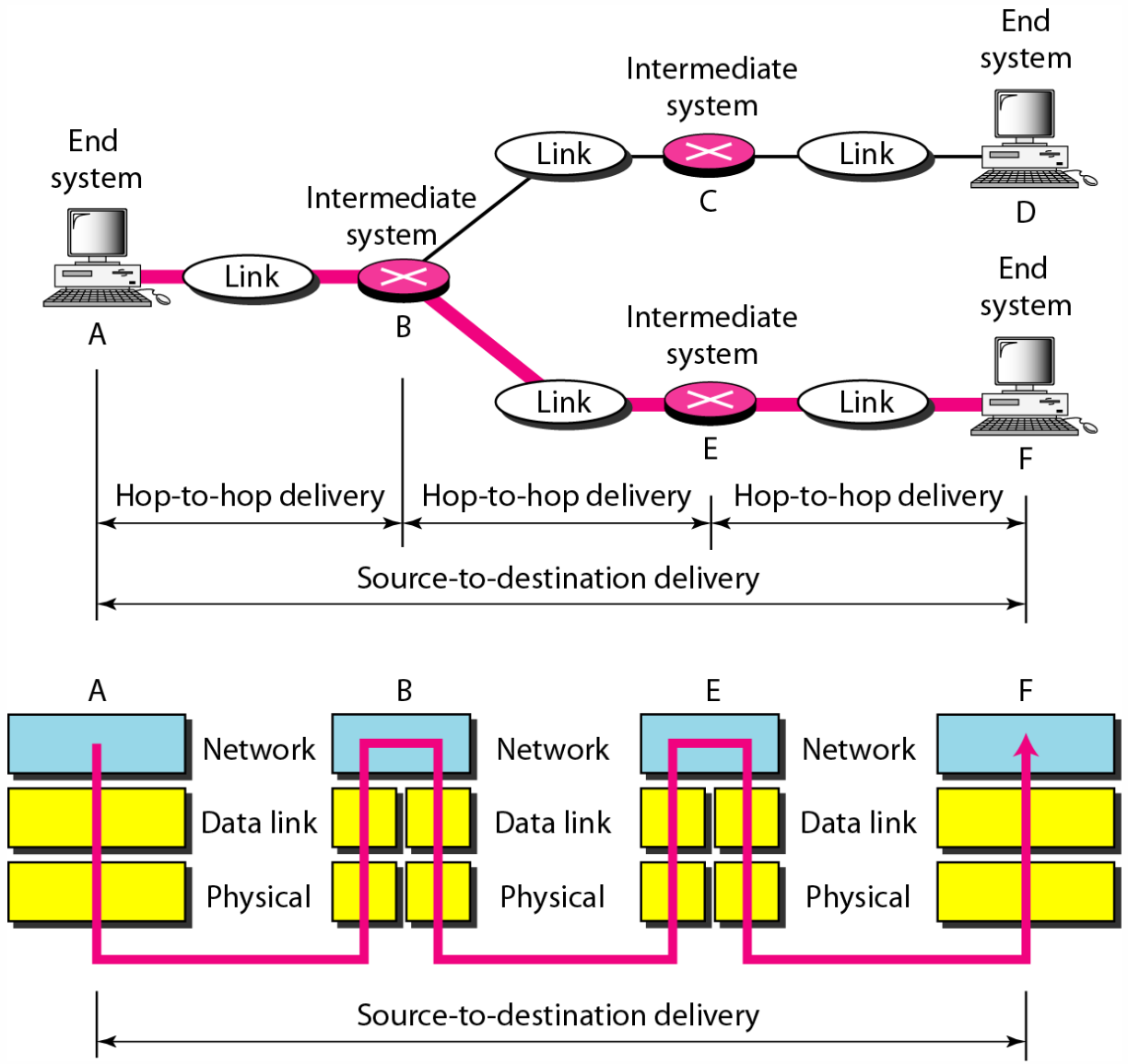
https://youtu.be/uwoD5YsGACg

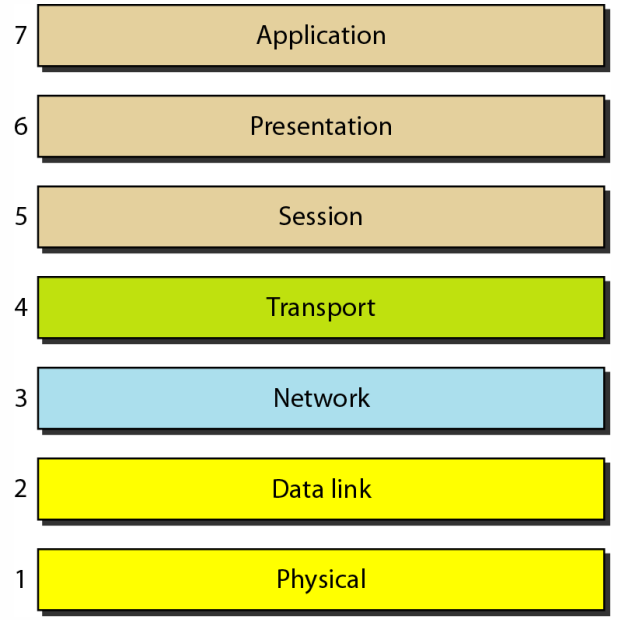
OSI LAYER 3: NETWORK LAYER

- The network layer is responsible for the **delivery** of individual **packets** from the **source** host to the **destination** host.
  - Logical addressing
  - Routing

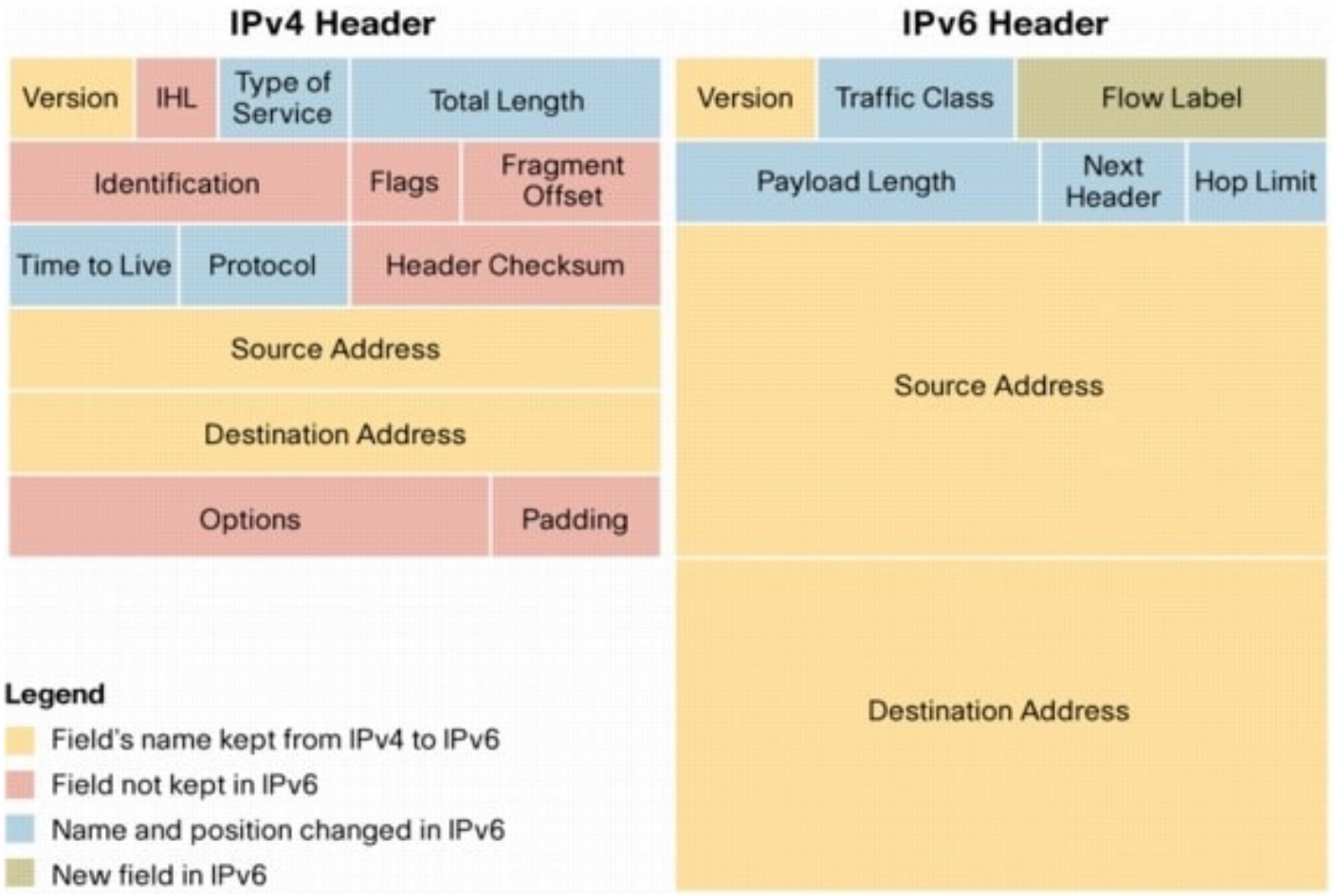


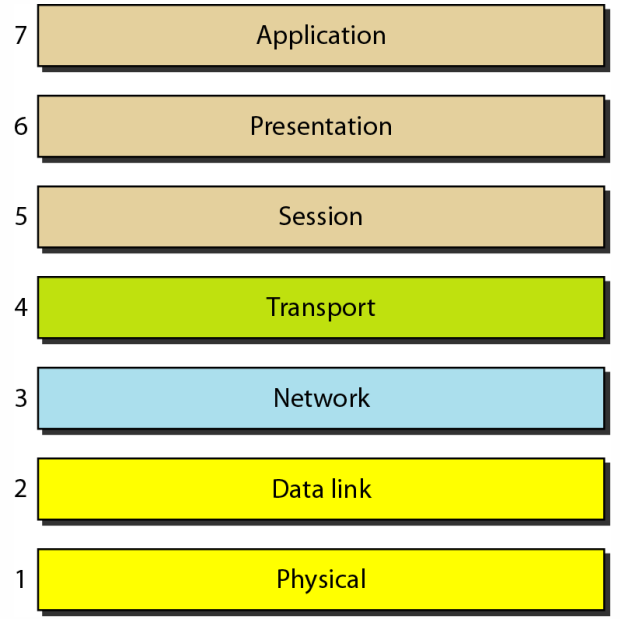
NETWORK LAYER: SOURCE-TO-DESTINATION DELIVERY



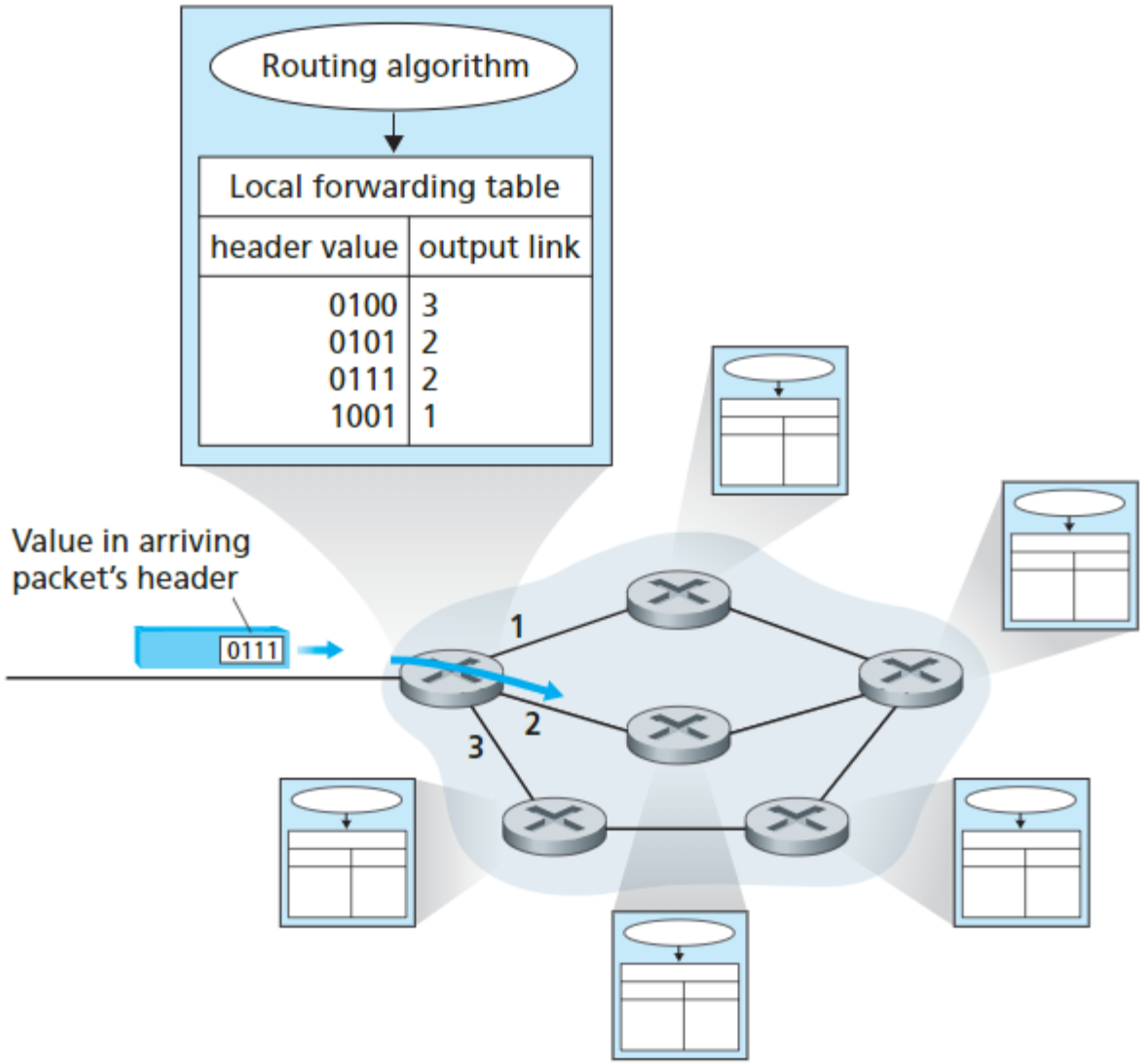


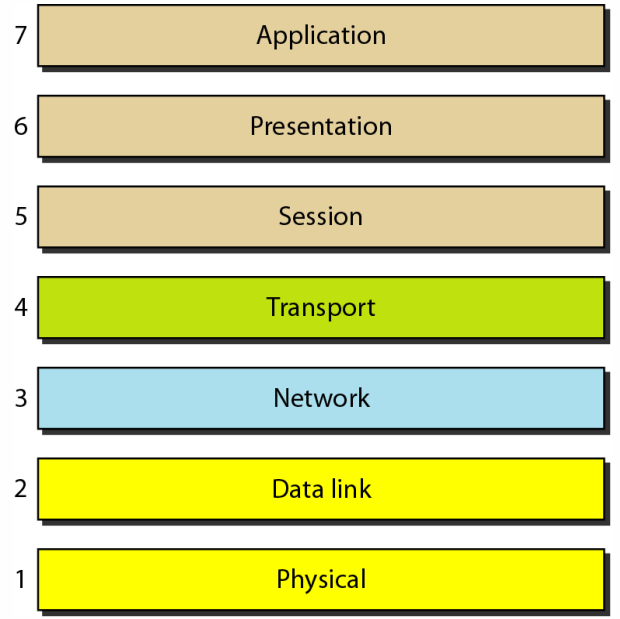
NETWORK LAYER: EXAMPLE HEADERS





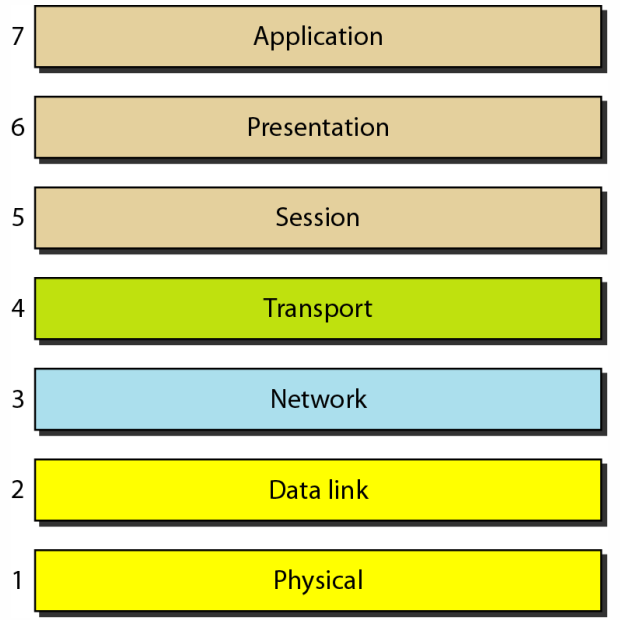
NETWORK LAYER: ROUTING ALGORITHMS DETERMINE FORWARDING TABLES



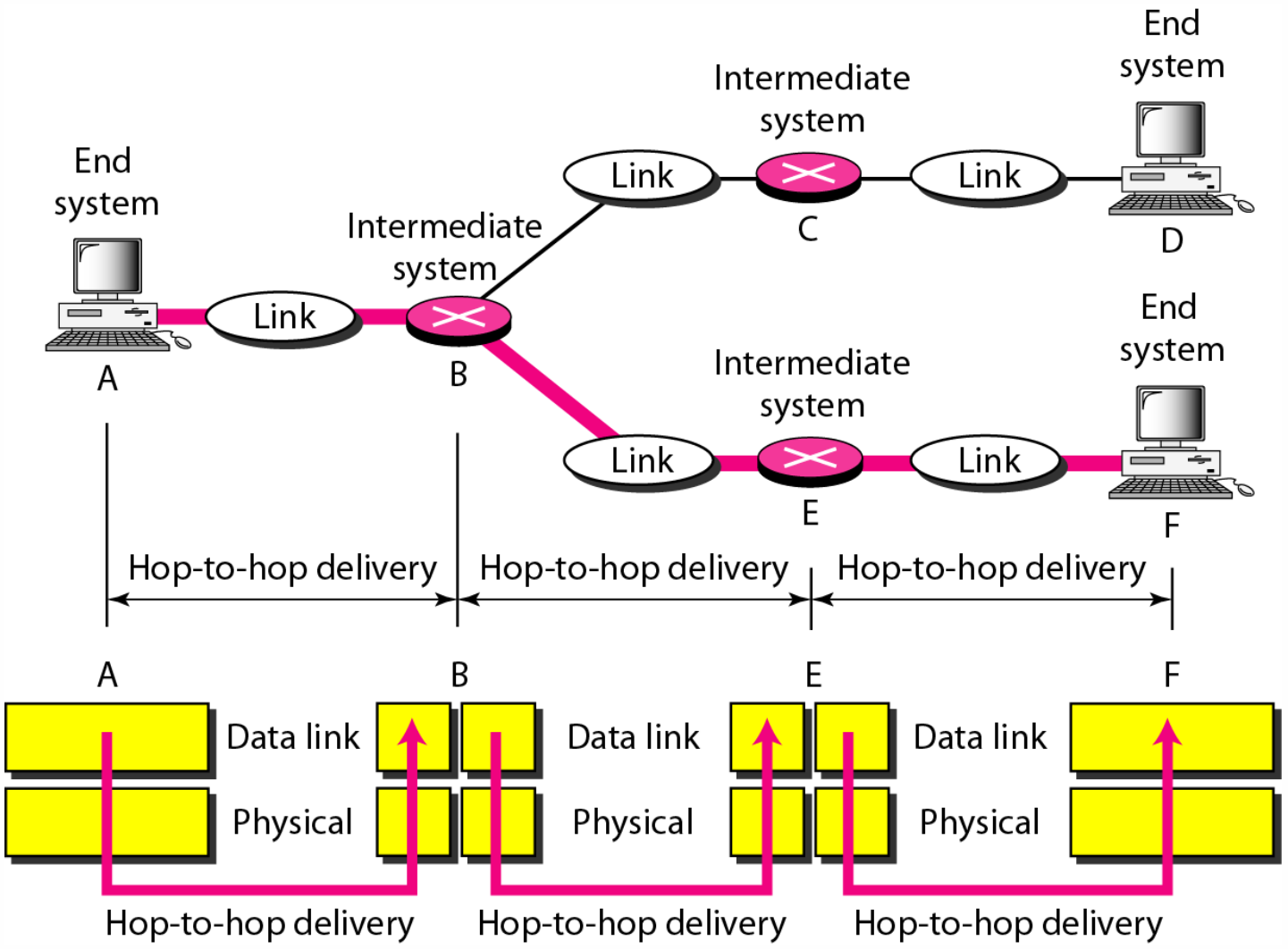


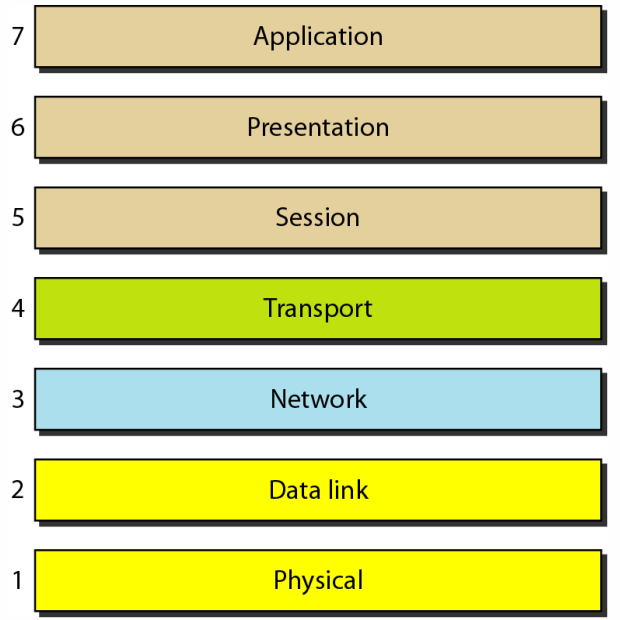
OSI LAYER 2: DATA LINK LAYER

- The data link layer is responsible for moving **frames** from **one hop (node) to the next**.
  - Framing
  - Physical addressing
  - Flow control
  - Error control
  - Access control

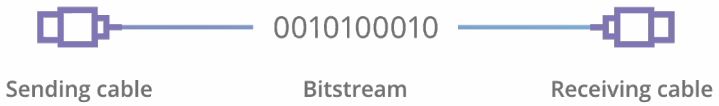


DATA LINK LAYER: HOP-TO-HOP DELIVERY



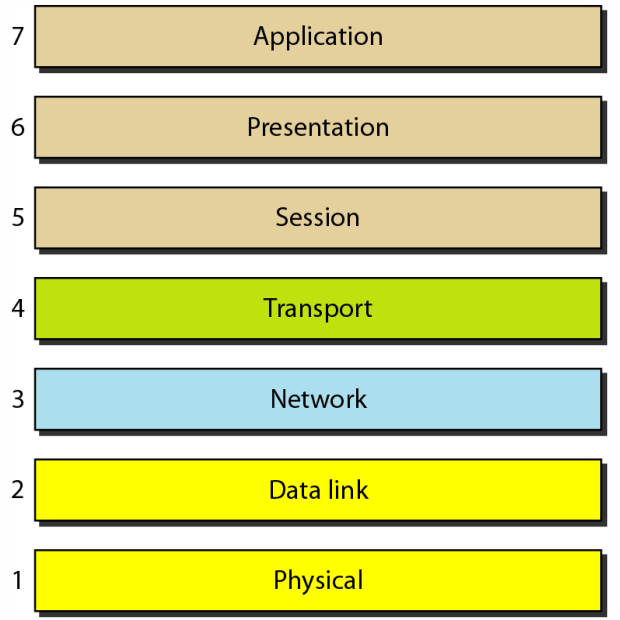


OSI LAYER 1: PHYSICAL LAYER



- This layer includes the physical equipment involved in the data transfer, such as the cables and switches.

- The physical layer is responsible for **movements** of individual **bits from one hop (node) to the next**.
  - Physical characteristics of interface and medium: pin assignment, connector, cables
  - Representation of bits: encoding
  - Data rate
  - Synchronization of bits
  - Line configuration: point-to-point, multipoint
  - Physical topology
  - Transmission mode: simplex, half-duplex, full-duplex



End-to-end overview: Sending an email

- Mr. Cooper wants to send Ms. Palmer an email.
- Mr. Cooper composes his message in an email application on his laptop and then hits ‘send’.
- His email application will pass his email message over to the application layer, which will pick a protocol (SMTP) and pass the data along to the presentation layer.
- The presentation layer will then compress the data and then it will hit the session layer, which will initialize the communication session.

End-to-end overview: Sending an email

- The data will then hit the sender's transportation layer where it will be segmented, then those segments will be broken up into packets at the network layer, which will be broken down even further into frames at the data link layer.
- The data link layer will then deliver those frames to the physical layer, which will convert the data into a bitstream of 1s and 0s and send it through a physical medium, such as a cable.

- Once Ms. Palmer's computer receives the bit stream through a physical medium (such as her wifi), the data will flow through the same series of layers on her device, but in the opposite order. First the physical layer will convert the bitstream from 1s and 0s into frames that get passed to the data link layer.
- The data link layer will then reassemble the frames into packets for the network layer. The network layer will then combine packets to make segments for the transport layer, which will reassemble the segments into one piece of data.

End-to-end overview: Sending an email

- The data will then flow into the receiver's session layer, which will pass the data along to the presentation layer and then end the communication session.

- The presentation layer will then remove the compression and pass the raw data up to the application layer.

- The application layer will then feed the human-readable data along to Ms. Palmer's email software, which will allow her to read Mr. Cooper's email on her laptop screen.

OSI MODEL: SUMMARY OF LAYERS