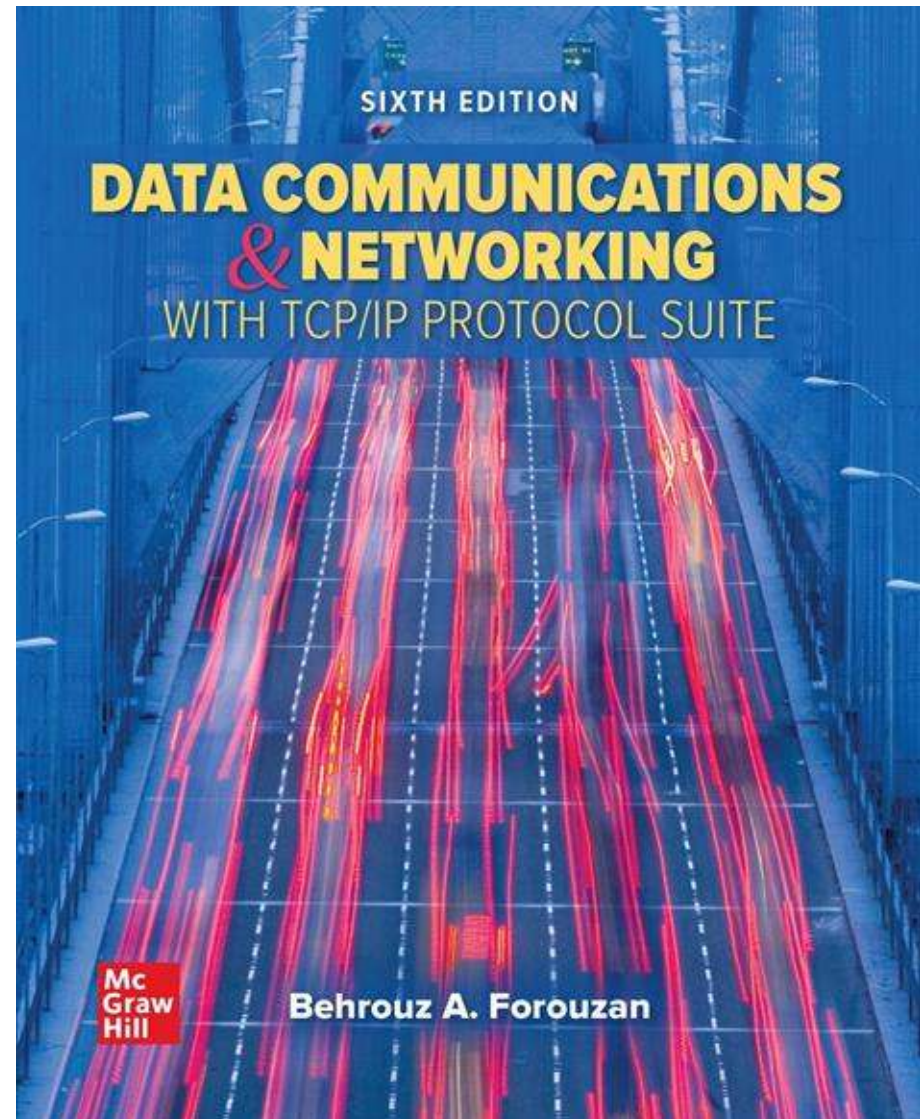


Chapter 01

Introduction

- Data Communications and Networking, With TCP/IP protocol suite Sixth Edition
- Behrouz A. Forouzan



Chapter 1-Part 2: Outline

- 1.4 PROTOCOL LAYERING
- 1.5 TCP/IP PROTOCOL SUITE
- 1.6 THE OSI MODEL

Protocol Layers and Service Models



- Computer network architecture is **complex**
 - Too many components
 - How to understand its architecture?
 - How to allow developers and users to deal with this complexity?
- **Solution** □
 - Computer networks functions are designed and implemented as **layers**
 - Layers are **logical groupings** of all the **processes or functions** required for effective **data exchange**
 - Layer n-1 provides some service to the layer n through a **well-defined interface (boundary between each two layers)**
 - Each **interface** defines what **information, operations, and services** a layer must provide for the layer **above** it.
 - These layers are distributed across **all** nodes in the network

Layers, protocols, and interfaces.

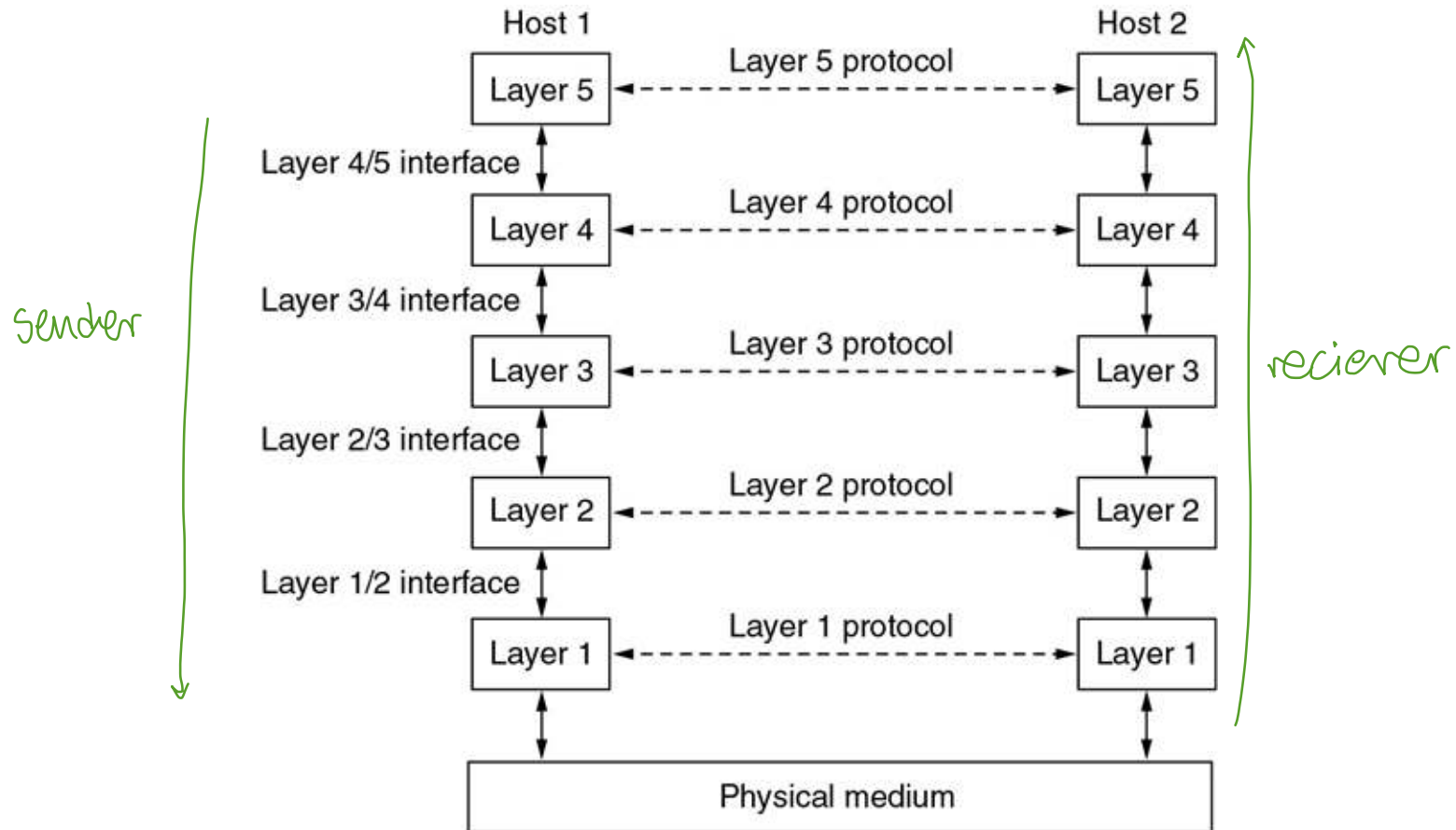
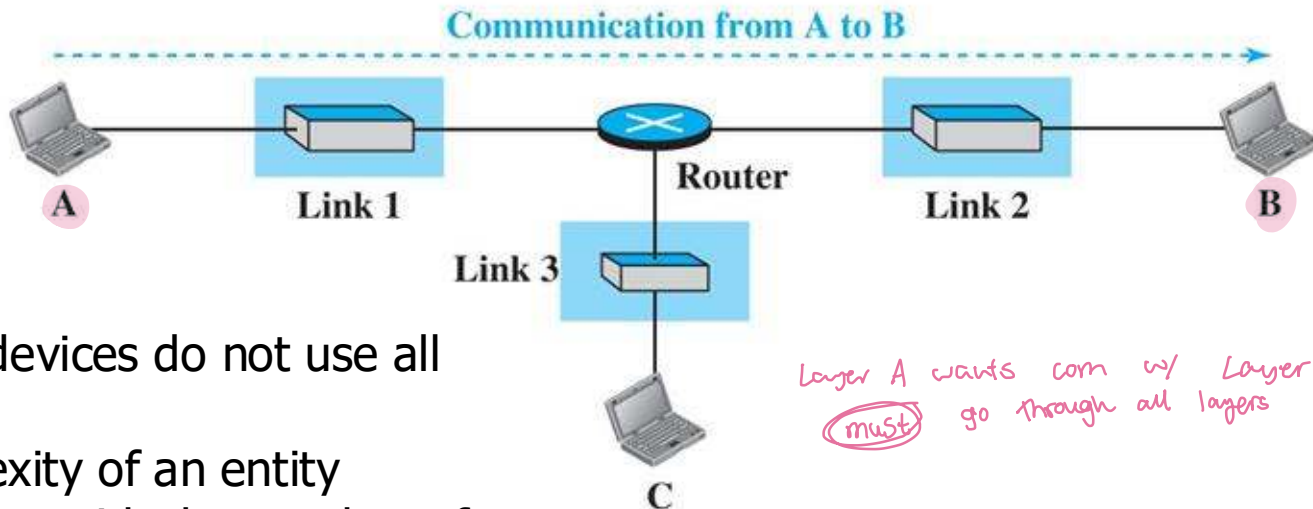
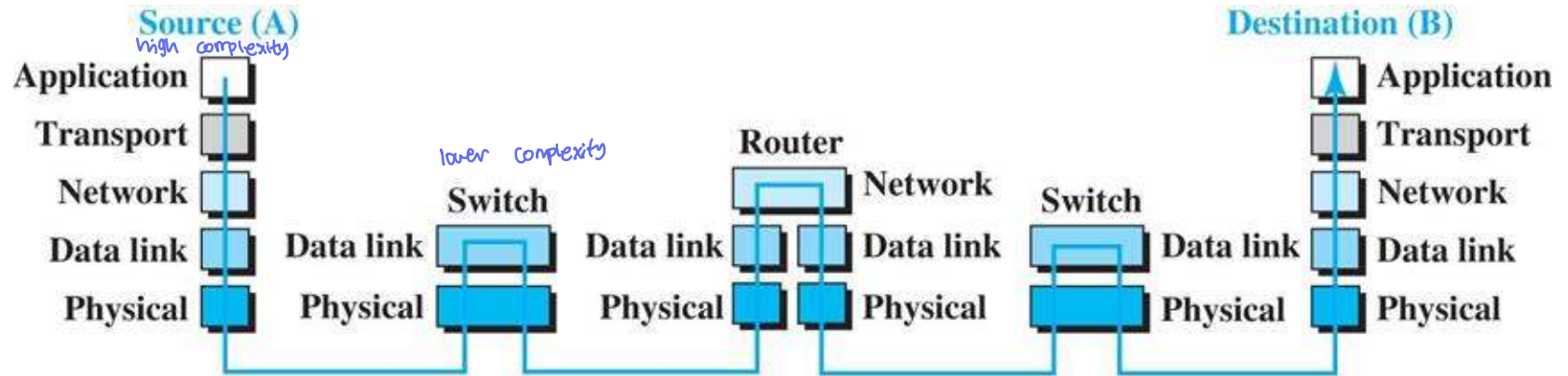


Figure 1.18 Communication through an internet



- Some devices do not use all layers.
- Complexity of an entity increases with the number of layers that it supports

Layer A wants com w/ Layer B
must go through all layers

Ex: 7 layers
program comp from scratch so build layer 1-7
each vendor work on separate layer
divide-conquer

Advantages of Layered Architecture

- Breaks the complicated communication process into layers of simpler processes which allows **easier hardware or software implementation**
- Each layer implements **distinct** set of protocols (functions) which means that :
 - The implementation of *each layer can be* **done independently** of the other layers.
 - This allows *different manufacturers to supply the hardware and software* needed to the different layers
 - encourages collaboration & Competition
- Well-defined layers interfaces allow **changing the implementation of one layer** with a completely different implementation **without affecting the other layers**

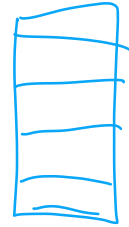
protocols

protocols



Robustness

Standard Protocol Models



layers look
like stack (CS210)
so combo of them is stack

- The protocols of the various layers are called **protocol stack**
- **Two Standard Protocol models (stack) exist:**
 - Open System Interconnect (**OSI**)
 - Transmission Control Protocol/Internet Protocol (**TCP/IP**)

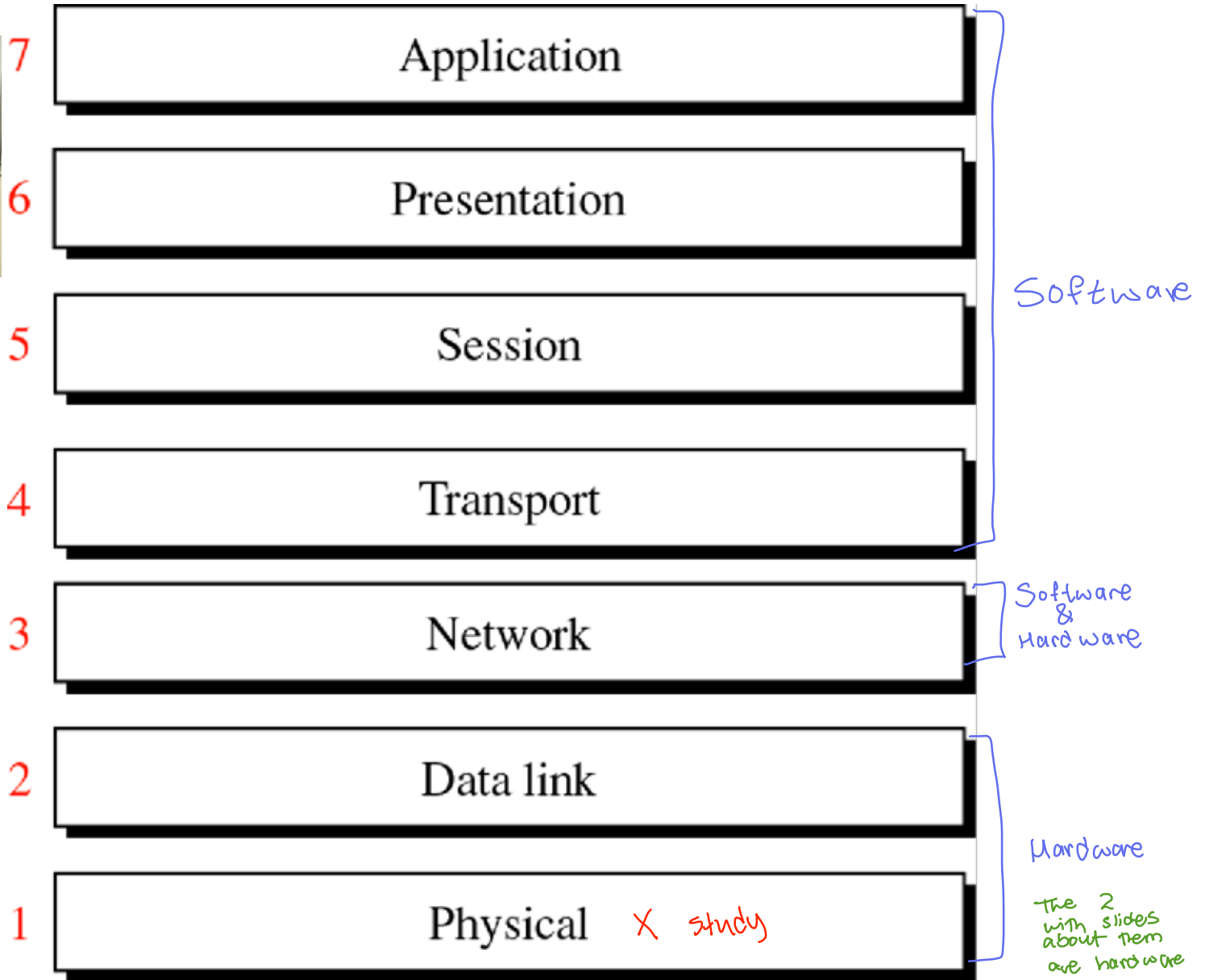
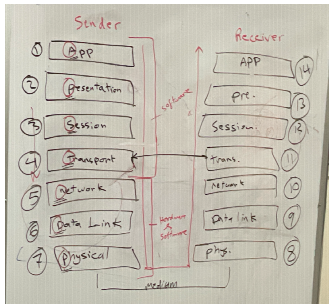
OSI Model

*developed
ISO
(opp of name)*



- Developed by ISO (the International Organization for Standardization) in 1970s
- Provides framework for standardization
- An open system is a set of protocols that allow any two different systems to communicate regardless of their underlying architecture.
- Describes how data and network information moves from an **application** in one computer to an **application** in another computer.
- Dominated before 1990

OSI Model ^{7 layers}



OSI Model

To remember the 7 layers is the sentence “All people seem to need data processing”

good mnemonic

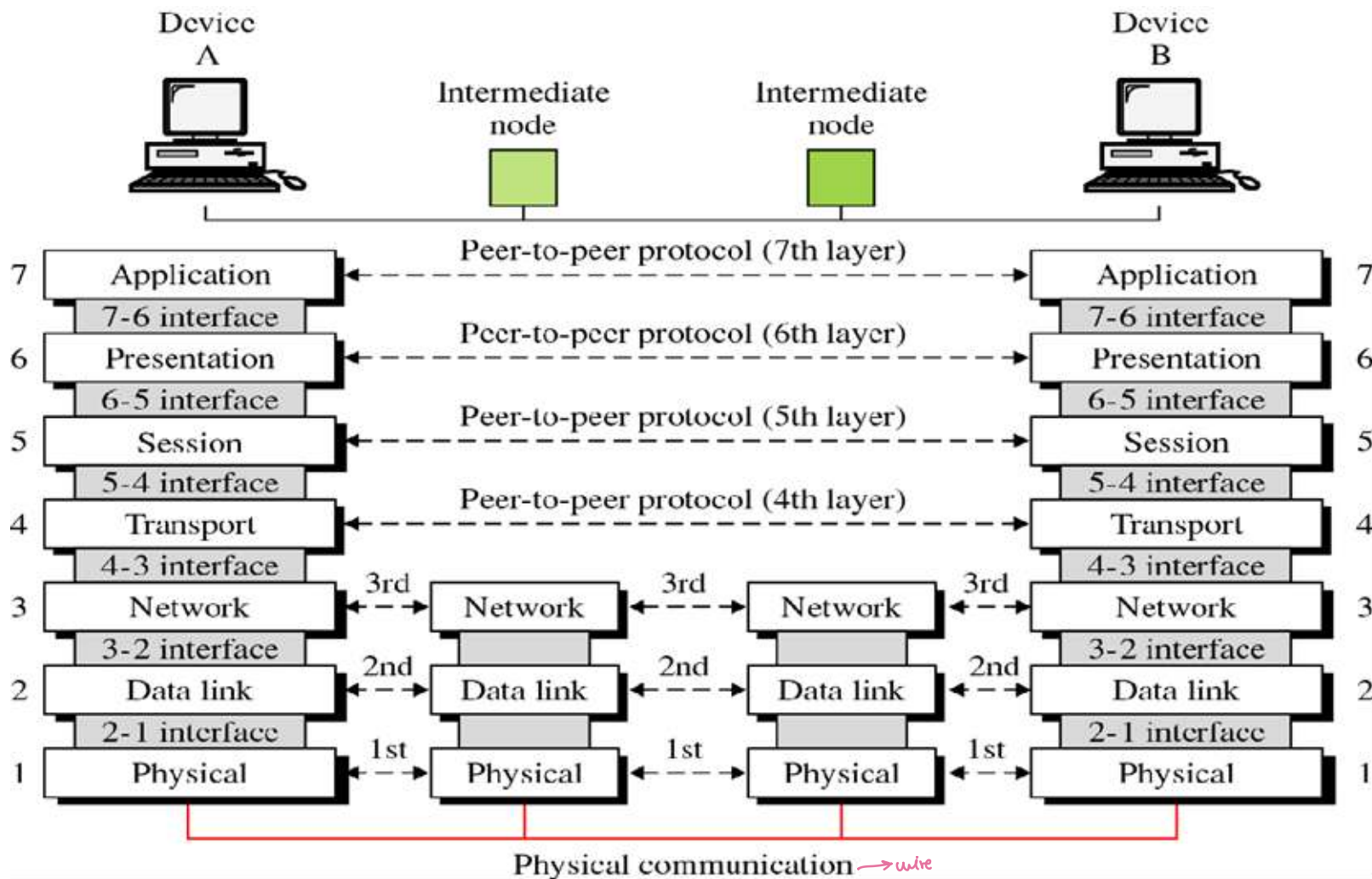
OSI Protocols Implementation

- A protocol layer can be implemented in software, in hardware, or in a combination of the two
- Application, Presentation, Session and Transport are implemented in software
- Network is a mixed implementation of *hardware and software*
- Physical and data link are implemented in *hardware* in the network interface card (NIC)

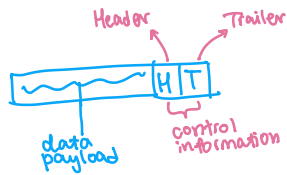
Peer-to-Peer Processes

For a message to be sent, must pass through all layers in both entirely

Peers are entities (processes, hardware devices) on two or more machines communicating at a **given layer**



OSI model-Basic Operation



deal w/ sender & receiver as nodes

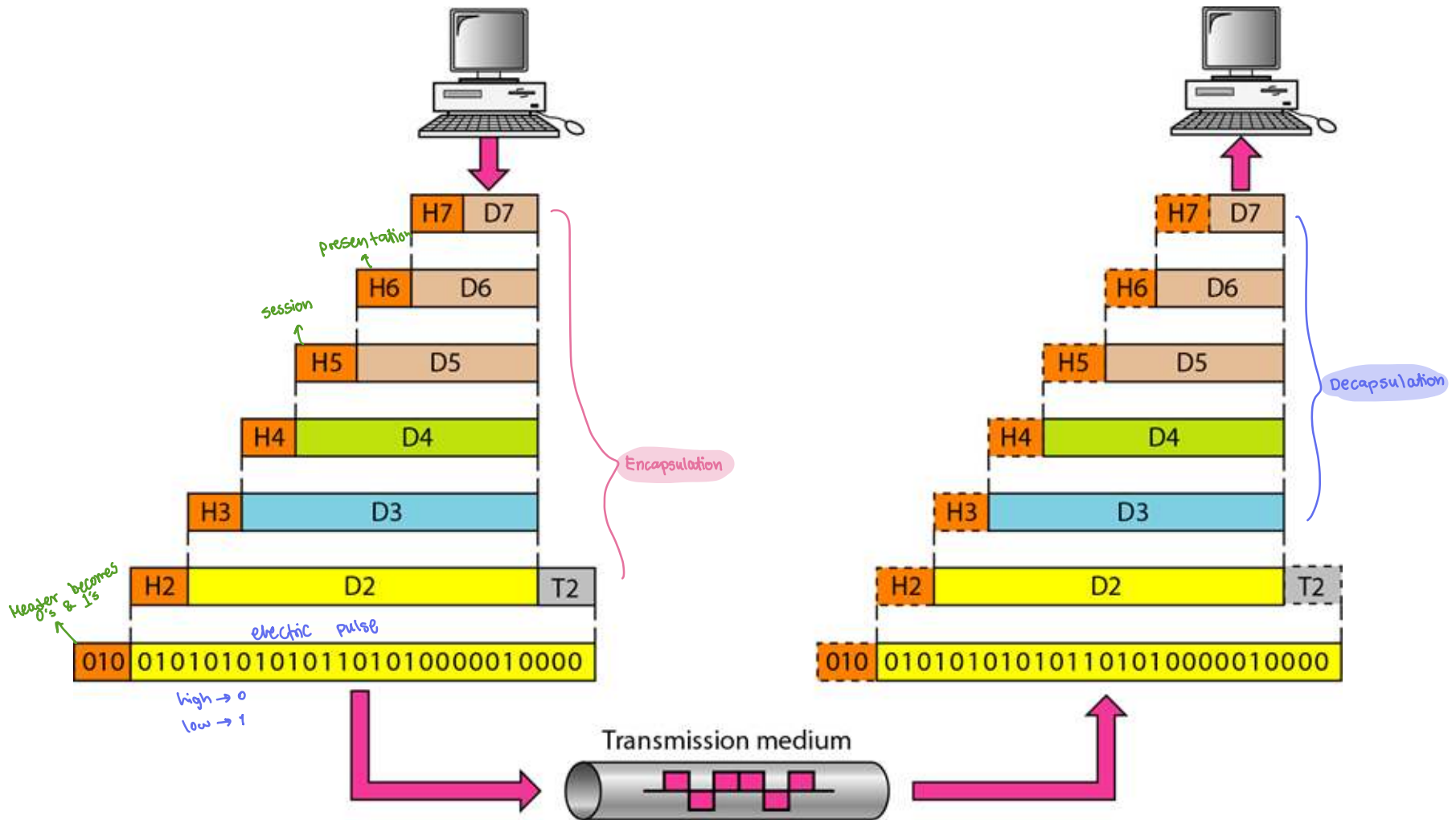
- **Peer-to-Peer communication:** Each layer on a **sending node** communicates (**logically**) with its peer layer on the **receiving node** using **formatted blocks of data** called **Protocol Data Units (PDU)**
- **PDU** = combination of **data (payload)** from the *next higher layer* and the **control information** of the *current layer* (Specific **requests** and **instructions**)
 - Control information are given in the **header** fields of the block except for the data link (has both header and trailer)
 - Control information is read and executed **ONLY** by the peer layer on the **receiving node**

allow data to move in specific

Data link layer → header/trailer

other layers → header

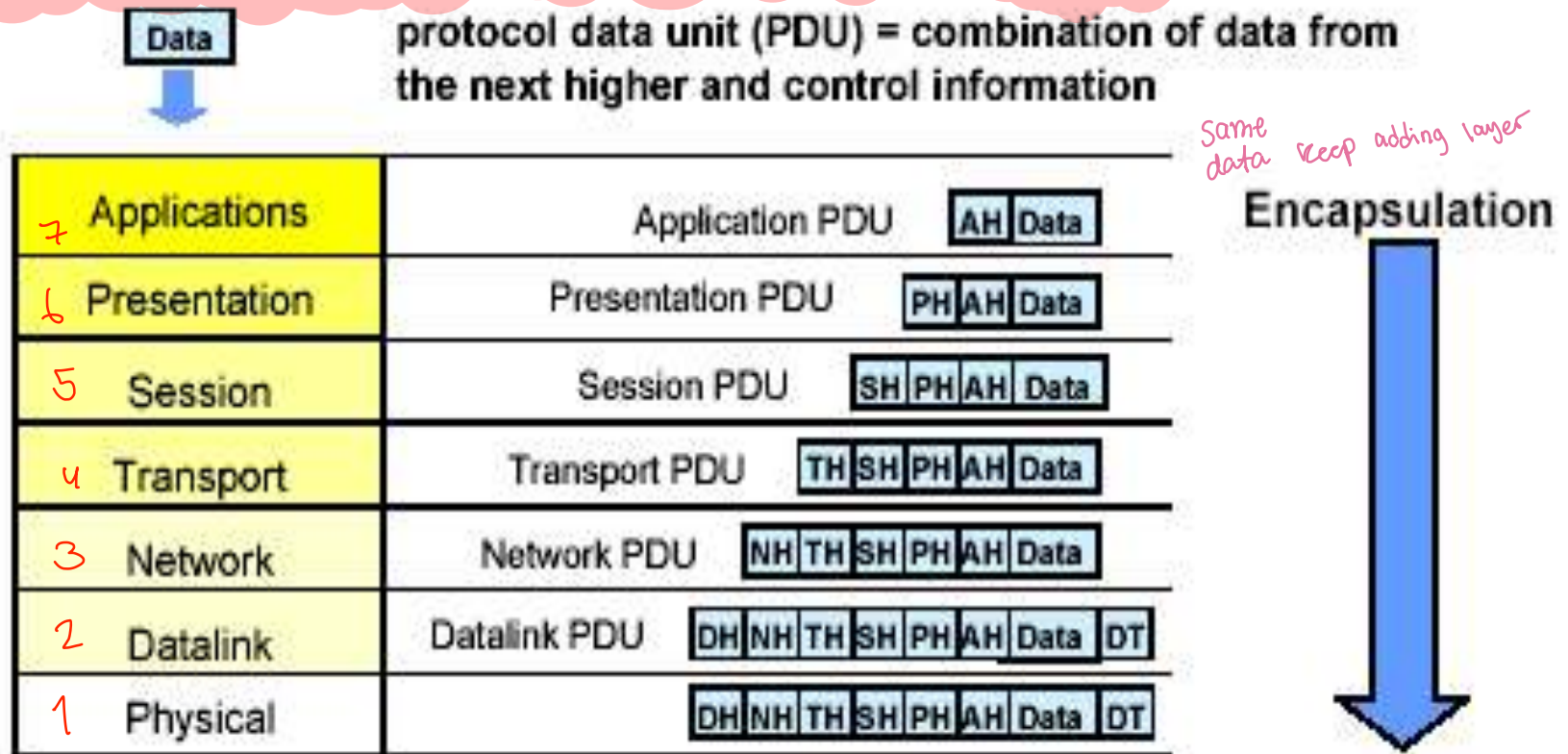
Figure 2.4 *An exchange using the OSI model*



only corresponding layer in receiver can remove control info

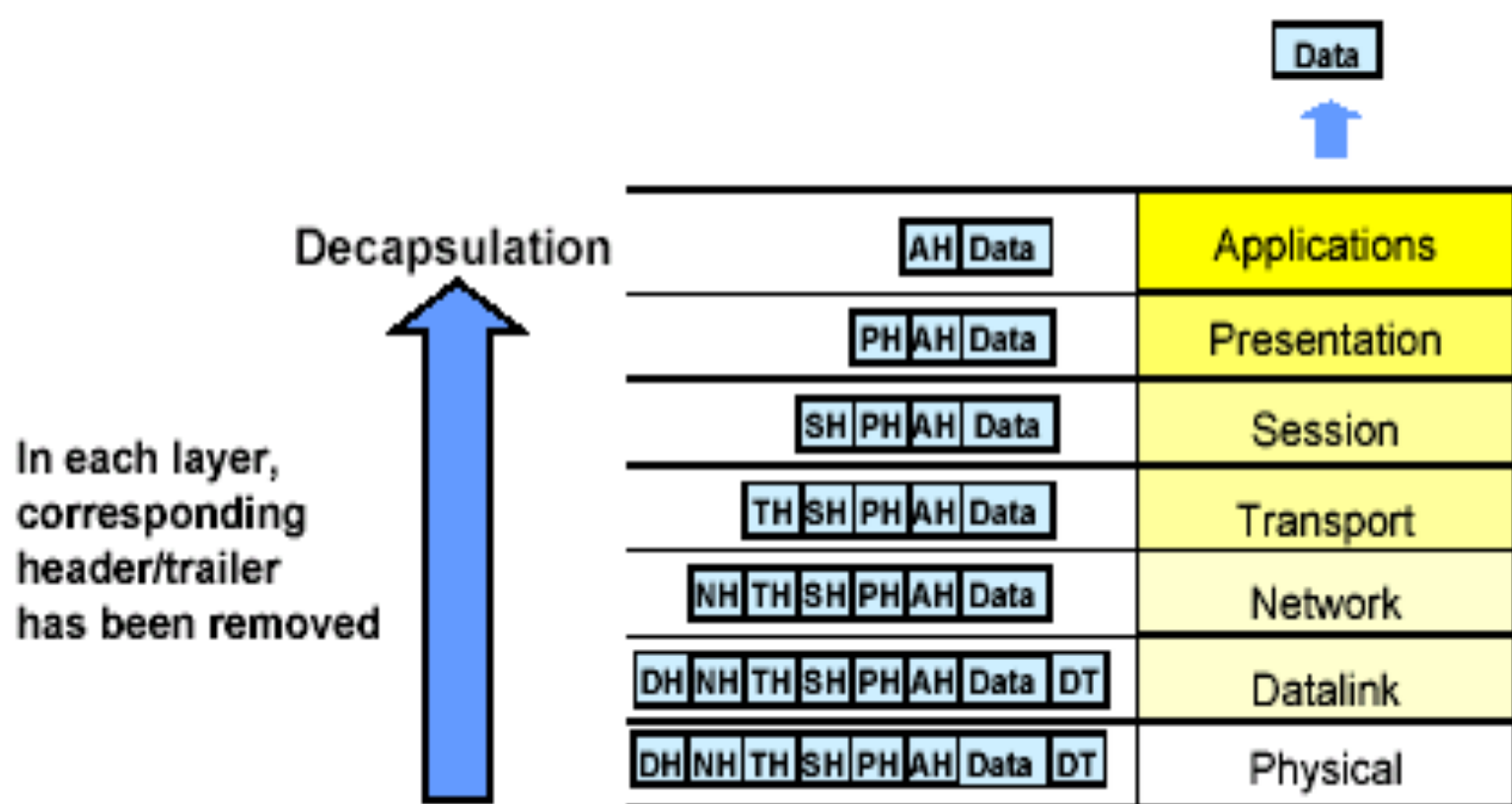
Data Encapsulation

Data encapsulation refers to the fact that layer N-1 carries in its data part the PDU of layer N without any knowledge of its content and its different parts.

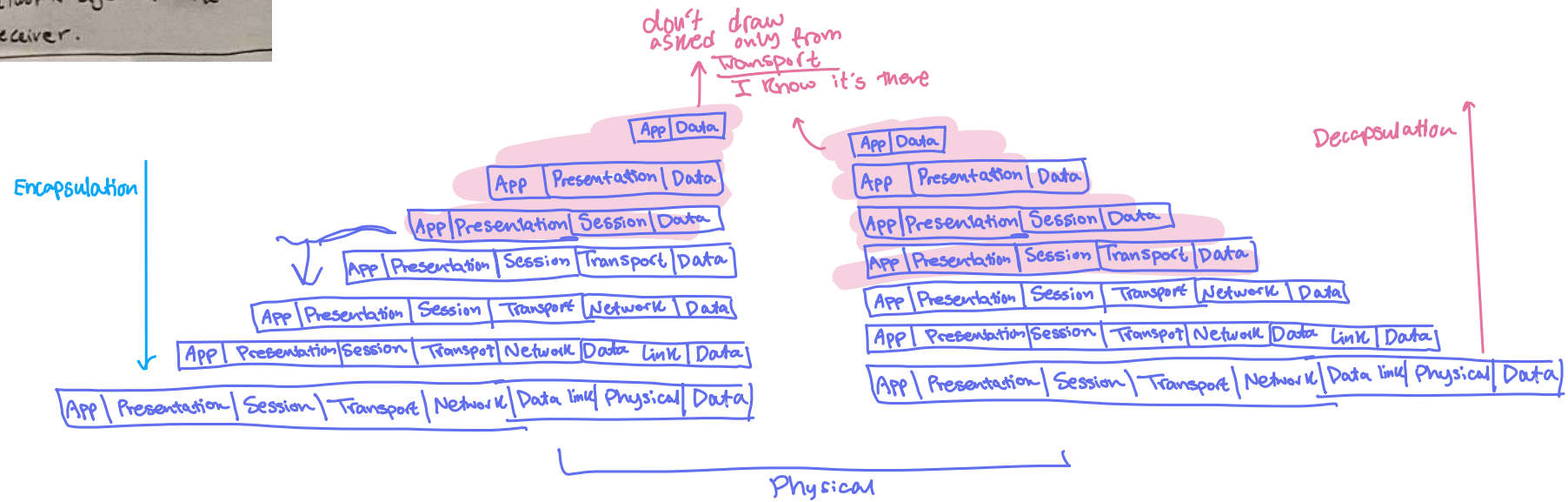


Additional of control information to data is referred to encapsulation

Decapsulation

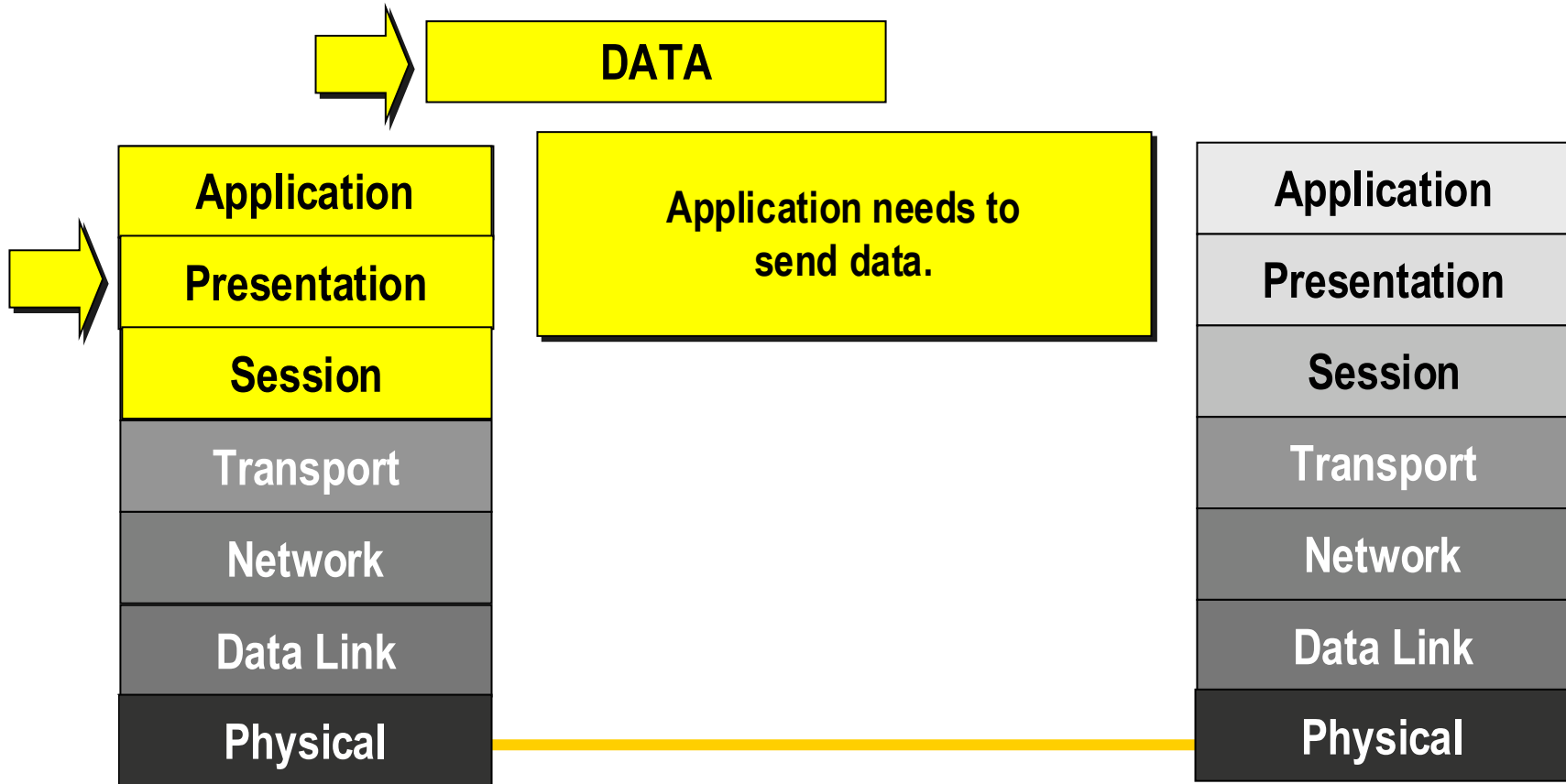


- Draw The encapsulation and decapsulation process for a message traveling from the transport layer of the sender to the network layer of the receiver.

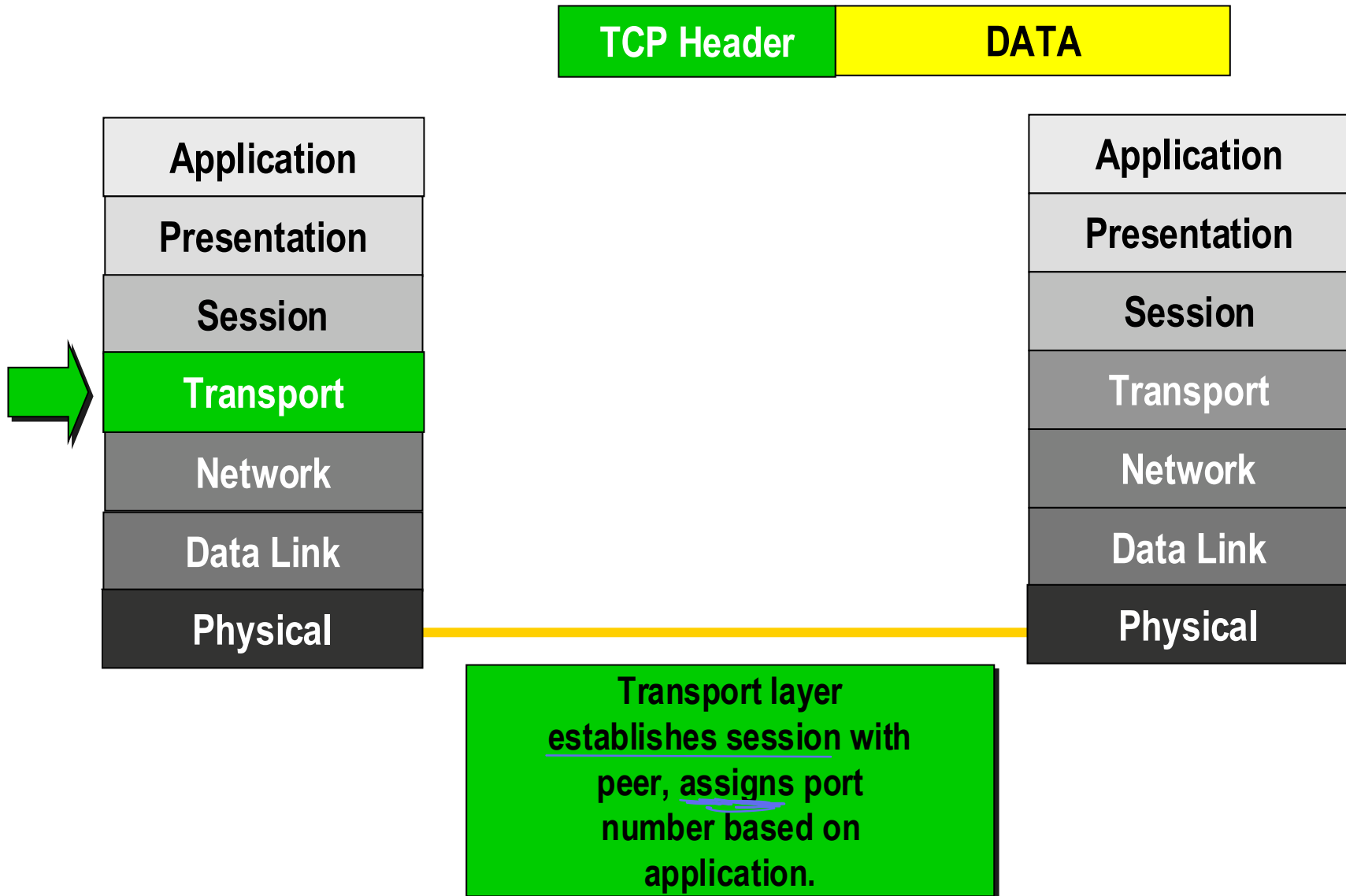


I email my friend
email : data (encapsulated)
every layer I'm attaching

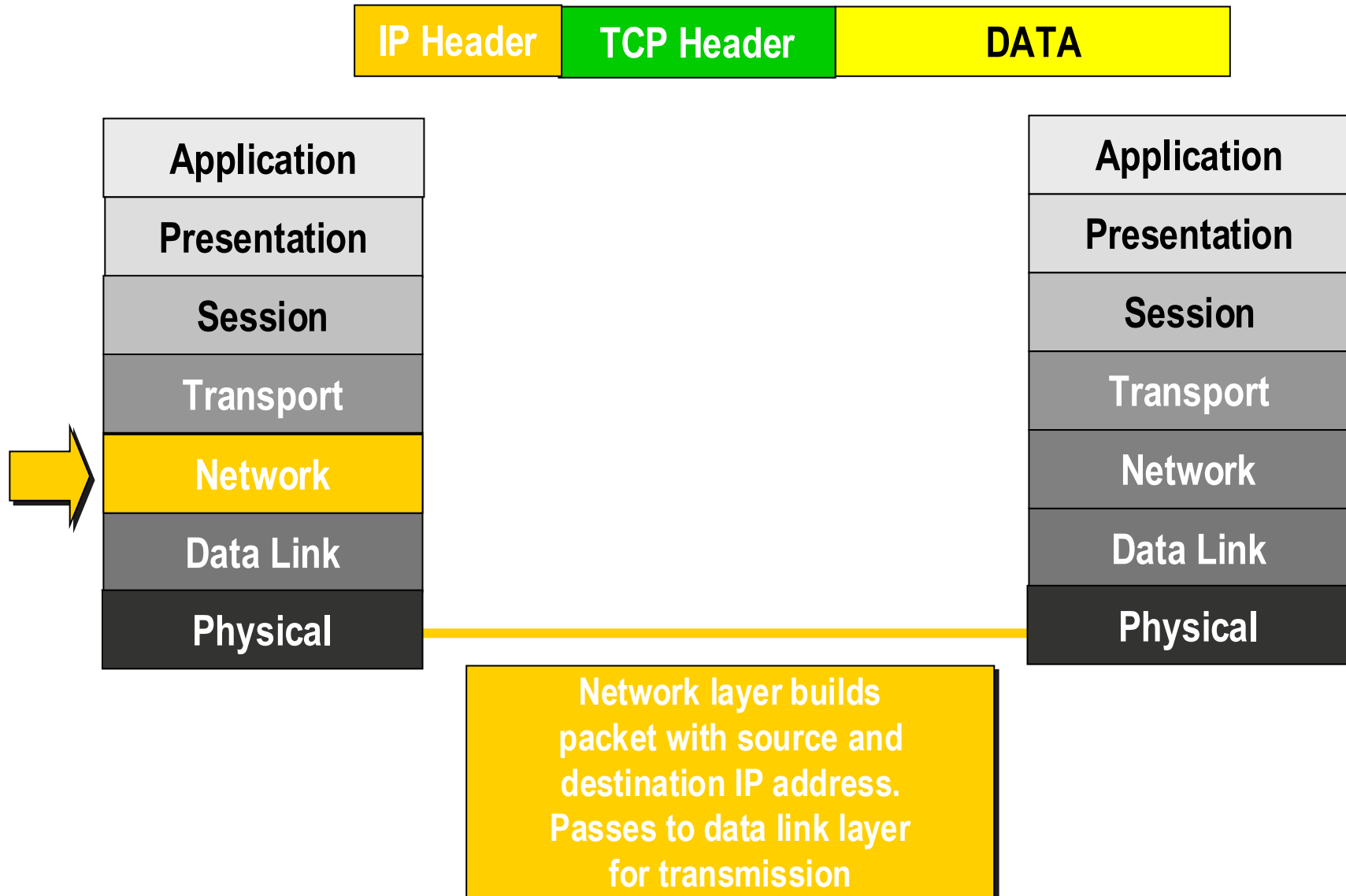
How Hosts Talk over a Network



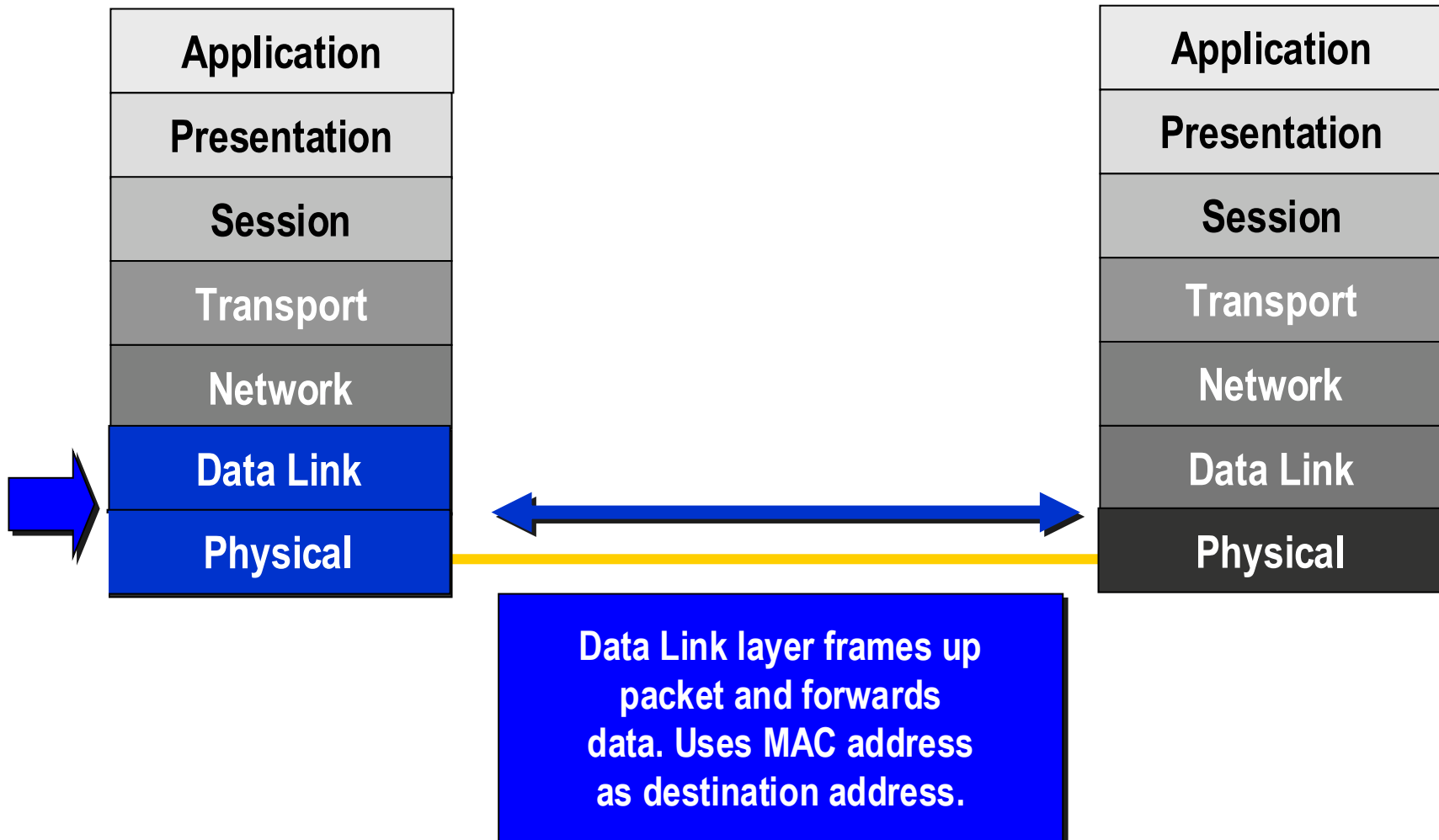
How Hosts Talk over a Network



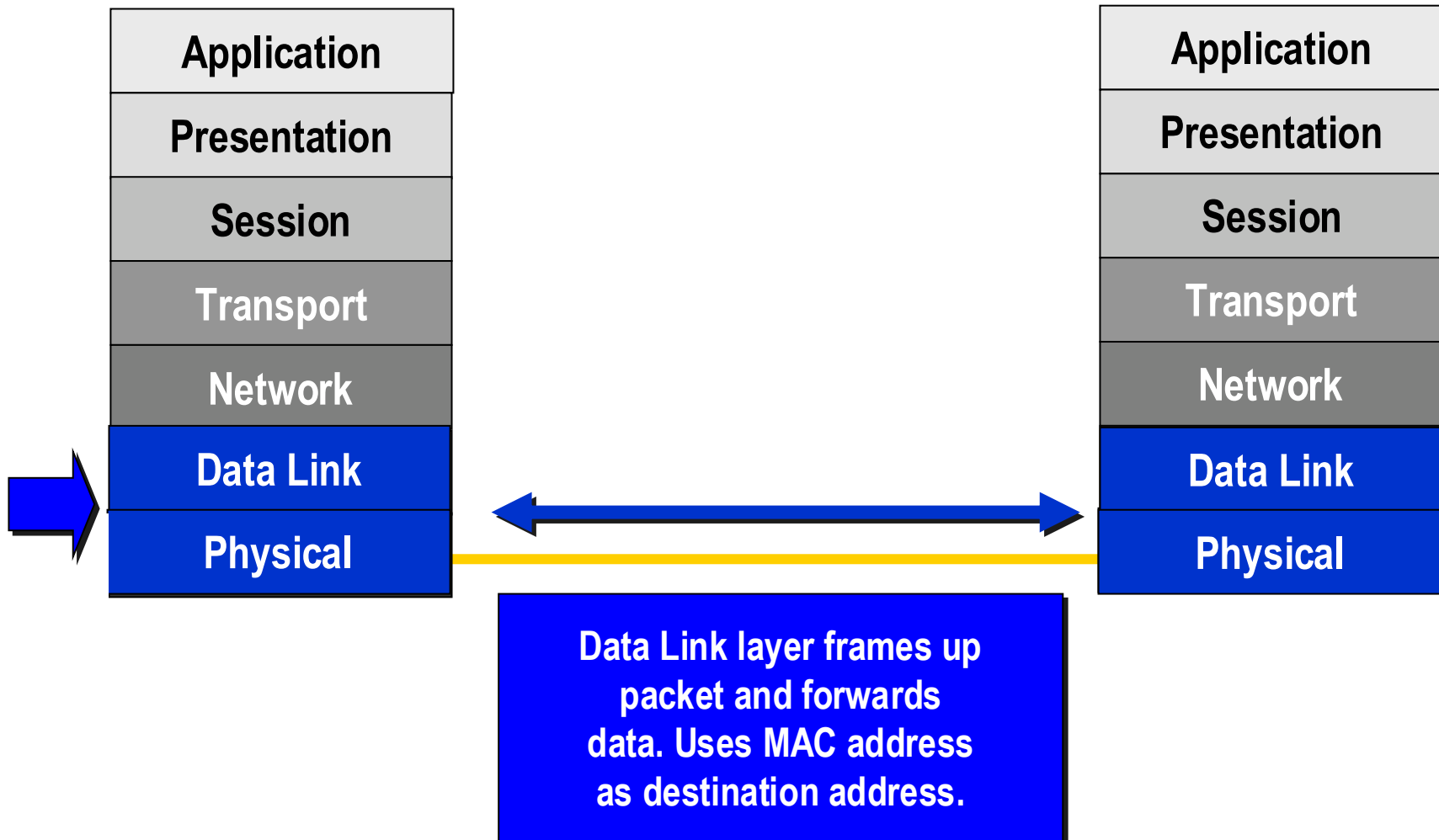
How Hosts Talk over a Network



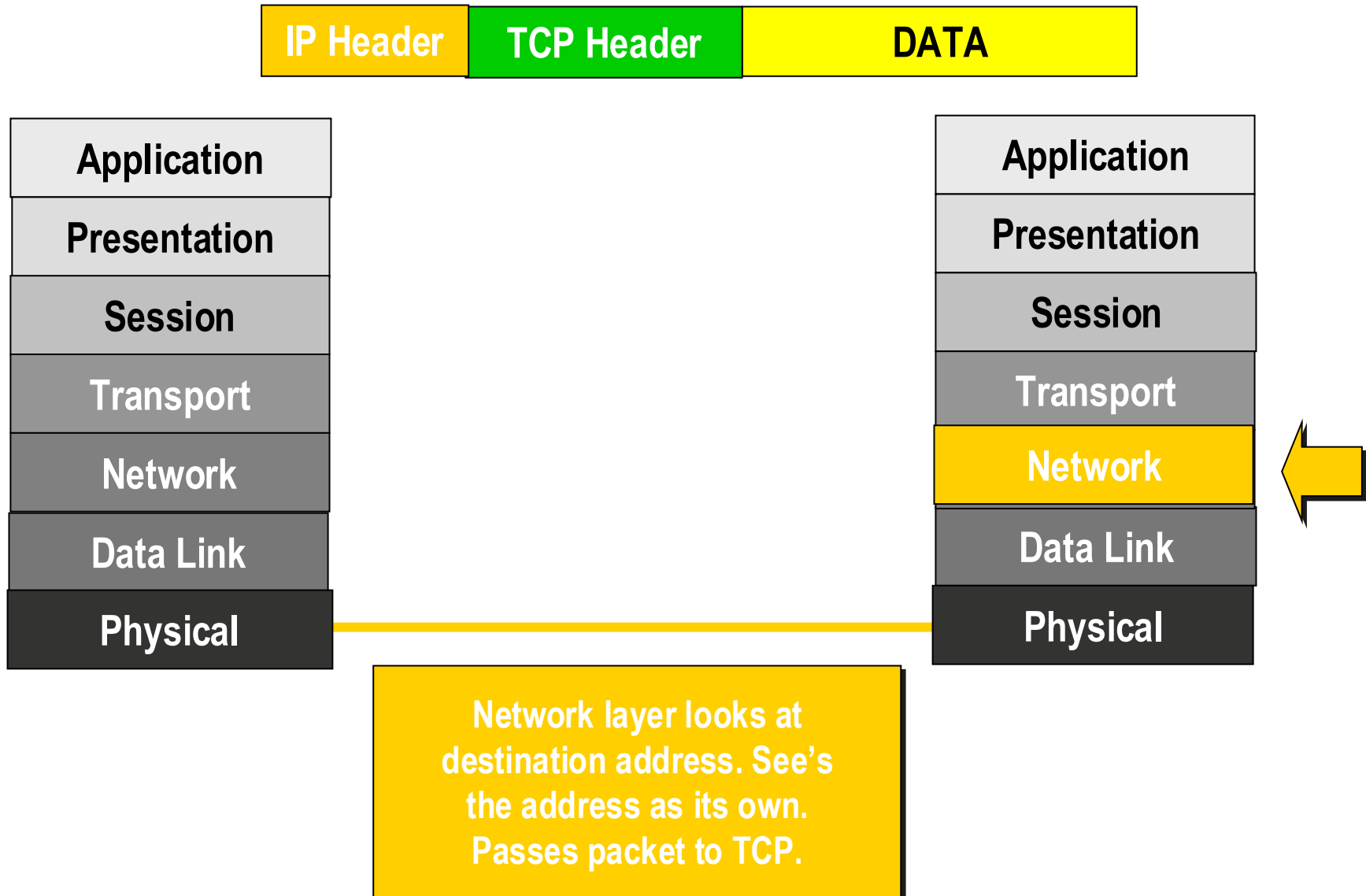
How Hosts Talk over a Network



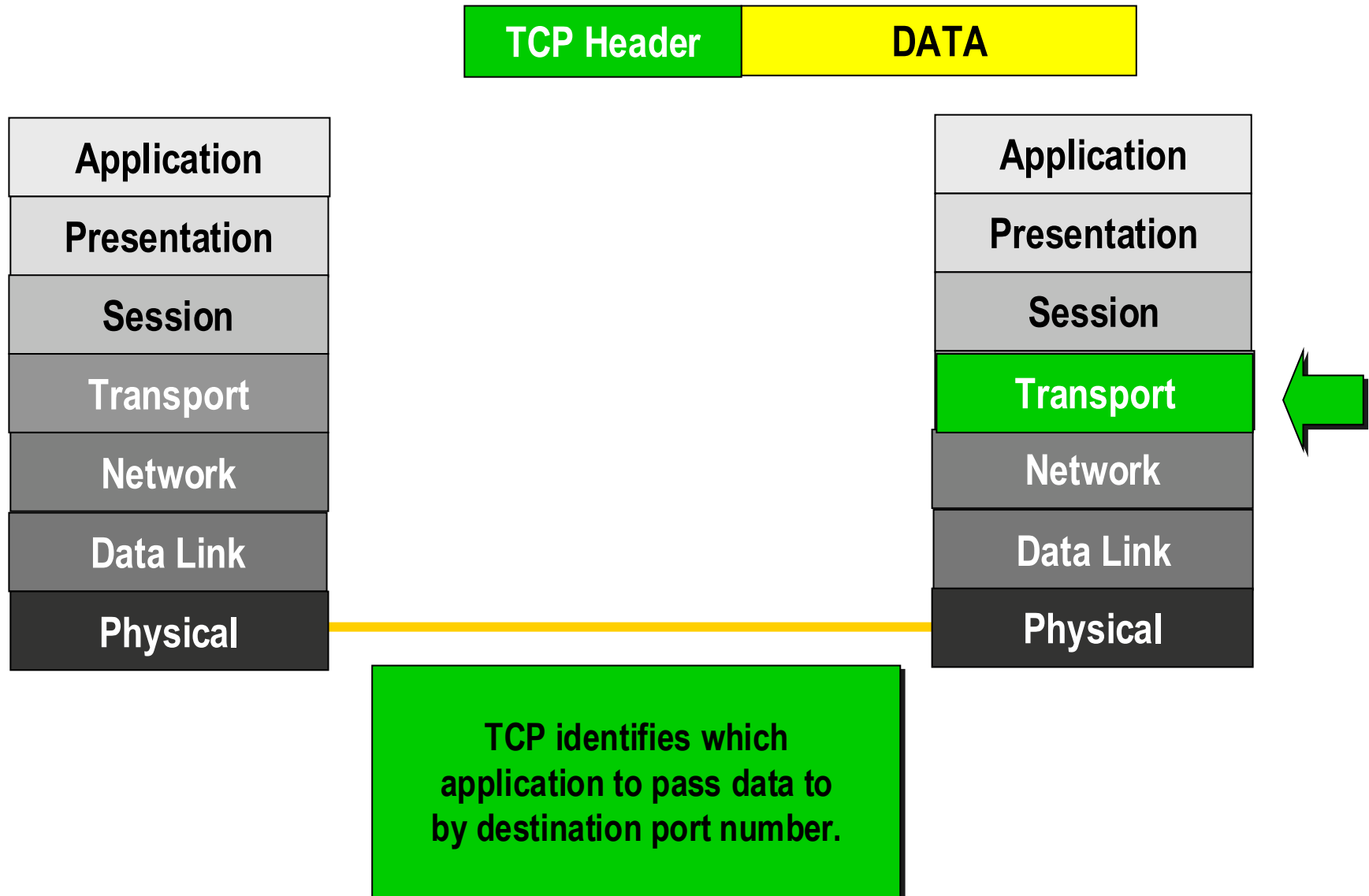
How Hosts Talk over a Network



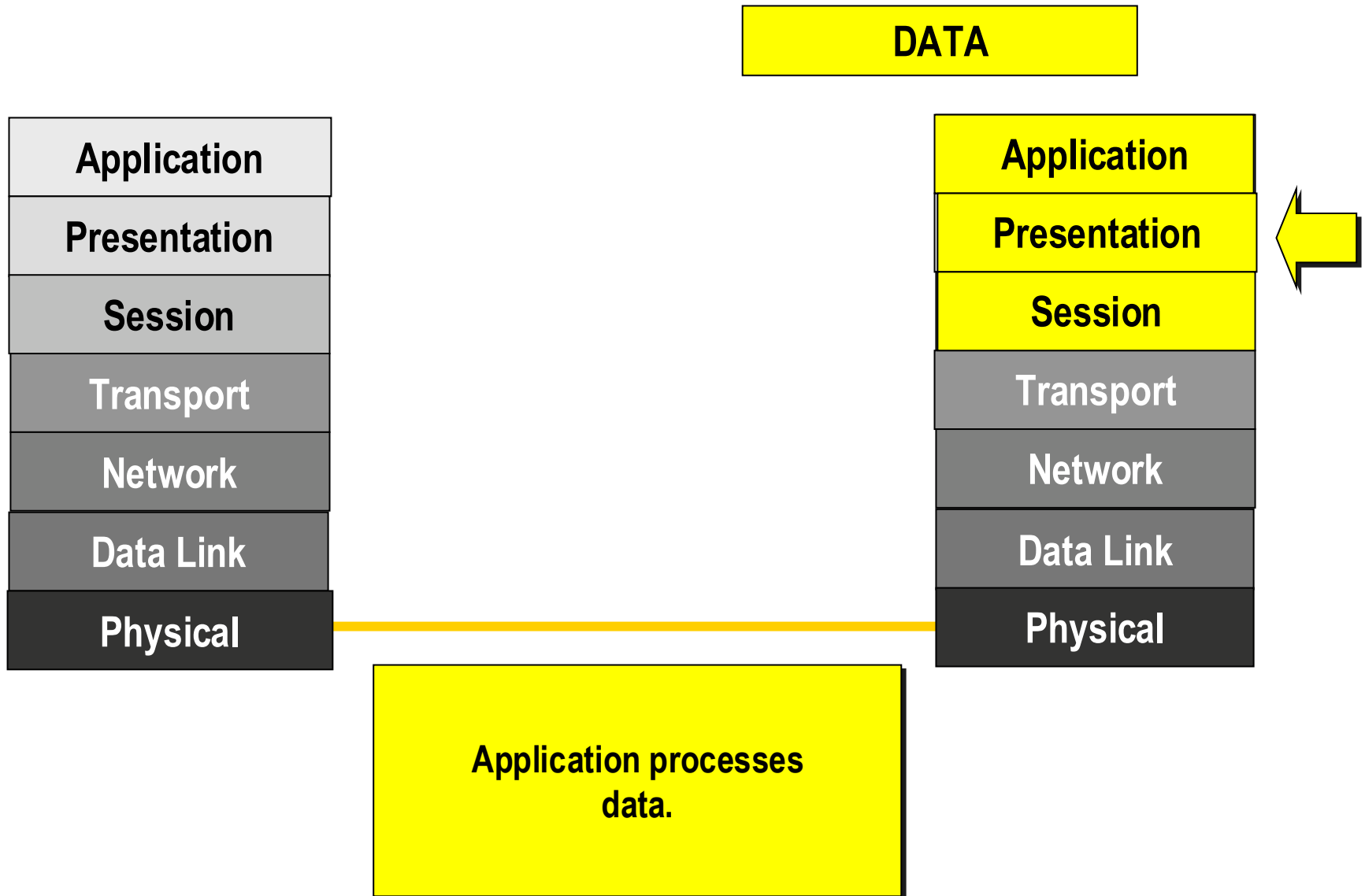
How Hosts Talk over a Network



How Hosts Talk over a Network

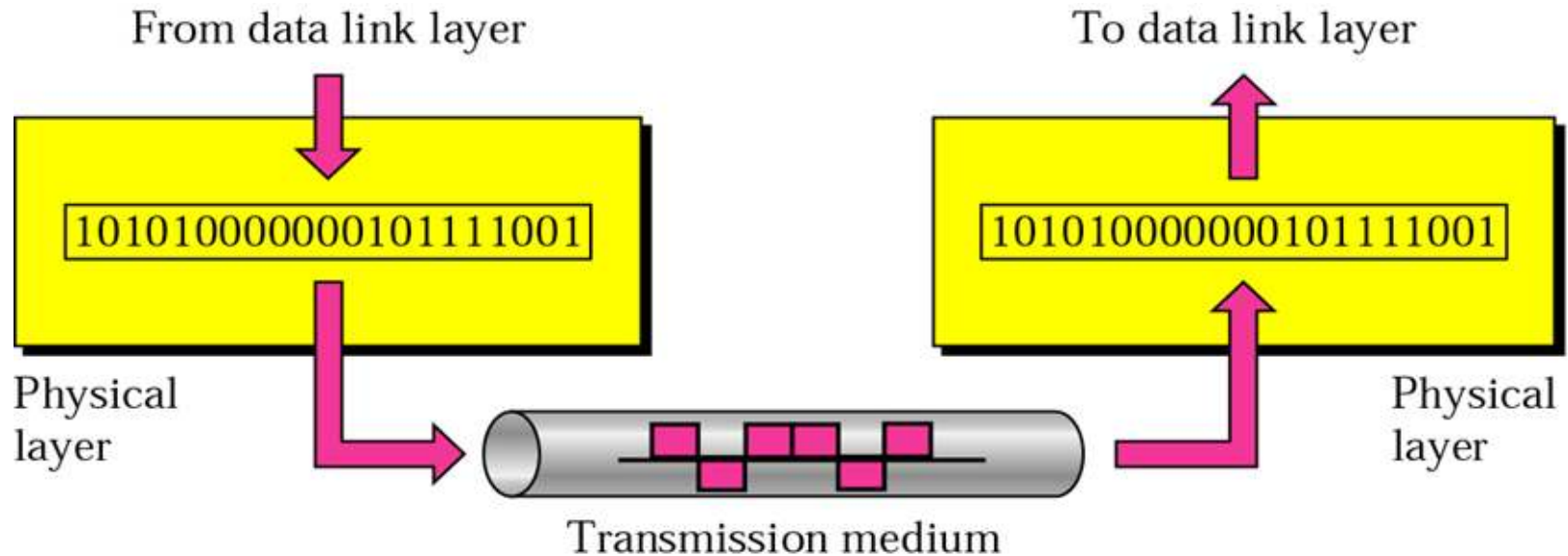


How Hosts Talk over a Network



Physical Layer

Located at sender & receiver



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

Physical Layer

- Deals with **the actual communication media**
 - Defines the **physical characteristics** of **interfaces** and **transmission media**
 - the way devices are connected to each other and to the link (topology) *at the end of our devices*
 - Shape, size and number of pins of connectors
 - What voltages and currents are used
 - The type of transmission media
 - Transmission mode (duplex type)
 - **Representation of bits** – encoding into Electrical or Optical signals *Define*
 - **Data Rate** = transmission rate = bandwidth (**number of bits sent per second**) *most common name* *memorize this IMP*
 - **Synchronization of bits** (sender and receiver clocks must be synchronized)
 - Devices that operates at this level: **Network card, hub, repeater**

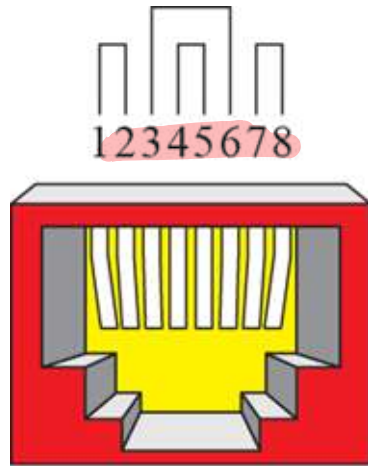
linked to my wires



amount of voltage decides 1's & 0's



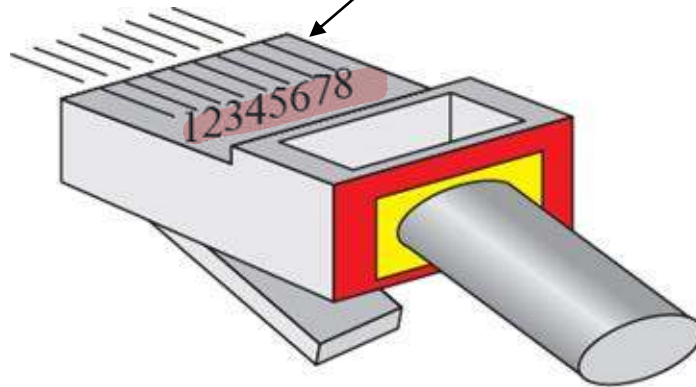
**In NIC or networking
device**



RJ-45 Female

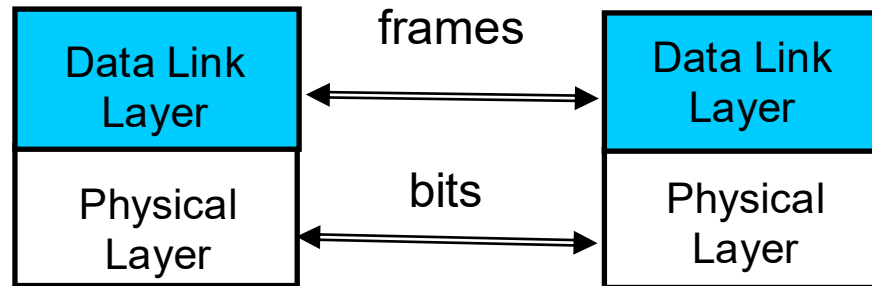
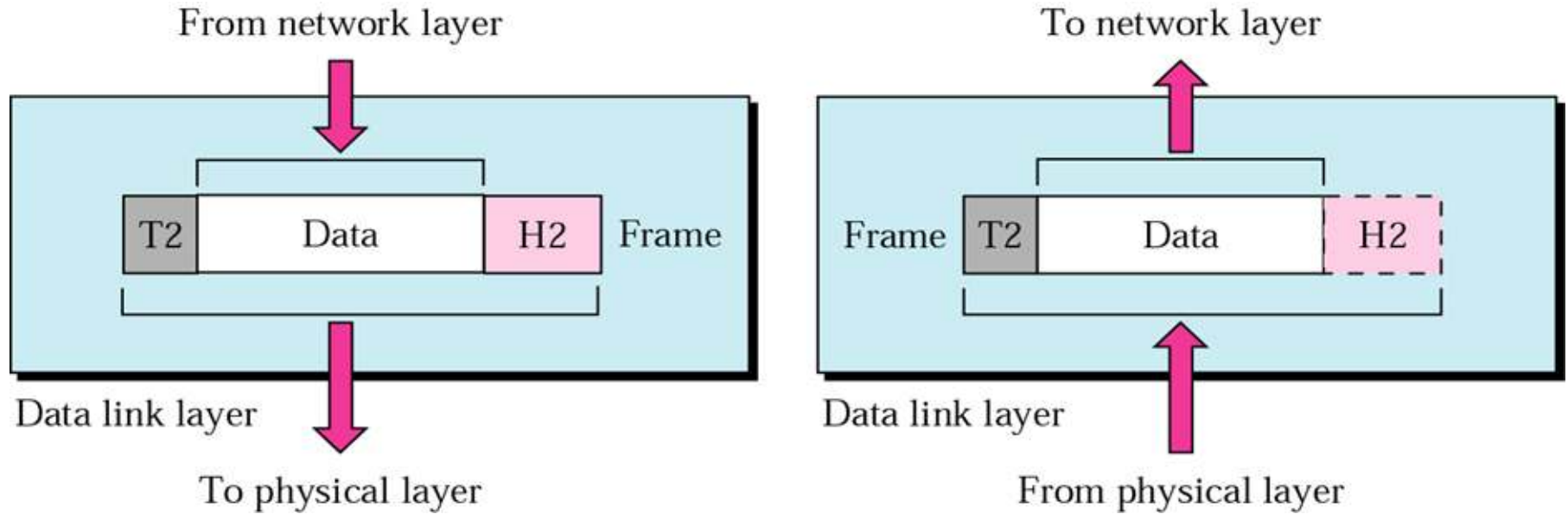
Connected to the Cable

*Organization of pins
must be consistent
message will be mixed up*



RJ-45 Male

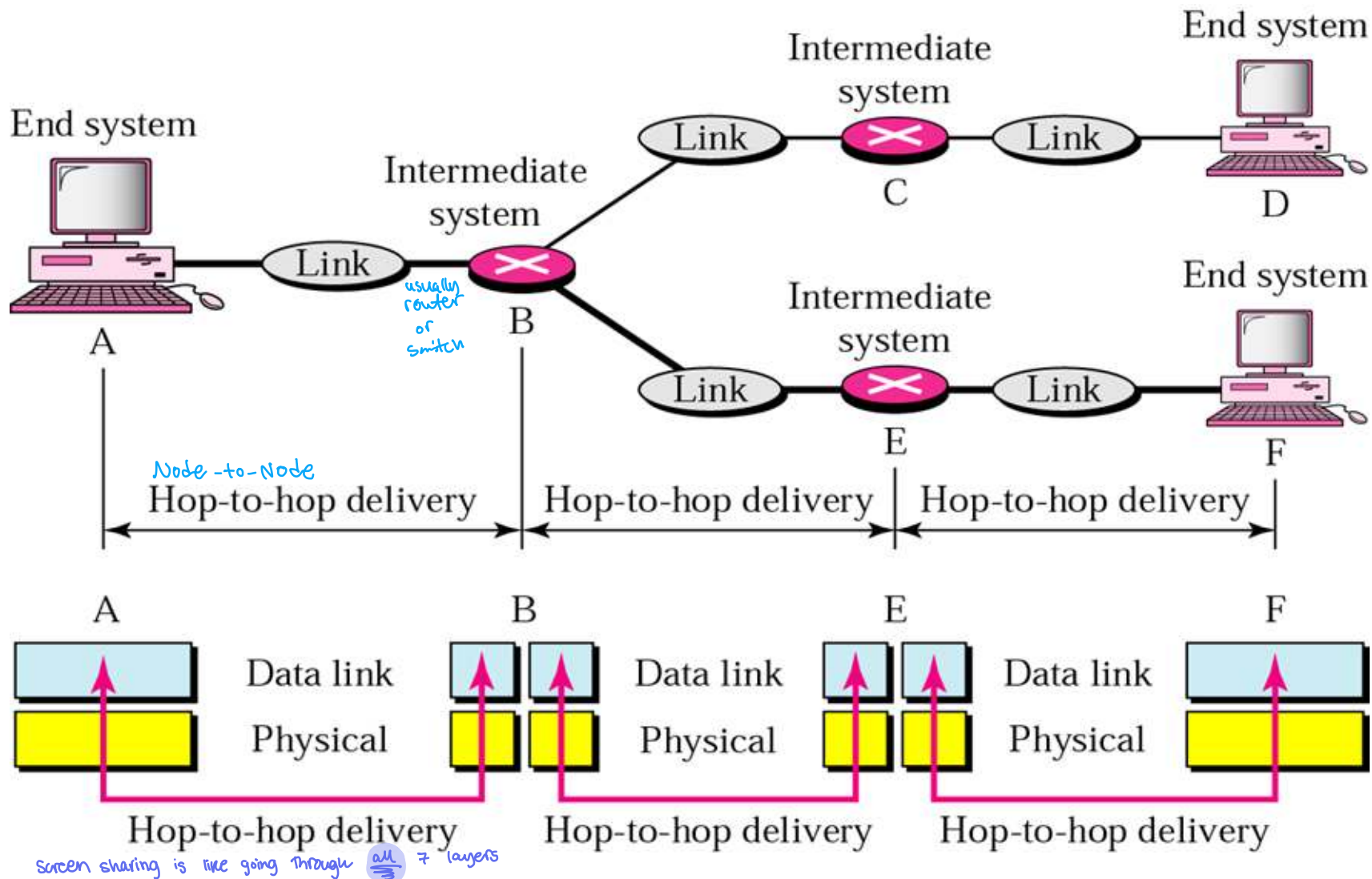
Data Link Layer



Note

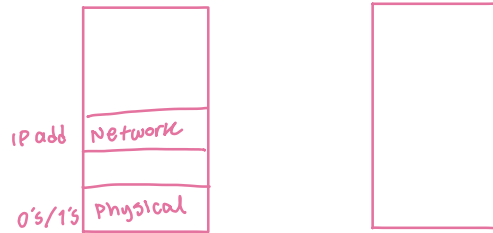
The data link layer is responsible for moving frames (data link PDU) from one hop (node) to the next.

Figure 2.7 *Node-to-node delivery*

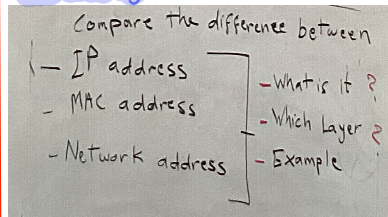


Data Link Layer

- Data Link layer PDU is called **frame**
- Transfers **frames** across direct connections **Node-to-Node** (hop-to-hop) delivery
- **Framing**: dividing the stream of bits into units called frames
which address am I sending to?
- **Physical Addressing**: sender and receiver physical addresses (Local address – hardware address – NIC address – LAN address)



Activity



Fill in blank
MCQ
T/F
Define
Give example

IP address:

- ① Building packet with source to pass to data link layer for transmission
- ② Network layer
- ③

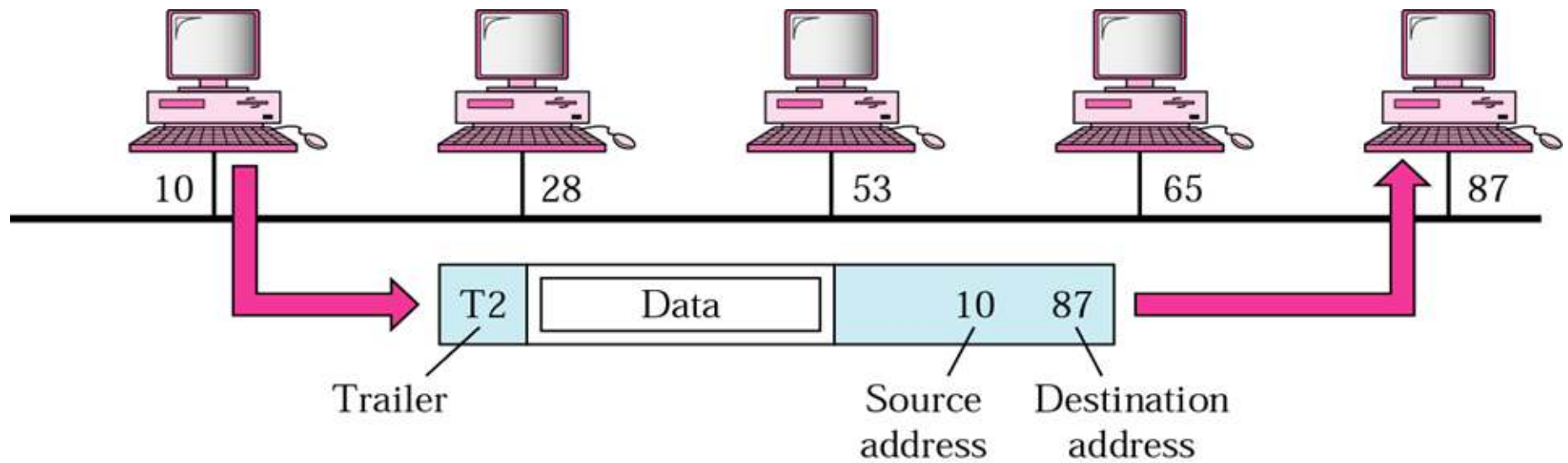
MAC address:

- ① Act as destination address when data link layer frames up packet
- ② Data link
- ③

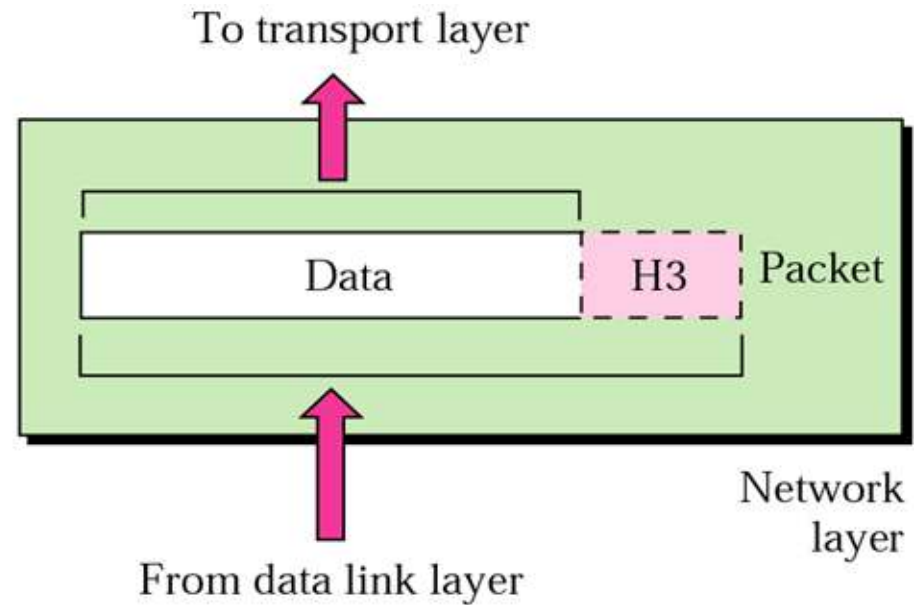
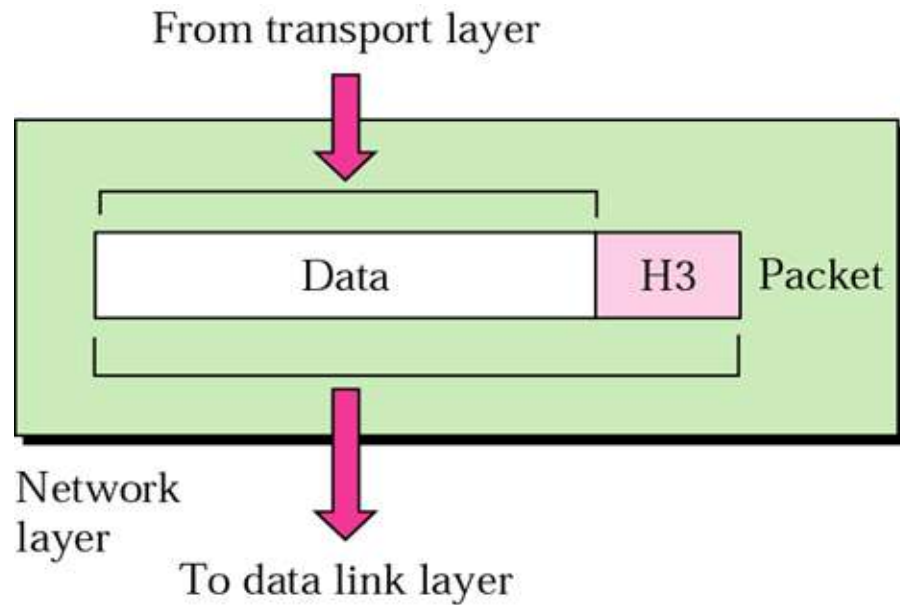
Network address:

- ① Look at destination address, passing packet to TCP
- ② Physical
- ③

Figure 2.8 *Example 1*



Network Layer

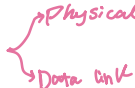




Note

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

Network Layer

- Network Layer PDU is called Packet or Datagram
- **Source-to-destination (host-to-host)** delivery of a **PACKET** possible across MULTIPLE networks.
- If two systems are connected to the same link, there is usually *no* need for a network layer (*in theory*).

- Logical addressing
 - A unique global address that distinguishes each host connected to the Internet
 - In the internet it is called IP address

- Routing
 - connecting devices (routers) route or switch the packets to their final destination.

Figure 2.10 *Source-to-destination delivery*

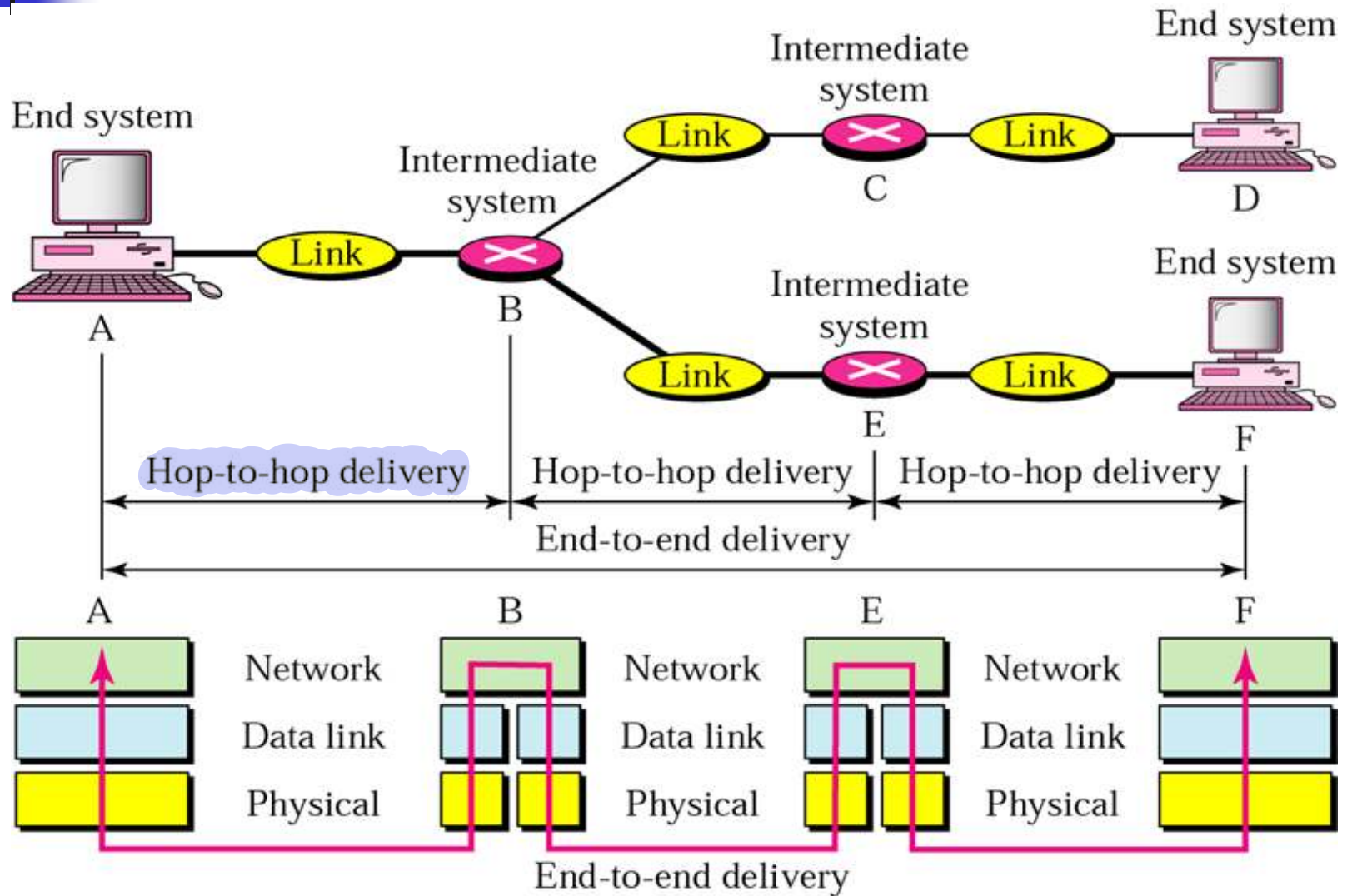
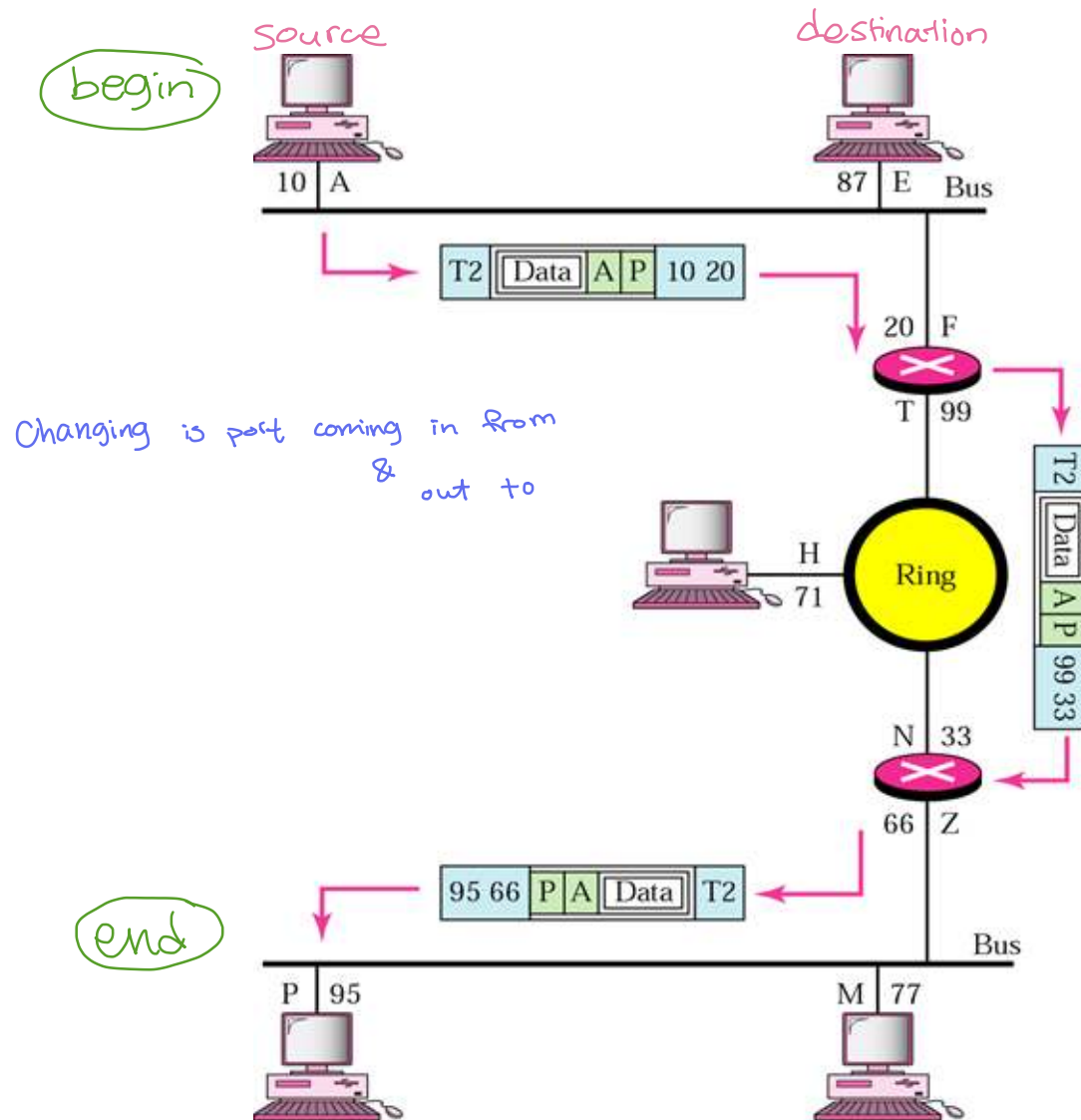


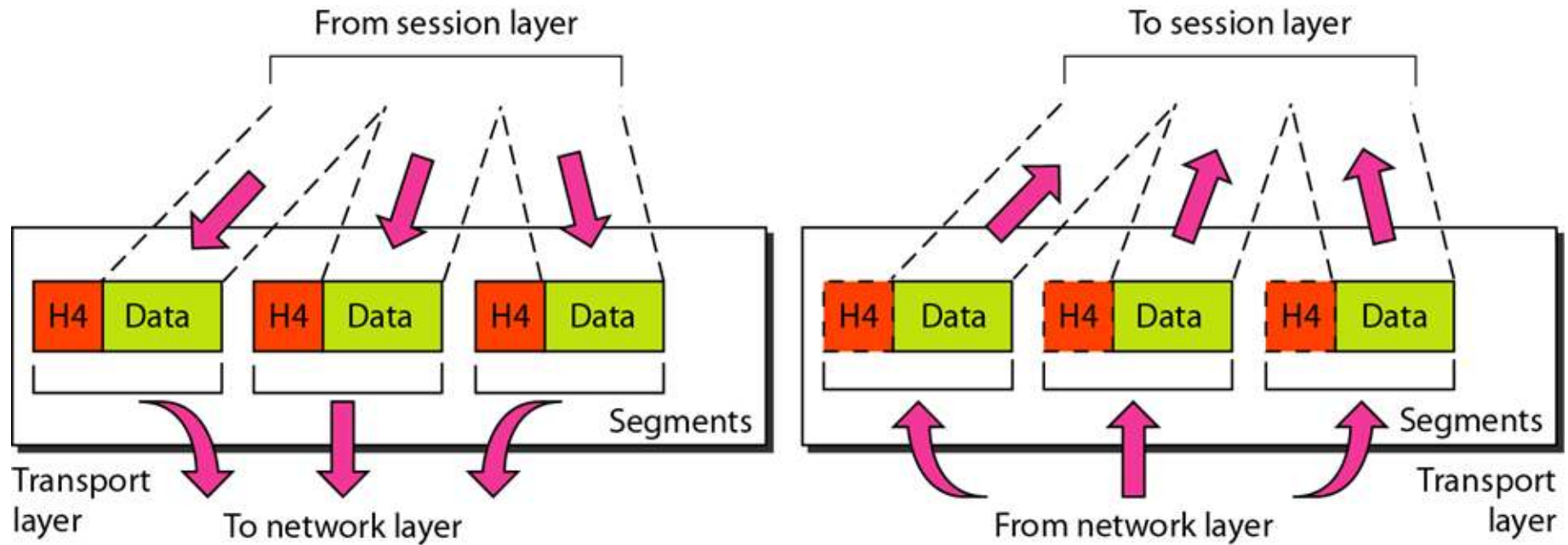
Figure 2.11 *Example 2*



Note

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

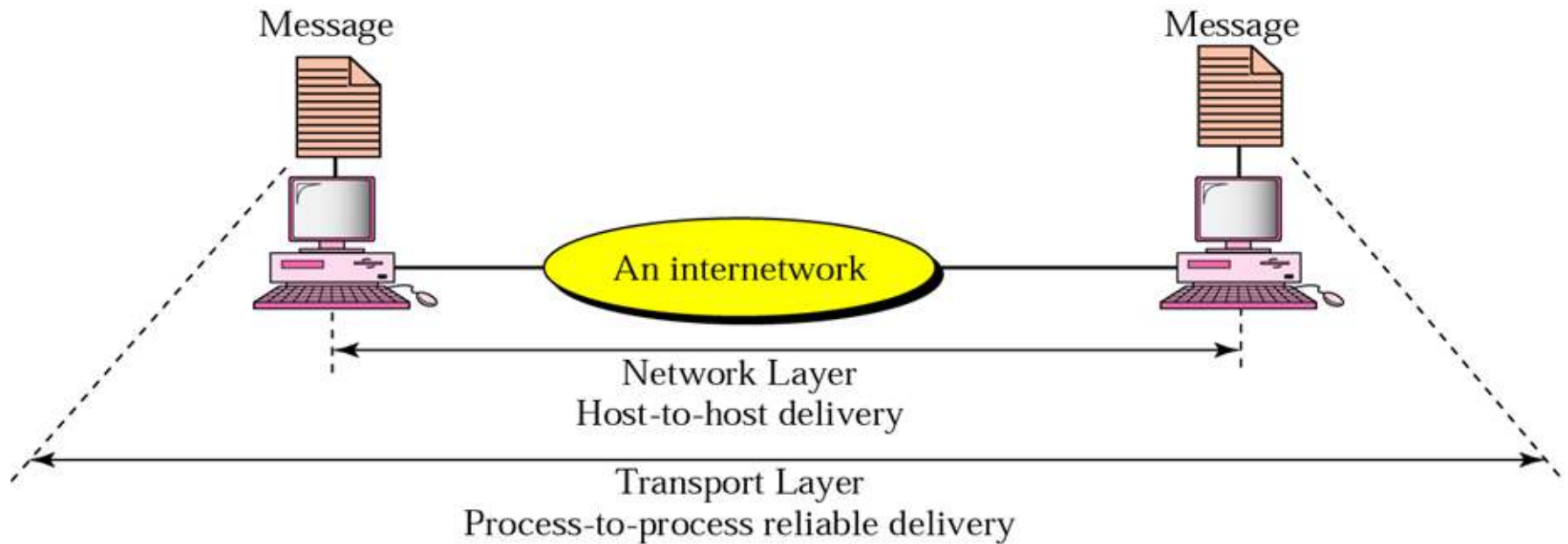
Figure 2.12 *Transport layer*



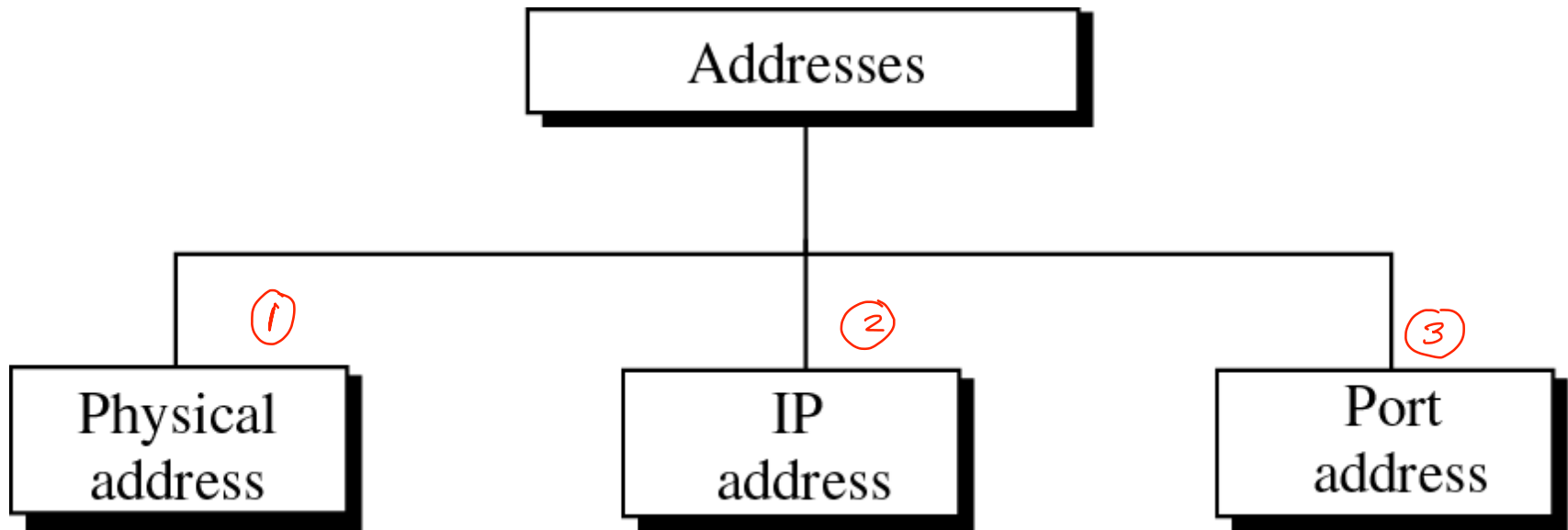
Transport Layer

- The transport layer is responsible for **Process-to-Process** delivery of the **ENTIRE MESSAGE** → *divided into*
- The network layer handles end-to-end (source-to-destination) delivery of INDIVIDUAL PACKETS; no relationship between packets, each one is considered **independently** but the transport layer ensures **whole message** arrives intact and in order
- Transport PDU is called **SEGMENT** → *dependent*
- **Process addressing** → *numbers it goes & in out with*
 - Port address

Figure 2.12 Reliable process-to-process delivery of a message



Addressing



Activity:

What does it identify?

- ① device's network interface, communication within LAN
- ② device on a network
- ③ specific application or service on a network device

Does it change or stay the same?

- ① No, usually permanent
- ② Yes
- ③ can, often does over time

Can many of them exist in a time?

- ①
- ②
- ③

Who assigns it?

- ① manufacturer of NIC
- ② router automatically assign or admin set manually
- ③ Internet Assigned Numbers Authority (IANA)

network interface
card

Layer Addresses

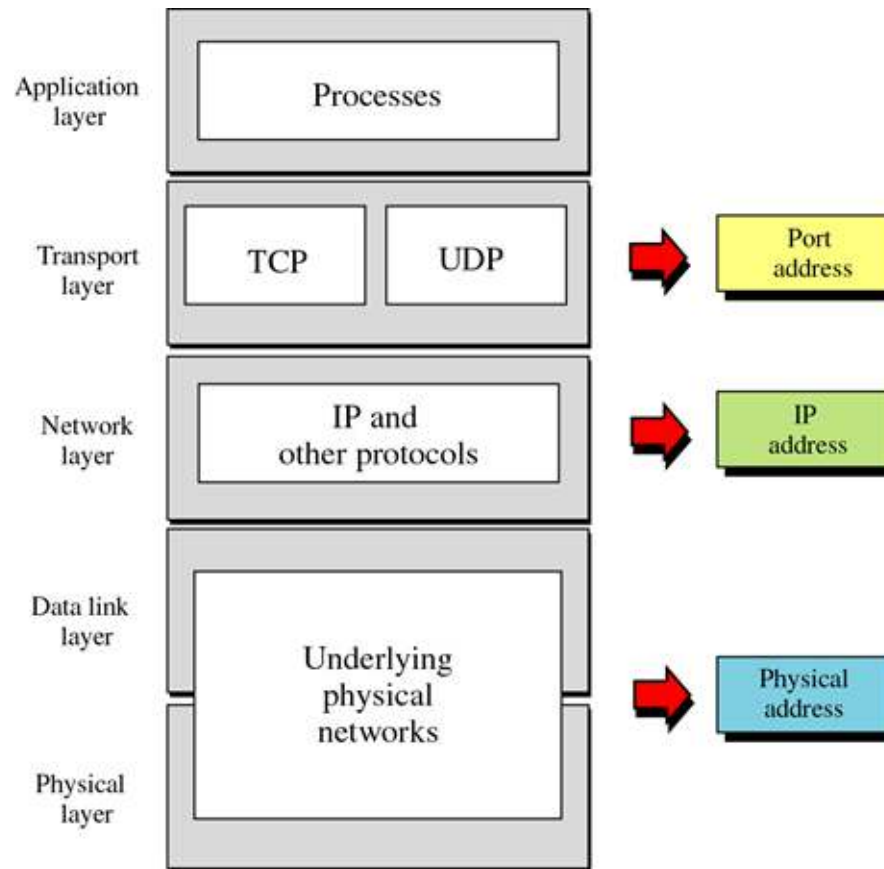
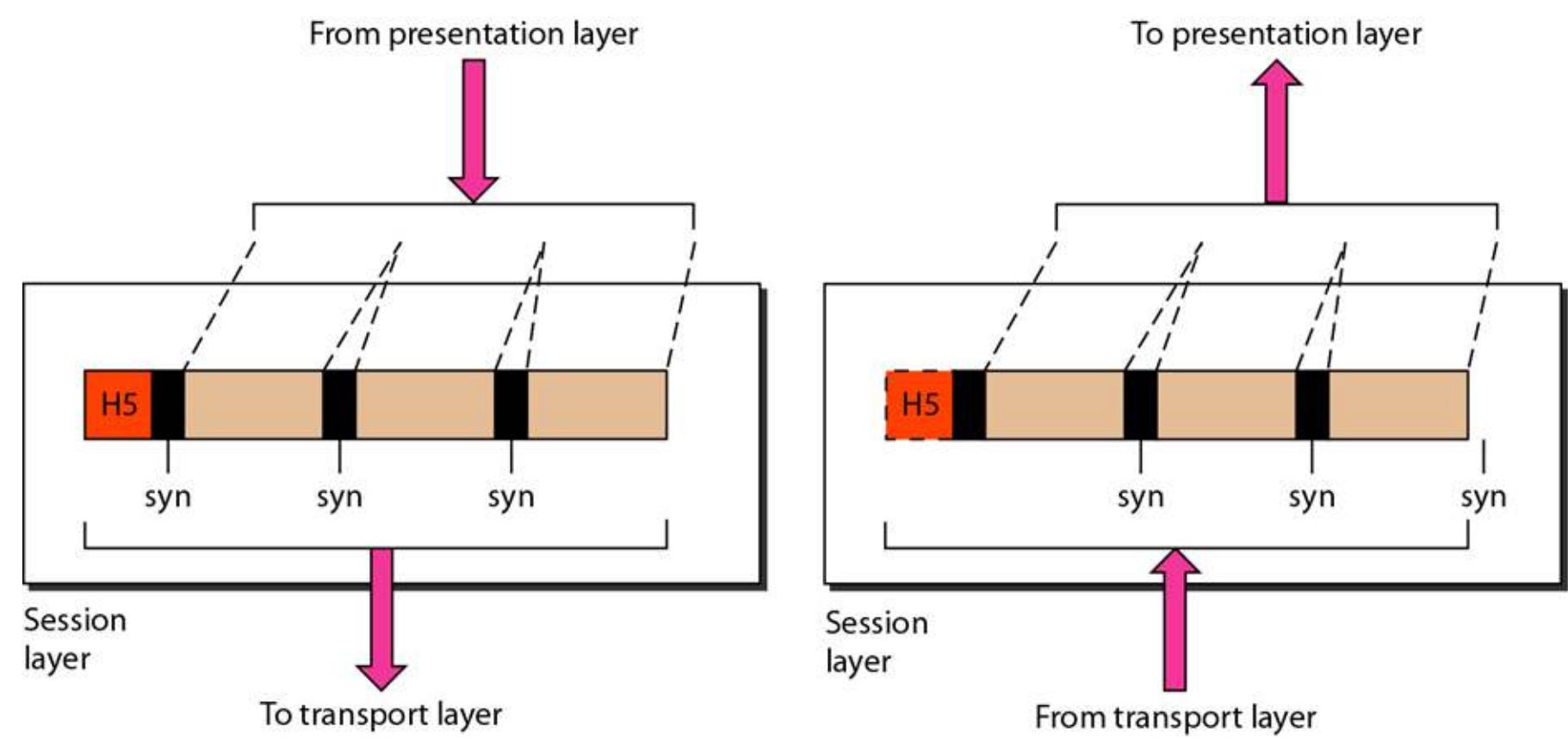


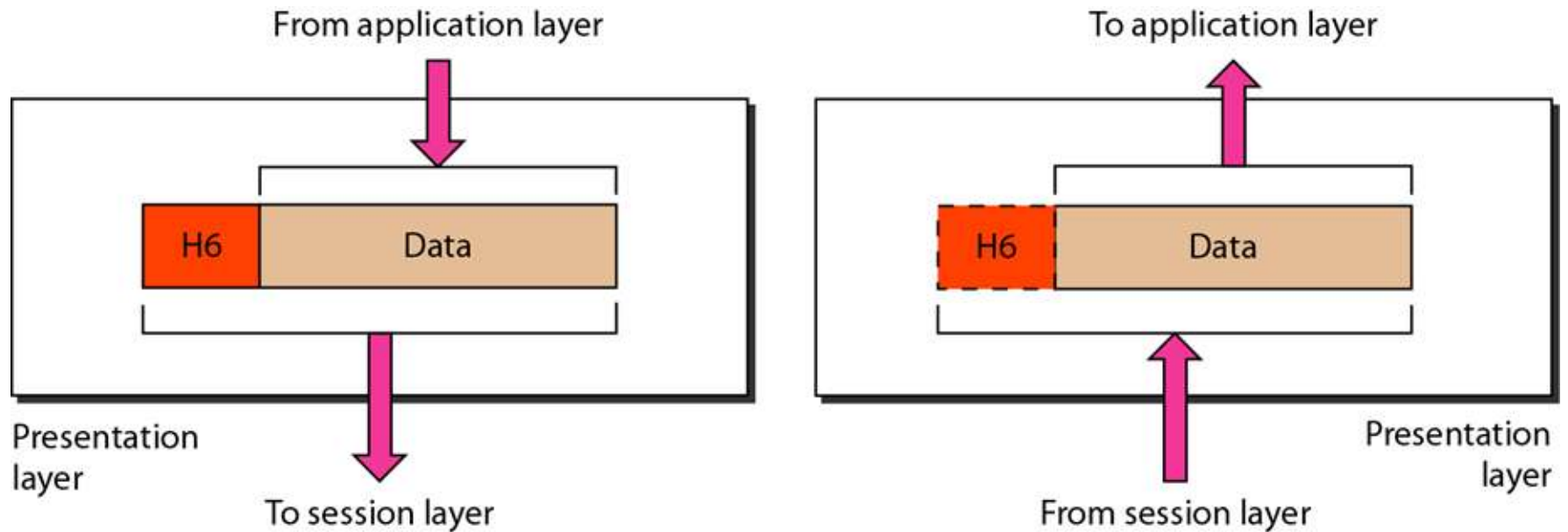
Figure 2.12 *Session layer*



Session

- **Setting up, managing, and terminating sessions (connections) between different applications**
 - Keeping different applications data **separate** from other application data
 - Multiple file downloads requested by a particular FTP application
 - Multiple **telnet** (remote connection to a device) connections from a single host
 - Browsing many Web pages at the same time
- **Dialog control**
 - Full/Half duplex: Processes either send and receive data at the same time or at different times
- **Synchronization checkpoints**
 - Allow long transmissions to continue from where they were after **a crash**

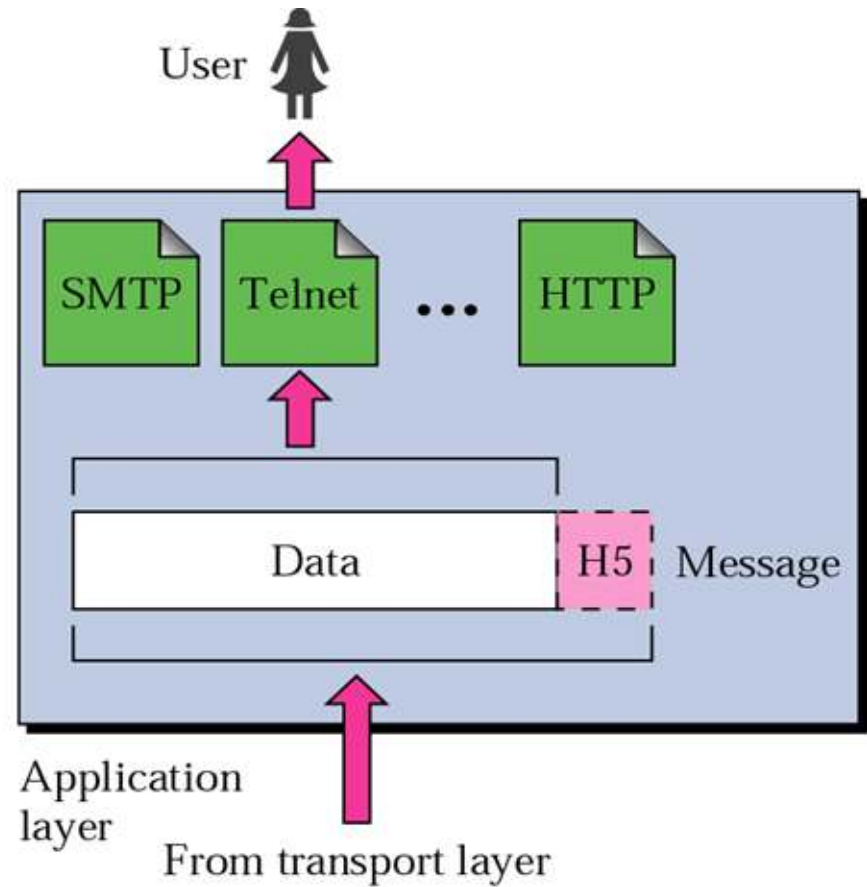
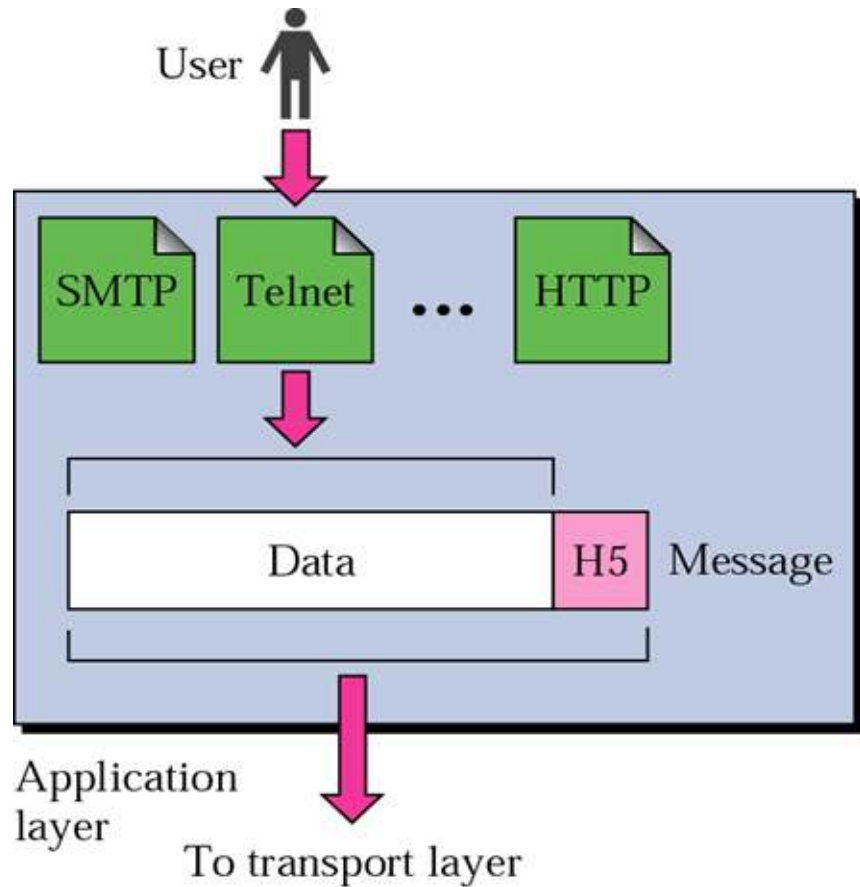
Figure 2.13 *Presentation layer*



Presentation

- Translation
 - Allows devices with different data representations to communicate (interoperability).
 - Sender format ☐ **common format**
☐ Receiver format
 - The input of "Cisco" on a Mainframe terminal, which is working with an EBCDIC code set, would result in "¢¹½³?" on a PC, because it uses ASCII.
- Encryption/decryption
- Compression => Less bits (multimedia applications)

Figure 2.15 *Application layer*



Application

- User interface and Network services that allow user applications to access the network
 - Internet Browser uses the HTTP application-layer protocol to access a WWW
 - Telnet => remote host access
 - File transfer, access and management
 - Mail services

all for OSI

② TCP/IP Protocol Suite

- Developed in 1970s
- Is a suite of protocols named after the two most important protocols TCP and IP but includes other protocols such as UDP, etc Has all kinds of protocols
- Consists of Five layers
- The first four lower layers correspond to the first four layers of the OSI model.
- **The three top layers** in the OSI model, however, are represented in TCP/IP by a **single layer** called the **application layer**.

Figure 1.17 Layers in the TCP/IP protocol suite

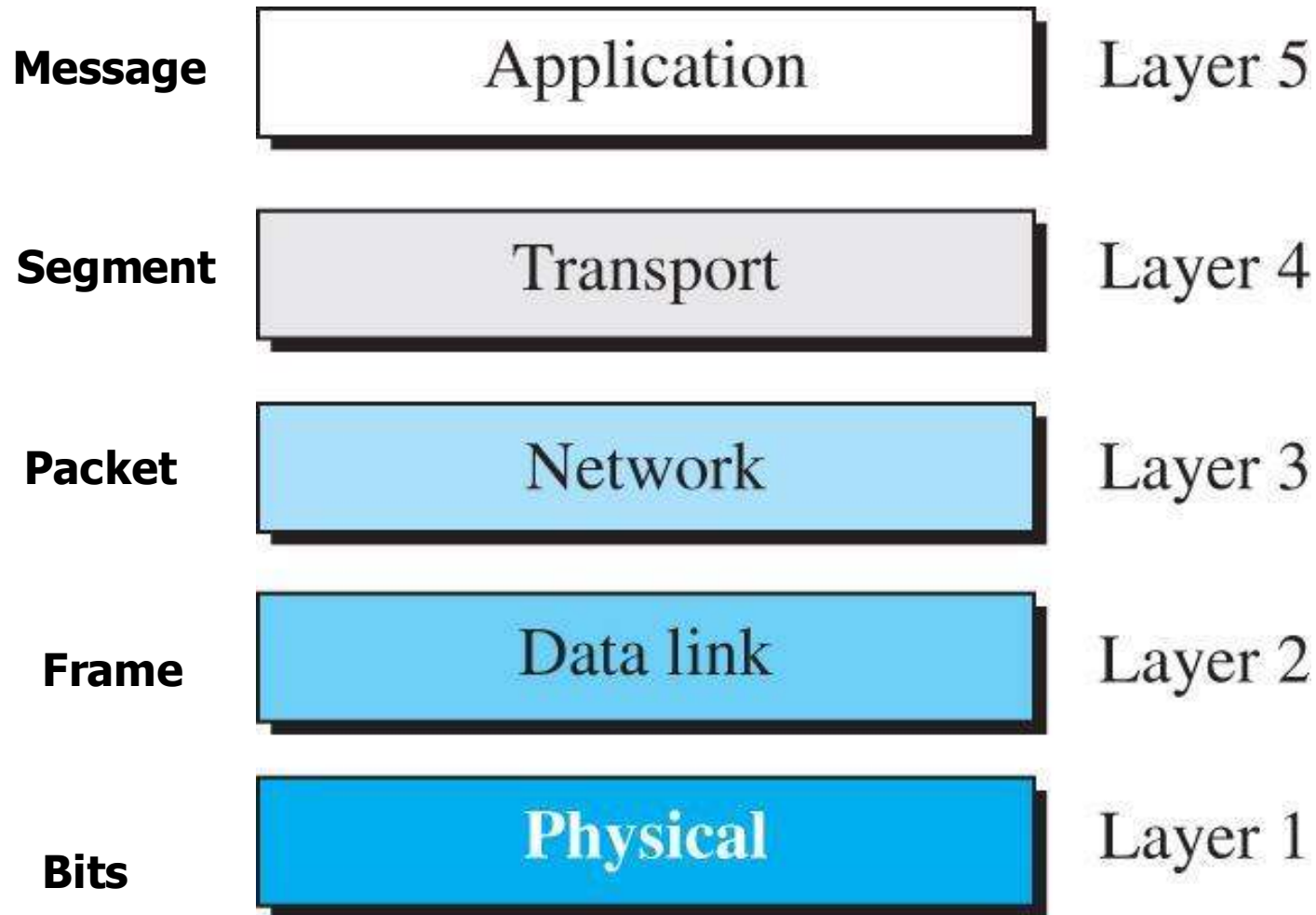


Figure 2.12: TCP/IP and OSI model

provide structured modular and flexible approach to networking

Why is the com divided into layers instead of using single layer?

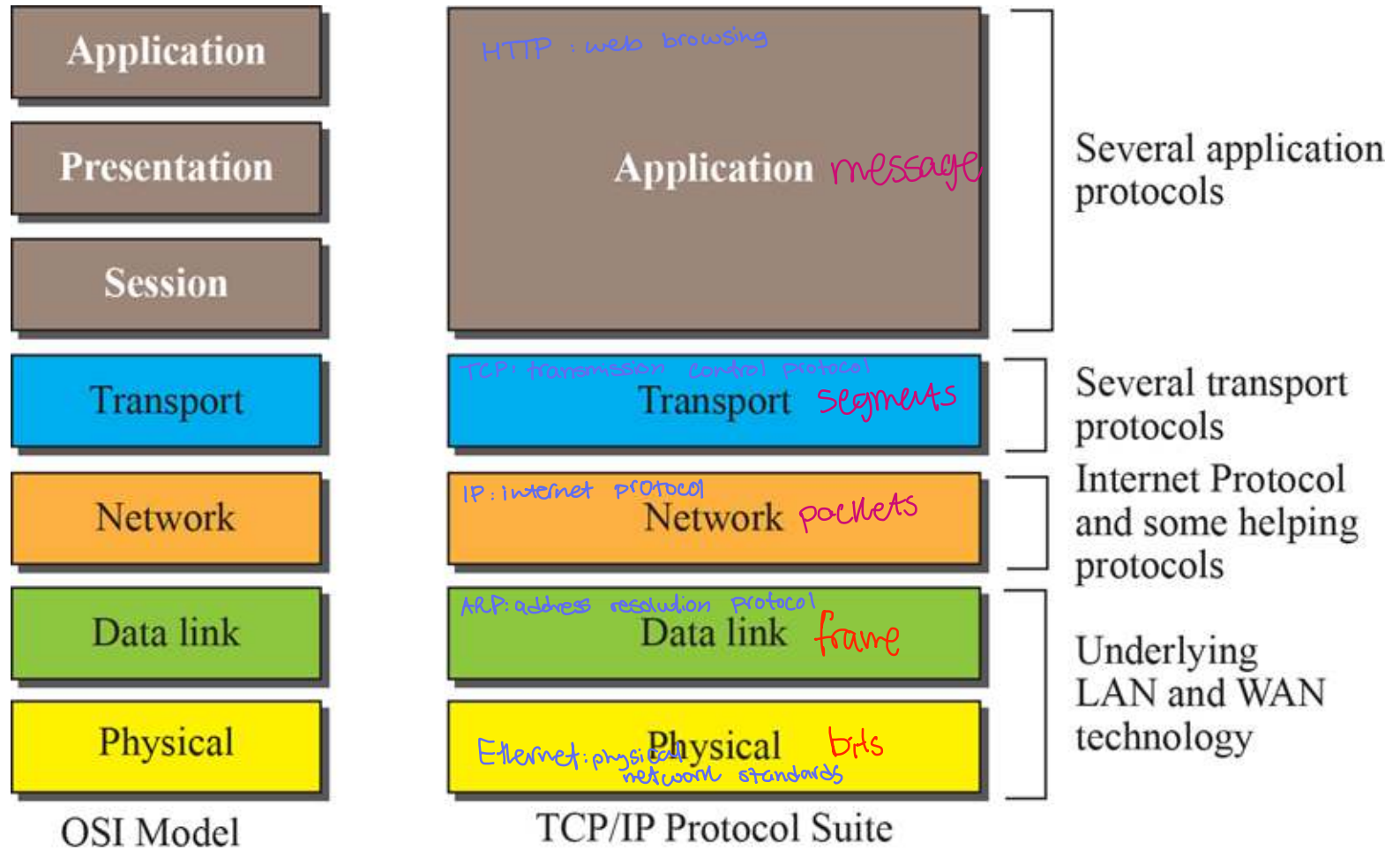
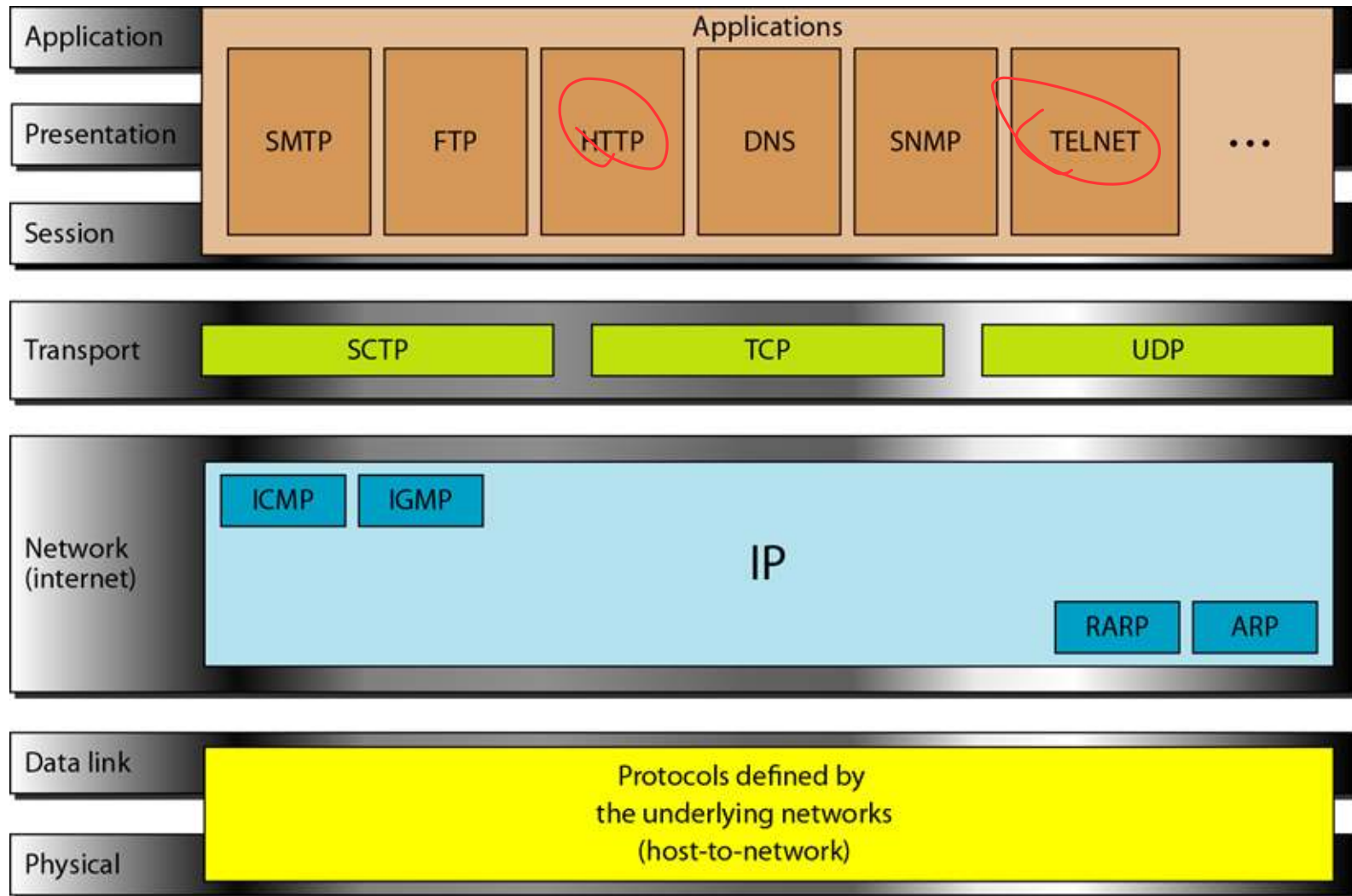


Figure 2.16 *TCP/IP and OSI model*



Original TCP/IP Model (4-layers)

