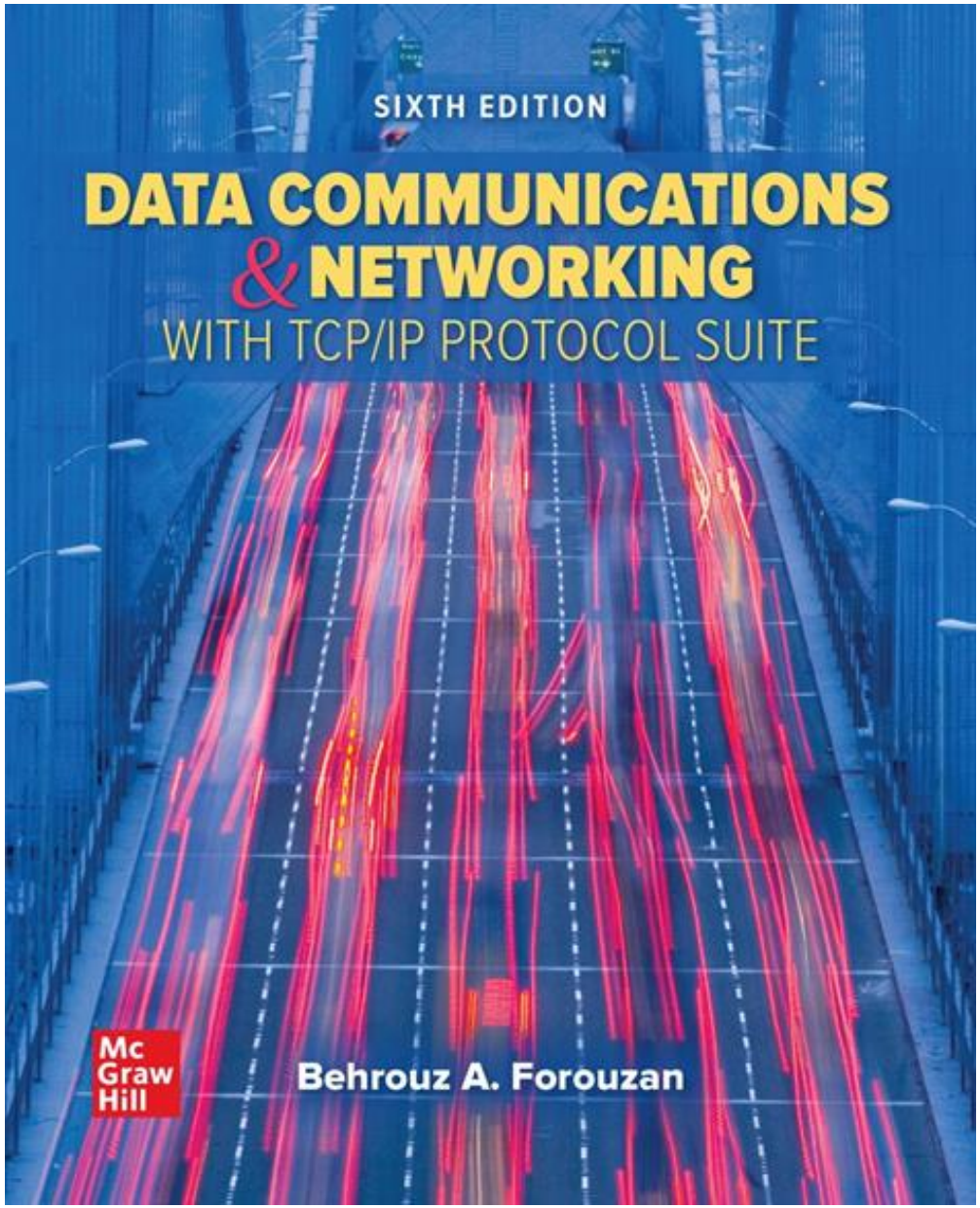
Chapter 01

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 l**ayers**
  - 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.

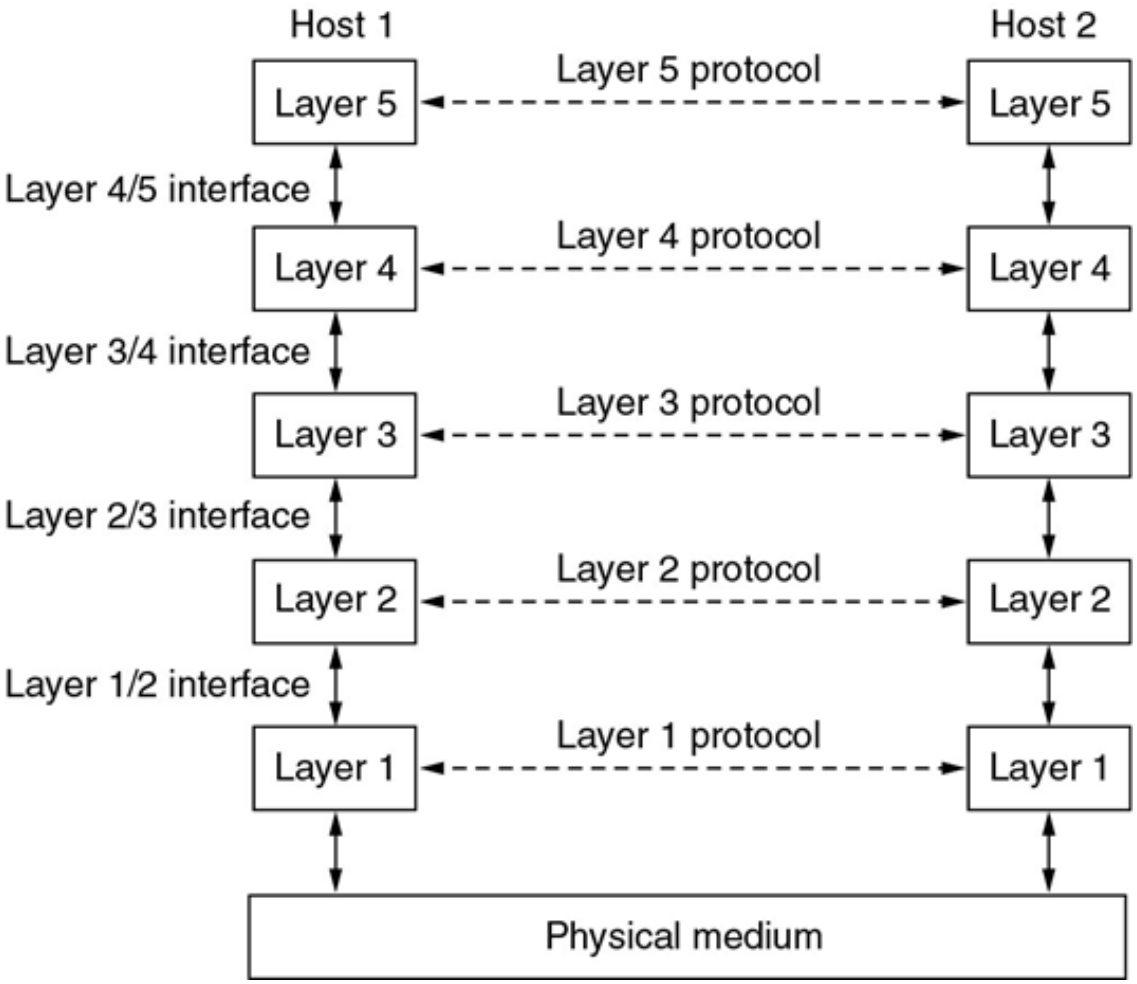
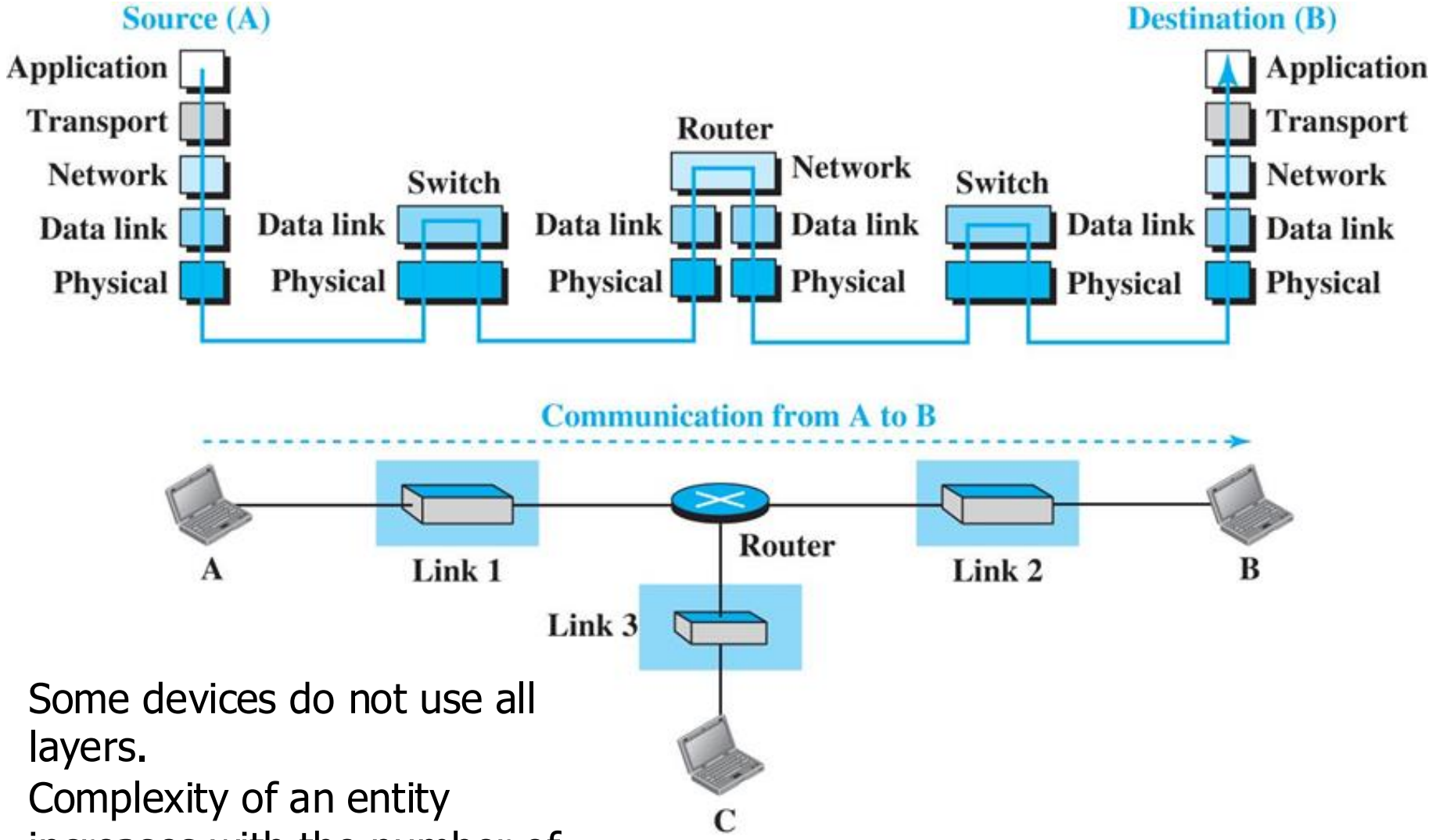


Figure 1.18 Communication through an internet



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

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**

Standard Protocol Models

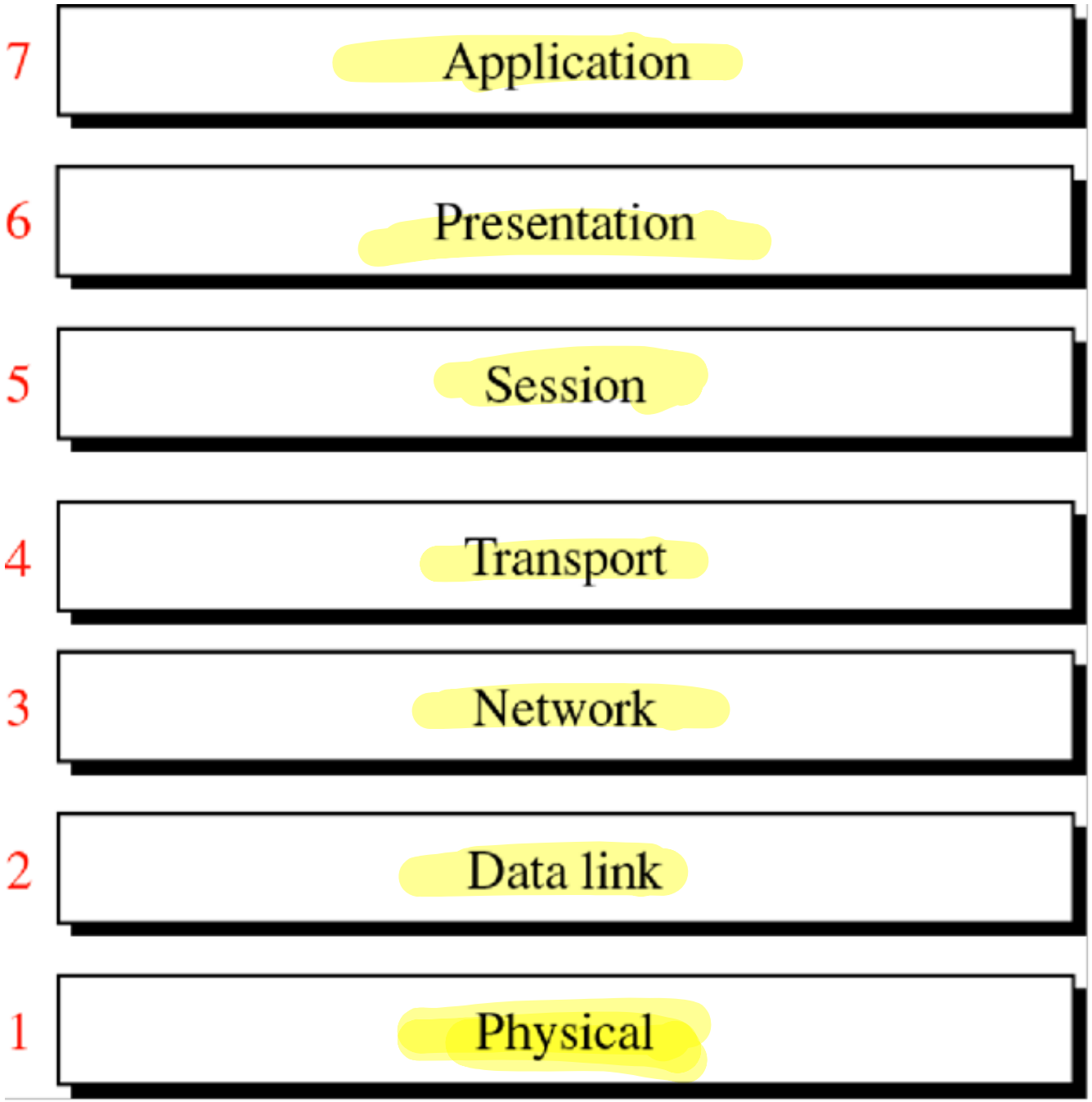
- The protocols of the various layers are called **protocol stack**

- **Two Standard Protocol models (stack) exist:**
  - Open System Interconnect (**OSI**)
  - Transmission Control Protocol/Internet Protocol (**TCP/IP**)

OSI Model

- Developed 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
Application
6
Presentation
5
Session
4
Transport
3
Network
2
Data link
1
Physical

OSI Model

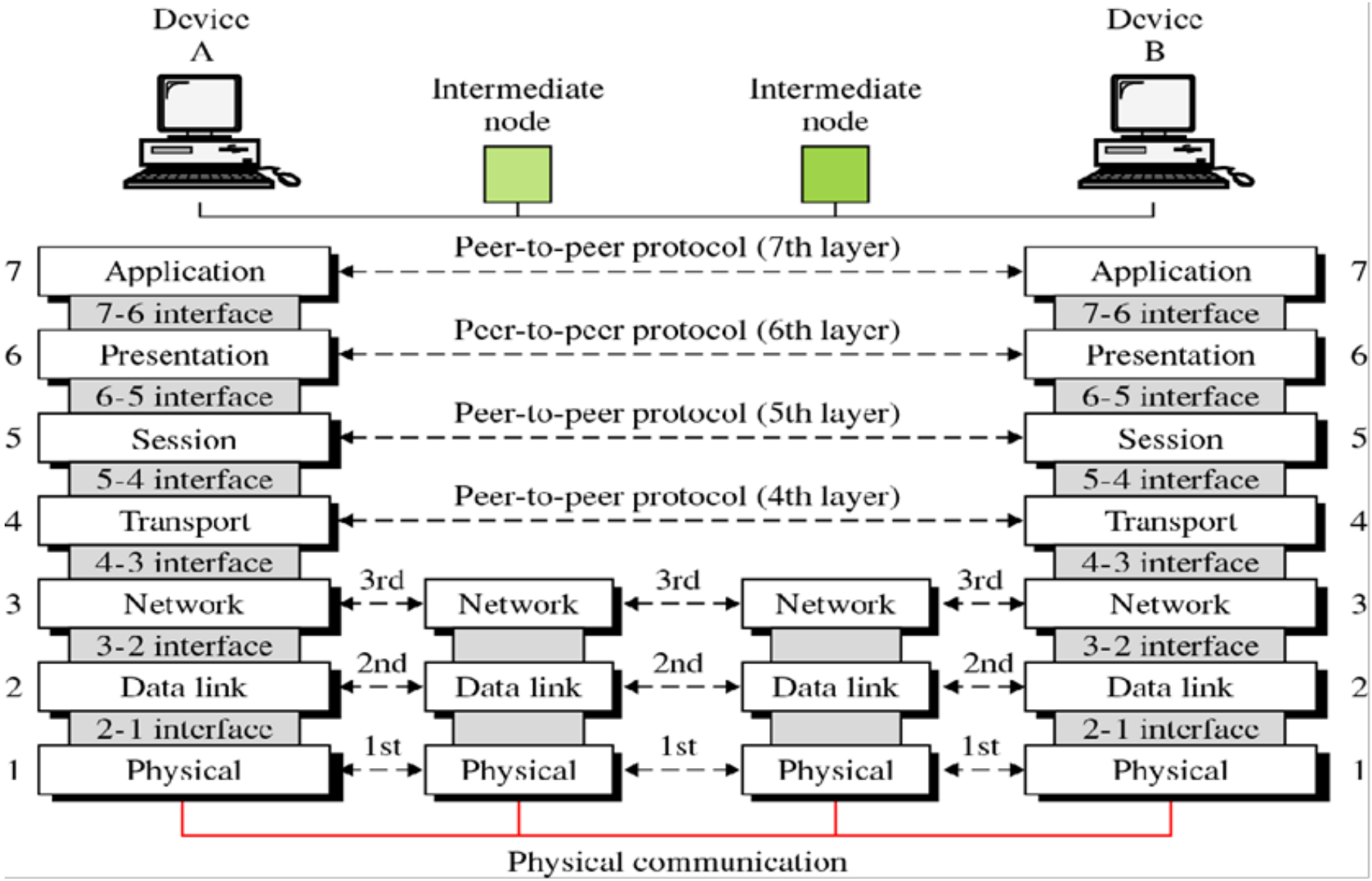
To remember the 7 layers is the sentence "All people seem to need data processing"

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

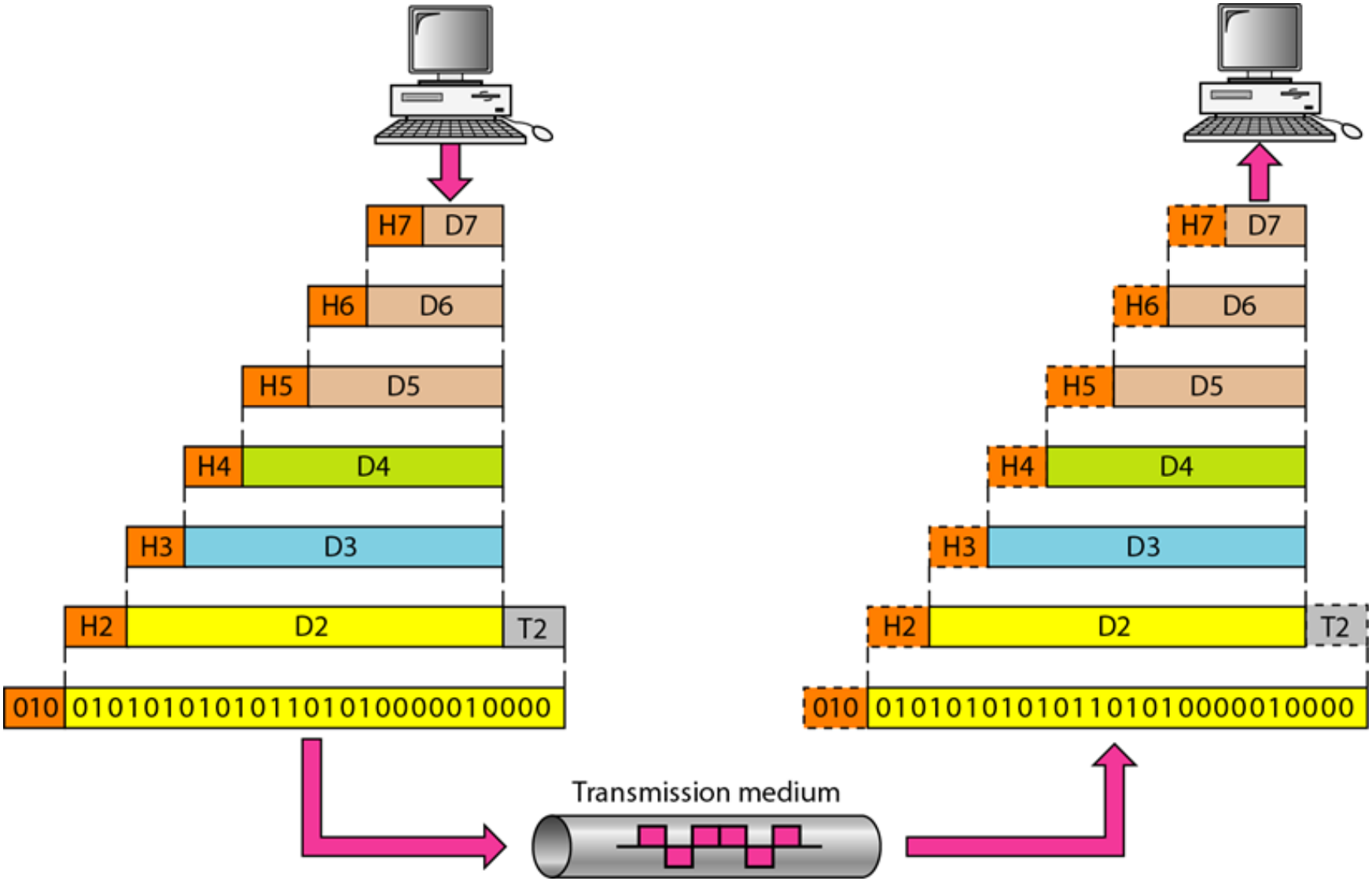
Peers are entities (processes, hardware devices) on two or more machines communicating at a **given layer**



OSI model-Basic Operation

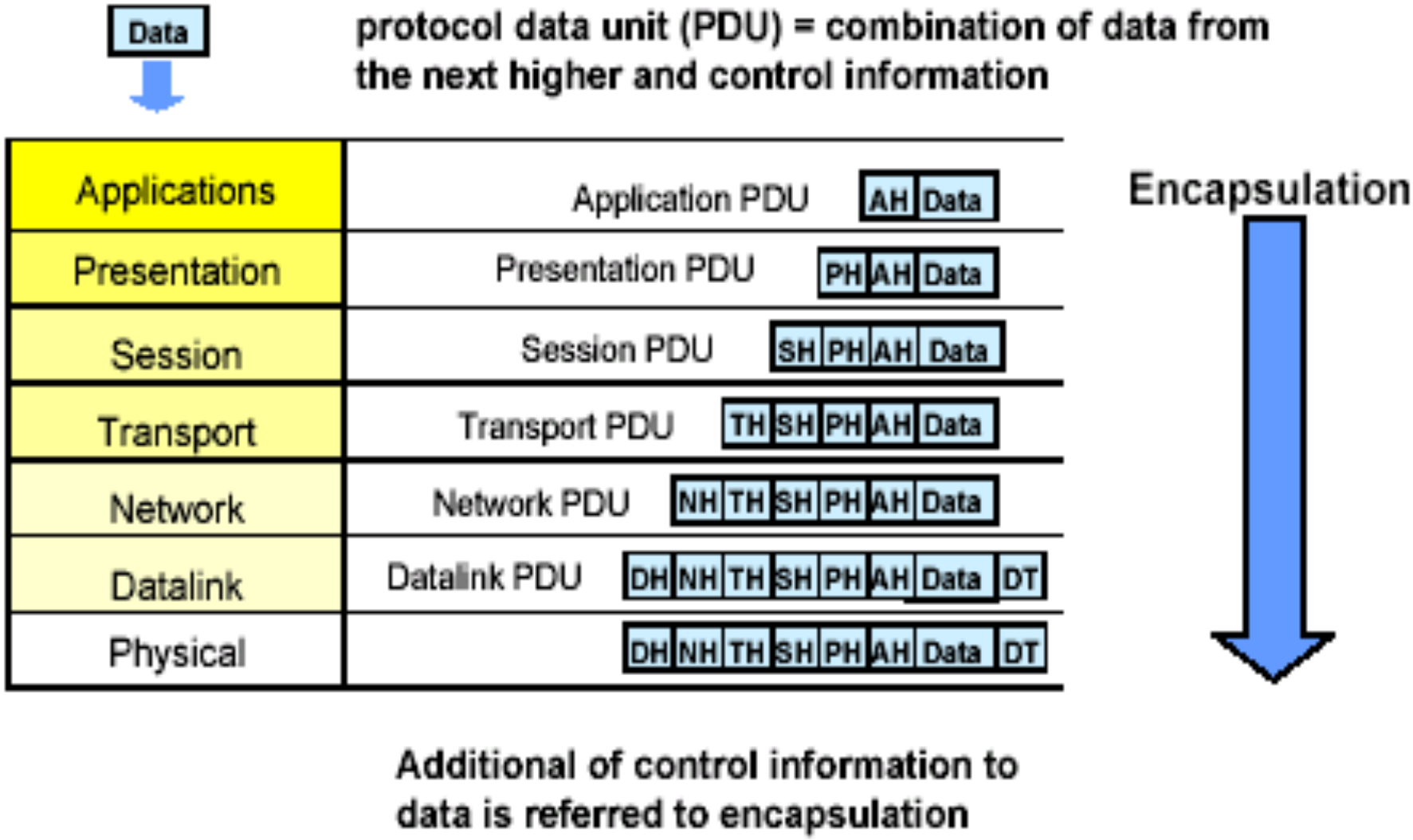
- **Peer-to-Peer communication**: Each layer on a **sending node** communicates (logically) with its peer layer on the **receiving node** using **formatted blocks of data** called Protocol Data Units (**PDU**)
- PDU = combination of **data (payload)** from the *next higher layer* and the **control information** 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**

Figure 2.4 *An exchange using the OSI model*

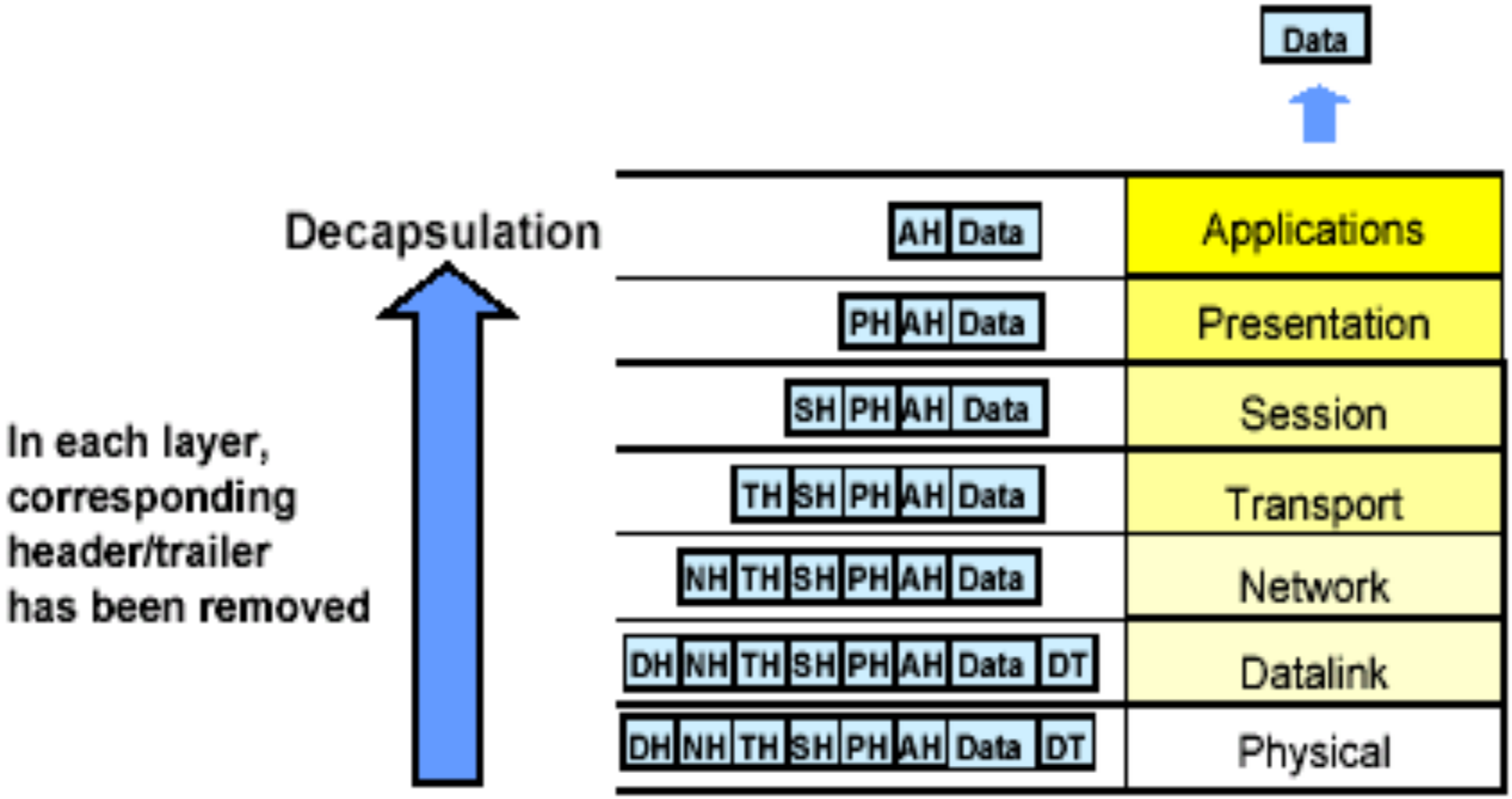


Data Encapsulation

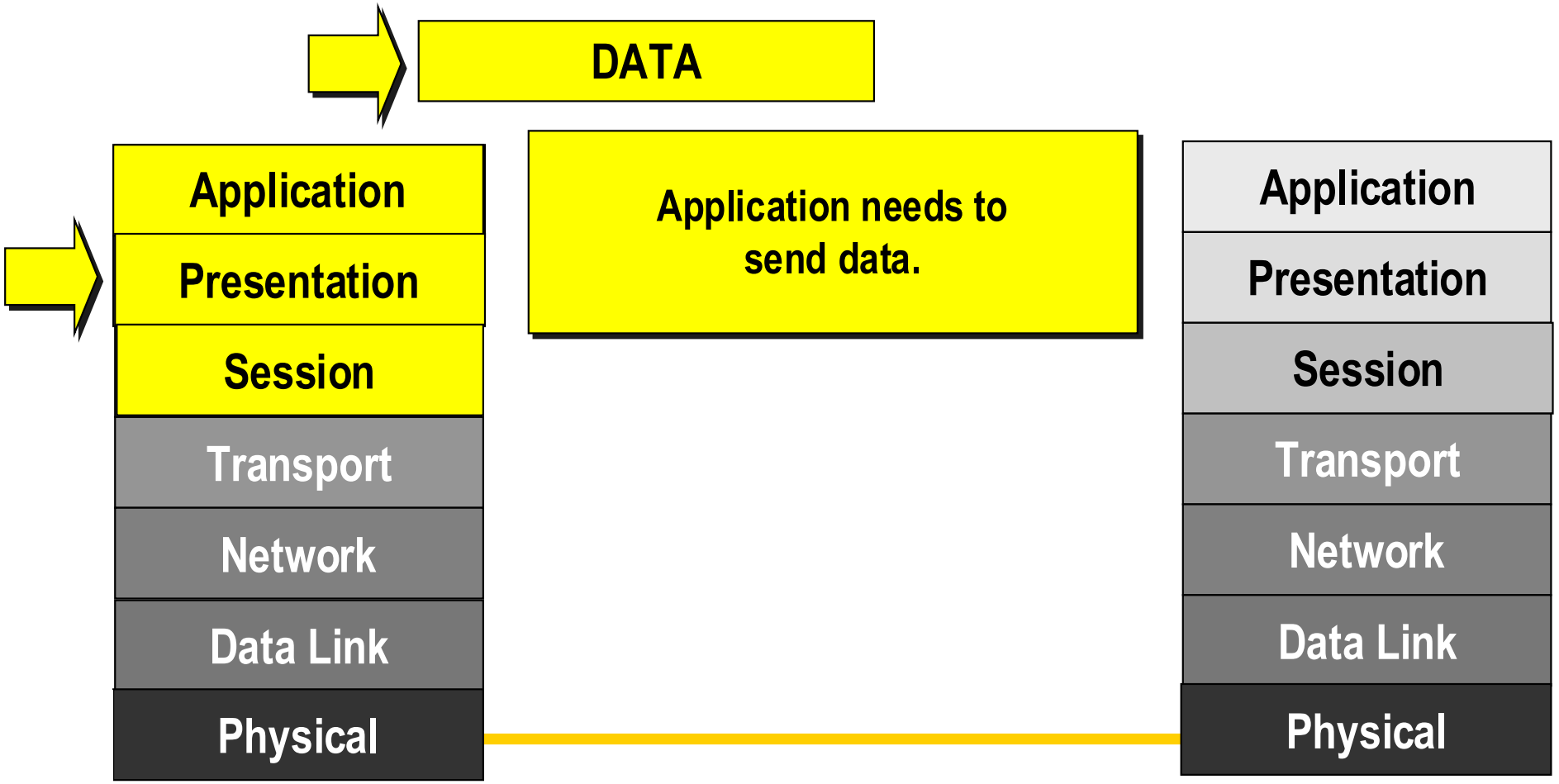
Data encapsulation refers to the fact that layer N-1 carries in its data part the PDU of layer N without any knowledge of its content and its different parts.



Decapsulation



How Hosts Talk over a Network



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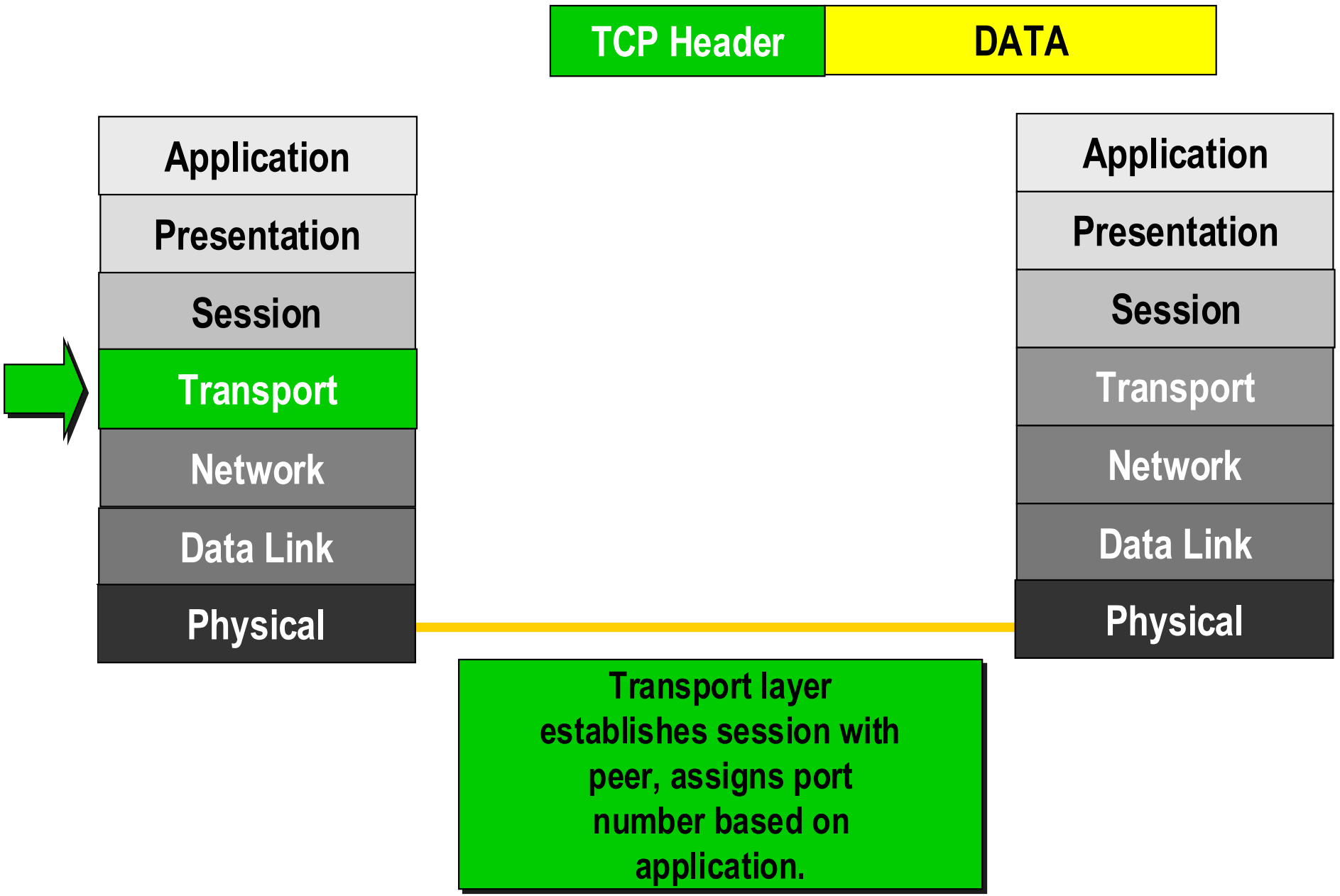

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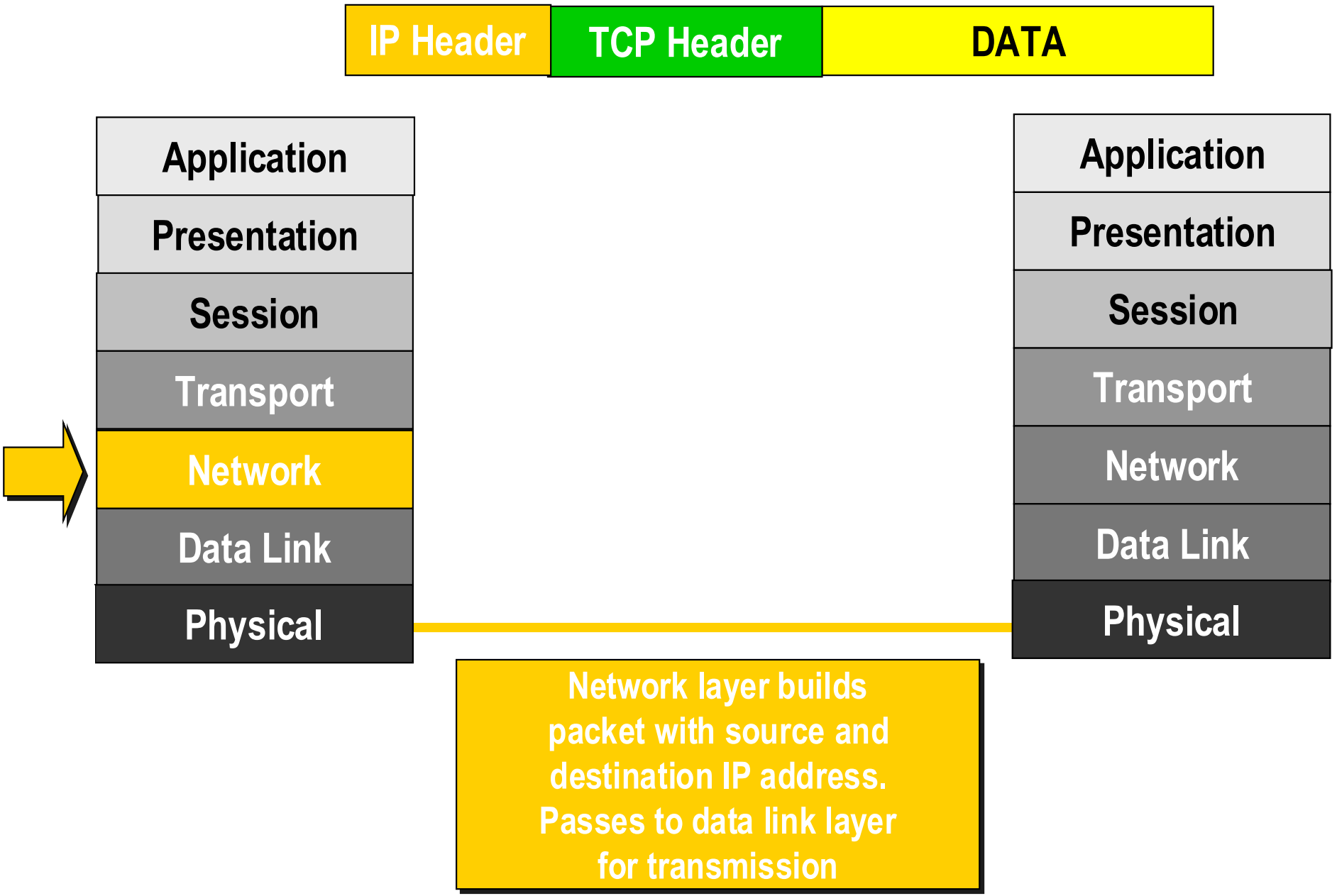

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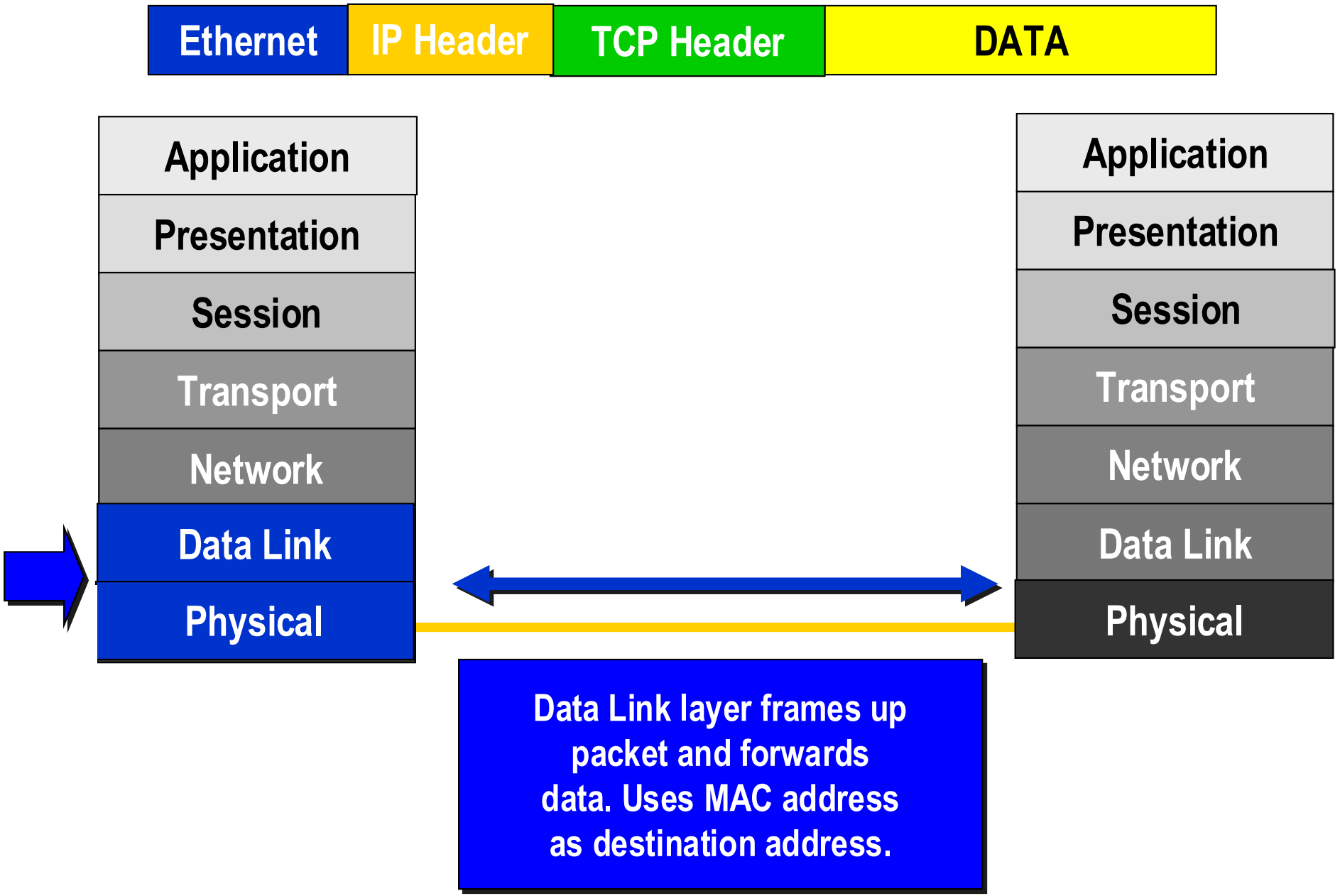

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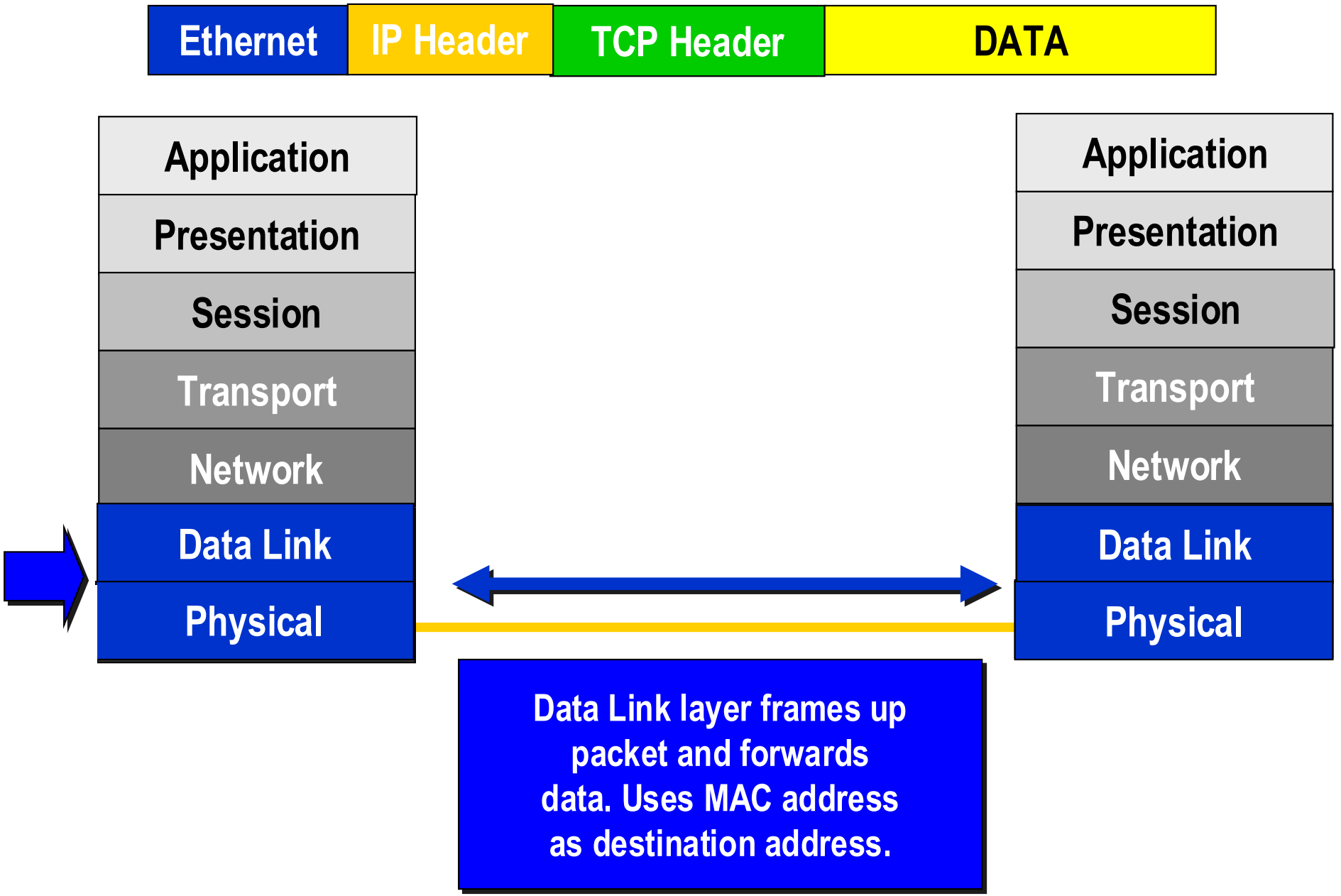

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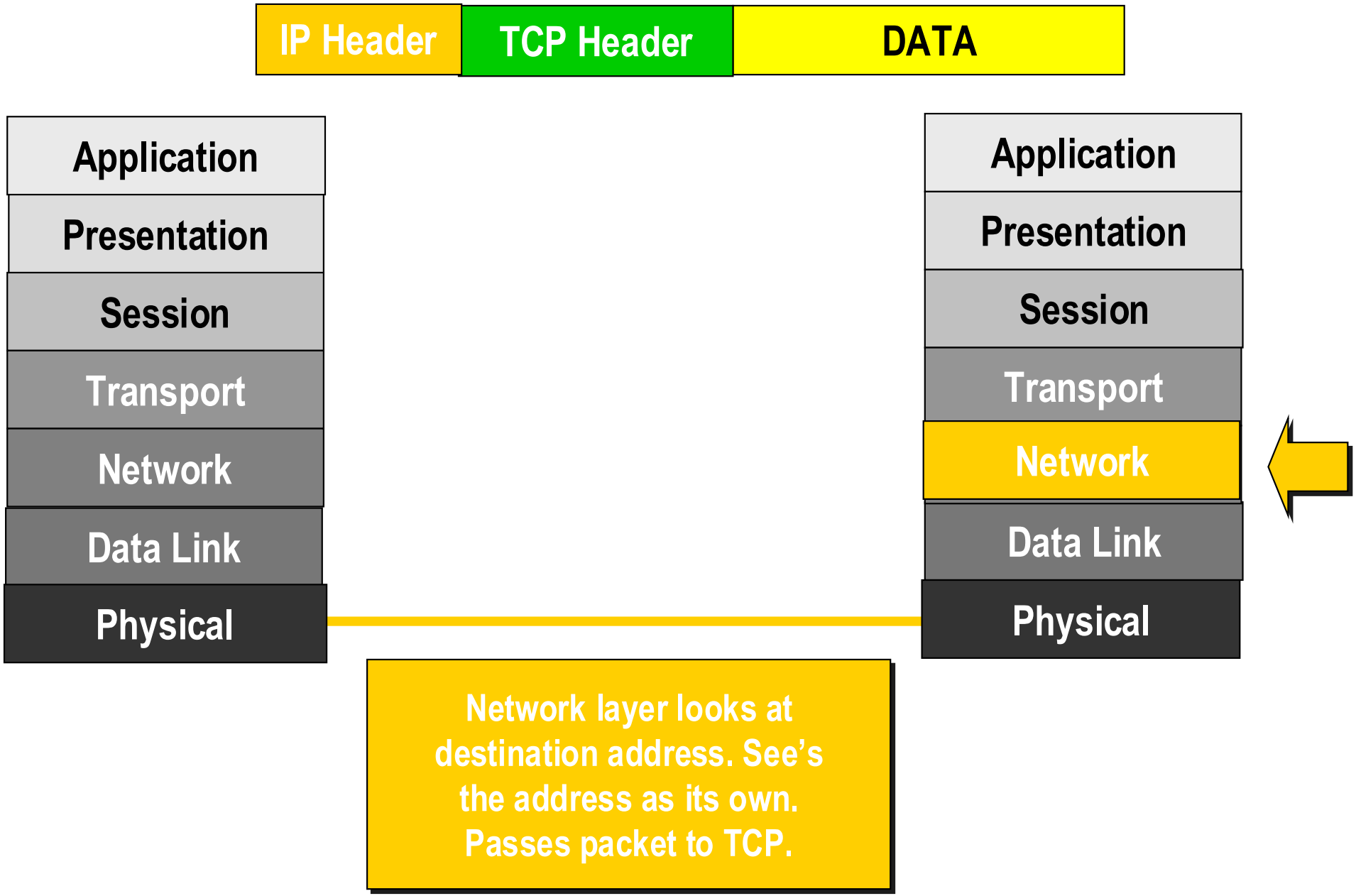

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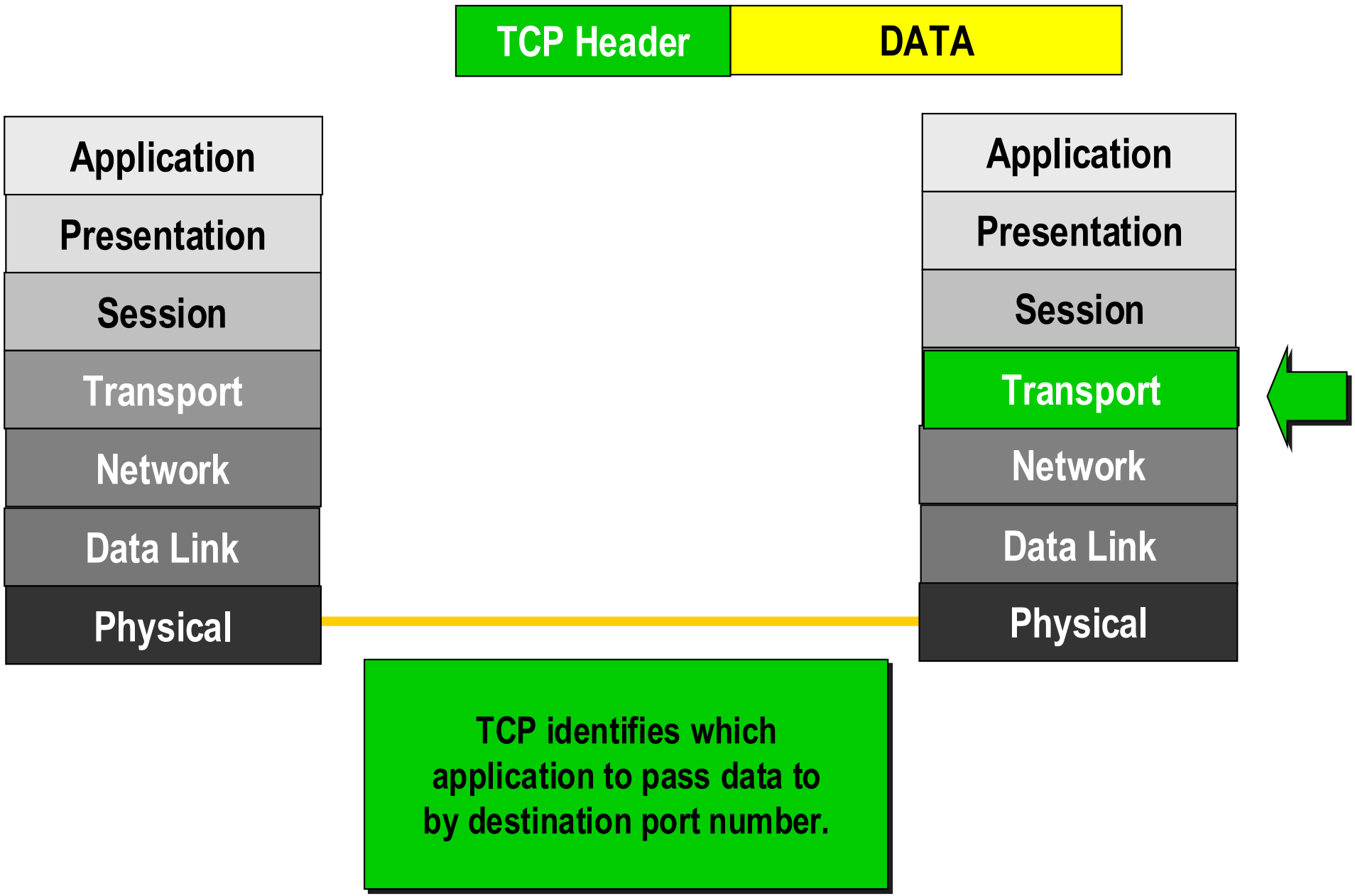
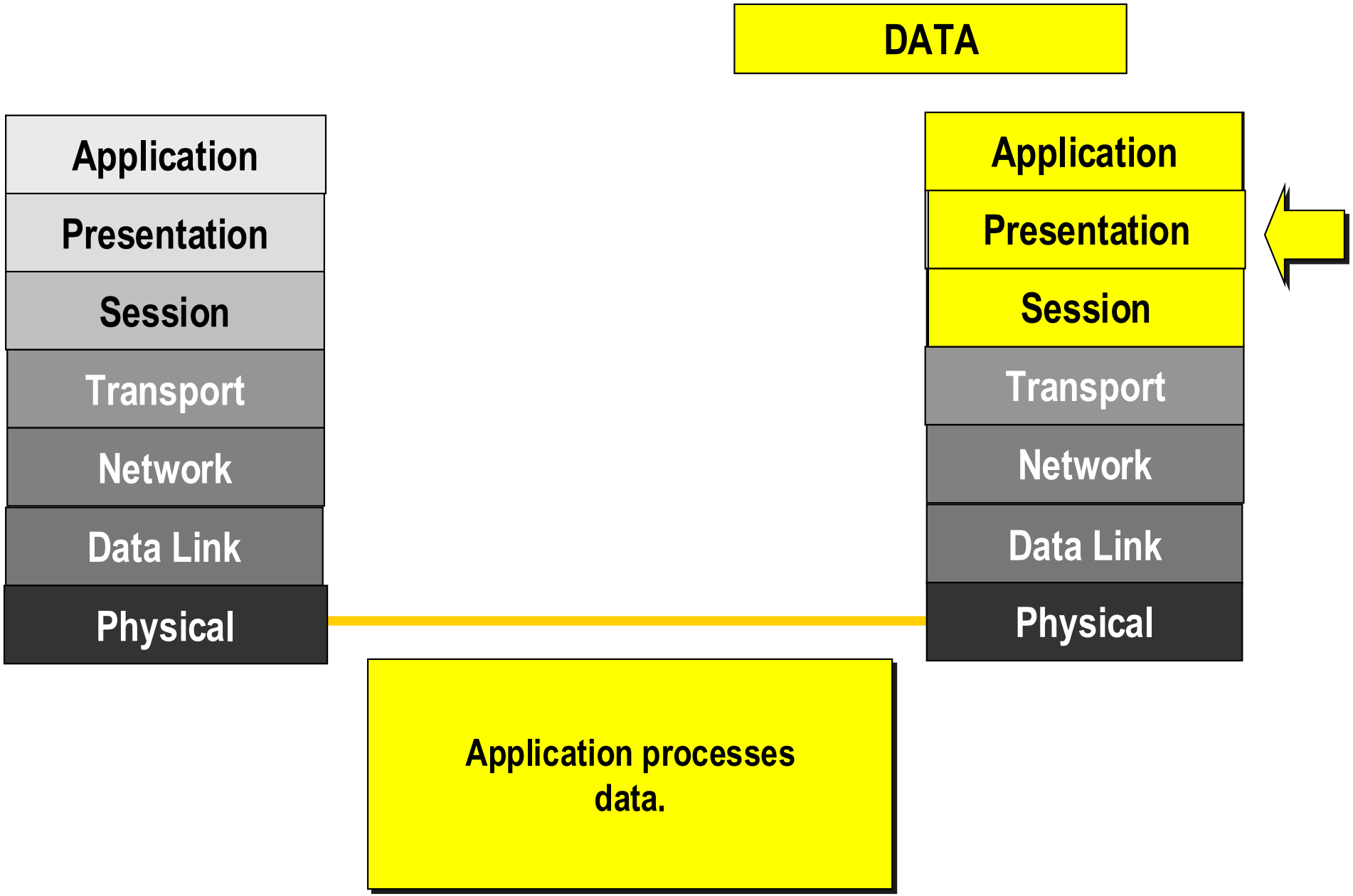
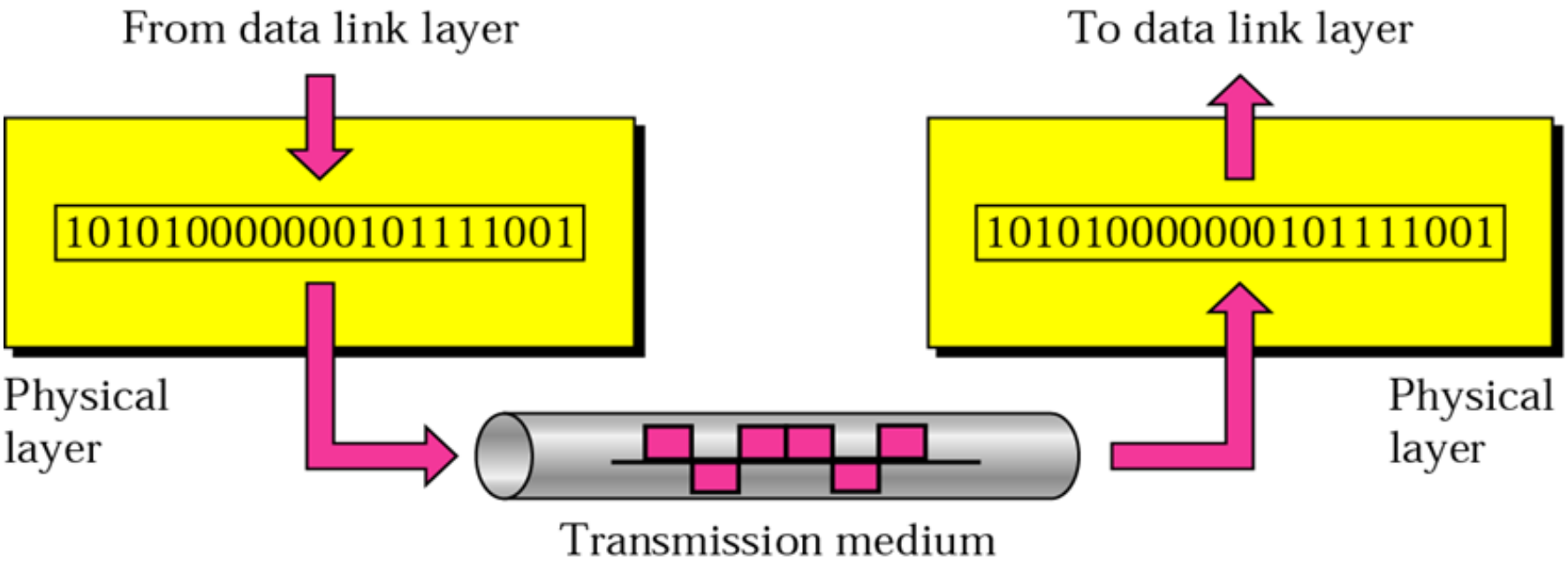


How Hosts Talk over a Network



Physical Layer



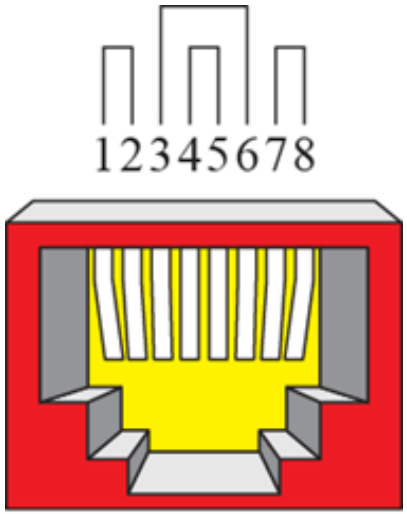
The physical layer is responsible for movements of individual bits from one hop (node) to the next.

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)
    - Shape, size and number of pins of connectors
    - What voltages and currents are used
    - The type of transmission media
    - Transmission mode (duplex type)

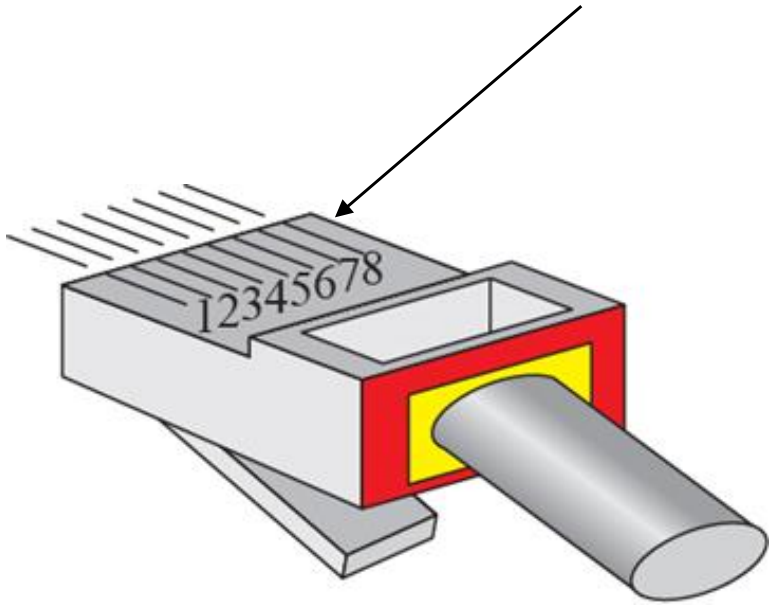
  - **Representation of bits** – encoding into Electrical or Optical signals
  - **Data Rate** = transmission rate = bandwidth (**number of bits sent per second**)
  - **Synchronization of bits** (sender and receiver clocks must be synchronized)
  - Devices that operates at this level: **Network card, hub, repeater**

In NIC or networking device



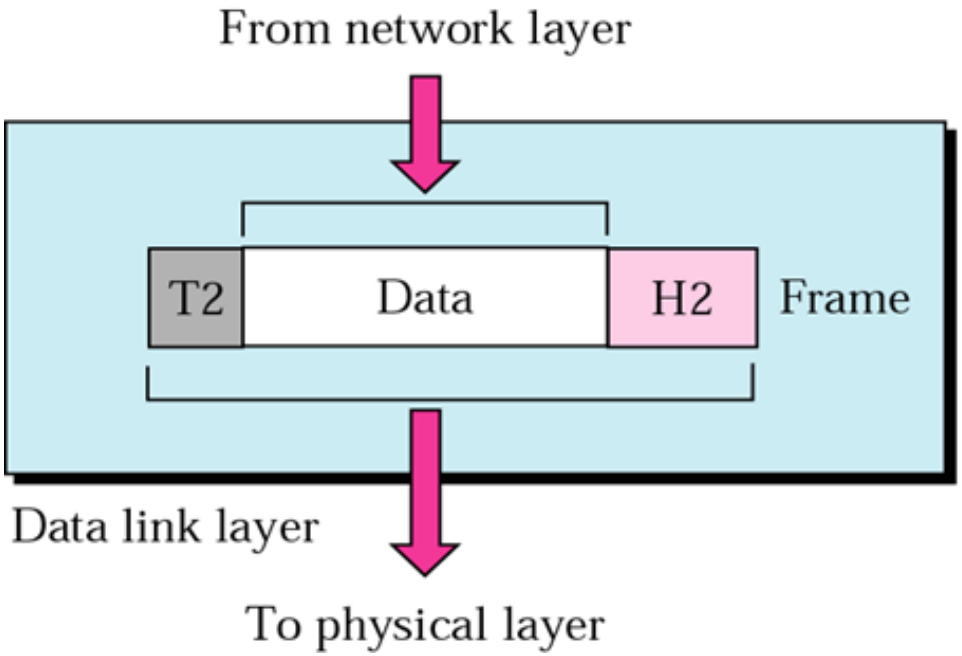
RJ-45 Female

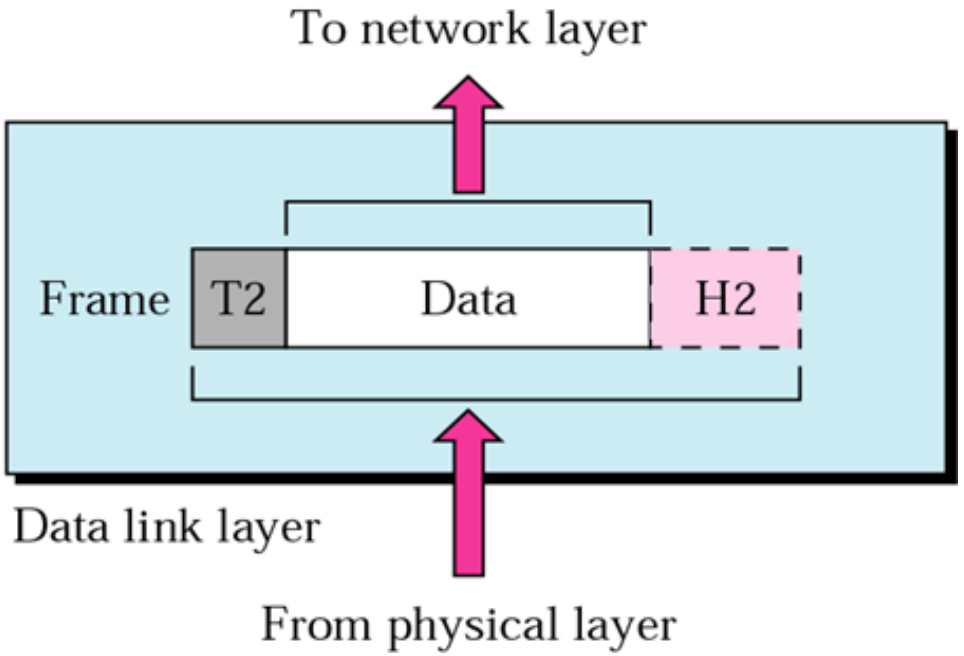
Connected to the Cable

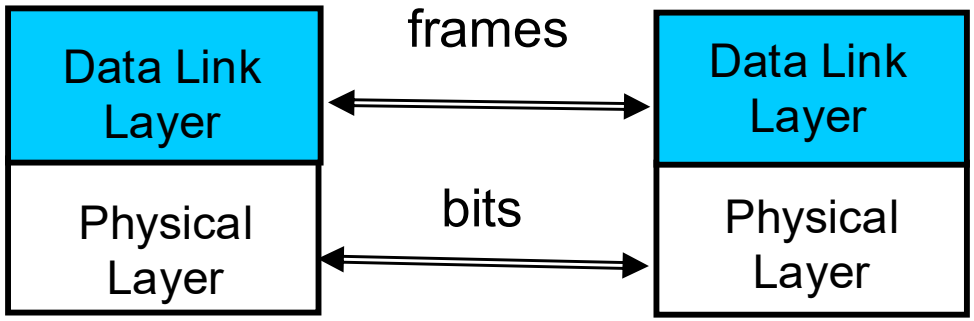


RJ-45 Male

Data Link Layer



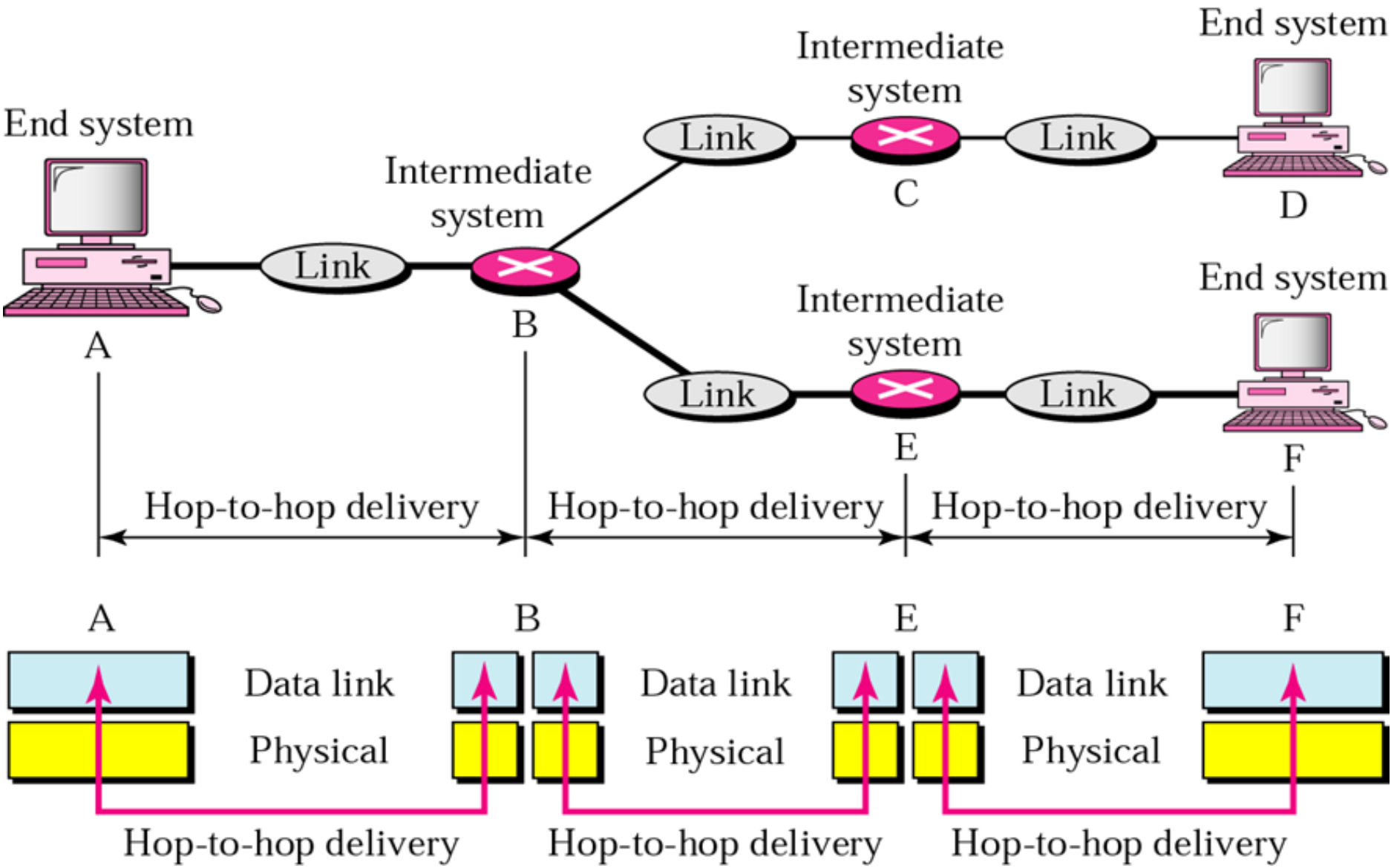




Note

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

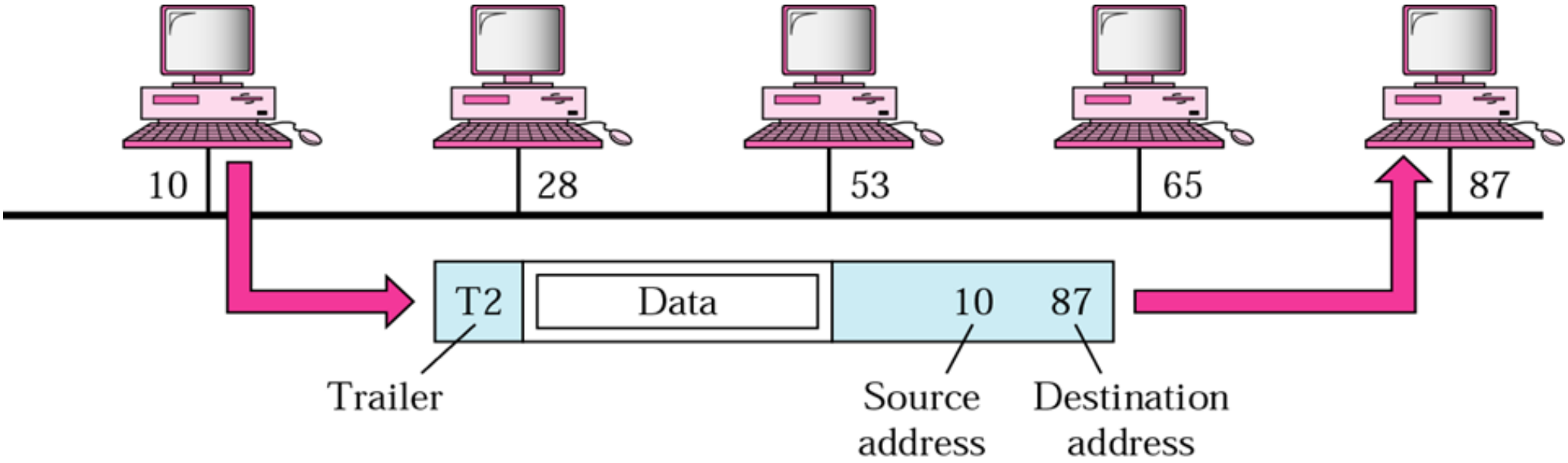
Figure 2.7 *Node-to-node delivery*



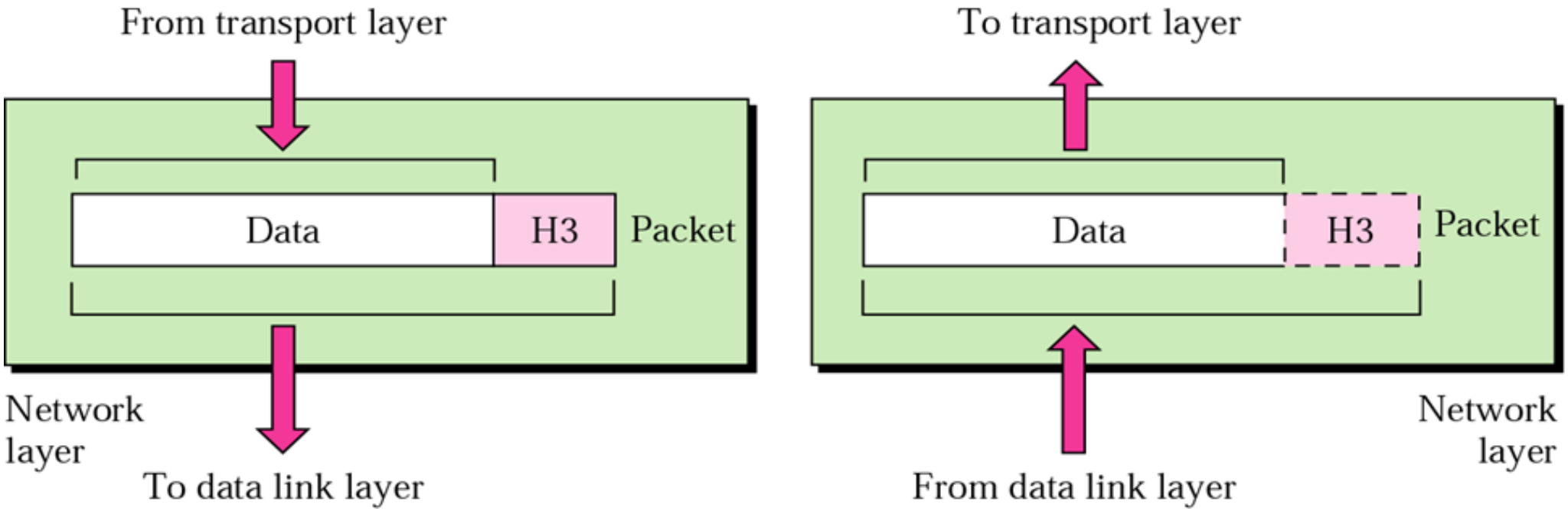
Data Link Layer

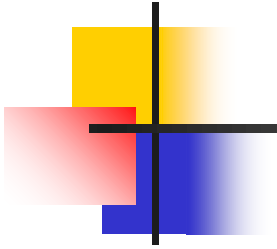
- **Data Link layer PDU is called frame**
- **Transfers *frames*** across *direct* connections Node-to-Node (hop-to-hop) delivery
- **Framing**: dividing the stream of bits into units called frames
- **Physical Addressing**: sender and receiver physical addresses (Local address – hardware address – NIC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

Figure 2.8 *Example 1*



Network Layer





Note

The network layer is responsible for the delivery of individual 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*

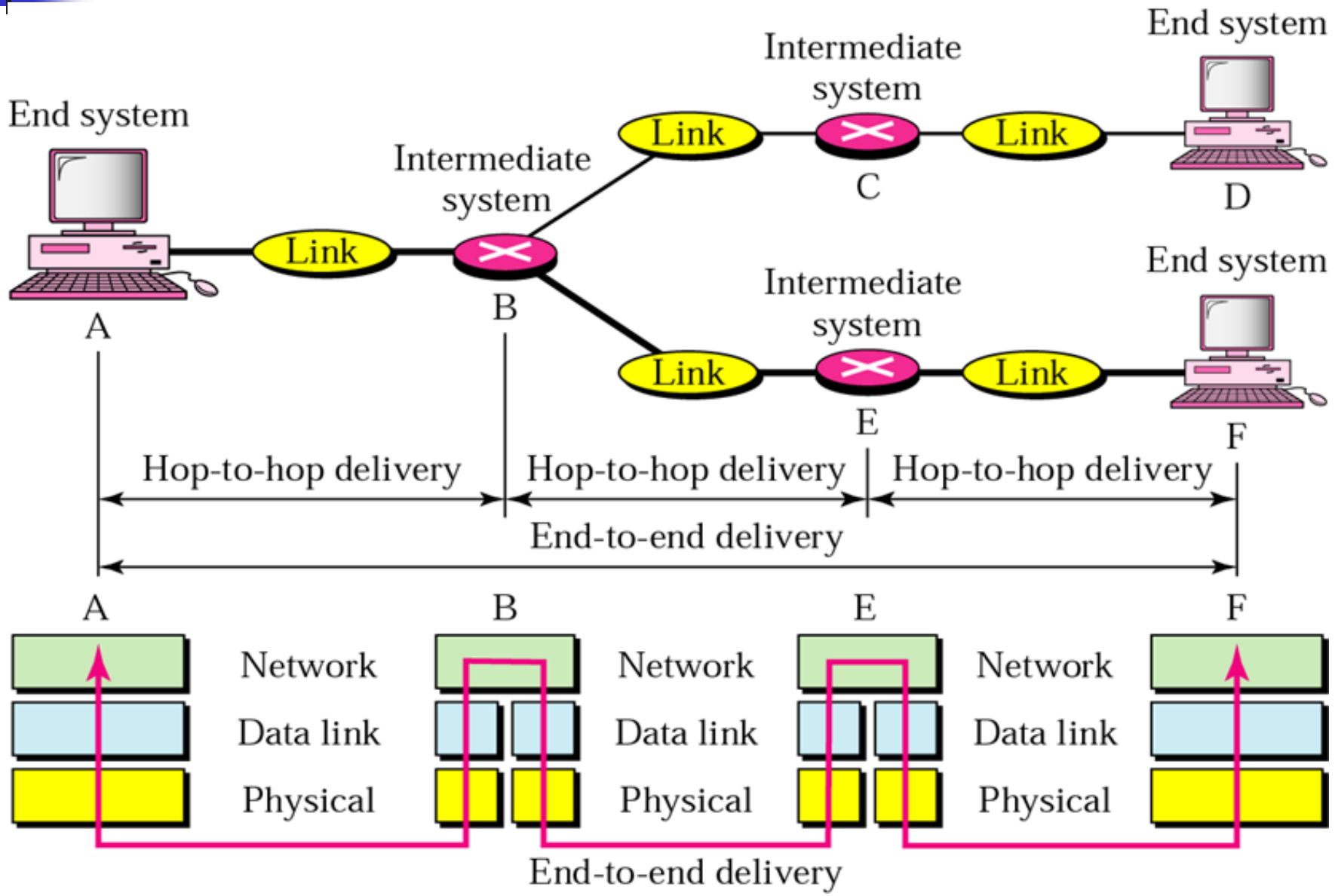
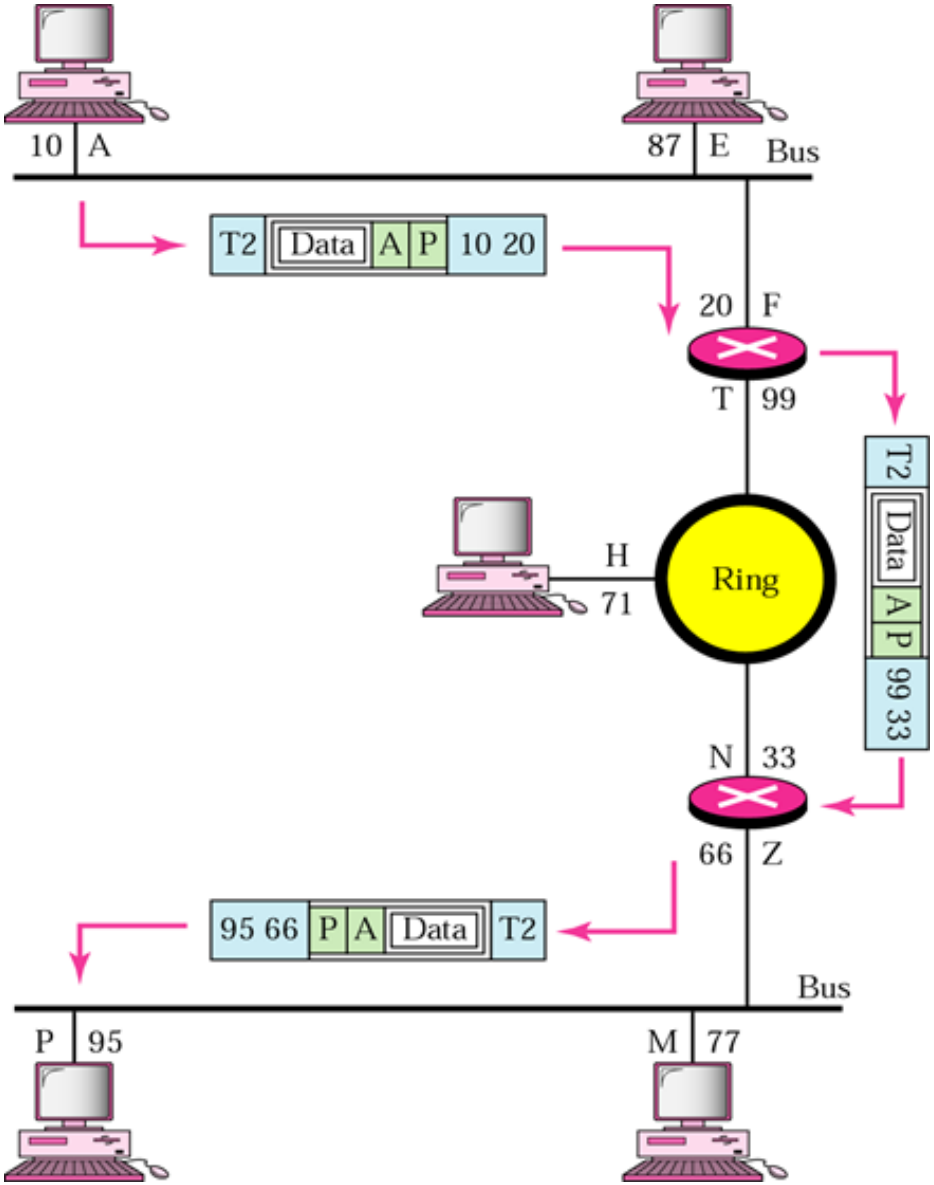


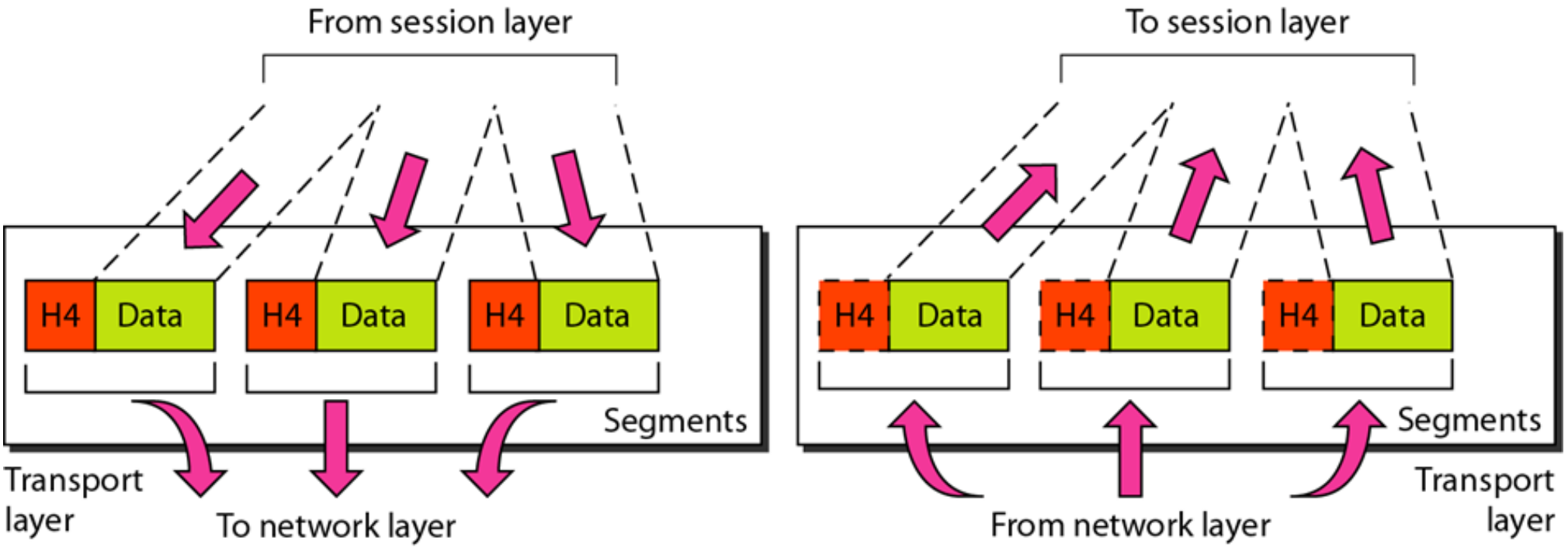
Figure 2.11 *Example 2*



Note

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

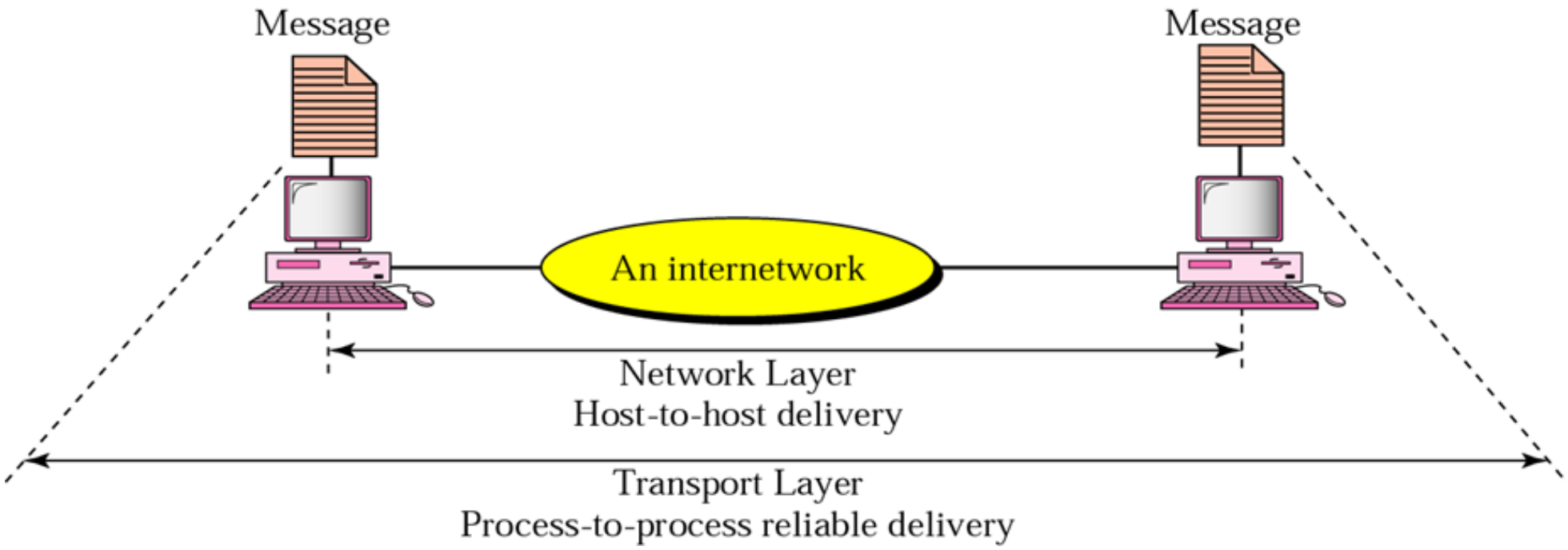
Figure 2.12 *Transport layer*



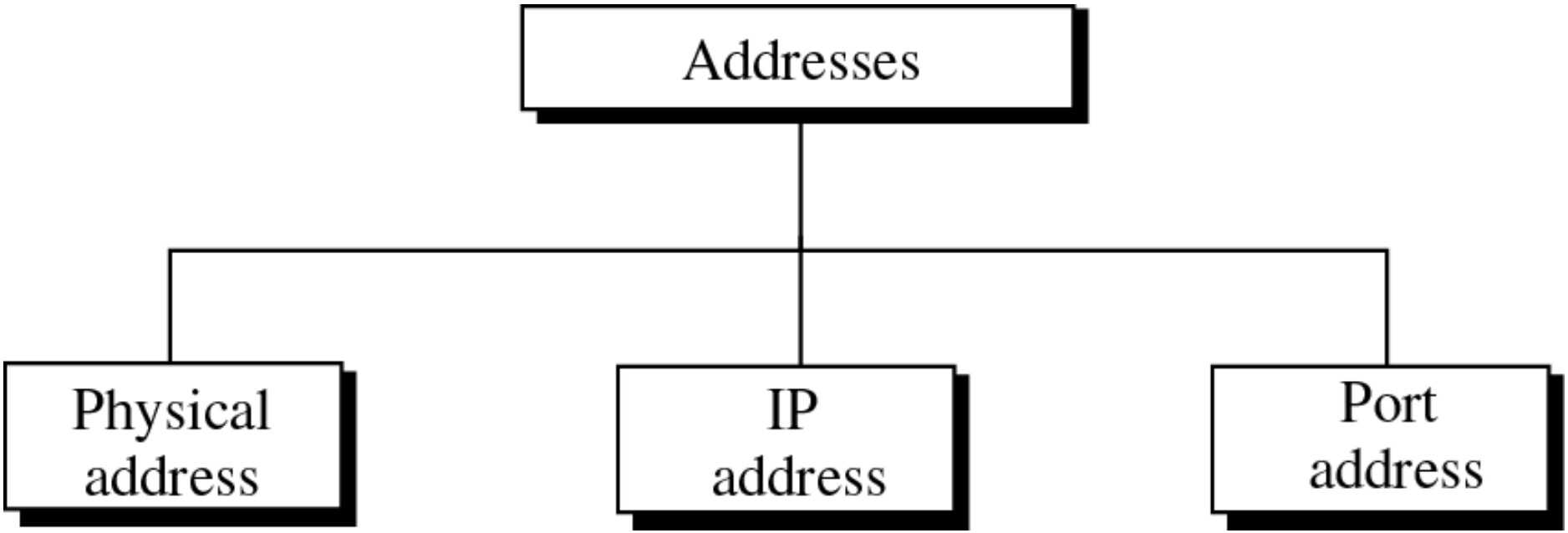
Transport Layer

- The transport layer is responsible for **Process-to-Process** delivery of the ENTIRE MESSAGE
- 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**
- Process addressing
  - Port address

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



Addressing



Layer Addresses

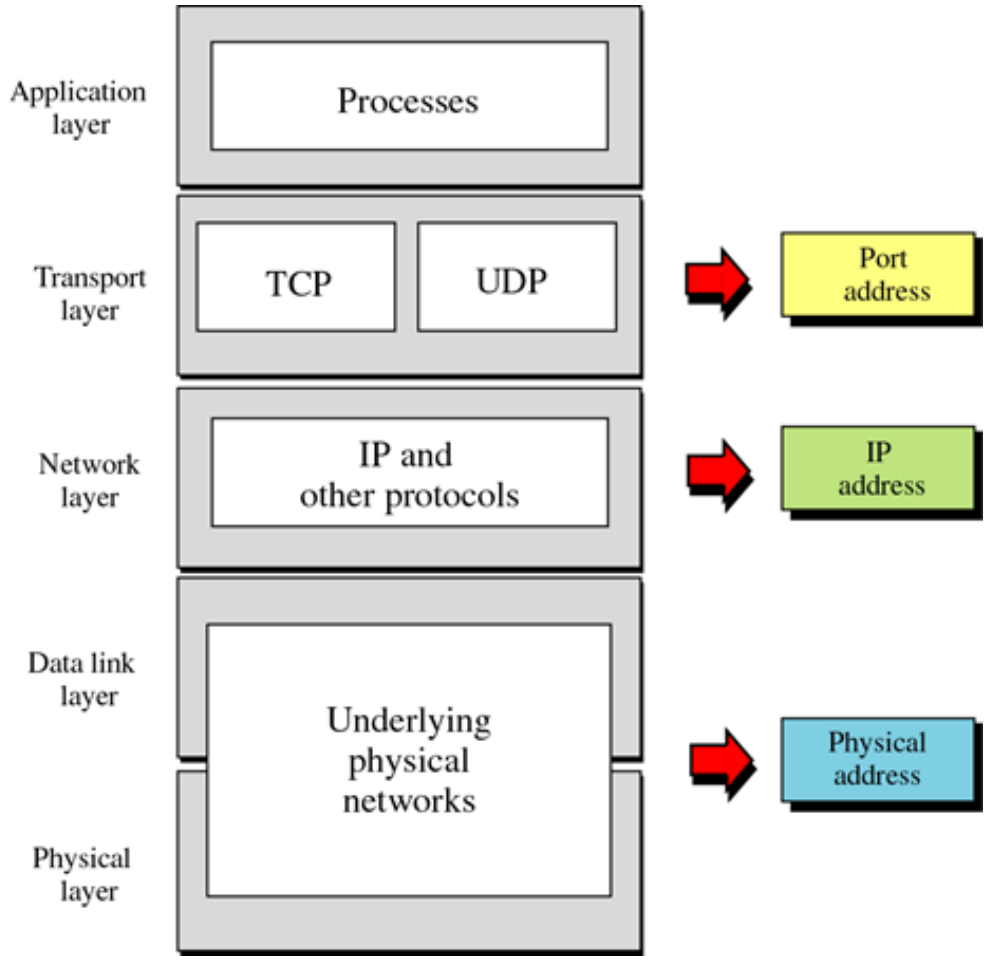
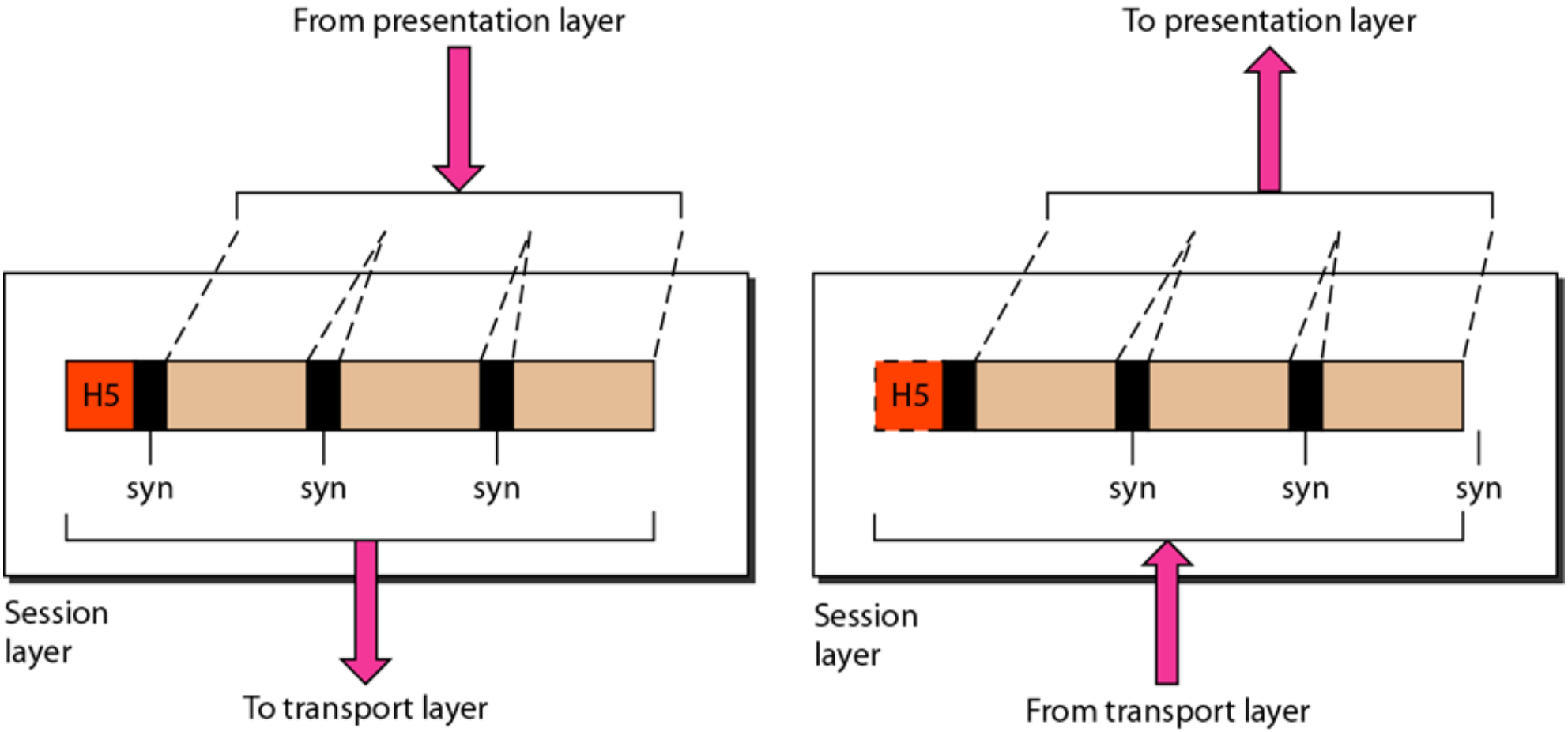


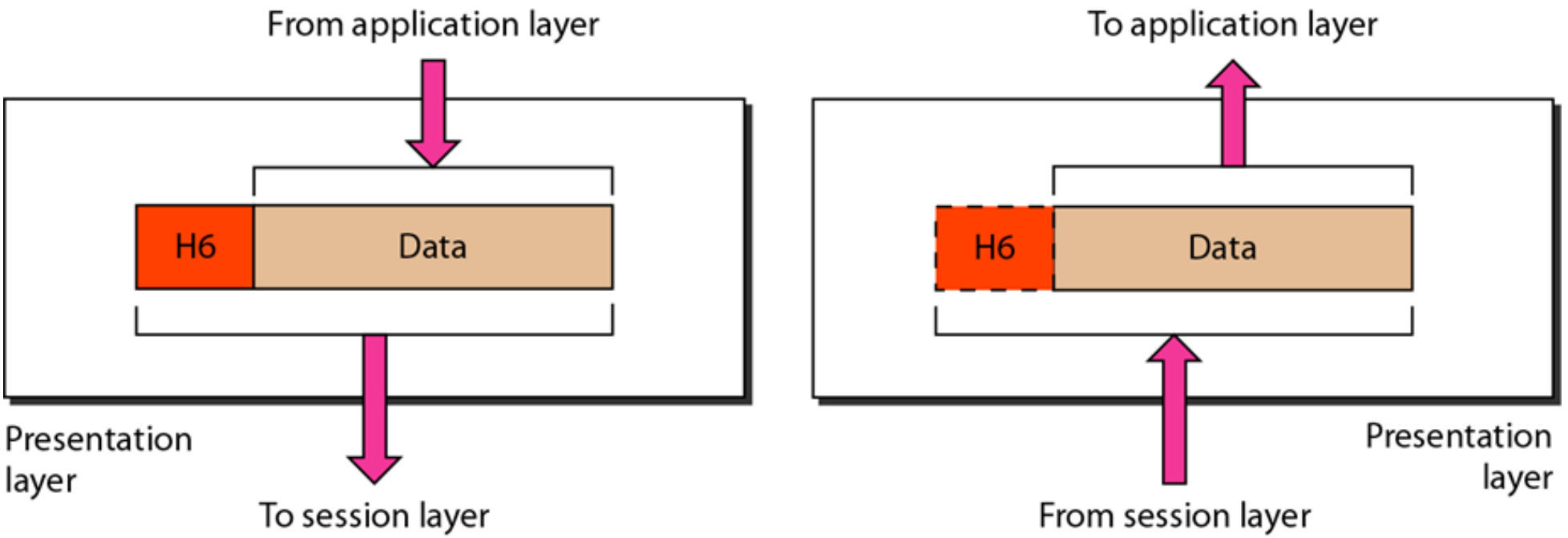
Figure 2.12 *Session layer*



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

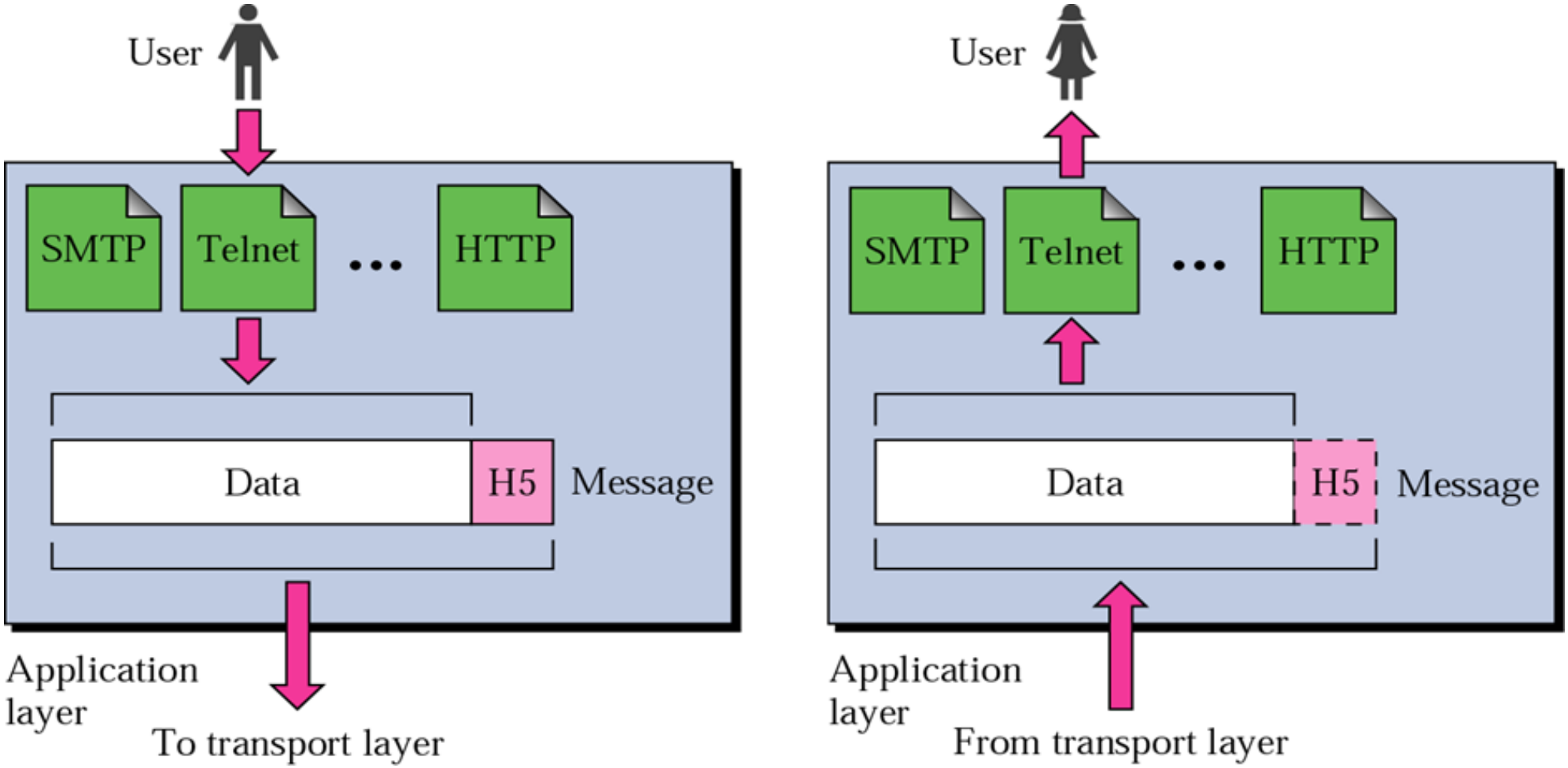
Figure 2.13 *Presentation layer*



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 "¢¹¹½³? " 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

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
- 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

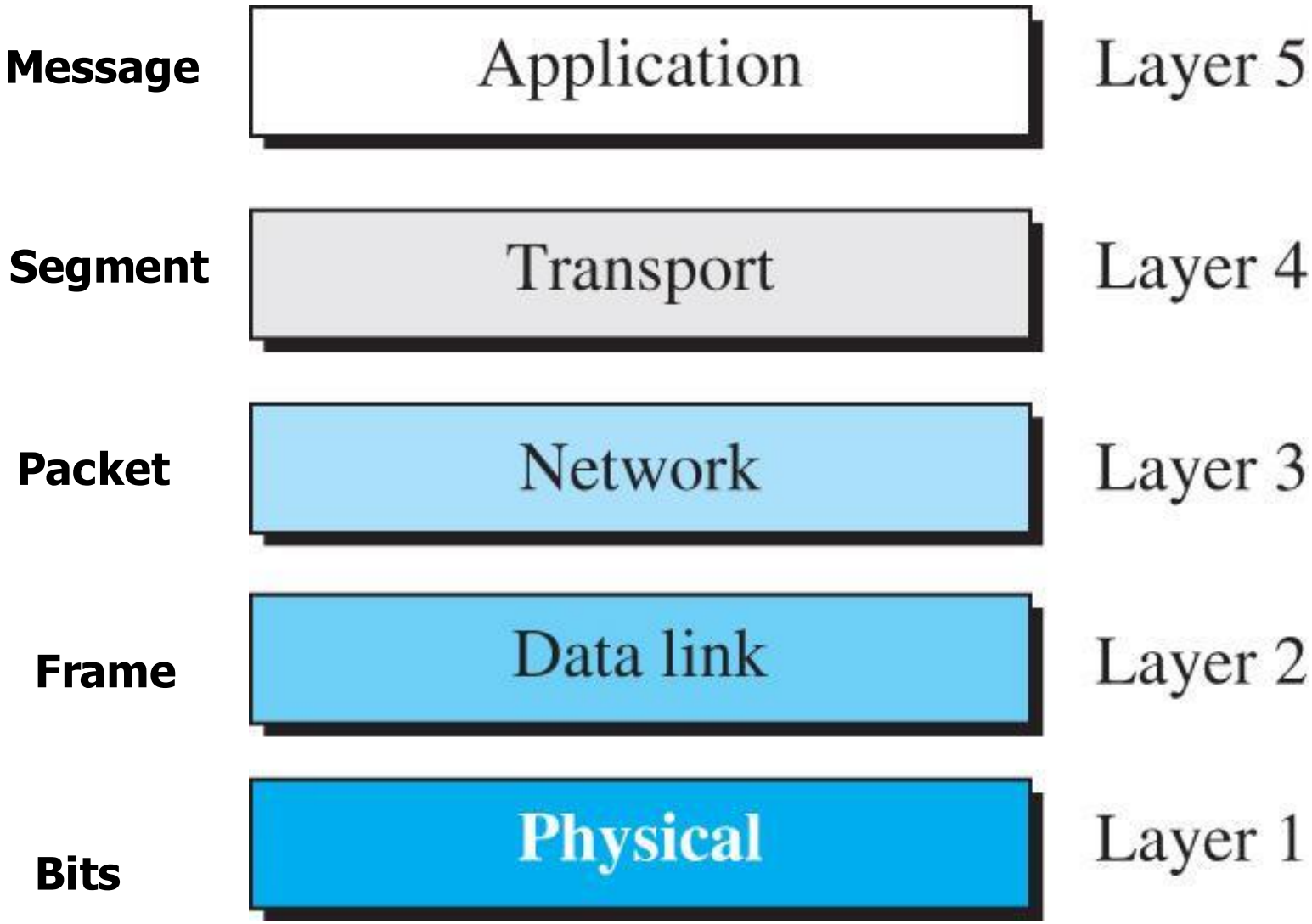


Figure 2.12: TCP/IP and OSI model

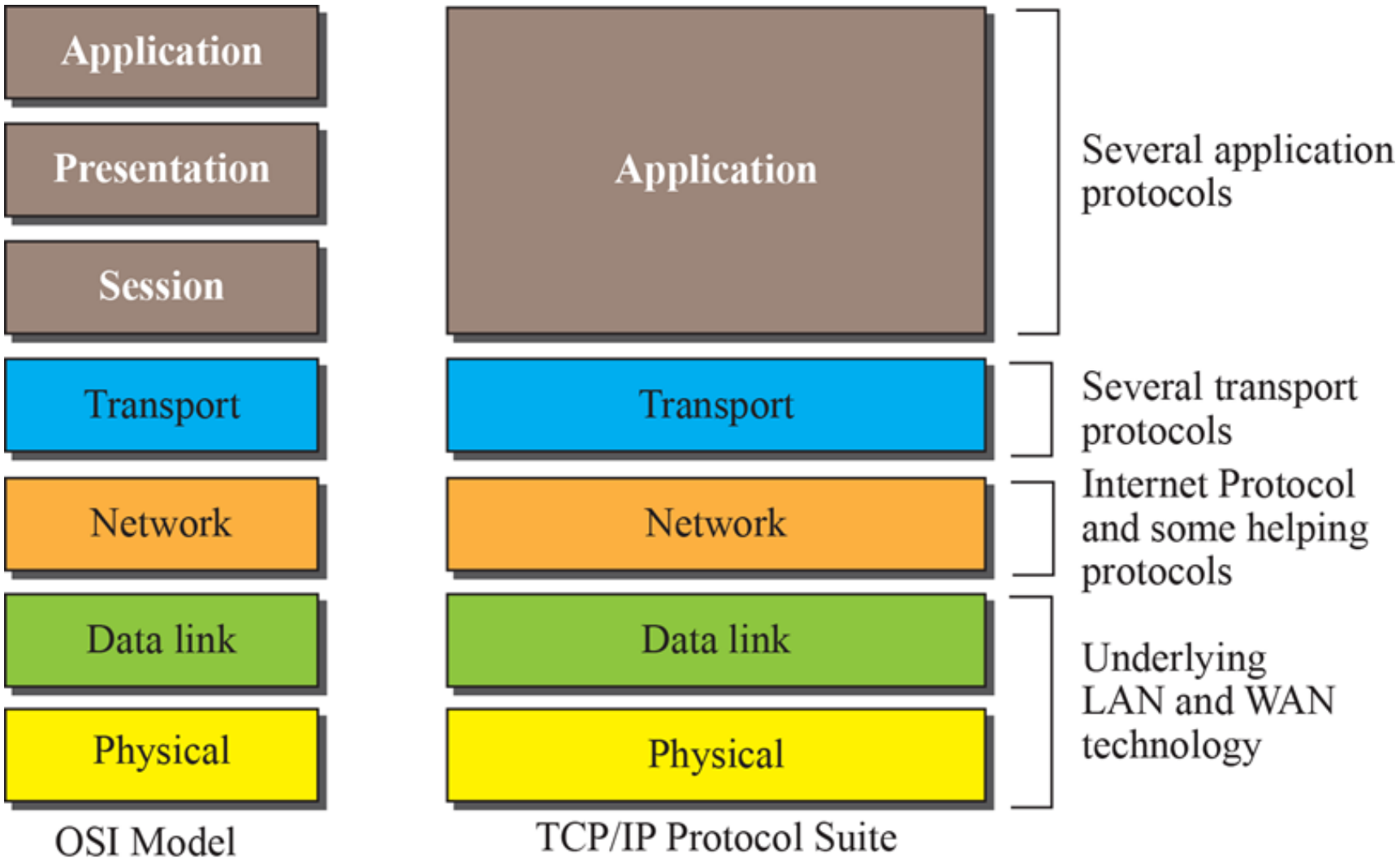
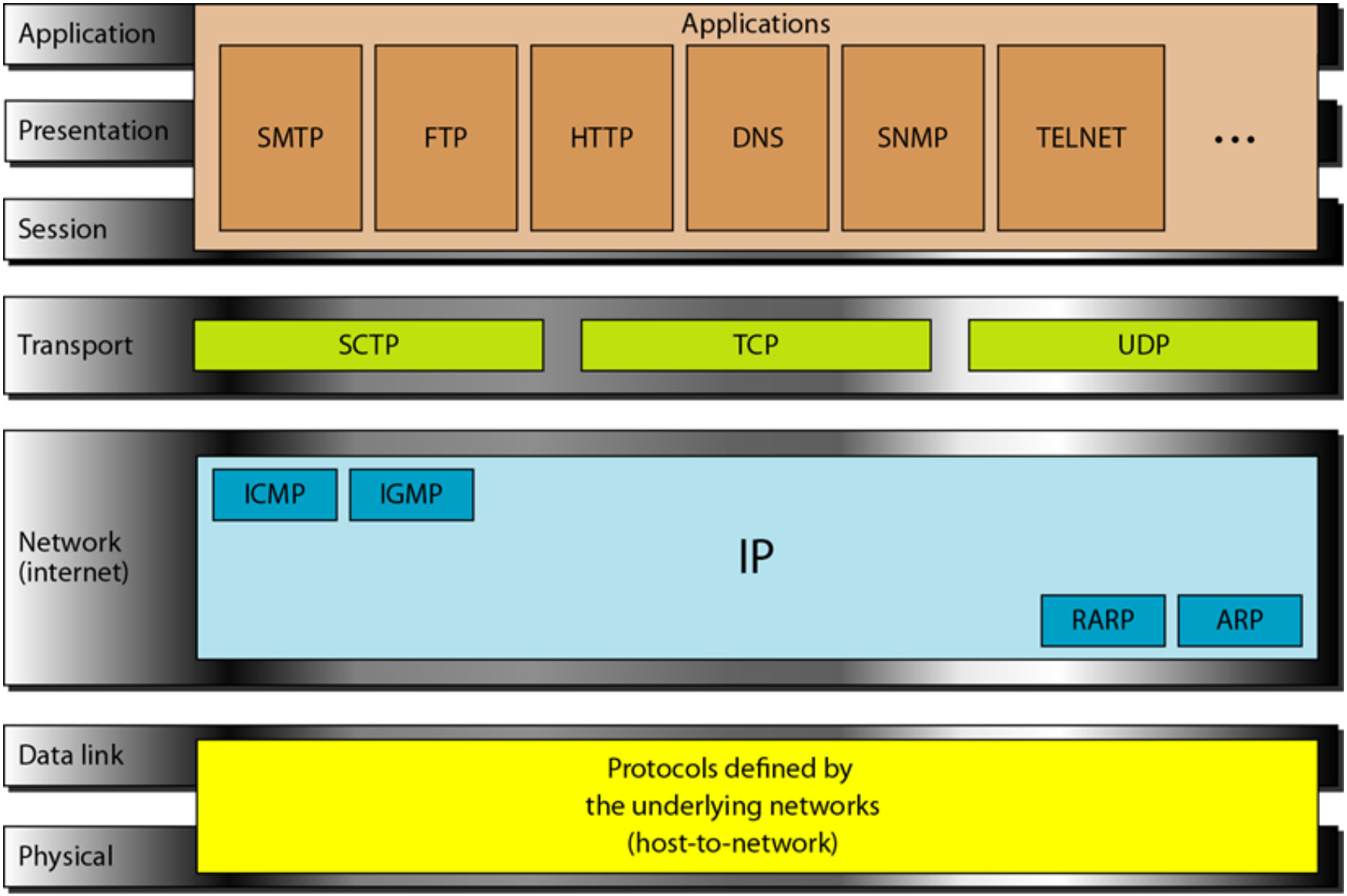


Figure 2.16 *TCP/IP and OSI model*



Original TCP/IP Model (4-layers)