

Data and Computer Communications

Chapter 2 – Protocol Architecture, TCP/IP, and Internet-Based Applications

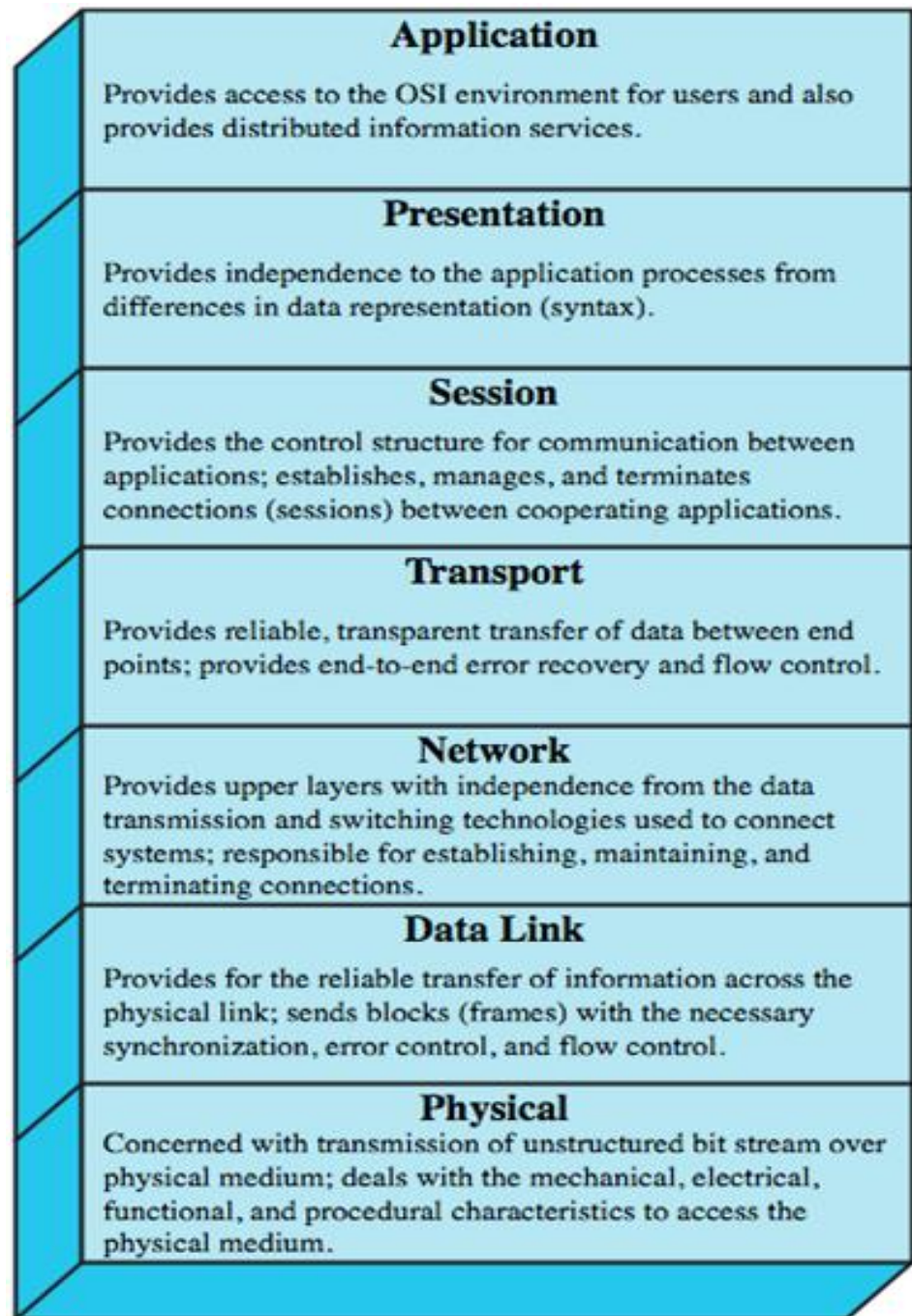
Need For Protocol Architecture

- data exchange can involve **complex procedures**
- better if task broken into **subtasks**
- implemented separately in **layers** in stack
 - each layer provides **functions** needed to perform communication for layers above
 - using functions provided by layers below
 - modularization **eases maintenance, updating of system**
- **peer layers communicate with a protocol**

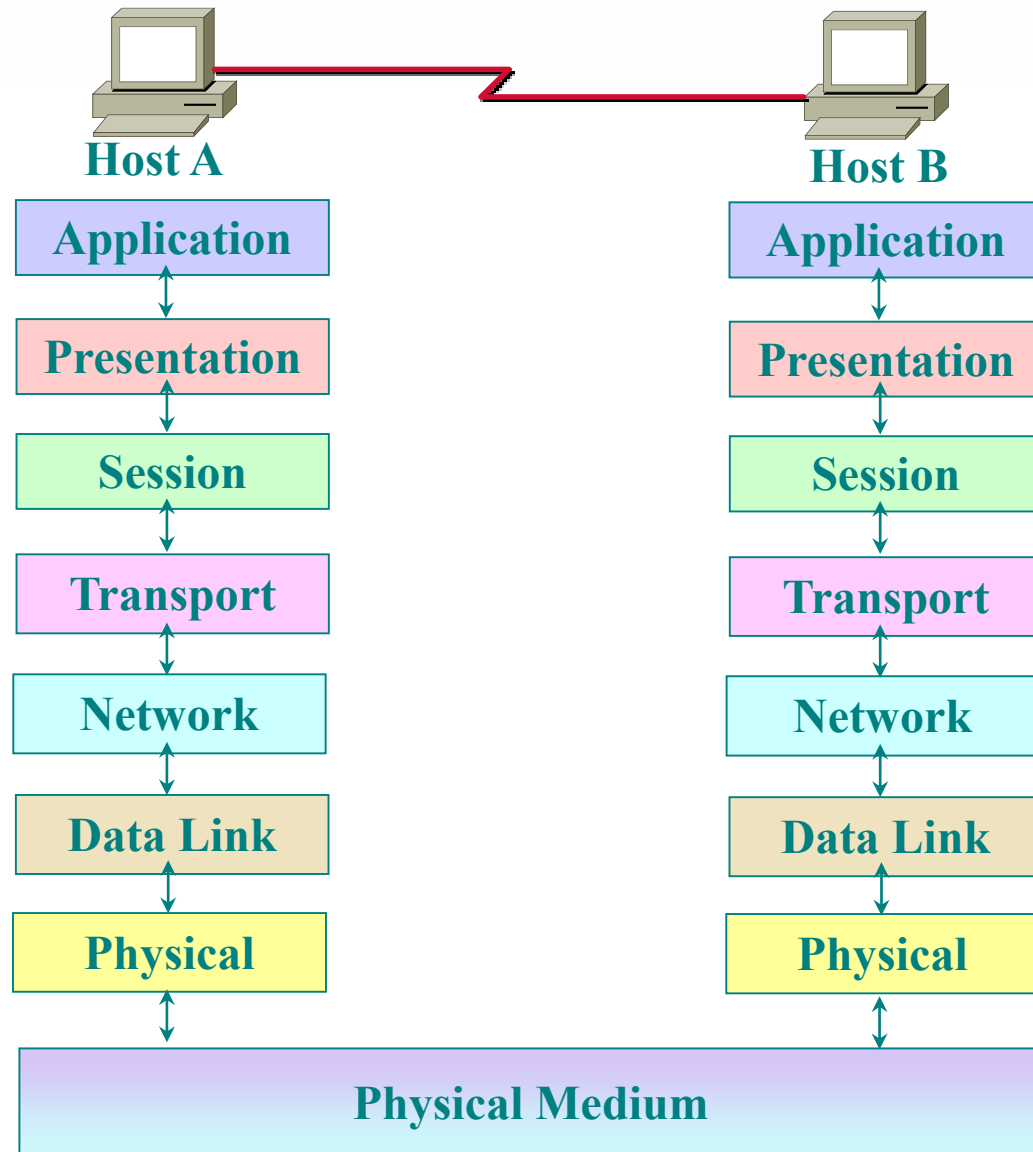
OSI

- **OSI**: Open Systems Interconnection
- Developed by the International Organization for Standardization (ISO)
- Has **seven** layers – *too many*
- Is a theoretical system delivered
- **TCP/IP** is the de facto **standard**

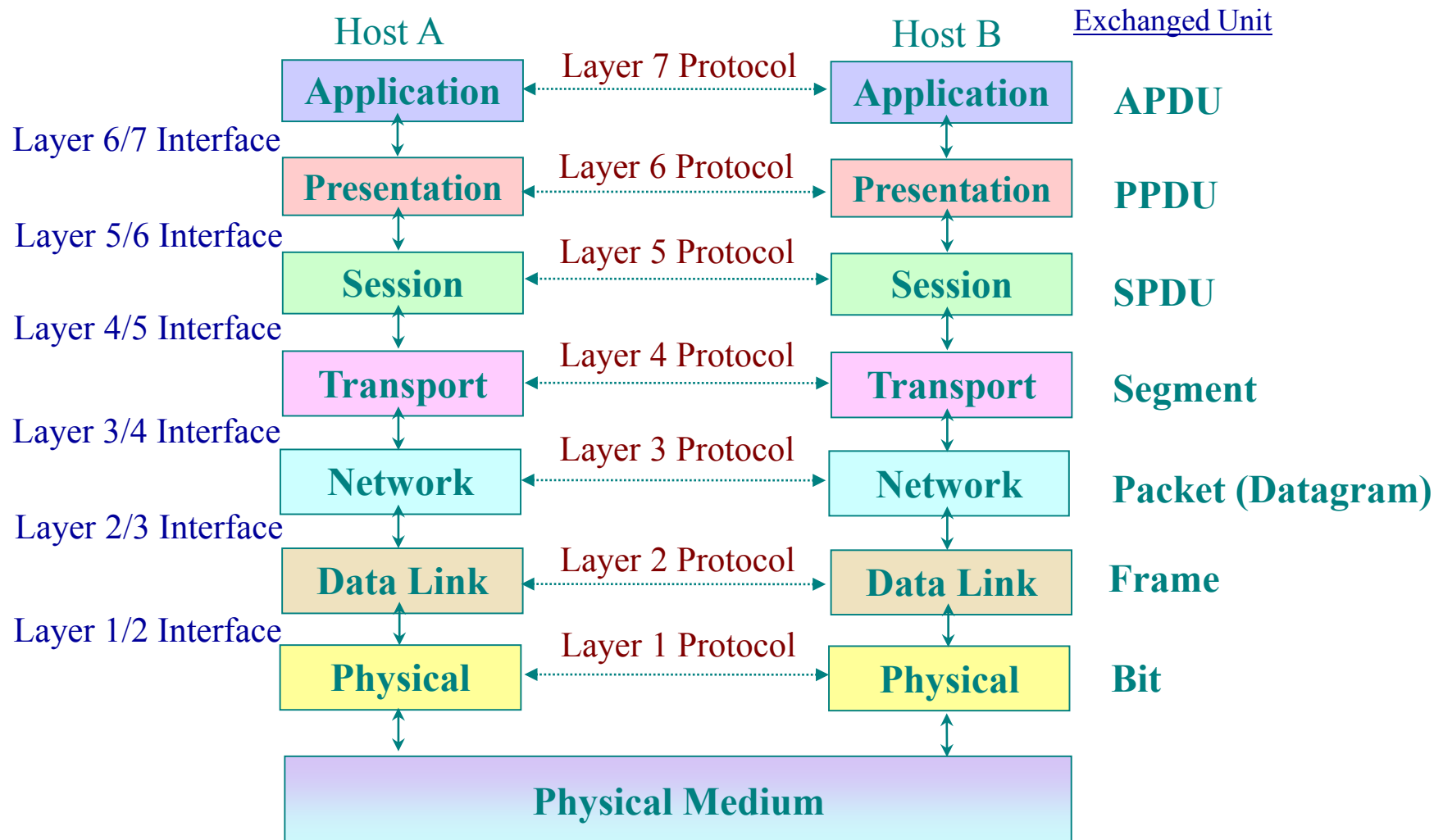
OSI Layers



ISO/OSI Reference Model



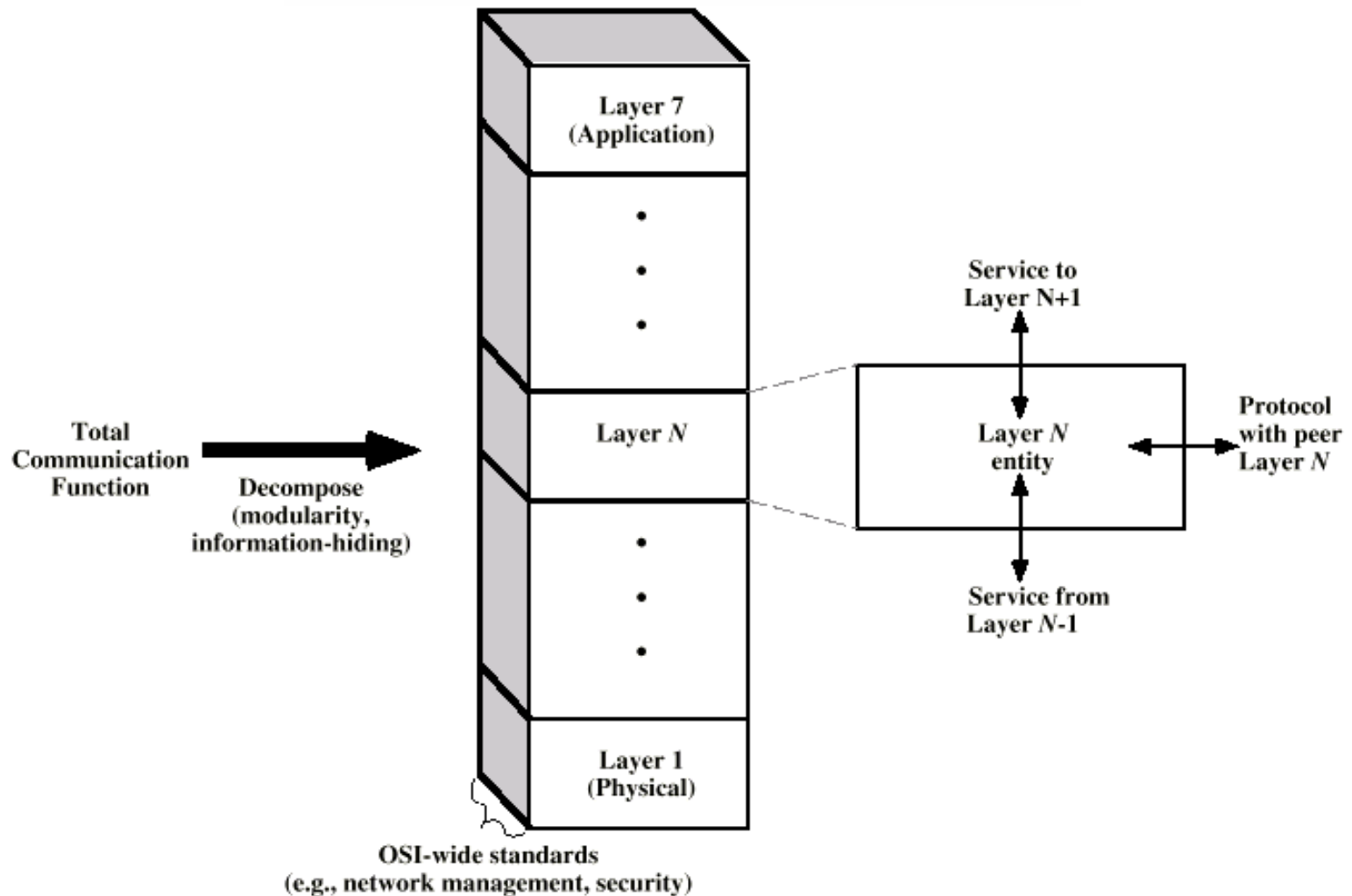
ISO/OSI Reference Model



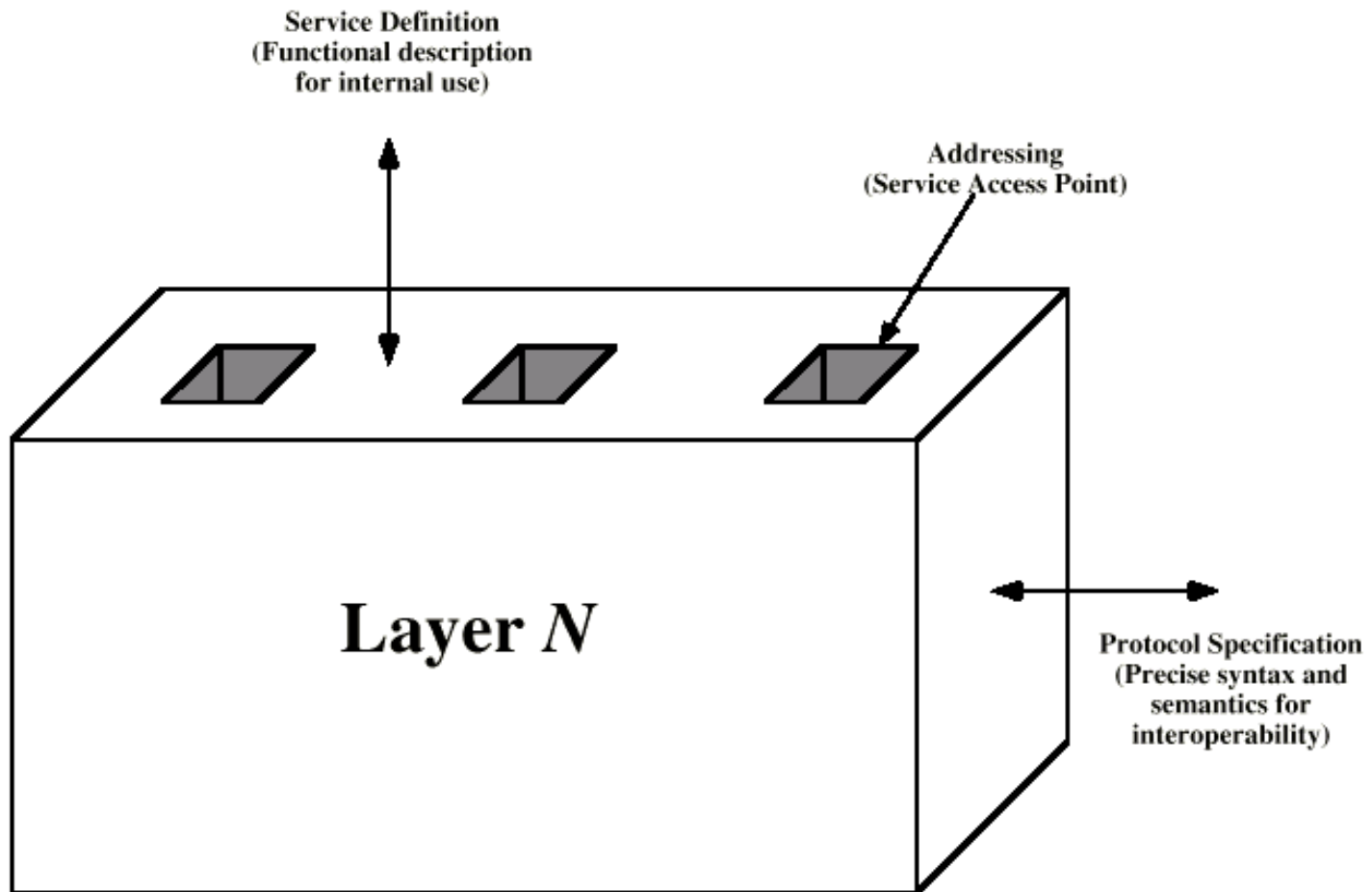
ISO/OSI Reference Model

- The entities comprising the corresponding layers on different machines are called **peers**.
- **Protocol**: It is an agreement between **peers** on how communication is to proceed.
- Peers can communicate by using **Protocols**.
- **Interface**: It defines the primitive operations and services the lower layer makes available to the upper layer.
- A **Service Access Point (SAP)** has an address that uniquely identifies where the service can be accessed.
- A set of layers and protocols is called a **Network Architecture**.

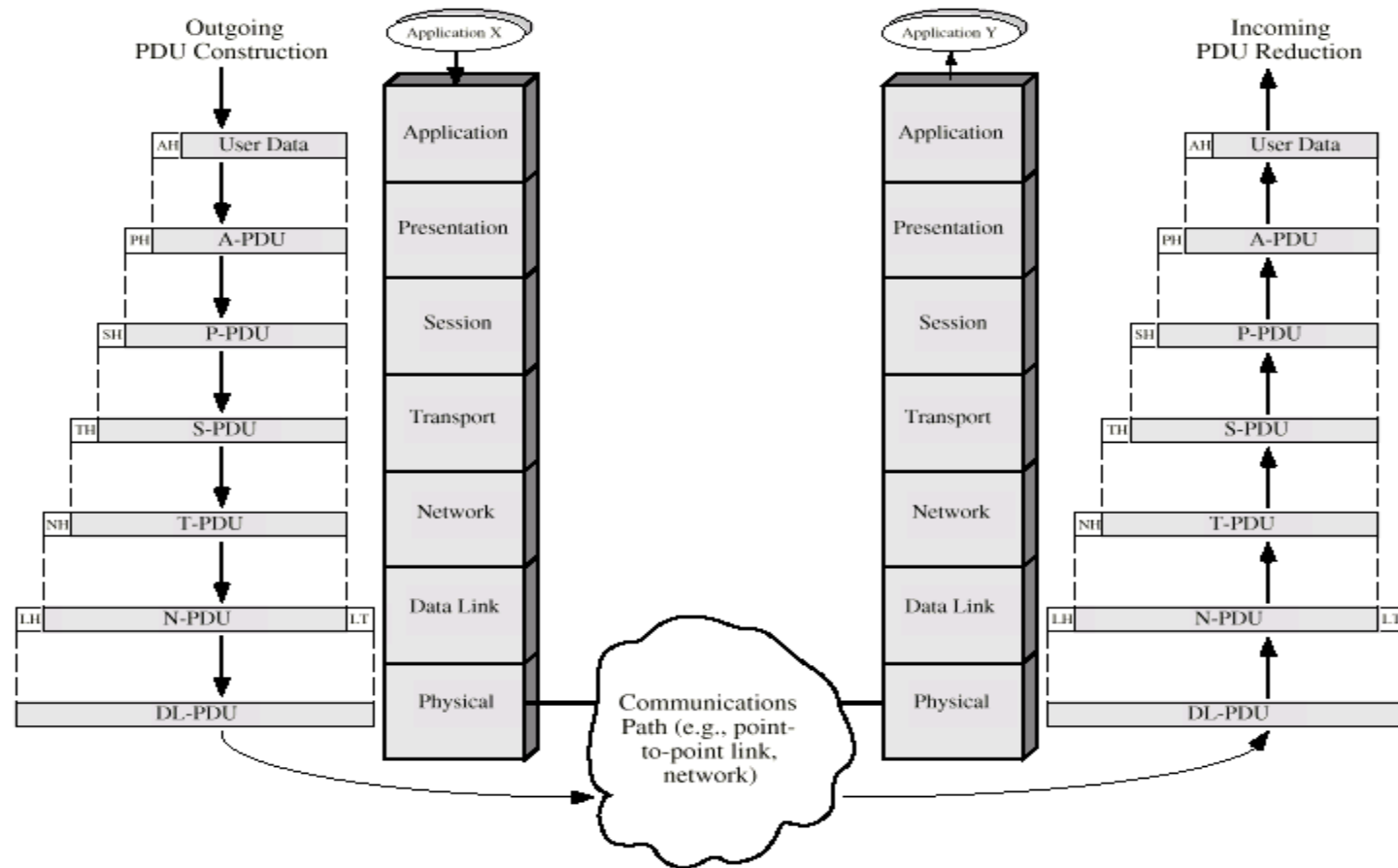
Standardized Protocol Architectures



Layer Specific Standards



The OSI Environment



ISO/OSI Reference Model

OSI Model				
Layer		Data unit	Function	Examples
Host layers	7. Application	Data	High-level APIs, including resource sharing, remote file access, directory services and virtual terminals	HTTP, FTP, SMTP
	6. Presentation		Translation of data between a networking service and an application; including character encoding, data compression and encryption/decryption	ASCII, EBCDIC, JPEG
	5. Session		Managing communication sessions, i.e. continuous exchange of information in the form of multiple back-and-forth transmissions between two nodes	RPC, PAP
	4. Transport	Segments	Reliable transmission of data segments between points on a network, including segmentation, acknowledgement and multiplexing	TCP, UDP
Media layers	3. Network	Packet/Datagram	Structuring and managing a multi-node network, including addressing, routing and traffic control	IPv4, IPv6, IPsec, AppleTalk
	2. Data link	Bit/Frame	Reliable transmission of data frames between two nodes connected by a physical layer	PPP, IEEE 802.2, L2TP
	1. Physical	Bit	Transmission and reception of raw bit streams over a physical medium	DSL, USB

ISO/OSI Reference Model

1. The Physical Layer:

- It concerns with transmitting raw bits over a communication channel.
- Voltage Levels for 0 and 1.
- Connectors: Number of pins and purpose of each pin.
- Transmission Media.
- Attenuation and Distortion.
- Analog PSTN Circuits and Digital Leased Circuits.

ISO/OSI Reference Model

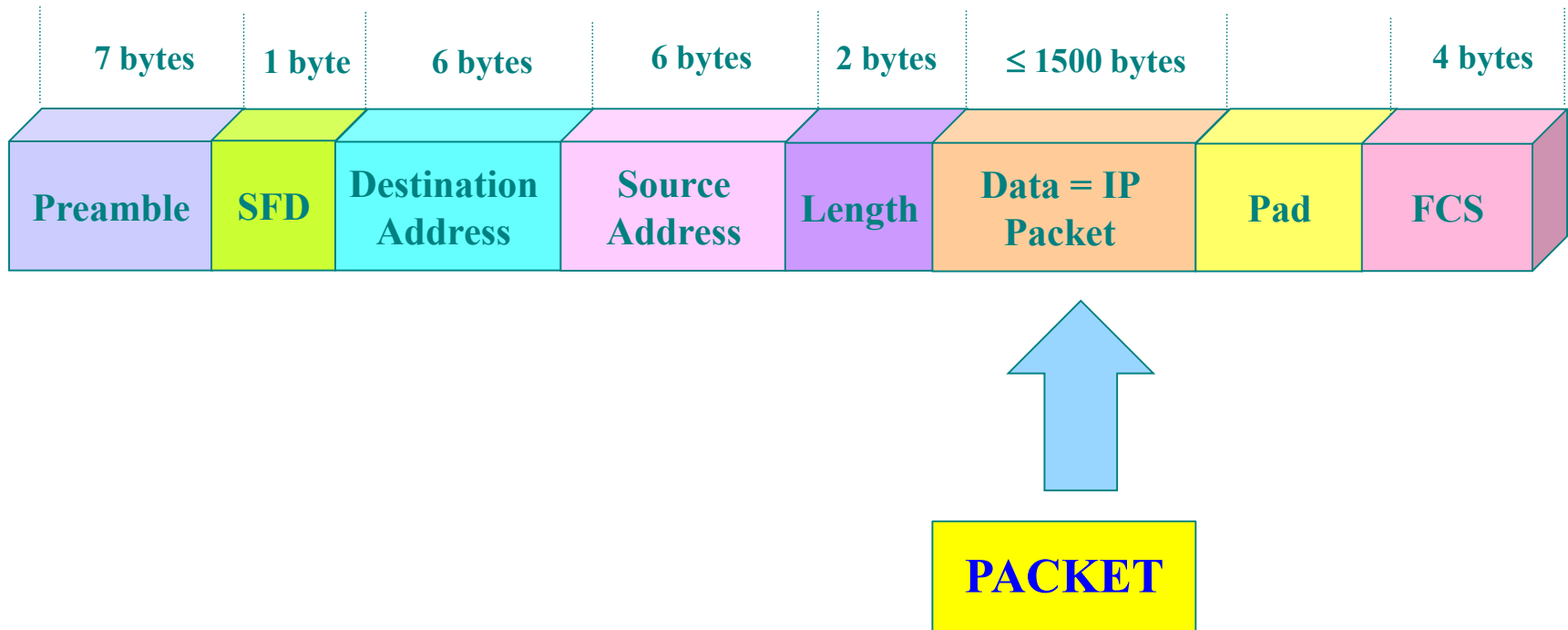
2. The Data Link Layer:

- **FRAME** is the basic protocol unit
- **Framing:**
 - create and recognize frame boundaries.
 - encapsulate datagram into frame, adding header, trailer



- **Addressing:**
 - MAC (Physical) Addressing.
- **Point-to-point Error Detection**
- **Point-to-point flow control**
- **Medium Access Control (MAC) Protocols**

Ethernet Frame

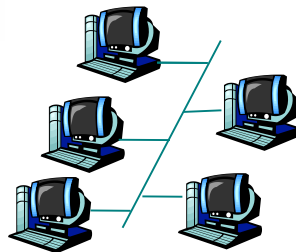


ISO/OSI Reference Model

2. The Data Link Layer:

Medium Access Control (MAC)

- single **shared** broadcast channel
- two or more **simultaneous** transmissions by nodes:
interference
 - **collision** if node receives two or more signals at the same time



shared wire (e.g.,
cabled Ethernet)



shared RF
(e.g., 802.11 WiFi)

ISO/OSI Reference Model

2. The Data Link Layer:

Medium Access Control (MAC) Protocols:

➤ **Channel Partitioning**

- divide channel into smaller “pieces” (time slots, frequency, code)
- allocate piece to node for exclusive use

➤ **Random Access**

- channel not divided, allow collisions
- “recover” from collisions

➤ **“Taking turns”**

- nodes take turns, but nodes with more to send can take longer turns

ISO/OSI Reference Model

3. The Network Layer:

- **PACKET (DATAGRAM)** is the basic protocol unit
- **Addressing**
 - IP Addressing
- **Routing:** It determines how packets are routed from source to destination.
- **Congestion Control:** Many packets in the subnet trying to use the same route.
- **Internetworking:** It allows *heterogeneous networks* to be interconnected.

ISO/OSI Reference Model

4. The Transport Layer:

- **SEGMENT** is the basic protocol unit
- **Disassembling and Reassembling:** It accepts data from a session layer, split it up to smaller units if needed, pass these to the network layer, and ensure that the pieces all arrive correctly at the other end.
- **End-to-end error control.**
- **End-to-end flow control.**
- **Addressing**
 - Ports

ISO/OSI Reference Model

5. The Session Layer:

- It allows users on different machines to **establish sessions** between them.
- **Interaction Management:** The data exchange associated with a dialog may be:
 - **Duplex:** Two-way simultaneous.
 - **Half-Duplex:** Two-way alternate.
 - **Simplex:** One-way.

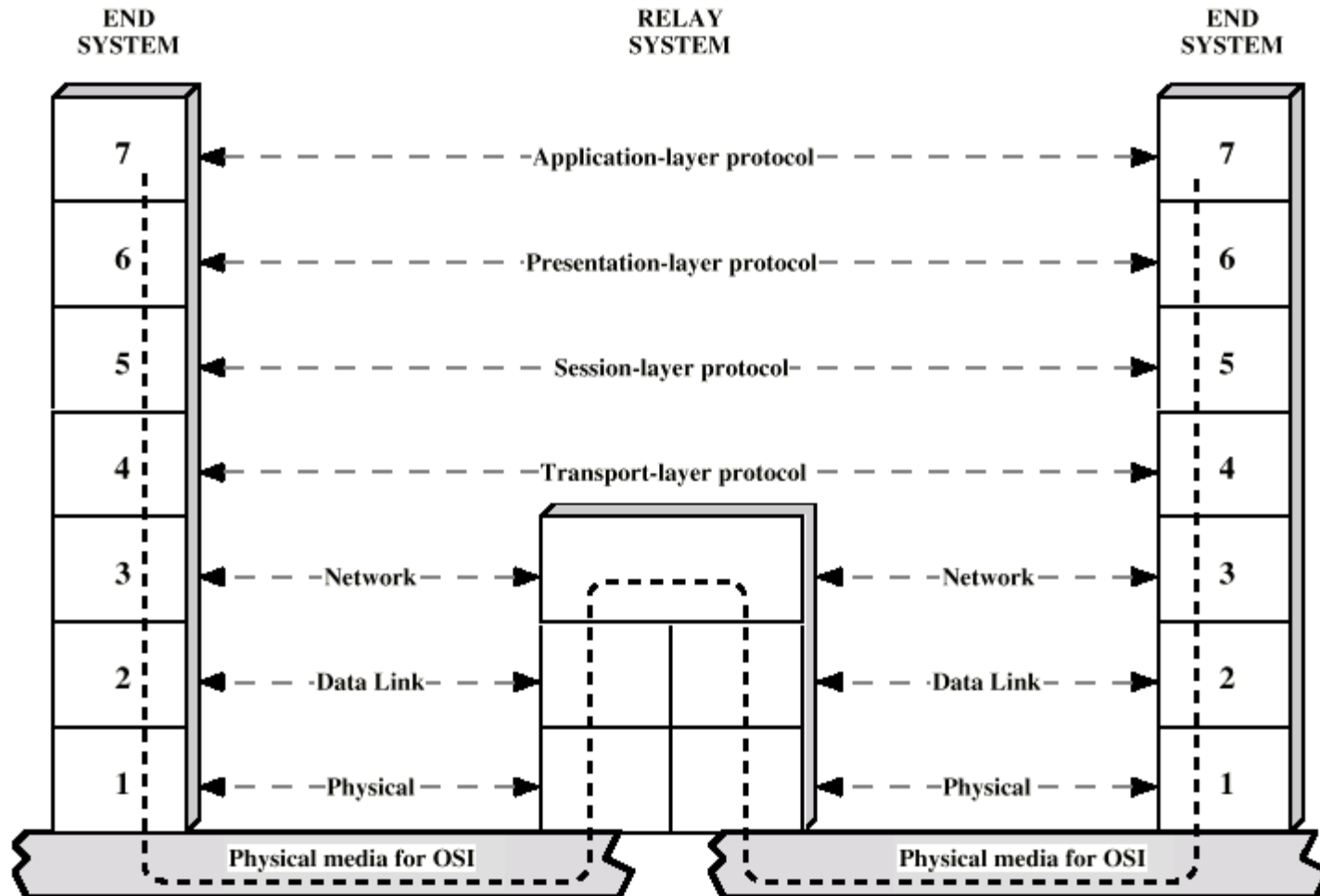
6. The Presentation Layer:

- Data Compression.
- Data Encryption.

7. The Application Layer:

- The application layer contains a variety of protocols that are commonly needed.

Use of a Relay



TCP/IP Protocol Architecture

- developed by **US Defense Advanced Research Project Agency (DARPA)**
- for ARPANET packet switched network
- used by the global Internet
- protocol suite comprises a large collection of standardized protocols

OSI v TCP/IP

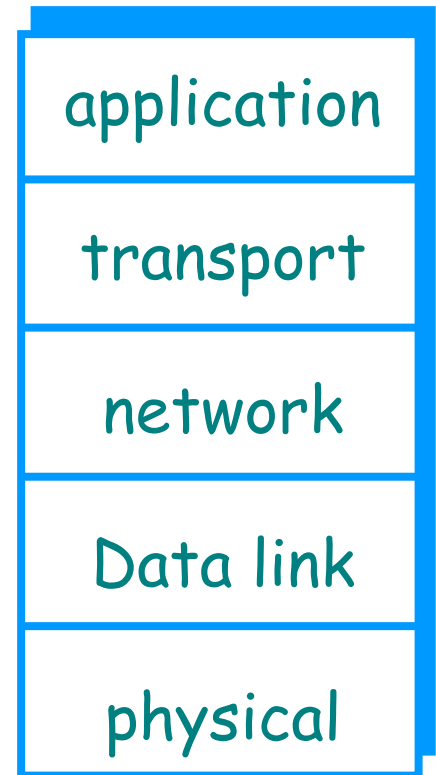
OSI

TCP/IP

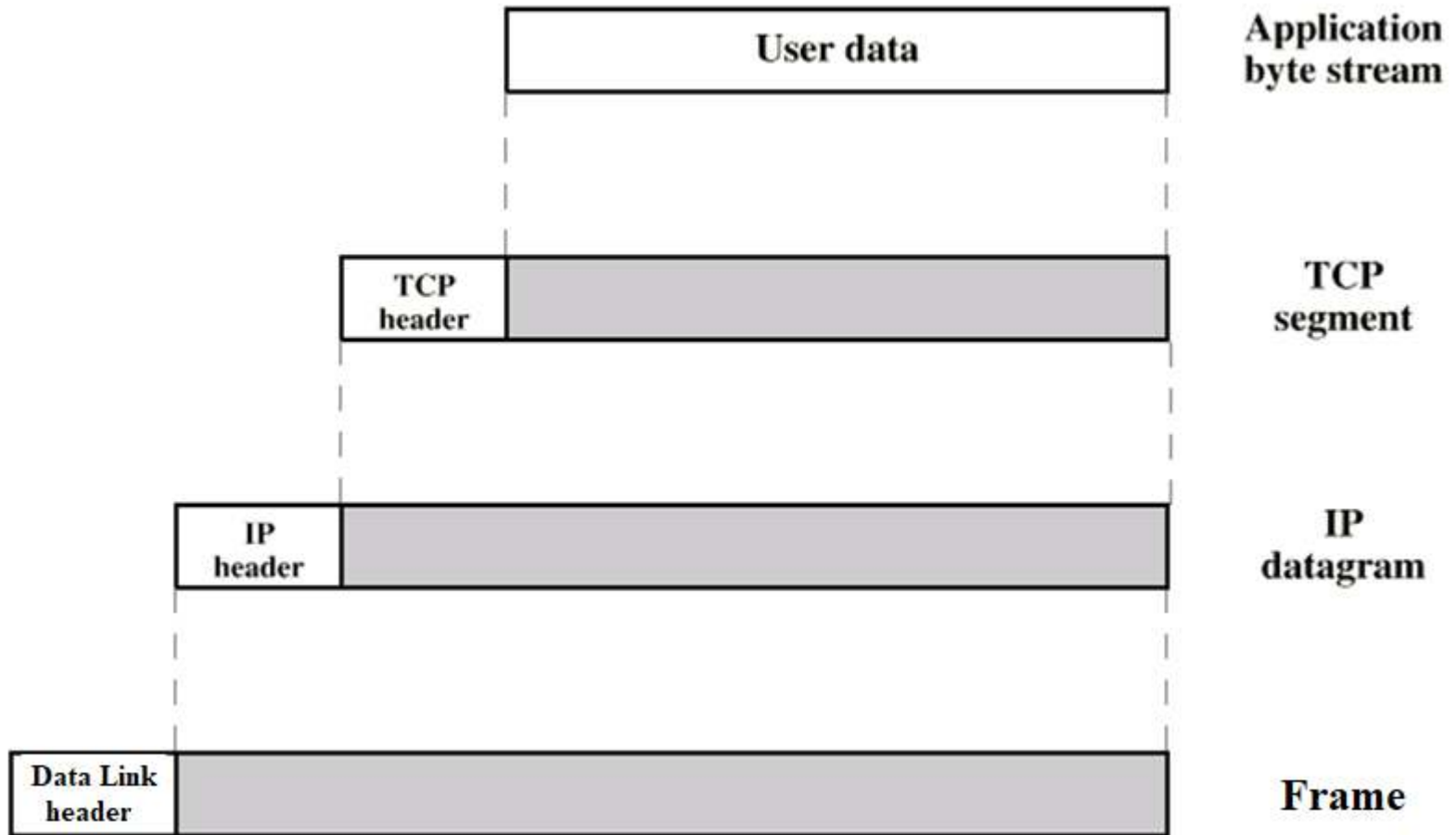
Application	Application
Presentation	
Session	
Transport	Transport (host-to-host)
Network	Network
Data Link	Data Link
Physical	Physical

Internet protocol stack

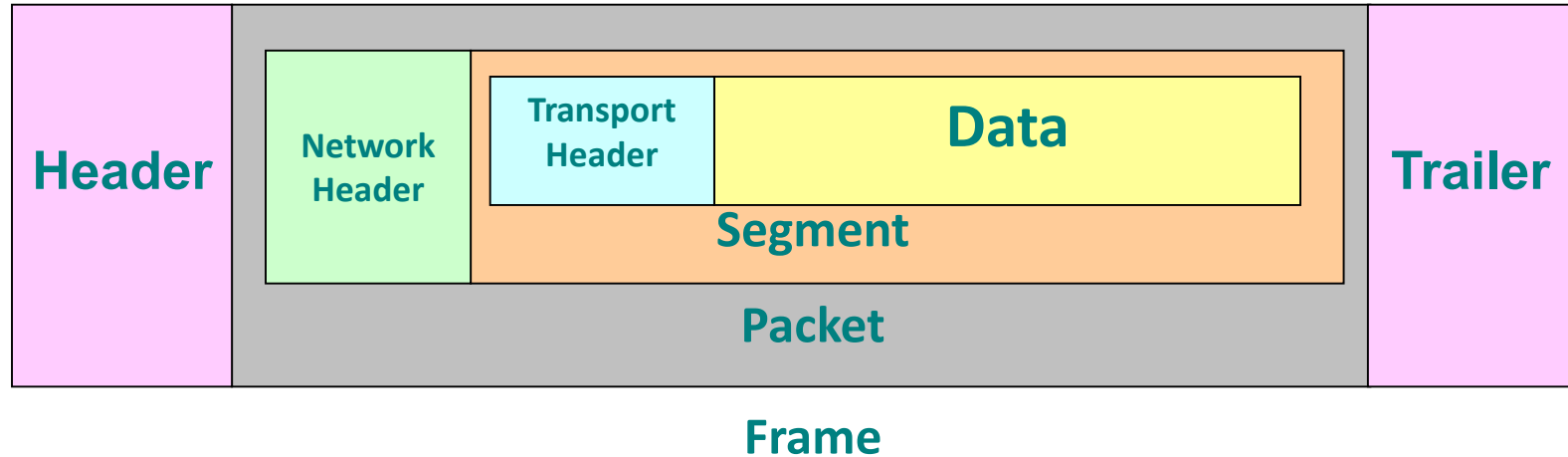
- **application:** supporting network applications
 - FTP, SMTP, HTTP
- **transport:** process-process data transfer
 - TCP, UDP
- **network:** routing of datagrams from source to destination
 - IP, routing protocols
- **link:** data transfer between neighboring network elements
 - PPP, Ethernet
- **physical:** bits “on the wire”



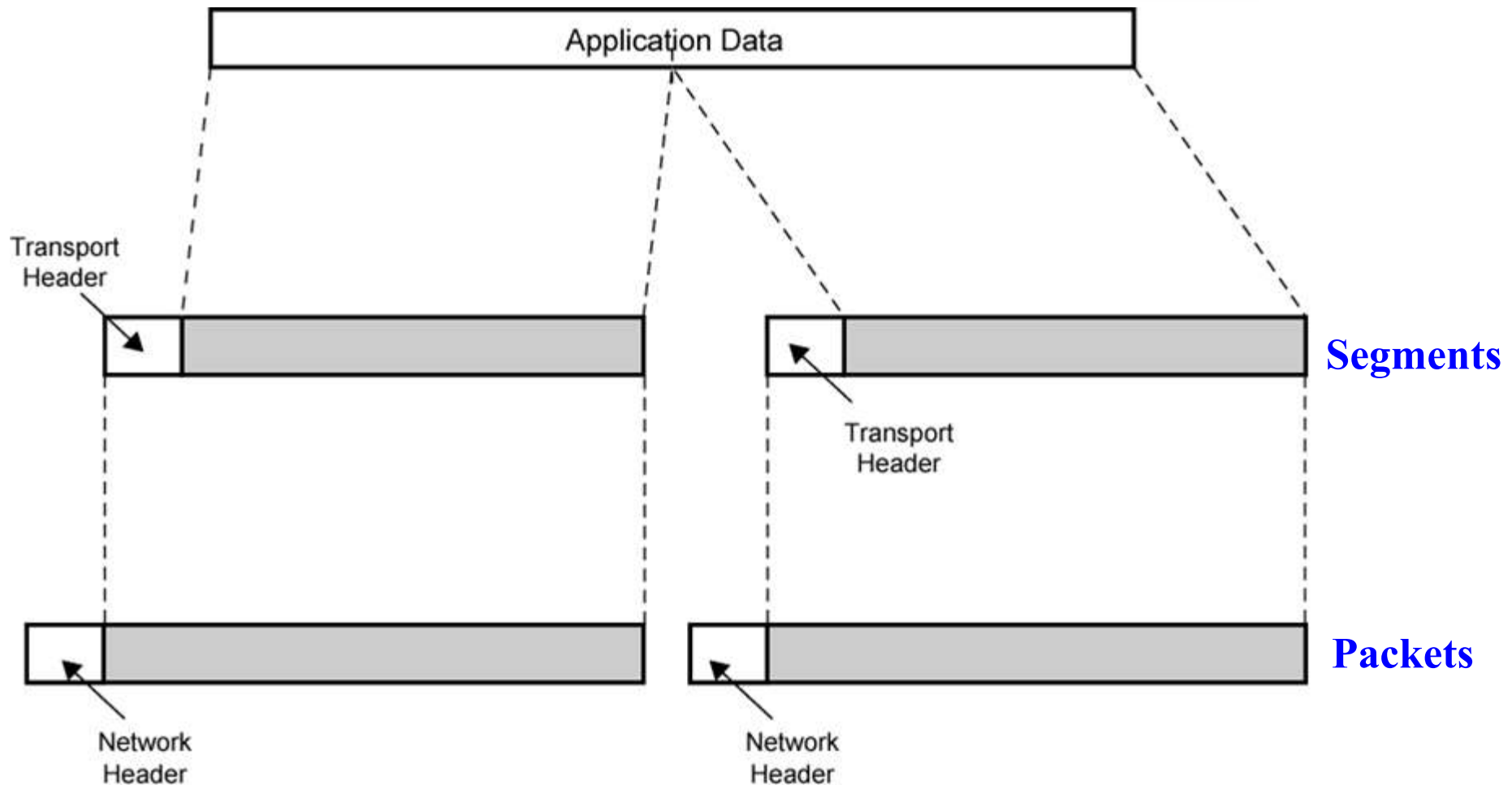
Operation of TCP/IP



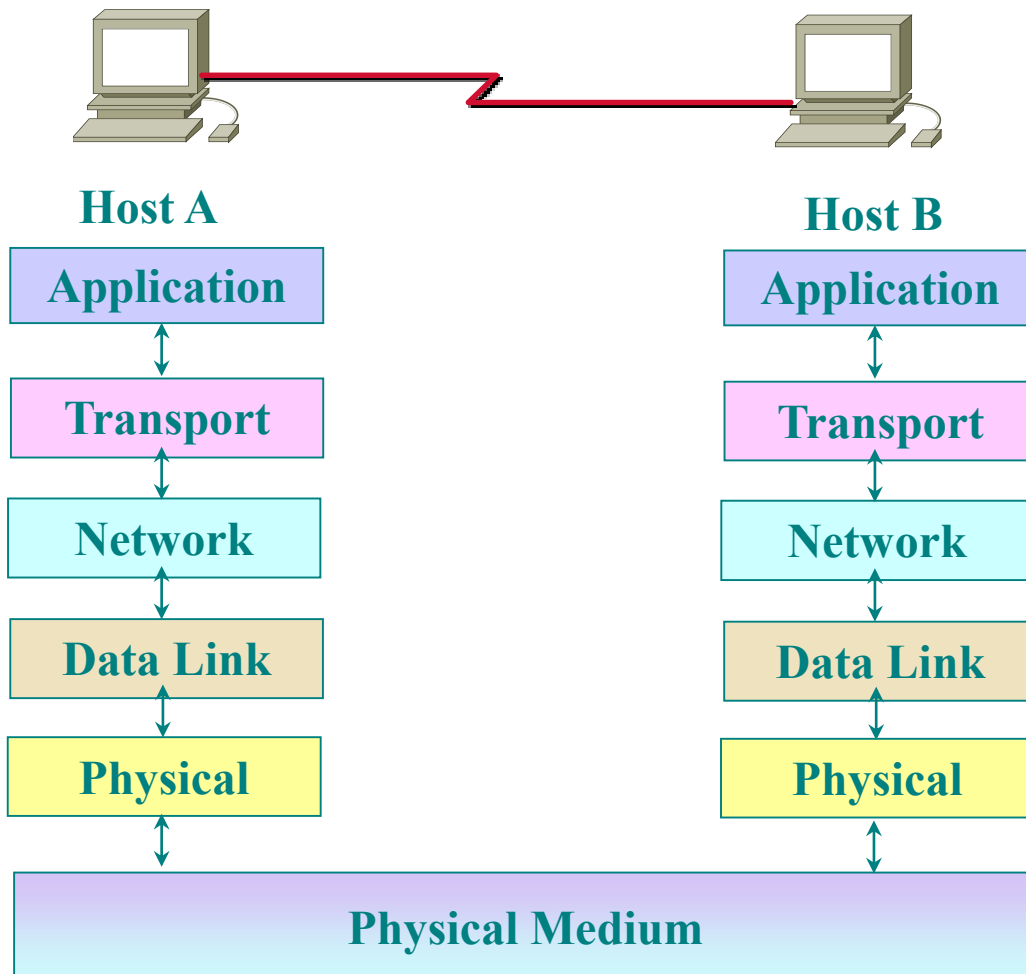
Encapsulation



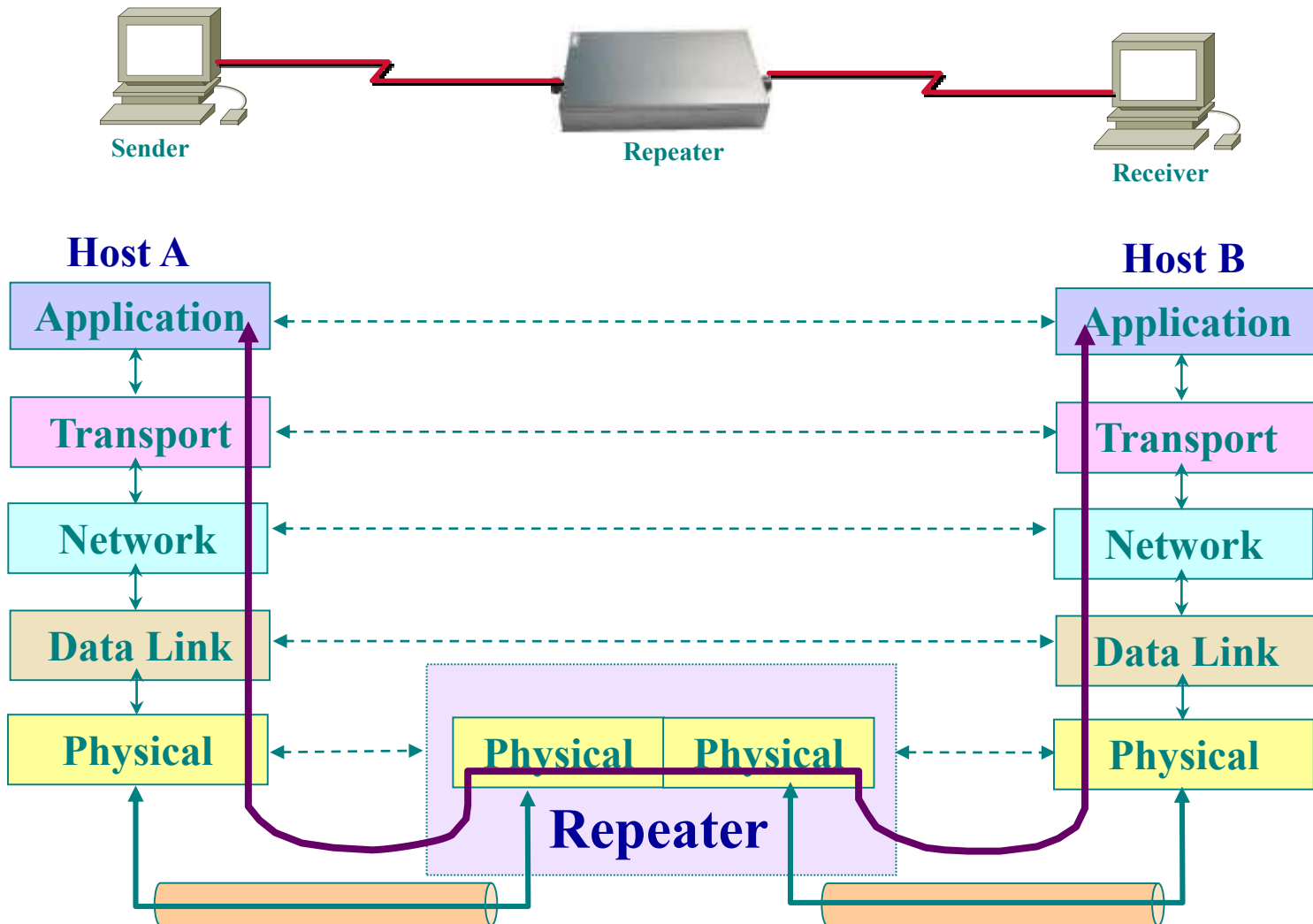
Protocol Data Units



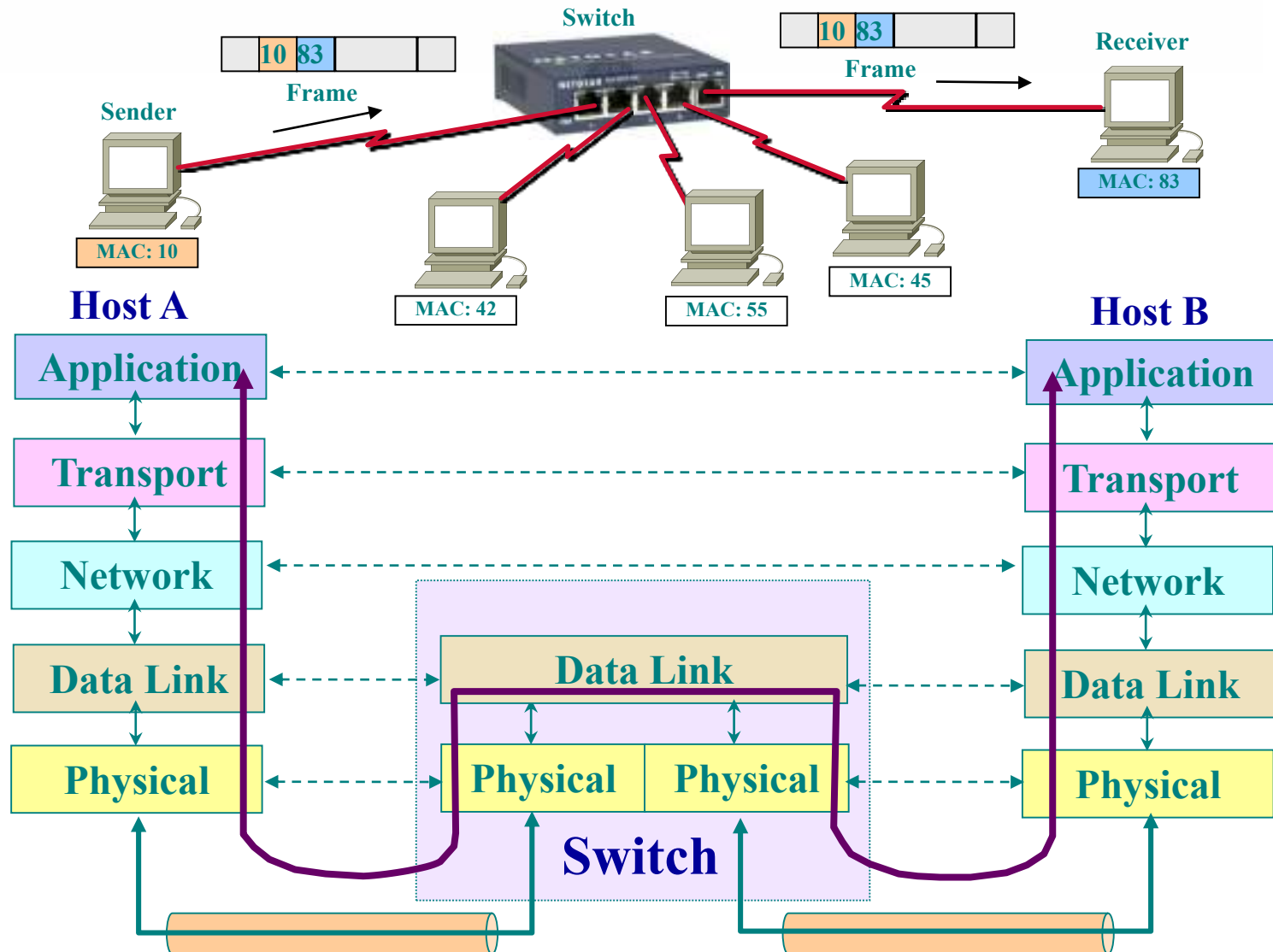
TCP/IP Reference Model



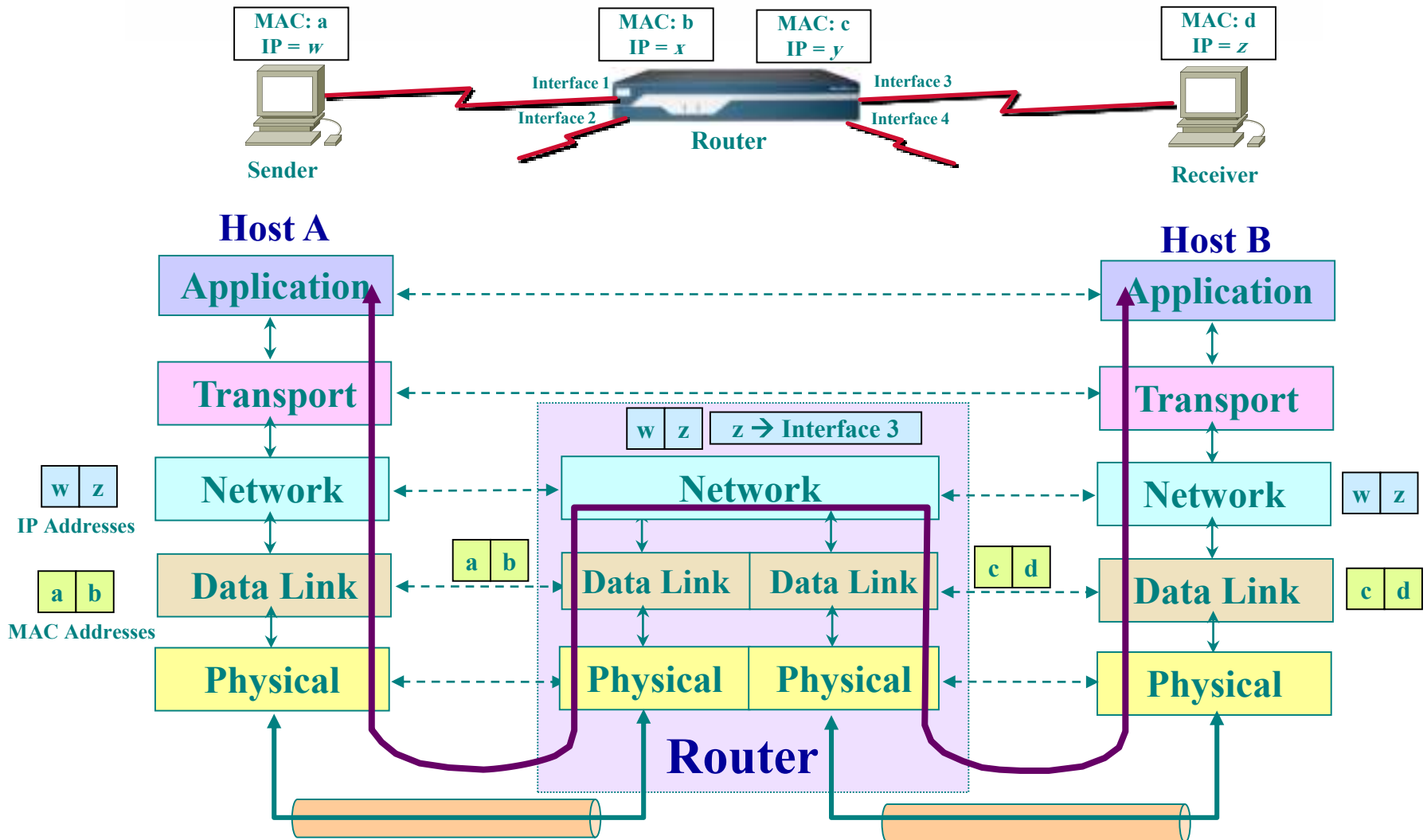
TCP/IP Reference Model



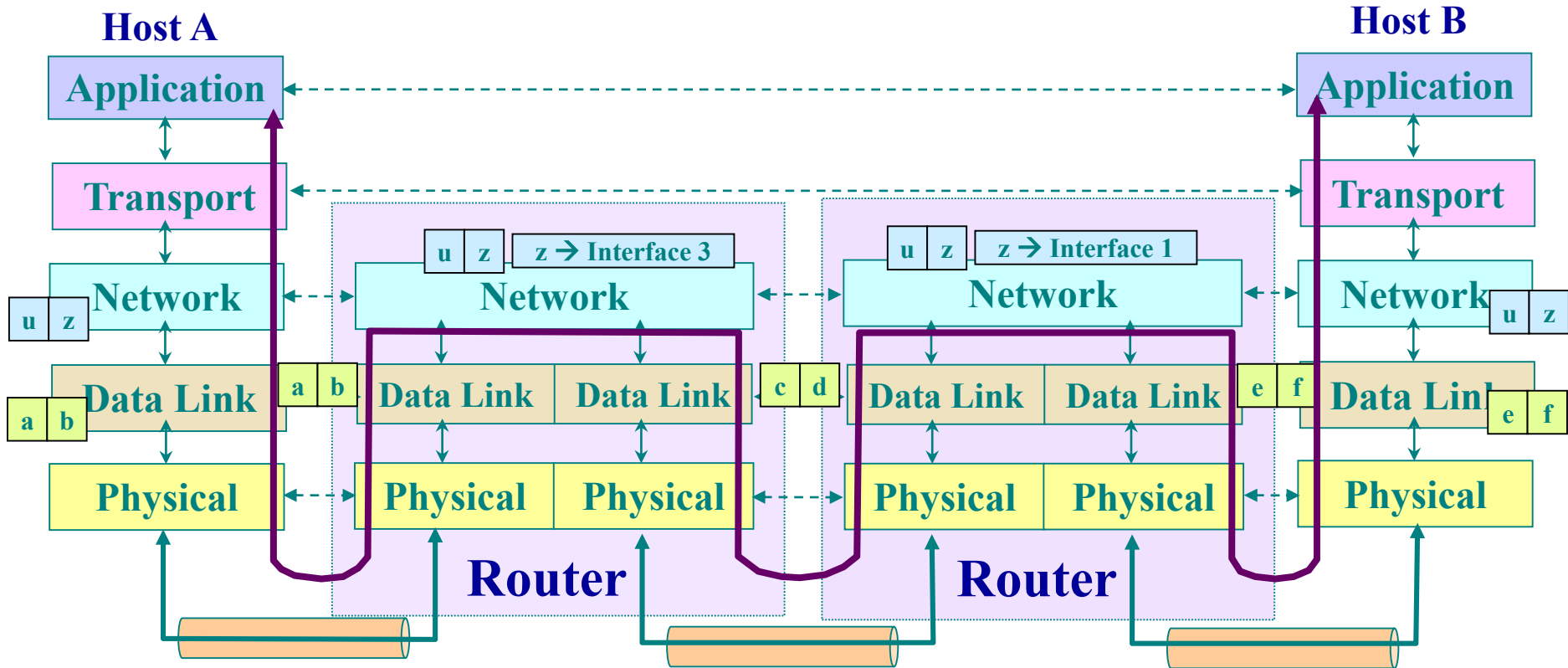
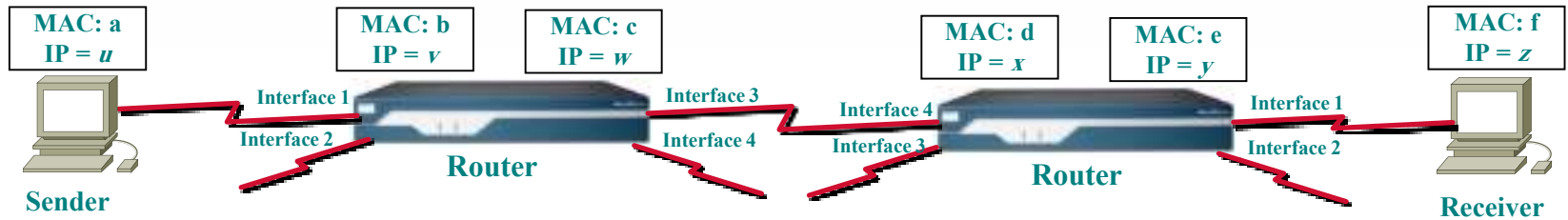
TCP/IP Reference Model



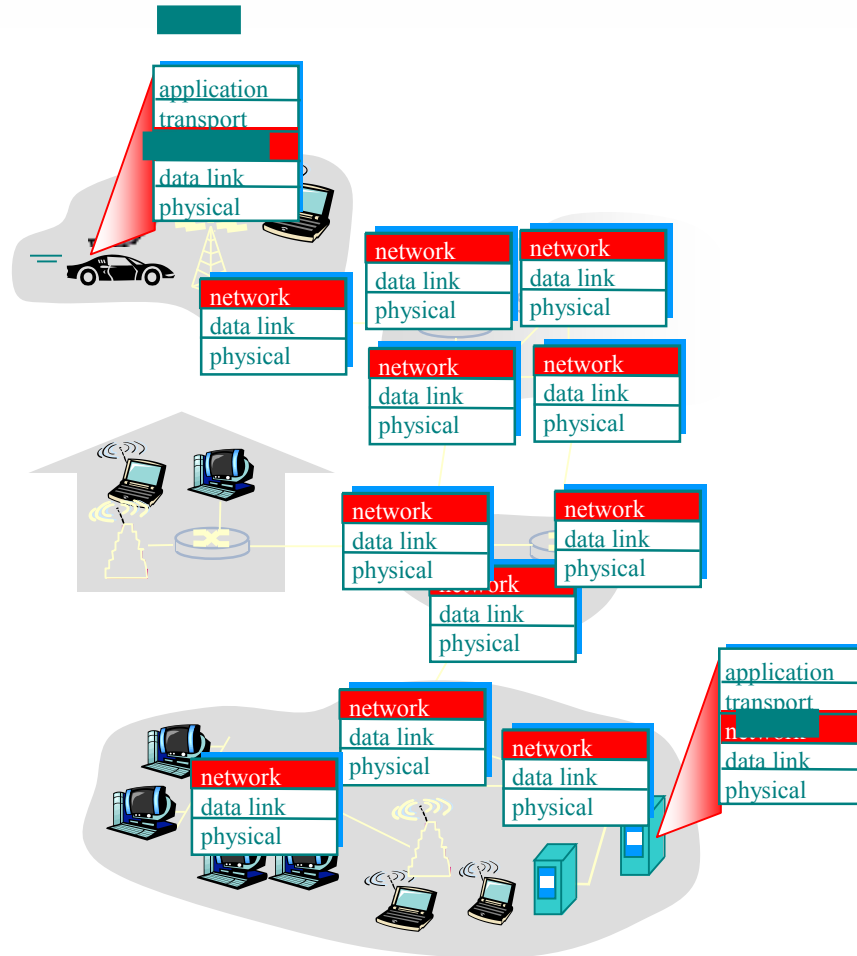
TCP/IP Reference Model



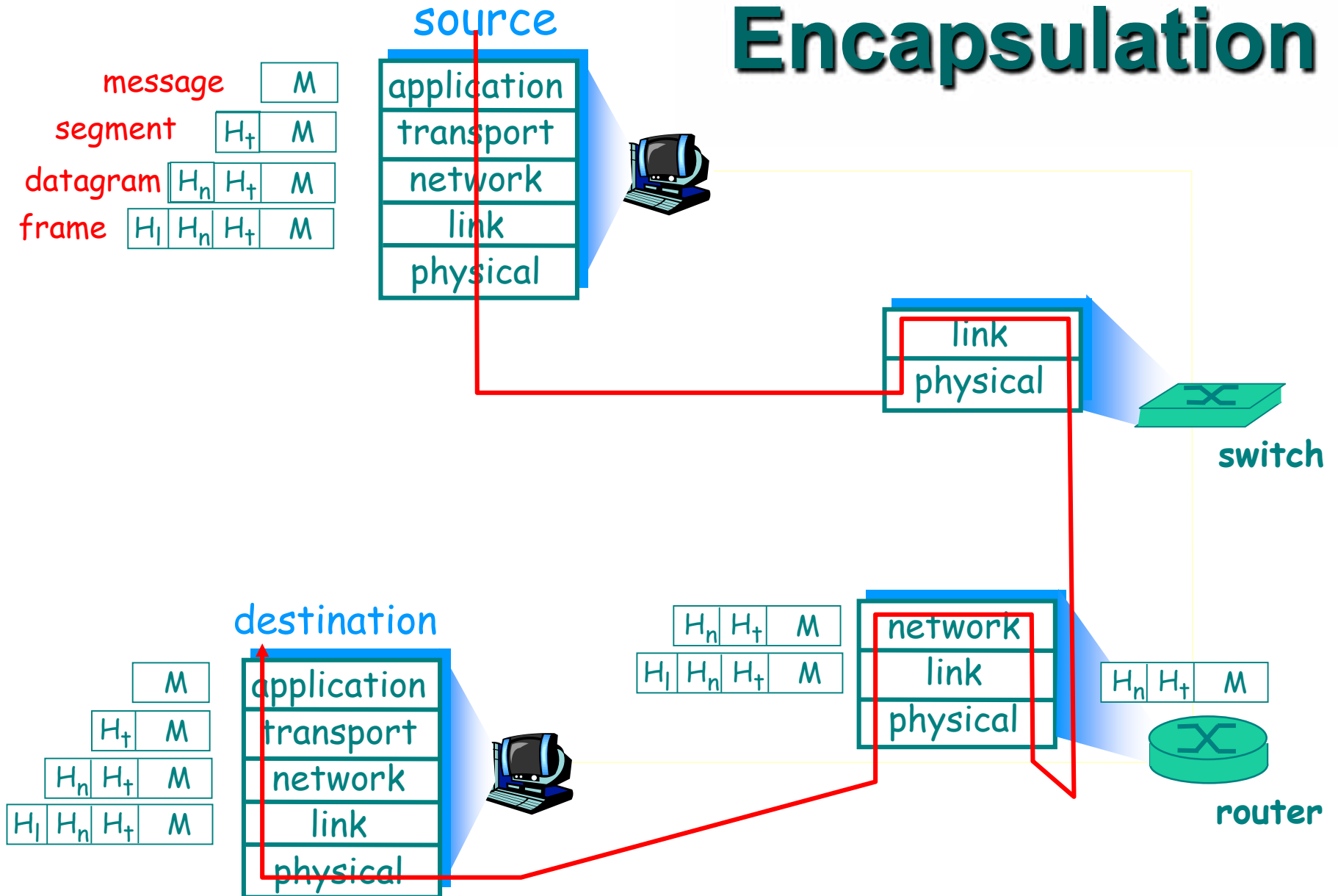
TCP/IP Reference Model



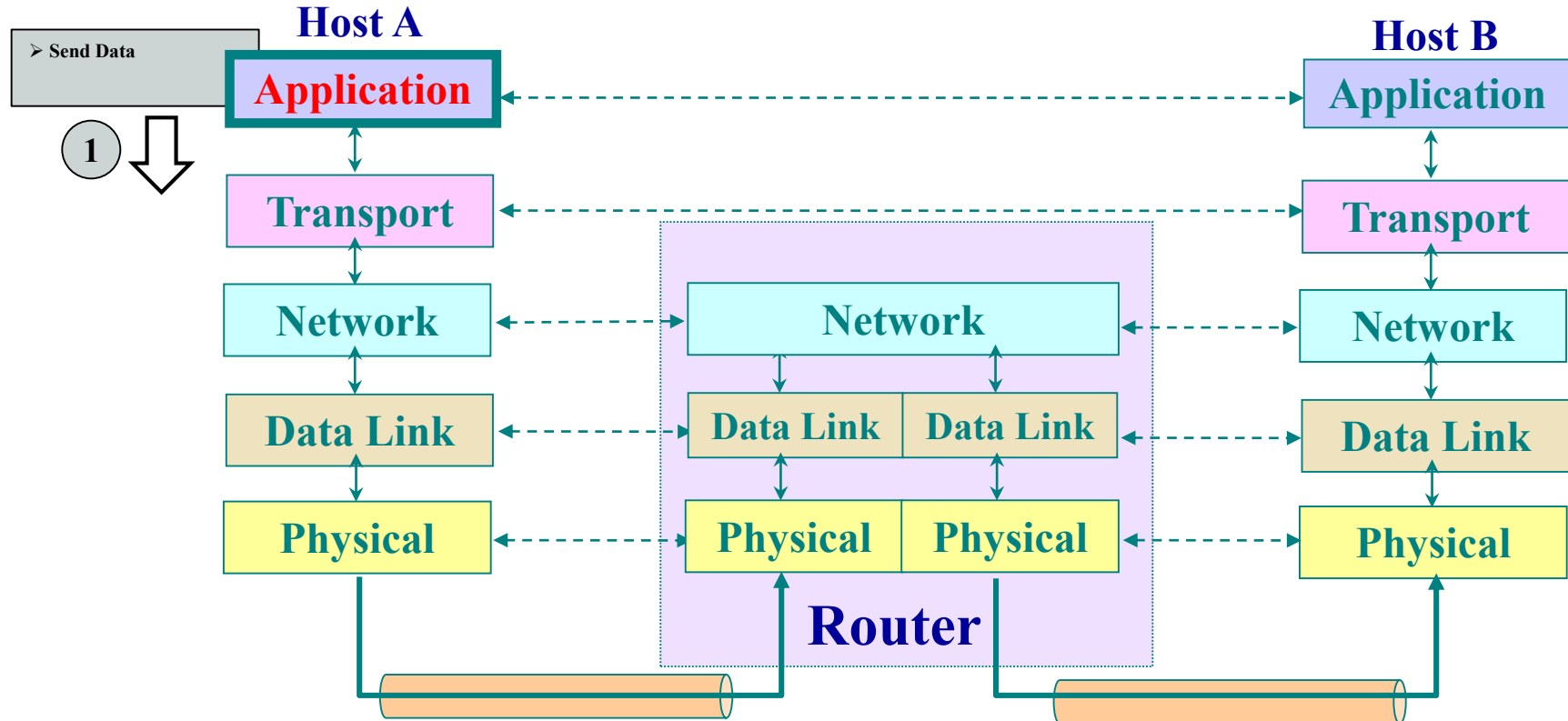
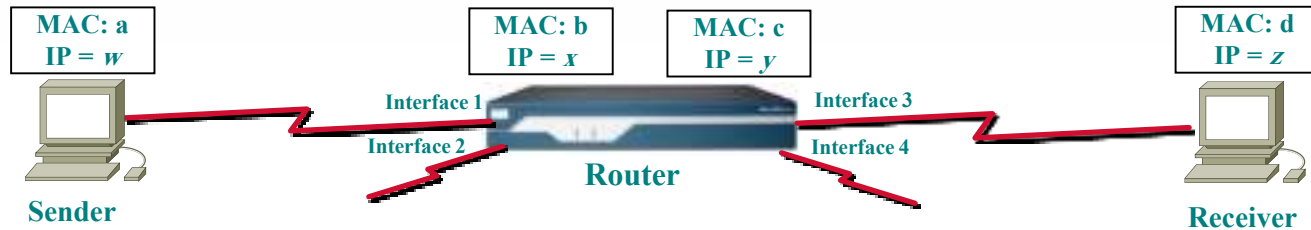
TCP/IP Reference Model



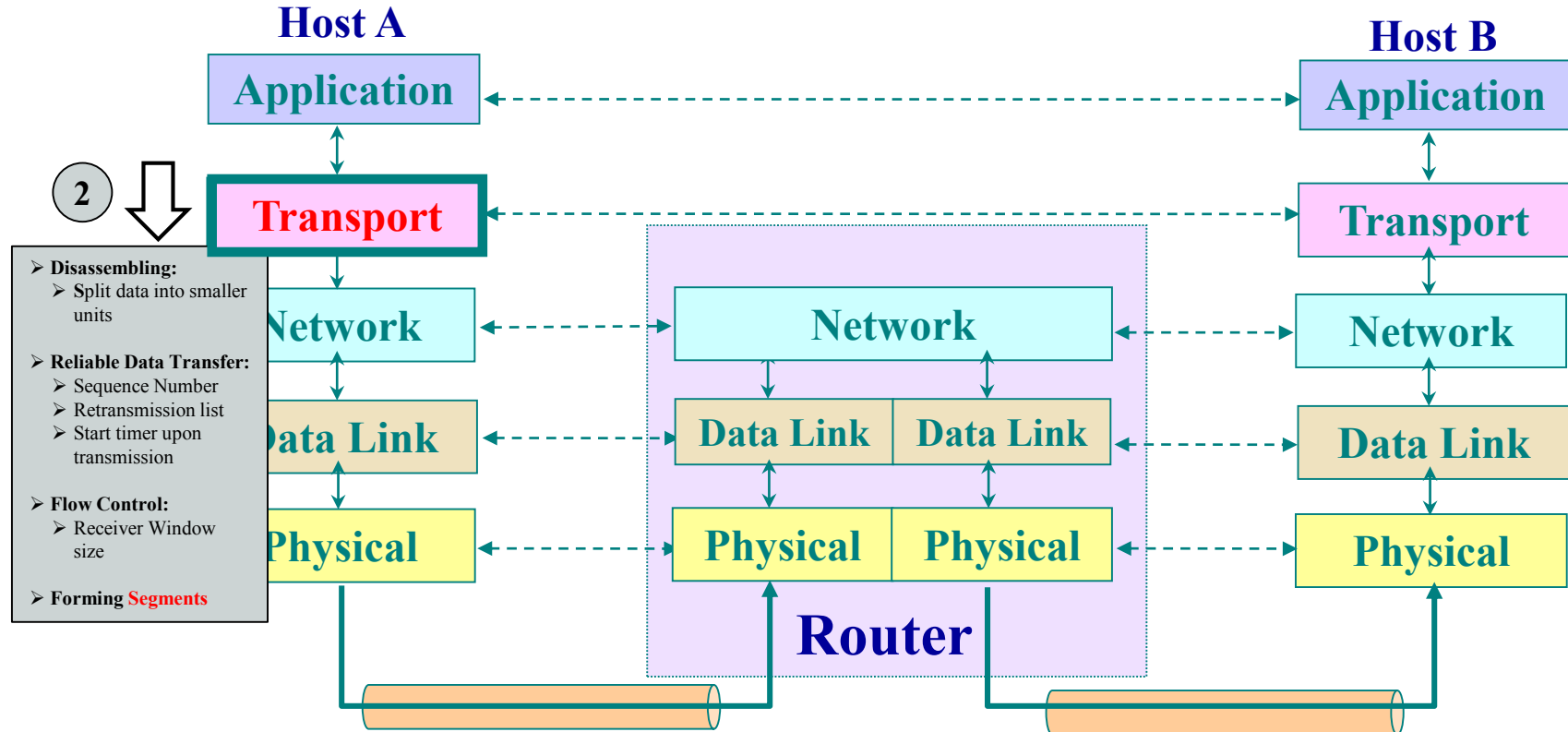
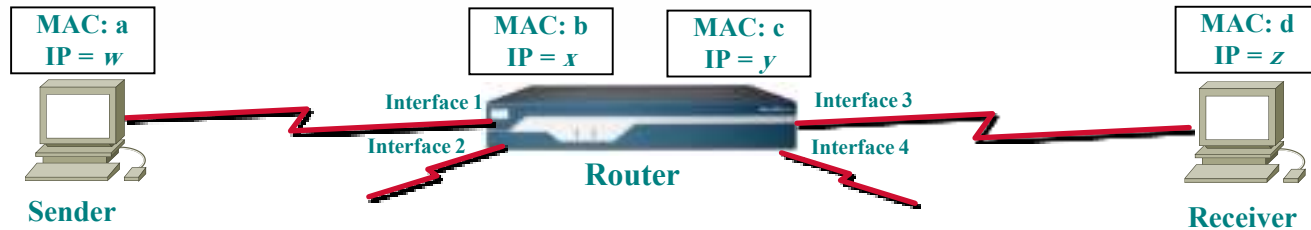
Encapsulation



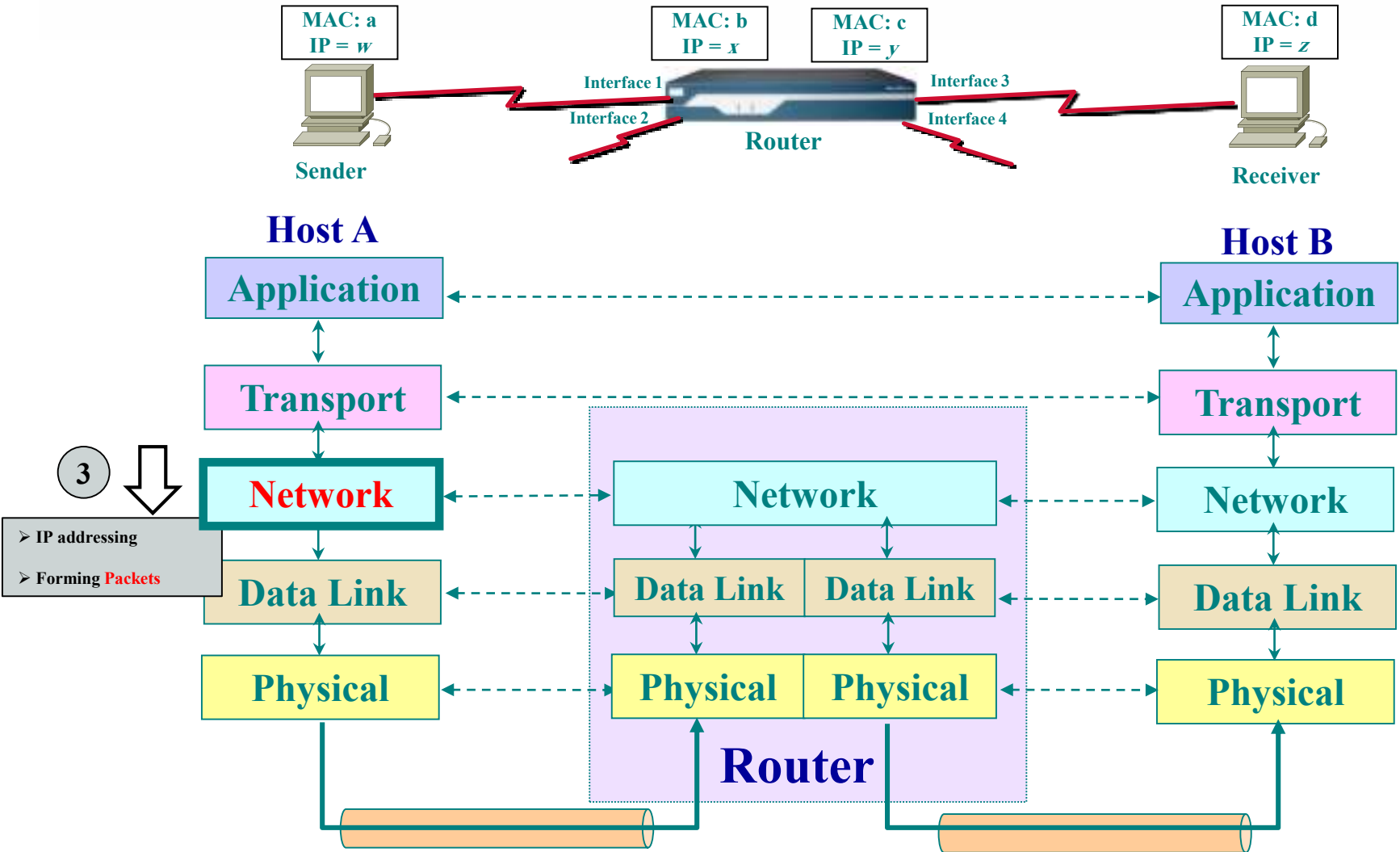
Example of Data Transmission



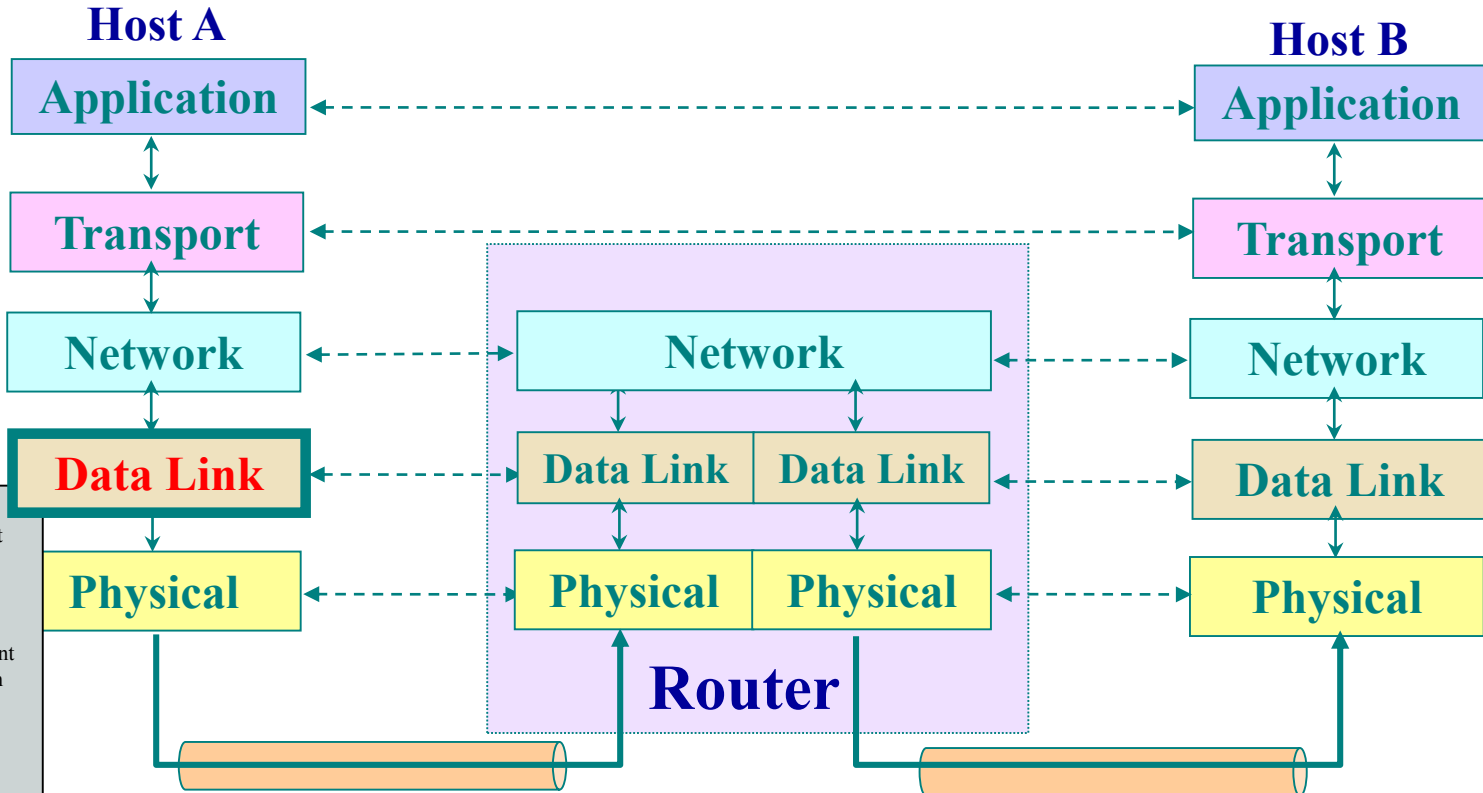
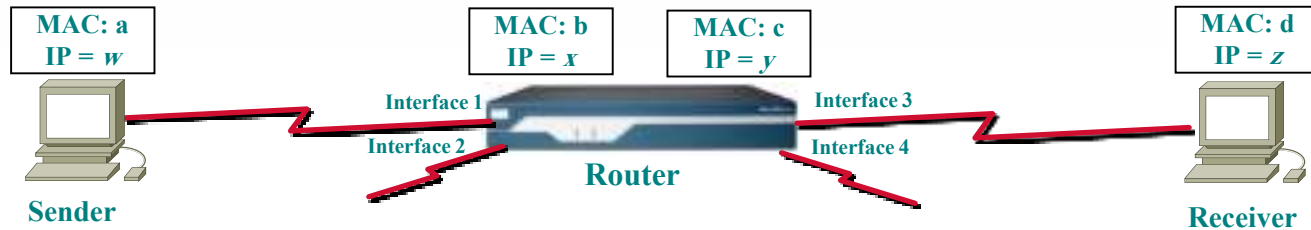
Example of Data Transmission



Example of Data Transmission



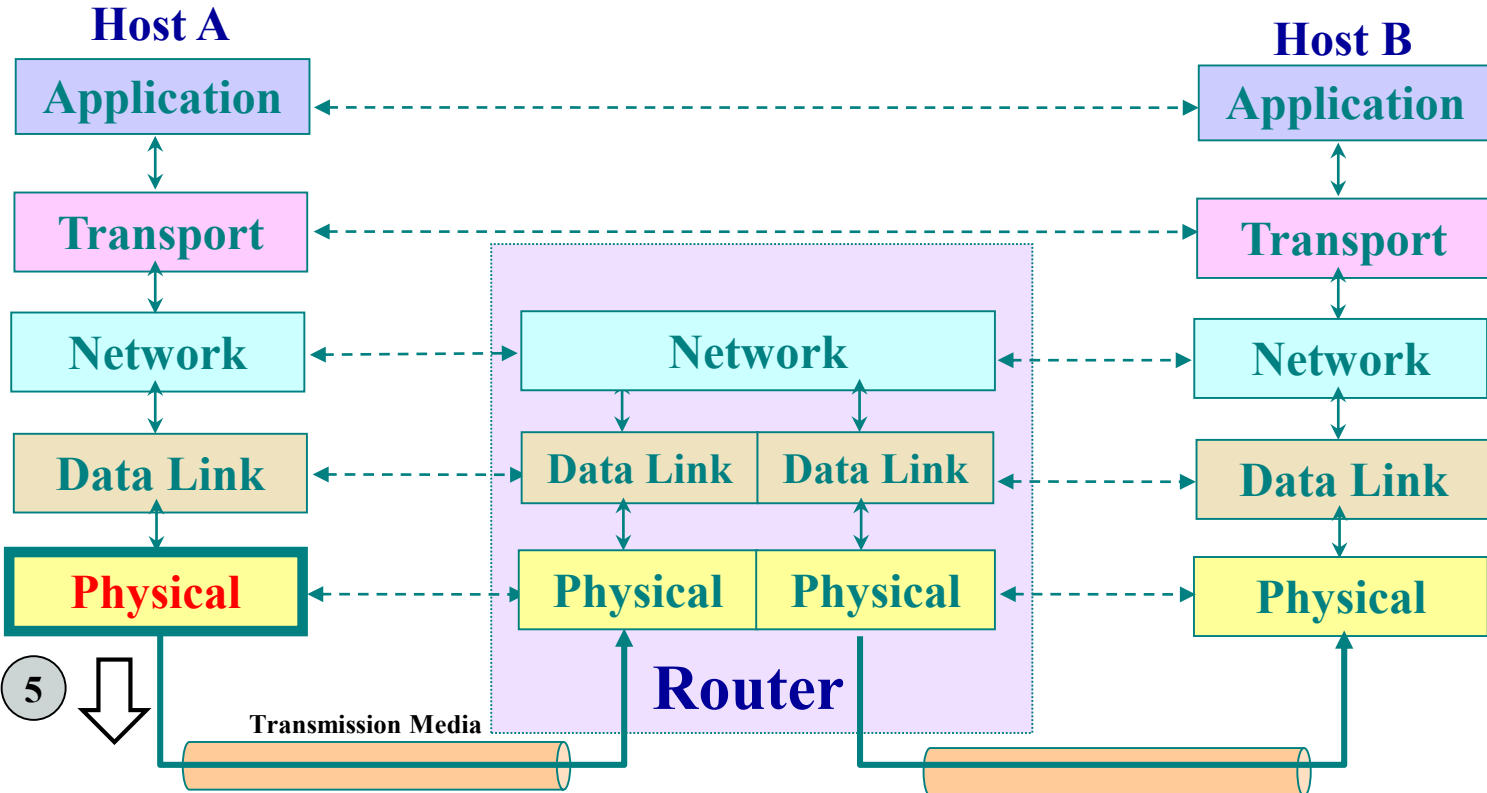
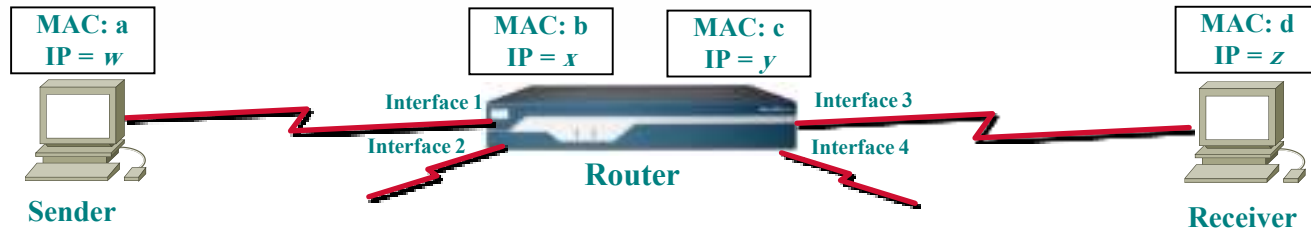
Example of Data Transmission



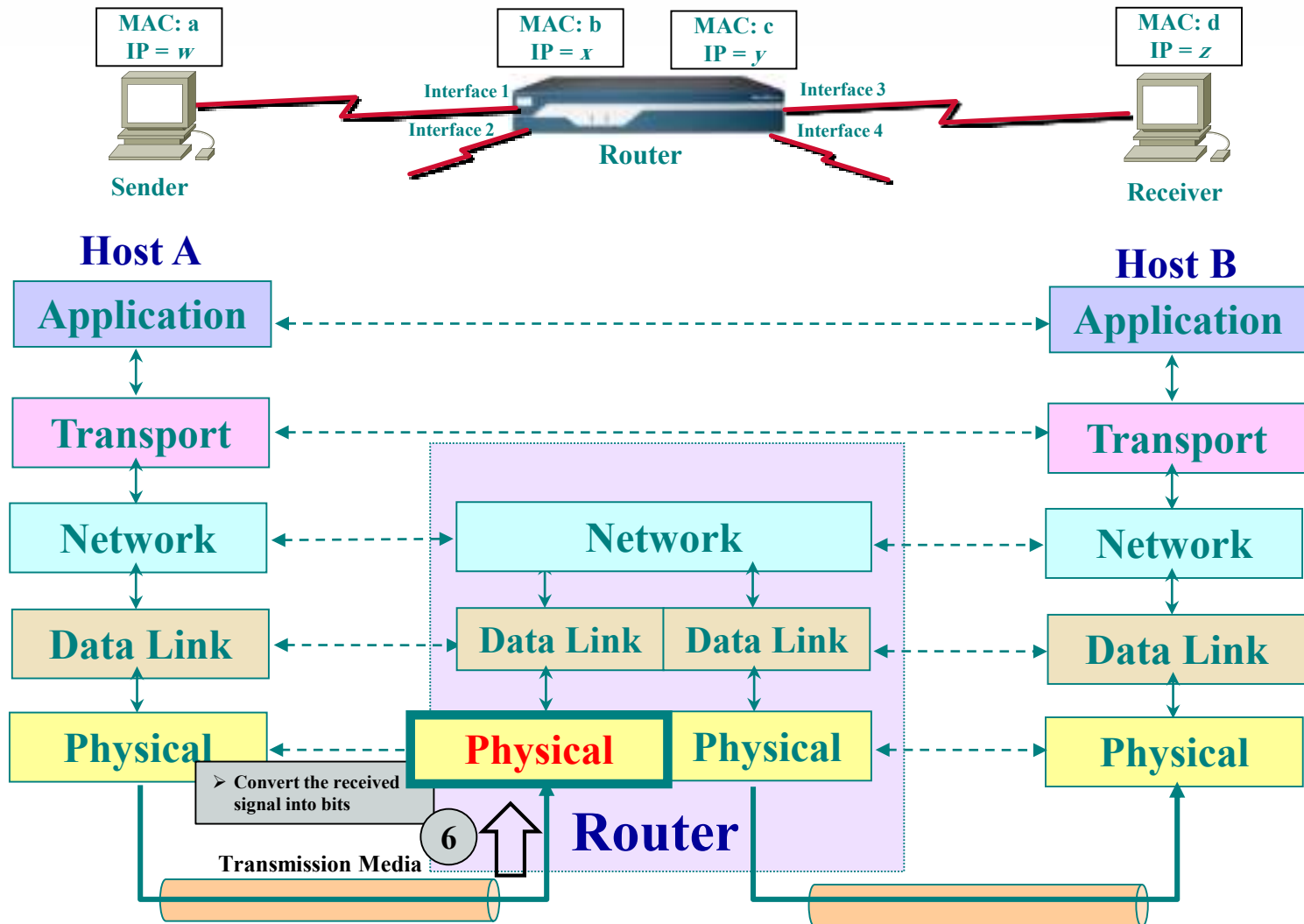
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- **Forming Frames**
- Encapsulate Packet into frame, adding header, trailer
- MAC (Physical) Addressing for point to point connection
- Computing checksum for error detection

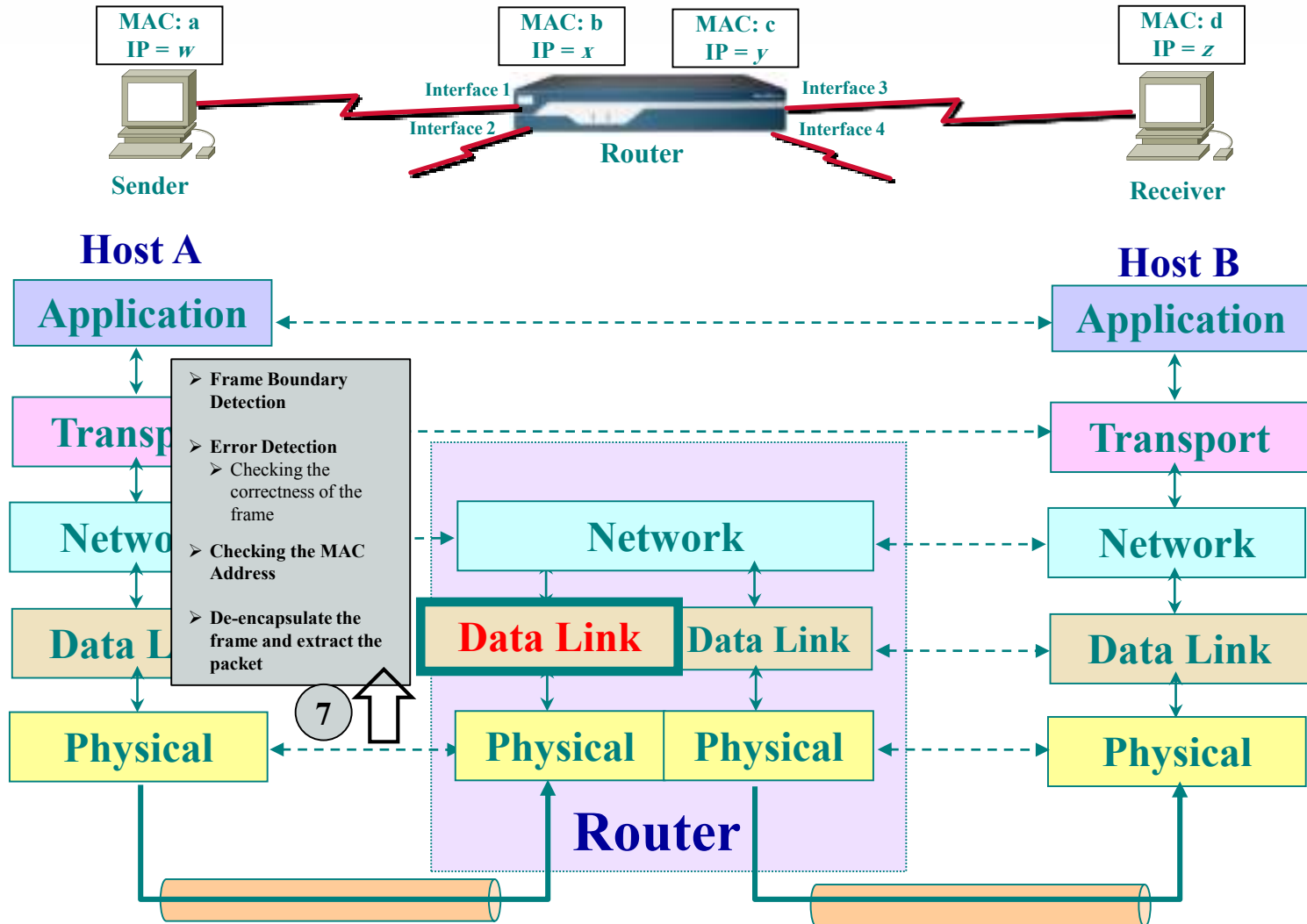
Example of Data Transmission



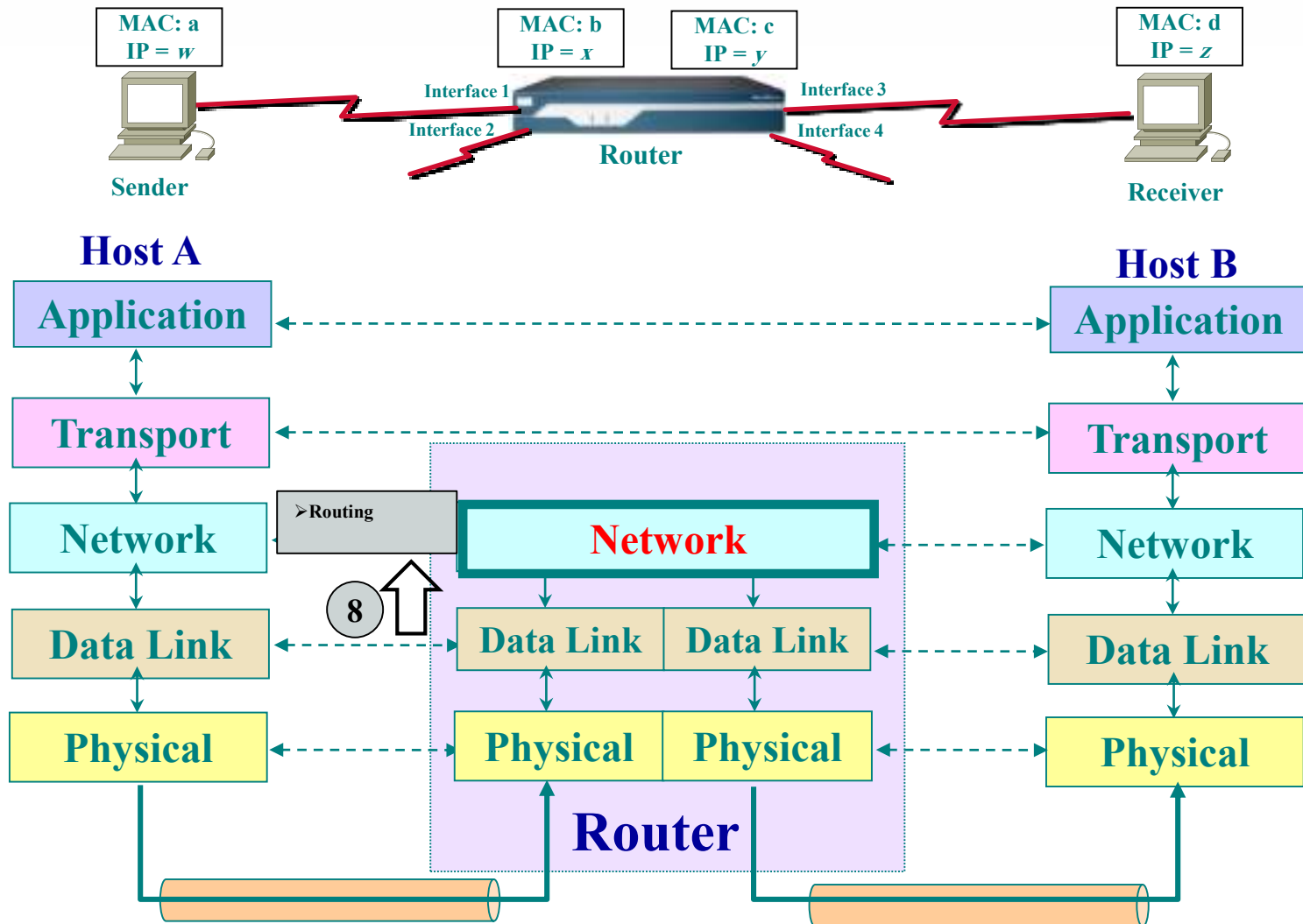
Example of Data Transmission



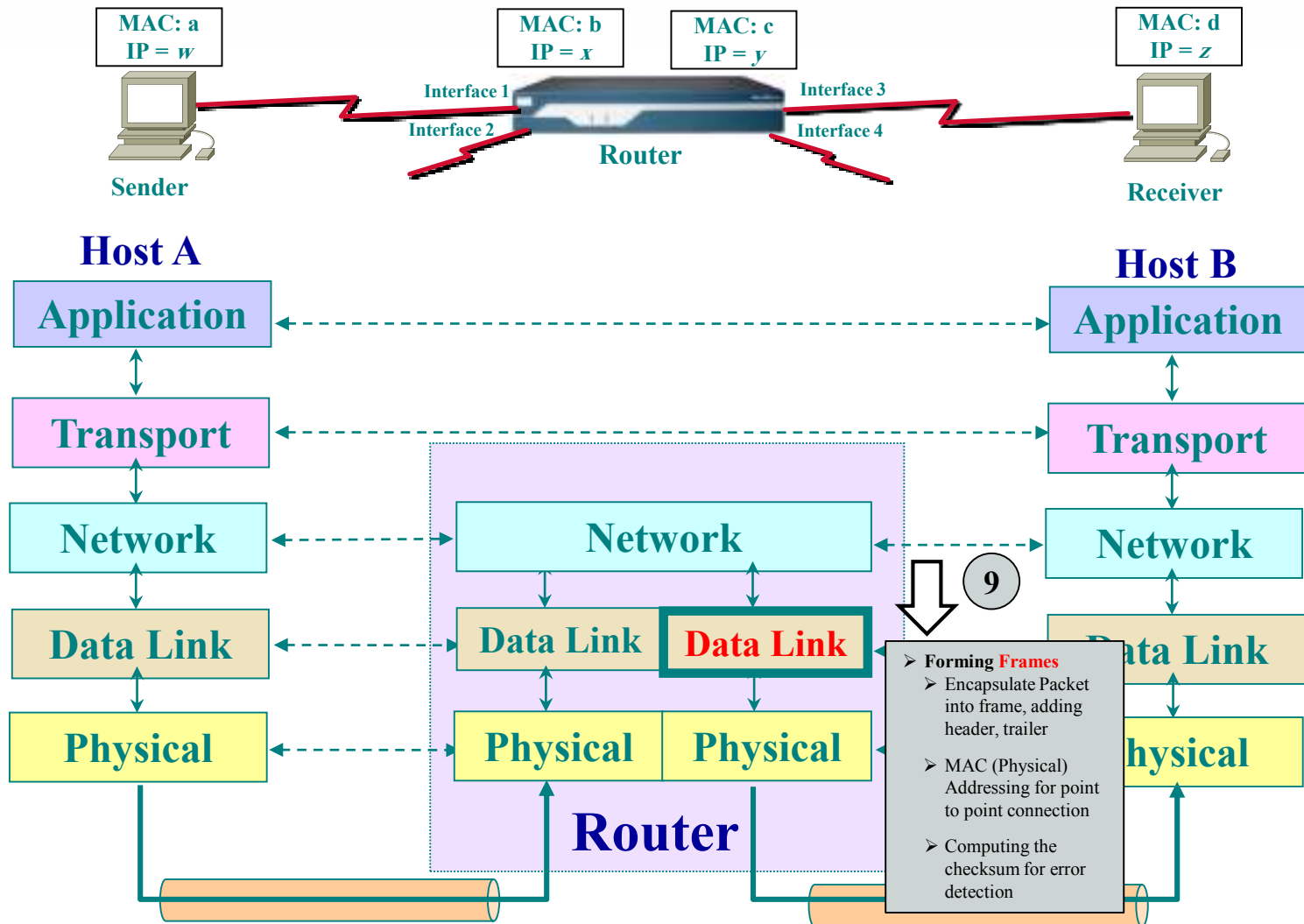
Example of Data Transmission



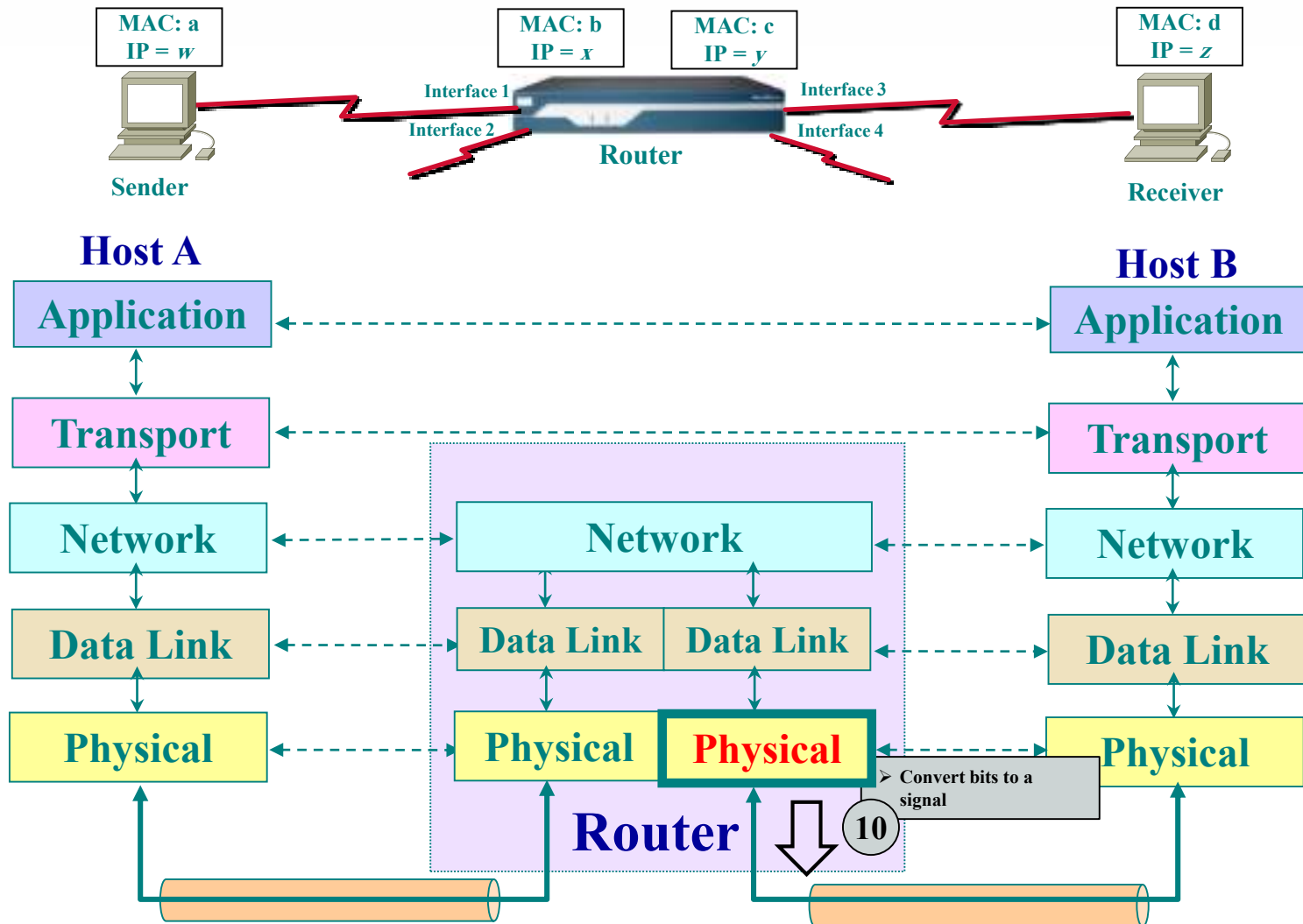
Example of Data Transmission



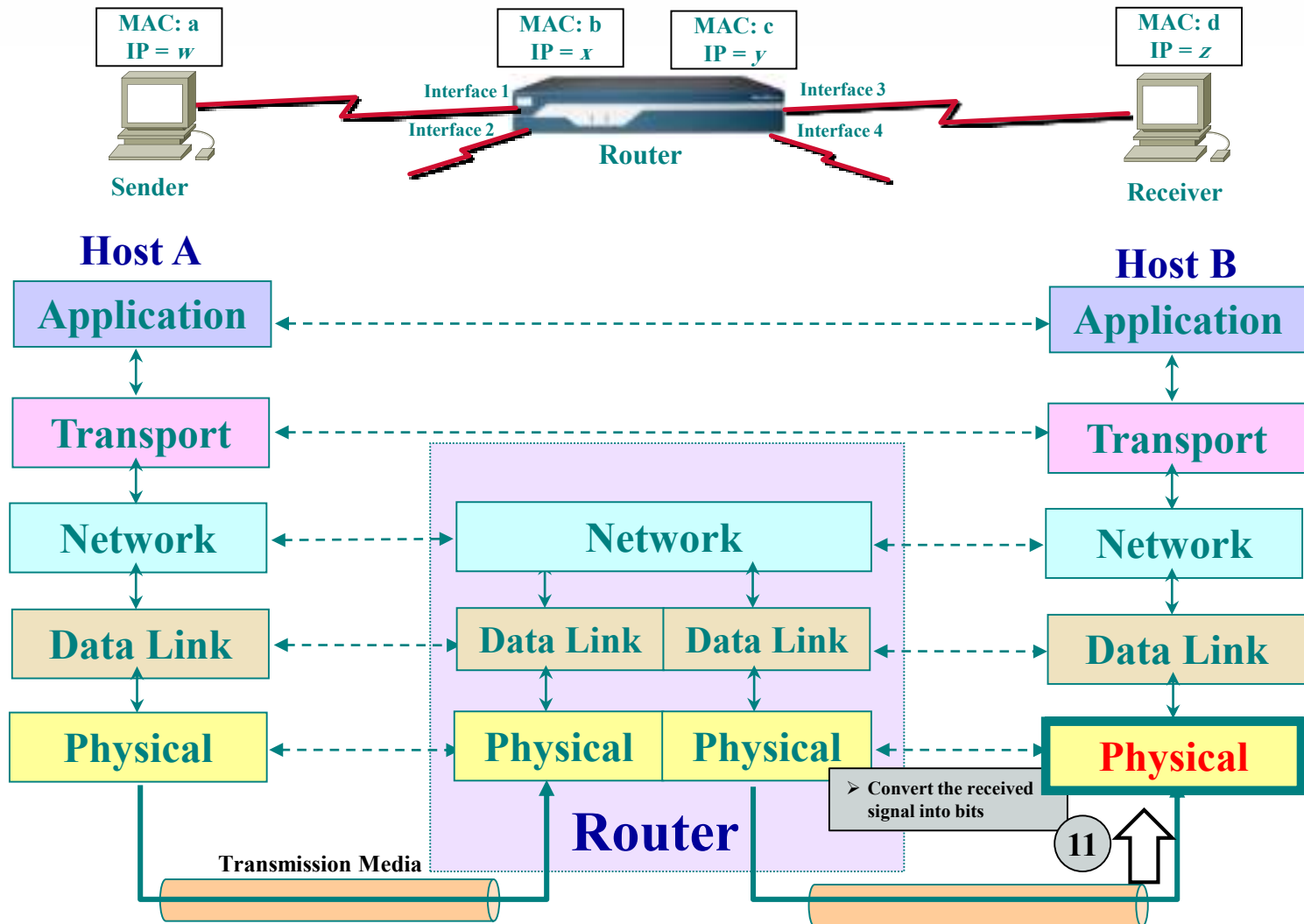
Example of Data Transmission



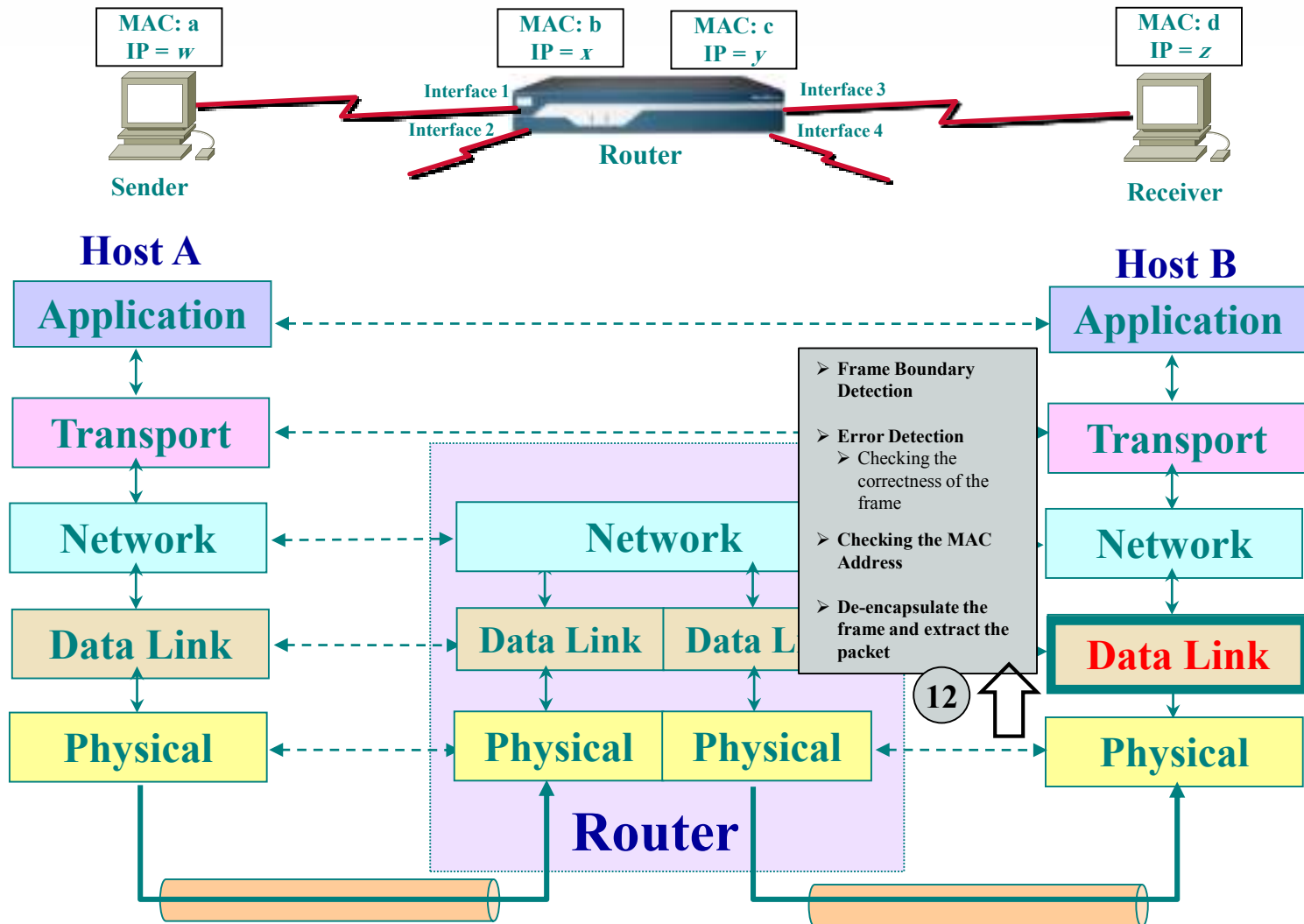
Example of Data Transmission



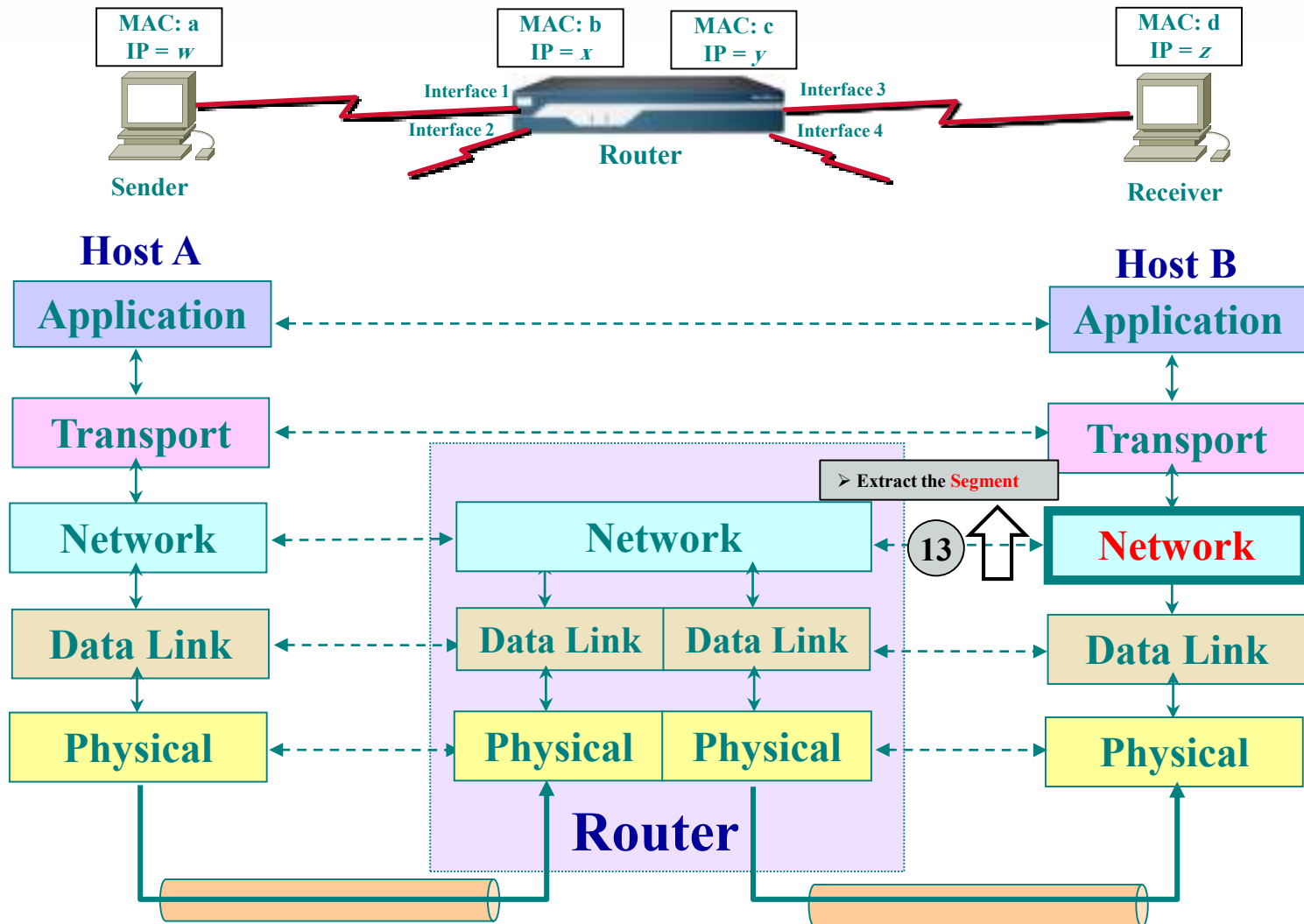
Example of Data Transmission



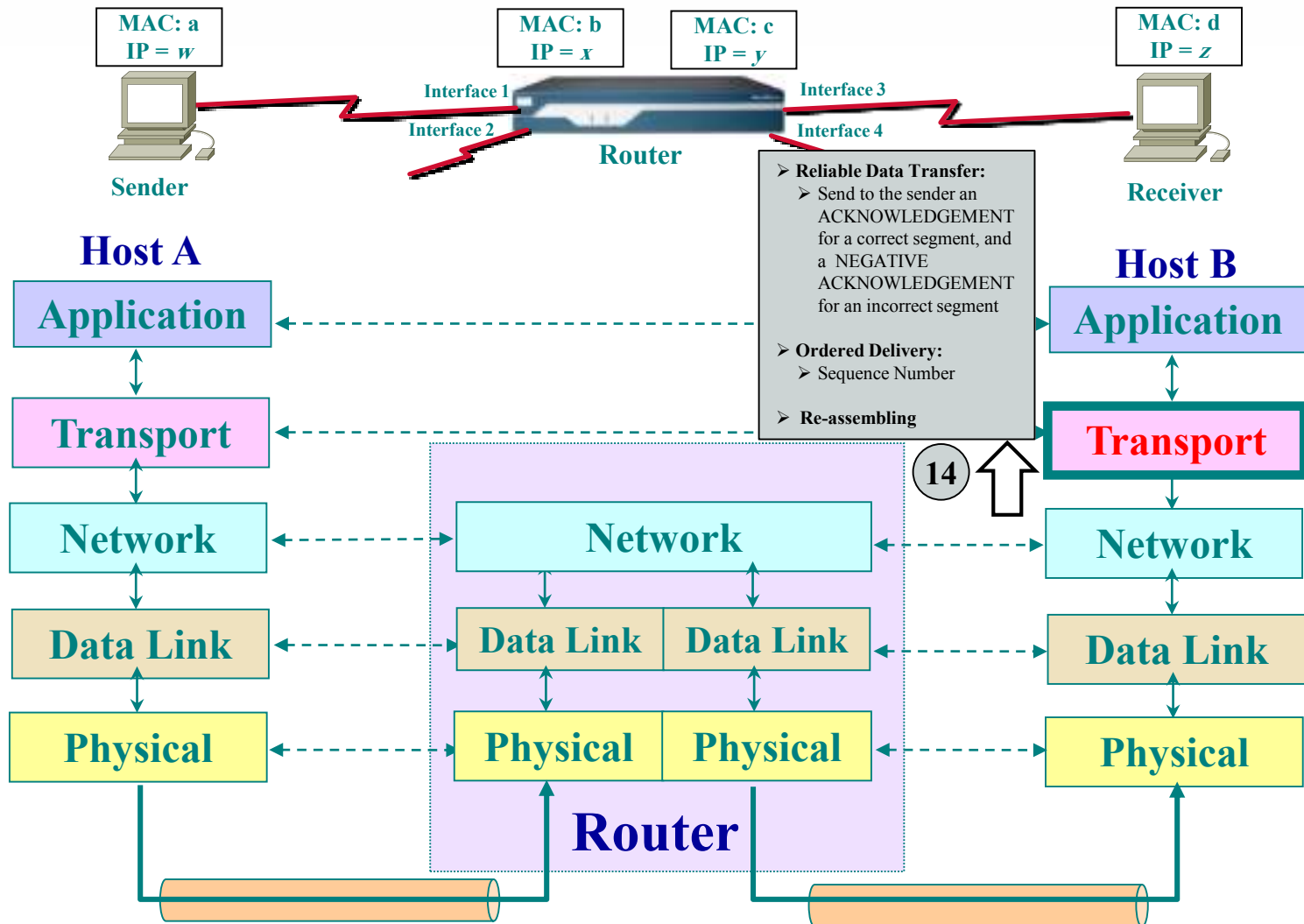
Example of Data Transmission



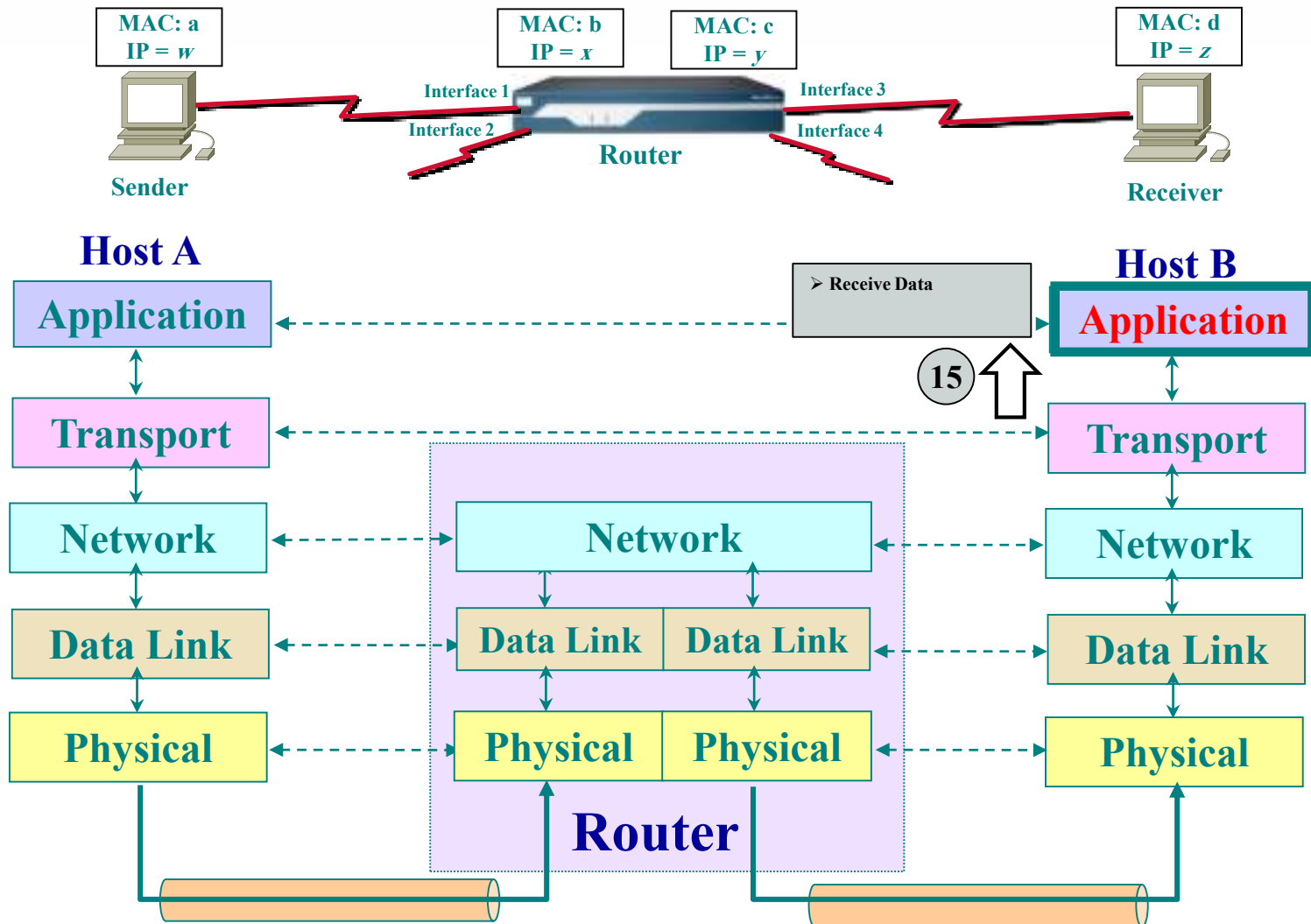
Example of Data Transmission



Example of Data Transmission



Example of Data Transmission

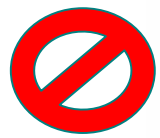


TCP/IP Layers

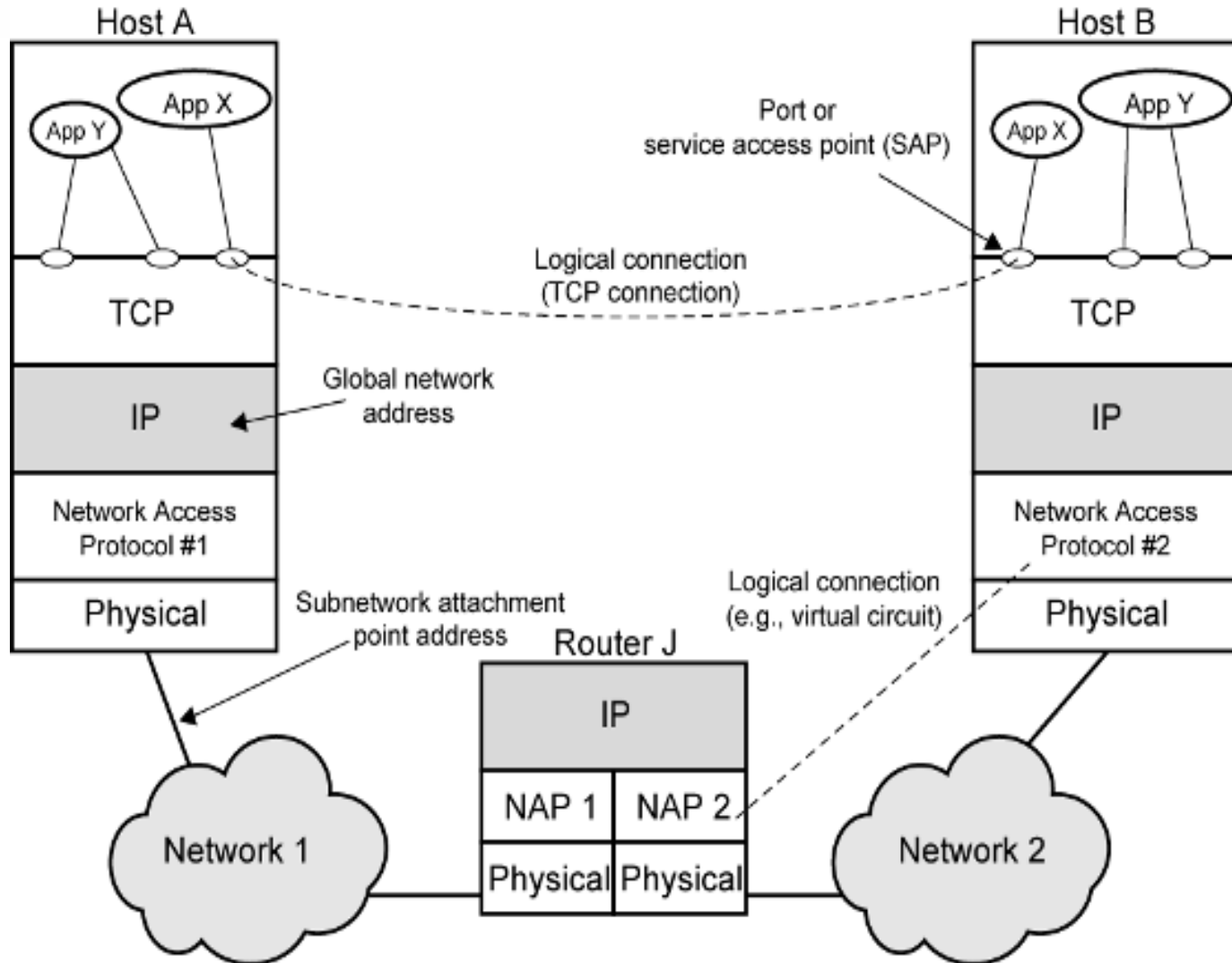
- Application layer
- Transport layer
- Internet layer
- Network access layer
- Physical layer

Addressing Requirements

- **two levels** of addressing required
- each host on a subnet needs a unique global network address
 - its **IP address**
- each application on a (multi-tasking) host needs a unique address within the host
 - known as a **port**



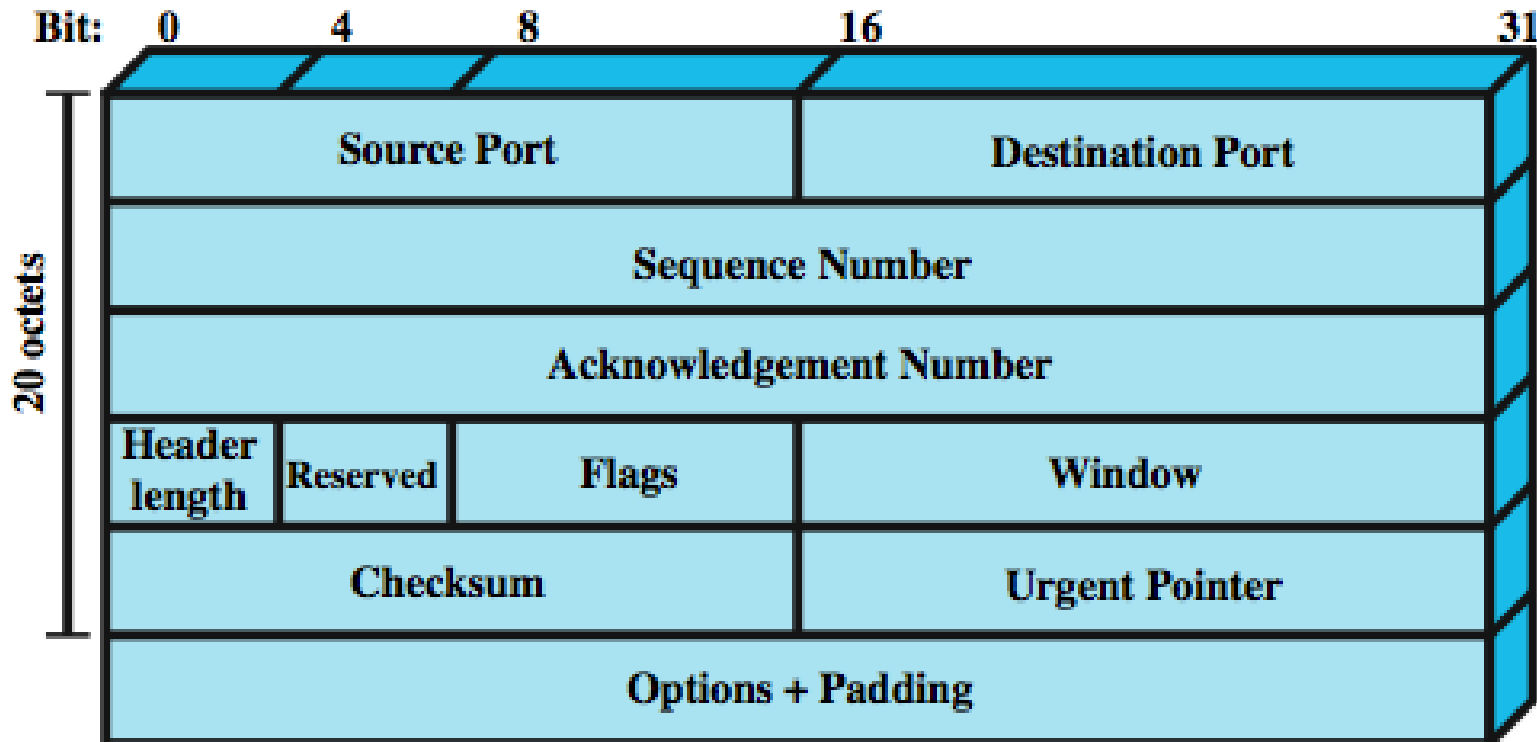
Operation of TCP and IP



Transmission Control Protocol (TCP)

- usual transport layer is (TCP)
- provides a **reliable connection** for transfer of data between applications
- a **TCP segment** is the basic protocol unit
- **TCP tracks segments between entities for duration of each connection**

TCP Header

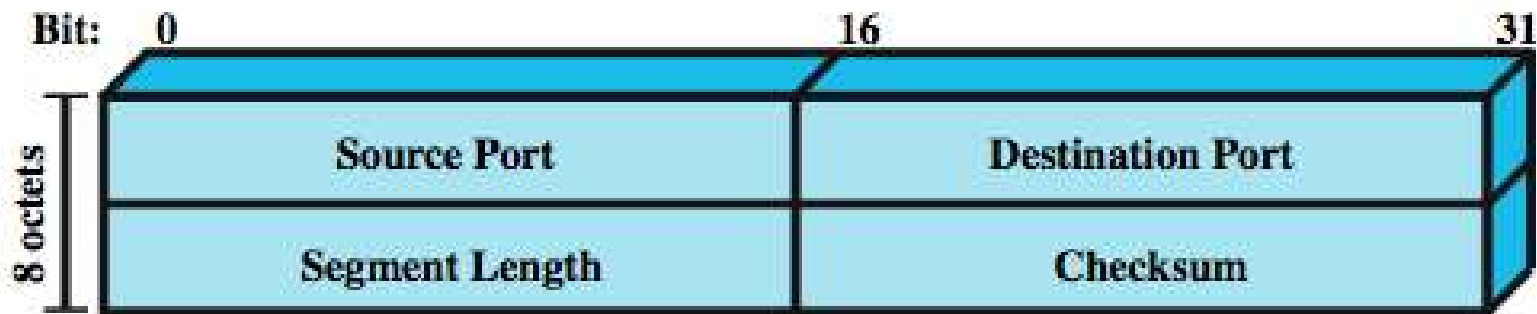


(a) TCP Header

User Datagram Protocol (UDP)

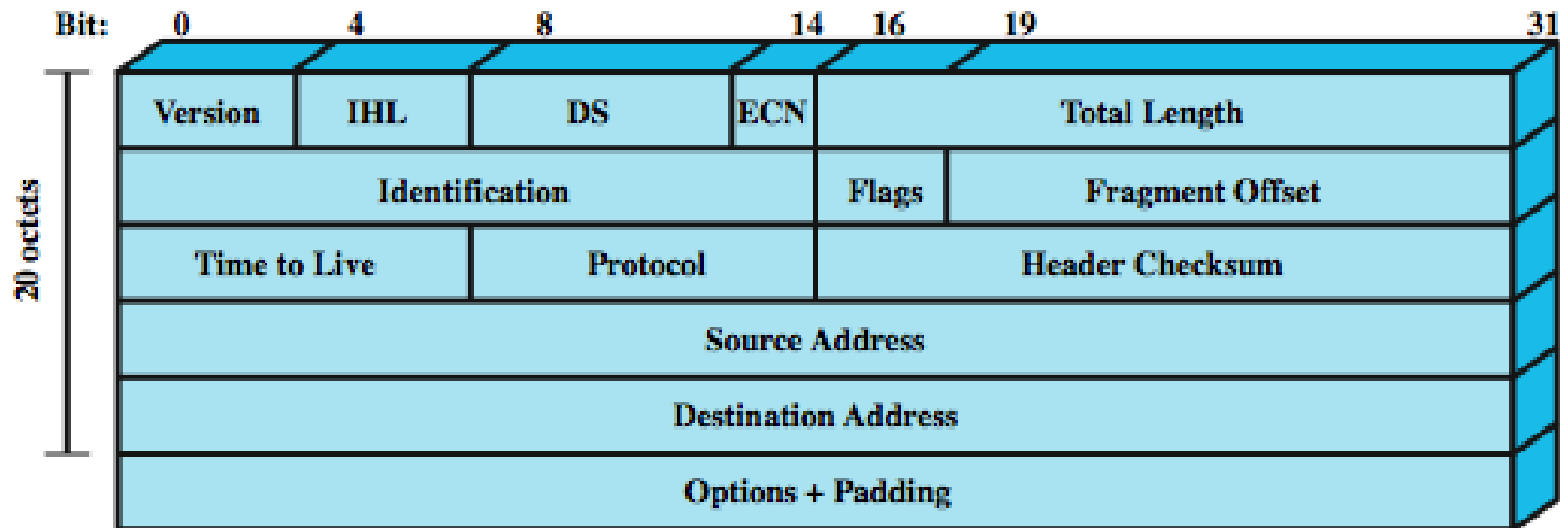
- an alternative to TCP
- no guaranteed delivery
- no preservation of sequence
- no protection against duplication
- minimum overhead

UDP Header



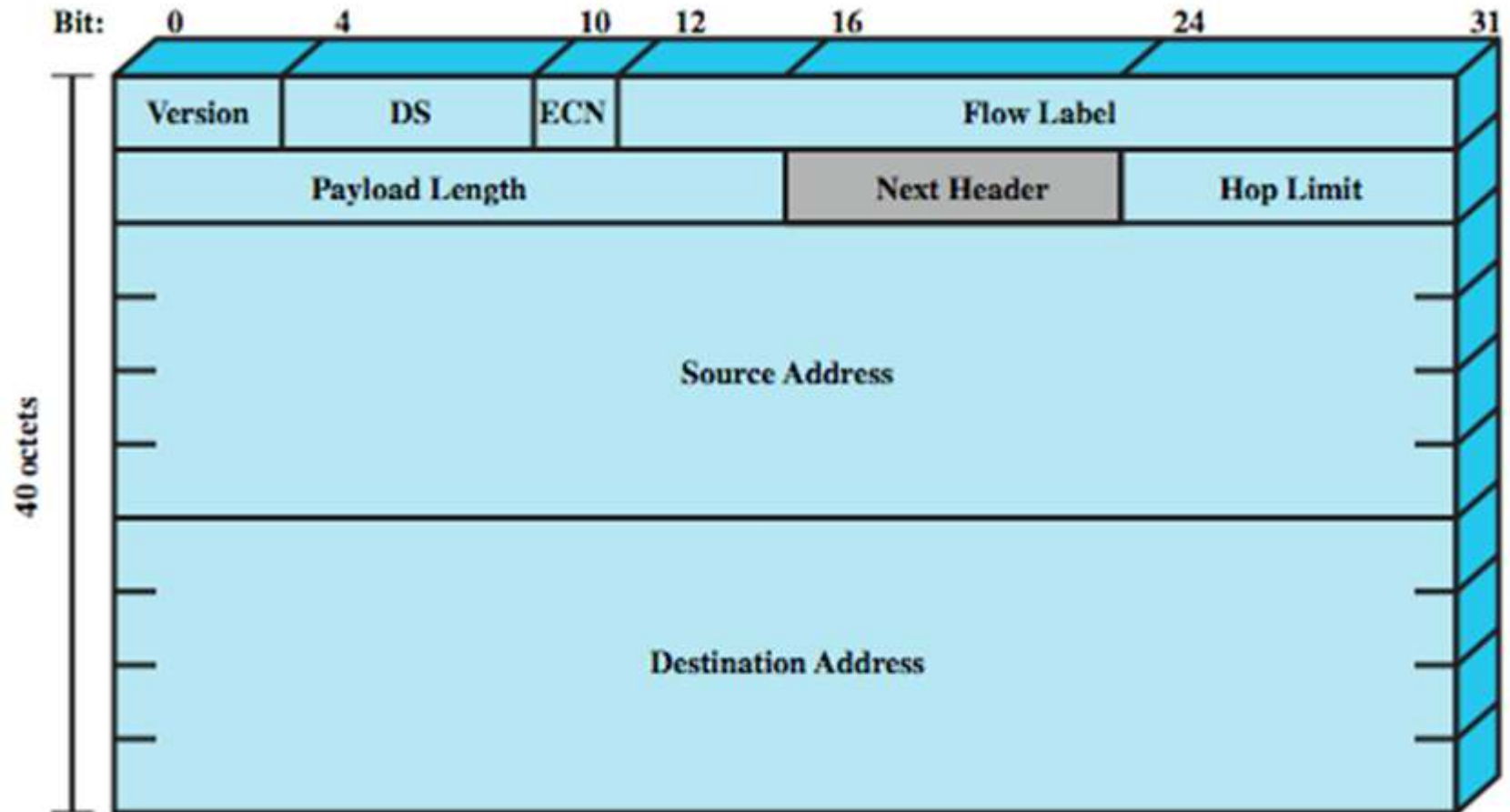
(b) UDP Header

IP Header



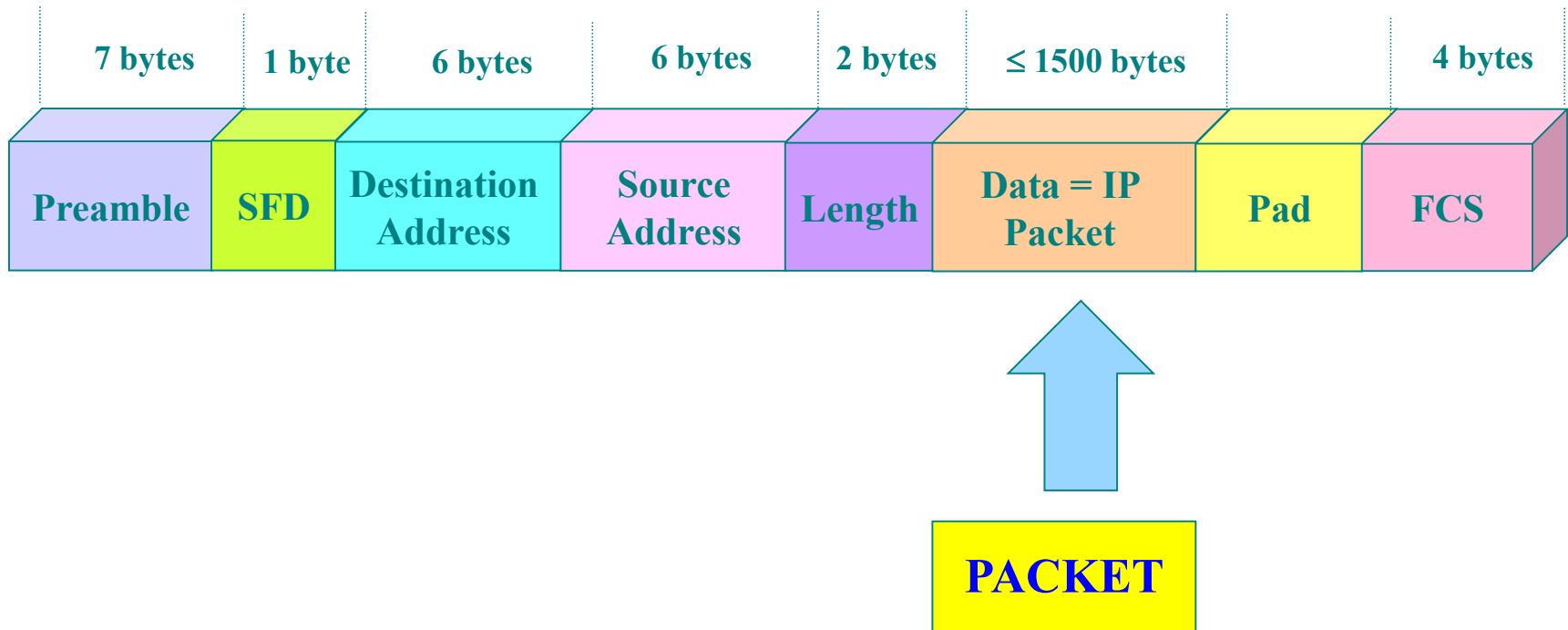
(a) IPv4 Header

IPv6 Header



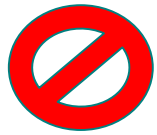
(b) IPv6 Header

Ethernet Frame

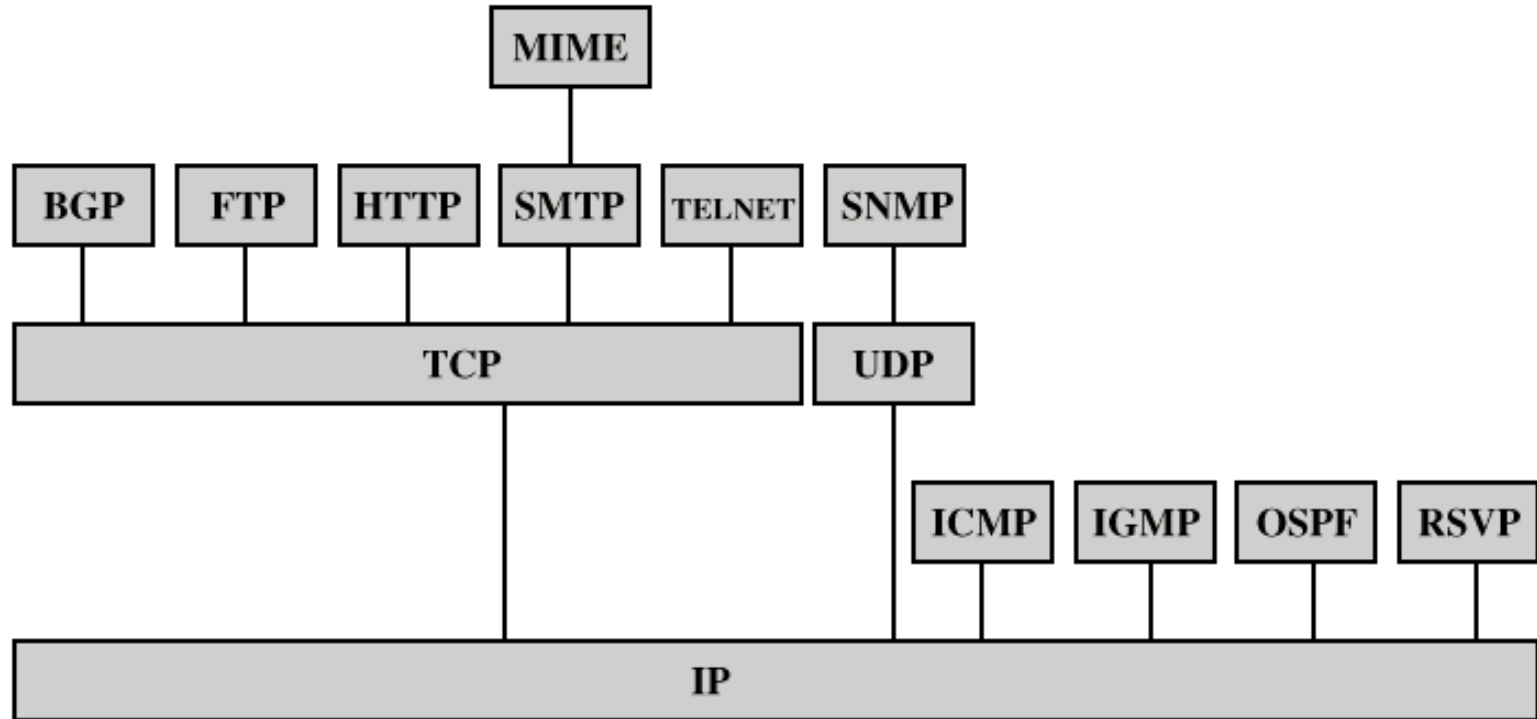
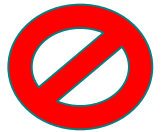


TCP/IP Applications

- have a number of standard TCP/IP applications such as
 - Simple Mail Transfer Protocol (**SMTP**)
 - File Transfer Protocol (**FTP**) – control and data connections
 - **Telnet**
 - **HTTP**



Some TCP/IP Protocols



BGP = Border Gateway Protocol
FTP = File Transfer Protocol
HTTP = Hypertext Transfer Protocol
ICMP = Internet Control Message Protocol
IGMP = Internet Group Management Protocol
IP = Internet Protocol
MIME = Multi-Purpose Internet Mail Extension

OSPF = Open Shortest Path First
RSVP = Resource ReSerVation Protocol
SMTP = Simple Mail Transfer Protocol
SNMP = Simple Network Management Protocol
TCP = Transmission Control Protocol
UDP = User Datagram Protocol

Traditional vs Multimedia Applications

- traditionally Internet dominated by info retrieval applications
 - typically using text and image transfer
 - E.g. email, file transfer, web
- see increasing growth in multimedia applications
 - involving massive amounts of data
 - such as streaming audio and video

Elastic and Inelastic Traffic

➤ elastic traffic

- can adjust to delay & throughput changes over a wide range
- E.g. traditional “data” style TCP/IP traffic
- some applications more sensitive though

➤ inelastic traffic

- does not adapt to such changes
- E.g. “real-time” voice & video traffic
- need minimum requirements on net arch

Summary

- introduced need for protocol architecture
- OSI Model & protocol architecture standardization
- TCP/IP protocol architecture
- traditional vs multimedia application needs