Data Communication and Computer Network
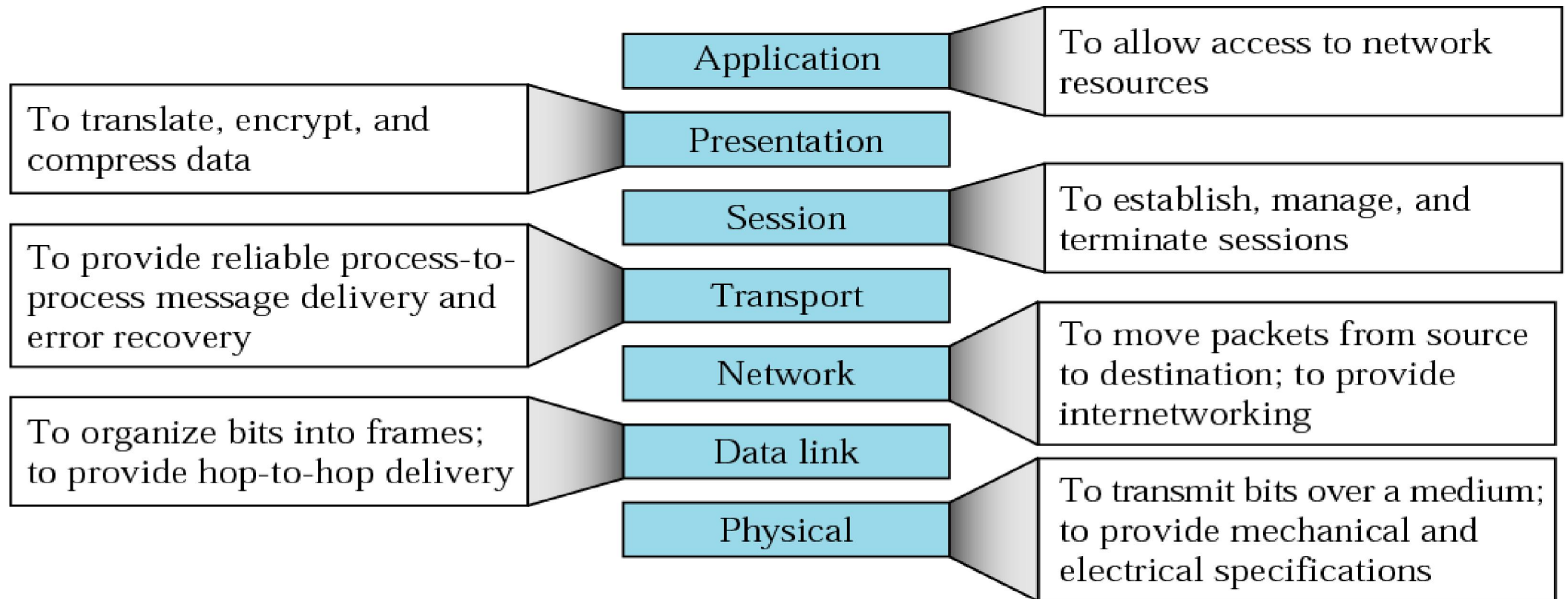
Protocol Architecture & Layering

Protocol Architecture

- ❑ Task of communication broken up into modules or layers
- ❑ Each layer has specific responsibilities

- ❑ Reason for layering – if one layer's implementation changed, other layers not affected <u>if interface remains unchanged</u>
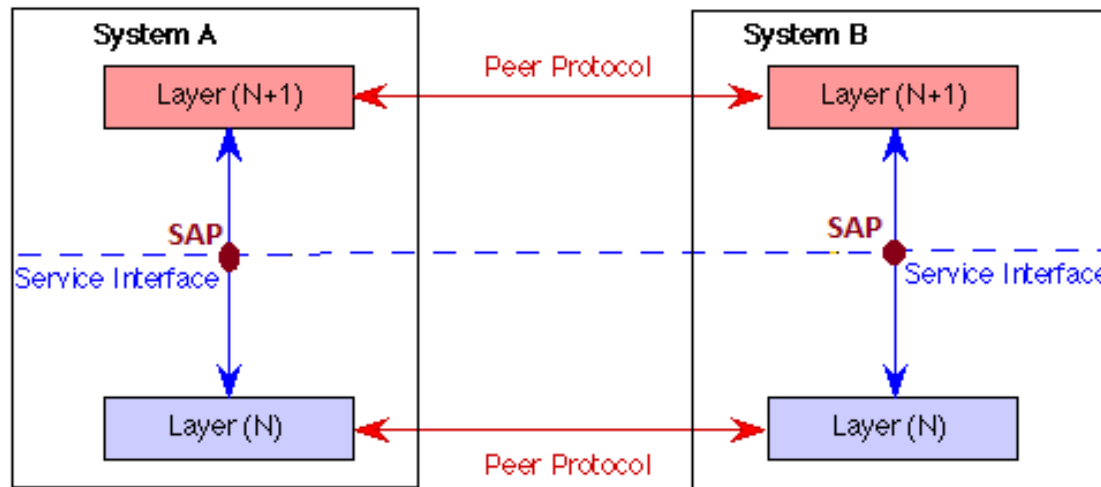
OSI Layers

❑ OSI Layers (Open Systems Interconnection)

❑ Developed by International Organization for Standardization (ISO)

❑ Seven Layers (depending on the complexity of the functionality each of these layers provide.)

  ✓ Application
  ✓ Presentation
  ✓ Session
  ✓ Transport
  ✓ Network
  ✓ Data Link
  ✓ Physical

OSI Layers in brief

	Layer	
	Application	To allow access to network resources
To translate, encrypt, and compress data	Presentation	
	Session	To establish, manage, and terminate sessions
To provide reliable process-to-process message delivery and error recovery	Transport	
	Network	To move packets from source to destination; to provide internetworking
To organize bits into frames; to provide hop-to-hop delivery	Data link	
	Physical	To transmit bits over a medium; to provide mechanical and electrical specifications

Interface, Protocol & Addressing

❑ Interface between two layers

  ➢ A Service Access Point (SAP) is a conceptual location at which one OSI layer can request the services of another layer

  ➢ Each layer expects some service from lower layer and provides some service to its higher layer

   ✓ e.g. application layer expects reliable communication from transport layer (no errors in frames, no lost frames, etc)

❑ Protocol – set of rules followed by same layer at different nodes e.g. between the transport layer of Tx and Rx

Protocol Data Units (PDUs)

❑ Control information added to data at each layer (in the form of header / trailer)

➢ Destination node address, sequence number, error detection code, etc

➢ Control information added by layer i^{th} at transmitter is used by layer i^{th} at receiver node

❑ PDUs called differently at different layers

➢ frame in data link layer, packet/datagram in network layer, packet/segment in transport layer, message in application layer

Operation of a Protocol Architecture
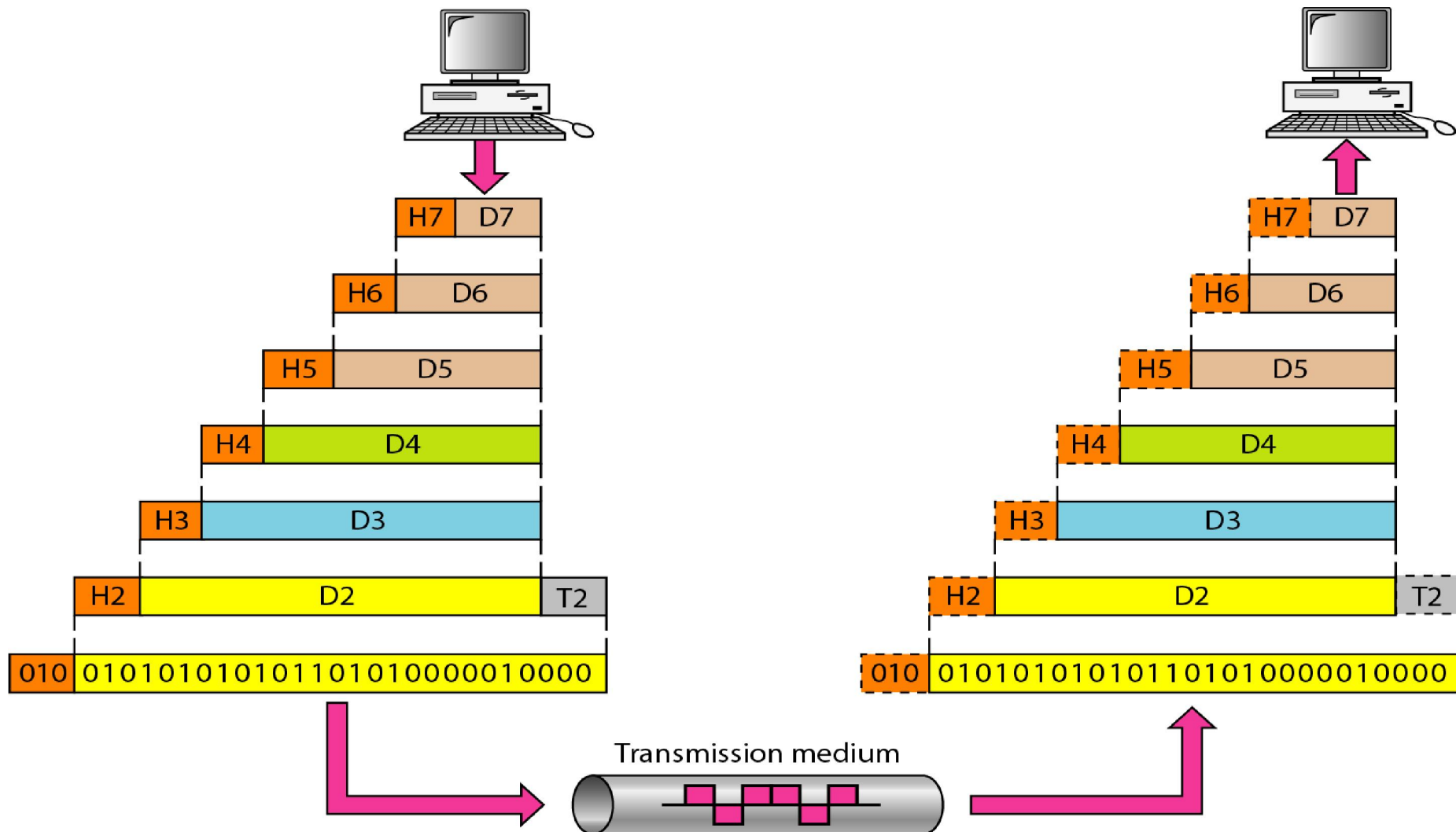
PDUs (contd.)

❑ Encapsulation

➢ At Tx: as data goes down, each layer adds header

➢ At Rx: as data goes up, each layer takes out its own header, carries out checks, hands up rest to higher layers if ok

❑ Number of layers to be used

➢ More the no. of layers, more headers added as the data goes downwards, more wastage

➢ Too few layers – defeats the purpose of layering (isolating functionalities in layers) itself

OSI Layers - brief overview

❑ Physical Layer

   ➢ Physical interface between data transmission device (e.g. computer) and transmission medium or network

   ➢ Specifies raw transmission details like connectors, medium, voltage levels, encodings used, data rate, etc.

❑ Data Link Layer

   ➢ Ensures reliable communication between two directly connected nodes

   ➢ Sends blocks of data (frames) with the necessary synchronization, error control, flow control

   ➢ Medium Access Control (MAC)

OSI Layers - brief overview (contd. 2)

❑ Network Layer

  ➢ Deals with **routing**: sending packets from source to destination nodes that are not directly connected

  ➢ Packets may not reach in order, can get lost (does not guarantee reliable communication)

  ➢ Congestion Control and Internetworking

  ➢ Some other functions (like fragmentation)

❑ Transport layer

  ➢ Ensures reliable, in-order delivery between any two applications ensures no frame loss, no error, no duplicate (Error Control, Flow Control)

  ➢ Segmentation & Reassembly

  ➢ Connection Establishment / Release

OSI Layers - brief overview (contd. 3)

❑ Session layer

➢ It deals with the concept of Sessions

➢ Controls the dialogues (connections) between computers

➢ Synchronization

❑ Presentation layer

➢ Compression and encryption

➢ Independence from data representation (Endianness, TLV(Type-Length-Value), Basic Encoding Rules(BER) or Packed Encoding Rule (PER) of ASN.1)
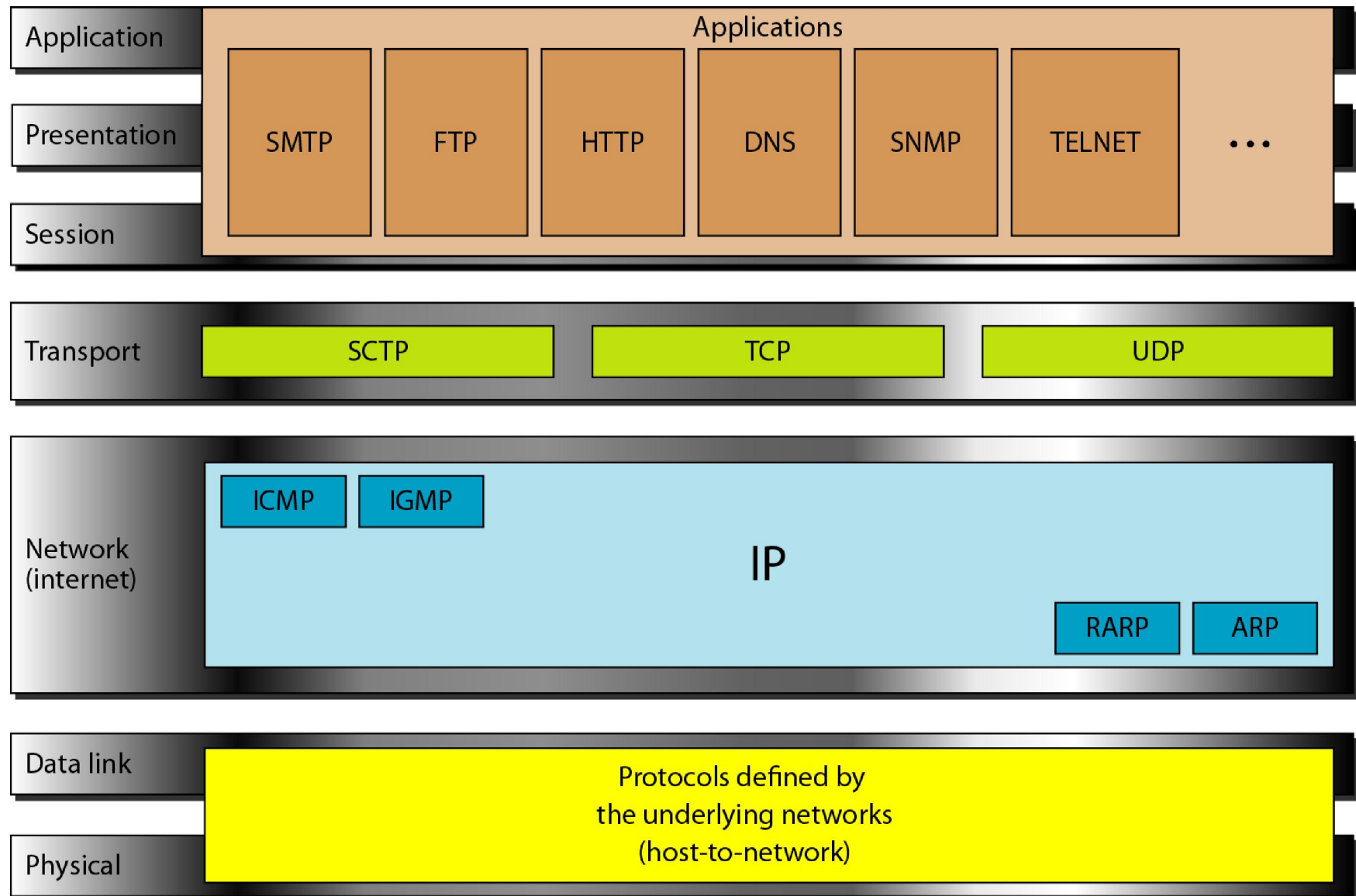
❑ Application layer

➢ Supports user applications (e.g. http, ftp)
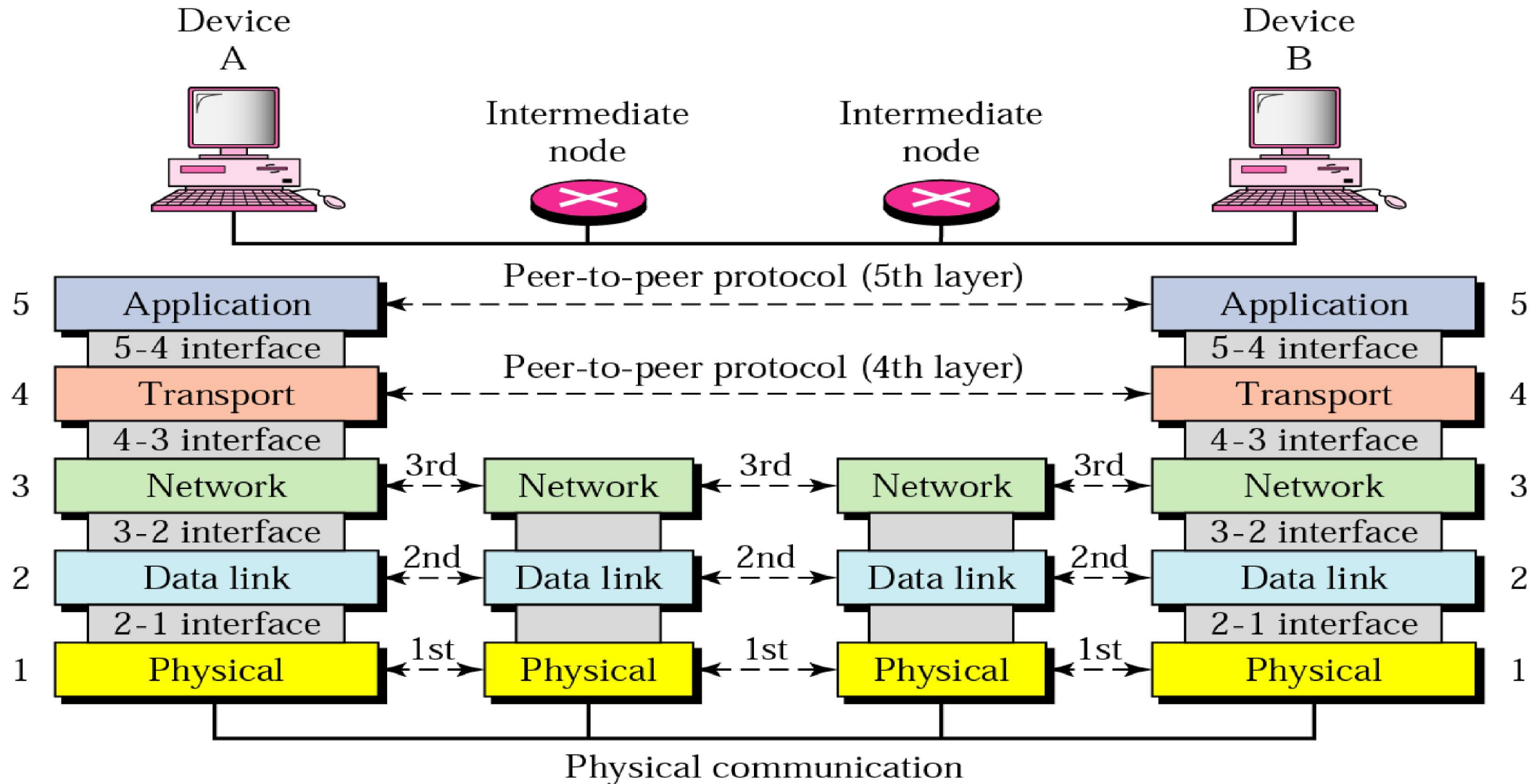
TCP/IP layers

❑ TCP layers – by US Defense Agency

❑ De-facto standard (not official, but working model)

❑ Used by the global Internet

❑ Five Layers

   ➤ Application
   ➤ Transport
   ➤ Network (Internet)
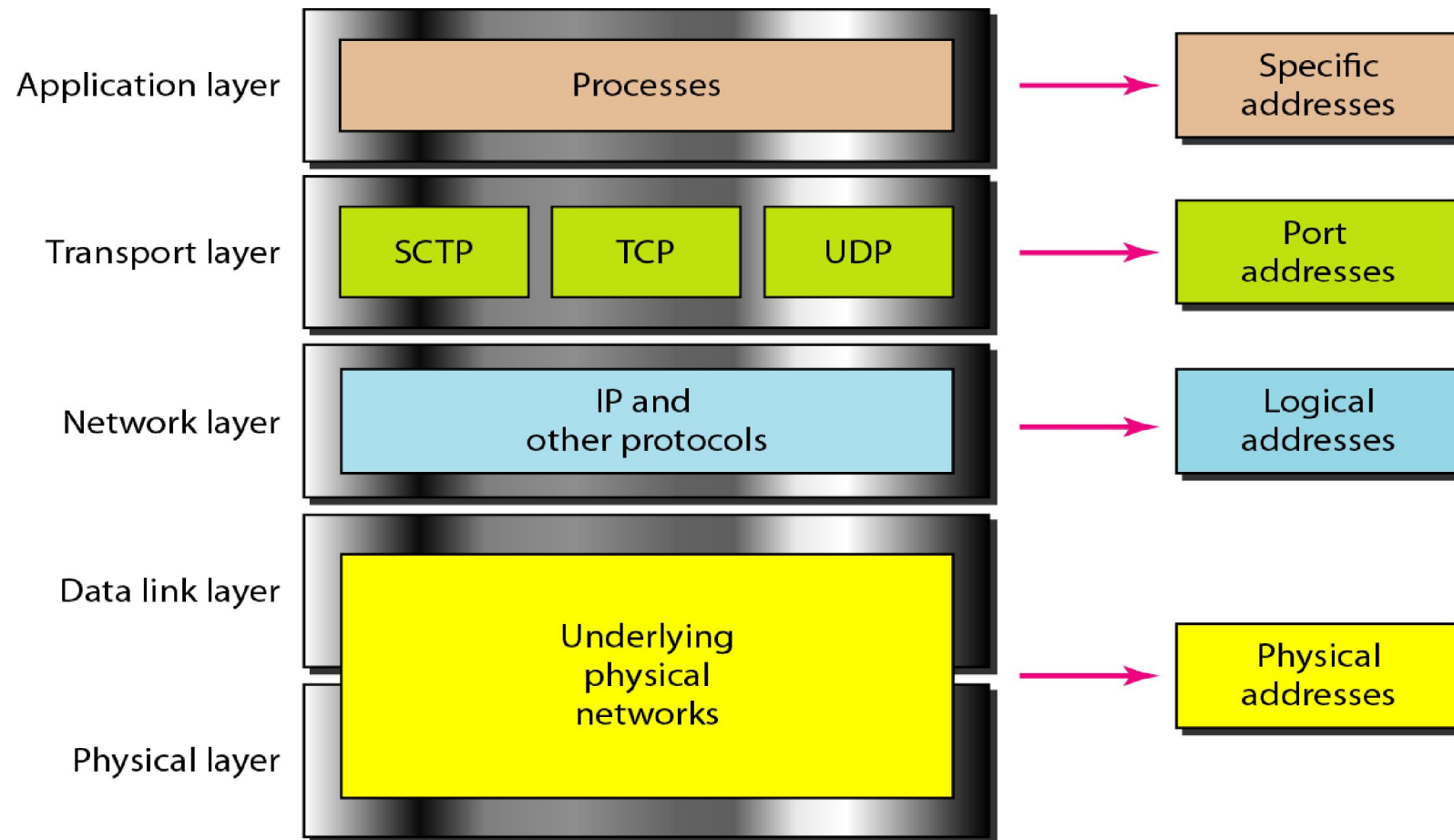   ➤ Data Link
   ➤ Physical

OSI model and TCP/IP

	Applications						
Application	SMTP	FTP	HTTP	DNS	SNMP	TELNET	...
Presentation							
Session							

Transport	SCTP	TCP	UDP

Network (internet)	ICMP	IGMP	IP	RARP	ARP

Data link	Protocols defined by the underlying networks (host-to-network)
Physical	

Protocols & Interfaces in TCP/IP stack

Relationship of layers and addresses in TCP/IP

Four levels of addresses are used in an internet employing the TCP/IP protocols: physical, logical, port, and specific.

Application layer	Processes	→	Specific addresses
Transport layer	SCTP	TCP	UDP	→	Port addresses
Network layer	IP and other protocols	→	Logical addresses
Data link layer	Underlying physical networks	→	Physical addresses
Physical layer			

Physical Address / MAC Address

Most local-area networks use a 48-bit (6-byte) physical address written as 12 hexadecimal digits; every byte (2 hexadecimal digits) is separated by a colon, as shown below:

07:01:02:01:2C:4B

A 6-byte (12 hexadecimal digits) physical address.

Data communication within a LAN

A node with physical address 10 sends a frame to a node with physical address 87. The two nodes are connected by a link (bus topology LAN). As the figure shows, the computer with physical address 10 is the sender, and the computer with physical address 87 is the receiver.
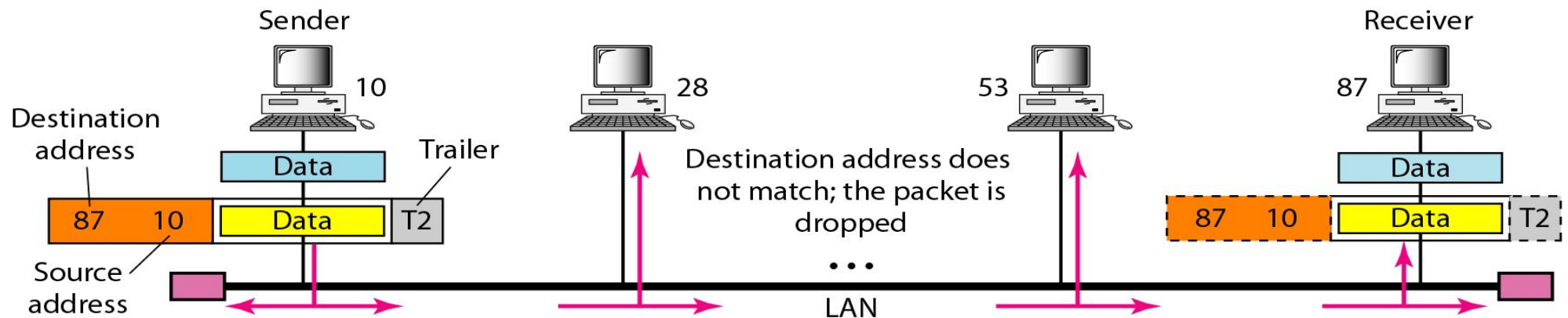
Logical Address /IP Address

An Internet Protocol address (IP address) is a numerical label assigned to each node participating in a computer network that uses the Internet Protocol for communication

Two principal functions: host or network interface identification and location addressing

IPv4 : 10.2.1.40
A 4-byte logical address

IPv6 : 2001:db8:0:1234:0:567:8:1
A 16-byte logical address

Data communication across internet

Example shows a part of an internet with two routers connecting three LANs. Each device (computer or router) has a pair of addresses (logical and physical) for each connection. In this case, each computer is connected to only one link and therefore has only one pair of addresses. Each router, however, is connected to three networks (only two are shown in the figure). So each router has three pairs of addresses, one for each connection.

Data communication across networks
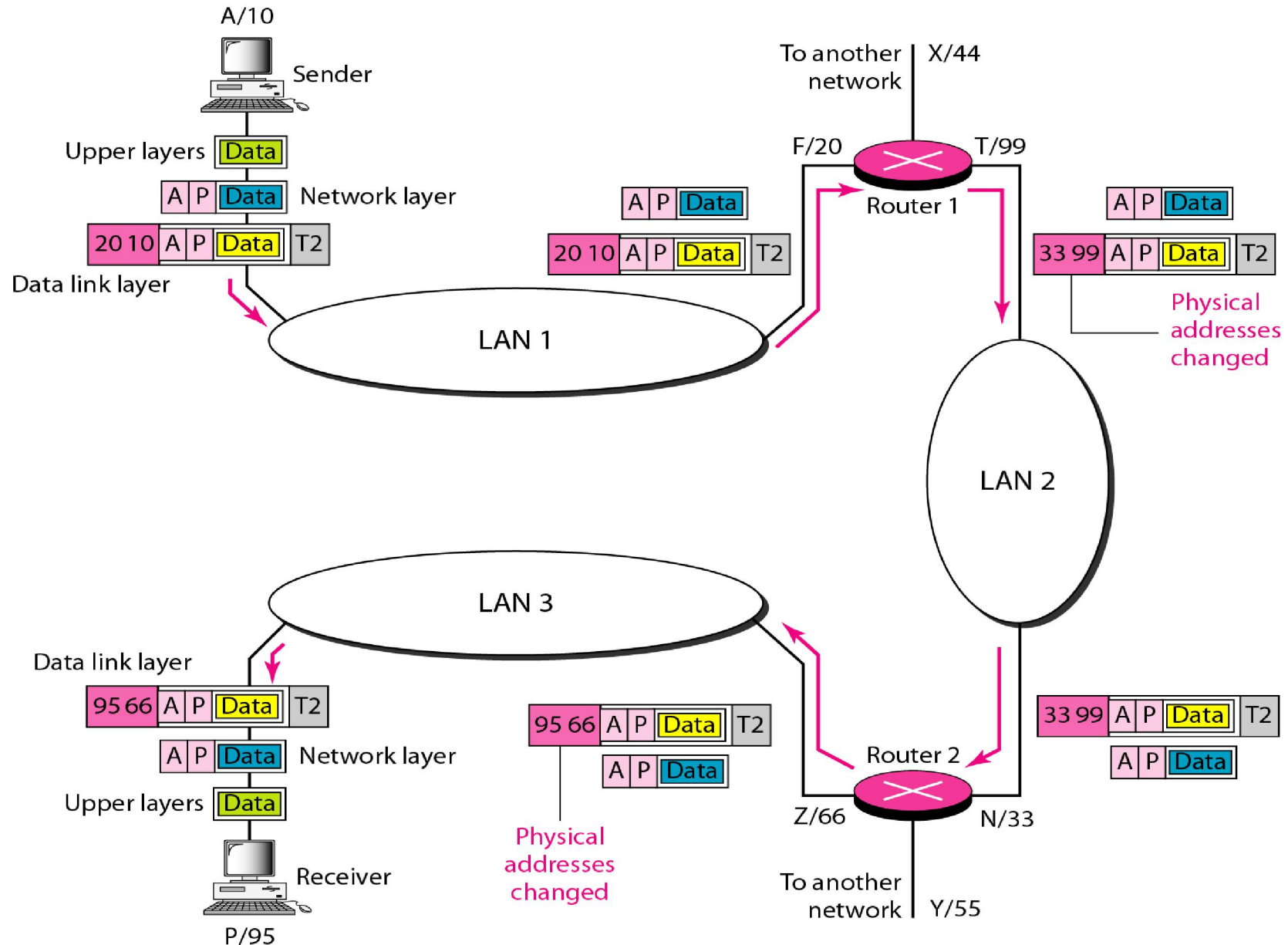
The physical addresses will change from hop to hop, but the logical addresses usually remain the same

Port addresses

753

A 16-bit port address represented
as one single number.

Well known port
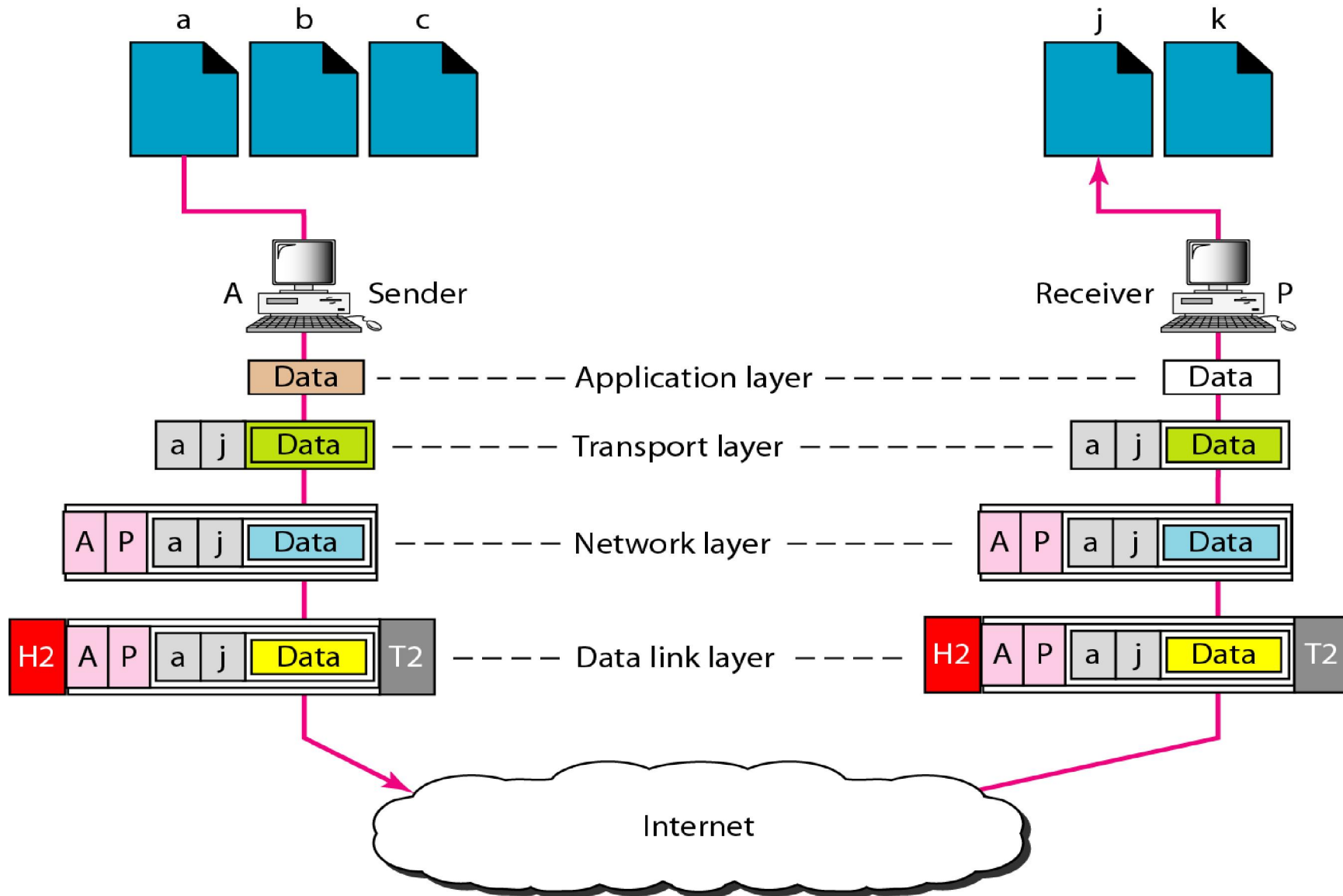
```
ftp : 20
Ssh : 22
http : 80
```

Data communicating via the Internet

Example shows two computers communicating via the Internet. The sending computer is running three processes at this time with port addresses a, b, and c. The receiving computer is running two processes at this time with port addresses j and k. Process a in the sending computer needs to communicate with process j in the receiving computer. Note that although physical addresses change from hop to hop, logical and port addresses remain the same from the source to destination.
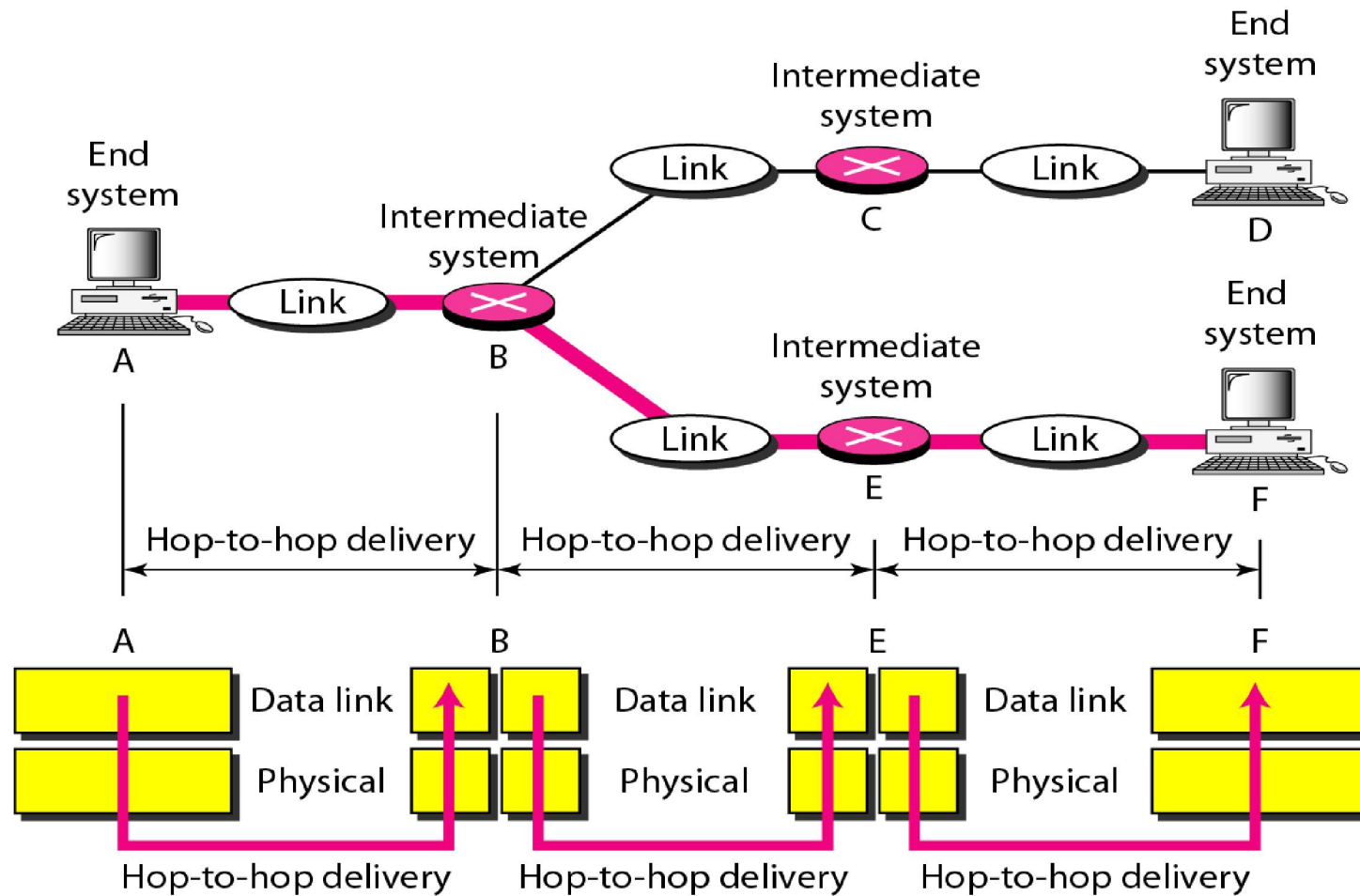
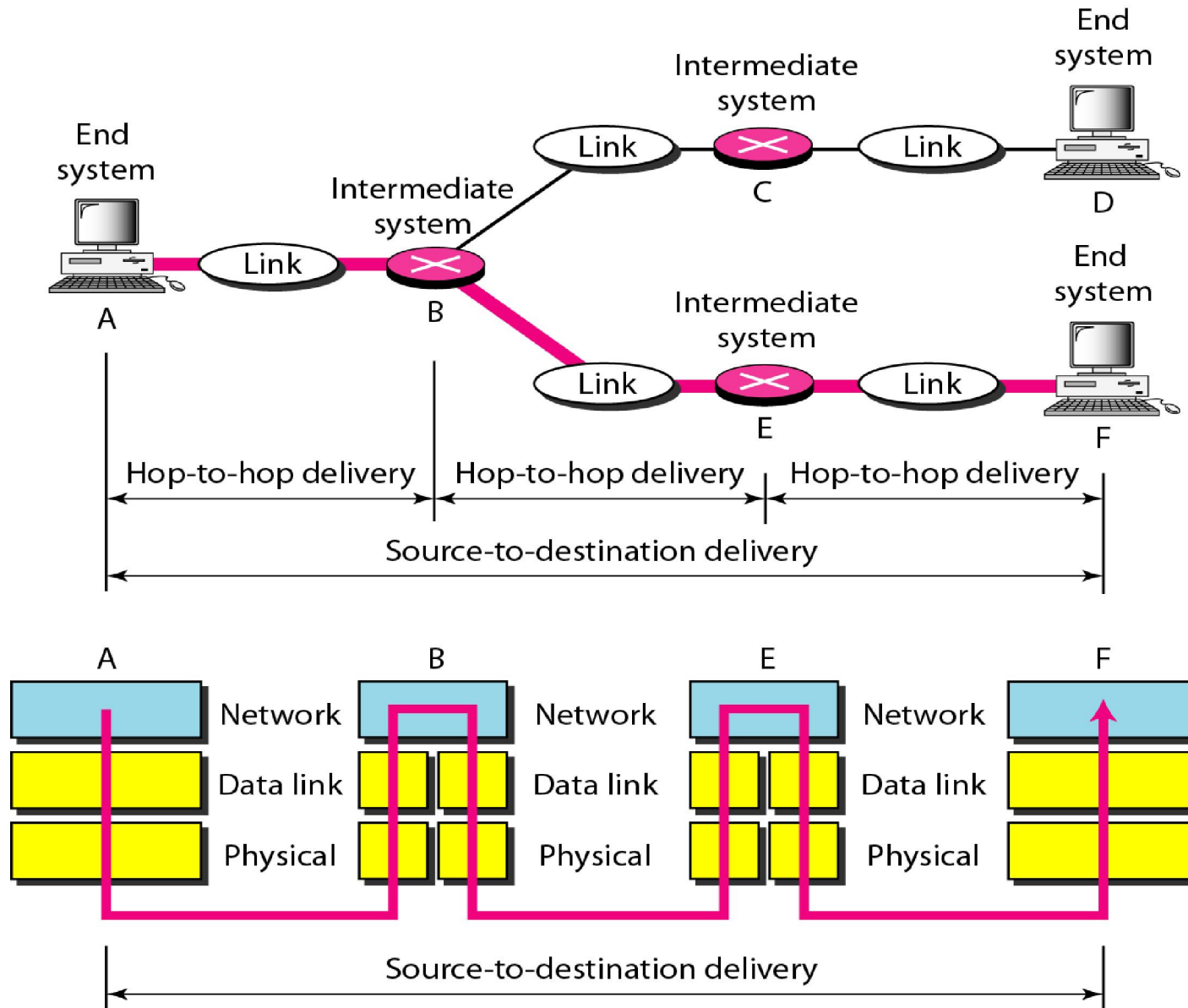# Appendix 4: Reliable process-to-process delivery of a message

Processes

Processes

An internet

Network layer
Host-to-host delivery

Transport layer
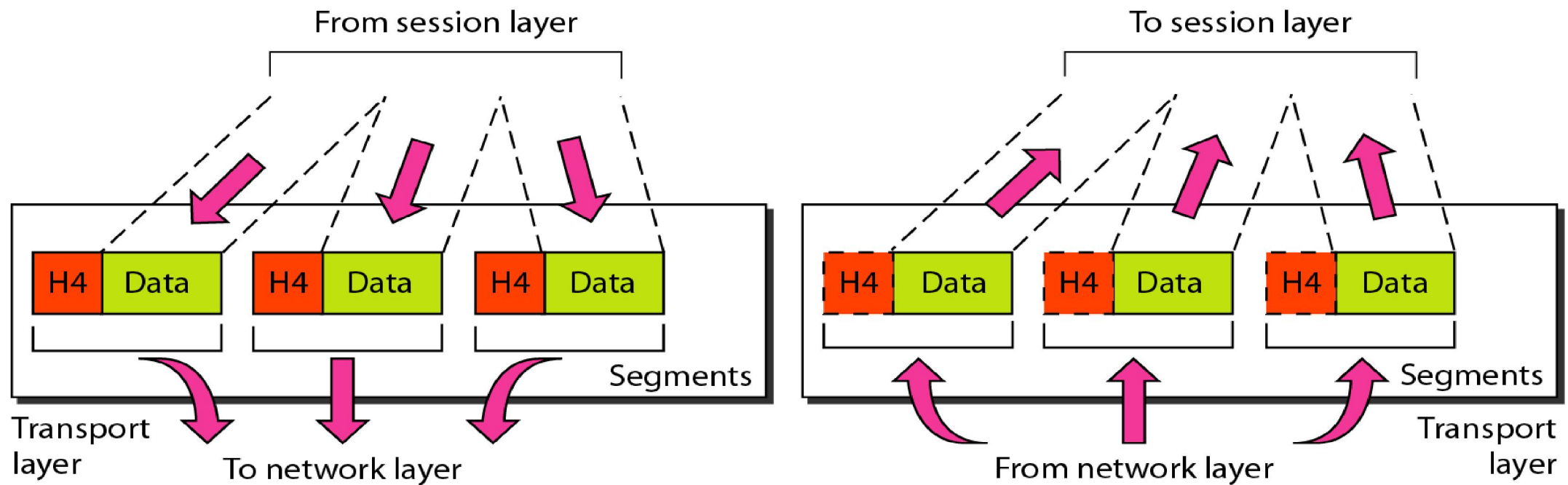Process-to-process delivery
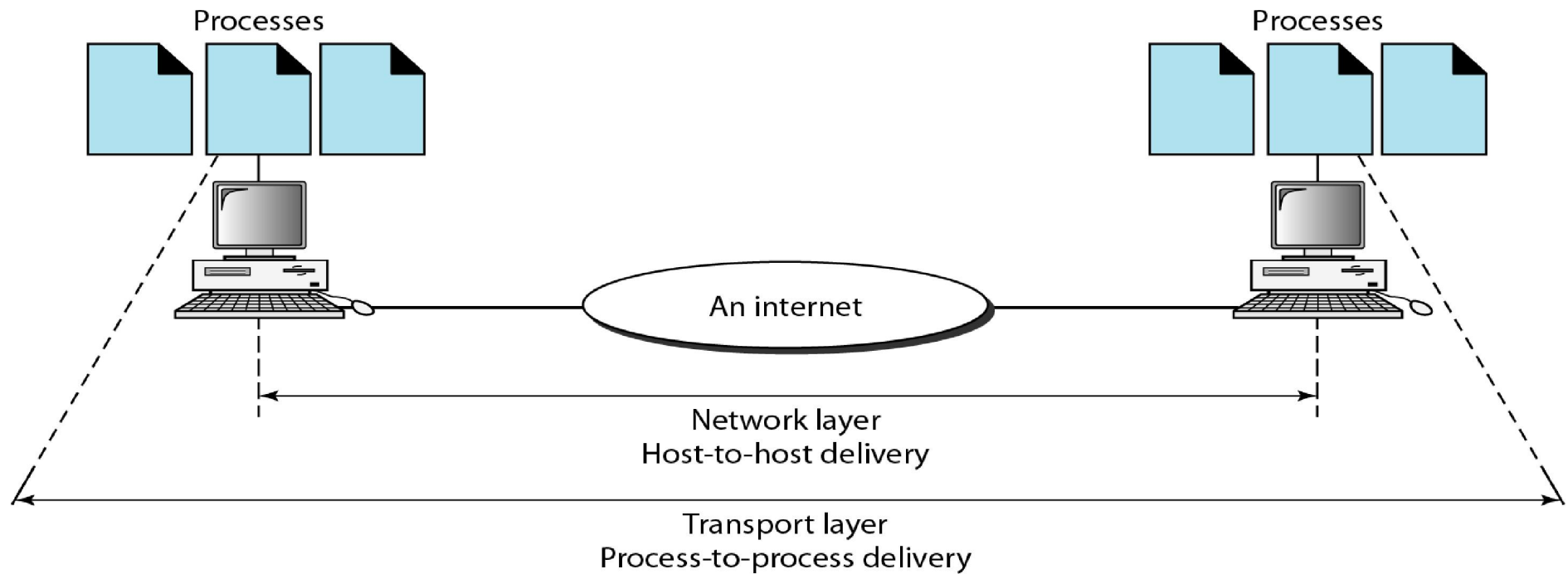
Port addresses
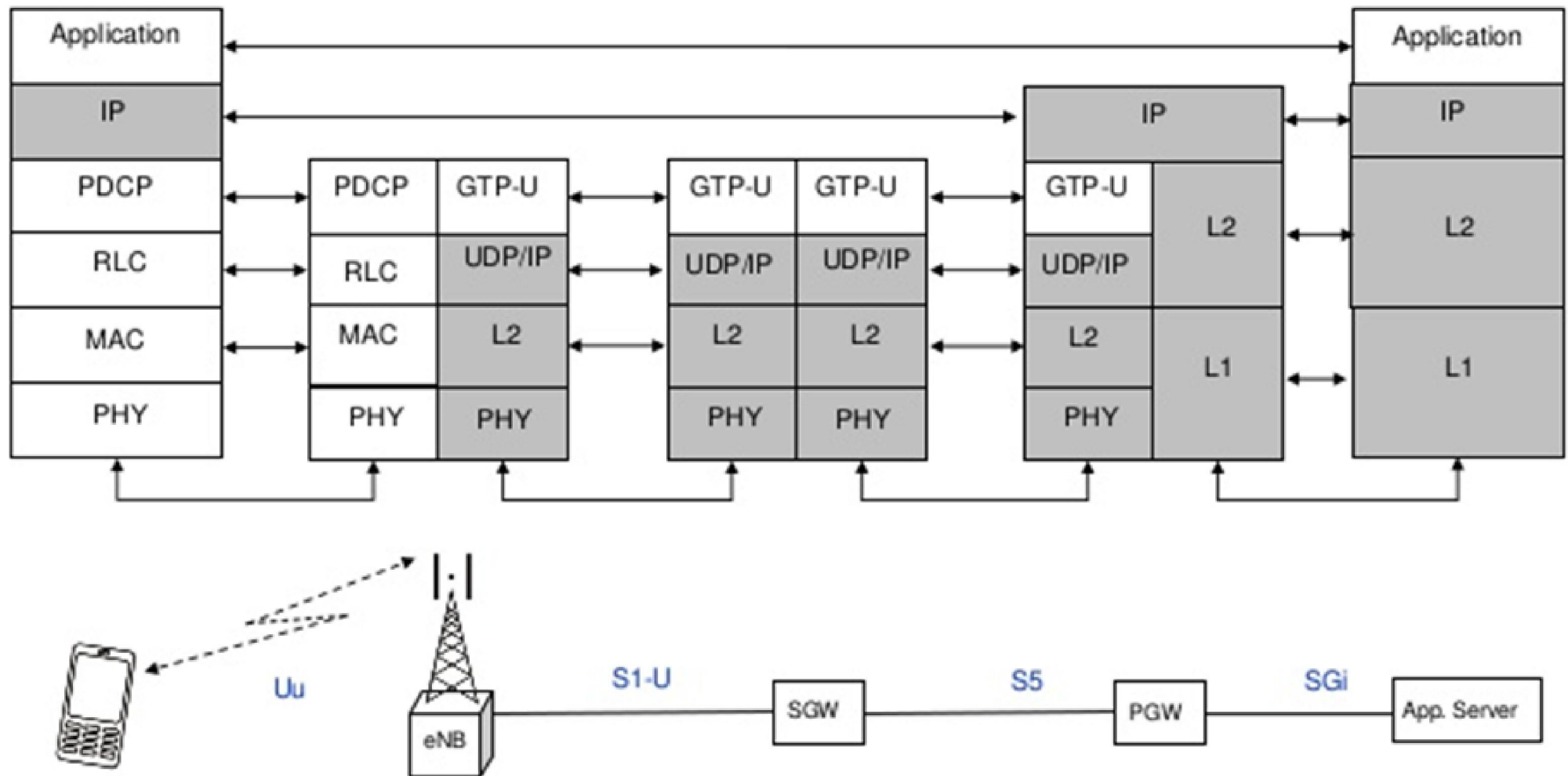
Appendix 1 : Hop-to-hop delivery (L2 switching)

Appendix 2 : Source-to-destination delivery (L3 Switching)

Appendix 3 : Segmentation & Reassembly

Appendix 4 : LTE data plane (User plane) protocol stack

Appendix 5 : LTE data plane (User plane) protocol stack (diff img)