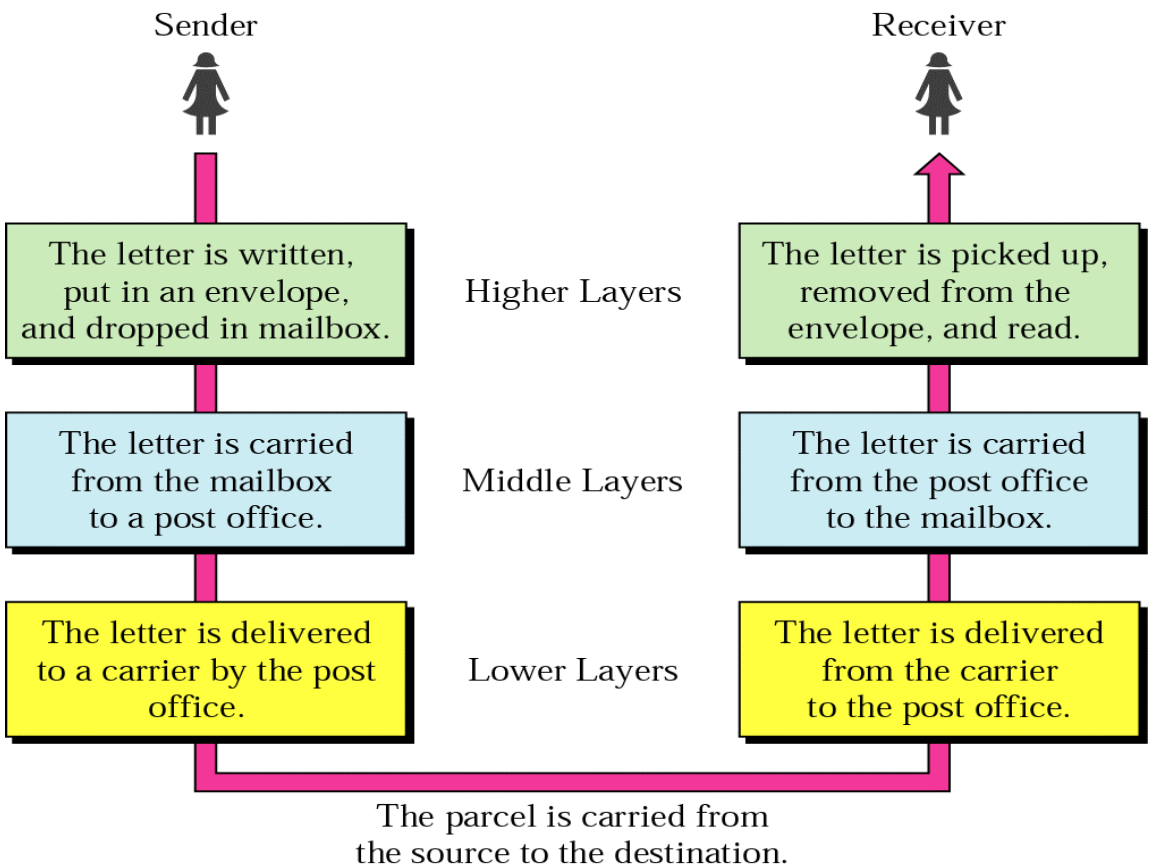
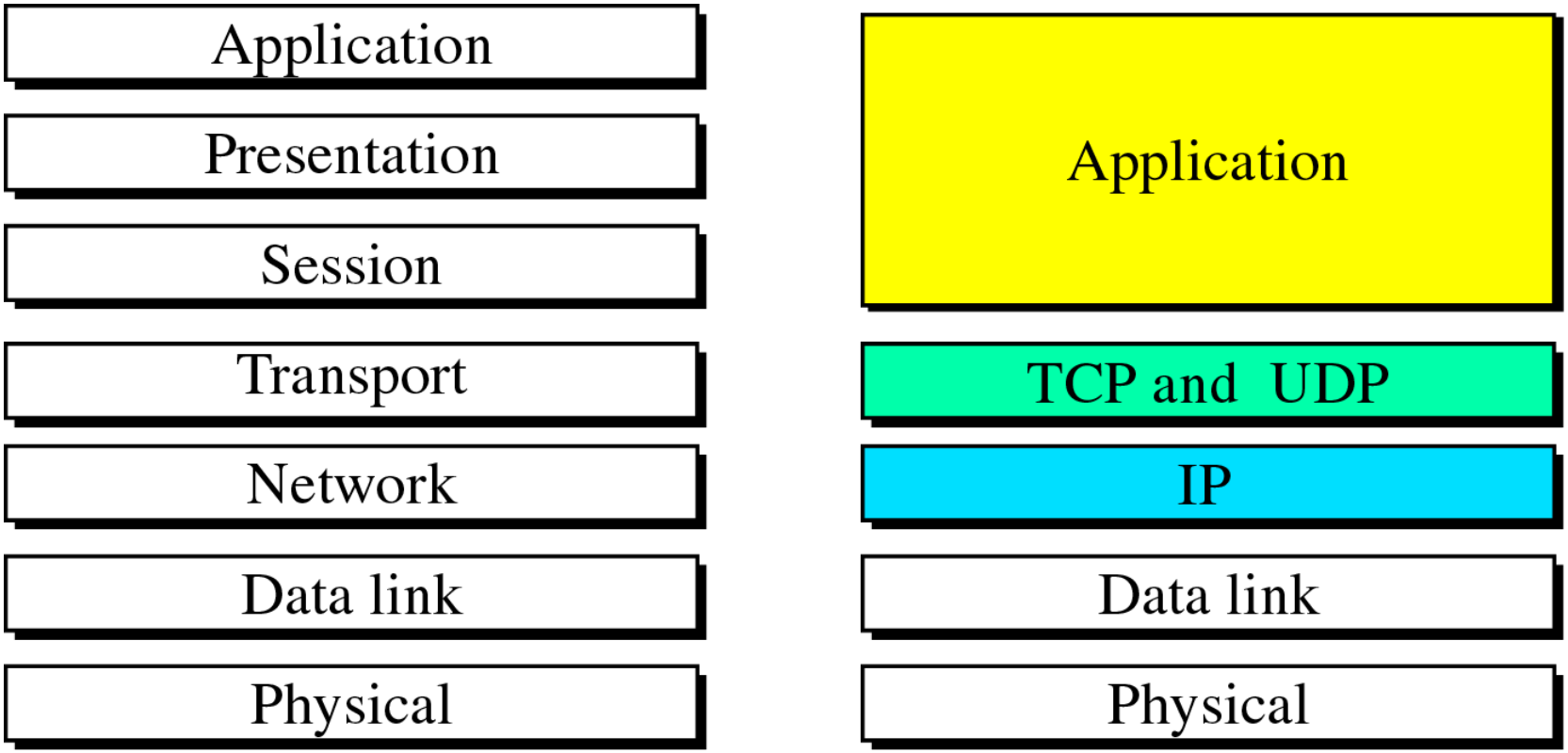
TCP/IP Reference Model

Sending a Letter



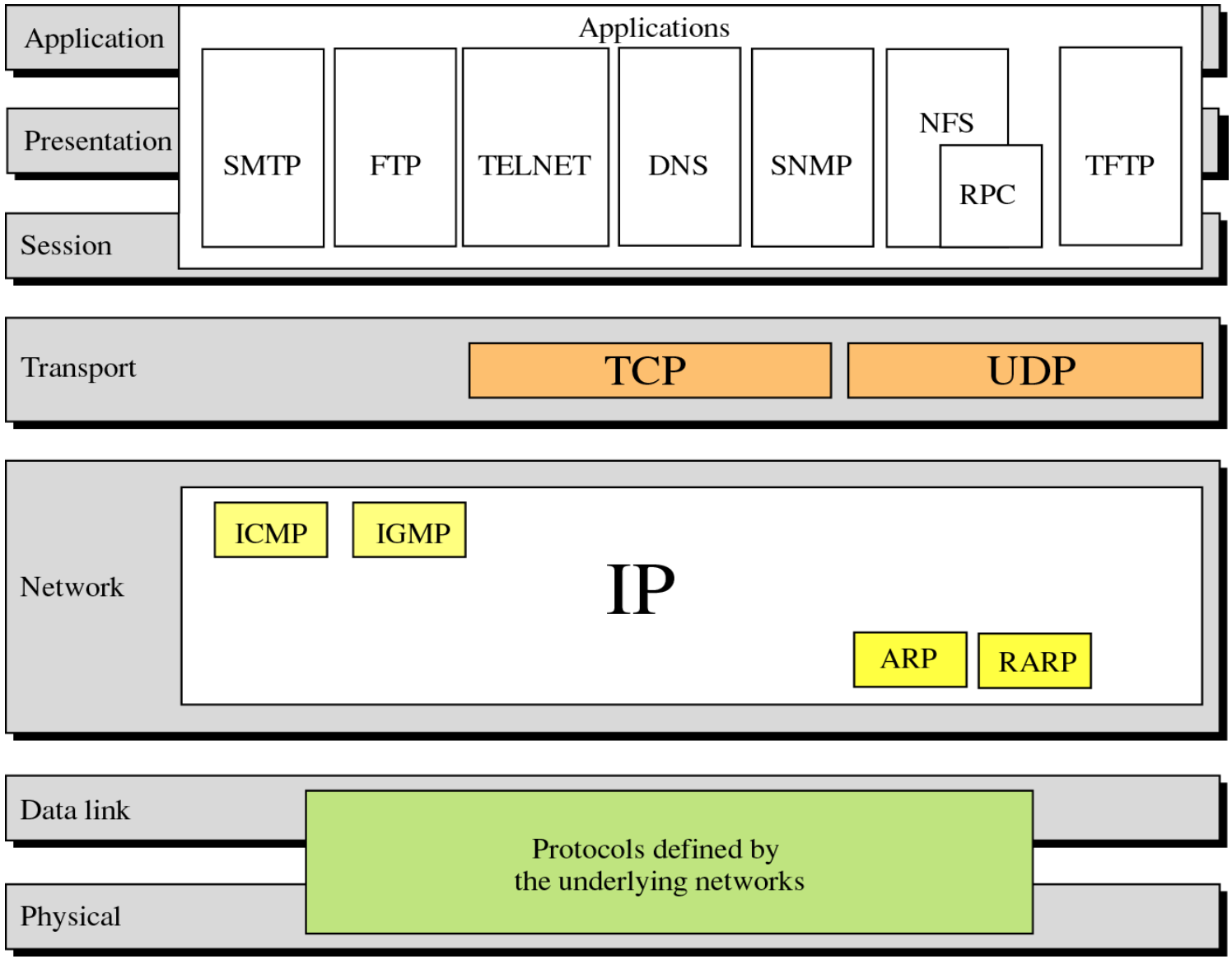
Comparison between OSI and TCP/IP



OSI model

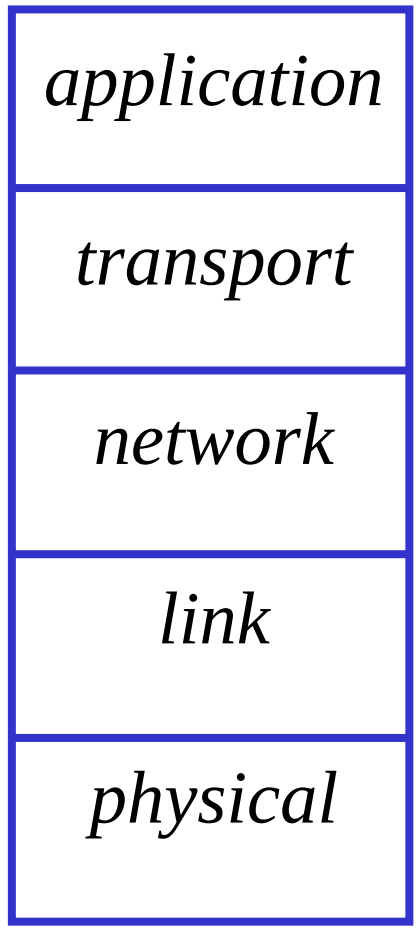
TCP/IP protocol suite

TCP/IP Reference Model

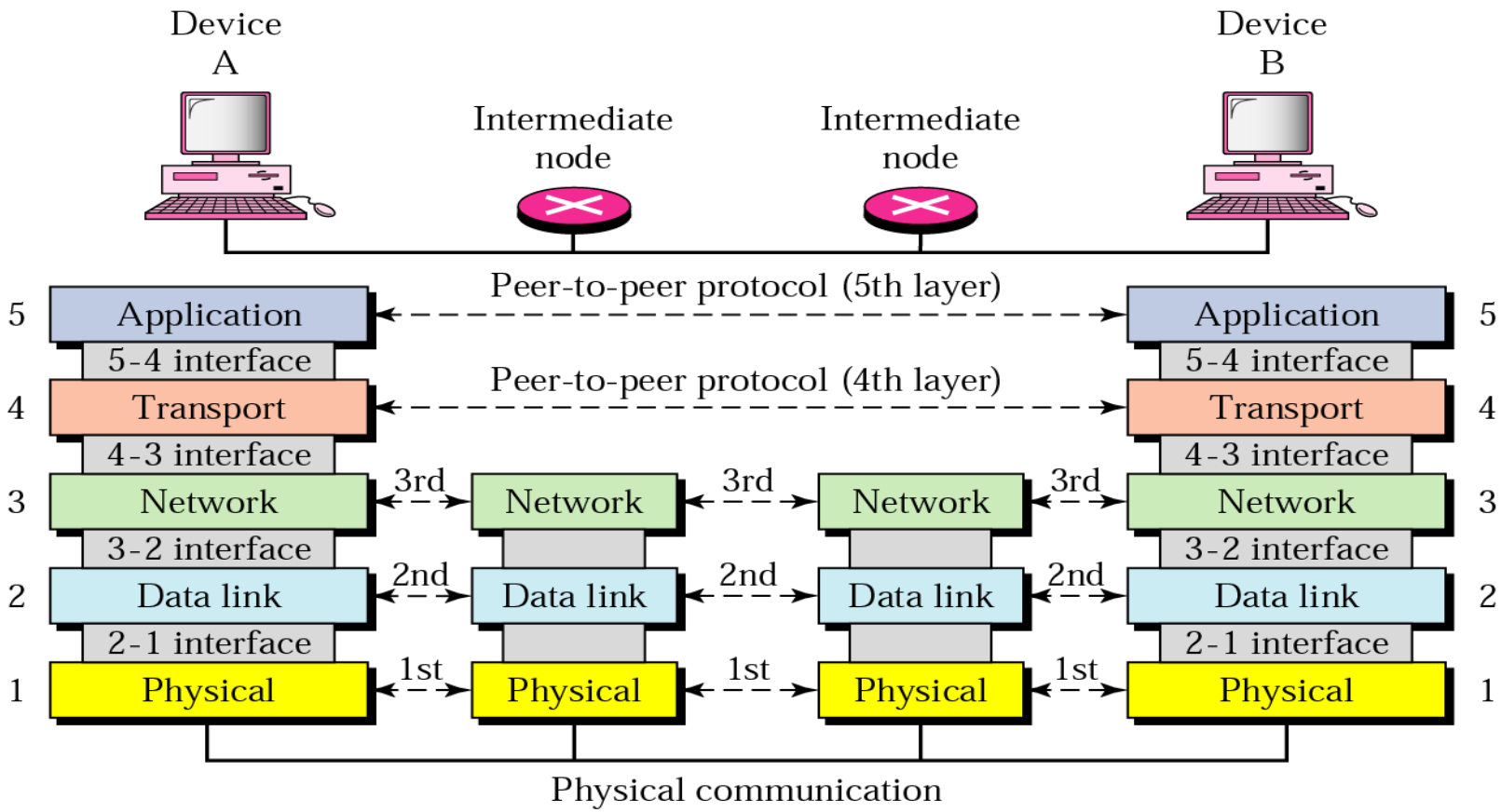


Internet protocol stack

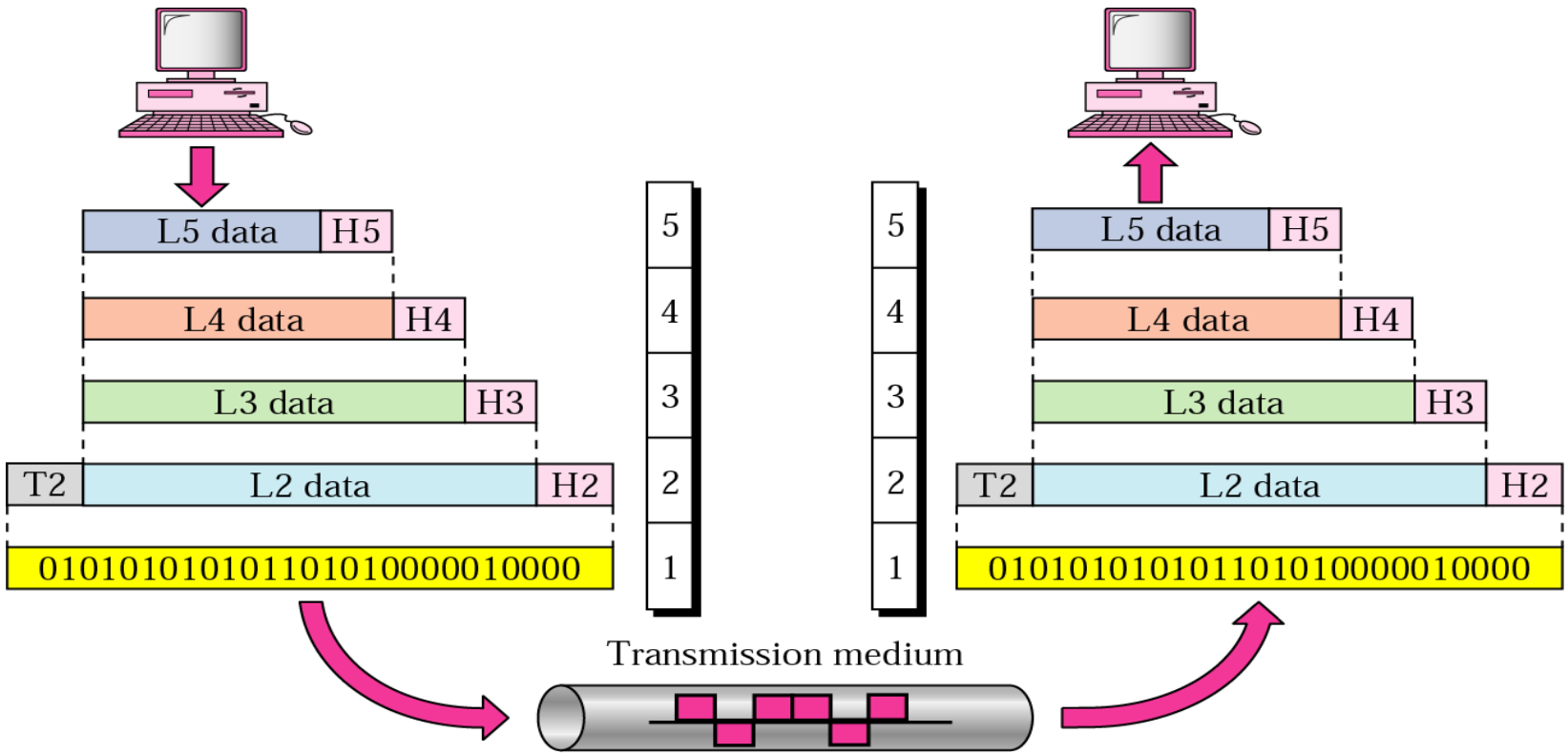
- application: supporting network applications
  - ftp, smtp, http
- transport: host-host data transfer
  - tcp, udp
- network: routing of datagrams from source to destination
  - ip, routing protocols
- link: data transfer between neighboring network elements
  - ppp, ethernet
- physical: bits “on the wire”



Peer to Peer Process



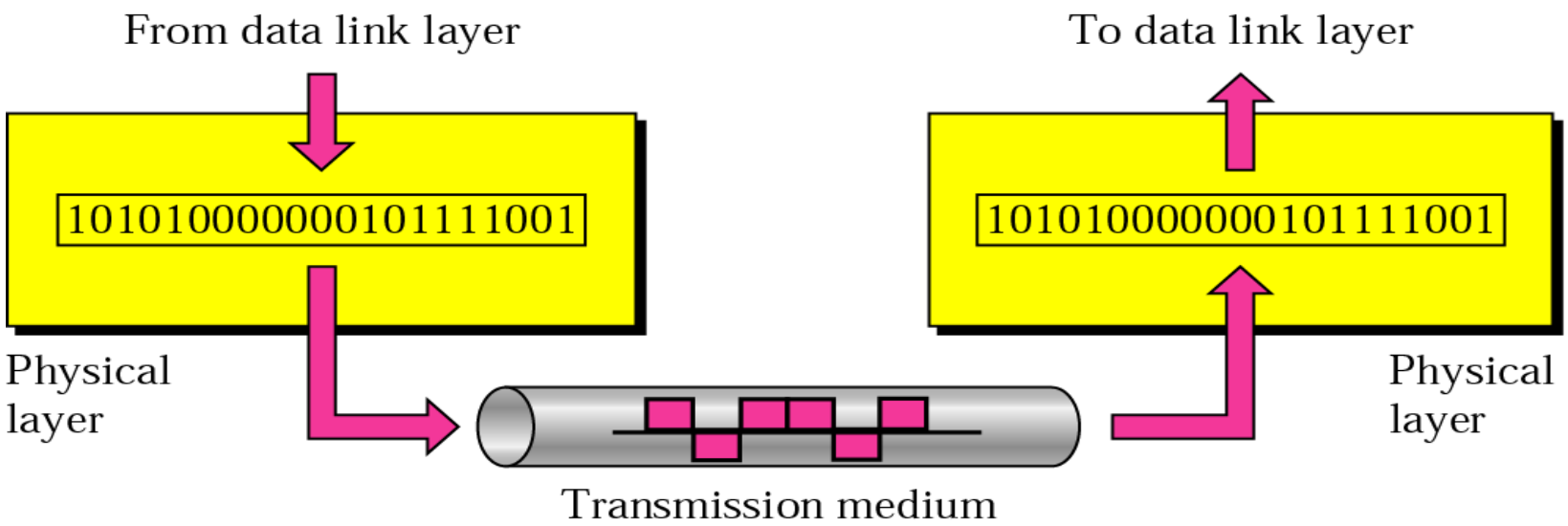
An Exchange Using TCP/IP Reference Model



TCP/IP Layers

- Physical Layer: Concerned with transmitting bits over a communication channel.
  - Issues largely deal with electrical and procedural interface to the physical transmission medium.

Physical Layer



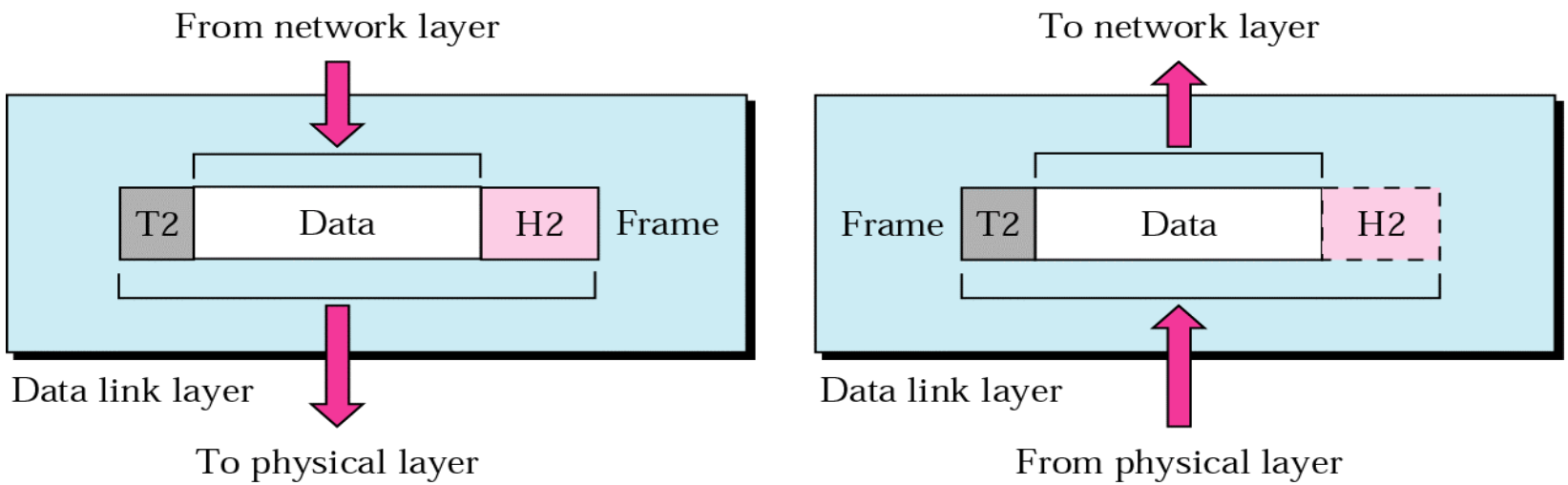
The physical layer is responsible for transmitting individual bits from one node to the next.

- Define the characteristics of the interface between the devices and the transmission media
- Encode bits into signals and decode signals to get bits
- Define transmission rate, which must be the same for both sender and receiver
- Synchronize clocks

TCP/IP Layers

- Data Link Layer: Concerned with transforming the raw physical layer into a `link' for the higher layer.
  - Issues largely deal with framing, error detection/correction and multiple access.

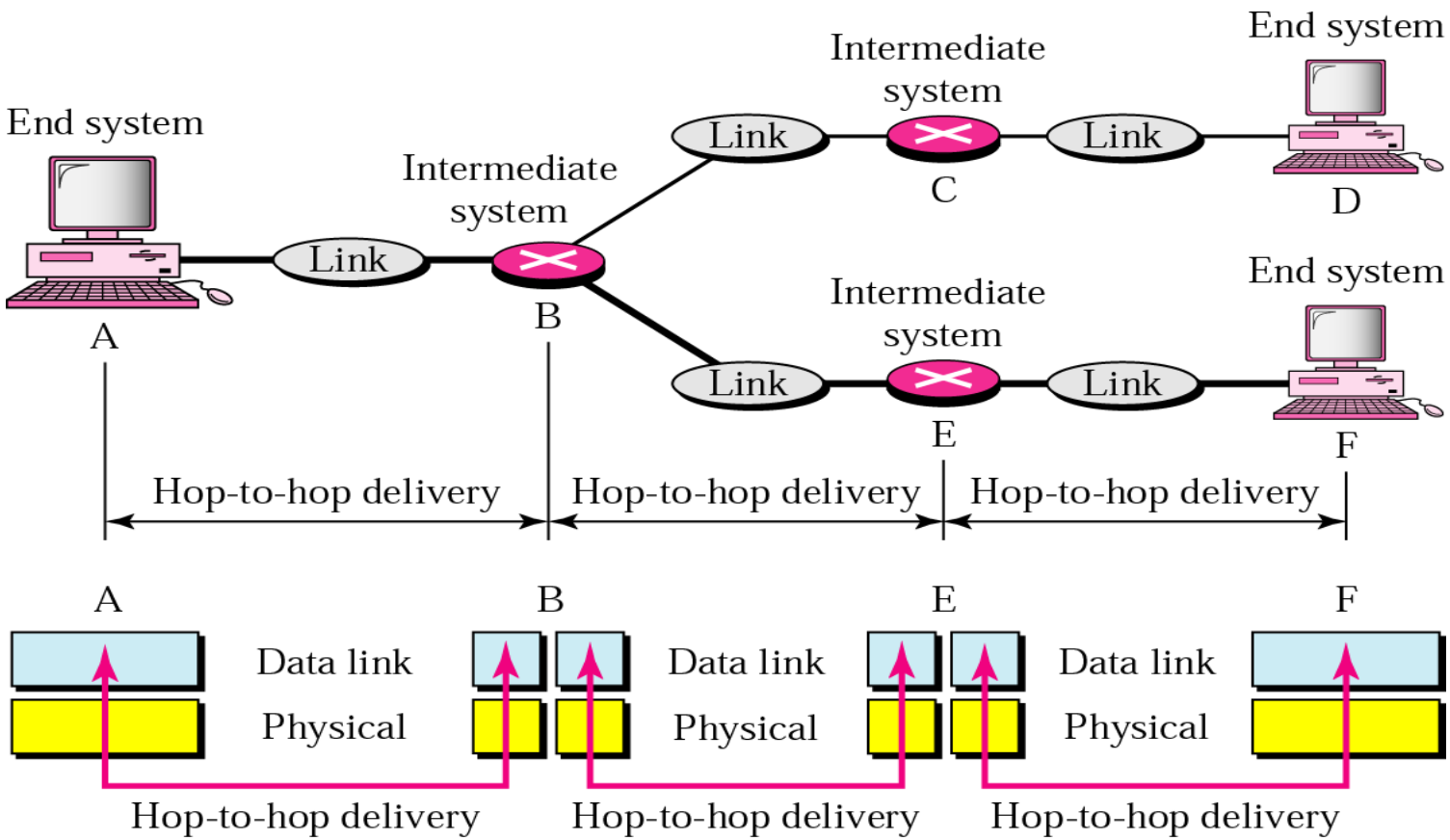
Data Link Layer



The data link layer is responsible for transmitting frames from one node to the next.

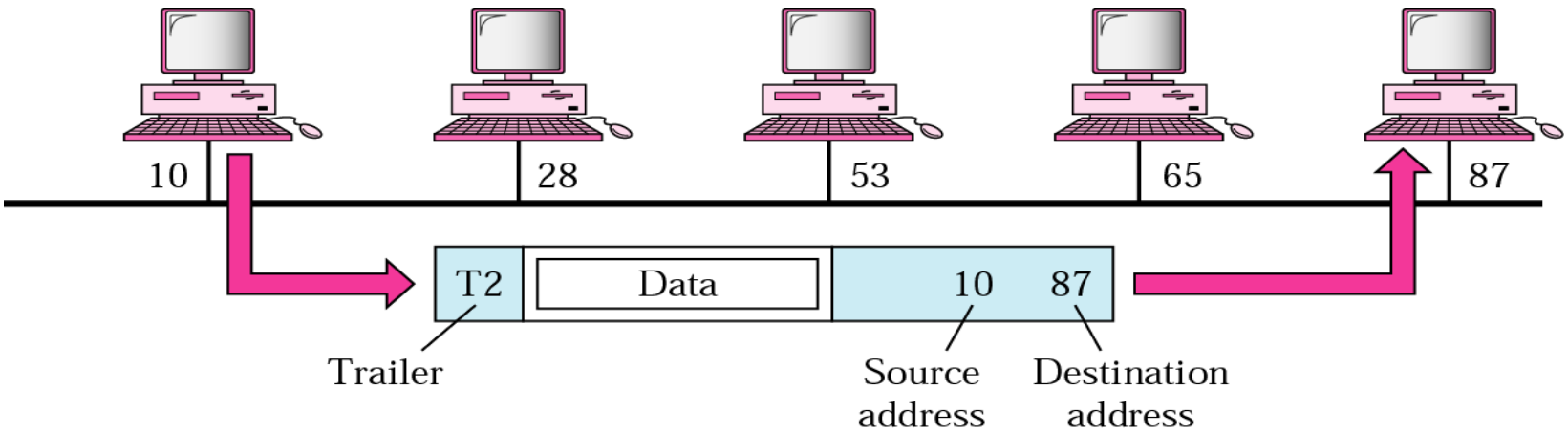
- Framing: divide the data stream into manageable data units called "frames"
- Physical addressing: insert the physical address of the next node into frame's header
- Flow control: prevent overflow at receiver
- Error control: make sure that frames are correctly received
- Access control: make sure that there is no link access conflict

Node-to-Node Delivery



Example

A node with physical address 10 sends a frame to a node with physical address 87. The two nodes are connected by a link. At the data link level this frame contains physical addresses in the header. These are the only addresses needed. The rest of the header contains other information needed at this level. The trailer usually contains extra bits needed for error detection



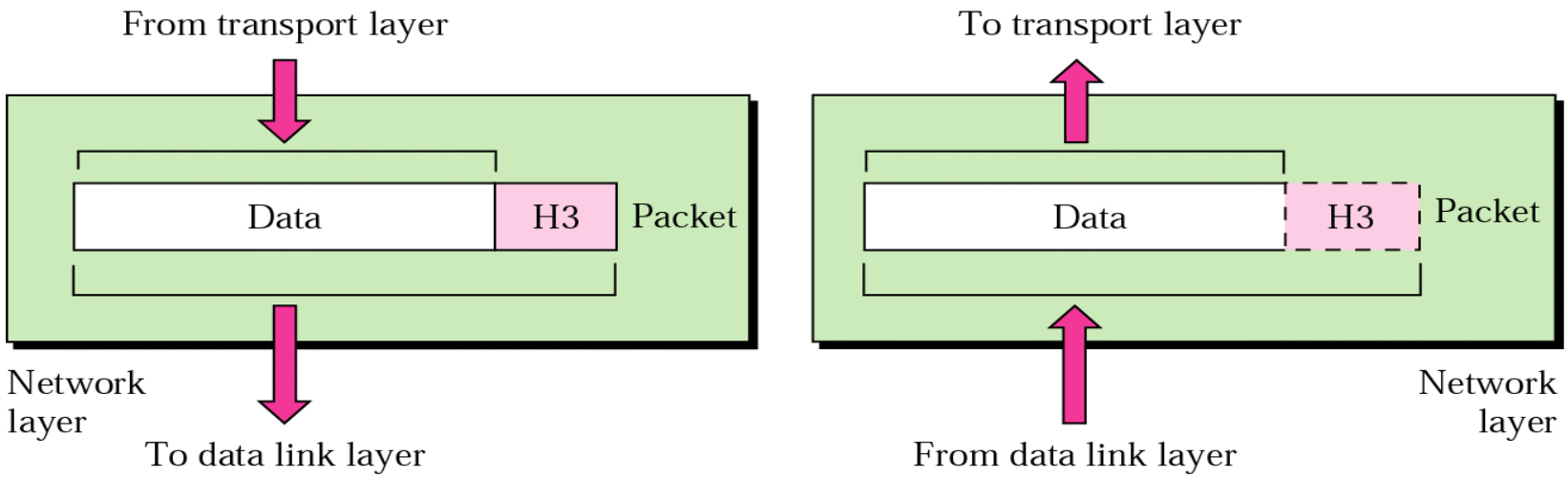
TCP/IP Layers

- Physical and data link
  - None defined, uses whatever machine connected to

TCP/IP Layers

- Internet Layer: Concerned with addressing and routing of packets.
  - Issues largely deal with addressing, subnetting and route determination.
- Internet Layer
  - IP
    - Unreliable, connectionless, best effort
    - Datagrams routed independently

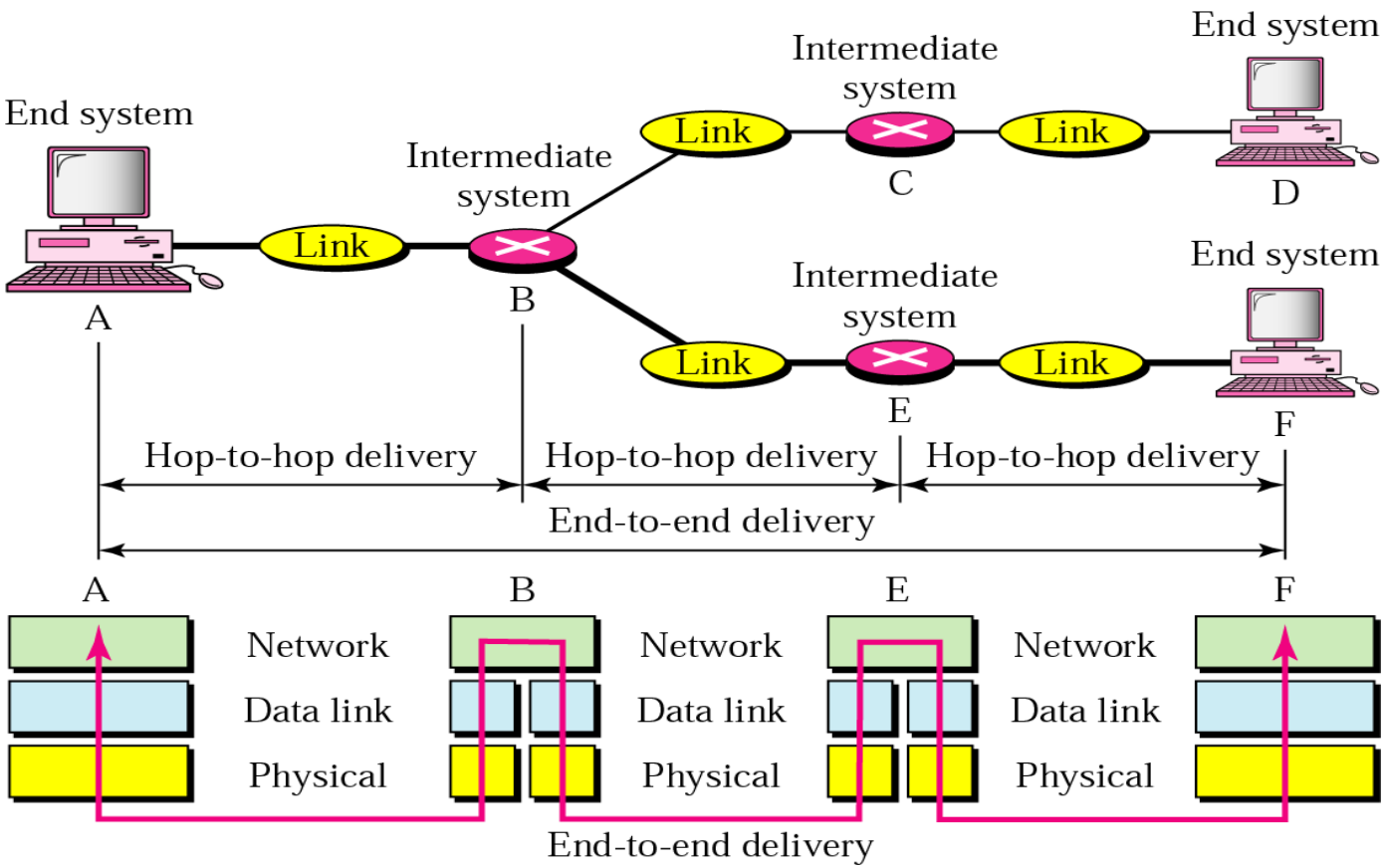
Network Layer



The network layer is responsible for the delivery of packets from the original source to the final destination.

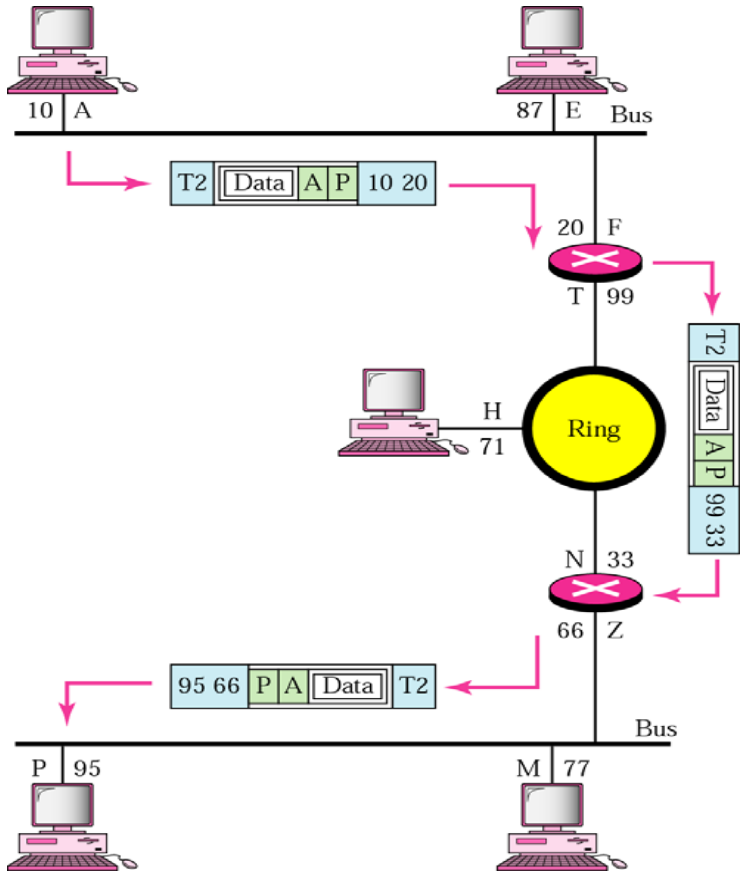
- Logical addressing: e.g., IP addresses
- Routing: how to get to the destination?

Source-to-Destination Delivery



Example

- We want to send data from a node with network address A and physical address 10, located on one LAN, to a node with a network address P and physical address 95, located on another LAN. Because the two devices are located on different networks, we cannot use physical addresses only; the physical addresses only have local jurisdiction. What we need here are universal addresses that can pass through the LAN boundaries. The network (logical) addresses have this characteristic.



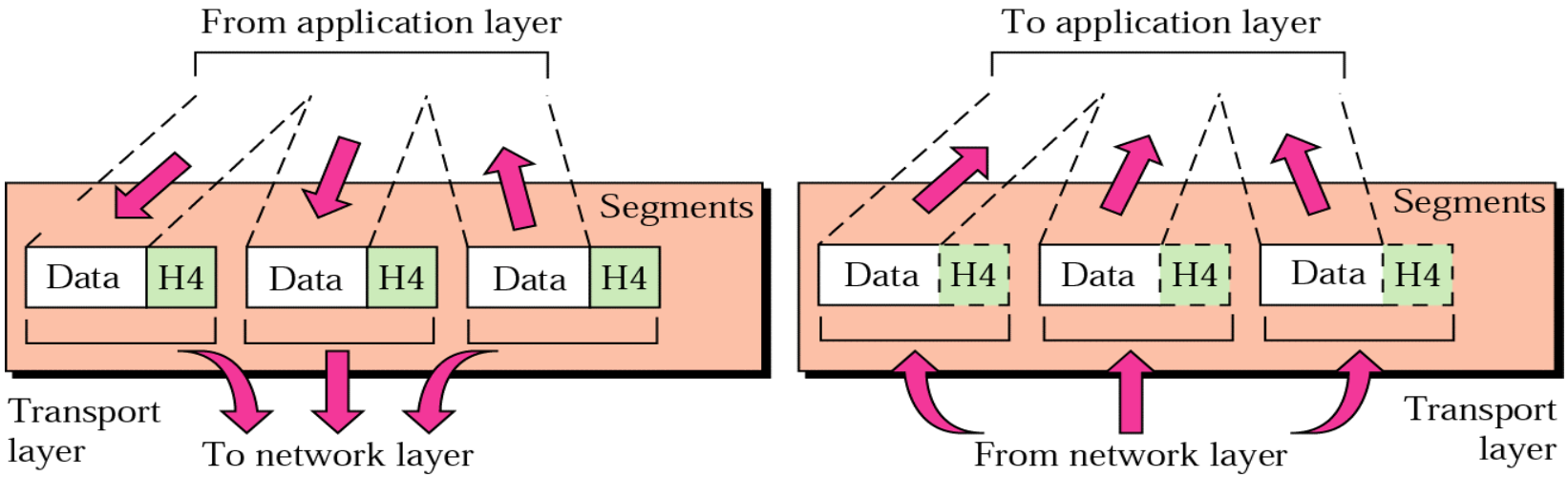
TCP/IP Layers

- Transport Layer: Concerned with end-to-end connection characteristics.
  - Issues largely deal with retransmissions, sequencing and congestion control.

TCP/IP Layers

- Transport layer
  - TCP
    - Adds connection multiplexing, in-order, reliable, stream with flow control
    - Send segments
  - UDP
    - Adds connection multiplexing to IP
    - Client/server

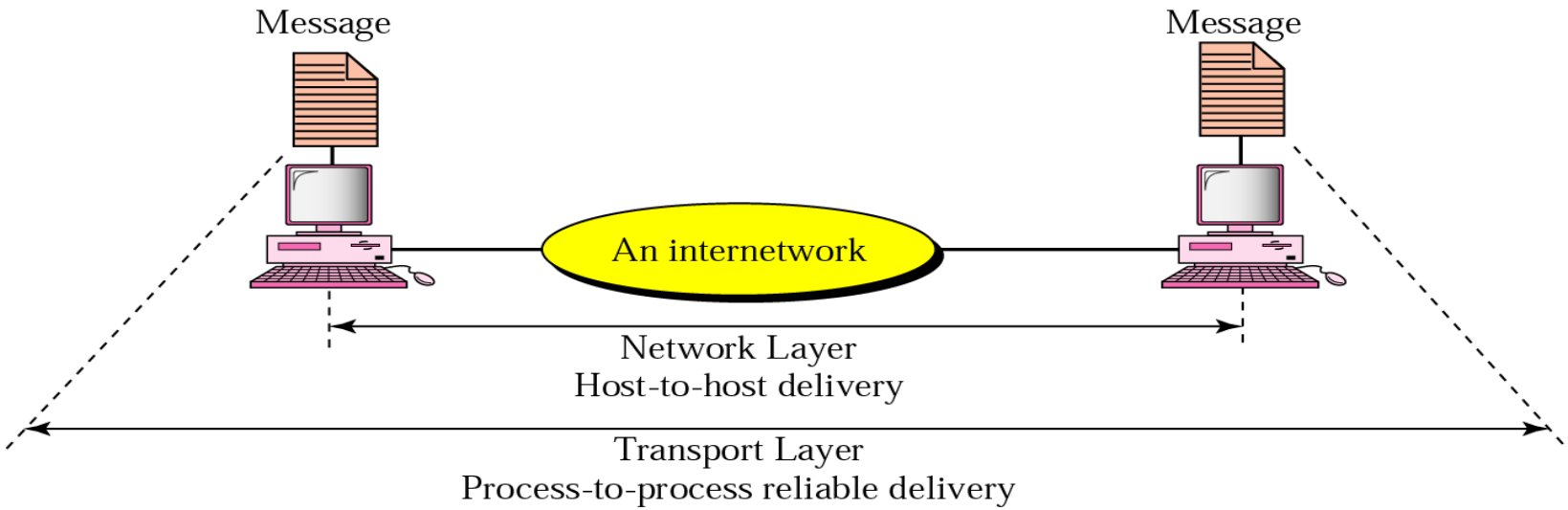
Transport Layer



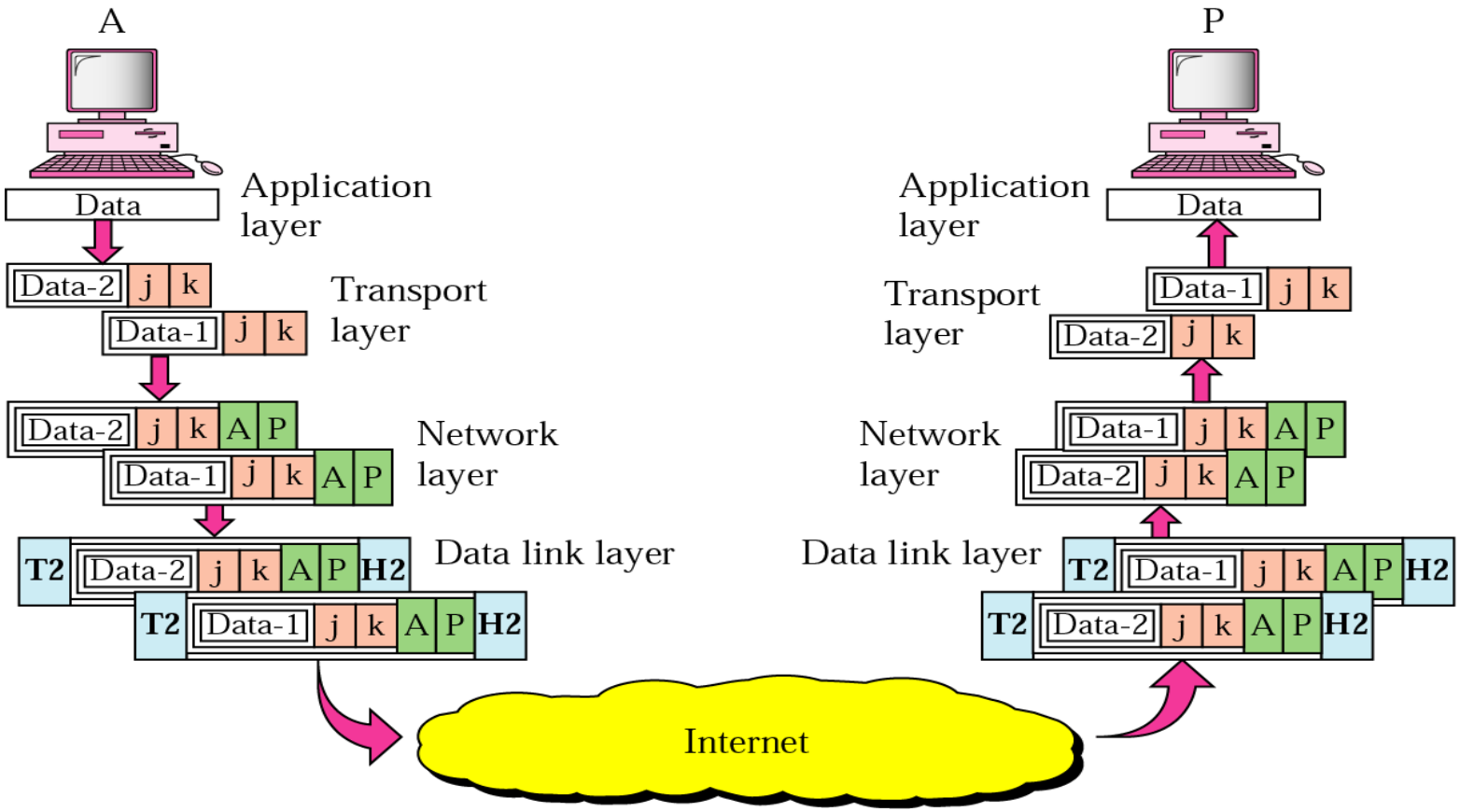
The transport layer is responsible for delivery of a message from one process to another.

- Port addressing: A process is associated with a “port”
- Segmentation and reassembly: Application data are divided into segments
- Connection control: connection-less or connection-oriented?
- Flow control
- Error control

Reliable Process-to-Process Delivery



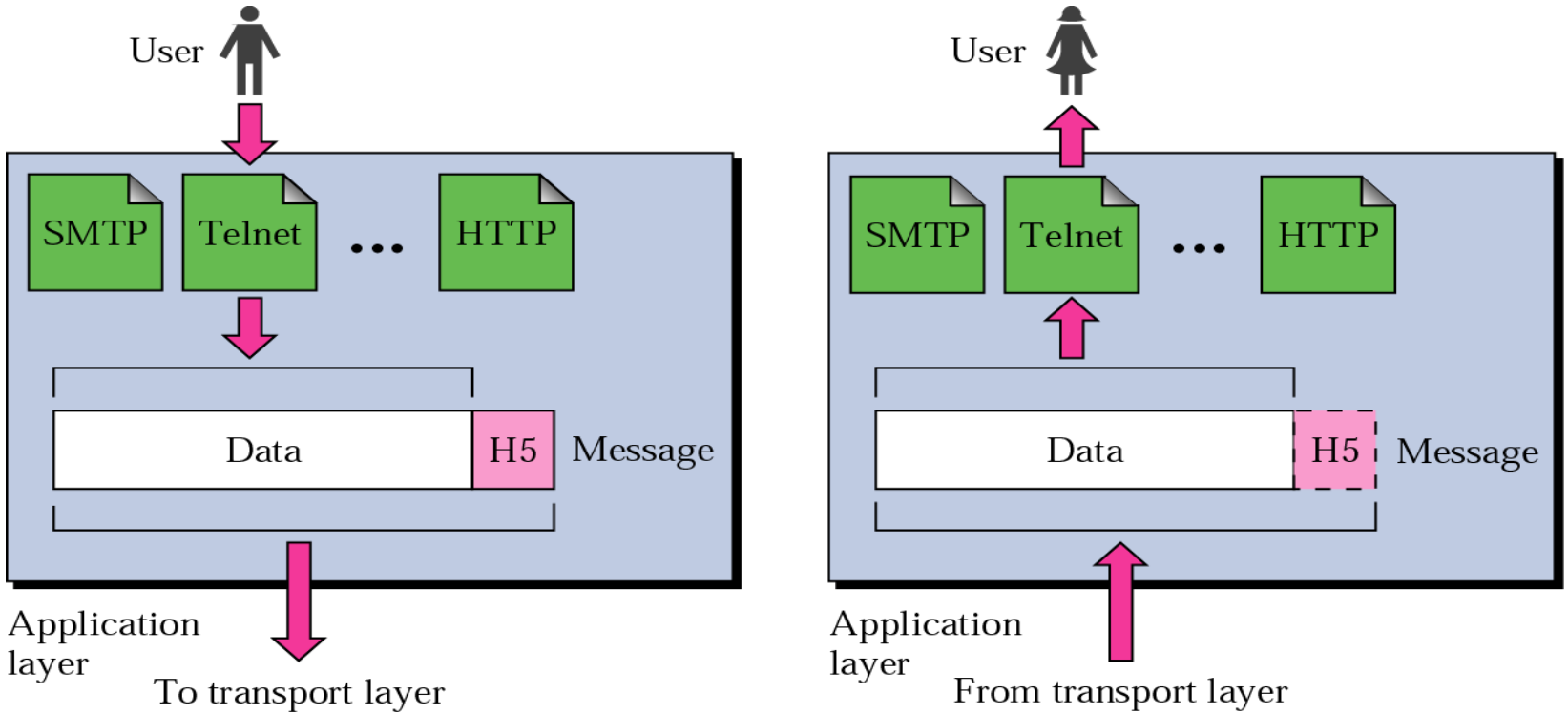
Example


A
P
Data
Application layer
Data-2 j k
Transport layer
Data-1 j k
Data-2 j k A P
Network layer
Data-1 j k A P
T2 Data-2 j k A P H2
Data link layer
T2 Data-1 j k A P H2
Internet
Application layer
Data
Transport layer
Data-1 j k
Data-2 j k
Network layer
Data-1 j k A P
Data-2 j k A P
Data link layer
T2 Data-1 j k A P H2
T2 Data-2 j k A P H2

TCP/IP Layers

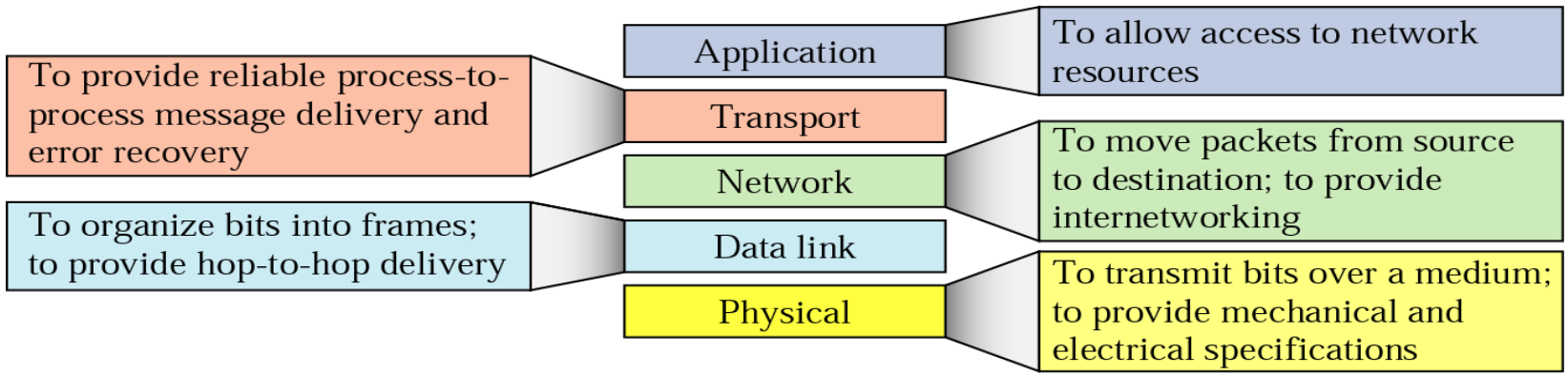
- Application Layer: Concerned with “application” protocols.
  - Issues largely deal with providing services to users and application developers.
- Application layer
  - Combines OSI’s application, presentation, and session layers

Application Layer



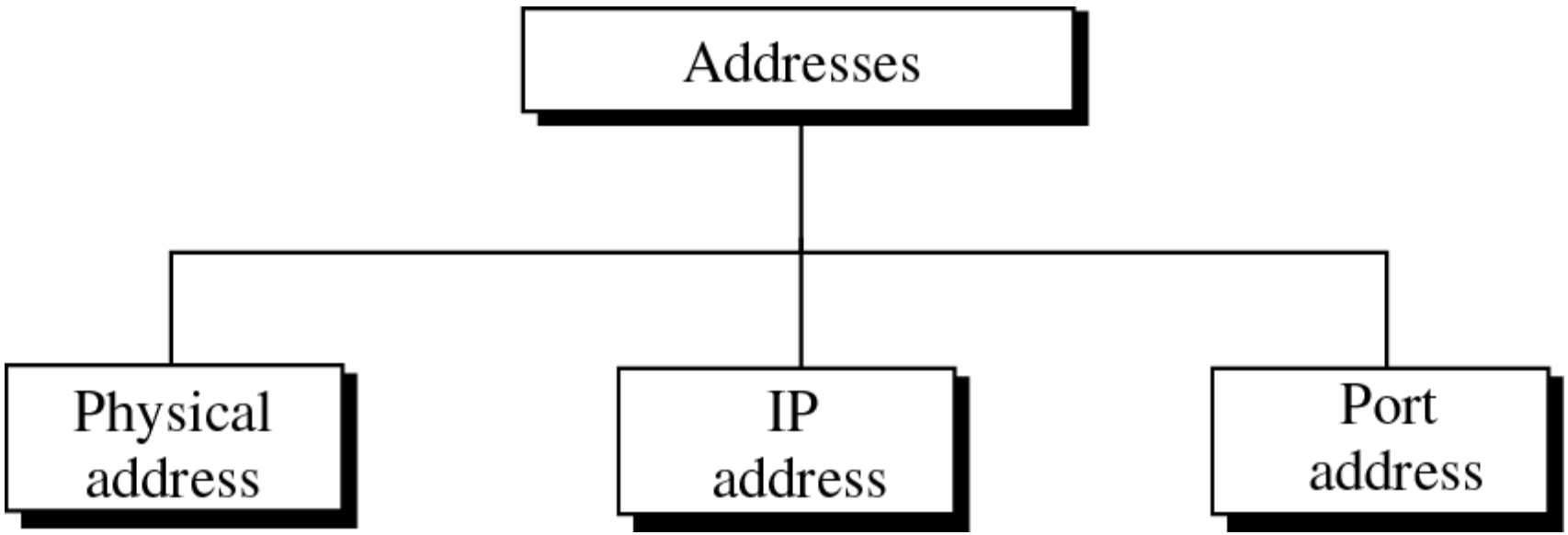
The application layer is responsible for providing services to the user.

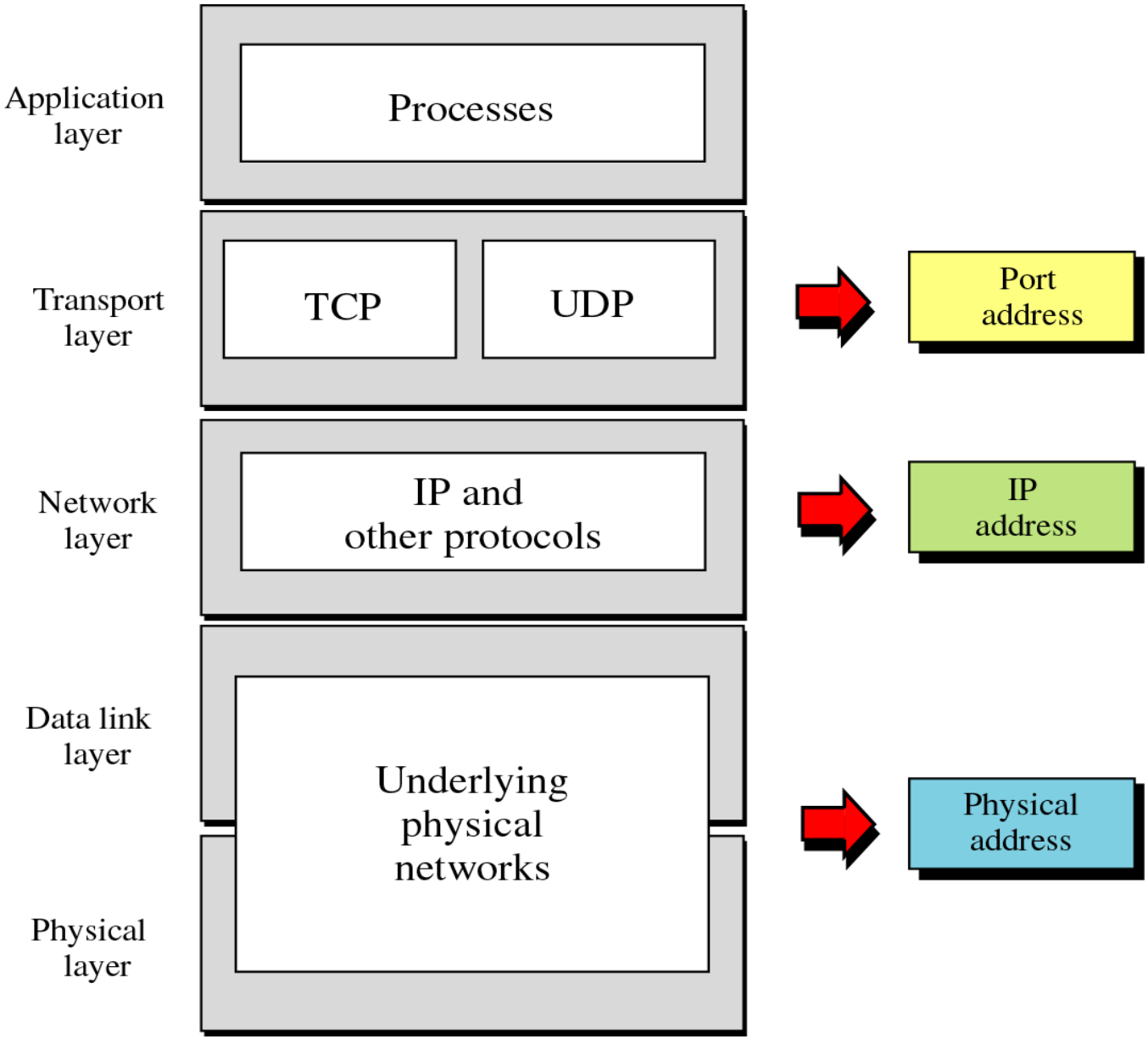
Summary of Layers



TCP/IP Layers

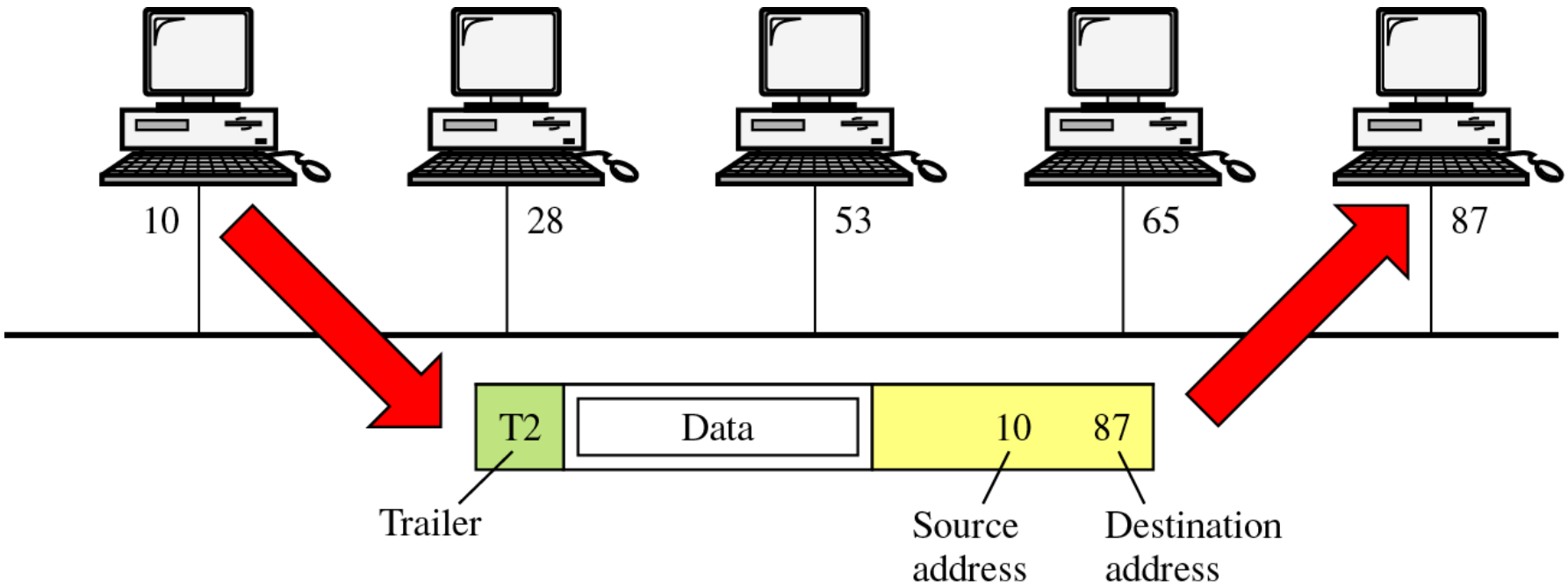
- Multiple levels of addresses
  - Applications: port number, machine name
  - LAN: IP address
  - Machine: physical




Application layer
Processes
Transport layer
TCP
UDP
Port address
Network layer
IP and other protocols
IP address
Data link layer
Underlying physical networks
Physical address
Physical layer

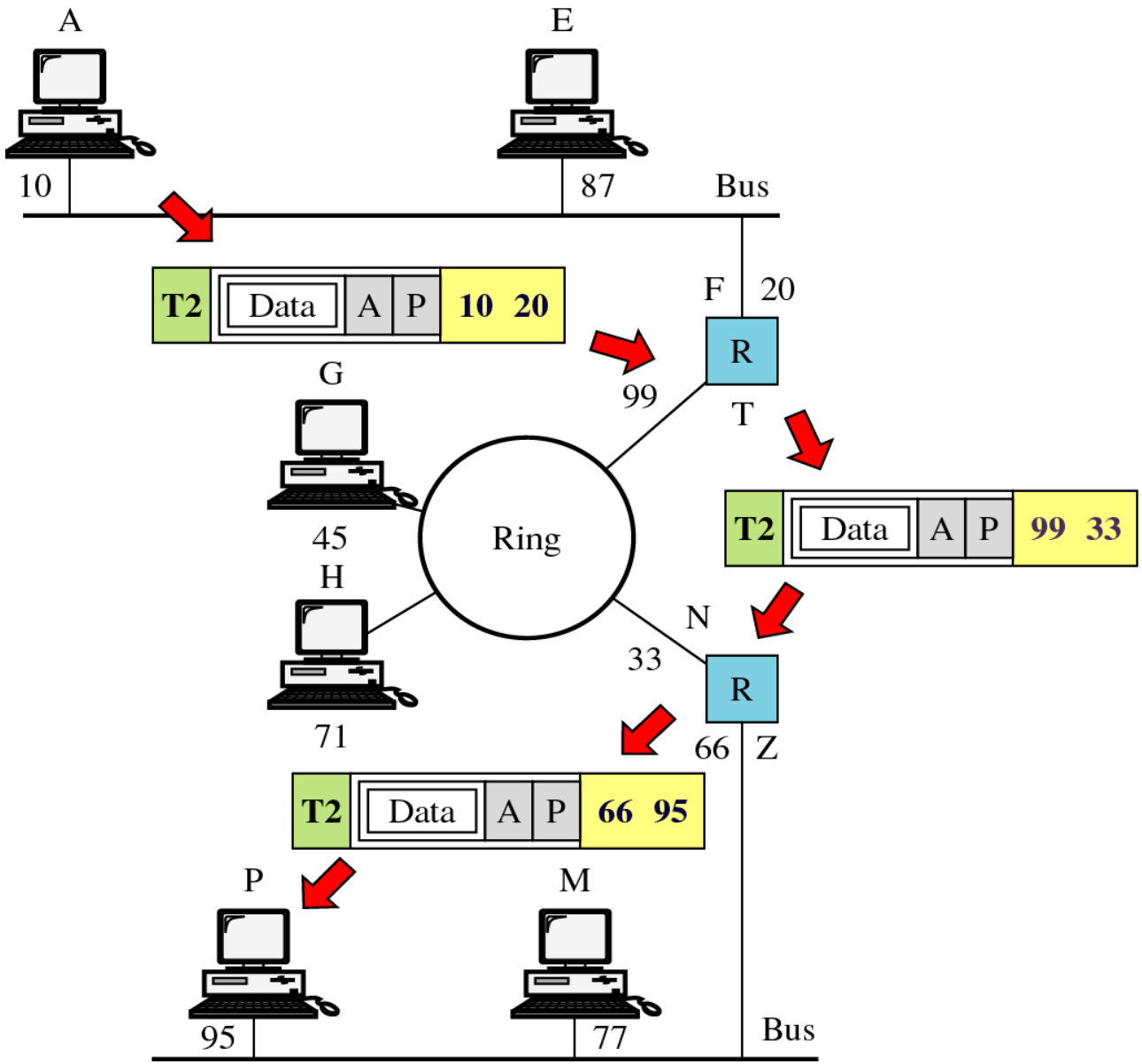
Physical Address

- For one LAN
- Example: IEEE 802.3
  - 48 bits
  - First 24 are manufacturer-specific
  - Has unicast, multicast, and broadcast addressing


10
28
53
65
87
T2
Data
10
87
Trailer
Source address
Destination address

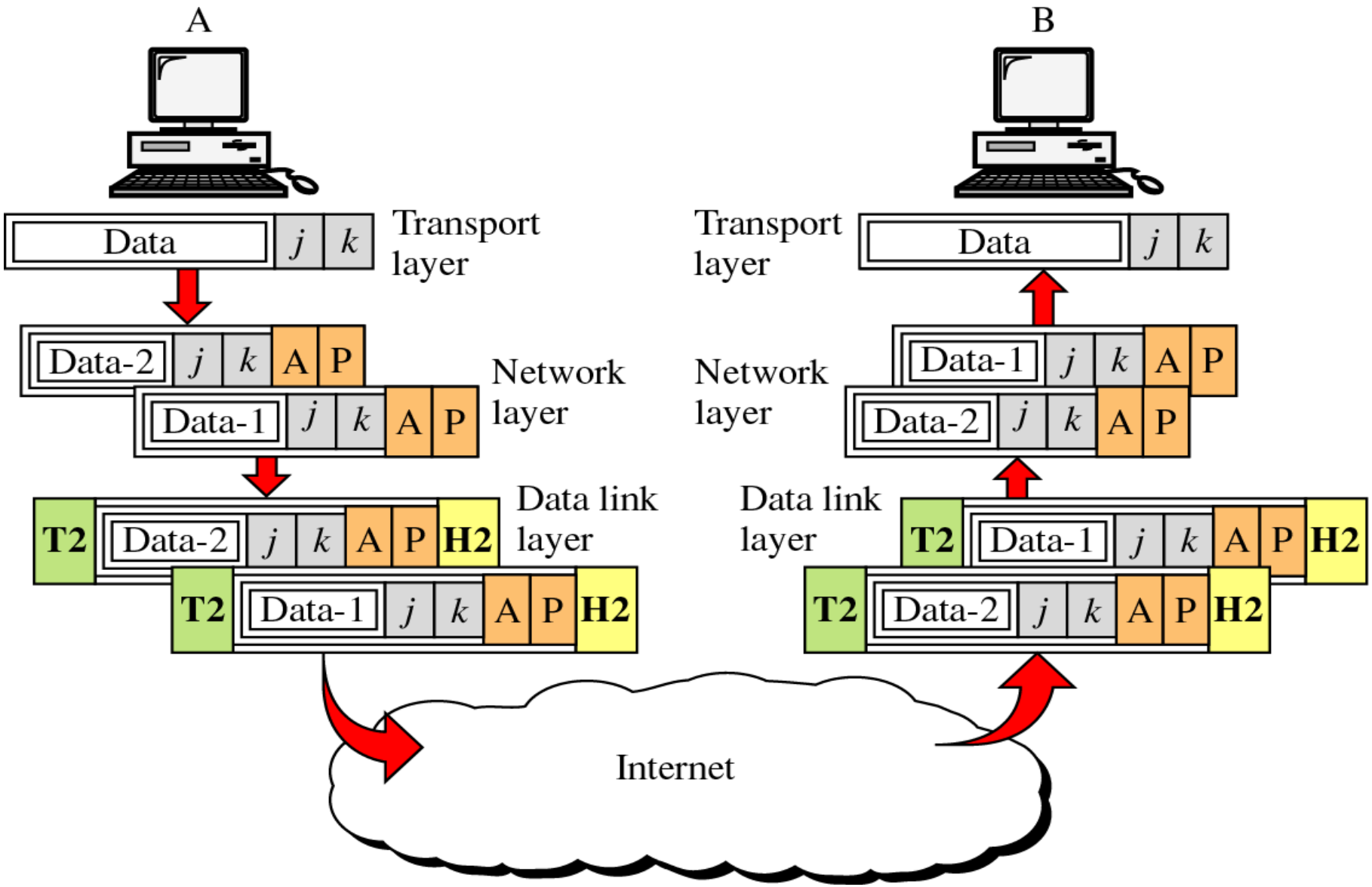
Internet Address

- IPv4: 32 bits
- IPv6: 128 bits
- Virtual as no physical hardware based on IP addresses
- Has unicast, multicast, and broadcast addresses
- Routable


A
E
10
87
Bus
T2
Data
A
P
10 20
F
20
R
99
G
T
45
Ring
T2
Data
A
P
99 33
H
N
33
R
71
66
Z
T2
Data
A
P
66 95
P
M
95
77
Bus

Ports

- 16-bit number in TCP and UDP header
- A *Socket* is the triple: IP address, port number, and TCP or UDP


A
B
Data
j
k
Transport layer
Data-2
A
P
Data-1
Network layer
T2
H2
Data link layer
Internet

Acknowledgement

- All figures obtained from publisher-provided instructor downloads

  Data Communications and Networking, 3rd edition by Behrouz A. Forouzan. McGraw Hill Publishing, 2004

  TCP/IP Protocol Suit by Behrouz A. Forouzan McGraw Hill Publishing