

EITF25 Internet--Techniques and Applications

Stefan Höst

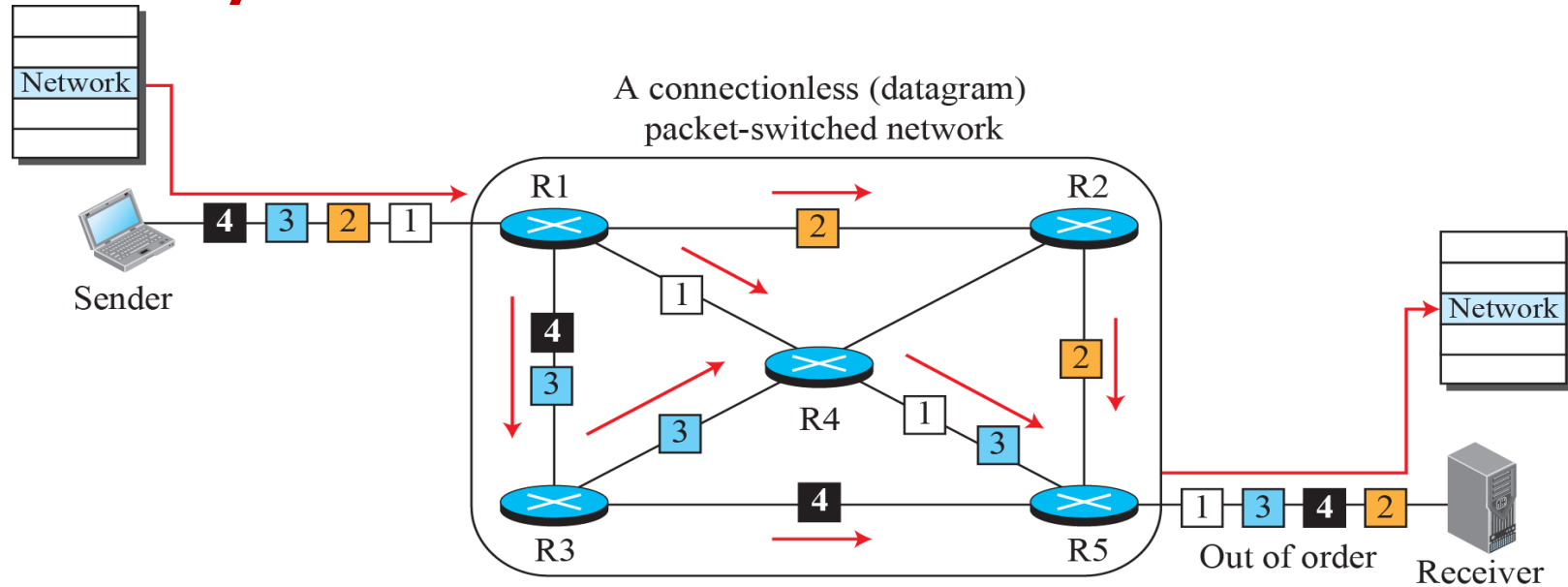
L8 Transport layer



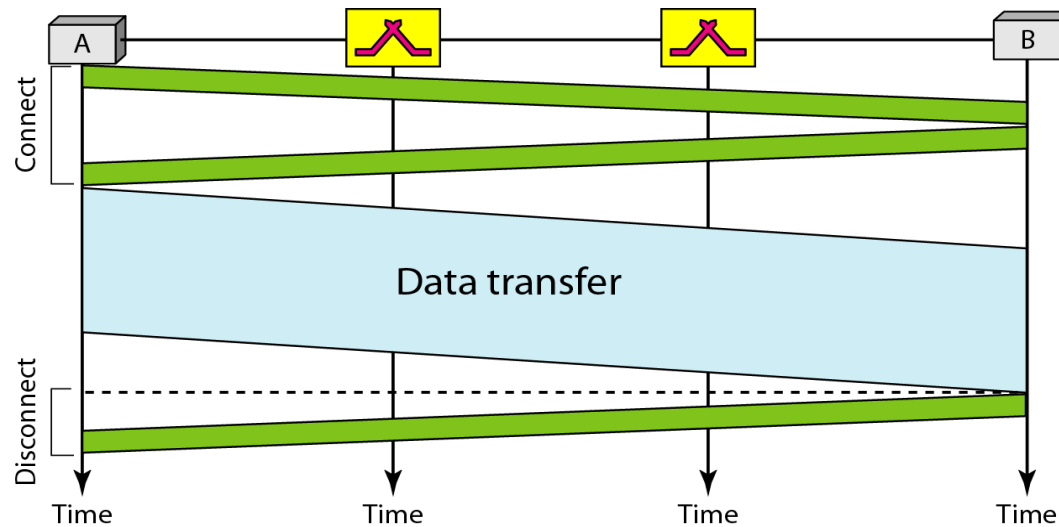
LUND
UNIVERSITY

Network Layer

- L3



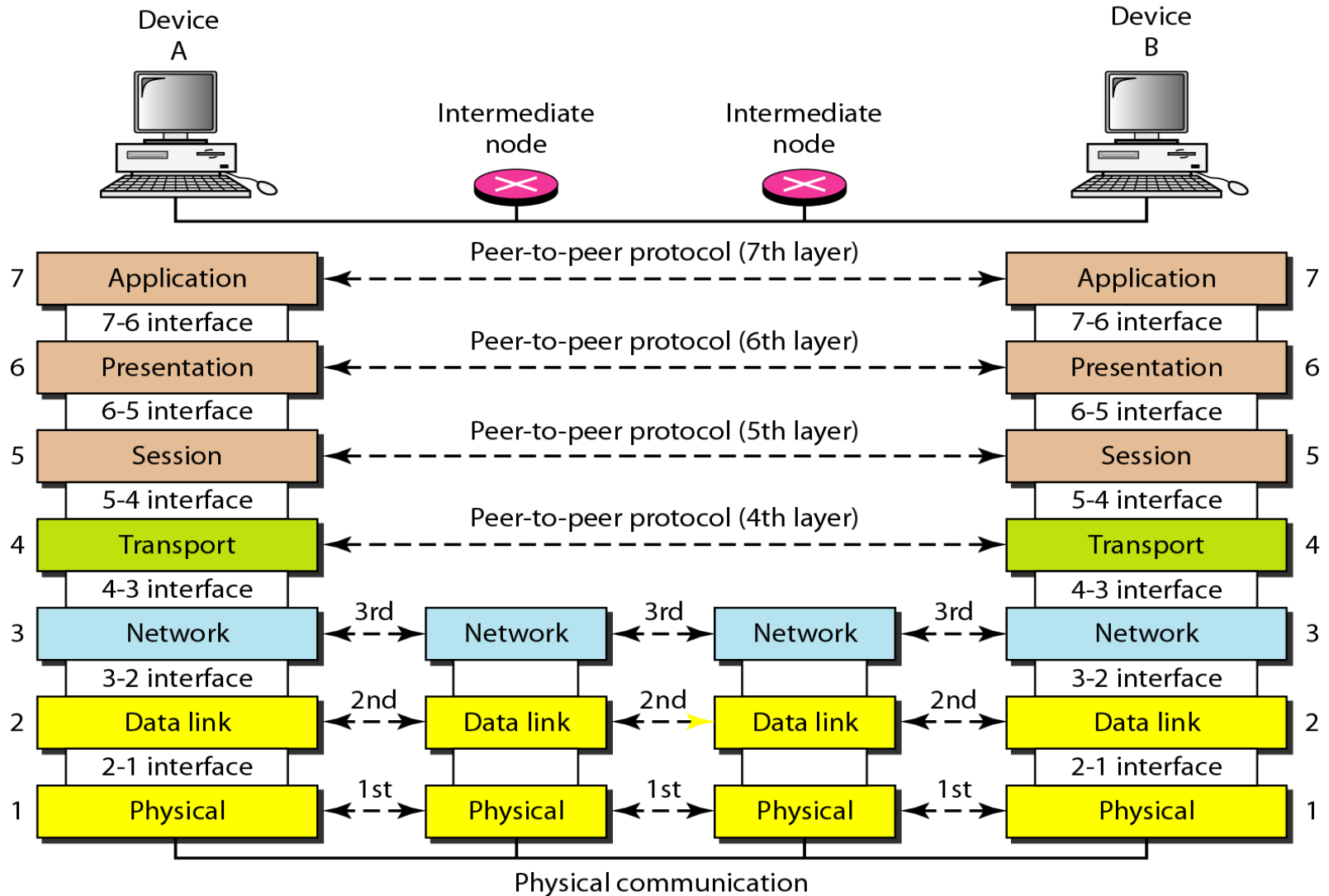
- L4?



Transport Layer

- Communication between applications
- Process-to-process delivery
- Client/server concept
 - Local host
 - Remote host
- Transport Protocol
 - Even more end-to-end

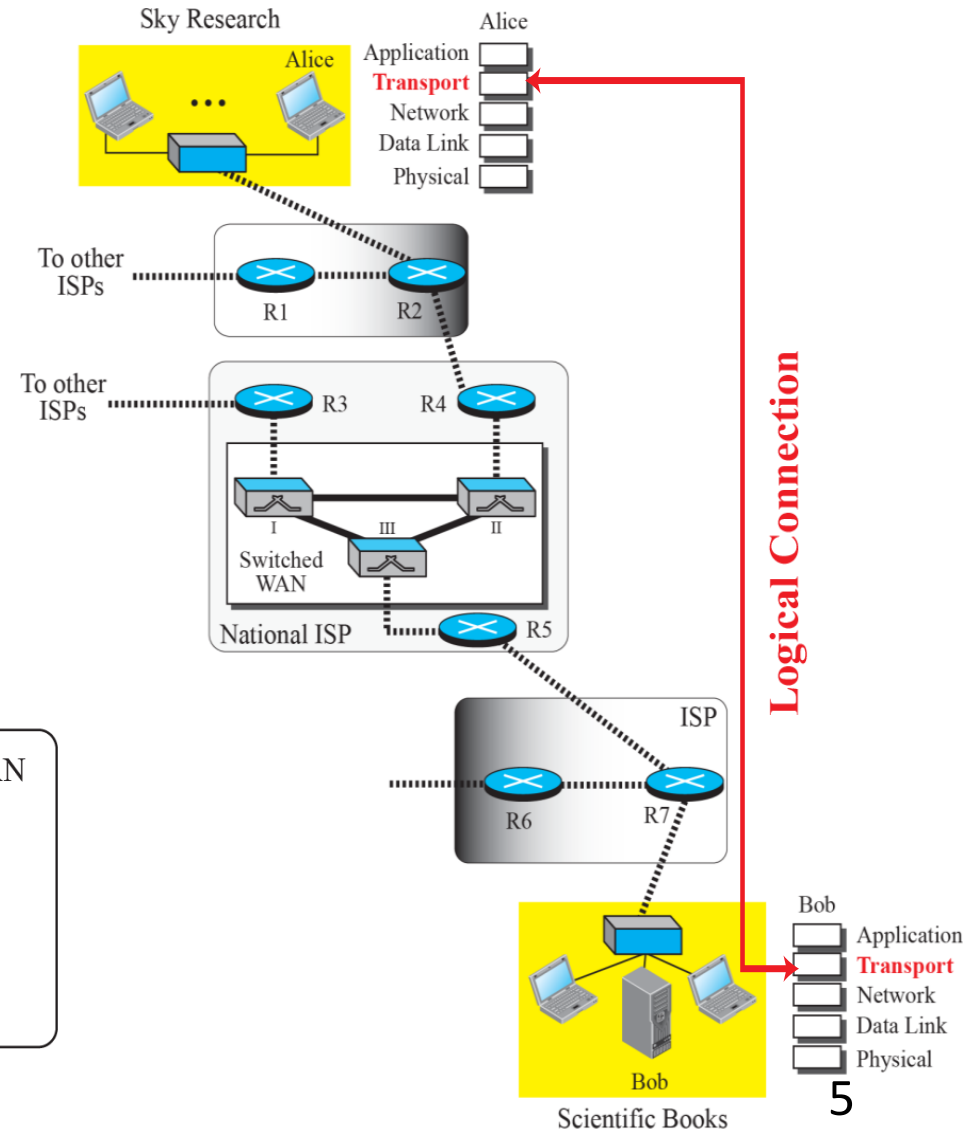
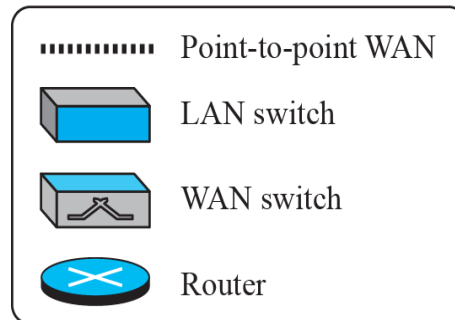
Transport Layer



Logical end-to-end connection

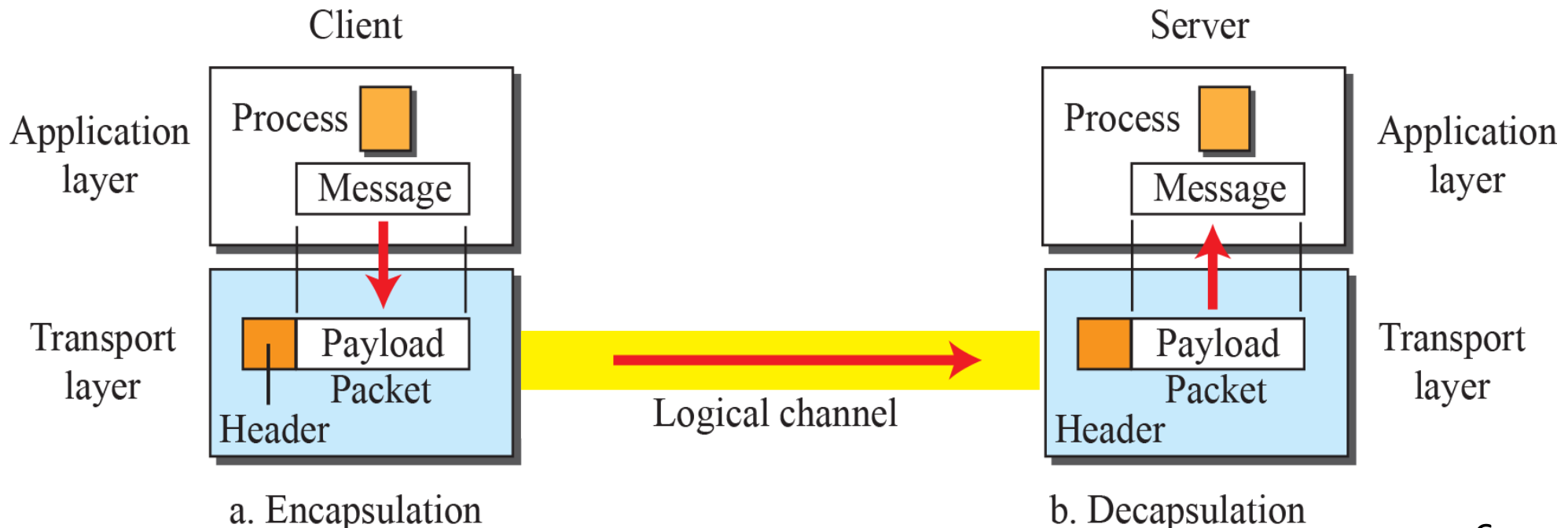
- Transport protocol creates a logical (virtual) connection between source and destination.

Legend



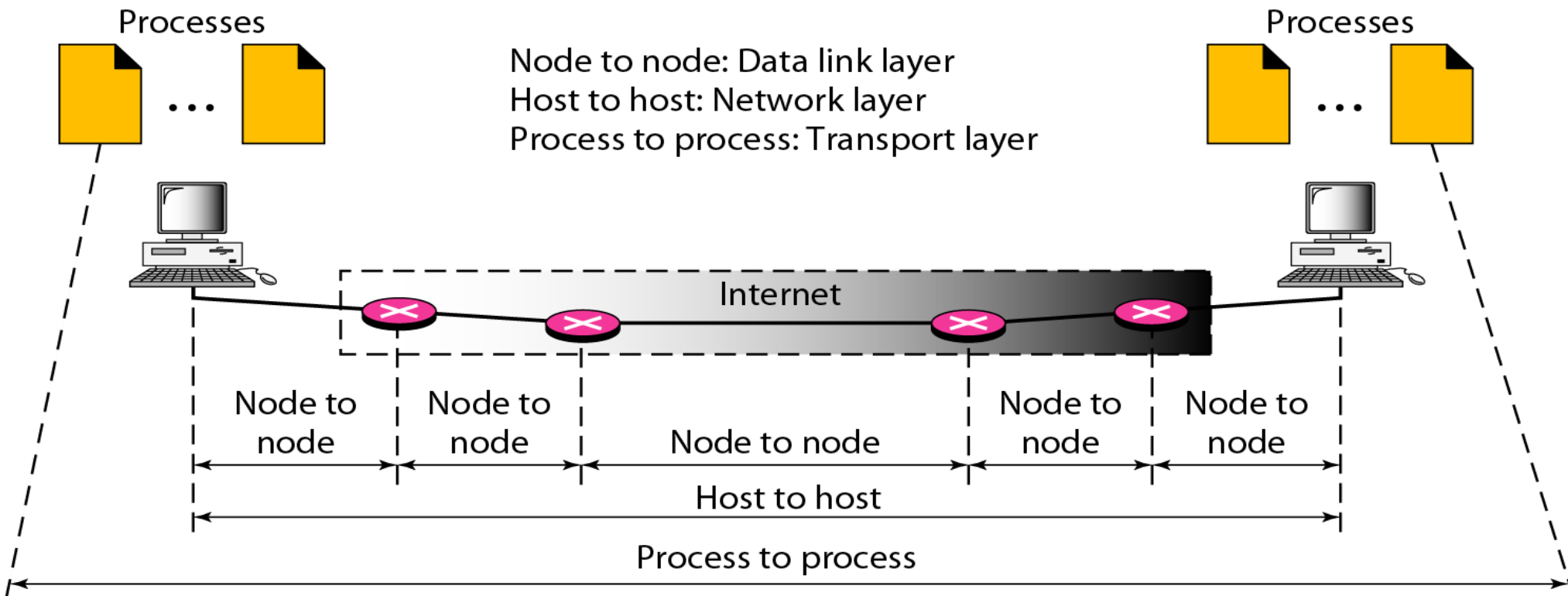
Transport protocol

- Encapsulates application data and ensures that it is sent to the correct receiving application to be decapsulated and used



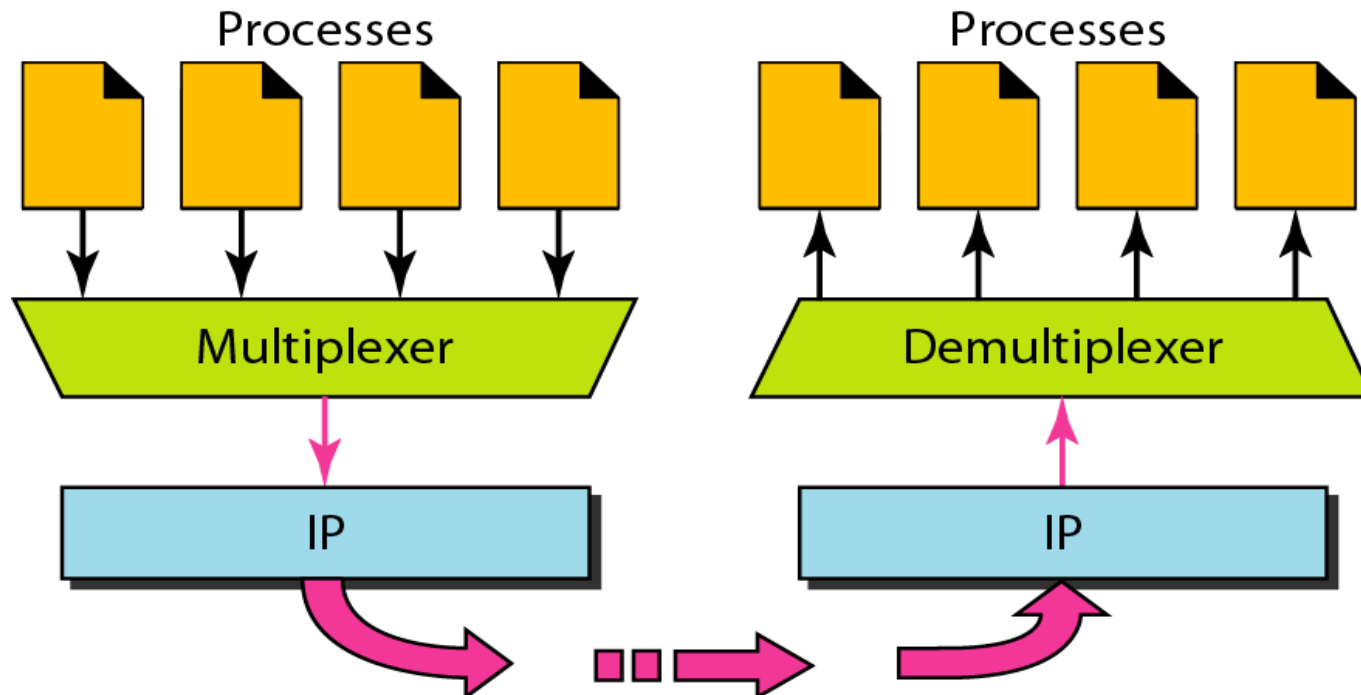
Host-to-host delivery

- Multiple applications even on the same host



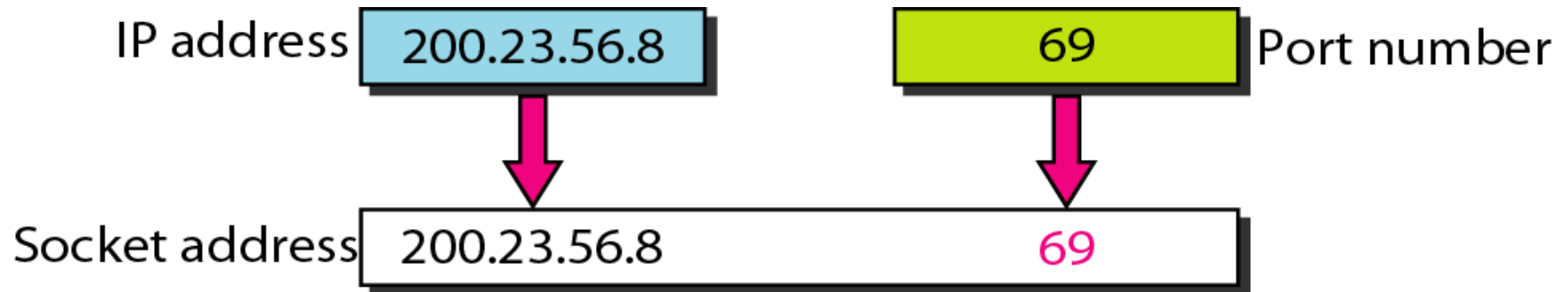
Multiplexing and demultiplexing

- **Socket addresses** allow multiplexing and demultiplexing multiple applications' data



Socket addresses

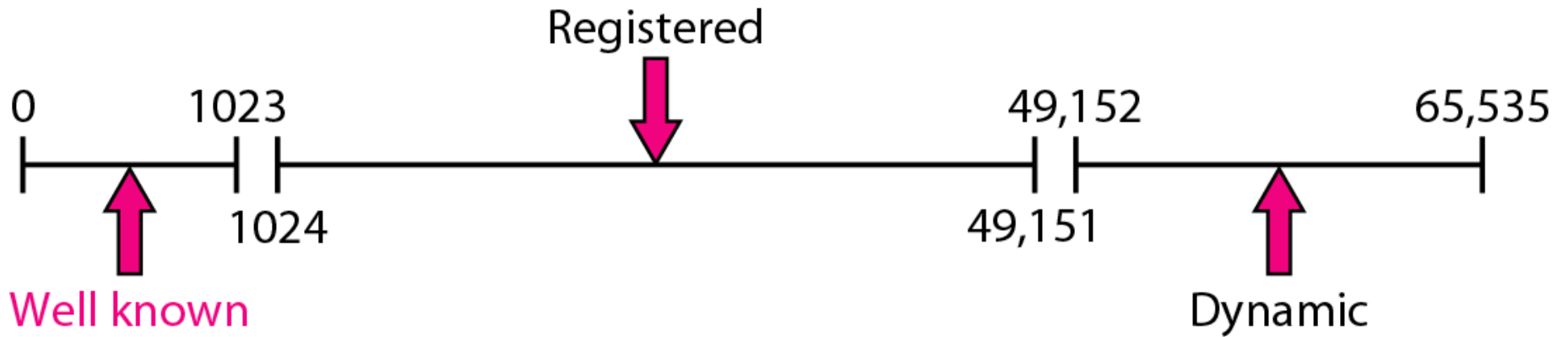
- Combination of IP address & port number
 - Unique for each process on the host



Port numbers

- Internet Cooperation for Assigned Names and Numbers Authority (ICANN) defines 3 types
 - **Well-known** ports (**0-1023**), assigned and controlled by Internet Assigned Numbers Authority (IANA)
 - **Registered** ports (**1024-49151**), to be registered with IANA to prevent duplication
 - **Dynamic** ports (**49152-65535**), neither controlled nor registered, to be used by any application

Port number ranges



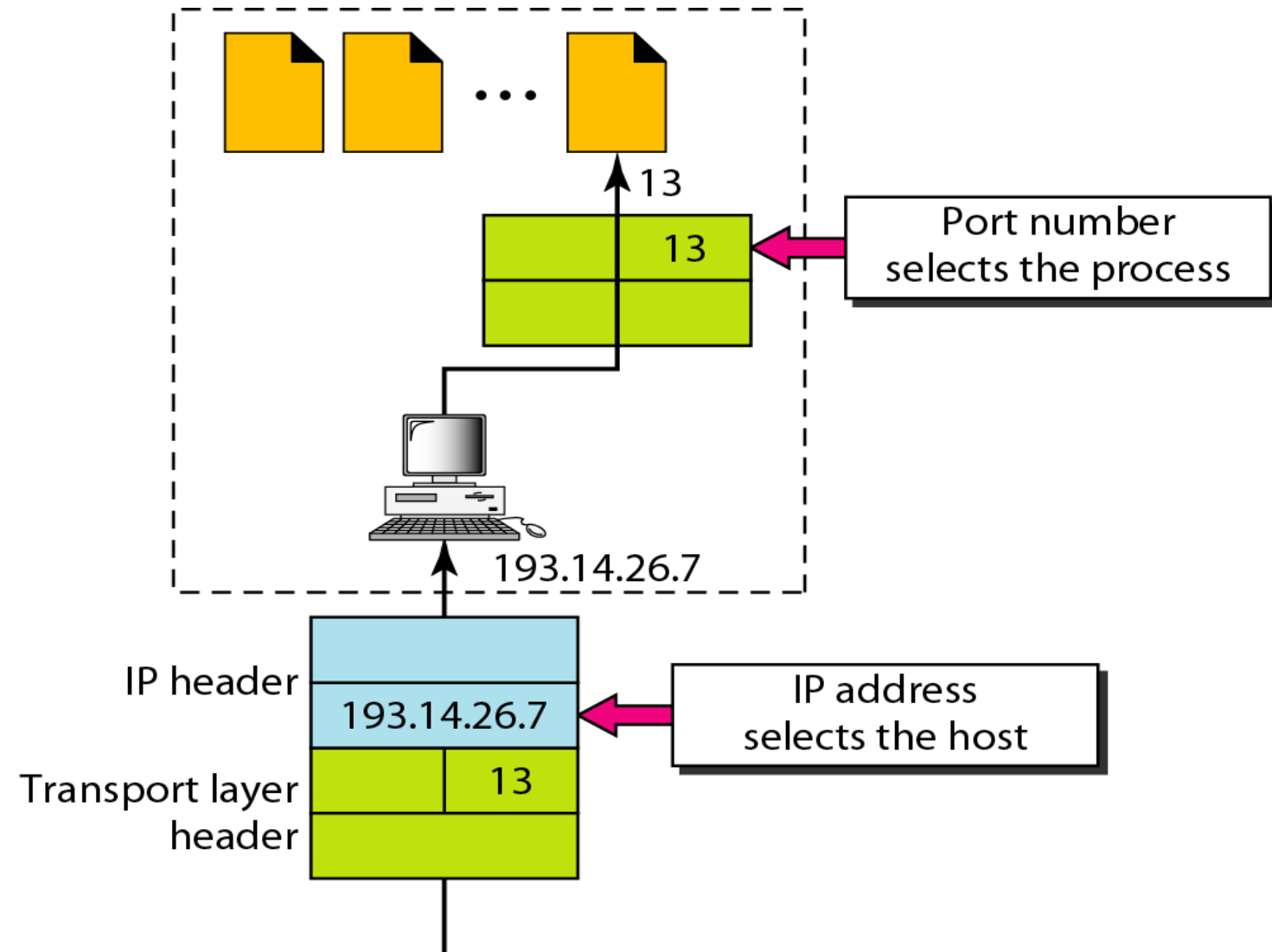
TCP

Port	Protocol	Description
7	Echo	Echoes a received datagram back to the sender
9	Discard	Discards any datagram that is received
11	Users	Active users
13	Daytime	Returns the date and the time
17	Quote	Returns a quote of the day
19	Chargen	Returns a string of characters
20	FTP, Data	File Transfer Protocol (data connection)
21	FTP, Control	File Transfer Protocol (control connection)
23	TELNET	Terminal Network
25	SMTP	Simple Mail Transfer Protocol
53	DNS	Domain Name Server
67	BOOTP	Bootstrap Protocol
79	Finger	Finger
80	HTTP	Hypertext Transfer Protocol
111	RPC	Remote Procedure Call

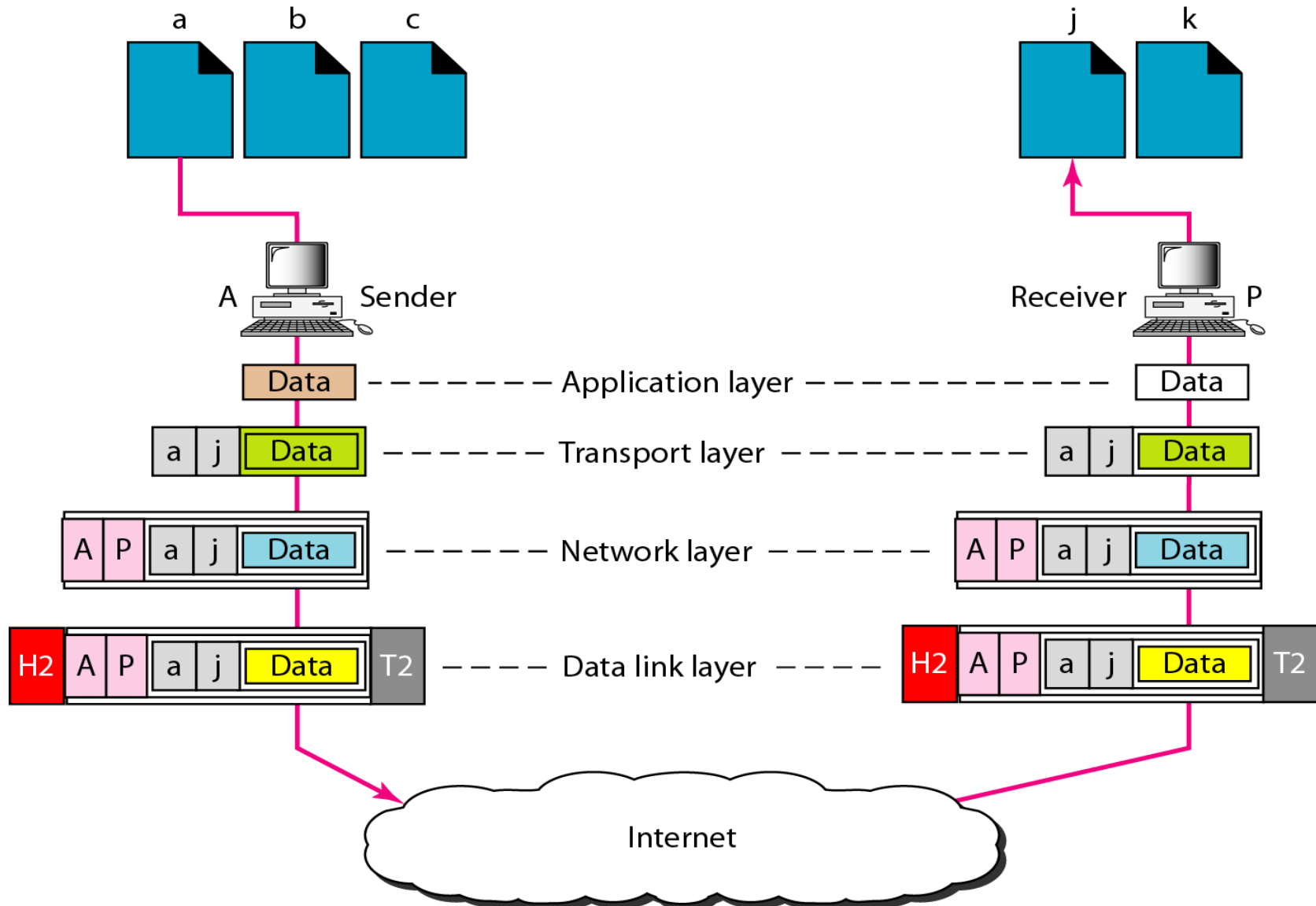
UDP

Port	Protocol	Description
7	Echo	Echoes a received datagram back to the sender
9	Discard	Discards any datagram that is received
11	Users	Active users
13	Daytime	Returns the date and the time
17	Quote	Returns a quote of the day
19	Chargen	Returns a string of characters
53	Nameserver	Domain Name Service
67	BOOTPs	Server port to download bootstrap information
68	BOOTPc	Client port to download bootstrap information
69	TFTP	Trivial File Transfer Protocol
111	RPC	Remote Procedure Call
123	NTP	Network Time Protocol
161	SNMP	Simple Network Management Protocol
162	SNMP	Simple Network Management Protocol (trap)

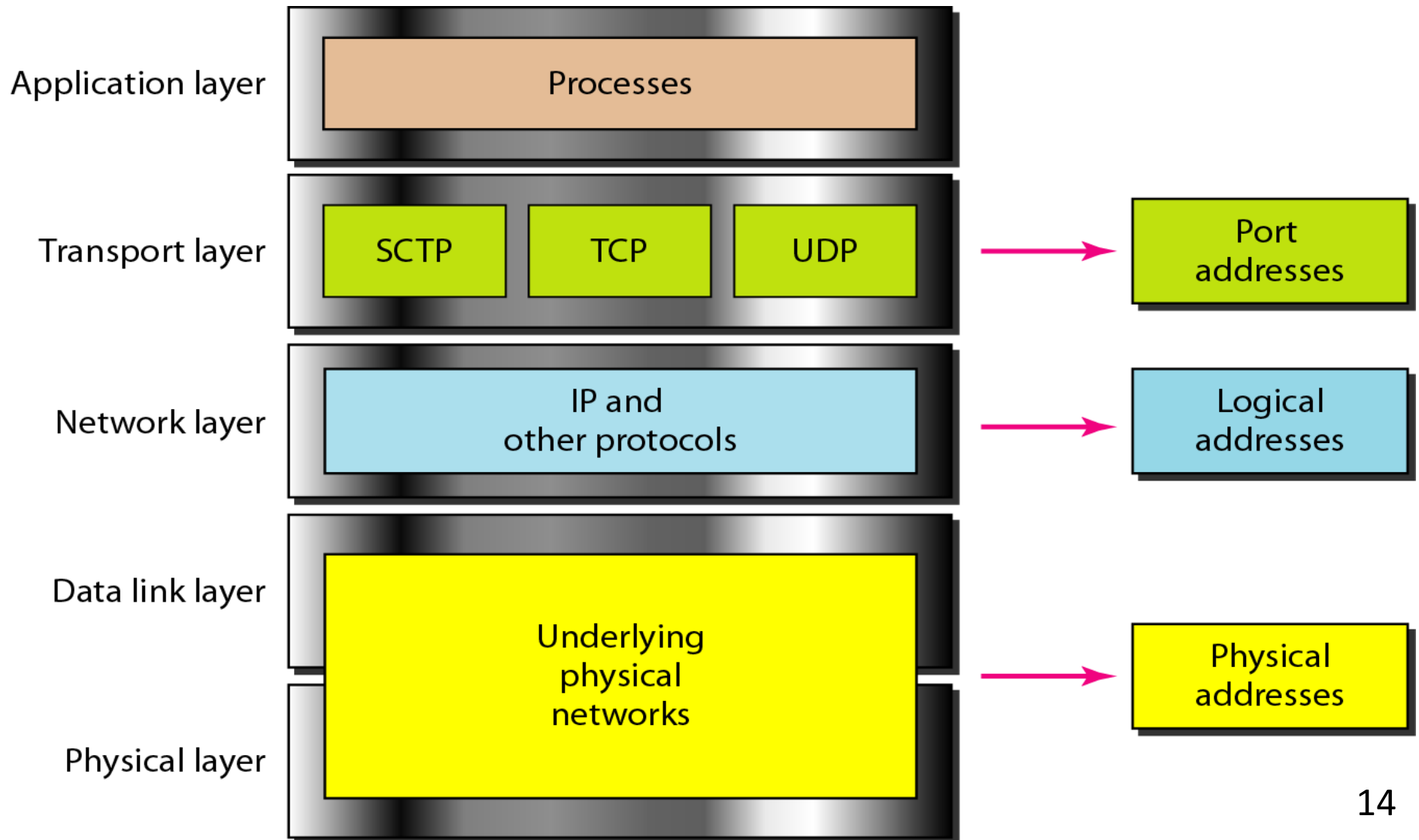
IP addresses and port numbers



Logical and port addresses

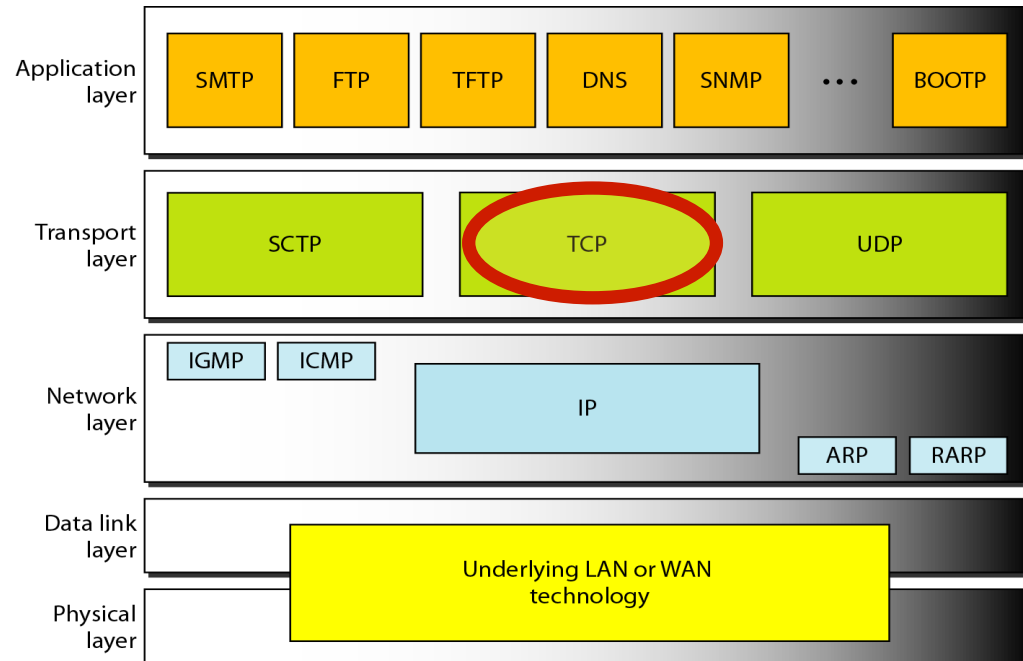


Addressing in TCP/IP

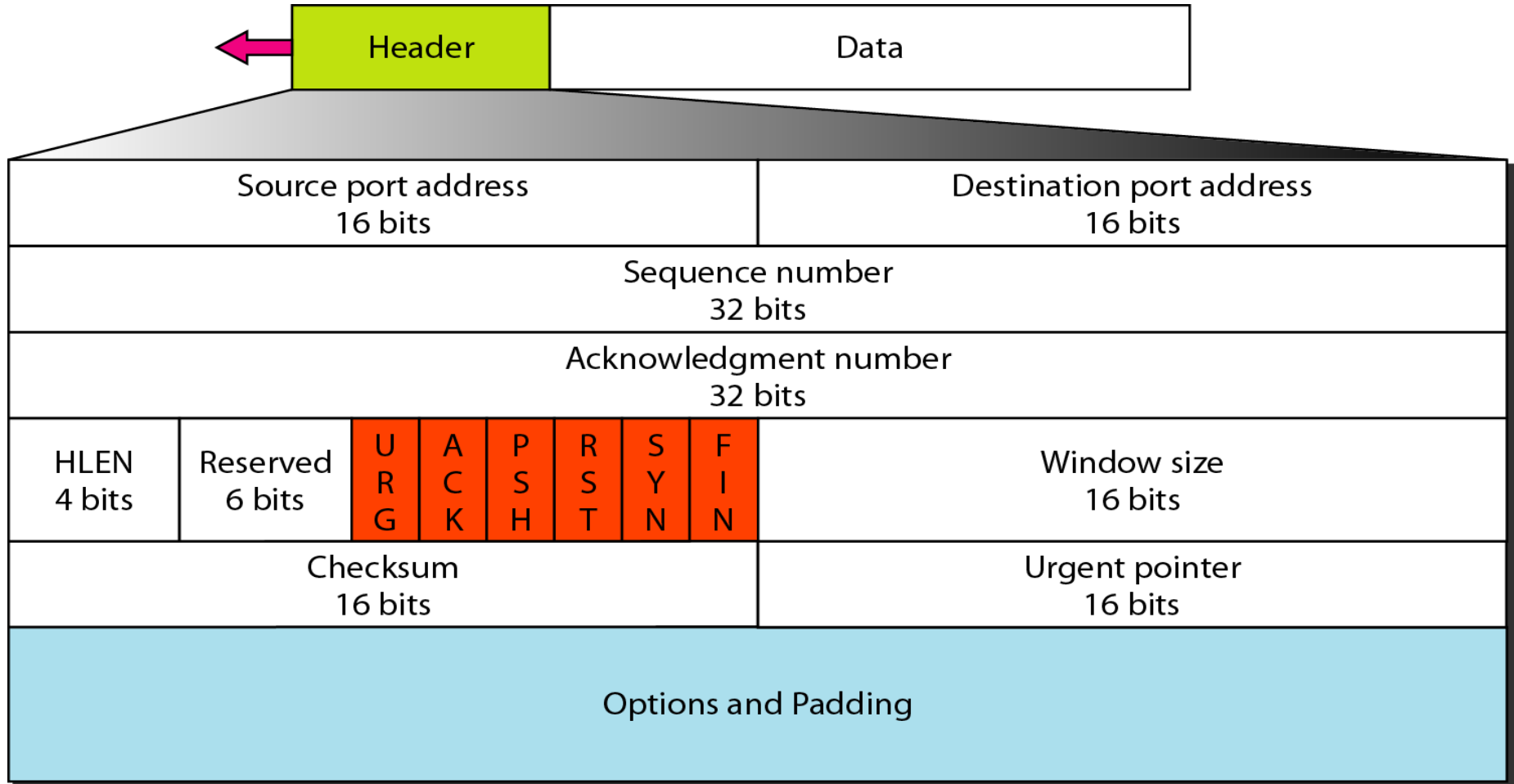


Transmission Control Protocol (TCP)

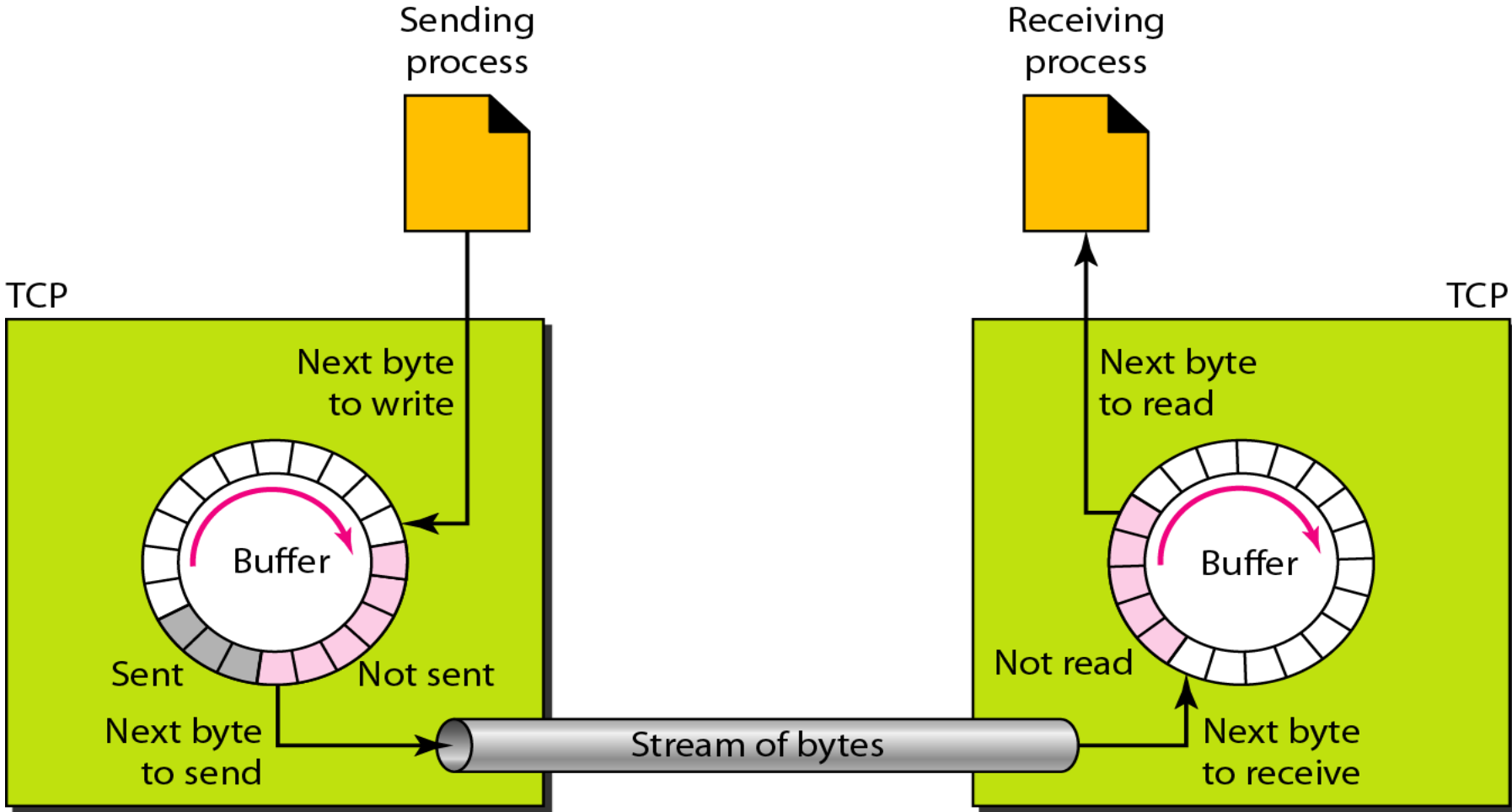
- Connection-oriented
 - Sessions
 - Byte stream service
 - Sequence numbers
- Reliable
 - Flow control
 - Error control
 - Retransmissions
 - Congestion control



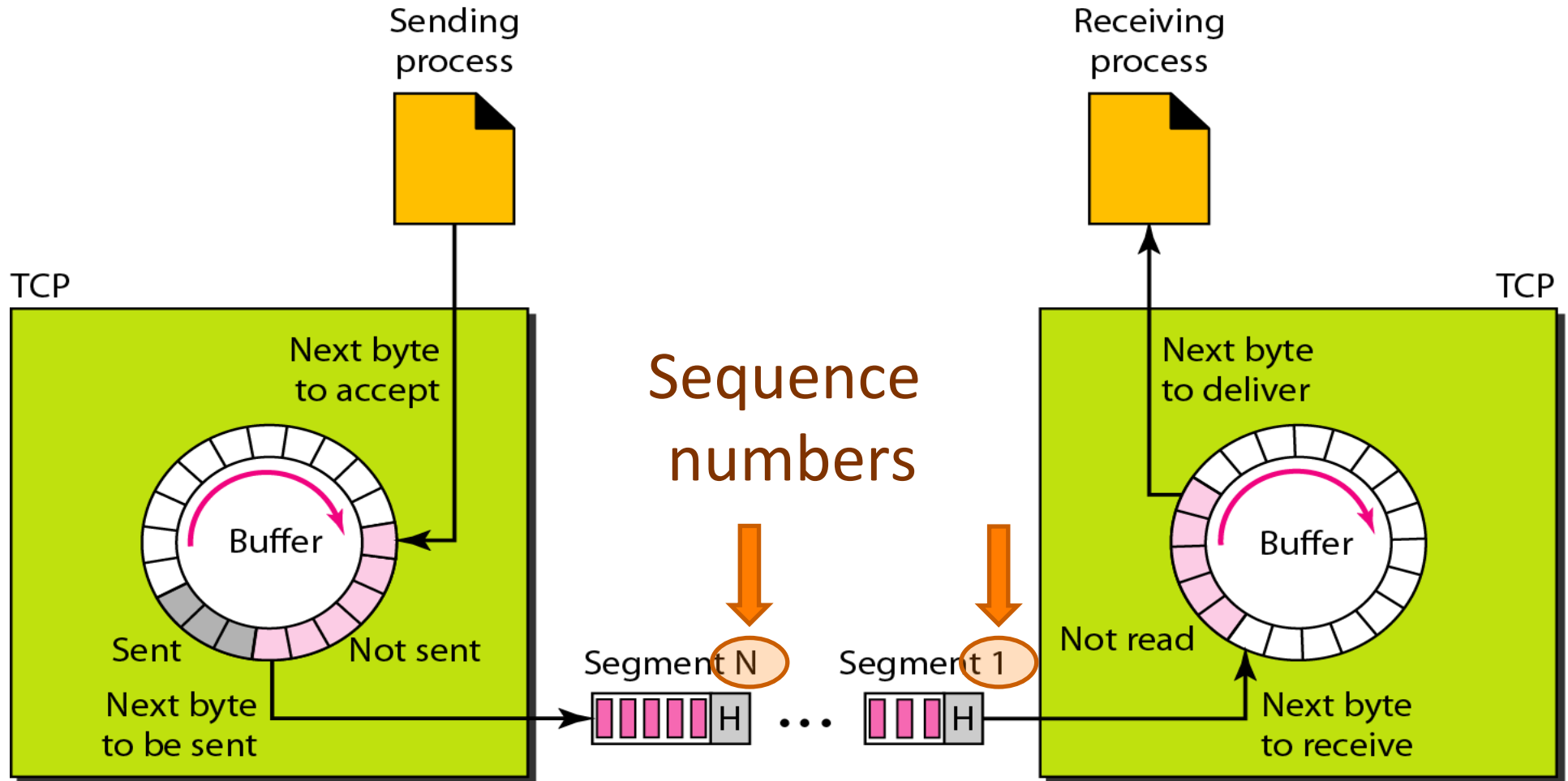
TCP header format



Sending and receiving buffers...



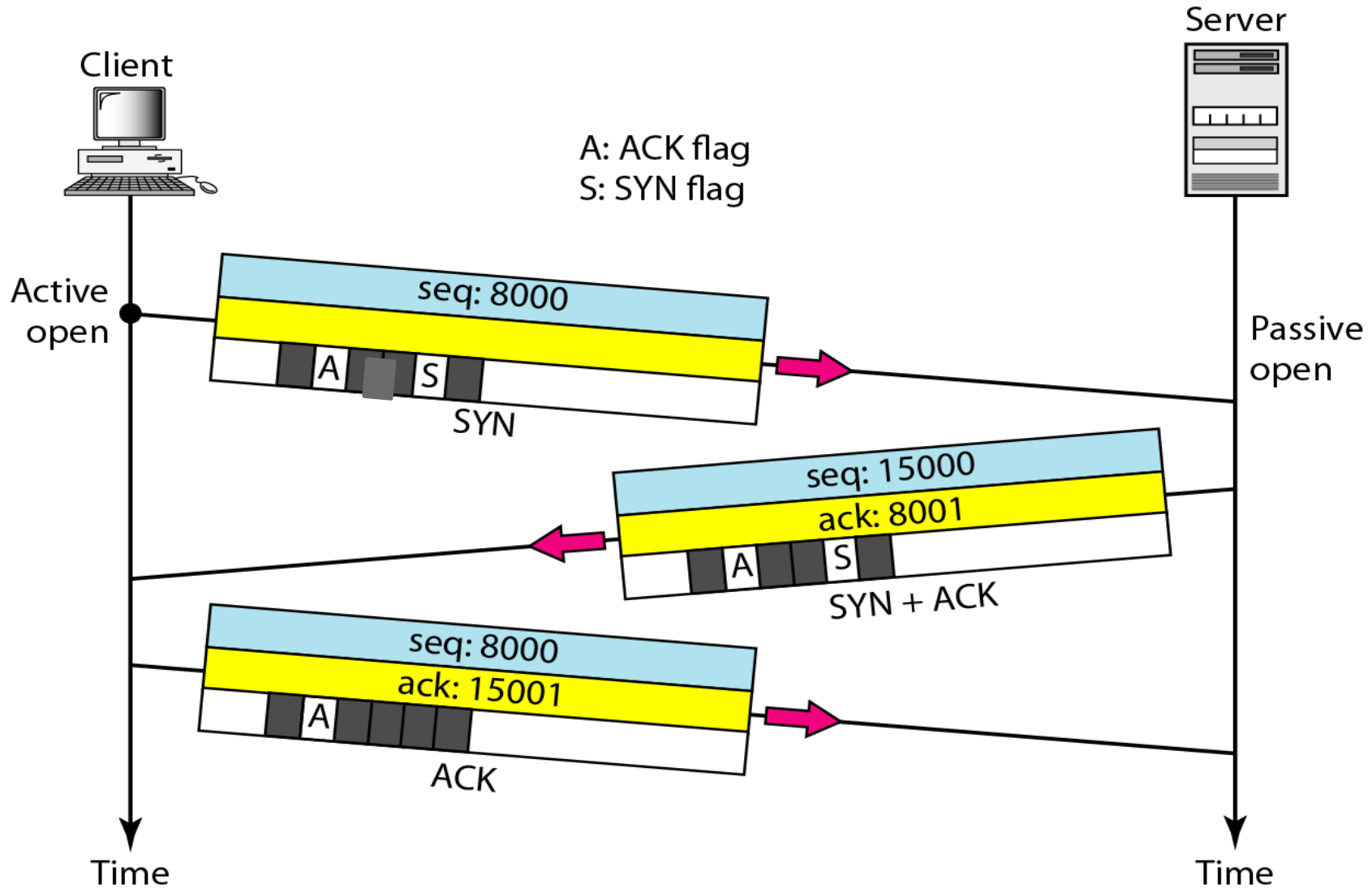
... turned into Segments



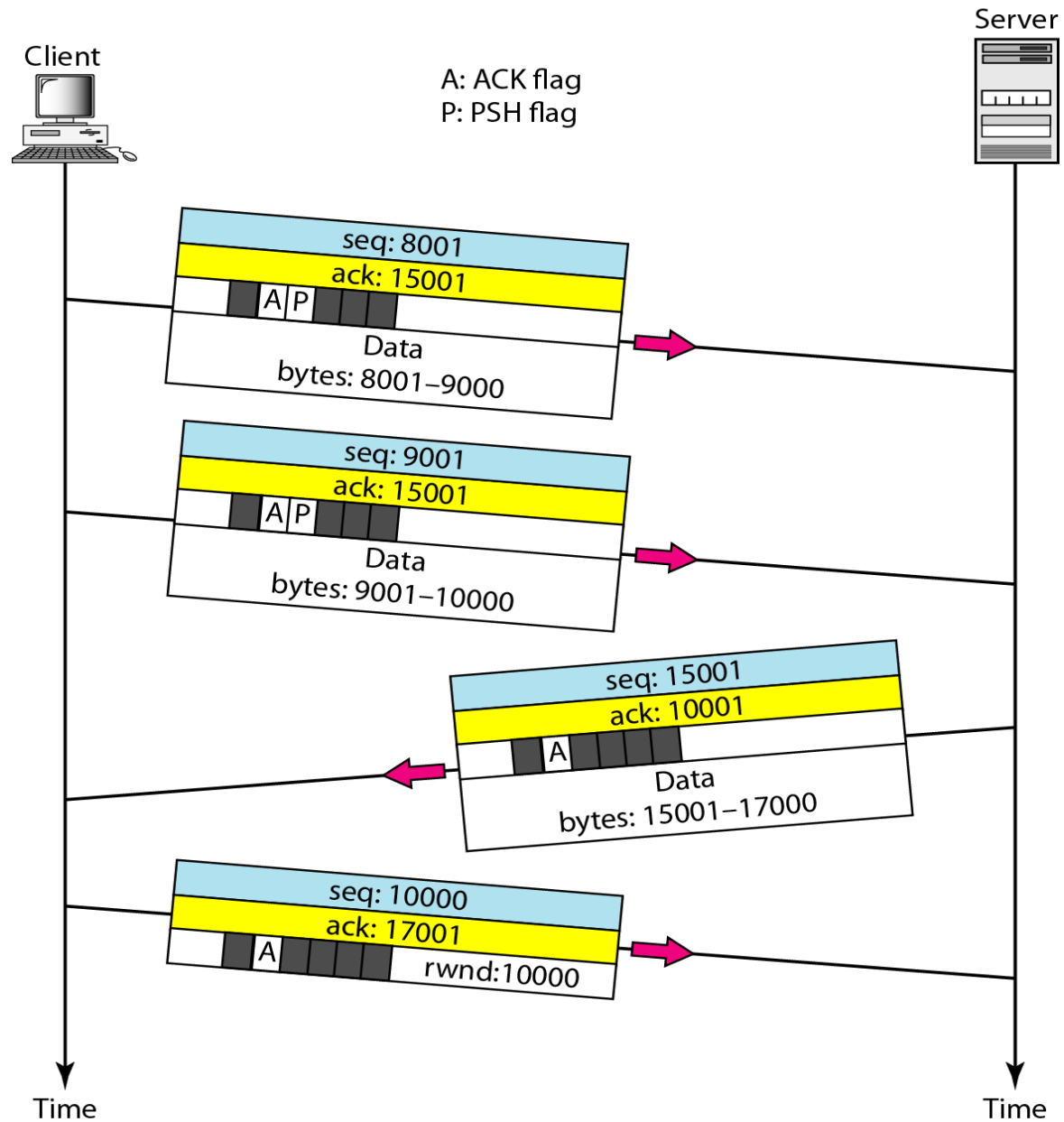
TCP operation

- Connection establishment
 - Three-way handshake
- Data transfer
 - Flow control
(→ congestion control)
 - Error control
(→ go back N with selective repeat)
- Connection termination
 - Three-way handshake
 - Half-close

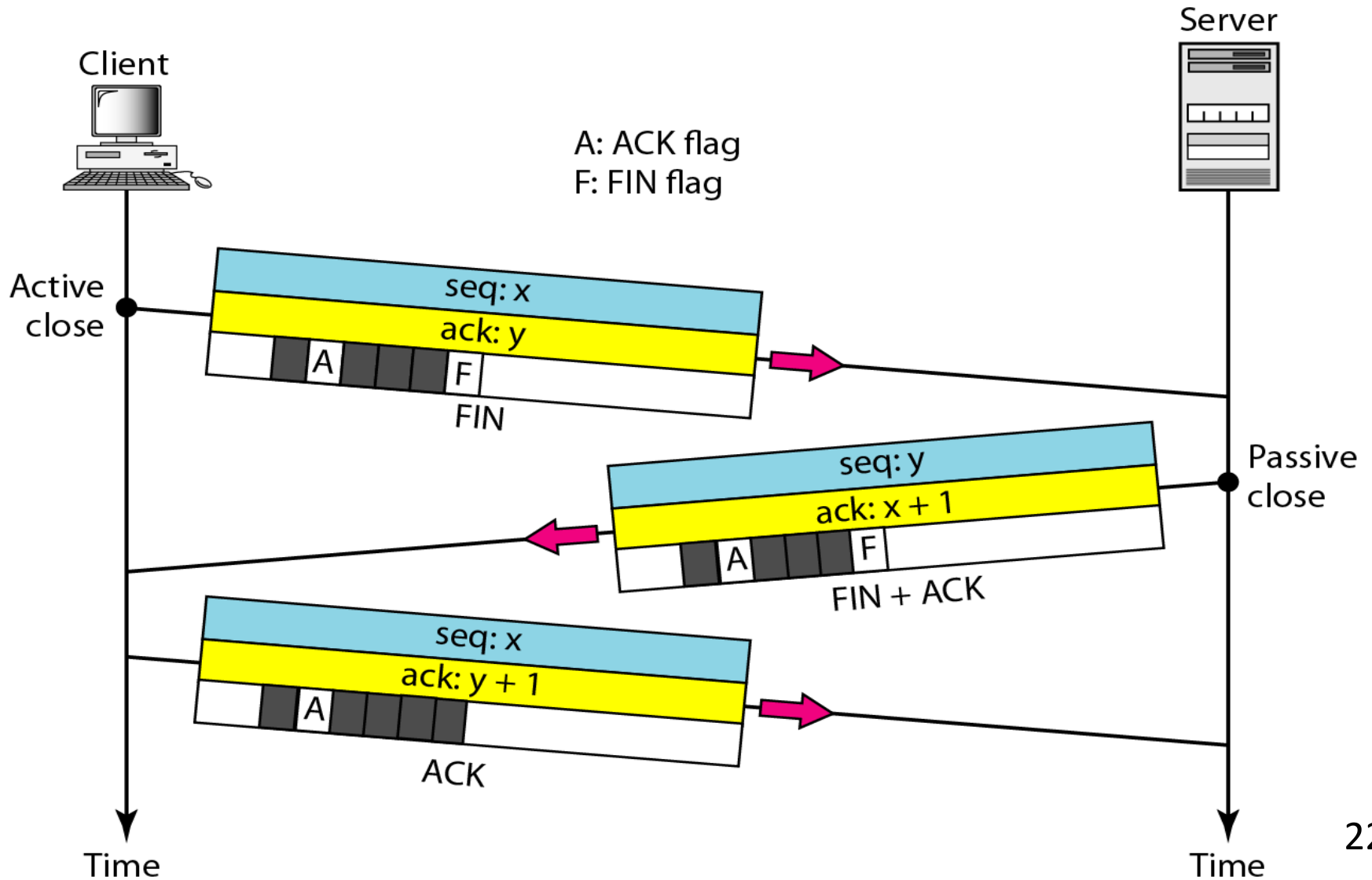
Connection establishment



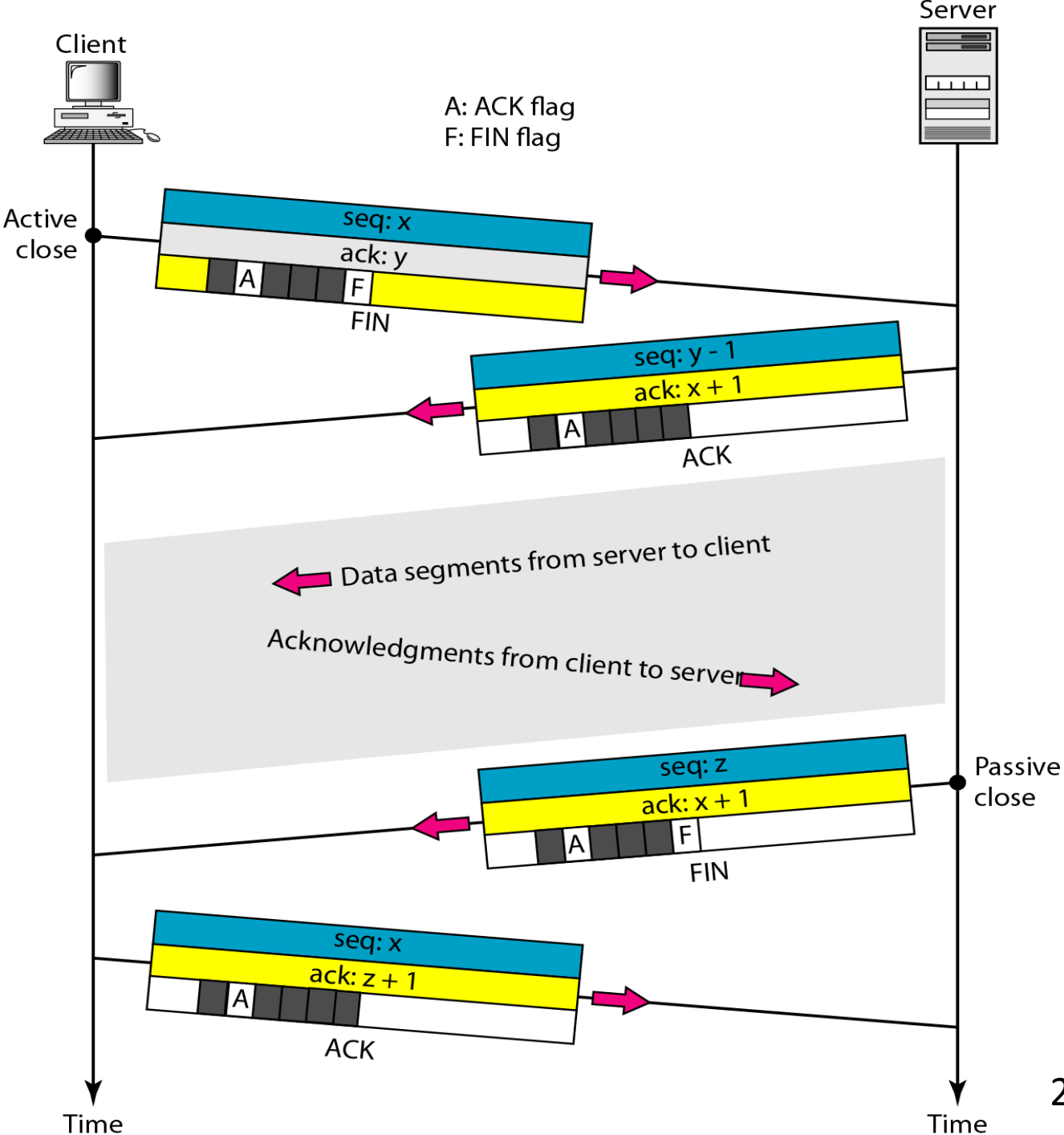
Data transfer



Connection termination



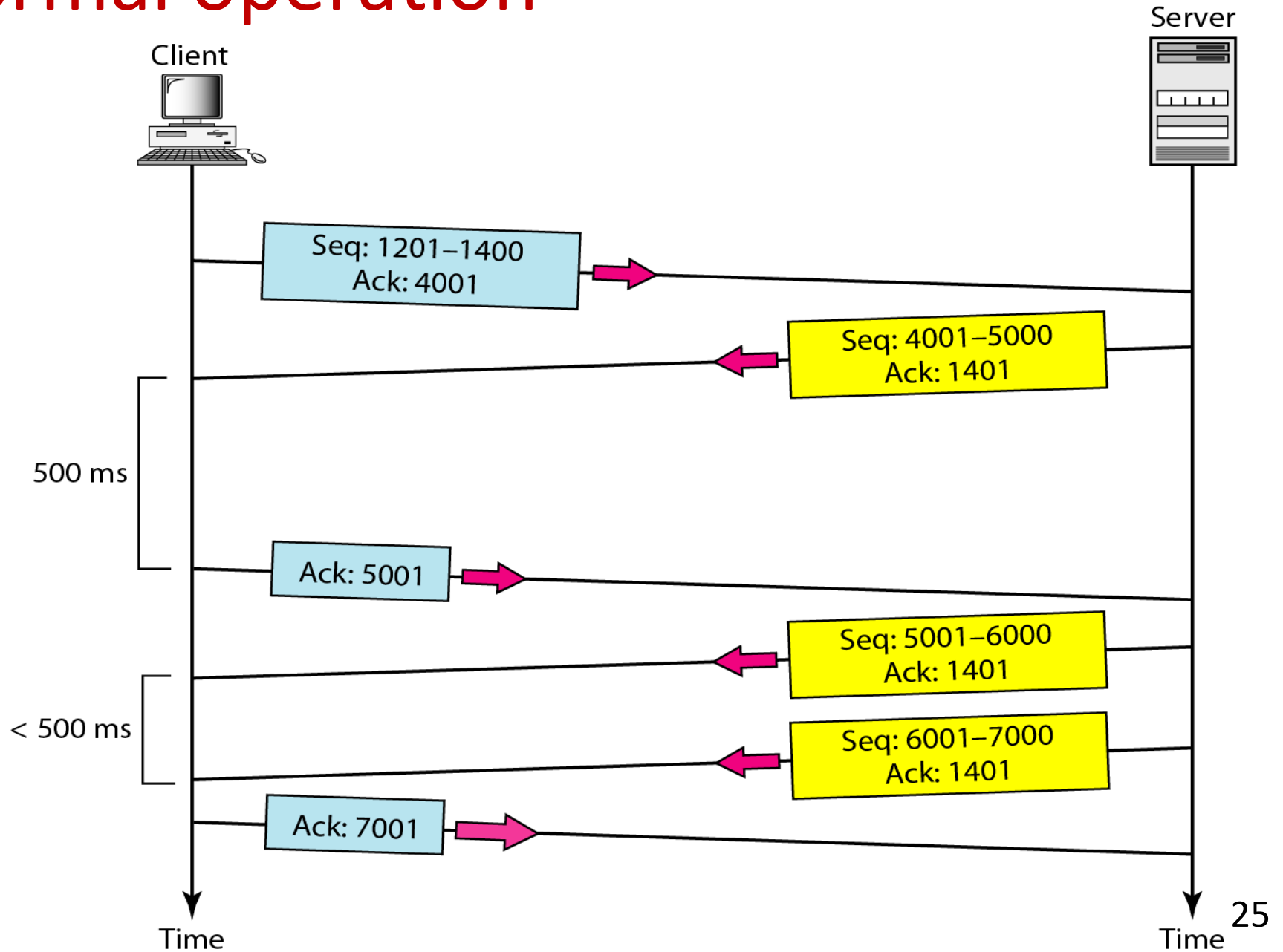
Half-close



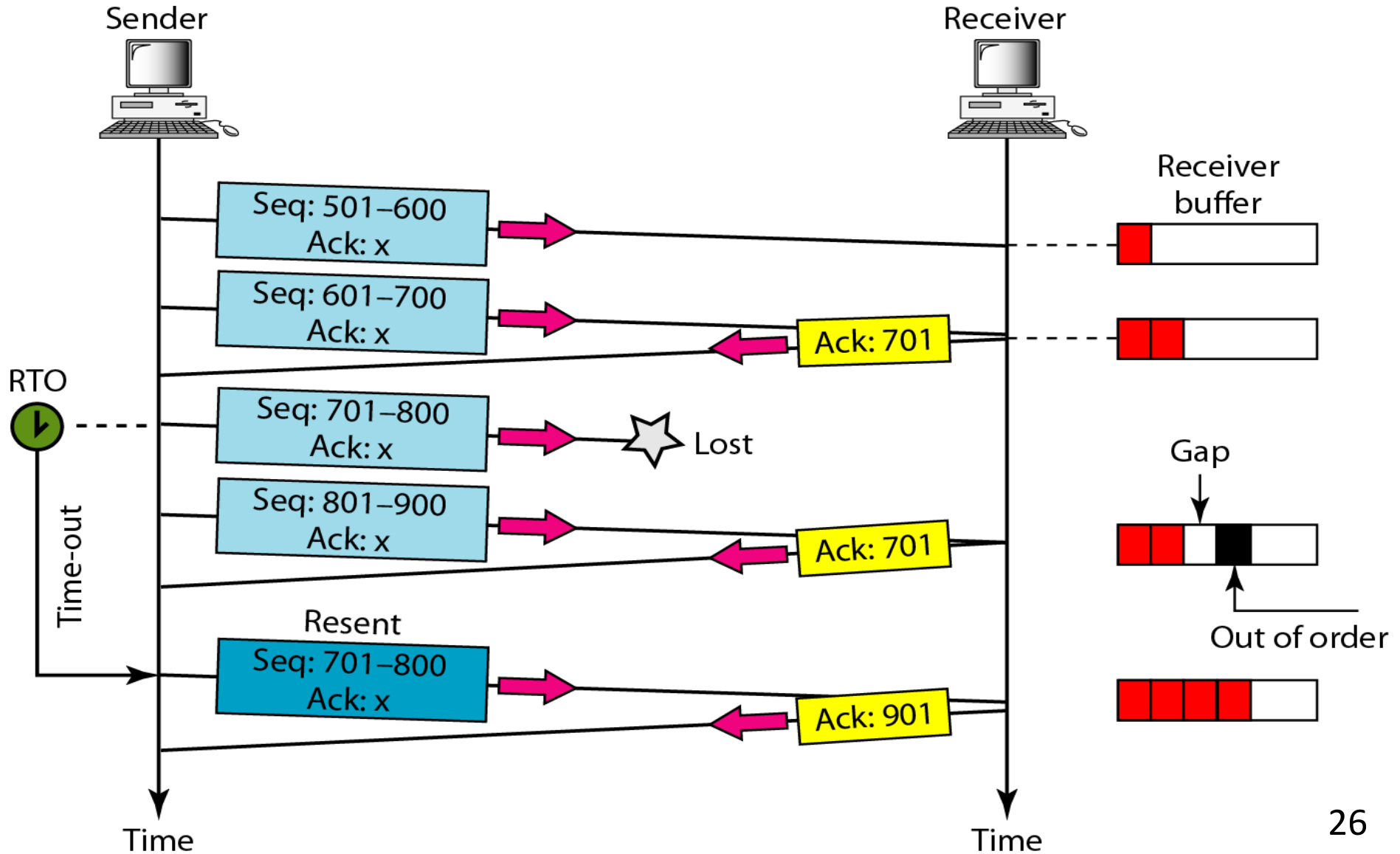
Error control in TCP

- Checksum
- Acknowledgement
 - ACK received data
- Retransmission
 - After time-out
 - After 3 duplicate ACK

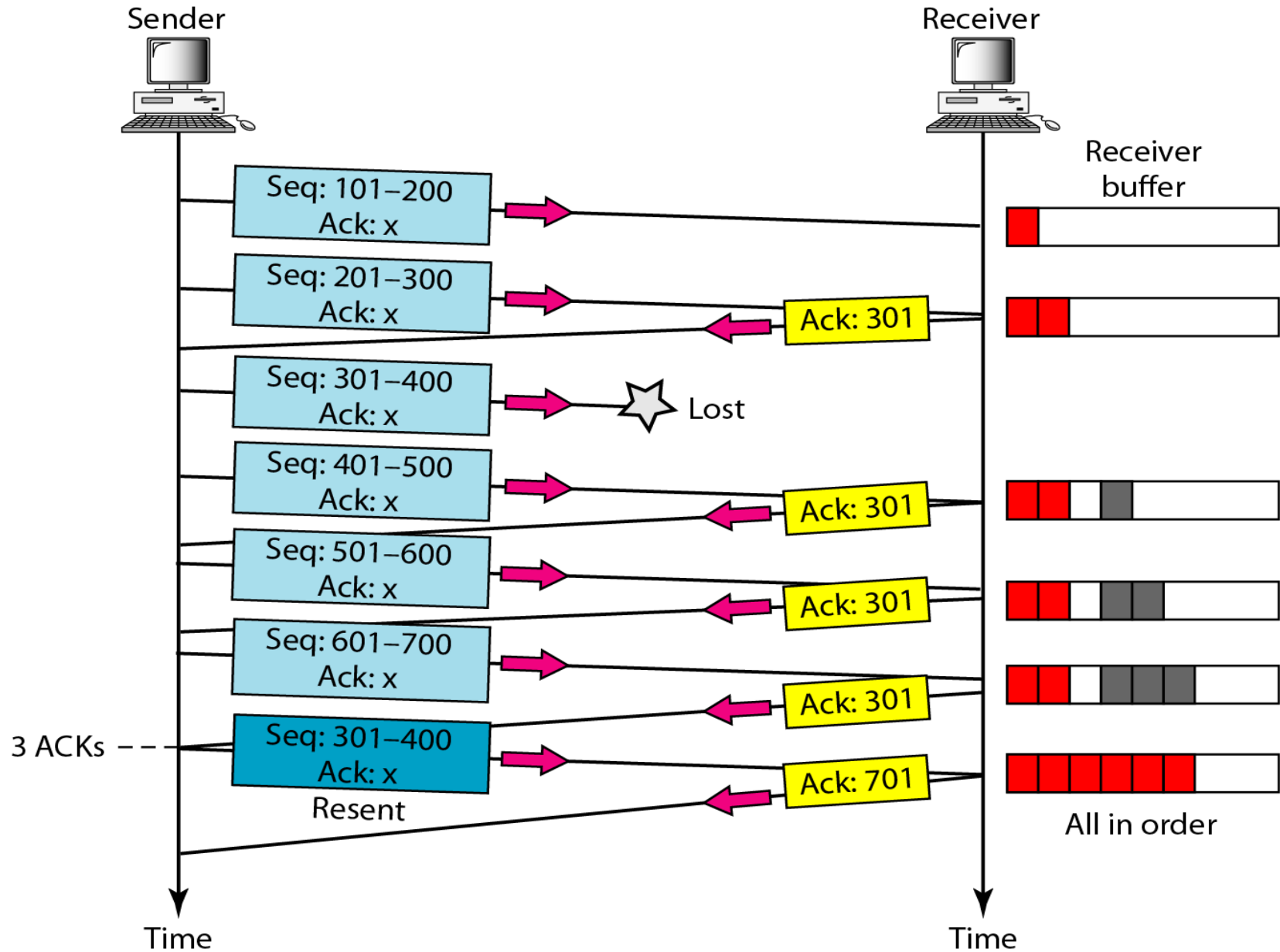
Normal operation



Lost segment

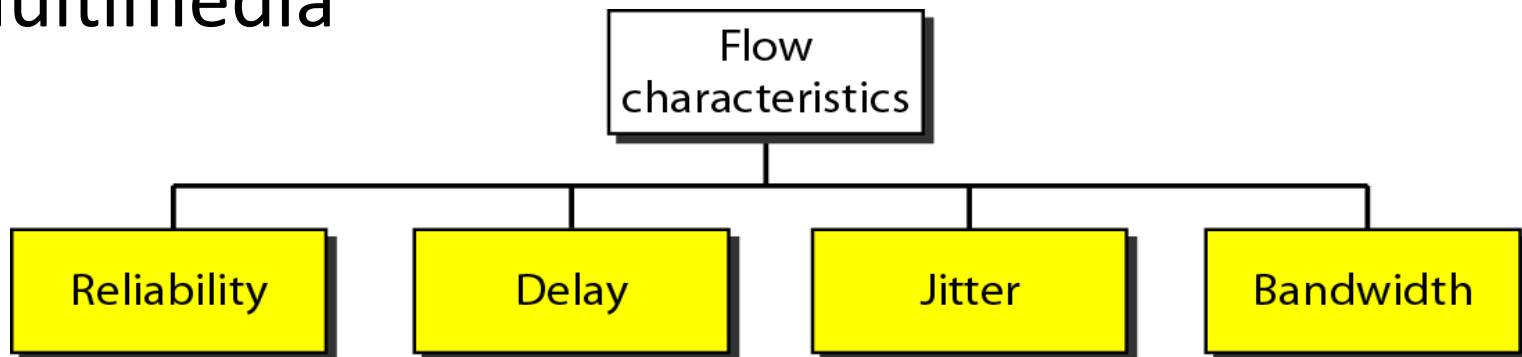


Fast retransmission



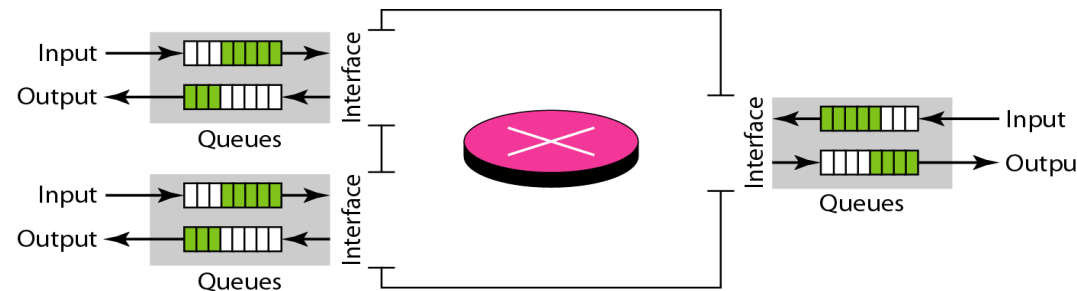
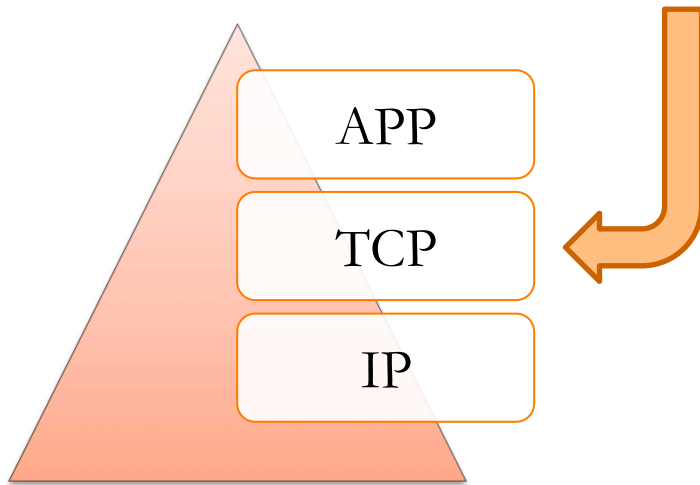
Quality of Service (QoS)

- Maintaining a functioning network
 - Meeting applications' requirements
 - Dealing with flow characteristics
- Network management
- Particularly important for real-time apps
 - Multimedia



Congestion avoidance

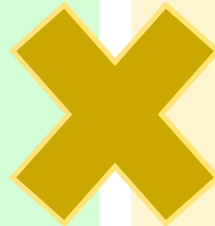
- Congestion = data load > network capacity
 - Arrival rate > processing rate
 - Processing rate > departure rate
- Congestion control



Summary and comparison: QoS

Multimedia Performance Requirements

- Sensitive to:
 - Delay
 - Jitter
- Not so sensitive to:
 - Packet loss
 - Corrupted packets



vs.

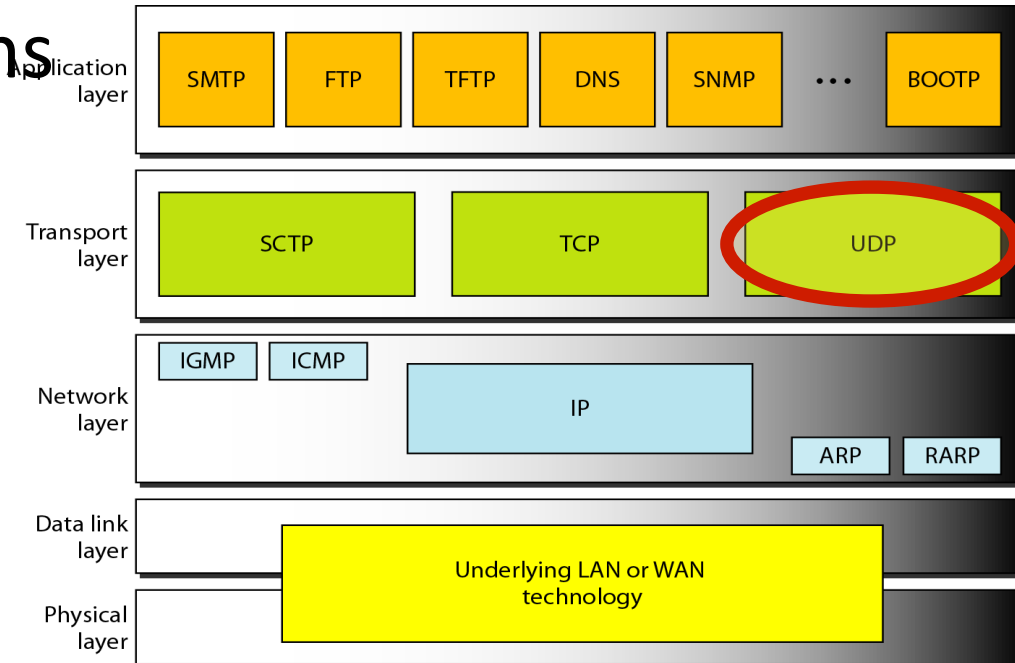
Characteristics of TCP

- Sensitive to:
 - Lost or corrupted packets
- Not so sensitive to:
 - Delay
- No multicasting!

So, what about UDP?

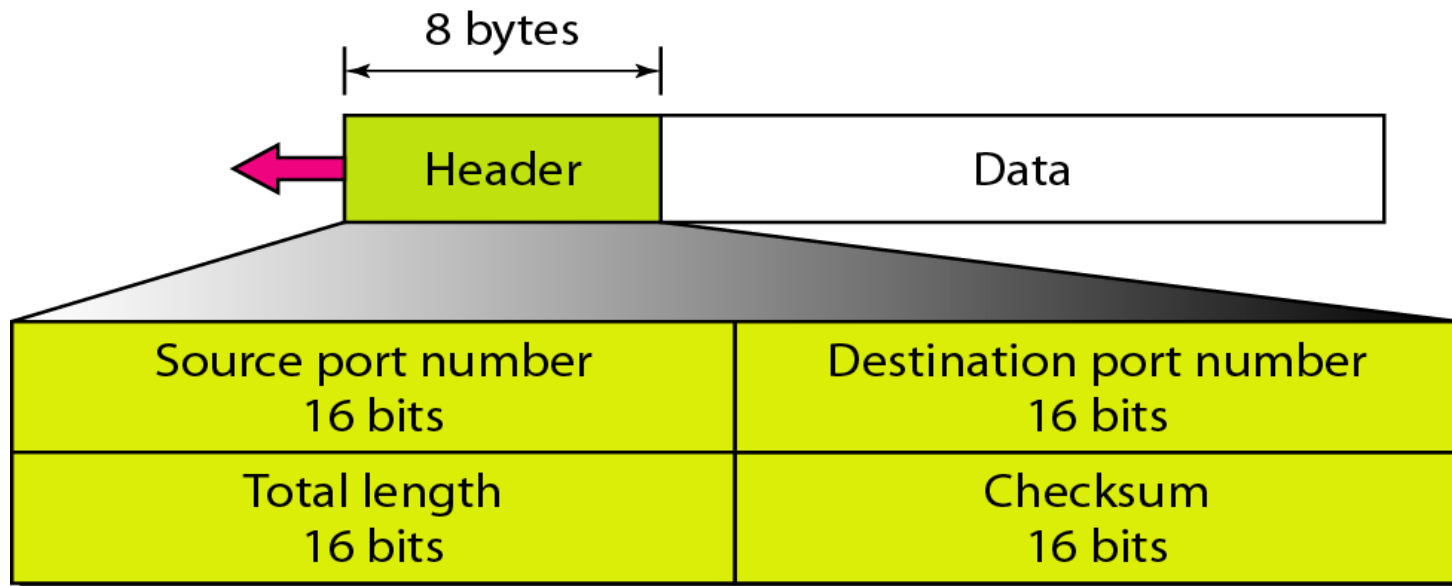
User Datagram Protocol (UDP)

- Connectionless
 - Independent datagrams
 - No sessions
- Unreliable
 - No error control
 - No flow control
- Process-to-process

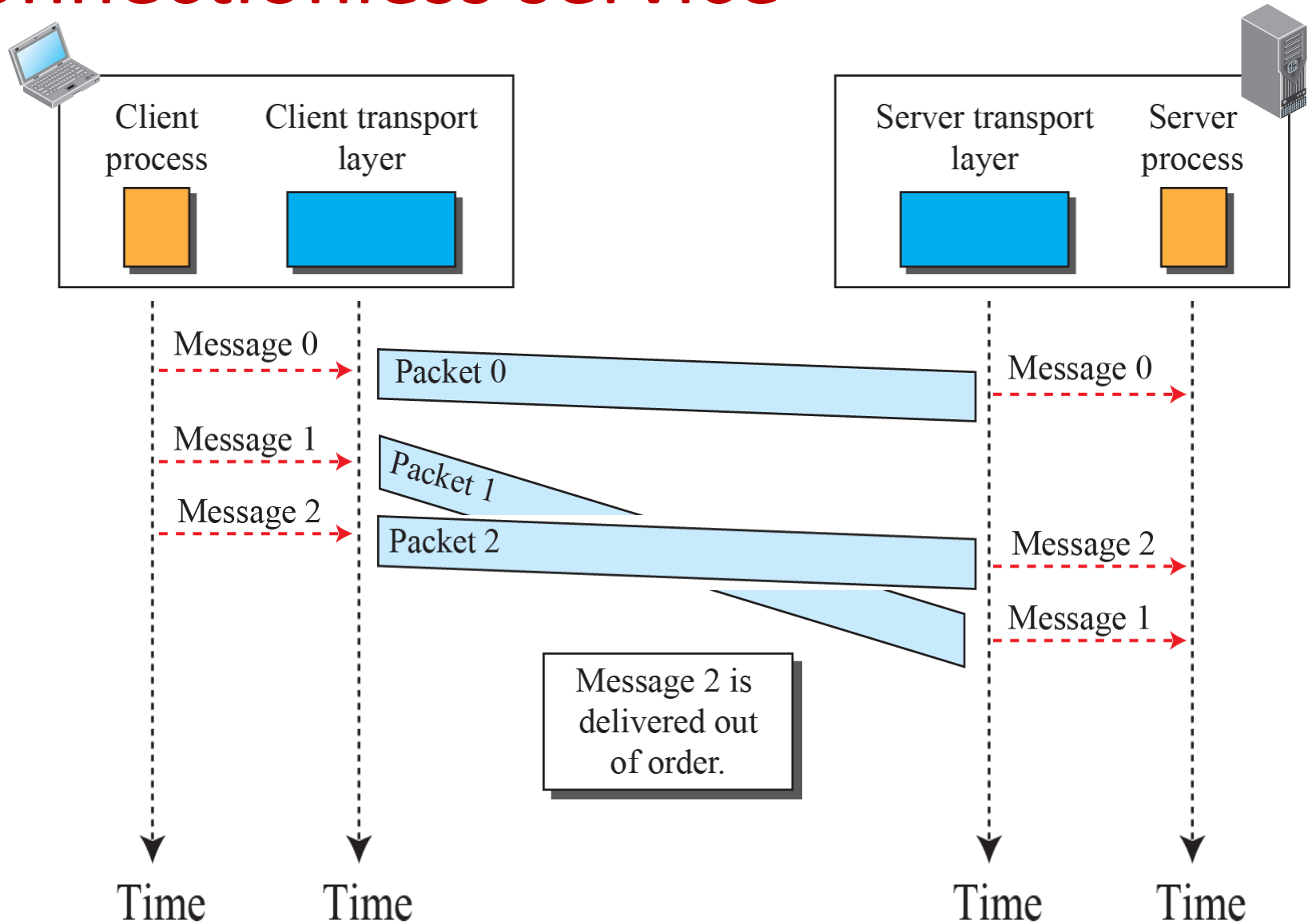


UDP header format

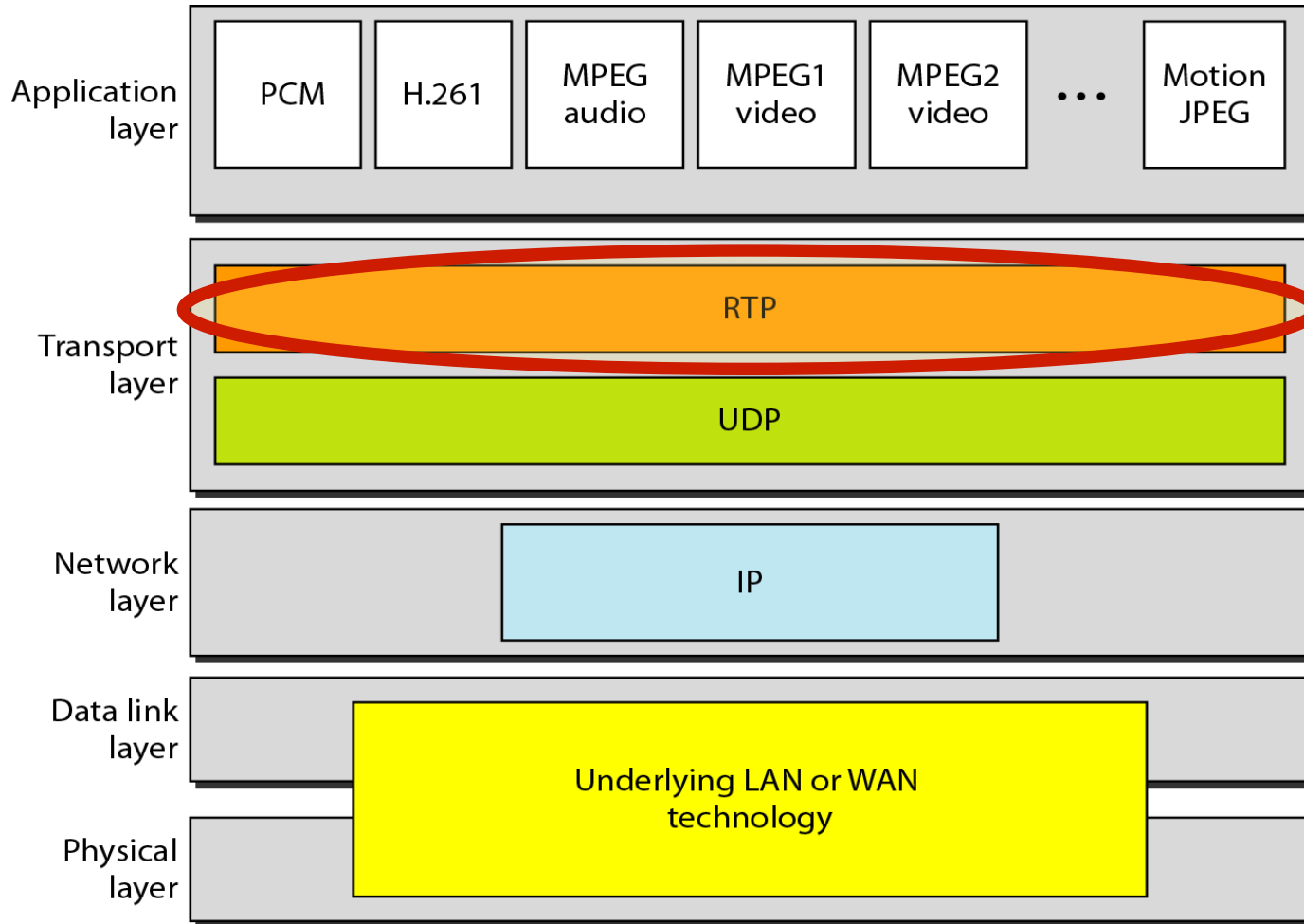
- Checksum optional
- No numbering
- No relation between datagrams



Connectionless service



Real-time Transport Protocol (RTP)



Sequence nbr
Time stamp