



## Chapter 12

# *Transmission Control Protocol*

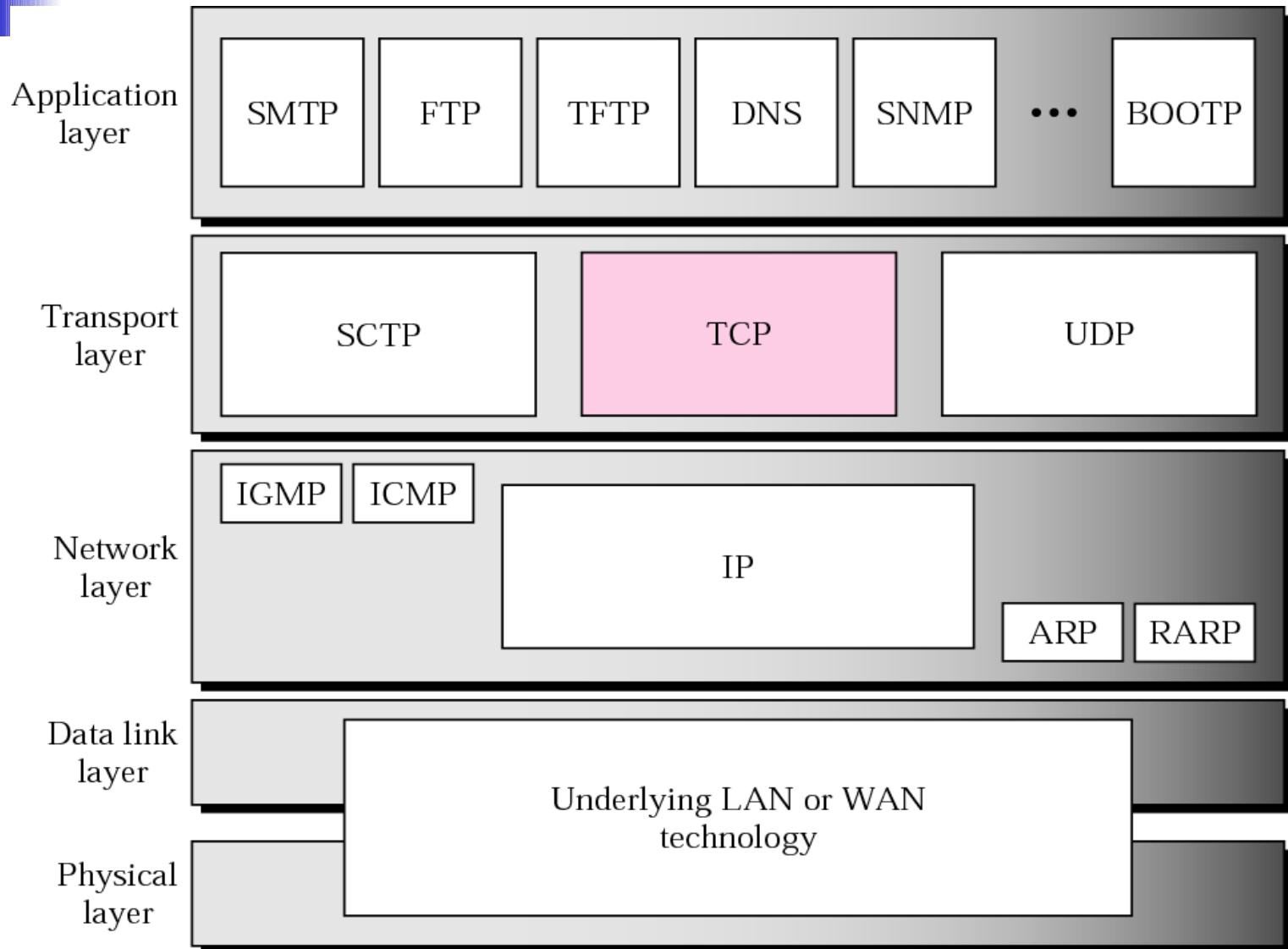
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## Objectives

*Upon completion you will be able to:*

- *Be able to name and understand the services offered by TCP*
- *Understand TCP's flow and error control and congestion control*
- *Be familiar with the fields in a TCP segment*
- *Understand the phases in a connection-oriented connection*
- *Understand the TCP transition state diagram*
- *Be able to name and understand the timers used in TCP*
- *Be familiar with the TCP options*

**Figure 12.1** *TCP/IP protocol suite*



# 12.1 TCP SERVICES

*We explain the services offered by TCP to the processes at the application layer.*

***The topics discussed in this section include:***

***Process-to-Process Communication***

***Stream Delivery Service***

***Full-Duplex Communication***

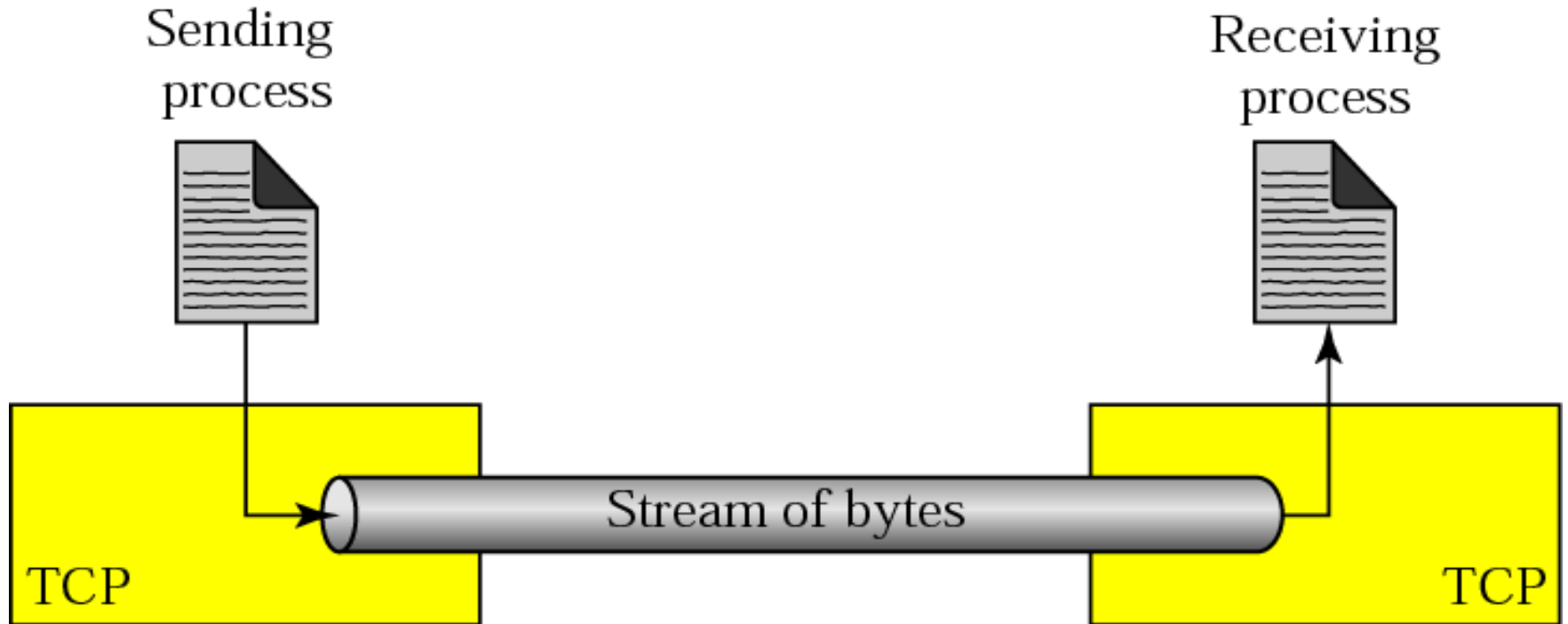
***Connection-Oriented Service***

***Reliable Service***

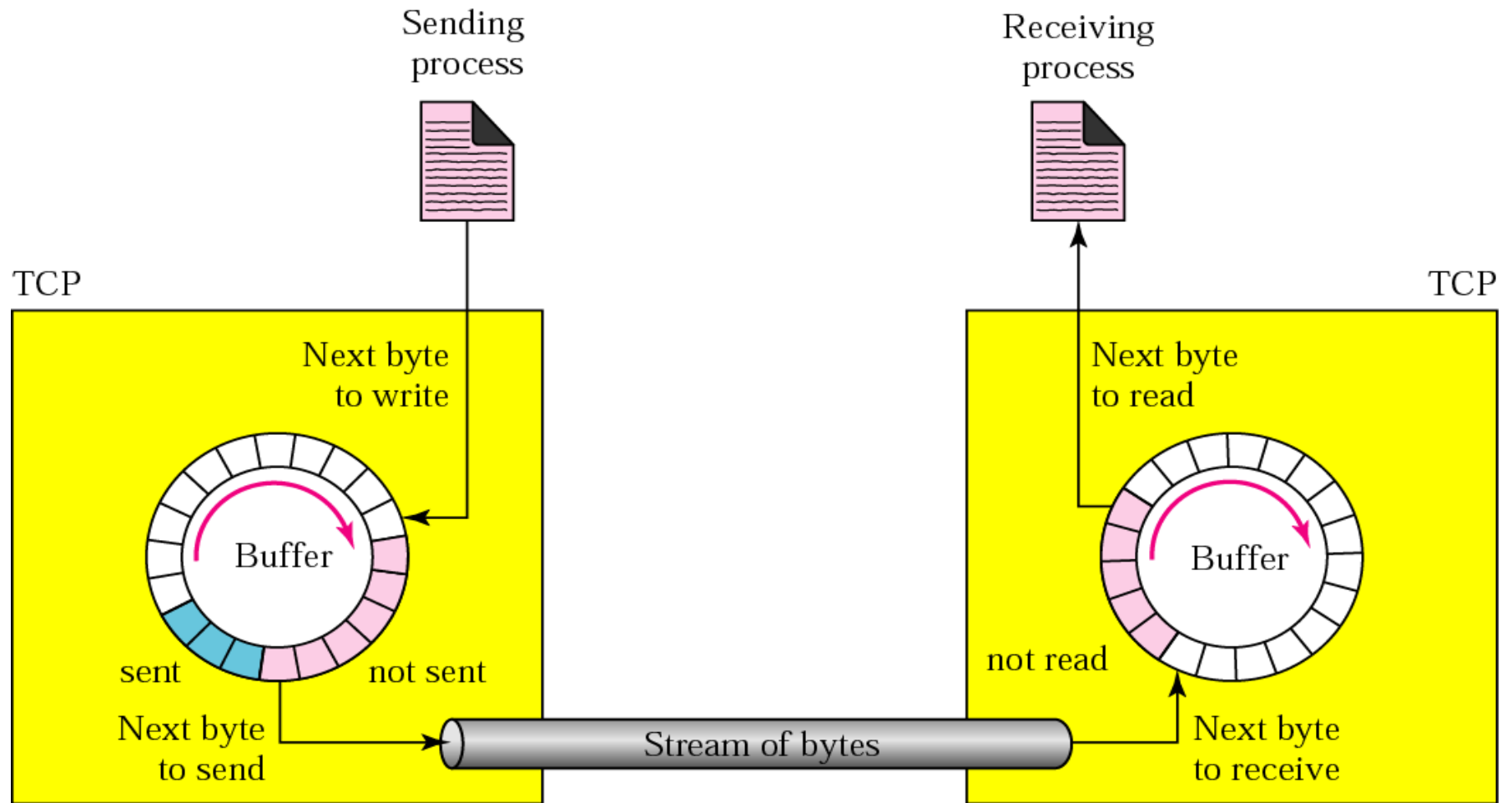
***Table 12.1 Well-known ports used by TCP***

<i>Port</i>	<i>Protocol</i>	<i>Description</i>
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

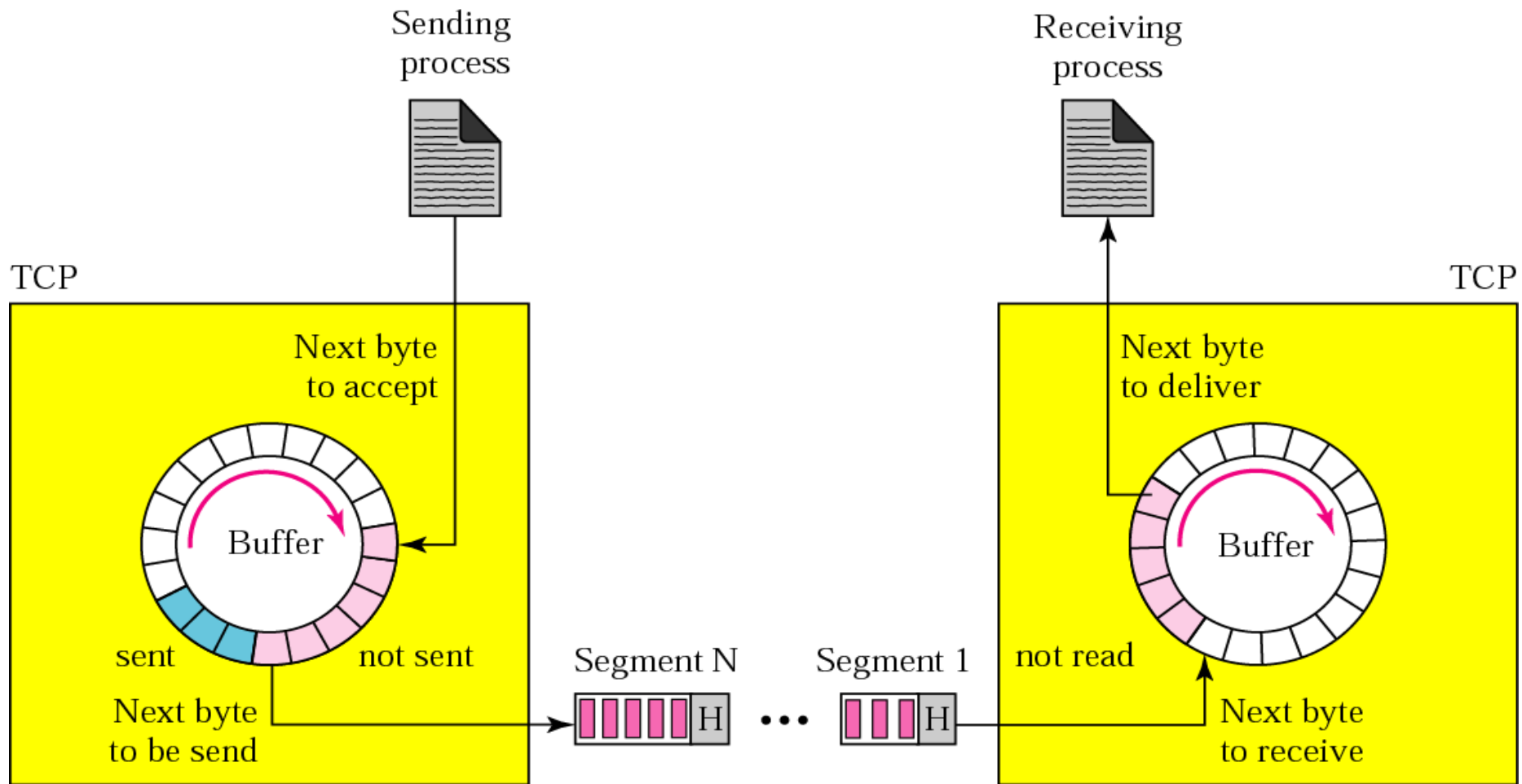
**Figure 12.2** *Stream delivery*



**Figure 12.3** *Sending and receiving buffers*



**Figure 12.4** *TCP segments*



## 12.2 TCP FEATURES

*To provide the services mentioned in the previous section, TCP has several features that are briefly summarized in this section.*

***The topics discussed in this section include:***

*Numbering System*

*Flow Control*

*Error Control*

*Congestion Control*





Note:

*The bytes of data being transferred in each connection are numbered by TCP. The numbering starts with a randomly generated number.*



## Example 2

*Suppose a TCP connection is transferring a file of 5000 bytes. The first byte is numbered 10001. What are the sequence numbers for each segment if data are sent in five segments, each carrying 1000 bytes?*

### *Solution*

*The following shows the sequence number for each segment:*

*Segment 1 → Sequence Number: 10,001 (range: 10,001 to 11,000)*

*Segment 2 → Sequence Number: 11,001 (range: 11,001 to 12,000)*

*Segment 3 → Sequence Number: 12,001 (range: 12,001 to 13,000)*

*Segment 4 → Sequence Number: 13,001 (range: 13,001 to 14,000)*

*Segment 5 → Sequence Number: 14,001 (range: 14,001 to 15,000)*



Note:

*The value in the sequence number field of a segment defines the number of the first data byte contained in that segment.*



Note:

*The value of the acknowledgment field in a segment defines the number of the next byte a party expects to receive.*

*The acknowledgment number is cumulative.*

## 12.3 SEGMENT

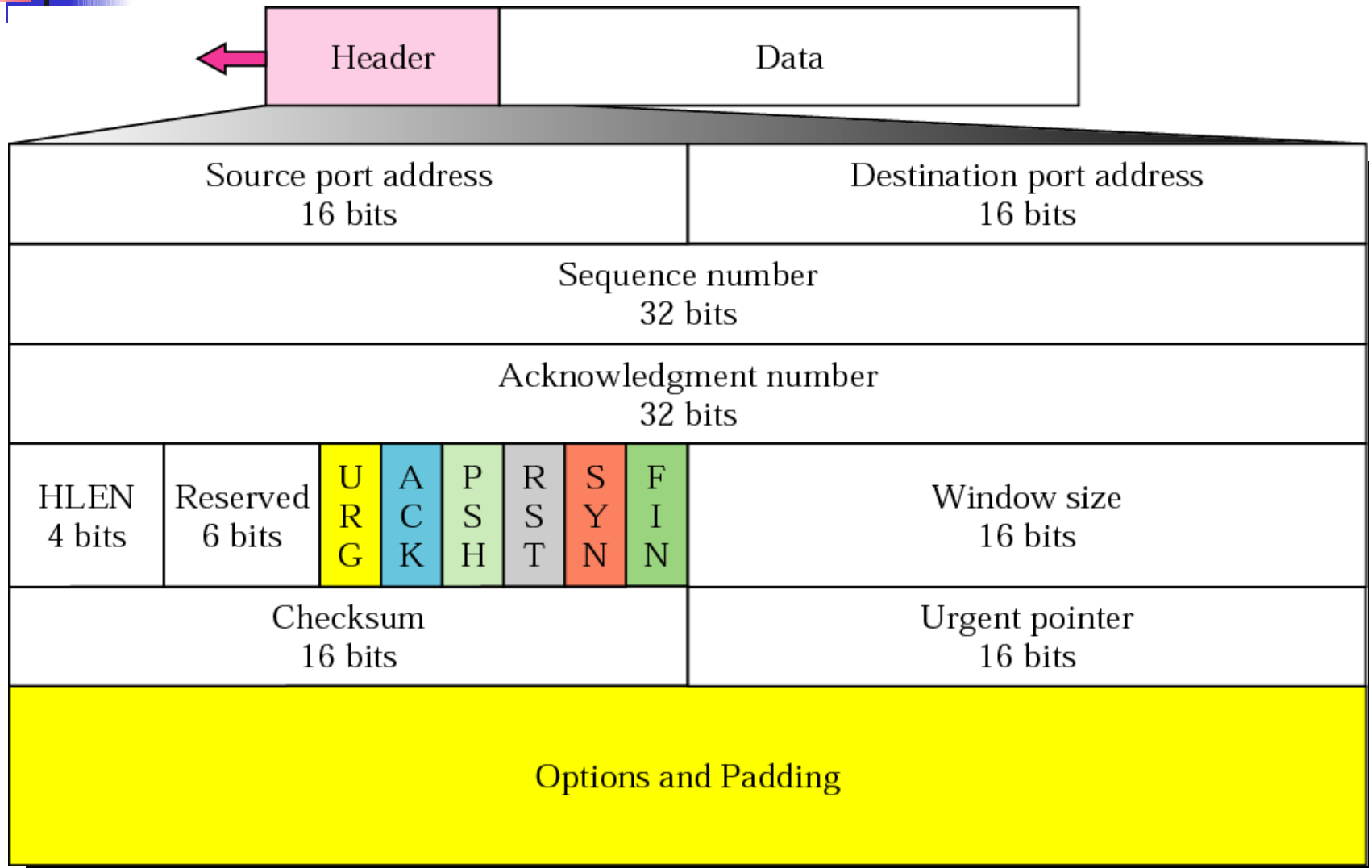
*A packet in TCP is called a segment*

***The topics discussed in this section include:***

*Format*

*Encapsulation*

**Figure 12.5** *TCP segment format*

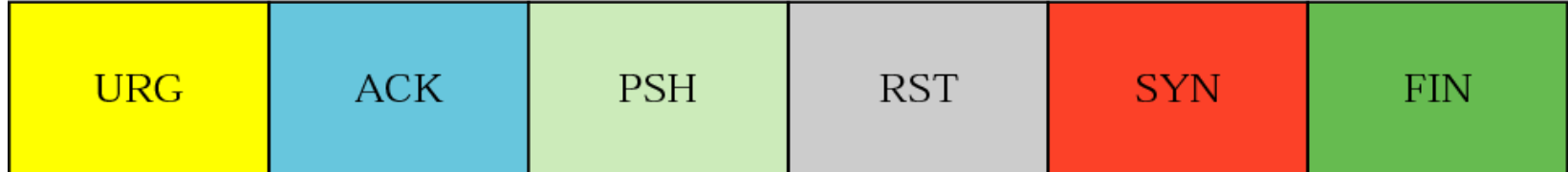




**Figure 12.6** *Control field*

URG: Urgent pointer is valid  
ACK: Acknowledgment is valid  
PSH: Request for push

RST: Reset the connection  
SYN: Synchronize sequence numbers  
FIN: Terminate the connection



***Table 12.2 Description of flags in the control field***

<i>Flag</i>	<i>Description</i>
URG	The value of the urgent pointer field is valid
ACK	The value of the acknowledgment field is valid
PSH	Push the data
RST	The connection must be reset
SYN	Synchronize sequence numbers during connection
FIN	Terminate the connection



**Figure 12.8** *Encapsulation and decapsulation*



## 12.4 A TCP CONNECTION

*TCP is connection-oriented. A connection-oriented transport protocol establishes a virtual path between the source and destination. All of the segments belonging to a message are then sent over this virtual path. A connection-oriented transmission requires three phases: connection establishment, data transfer, and connection termination.*

***The topics discussed in this section include:***

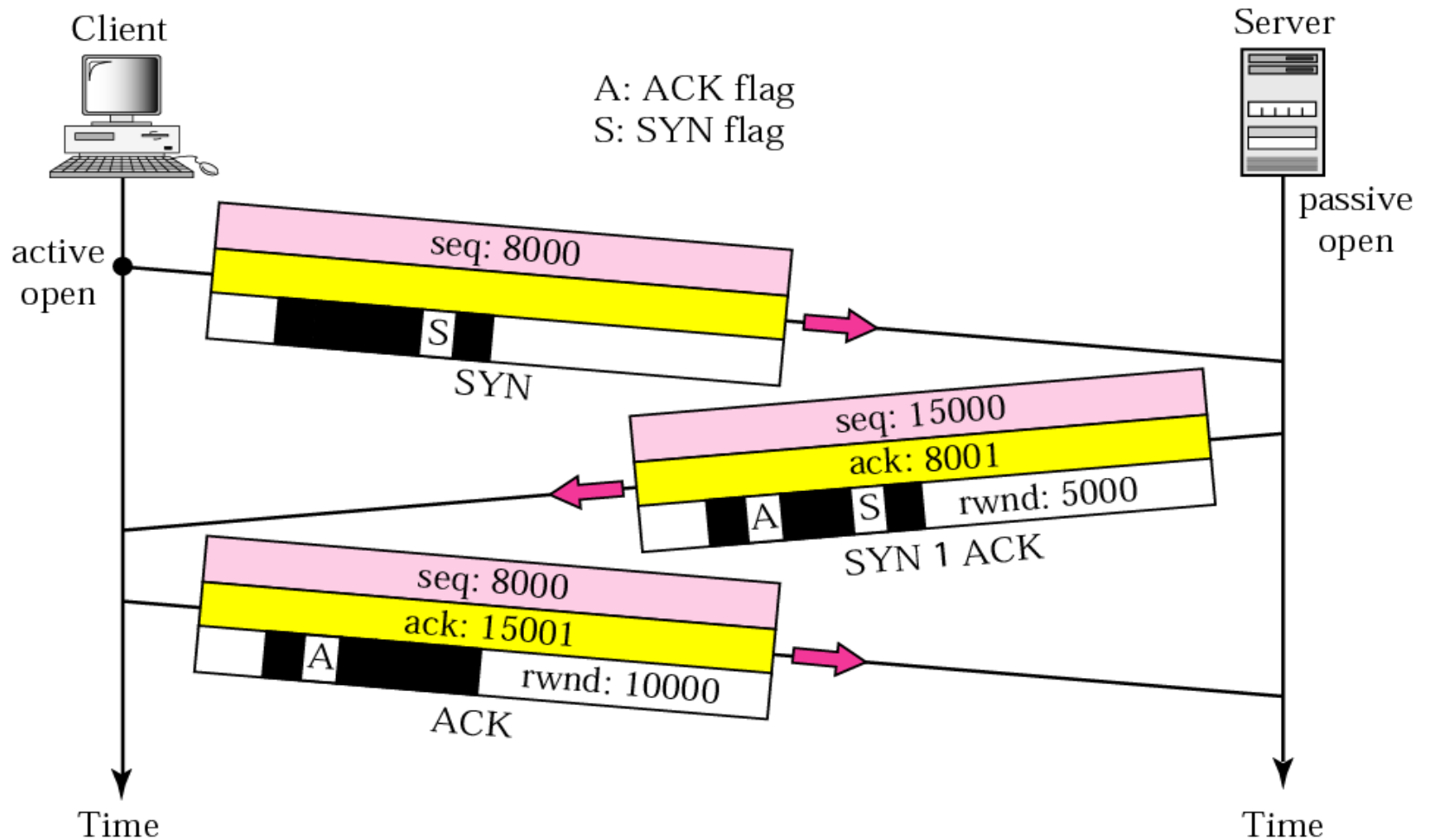
***Connection Establishment***

***Data Transfer***

***Connection Termination***

***Connection Reset***

**Figure 12.9** *Connection establishment using three-way handshaking*





Note:

*A SYN segment cannot carry data, but it consumes one sequence number.*



Note:

*A SYN + ACK segment cannot carry data, but does consume one sequence number.*



**Note:**

***An ACK segment, if carrying no data,  
consumes no sequence number.***

Comment: Forouzan's interpretation is inconsistent with [RFC 9293, Aug. 2022] (see the separate set of slides).

**Figure 12.10** *Data transfer*

