Chapter 12

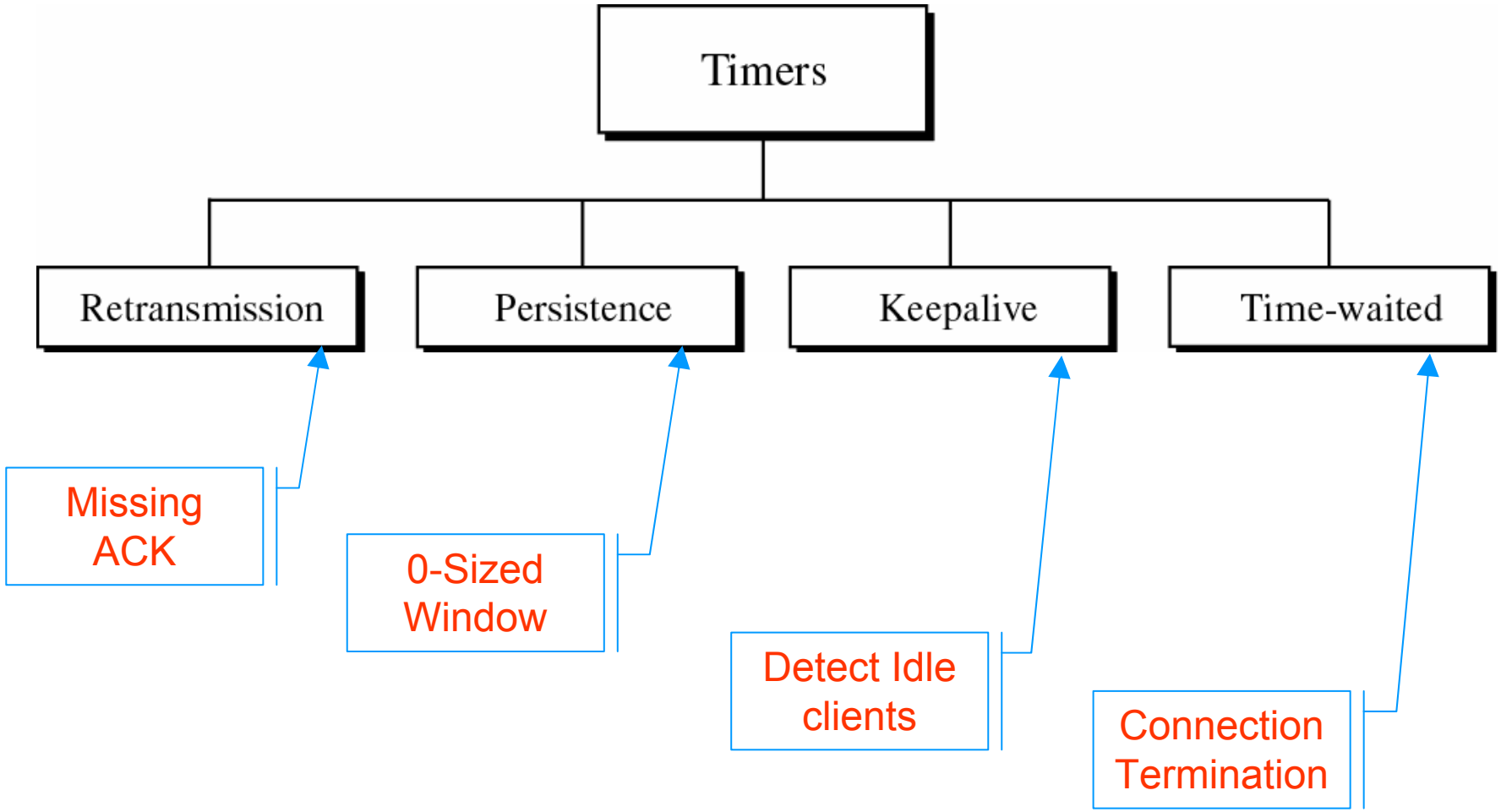
Transmission Control Protocol (TCP) – Part Two

CONTENTS

Part One

Part Two

12.7 TCP Timers



12.7.1 Retransmission Timer

- How long to wait for an ACK of a previously sent segment before retransmission.
- Depends on distance and network traffic density.
  - Retransmission time should be *dynamic*.
  - Retransmission time = 2 × RTT
- Dynamic Calculation of RTT:
  - Use a timestamp TCP option (discussed later), or
  a) Actually measure RTT of first two segments of a connection
  b) $RTT_{\text{new estimate}} = \alpha \times RTT_{\text{old estimate}} + (1 - \alpha) \times RTT_{\text{actual}}$
  c) Typically, $\alpha = 0.90$
  d) Do NOT consider retransmitted segments into the above calculation of RTT

12.8 Congestion Control

- Congestion occurs when some routers along the path run out of buffers and drop packets.
- Sending TCP assumes that a missing ACK is due to congestion.
  - Retransmission will only aggravate the congestion
- A *Congestion Window* (CongWin) is used to control number of segments transmitted simultaneously (i.e. before waiting for an ACK)

- Sender Window = Min (*RecvWin* , *CongWin*)

- During connection establishment, each party specifies its maximum Receiving Window (*RecvWinMax*), and the **Maximum Segment Size** (*MSS*) it can receive.

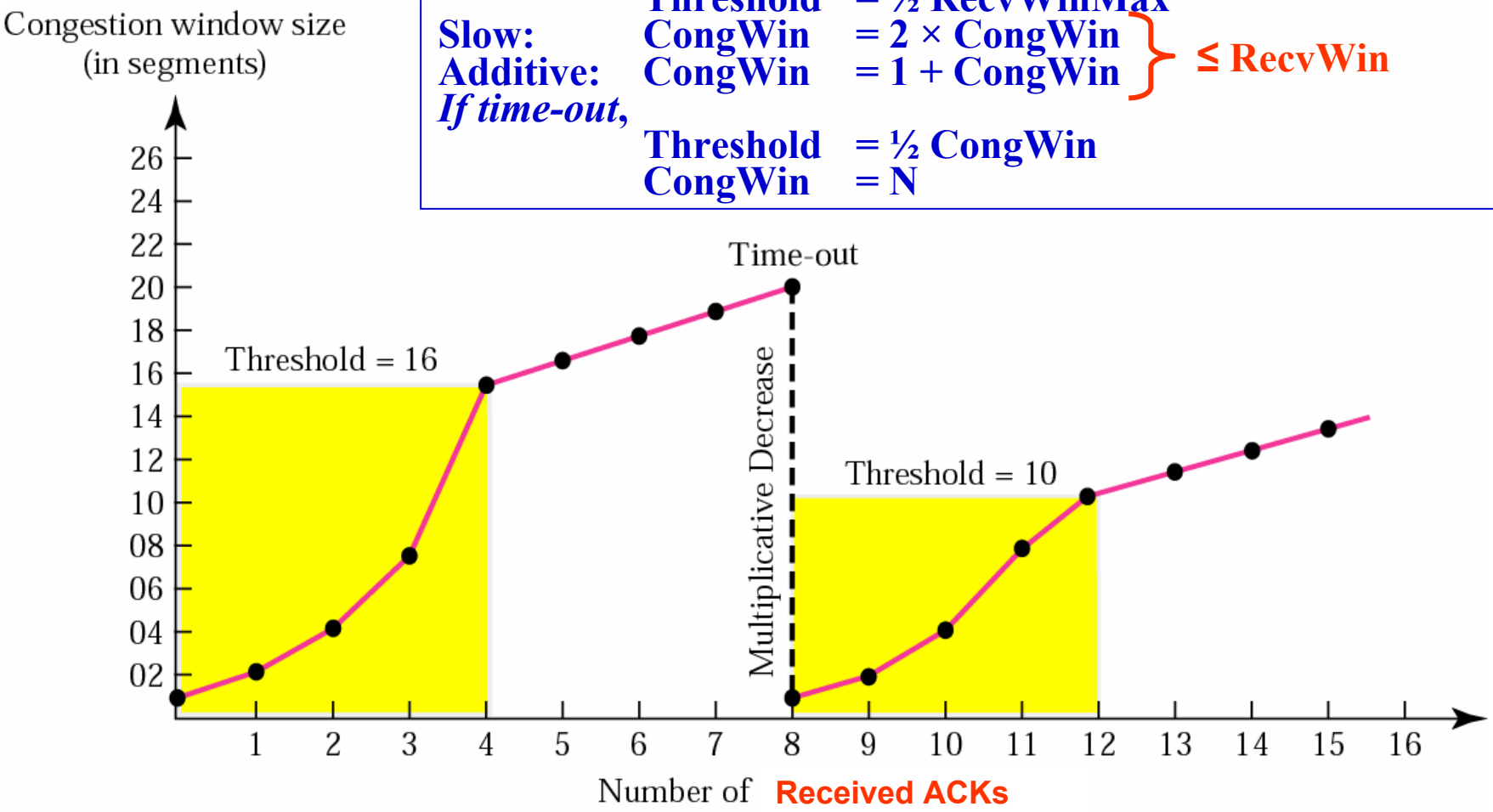
The (Slow Start, Additive Increase, Multiplicative Decrease) Cycle

Initially,

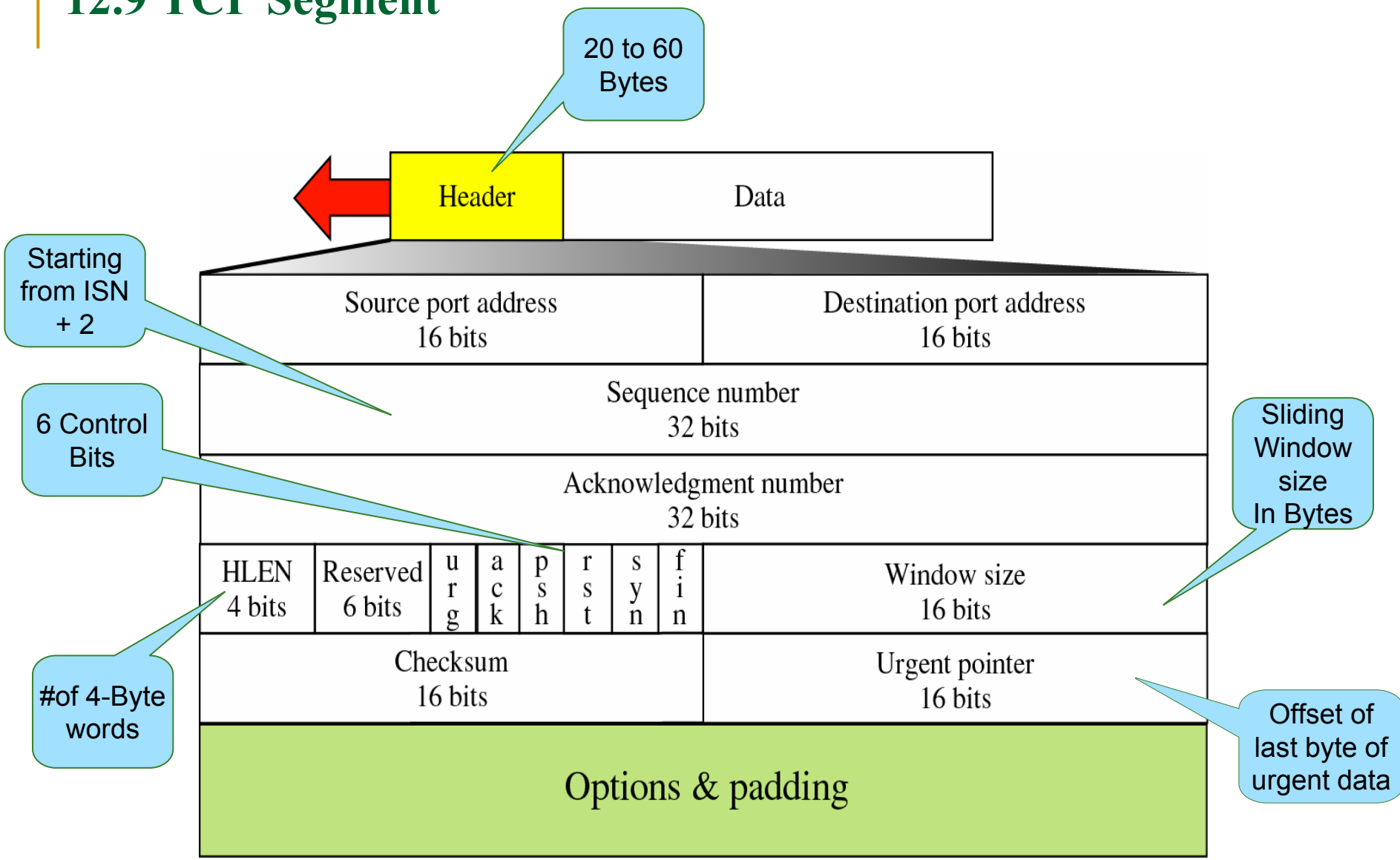
CongWin = Receiver's MSS = N
Threshold = ½ RecvWinMax
Slow: CongWin = 2 × CongWin
Additive: CongWin = 1 + CongWin } **≤ RecvWin**

If time-out,

Threshold = ½ CongWin
CongWin = N



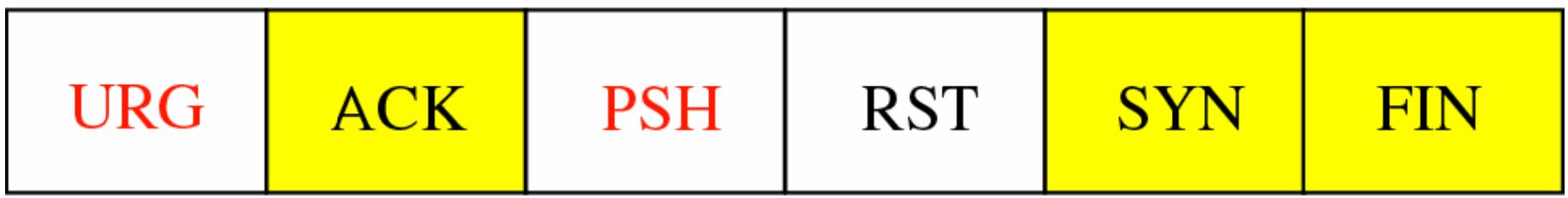
12.9 TCP Segment



Control Fields

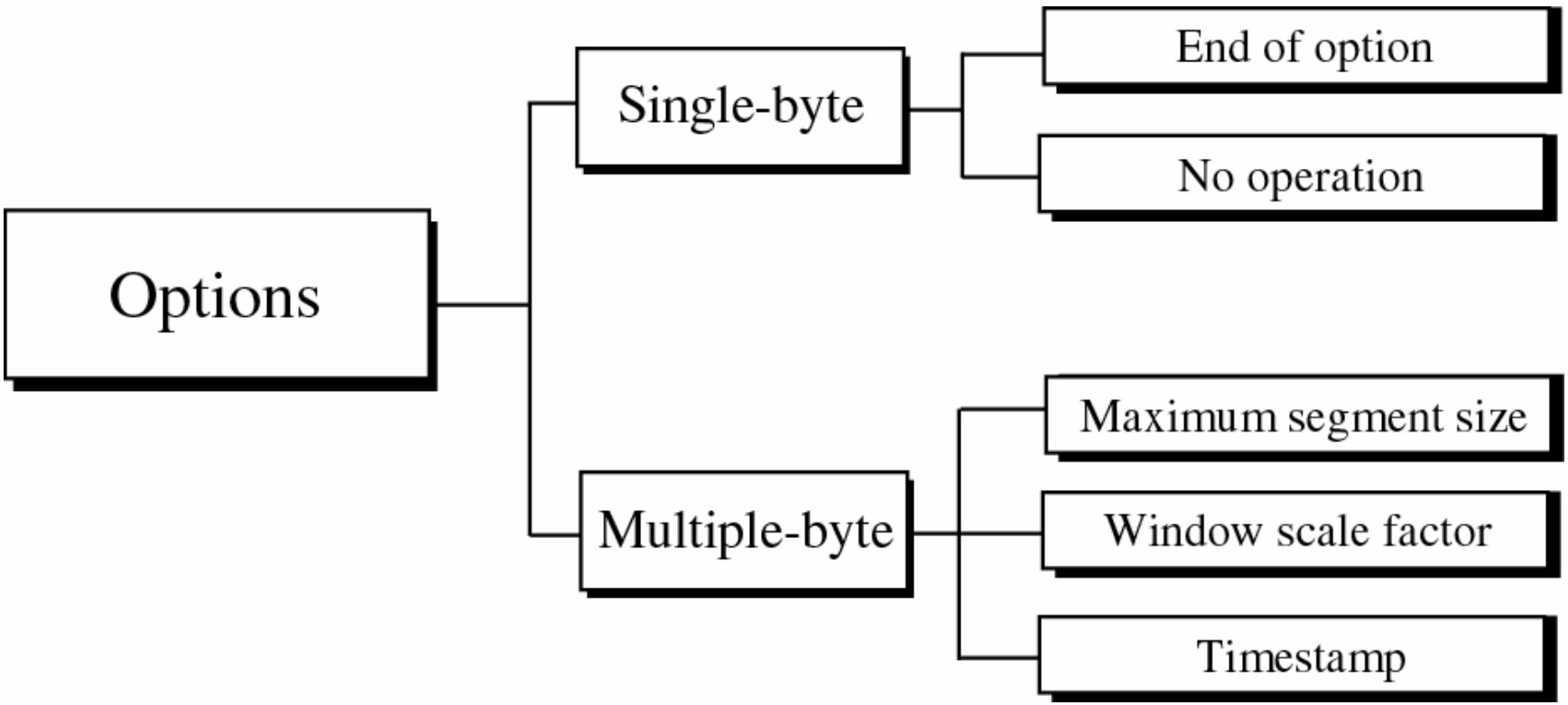
- Enable flow control, connection establishment & termination, and mode of data transfer.
- One or more bits may be set at the same time
- Discussed in detail later

URG: Urgent pointer is valid	RST: Reset the connection
ACK: Acknowledgment is valid	SYN: Synchronize sequence numbers
PSH: Request for push	FIN: Terminate the connection



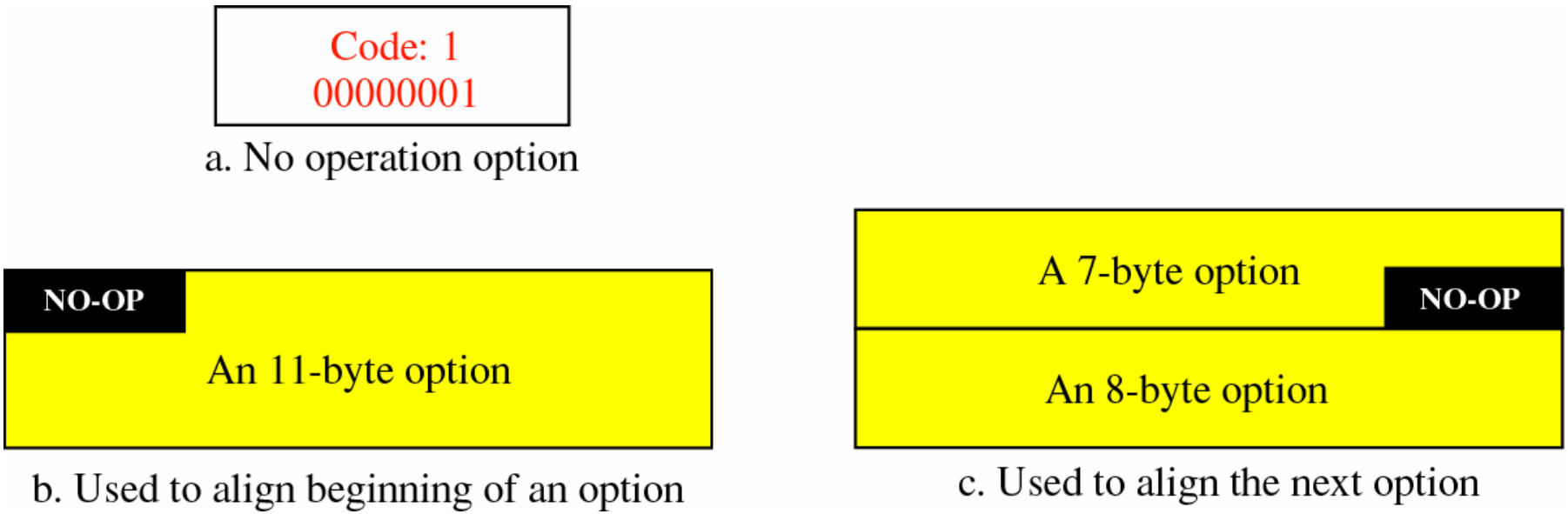
12.10 Options

- Up to 40 bytes of optional information to the destination



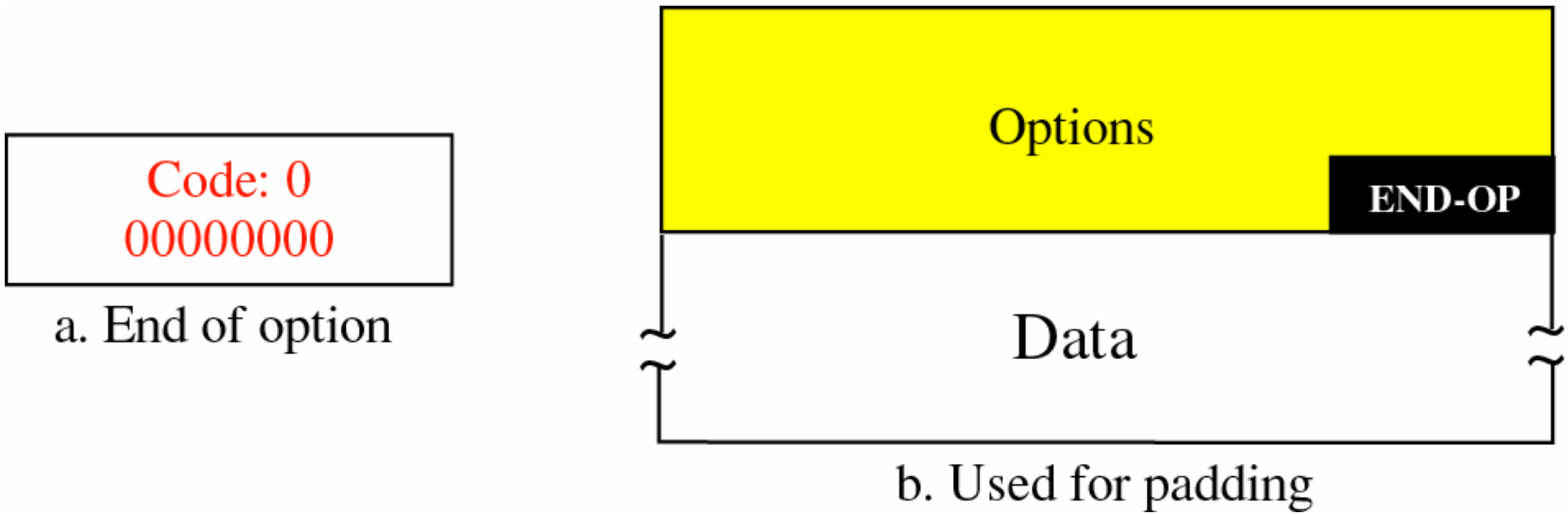
No-operation Option

- A Filler option used for alignment purposes only.



End-of-option Option

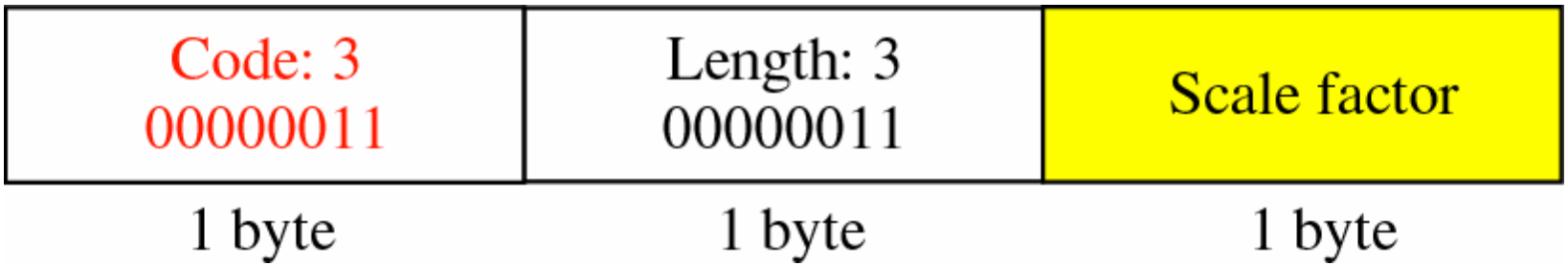
- Used as a padding to terminate options. Only ONE may be present.
- The remainder of this 32-bit word is garbage
  - Payload data starts at the next 32-bit word.



Maximum segment size (MSS) Option

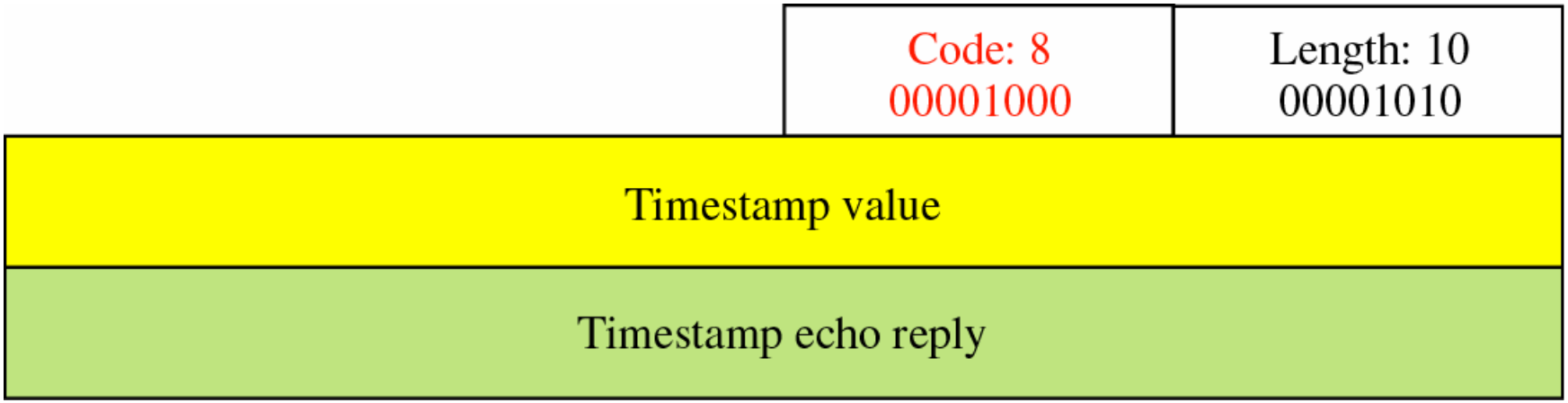
- The maximum number of data bytes I can receive in one segment
- Each party determines its MSS during connection establishment
  - Cannot be changed later.
- Defaults to 536 bytes

Window scale factor Option



- The 16-bit Window Size in the header is too small for high-speed links (e.g. OC-24 @ 1.2Gbps)
- Actual Sender Window size = WinSize in header × $2^{\text{WinScaleFactor}}$
- WinScaleFactor ≤ 16
- This option may only appear during connection establishment.
  - Header.WinSize may change, but WinScaleFactor is constant throughout the entire connection

Timestamp Option

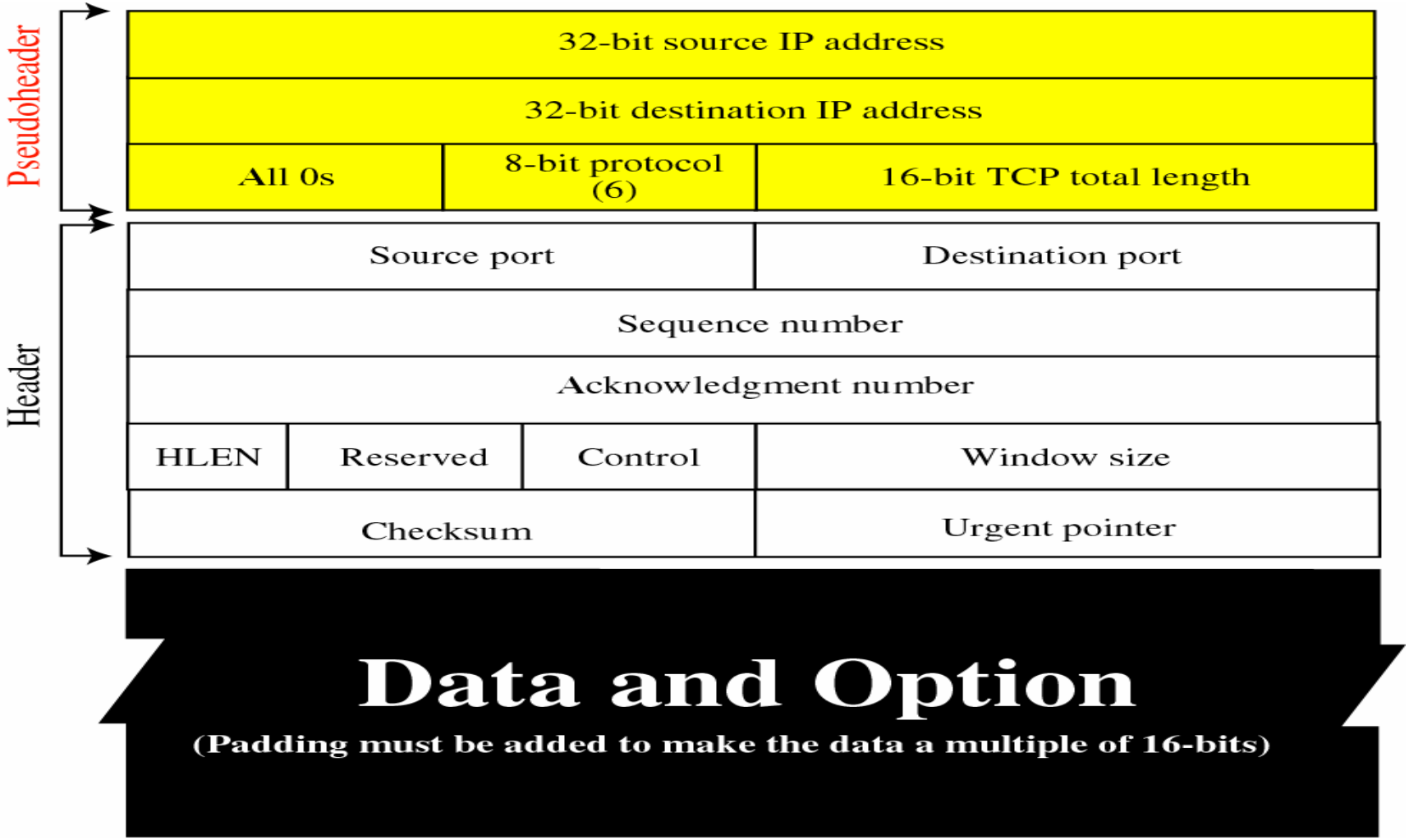


- Set by the sender just before the segment leaves (to IP layer)
- Echoed by the receiver just before it ACKs the segment
- The sender measure RTT as:

  the arrival time of the ACK - the timestamp echo reply.

12.11 Checksum

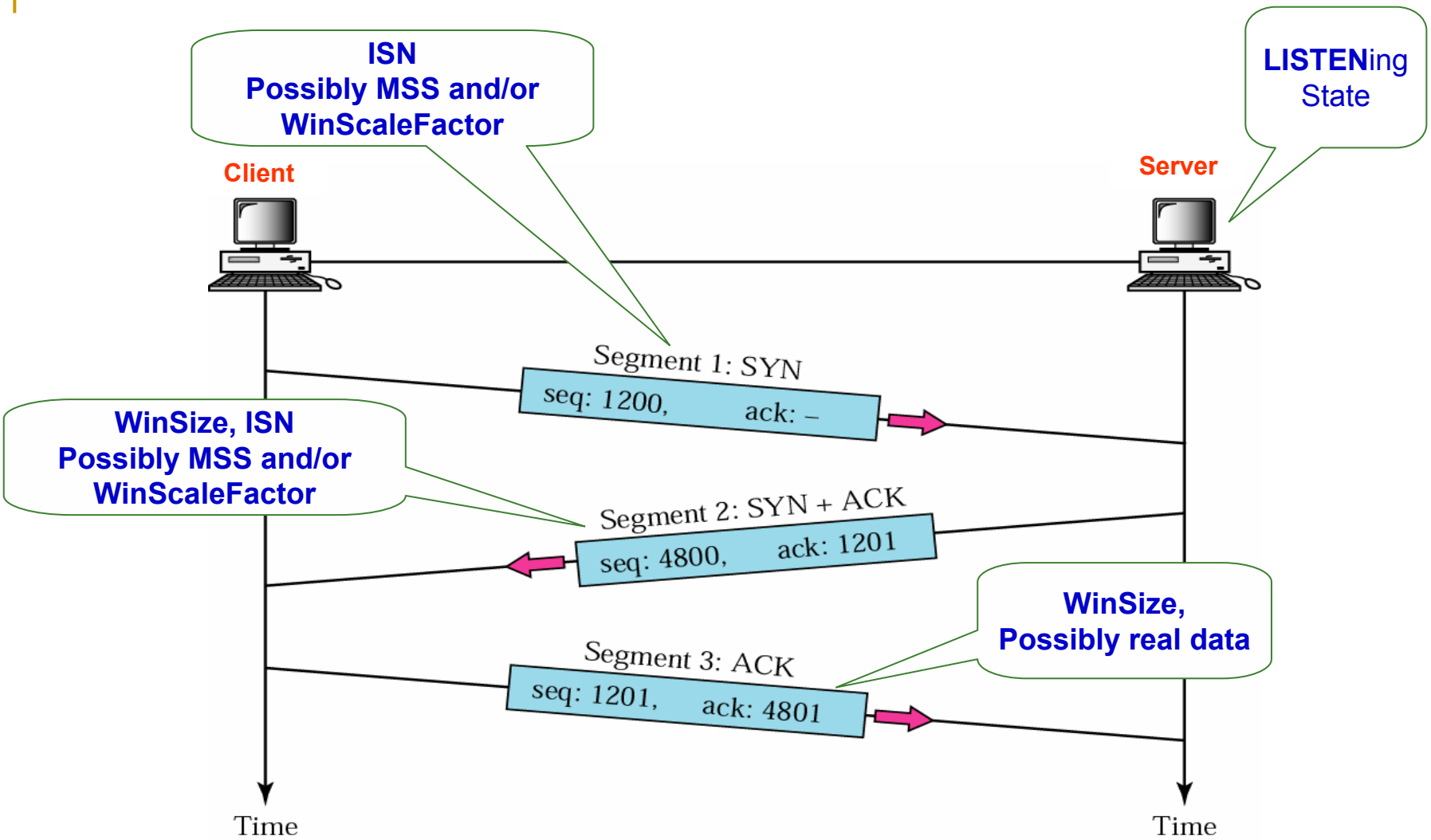
- Same as in UDP, but mandatory



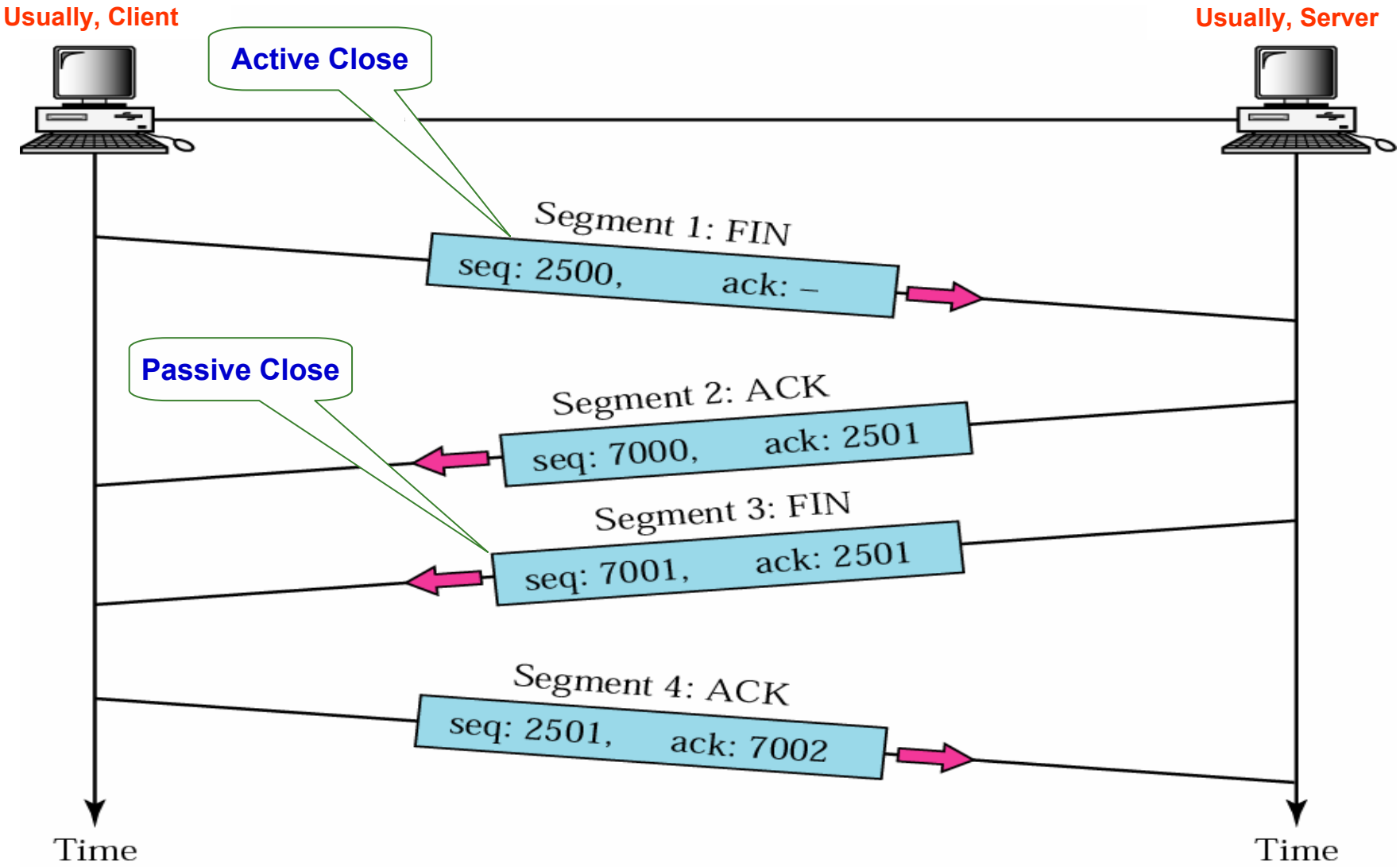
12.12 Connection

- Connections must be ***established*** to facilitate acknowledgements, and retransmissions.
- Connections are ***terminated*** at the end.
- A connection may be ***reset*** at any time in one of these 3 cases:
  1. A destination rests a connection requested for a nonexistent port
  2. One party encounters abnormal situation, so it resets the connection
  3. One party detects that the other party has been idle for too long.

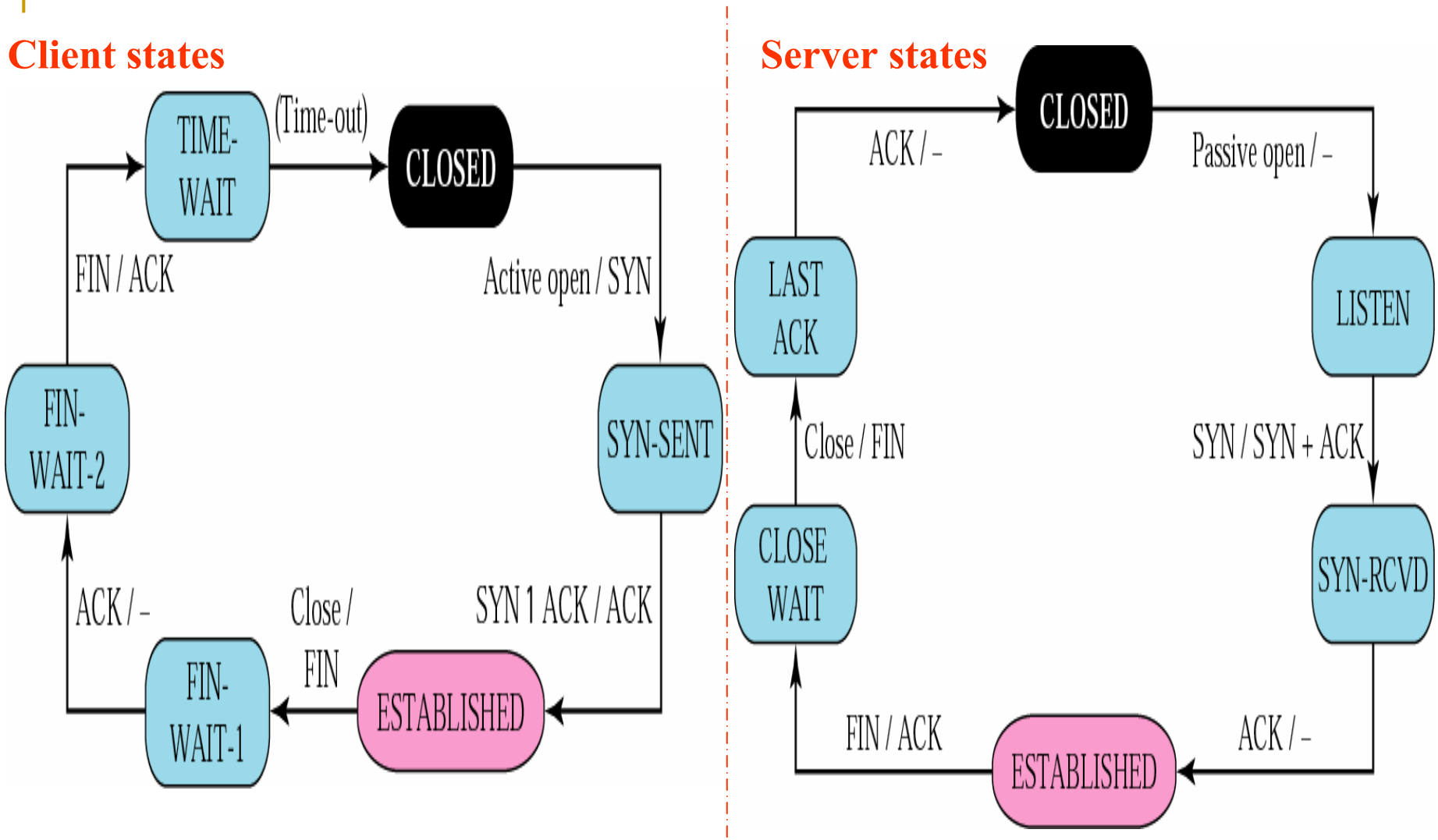
Connection Establishment: A 3-way Handshaking



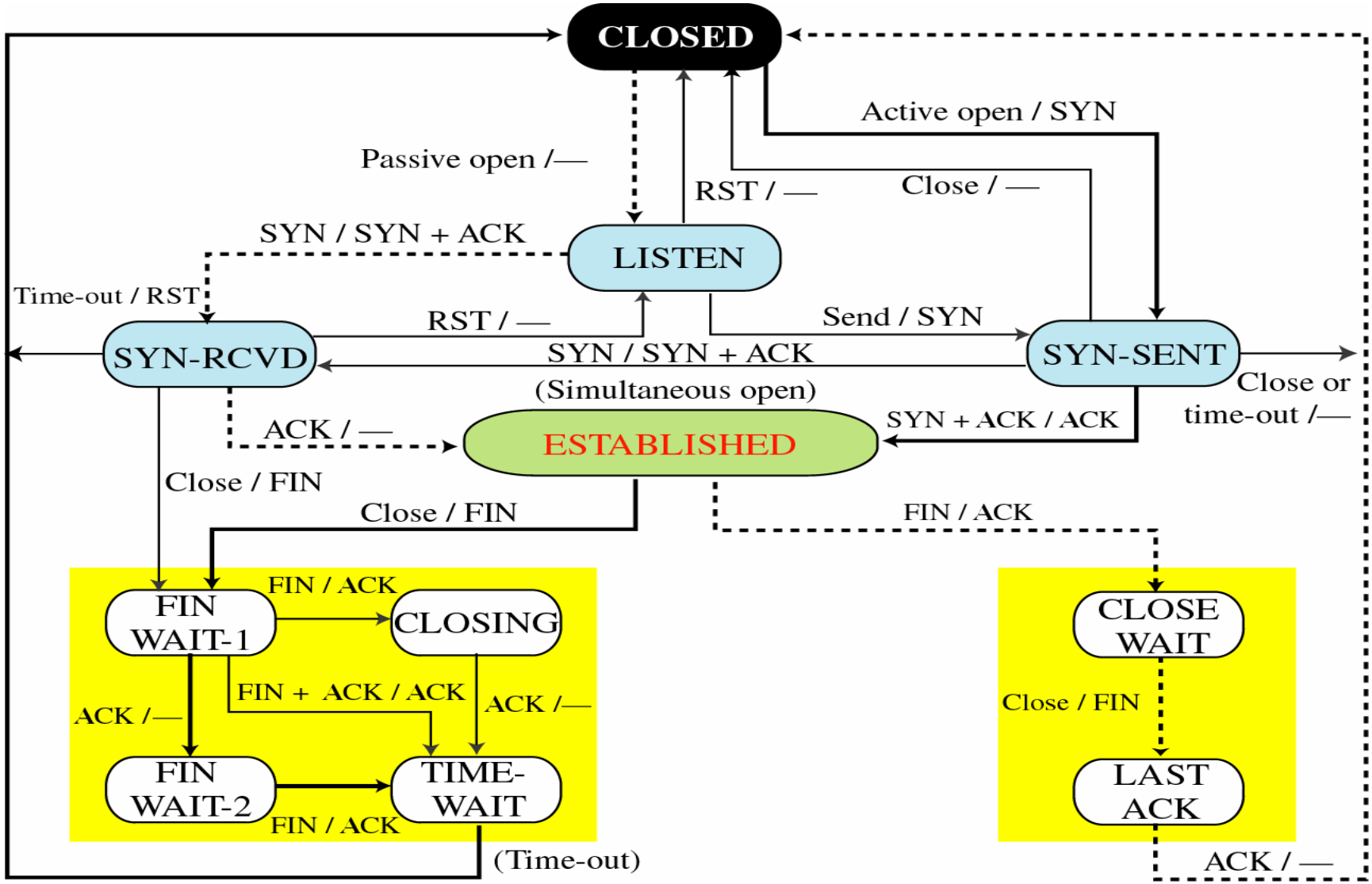
Connection Termination: A 4-way handshaking



12.13 TCP FSM: State Transition Diagram



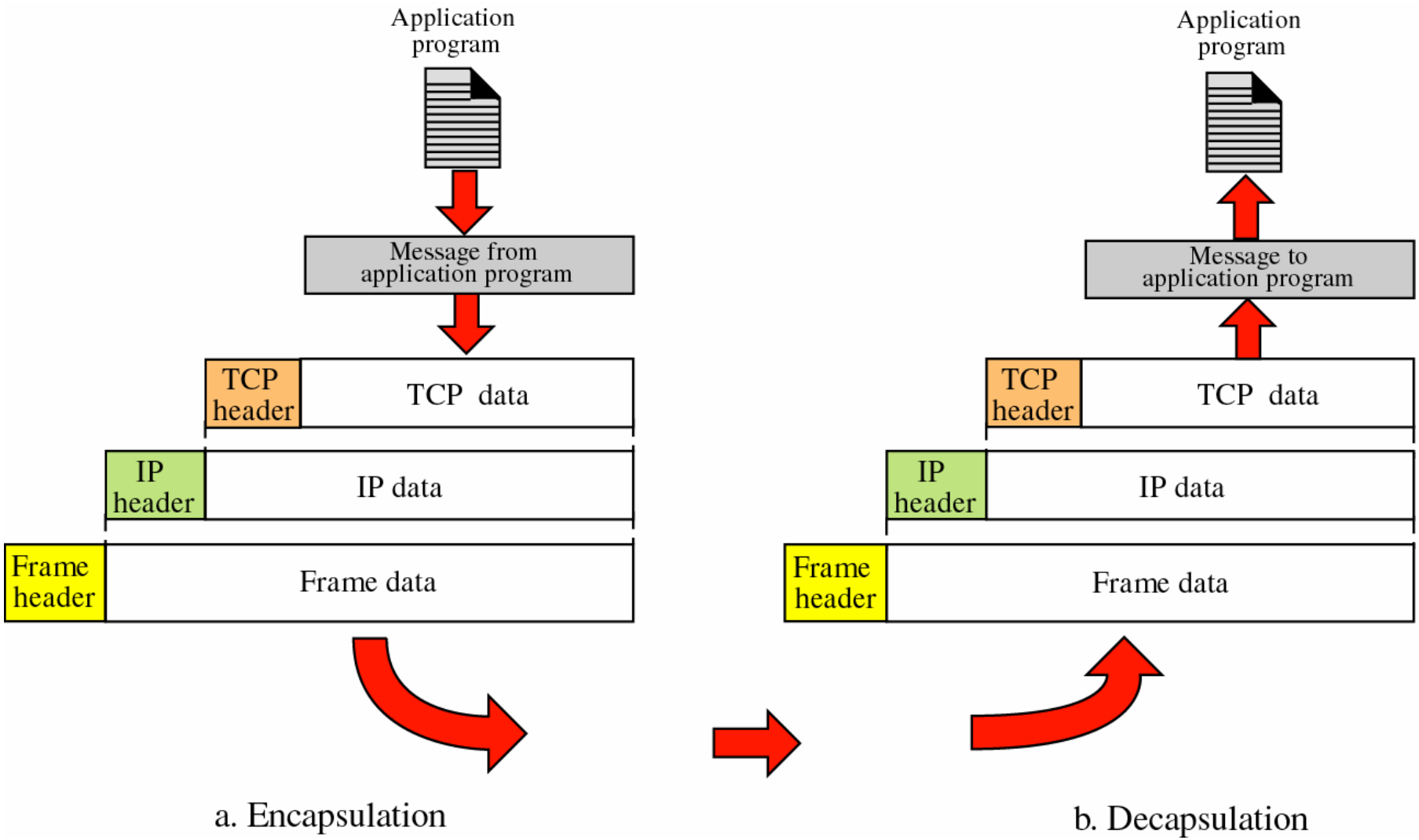
Complete State Diagram



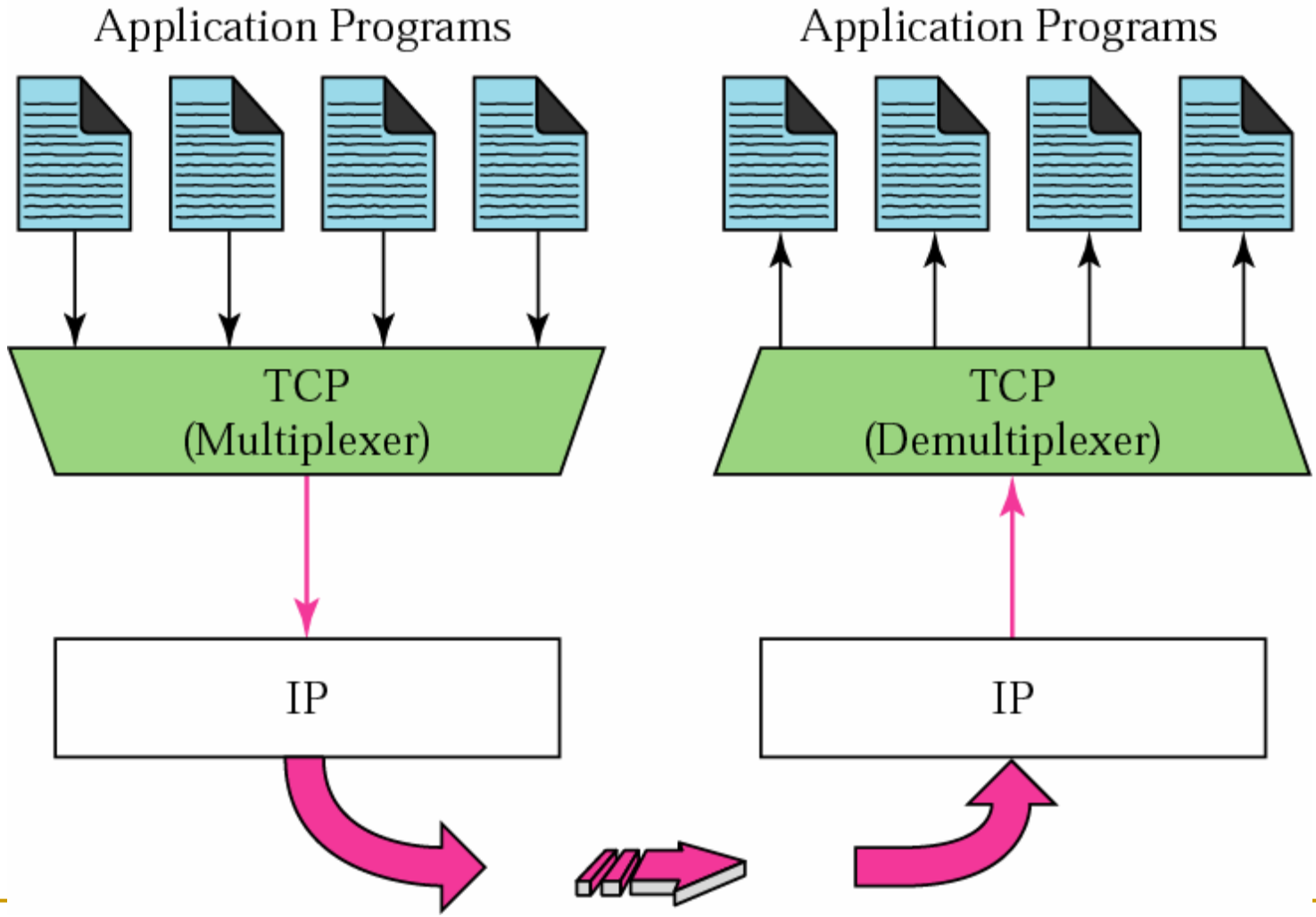
12.14 TCP Operation

- Encapsulation and decapsulation
- Buffering
- Multiplexing and demultiplexing
- Pushing Data
  - Send NOW, deliver to server application ASAP
- Urgent Data
  - Delivered to other application out-of-order

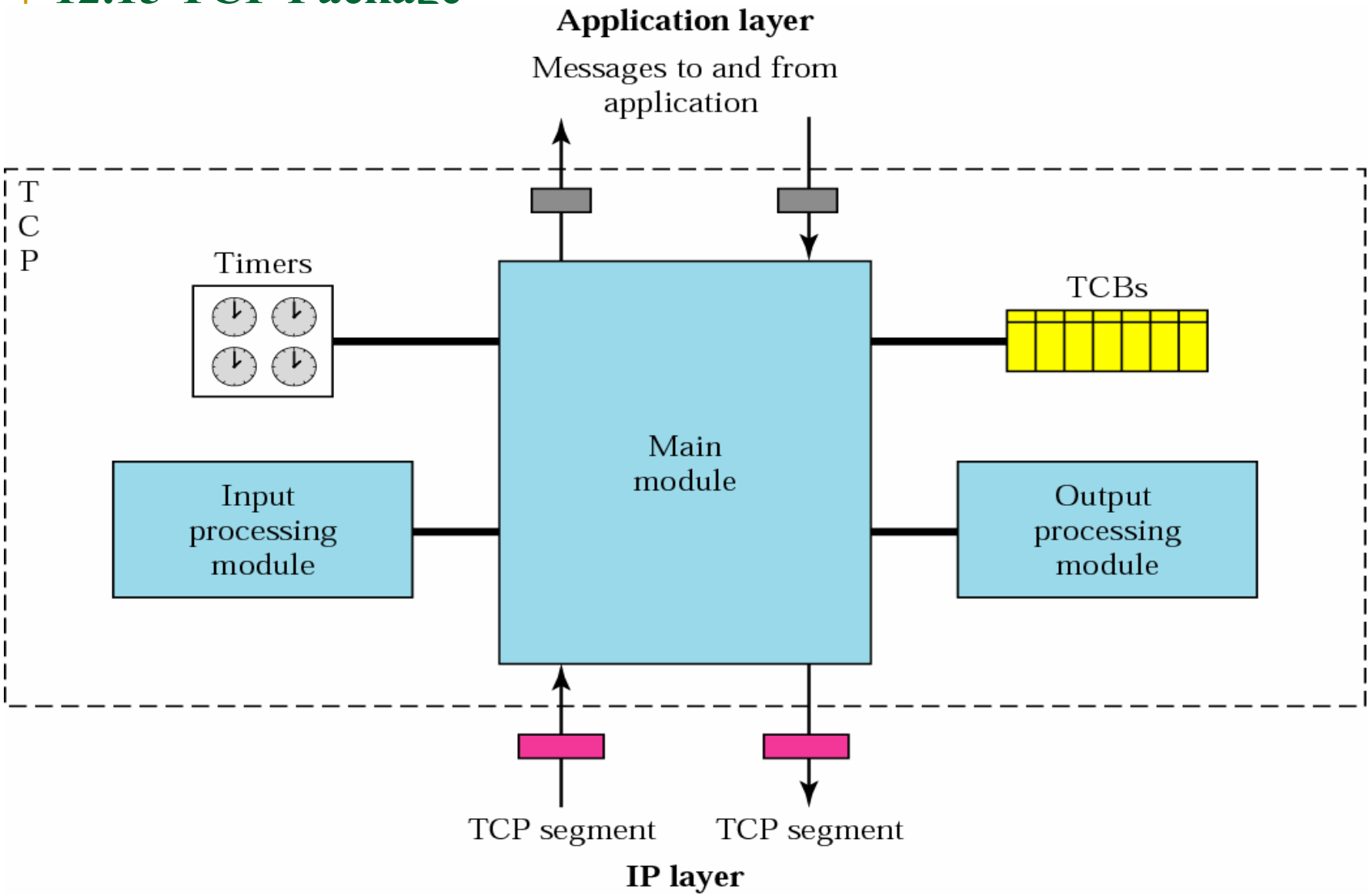
Encapsulation and decapsulation



Multiplexing and demultiplexing



12.15 TCP Package



Transmission Control Blocks