Transport Layer

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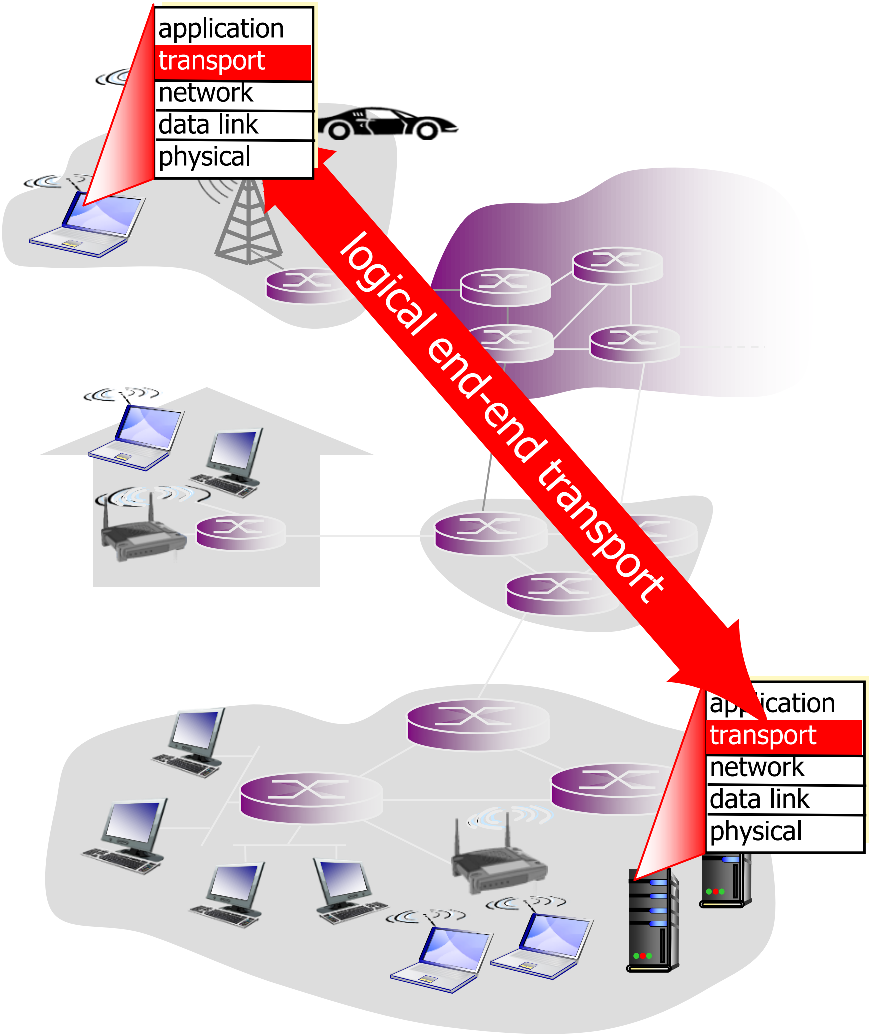
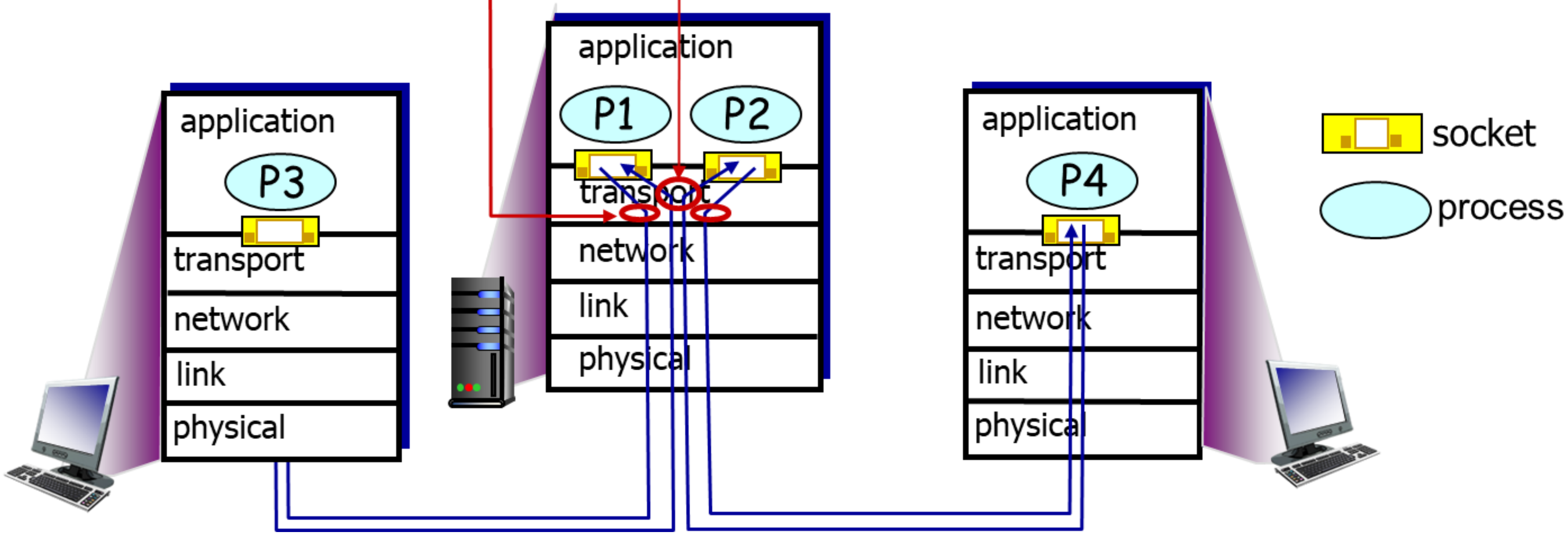
Transport level



Multiplexing/demultiplexing

multiplexing at sender:
handle data from multiple sockets, add transport header (later used for demultiplexing)

demultiplexing at receiver:
use header info to deliver received segments to correct socket



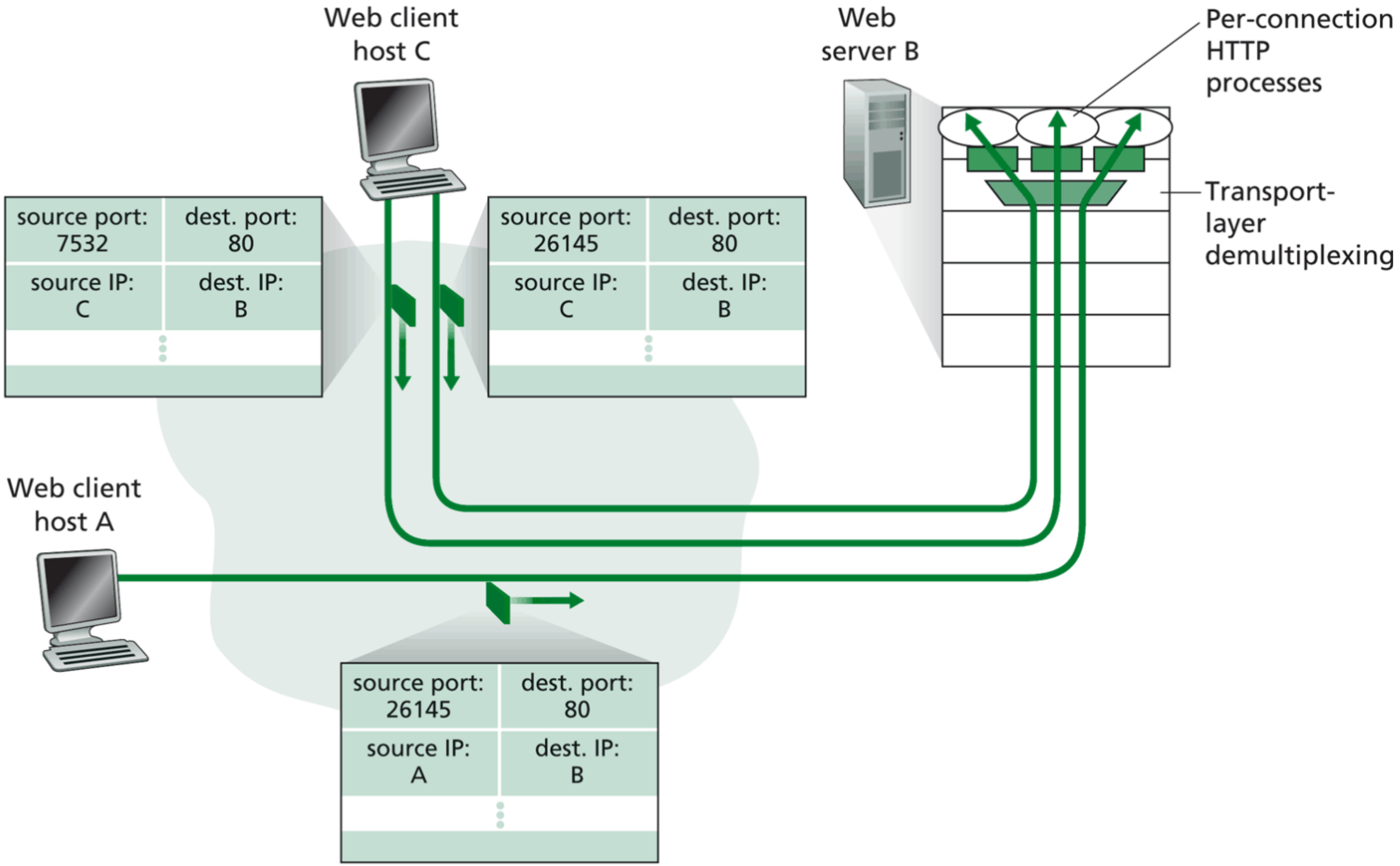
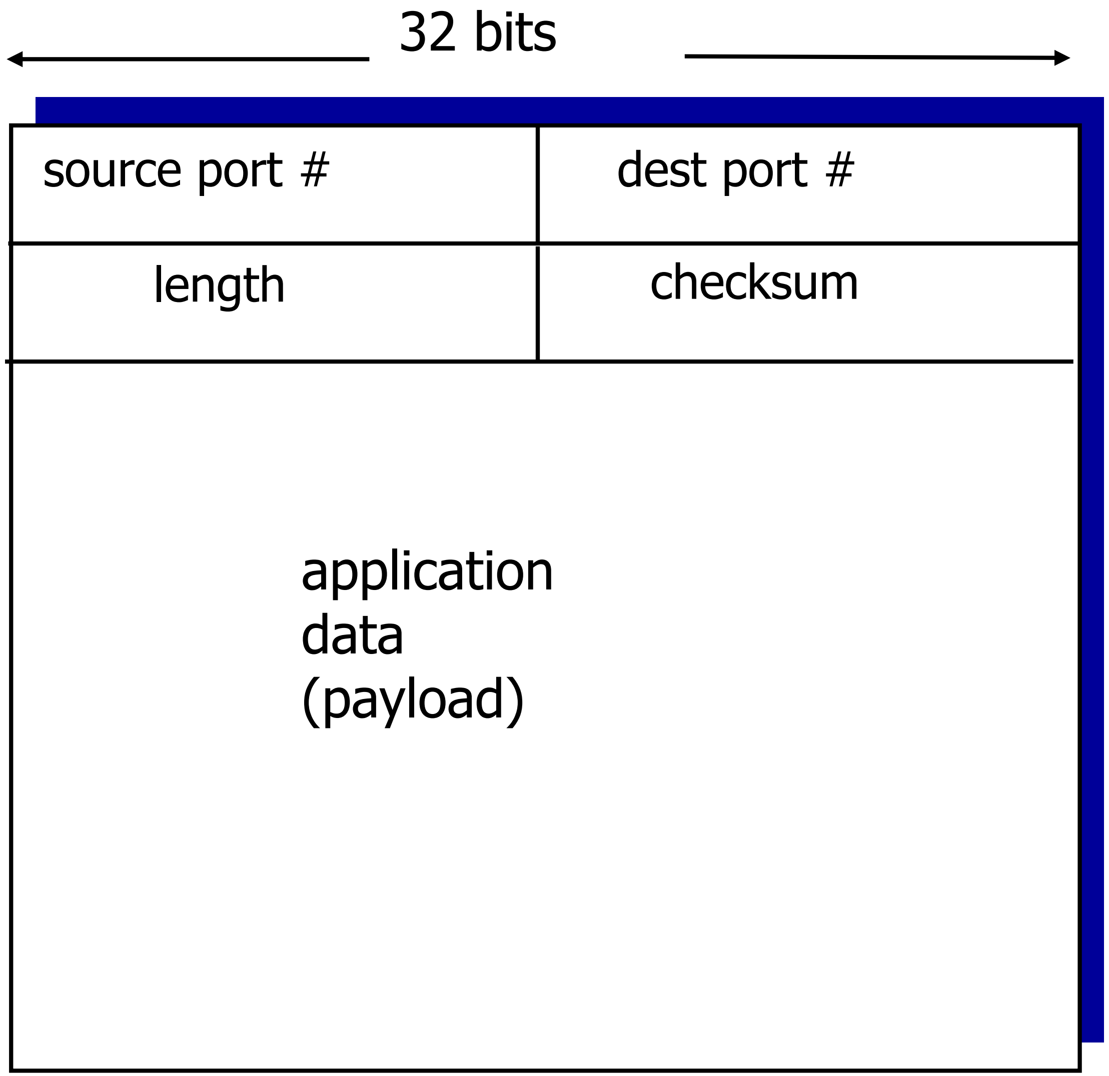


Figure 3.5 ♦ Two clients, using the same destination port number (80) to communicate with the same Web server application

UDP: segment header



32 bits

source port #

dest port #

length

checksum

application data (payload)

UDP segment format

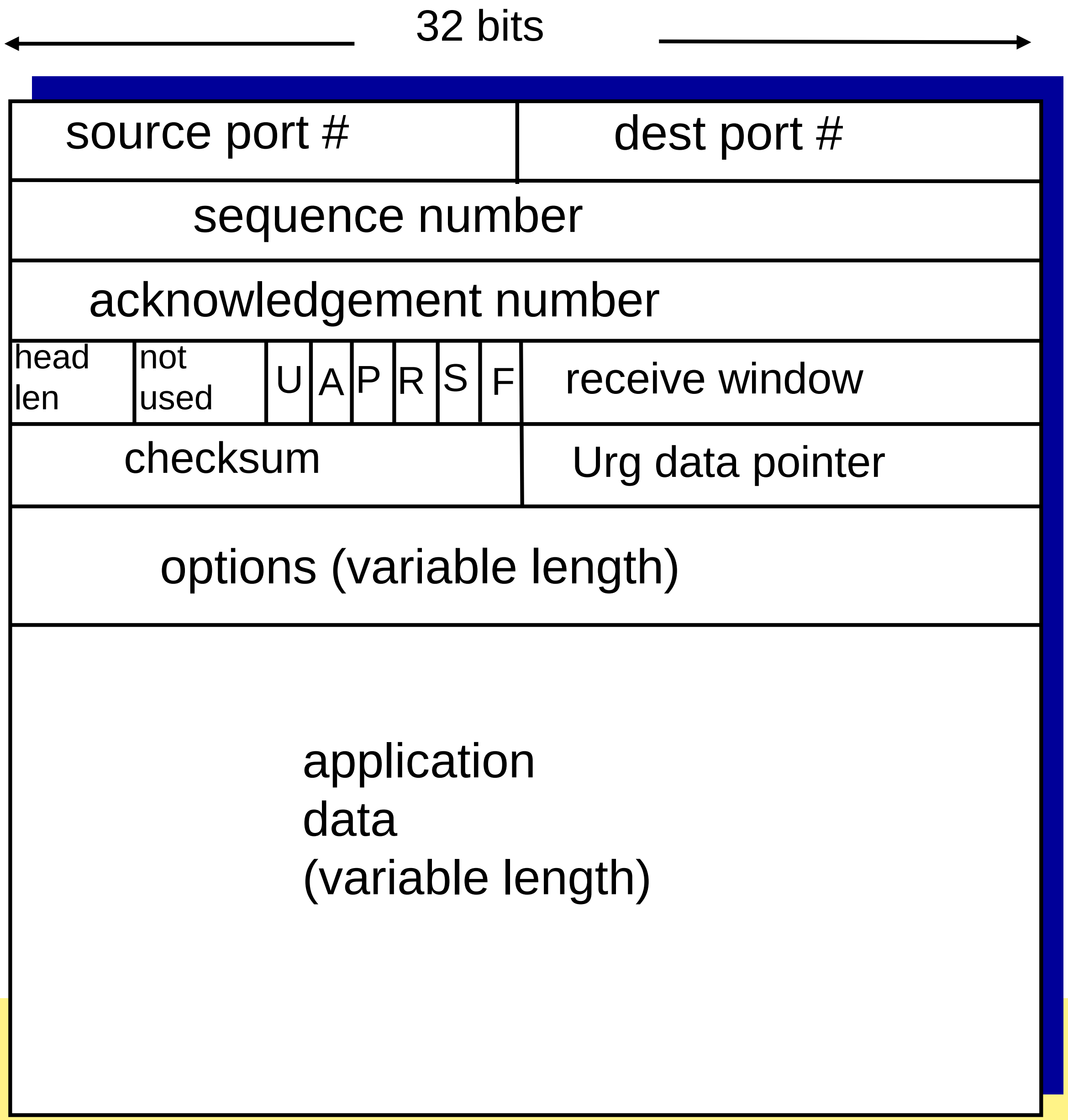
Internet checksum: example

example: add two 16-bit integers

		1	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0
		1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
wraparound	1	1	0	1	1	1	0	1	1	1	0	1	1	1	0	1	1
sum		1	0	1	1	1	0	1	1	1	0	1	1	1	1	0	0
checksum		0	1	0	0	0	1	0	0	0	1	0	0	0	0	1	1

Note: when adding numbers, a carryout from the most significant bit needs to be added to the result

TCP segment structure (TCP Header)



32 bits

source port #

dest port #

sequence number

acknowledgement number

head len

not used

U

A

P

R

S

F

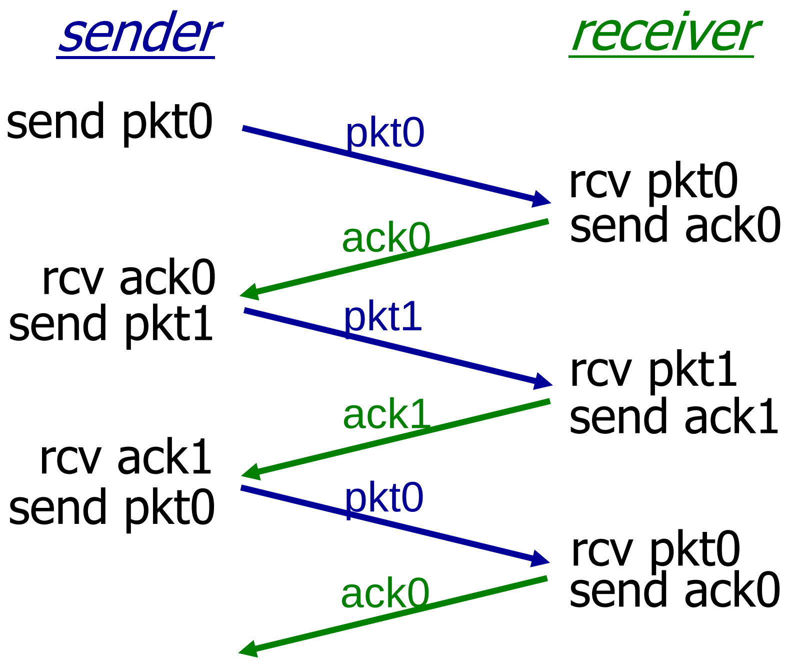
receive window

checksum

Urg data pointer

options (variable length)

application data (variable length)



sender

receiver

send pkt0

pkt0

rcv pkt0
send ack0

ack0

rcv ack0
send pkt1

pkt1

rcv pkt1
send ack1

ack1

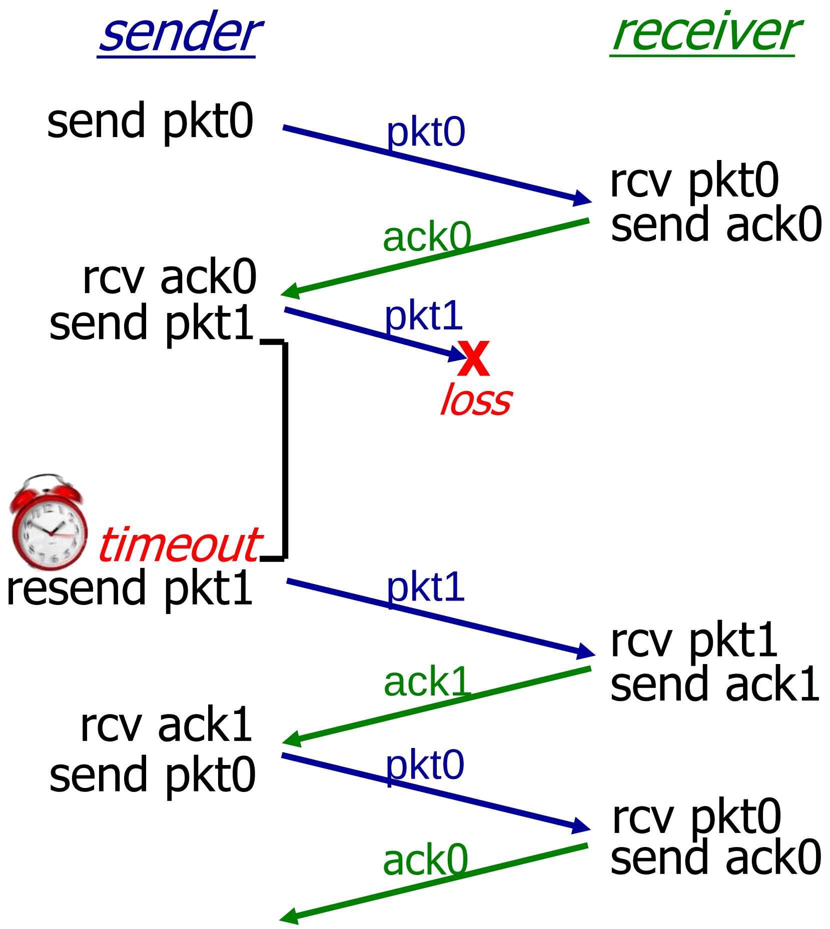
rcv ack1
send pkt0

pkt0

rcv pkt0
send ack0

ack0

(a) no loss



sender

receiver

send pkt0

pkt0

rcv pkt0
send ack0

ack0

rcv ack0
send pkt1

pkt1

timeout

resend pkt1

pkt1

rcv pkt1
send ack1

ack1

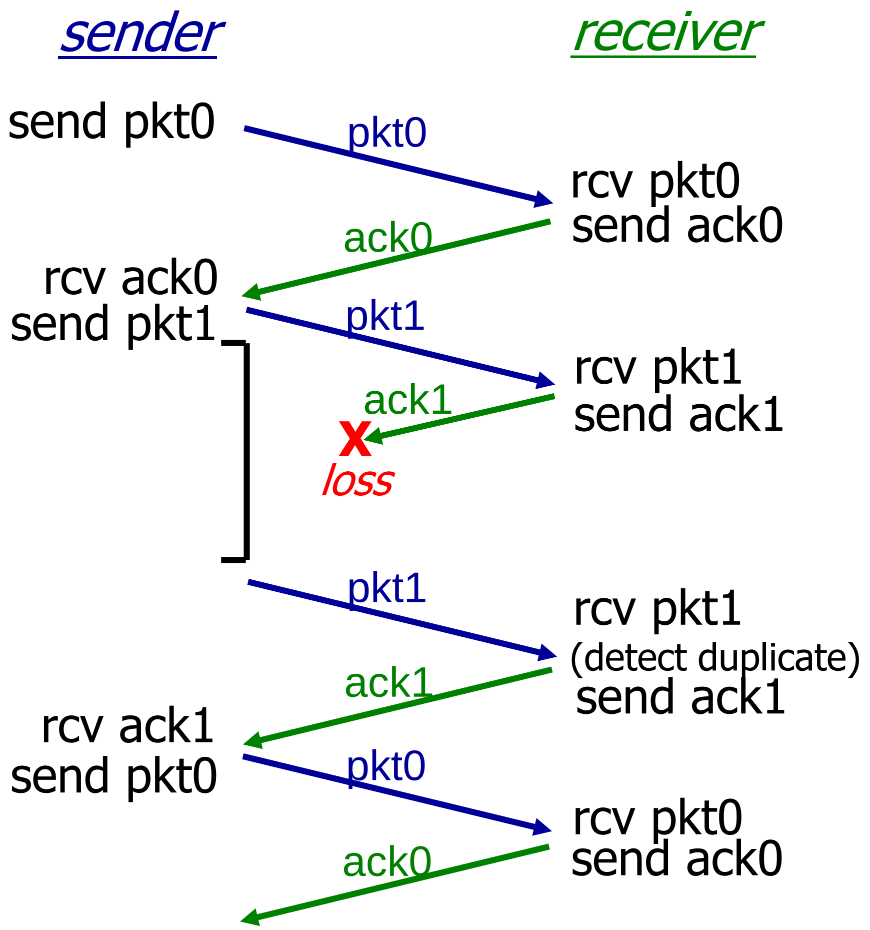
rcv ack1
send pkt0

pkt0

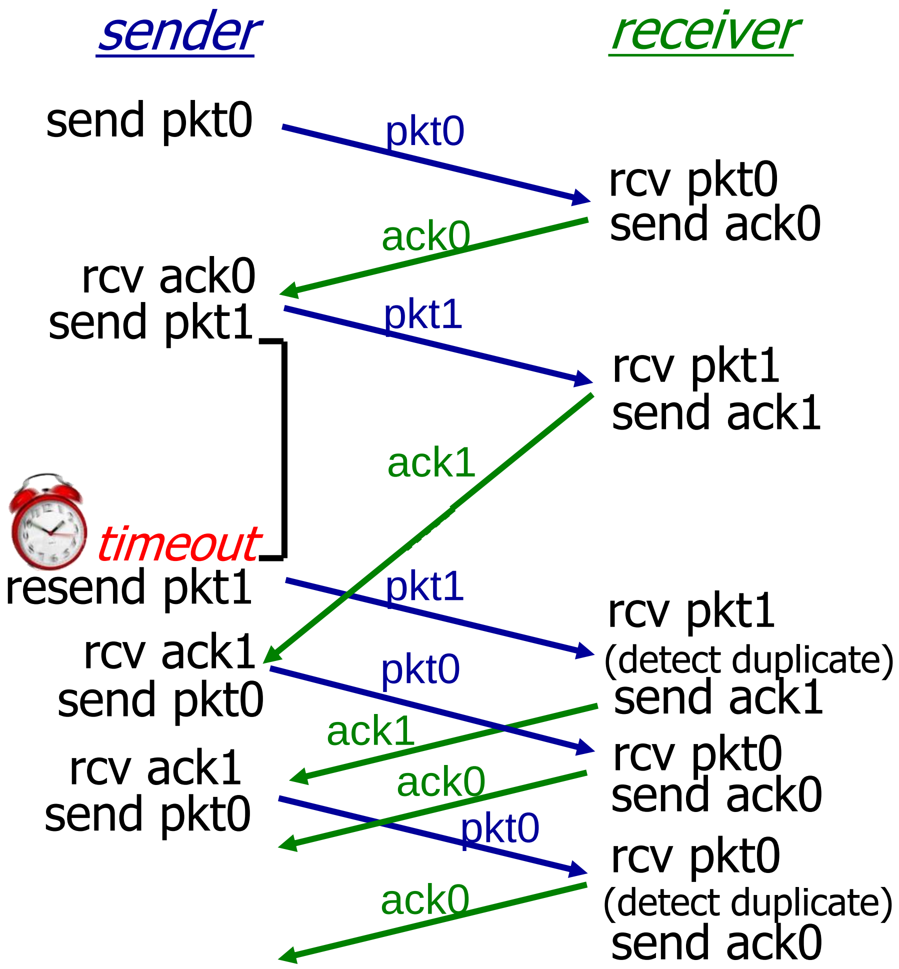
rcv pkt0
send ack0

ack0

(b) packet loss

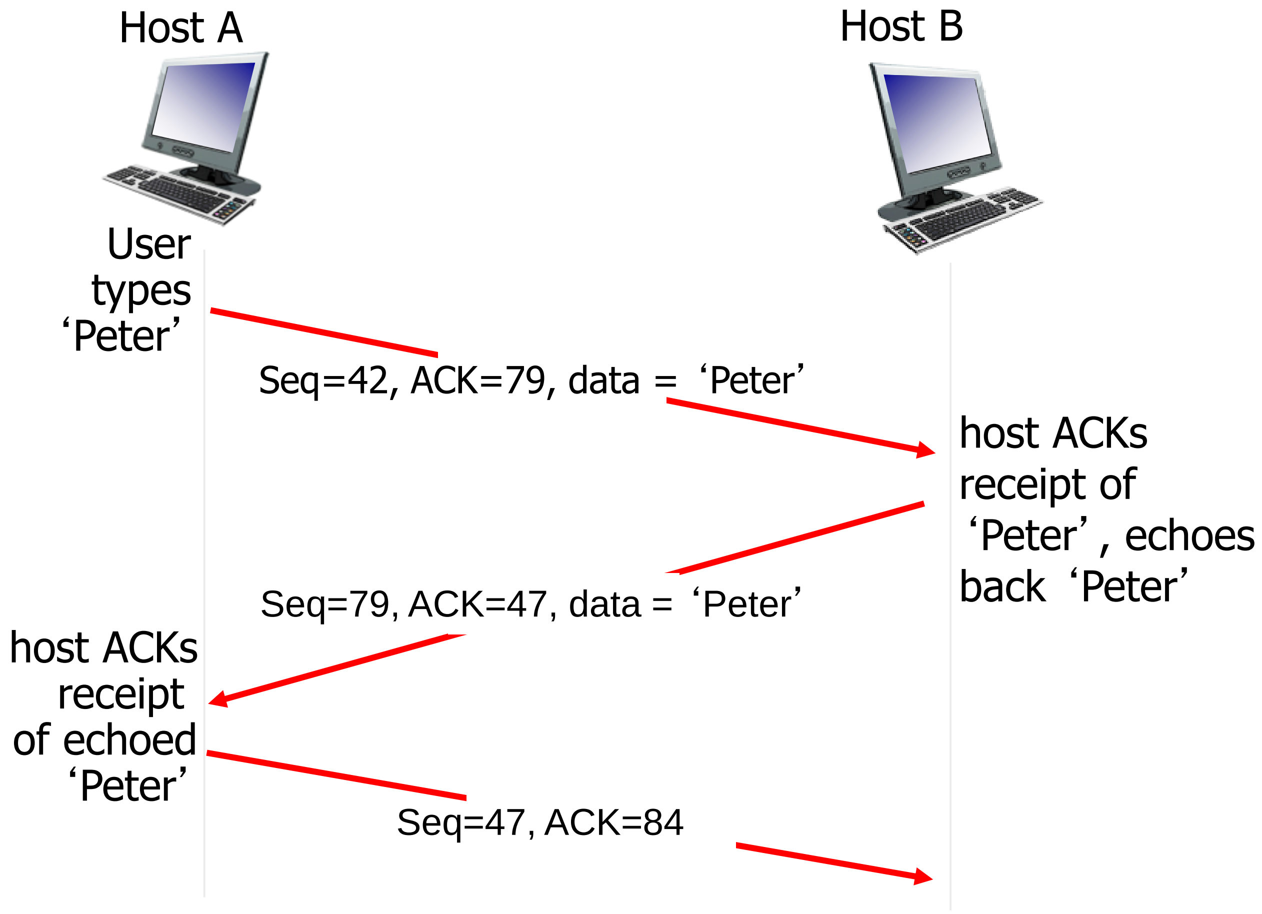


(c) ACK loss



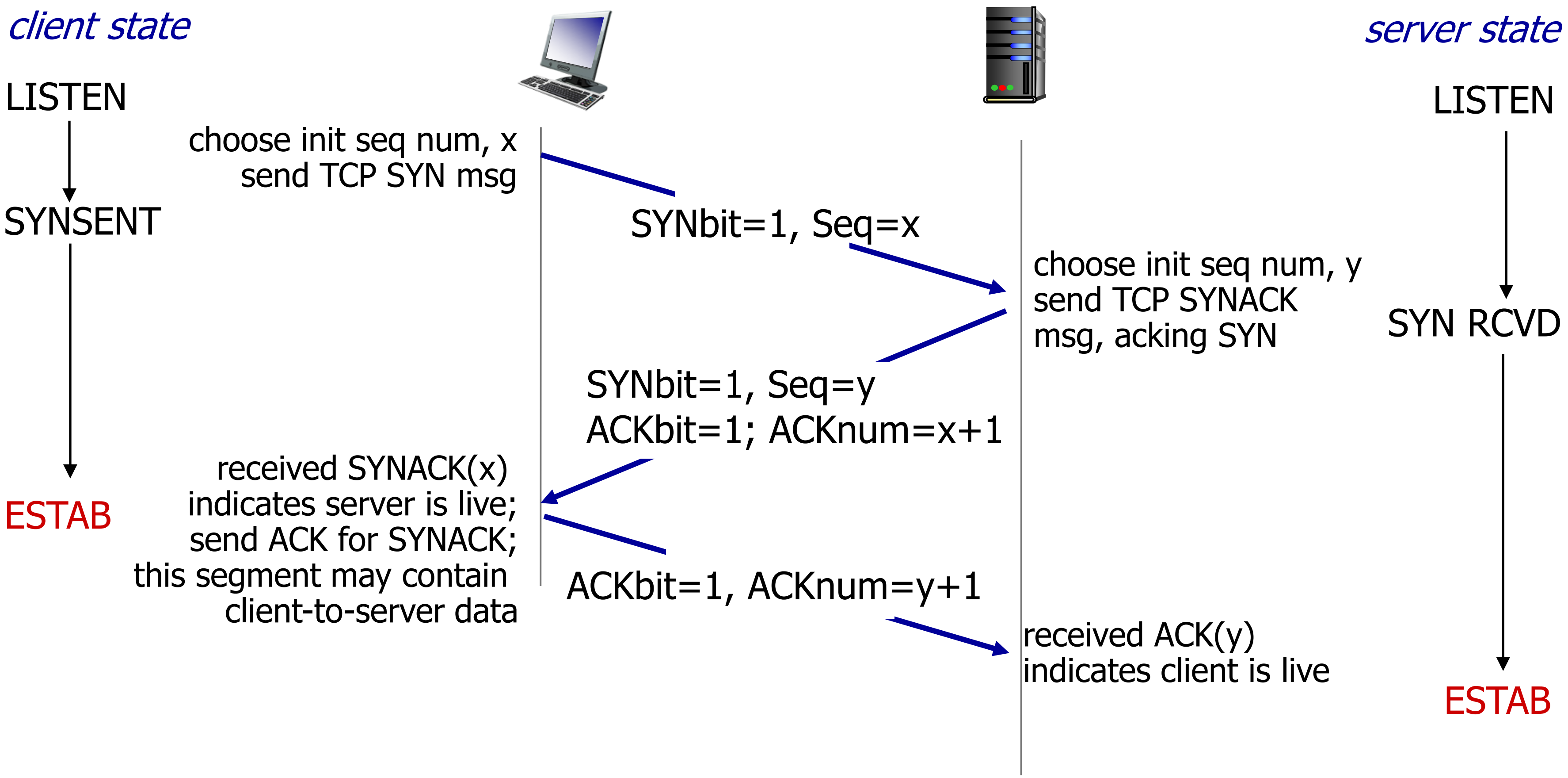
(d) premature timeout/ delayed ACK

TCP seq. numbers, ACKs


Host A
Host B
User types ‘Peter’
Seq=42, ACK=79, data = ‘Peter’
host ACKs receipt of ‘Peter’, echoes back ‘Peter’
Seq=79, ACK=47, data = ‘Peter’
host ACKs receipt of echoed ‘Peter’
Seq=47, ACK=84

simple telnet scenario

TCP 3-way handshake



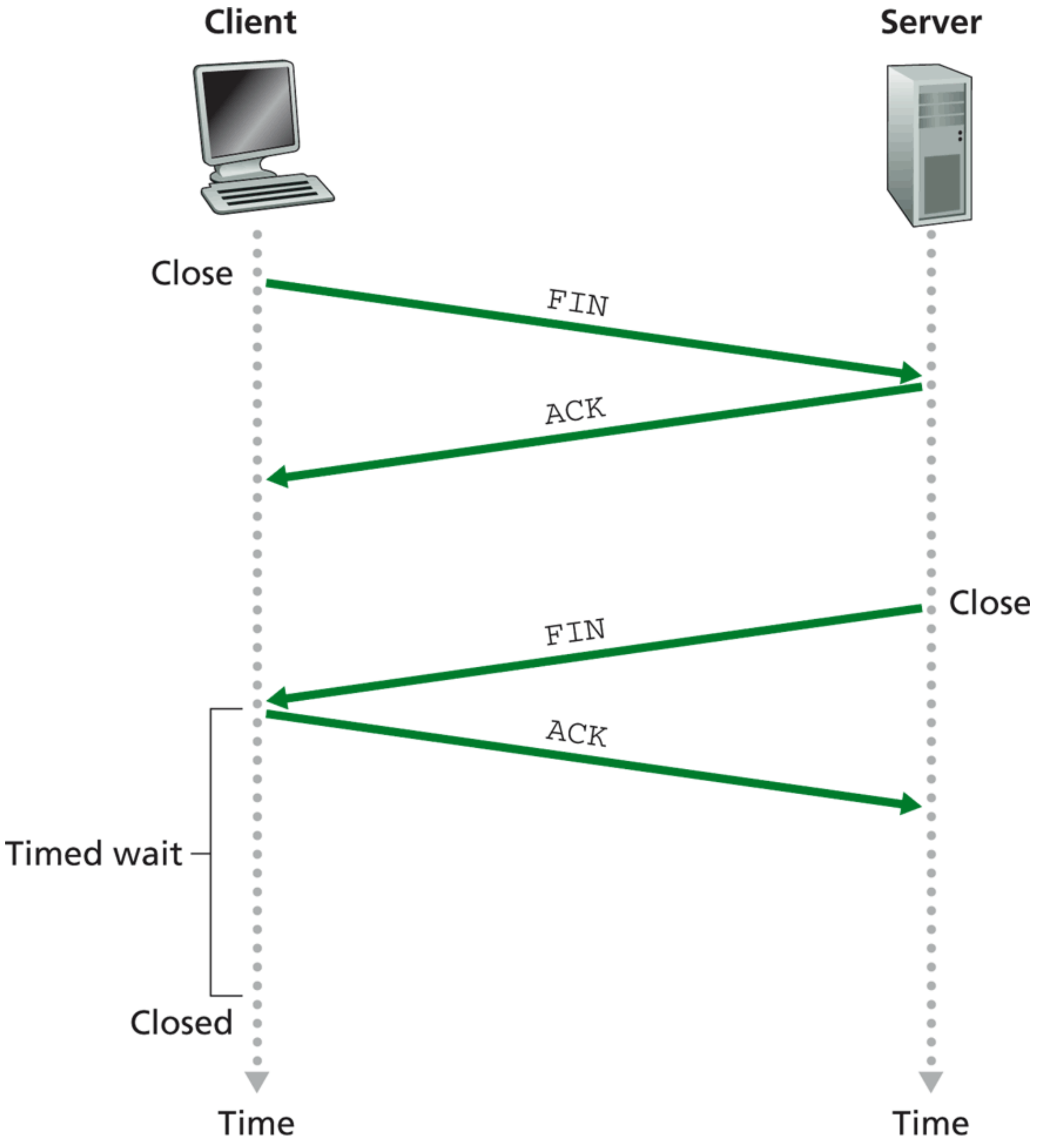
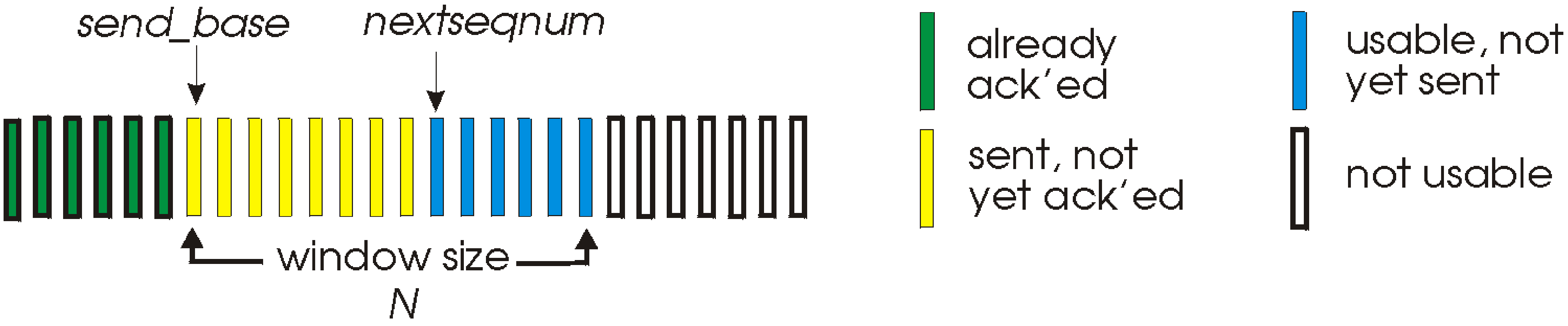
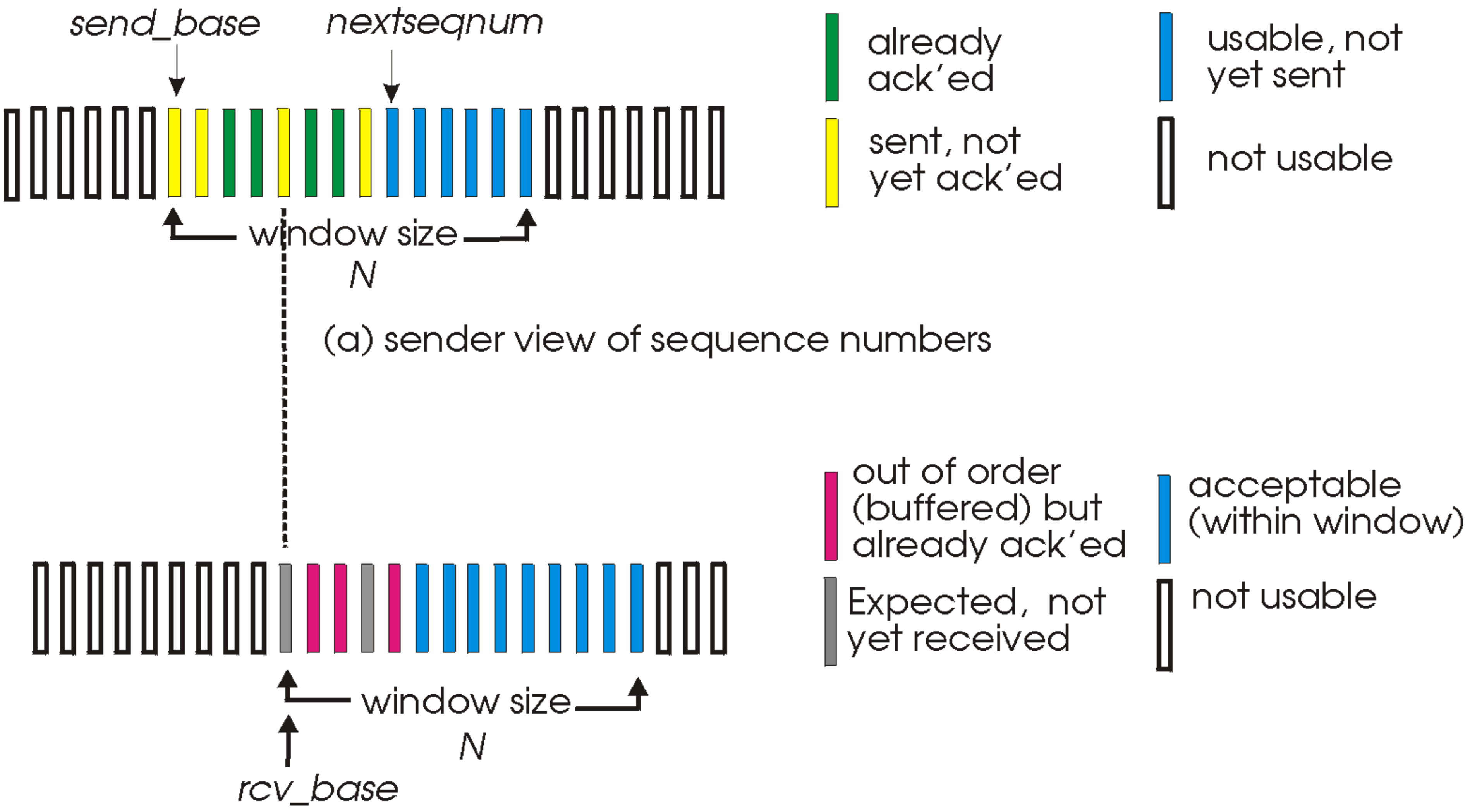


Figure 3.39 ♦ Closing a TCP connection

Go Back N


send_base
nextseqnum
window size
N
already ack'ed
usable, not yet sent
sent, not yet ack'ed
not usable

Selective Repeat

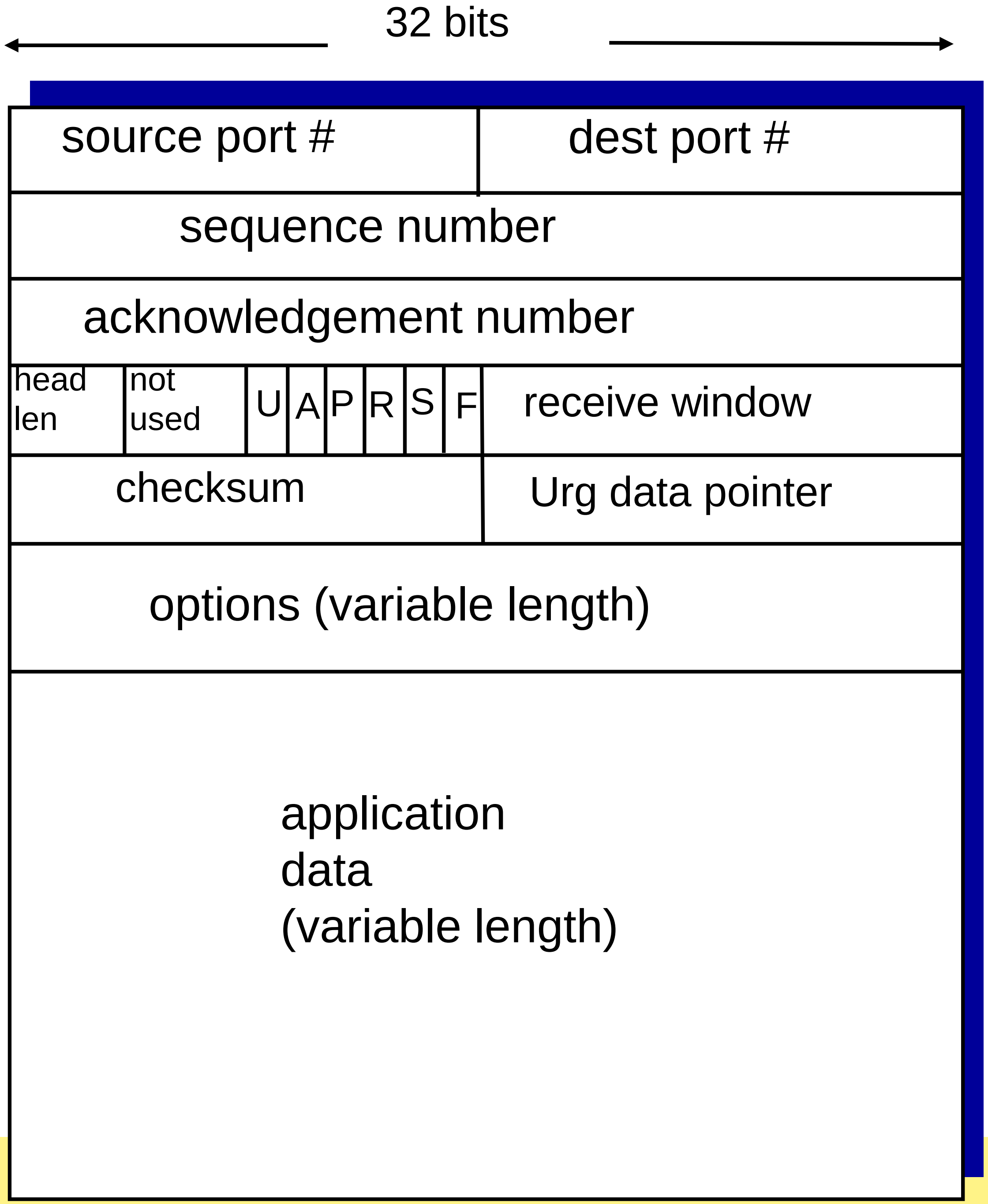


(a) sender view of sequence numbers

(b) receiver view of sequence numbers

TCP segment structure

TCP Header



32 bits

source port #

dest port #

sequence number

acknowledgement number

head len

not used

U A P R S F

receive window

checksum

Urg data pointer

options (variable length)

application
data
(variable length)