Computer Networks

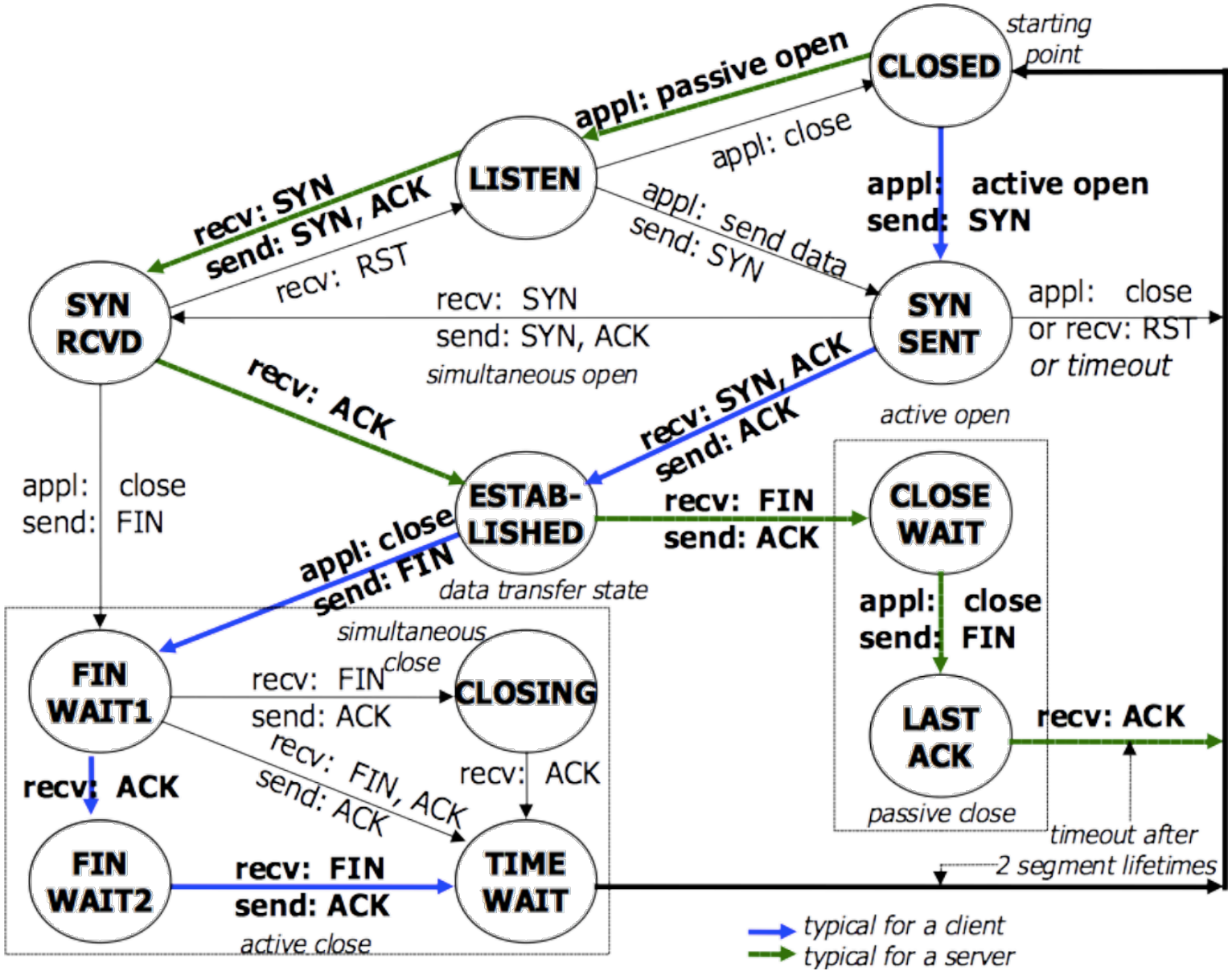
Tutorial 6:

Transmission Control Protocol

Scope of This Tutorial

- TCP state machine
- TCP acknowledgements
- Nagle algorithm
- Congestion window

TCP State Machine



Exercise 1

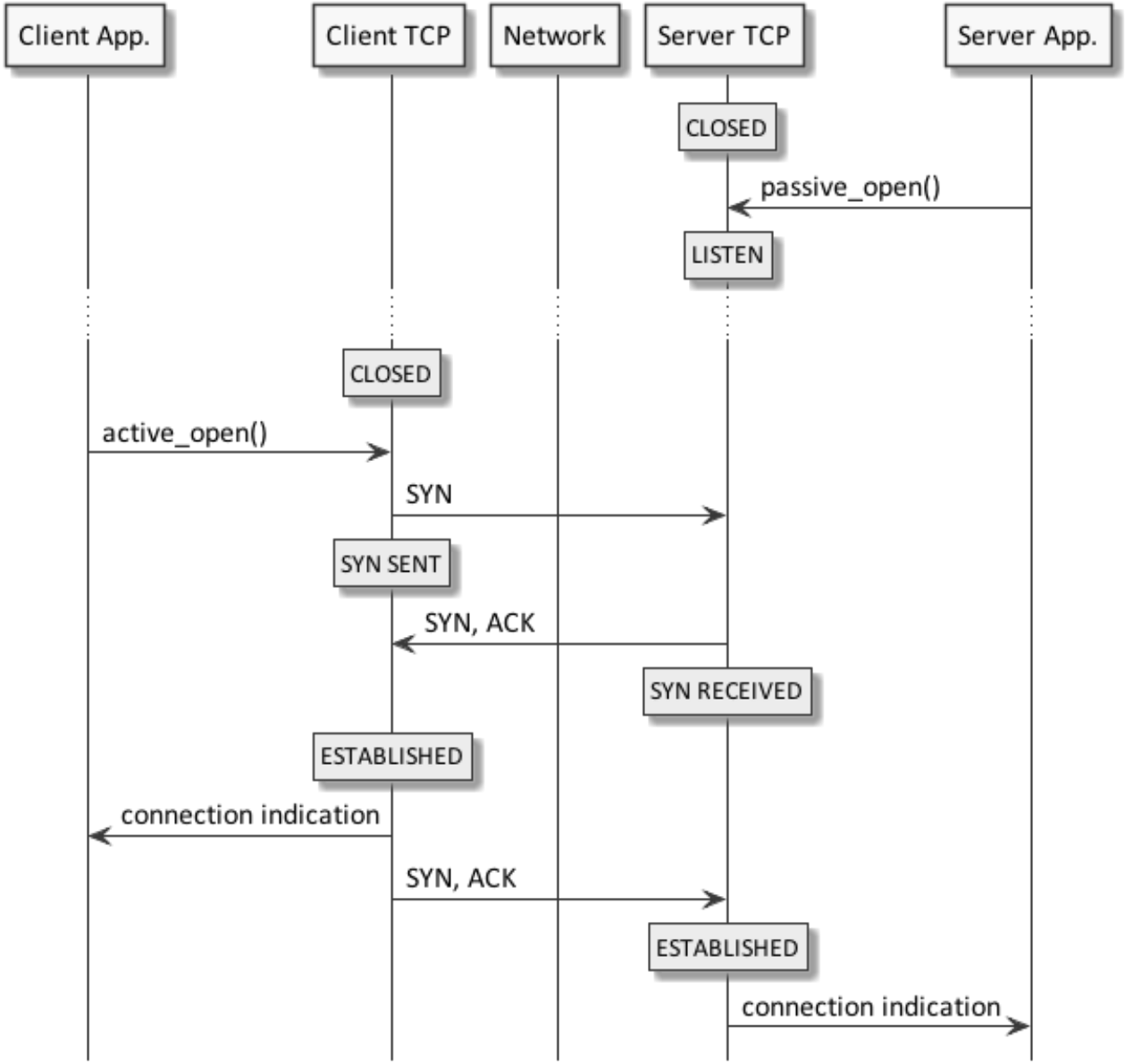
Draw message sequence chart that illustrates interactions between

- client application
- client TCP instance
- network
- server TCP instance
- server application

for the following scenarios:

A. The server application enters into the Listen state & later the client application opens a connection with the server.
B. Simultaneously server and client open the connection.
C. Simultaneously server and client close the connection.

Solution to Exercise 1A



TCP Acknowledgements

TCP sequence number – indexes the first data byte carried by the segment

TCP acknowledgement number – index of the first expected byte

Notations used in the exercise:

- ISN_A – initial sequence number declared by node A
- ISN_B – initial sequence number declared by node B
- SEQ_N – sequence number
- ACK_N – acknowledgement number

Exercise 2

A and B create a TCP connection with ISN_A=20,000 and ISN_B=5,000.
A sends three 1000-byte packets (Data1, Data2 and Data3 below), and B ACKs each.
Then B sends a 1000-byte packet DataB to A and terminates the connection with a FIN.
In the table below, fill in the SEQ and ACK fields for each packet shown.

A sends	B sends
SYN, ISN_A=20,000	
	SYN, ISN_B=5,000, ACK_N=20,001
ACK, SEQ_N=20,000, ACK_N=5,001	
Data1, SEQ_N=20,001, ACK_N=5,001	
	ACK, SEQ_N=_____, ACK_N=_____
Data2, SEQ_N=_____, ACK_N=_____	
	ACK, SEQ_N=_____, ACK_N=_____
Data3, SEQ_N=_____, ACK_N=_____	
	ACK, SEQ_N=_____, ACK_N=_____
	DataB, SEQ_N=_____, ACK_N=_____
ACK, SEQ_N=_____, ACK_N=_____	
	FIN, SEQ_N=_____, ACK_N=_____

Nagle Algorithm *RFC 896*

A TCP endpoint generating small data segments should queue them until

- either it accumulates a full segment's worth
- or receives an ACK for the previous batch of small segments

  The full-segment threshold is not reached – this means that
  - only one (consolidated) segment will be sent per RTT

Exercise 3

A user moves the computer mouse and sees the mouse-cursor's position updated on the screen.

The mouse-position updates are being transmitted over a TCP connection with a relatively long RTT

The user attempts to move the cursor to a specific point

How will the user perceive the mouse's motion

a) with the Nagle algorithm?

b) without the Nagle algorithm?

Note: There is a BSD socket option that allows for switching on or off the Nagle algorithm

Congestion Window

Slow start

cwnd grows exponentially till rwnd or sstresh

after each RTT

cwnd = 1 MSS

= 2 MSS

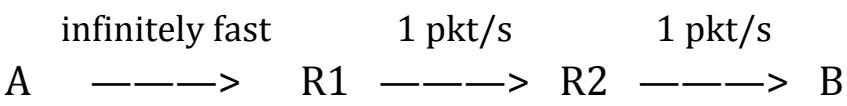
= 4 MSS

= 8 MSS

Congestion avoidance

cwnd += 1 MSS every RTT

Exercise 4



Assume:

- ACKs travel instantly from B to R (and thus to A)
- there are no propagation delays, so the RTT_{noLoad} is 4

If A uses sliding windows with a window size of 6, the queue at R1 will eventually have size 2
A uses **threshold** slow start with ssthresh = 6, and with cwnd initially 1.

Which packet is sent by every node in the time span from 0 to 10 s?

Note that if, instead of using slow start, A simply sends the initial windowful of 6 packets all at once, then the queue at R1 will initially hold 6-1 = 5 packets