TCP State Machine

Network Programming

Overview

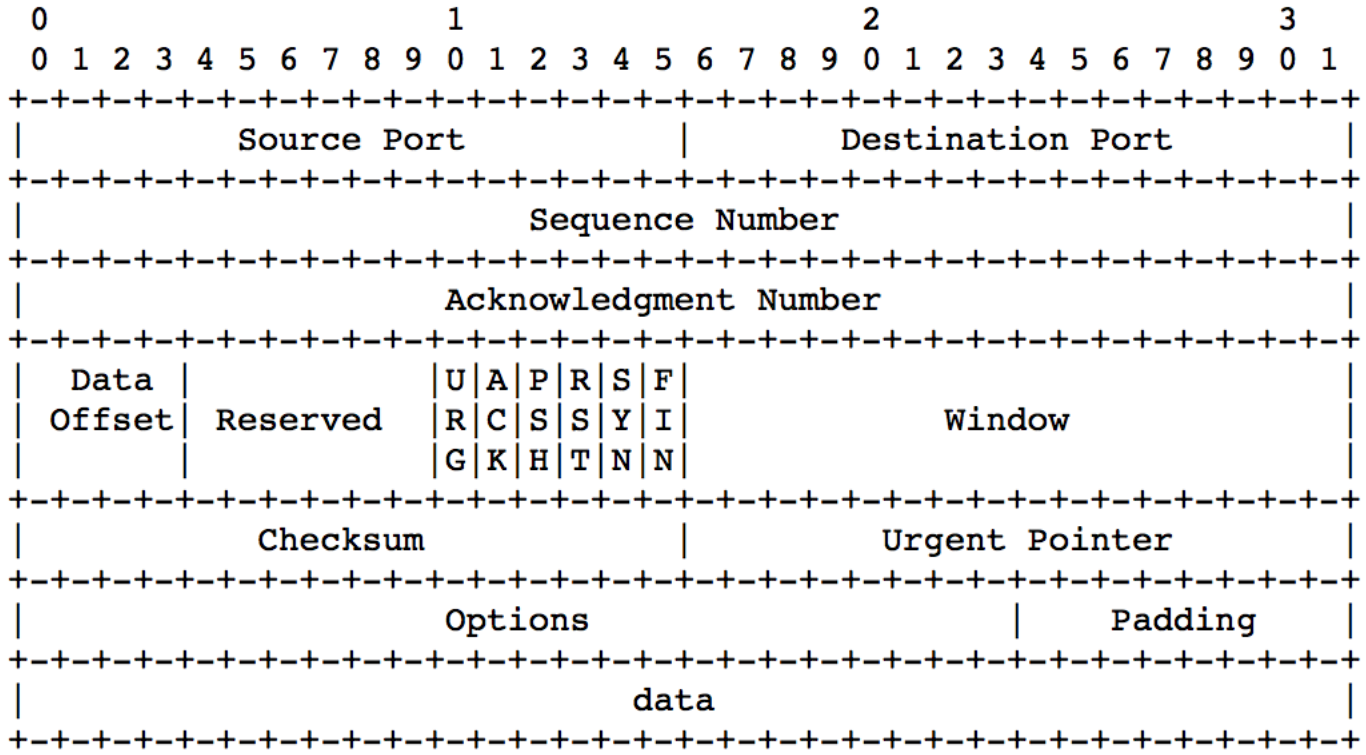
- TCP (Transmission Control Protocol) provides reliability
  - In-order
  - Connection-oriented
- Uses a "state machine"
  - transitions from one state to another based on input / actions

IP

- Connectionless delivery
  - Each datagram handled individually
- Unreliable
  - No guarantee
- Fragmentation + reassembly
  - Hardware MTU
- Routing
- Error detection

TCP Segment Format

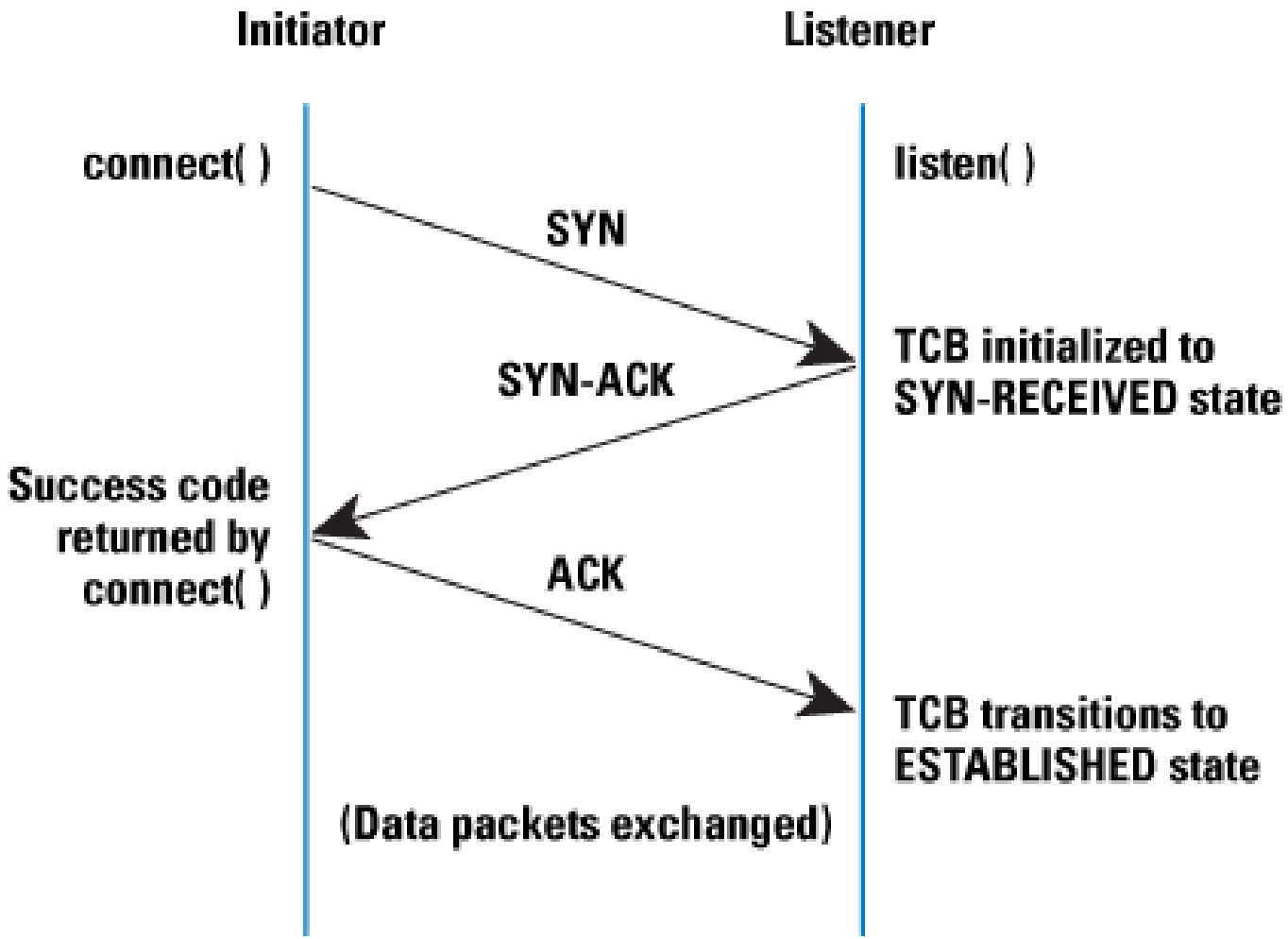
https://tools.ietf.org/html/rfc793#section-3.1



TCP Header Format

Note that one tick mark represents one bit position.

Three Way Handshake



Three Way Handshake

- Initiator sends first segment
  - SYN, seq=x
- Listener responds
  - SYN, seq=y, ACK=x+1
- Initiator ACKs the ACK
- Necessary and sufficient

TCP Builds on IP

- Unreliable packet delivery
- Messages can be lost, delayed, duplicated, or arrive out of order
- TCP requires a timeout mechanism
  - If we don’t receive an ACK for segments we have sent, resend

3WHS: What We Get

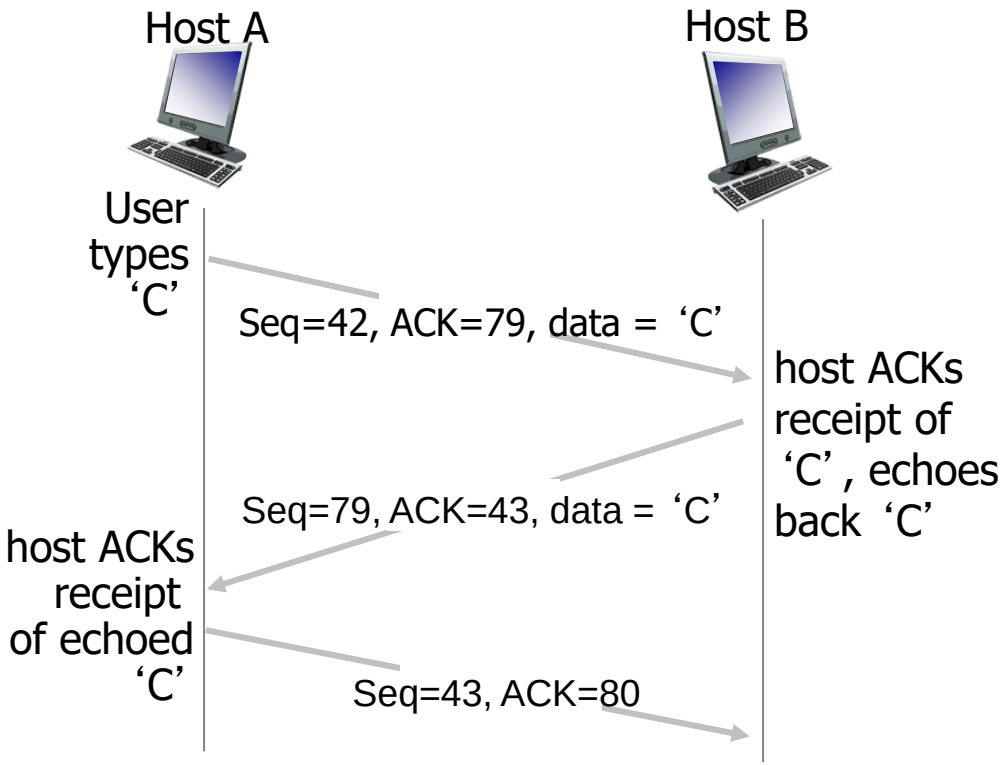
- Guarantees both sides are ready
  - Also, they know they are ready
- Both have agreed to their respective Initial Sequence Numbers
- RFC 761, Section 3.3 covers ISNs
  - https://tools.ietf.org/html/rfc761#section-3.3
  - “It should be noted that this strategy does not protect against spoofing or other replay type duplicate message problems.”

TCP "Normal" Behavior

- Send the data
- Wait for an acknowledgement (ACK)
- More data? Repeat.
- Simple, right?

Simple Telnet Example

- Source on last slide



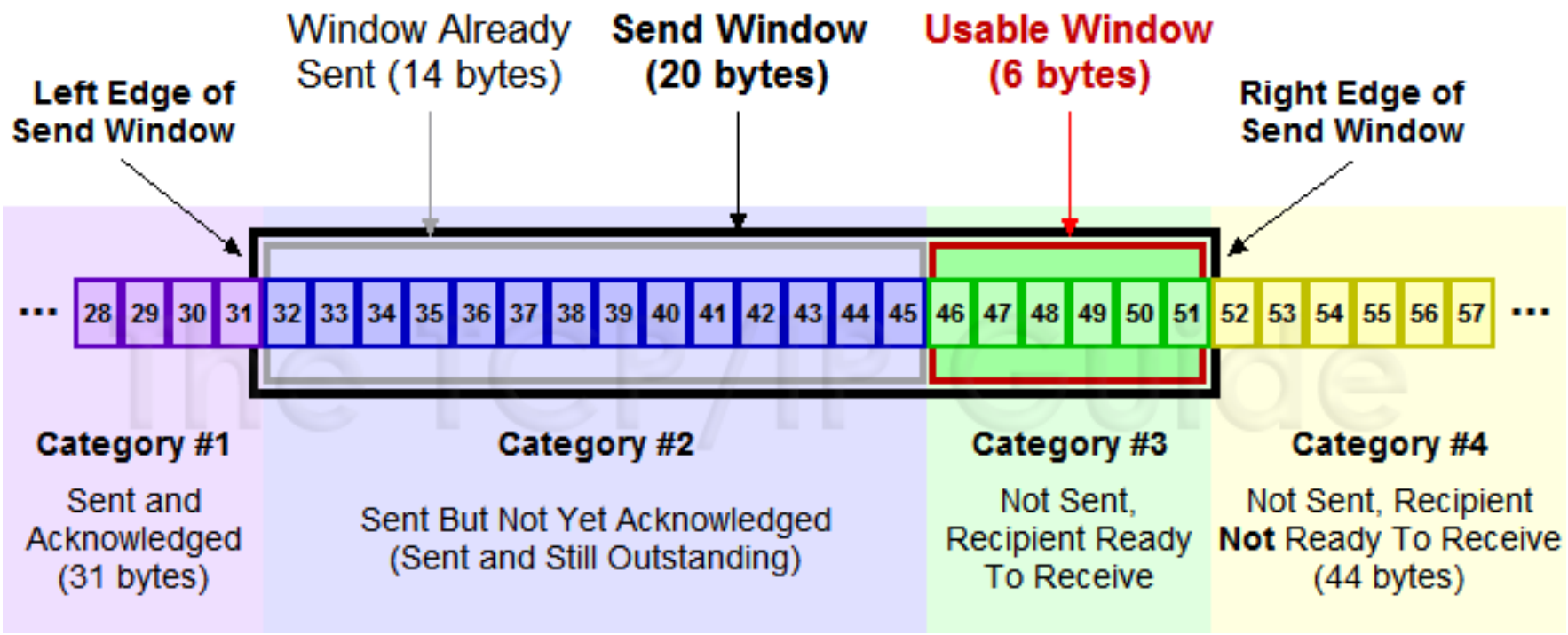
simple telnet scenario

High latency networks?

- We would spend a lot of time waiting for ACKs
- The network would go largely underutilized
- Any way around this problem?

Sliding (dynamic) Windows

- http://packetlife.net/blog/2010/jun/7/understanding-tcp-sequence-acknowledgment-numbers/



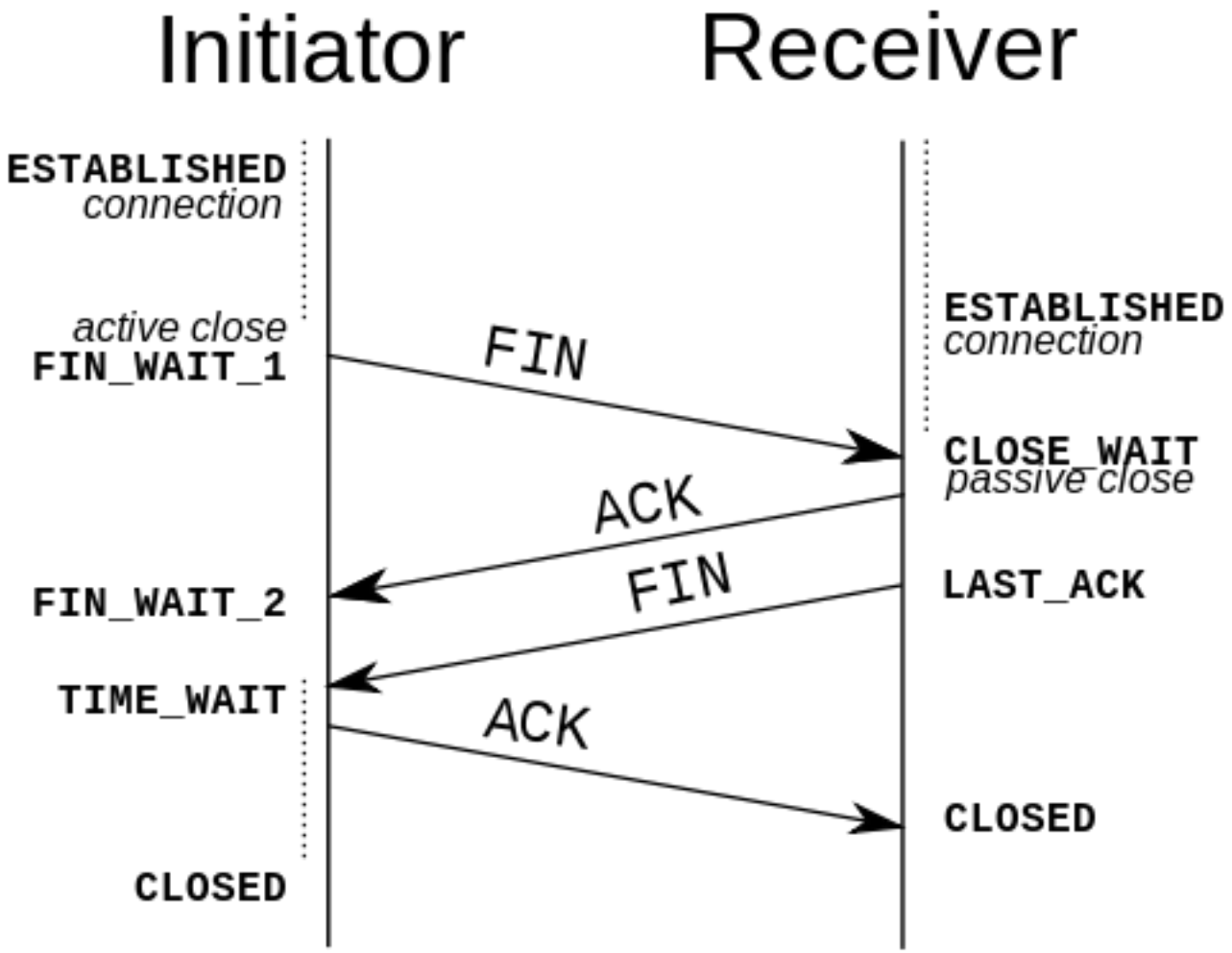
TCP Close Connections

- Use a modified 3WHS
- Recall TCP is full-duplex, there are two independent streams
- When A decides it's done, close connection (one direction):
  - wait for final ACK, then send FIN
  - B ACKs the FIN

TCP Close Connections pt 2

- B decides to close its connection
  - Send FIN, ACK x+1
- A receives FIN + ACK segment
  - Send ACK y+1
- Connection closed in both directions

Four Way Handshake



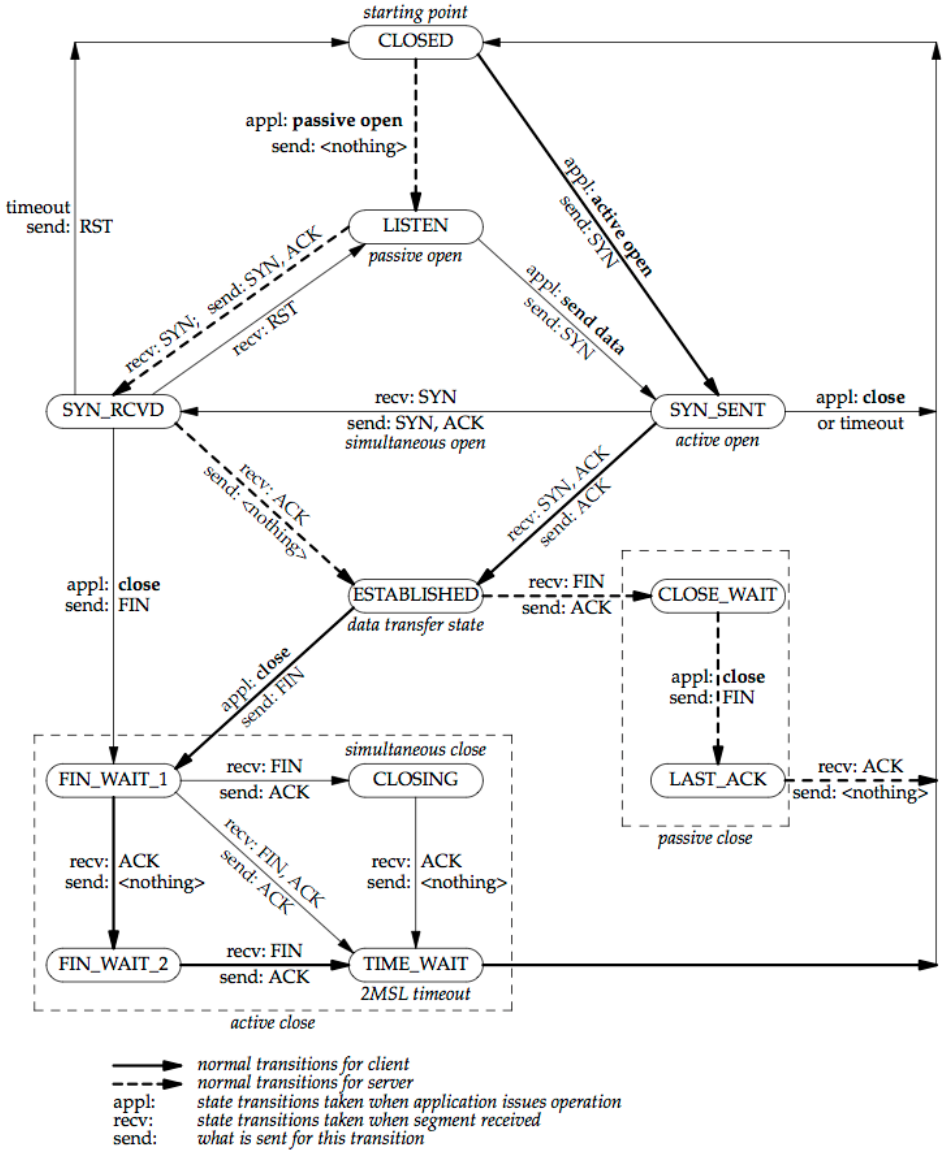
4WHS: Details

- Initial FIN is important
  - TCP ACKs and informs application
  - Receiver FIN _NOT_ sent immediately
- Receiver app closes connection
  - Sends 2nd FIN, ACK
- Initiator receives FIN+ACK, responds with ACK

TCP Connection Reset

- Normally use **`close()`** to close connection
- Sometimes things go wrong; we must break the connection
- Send a TCP segment with RST=1
- Other host aborts connection

TCP State Machine



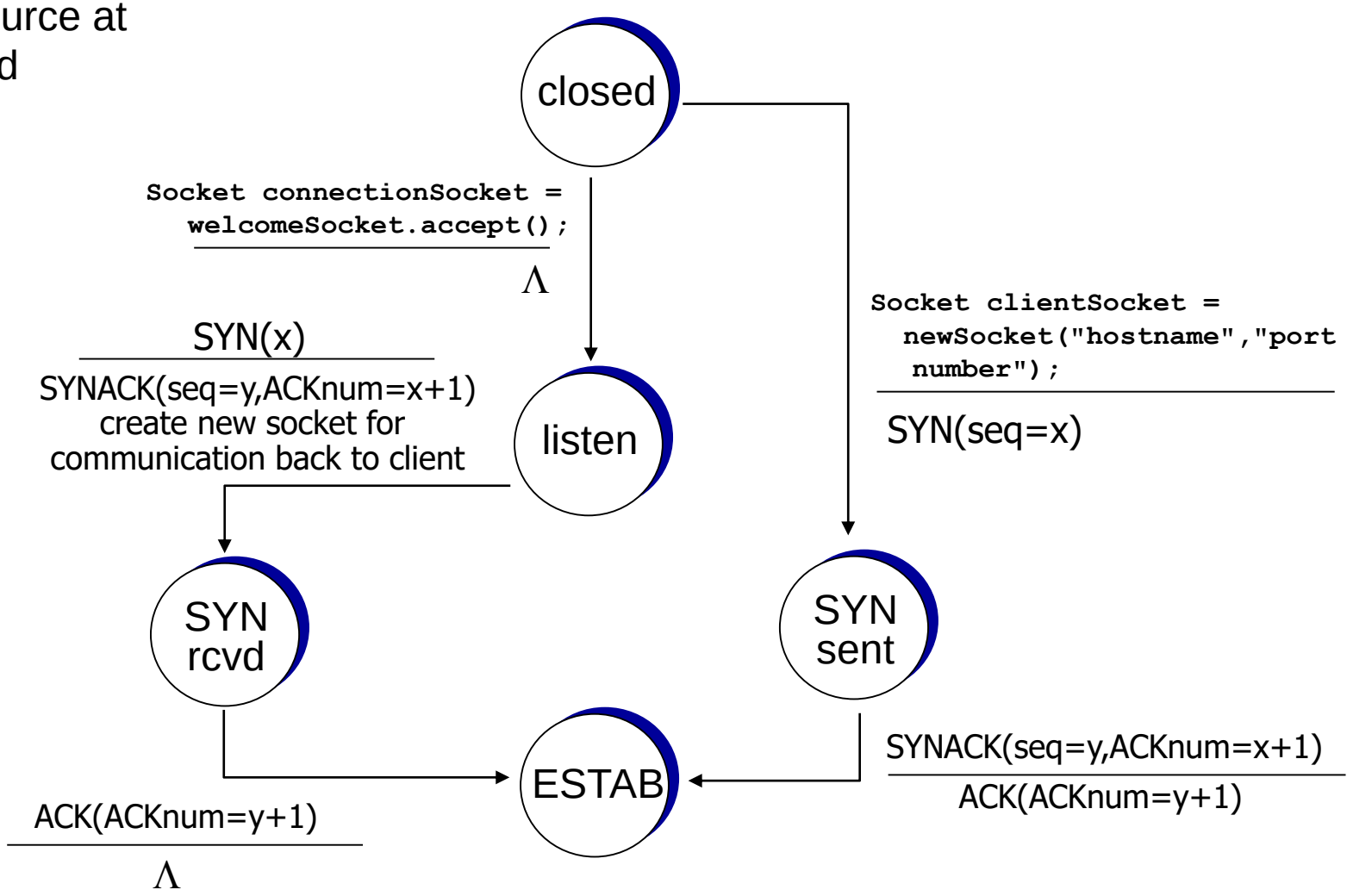
Source:
https://www.ibm.com/support/knowledgecenter/en/SSLTBW_2.1.0/com.ibm.zos.v2r1.halu101/constatus.htm

TCP State Machine

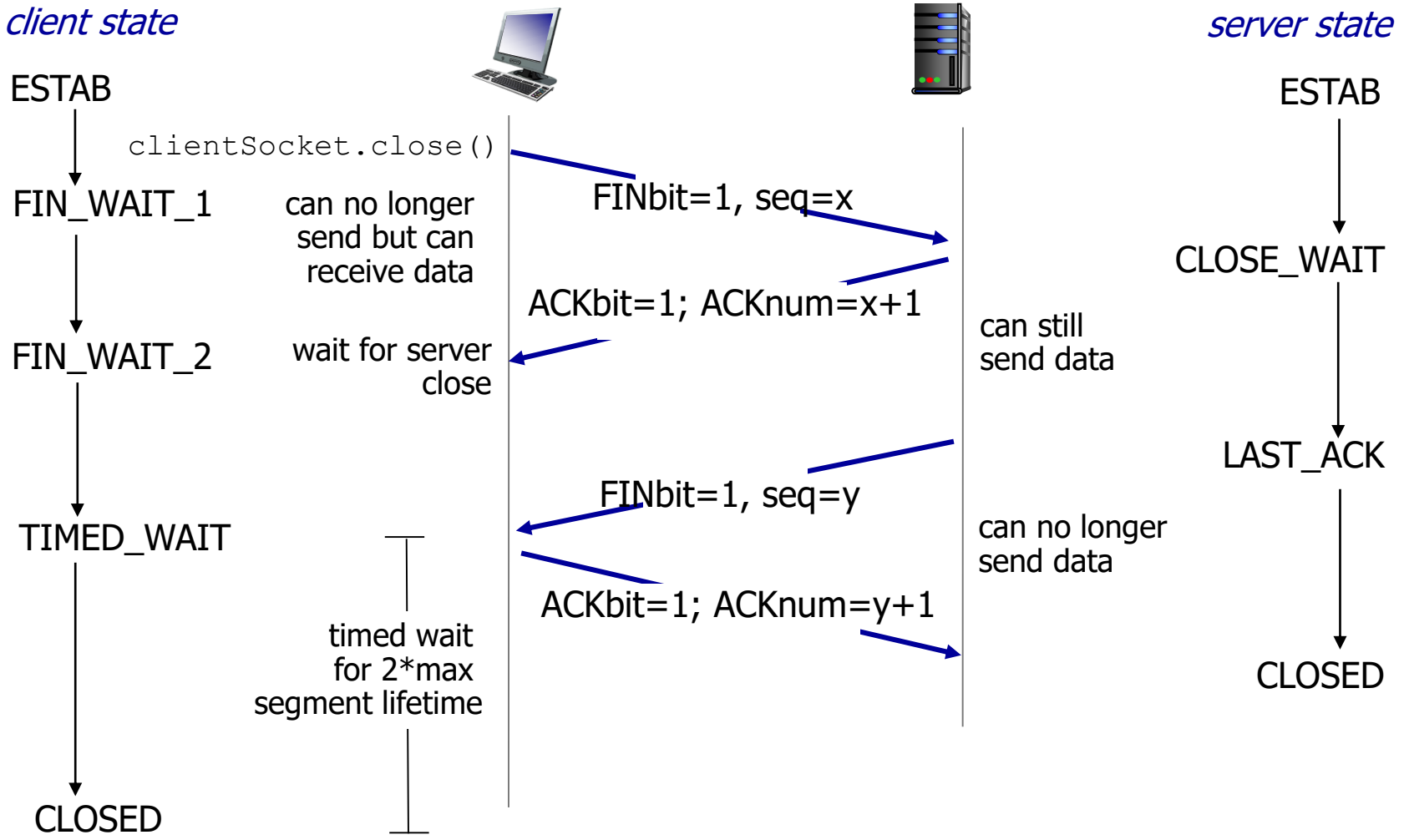
- Begins in CLOSED state
- Passive open (wait for connection)
- Active open (initiate connection)
  - When moving from CLOSED to SYN SENT, emit SYN segment
  - Other host sends SYN/ACK, send ACK and move to ESTABLISHED

TCP 3-way handshake: FSM

Source at end



TCP: closing a connection



Source at end

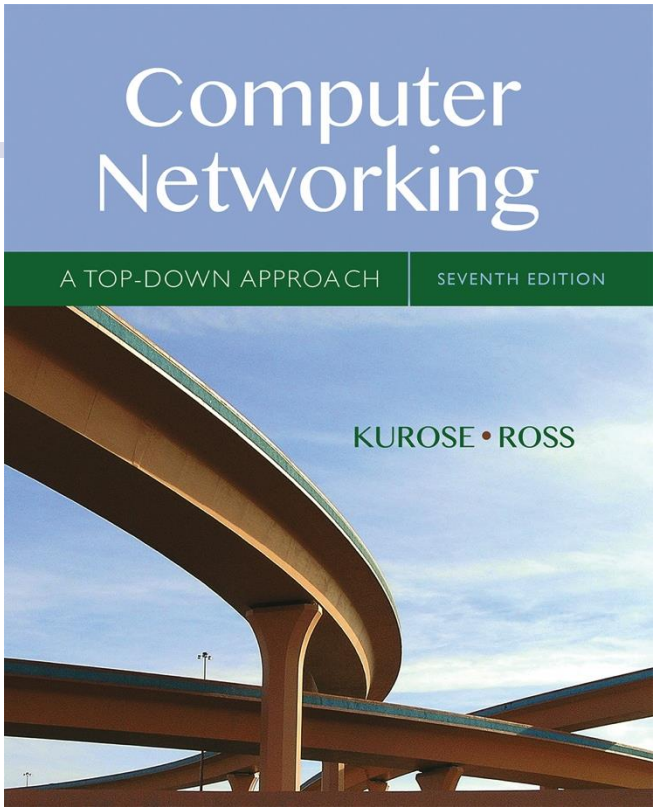
TIME_WAIT State

- Handles unreliable delivery
- TCP defines MSL for transit lifetime
- Don’t let old streams interfere with current streams
  - Timers allow TCP to distinguish between old and new streams
  - Prevents old duplicates from being mistaken for segments in current stream

HW2 Clarification

- Usernames, guess words, and secret words are **not** case-sensitive

Chapter 3
Transport Layer



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