Shakin' Hands and Living in SYN: A TCP Tale

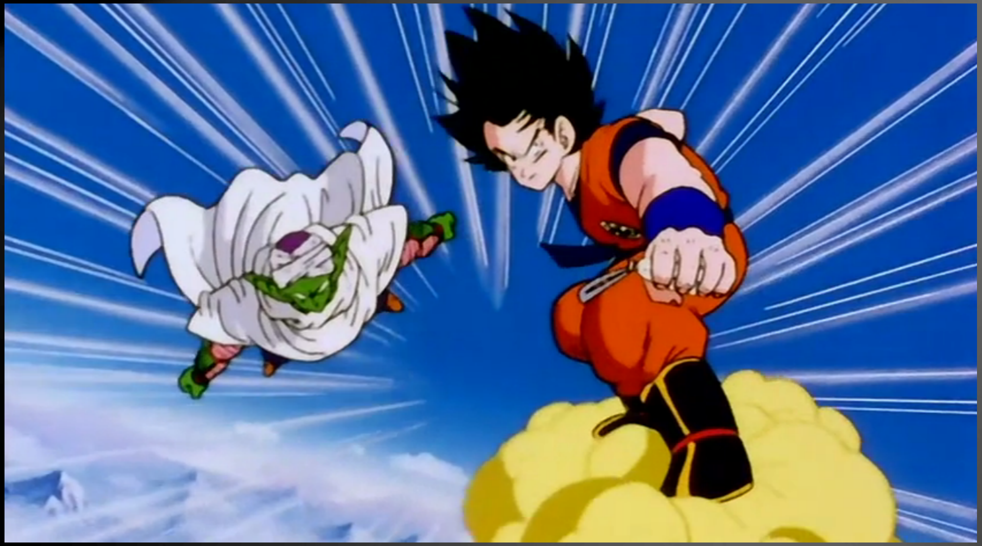
CSE 461 Section

Joke Later!

- Let’s learn things first!

TCP Is Reliable

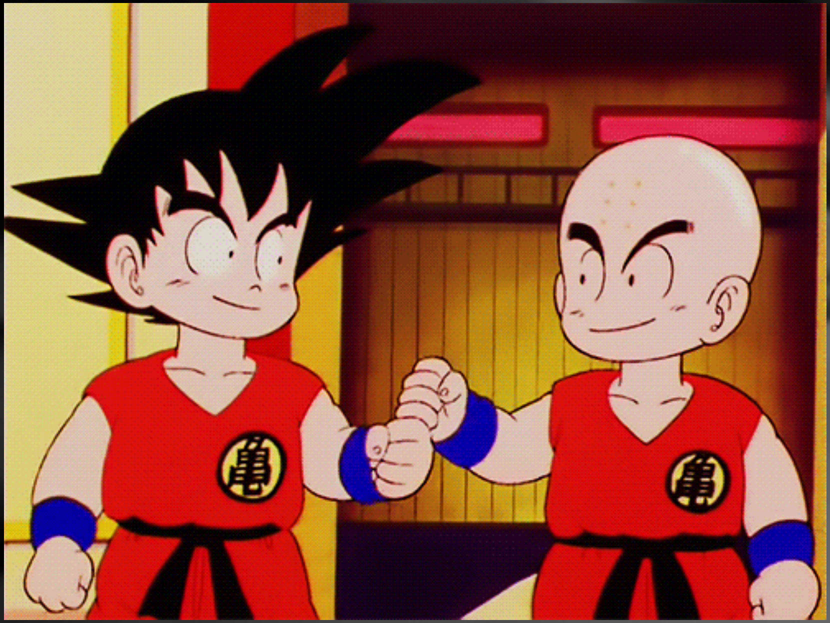
- What do we mean by “reliable?”
  - We know when the other party receives or doesn’t receive certain data
  - Data arrives intact
  - Data arrives in the correct order (to the application layer, at least)



Where This Reliability Comes From

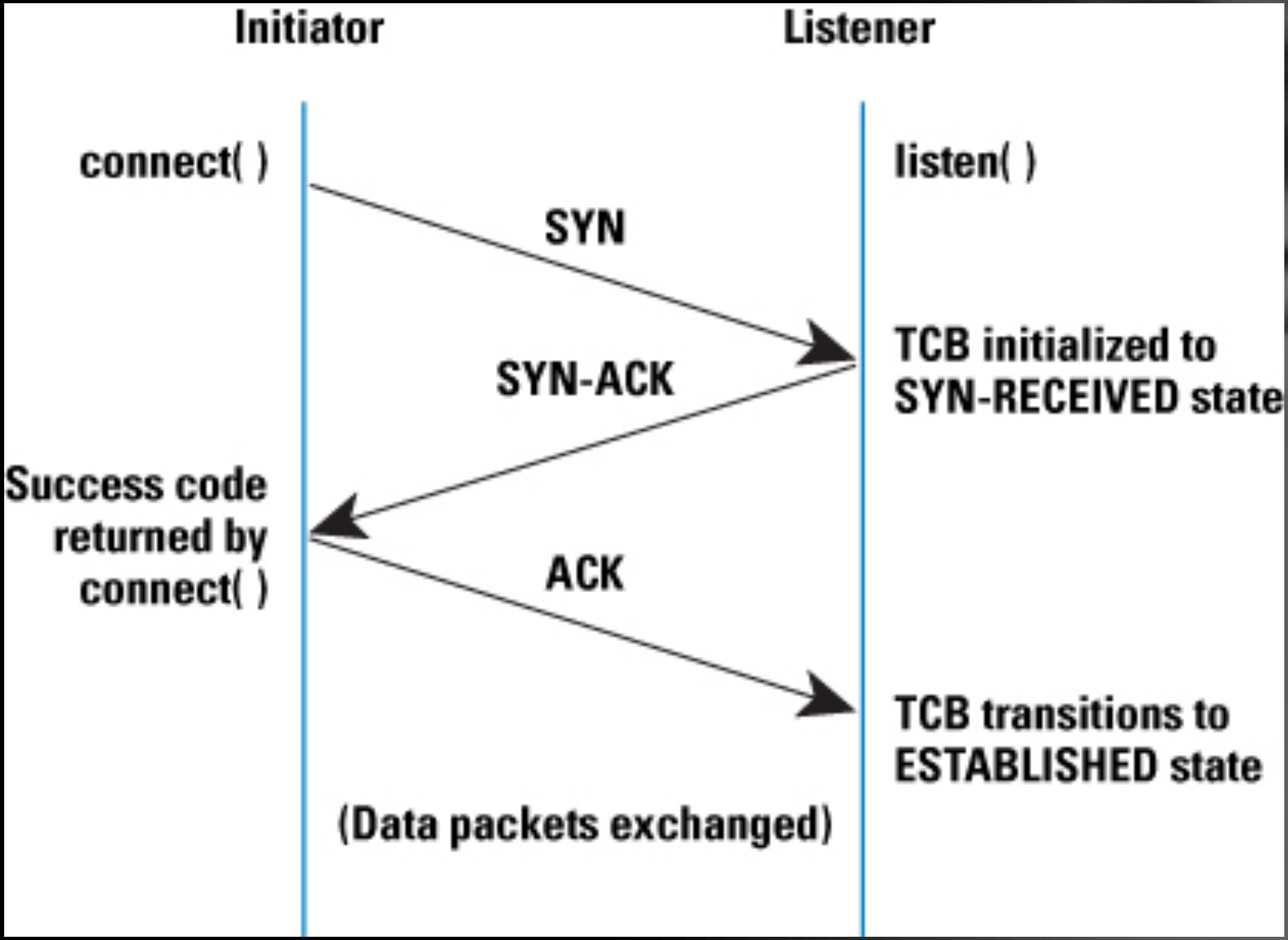
- What’s the main mechanism for ensuring this reliability?
  - Sequence numbers!
  - They allow packets to be identified, acknowledged, and , implicitly re-requested
  - For TCP to work, clients must know each other’s sequence number schemes

Starting Communication: The Three-Way Handshake



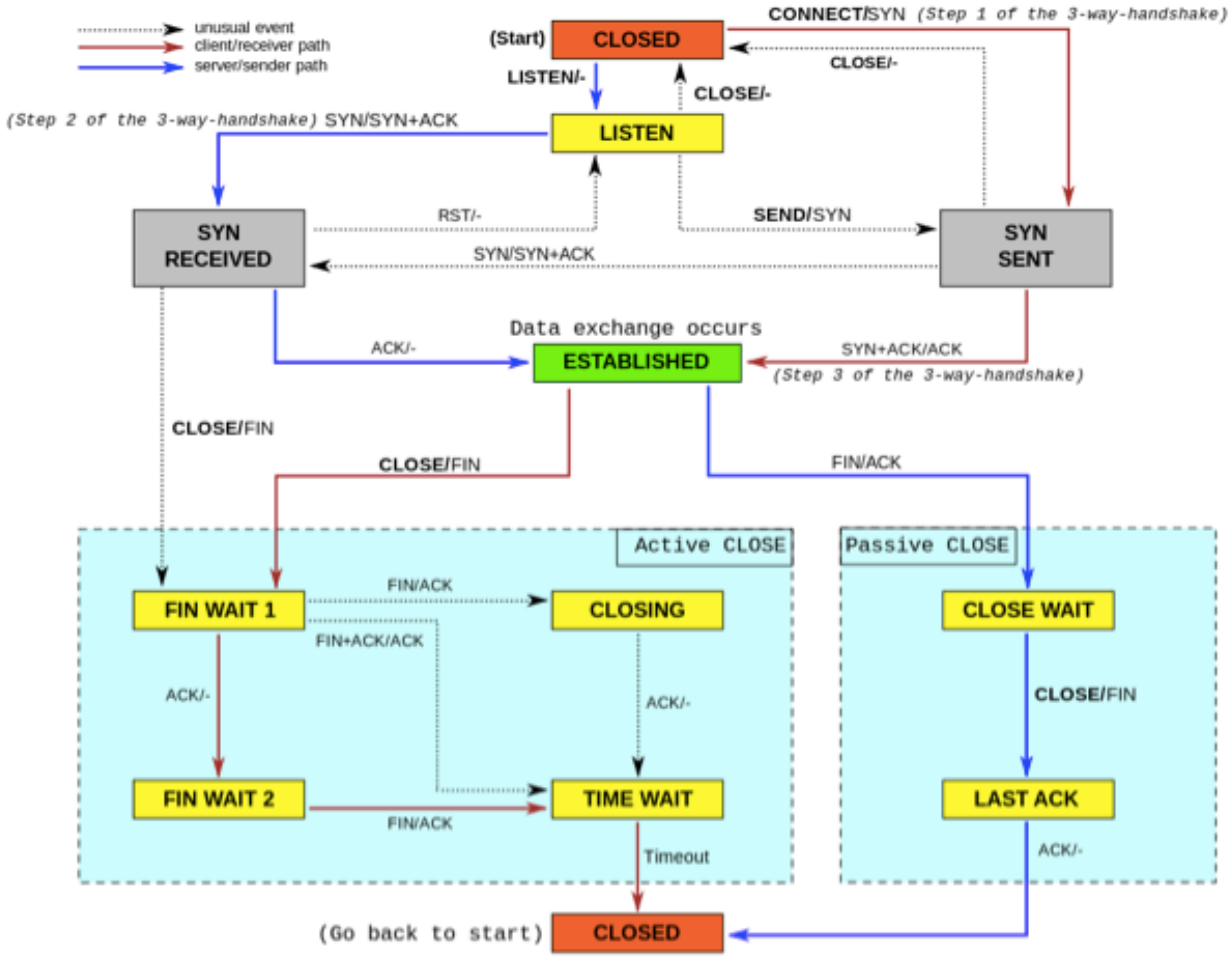
- Need to synchronize with each other's sequence numbers
- How can we do this?
- Active open vs. passive open
  - connect() vs. listen()
- SYN packet
  - Send own sequence number A
- SYN/ACK packet
  - Acknowledge with A+1, send own sequence number B
- ACK packet
  - Acknowledge with B+1
- Demonstration

Three-Way Handshake Diagram


Initiator
Listener
connect( )
listen( )
SYN
TCB initialized to SYN-RECEIVED state
SYN-ACK
Success code returned by connect( )
ACK
TCB transitions to ESTABLISHED state
(Data packets exchanged)

Ending Communications

- We need a protocol for stopping communications
- What could we do?
- Let’s send packets to close the connection!
- FIN/ACK sequence



unusual event
client/receiver path
server/sender path

(Start) CLOSED

CONNECT/SYN (Step 1 of the 3-way-handshake)

CLOSE/-

LISTEN/-

CLOSE/-

(Step 2 of the 3-way-handshake) SYN/SYN+ACK

LISTEN

SYN RECEIVED

RST/-

SEND/SYN

SYN SENT

SYN/SYN+ACK

Data exchange occurs

ACK/-

ESTABLISHED

SYN+ACK/ACK
(Step 3 of the 3-way-handshake)

CLOSE/FIN

CLOSE/FIN

FIN/ACK

Active CLOSE

Passive CLOSE

FIN WAIT 1

FIN/ACK

CLOSING

CLOSE WAIT

FIN+ACK/ACK

ACK/-

ACK/-

CLOSE/FIN

FIN WAIT 2

TIME WAIT

LAST ACK

FIN/ACK

Timeout

ACK/-

(Go back to start) CLOSED

TCP Half-Open

- TCP Half-Open
  - One client is in the open state; the other is not
- How could this happen?
  - One endpoint has crashed
  - One endpoint has removed the socket
  - One endpoint has received a SYN and sent a SYN/ACK, but the other side has not ACKed the SYN/ACK yet
  - One endpoint has sent a FIN and received an ACK, but the other side has not sent a FIN yet
  - RST packet often sent in these cases

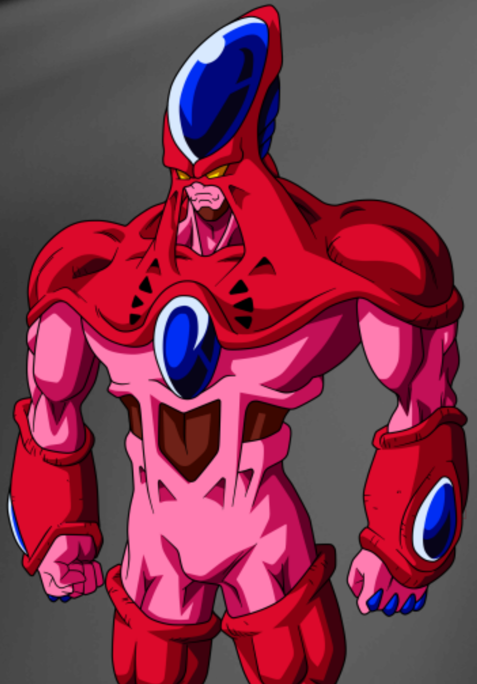
SYN Flooding

SYN Flooding Countermeasures

- What ideas can we think of to make it so that SYN flooding doesn't work?
  - Constraint: we don't want to break TCP!)
  - Identify SYN flooders and filter their packets
  - Reduce our timeout until we garbage-collect TCBs
  - Recycle half-open TCP connections
  - Use SYN cookies
    - Sequence number encodes all of the data that would otherwise be stored
    - This allows us to garbage-collect our SYN queue and still respond to subsequent ACKs

TCP Connection Hijacking

- TCP is not (by default) encrypted
- This means anyone sniffing our packets can see the sequence numbers being used
- How is this a problem?
  - For many protocols, the sequence and acknowledgement numbers are the other "security"
  - Using these numbers can make a host think that you're sending the next packet in a communication session
  - This can cause the communication to be re-addressed to a new IP address/port



TCP Veto

- In TCP, how does a server know to discard a duplicate packet? What does it check for?
  - Correct checksum
  - Same sequence number
- How are sequence numbers generated?
  - Randomly at first, then incremented
  - Often, this increment is unpredictable, and depends on received data length
  - How could we secret inject a packet into communication?
    - Predict the length and sequence number of some data in the future
    - Pre-empt that data with a similar packet

Joke Time

- Two jokes

Questions?