

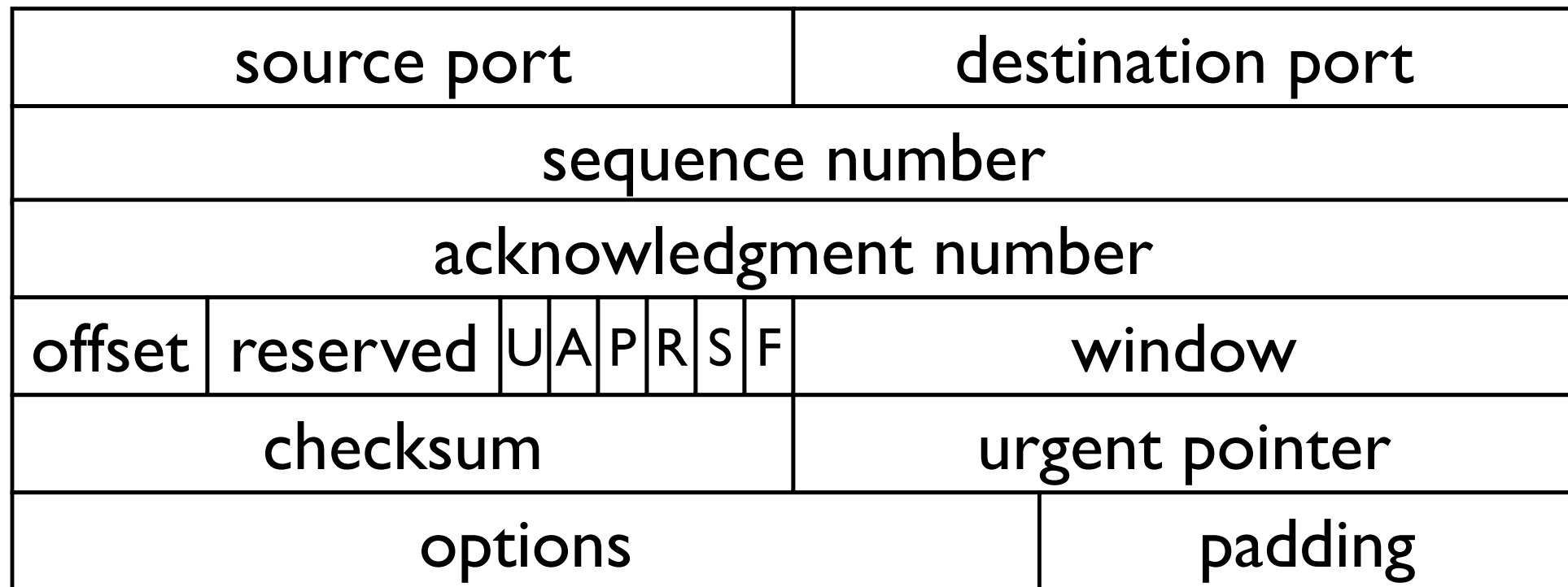
TCP Setup and Teardown

3-way handshake, simultaneous open, and the TCP state machine

Problem

- Reliable communication typically benefits from have some state on each end of a connection
- Problem: connection establishment
 - How do you set up this state?
- Problem: connection teardown
 - How do you clean up (reuse ports, etc.)?

TCP Header



← 32 bits (4 octets) →

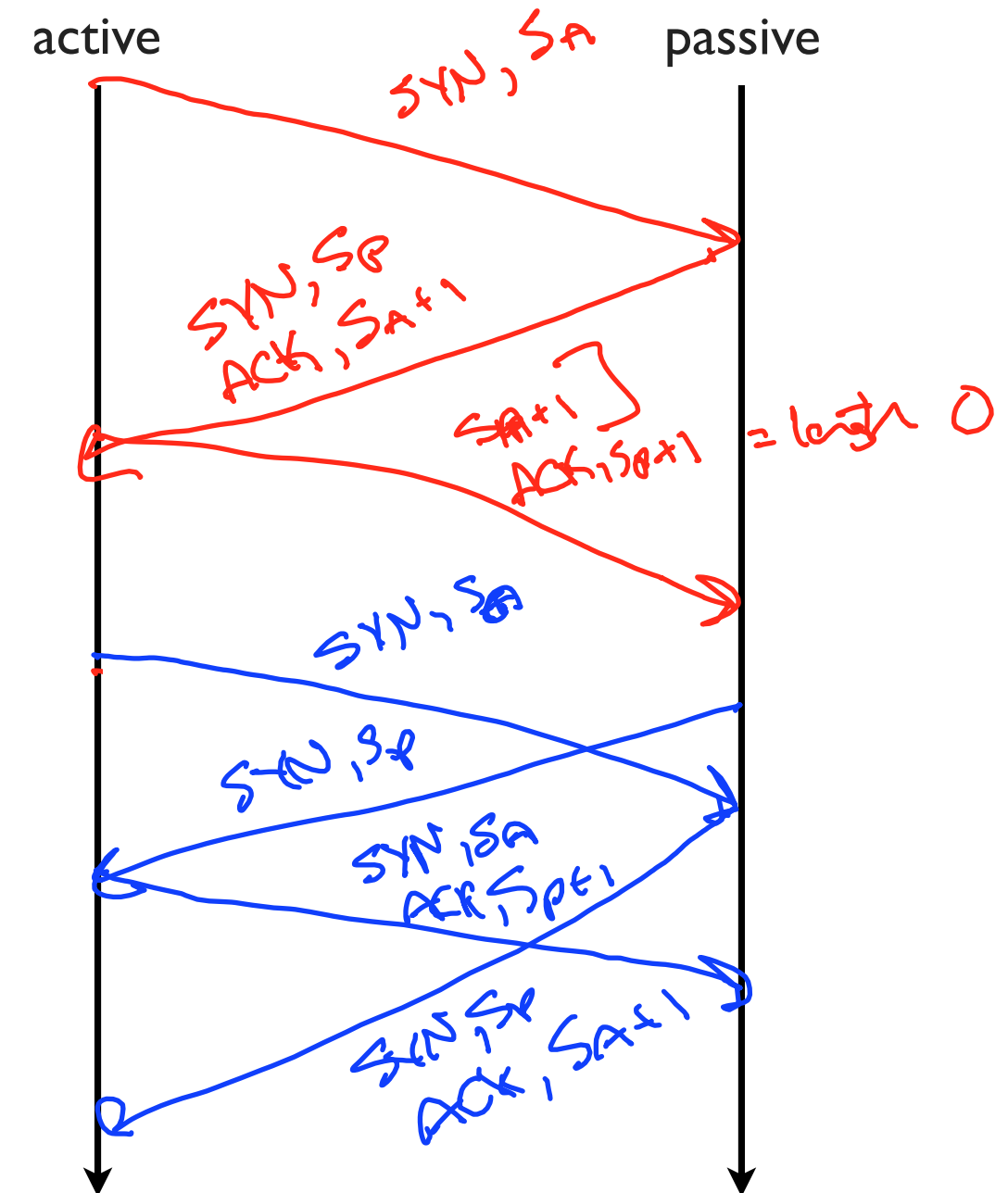
Connection Setup

source port					destination port				
sequence number									
acknowledgment number									
offset	reserved	U	A	P	R	S	F	window	
checksum					urgent pointer				
options							padding		

← 32 bits (4 octets) →

3-way Handshake

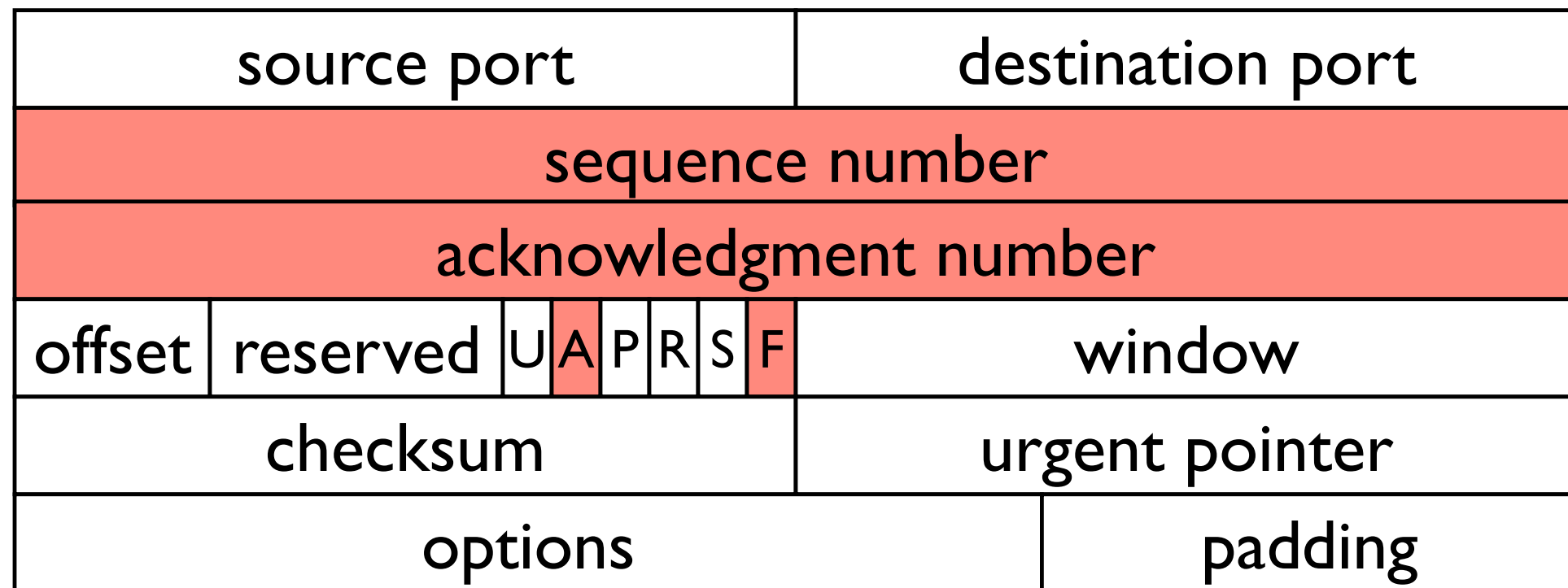
- Active opener sends first packet
 - SYN with sequence number
- Passive opener responds
 - SYN with sequence number
 - ACKs active opener's SYN packet
- Active opener responds
 - ACKs passive opener's SYN packet
- Also support “simultaneous open”
 - Two SYNs pass each other
 - Each side ACKs the other



TCP Connection Setup (no data)

TCP Connection Setup (with data)

Connection Teardown



← 32 bits (4 octets) →

Connection Teardown

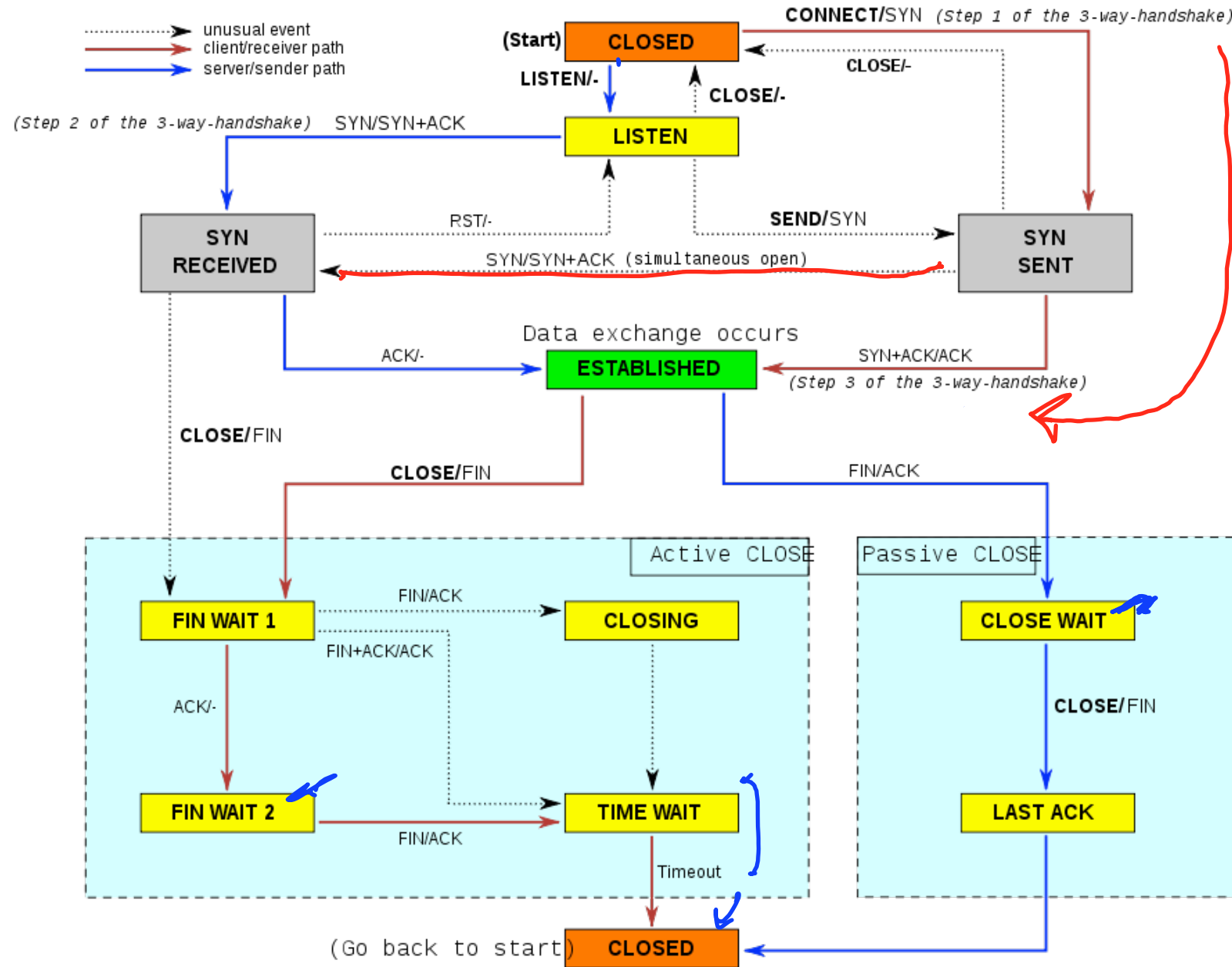
- FIN bit says no more data to send
 - ▶ Caused by close() or shutdown() on other end
- Both sides must send FIN to terminate a connection
- Typical teardown exchange:
 - ▶ A → B: **FIN**, seq S_A , ack S_B
 - ▶ B → A: ack $S_A + 1$
 - ▶ B → A: **FIN**, seq S_B , ack $S_A + 1$
 - ▶ A → B: ack $S_B + 1$
- Can also have simultaneous close
- Can A and B forget about closed socket after final message?

Cleaning Up Safely

- Problems with closed socket
 - ▶ What if final ack is lost in the network?
 - ▶ What if the same port pair is immediately reused for a new connection?
- Solution: “active” closer goes into TIME WAIT
 - ▶ Active close is sending FIN before receiving one
 - ▶ Keep socket around for 2MSL (twice the “maximum segment lifetime”)
- Can pose problems with servers
 - ▶ OS has too many sockets in TIME WAIT, slows things down
 - ▶ Hack: Can send RST and delete socket, set SO_LINGER socket option to time 0
 - ▶ OS won't let you re-start server because port still in use (SO_REUSEADDR option lets you re-bind used port number)

Connection Teardown

Full TCP FSM



connector established

connection
teardown