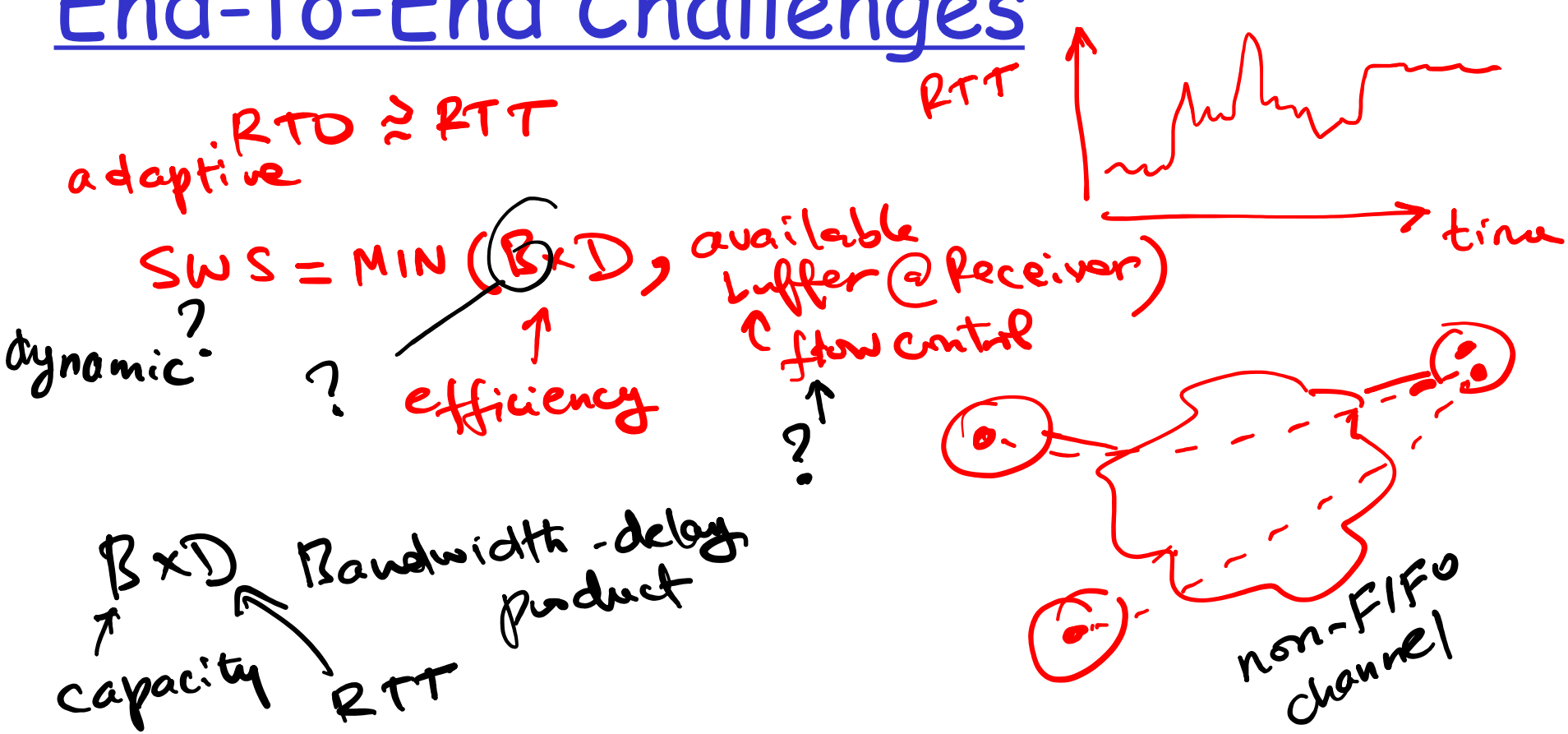
End-to-End Challenges



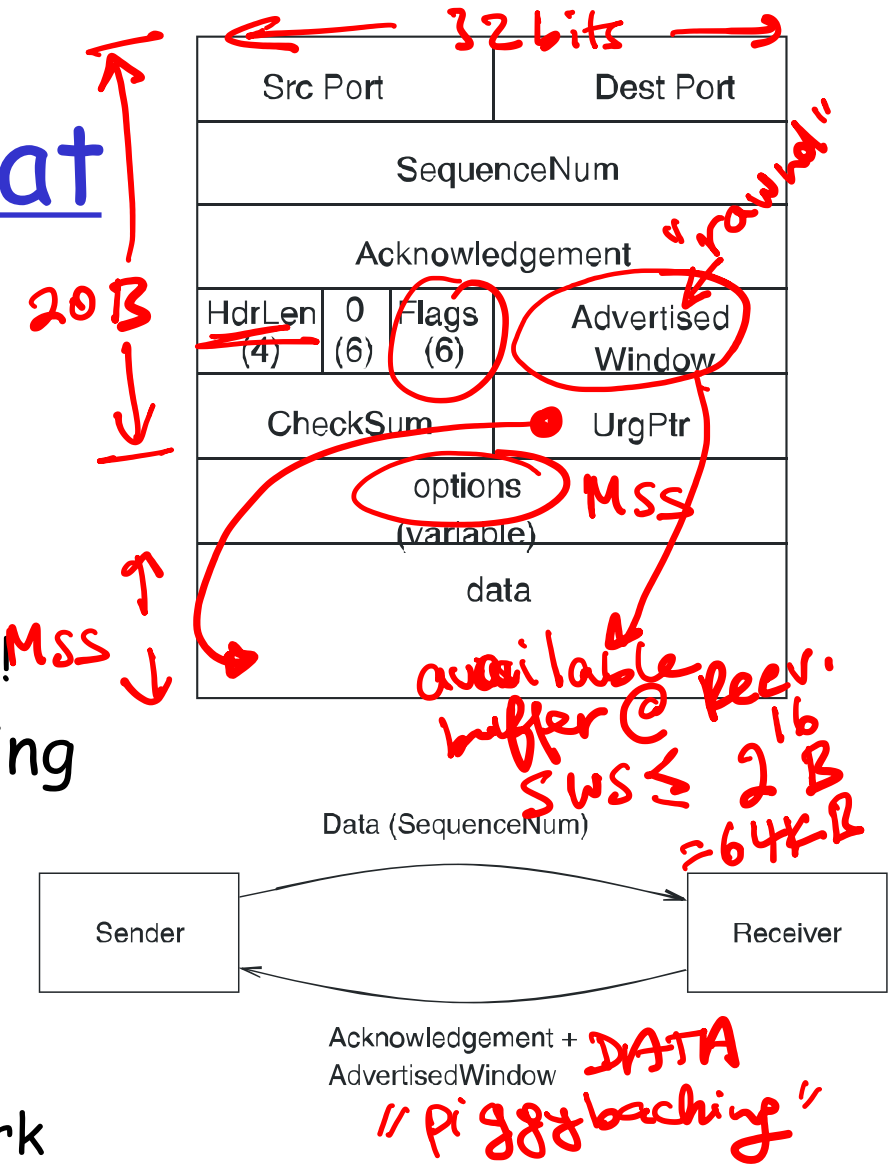
End-to-End Challenges

Based basically on a reliable sliding window protocol, but it's challenging!

- Potentially different RTT
  - need adaptive timeout mechanism
- Potentially long delay in network
  - need to be prepared for arrival of very old packets
- Potentially different buffering at destination
  - need to accommodate different amounts of buffering
- Potentially different network capacity
  - need to be prepared for network congestion

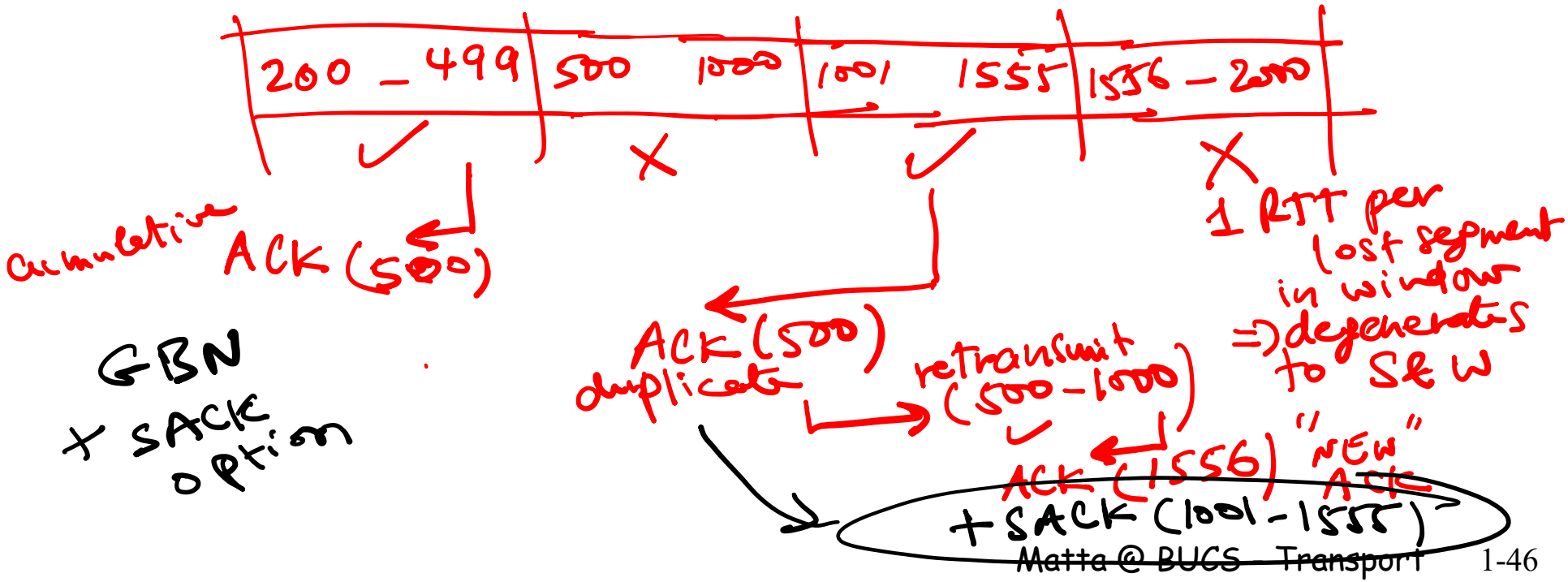
TCP Segment Format

- Demultiplexing: each connection identified with 4-tuple:
  - **<SrcPort, SrcIPAddr, DstPort, DstIPAddr>**
  - IP addresses obtained from IP layer!
- Basically, a sliding window operating at byte (not segment) level
  - Acknowledgment, SequenceNum, AdvertisedWindow
  - Piggybacking ACK on data segments destined for sender improves network utilization
- Flags
  - SYN, FIN, RESET, PUSH, URG, ACK



TCP Reliability & Flow Control

- Like SR with Explicit Rtx/cumulative ACKs:
  - storing ***out-of-order*** bytes
  - using ***one timer*** for all unacked bytes
  - using ***duplicate ACK*** to fast retransmit
  - On retransmission, ***only one segment retransmitted***



TCP Reliability & Flow Control

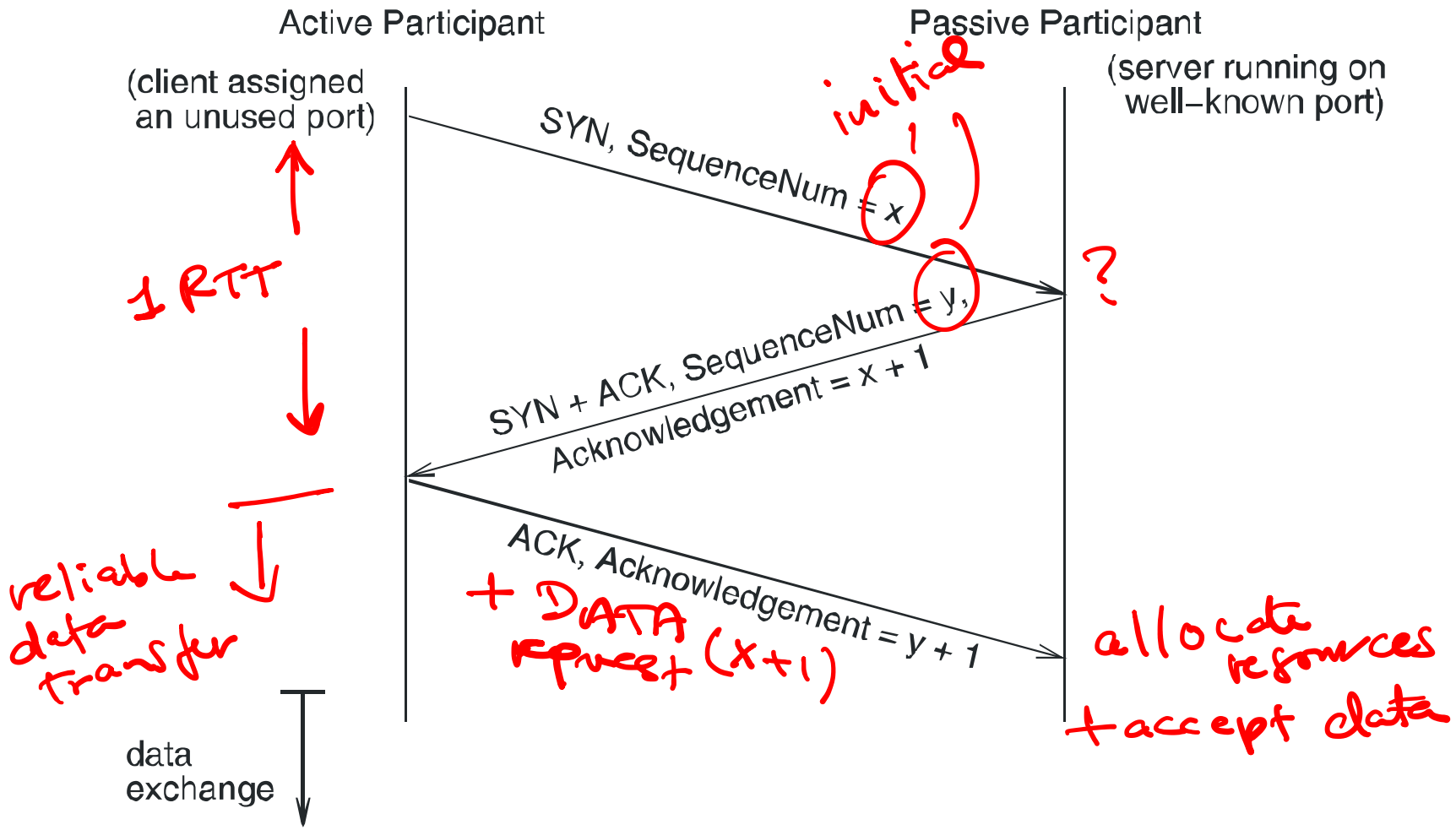
- Like SR with Explicit Rtx/cumulative ACKs:
  - storing *out-of-order* bytes
  - using *one timer* for all unacked bytes
  - using *duplicate ACK* to fast retransmit
  - On retransmission, *only one segment retransmitted*
- A new version, with SACK option, is more like GBN with selective repeats!
- At sender:
  - *LastByteSent – LastByteAcked ≤ AdvertizedWindow*
  - If zero, sender keeps sending 1-byte data segments

"rawnd"

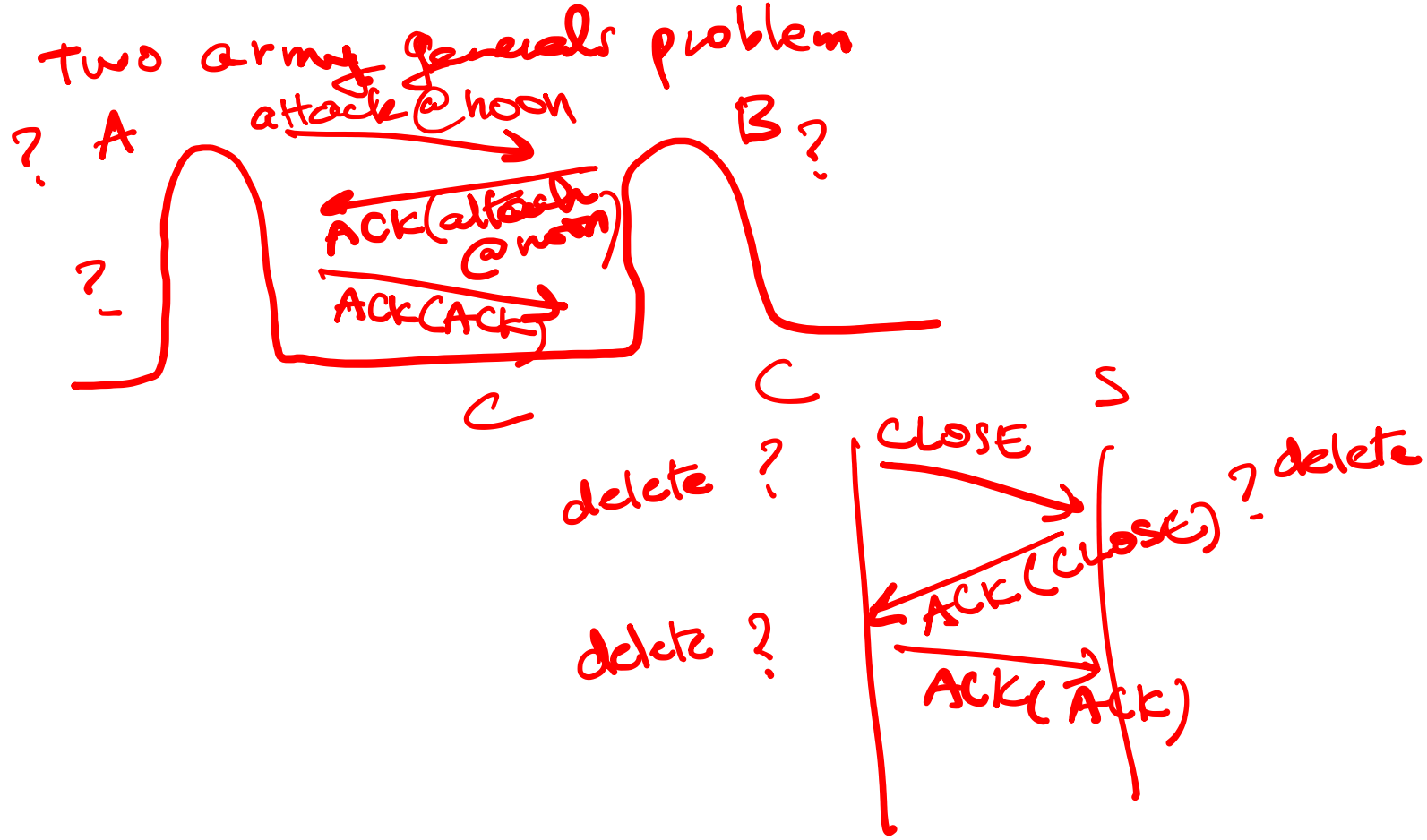
smart sender / dumb receiver

TCP Connection Establishment

- Three-Way Handshake

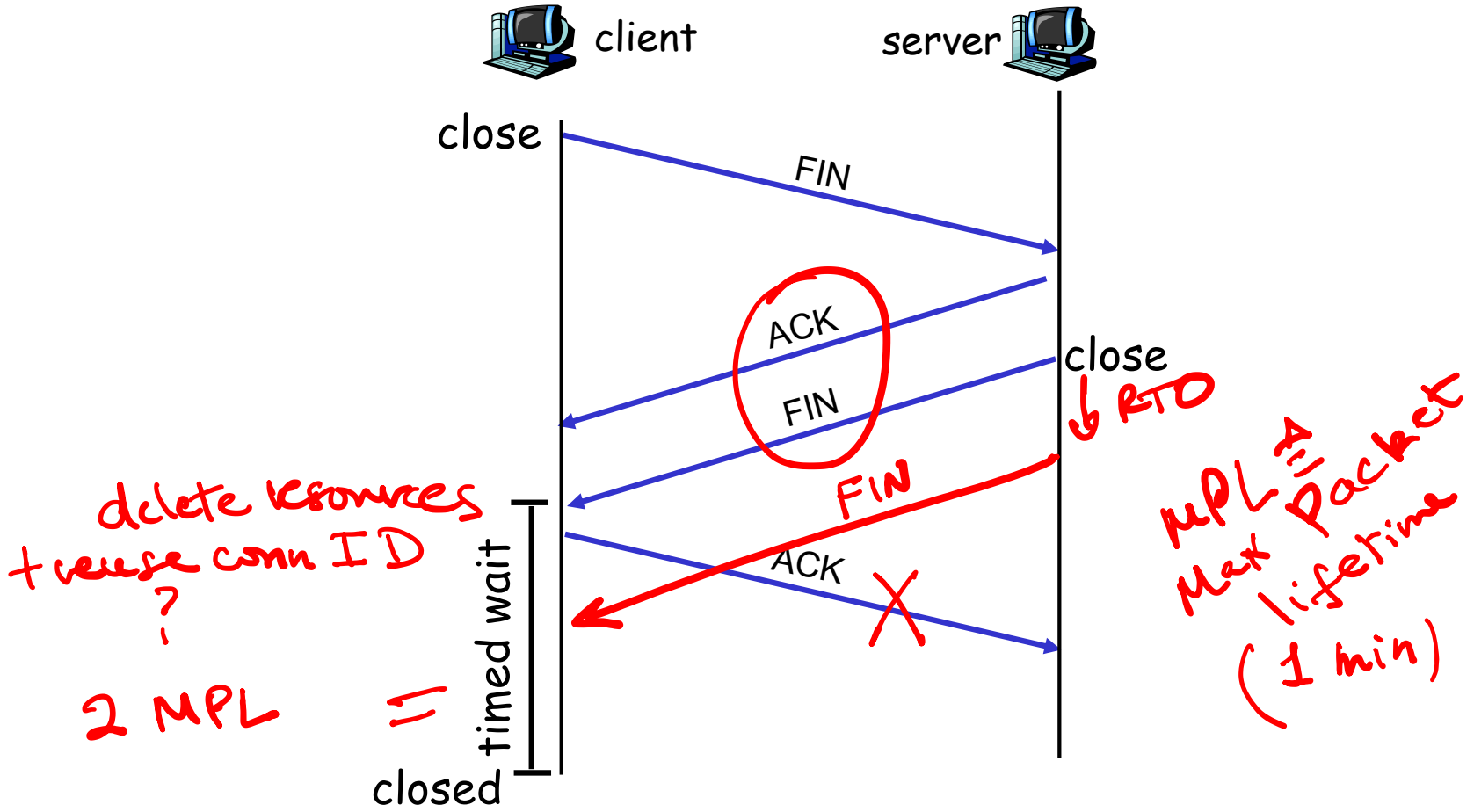


TCP Closing

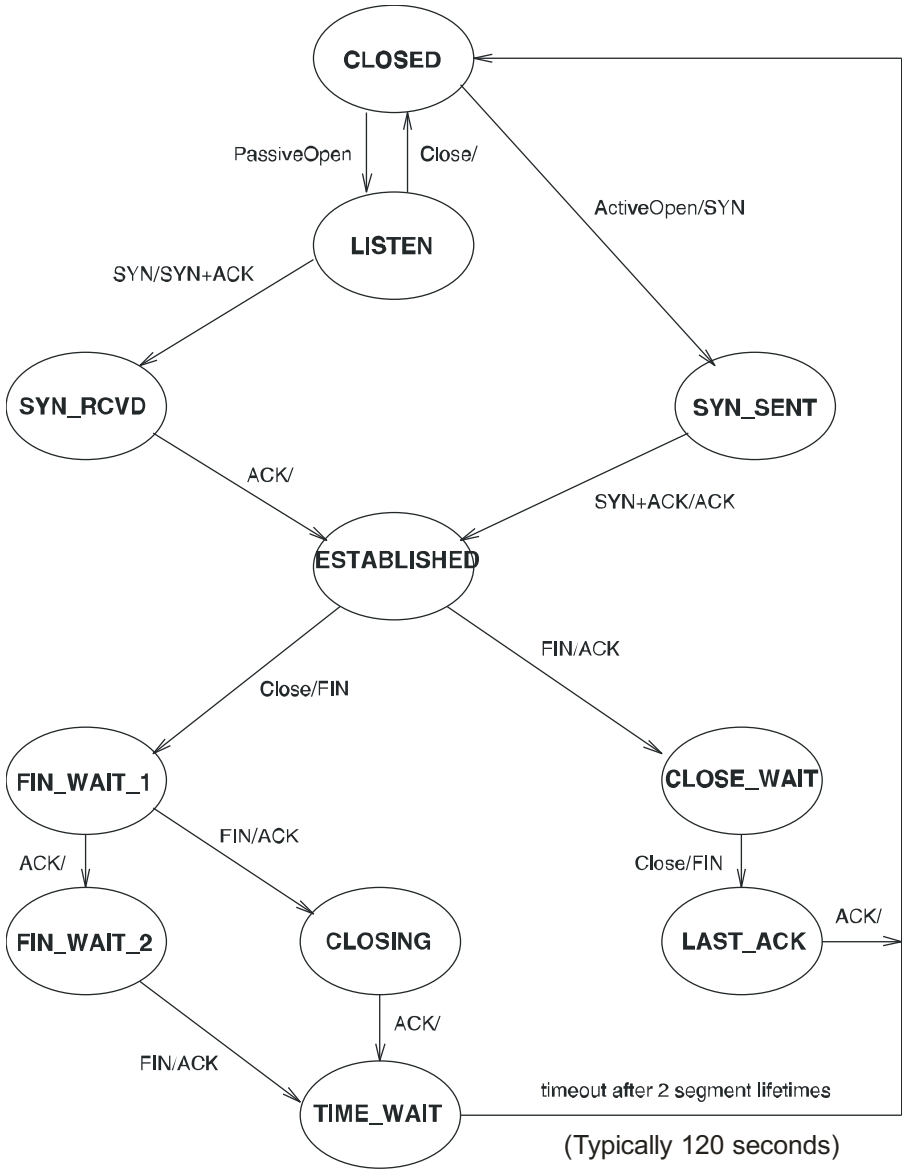

Two army generals problem
attack @ noon
A
B
?
?
ACK(attack @ noon)
ACK(ACK)
C
C
S
CLOSE
delete ?
delete ?
ACK(CLOSE)
delete ?
ACK(ACK)

TCP Closing

- Modified Three-Way Handshake



TCP State Transition Diagram



MPL = 1 min
Guarantee from the network!