Computer Networks

TCP Fast Retransmit / Fast Recovery (§6.5.10)

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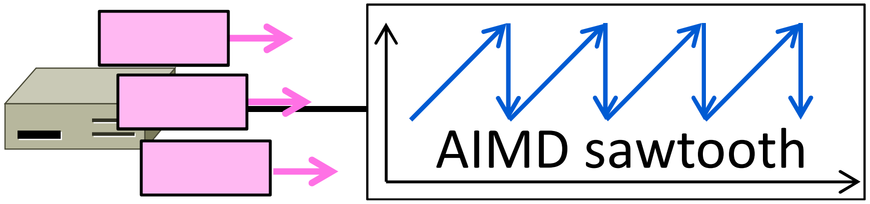
Topic

- How TCP implements AIMD, part 2
  - "Fast retransmit" and "fast recovery" are the MD portion of AIMD



Recall

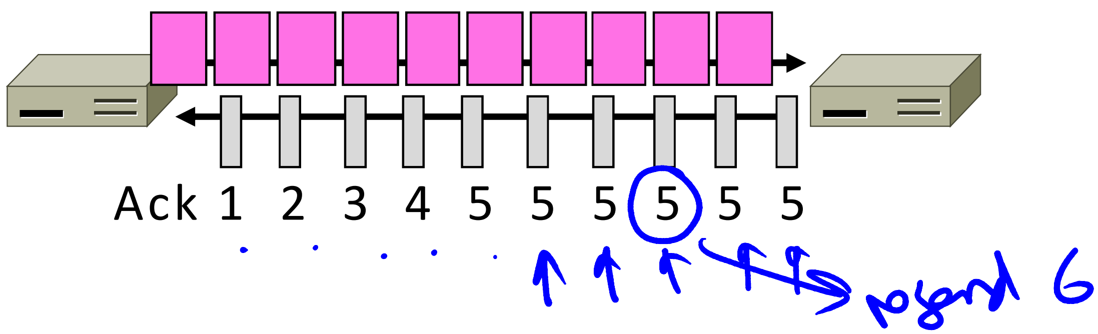
- We want TCP to follow an AIMD control law for a good allocation
- Sender uses a congestion window or cwnd to set its rate (≈cwnd/RTT)
- Sender uses slow-start to ramp up the ACK clock, followed by Additive Increase
- But after a timeout, sender slow-starts again with cwnd=1 (as it no ACK clock)

Inferring Loss from ACKs

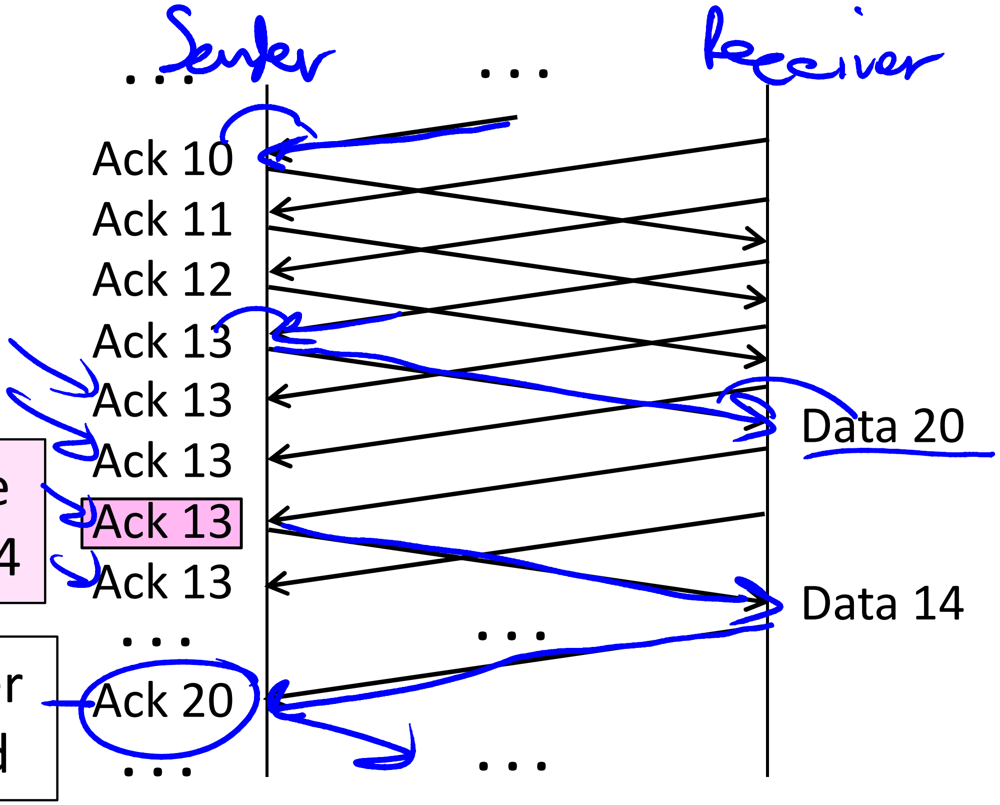
- TCP uses a cumulative ACK
  - Carries highest in-order seq. number
  - Normally a steady advance
- Duplicate ACKs give us hints about what data hasn't arrived
  - Tell us some new data did arrive, but it was not next segment
  - Thus the next segment may be lost

Fast Retransmit

- Treat three duplicate ACKs as a loss
  - Retransmit next expected segment
  - Some repetition allows for reordering, but still detects loss quickly



Fast Retransmit (2)



Data 14 was lost earlier, but got 15 to 20

Third duplicate ACK, so send 14

Retransmission fills in the hole at 14

ACK jumps after loss is repaired

Fast Retransmit (3)

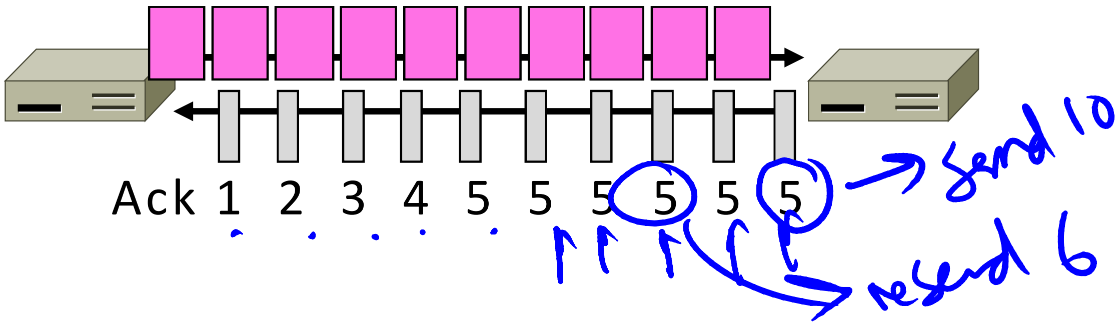
- It can repair single segment loss quickly, typically before a timeout
- However, we have quiet time at the sender/receiver while waiting for the ACK to jump
- And we still need to MD cwnd …

Inferring Non-Loss from ACKs

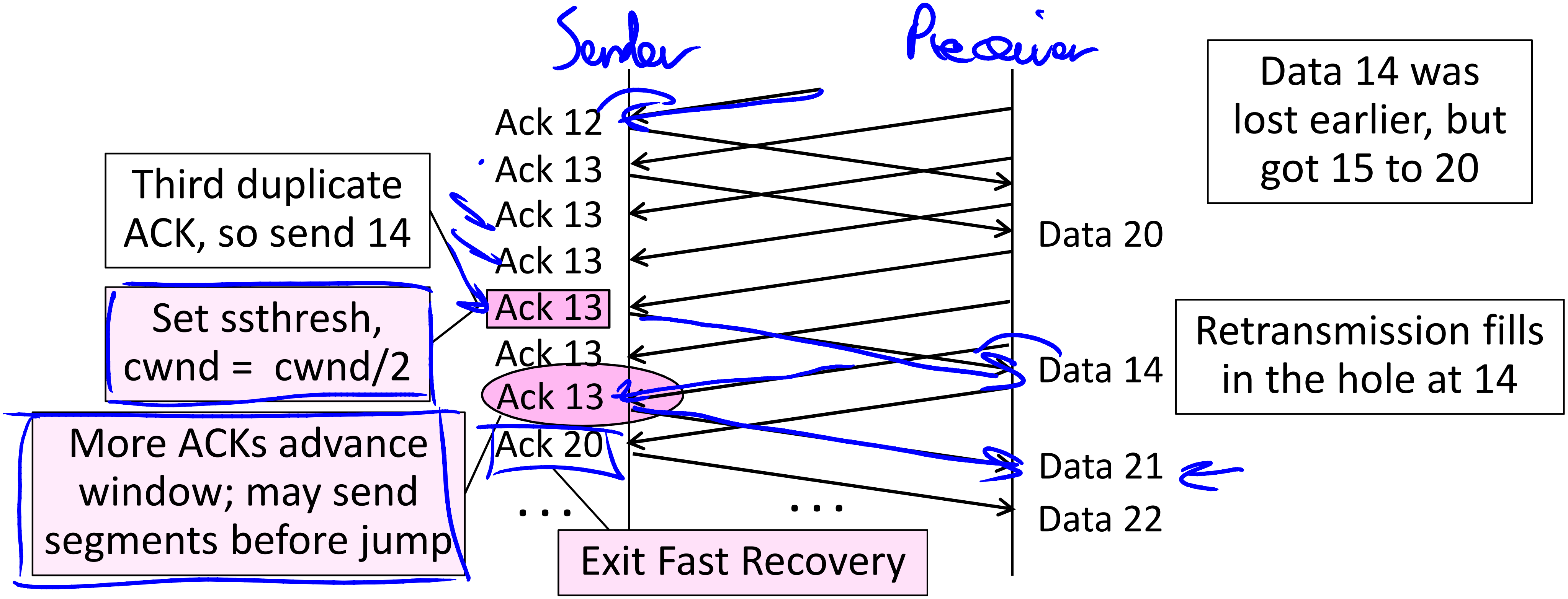
- Duplicate ACKs also give us hints about what data has arrived
  - Each new duplicate ACK means that some new segment has arrived
  - It will be the segments after the loss
  - Thus advancing the sliding window will not increase the number of segments stored in the network

Fast Recovery

- First fast retransmit, and MD cwnd
- Then pretend further duplicate ACKs are the expected ACKs
    - Lets new segments be sent for ACKs
    - Reconcile views when the ACK jumps



Fast Recovery (2)



Data 14 was lost earlier, but got 15 to 20

Third duplicate ACK, so send 14

Set ssthresh, cwnd = cwnd/2

Retransmission fills in the hole at 14

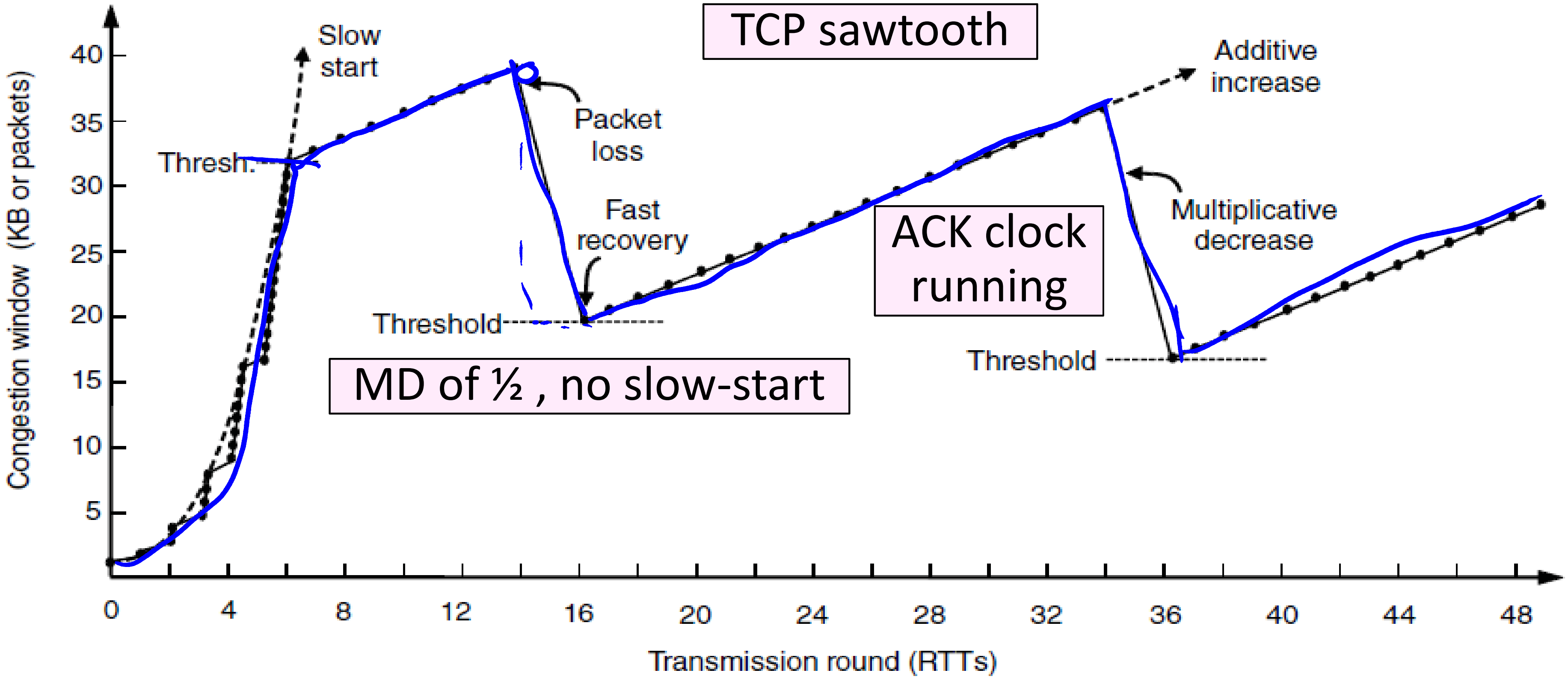
More ACKs advance window; may send segments before jump

Exit Fast Recovery

Fast Recovery (3)

- With fast retransmit, it repairs a single segment loss quickly and keeps the ACK clock running
- This allows us to realize AIMD
  - No timeouts or slow-start after loss, just continue with a smaller cwnd
- TCP Reno combines slow-start, fast retransmit and fast recovery
  - Multiplicative Decrease is ½

TCP Reno



TCP sawtooth

ACK clock running

MD of ½ , no slow-start

TCP Reno, NewReno, and SACK

- Reno can repair one loss per RTT
  - Multiple losses cause a timeout
- NewReno further refines ACK heuristics
  - Repairs multiple losses without timeout
- SACK is a better idea ✓
  - Receiver sends ACK ranges so sender can retransmit without guesswork

END

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