6. TCP Congestion Control

- TCP congestion control prevents the sender from congesting the network with too much data

Step 1. ➡ Sender probes the network capacity by dynamically adjusting its congestion window size (cwnd) estimated by sender
  - Sender makes sure: swnd ≤ cwnd (*)
  - Combined with TCP flow control, we have
    - swnd = min(rwnd, cwnd) ↪ swnd ≤ rwnd ↳ informed by the receiver

Step 2 ➡ Congestion detection

Step 3 ➡ Upon detecting congestion, sender slows down its transmissions

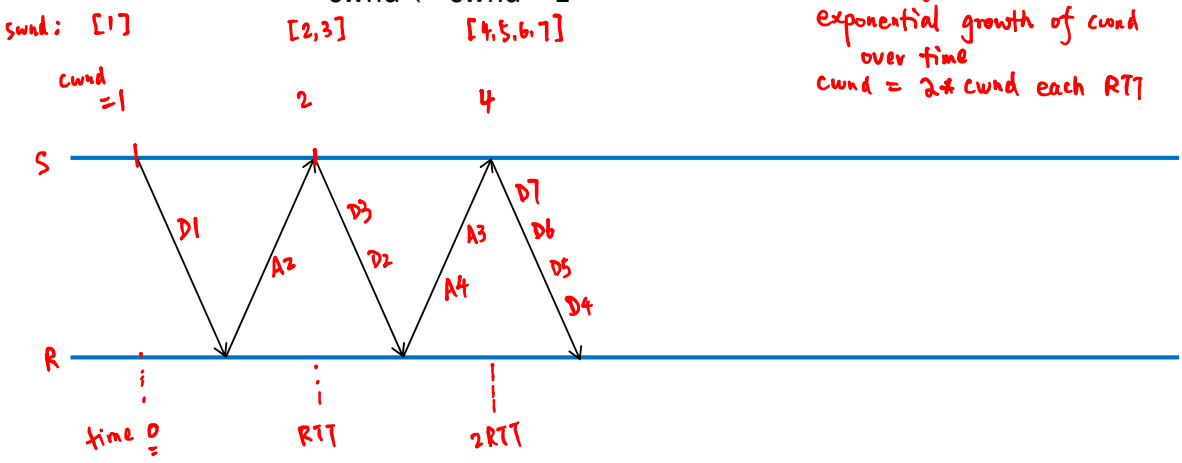
TCP Congestion Control: Probing the Network Capacity

- Probing the network capacity in two phases: { fast probing / slow probing
  - Phase 1: Slow Start (SS)
    - Starts with cwnd = 1 (MSS) Max Segment Size
      - MSS (Maximum Segment Size) for TCP is 536 bytes by default
    - Each time a non-duplicate ACK is received, increment cwnd

swnd = min(cwnd, rwnd)

cwnd ← cwnd + 1

⇓ exponential growth of cwnd over time
cwnd = 2* cwnd each RTT



TCP Congestion Control: Probing the Network Capacity

- Probing the network capacity in two phases:
  - Phase 2: Congestion Avoidance (CA)
    - Enters CA when cwnd ≥ ssthresh
    - Each time a non-duplicate ACK is received,

      cwnd ← cwnd + 1/⌊cwnd⌋

Ex: ssthresh = 4

linear growth of cwnd over time

TCP Congestion Control: Congestion Detection

Step 2

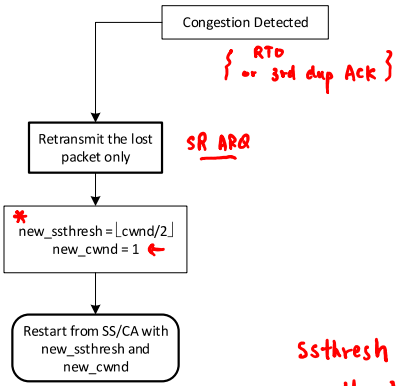
- How to detect congestion?
  - Interprets segment loss as congestion signal
  - Retransmits the lost segment upon
    - RTO
    - Reception of the 4th ACK with the same sequence number
      - This is called Fast Retransmit

3rd dup Ack

TCP Congestion Control: Slowing Down Transmission

Step 3

- Sender slows down its transmissions upon congestion detection and recover from congestion
  - * TCP Tahoe
  - * TCP Reno
  - * TCP New Reno



TCP Tahoe Flowchart