Lecture 18: The TCP Congestion Game

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These are the rules of the game by which we simulate TCP:

- Let there be one sender, one receiver, and one bottleneck router (which has a infinitely fast link in and a slow link out).
- Let the students be packets.
- Let each packet be acked immediately; no delayed acks.
- Let the instructor be the clock that drives the simulation. Graph/observe any quantities at the end of each clock tick.
- Queuing in the router is represented by sheets of paper on the floor – 4 sheets for 4 packets.
- When there is loss, lost packets hitch a ride with the next packet that makes it so that we can observe at the sender when their loss is inferred.
- Note that we can also check cwnd by seeing how many packets are "out there in the network" including any lost packets.
- Hide Fast Retransmit and Fast Recovery details by assuming acks tell us everything about which packets made it and didn't. We can ignore sequence numbers too, effectively providing a congestion-controlled but unreliable transport.

Stop and Wait.

Simulate this as a warm-up exercise. Notice the low link utilization (1 out of 4 clock ticks) and negligible queuing at the router. Graph router queuing versus time, with an X on top when there is packet loss. Graph number of acks versus time as a proxy for throughput (since sequence number is too hard to track).

Slow-Start

Blow out the queue until there is loss. Graph cwnd versus time too. Notice that many packets can be lost. Notice the bursts in transmission of at most 2x the bottleneck rate and the self-clocking effect in the acks.

AIMD

Go through a couple of rounds of the sawtooth with all the graphs as before. Carry a special object to signal each RTT round and hence cwnd increase. Notice the delay between loss and cwnd reduction. Notice the single packet loss. Notice the transmission pause after loss is observed.

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