Announcements

- Lab 1
  - Was due yesterday (Thu)
  - Have until midnight on Saturday to submit for up to 90% credit

- Lab 2
  - Due Thursday, Oct. 7 at beginning of class
  - Go to class and get an automatic extension until midnight that day
Lab 1 Review

• Stop-and-Wait
  • Pros
    – Easy implementation
    – Low memory usage
  • Cons
    – Inefficient use of bandwidth
    – Throughput mostly capped by RTT, not BW
Lab 2 Overview

- Sliding-window
  - Can have multiple unacknowledged packets
  - Need to handle packet reordering
- Lab 1 Grade = Max(Lab 1, Lab 2)

(a) a stop-and-wait protocol in operation  
(b) a pipelined protocol in operation
Lab 2 Demo
TCP Review

- sacrifices timeliness for accuracy
- how would we reliably stream live TV?
- connection setup
- connection teardown
- two types of control:
  - flow control
  - congestion control
TCP Connection Setup

- 3-way handshake
- Learn each other’s sequence numbers
- Establish window size
TCP Connection Teardown

- Modified 3-way handshake
- Need to verify both sides are truly closed (FINs get ACKed)
- Both sides need to send FINs

- A → B: FIN
- B → A: ACK
- B → A: FIN
- A → B: ACK
Sliding Window Review

- Sliding window protocol tries to fill the pipeline more efficiently than stop and wait

- Sender:
  - Verify packets are reaching destination via ACKs before sending more data

- Receiver:
  - Inform sender if packets are missing via cumulative ACKs
  - Discard packets clearly out of range
Flow Control Review

- Purpose: prevent sender from sending too fast (or too slow)
- Implemented by the sliding window protocol
- Window size advertised by receiver
- Sender adjusts to not fill-up receiver’s buffer
- Receiver sending feedback is what allows for flow control
Congestion Control Review

- Prof. Levis’ second favorite lecture. *hint hint*
- Purpose: prevent over-subscription of data links
- States
  - Slow start
    - cwnd += 1 for every ACK received
    - Exponential growth
  - Congestion avoidance
    - Cwnd += 1/cwnd (Increase by 1 per RTT)
    - Linear growth
Congestion Control Example

- Nodes A, B are happily communicating over a dedicated link in congestion avoidance mode.
- Heavy noise on the link disrupts traffic, causing a timeout to occur on a packet.
- Go back to CWND = 1 in slow start mode.
- Switch to congestion avoidance once CWND reaches half the original CWND that got us in trouble.
Additive Increase, Multiplicative Decrease

Figure from Brad Karp
Lab 2

Start Early! Good Luck!