Announcements

- Review session on Tuesday 10/15
- Midterm on Wed 10/16
- No class on Monday
- Practice midterm is online.
Revisiting AIMD

Congestion Window (CWND)

# of packets sent out at a time

On Ack:

\[ \text{Cwnd} = \text{Cwnd} + K \]

On loss:

\[ \text{Cwnd} = \frac{\text{Cwnd}}{2} \left\lfloor \frac{\text{Cwnd} \times 0.5}{2} \right\rfloor \]

\[ \text{cwnd} = \text{cwnd} + K \]

\[ \text{cwnd} = \text{cwnd} \left\lfloor \frac{\text{cwnd} \times 0.5}{2} \right\rfloor \]

\[ \text{MSS: Max Segment Size} \]

\[ \text{AIMD: Increase by One packet each time Cwnd is acknowledged.} \]

\[ \text{How much should we increase each} \]

\[ k = \frac{\text{MTU}}{\text{CWND}} = \frac{\text{MSS}}{\text{CWND}} \]
Problem: How long does it take to use up link capacity?

\[ \text{CWND} = 1 - I \]

\[ \text{Cap} = 1000 \]

\[ 100 \text{ms} \times 1000 \]

\[ \sim 500 \]

\[ \frac{1}{2} \text{CWND}^2 \]

\[ \text{CWND} \text{ RTT} \]
How to use link capacity quicker?

Slow START

Stop Slow Start Here

$2^t = 1000$

$\text{CWND} = 1$

$SS = \text{True}$

On Ack

if $SS$:

$\text{CWND} = \text{CWND} + \frac{1}{4}$

else:

$\text{CWND} = \text{CWND} + \left(\frac{\sqrt{2}}{\text{CWND}}\right)$

On Loss

$\text{CWND} = \text{CWND} / 2$

$SS = \text{false}$
Problem: When to stop slow start?

\[ \Delta \text{Loss} \]

So far:

\[ \text{We said } \text{CWND} = \frac{\text{CWND}}{2} \]

on each loss.

But consider a case where \( \text{CWND} = 800 \)

\( \Delta \) 50 packets lost: \( \text{CWND} = \frac{\text{CWND}}{250} \)
How to multiplicatively decrease Nagels

Fast Recovery

Remember: Duplicate Ack provide another means to detect loss.

Much more likely to receive DUPLICATE on congestion: Why

CWND = 10

AIMD: probably off by one

One packet lost

See lots more for DUPLICATE
Still need timeouts though. Why?

Consider sending a file with 10 packets

\[1 2 3 4 5 6 7 8 9 X\]

No more packets to send \Rightarrow no more dup acks

But also

Timeout is triggered when

Lost many packets, unlikely to be able to see duplicate ACKs

Path change (e.g., link failed)

Likely drop all packets in window \Rightarrow loss detected by timeout.
Idea:

When congestion loss divide by 2

When loss for other reasons start from scratch

\[ Ss = \text{True} \]
\[ CWND = 1 \]
\[ DUPACK = 0 \]

On new ACK:

\[ DUPACK = 0 \]
if \( Ss \):
\[ CWND = CWND + 1 \]
else:
\[ CWND = CWND + \frac{1}{2}CWND \]

On DUPACK:

\[ \text{DupAck} + 1 \]
if \( \text{DupAck} = 3 \): # loss detected
\[ CWND = CWND / 2 \]

ON Timeout (RTO):
\[ CWND = 1 \] # Bad loss
\[ Ss = \text{True} \]