Announcements

• Additional office hours on Tuesday (one day before the exam)
• P2 discussions on Monday
High Speed Data Transfer

• Internet applications are becoming data-intensive
  – Links today have large bandwidth
  – Short and long links

• Why do we care about bandwidth-delay product?

• If we want the link to be fully utilized, how many in-flight packets do we want?
TCP Reno Review

• Takes a long time to increase cwnd
• If there are some packet drops in between, we incur this delay multiple times within a session
BIC-TCP

- Binary search within min and max window
- Min = cwnd prior to packet loss
- Max = cwnd with packet loss

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“correct” cwnd must be somewhere here
Stability vs Agility

• Increase is larger when farther away from the capacity

• What happens if the capacity increases after the last packet loss?

• What happens if the capacity decreases after the last packet loss?
BIC – TCP Window Growth

• Four phases during growth
  – Additive increase \( (S_{\text{max}}) \) followed by logarithmic increase (binary search)
  – Exponential increase followed by additive increase

• CUBIC simplifies the mechanisms

From Ha08
• Replace different phases with a cubic function
• Concave and convex regions
Cubic Window Growth Function

\[ f(x) = ax^3 + bx^2 + cx + d \]

\[ W(t) = C(t-K)^3 + W_{\text{max}} \]

\[ K = \sqrt[3]{\frac{W_{\text{max}}b}{C}} \]
Regions of Window Adjustment

- TCP Friendly region
  - How do we know we are in this region?
- Concave region
- Convex region
- Multiplicative decrease
- Fast Convergence
  - How do we know we should go into this region?
From Ha08

(a) RTT 8 ms.

(b) RTT 82 ms.
From Hemminger07
• Why larger buffer leads to more utilization?
• What happens if the buffer is too large?

From Hemminger07