Challenges on TCP: “long, fat pipes”

- Example: 1500 byte segments, 100ms RTT, want 10 Gbps throughput
- Requires window size W = 83,333 in-flight segments
- Throughput in terms of loss rate:

$$\frac{1.22 \cdot MSS}{RTT\sqrt{L}}$$

- ➜ $L = 2 \cdot 10^{-10}$ *Wow*
- New versions of TCP for high-speed needed!

TCP Reno

- TCP Reno
  - slow start
  - congestion avoidance
  - timeout
  - on 3rd dupack, fast recovery
    - ssthresh=cwnd/2
    - cwnd=ssthresh

TCP Tahoe

- “Old” TCP
- TCP Tahoe
  - slow start
    - when cwnd < ssthresh, exponential increase
  - congestion avoidance
    - when cwnd >= ssthresh, linear increase
  - timeout
    - ssthresh=cwnd/2, cwnd=1 MSS
  - fast retransmit

TCP throughput

- What’s the average throughout of TCP (Reno) as a function of window size and RTT?
  - Ignore slow start
- Let W be the window size when loss occurs.
- When window is W, throughput is W/RTT
- Just after loss, window drops to W/2, throughput to W/2RTT.
- Average throughout: 0.75 W/RTT
- Loss event rate: 1/[3/8(W/MSS)^2]