TCP Congestion Control

- Closed-Loop Control
- Dynamically changes sender window size (congestion window size)

Issue

- Fairness

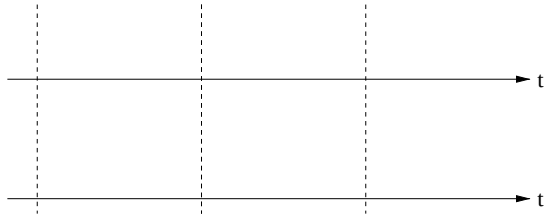
TCP Congestion Control

Flow Control - Congestion Control

- Flow Control: mechanism to prevent the sender from sending data when the receiver buffer is full.
- Congestion Control: mechanism to prevent congestion within the network.

TCP Congestion Control

Congestion Window - Transmission Rate



transmission rate $\leq$

MSS: Maximum Segment Size

TCP Congestion Control Algorithm (Tahoe)

Parameters

- $RcvWin$
- $threshold$
- w
- $CongWin = wMSS$
- $n = \min\{RcvWin, CongWin\}$

Init

- Set $threshold$
- Set $w = 1$

Slow Start

- As long as $w \leq threshold$, for every received ACK set

$$w = w + 1$$

Congestion Avoidance

- When $w > threshold$, for every w ACK received set

$$w = w + 1$$

Loss

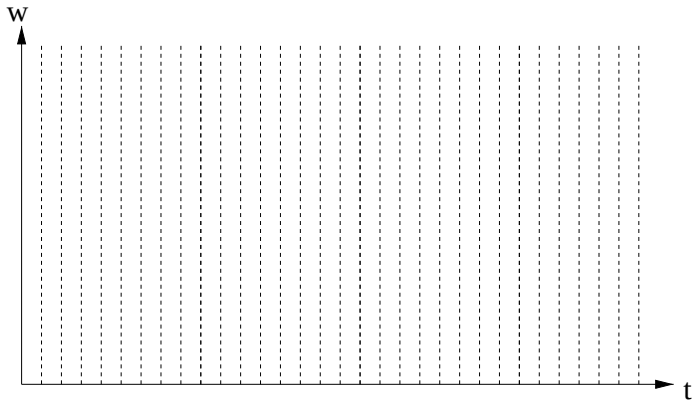
- When a ACK is not received when time-out expires, set

$$threshold = \frac{w}{2}$$

$$w = 1$$

- Got to "slow start"

TCP Congestion Control Algorithm



TCP Congestion Control: Average Transmission Rate

Simple Model:

- Ignore "Slow Start" Phase
- Assume constant $threshold = W$

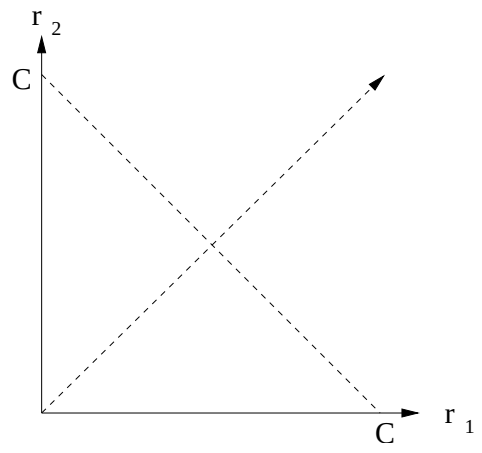
$$\begin{aligned}
\text{Aver. Trans. Rate} &= \frac{1}{W/2+1}\sum_{k=W/2}^{W}\frac{kMSS}{RTT} \\
&= \frac{1}{W/2+1}\left[\frac{W(W+1)}{2} - \frac{(W/2-1)W/2}{2}\right]\frac{MSS}{RTT} \\
&= \frac{1}{W/2+1}\frac{0.75W^2+0.5W}{2}\frac{MSS}{RTT} \\
&\approx \frac{1}{W/2}\frac{0.75W^2}{2}\frac{MSS}{RTT} = \frac{0.75\cdot W\cdot MSS}{RTT}
\end{aligned}$$

TCP Congestion Control: Fairness

Simple Model:

- Ignore "Slow Start" Phase
- 2 Connection share one Link with Capacity C

Additive-Increase, Multiplicative-Decrease (AIMD) algorithm



TCP Congestion Control

Observations:

- Simple and Scalable
- Does not make any assumptions about Network Layer
- Max-Min Fair

TCP Congestion Control

Drawbacks

- Based on Packet Loss
- No QoS-Guarantees
- Is Max-Min Fairness what we want?
- Assumes User Cooperation
- Vulnerable to UDP sessions
- Average Transmission Rate dependent on RTT