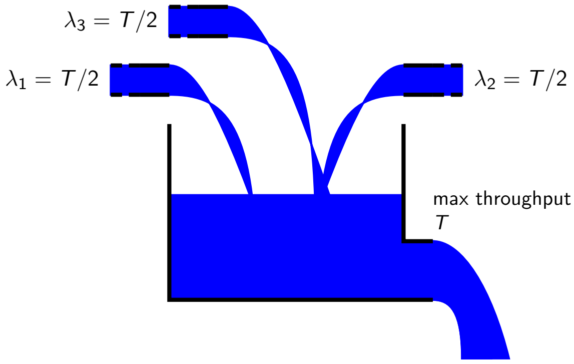
Congestion Control

Lecture given by Emmanuel Lochin

ISAE-SUPAERO

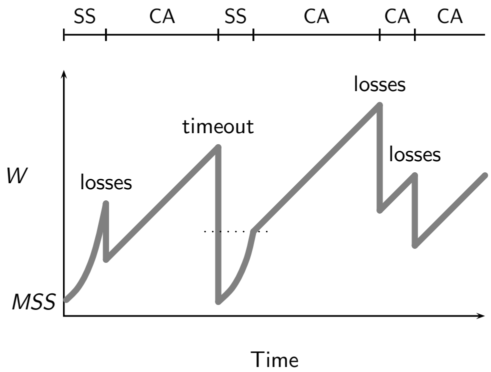
Understanding Congestion

- A router behaves a lot like a kitchen sink

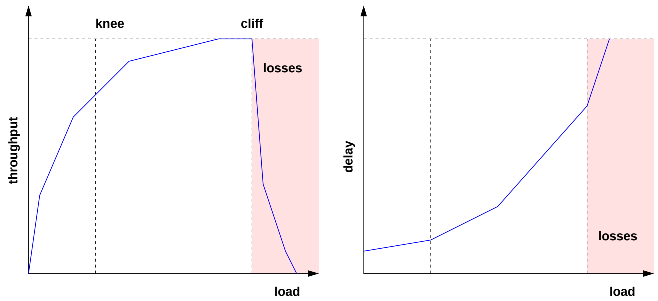


TCP Sender Behavior

SS=**slow start** CA=**congestion avoidance**

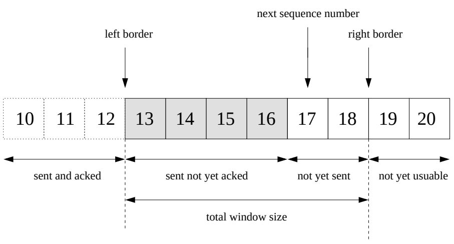


To sum up



- congestion avoidance : operate system at "knee" phase
- congestion control : operate system near "cliff" phase

Strategie to prevent congestion : the sliding window



Congestion control versus flow control

- Congestion control is linked to the network $\Rightarrow$ prevents router buffer overflow
- Flow control is linked to the receiver buffer $\Rightarrow$ prevents receiver buffer overflow

TCP NewReno
RFC6582

- **Slow-start** ($cwnd < ssthresh$) : $cwnd \leftarrow 2 \times cwnd$ every RTT (or $cwnd + 1$ on every ACK)
- **Congestion avoidance** ($cwnd > ssthresh$) : $cwnd \leftarrow cwnd + 1/cwnd$ on every ACK (or $cwnd + 1$ every RTT)
- Losses
  - **Fast retransmit** $cwnd, ssthresh \leftarrow cwnd/2$ on triple dup-ACK (a.k.a. losses ... or something else ?)
  - **Fast recovery** $cwnd \leftarrow ssthresh + n_{\mathrm{dupack}}$ for isolated losses
  - $cwnd \leftarrow 1, ssthresh \leftarrow cwnd/2$ on timeout
- Generalised $AIMD(a, b)$
  - CA : $cwnd \leftarrow cwnd + a$
  - **Loss** : $cwnd \leftarrow (1 - b)cwnd$
  - NewReno : $a = 1, b = 1/2$

Congestion control and fairness

- TCP uses the AIMD algorithm to fairly share the bottleneck capacity
- Let $r_i(t)$ the sending rate of r flow at time t and $c(t)$ a congestion detection function. The AIMD principle can be expressed as follows :

$$r_i(t+1) = \begin{cases} \alpha_{inc} + \beta_{inc}.r_i(t) & \text{si} \quad c(t) = 0 \\ \alpha_{dec} + \beta_{dec}.r_i(t) & \text{si} \quad c(t) = 1 \end{cases}$$

  - AIMD : $\alpha_{inc} > 0; \beta_{inc} = 1; \alpha_{dec} = 0; 0 < \beta_{dec} < 1$
  - MIMD : $\alpha_{inc} = 0; \beta_{inc} > 1; \alpha_{dec} = 0; 0 < \beta_{dec} < 1$
  - AIAD : $\alpha_{inc} > 0; \beta_{inc} = 1; \alpha_{dec} < 0; \beta_{dec} = 1$
  - MIAD : $\alpha_{inc} = 0; \beta_{inc} > 1; \alpha_{dec} < 0; \beta_{dec} = 1$

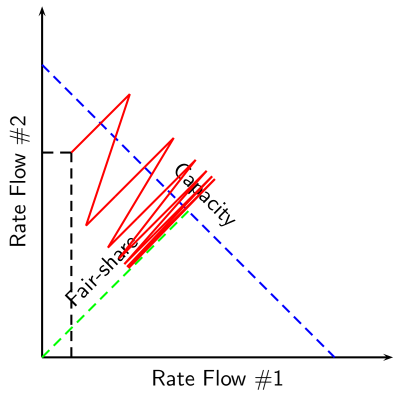
$c(t) = 1 \Rightarrow$ congestion event (i.e. loss, increase of the delay, ...)

Congestion control and fairness

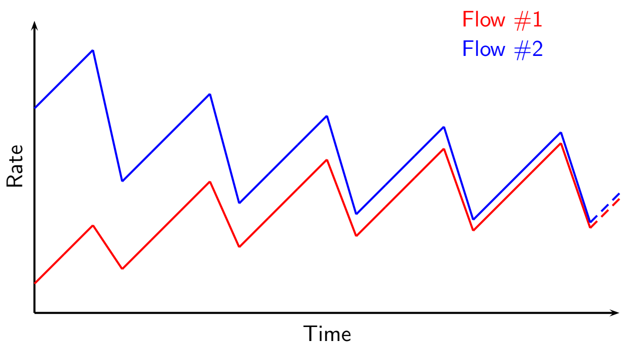
$$r_i(t+1) = \begin{cases} 1 + r_i(t) & \text{si} \quad c(t) = 0 \\ \frac{1}{2}.r_i(t) & \text{si} \quad c(t) = 1 \end{cases}$$

$c(t) = 1 \Rightarrow$ congestion event (i.e. loss, increase of the delay, ...)

Congestion control and fairness



Congestion control and fairness



Acknowledgements

This lecture has been designed using several materials collected from the @