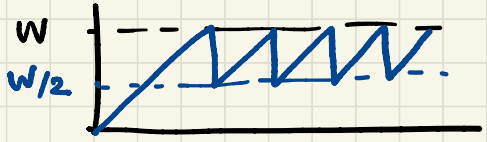
Oct 13 : Finish Up TCP

Topics :

- ✓ Timeout (RTO) Estimation
  - ↳ RTT, Variation
  - ↳ Smoothing EWMA.
- ✓ TCP : Packets to Bytes.
- ✓ AIMD
- ✓ Rough Throughput

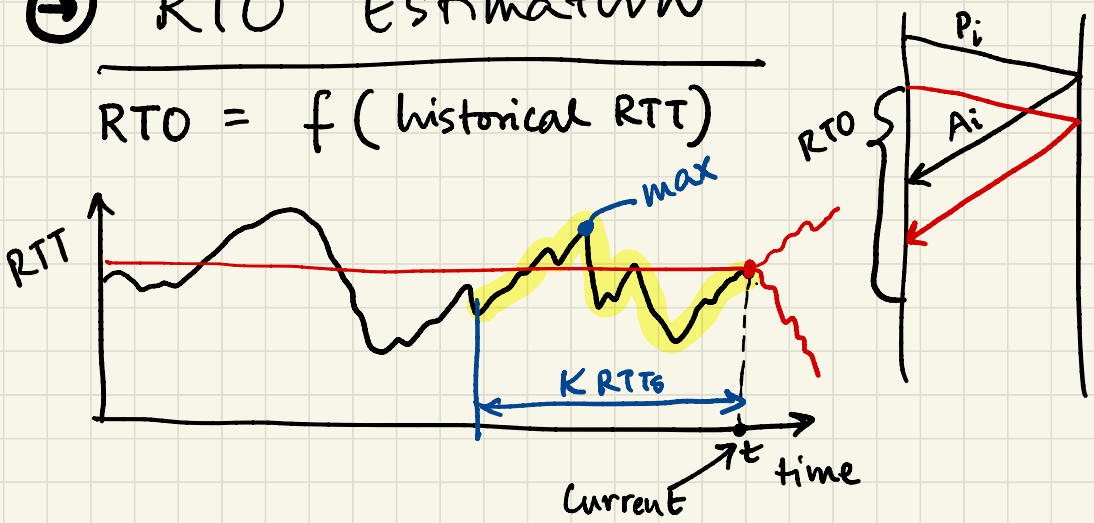


$$\frac{W}{RTT} + \frac{W/2}{RTT} = 0.75 \cdot \frac{W}{RTT}$$

- ✓ Flow control
- ✓ TCP Fairness
- TCP over wireless.
- Bottleneck bandwidth estimation (via pkt pair).

RTO Estimation

RTO = f (historical RTT)



RTO = max { last k RTT } → periodic outliers will affect max

mean { last k RTT } →

RTO = weighted avg. of historical RTTs + Safety factor

↓ Estimated RTT ($\hat{R}$)

↓ Deviation of RTT ($\hat{\Delta}$)

$$RTO(t) = \hat{R}(t) + \hat{\Delta}(t)$$

$$\hat{R}(t) = \alpha \hat{R}(t-1) + (1-\alpha) R(t)$$

α = 0.8, $(1-\alpha)$ = 0.2

← RTT measured at time t

$$\hat{R}(t-1) = \alpha \hat{R}(t-2) + (1-\alpha) R(t-1) \quad \text{——(*)}$$

$$\hat{R}(t) = \alpha\left(\alpha \hat{R}(t-2) + (1-\alpha) R(t-1)\right) + (1-\alpha) R(t)$$

$$= \alpha^2 \hat{R}(t-2) + \alpha(1-\alpha) R(t-1) + (1-\alpha) R(t)$$

$(0.8)^2 = 0.64$

$$\boxed{\hat{R}(t) = \alpha \hat{R}(t-1) + (1-\alpha) R(t)}$$

$$\boxed{\hat{\Delta}(t) = \alpha \hat{\Delta}_{(t-1)} + (1-\alpha) \left| R(t) - \hat{R}(t) \right|}$$

$$RTO(t) = \hat{R}(t) + 4\hat{\Delta}(t)$$

$\hat{R}(t)$: Est. RTT

$\hat{\Delta}(t)$: Est dev(RTT)

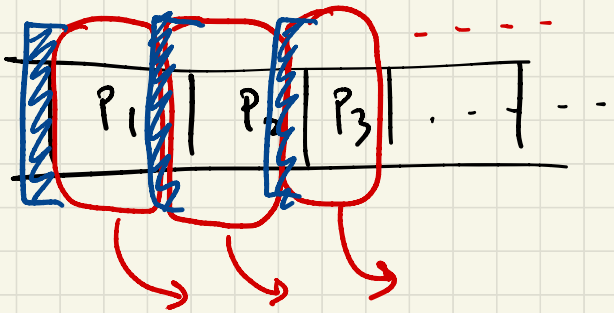
TCP Packets → Bytes.

CW → Expressed in # of bytes.

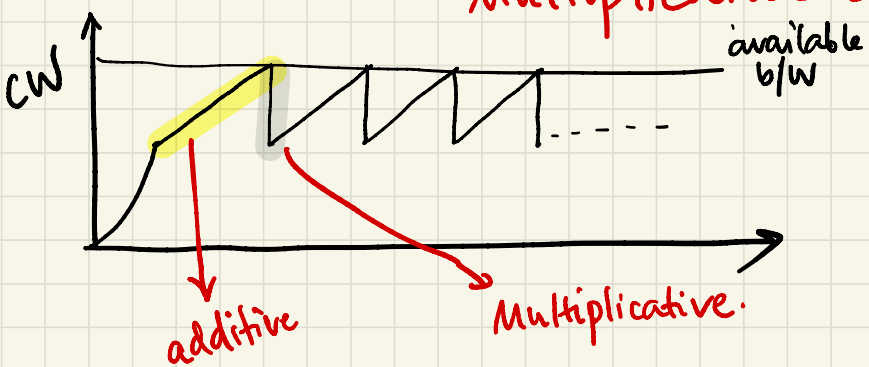
Segment

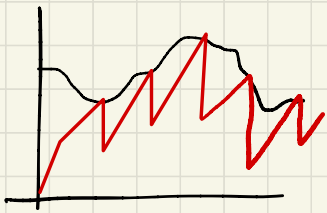
MSS bytes

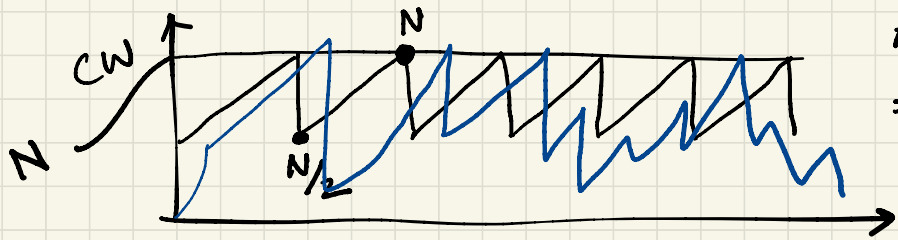
Maximum Segment size.



AIMD → Additive Increase but Multiplicative Decrease.

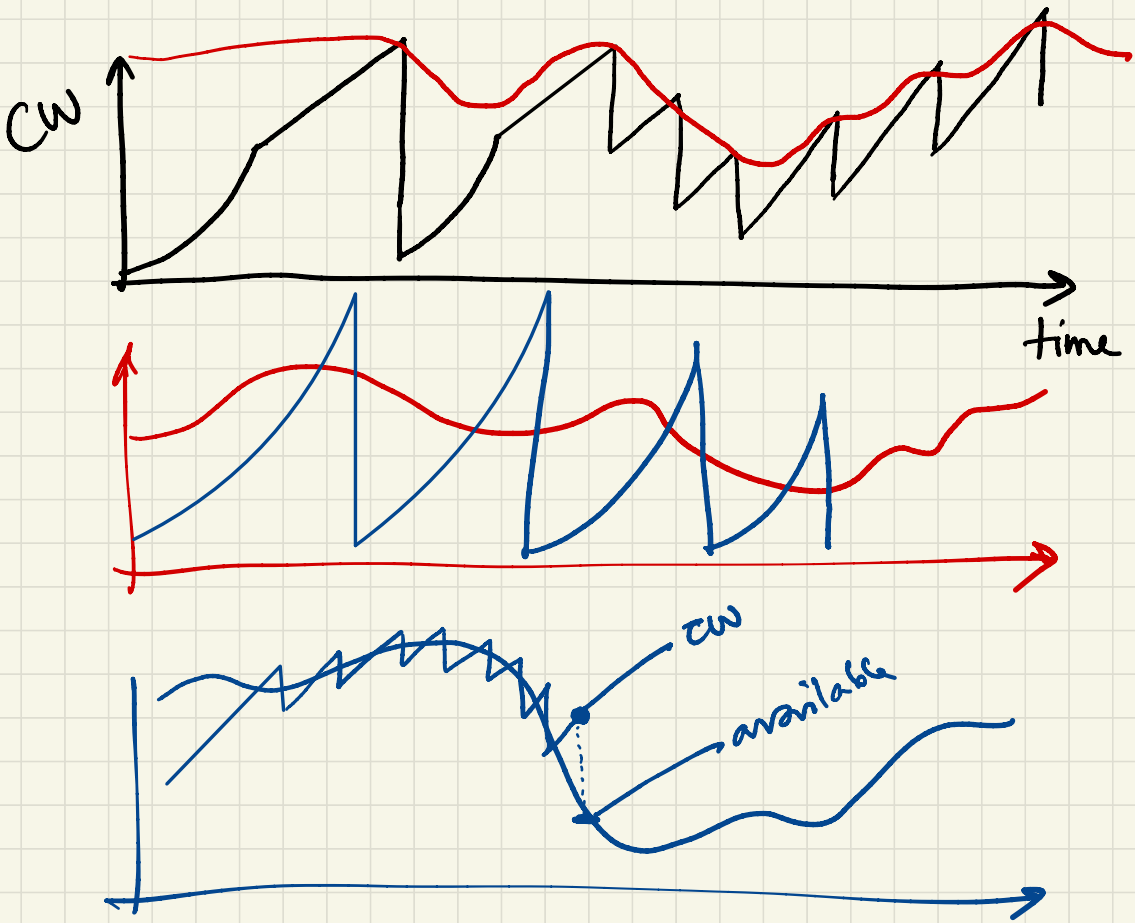




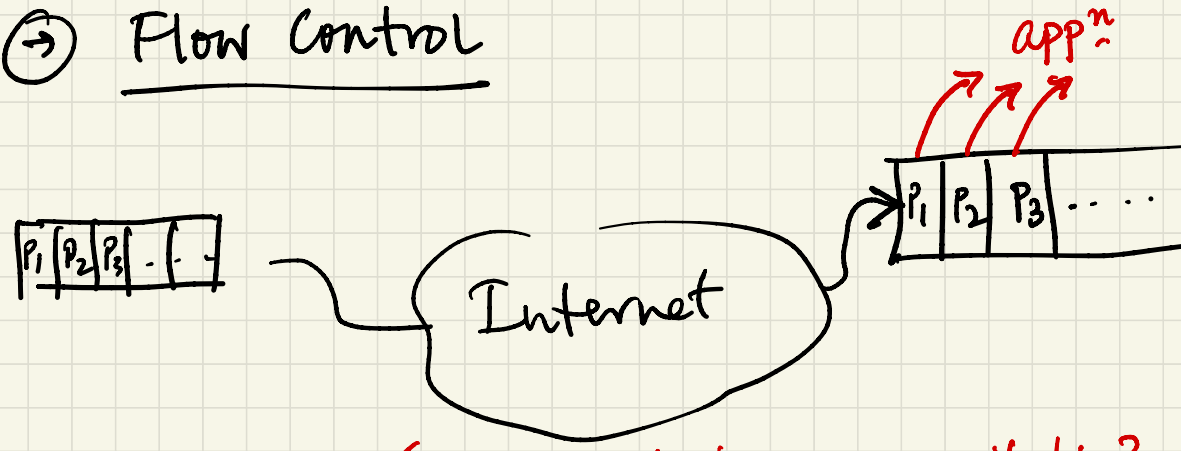


Saw tooth behavior of CW

Avg Throughput $= \frac{\frac{N}{RTT} + \frac{N/2}{RTT}}{2} = 0.75 N/RTT$

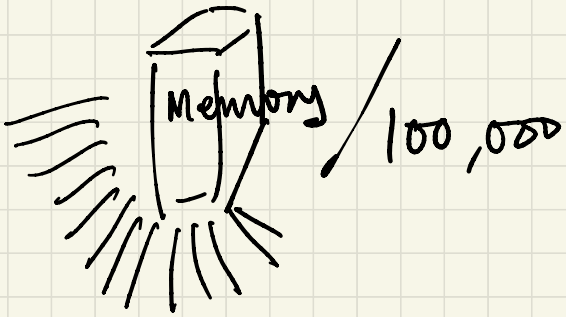


⑦ Flow Control

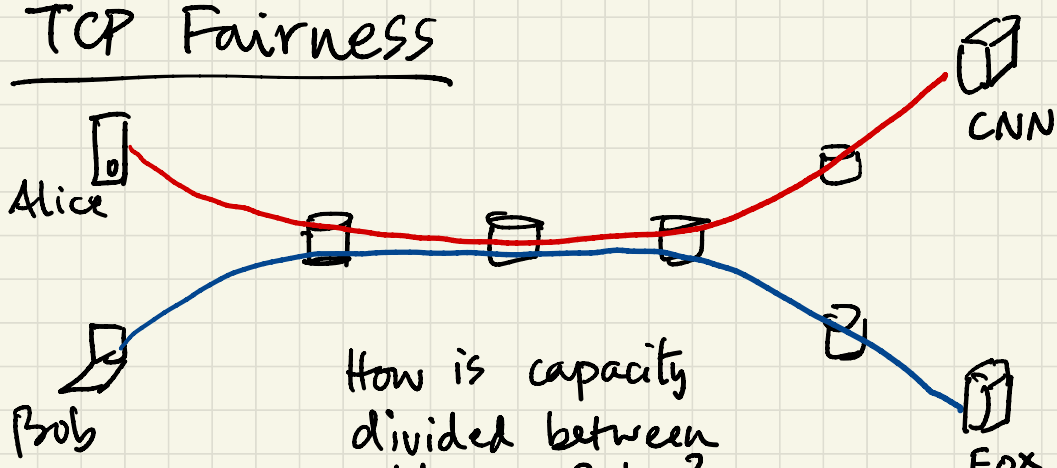


ACK {B = No. of bytes still available at Rx}

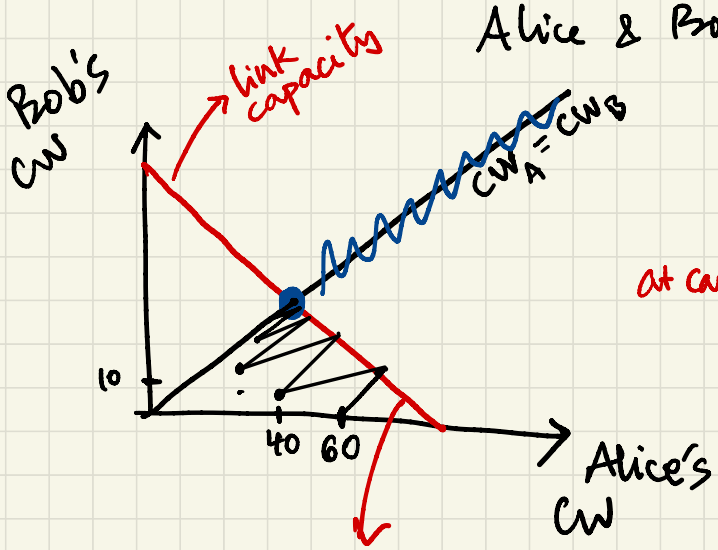
Tx transmits min {CW, B}



⊖ TCP Fairness



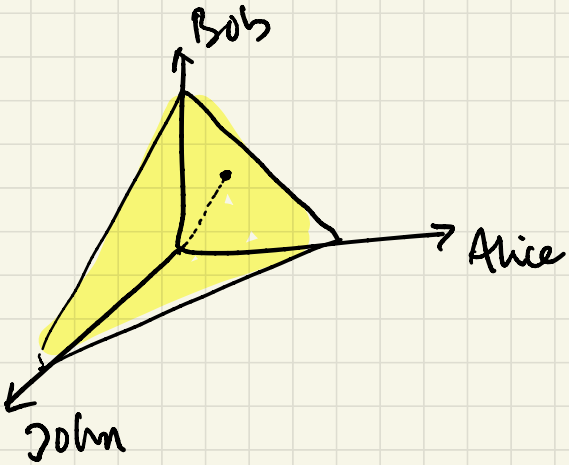
How is capacity divided between Alice & Bob.?



Capacity = 100

Alice	Bob
CW = 60	CW = 0
at capacity	
CW = ~~80~~ 40	CW = ~~20~~ 10
~~65~~	35
32.5	17.5

$CW_A + CW_B = \text{Constant} = \text{Capacity}$



TCP HW#2 will be released tomorrow