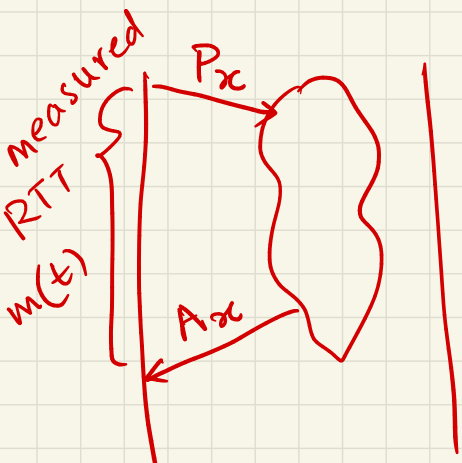
Oct 18, 2021

Agenda

- RTO estimation
- Packets to Bytes
- TCP Flow control
- TCP fairness
- TCP cross layer
- TCP over wireless



➔ TCP RTO Estimation

RTO = weighted avg. of historical RTTs + safety factor

weighted avg. of historical RTTs → Estimated RTT ($\hat{R}$)

safety factor → Deviation of RTT ($\hat{\Delta}$)

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

weights

$\alpha = 0.8$

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

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

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

$$= 0.64\, \hat{R}(t-2) + 0.16\, m(t-1) + 0.2\, m(t)$$

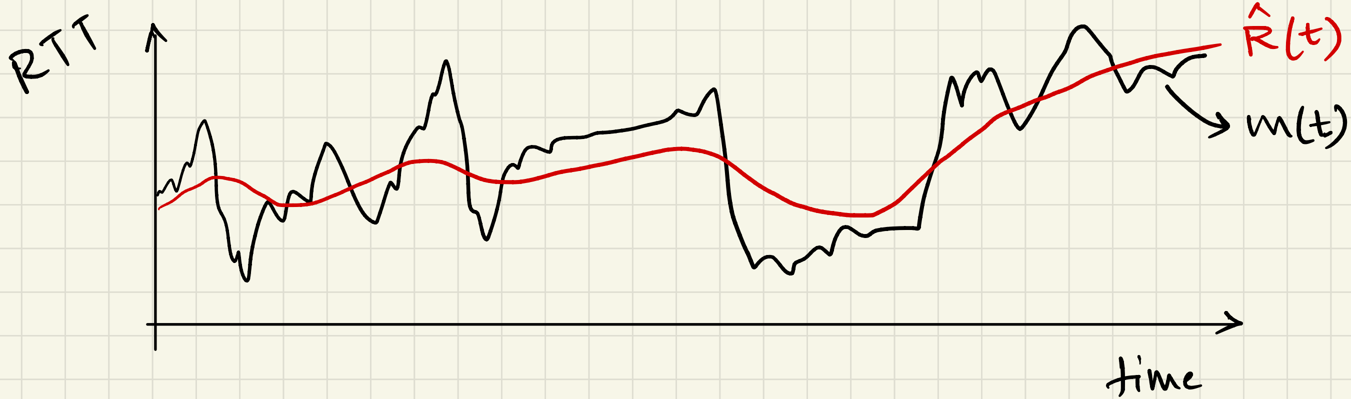
called

All RTT history up until time (t-2) has a weight of 64%.

EWMA ⇒ Exponential weighted moving average.

→ Deviation of RTT $\hat{\Delta}(t) = \hat{R}(t) - m(t)$

$$\hat{\Delta}(t) = \underbrace{\alpha \hat{\Delta}(t-1) + (1-\alpha)\{\hat{R}(t) - m(t)\}}_{\text{smoothen the } \hat{\Delta}(t) \text{ as well.}}$$



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

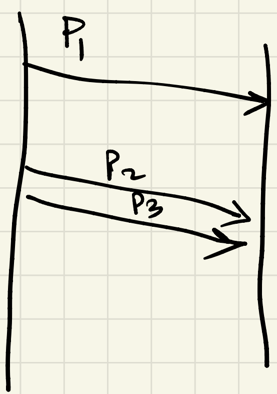
Retransmit timeout estimation over time.

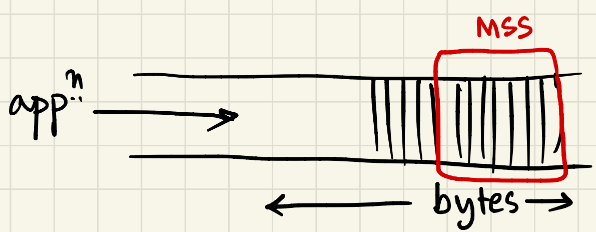
When estimating $\hat{R}(t)$ ignore dupACKs, and any stale ACKs that is <u>left of</u> Tx's window base.

→ <u>Packets to Bytes</u>

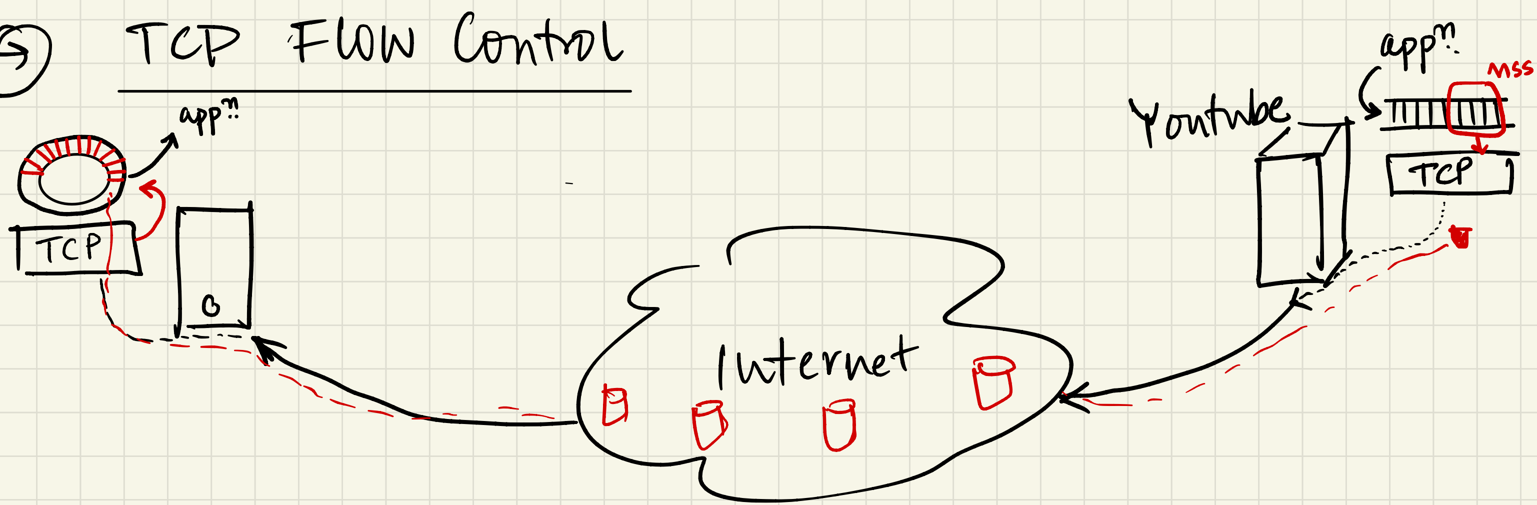
In reality, TCP operates as a byte stream.

MSS : maximum segment size





TCP Flow Control

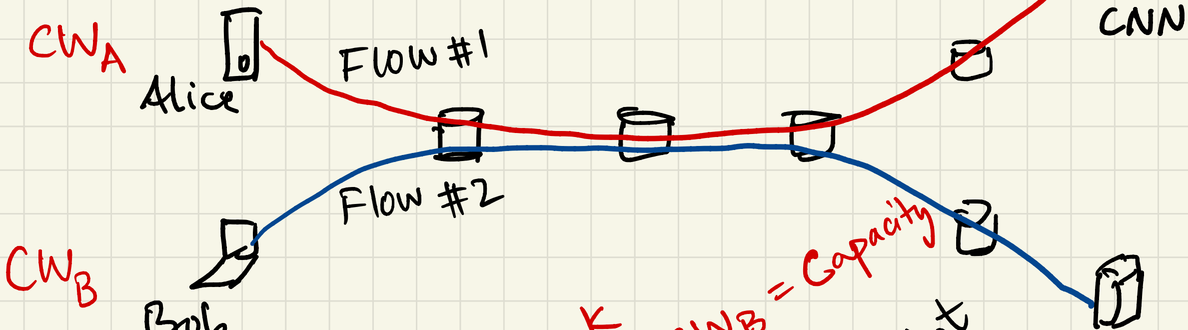


- If R_x's buffer fills up, it's sad because congestion happened right at the entrance of the app^n layer.

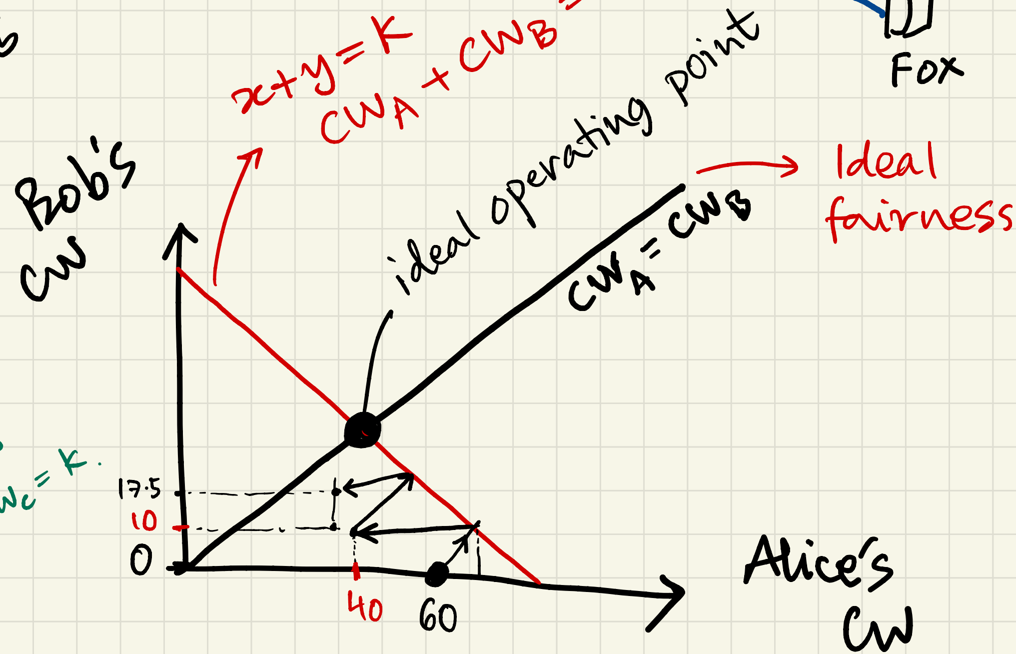
- R_x TCP includes how much space is available in its socket buffer. → B bytes. → ACK includes value B.

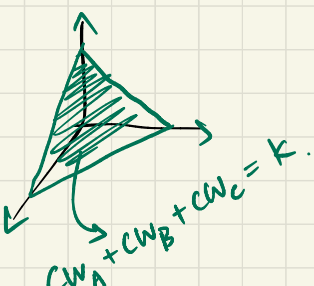
- When T_x TCP gets ACK, it decides to send : min { B , CW }
  ↳ The CW does not change..... CW keeps following the protocol.

⊙ TCP Fairness



How is capacity divided between Alice & Bob.?

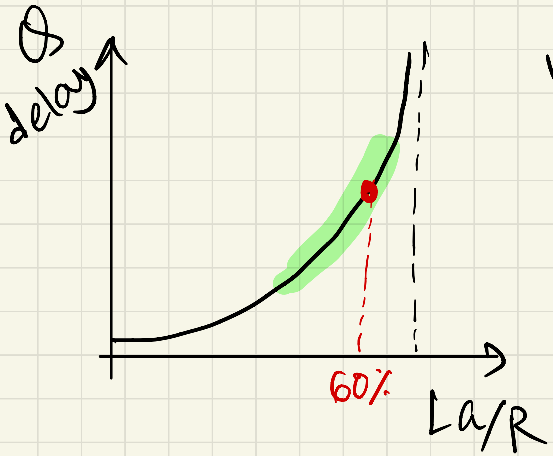


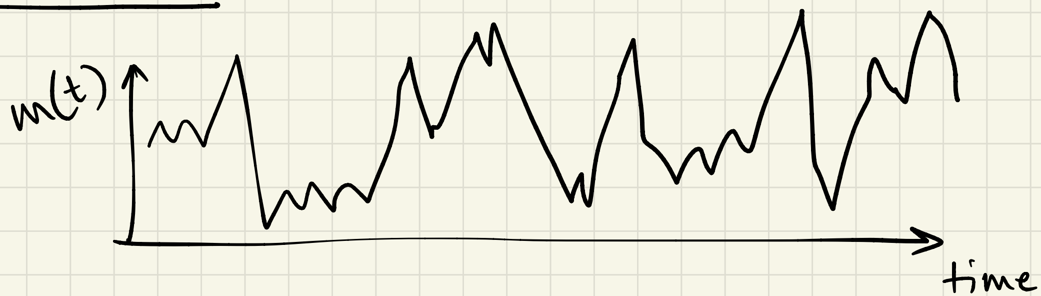


If capacity = 100

CW_A		CW_B
60	40	0
~~80~~	20 + 20	~~20~~
40	50	10
~~65~~	25 25	~~35~~
32.5		17.5
⋮		⋮
50		50

TCP RED (Random Early Drop) → Cross Layer Hints

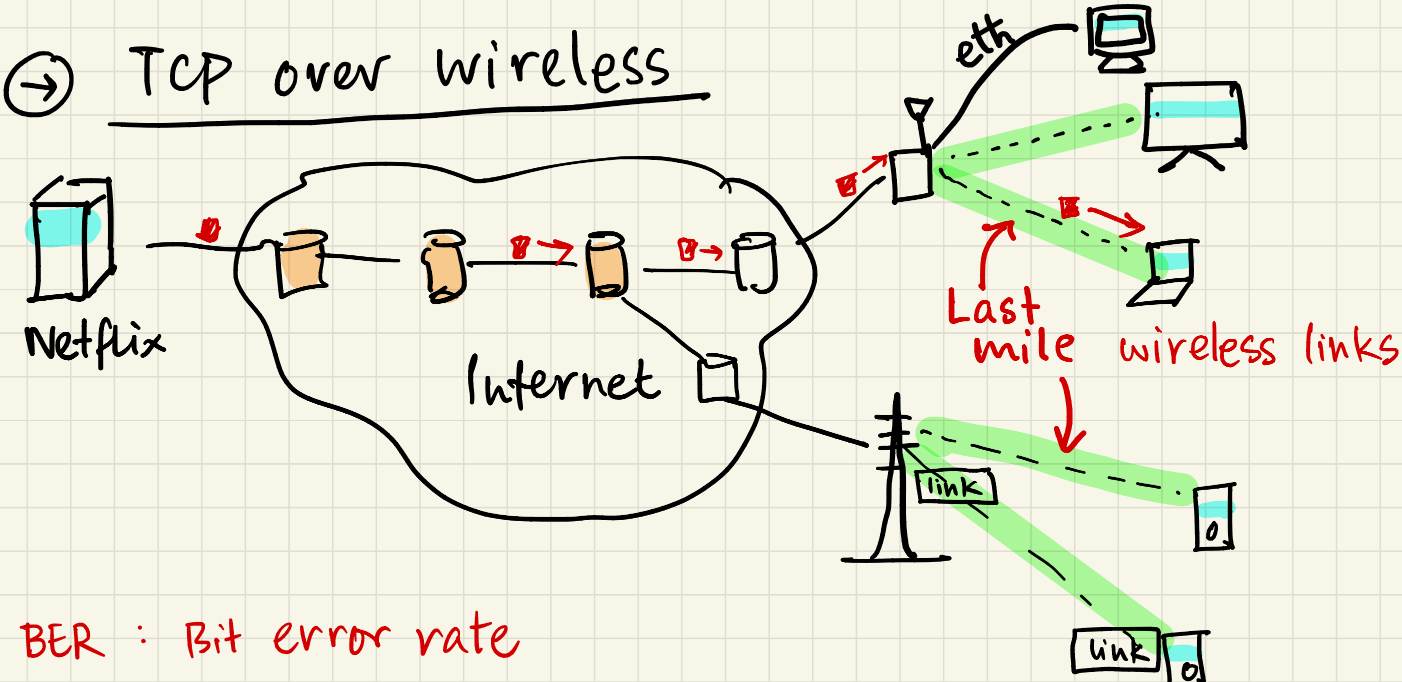




→ Hack / workaround for the network layer to give feedback to TCP about it's queue size / congestion.

RED → Network layer drops a random data packet from each flow, so that the router queue does not fill up above some threshold (say 60%)

→ TCP over wireless



BER : Bit error rate

Wireless ~ 1 bit in error every 10^{4-6} bits ⇒ $\frac{1}{100}$ pkts corrupt

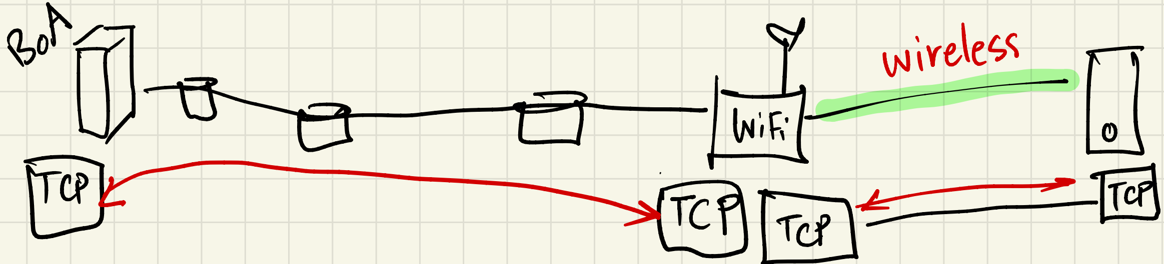
10^{-5}

wired $\overset{BER}{\sim}$ 10^{-12} → $\frac{1}{\text{million}}$ pkt corrupt

→ TCP must differentiate between wireless losses & congestion losses (at router) because :

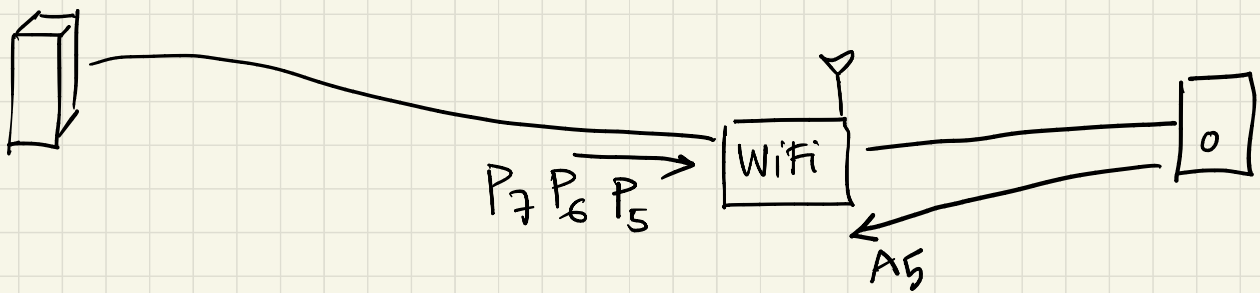
If congestion loss
then reduce CW
else if wireless loss
then simply retransmit & don't change CW.

① Split TCP.



violates TCP's end to end principle

②



TCP snoop because link layer is snooping into TCP header so that it can retransmit lost packets.

End of Transport /TCP.