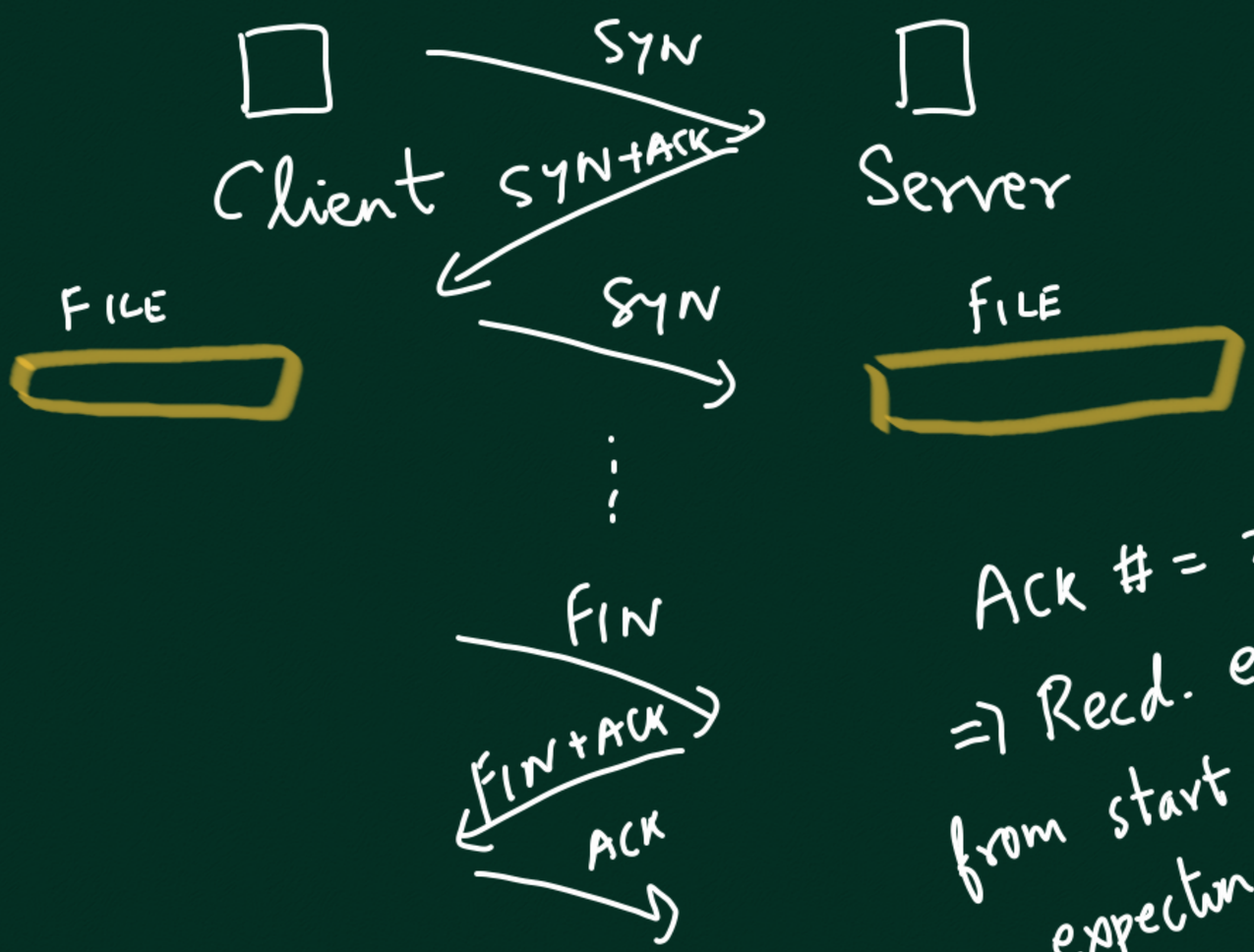
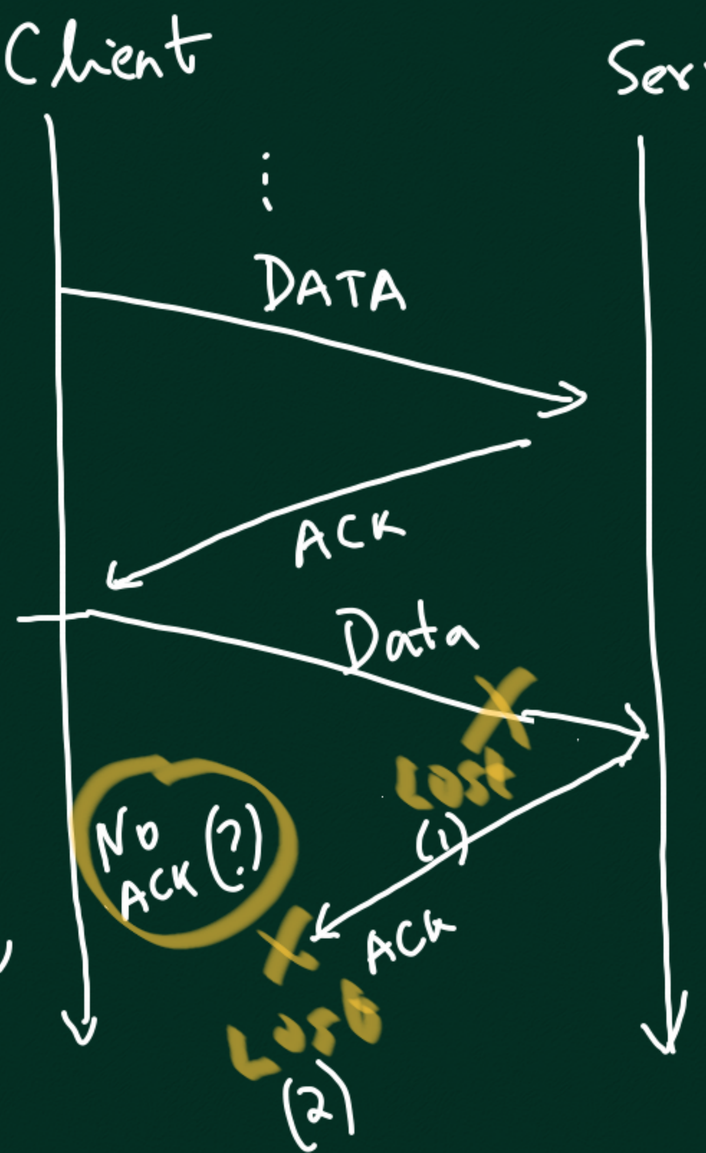
TCP

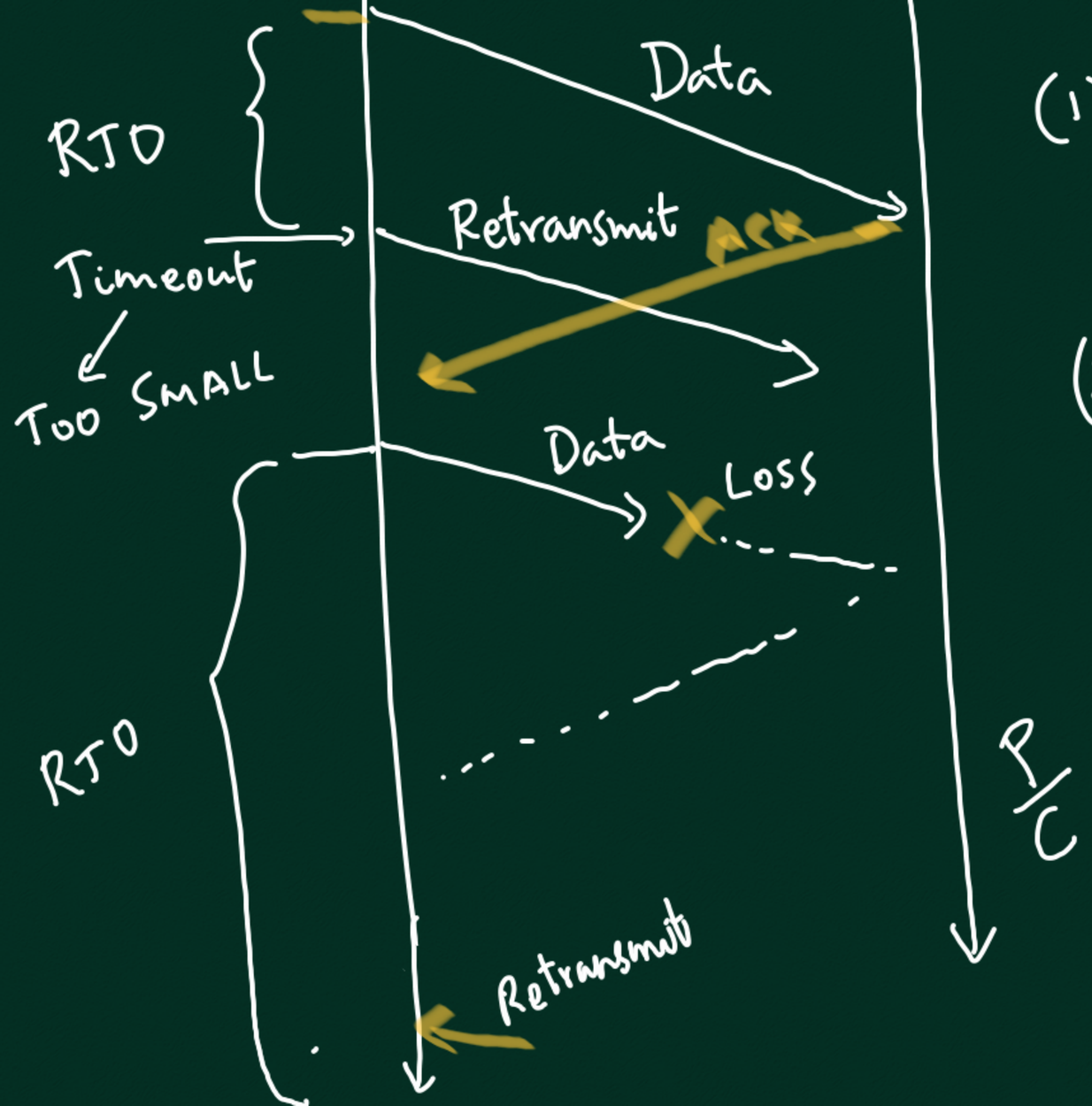


Ack # = x
⇒ Recd. everything from start to (x-1), expecting x next

(1) Retransmission of lost packets



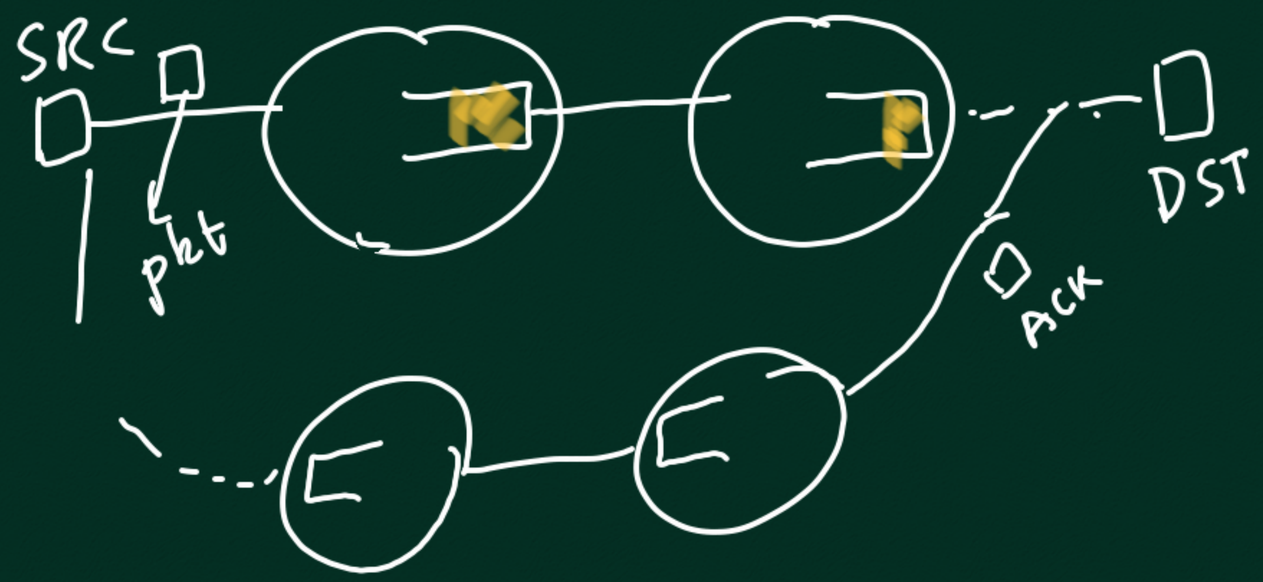
What should Retrans. Timeout (RTO) be?



Issues

(1) RTT can be ms – secs (across connections)
in Internet (location of SRC/DST)

(2) RTT for same connection is variable



RTT

min

Speed of light delays

+ transmission delays (P/C)

(if queuing delay = 0)

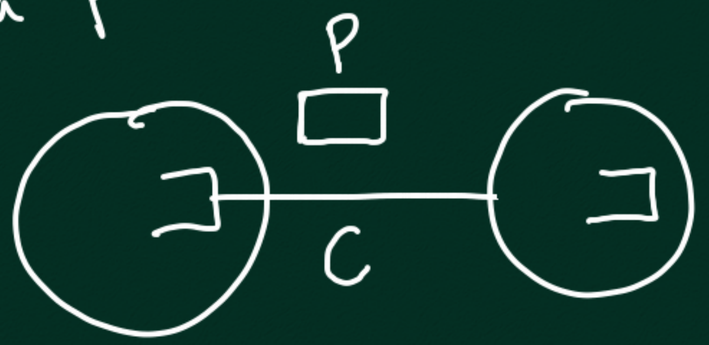
path change (L3)

window of time

window of time

time

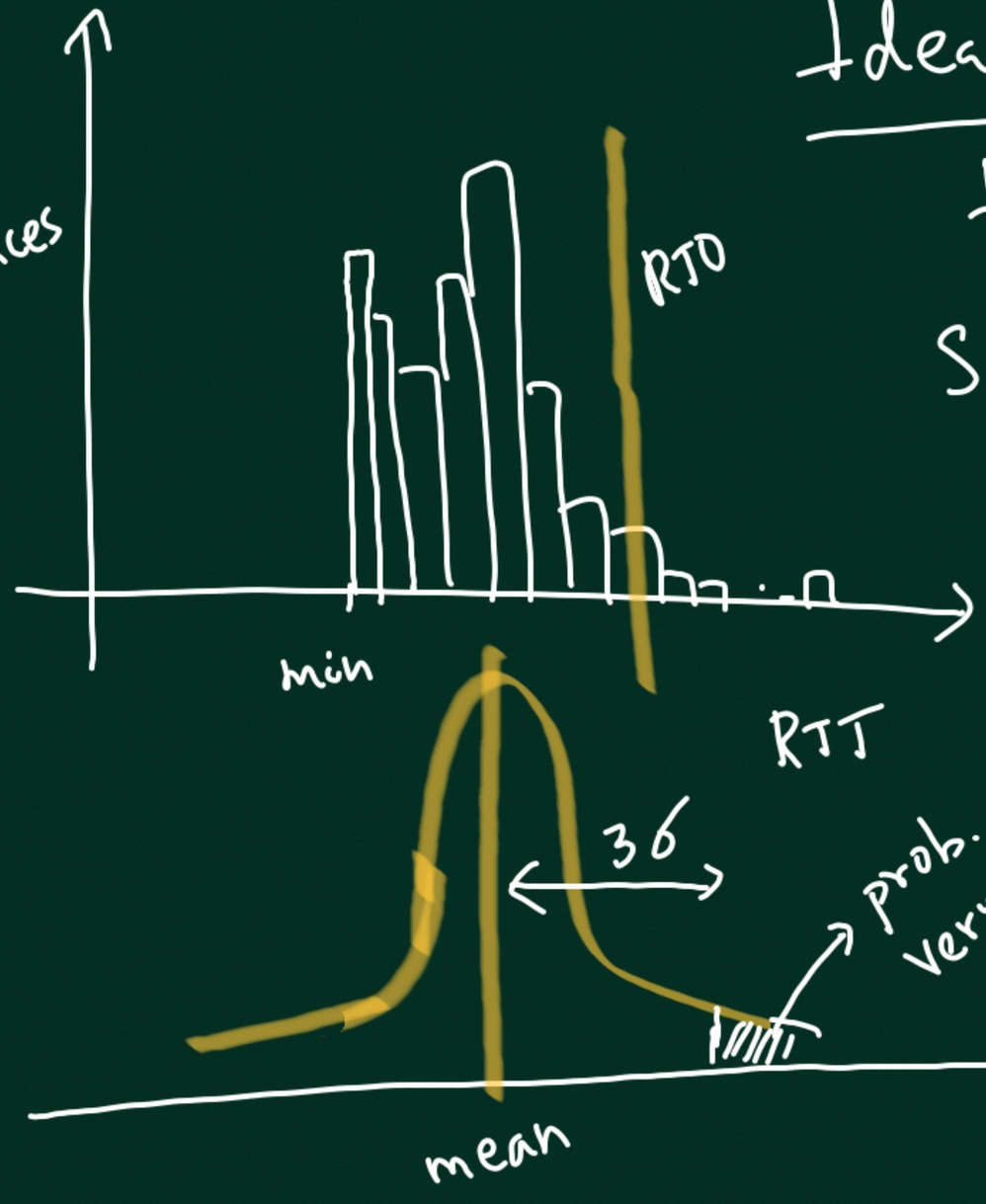
Time at which Data pkts sent out



STORE & FORWARD

↳ Wait for Full Pkt to reach router before fwding to output queue

Histogram of RTT



Idea: Measure RTT over time

Set RTO = mean + const. std dev

Random numbers : $x_1, x_2, \cdots, x_N$ $\quad x_{N+1}, x_{N+2}$

$$M = \frac{1}{N}\sum_{i=1}^{N} x_i$$

Can be Comput. intensive if 1000s of ACKs arriving per sec

Estim. of std dev $= \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - M)^2}$

Mean Deviation $= \frac{1}{N}\sum_{i=1}^{N}|x_i - M|$

ALGO Used by TCP (for RTO)

RFC

REQUEST FOR COMMENTS

Sample RTT ; Current estimate of mean EstimRTT

↳ latest RTT estimate

② EstimRTT = $(1-\alpha)$ EstimRTT + α SampleRTT

M

$\alpha \in (0,1)$

① Difference = SampleRTT − EstimRTT

(like $x_i - M$)

First ←

like $\frac{1}{N}\sum_i |x_i - m|$

Deviation = $(1-\beta)$ Deviation + β |Difference|

$$Timeout = \mu \times EstimRTT + \phi \times Deviation$$

$\mu = 1$; $\phi = 4$

$\alpha = \frac{1}{8}$; $\beta = \frac{1}{4}$ by default

TCP Vegas

Congestion & Flow Control

↳ Congestion at DST ??

FIELD in TCP Hdr

Adv. Window

= Free Buffer available

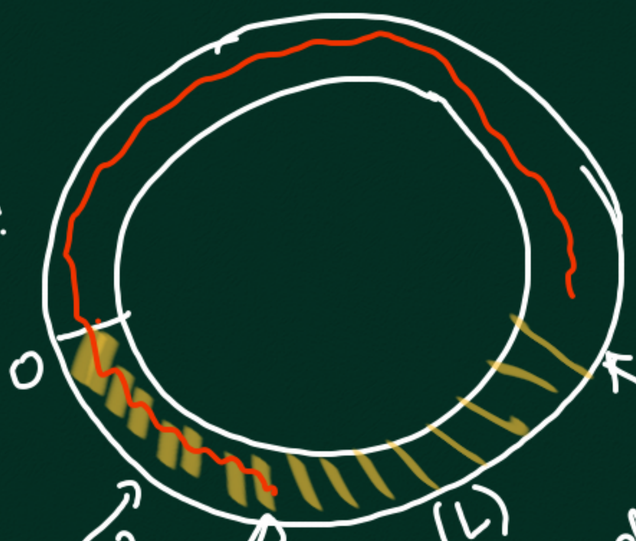
If N>L

$$\left(M - \underbrace{(N-L-1)}_{\text{used}}\right)$$

If N<L : $L - N + 1$

at DST

TCP :



Total Buffer Size = M

Adv. Window $= \left(M-(N-L-1)\right) \bmod M$

SRC

Window = min ((congestion Window , Adv. Window))

Window → Max. Bytes Un-Acked SRC can send out

(congestion Window) → Network Congestion