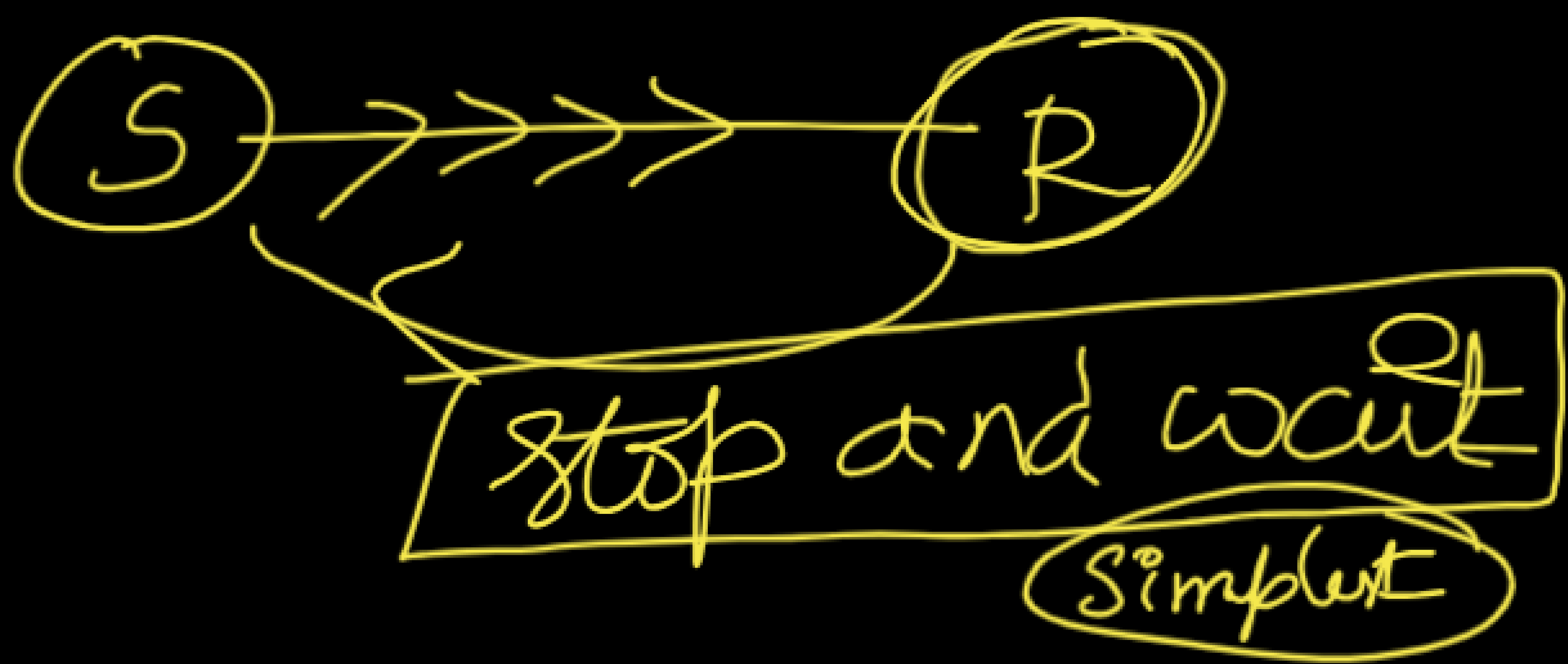
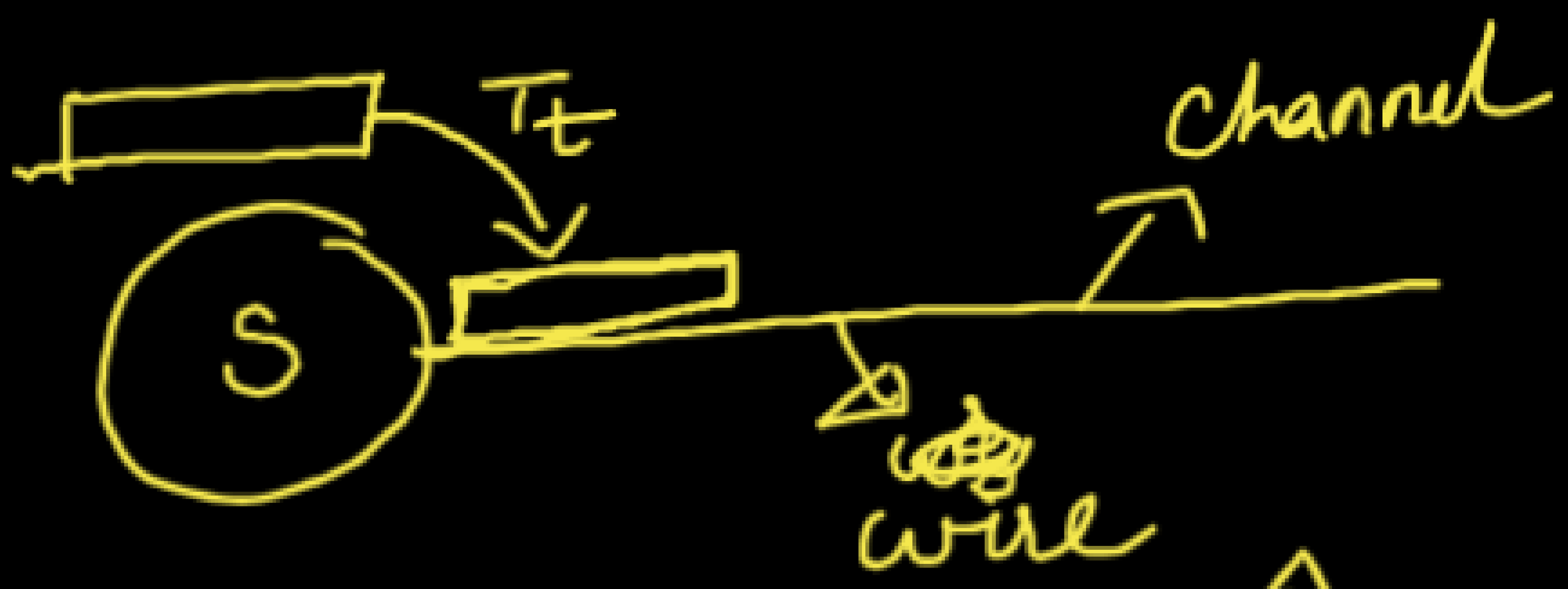
Flow Control:



Transmission delay :- (T_t)

BW → bps

$T_t \rightarrow L/B$



T_t → packet → longer ↑

smaller ↓.

BW = 1 bps

L = 10 bits

$T_t \rightarrow 1$s

1s → 1b.

10b → ? 10sec.

$$T_t = \frac{L}{B}$$

b   B   Bbps →

bps

$L = 1000$ bits $BW = 1k$ bps $T_t = \frac{L}{B} = \frac{1000 \text{ bits}}{1000 \text{ bps}}$

$= 1$ sec.

$L = 1kb$ $BW = 1kbps$ $T_t =$

Data

K − 1024

m − (1024)(1024)

G − $(1024)^3$

CS → 2^K

BW ✓

K − 1000 ✓

m − 10^6 ✓

G − 10^9 ✓

→ Signal.

↓

Physics.

↓

(10^k)

Propagation delay : (T_p)

$T_t \rightarrow$ packet $\rightarrow L$

$T_p \rightarrow$ 1 bit ~~Lt~~

1 bit

$T_p = \dfrac{d}{v}$

2×10^8 m/s

2x1

optical fibres

light $\rightarrow$ 3×10^8 m/s

70%

optical.

$3 \times 10^8 \times 70\%$

$= 2.1 \times 10^8$ m/s

$d = 2.1\,km$, $v = 2.1 \times 10^8\, m/s$.

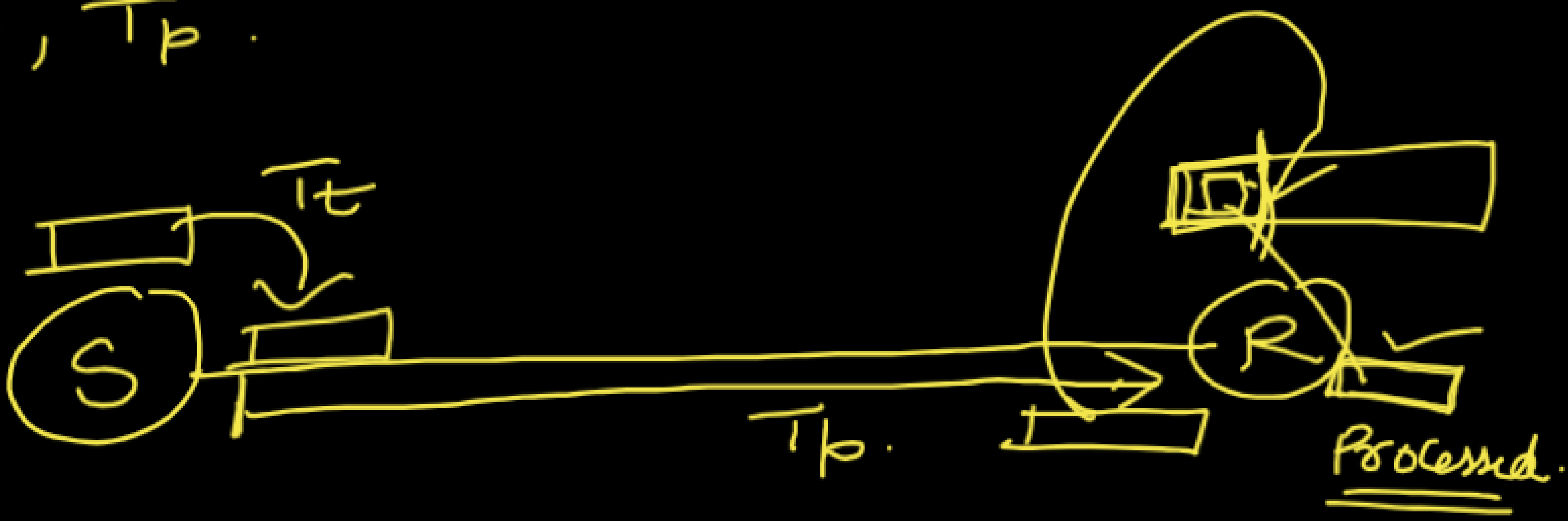
$$T_p = \cancel{2.1\times} \frac{d}{v} = \frac{\cancel{2.1} \times 10^3 \; \cancel{m}}{\cancel{2.1} \times 10^8 \; \cancel{m}/\cancel{s}} \, s$$

$$10^{-5} \times \frac{10^{-3}}{10^{-3}} m \qquad = 10^{-5} \times \frac{10^{-6}}{10^{-6}} \qquad \mu, m$$

$$10^{-2}\, ms \qquad = \frac{10^{-5}}{10^{-6}} \mu = \frac{1}{10^{-1}} \mu s$$

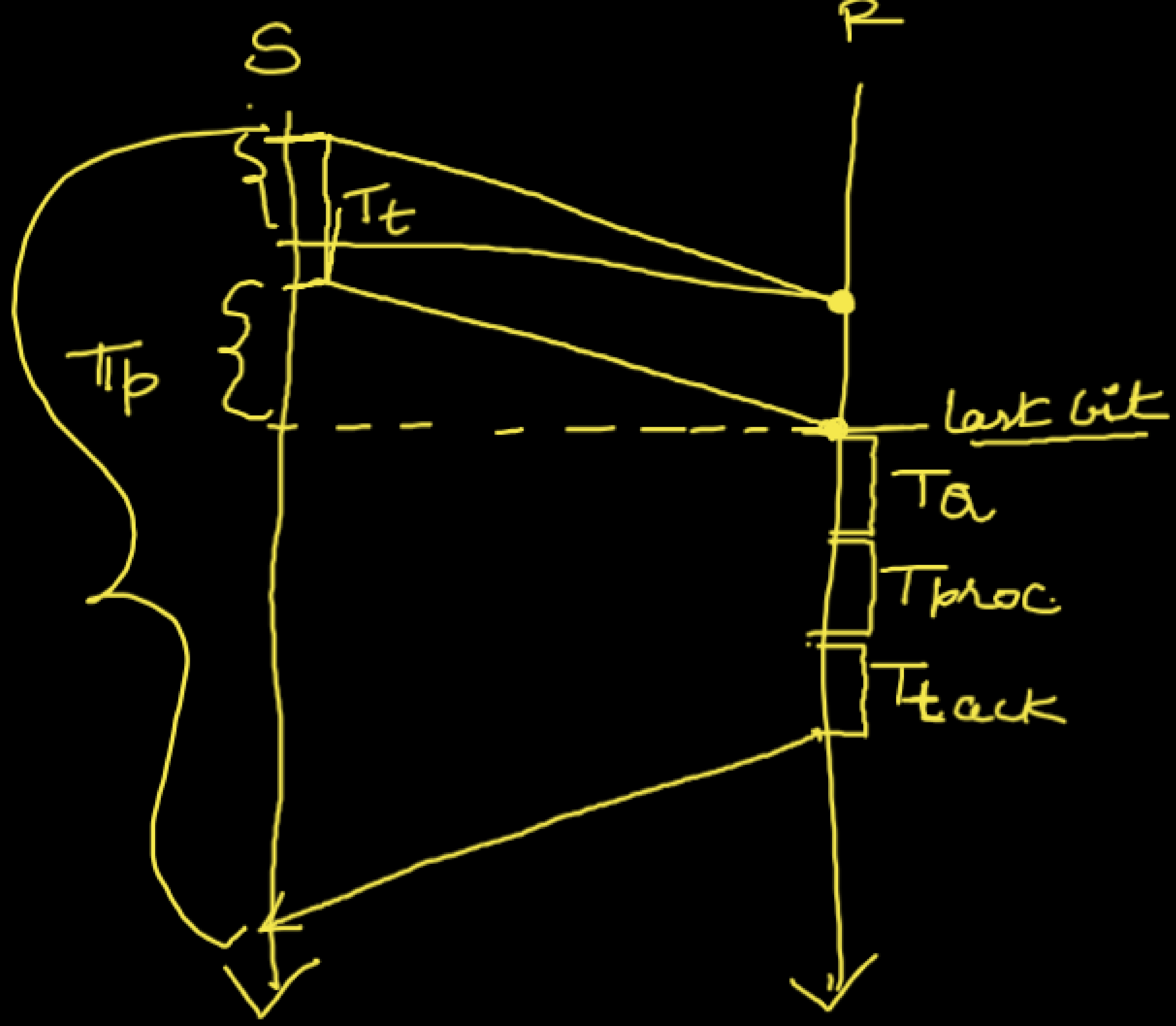
$$= 10 \mu s$$

T_t, T_p.



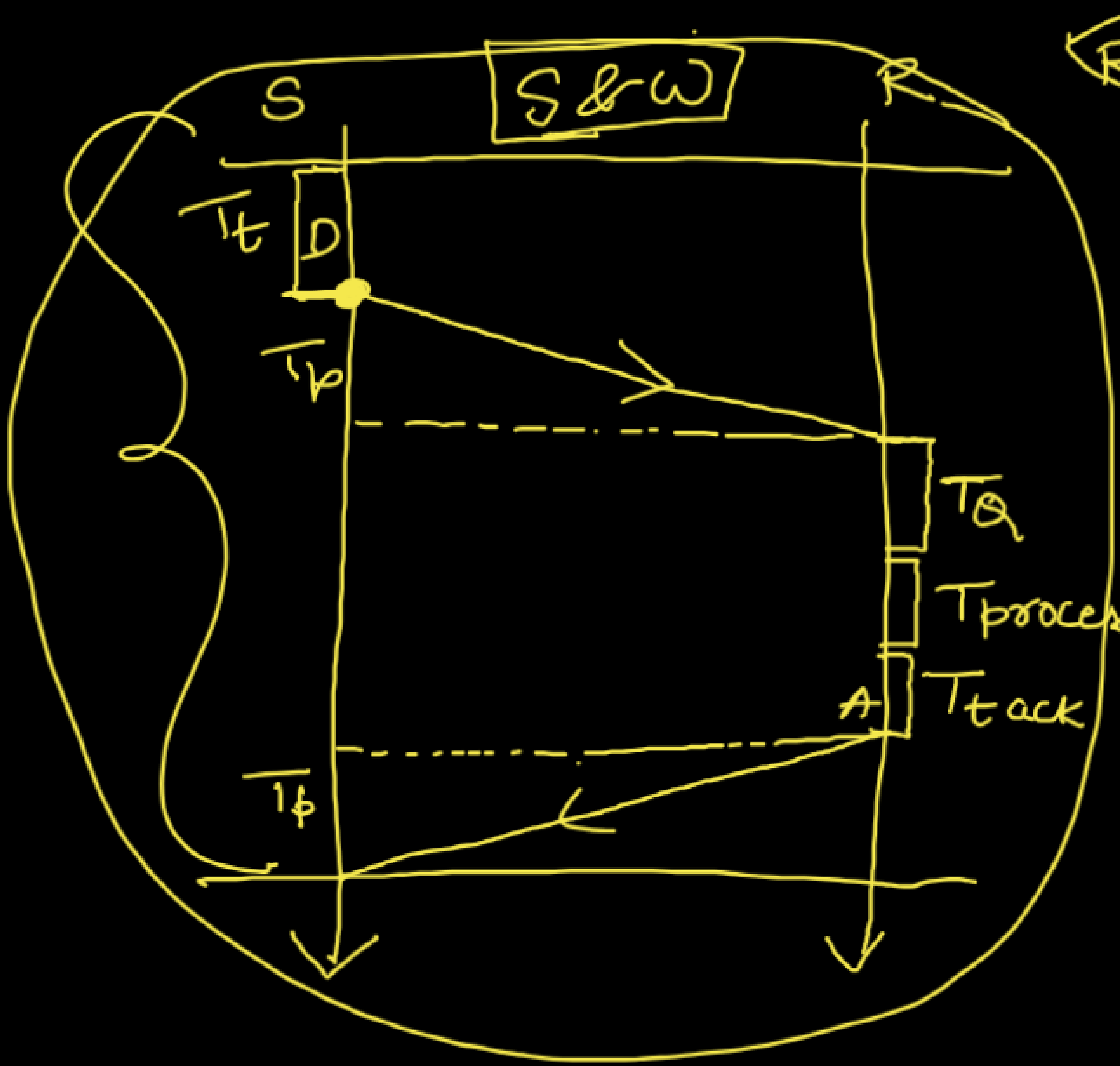
Queuing delay → NO Formula.

Processing delay :- NO Formula.



S
R
Tt
Tp
last bit
Ta
Tproc
Ttack

point to point.



RTT = 2 * T_p

Total time

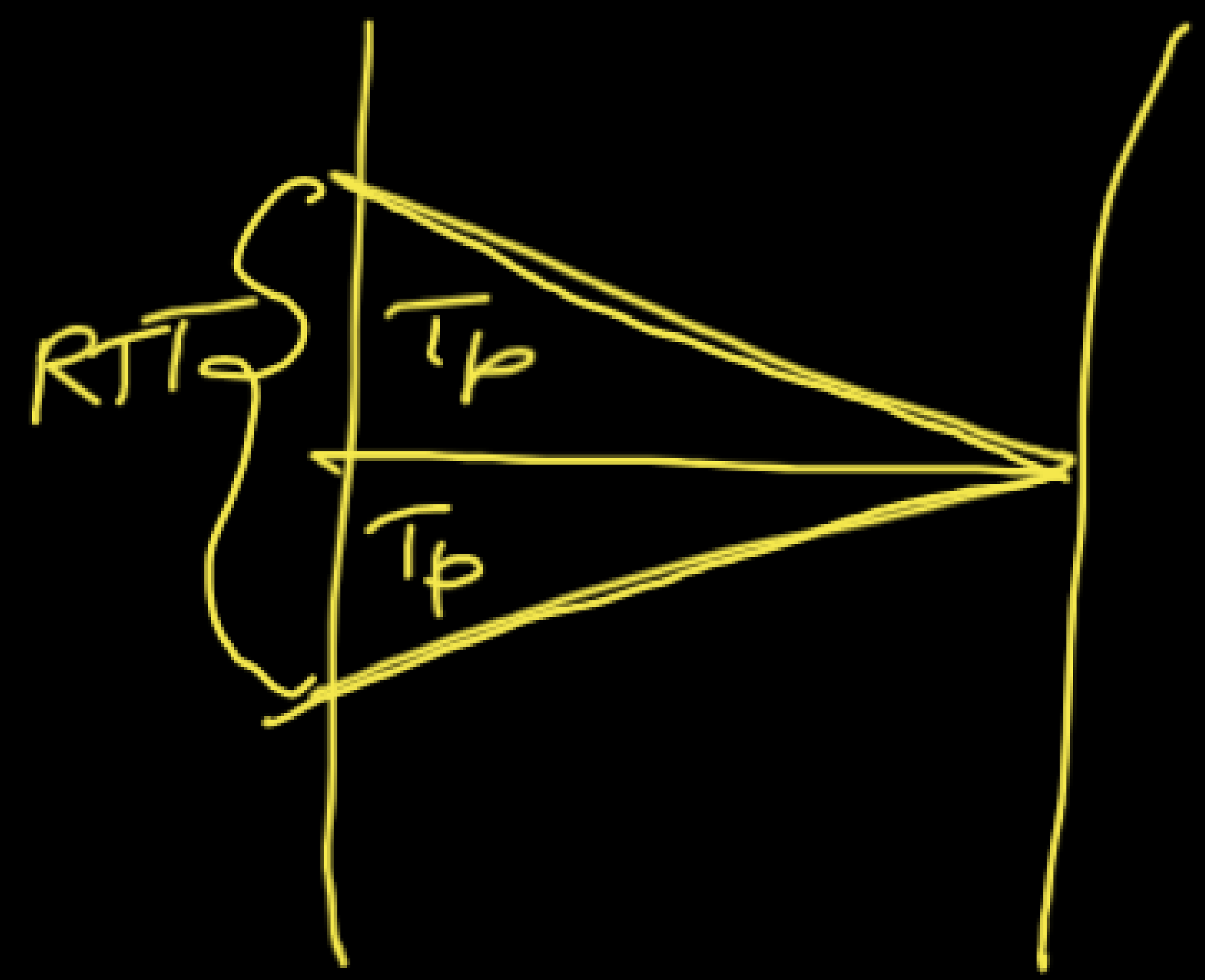
$= T_{t\,data} + T_Q + T_{proc} + T_{ack} + 2 \times T_p$

$$TT = \underbrace{T_{t\,data} + \cancel{T_{t\,ack}}} + 2 * T_p .$$

$$T_{t\,data} = \frac{L_{data}}{BW} \qquad \Bigg| \qquad T_{ack} = \frac{L_{ack}}{BW}$$

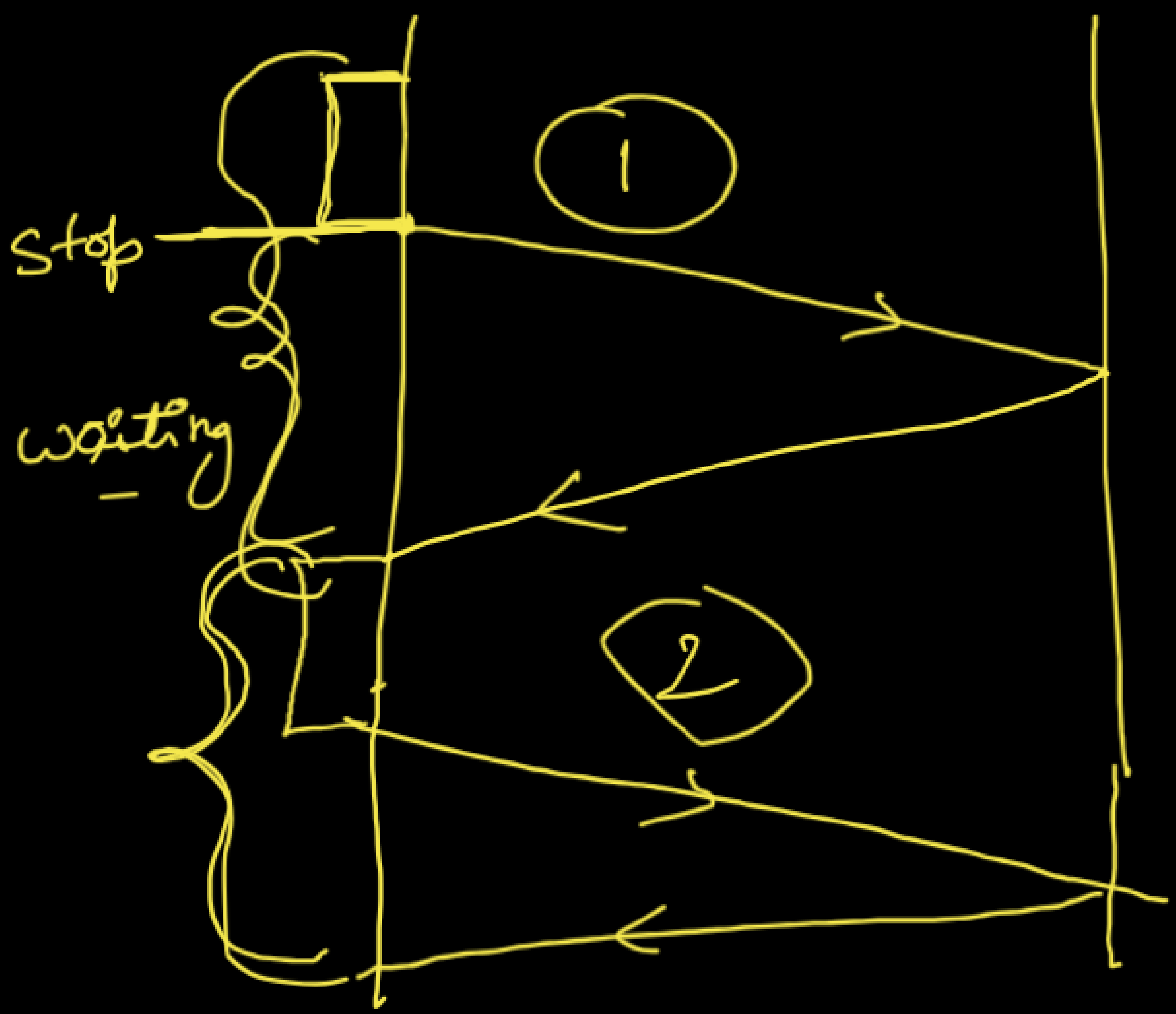
$$\underline{\underline{L_{data}}} \ggg \underline{\underline{L_{ack}}}$$

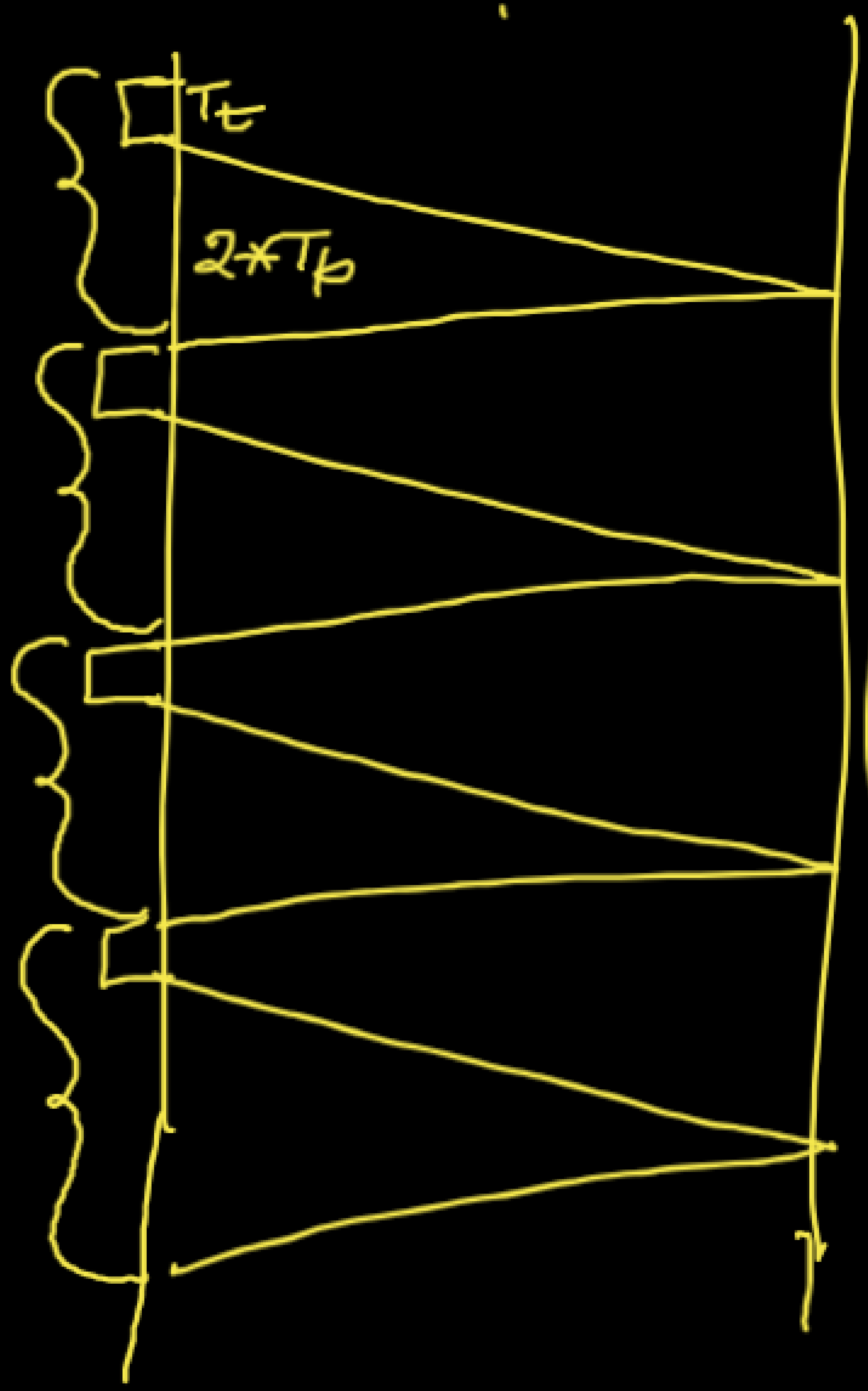
$$\boxed{TT = T_t + 2T_p .}$$



$$RTT = 2 * T_p.$$

Stop and wait



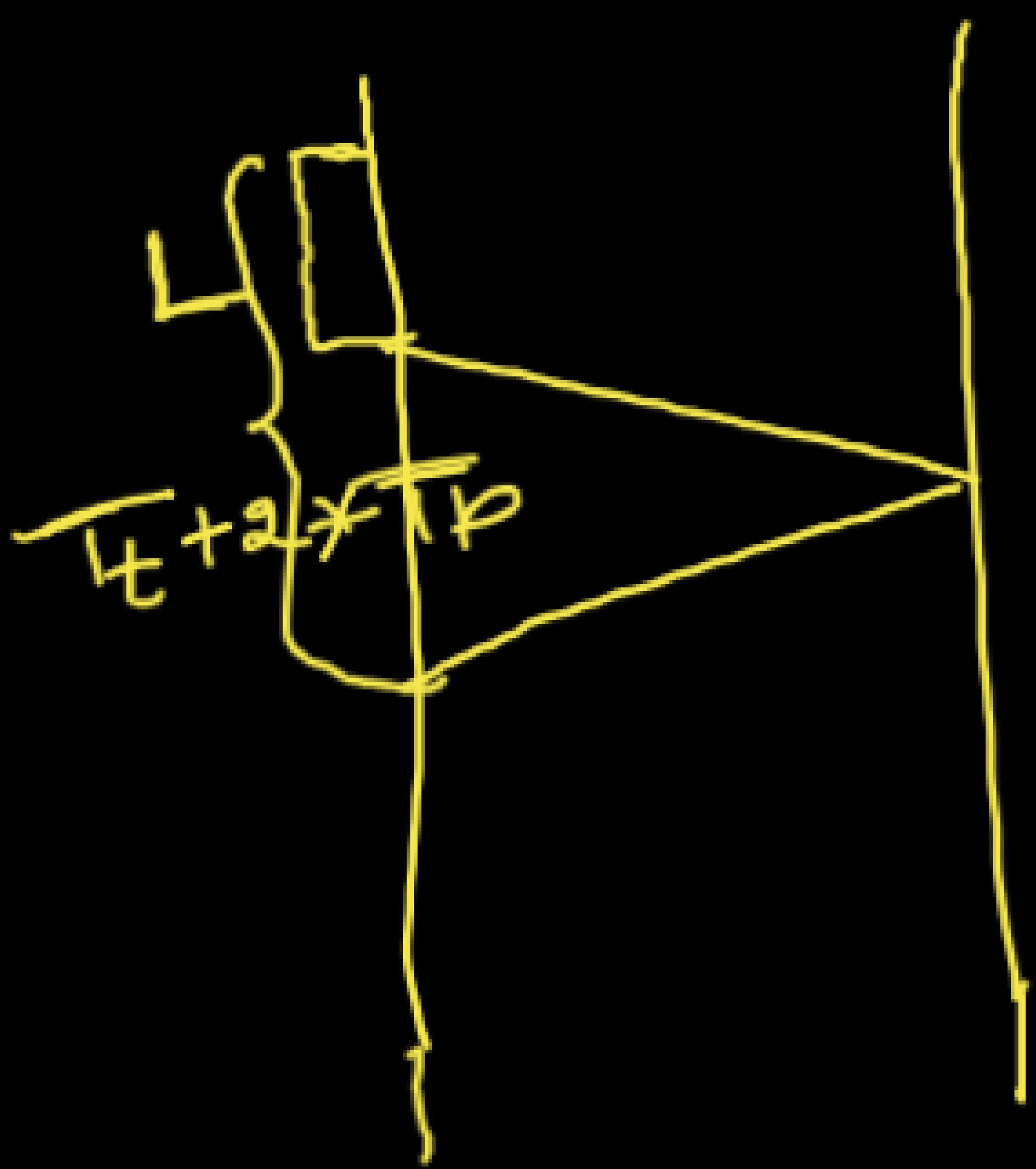


$$\eta = \frac{\text{useful time}}{\text{Total time}}$$

$$\eta = \frac{\cancel{T_t}/T_t}{\frac{T_t + 2*T_p}{T_t}}$$

$$= \frac{1}{1 + 2*\frac{T_p}{T_t}} \qquad \frac{T_p}{T_t} \rightarrow a$$

$$= \frac{1}{1+2a}$$



Throughput $= \frac{\text{bits}}{\text{sec}}$

$(T_t + 2*T_p)$ sec — $\boxed{L \text{ bits}}$

1 sec → ?

$$= \frac{(L/B)\, B}{T_t + 2*T_p} \quad B \to \text{BW}$$

$$= \frac{T_t\, B}{T_t + 2*T_p}$$

$\boxed{a = T_p / T_t}$

$$= \frac{B}{1+2a} = \left(\frac{1}{1+2a}\right) B$$

$$= \eta B$$

Throughput

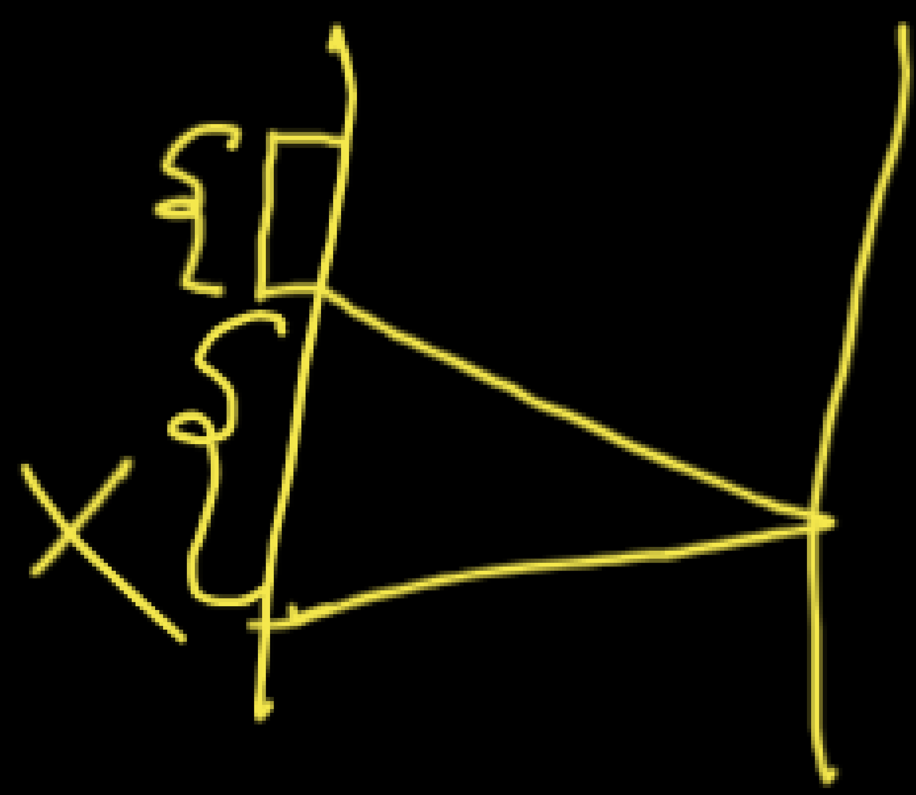
&

effective BW

&

Bandwidth utilization

$$= \eta * B$$



5 min Break

8:07

SRW

$T_t + 2 \times T_p$

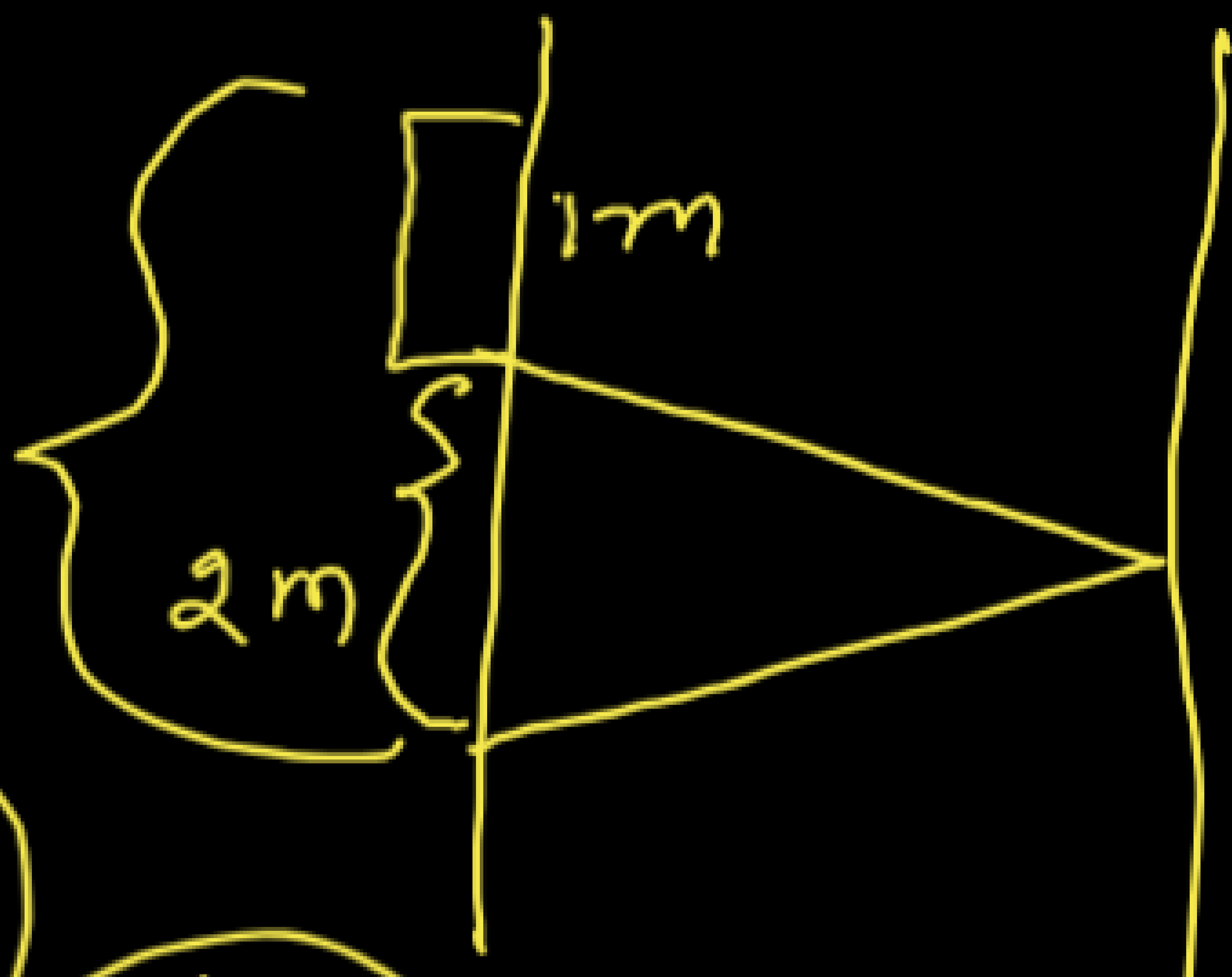
$$\eta = \frac{1}{1+2a}$$

$$EBW = \eta \times BW$$

$T_t = 1\,ms$, $T_p = 1\,ms$

$\eta = ?$ $\quad a = \frac{T_p}{T_t} = \frac{1}{1} = 1$

$\eta = \frac{1}{1+2a} = \frac{1}{3}$



3m → 3 pack

1 packet

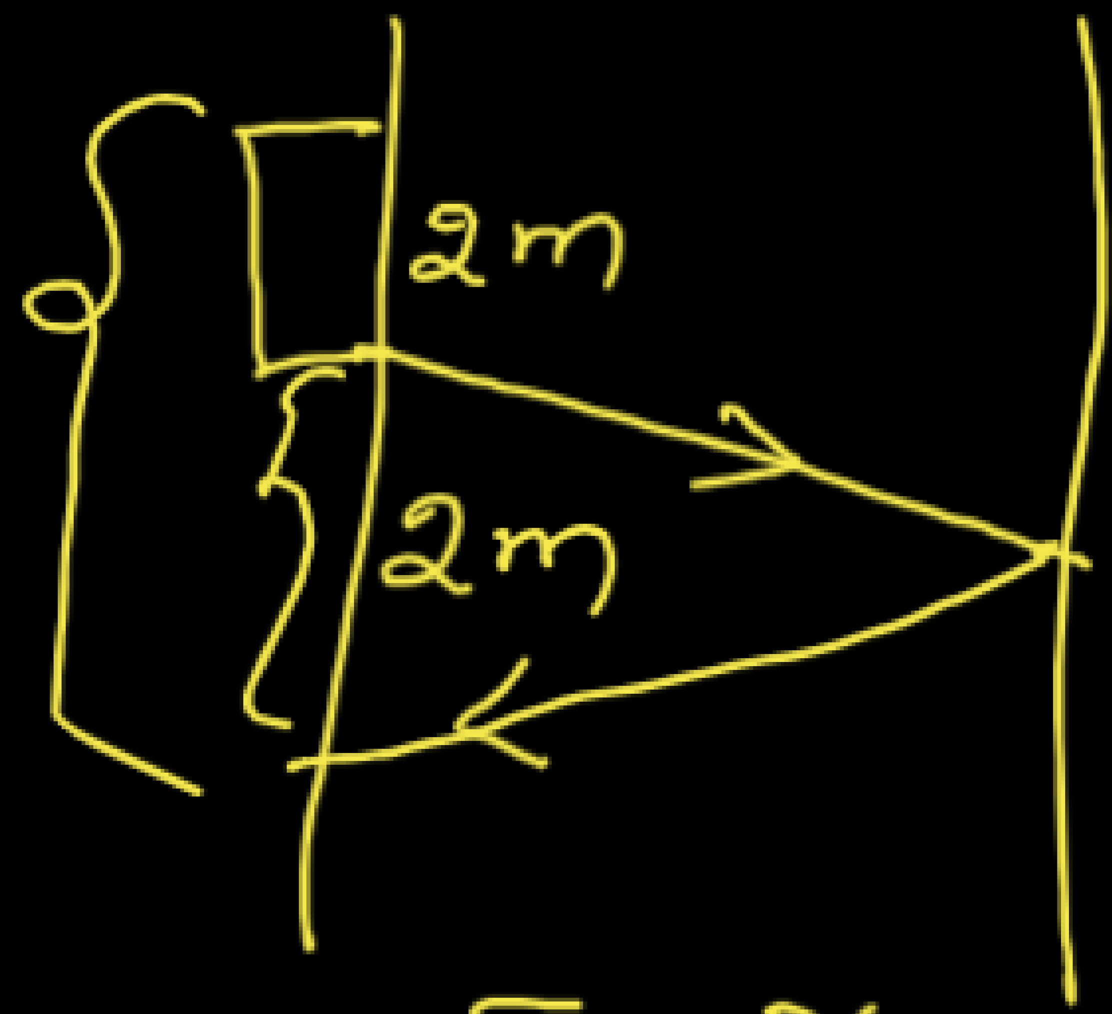
$\frac{1\,ms}{3\,ms}$

$1/3$ $\quad$ 33.33%

$T_t = 2\,ms \quad T_p = 1\,ms \rightarrow \eta = ?$

$$a = T_p/T_t = 1/2$$

$$\eta = \frac{1}{1+2\times 1/2} = 1/2$$



2 packets

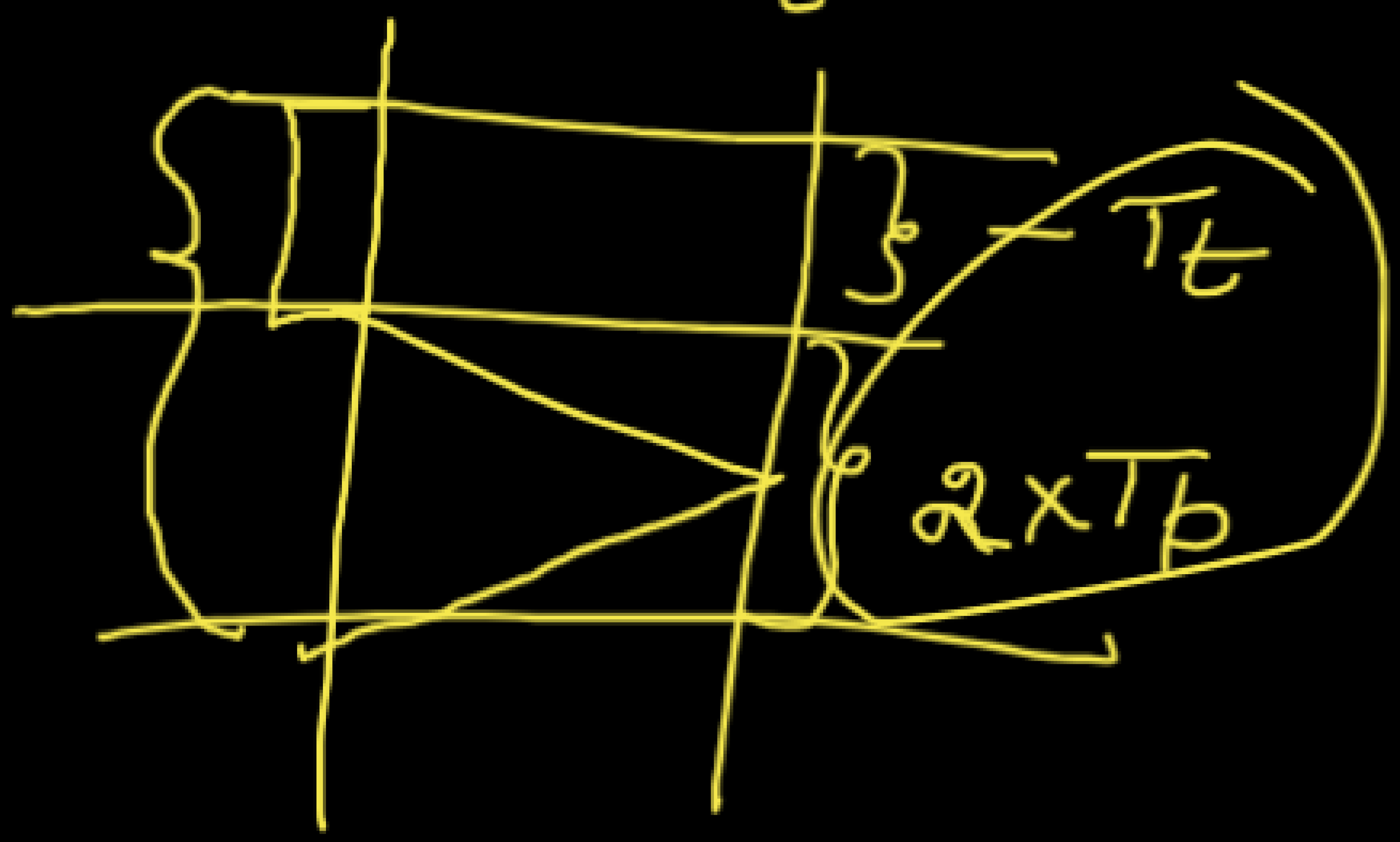
1 packet

$$\frac{2}{4} = 50\%.$$

what is rel b/w T_p and T_t for $\eta = 50\%$

$$\eta = \frac{1}{1 + 2 * \frac{T_p}{T_t}} \Rightarrow 0.5 = \frac{1}{1 + 2 * \frac{T_p}{T_t}}$$

$$\frac{T_p}{T_t} = \frac{1}{2} \Rightarrow T_t = 2 * T_p .$$



$$T_t = 2 * T_p$$

$$T_t \geq 2 * T_p$$

atleast 50%

what is length of the packet for atleast 50% efficiency

$$T_t \geq 2 * T_p \Rightarrow \frac{L}{B} \geq 2 * T_p$$

$$\Rightarrow \boxed{L \geq 2 * T_p * B}$$

60% $\eta = 0.6 \Rightarrow$

70% $\eta = 0.7 \Rightarrow$

$T_p \longleftrightarrow T_t$

$L = ?$ T_p, β

$B = 4\ Mbps$, $T_p = 1\ ms$, $L = ?$ $\eta \geq 50\%$

$L \geq 2 * T_p * B$

$2 * 10^{-3} * 4 \times 10^{6} = 8000$ bits

Bytes

$\rightarrow 1000\ B$

$\neq 1KB$.

$\downarrow$

1024

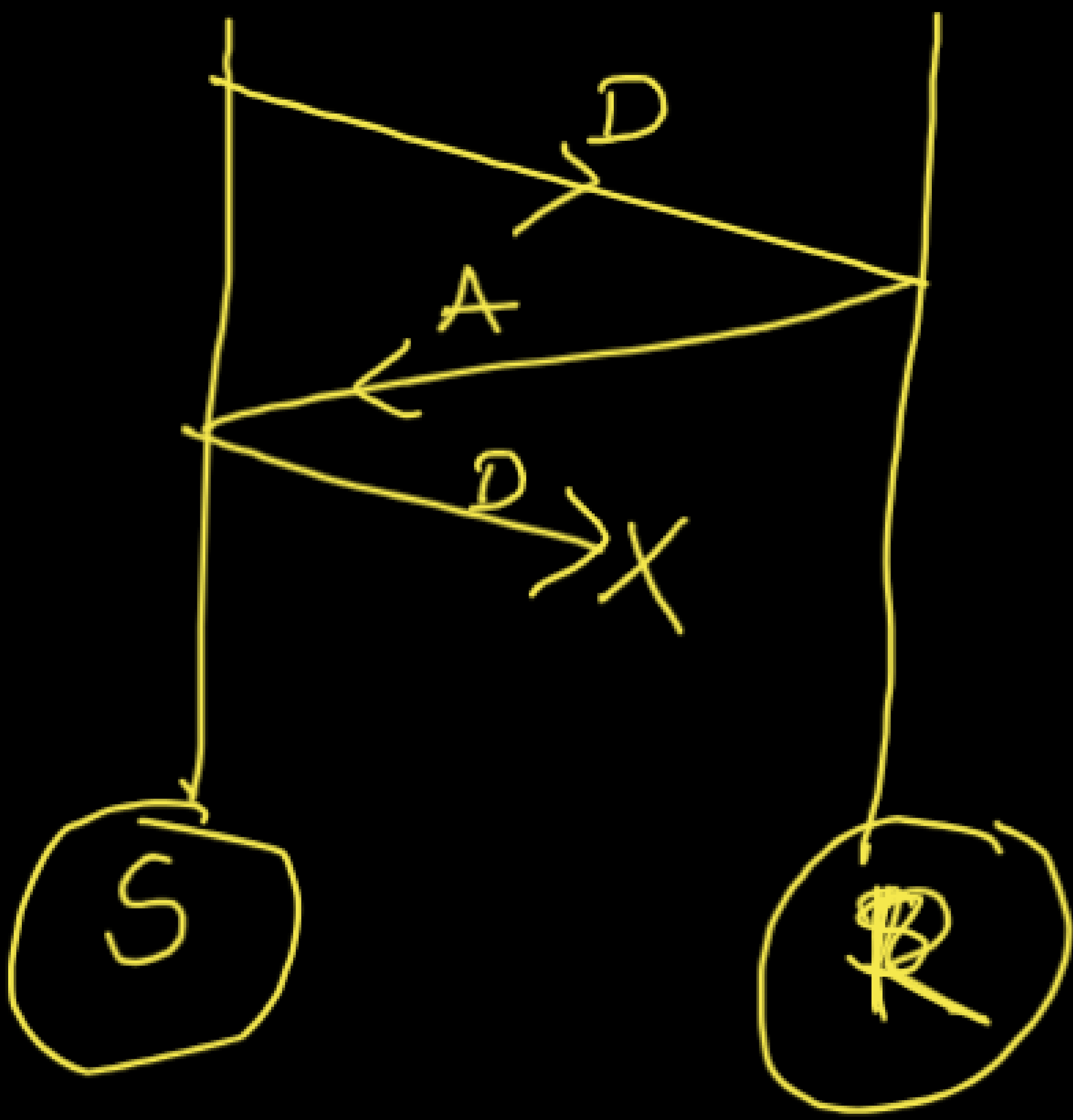
$$\eta = \frac{1}{1 + 2\frac{T_p}{T_t}} = \frac{1}{1 + 2 * \frac{d}{V} \times \frac{B}{L}}$$

$d\uparrow \quad \eta\downarrow \rightarrow$ S&W $\times$ WAN

$L\uparrow \quad \eta\uparrow \rightarrow$ (Bursty data
S&W ✓)

small packets
S&W $\times$

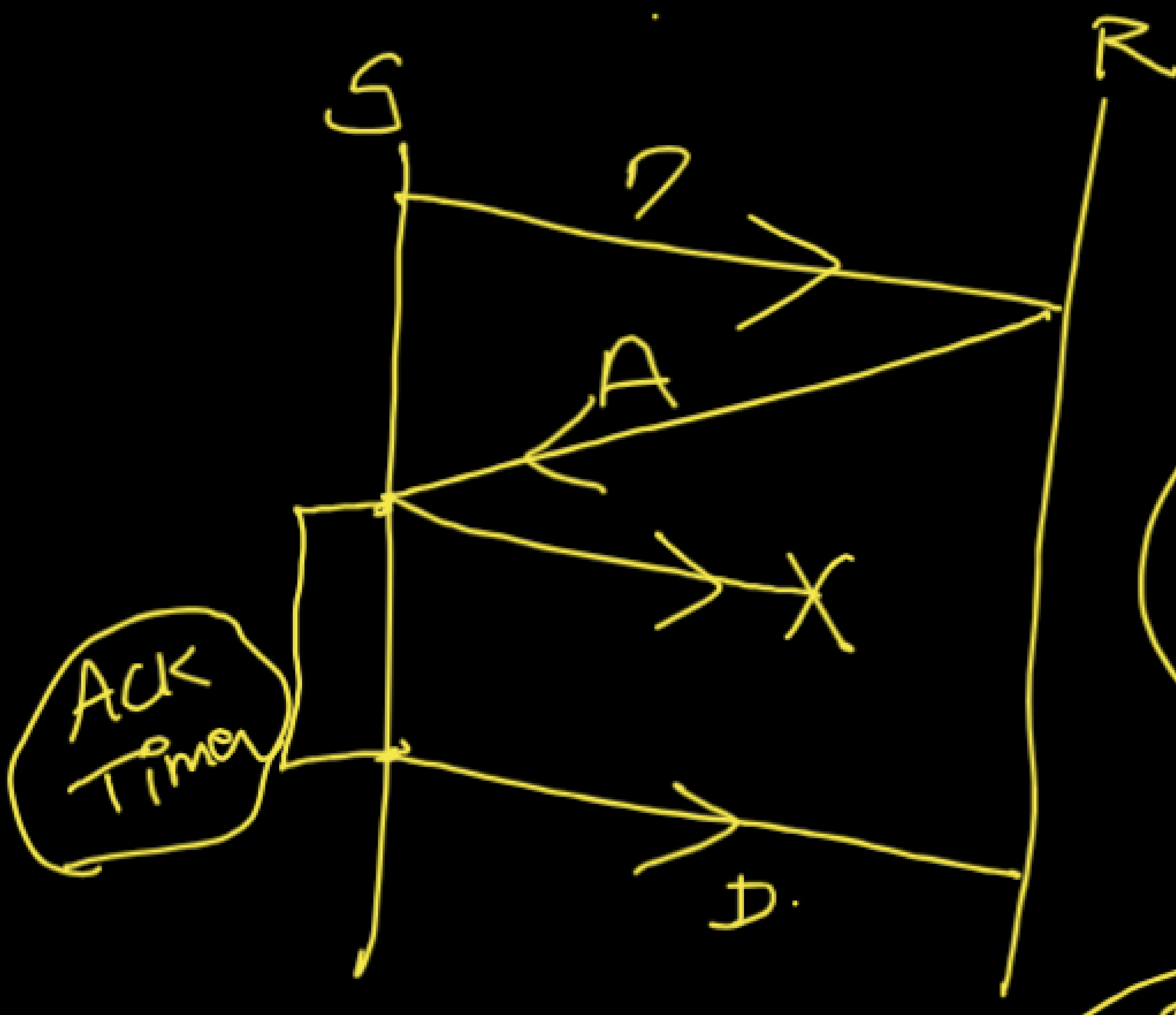
Problem in stop and wait :



R → no packet.

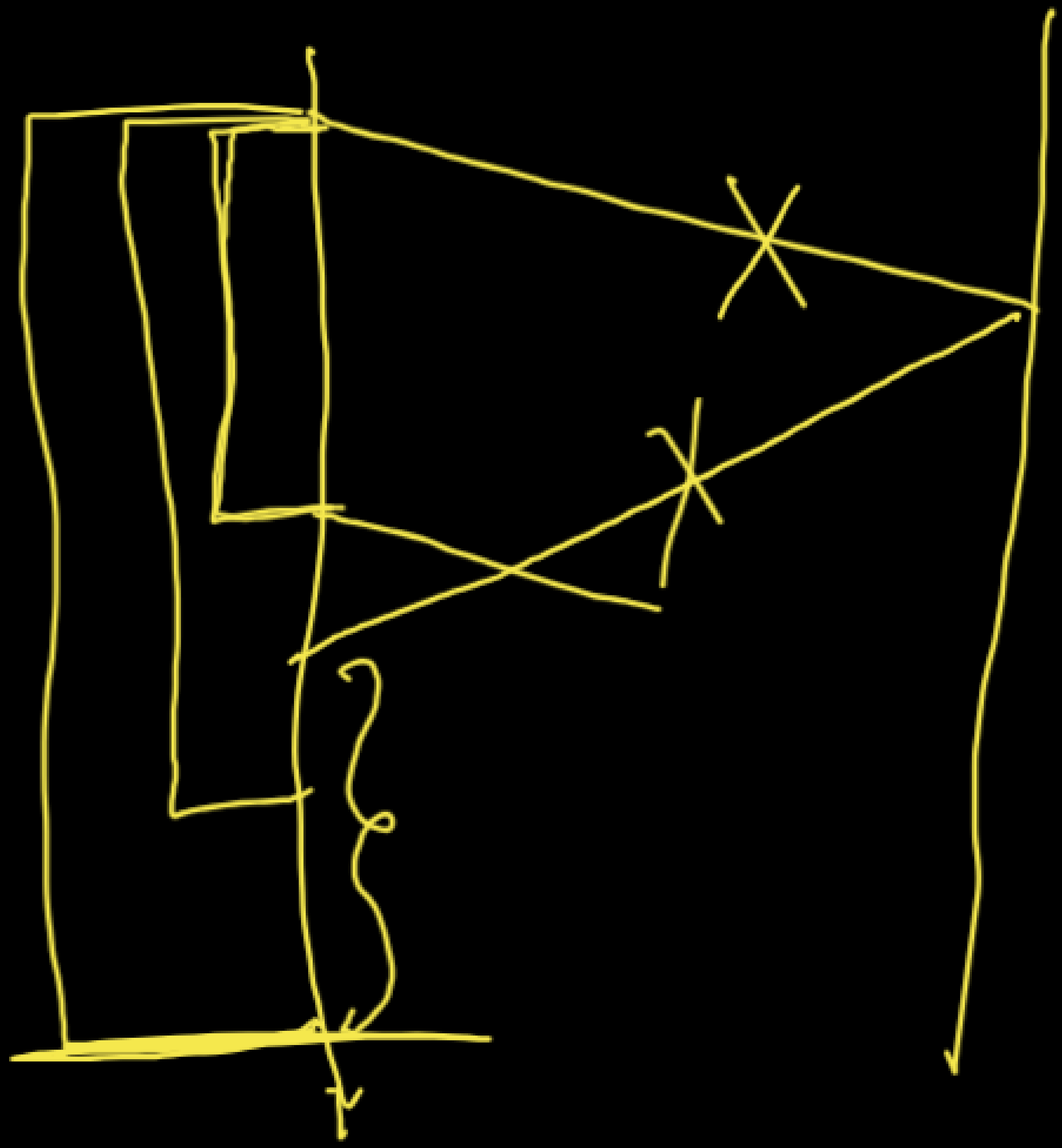
S → ack is on the way

Deadlock



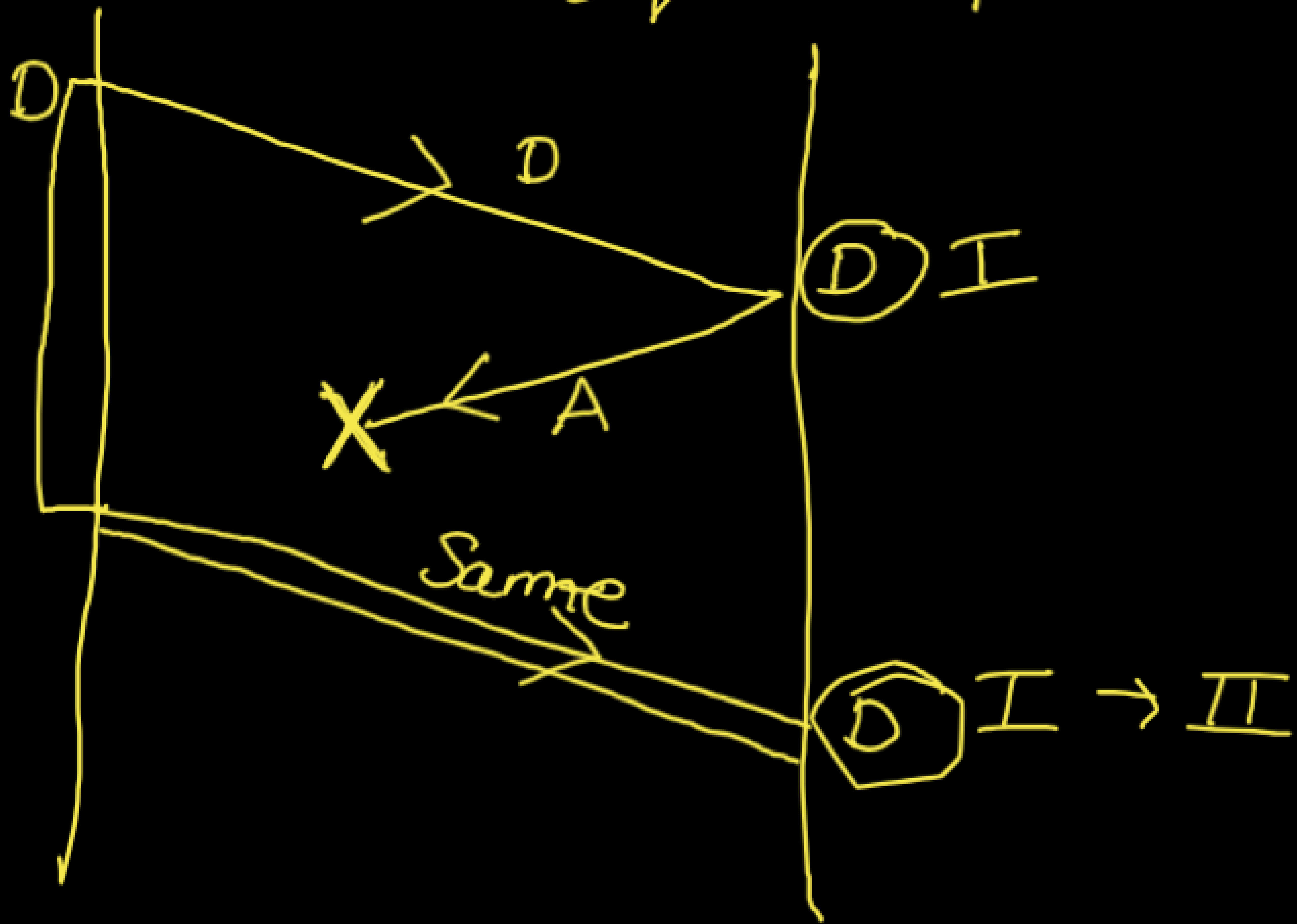
S&W + Ack timer

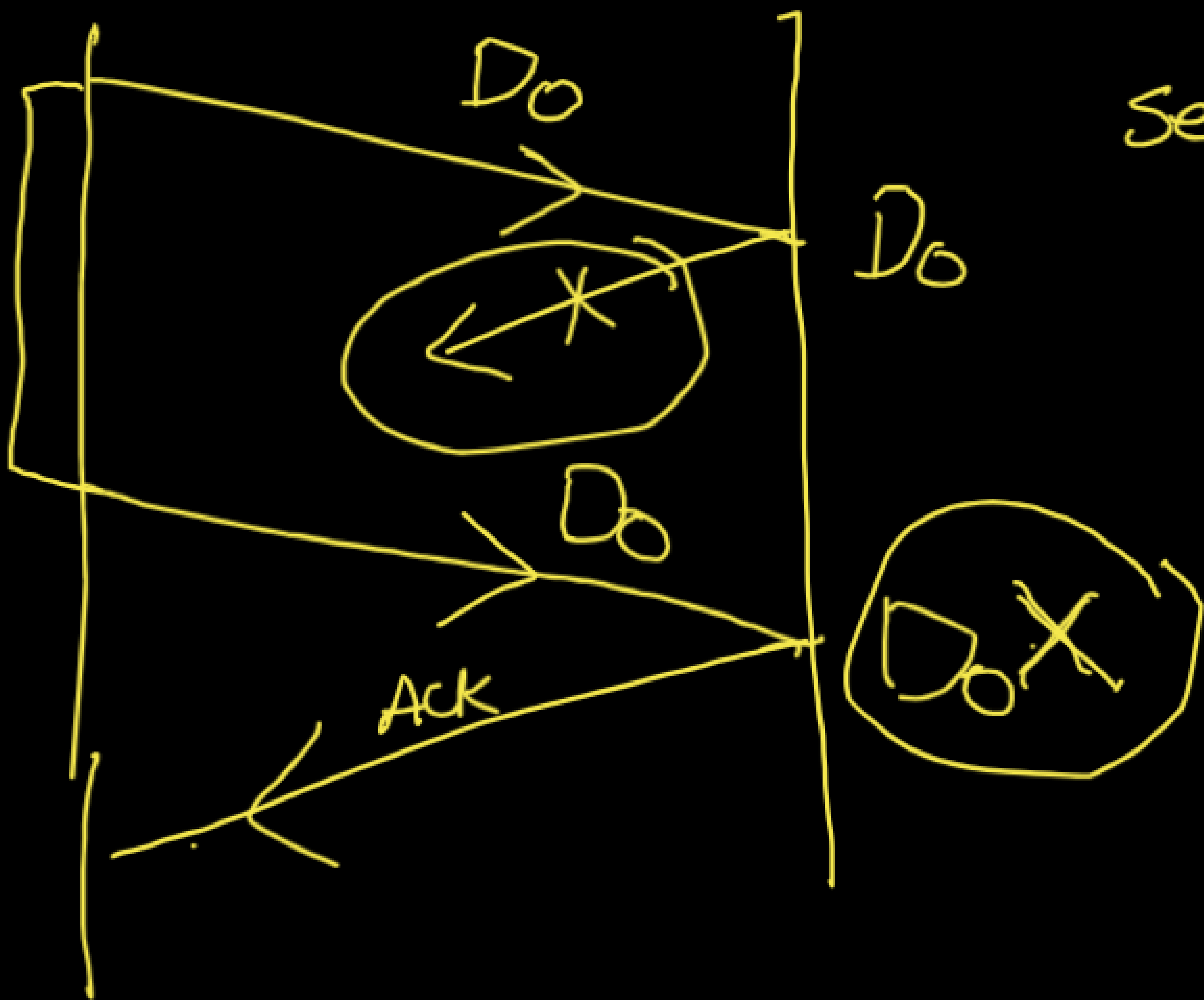
S&W ARQ.



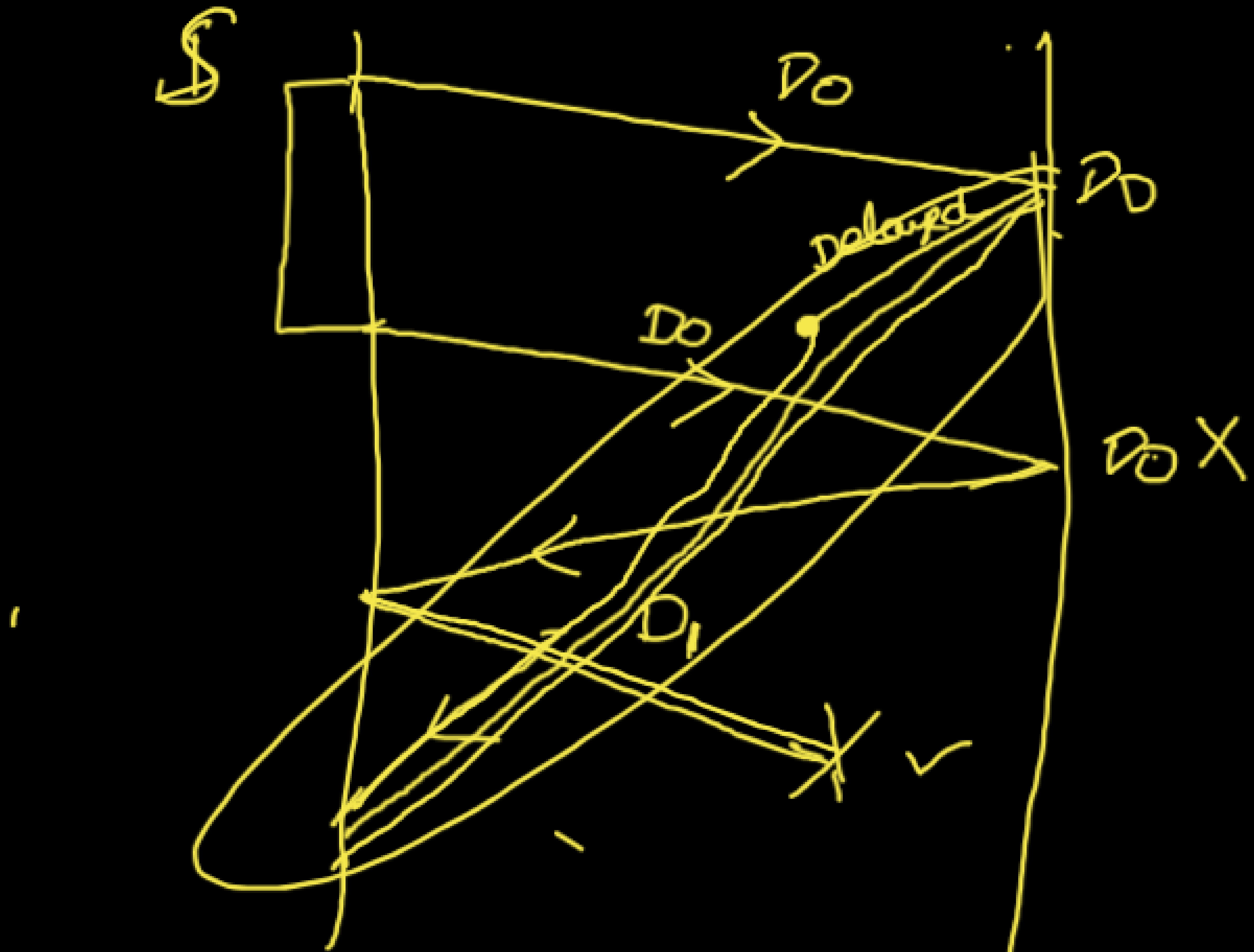
too small & too long.

Duplicate packet



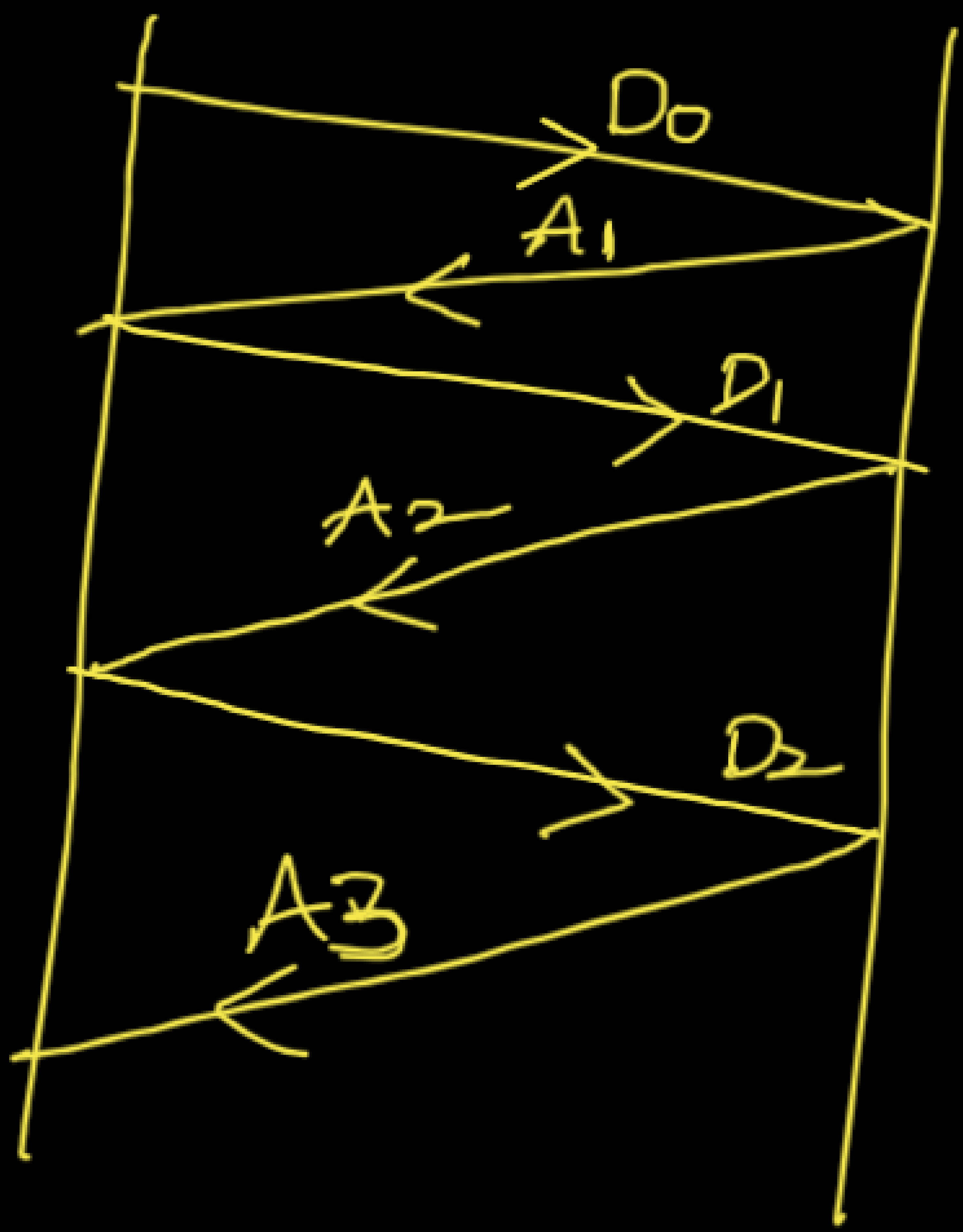


Seq num
for data



Seq numbers to ack also

D_1 – missing packet



+1

Stop and wait

+

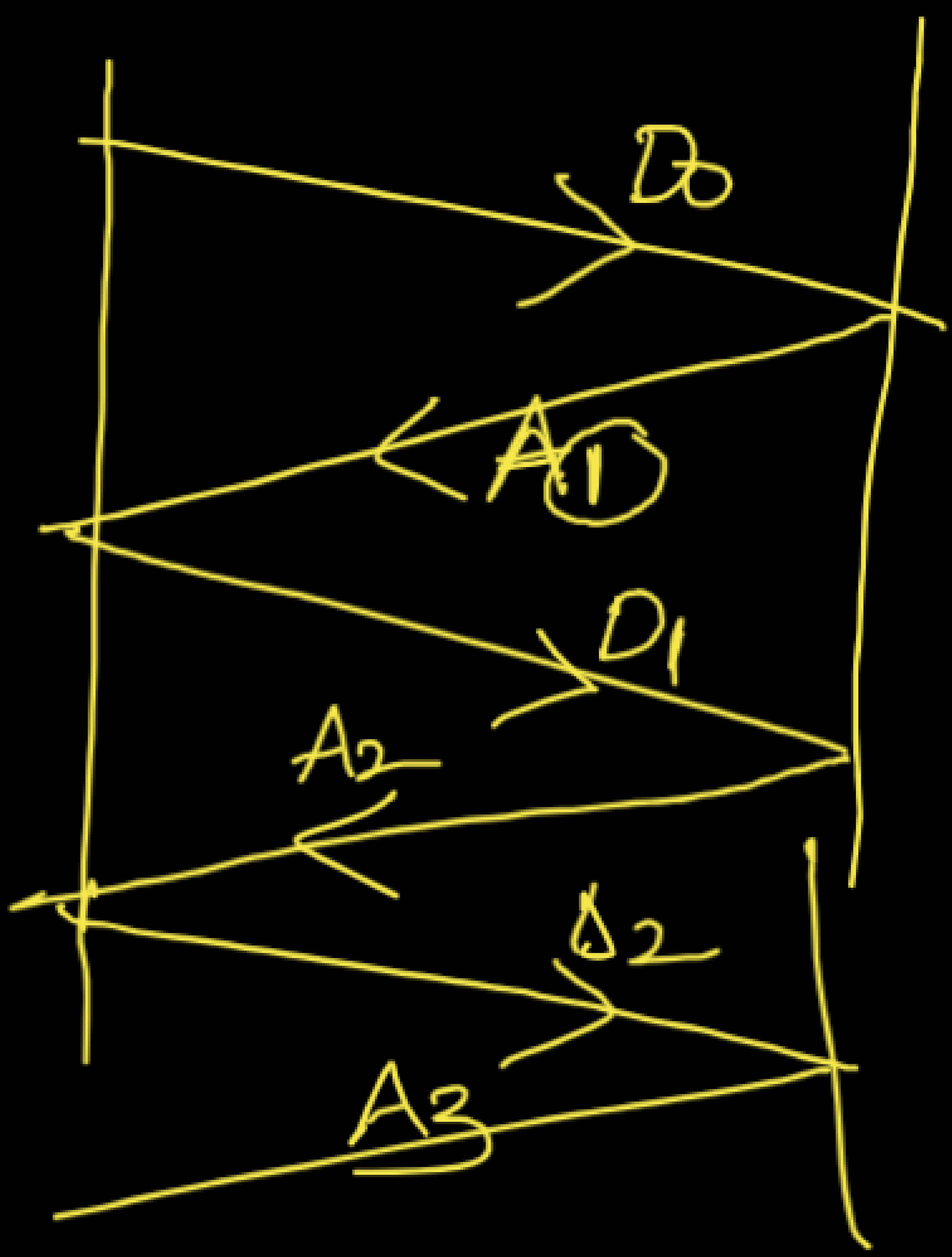
Timer

+

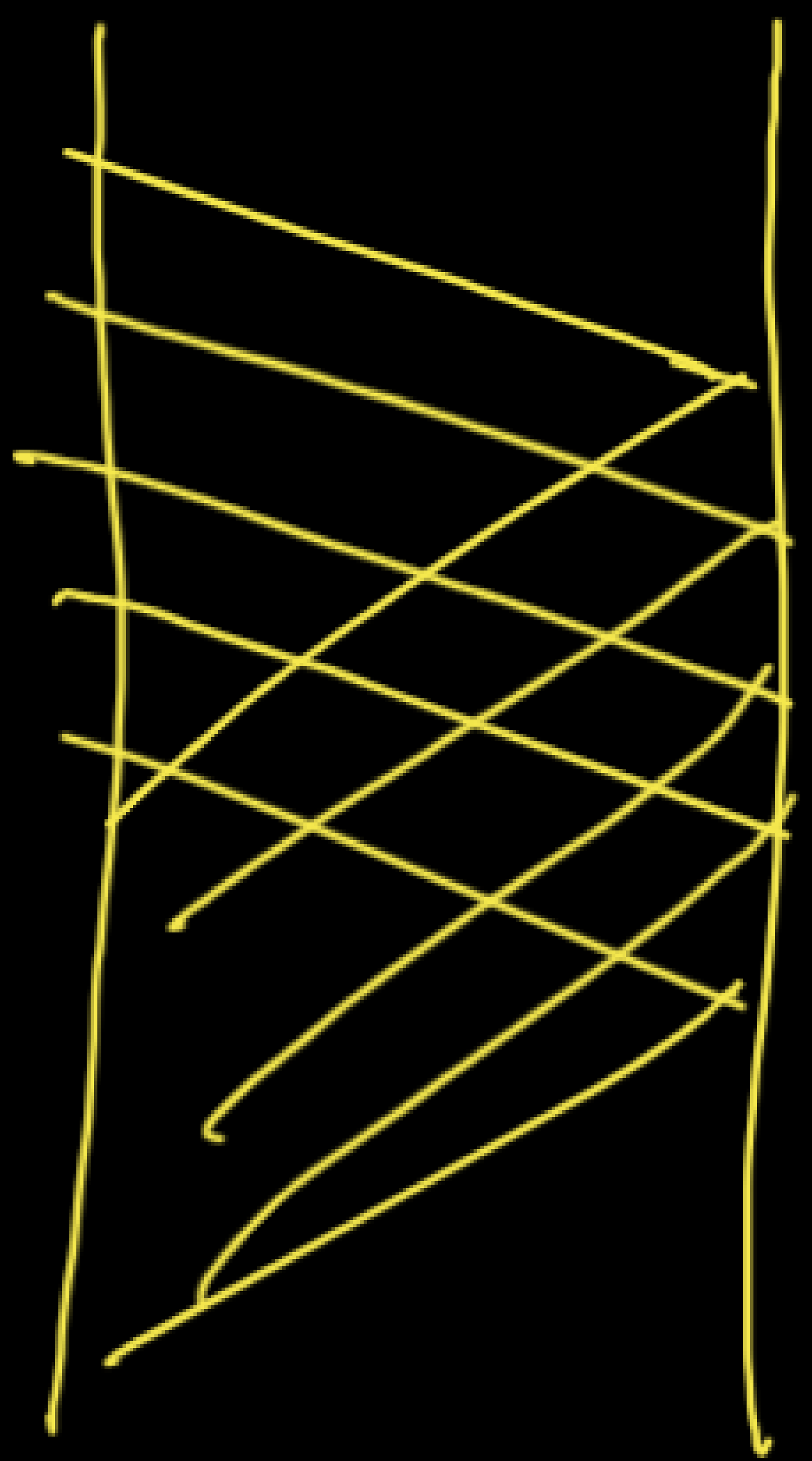
Seq Data

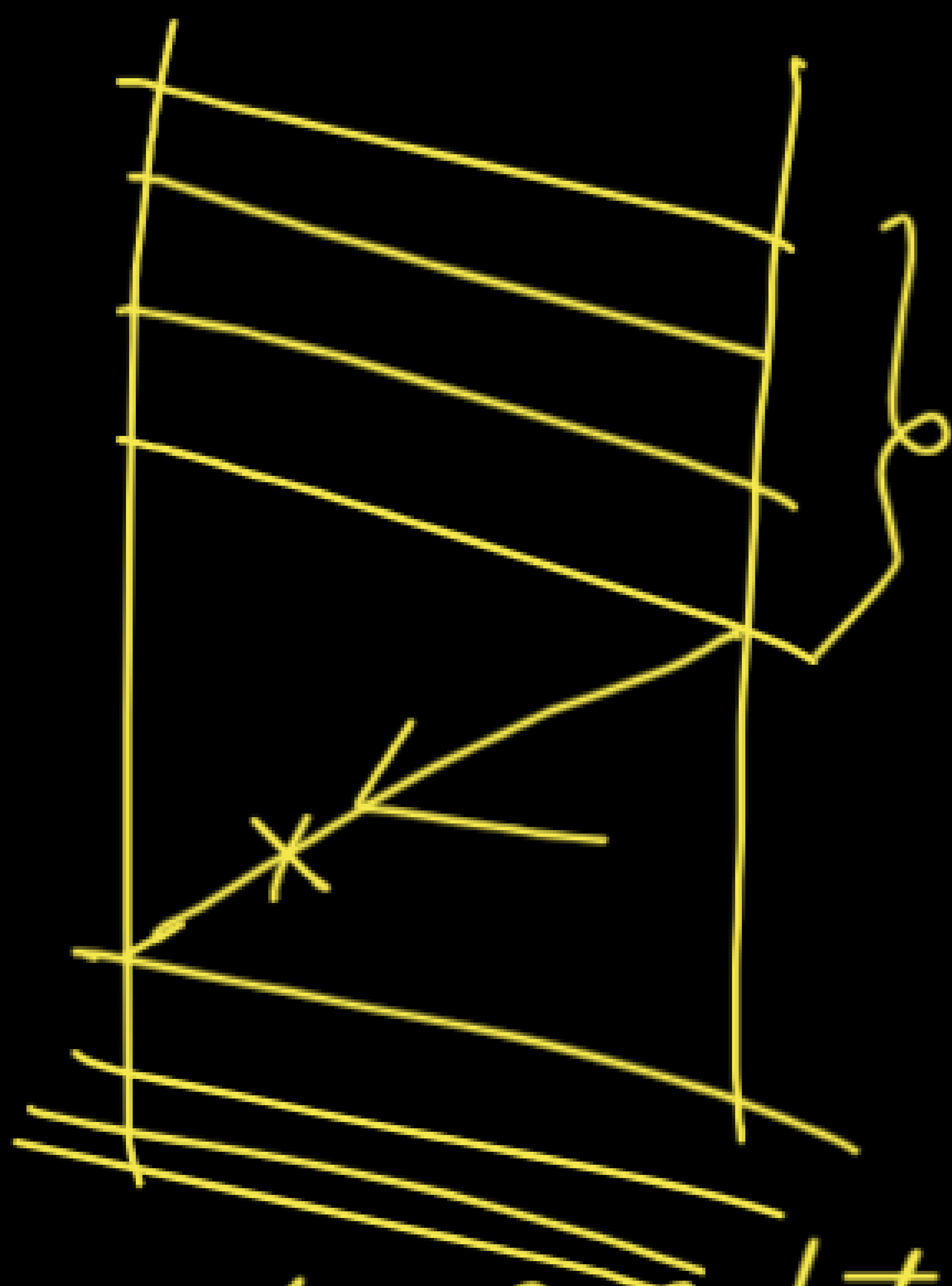
+

Seq ACK


D0
A1
D1
A2
D2
A3

$R\uparrow$ $T\uparrow$ $R\downarrow$ $T\downarrow$





Independent

cummulative.

S and w 10 packets are sent $S \rightarrow R$, every 4^{th} packet is lost. How many packets are transmitted in total?

1 2 3 4 4 5 6 7 7 8 9 10 10

13

S → R 400 packets, but channel has error prob 0.2, then total transmissions

$$400 + \underline{(400)(0.2)} + \underline{(400)(0.2)(0.2)}$$

$$\frac{400}{1-0.2} = \frac{400}{0.8} \qquad (0.2)$$

$$= \underline{\underline{500}} \quad \ldots$$

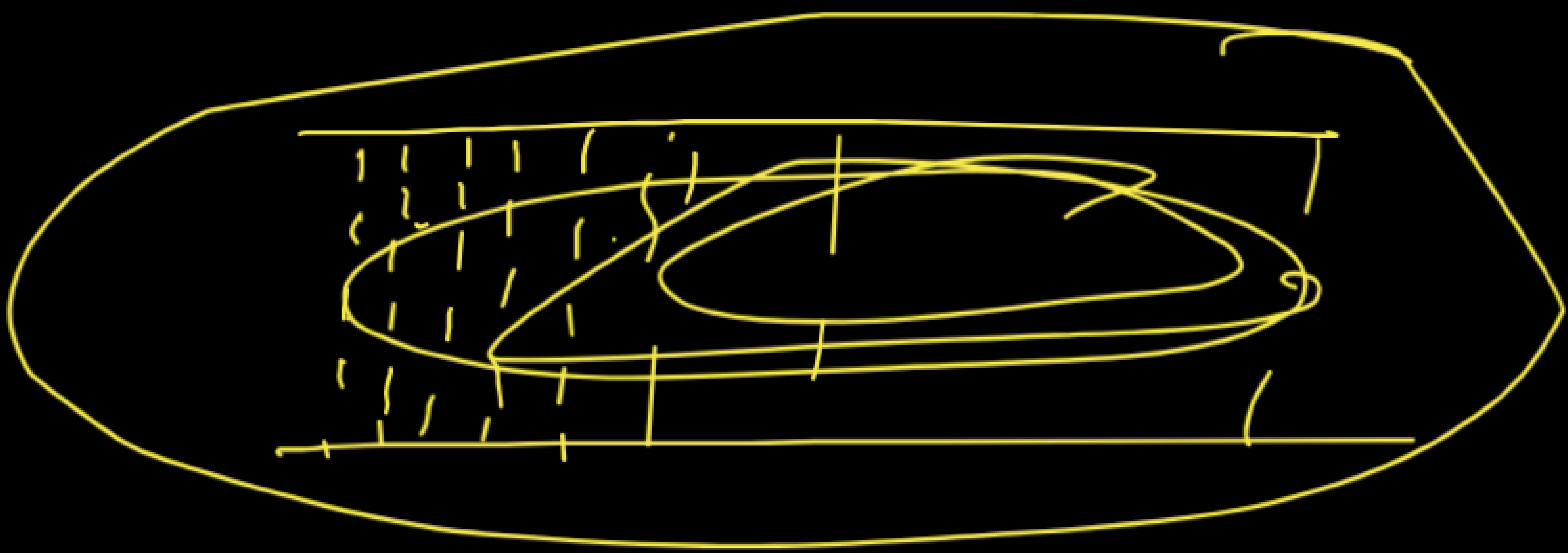
$\underline{\underline{n}} \rightarrow \quad \underline{\underline{p}} \rightarrow$

$n + np + np \cdot p + nppp + \cdots\cdots$

$n(1 + p + p^2 + p^3 + \cdots\cdots)$

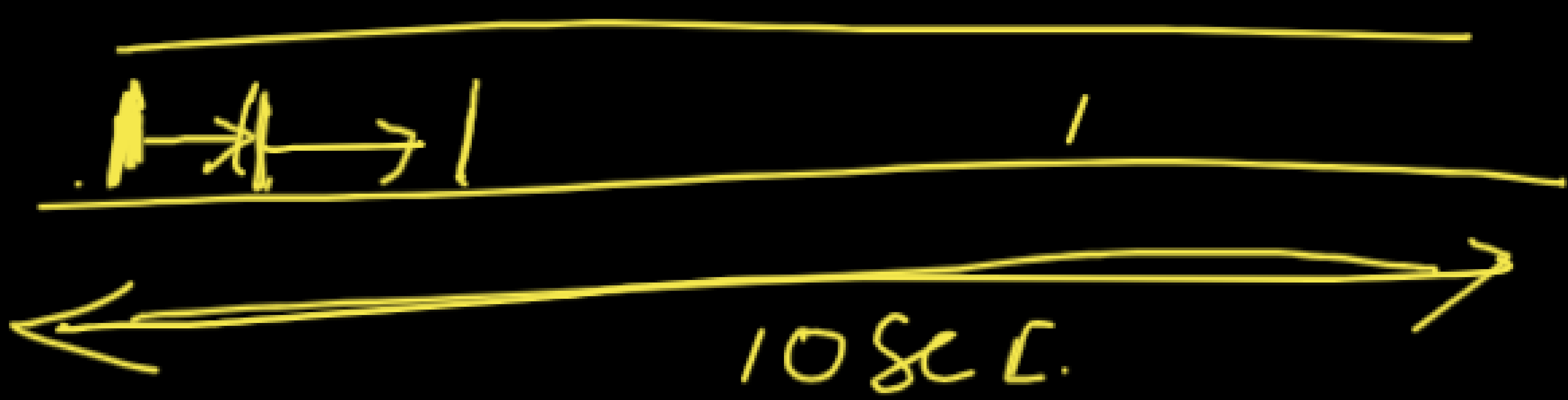
$n\left(\frac{1}{1-p}\right)$

capacity of a channel:



Capacity

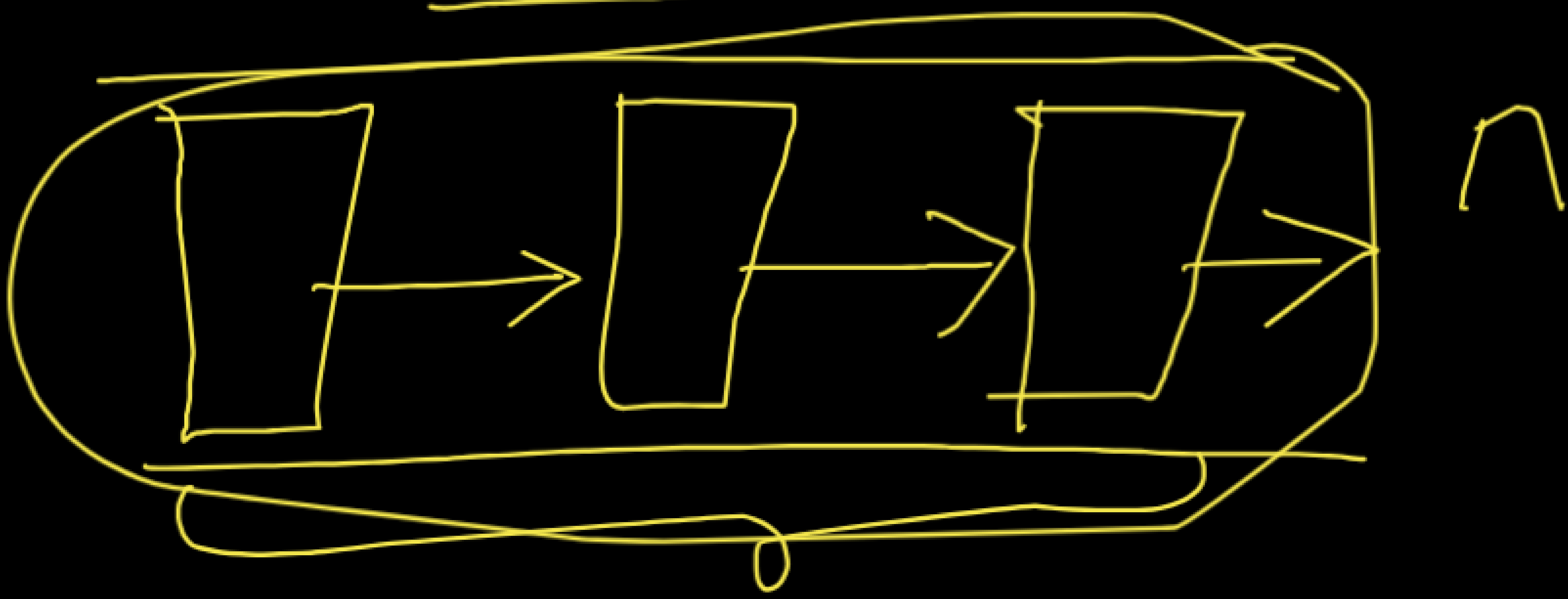
$B = 1$ bps



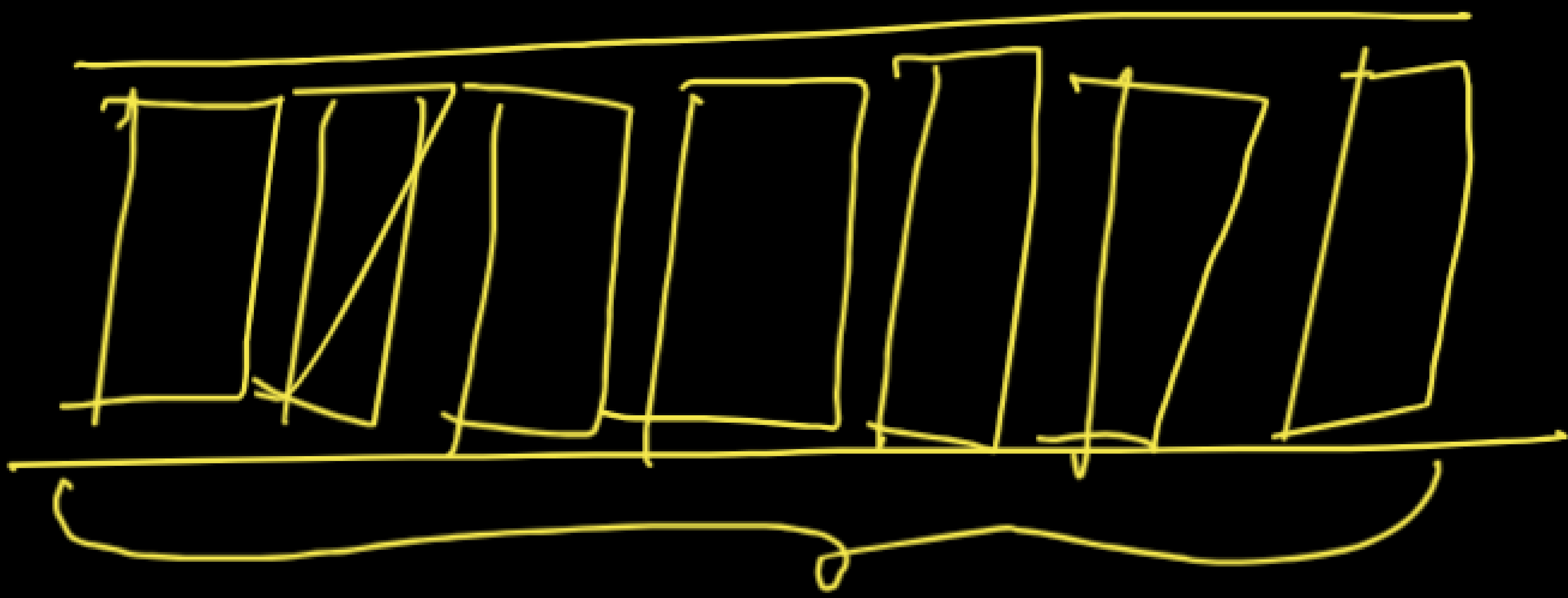
$1 \times 10 = 10$ bits

Capacity = $BW * T_p$

S&W



1 packet.



Pipelining → sliding window protocol