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# PROBLEM 2

DOWN_LINK = 10 Mbps = 1250 000 B

UP_LINK = 1 Mbps

PACKET_SIZE = 1500 B

ACK_SIZE = 60 B

RTT = 200 ms = 0,2 s

1) If 100% of download link capacity is used, the size of the TCP WINDOW would be:

$$W = \text{DOWN\_LINK} \cdot \text{RTT} = 1250000 \cdot 0{,}2 = 250000 \text{ B}$$

- To store W, 18 bits are needed, but the TCP HEADER's field for the window size is 16 bits only; so the only way to store it is by putting a multiplicator in the OPTION FIELD, and by rescaling W in 16 bits.

2) To receive a packet of PACKET_SIZE = 1500B with a DOWN_LINK = 1,25 MB/s, to send a single Byte we need $\frac{1{,}25}{1500}$, so to send an ACK of ACK_SIZE = 60B it takes $\frac{1{,}25}{1500} \cdot 60 = 0{,}05$ MB/s, so $0{,}05 \cdot 8 = 0{,}4$ Mb/s. So we use 40% of UPLINK.

## 3) - A

After a loss the window if halfed, then is incremented of PACKET_SIZE every RTT. If there is a loss every 5s, then between two consecutive loss the congestion window is incremented by:

$$W = \frac{5s}{RTT} \cdot \text{PACKET\_SIZE} = 25 \cdot 1500 = 37500 \text{ B}$$

// Here W does not refer to the WINDOW SIZE

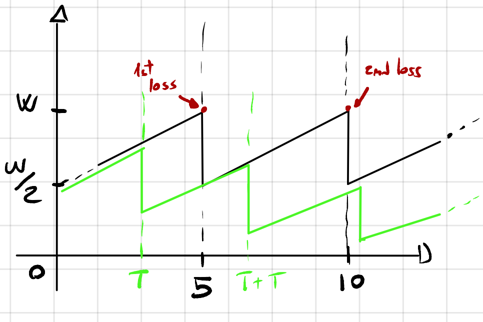
## 3) - B

Considering that the WINDOW W always back to it's original dimension between 2 consecutive fail, the throughput is:

$$X = L/S = \frac{3/8 W^2}{RTT \cdot W/2} \approx 937500 \text{ B/s}$$

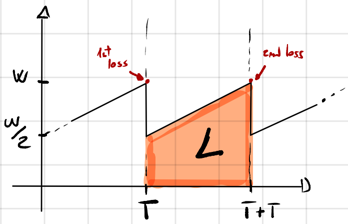
## 4 - A

- To permit W, halfed for a fail, to get back to it's original dimension we need T=5 (BLACK FUNCTION IN THE RIGHT DRAWING)
  If T<5, the window W will decrease after in each fail and the throughput too (GREEN FUNCTION ON THE RIGHT DRAWING)




- To express X in function of we just have to consider the L is the AREA under the function W in the interval between 2 consecutive crashes so:

$$X = \frac{L}{S} = \frac{\int_{T}^{T+T} W \, dT}{S}$$




## 4 - B

- With T>5 Nothing happens until the NETWORK CAPACITY is reached.
- The dimension W of the window must be at most the DOWNLOAD_LINK capacity.

We know that after e failure $W = W/2$ and then is increased of one PACKET_SIZE every RTT, this means that afte each second 7500 B are addet to the window size.

Given T:

$$\frac{W}{2} + 7500T \leq \text{DOWNLAD\_LINK} \Rightarrow$$

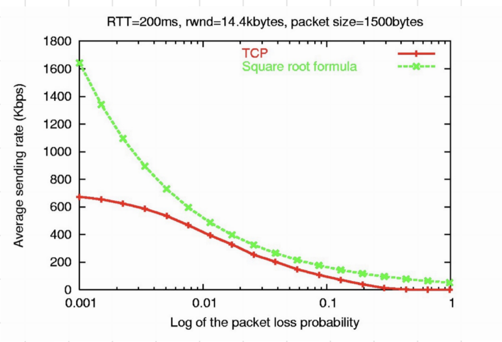
$$\Rightarrow 125000 + 7500 \cdot T \leq 1250000 \Rightarrow$$

$$\Rightarrow T \leq \frac{1250000 - 125000}{7500} = 150$$

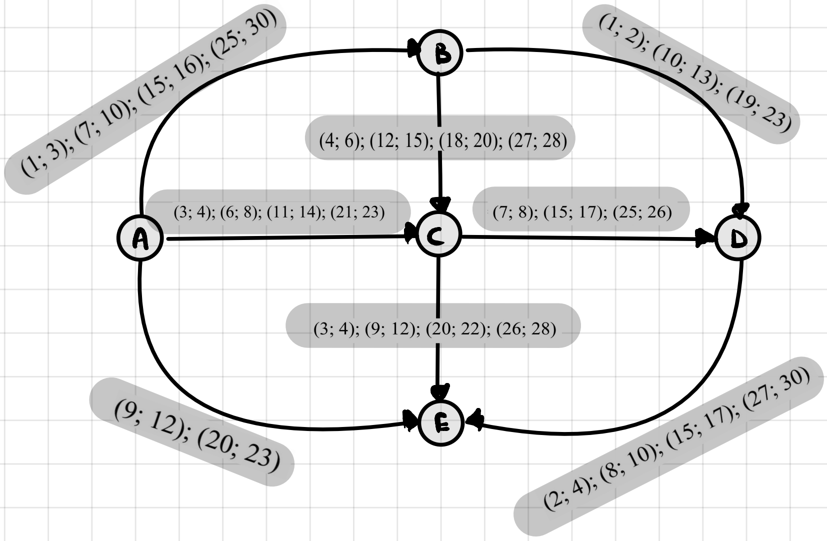
- So for T≥160 W hits the network capacity

## 4 - C

- When $T > T_0 \mid T_0 = 150$ if a new packet is sent, It will be lost for sure, so the probability $p = \mathbb{P}(\text{losing a packet}) = 1$
- The Troughput goes down because time-out becomes too frequent as showed in the slides.

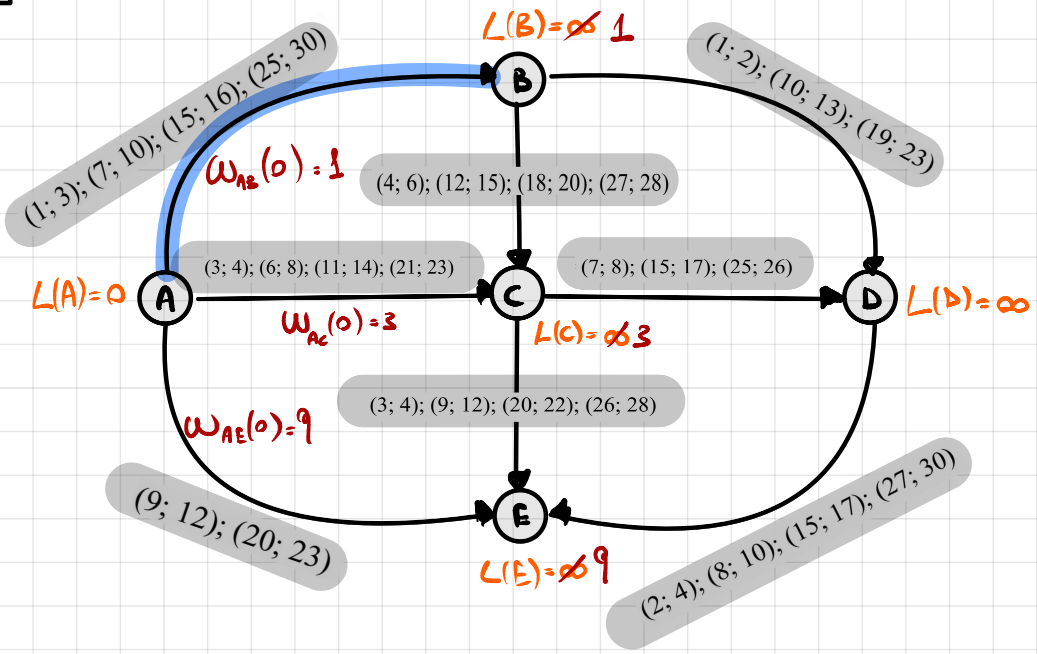


# PROBLEM 1

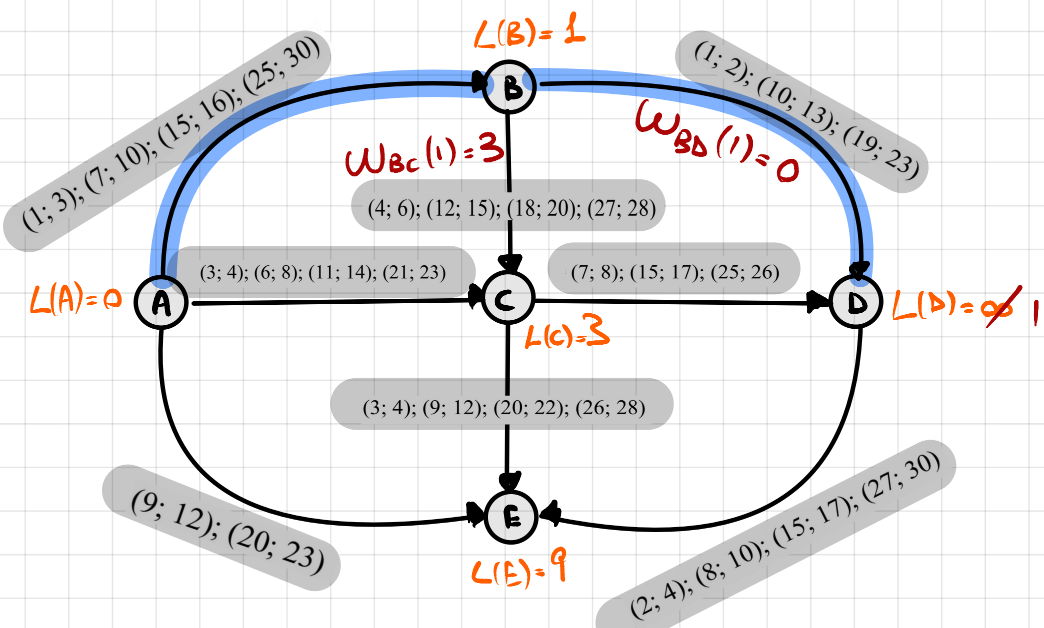



A

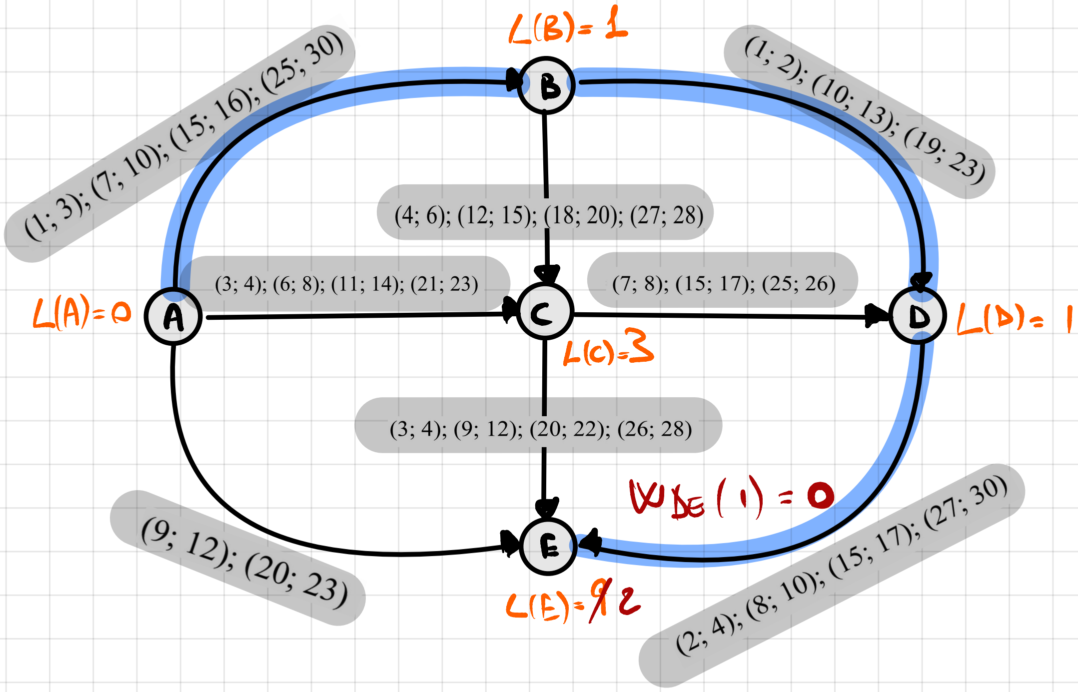
## t=0



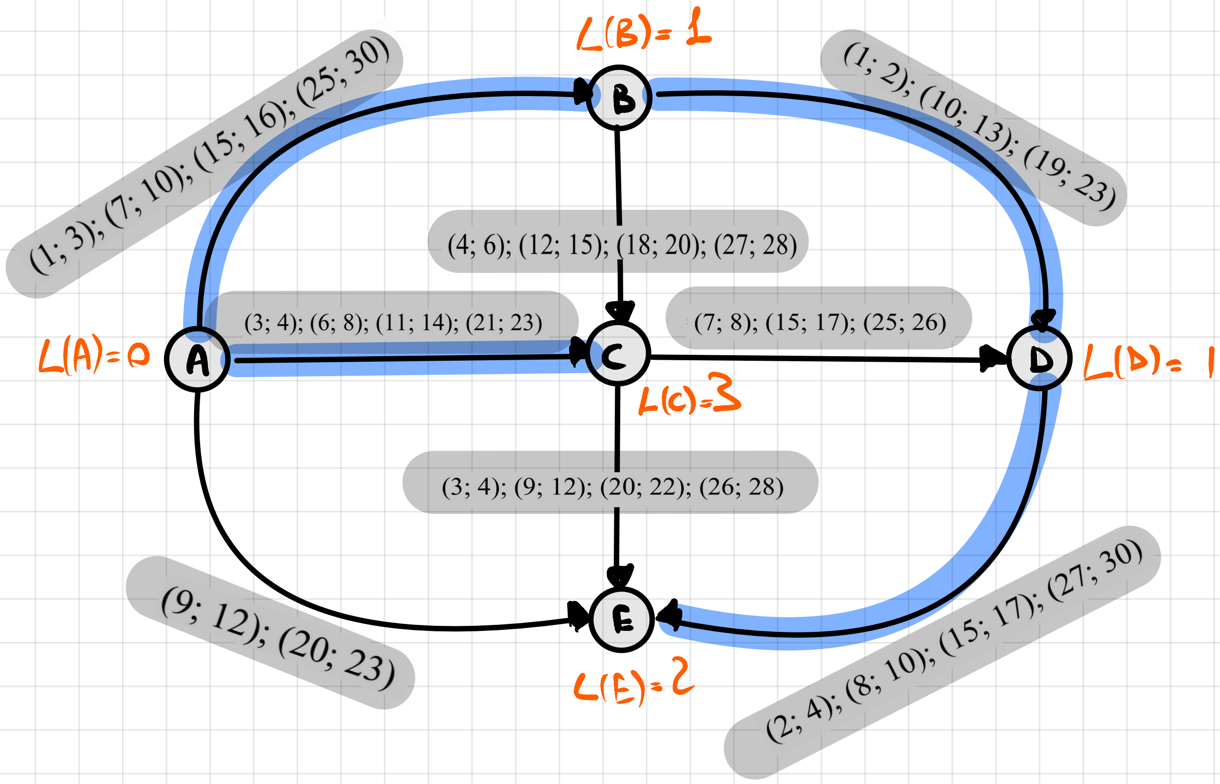

## t=1



## t=2




## • FINAL CONFIGURATION




B The path doesn't hold; If $t=5$ the node A cannot send any message, in our path it must wait $t=7$ to reach B and then $t=10$ to finally reach D. Of course we can use the path $A \to C \to D$ to deliver at $t=7$.