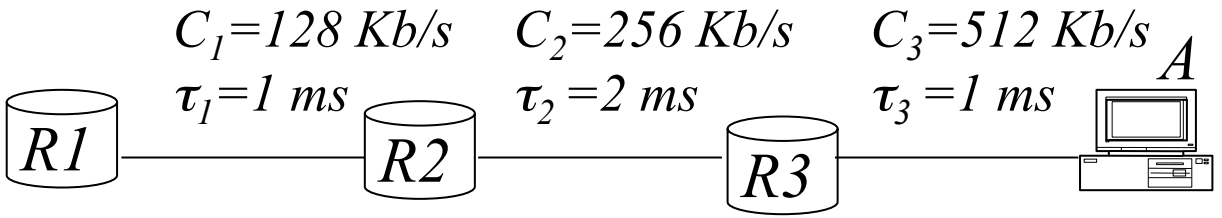
Politecnico di Milano
Scuola di Ingegneria Industriale e dell'Informazione

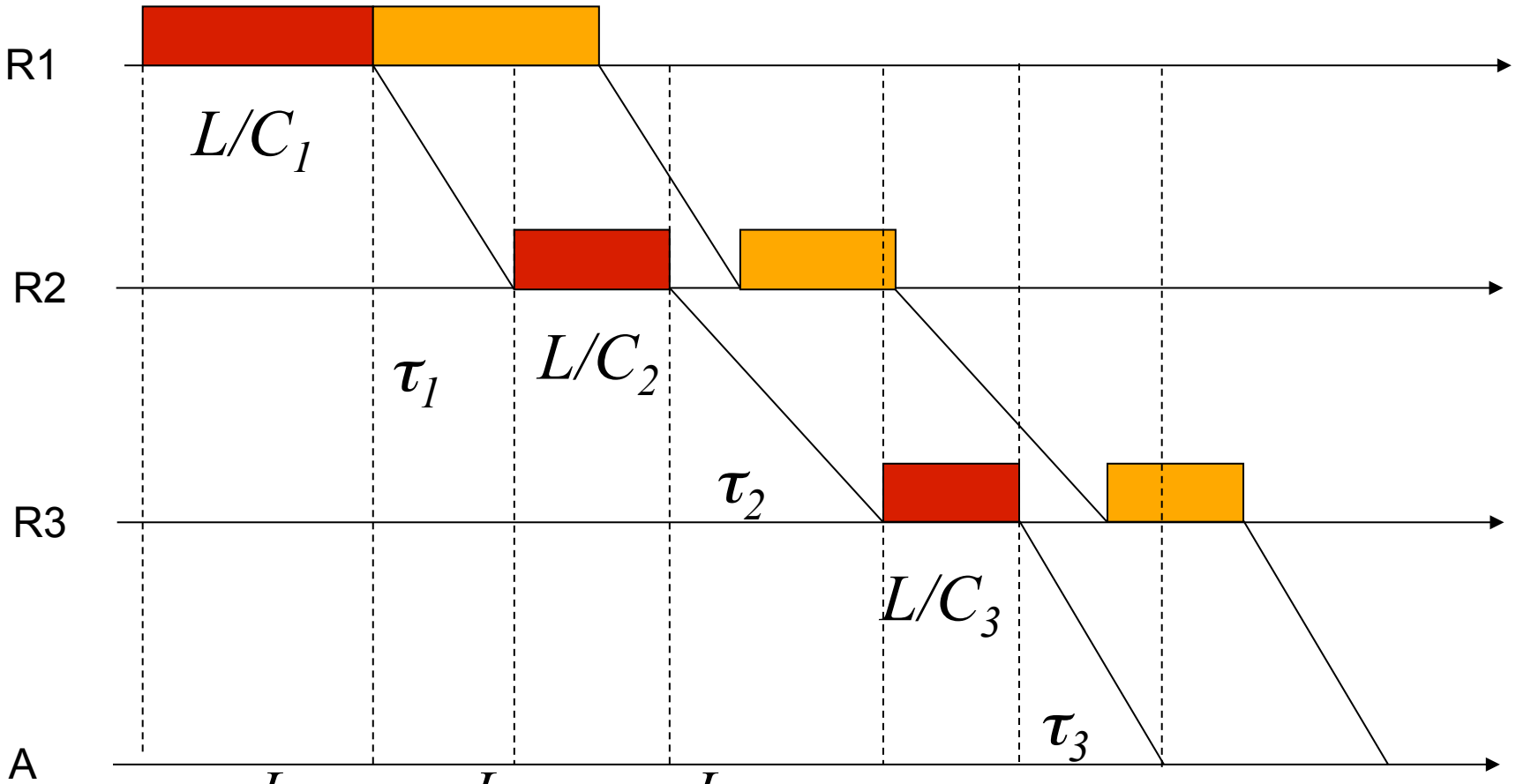
E1
Packet switching

Exercise 1

- Consider the network below. At time t=0 the output queue of R1 has 2 packets to A. Assuming packet length of 512 bits, indicate for each packet the time it is completely received by destination.



Solution 1

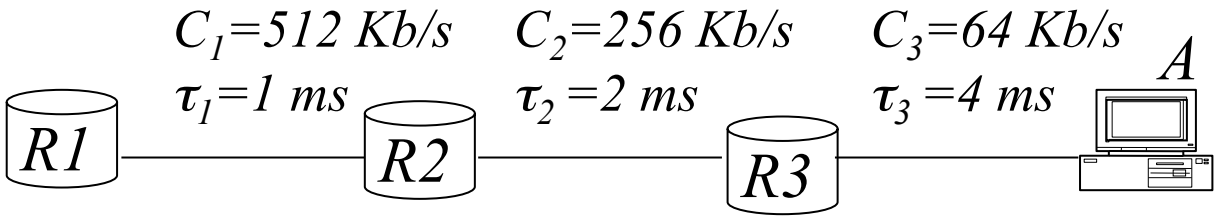


$$T_1 = \frac{L}{C_1} + \tau_1 + \frac{L}{C_2} + \tau_2 + \frac{L}{C_3} + \tau_3 = 4 + 1 + 2 + 2 + 1 + 1 = 11\,\text{ms}$$

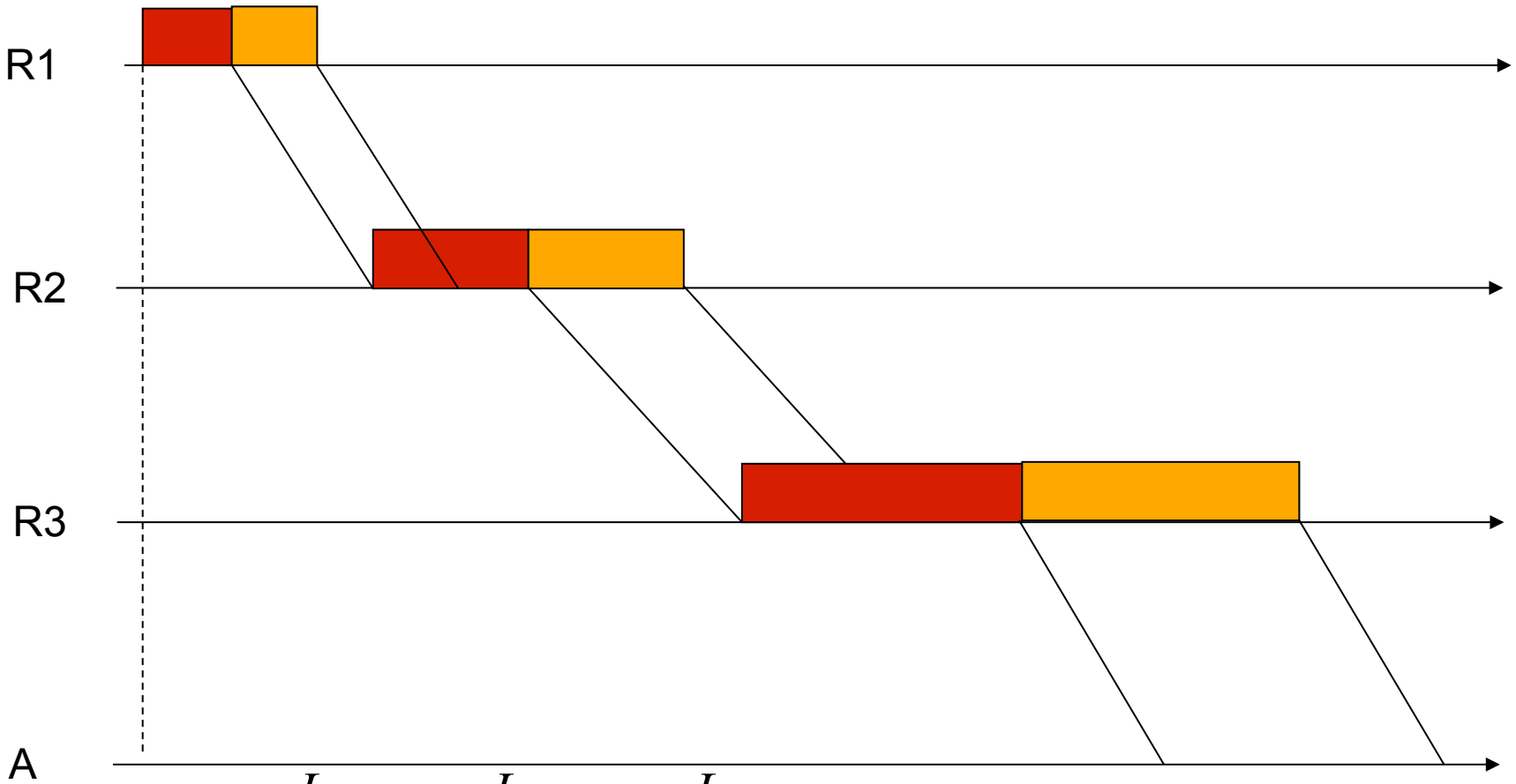
$$T_2 = \frac{2L}{C_1} + \tau_1 + \frac{L}{C_2} + \tau_2 + \frac{L}{C_3} + \tau_3 = 15\,\text{ms}$$

Exercise 2

- Consider the network below. At time t=0 the output queue of R1 has 2 packets to A. Assuming packet length of 512 bits, indicate for each packet the time it is completely received by destination.



Solution 2

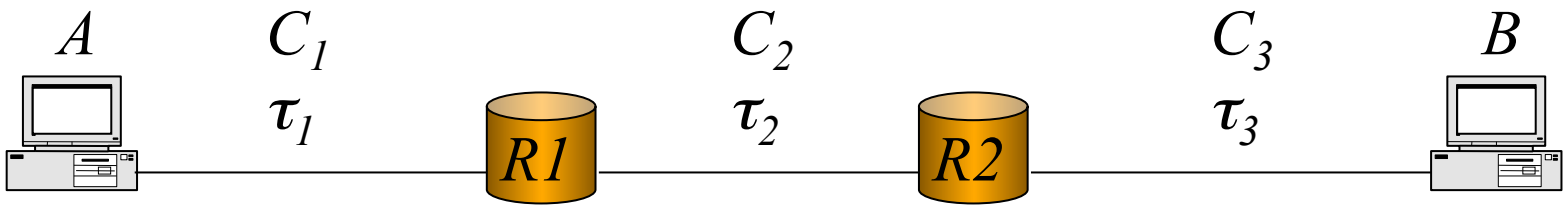


$$T_1 = \frac{L}{C_1} + \tau_1 + \frac{L}{C_2} + \tau_2 + \frac{L}{C_3} + \tau_3 = 4 + 1 + 2 + 2 + 8 + 4 = 21\,\text{ms}$$

$$T_2 = \frac{L}{C_1} + \tau_1 + \frac{L}{C_2} + \tau_2 + \frac{2L}{C_3} + \tau_3 = T_1 + \frac{L}{C_3} = 29\,\text{ms}$$

Exercise 3

- Consider the network below

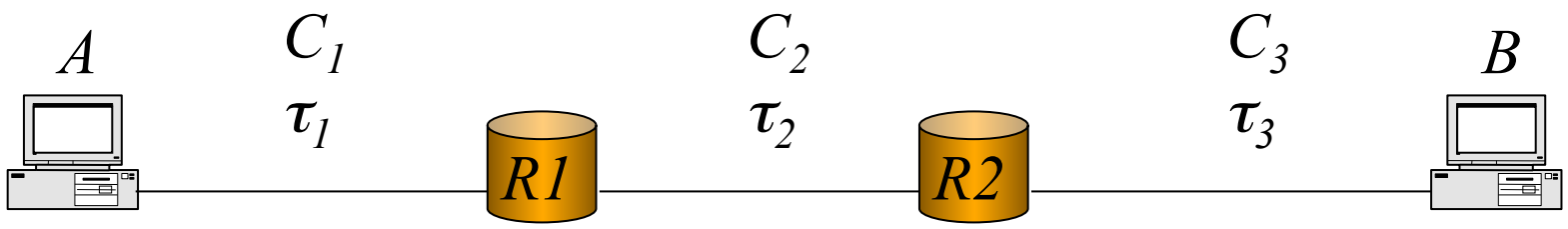


a) Calculate in parametric form the time necessary to transmit a packet from A to B (header h, data D).

b) Assume you divide the packet in 2 fragments. Calculate in parametric form the time necessary to transmit all fragments. Assume $C_2 \leq C_1 \leq C_3$

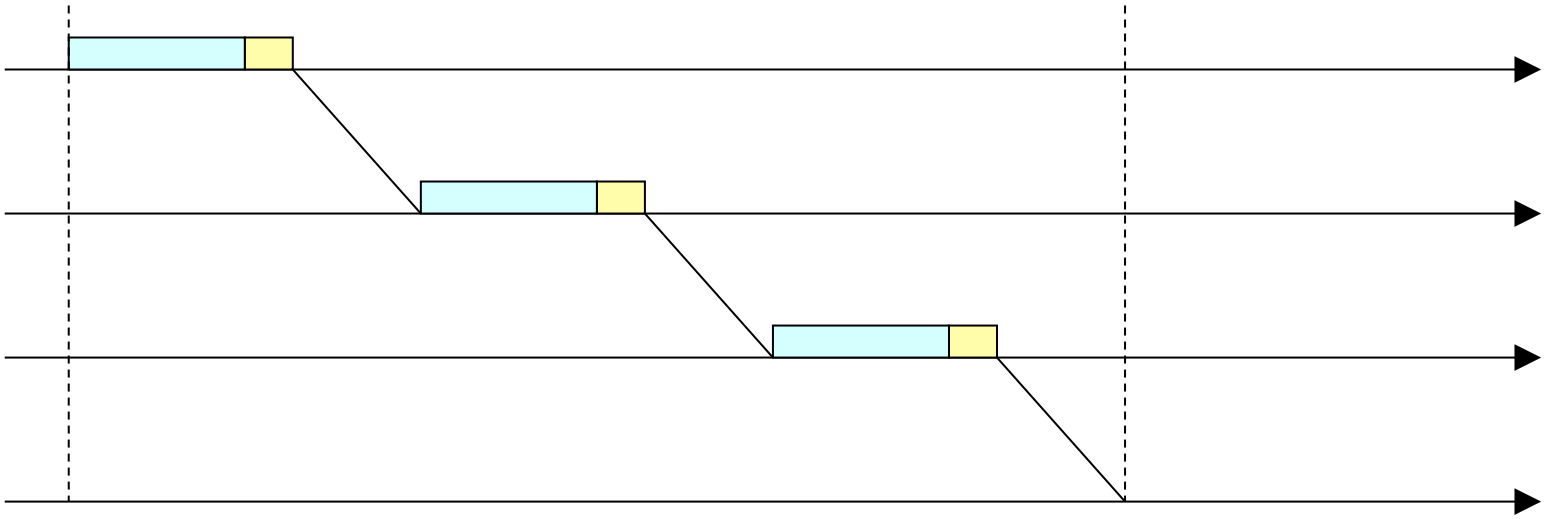
c) What is the number of fragments that minimizes delay?

Solution 3

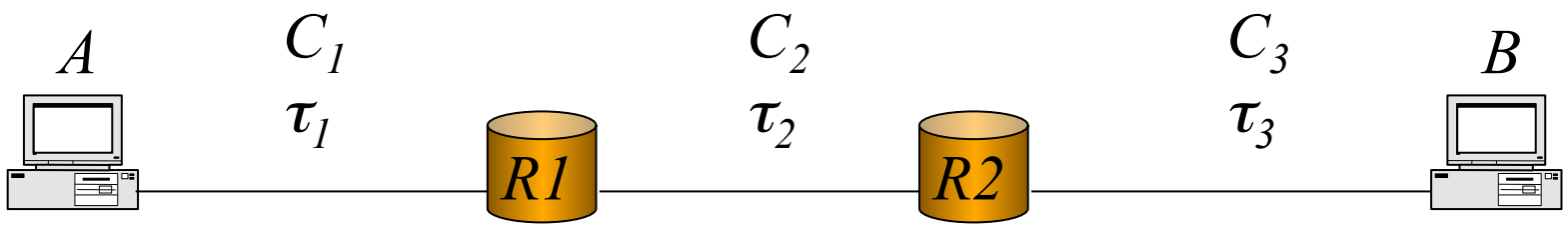


a)

$$T = \frac{h+D}{C_1} + \tau_1 + \frac{h+D}{C_2} + \tau_2 + \frac{h+D}{C_3} + \tau_3$$

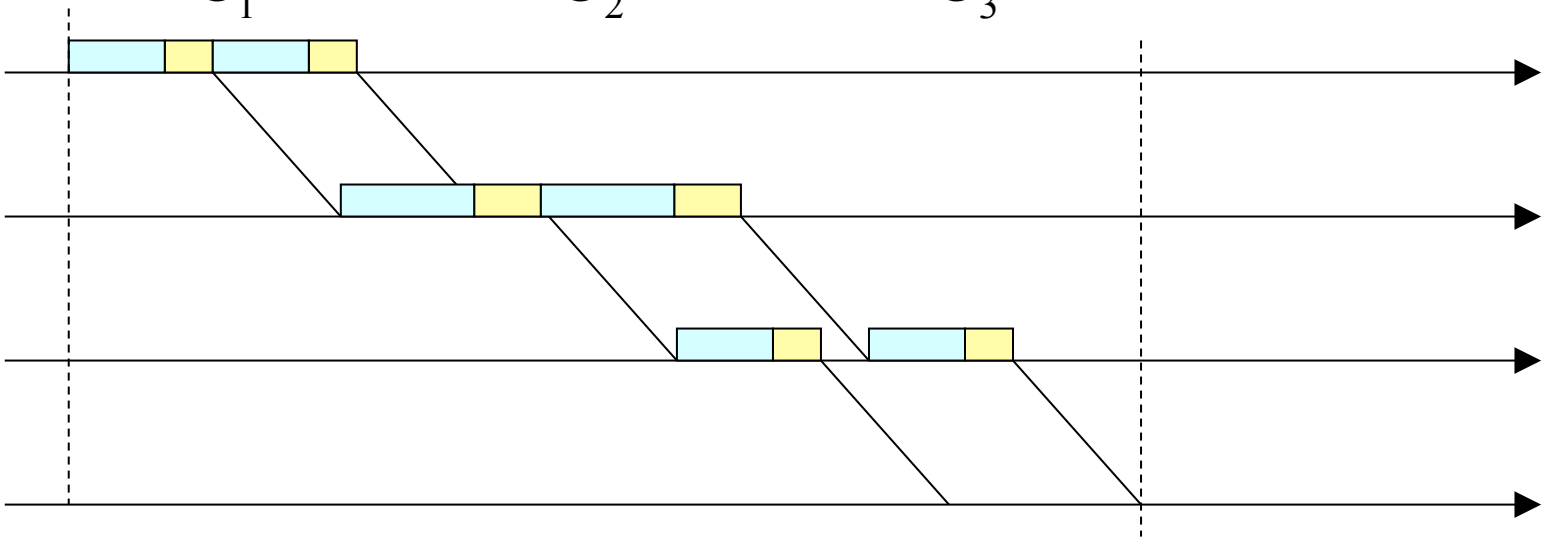


Solution 3

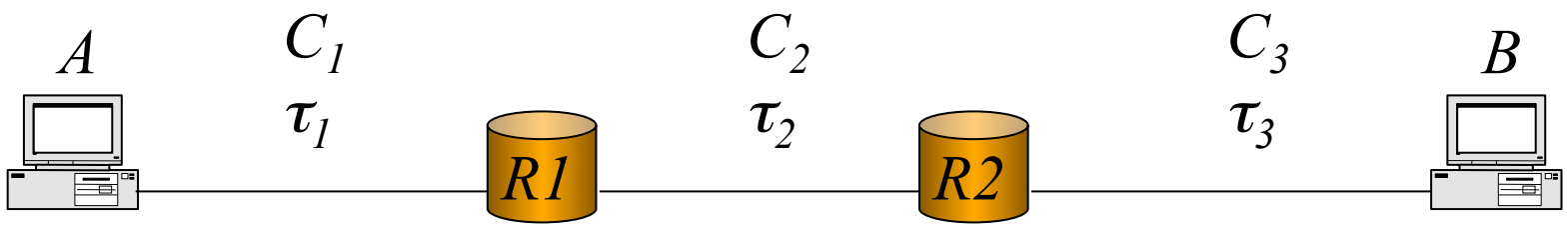


b) $d = D/2$

$$T = \frac{h+d}{C_1} + \tau_1 + \frac{2(h+d)}{C_2} + \tau_2 + \frac{h+d}{C_3} + \tau_3$$



Solution 3



c)

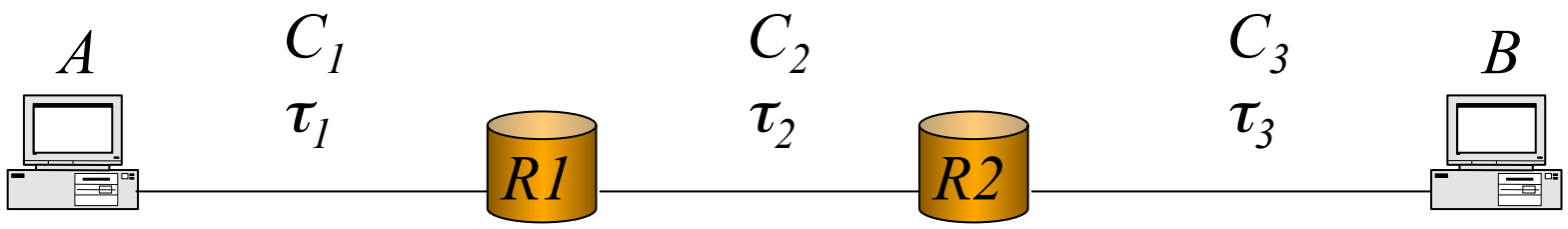
$$T = \frac{h + D/n}{C_1} + \tau_1 + \frac{n(h + D/n)}{C_2} + \tau_2 + \frac{h + D/n}{C_3} + \tau_3 =$$

$$= \left(\frac{h}{C_1} + \tau_1 + \frac{D}{C_2} + \tau_2 + \frac{h}{C_3} + \tau_3 \right) + \frac{D}{nC_1} + \frac{nh}{C_2} + \frac{D}{nC_3}$$

$$\frac{\partial T}{\partial n} = \frac{h}{C_2} - \frac{D}{n^2 C_1} - \frac{D}{n^2 C_3} = 0$$

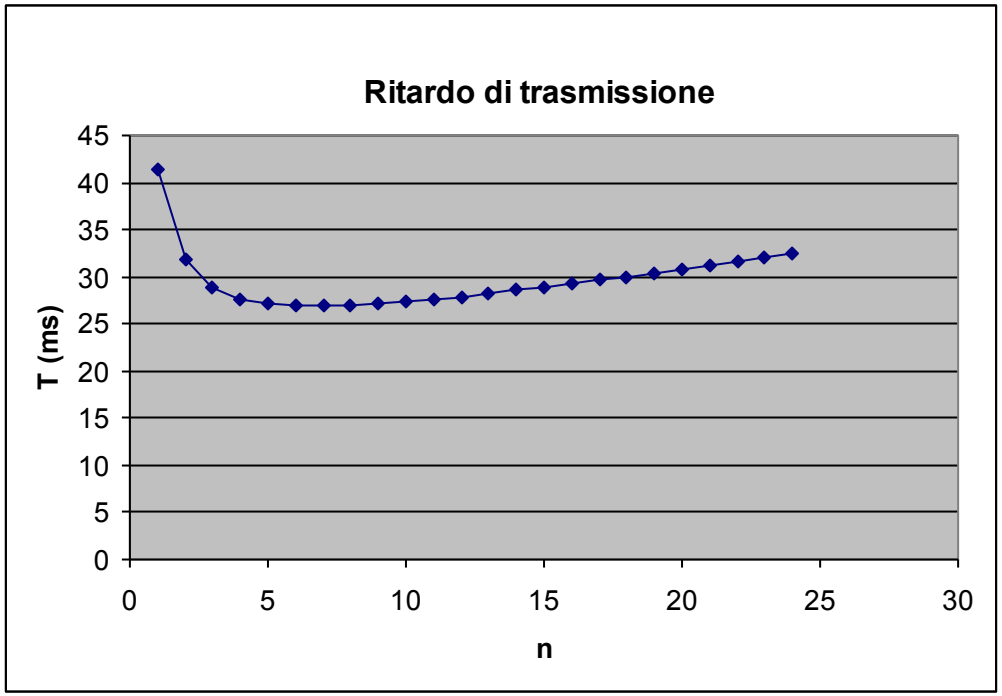
$$n^* = \sqrt{\frac{C_2}{h}\left(\frac{D}{C_1} + \frac{D}{C_3} \right)}$$

Solution 3



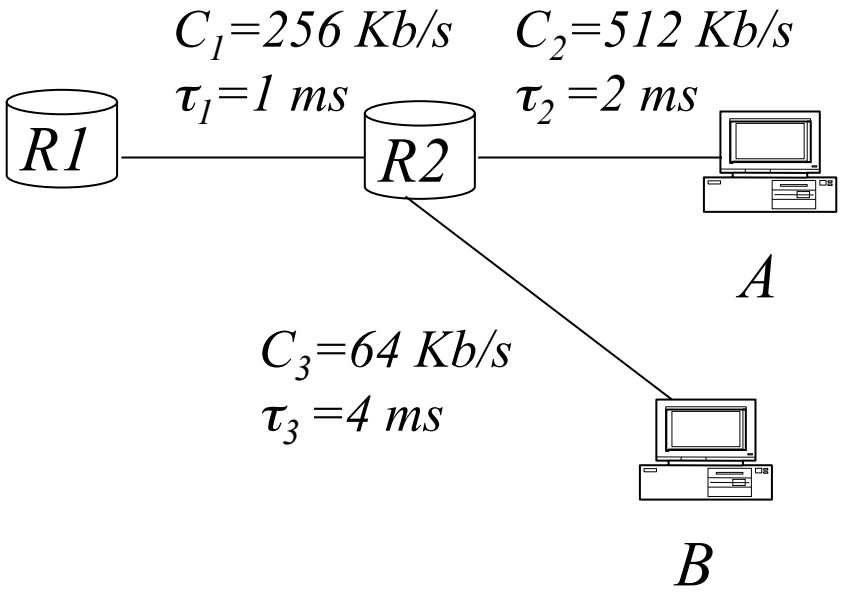
C_1=1 Mbit/s
C_2=900 Kbit/s
C_3=1 Mbit/s
$\tau_1 = \tau_2 = \tau_3$=3 ms
h=400
D=10000

$$n^* = \sqrt{\frac{C_2}{h}\left(\frac{D}{C_1} + \frac{D}{C_3}\right)} = 6,71$$

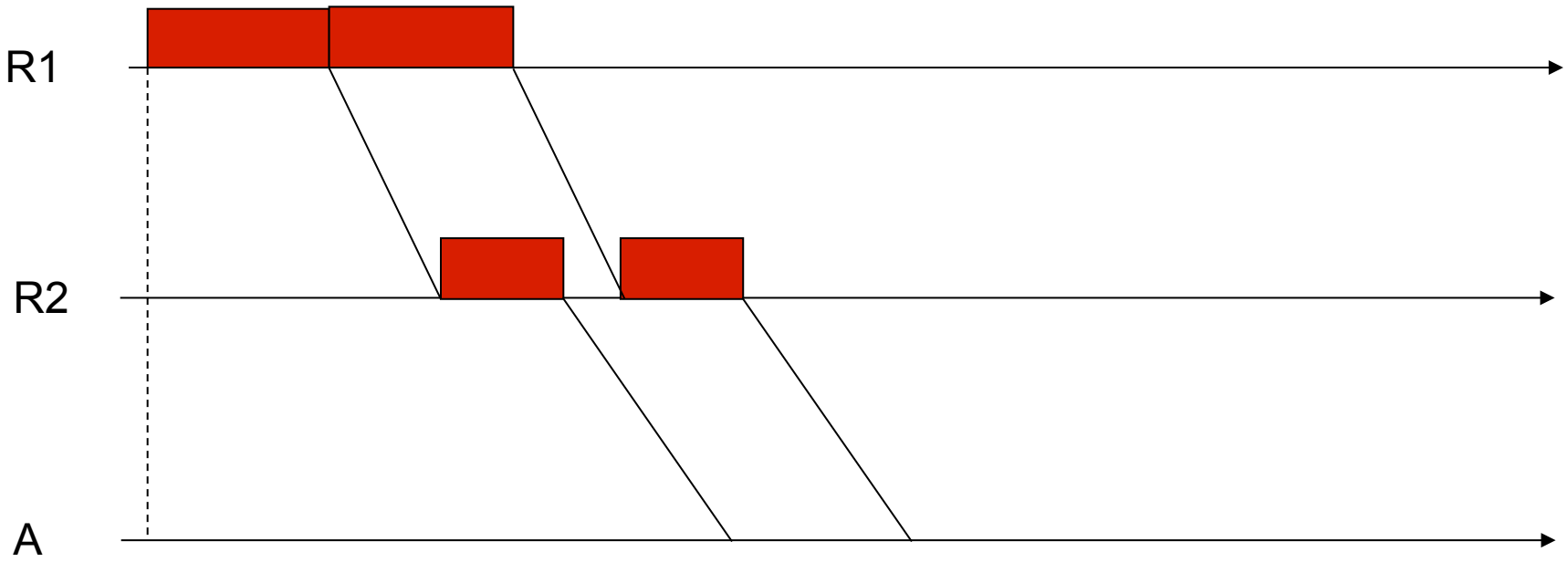


Exercise 4

- Consider the network below. At time t=0 the output queue of R1 has 4 packets towards respectivelyA,A,B,B and the channel is available. Assuming packet length of 512 bits, calculate the time each packet is completely received by destination.



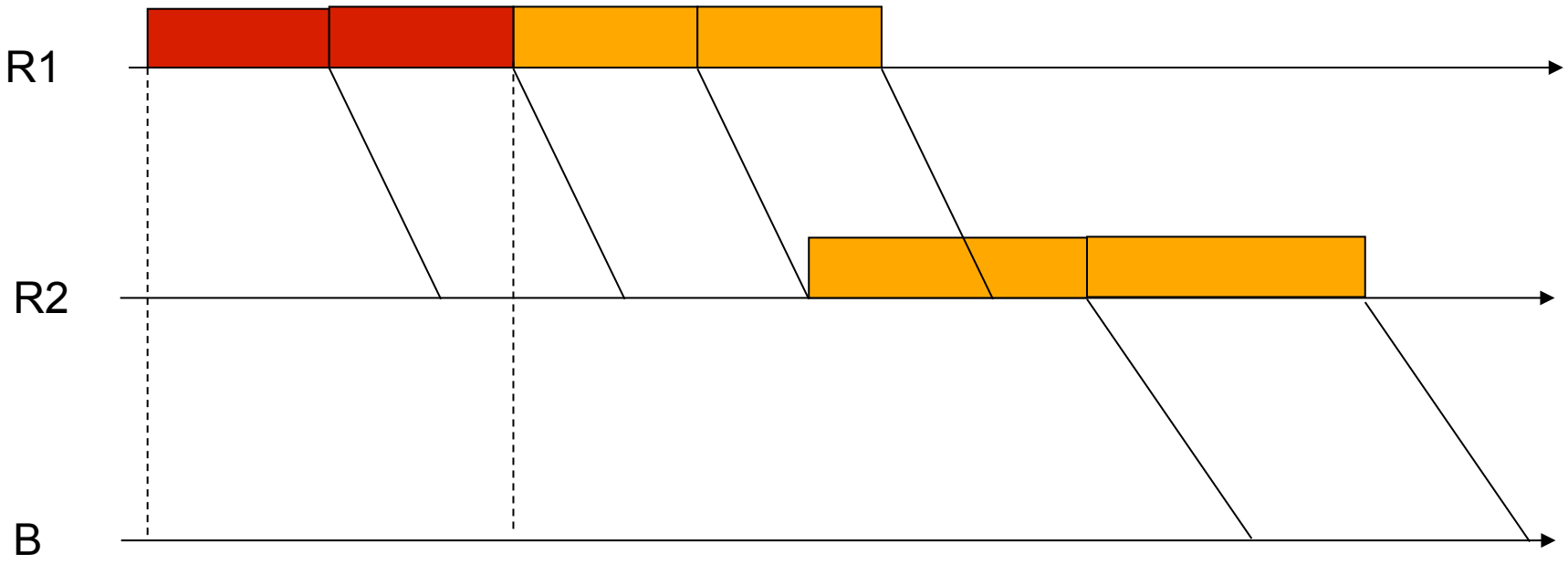
Solution 4



$$T_1 = \frac{L_1}{C_1} + \tau_1 + \frac{L_1}{C_2} + \tau_2 = 2 + 1 + 1 + 2 = 6 \text{ ms}$$

$$T_2 = \frac{(L_1 + L_2)}{C_1} + \tau_1 + \frac{L_2}{C_2} + \tau_2 = 8 \text{ ms}$$

Solution 4

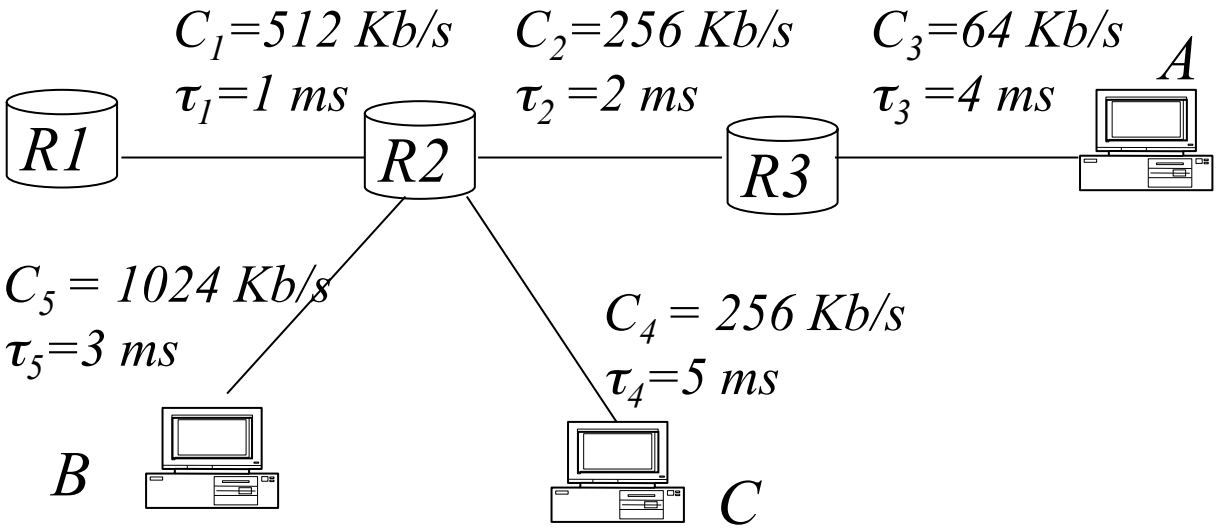


$$T_3 = \frac{L_1 + L_2 + L_3}{C_1} + \tau_1 + \frac{L_3}{C_3} + \tau_3 = 6 + 1 + 8 + 4 = 19 \text{ ms}$$

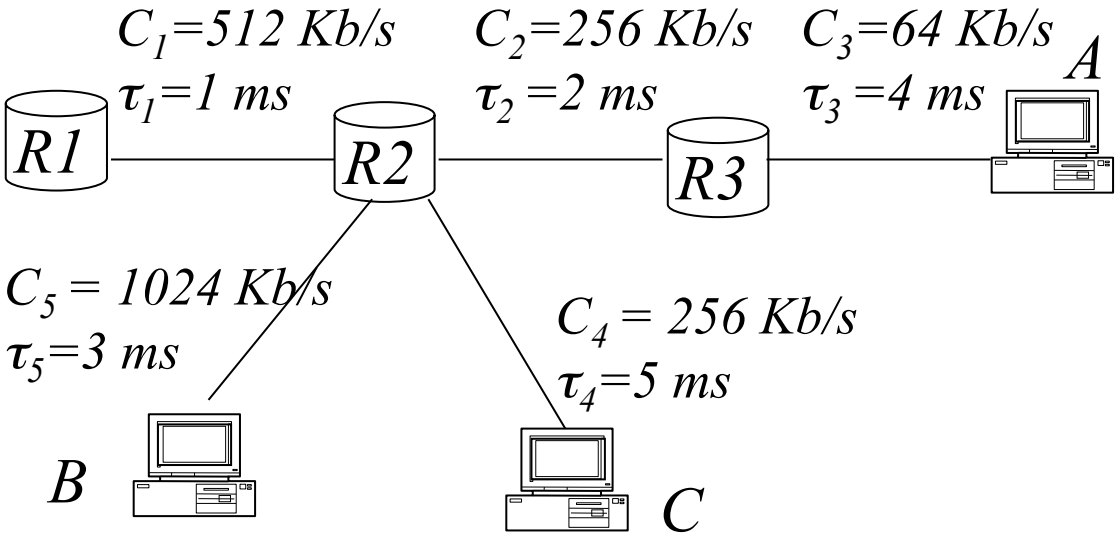
$$T_4 = T_3 + \frac{L_4}{C_3} = 27 \text{ ms}$$

Exercise 5

- Consider the network below. At time t=0 the output queue of R1 has 6 packets towards respectively A,A,B,B,C,C and the channel is available. Assuming packet length of 512 bits, calculate the time each packet is completely received by destination.



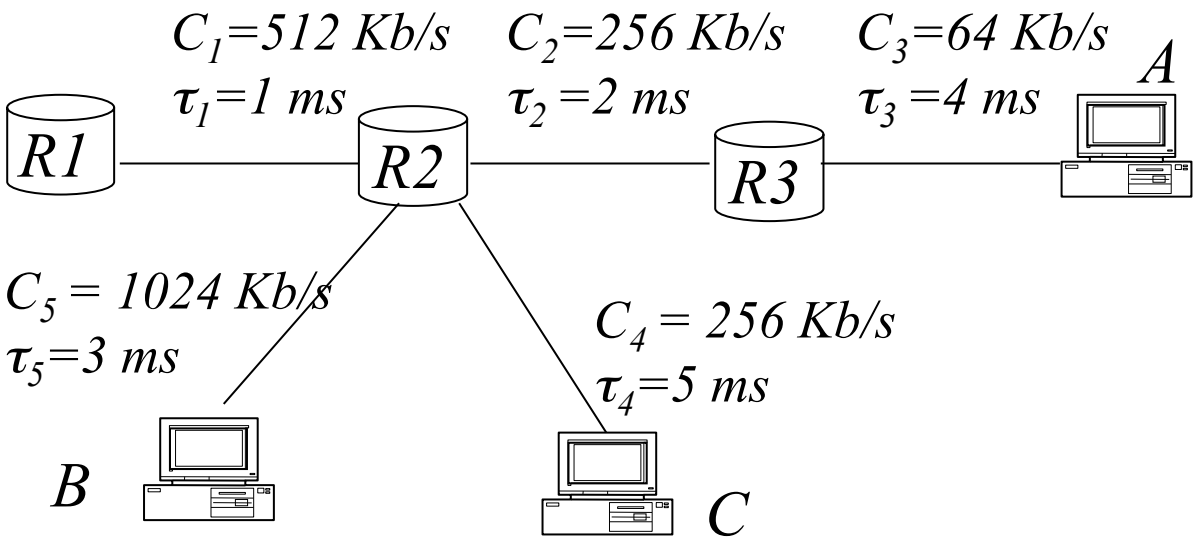
Solution 5



$$T_1 = \frac{L}{C_1} + \tau_1 + \frac{L}{C_2} + \tau_2 + \frac{L}{C_3} + \tau_3 = 18\,\text{ms}$$

$$T_2 = T_1 + \frac{L}{C_3} = 26\,\text{ms}$$

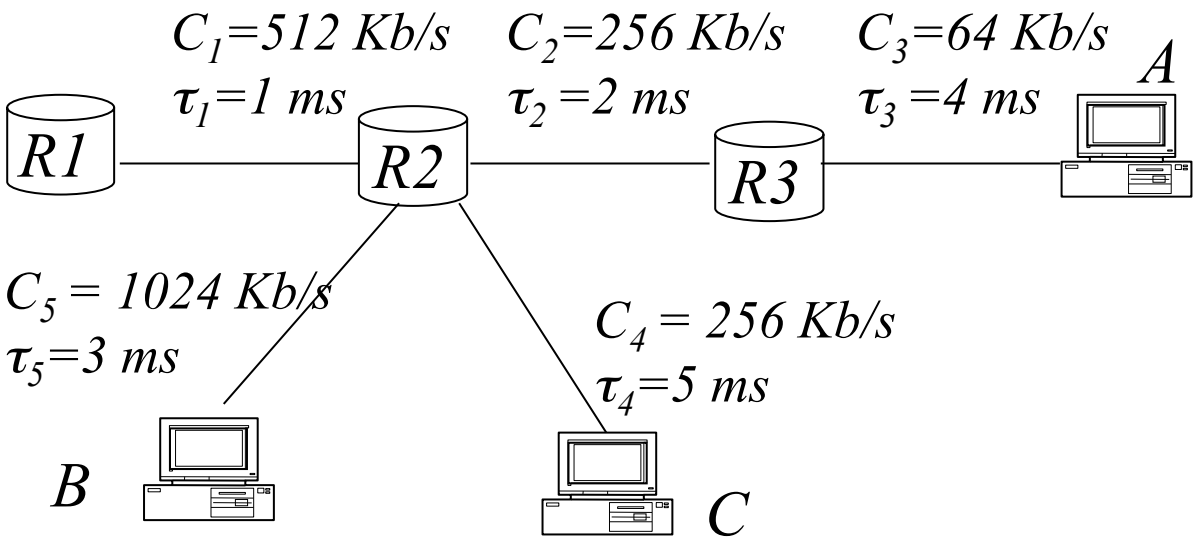
Solution 5



$$T_3 = \frac{3L}{C_1} + \tau_1 + \frac{L}{C_5} + \tau_5 = 7.5\,\text{ms}$$

$$T_4 = \frac{4L}{C_1} + \tau_1 + \frac{L}{C_5} + \tau_5 = 8.5\,\text{ms}$$

Solution 5



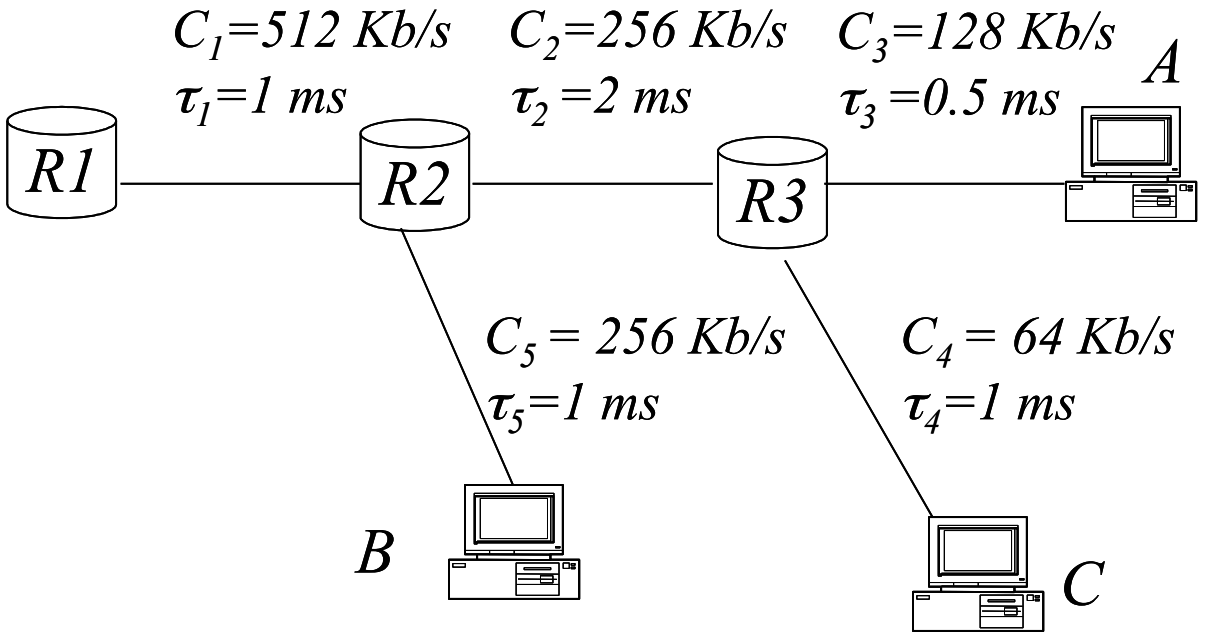
$$T_5 = \frac{5L}{C_1} + \tau_1 + \frac{L}{C_4} + \tau_4 = 13 \text{ ms}$$

$$T_6 = T_5 + \frac{L}{C_4} = 15 \text{ ms}$$

Other exercises

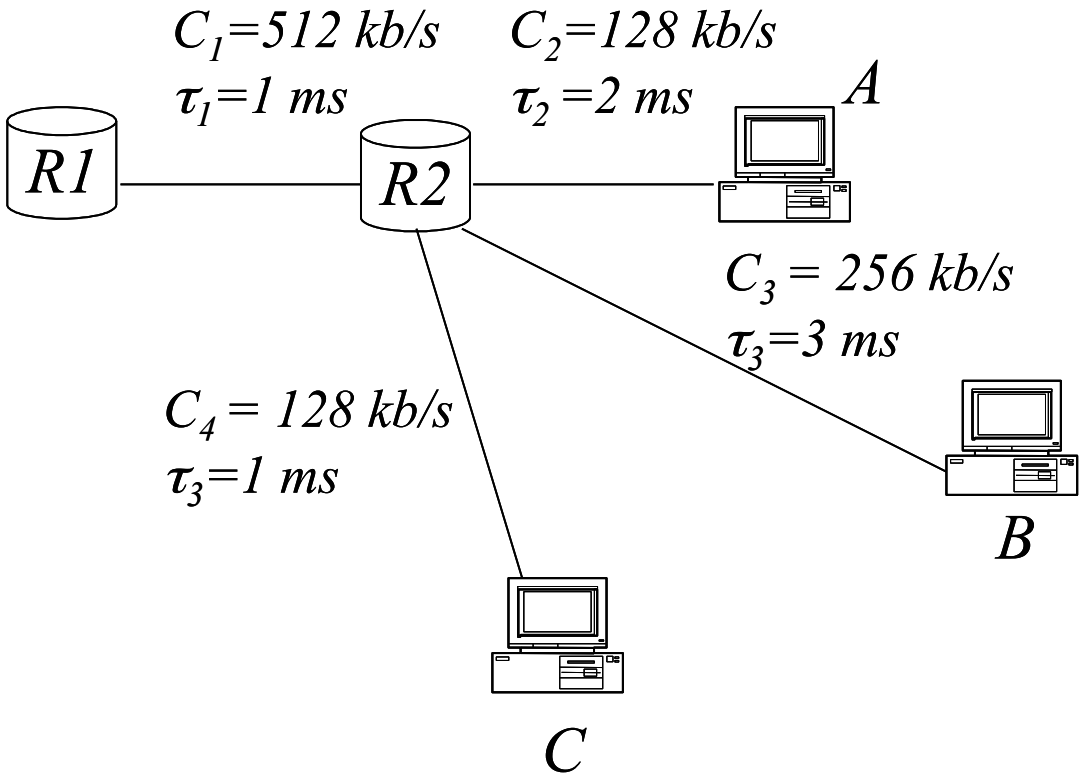
Exercise 6

- R1 queue: A,A,B,B,C
- L =1024 bits



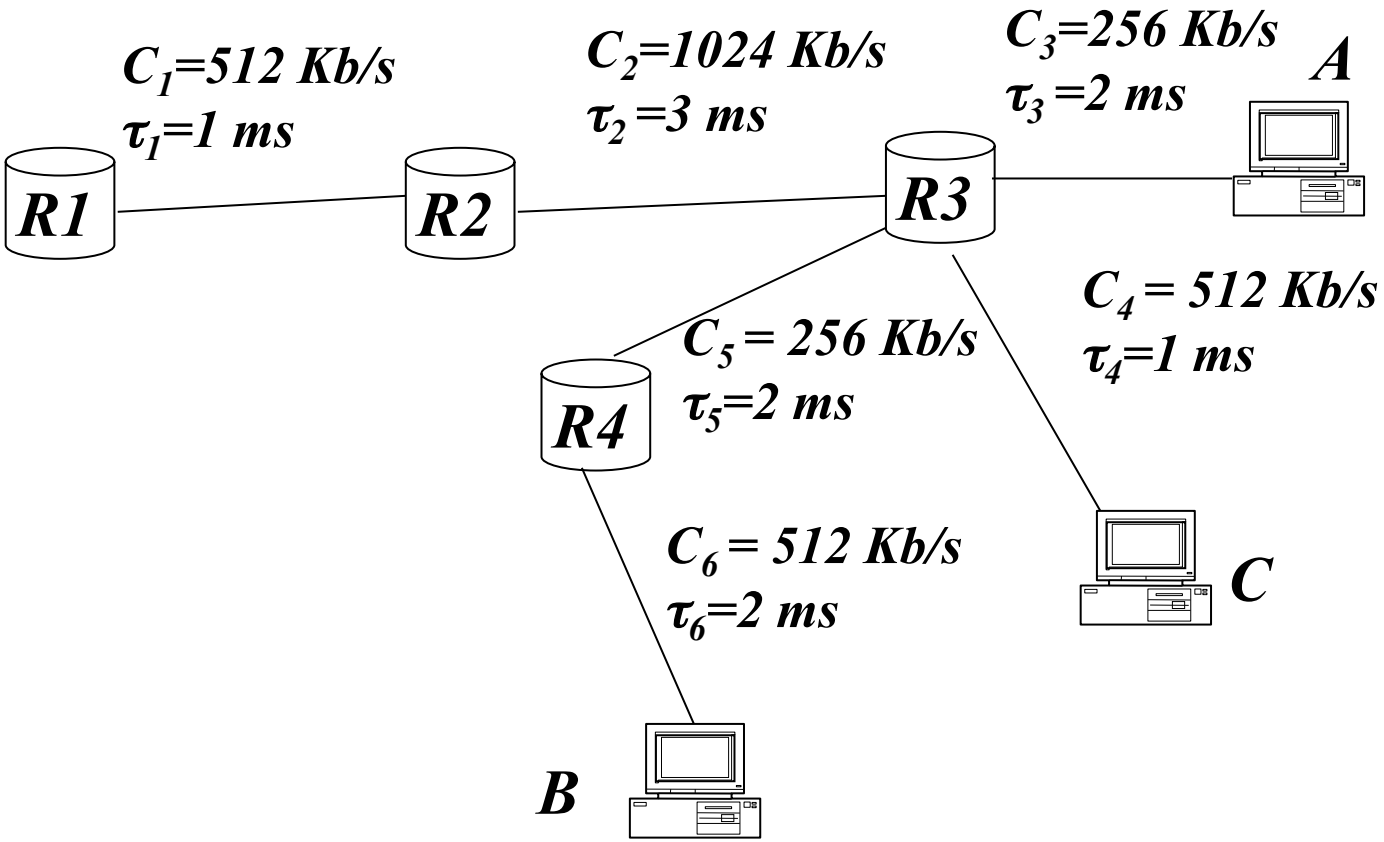
Exercise 7

- R1 queue: A,A,C,B,B
- L =512 bits



Exercise 8

- R1 queue: A,A,C,B,B,A
- L =256 bits



Exercise 9

- R1 queue: A,B,A,B,C,C,D,D
- L =1024 bits