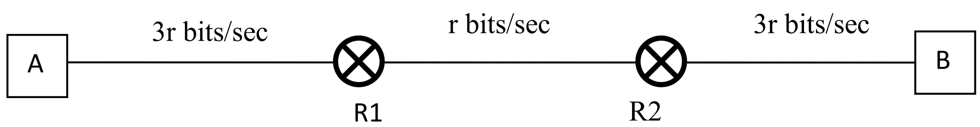
IS 504 – Exercise 2

Consider a slightly modified version of the network considered in the first exercise. Assume that:

- Length of each link is x meters,
- Data transfer rate of the link between routers R1 and R2 is r bits/sec,
- Data transfer rates of the links between the host A and the router R1 and router R2 and host B are 3r bits/sec,
- Signal propagation speed in the medium is c meters/sec,
- Each packet consists of L bits (containing data and header),
- Processing [redacted] delays are negligible,
- Links are reliable (no loss, no corruption) and reliable data transfer protocol is not needed/used.
- No other traffic is present in the network.



a. Suppose n packets will be sent by A to B and transmission will start at time 0. When will all packets be delivered to B? (derive a formula in terms of n, x, r, c, L)
b. How long is the queueing delay in the first router for each of these packets?

Solution

a)

Propagation delay on each link = $d_{prop} = \frac{x}{c}$

Packet transmission delay on the first and the third links = $d_{trans-A-R1} = d_{trans-R2-B} = \frac{L}{3r}$

Packet transmission delay on the second link = $d_{trans-R1-R2} = \frac{L}{r}$

Note that

$$d_{trans-A-R1} = d_{trans-R2-B} = \frac{d_{trans-R1-R2}}{3}$$

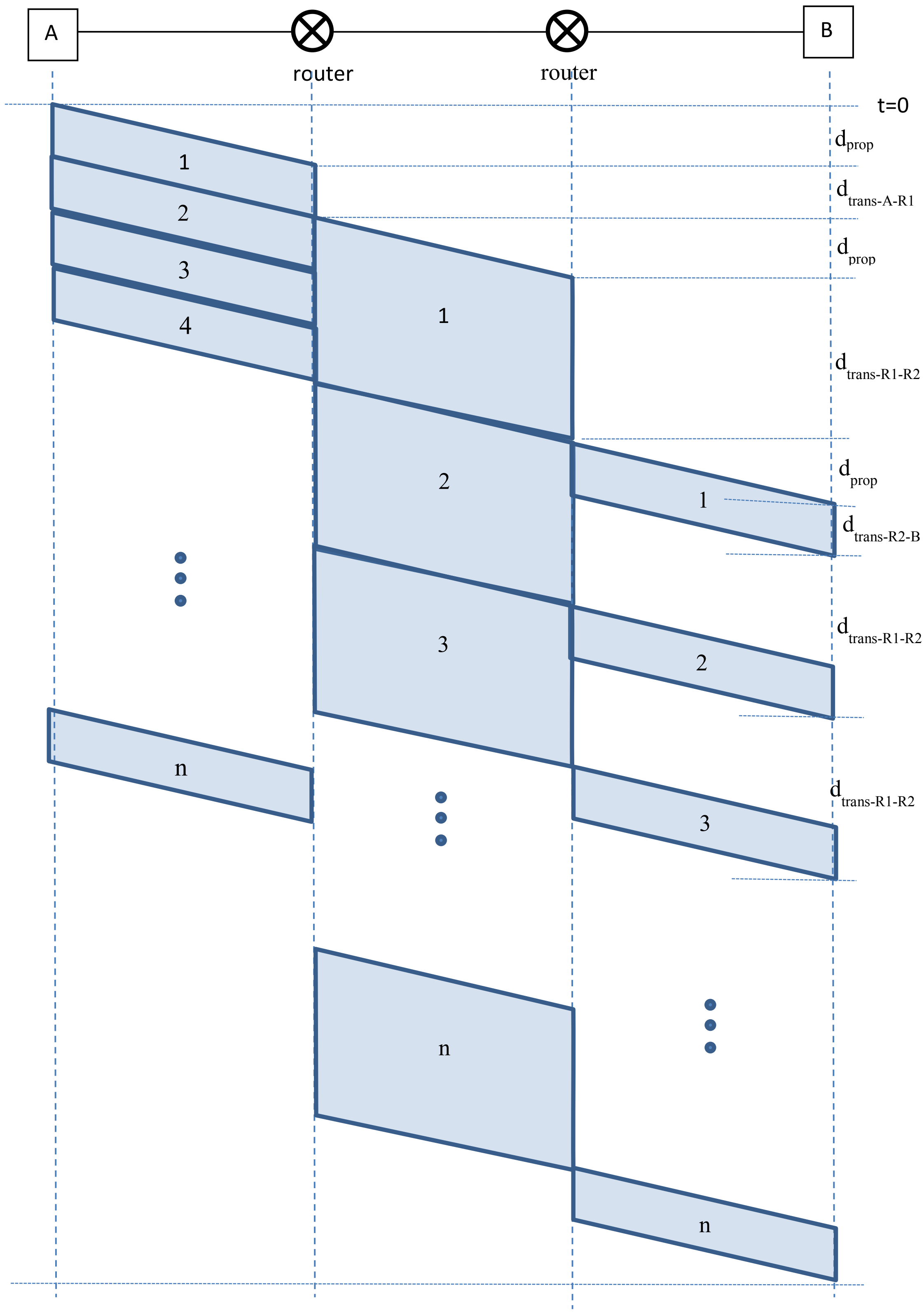
As it can be seen from the following time-space diagram the packets will be delivered to B at:

$$d = d_{prop} + d_{trans-A-R1} + d_{prop} + d_{trans-R1-R2} + d_{prop} + d_{trans-R2-B} + (n-1) * d_{trans-R1-R2}$$

By rearranging the terms:

$$d = 3 * d_{prop} + d_{trans-A-R1} + d_{trans-R2-B} + n * d_{trans-R1-R2}$$

$$d = 3 * \frac{x}{c} + \left(n + \frac{2}{3}\right) * \frac{L}{r}$$



A
router
router
B
t=0
d_{prop}
$d_{trans-A-R1}$
d_{prop}
$d_{trans-R1-R2}$
d_{prop}
$d_{trans-R2-B}$
$d_{trans-R1-R2}$
$d_{trans-R1-R2}$
1
2
3
4
n
1
2
3
n
1
2
3
n

b)

As it can be seen from the time-space diagram

- The first packet does not experience queuing. Therefore, the queuing delay for the 1st packet is:

$$d_{queue-1} = 0$$

- The second packet is received after $d_{trans-A-R1}$ seconds after the first packet and waits for the transmission of the first packet. Therefore, the queuing delay for the 2nd packet is:

$$d_{queue-2} = d_{trans-R1-R2} - d_{trans-A-R1} = \frac{L}{r} - \frac{L}{3r} = \frac{2L}{3r}$$

- The second packet is received after $2 * d_{trans-A-R1}$ seconds after the first packet and waits for the transmission of the first and the second packets. Therefore, the queuing delay for the 3rd packet is:

$$d_{queue-3} = 2 * d_{trans-R1-R2} - 2 * d_{trans-A-R1} = 2 * \frac{L}{r} - 2 * \frac{L}{3r} = \frac{4L}{3r}$$

So we can generalize this as:

- The ith packet is received after $(i-1) * d_{trans-A-R1}$ seconds after the first packet and waits for the transmission of the (i-1) packets. Therefore, the queuing delay for the ith packet is:

$$d_{queue-i} = (i-1) * d_{trans-R1-R2} - (i-1) * d_{trans-A-R1} = (i-1) * \frac{L}{r} - (i-1) * \frac{L}{3r}$$

Hence:

$$d_{queue-i} = \frac{2(i-1)L}{3r}$$