IS 504 - Homework 1, due: 22 Oct 2023

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1. Given information:

- Propogation speed = 200×10^6 m/sec
- Host A to Router R distance = 200 km = 200×10^3 m
- Host B to Router R distance = 100 km = 100×10^3 m
- Host C to Router R distance = 400 km = 400×10^3 m
- Bandwith of the links:
  - A-R link = 2 Mbps = 2×10^6 bps
  - B-R link = 10 Mbps = 10×10^6 bps
  - C-R link = 5 Mbps = 5×10^6 bps
- Header size = 25 bytes = 200 bits

As we know that,

Packet length = $L = h + m$

Packet transmission delay = $d_{trans} = \frac{L}{r} = \frac{h+m}{r}$, where r represents link transmission rate (bps)

Propogation delay on each link = $d_{prop} = \frac{x}{c}$, where c is propogation speed = 200×10^6 m/sec

a. Transmission delay = $\frac{800 + 200}{2 \times 10^6} = 0.0005$ seconds

Propagation delay = $\frac{200 \times 10^3}{200 \times 10^6} = 0.001$ seconds

b. Transmission delay = $\frac{800 + 200}{10 \times 10^6} = 0.0001$ seconds

Propagation delay = $\frac{100 \cdot 10^3}{200 \times 10^6} = 0.0005$ seconds

c. Transmission delay = $\frac{800 + 200}{5 \times 10^6} = 0.0002$ seconds

Propogation delay = $\frac{400 \times 10^3}{200 \times 10^6} = 0.002$ seconds

d. Transmission delay = $\frac{8000 + 200}{2 \times 10^6} = 0.0041$ seconds

Propogation delay = 0.001 (same as before)

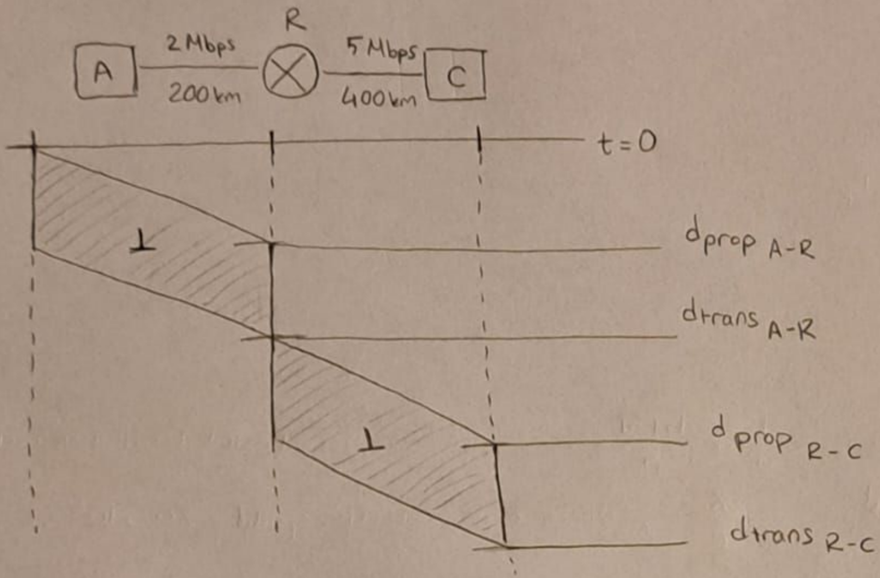
e. Transmission delay $= \dfrac{8000+200}{10 \times 10^6} = 0.0008$ seconds

Propagation delay $= 0.0005$ seconds (same as before)

f. Transmission delay $= \dfrac{8000+200}{5 \times 10^6} = 0.0016$ seconds

Propagation delay $= 0.002$ seconds (same as before)

2.



- Host A sends a 1000 byte message to Host C. The total message size, 1000 bytes, which is equivalent to 8000 bits.

$d_{prop\ A-R} = 0.001$ (as calculated in previous answer)

$d_{trans\ A-R} = \dfrac{8000+200}{2 \times 10^6} = 0.00405$ seconds

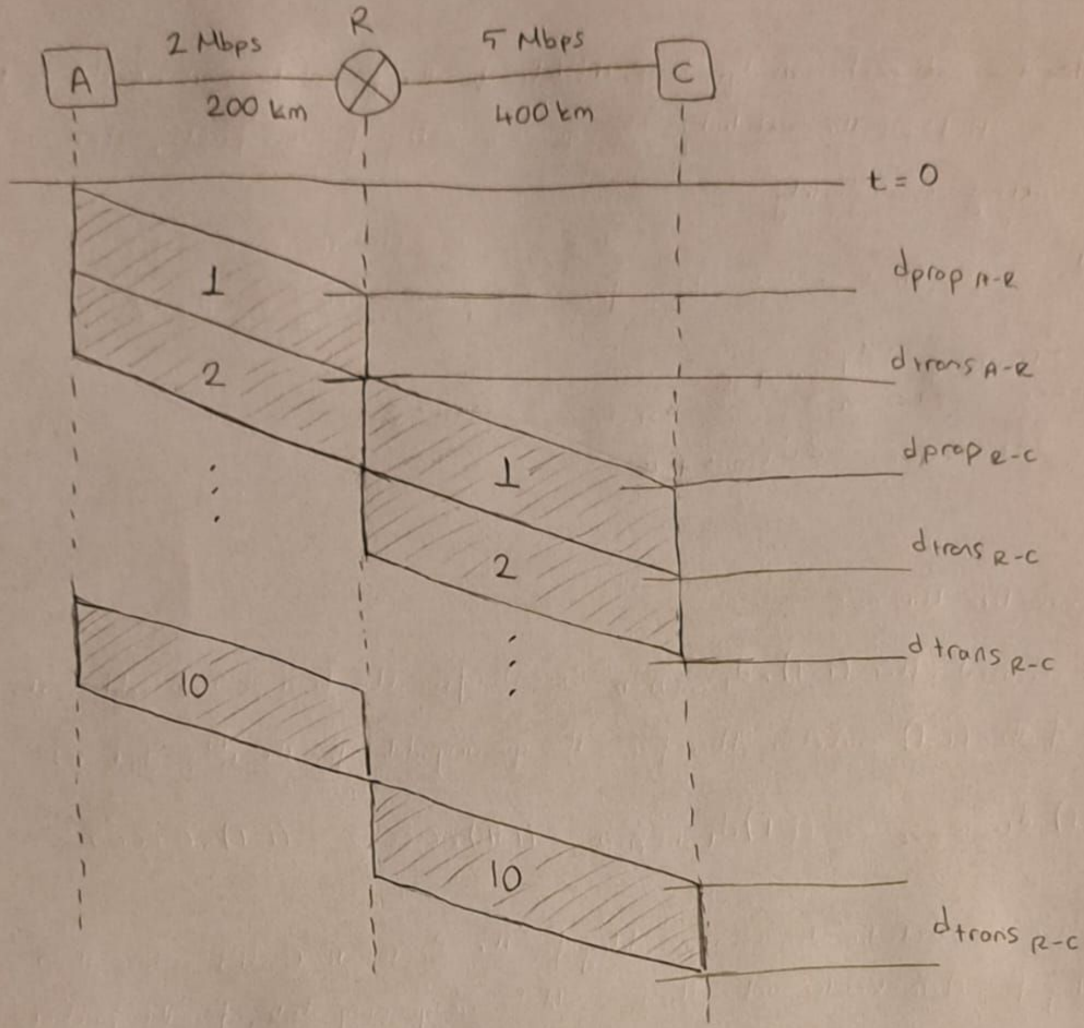
$d_{prop\ R-C} = 0.002$

$d_{trans\ R-C} = \dfrac{8000+200}{5 \times 10^6} = 0.00164$ second

Therefore total delay can be found as:

$$d_{prop\ A-R} + d_{trans\ A-R} + d_{prop\ R-C} + d_{trans\ R-C} = 0.00869 \text{ seconds}$$

3.



$$d_{trans\ A-R} = \frac{800+200}{2 \times 10^6} = 0.0005 \text{ sec}$$

$$d_{prop\ A-R} = 0.001 \text{ sec}$$

$$d_{trans\ R-C} = \frac{800+200}{5 \times 10^6} = 0.0002 \text{ sec}$$

$$d_{prop\ R-C} = 0.002 \text{ sec}$$

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

$$d = d_{prop_{A-R}} + d_{trans_{A-R}} + d_{prop_{R-C}} + d_{trans_{R-C}} + (n-1)\, d_{trans_{R-C}}$$

By rearranging the terms:

$$d = d_{prop_{A-R}} + d_{trans_{A-R}} + d_{prop_{R-C}} + 10 \times d_{trans_{R-C}}$$

$$d = 0.001 + 0.0005 + 0.002 + 0.002 = 0.0055 \text{ sec}$$

b. The queuing delay for each packet is the time it takes for the packet to wait at the router before it can be transmitted on the next link. The queuing delay for the first packet is 0, as it starts transmitting immediately.

$d_{queue-1} = 0$

$d_{queue-2} = d_{trans\,R-C} - d_{trans\,A-R}$

$d_{queue-3} = 2d_{trans\,R-C} - 2d_{trans\,A-R}$

$\vdots$

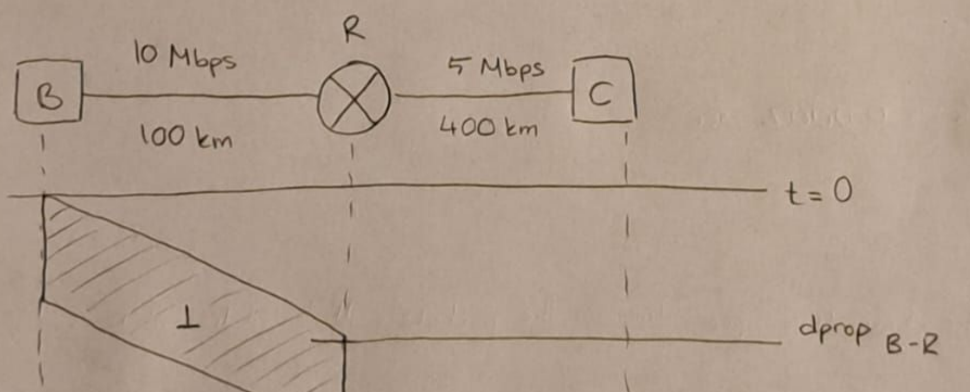
Therefore we can generalize this as:

The i^{th} packet is received after $(i-1) \times d_{trans\,A-R}$ seconds after the first packet and waits for the transmission of the $(i-1)$ packets. Therefore, the queuing delay for the i^{th} packet is:

$$d_{queue-i} = (i-1)\, d_{trans\,R-C} - (i-1)\, d_{trans\,A-R} = (i-1) \times 0.0002 - (i-1) \times 0.0005$$

- Nevertheless, here we see that the transmission delay for the Router-to-C link is less than the transmission delay for A-to-Router link. There would be no queuing delay for the packets traveling from Host A to Router and then to Host C. The packets would flow smoothly without waiting in a queue, and the average queuing delay in this scenario is zero.

4.

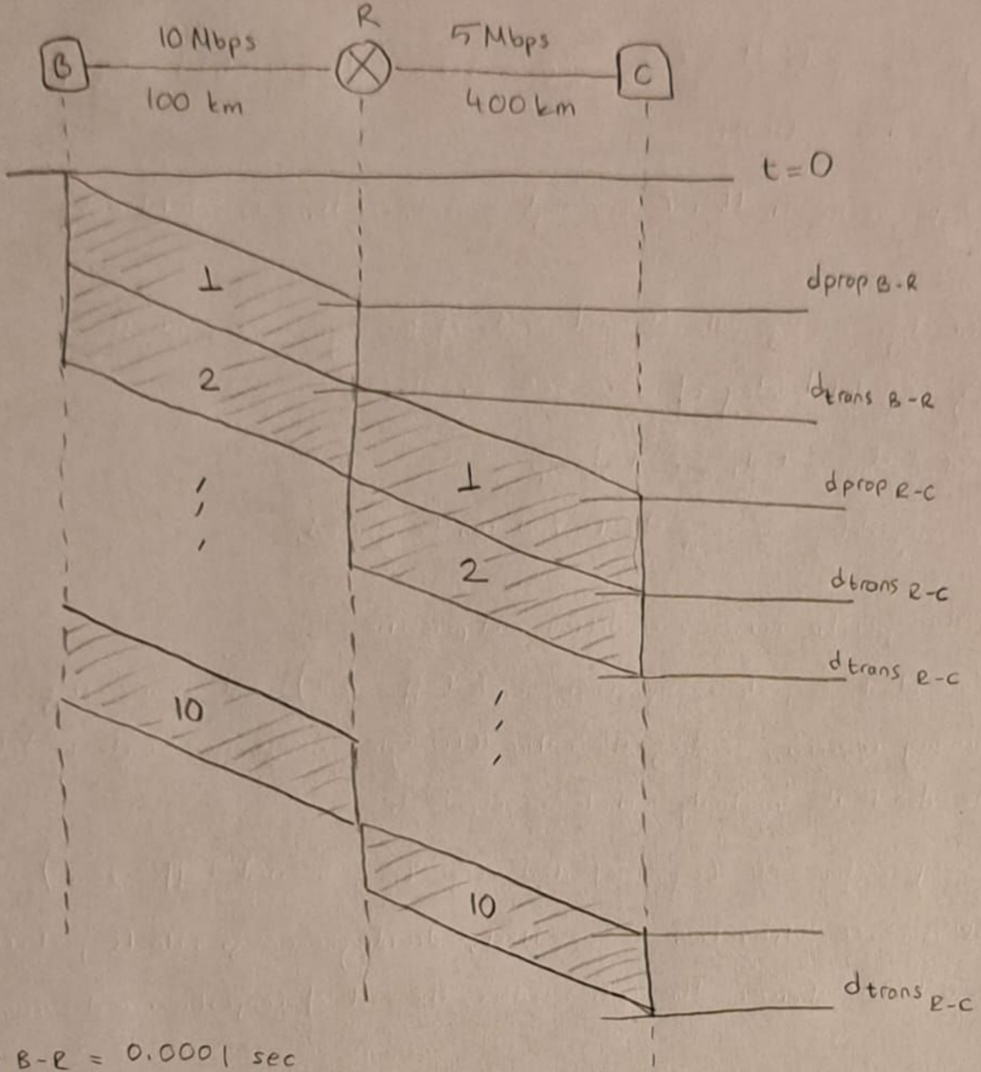


$d_{prop\,B-R} = 0.0005$ sec $\qquad d_{prop\,R-C} = 0.002$ sec

$d_{trans\,B-R} = 0.0008$ sec $\qquad d_{trans\,R-C} = 0.0016$ sec

Total delay $= d_{prop\,B-R} + d_{trans\,B-R} + d_{prop\,R-C} + d_{trans\,R-C} = 0.0049$ sec

5.



$d_{trans\ B-R} = 0.0001$ sec

$d_{prop\ B-R} = 0.0005$ sec

$d_{trans\ R-C} = 0.0002$ sec

$d_{prop\ R-C} = 0.002$ sec

a. $d = d_{prop\ B-R} + d_{trans\ B-R} + d_{prop\ R-C} + d_{trans\ R-C} + (n-1)\, d_{trans\ R-C}$

$d = 0.0005 + 0.0001 + 0.002 + 10 * 0.0002 = 0.0046$ sec

b. $d_{queue\text{-}i} = (i-1)\left[d_{trans\ R-C} - d_{trans\ B-R} \right]$, $d_{queue\text{-}1} = 0$

$$\text{Average queuing delay} = \frac{d_{queue\text{-}1} + d_{queue\text{-}2} + \ldots + d_{queue\text{-}10}}{10} = 0.00045 \text{ sec}$$

6. Host A sends a 100-byte message to Host C in a single packet, resulting in a total delay of 0.0037 seconds. Host B has two options:

a. Host B sends a 1000-byte message to Host C in a single packet, resulting in a total delay of 0.0049 seconds.

b. Host B sends a 1000-byte message into 10 equal chunks of 100 bytes and sends them in separate packets, resulting in a total delay of 0.00505 seconds.

$$d_{nodal} = d_{proc} + d_{queue} + d_{trans} + d_{prop}$$

given packet processing delays are very shorts and can be ignored.

The best option depends on the specific network conditions and priorities.

- If network resources are abundant (e.g. low congestion, ample buffer zone), and minimizing transmission time is the primary concern, sending the entire 1000-byte message in a single packet by Host B may be suitable due to its simplicity and lower overhead.
- If network conditions are less favorable (e.g. potential congestion, limited buffer zone), and reliability and efficient resource utilization are essential, dividing message into 10 packets of 100-bytes each may be a better choice. This option reduces the risk of congestion and ensures smoother data flow.
- Using Host A is ideal for very short messages but may not be suitable for longer messages that may require fragmentation. (Since it takes 0.0055 seconds of total delay for 1000-bytes message into 10 packets, comparing the total delays, using Host B is more efficient in terms of time)

In conclusion, the best option depends on the specific network environment and priorities. Network administrators should choose the option that best aligns with their network's conditions and requirements, whether it is minimizing transmission time or ensuring network reliability.

7. To ensure that no packet loss occurs at router R, we need to consider the capacity of the link and the sending (transmission) rates of both Host A and Host B. The constraint on T to ensure no packet loss can be derived as follows;

1. The combined sending rate of Host A and Host B is given by:

$$R_A + R_B = 800{,}000 \text{ (bits/second)} + (1000 \text{ bytes} / T \text{ bits/second})$$

2. The capacity of the link is determined by the bandwidth and propagation delay:

$$\text{Capacity} = (\text{Link Bandwidth}) / (\text{Propagation Delay}) = (5 \text{ Mbps}) / (0.0002 \text{ sec}) = 2.5 \text{ Gbps}$$

For no packet loss, the combined sending rate should be less than or equal to the link capacity:

800,000 bits/second + (1000 bytes / T bits/second) $\leq$ 2.5 Gbps

Now, we need to solve for T,

1000 bytes / T bits/second $\leq$ 2,500,000,000 bits/second - 800,000 bits/second

T $\geq$ 1000 bytes / 2,499,200,000 bites/second

T $\geq$ 0.0000004 seconds

Therefore, the constraint on T to ensure no packet loss at router R is that T should be greater than or equal to 0.0000004 seconds (4 microseconds). This means that Host B can send a 1000 byte message to Host C every T seconds as long as T is greater than or equal to 4 microseconds.