CS4121 Assignment 2 Due: 08/30/18

In all the following questions, you should assume 1Kb=10^3b, 1Mb=10^6b, and 1Gb=10^9b

Also, all your answers must be justified.

In the following four questions, we are sending a 30 Mbit MP3 file from a source host to a destination host. All links in the path between source and destination have a transmission rate of 10 Mbps. Assume that the propagation speed is 2 * 10^8 meters/sec, and the distance between source and destination is 10,000 km.

1. (2 points) Initially suppose there is only one link between source and destination. Also suppose that the entire MP3 file is sent as one packet. What is the transmission delay?

   Answer: $3s$

   Justification:

$$d_{trans} = \frac{L}{R} = \frac{30Mb}{10Mb}s = 3s$$

2. (2 points) Referring to the above question, what is the end-to-end delay (transmission delay plus propagation delay)?

   Answer: $3.05s$

   Justification:

$$\begin{aligned} d_{end-to-end} &= d_{trans} + d_{prop} = \frac{L}{R} + \frac{m}{s} \\ &= \frac{30Mb}{10Mb}s + \frac{10000km}{2\times10^8 m}s \\ &= \frac{30Mb}{10Mb}s + \frac{10000km}{2\times10^5 km}s \\ &= \frac{30Mb}{10Mb}s + \frac{10000km}{200000km}s \\ &= 3s + 0.05s = 3.05s \end{aligned}$$

3. (2 points) Now suppose there are two links between source and destination, with one router connecting the two links. Each link is 5,000 km long. Again suppose the MP3 file is sent as one packet. Suppose there is no congestion, so that the packet is transmitted onto the second link as soon as the router receives the entire packet. What is the end-to-end delay?

Answer: $6.05s$

Justification:

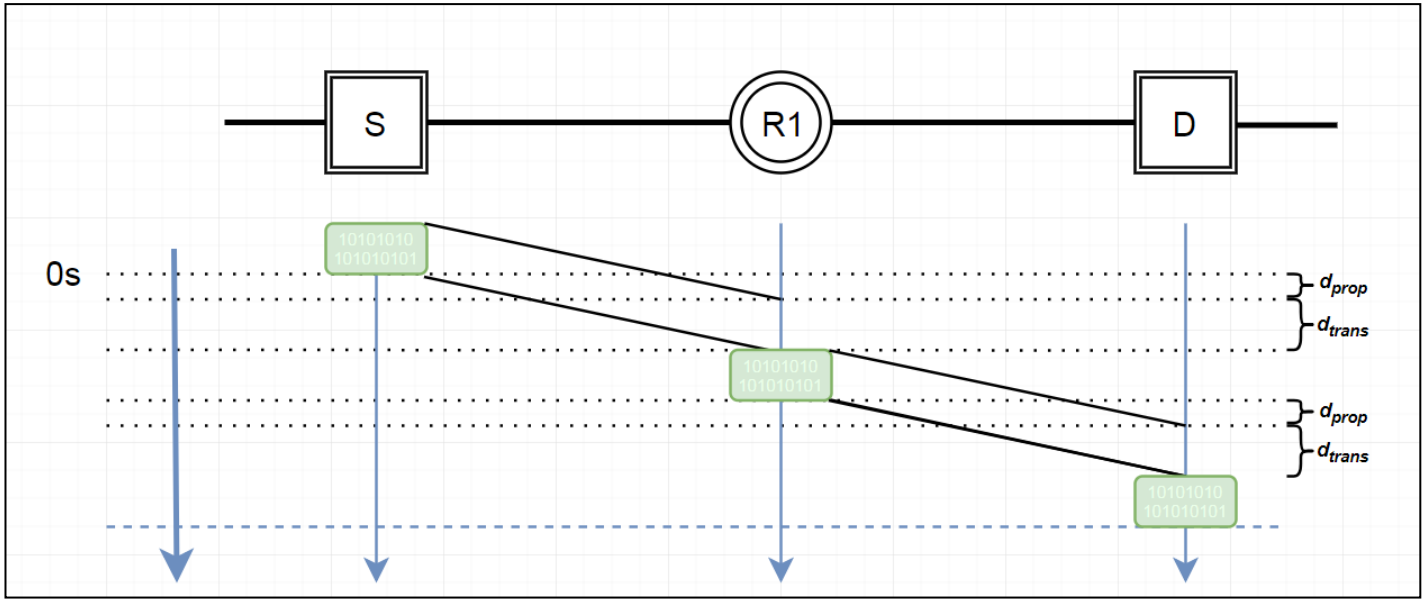
$$d_{end-to-end} = 2d_{trans} + 2d_{prop} = 2\frac{L}{R} + 2\frac{m}{s}$$

$$2\left(\frac{5000km}{2\times10^8 m}s\right) + 2(3s)$$

$$= 2\left(\frac{5000km}{2\times10^5 km}s\right) + 2(3s)$$

$$= \frac{10000km}{200000km}s + 6s$$

$$= \frac{1}{20}s + 6s = 0.05s + 6s = 6.05s$$



4. (2 points) Now suppose that the MP3 file is broken into 3 packets, each of 10 Mbits. Use the same setup as in question 3 above. Ignore headers that may be added to these packets. Also ignore router processing delays. Assuming store and forward packet switching at the router, what is the end-to-end delay?

Answer: $4.05s$
Justification:

$$d_{end-to-end} = 4d_{trans} + 2d_{prop} = 4\frac{L}{R} + 2\frac{m}{s}$$

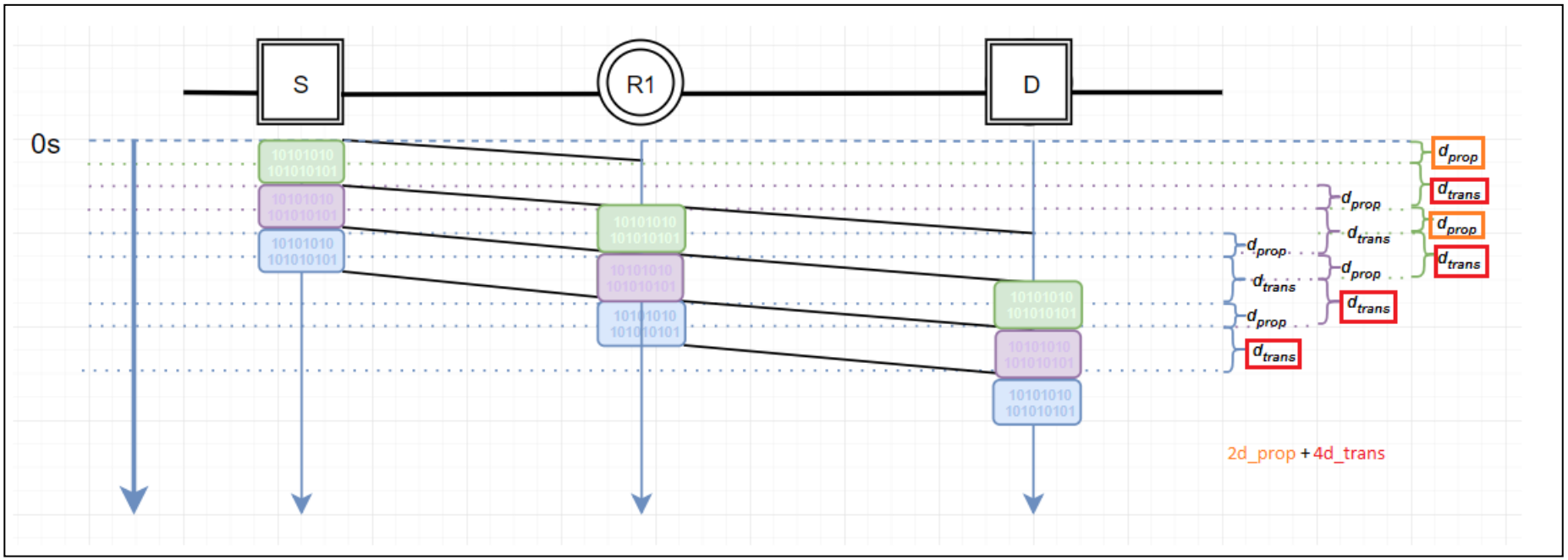
$$= 4\left(\frac{10Mb}{10Mb}s\right) + 2\left(\frac{5000km}{2\times10^{8}m}s\right)$$

$$= 4\left(\frac{10Mb}{10Mb}s\right) + 2\left(\frac{5000km}{2\times10^{5}km}s\right)$$

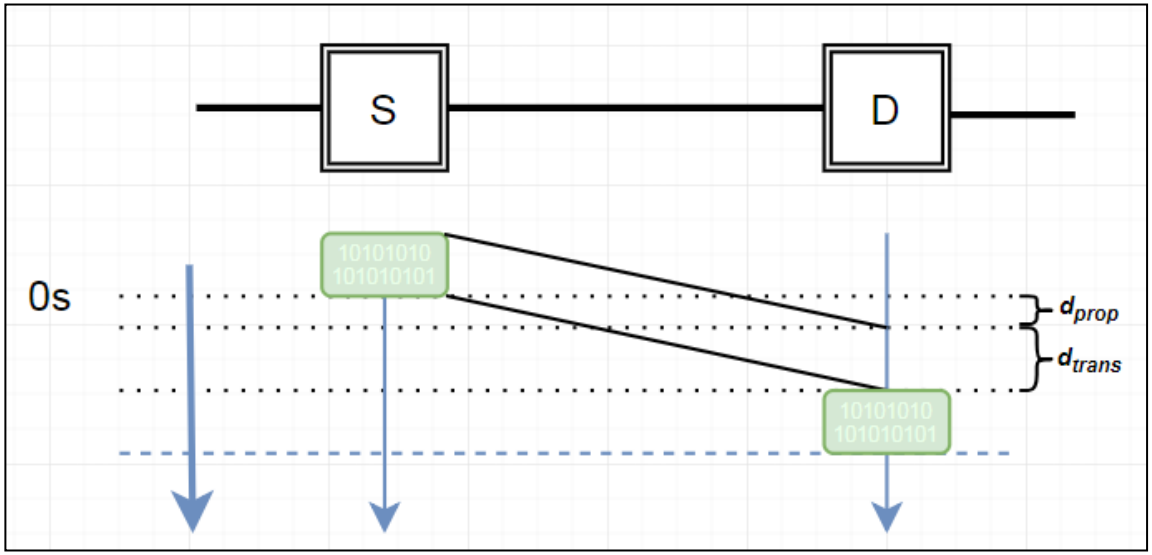
$$= 4\left(\frac{10Mb}{10Mb}s\right) + 2\left(\frac{5000km}{200000km}s\right)$$

$$= 4s + \frac{10000}{200000}s$$

$$= 4s + \frac{1}{20}s = 4.05s$$



5. (9 points) Suppose two hosts, A and B, are separated by 20 kilometers and are connected by a direct link of R=100Mbps. Suppose the propagation speed over the link is 2.5*10^8 meters/sec. Considering sending a file of 100,000 bits from A to B as one big message. Ignore the processing and the queuing delays. For parts a and c, express your final results in the unit of second.



a. (3 points) How long does it take to send the file? **Note, we count the time from the moment the first bit of the file leaves A until the moment the last bit arrives B.**

Answer: $1.08ms$

$$d_{trans} = \frac{L}{R} = \frac{1\times10^5 b}{100\times10^6 b}s = \frac{1}{1000}s = 0.001s$$

Justification: $d_{prop} = \frac{m}{s} = \frac{20\times10^3 m}{2.5\times10^8 m}s = \frac{20000m}{250000000m}s = \frac{2}{25000}s = 0.00008s$

$$d_{end-to-end} = d_{trans} + d_{prop} = \frac{L}{R} + \frac{m}{s} = 0.001s + 0.00008s = 0.00108s$$

b. (3 points) What is the maximum number of bits that will be in the link at any given time?

Answer: $8kb$

Justification:

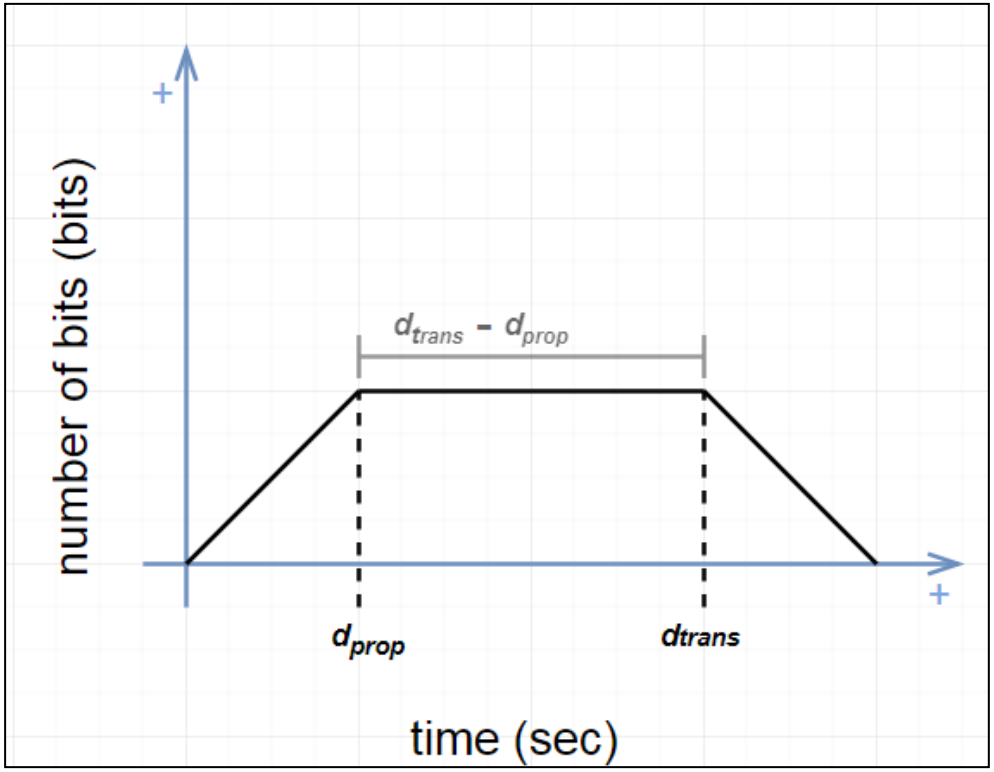
$d_{trans} > d_{prop}$

$$\max = \frac{Rm}{s} = \frac{100\times10^{6} b(20\times10^{3} m)\sec}{2.5\times10^{8} m\sec} = 8000b$$

c. (3 points) For how long time, the number of bits in the link is equal to the maximum number of bits (the quantity you derived in b.)?

Answer: 0.92ms

Justification:



$d_{trans} - d_{prop} = 0.001s - 0.00008s = 0.00092s$

6. (6 points) Suppose two hosts, A and B are separated by N-1 packet-switching switches, therefore N links. Each link is M meters long with transmission rate R bps. Assume propagation speed is S meters/sec. A needs to send a file to B. It breaks the file into K segments, each by the size of L bits, and sends them down the link.

   Derive a formula for the overall end-to-end delay as a function of M, S, L, R, K, and N.

   Answer: $d_{end-to-end} = \frac{M}{S}(N) + \frac{L}{R}(N-1+K) = \frac{RMN + SL(N-1+K)}{SR}$

   Justification (must show time table **clearly**):