EECS 325: Assignment 1

Shaochen (Henry) ZHONG, `sxz517`

Due and submitted on 02/06/2020
EECS 325, Dr. WANG

Question 1

1.a.

$$\text{Transmission Delay} = \frac{\text{Average Packet Length}}{\text{Transmission Rate}} = \frac{125 \cdot 8 \text{ bits}}{10^8 \text{ bits/s}} = 10^{-5} \text{ sec} \tag{1}$$

1.b.

$$\text{Traffic Intensity} = \frac{80 \cdot 1000 \cdot 125 \cdot 8 \text{ bits}}{10^8 \text{ bits}} = 0.8 \tag{2}$$

$$\Longrightarrow \text{Average Queue Length} = \frac{\text{Traffic Intensity}}{1 - \text{Traffic Intensity}} = \frac{0.8}{1 - 0.8} = 4 \text{ Packets} \tag{3}$$

1.c.

$$\text{Average Waiting Time} = \text{Average Queue Length} \cdot \text{Transmission Delay} = 4 \cdot 10^{-5} \text{ sec} \tag{4}$$

Question 2

2.a.

$$\text{Length of Packets} = \frac{10^7 \text{ bytes}}{1000 \text{ bytes}} \cdot (1000 + 60) = 1.06 \cdot 10^7 \text{ bytes} \tag{5}$$

$$d_{\text{trans}} = \frac{L}{R} = \frac{1.06 \cdot 10^7 \cdot 8 \text{ bits}}{4 \cdot 10^6 \text{ bps}} = 21.2 \text{ sec} \tag{6}$$

2.b.

$$\frac{\text{Goodput}}{R} = \frac{\text{Payload}}{\text{Length of Packets}} \tag{7}$$

$$\implies \text{Goodput} = \frac{10 \text{ mb}}{106 \text{ mb}} \cdot 4 \text{ mbps} = 3.77 \text{ mbps} \tag{8}$$

Question 3

3.a.

$$d_{\text{prop}} = \frac{\text{Distance Traveled}}{\text{Propagation Speed}} = \frac{2 \cdot 750 \cdot 1000 \text{ m}}{3 \cdot 10^8 \text{ m/s}} = 0.005 \text{ s} \tag{9}$$

3.b.

$$d_{\text{trans}} = \frac{L}{R} = \frac{1250 \cdot 8 \text{ bits}}{100 \cdot 10^6 \text{ bps}} = 0.0001 \text{ sec} \tag{10}$$

$$\text{Average Throughput} = \frac{L}{d_{\text{trans}} + \ 2(d_{\text{prop}})} = \frac{1250 \cdot 8 \text{ bits}}{0.0002 + 2(0.005)} = 990,099 \text{ bps} \tag{11}$$

3.c.

$$\begin{aligned} \text{Average Throughput} = \frac{x}{d_{\text{trans}} + \ 2(d_{\text{prop}})} = \frac{x \text{ bits}}{0.0001 + 2(0.005)} = 100 \cdot 10^6 \text{ bps} \\ \implies x = 1,010,000 \text{ bits} \end{aligned} \tag{12}$$

Question 4

4.a.

$$d_{\text{trans}} = \frac{1500 \cdot 8 \text{ mb}}{1 \text{ Mbps}} + \frac{1500 \cdot 8 \text{ mb}}{0.5 \text{ Mbps}} + \frac{1500 \cdot 8 \text{ mb}}{1 \text{ Mbps}} + \frac{1500 \cdot 8 \text{ mb}}{2 \text{ Mbps}} \tag{13}$$

$$= (12 + 24 + 12 + 6) \text{ ms} = 54 \text{ ms}$$

$$\implies \text{Total Time} = d_{\text{trans}} + d_{\text{prop}} = 54 + (2 + 20 + 30 + 2) = 108 \text{ ms} \tag{14}$$

4.b.

$$d_{\text{total}} = (3 \cdot d_{\text{trans}_1} + d_{\text{prop}}) + (2 \cdot d_{\text{trans}_2} + d_{\text{prop}}) + (d_{\text{trans}_3} + d_{\text{prop}}) + (d_{\text{trans}_4} + d_{\text{prop}}) \tag{15}$$

$$= (3 \cdot 12 + 2) + (2 \cdot 24 + 20) + (12 + 30) + (6 + 2) = 156 \text{ ms}$$

A - R1	R1 - R2	R2 - R3	R3 - B
1			
2	(1) sending 2, 3 queued		
3			
4	(2), 3, 4, 5	(1)	
5			(1)
6	(3), 4, 5, 6, 7	(2)	
7			(2)
8	(4), 5, 6, 7, 8, 9	(3)	
9			(3)
10	(5), 6, 7, 8, 9, 10, 11 added at the end of the timeframe as packet 5 is sent, and 6 becomes (6)	(4)	
11			(4)
12	(6), 7, 8, 9, 10, 11, 13 12 dropped	(5)	
13			(5)
14	(7), 8, 9, 10, 11, 13, 15 14 dropped	(6)	
15			(6)
16	(8), 9, 10, 11, 13, 15, 17 16 dropped	(7)	
17			(7)
18	(9), 10, 11, 13, 15, 17, 19 18 dropped	(8)	
19			(8)
20	(10), 11, 13, 15, 17, 19 20 dropped	(9)	
			(9)
	(11), 13, 15, 17, 19	(10)	
			(10)
	(13), 15, 17, 19	(11)	
			(11)
	(15), 17, 19	(13)	
			(13)
	(17), 19	(15)	
			(15)
	(19)	(17)	
			(17)
		(19)	
			(19)

Figure 1: Packets Queue Visualization from A to B

4.c.

Packet 12, 14, 16, 18, 20 will be dropped according to [Figure 1].

4.d.

4.d.a

The worst-case end-to-end delay from A to B will happen if a packet is considered to be the 6th packet in the queue of $R1$, as it is added due to one packet of $R1$ has just been sent. By such case such packet must wait through $5 \cdot d_{\text{trans}_2}$ plus a standard d_{total} calculated in *Question 4*.

$$\begin{aligned} d_{\text{max}_{AB}} &= 5 \cdot d_{\text{trans}_2} + d_{\text{total}} \\ &= 5 \cdot 24 + 108 = 228 \text{ ms} \end{aligned} \tag{16}$$

4.d.b

he worst-case end-to-end delay from B to A will happen if a packet is considered to be the 6th packet in the queue of $R3$, as it is added due to one packet of $R3$ has just been sent, then it encounters the scenario of **Section 4.d.a** By such case such packet must wait through $5 \cdot d_{\text{trans}_3}$ (there will be 5 packets queued since $d_{\text{trans}_4} = 2 \cdot d_{\text{trans}_3}$, an identical relationship as d_{trans_1} and d_{trans_2}), then $5 \cdot d_{\text{trans}_2}$, plus a standard d_{total} calculated in *Question 4*.

$$\begin{aligned} d_{\text{max}_{BA}} &= 5 \cdot d_{\text{trans}_3} + 5 \cdot d_{\text{trans}_2} + d_{\text{total}} \\ &= 5 \cdot 12 + 5 \cdot 24 + 108 = 288 \text{ ms} \end{aligned} \tag{17}$$