Rüstem Ozan ÖZDEMİR
1938935

HOMEWORK 1

1- $d_{tras} = \frac{L}{R}$ where $L_{max} = 200+800 = 1000$ bit

$R_{tras\text{-}S\text{-}R1} = 50\times10^6$ bit/sec

$R_{tras\text{-}R1\text{-}R2} = 20\times10^6$ bit/sec

$R_{tras\text{-}R2\text{-}D} = 100\times10^6$ bit/sec

$d_{prop} = \frac{d}{s}$ where $d_{S\text{-}R1} = 2\times10^3$ m

$d_{R1\text{-}R2} = 10\times10^3$ m

$d_{R2\text{-}D} = 2\times10^3$ m

$s = 2\times10^8$ m/sec

$d_{tras\text{-}S\text{-}R1} = \frac{10^3 \text{ bit}}{50\times10^6 \text{ bit/sec}} = 0.02\times10^{-3}$ sec $= 2\times10^{-5}$ sec

$d_{prop\text{-}S\text{-}R1} = \frac{2\times10^3 \text{ m}}{2\times10^8 \text{ m/sec}} = 1\times10^{-5}$ sec

$d_{tras\text{-}R1\text{-}R2} = \frac{10^3 \text{ bit}}{20\times10^6 \text{ bit/sec}} = 0.05\times10^{-3}$ sec $= 5\times10^{-5}$ sec

$d_{prop\text{-}R1\text{-}R2} = \frac{10\times10^3 \text{ m}}{2\times10^8 \text{ m/sec}} = 5\times10^{-5}$ sec

$d_{tras\text{-}R2\text{-}D} = \frac{10^3 \text{ bit}}{100\times10^6 \text{ bit/sec}} = 0.01\times10^{-3}$ sec $= 1\times10^{-5}$ sec

$d_{prop\text{-}R2\text{-}D} = \frac{2\times10^3 \text{ m}}{2\times10^8 \text{ m/sec}} = 1\times10^{-5}$ sec

Trasferring time of the packet from S to D:

$d = d_{prop\text{-}S\text{-}R1} + d_{tras\text{-}S\text{-}R1} + d_{prop\text{-}R1\text{-}R2} + d_{tras\text{-}R1\text{-}R2} + d_{prop\text{-}R2\text{-}D} + d_{tras\text{-}R2\text{-}D}$

$= 1\times10^{-5}$ sec $+ 2\times10^{-5}$ sec $+ 5\times10^{-5}$ sec $+ 5\times10^{-5}$ sec $+ 1\times10^{-5}$ sec $+ 1\times10^{-5}$ sec

$= 15\times10^{-5}$ sec $= 0.00015$ sec

2- a) Trasferring time of the packet from S to D:

$d = d_{prop\text{-}S\text{-}R1} + d_{tras\text{-}S\text{-}R1} + d_{prop\text{-}R1\text{-}R2} + d_{tras\text{-}R1\text{-}R2} + d_{prop\text{-}R2\text{-}D} + d_{tras\text{-}R2\text{-}D}$
$+ (n-1)^{*}\, d_{tras\text{-}R1\text{-}R2}$

where n: number of packets

$n = \frac{8\times10^6 \text{ bits (file size)}}{8\times10^2 \text{ bits/packet (data field)}} = 10^4$

$d = 15\times10^{-5}$ sec $+ 9999 \times 5\times10^{-5}$ sec

$= 50010\times10^{-5}$ sec $= 0.5001$ sec

(2)

2-b) Generally, long term average throughput is calculated by taking minimum of trasmission rate between links. Since the speeds and distances between links are different, throughput can be calculated as follows:

$$t = \frac{\text{Total bits}}{\text{Total delay time}} = \frac{10^3 \times 10^4 \text{ bits}}{0.5001 \text{ sec}} = 1.9996 \times 10^7 \text{ bits/sec} = 19.996 \times 10^6 \text{ bits/sec}$$

$$R_{throughput} = \min\{R_{tras-S-R1}, R_{tras-R1-R2}, R_{tras-R2-D}\}$$
$$= \min\{50\times10^6 \text{ bits/sec}, 20\times10^6 \text{ bits/sec}, 100\times10^6 \text{ bits/sec}\}$$
$$= 20\times10^6 \text{ bits/sec}$$

Thus, 19.996×10^6 bits/sec $\cong 20\times10^6$ bits/sec

c) on R1:
The second packet is received after $d_{tras-S-R1}$ seconds after the first packet and waits for the trasmission of the first packet. Therefore, the queueing delay for the 2nd packet:

$$d_{queue-2} = d_{tras-R1-R2} - d_{tras-S-R1} = 5\times10^{-5} \text{ sec} - 2\times10^{-5} \text{ sec} = 3\times10^{-5} \text{ sec}$$

10000th packet is received after $(10000-1)\times d_{tras-S-R1}$ seconds after the first packet and waits for the trasmission of the $(10000-1)$ packets. Therefore, the queueing delay for 10000th packet:

$$d_{queue-10000} = 9999\times d_{tras-R1-R2} - 9999\times d_{tras-S-R1}$$
$$= 9999\times5\times10^{-5} \text{ sec} - 9999\times2\times10^{-5} \text{ sec} = 29997\times10^{-5} \text{ sec}$$

As you can see from above, maximum queueing delay in R1 is 29997×10^{-5} sec.

on R2:
10000th packet is received after $(10000-1)\times d_{tras-R1-R2}$ seconds after the first packet and waits for the trasmission of the $(10000-1)$ packets. Therefore, the queueing delay for 10000th packet:

$$d_{queue-10000} = 9999\times d_{trans-R2-D} - 9999\times d_{tras-R1-R2}$$
$$= 9999\times1\times10^{-5} - 9999\times5\times10^{-5} = -39996\times10^{-5} \text{ sec (No wait)}$$

Maximum delay in R2 is zero.

3-a) To be obtain earliest time of packet lost, packet size can be considered as header(200 bit) + data field (1 bit) = 201 bit/packet

Total trasmission time of 201 bit/packet from S to R1:

$$d_{trans-S-R1} \times 201 \text{ bit/packet} = 402\times10^{-5} \frac{\text{bit*sec}}{\text{packet}}$$

At that time, trasmission time from R1 to R2:

$$x * d_{tras-R1-R2} = 402\times10^{-5} \frac{\text{bit*sec}}{\text{packet}}$$

$$x = \frac{402\times10^{-5} \frac{\text{bit*sec}}{\text{packet}}}{5\times10^{-5} \text{ sec}} = 80.4 \text{ bit/packet}$$

3-a) continue...

Other $201-80.4=120.6$ bit/packet should be wait on the buffer of R1 for no loss.

Router size $= 8\times10^5$ bit

$$\frac{8\times10^5 \text{ bit}}{120.6 \text{ bit/packet}} = 0.06633\times10^5 \text{ packet} = 6633 \text{ packet}$$

$$\text{Earliest time for first lost} = 6633 \times \frac{201 \text{ bit}}{50\times10^6 \text{ bit/sec}} = 26664\times10^{-6} \text{ sec}$$

3-b)

Input bit rate $= 201$ bit/packet

Output link rate $= 80.4$ bit/packet

After 6632 packet is delivered successfully, 6633th packet will be lost. After those processes nearly 3 out of 5 packages will be lost because $R_{trans\text{-}S\text{-}R1} = 50\times10^6$ bit/sec and $R_{trans\text{-}R1\text{-}R2} = 20\times10^6 \frac{\text{bit}}{\text{sec}}$

Although we have router buffer (8×10^5 bit), it can be ignored regarding total number of bits (200 bit header and 1 bit data field)

1) $(8\times10^6 - 6633)\times\frac{3}{4} = 4796020$ bit

2) 6633th packet (1 bit → loss)

Total number of loss (bit) $= 4796020 + 1 = 4796021$ bit

$$\text{Total number of loss (packet)} = \frac{4796021 \text{ bit}}{1 \text{ bit/packet}} = 4796021 \text{ packet (Router 1)}$$

Total number of delivered (bit) $= 8000000 - 4796021 = 3203979$ bit

$$\text{Total number of delivered (packet)} = \frac{3203979 \text{ bit}}{1 \text{ bit/packet}} = 3203979 \text{ packet (Router 1)}$$

Since Router 2 has no queueing delay time, incoming packet can pass through and no packet loss will happen.

Thus, total number of delivered (packet) $= 3203979$ packet (Router 2)

total number of loss (packet) $= 0$ packet (Router 2)