Comp 2322 Computer Networking

Homework One

Due time: 11:59pm, February 9, 2025, Sunday

Total marks: 10 points

Submission Requirements:

You need to submit the homework to the blackboard via Learn@PolyU on or before the due time. Late submission will cause the marks to be deducted 25% per day.

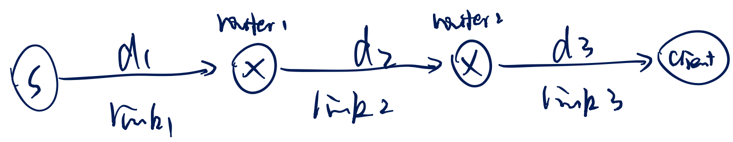
Questions:

1. Consider a packet of length L which begins at end system A and travels over three links to a destination end system. These three links are connected by two packet switches. Let d_i, s_i, and R_i denote the length, propagation speed, and the transmission rate of link i, for i = 1, 2, 3. The packet switch delays each packet by d_{proc}.

a) Assuming no queuing delays, in terms of d_i, s_i, R_i (i = 1,2,3), and L, what is the total end-to-end delay for the packet? (2 points)

b) Suppose the packet is 2,000 bytes, the propagation speed on all three links is 3×10^8 m/s, the transmission rates of all three links are 2 Mbps, the packet switch processing delay is 2 msec, the length of the first link is 3,600 km, the length of the second link is 3,000 km, and the length of the last link is 4,500 km. Please compute the end-to-end delay for the packet. (2 points)

a)



$$\text{Total Delay} = \left(\frac{d_1}{s_1} + d_{proc} + \frac{L}{R_1}\right) + \left(\frac{d_2}{s_2} + d_{proc} + \frac{L}{R_2}\right) + \frac{d_3}{s_3} + \frac{L}{R_3}$$

$$= 2\,d_{proc} + \left(\frac{d_1}{s_1} + \frac{L}{R_1}\right) + \left(\frac{d_2}{s_2} + \frac{L}{R_2}\right) + \left(\frac{d_3}{s_3} + \frac{L}{R_3}\right)$$

b) $R = 2 \times 10^6$ Bytes/sec $=$ 2000 Bytes/msec

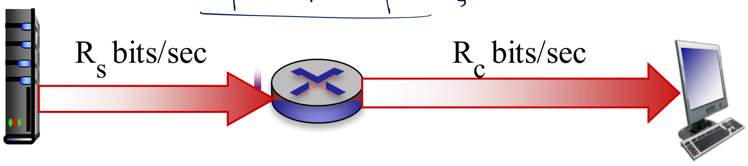
$d_1 = 3600\text{km}$ $\quad d_2 = 3000\text{ km}$ $\quad d_3 = 4500\text{ km}$

$$\text{Total Delay} = 2 \times 2\text{msec} + 3 \times \frac{L}{R} + \frac{d_1}{s} + \frac{d_2}{s} + \frac{d_3}{s}$$

$$= 4 + 3 + \frac{11100\text{ km}}{3 \times 10^8\text{ m/s}}$$

$$= 7 + \frac{1.11 \times 10^7}{3 \times 10^5\text{ m/sec}} = 44\text{ msec.}$$

2. Consider an end to end path from a server to a client shown as the figure. Assume that the links along the path from the server to the client are the first link with rate R_s bits/sec and the second link with rate R_c bits/sec. Suppose the server sends a pair of packets back to back to the client, and there is no other traffic on this path. Assume each packet of size L bits, and both links have the same propagation delay d_{prop}. Before: $\frac{L}{R}$, after: $\frac{d}{s}$



a) What is the packet inter-arrival time at the destination? That is, how much time elapses from when the last bit of the first packet arrives until the last bit of the second packet arrives? (2 points)

b) Now assume that the second link is the bottleneck link (i.e., $R_c < R_s$). Is it possible that the second packet queues at the input queue of the second link? Explain. (2 points)

c) Now suppose that the server sends the second packet T seconds after sending the first packet. How large must T be to ensure no queuing before the second link? Explain. (2 points)

(a) The throughput

$= \min(R_c, R_s)$

So when $R_c < R_s$, modelled as

$S \xrightarrow{R_c} \otimes \xrightarrow{R_c} D$

Router

So the inter-arrival time

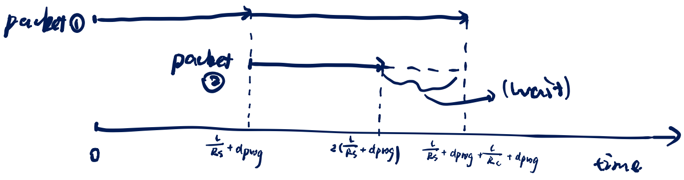
$= \frac{L}{R_c}$

Otherwise, $R_c \geq R_s$, inter-arrival time

$= \frac{L}{R_s}$

(b) The answer is yes, here's explanation.

we can draw the time line:

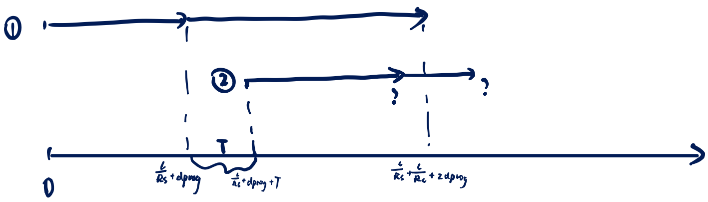


As $R_c < R_s$, $\frac{L}{R_c} > \frac{L}{R_s}$

$\therefore 2(\frac{L}{R_s} + d_{prog}) < 2d_{prog} + \frac{L}{R_s} + \frac{L}{R_c}$.

for packet ②, it has to wait $\Delta t = \frac{L}{R_c} - \frac{L}{R_s}$ to queue

(c)



when ② arrives at router.

Time elapsed $= \frac{L}{R_s} + d_{prog} + T + \frac{L}{R_s} + d_{prog}$.

So: to ensure ② will not queue:

$$2(\frac{L}{R_s} + d_{prog}) + T \geq \frac{L}{R_s} + \frac{L}{R_c} + d_{prog}$$

$$T \geq \frac{L}{R_c} - \frac{L}{R_s}.$$