Comp 2322 Computer Networking

<u>Homework One</u>

Due time: 11:59pm, February 5, 2024, Monday

Total marks: 10 points

<u>Submission Requirements:</u>

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.

<u>Questions:</u>

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 1,000 bytes, the propagation speed on all three links is 3×10^8 m/s, the transmission rates of all three links are 4 Mbps, the packet switch processing delay is 1 msec, the length of the first link is 4,200 km, the length of the second link is 2,400 km, and the length of the last link is 3,000 km. Please compute the end-to-end delay for the packet. (2 points)

a)

End-to-end delay for each link is transmission delay+ propagation delay+ number of processing delays between

So

transmission delay for link 1=L/R1

propagation delay for link 1=d1/s1

transmission delay for link 2= L/R2

propagation delay for link 2= d2/s2

transmission delay for link 3= L/R3

propagation delay for link 3= d3/s3

Total end-to-end delay= L/R1+ d1/s1+dproc+ L/R2+ d2/s2+dproc+ L/R3+ d3/s3

b)

Transform distance into meters, assume distance of link 1,2,3 as d1,d2,d3

d1 = 4,200 km = 4,200,000 m

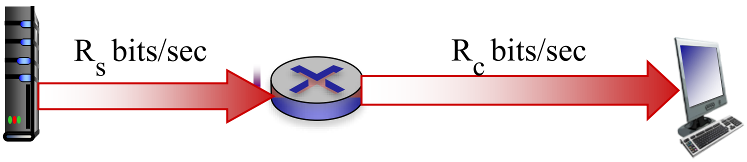
d2 = 2,400 km = 2,400,000 m
d3 = 3,000 km = 3,000,000 m
So according to formula above:
transmission delay for link 1=L/R1= 1,000 bytes / (4 Mbps / 8 bits/byte) = 2 ms
propagation delay for link 1=d1/s1= 4,200,000 m / (3×10^8 m/s) = 14 ms

transmission delay for link 2= L/R2= 1,000 bytes / (4 Mbps / 8 bits/byte) = 2 ms
propagation delay for link 2= d2/s2= 2,400,000 m / (3×10^8 m/s) = 8 ms

transmission delay for link 3= L/R3= 1,000 bytes / (4 Mbps / 8 bits/byte) = 2 ms
propagation delay for link 3= d3/s3= 3,000,000 m / (3×10^8 m/s) = 10 ms

dproc=1ms
Total end-to-end delay
= L/R1+ d1/s1+dproc+ L/R2+ d2/s2+dproc+ L/R3+ d3/s3
=2+14+1+2+8+1+2+10
=40 ms
The final end-to-end delay for the packet is 40ms

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}.



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)

If the last bit of the first packet arrives until the last bit of the second packet arrives which means the first link will be the bottleneck link, then second packet is queued at the first link waiting for the transmission of first packet.

So the packet inter-arrival time at the destination is simply the transmission delay for the first packet which is L/R_s.

b)

If it is assumed that the second link is the bottleneck link , it must be true that the second packet arrives at the input queue of the second link before the second link finishes the transmission of the first packet.

Which means the arrival time, First link< Second link

First link: $L/R_s + L/R_s + d_{prop}$

Second link: $L/R_s + d_{prop} + L/R_c$

$L/R_s + L/R_s + d_{prop} < L/R_s + d_{prop} + L/R_c$

The left hand side of the above inequality represents the time needed by the second packet to arrive at the input queue of the second link (the second link has not started transmitting the second packet yet).

The right hand side represents the time needed by the first packet to finish its transmission onto the second link.

c)

If we suppose that the server sends the second packet T seconds after sending the first packet, we will ensure that there is no queuing delay for the second packet at the second link if we have:

$L/R_s + L/R_s + d_{prop} + T >= L/R_s + d_{prop} + L/R_c$

$T>=L/R_s + d_{prop} + L/R_c-L/R_s- L/R_s -d_{prop}$

$T>= L/R_c-L/R_s$

So the minimum value of T is $L/R_c - L/R_s$ to ensure no queuing before the second link