**Comp 2322 Computer Networking**

**Homework One Solutions**

**Total marks: 10 points**

**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 , , and denote the length, propagation speed, and the transmission rate of link *i*, for *i* = 1, 2, 3. The packet switch delays each packet by .
2. Assuming no queuing delays, in terms of , , (i = 1,2,3), and *L*, what is the total end-to-end delay for the packet? (2 points)

Ans:

The first end system requires to transmit the packet onto the first link; the packet propagates over the first link in ; the packet switch adds a processing delay of ; after receiving the entire packet, the packet switch connecting the first and the second link requires to transmit the packet onto the second link; the packet propagates over the second link in ; the second packet switch also adds a processing delay of ; Similarly, the second packet switch requires to transmit the packet onto the third link, and the packet propagates over the second link .

So the total end-to-end delay is

1. Suppose the packet is 1,500 bytes, the propagation speed on all three links is m/s, the transmission rates of all three links are 3 Mbps, the packet switch processing delay is 2 msec, the length of the first link is 4,500 km, the length of the second link is 3,000 km, and the length of the last link is 1,500 km. Please compute the end-to-end delay for the packet. (2 points)

Ans:

(s)

1. 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 bits/sec and the second link with rate 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 .

Rc bits/sec



Rs bits/sec

1. 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)

Ans:

Denote the first packet as A and the second packet as B.

If the bottleneck link is the first link (), then packet B is waiting at the first link for the transmission of packet A. So the packet inter-arrival time at the destination is the packet B’s transmission delay at the first link .

If the bottleneck link is the second link (), packet B is waiting at the second link for the transmission of packet A. So the packet inter-arrival time at the destination is the packet B’s transmission delay at the second link .

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

Ans:

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) is

The time needed by the first packet to finish its transmission onto the second link is

If the second link is the bottleneck link (i.e., ), then

Thus, the second packet must arrive at the input queue of the second link before the second link finishes the transmission of the first packet.

1. 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)

Ans:

If we send the second packet *T* seconds later, to ensure that there is no queuing delay for the second packet at the second link, we should have:

Then,

Thus, the minimum value of T is .