

Computer Communication Networks: Homework #1

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Q1

Suppose users share a 6 Mbps link, and the total number of users is 4. Also suppose each user transmits continuously at 2 Mbps when transmitting, but each user transmits only 40 percent of the time. (See the discussion of statistical multiplexing in Section 1.3.)

A) When circuit switching is used, how many users can be supported?

$$n_{max} = \frac{B_{out}}{B_{in}} = \frac{6\text{Mbps}}{2\text{Mbps}} = 3 \text{ Users}$$

B) Find the probability that a given user is transmitting.

$$p_{not\ 0} = \binom{4}{0} (0.4)^0 (1 - 0.4)^{4-0} = 0.216 \rightarrow p_{not\ 0} = 1 - 0.1296 = 0.8704$$

C) Find the probability that only one of the four users is transmitting.

$$p_1 = \binom{4}{1} * (0.4)^1 (1 - 0.4)^{4-1} = 0.3456$$

D) Find the probability that at any given time, all four users are transmitting simultaneously. Find the fraction of time during which the queue grows.

$$p_{all} = \binom{4}{4} * (0.4)^4 (1 - 0.4)^{4-4} = 0.0256$$

Now, the queue grows when there are more active users than there is possible active links, therefore, the fraction of time probability is the same as P(4) which is 2.56%.

Q2

A) How long does it take a packet of length 3,000 bytes to propagate over a link of distance 3,5000 km, propagation speed $2.4*10^8$ m/s, and transmission rate 16 Mbps?

$$d_{prop} = \frac{distance}{speed} = \frac{35,000}{2.4 * 10^8 \text{m/s}} \approx 0.1458s \approx 145.8ms$$

B) More generally, how long does it take a packet of length L to propagate over a link of distance d, propagation speed s, and transmission rate Rbps?

The general form of the propagation delay is:

$$d_{prop} = \frac{distance}{speed}$$

C) Does this delay depend on packet length?

The delay does not depend on the packet length. Delay is a function of only distance and speed and not the length.

D) Does this delay depend on transmission rate?

No. The transmission rate does not effect the delay whatsoever since it is, again, only based on the speed of the physical medium and the length between the 2 devices.

Q3

Suppose Host A wants to send a large file to Host B. The path from Host A to Host B has three links, of rates R1=800 kbps, R2=4 Mbps, and R3=1 Mbps.

A) Assuming no other traffic in the network, what is the throughput for the file transfer?

Throughput is always limited by the slowest link therefore the throughput 800kpbs.

B) Suppose the file is 4 million bytes. Dividing the file size by the throughput, roughly how long will it take to transfer the file to Host B?

If a file is 4 million bytes, then it is 32 million bits. The time it takes is then the following algebra:

$$Time = \frac{Size}{Throughput} = \frac{32 * 10^6}{800 * 10^3} = 40 \text{ seconds}$$

C) Repeat (A) and (B), but now with R2 reduced to 600 kbps.

When reduced to 600 kbps, the time taken is now...

$$Time = \frac{Size}{Throughput} = \frac{32 * 10^6}{600 * 10^3} \approx 53.33 \text{ seconds}$$

Q4**A) Which layers in the Internet protocol stack does a router process?**

The protocol layers used in a router is the Physical, Link, and Network layer.

B) Which layers does a link-layer switch process?

The layers that the switch uses are the Link and Physical layer.

C) Which layers does a host process?

The host covers all 5 layers, that being the Application, Transport, Network, Link, and Physical layers.

Q5

Equation $d_{end-to-end} = \frac{N*L}{R}$ (Equation 1.1 in textbook) gives a formula for the end-to-end delay of sending one packet of length L over N links of transmission rate R. Generalize this formula for sending P such packets back-to-back over the N links.

$$d_{end-to-end} = (N + P - 1) * \frac{L}{R}$$

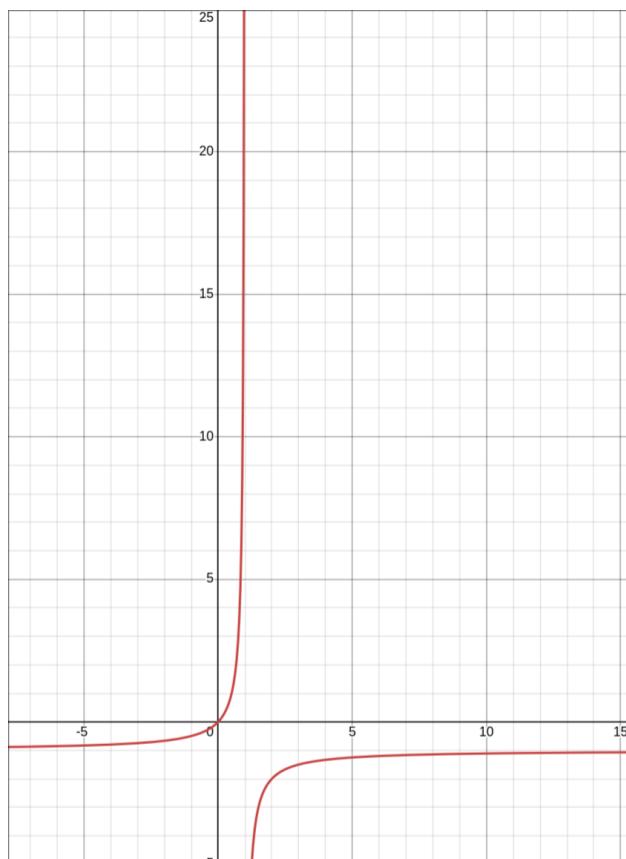
Q6

Consider the queuing delay in a router buffer. Let I denote traffic intensity, that is, $I = \frac{L*a}{R}$. Suppose that the queuing delay takes the form $\frac{I*L}{R*(1-I)}$ for $I < 1$.

A) Provide a formula for the total delay, that is, the queuing delay plus the transmission delay.

$$d_{total} = d_{queueing} + q_{trans} = \frac{I * L}{R * (1 - I)} + \frac{L}{R} = \frac{L}{R} * \left(\frac{I}{1 - I} + 1 \right) = \frac{L}{R} * \left(\frac{I}{1 - I} + \frac{1 - I}{1 - I} \right) = \frac{L}{R} * \left(\frac{1}{1 - I} \right) \rightarrow \\ \frac{L}{R} * \left(\frac{1}{1 - \frac{L*a}{R}} \right)$$

B) Plot the total delay as a function of $\frac{L}{R}$.



Q7

Consider the Figure below. Suppose that each link between the server and the client has a packet loss probability p , and the packet loss probabilities for these links are independent.

A) What is the probability that a packet (sent by the server) is successfully received by the receiver?

The probability that a packet is successfully received by the receiver is just the probability that all N links successfully received it. Therefore, it is simply the following:

$$P_{success} = (1 - p)^N$$

B) If a packet is lost in the path from the server to the client, then the server will re-transmit the packet. On average, how many times will the server re-transmit the packet in order for the client to successfully receive the packet?

If a packet is lost in the path, the amount of retries that a packet has to be sent before it succeeds is the following:

$$\text{average retries} = \frac{1}{(1 - p)^N} - 1$$