CSE3300/CSE5299: Computer Networking
Homework 1
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Due Date: 9/12, 2022, Monday. Submission through HuskyCT.

Full score: 100 for CSE3300 students; 120 for CSE5299 students (will be normalized to 100 when entering the grade in HuskyCT).

1. Packet-switched network and circuit-switched network (20 points). Consider an application that transmits data at a steady state (e.g., the sender generates an *N*-bit unit of data every *k* time units, where *k* is small and fixed). Also, when such an application starts, it will continue running for a relatively long period of time. Answer the following questions. Briefly justify your answers.

   a. (10 points) Would a packet-switched network or a circuit-switched network be more appropriate for this application? Why?

- If the data being sent is steady, the better network would most likely be circuit switched, due to the fact that a circuit switch network is a dedicated "pipe" between 2 points. As a result, the data being sent is an uninterrupted stream, is used enough to warrant its own line (unlike packets, which isn't always steady), and resources are already allocated as the data doesn't need to be forwarded anywhere, meaning better efficiency.

   b. (10 points) Suppose that a packet-switched network is used and the only traffic in this network comes from such applications as described above. Furthermore, assume that the sum of the application data rates is less than the capacities of each and every link. Will the network be congested? Why?

- There would be no congestion due to the fact that the net data rates are less than the capacities of every link. Even if they would theoretically be sending data through every available link simultaneously, there still would be very little queueing occurring because of the available bandwidth.

2. Circuit switching and packet switching (25 points). Suppose a group of users share a 1 Mbps link. Each user requires 100 Kbps when transmitting, but each user transmits only 20% of the time.

a. (10 points) When circuit switching is used, how many users can be supported?

- It can be calculated by doing 1Mbps/100Kbps, which is 10 people.

b. (15 points) Suppose packet-switching is used. If there are 50 users, use the binomial distribution to compute the probability that more than 10 of the 50 users are transmitting simultaneously at any given time. (Hint: You can write a program to compute this probability.)

- Using a simple binomial probability, we have users = n = 50 and probability=p =10/50=20% and we use the equation $(n\,x)\,p^{x}(1-p)^{n-x}$. As a result, we end up getting P(x = 10) = 0.42, where x is users transmitting simultaneously.

3. Transmission delay and propagation delay (15 points). Suppose two hosts, *A* and *B*, are connected by a 10 Mbps link. The length of a packet is 12 Kb (Kilobits, i.e., 12 $\times 10^3$ bits or 1500 bytes). The length of the link is 10 km. Assume that signals propagate at the speed of light (i.e., the ideal speed of 3×10^8 m/s (meters per second)).

a. (7 points) What is the propagation delay from *A* to *B*?

- Tp = D/S = $\frac{10000m}{3x10^{8}}$ = $\frac{1}{30000}$ = $3.333x10^{-5}$s

b. (8 points) What is the transmission delay of the packet at *A*?

- Tt = L/R = $\frac{12Kb}{10Mbs}$ = $\frac{1.2x10^{4}}{1x10^{7}}$ = 0.0012s

4. End-to-end delay (25 points). Consider a packet of length 1,000 bytes that begins at end system *A* and travels over three links to a destination end system *B*. These three links are connected by two packet switches. The propagation speed on all three links is 2.5×10^8 m/s, the capacity of the three links is 20 Mbps, 100 Mbps and 30 Mbps, respectively, the packet switch processing delay is 1 msec, and the lengths of the three links are 500 km, 200 km, and 700 km, respectively. Suppose there is no queuing delay. What is the end-to-end delay? Describe the components in the end-to-end delay and show intermediate steps.

- The end to end delay from system A to B is, found by using the equation $\Sigma(dproc + (\frac{L}{R}) + (\frac{D}{S}))$ for multiple different links, where dproc is the processing delay (1ms), L is the length of link, R is the bandwidth, D is the physical link length, and S is the propagation speed. First, we need to convert everything to bits so 1000 bytes is 8000 bits, 20 Mbps is $2x10^7$bits, 100Mbps is $1x10^8$, and 30 Mbps is $3x10^7$. We have each link be counted as Li, so as a result, using the equation, L1 is 0.0034s, L2 is 0.0019s, and L3 is 0.0041s. Adding these individual link delays gets us a total of 0.0094s of delay.

5. Calculate the mean and the standard deviation of round-trip times (15 points). In this problem, we will use a widely-used program, "ping". You may want to read about it if you are not already familiar with it (e.g., type "man ping" in Google).

   a. (5 points) Describe briefly the function of "ping".

      - The Ping function is "used to gauge the reachability of any site or address on the Internet. It returns the time taken by the ping (a packet of data) to reach that address and return back to the sender".

   b. (5 points) Try using "ping" on your computer. Specifically, use 5 probes, each probe of 40 bytes, to obtain 5 samples of round-trip times from the machine you are using to a destination machine that you choose (e.g., www.uconn.edu). List the command you use and the results you get.

      - Used the commands "ping www.uconn.edu -l 40" and typed that in 5 times

   c. (5 points) Calculate the mean and the standard deviation of the round-trip times.

      - Received the 5 times: 2ms, 3ms, 2ms, 2ms, and 5ms, meaning that

        Mean: $\frac{2+3+2+2+5}{5}$ = 2.8ms

      Standard Deviation: using $\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(x_i - \mu)^2}.$ the deviation is 1.166