CS244a: An Introduction to Computer Networks

Problem Set #1: Due 12noon, Tuesday 22nd January 2008.

Your solution should be handed to Ann Coulthard in Gates 351, or in the box outside her door.

Pay close attention to units. A byte of storage is 8-bits, and 1-kilobit of storage is 1024 bits. By convention, the rules are different between storage and data rate: 1kb/s is 1,000 bits per second. Show your reasoning clearly. If your reasoning is correct, but your final answer is wrong, you will receive most of the credit. If you just show the answer without reasoning, and your answer is wrong, you may receive no points at all. Hand in your solution on separate paper.

1. **(4 points) General Probability.**
   (a.) If there are 50 students taking CS244a, what is the probability that none of them has a birthday on the first day of class? (Assume there are exactly 365 days in a year).
   (b.) How many students would there need to be in the class for the probability in (a) to be less than 50%?
   (c.) What is the probability that five years running, no student has a birthday on the first day of class? (Assume the same number of students takes the class each year, and no-one retakes the class).
   (d.) Would your answer to (c) be larger or smaller if one or more students retook the class within the five year period?

2. **(10 points) General**. The buffer in a router contains, on average, 256 kbytes of data. We find that the average length of a packet is 200 bytes, and that a packet is buffered, on average, 12ms by the router.
   (a.) Assuming that no packets are dropped by the router, what is the average arrival rate? Express your answer in *bits* per second.
   (b.) Now assume that because of a malfunction, the router arbitrarily and randomly drops 25% of the arriving packets. Assuming the same arrival rate as in part (a), what is the average delay of a packet in the router? Express your answer in milliseconds.

3. **(9 points) General.** You are given a communication link that transmits *R* bits per second. The objective is to transmit a file of length *L* bits. The bits are sent in packets; *P* bits of the file are sent in each packet, except for the last which contains all the leftover bits. A header of length *H* bits is added to each packet before it is transmitted over the link. Consecutive packets must be separated by at least *G* seconds. Write down an expression for the total time to transmit the file.

4. **(4 points)** Chapter 1, Kurose and Ross: Question 6 (page 71)
5. **(4 points)** Chapter 1, Kurose and Ross: Question 8 (page 71)
6. **(4 points)** Chapter 1, Kurose and Ross: Question 12 (page 72)
7. **(4 points)** Chapter 1, Kurose and Ross: Question 22 (page 74)

8. **(5 points).** A FIFO queue has the following cumulative arrival process: $A(t) = 100 + t$. The outgoing link operates at 4bits/second. Each time the queue goes empty, the outgoing link goes idle until there are 100 bits in the queue, and starts operating again at 4bits/second.

Write down expressions for the queue occupancy, $X(t)$, the time-average queue occupancy $\overline{X}$, and the delay of a single bit through the queue, $d(t)$.

9. **(Bonus Question).** We flip a coin with equal probability of landing heads or tails. We want to know the expected number of coin flips it takes for two different sequences to occur:

   Sequence 1: *Tails, Heads, Tails*
   Sequence 2: *Tails, Heads, Heads*

   Which of the following are true (starting from scratch):
   (a.) The expected number of flips until each sequence occurs is the same.
   (b.) The expected number of flips until Sequence 1 is longer than for Sequence 2.
   (c.) The expected number of flips until Sequence 2 is longer than for Sequence 1.