KING FAHD UNIVERSITY OF PETROLEUM & MINERALS

COLLEGE OF COMPUTER SCIENCES & ENGINEERING

COMPUTER ENGINEERING DEPARTMENT

COE 540 – Computer Networks

Assignment 3 – Due Date April 7th, 2012

Problem #	Maximum Mark	Mark
1	40	
2	40	
3	30	
4	30	
5	30	
6	20	
7	40	
Total	210	

Problem (1): On the subject of discrete Markov chains.

(40 points) Data in the form of fixed-length packets arrive in slots on the **two** input lines of a multiplexer. A slot contains a packet with probability p, independent of the arrivals during other slots or on the other line. The multiplexer transmits one packet per time slot and has the capacity to store **one** packet only. If no room for a packet is found, the packet is dropped.

a) **(10 points)** Let N be the number of packets arriving to the multiplexer in a *given* time slot. Specify the probability distribution for *N* and its name. Compute the mean for N.
b) **(5 points)** Draw the state diagram and specify the 1-step probability transition matrix ***P*** – The state is taken to be the number of packets in the multiplexer.
c) **(10 points)** For p = 0.3 compute the mean multiplexer throughput in packets per time slot and the probability of packet drop from the multiplexer buffer.
d) **(5 points)** Repeat part (c) for p = 0.8.
e) **(10 points)** Repeat part (c) for an arbitrary value of p.

Problem (2): On the subject of basic queueing models.

(40 points) Consider an M/M/1 queueing system where the average arrival rate of customers is equal to $\lambda = 0.5$ customers per time unit while the average service rate is equal to $\mu = 1$ customers per time unit.

a) (10 points) Let the number of customers arriving in a certain period of t time units be a random variable denoted by A. Specify the probability distribution of the random variable A. What is the probability that 0 customers arrive in 1 time unit? What is the probability that 100 customers arrive in 1 time unit?
b) (10 points) Let the service time taken by a customer, in time units, be denoted by τ. Specify the distribution of the random variable τ and its mean. Compute the probability that the service time τ be greater than 1 time unit? Compute the probability that the service time τ be less than 1 time unit?
c) (4 points) What is the average utilization of the queueing system specified in this problem at steady state? Compute the probability that system is ideal?
d) (2 points) What is the probability that the system has only 10 customers?
e) (4 points) If the system is observed for long enough time, what is the fraction of time when the number of customers in the system are 10 or above?
f) (10 points) Compute the mean waiting time for a customer in buffer before it is served?

Problem (3): On the subject of basic queueing model.

(30 points) A c-line Private Branch Exchange (PBX) system can be modeled as a queue with no buffering space and finite number of servers *c*. The model is denoted by M/M/c/c. Let the arrivals process for this PBX be a Poisson process with rate λ incoming calls per second, and the average call holding time be $E[\tau] = 1/\mu$ seconds (i.e. μ is the average service rate in calls per second). Let $c = 4$, λ = 0.5, and $\mu = 0.25$.

a) **(10 points)** Draw the equivalent state transition diagram for the PBX.
b) **(4 points)** Compute the probability of an incoming phone call finds all phone lines free.
c) **(6 points)** Compute the probability of an incoming phone call being blocked.
d) **(10 points)** If the computed blocking probability in part (c) is not acceptable and it is desired to reduce the blockage to 1%. What is the number of output phone lines required for the PBX?

Problem (4): On the subject of M/G/1 queues.

(30 points) Assume traffic is arriving at the input port of a router according to a Poisson arrival process of rate λ = 100 packets/sec. If the traffic distribution is as follows:

20% of packets are 256 Bytes long,
40% of packets are 512 Bytes long,
30% of packets are 1024 Bytes long,
10% of packets are 4096 Bytes long

If the transmit speed of the router output port is 1.5 Mb/s

a) Plot the probability mass function for the packet size in bytes?
b) Plot the cumulative distribution function for the packet size in bytes?
c) Compute the mean and standard deviation for both the packet size and also the packet service time.
d) Compute the utilization ρ for the queue and the probability of the system being idle.
e) Compute the average number of packets in the system, $\mathrm{E}[\mathrm{N}]$.

Problem (5): On the subject of error codes.

(30 points) Suppose that data are transmitted in blocks of sizes 2048 bits. It is desired to transmit a file whose size is 2 M bits. What is the maximum bit error rate under which error detection and retransmission mechanism (1 parity bit per block) is better than using Hamming code? Assume that bit errors are independent of one another and no bit error occurs during retransmission.

Problem (6): On the subject of error codes.

(20 points) A bit string 1001 1101 is transmitted using standard CRC method described in text. The generator polynomial is $x^3 + 1$.

a) Compute the transmitted frame $T(x)$

b) Suppose that the third bit from left is inverted during transmission. Specify the error syndrome polynomial $E(x)$

c) Show that the error in part (c) is detectable.

d) Give an example of bit errors in the bit string transmitted that will not be detected at the receiver.

Problem (7): On the subject of PPP protocol.

(40 points) Consider the PPP protocol discussed in class

a) Give at least one reason why PPP uses byte stuffing instead of bit stuffing to prevent accidental flag bytes within the payload from causing confusion.

b) What is the minimum overhead to send an IP packet using PPP? Count only the overhead introduced by PPP itself, not the IP header overhead. What is the maximum overhead.