ELEN E6761: Communication Networks
Midterm Exam

Oct. 21, 2014

Name

Question 1	10	
Question 2	30	
Question 3	40	
Question 4	20	
Total	100	

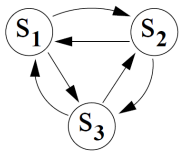
Please Read Carefully Before You Start:

- You are allowed to use one page formula sheet, however you should use your own formula sheet and are not allowed to exchange it with someone else's during the exam.
- The time limit is 1 hour and 30 minutes.
- If additional space is needed, use the back of the page for each problem.
- Show your work and clearly write all the steps. If you use a theorem or property, you should mention the name of the theorem or describe the property, otherwise you will not get full credit.

Version A

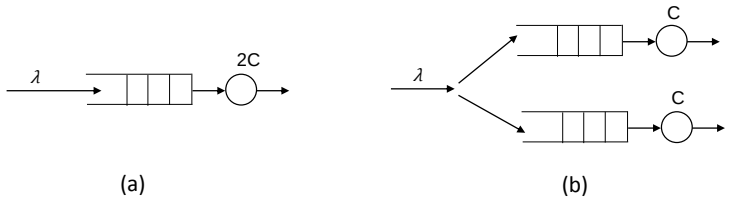
Question 1. (10 points) Circle the correct answer:

1. (2 points) The IP (routing protocol) corresponds to which layer of the protocol stack:
   (a) Physical layer
   (b) Link layer
   (c) Network layer
   (d) Transport layer
   (e) Application layer.
2. (2 points) WiFi in an standard for which layer of the protocol stack:
   (a) Physical layer
   (b) Link layer
   (c) Network layer
   (d) Transport layer
   (e) Application layer.
3. (2 points) Strategies such as FDMA and TDMA
   (a) are more suitable for bursty traffic than for constant rate traffic
   (b) are more suitable for constant rate traffic than for bursty traffic
4. (2 points) Consider a transmission line with capacity C. Suppose each user transmits at peak rate R for 90% of the time and remains silent 10% of the time. What is the best way to allocate the capacity among the users to accommodate more than C/R users?
   (a) circuit switching
   (b) packet switching
5. (2 points) What is the period of the following discrete-time Markov chain



   (a) 1
   (b) 2
   (c) 3
   (d) 4

Question 2. (30 points) Consider the following two systems when packets arrive as a Poisson process with rate λ and packet sizes are iid exponentially distributed with mean $\frac{1}{\mu}$ bits. In system (a), there is one (unlimited) buffer and all the packets are served by one server at rate $2C$ bits/second. In system (b), there are two (unlimited) buffers, each with a server that serves at rate C bits/second, and each arriving packet is randomly routed to one of the buffers with probability 0.5.



(i) (10 points) What is the stability condition of each system?

(ii) (20 points) Calculate the average time that a packet spends in each system. Which system is better?

Question 3. (40 points) Consider a slotted ALOHA system with n backlogged stations and one receiver. Each station attempts a transmission in any time slot with probability q. Assume that the stations are backlogged all the time.

1. (10 points) Suppose the receiver can receive at most one packet in each time slot. What is the probability that it takes exactly k time slots for a transmission to be successful?

2. Now suppose the receiver is improved so that if no more than *two* stations transmit in the same slot, both packets are received correctly. Therefore collision takes place only if three or more stations transmit during the same slot.

   (a) (15 points) What is the throughput (r) as a function of n and q?

(b) (10 points) What is the optimal q^* to maximize the throughput in part (a)?

(c) (5 points) Suppose n is very large. Find an approximate expression for the maximum throughput of the system.

Question 4. (20 points) Consider a simple $M/M/1$ queue with arrival rate "λ" and mean service time "m".

(a) (10 points) What is the probability that an arriving customer does not have to wait in buffer in order to get service?

(b) (10 points) Suppose the customer arrives at an empty queue. What is the probability that the customer leaves the system before the next customer arrives?