CMPE 107 Spring 2015 **Take-Home Exam**

MUST BE SUBMITTED IN HARD COPY BY JUNE 10 NO LATER THAN 5PM

Grading system: presentation = 25%, content = 75%

Name:

1. (20 points) M/M/1 and M/M/1/K queuing system: Consider the M/M/1/K queuing system [see Lecture 14 notes].

(a) Compute the variance of the number of users in the M/M/1 system

(b) For the M/M/1/K system show that, for $\rho < 1$,

$$\pi_n = \frac{\rho^n(1-\rho)}{1-\rho^{K+1}} \quad n = 0,\ 1, 2, \ldots, K-1;\ \rho = \frac{\lambda}{\mu}$$

$$\overline{N} = \frac{\rho}{1-\rho} - \frac{(K+1)\rho^{K+1}}{1-\rho^{K+1}}$$

2. (15 points) 1-persistent CSMA: Consider the 1-persistent CSMA example we discussed in class.

(a) Prove that

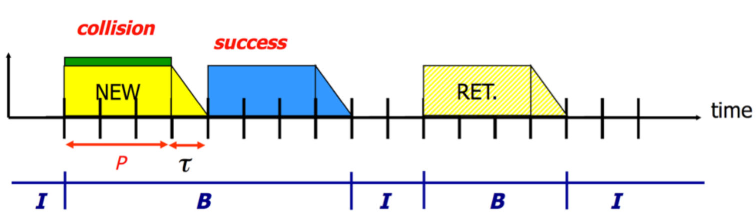
$$\pi_0 = \frac{P_{10}}{1+P_{10}}; \quad \pi_1 = \frac{P_{10}+P_{11}}{1+P_{10}}; \quad \pi_2 = \frac{1-(P_{10}+P_{11})}{1+P_{10}}$$

Discuss whether other equations for the state probabilities are possible.

(b) Explain why the approximations for P_{10} and P_{11} are valid.

(c) Compute the approximated throughput of the system. Is the result in the slide shown in class correct? You can never tell when I write the slides!

3. (30 points) Slotted CSMA: Consider CSMA with non-persistent carrier sensing. The channel is time-slotted with a time slot lasting one propagation delay (τ), as shown in the figure below. Assume the same assumptions we made for the discussion of CSMA and slotted ALOHA. Namely: Poisson arrivals with parameter λ, fixed packet lengths of duration P seconds, a fully-connected network with all nodes having τ seconds of propagation delay from each other, and a magical secondary channel over which ACKs are sent without error in zero time.



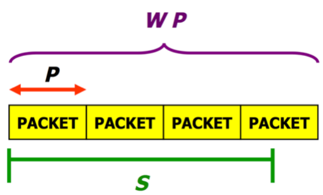
(a) Using a similar approach to the one we discussed for slotted ALOHA, computer the throughput of the protocol.

(b) Discuss [not compute] what changes you would need to do to the analysis in order to consider the existence of acknowledgments being sent over the same channel.

(c) Compare your result with the result we obtained in class for CSMA. What benefits [if any] do you see in the analysis of CSMA using a time-slotted channel from the standpoint of performance analysis?

4. (20 points) "Wireless Ethernet channel access": As we discussed in class, CSMA improves on the performance of ALOHA tremendously. The remaining limitation is that, once a packet is sent, feedback occurs a round-trip time after the entire packet is transmitted. The solution to improve on the performance of CSMA is to listen to the channel while a packet is being sent. This is called *collision detection,* and we discussed this in class. However, in wireless systems like WiFi cards, nodes cannot listen to the channel while transmitting. You are asked to think of what CSMA/CD does, the analysis we did, and propose a way to emulate CSMA/CD but having nodes that are "half-duplex" [can transmit or receive but not at the same time]. You can use ANY published approach or your own. However, you also have to DISCUSS how you would analyze the throughput of your proposal based on the analysis method we discussed over the last few lectures.

5. (15 points) Why TCP can be better than stop-and-wait ARQ: Consider the selective repeat ARQ scheme. Assume that each packet lasts P sec., and that the sender and receiver have a buffer of W packets that is large enough so that $W \times P > S$, where S is the time needed for a packet to be correctly acknowledged by the receiver to the sender [see class notes on ARQ analysis], as shown in the figure below for a buffer of size $W = 4$.



Also assume that W is so large that is in effect infinite, and that the retransmission timeout T is such that $T > S$, and that the probability that a packet and its ACK are delivered correctly is $1 - p$. Show that the efficiency of this ARQ scheme equals $1 - p$.

Hint: Use the approach we used for stop-and-wait ARQ but be careful on considering time elapsed or attempts.