CSE 4215/5431: Mobile Communications
Assignment 1 (Released Feb 4, 2010)
Submission deadline: 5:30 pm, Feb 18, 2010

1. The assignment can be handwritten or typed. It MUST be legible.
2. You must do this assignment individually.
3. Using a source without proper citation is an instance of academic dishonesty.

Question 1

In this problem we will walk through the derivation of the medium utilization in ALOHA and slotted ALOHA. This is probably derived in many textbooks. You will learn much more if you work through this question without looking at other sources.
The analysis assumes that packets (frames) are of length L and the data transmission rate is R (note that this abstracts away the modulation scheme and other physical layer details). Since nodes in ALOHA do an exponential backoff upon collisions, it is reasonable to assume that the number of packets arriving in any interval follows the Poisson distribution. If you do not recall what this is, feel free to look up books, wiki or other sources. You need not cite these sources. Incidentally Poisson distributions are used to model the number of telephone calls placed in an unit of time in traditional telephony and decades of logs from phone companies have shown that this is a good model.
Notice that if a packet was transmitted at time t, no other packet should have been transmitted in the time interval $(t - X, t + X)$ where $X = R/L$ is the duration of a packet transmission.
(a) Using the Poisson transmission with rate λ, write down an expression for the probability that no other packets are transmitted in the interval $(t - X, t + X)$.
(b) Using calculus, derive the value of λ at which the expression derived in part (a) is maximized.
(c) What is the corresponding throughput? Hint: in a stable system, the rate at which packets enter the system is equal to the rate at which packets leave the system.
(d) Now consider slotted ALOHA. In this protocol, time is divided into slots, each of length X. A packet can arrive anytime but can only be transmitted in the next slot. Thus a packet being transmitted in slot k can collide only with another that arrived during slot $k - 1$. Assuming again that the arrivals obey a Poisson distribution with rate λ, write down an expression for the probability that there is no collision during a time slot.
(e) Optimize λ and find the maximum possible throughput.

Question 2

In this problem we will learn a quantitative model often used in traffic engineering. The Erlang B equation expresses the relationship between the probability of blockage $B(N, \rho)$ to the number of channels N and the normalized call density $\rho = \lambda/\mu$ where λ is the call arrival

rate and μ is the service rate or inverse of the average call duration. The Erlang B formula is

$$B(N, \rho) = \frac{\rho^N / N!}{\sum_{i=1}^{N} \rho^i / i!}$$

Use this formula to solve the following problem.
To provide telephone access to commercial ferries a company installs a multi-channel wireless telephone system in a ferry. The wireless radio system connects to a base station on the shore through the air. The base station is connected to the traditional phone system using wires.
(a) If the company installs a 4-channel system, what is the probability if having a person come to the phone and finding that all lines are busy? Assume that the average length of a telephone call is 3 minutes and each of the 150 passengers on the ferry make on average 1 call per hour.
(b) How many channels are needed to keep the blockage probability below 2 per cent?

Question 3

In the RMAC protocol covered in class, we assumed that the number of sources that had packets to send at any time step is completely unpredictable and therefore all numbers were equally likely (i.e. the a priori probabilities are all equal). Is this reasonable? Under what situations? Write down any improvements you can think of in this regard.

Question 4

Assume a number of mobile users are on a cellular telephone system. The area has an uneven terrain including mountains and valleys. What implications would this have on signal propagation. Assume user A is using his phone to watch a video while user B is sending and receiving emails. From each of their perspectives, which is more preferable - CDMA, TDMA, FDMA? Justify your answer with arguments.

Question 5

Suppose three users, each sending data at 1 MB/s are sharing a channel. Suppose that the system is implemented using CDMA with the chip period being one tenth of a bit period.
(a) Assuming BPSK coding, what is the bandwidth used by the company? List all simplifying assumptions you need to make to carry out this computation.
(b) What are the pros and cons from the company's point of view in supporting more subscribers? How would you expect the user experience to change as more subscribers are added?