HW #3

ELEN E4710 - Intro to Network Engineering — Due 10/25/2004
Fall 2004 — Prof. Rubenstein

Homework must be turned in at the beginning of class on the due date indicated above. CVN students have one additional day. Late assignments will not be accepted.

1. Suppose that n devices share a LAN, where each device sends frames that take L microseconds to transmit onto the wire, with $L > 2\tau$ where τ is the maximum propagation delay on the LAN. k of these n devices use ALOHA, where the backoff occurs at rate λ, the other $n - k$ devices use slotted ALOHA with slots of size L and backoff at rate λ. What is the probability of successful transmission for

   (a) A device using ALOHA (w/o carrier sensing)

   (b) A device using slotted ALOHA

   (c) A device drawn at uniformly at random from the set of devices.

2. Suppose there are two types of devices. Type s transmits packets of size L, the other type t transmits packets of size $2L$. A slotted ALOHA collision avoidance mechanism is used, where slots accomodate size L packets. Suppose there is one of each type of device attempting to transmit upon the same medium (i.e., 2 devices total), where it takes time T to output a frame of size L.

   (a) Suppose carrier sensing is not used. What should the backoff time λ_t be in terms of λ_s so that each device is as likely as the other to successfully transmit a packet?

   (b) Suppose the goal is to equalize the expected amount of bandwidth a device transmits within an interval. What should λ_t be in terms of λ_s in this case?

   (c) Suppose device t has the ability to sense the line. Explain (in a sentence or two) why this makes no difference.

   (d) Suppose device s has the ability to sense the line. Show (mathematically) why this does make a difference.

3. N devices share a LAN and frame transmission times are segmented into slots such that two transmissions during the same slot always cause transmission failures, whereas two transmissions during different slots do not cause transmission failures. Assume that each device has a frame to send every time-slot, but only performs the transmission with a probability p.

   (a) Suppose this slotted collision avoidance mechanism is implemented using slotted ALOHA, where slots last for time T. What is the rate of the backoff timer as a function of T and p?

   (b) What is the probability of a successful transmission in a given timetick (in terms of N and p).

   (c) What is the probability that device 1's transmission is successful, given device 1 attempts a transmission?

   (d) What is the expected number of successful transmissions per time-slot?

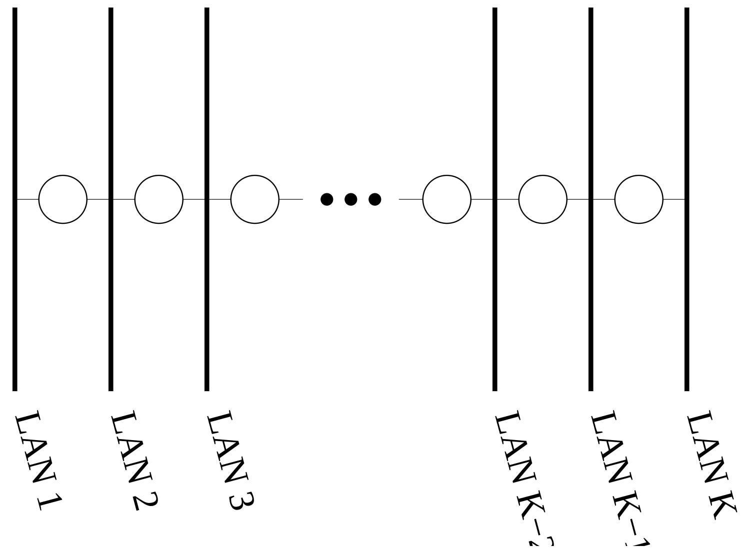
   (e) What value of p (in terms of N) maximizes the probability in part 3b.

4. $N+1$ devices numbered $1, \cdots, N+1$ share a LAN and frame transmission times are segmented into slots such that two transmissions during the same slot always cause transmission failures, whereas two transmissions during different slots do not cause transmission failures. Odd numbered slots are used to send new transmissions. If the transmission fails because of a collision, then the subsequent even slot is used to attempt a retransmission. The probability that a device transmits on an odd-numbered slot is p, where the decision to transmit is independent from the device's previous transmission history and from the transmission decisions of the other devices. Given the device's transmission in an odd slot collides with other transmissions, the device reattempts the transmission during the even round with probability q. The decision to retransmit during the even round is independent of the decisions by the other devices that also experienced a collision in the previous odd round.

   Let $X_{i,j}$ be an indicator random variable that equals one if device i attempts a transmission during round $2j+1$ and 0 otherwise. Let $Y_{i,j}$ be an indicator random variable that equals 1 if device i succeeds in completing its transmission (if one is made) in either round $2j+1$ or in round $2j+2$.

   What is $P(Y_{1,5} = 1 | X_{1,5} = 1)$?

5. Let C_1, C_2, C_3 be three connections that use CDMA to transmit upon the same channel using chipping signals (1,1,1,1,1,1,1,1), (1,1,-1,-1,1,1,-1,-1), and (1,1,-1,-1,-1,-1,1,1) respectively. If the received chipping signal is (1,1,1,1,-1,-1,3,3), what was the value of the bit transmitted by connections C_1, C_2, C_3 (where the value is either 1 or -1)?



6. In the bridged LAN pictured above, k LANs are bridged together using switches. Each LAN contains n devices such that there are kn devices on the bridged LAN. The devices participate in a slotted protocol, with each device transmitting a frame in a given slot with probability p, the destination location is uniformly distributed among the other devices.

   (a) An additional device D is added to LAN 1 (so that there are $n+1$ devices on this LAN). If X_i is a random variable that equals 1 if device D tries to transmit during the ith slot, and S_i is a random variable that equals 1 when D's transmission during the ith slot is successful, what is $\Pr(S_i = 1 | X_i = 1)$?

   (b) Suppose device D reduces the probability of transmission to p/n. How does this affect $\Pr(S_i = 1 | X_i = 1)$?