Assignment 3, CSL374/672, Semester-2 2012-13
Due Date: Monday, Feb. 25, 5pm

1. Consider a scenario in which n hosts share the same medium. The medium has bandwidth (max. data rate) c. Time is divided into slots of duration T seconds (i.e. $[lT, (l+1)T]$, $l = \ldots, -1, 0, 1, \ldots$). Each host transmits a frame of size cT bits at bit rate c during any given time slot with probability p independent of all other hosts. Such a frame transmission begins at the start of any slot. If only one frame is transmitted in a time-slot then we say the transmission was successful. If more than one frame is transmitted then we say that a "collision" has occured and none of the transmissions in that slot were successful.

   (a) Derive an expression for the expected number of successful transmission in a time-slot in terms of n and p.

   (b) For a fixed number of hosts n, what is the largest possible expected bit rate of successful transmissions (i.e. maximum throughput found by varying p)? Draw a plot of maximum throughput as a function of n (from $n = 1, 2, \ldots, 50$). Interpret your results.

   (c) What is the limit of maximum throughput as $n \to \infty$?

2. Four wireless nodes are placed on a straight line (see Figure 1). Let $D(i, j)$ denote the distance between nodes i and j. Each node has a circular communication range of $r = 1.5R$. This means that a packet transmitted by node i is received by a node j if and only if $D(i, j) < r$ *and* $D(k, j) > r$ for all $k \in T, k \neq i$, where T is the set of nodes transmitting data at the same time as i.

   All nodes employ the `RTS-CTS-DATA-ACK` protocol with exponential-backoff (on collision) for transferring data that was discussed in class. Assume that b has an infinite amount of back-logged data to transmit to a. This means that b always has data to transmit to a. Similarly d has an infinite amount of data to transmit to c. Nodes a and c have no data to transmit.

   In such a scenario it is very likely that the throughput from d to c is significantly lower than that from b to a. Explain why this is true. Make any reasonable assumptions and state them clearly. (A rough explanation will do.)

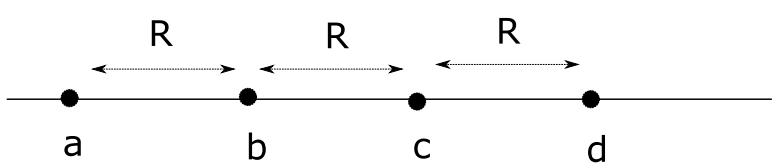

Figure 1: 4-node wireless topology

3. Assume that there are n nodes connected to a single bus such as in an Ethernet. These nodes are uniquely numbered from 1 to n. Any time a node sends out a data frame it includes its own "number" in the frame. Design a medium access protocol with the following properties. (Focus only on the medium-access details about the protocol. Do not discuss modulation, framing, CRC etc.)

   (a) Only a node possessing a "token" is allowed to transmit data. Assume that node 1 has the token at first. After any node possessing the token has finished transmitted its share of data, it must relinquish it to another node by explicity broadcasting a message on the Ethernet.

   (b) The protocol is hard-coded (manually entered) with the highest node number n by the system administrator.

(c) The protocol is robust to one or more node failures.

(d) Every node is guaranteed a chance to transmit data every τ seconds, where τ is some large time interval.

Make any reasonable assumptions if necessary and state them clearly.