ECE6615: Sensor Networks
Spring 2017
Homework 2

Given: February 21, 2017
Due: March 10, 2017 (Midnight) + 1 week for "off Campus" students

Submission Instructions:

Submit your homework as a **single** DOC or PDF file to infocom@ece.gatech.edu
Attach the MATLAB codes as a single zip file.
Mention "**[ECE6615] Homework 2**" in the subject line.
No hardcopies will be accepted. Scanned pages are fine.

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Question 1 (LEACH Protocol)

For this question, use the simulation of LEACH algorithm in MATLAB. An example of the simulation can be found in the attached zip file.

Consider 100 nodes spread in a rectangle between the coordinates (0,0) and (100,100). Consider the sink is at (50, 175). Assume that 10% of the nodes are chosen as cluster heads.

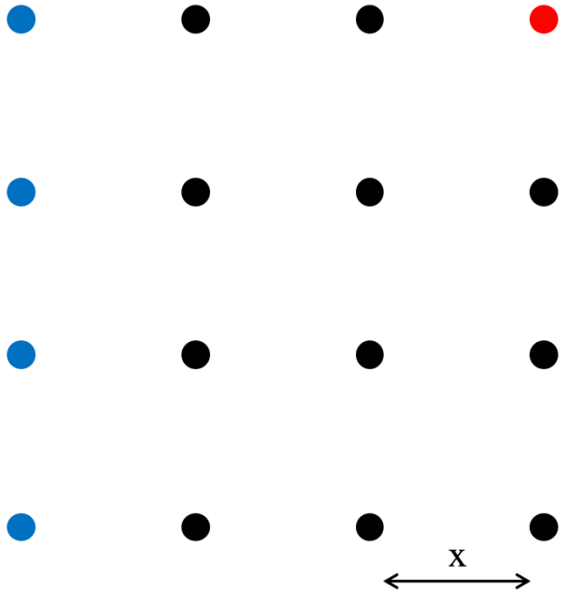
Make necessary changes to the source code and answer the following questions. Provide plots to show what you observe and justify your observations.

a) Take the percentage of nodes chosen as cluster heads as 10%, 20%, …, 100%, and compare the number of rounds at which 80% of the nodes are dead.

b) Increase the total number of nodes from 100, 200, …, 500 and find the number of rounds at which 80% of the nodes are dead. Assume that number of cluster heads is 10%.

Question 2 (S-MAC Protocol)

Consider the grid topology in the Figure:



The blue nodes sense the temperature and send them to the red node. Assume that all immediate horizontal and vertical neighbors of a node are accessible (sqrt(2)*x > R > x). The time taken for transmitting a packet is 3 sec. Assume S-MAC with adaptive listening is the MAC protocol at each node. All the nodes are awake for 1 sec. and asleep for 4 sec. For example, all the nodes are awake from t=0 to t=1, go to sleep until t=5, and repeat. Assume perfect carrier sensing and when a particular node transmits during time $[t_0, t_0+3]$, no other node in its neighborhood can transmit simultaneously. Also assume that RTS/CTS exchanges are instantaneous and if a node starts transmitting, it will continue until the packet is transmitted

a) Find the time at which the packets reach the sink.

b) If the current consumption by the node during sleep period is 865 µA and while awake is 17.9 mA, find the total power consumption of the network.

c) Assuming S-MAC is not used and the nodes does not go to sleep, find the time at which packets reach the sink and the total power consumption of the network.

d) If S-MAC is replaced by B-MAC, how will the performance of the network be affected. Explain qualitatively.

Question 3 (Routing Protocols)

a) What are the conditions/assumptions, with respect to the data flow architecture, in which the *directed diffusion routing* is applicable.

b) Sensors are deployed in a forest to collect raw information like temperature, etc. and record events that happened. One example of such event is elephant sighting. External users are only interested in these events, but not the raw information. Explain whether *directed diffusion* can be applied for this scenario. Identify the various terminologies (interests, gradients, etc.) for this application.

c) In this problem, we try to find the optimal number of hops through which the data must be transmitted so that the total energy consumption of the network is minimized.

- Consider a network where source and sink nodes are separated by a distance of 100 m.
- Assume the energy model explained in slide 72 of Chapter 7 with the path loss exponent α as 4.
- The current required for electrical components and the amplifier are given by I_{Elec} = 7.8 mA and I_{Amp} = 15 mA respectively and the nodes are powered by 3 V batteries.
- We can send the data directly from the source to sink or through several hops.

For the above scenario, answer the following questions.

i) Using MATLAB, plot the energy consumption of the entire network to transmit one bit data, as a function of number of hops.

ii) From this, determine the optimal inter-node distance for energy efficient transmission.

Question 4 (Error Control Techniques)

Consider a sensor network with a data rate of 16 kbps and a packet size of 512 bits. Assume that the channel between the nodes is an AWGN channel and BPSK modulation is used. The SNR at the receiving node is 6 dB.

a) Find the bit error rate of the link.

b) Find the packet error rate if no FEC is used.

c) If we use ARQ, what is the latency of the packet in terms of expected number of retransmissions.

d) Find the packet error rate if BCH (63, 57, 1) is used.

e) Compute the effective throughput that can be achived when using the above BCH code.

f) Find the effective throughput and the packet error rate if BCH (15, 11, 1) is used instead.

g) Compare the tradeoffs of reliability, delay and throughput when different BCH codes mentioned above are used.

Question 5 (Transport Layer Solutions)

Figure below shows a wireless sensor network used to measure the temperature inside an industrial refrigerated room. In this picture, red nodes represent sensors that have detected a sudden increase in the temperature (corresponding to the same event). These nodes need to report this information to the sink or command center. The radio range of each node is *r*.

a) **Qualitatively** explain how PSFQ and ESRT will perform in this situation and compare both protocols in terms of total number of packets transmitted.

b) How does this affect the total energy consumption? Under which protocol is the network more likely to be congested?

Consider the following assumptions:

1. Consider that the network has been working for some time and that ESRT is working under no congestion and with high reliability. Assume that in this condition, only 50% of the nodes will report the event.
2. Consider that all packets are sent using the shortest path and that routes has already been pre-established.
3. Consider that a simple MAC protocol is used and that only 1 of every 4 packets is lost.