ECE6615: Sensor Networks
Spring 2017
Homework 1

Given: January 23, 2017
Due: February 10, 2017 (Midnight) + 1 week for "off Campus" students

Submission Instructions:

Submit your homework as a DOC or PDF file to infocom@ece.gatech.edu
Mention "**[ECE6615] Homework 1**" in the subject line.
No hardcopies will be accepted. Scanned pages are fine.

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Question 1 (Energy Consumption)

a) Given a battery with 1.5 V and 2200 mAh. How long can it power a device that has a demand of 1.1 W?

b) Given a Tmote Sky node that consumes 865 μA when the radio is not transmitting and 17.9 mA when the radio is transmitting. It is powered using two batteries. Each battery has 1.5 V and 2200 mAh. How long do the batteries last, if the device is transmitting 10% of the total time?

Question 2 (Energy Modeling and Reliability):

For this question, consider the energy consumption models for sensing, computation, and communication. You will also need to use the RF230 Transceiver datasheet:
http://www.atmel.com/dyn/resources/prod_documents/doc5131.pdf

Assume a network where each sensor should wake up once a second, measure a value, perform calculations and transmit it over the network. Consider the following:

- Assume sensing energy is negligible
- Calculations needed: 5K instructions (for measurement and preparation for sending)
- Time to send information: 50 bytes for sensor data, (another 250 bytes for forwarding external data)
- Energy needed to sleep for the rest of the time (sleep mode)

Assume IRIS mote (Atmel processor + RF230 transceiver) with the following:

- Computation power (Pp) is 24mW for IRIS
- 1 instruction takes an average of 3 cycles, where Atmel processor operates at 8MHz
- For start-up, assume PLO = 4.5mW, tst = 1.065ms
- For switch, assume PLO = 23.4mW, tsw = 25 us
- For receive energy, PLO + PRX = 46.5 mW
- For transmit energy, PLO + PTX = 49.5mW
- For sleep energy, PSL = 24 uW
- Assume transmission rate as 250kbps
- The sensor is supplied with 2 x 1.5V AA batteries, each of which has energy of 1150mAh

Answer the following questions:

a) Find the total energy consumption of a mote in one second.
b) Assuming the batteries lose 15% energy/year, calculate the lifetime of a mote.
c) Start-up and switching are much more complicated that can be modeled by a single parameter PLO. Refer to Figure 7-1, Table 7-1, and Table 11-8 in the RF230 Transceiver datasheet and discuss the effects of the start-up and switching mechanism on the overall lifetime.
d) What are the consumed power and time for
    i) Start-up for transmit
    ii) Start-up for receive
    iii) Switching from receive to transmit and
    iv) Switching from transmit to receive?

Question 3 (Query Processing):

Consider a sensor network composed of 150 sensor devices deployed in the ground floor of the Georgia Tech Campus Recreation Center. There are temperature sensor devices uniformly distributed in the main fitness room, in the two swimming pools, and in the five locker rooms. You want to constitute a temperature map of the floor at various resolutions in order to adapt the AC/Heating system parameter values, the minimum resolution being the average temperature of the entire floor and the maximum resolution being the temperature of each sensor. You should also be able to adjust the temperature by areas independently, e.g., the main fitness room and the swimming pools average temperatures should be different. The required resolution for the temperature map can change over time. Consider that sensor nodes are battery powered and that lifetime is a crucial property for this sensor network.

Describe a solution to this task. In particular, you should:

(a) Propose an adaptive aggregation scheme that accounts for the required resolution of the temperature map. You can assume that the network topology is fixed, but you want to distribute the energy consumption uniformly among all the nodes.

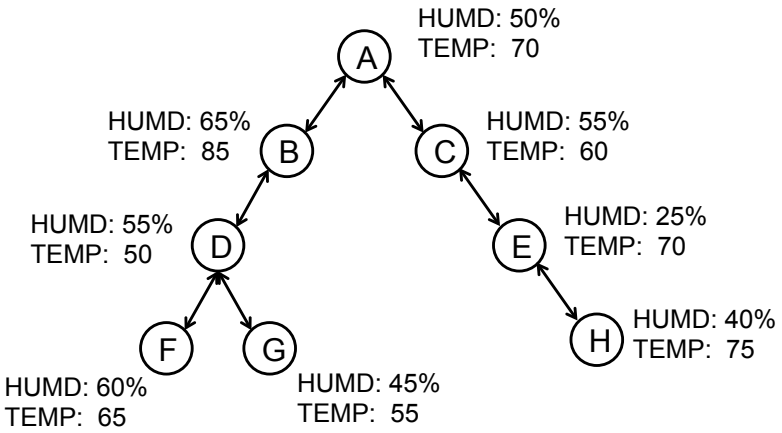
(b) Propose a communication protocol aimed at dynamically exploiting the spatial-temporal correlation of the measurements.

(c) Specify a SQTL-like query message that would efficiently provide support to this specific application. Briefly discuss pros and cons for your design choices and clearly state all the working assumptions made.

(d) Consider a TAG scheme with the query:

SELECT AVE (temperature), humidity/10%, FROM sensors, Group BY humidity/10%

According to the topology in the following figure, what is the information table that can be generated at A?



Question 4 (Physical Layer – Error Rate)

Consider a chain topology of 5 nodes where inter-node distance is 15m. End-to-end packet error rate of 10^{-2} is required for an application.

Answer the following questions.

a) Assuming independent and identical errors at each hop, what is the required packet error rate for each hop?

b) For a packet size of 50bytes, and independent and identical bit errors, what is the required bit error rate at each hop?

c) For a Mica2 mote that uses 2-FSK modulation, what is the required SNR in dB at the data rate of 250kbps?

d) Consider a log-normal fading channel model without shadowing (X=0). At the highest data rate and transmit power of 0dBm, what is the maximum path loss exponent that can be accommodated to guarantee the error requirement?

Consult the datasheets when necessary and state any references to the datasheet and assumptions you make.

Question 5 (Physical Layer – Path Loss)

a) A telephone line is known to have a loss of 20 dB. The input signal power is measured at 1 Watt, and the output signal noise level is measured at 1 mW. Using this information, calculate the output signal to noise ratio in dB.

b) What is the maximum data rate that can be supported on a 10 MHz noise-less channel if the channel uses eight-level digital signals?

c) A sine wave is used for two different signaling schemes (i) BPSK and (ii) QPSK. The duration of a signal element is 10^{-5} s. If the received signal is of the form $s(t)=0.005\ sin(2\pi 10^6 t+\theta)$ volts and if the measured noise power at the receiver is 2.5×10^{-8} watts, determine the E_b/N_0 in dB for each modulation.

d) Determine the mean received power at the receiver node. The distance between the transmitting station and the receving node is 500m. The transmitter and receiver antenna gains are 10dB and 5 dB respectively. Use path loss exponent of 4. The transmitted power is 30 dBm. Do all calculations using dB. Assume that the frequency of transmission is 2.4 GHz.