ECE6615: Sensor Networks

Spring 2017

Homework 3

Given: **March 26, 2017**
Due: **April 22, 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 3**" in the subject line.
No hardcopies will be accepted. Scanned pages are fine.

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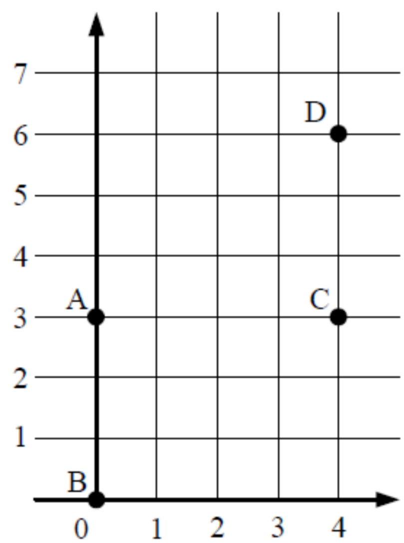
Question 1 (Localization)

Consider a sensor network where the anchor node can estimate the distances between itself and a sensor using the Received Signal Strength Indicator (RSSI). The RSSI is modeled by the following simplified equation:

$$P_r = P_t - 20\log(d),$$

where P_r is the received signal strength, P_t = 0 dBm, which is the transmitting power, and it is the same for all sensors, and d is the distance between the two sensors. Assume that the minimum received signal strength for a correct reception is -50 dBm. Four anchors are deployed at the locations shown in figure below. Note that the unit of the length in the figure is 10^2 m. Use the following information to determine the position of node E and F.

- The RSS from E to A is -40dBm.
- The RSS from E to B is -50dBm.
- The RSS from F to C is -40dBm.
- The RSS from F to D is -50dBm.
- E and F cannot hear each other.



Question 2 (Wireless Multimedia Sensor Networks)

Consider the time hopping impulse radio ultra wide band system described in Section IV.B. (Physical Layer Model) of the paper:

T. Melodia, I. F. Akyildiz, "Cross-layer QoS-Aware Communication for Ultra Wide Band Wireless Multimedia Sensor Networks," IEEE Journal of Selected Areas in Communications, Vol. 28, no. 5, pp. 653-663, June 2010.

a) Two users are concurrently transmitting a sequence of three bits over three frame periods. User 1 is transmitting the sequence "111", and User 2 is transmitting the sequence "000". Using MATLAB, plot for each of the following cases the signals concurrently transmitted by User 1 and User 2 during the time interval $[0, 4T_f]$
   i) Case1: $c^{(1)}$ =[0 0 0] and $c^{(2)}$ =[4 4 4]
   ii) Case2: $c^{(1)}$ =[3 1 6] and $c^{(2)}$ =[4 2 7]

   Use a single pulse to represent each bit, and the SNR level of your choice. The parameters of the system are listed in the table below.

Parameter	**Value**
T_f [ns]	1.6
T_c [ns]	0.2
τ_p [ns]	0.1
δ [ns]	0.1
N_h	8
N_s	1

b) What is the motivation behind using Time-Hopping Impulse Radio Ultra Wide Band for wireless multimedia sensor networks?

c) How are collisions prevented in TH-IR-UWB?

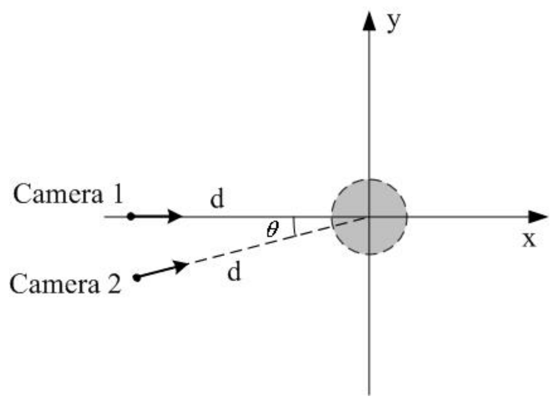
d) Cross layer module aims to provide high reliability with low energy consumption. However, cross layer module is not tailored for real-time data applications since end-to-end reliability and latency bounds are not guaranteed. Can the routing algorithm be changed for real-time traffic?

Question 3 (Wireless Multimedia Sensor Networks – Correlation Based Communication)

As shown in figure below, two camera sensors are deployed to observe an area of interest in a WMSN. The area of interest is in the center of the coordinate system, and the locations and sensing directions of the cameras are given as shown in the figure. The correlation between the two cameras could be estimated as introduced in slide 97 of Chapter12.

a) Calculate the spatial correlation coefficient (ρ_{12}) between Camera 1 and Camera 2 when θ equals to $\pm\pi/6, \pm\pi/3,$ and $\pm\ \pi/2$. Plot ρ_{12} as a function of θ ($\theta \in [-\pi/2, \pi/2]$) and comment on your results. Assume d = 2 in the figure.

b) Suppose each camera has observed one image ($X_i, i = 1,2$) and the entropies of the individual images are the same ($H(X_1) = H(X_2)$). If the value of θ is selected from the set $\{\pm\pi/6, \pm\pi/3,$ and $\pm\ \pi/2\}$, based on the results in part (a), which value of θ will result in the largest joint entropy of the two cameras?



Question 4 (Wireless Underwater Sensor Networks)

a) Using MATLAB, plot the Transmission Loss (TL) based on the deterministic Urick formula, $TL_{Urick}(f_0, d)$, using three different spreading factors (k = 1, 1.5, 2) when the carrier frequency f_0 is set to 20 kHz and the distance d ranges in 1–5 km. Consider $\alpha(f) = 0.0006$; $A = 7.5$ dB.

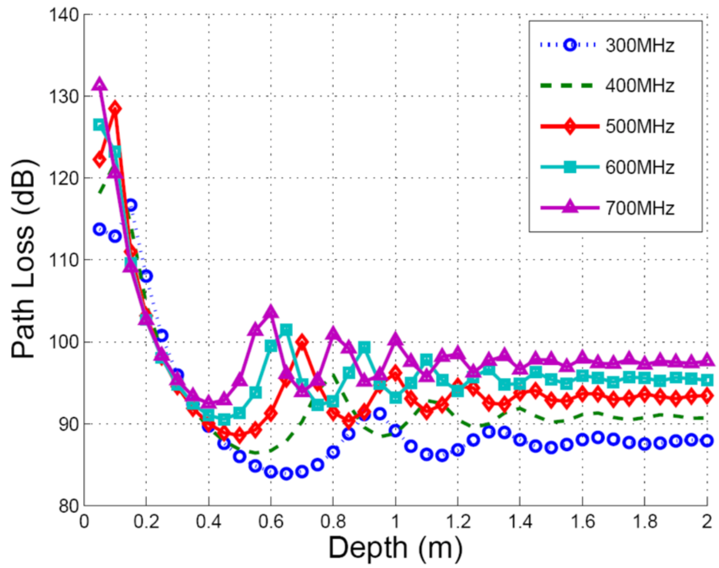
b) If a transmitter's battery had a residual energy of 1 kJ, what would be the residual lifetime of the node if it periodically transmitted packets of 10 bytes every 10 minutes to a receiver at a distance of 5 km? Assume that $TL = TL_{Urick}$ and that the target SNR is 20 dB and the ambient noise N is 70 dBre1Pa). Also assume k=2, H=1m, and a data rate equal to 1 kbit/s.

Question 5 (Wireless Underground Sensor Networks)

Two EM wave-based wireless sensors are buried underground at the same depth. The following parameters are given:

- The distance between the two sensors is 4 m
- The volumetric water content is 20% (α=3[m^{-1}], β=77[rad m^{-1}])
- The operating frequency is 500 MHz
- The antenna gains Gt=10 dB, Gr=5 dB
- The transmitted power is 5 mW
- The received power is $1.426*10^{-5}$ mW

a) Using the curves in the following figure, compute the minimum possible depth at which the sensors are buried.



Two-way Path Loss

b) How would the received power be if, instead of EM waves, we use MI (Magnetic Induction) as a communication medium?

Question 6 (6LoWPAN)

In 6LoWPAN, the addresses are compressed to reduce the packet length. Find the compressed address of a source node if the address seen from a remote server is for the following cases 2001:2EC3:11AA:4500:0022:1020:35FC:0003, where this node is the destination of this packet for the following cases of SAM field:

SAM	Compressed Address
00	
01	
10	

If the packet was sent as a multicast, find the Group Identifier used for the following fields of DAM field:

DAM	Group Identifier
00	
01	
10	
11	