ECE6615: Sensor Networks

Spring 2015

Homework 3 for Distance Learning Students

Given: **March 21, 2015**
Due: **April 26, 2015 (MIDNIGHT 11:59pm)**

Submission Instructions:

1. Please put "**[ECE6615] HOMEWORK 3 - DL**" in the subject line.
2. Submit your homework as on-line files (such as a DOC or a PDF file) to **infocom@ece.gatech.edu**.
   No hard copy will be accepted!!

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QUESTION 1 (Localization: Range-based)

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 4. Note that the unit of the length in Figure 4 is 10^2 m. Use the following information to determine the position of node E and F.

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

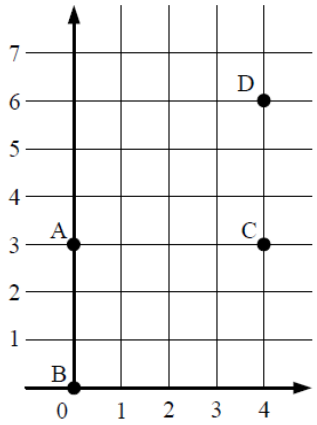


Figure 4

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. Case 1: $c^{(1)} = [0\ 0\ 0]$ and $c^{(2)} = [4\ 4\ 4]$

ii. Case 2: $c^{(1)} = [3\ 1\ 6]$ 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 Table 1.

Table 1

Parameter	Value
$T_f[ns]$	1.6
$T_c[ns]$	0.2
$\tau_p[ns]$	0.1
$\delta[ns]$	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?

QUESTION 3 (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 α(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 5 km of distance (assume that TL=TL_{Urick} and that the target SNR is 20 dB and the ambient noise N is 70 dBre1μPa)? Assume k=2, H=1m, and a data rate equal to 1 kbit/s.

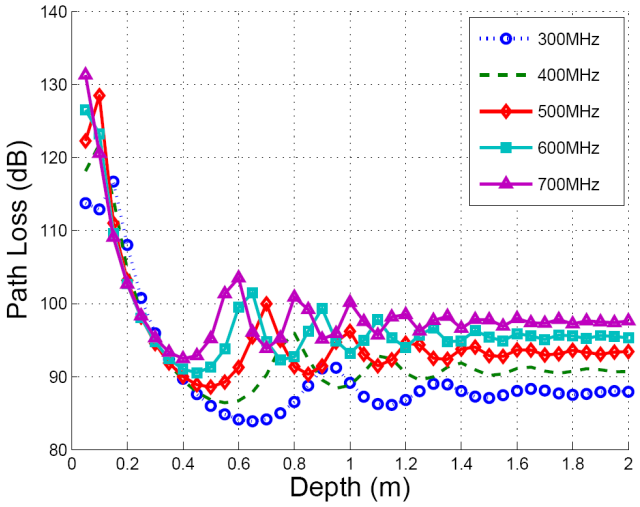
Question 4 (Underground Sensor Networks)

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 4m
- 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?