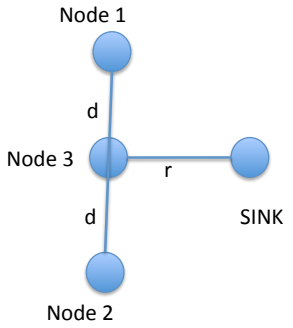
Internet of Things, Exam– September 22, 2014 Available time: 1h 45m

Family Name	
Given Name	
Student ID	

1 – Exercise (6 points)

A wireless sensor network is composed of three nodes and a sink. The three nodes mount temperature sensors and are set to deliver 1 temperature sample to the sink at a frequency of 1 [Hz]. The temperature sample is carried by packest with size L=128[byte]. Assuming that: the energy for acquiring one temperature sample is Es=40[uJ], the energy required to operate the TX/RX circuitry is E_c=50 [nJ/bit], the energy required to support sufficient transmission output power $E_{tx}(d)= k\ d^2$ [nJ/bit], being k=1 [nJ/bit/m^2], the energy for processing one temperature sample Ep=20[uJ], d=5[m] and r=5[m]



Find out the energy consumed by each one of the three sensors in the two cases:

1. the sensors send the temperature sample directly to the sink,
2. sensor 1 and sensor 2 send their sample to sensor 3, sensor 3 performs the average of the three samples (from 1, 2 and its own) and sends a single packet to the sink (in this case, the energy consumed by sensor 3 for processing is 3 x Ep)

Find out the network lifetime (time at which the first sensor node runs out of energy) in the two previous cases, if all the nodes have an initial energy budget Eb=100[mJ].

2- Exercise (6 points)

A sensor network runs the IEEE 802.15.4 protocol and is composed by 4 sensor nodes directly connected to the PAN Coordinator. The Beacon Interval is composed of CFP slots only and each slot can carry a packet of size L=127[byte] and the nominal rate is R=250[kbit/s]. The sensor nodes have the following traffic requirements:

- Sensor 1, Sensor 2: need a channel of 100[bits/s]
- Sensor 3 and 4 need a channel of 500[bits/s]

Find out a feasible structure for the BI indicating the CFP duration, the slot duration, the duty cycle and the number of slots assigned to each terminal.

Assuming that the energy consumed in a slot for receiving/transmitting is E=40[uJ], the energy for overhearing other nodes' transmission is Eov= 30[uJ], the energy for being idle is Ei=10[uJ], and the energy for sleeping is Es=1[nJ], find out the energy consumption for the three sensor node assuming that sensor 1 is in range of sensor 3 (and *viceversa*) and sensor 2 is in range of sensor 4 (and *viceversa*).

3-Exercise (4 points)

A Sensor network is operated according to the SPARE MAC protocol with the following parameters, signaling sub-frame size, N=10, data sub-frame size M=6. All the sensor nodes are in transmission range one another, each slot carries packets of L=128[byte] and the nominal rate is R=500 [kbit/s]. What is the maximum number of sensor nodes that can be supported by the network (EXPLAIN WHY)? What is the data rate corresponding to one slot in the data sub-frame?

Questions (10 points)

1. Briefly explain the usage and differences between *Message ID* and *Token* fields of *COAP*.
2. Briefly explain how the PAN coordinator assigns CFP slots to sensor nodes.
3. Tell which one(s) of the following statement is (are) true and which one(s) is (are) false. BRIEFLY MOTIVATE THE ANSWER. UNMOTIVATED RESPONSES WILL NOT BE CONSIDERED
    a. The ETX metric measures the average time to send a packet successfully over a link
    b. The *trigger* command of binary tree algorithm is sent out after successful slots
    c. The slotted ALOHA has higher collision probability than un-slotted ALOHA having fixed all the other parameters
    d. The Route Request messages of AODV are sent out in unicast (at IP level)
4. Define all the sources of energy consumption for a sensor node in a sensor network.