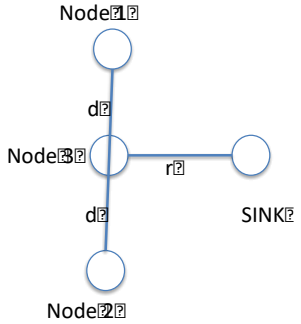
Internet of Things, Exam– February 18, 2015 Available time: 1h 45m

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 2 [Hz]. The temperature sample is carried by packets 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 case 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=60[mJ].

2- Exercise (6 points)

A sensor network runs the IEEE 802.15.4 protocol and is composed by 5 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[bit/s] with probability 0.5, and a channel of 25 [bit/s] with probability 0.5
- Sensor 3 and 4 need a channel of 500[bit/s]
- Sensor 5 needs a channel of 50 [bit/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 sensor nodes assuming that sensors 1, 3 and 5 are in range (and *viceversa*) and sensor 2 is in range of sensor 4 (and *viceversa*).

3-Exercise (4 points)

Two sensors wake up, send one packet and get back to sleep. Assuming that: the wake-up time for the two sensors is Tw1=500[us] and Tw2=750[us], the packet sizes used by the two sensors are L1=50[byte] and L2=127[byte] respectively, the power drained during wake-up is Pte1=1 [uW], Pte2=1 [uW], and the transmitted power is P=10 [uW] for both sensors (including power for operating the circuitry and emitted power), write the consumed energy per bit for the two sensors if the trasmisisone rate is R= 250[kb/s] (consumed energy/number of transmitted bits)

Questions (10 points)

1. Briefly explain the *COAP Observe* operation mode.
2. Briefly explain how the DODAG creation process in RPL.
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 ETT metric measures the average number of transmissions to send a packet over a link
    b. Shoute's estimate gives the collision probability in a reference slot
    c. The tag arbitration efficiency in RFID system is inversely proportional to the time to resolve all the tags in the system
    d. The Route Reply messages of AODV are sent out in unicast (at IP level)
4. Assign ZigBee addresses in the following tree network topology. Solid circles are ZigBee routers, empty circles are ZigBee and devices