Internet of Things, July 27, 2017 **Total Available time: 1.45 hours**

1 – Exercise (7 points)

A IEEE 802.15.4 network is composed of a PAN Coordinator and four motes. Each motes is assigned 3 slots in the Collision Free Part, and each slot can carry packets of 128 [byte]. The nominal rate is R=250 [kb/s] and the active part is composed of the beacon slot and the CFP only. The network is operated with a duty cycle η=10%. The motes have the following traffic pattern:

- Mote 1 and mote 2 generate packets according to a Poisson process with parameter λ_1=0.5 [packets/s]
- Mote 3 and 4 generate packets according to a Poisson process with parameter λ_2 = 2 [packet/s]

Find (i) the duration of the Beacon Interval, (ii) the equivalent rate defined as "one slot per Beacon Interval", (iii) the duration of a slot, (iv) the equivalent rate defined as "one slot per Beacon Interval", (iv) the average energy consumed by Mote 1 assuming that Mote 1 is in range only with Mote 3 and E_{rx} = 1[uJ], E_{tx},=3 [uJ], E_{idle} = 0.5 [uJ] and E_{sleep} = 1[nJ] to be respectively the energy for receiving, transmitting (circuitry + emitted power) , being idle and sleeping in a slot.

2 – Exercise (6 points)

Find the average efficiency of binary tree collision resolution protocol with an initial population of 2 tags.
What is the efficiency if the tree is ternary (the splitting after collision is ternary)?

3 – Exercise (6 points)

A MQTT client (Client 1) is subscribed to the topic /temp. The MQTT broker is connected to 2 additional MQTT clients which publish messages on the topic /temp according to the following traffic processes:

Client 2 publishes one message on topic /temp every 10 minutes
Client 3 publishes one message on topic /temp every 30 seconds

Find the energy consumed by the MQTT Client 1 in a time period of 1 hour in the three cases where the all the publish messages require QoS level 0, 1 and 2. Clearly describe the message exchange session between the MQTT broker and Client 1 in the three cases.
Use the following parameters: energy for sending/receiving MQTT publish messages, E_{rx}=10[uJ], energy for sending/receiving MQTT signaling messages (various ACK messages), E_{tx}= 3 [uJ], energy for being idle E_{idle}=0[uJ].

3 – Questions (7 points)

1. Tell if the following statements are true or false. **MOTIVATE THE ANSWER. UNMOTIVATED ANSWER WILL NOT BE CONSIDERED**
    a. The IEEE 802.15.4 MAC layer is based only on random access procedures.
    b. In RFID collision arbitration, the Schoute's estimate provides an estimate of the total number of already resolved tags.
    c. ZigBee cluster tree routing has higher signaling overhead than ZigBee AODV routing.
    d. The Expected Transmission Time (ETT) is better suited as routing metric in cases where wireless links have different data rate and/or propagation delays
2. Briefly explain the use of the route discovery table in ZigBee-AODV protocol.
3. Briefly explain the use of DIO messages in RPL.