Internet of Things, Exam– Feb 10, 2022 **Total Available time: 1.45hours**

1 – Exercise (7 points)

A personal area network (PAN) is composed of 4 motes and a PAN Coordinator. The PAN works in beacon-enabled mode. Mote 1 and Mote 2 have statistical (non-deterministic) traffic towards the PAN coordinator characterized by the following probability distribution: $P(r_{1,2}=75[bit/s])=0.5$, $P(r_{1,2}=225\ [bit/s])=0.1$, $P(r_{1,2}=0\ [bit/s])=0.4$. Mote 3 and Mote 4 have deterministic traffic towards the PAN coordinator with a required rate, $r_{3,4}$ of 450 [bit/s]. Assuming that: (i) the active part of the *Beacon Interval* (BI) is composed of *Collision Free Part* only; (ii) the motes and the PAN coordinator use b=225 [bit] packets for their transmissions which fit exactly one slot in the CFP, (iii) the nominal rate is 125 [kb/s], find the **duration of the single slot**, the **duration of *Beacon Interval* (BI)**, the **duration of the CFP,** the **duration of the inactive part**, a **consistent slot assignment** for all the uplink transmissions and corresponding the **duty cycle.**

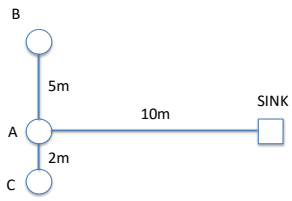
Assuming that the energy consumption parameters are the following ones, find the average energy consumption in a beacon interval of the PAN coordinator; energy for receiving a packet E_{rx} =4[uJ], energy for transmitting a packet E_{tx} =7[uJ], energy for being idle in a slot E_{idle} = 3[uJ], energy for sleeping in a slot E_{sleep} = 3[nJ].

2 – Exercise (4 points)

A ZigBee tree network is characterized by the following parameters: number of ZigBee routers per level, R_m=2, number of end devices per level, D_m=1, tree depth, L_m=3. How many addresses are needed to address all the devices in the network? Sketch the network structure properly assigning the addresses to end devices, ZigBee routers and ZigBee coordinator.

3 – Exercise (5 points)

Nodes A, B and C in the figure periodically collect and send temperature samples to the remote sink. The transmission phase is managed through a dynamic clustering approach which works as follows: two nodes send their samples to the cluster head which then takes the average out of all the sample (two received + one obtained locally) and sends a single packet to the SINK.



The cluster head role is assigned in a round robin fashion starting from node A (node A, then B, then C, then A, etc.) (when cluster head is C, B sends its message directly to C, and viceversa – not through A).

Find the **energy consumed by A, B and C** in one round (all the three nodes played the role of clusterhead) and the network lifetime (time to the first "death") with the following parameters: energy for collecting one sample, E_s= 1[uJ], energy required to operate the TX/RX circuitry E_c=6 [uJ/packet], energy required to support sufficient transmission output power $E_{tx}(d)= k\ d^2$ [nJ/packet], being k=120 [nJ/packet/m^2], energy for taking the average of 3 samples E_p= 4 [uJ], initial energy budget E_b=150[uJ] for all the three nodes.

3 – Questions (9 points)

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CON [1212]
GET /humidity
(Token 2323)
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1.A COAP client issues the request message at the right. Briefly explain the meaning of all the lines in the message and write a consistent and complete response from the COAP server assuming that the server includes the requested resource in the response message **(CLEARLY EXPRESS THE MESSAGE ID AND THE TOKEN ID IN THE RESPONSE MESSAGE)**

2. A sensor node performs channel access according to the CSMA/CA scheme of the IEEE 802.15.4 standard. Assuming that the probability of finding the channel busy is p=0.2 at each backoff period, find the probability that the sensor node does actually access the channel at the first attempt

3. A Dynamic Frame ALOHA system is used to arbitrate 3 tags. What is the average throughput after the first two frames if their length is r_1=2 (frame 1) and r_2=2 (frame 2)?