

Family Name	
Given Name	
Student ID	

1 – Exercise (7 points)

A personal area network (PAN) is operated according to the IEEE 802.15.4 beacon enabled mode.

- The Collision Access Part (CAP) of the superframe is composed of 20 slots.
- The inactive part of the beacon interval is composed of 1600 slots and the duty cycle is 2.02%.
- Each slot (of CAP and CFP) carries 127 [byte] packets.
- The nominal data rate is 250 [kb/s].

How many slots are available in the CFP? What is the rate of the channel defined as “one slot per beacon interval”?

Using the numbers found above, suppose that two motes (Mote 1 and Mote 2) are active in the PAN with the following traffic patterns

- $P(\text{amount of data generated in one BI}=508[\text{byte}])=0.3$
- $P(\text{amount of data generated in one BI}=0[\text{byte}])=0.3$
- $P(\text{amount of data generated in one BI}=635[\text{byte}])=0.4$

1. Define a consistent slot assignment in the CFP for the two motes (the motes do not use the CAP).
2. How many additional motes requiring a channel of 150 [bit/s] could be added to the network?
3. Find the average energy consumption of the two motes (assume that the two motes do not overhear the transmissions of each other). The total energy for receiving in a slot is $E_{rx}=20$ [uJ], the total energy to transmit in a slot is $E_{tx}=30$ [uJ], the energy of being idle in a slot is $E_{idle}=15$ [uJ] and the energy for sleeping in a slot is $E_{sleep}=0.5$ [uJ]
4. What is the total capacity of the CAP?

Exercise 2 (7 points)

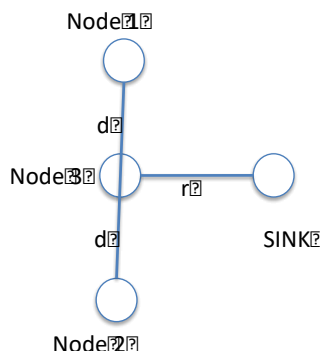
A sensor network is composed of a three nodes and a sink (see figure). Node 1, Node 2 and Node 3 periodically have to deliver to the sink packets whose length is $l=128$ [byte]. Assuming that:

- 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/m²]
- $d=5$ [m] and $r=5$ [m]

find out the energy consumed by the three nodes to send a packet to the sink node in the following two cases:

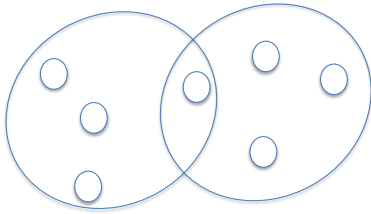
1. the three nodes directly send their packet to the sink
2. Node 1 and Node 2 send their packets to Node 3 which then delivers the packets to the sink.

Find the value of r (keeping $d=5$ [m]) for which the overall energy consumption in case 1 and case 2 is the same (sum of the energy consumed by the three nodes).



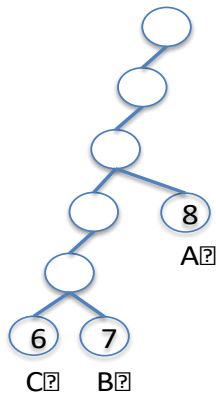
Exercise 3 (5 points)

The wireless sensor network in the figure is running the SPARE MAC protocol. What is the minimum number of slots required in the signaling subframe and in the data subframe? Using these numbers, assume now that the sensor nodes need to exchange data packet at a rate $r = 0.5$ [kb/s]; knowing that the slots (signaling and data) contains exactly packets of 128 [byte], find out the SPARE MAC frame size, slot duration and nominal data rate.

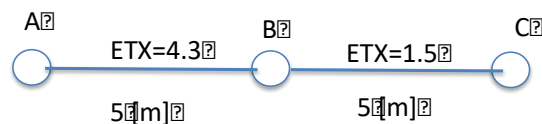


3 – Questions (9 points)

- The figure represents a possible outcome of the execution of a binary tree algorithm with three tags A, B and C to be resolved. For each node in the tree, the figure reports the slot number and the outcome of the transmission (success or collision, empty circles are successful ones). What is the efficiency of this outcome? What is the probability for this outcome to happen?



- What is the overall average energy consumption for delivering one packet from node A to node C in the network? The figure shows the Expected Transmission Count (ETX) and the link length for each link. Assume that the A sends the packet to B which then forwards it to C. 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/m²]. Neglect overhearing.



- A Dynamic Frame ALOHA system estimates the current backlog of unresolved tags to be 2. What is the single-frame throughput assuming that the system optimally set the frame length ACCORDING TO THE BACKLOG ESTIMATE and knowing that the real number of unresolved tags is 4.