Internet of Things, ***September 6, 2019*** **Total Available time: 1.30 hours**

1 – Exercise (6 points)

A IEEE 802.15.4 network is composed of a PAN Coordinator and three motes. Each mote is assigned 2 slots in the Collision Free Part for uplink traffic, and the PAN coordinator is assigned 6 slots in the CFP for downlink traffic (two slots dedicated to each one of the four motes). Each slot can carry packets of 256 [byte]. The nominal rate is R=125 [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=1%. The motes and the PAN coordinator have the following traffic pattern:

- Mote 1 and mote 2 generate packets towards the PAN coordinator according to a Poisson process with parameter λ_1=0.01 [packets/s]
- Mote 3 generates packets towards the PAN coordinator according to a Poisson process with parameter λ_2 = 0.5 [packet/s]
- The PAN coordinator generates packets toward each one of the three motes according to a Poisson process with parameter λ_3 = 0.1 [packet/s]

Find (i) the duration of the Beacon Interval, (ii) the duration of a slot, (iii) the average energy consumed by Mote 3 assuming that Mote 3 can overhear the transmissions of Mote 1 and Mote 2; 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.

Solution

N_{cfp}= 2x3 + 6 = 12
N_{active} = 12+1=13
T_{slot}=256[byte]/125[kb/s] = 16,384[ms]
T_{active} = N_{active} T_{slot} = 212,99 [ms]
BI = T_{active} /η = 21,299[s]
N_{sleep}=1299
E3= E_{rx} + P^3_0 [$2E_{idle}$] + P^3_1 [E_{tx} + E_{idle}] + $P^3_{>=2}$ [$2E_{tx}$] + 2 {P^1_0 [$2E_{idle}$] + P^1_1 [E_{rx} + E_{idle}] + $P^1_{>=2}$ [$2E_{rx}$]} + 3 {P^p_0 [$2E_{idle}$] + P^p_1[E_{rx} + E_{idle}] + $P^p_{>=2}$ [$2E_{rx}$] } + 1299 E_{sleep}

2 – Exercise (6 points)

At the end of frame 0 of Dynamic FRAME ALOHA 2 collided slots are observed.
With the available data is it possible to determine the size of frame 0? ***(1 point)***
What is the size of the next frame (frame 1) if Shoute's estimate is used? ***(2 points)***
Assuming that the number of tags transmitting in one slot is distributed according to a Poisson point process with parameter λ=2 tags, find the average backlog ***(3 points)***

Solution

No, it's not possible
Round(2.39 c) = 5
See slides on RFID

3 – Exercise (6 points)

A MQTT client (Client 1) is subscribed to the topic *luminosity*. The MQTT broker is connected to 2 additional MQTT clients which publish messages on the topic *luminosity*. Client 2 and Client 3 generate 5 and 10 messages on the topic *luminosity*.
The message error rate for the link between Client 1 and the broker is 5%. The links Client 2-Sink and Client 3-sink are fully reliable (message error rate = 0). Find the average energy consumed by the MQTT Client 1 in the case where all the publish messages require QoS level 1, assuming that the ACK messages are fully reliable. Clearly describe the message exchange session between the MQTT broker and Client 1.
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].

Solution

The expected transmission count over link Client 1-Broker is ETX=1.052.
The average energy consumption is:
-E_1 = 15 (ETX-1) [E_{rx}] + 15 (E_{rx}+E_{tx})(assuming that Client 1 receives but does not decode the broken messages)
- E_1 = 15 (E_{rx}+E_{tx}) (assuming that the broken messages do not even reach Client 1)

3 – Questions (8 points)

1. Tell if the following statements are true or false. **MOTIVATE THE ANSWER. UNMOTIVATED ANSWER WILL NOT BE CONSIDERED**
    a. 6LowPAN uses plain IP at the networking level without any adaptation F
    b. Higher Spreading Factor in LoRa means lower transmission time F
    c. The ETX decreases as the bit error rate increases F
    d. Route Response messages are sent in broadcast F
2. Briefly explain COAP *Block Transfer* mode. See slides
3. Briefly explain the differences between MQTT and MQTT-SN See slides