

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 3 slots in the CFP for downlink traffic (one slot dedicated to each one of the three motes). Each slot can carry packets of 128 [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 $\eta=1\%$. 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 $\lambda_1=0.01$ [packets/s]
- Mote 3 generates packets towards the PAN coordinator according to a Poisson process with parameter $\lambda_2 = 0.5$ [packet/s]
- The PAN coordinator generates packets toward each one of the three motes according to a Poisson process with parameter $\lambda_3 = 0.1$ [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

$$N_{cfp} = 2 \times 3 + 3 = 9$$

$$N_{active} = 9 + 1 = 10$$

$$T_{slot} = 128[\text{byte}] / 125[\text{kb/s}] = 8,192[\text{ms}]$$

$$T_{active} = N_{active} T_{slot} = 81,92 [\text{ms}]$$

$$BI = T_{active} / \eta = 819,2\text{ms}[s]$$

$$E_3 = E_{rx} + P^3_0 [2E_{idle}] + P^3_1 [E_{tx} + E_{idle}] + P^{3>=2} [2E_{tx}] + 2 \{P^1_0 [2E_{idle}] + P^1_1 [E_{rx} + E_{idle}] + P^{1>=2} [2E_{rx}]\} + 3 \{P^0_0 [E_{idle}] + P^{0>=1} [E_{rx}]\} + N_{sleep} E_{sleep}$$

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 $\lambda=2$ tags, find the average backlog (3 points)

Solution

No, it's not possible so solo che ci sono 2 o piu di slot ma non posso sapere quanti

$$\text{Round}(2.39 \text{ c}) = \text{X} \quad 5$$

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 $ETX=1.11$.

The average energy consumption is:

$$- E_1 = 15 (ETX-1) [E_{rx}] + 15 (E_{rx}+E_{tx}) \text{ (assuming that Client 1 receives but does not decode the broken messages)}$$

$$- E_1 = 15 (E_{rx}+E_{tx}) \text{ (assuming that the broken messages do not even reach Client 1)}$$

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. Lower Spreading Factor in LoRa means higher transmission time **T**
 - c. The ETT decreases as the bit error rate increases **F**
 - d. Route Reply messages are sent in broadcast **F**
2. Briefly explain COAP *Observe* mode. What is it for? **See slides**
3. Briefly explain the differences between magnetic coupling and electromagnetic coupling in RFID **See slides**