##### 1 – Exercise (7 points)

A personal area network (PAN) is composed of 5 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(r1,2=25[bit/s])=0.5, P(r1,2=225 [bit/s])=0.1, P(r1,2=0 [bit/s])=0.4. Mote 3, Mote 4 and Mote 5 have statistical traffic towards the PAN coordinator with a required rate, r3,4,5 defined by the following probability distribution P(r3,4,5=200[bit/s])=0.5, P(r3,4,5 =100[bit/s])=0.5. Assuming that: (i) the active part of the *Beacon Interval* (BI) is composed of *Collision Free Part* and 3 slots of the *Collision Access Part*; (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 250 [kb/s], find the **duration of the single slot**, the **duration of *Beacon Interval* (BI)**, the **duration of the CFP, the duration of the active part,** 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 Mote 1 (); energy for receiving a packet Erx =4[uJ], energy for transmitting a packet Etx =7[uJ], energy for being idle in a slot Eidle = 3[uJ], energy for sleeping in a slot Esleep = 3[nJ].

Solution

Ts=b/R=225[bit]/250[kb/s]=900us

BI=b/25[bit/s]=225[bit]/25[bit/s]=9s

Mote 1 and 2 need 9 slots in the CFP

Mote 3, 4 and 5 need 8 slots in the CFP

TCFP=(18+24) x Ts =37,8ms

TACTIVE=37,8ms + 4TS= 41,4ms

TINACTIVE=BI-TACTIVE=8961,3ms

Duty cycle = TACTIV/BI=4.2x10-3

Nsleep=9957

The energy consumed by Mote 1 is (assuming mote 1 only in range of mote 2):

E1=ETX+48Eidle+[0.5 (EtX+8EIDLE) + 0.1 8 ETX] + [0.5(Erx+8Eidle)+0.1 8 Erx] + NSLEEP ESLEEP

## 2 – Exercise (4 points)

A LoraWAN network is characterized by N1 stations transmitting with SF1 and N2 stations transmitting with SF2. The corresponding data rates of station of type 1 and 2 are respectively r1=20kb/s and r2=100kb/s. Stations of type 1 and 2 generate uplink transmissions according to Poisson point process with parameter [packet/s] and [packets/s] respectively. Indicate the higher SF between SF1 and SF2 (MOTIVATE YOUR ANSWER) Assuming that both stations of type 1 and 2 transmits packets of length L=100 byte, find the collision probability of a station of type 1.

Solution

SF1>SF2

T1=L/r1=40ms

T2=L/r2=8ms

## 3 – Exercise (5 points)

A Dynamic Frame ALOHA system is used to arbitrate 3 tags. The length of the first frame is r1=1; the length of the second frame is set according to Schoute’s estimate; the length of the following frames (from frame 3 on) is optimally set to the current backlog. Find the average efficiency of the collision arbitration process.

Solution

Frame 1: collision

Frame 2: r2=2

L3=2+P(S=0) L3\* +P(S=1)L2

P(S=0)=1/4, P(S=1)=3/4

L3\*=3+P(S=0) L3\*+P(S=1)L2

P(S=0)=(1/3)3 3= 1/9

P(S=1)= 3x3x2(1/3)3=2/3

L2=4

L3\*=3+1/9L3\*+2/3L2

8/9 L3\*=17/3

L3\*=9/8 x 17/3=51/8

L3=2+1/4 51/8 + ¾ 4 = 5+51/32=211/32=6,5

Eta=3/6,5

Accepted also the following

Frame 1: collision

Frame 2: r2=2

L3=2+P(S=0) L3 +P(S=1)L2

P(S=0)=1/4, P(S=1)=3/4

L3=2+1/4 L3+3/4 4

L3=20/3

Eta=9/23

## 4 – Questions (9 points)

1-A MQTT client sends the following PUB message to the MQTT broker. Assuming that 3 MQTT clients are subscribed to the topic “matteo/temp”, indicate all the actions performed by the broker upon receiving the message.

packeId 2

topicName “matteo/temp”

QoS 1

retainFlag true

Payload “temperature:30”

dupFlag false

Stores locally the message (because retain flag is set to true)

Send PUB ACK back

Send PUB message to the three cilients subscribed

2-Motes compete for accessing in the Collision Access Part (CAP) of IEEE 802.15.4. The probability of finding the channel idle in a contention window is p=0.8. Write the expression of the probability for a generic mote to accessing the channel within the first three carrier sensing attempts (the first, the second or the third attempt).

P=p2 + (1-p2)p2 + (1-p2)2p2

3- Clearly define the sensitivity parameter. Two motes have sensitivity values of -95dBm (mote 1) and -105dBm (mote 2) and run the same PHY communication technology. Tell if the following statements are true or false (MOTIVATE THE ANSWER)

-If a transmitter uses a fixed emitted power level P, the maximum distance between the transmitter and mote 2 is higher than the maximum distance between transmitter and mote 1 TRUE, -105 dbm non viene captato perche puo captare da -95 in su. Il 2 puo sentire potenze piu piccole

- If a transmitter uses a fixed emitted power level P and is at distance d from both mote 1 and mote 2, the received power level at mote 1 is higher than the received power level at mote 2 FALSE, la Potenza ricevuta daimote è la stessa sono alla stessa distanza. La Potenza non dipende dalla sensitivtà.