Internet of Things, ***June 4, 2018*** **Total Available time: 1.30 hours**

1 – Exercise (6 points)

A personal Area Network based on IEEE 802.15.4 beacon enabled mode (only CFP) is deployed to collect humidity samples out of 10 sensor nodes. 5 sensor nodes are characterized by the following traffic requirements: P(r=32[bit/s])=0.3, P(r=160[bit/s])=0.5, P(r=0)=0.2. The remaining 5 sensor nodes have deterministic traffic with rate r= 16[bit/s].
Assuming that the nominal rate is R=250[kb/s], that the humidity samples are L=25[byte] long and fit exactly in one slot of the CFP, design the Beacon Interval structure (slot duration, BI duration, number of slots in the BI) which minimizes the duty cycle under the requirement that all sensor nodes have the required average channel rate towards the sink/PAN coordinator. Find the duty cycle.

Solution
BI= 25[byte]/16[bit/s] = 12.5[s]
N_1=10 slots
N_2= 1 slot
$N_{cfp} = 5N_1+5N_2=55$
N_{active}= 56
T_s= 25[byte]/250[kb/s] = 800[us]
$T_{active}=T_s\ N_{active}$ = 44.6[ms]
Duty cycle= T_{active}/BI = 3 10^{-3}

2 – Exercise (6 points)

A Dynamic Frame ALOHA system is used to arbitrate 3 tags. Find out the collision arbitration efficiency knowing that the first frame has size r_1=1 (***hint***: since the first frame has size 1, all the tags will collide with probability 1, the length of the following frames is optimally set to the current real backlog).
Solution

$$L_3 = 3 + L_3 P(S_1 = 0) + L_2 P(S_1 = 1)$$

$$P(S_1 = 0) = \frac{1}{9} \qquad P(S_1 = 1) = \frac{2}{3}$$

$$L_3 = 3 + \frac{1}{9} L_3 + \frac{2}{3} L_2$$

$$L_2 = 2 + P(S_2 = 0) \quad L_2 = 4$$

$$L_3 = \frac{51}{8}$$

$$\eta = \frac{3}{\frac{51}{8} + 1} = \frac{24}{59}$$

3 – Exercise (6 points)

A LoraWAN network is composed of one gateway and two sets of clients. Set 1 contains N_1= 50 clients which generate uplink packets according to Poisson process with parameter λ_1=0.1 [messages/minute] and using a Spreading Factor SF_1=7 with related transmission time T_1= 10[ms]. Set 2 is composed of N_2=100 clients which generate uplink packets according to Poisson process with parameter λ_2=0.2 [messages/minute] and using a Spreading Factor SF_2=12 with related transmission time T_2= 100[ms]. Find the collision probability for a client of type 1 and 2 and the collision probability of a generic client.
Solution

$$P_1 = 1 - e^{-2N_1\lambda_1 T_1} e^{-\lambda_2 N_2 (T_1+T_2)}$$

$$P_2 = 1 - e^{-2N_2\lambda_2 T_2} e^{-N_1\lambda_1 (T_1+T_2)}$$

$$P = \frac{\lambda_1 N_1}{\lambda_1 N_1 + \lambda_2 N_2} P_1 + \frac{\lambda_1 N_1}{\lambda_1 N_1 + \lambda_2 N_2}$$

3 – Questions (8 points)

1. Briefly explain the use of persistent sessions in MQTT?

See slides

2. A mote runs the IEEE 802.15.4 Carrier Sense Multiple Access procedure. The current parameters are CW=2, NB=3, BE= 3. Briefly explain what is the use of these parameters. In which range the mote will choose the next slot for sensing the channel?

See slides

3. Briefly explain the use of the *Observe mode* in the COAP

See slides