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Exercise IEEE 802.15.4

Internet of Things

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1.1. Data

- $\lambda = 0.15$ persons/frame
- Beacon-enabled mode
- CFP only
- 1 packet fits 1 slot
- 1 PAN coordinator
- 3 camera nodes
- R = 250 kbps
- L = 128 Byte

1.2. Exercise 2.1

We can compute the Probability Mass Function of the output rate using the Poisson distribution.

$$P(N = k) = \frac{e^{-\lambda}\lambda^k}{k!} = \frac{e^{-0.15}0.15^k}{k!} \tag{1.1}$$

We can compute the PMF of the output rate by setting the right value of k in the Poisson distribution formula, where N is the observed number of people in the frame.

$$P(r = r_0) = P(N = 0) = \frac{e^{-0.15}0.15^0}{0!} = e^{-0.15} = 0.8607 \tag{1.2}$$

$$P(r = r_1) = P(N = 1) = \frac{e^{-0.15}0.15^1}{1!} = 0.15e^{-0.15} = 0.1291 \tag{1.3}$$

$$P(r = r_2) = P(N > 1) = 1 - P(N = 0) - P(N = 1) = \\ = 1 - 0.8607 - 0.1291 = 0.0102 \tag{1.4}$$

1.3. Exercise 2.2

We can compute the slot time T_s from the definition of nominal bit rate.

$$R = \frac{L}{T_s} \tag{1.5}$$

$$T_s = \frac{L}{R} = \frac{128 \cdot 8 \text{ bit}}{250 \text{ kbit/s}} = 4.096 \text{ ms} \tag{1.6}$$

We compute the equivalent bit rate, r, by considering the smallest quantity of data that the modes can transmit.

$$r = \frac{1 \text{ kByte}}{10 \text{ s}} = 100 \text{ Byte/s} = 800 \text{ bit/s} \tag{1.7}$$

We can compute the number of slots needed by the camera nodes, considering the worst case, in which they need to send 6 KByte.

$$r_{max} = \frac{6 \text{ kByte}}{10 \text{ s}} = 600 \text{ Byte/s} \tag{1.8}$$

$$N_1 = N_2 = N_3 = \frac{r_{max}}{r} = 600 \text{ Byte/s}/100 \text{ Byte/s} = 6 \tag{1.9}$$

$$N_{CFP} = N_1 + N_2 + N_3 = 18 \tag{1.10}$$

Since the system doesn't use the CAP, but only the CFP, the active part is formed by the beacon, which uses one slot, and N_{CFP} slots for the camera nodes.

$$T_{ACTIVE} = (N_{CFP} + 1) \cdot T_S = 77.824 \text{ ms} \tag{1.11}$$

We can compute the BI starting from r and L as follows, and use it to compute $T_{INACTIVE}$.

$$BI = \frac{L}{r} = \frac{128 \text{ Byte}}{100 \text{ Byte/s}} = 1.28 \text{ s} \tag{1.12}$$

$$T_{INACTIVE} = BI - T_{ACTIVE} = 1.28 \text{ s} - 77.824 \text{ ms} = 1.202 \text{ s} \tag{1.13}$$

Finally, we compute the duty cycle.

$$\eta = \frac{T_{ACTIVE}}{BI} = 0.0608 = 6.08 \text{ \%} \tag{1.14}$$

1.4. Exercise 2.3

We need to compute the maximum N_{CFP} to have $\eta \leq 10\%$. We express η as a function of N_{CFP} and impose the limit on η.

$$\eta = \frac{(N_{CFP} + 1) \cdot T_S}{BI} \leq \frac{1}{10} \tag{1.15}$$

$$N_{CFP} \leq \frac{BI}{10 \cdot T_S} - 1 = 30.25 \tag{1.16}$$

Finally, we compute the number of additional cameras, $N_{additional}$, considering that every camera node uses 47 slots and we have 3 camera nodes.

$$N_{additional} = \lfloor \frac{30.25}{6} - 3 \rfloor = 2 \tag{1.17}$$