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SCUOLA DI INGEGNERIA INDUSTRIALE
E DELL'INFORMAZIONE

Course: Internet of Things - 5 CFU

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Homework – Exercise 1

Abstract

The ESP32 node produces a different payload depending on the number of vibration peaks detected in a 10-second window. The peak count is a Poisson random variable with λ = 0.4 peaks/window. The system delivers the payload in CFP, hence contention-free: each slot carries exactly one packet of L = 128 B and the CFP is sized according to the expected load.

The system is operated with IEEE 802.15.4 in beacon-enabled mode, CFP only. Assume: $R = 250kbps$, $L = 128bytes$ where R is the nominal bit rate and L is the packet size.

Question 1 – Output rate PMF

The output rate r is obtained by dividing the payload transmitted each reporting period ($T_{rep} = 10\ s$) by T_{rep} itself.
The pseudocode distinguishes three branches (0 peaks, 1 peak, ≥ 2 peaks); the PMF follows from the Poisson distribution:

- $P(x = 0) = e^{-\lambda} = e^{-0,4} = 0,6703 \rightarrow r_0 = \frac{512\ B * 8}{10} = 409,6\ bps$
- $P(x = 1) = \lambda * e^{-\lambda} = 0,2681 \rightarrow r_1 = \frac{2048\ B * 8}{10} = 1638,4\ bps$
- $P(x \geq 2) = 1 - P(x = 0) - P(x = 1) = 0,0616 \rightarrow r_2 = \frac{4096\ B * 8}{10} = 3276,8\ bps$

Question 2 – CFP slot assignment

Since L = 128 B and one packet fits exactly in one slot, the number of slots needed per payload is $\frac{512}{128} = 4, \frac{2048}{128} = 16, \frac{4096}{128} = 32$.
Sizing the CFP "according to the expected load" translates into the per-node average slot budget:

$$E[s] = 0{,}6703 * 4 + 0{,}2681 * 16 + 0{,}0616 * 32 = 8{,}94 \frac{slots}{node}$$

Rounded up to 9 slots/node, with 3 monitoring nodes:

$$N_{slots} = 9 * 3 = 27$$

Question 3 – Times and duty cycle

- Slot duration: $T_s = \frac{L}{R} = 128 \cdot \frac{8}{250000} = 4{,}096\ ms$
- $T_{active} = N_{slots} \cdot T_s = 27 \cdot 4{,}096\ ms = 110{,}592\ ms$
- $T_{inactive} = T_{rep} - T_{active} = 10 - 0{,}110592 = 9{,}8894\ s$
- Duty cycle $\delta = \frac{T_{active}}{T_{rep}} = 1{,}106\ \%$

Question 4 – Maximum number of nodes with $\delta < 10\%$

Constraint: $n \cdot 9 \cdot \frac{T_s}{10} < 0{,}10 \rightarrow n < 27{,}13$.

Therefore $n_{max} = 27$ total nodes.

Check: $\delta(27) = 9{,}95\ \%,\ \delta(28) = 10{,}32\ \%$.