POLITECNICO
MILANO 1863

ANTLAB

IoT Homework 2024/2025

PART 1 – Exercise 1

Exercise 1 (1/2)

Assignment: Low-Cost IoT System for Forklift Tracking and Monitoring

Context

A logistics company operates a warehouse composed of a 500 m^2 **underground** indoor area and a 1 km^2 outdoor yard.
Electric forklifts are used across both zones and return to specific docking stations to recharge.+

Objective

Design a low-cost IoT system to:
(1) localize forklifts in real time
(2) monitor their status, including daily distance traveled, maximum and average speed, and impact detection.

Exercise 1 (2/2)

Requirements

Your design must include:

- A description of the hardware installed on each forklift, including sensors, processing unit, and communication module.
- The chosen connectivity strategy, communication protocol, and data transmission frequency.
- A backend architecture detailing how data is ingested, processed, stored, and visualized.
- Pseudocode outlining the core logic running on each forklift (data collection, impact detection, communication)
- **A graphical system-wide building block diagram** showing the architecture from edge devices to the backend platform, including key data flows and system components.

Solutions should prioritize simplicity, low cost, and scalability.
Design choices must be clearly justified.

Deliver a report (Exercise1.pdf) of 2/3 pages with all the choices.
Then fill this form!

PART 2 – 802.15.4

Exercise 2 (1/2)

Consider the following pseudocode for a ESP32-based IoT monitoring system

```
// Global Timer Handle
declare timer_handle as esp_timer_handle_t

// Initialization
function setup_camera():
        initialize_camera(QVGA)


function setup_timer():
    declare timer_config as esp_timer_create_args_t
    set timer_config.callback to process_frame
    set timer_config.name to "10_sec_timer"
    call esp_timer_create(&timer_config,
    &timer_handle)
    call esp_timer_start_periodic(timer_handle,
    10_000_000) // 10s
```

```
function app_main():
    call setup_camera()
    call setup_timer()
    loop forever:
        delay(100 ms)


// Called every 10 seconds
function process_frame(arg):
        image = capture_camera_frame()
        person_count = estimate_number_of_people(image)
        if person_count == 0:
            payload = create_message(size=1KB)
        else if person_count == 1:
            payload = create_message(size=3KB)
        else:
            payload = create_message(size=6KB)
```

Exercise 2 (2/2)

Assuming the system is operated with IEEE 802.15.4 in beacon-enabled mode (CFP only) and that the number of people present in the camera frame at any instant follows a Poisson distribution with an average rate of lambda = 0.15 persons/frame

1. Compute the Probability Mass Function of the output rate of the ESP32 P(r = r_0), P(r = r_1), P(r = r_2), where r_0, r_1 and r_2 are the output rates when there are 0, 1 or more than 1 persons in the captured frame, respectively.

2. Based on the output rate PMF, compute a consistent slot assignment for the CFP in a monitoring system composed of 1 PAN coordinator and 3 camera nodes. Assume nominal bit rate R=250kbps, packets of L=128bytes, 1 packet fits exactly in one slot. Compute Ts (slot time), Number of slots in the CFP, Tactive, Tinactive and the duty cycle of the system.

3. How many additional cameras can be added to keep the duty cycle below 10%?

Answer in a PDF “Exercise2.pdf”. Report the numerical values in the **form**!

PART 3 – RFID

Exercise 3 - RFID

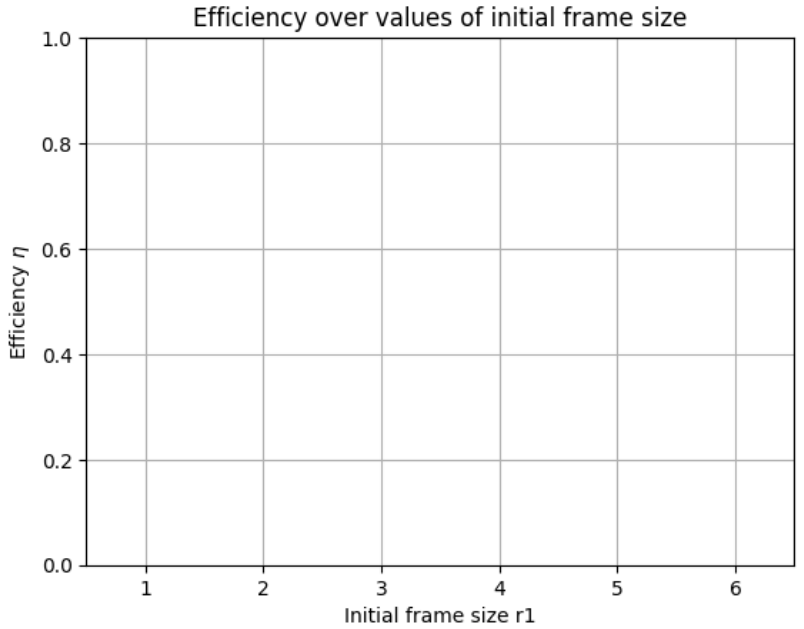
A RFID system based on Dynamic Frame ALOHA is composed of N=4 tags

1. Find the overall collision resolution efficiency **η** in the different cases in which the initial frame size is set to **r1=**1,2,3,4,5,6

- Assume that after the first frame, the frame size is correctly set to the current backlog size
- Assume as given the duration of the arbitration period with N=2,3 tags when r=N

  (**L_2=4, L_3=51/8**)

2. After computing the values of the efficiency with the different frame sizes, **produce a plot** with values of **η over r1** (as figure) -> add in the report



3. For what values of **r1** we have the maximum value for **η? Comment.**

Answer in PDF "Exercise3.pdf" and fill the form!

Challenge deliverables

One PDF report for each of the exercises:

- **Exercise1.pdf**
- **Exercise2.pdf**
- **Exercise3.pdf**

FILL THE FORM with short answers for the exercises!!!

The files should be included in a ZIP (personcode1_personcode2.zip) and uploaded in WeBeep

For 2-people teams:

- Choose your team leader and name the file as:
  <leader_personcode>_<other_personcode>.zip

- **Only the teamleader** should upload the challenge in WeBeep
  Do not upload the same challenge more times

- *Can I take the challenges with the other class students*?
  YES, **but** only the team leader should upload the challenge in WeBeep

Delivery Deadline

- **STRICT** Deadline:

  May 25, 2025 h 23.59

- Max 2 people

GOOD LUCK!