POLITECNICO
MILANO 1863

ANTLAB

IoT Challenge #1

Wokwi and Power Consumption

What to do?

1. Develop on Wokwi a simple parking occupancy node using the **HC-SR04** ultrasonic distance sensor and the ESP-NOW for the communication.
   - Go in Deep Sleep with a defined duty-cycle **X**

2. Perform an Estimation of the Power and Energy consumption for a full cycle and estimate the time it last with one battery of Energy **Y**

3. Comment the results and suggest some possible improvements in order to reduce the overall energy consumption. Prove your considerations implementing them (when possible) and performing new energy estimation.

4. Solve a theoretical exercise on optimizing the sink position in a wireless sensor network

1. Parking occupancy node Specification

- The Node aim is to communicate to a central ESP32 sink node the occupancy of a parking slot (in the emulation use the broadcast address: 8C:AA:B5:84:FB:90)

- Emulate an ESP32 using Wokwi and use the **HC-SR04** ultrasonic distance sensor to estimate the presence of a car in a parking spot (distance <= 50 cm)

ANTLAB

1. Parking occupancy node Specification

- The sensor node in order to save energy implements a duty cycle, where each **X seconds** it wakes up from Deep sleep and transmit a String «FREE»/«OCCUPIED» to the ESP32 sink node, in case the parking spot is empty/occupied by a car
- As soon as the transmission is performed, the node goes back in Deep Sleep state.
- The sensor node will communicate the presence of a car using the ESP-NOW protocol to a central ESP32 sink node (The sink node has no energy constraints)

1. Parking occupancy node Specification

- Assume the ESP32 sink node is always reachable by every sensor nodes.
- A sensor node is present on every parking spot

For the duty cycle period, compute **X** as follows:
Take the last 2 digits of the team leader person code, perform modulo 50 and add 5

leader_personcode = 106929**AB**

X=**AB%50+5**

E.g. *leader_personcode* = 1069291**1**

X = 11%50+5 = 16 seconds

ANTLAB

2. Energy Consumption Estimation

- Compute the duty-cycle from point 1 and perform an Energy Consumption estimation of the sensor node:

  1. Estimate the average **Power** consumption for each state of the node (Deep Sleep state, Idle, Transmission State, Sensor reading, ...)
  2. Estimate the **Energy** consumption of 1 transmission cycle

Refer to the **Power** Consumption CSV file measurements provided on Webeep for the estimation of the power and energy consumption

2. Energy Consumption Estimation

- **Estimate the time** the sensor node last before changing the battery

Consider the **Energy** of the battery to be **Y** Joule with **Y** computed as the last 4 digits of leader personcode plus 5:

leader_personcode= 1069**ABCD**

Y=**ABCD%5000+15000 [Joule]**

E.g. code=1069**2911**

Energy = **2911%5000**+15.000 = 17.911 [J]

ANTLAB

3. Comment Results and Improvements

- Deliver a PDF with:
  1. Code Explanation.
  2. Energy Computations and Plots description.

- Starting from the system requirements, propose some possible Improvements aiming to reduce the Energy Consumption without modifying the main task of the parking sensor node. «Notify to a Sink node the occupancy state of a parking spot»
  - Simulate the system when possible.
  - Provide a "Proof" as support of your optimization:
    - Re-compute the Energy Plot estimation
    - Compare and Discuss the result obtained at point 2

4. Optimizing Sink Position in a Wireless Sensor Network

In the parking lot, there are 10 sensors that monitor the parking spaces.

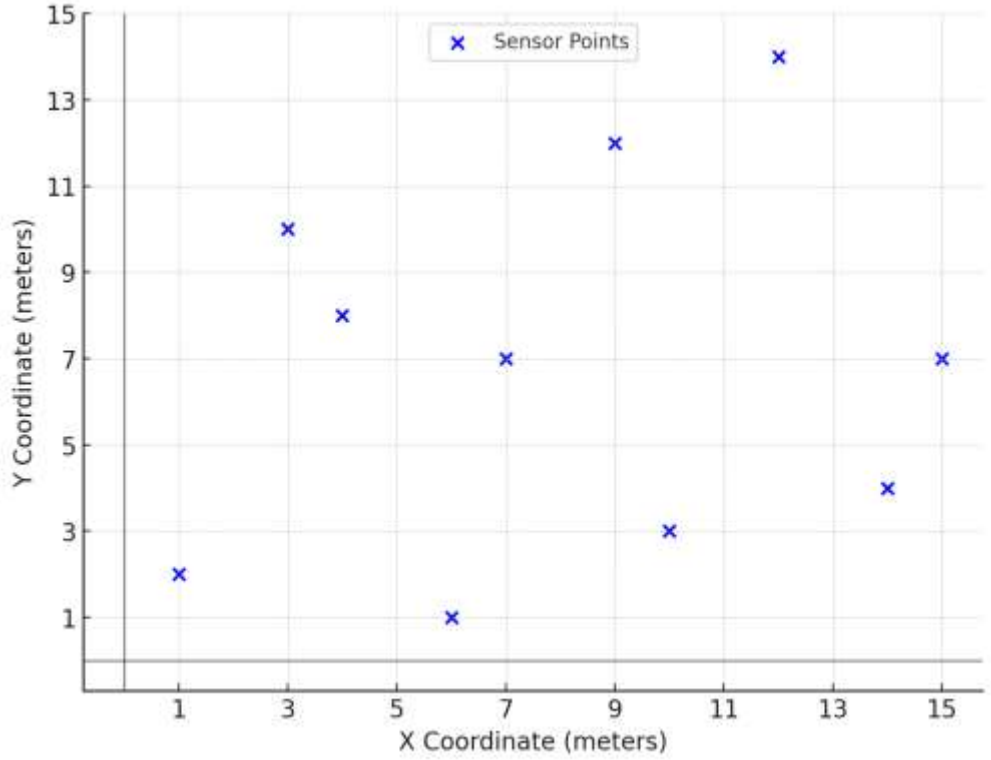
Each sensor has a fixed position (x,y) in the parking lot reported in Table.

Sensor	Coordinates (x,y)
1	(1, 2)
2	(10, 3)
3	(4, 8)
4	(15, 7)
5	(6, 1)
6	(9, 12)
7	(14, 4)
8	(3, 10)
9	(7, 7)
10	(12, 14)

4. Optimizing Sink Position in a Wireless Sensor Network

In the parking lot, there are 10 sensors that monitor the parking spaces.

Each sensor has a fixed position (x,y) in the parking lot reported in Table.



ANTLAB

4. Optimizing Sink Position in a Wireless Sensor Network

- Each sensor transmits a status update every 10 minutes.
- The packet size is b = 2000 bit, and the initial energy per sensor is Eb=5 mJ.
- The energy consumption for transmission depends on the distance between the sensor and the sink:

  - Energy for the TX/RX circuitry: Ec = 50 nJ/bit
  - Energy for transmission: Etx(d)=k·d^2 nJ/bit, where d is the distance from the sensor to the sink, and k=1 nJ/bit/m²

4. Optimizing Sink Position in a Wireless Sensor Network (Objectives)

A. **Find the lifetime of the system** when the sink is placed at the fixed position (xs,ys)=(20,20). The lifetime is defined as the time until the first sensor's battery dies, based on the energy consumption of the sensors.

B. **Find the optimal position of the sink** that maximizes the system lifetime. Provide the coordinates (xs,ys) of the sink that minimizes the energy consumption of the worst-case sensor (the sensor that consumes the most energy).

C. **Discuss the trade-offs** involved in choosing a fixed sink position versus dynamically moving the sink. Consider the impact on system lifetime and energy consumption of each sensor.

Challenge deliverables

What to deliver:

- A **PDF (Named Challenge.pdf)** report containing the explanation of the code logic, the estimation of the power and energy consumption and the reasoning on possible improvements of the sensor node. (Put your NAME and PERSON CODE !!)
  Organize a **clean** report! Very bad reports will be penalized
- **Export of Wokwi project and the shared Public link (when possible)**
  COMMENT AND INDENT YOUR CODE

- **A PDF (Named Exercise.pdf)** containing a well-structured and commented solution for the "Optimizing Sink Position in a Wireless Sensor Network" Exercise.

All the files should be included in a ZIP named as follow:

2-teams: <leader_personcode>_<personcode2>.zip
Single: <leader_personcode>.zip
E.g. 10692911.zip or 10692911_10692912.zip

ANTLAB

For two people teams:

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

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

- *Can I take the challenges with the other class students (Prof. Redondi/Cesana)*?
  YES, **but** only the team leader should upload the challenge in WeBeep

Challenge delivery: HOW?

How to deliver?

- Upload the files in a zip archive as .zip file on the **folder #1** on WeBeep “Assignments” folder

- Fill this **form** with the Energy Consumption Estimation for 1 transmission cycle and the node lifetime

Delivery Deadline

- **STRICT** Deadline:

  March 20, 2025 h 23.59 (FIRM)

- Max **2** people

Good Luck!

ANTLAB