Universidade Nova de Lisboa

Laboratory assignment – 1st evaluation work

Energy efficiency monitoring system

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1. Introduction.

The purpose of this work assignment is to develop an energy efficiency control system for a room in a building. The system must be structured, and Its components must be reasonably identified, being it the objective of this work to implement several sensors and actuators, that posteriorly operated by data processing and decision making, referred from now on as Control Part.

Since one of the objectives is to maximize Power saving, the intention is to develop a Smart System that is capable of saving energy when there is no need to spend It, therefore the choice of some sensors and actuators are based on that, they are responsible for getting data informing about the existing presence of user in the room, and based on that, perform certain functionalities in the room that are processed and configurated on the control part of the system.

This work assignment can be categorized as a IoT (Internet of things) implementation, therefore every decision and justification of implementation, architecture and structure on this work are based on what exists and what is possible to do under this domain, alongside the specifications requested by work assignment for an energy efficiency monitoring system.

Even if the Control part is not implemented in this first work of the class, the idealization and abstraction of it still plays a fundamental role on considerations taken on building the structure and requirements for this system.

This system will be composed of two parts: one is responsible for security, other is responsible for Power management.

2. Architecture

A general architecture for a system is configurated in a way of dividing and categorizing diverse types of technologies on different blocks with distinguished objectives and functionalities. On different IoT systems equivalent layer hierarchy can be referred in designation differently but, in the end, having similar or equal functionalities, a layer can even be divided into more layers, this way adopting a functionality of lower- or upper-layers hierarchy thus having a more concrete function in the system.

In this work our simulation and implementation, take part on Sensing Layer. Network and Middle-Ware layer will be implemented further on.

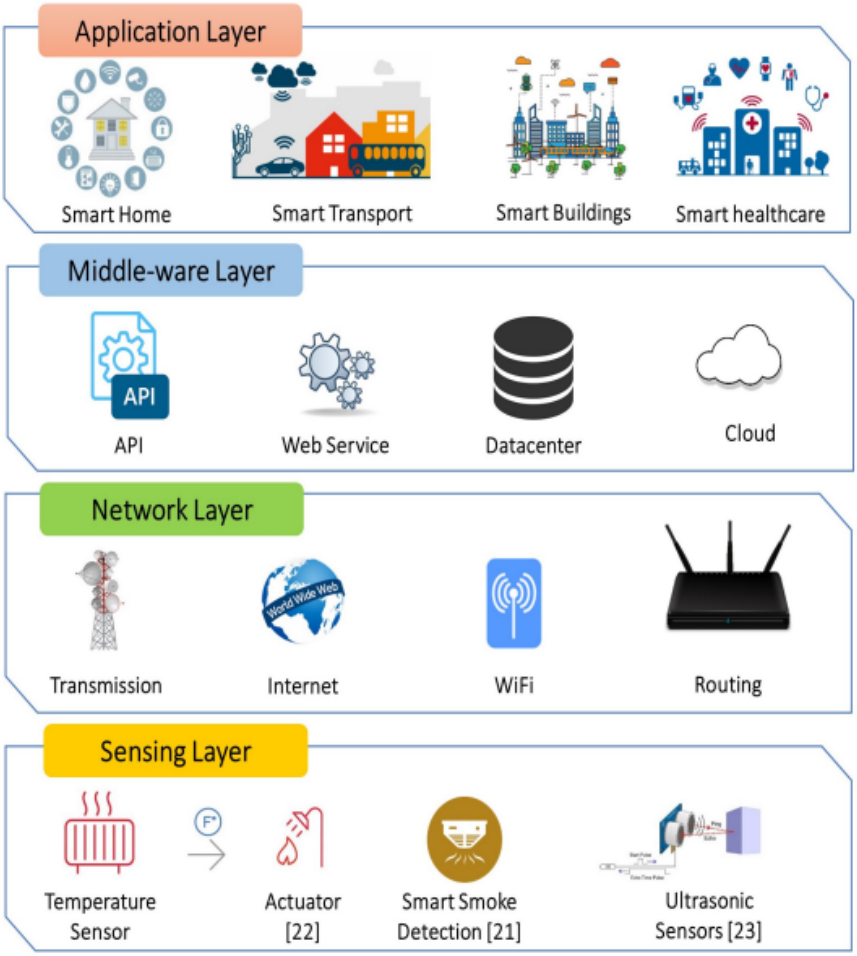

***Figure 1**-Representation of IoT architecture Layers[1]*

2.1. Physical Layer

Generally, when Physical Layer is referred in IoT (Internet of things domain), consists of front-end hardware components that are used for building a system such as sensors, actuators, receivers, transmitters, controlled and automotive devices that operate directly with farm environment. Making connection controller devices that are responsible for operating field sensors. Physical parameters are measured directly providing environment measures such as Humidity, Precipitation, temperature, gas, etc. Alternatively, information that is directly acquired can be processed or computed locally as well as providing local interface, leading to relieve processing power of upper layers in decisions making or processing certain farming inputs into data. This layer is directly connected to the Network Layer to where data is transmitted and received. Below an illustration of a common physical Node sensor described in [4]. Where sensing is the sensors' function, compute is the controller device function locally and communicate to a Node Network.

2.2. Security System

The system is designed to allow access through an RFID reader, that only gives access to determine RFID cards. While a card is not read and presence motion is not detected, it means that the system keeps idle, and the Smart lock is closed.

In case the RFID reader does not detect a valid ID and motion is detected inside the building means that there is a hostile intrusion, therefore an alarm is triggered meaning that there was unauthorized access to the building.

If the RFID reader detects a card with a valid ID, the rest of the system will be initialized (Sensors and Actuators), and the presence detection of intrusion will no longer be active.

After the system is initialized, and the card is read again, means that the person inside left the building, meaning that the security system will be back to active.

The behavior of security routine keeps in loop represented in ***figure 2***.

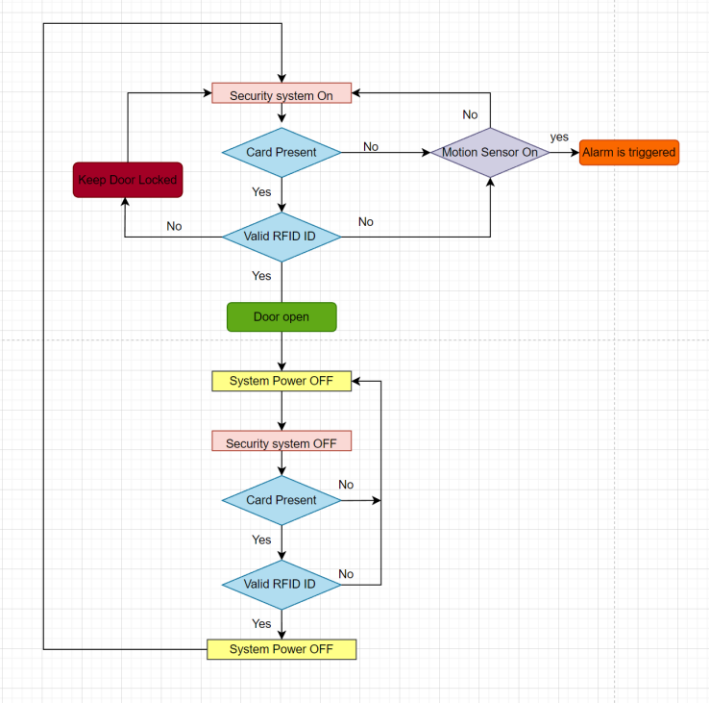

***Figure 2**- Security system procedure*

2.3. System Power

When this part of the system is initialized all physical sensors and actuators will be activated and work under its defined configuration on control part of the system. There are ambient sensors responsible for measuring Temperature, Humidity and Luminosity of the building, based on that data actuators operate.

Actuators are composed of Luminosity Lamps and a relay that triggers a ventilation fan or a heating resistor depending on the decision coming by control part on middleware layer.

3. Structure

The structure of the system is exposed in 3 different ways, the more diverse representations the best understanding of the system is possible to be achieved, it is represented by general Block diagram, use cases and class diagram were used.

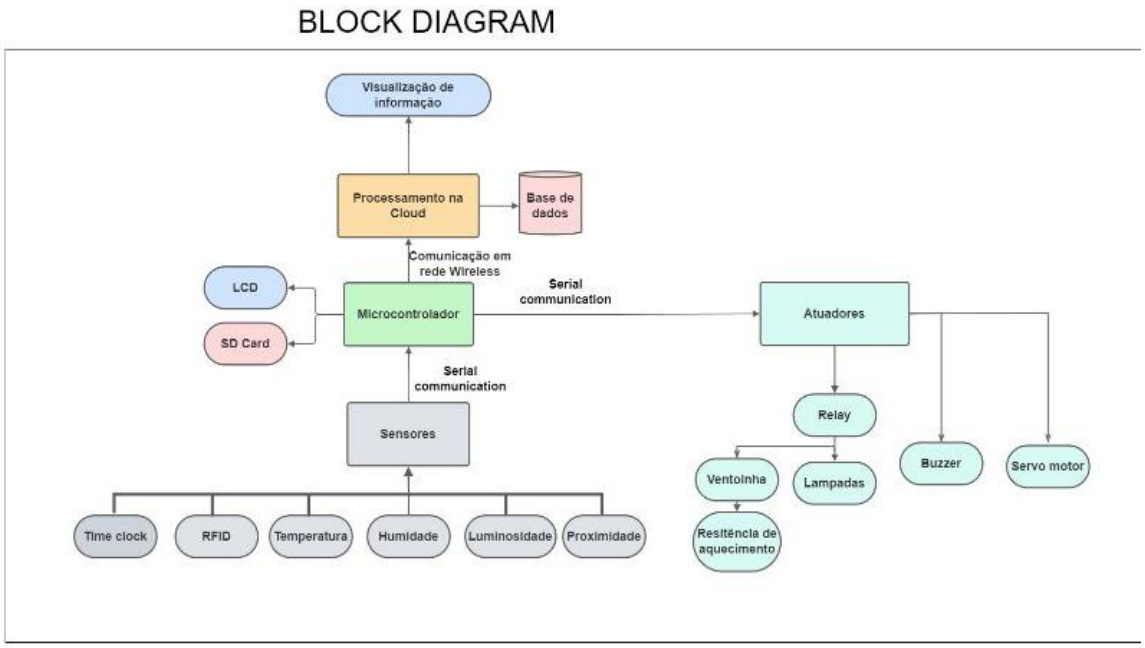

***Figure 3**-Block diagram of the System*

This diagram includes every Hardware part that is needed to completion of this work, and it is possible to Understand the different Layers of architecture.

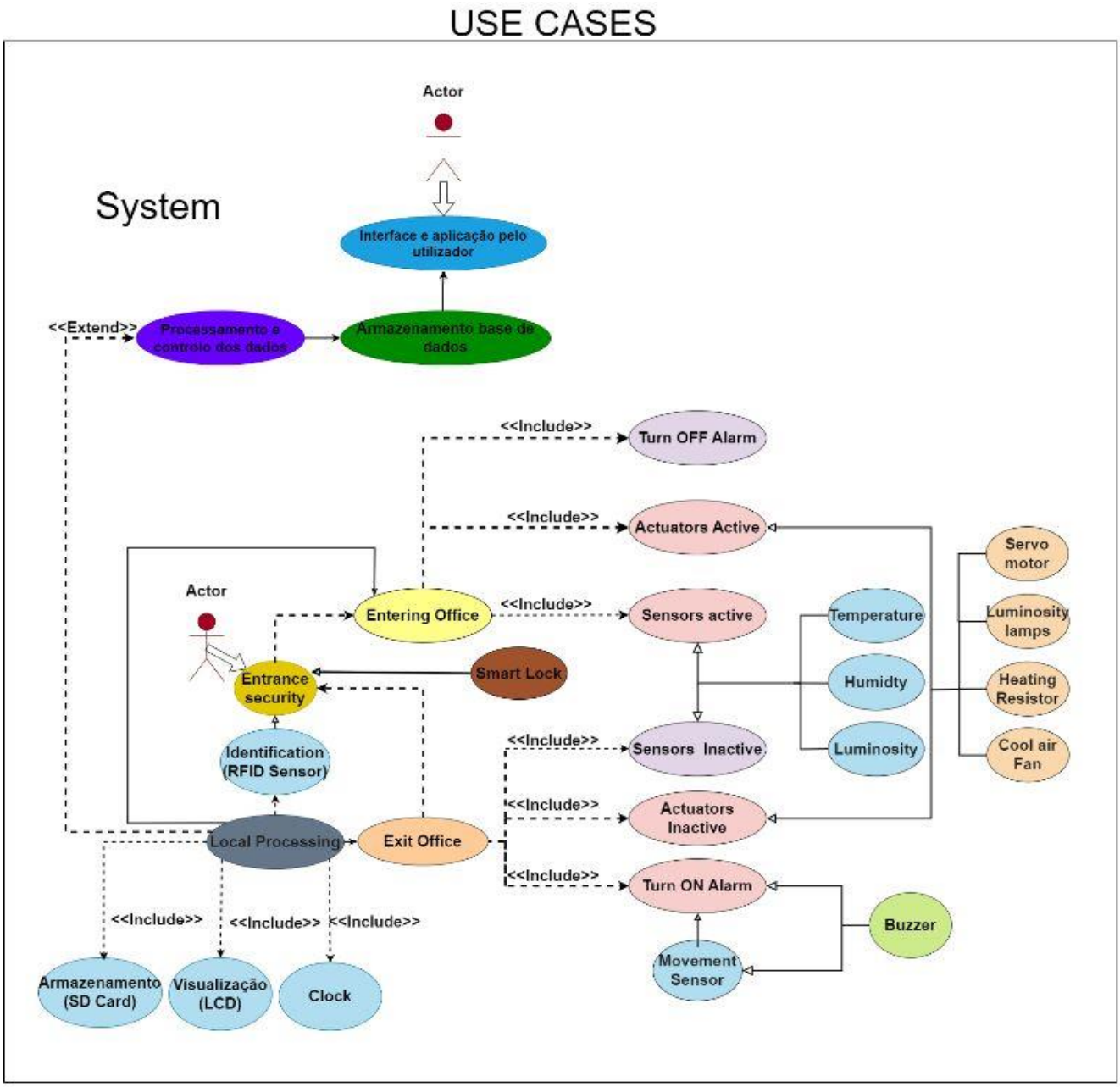

***Figure 4**- Diagram of Use cases*

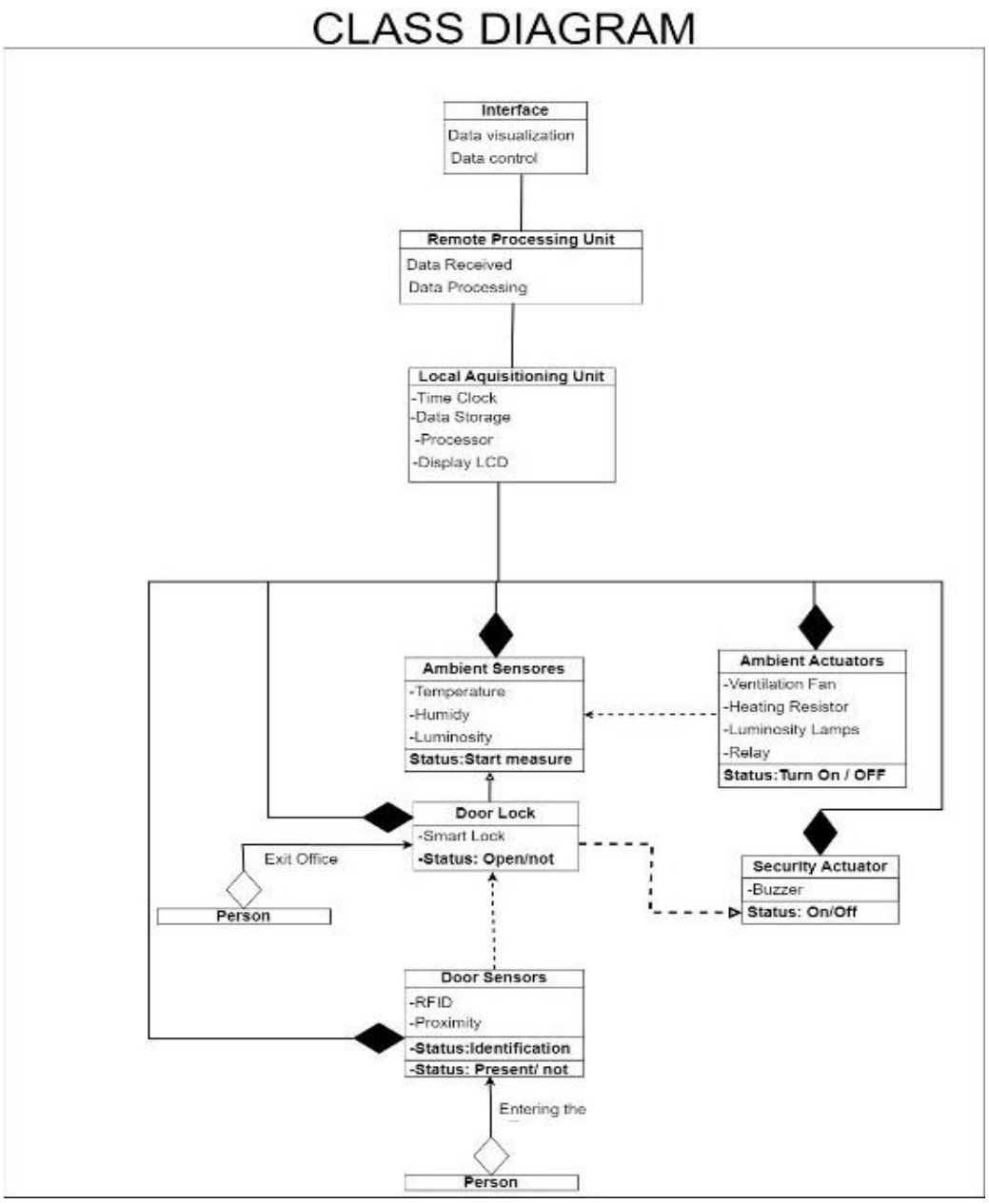

***Figure 5**- Class diagram of the system*

The type of wiring and protocols used for Hardware:

- SPI interface: SD Card Adapter, MFRC522(RFID Reader).
- Digital pin Input: DHT22, HC-501.
- Analog Pin Input: LDR (Light dependent Resistor), buttons
- I2C Interface: OLED SSD1306.
- PWM signaling: Standard Servo Motor, Active Piezoelectric Buzzer.
- Analog Pin Outputs: Relays, LEDs

4. Simulation of the project.

For the simulation part of the system that was developed, a prototype was developed on WOKWI, the hardware used is as follows: 3 sensors of Temperature and Humidity(DHT22), Luminosity (LDR) , Detection(PIR), includes a SD Card adapter for local data storage of the values gathered in JSON format, 3buttons in which 2 of them are for regulating the threshold of temperature in the room, depending on that value the system activates or deactivates the LEDs controlled on the relay.

If the temperature is too high the orange Led simulating a heating resistor shuts down, otherwise if the temperature is too low, the Led goes level HIGH. The green Led also simulates an actuator, in this case the ventilation fan, that always enabled except when the temperature threshold coincides with the real temperature.

The red led and buzzer triggers whenever PIR sensor goes to state LOW, meaning that it detected motion.

The Servo motor simulates a door lock that rotates between 0 and 90 degrees depending on the lock state, open or close, simulating a lock rotating to the latch.

Finally, there are 3 buttons which the 2 of the bottoms are supposed to be used for local control by user to adjust the temperature threshold he desires.

The other button is just used to change what the display is showing, either room current ambient values read, or supposedly see who is currently inside the building (by analyzing the current RFID card that passed on the reader.

Unfortunately, the RFID Reader could not be simulated, since there is no such device on WOKWI simulator, although everything regarding the RFID Reader will be solely implemented in a physical breadboard montage. The following figure show us the simulation on wokwi that was described.

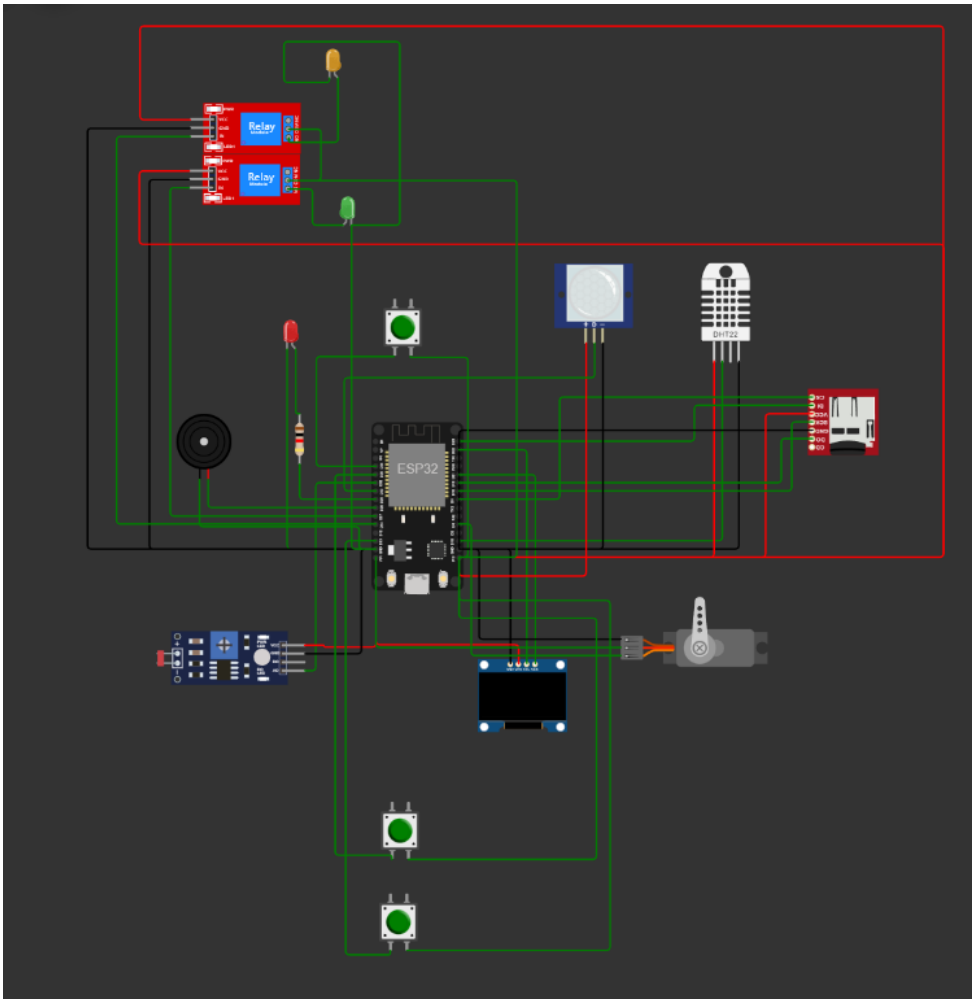

***Figure 6**-Simulation of the system on Wokwi*

5. Implementation of the project

The prototype was developed similarly to the digital simulation, although it has some differences, because some hardware is different and lack of stock on some hardware as well.

The RFID reader is implemented, and it appears working well, the major differences are that buttons are not implemented for setting temperature threshold value or Oled LCD screen change.

The major difference is The SD Card reader implementation could not be done.

Since this was implemented on simulation, it would be easy to replicate It in real scenario, it was chosen not to implement It again because of the confusion on wiring and lack of pins available on ESP32.

The SD Card reader implementation could not be resolved.

Besides this, everything is like the simulation.

The RFID is configurated locally on ESP32 memory to be able to read RFID Cards ID, and only one card is considered valid, this way It is easier to test out this implementation.

Everything works as described on the use cases.

6. Conclusion.

In the simulation software on Wokwi there is no RFID sensor, so it was not simulated, but in the physical assembly the sensor is working well.

The card reader is not fully implemented in physical assembly and need to be fixed at a later point, since there is no more available GPIO's for SPI integration, since this is used for RFID Reader sensor.

All the sensors and actuators work well, and some basic data processing is made on the ESP32 microcontroller, however decision making, and control of the system is meant to be implemented through data processing that is done remotely on a Network environment, such implementation will be done on a future work of this course, by integrating IoT (Internet of things) concept.

Anexos:

https://wokwi.com/projects/331628654039663187

[1]- “A Survey on IoT Security: Application Areas, Security Threats, and Solution Architectures”, DOI 10.1109/ACCESS.2019.2924045, IEEE Access