1. Introduction

The needs for access control and resource management

A major problem that one perceives when visiting a hospital is the location and management of doctors and nursing staff in situations of overload due to increased traffic and the lack of discipline from patients who do not obey staff orders and are removed without permission from their chambers . Also the management of the security personnel is utmost importance for the timely response to illegal actions

These developments have highlighted the need to implement resource management systems in a hospital environment. Various risks may arise from unauthorised access to wards and areas of the hospital .It is important to known the location of staff, medical equipment and patients in medical emergency situations when the times is of the essence. Also in situations such as a fire event it is important to know the exact number of people trapped in the area for an effective evacuation operation

2. Objective of project

The resource management system ,unlike for another systems to have been proposed does not aim for the exact location of resource at the level of few centimetres but at the chamber/room level. This is achieved with RFID sensors at the building doors with passive cards or tags in people's possession .Thus with cheaper and less equipment the results provided by the system are adequate for the resource management needs of the hospital.

In each chamber the ID's of the attenders and additional data such as temperature, humidity, door status, fire sensor status are collected and sent to the central station a computer and with appropriate software analysed and displayed on a screen , Emphasis is placed on human safety so that the system to facilities evacuation of the building in case of fire or other emergency situation not to be hindered by the system. The simulation was done on a mock-up materials obtained from online stores and local stores.

More specifically , the system will provide the following functions:

- Monitoring of manpower and equipment via graphics visualization from a work station
- Search for a specific employee or patient and indication of the system in which chamber the selected one is located

- Notification by sound and visual means for opening of a window or balcony door without the consent of the chamber manager
- Notification by sound and visual means in the event that someone escapes or enters a chamber without the intended use if RFID card or tag
- Notification by sound and visual means in case of fire. The operator has full knowledge of the people inside the building.
- Release all locking mechanisms for doors in case of fire. In this way the building can be evacuated without danger.
- Release switch locking mechanisms for doors on both sides (inside and outside)for emergency cases without the intervention of the microcontroller to eliminate the slightest possibility of the doors not opening due to malfunction of the electronics.
- Retrieve history of movement for the chamber in an excel file. Since in hospital the installation of CCTV in the chambers is against the law on personal data, such a system could be useful in legal matters
- Ability to monitor temperature and humidity in the chambers so there is knowledge of all rooms for a single point. The management of the heating of the chambers will ba facilitated
- Distributed data storage for each chamber locally. With this technic in case of collapes of the workstation the system can recover within a few second without losing the information about status of each chamber. Also while the system management workstation is down , the system works in the background.
- Notification of the hospital's security staff in case the system user activates the corresponding button if he/she deems it necessary.

3. System Design

For the design of the system, two design alternatives are presented that differ in the way for the passive cards/tags are recorded and in the existence or not of a locking mechanism on the door.

The first proposal involves the installation two RFID readers ,one placed outside the room and one inside. This design in addition to controlling and managing resource provides access control to the hospital premises. It is a design suitable for environment such a public hospital that aim to suppress and terminate uncontrolled access into patient care rooms

The second proposal involves replacing the two RFID readers with an RFID carpet at each entrance and without a locking mechanism for locking doors. Thus access at the premises does not require unlocking the doors. It is a design in disciplined environment as private clinics. The two proposals are described in details below and illustrations are shown.

Proposal 1

Figure 1 illustration the design of the architecture of each room of the resource management system. The two RFID readers are connected to the SPI bus of the EPS32-C6 microcontroller with the microcontroller as master and the two RFID readers as slave. Additional detectors are connected to the microcontroller via digitals pins lsuch as TCRT500 sensor for motion detection at the room door, the fire detector sensor for flame detection in the room ,the DTH11 sensor for reading temperature and humidity on and finally the magnetic contact for windows control. Two switches turn on and off the circuit that powers LED 1 which simulates a door locker with fail safe which means when the power is cut off the device remains unlocked. A type of door locker is illustration in figure 2.

Since the system was not designed using the fault tolerance technique , a technique applied to critical computing system where the hardware is repeated several times, it is duty of the engineer to designing the system to safeguard the human life.

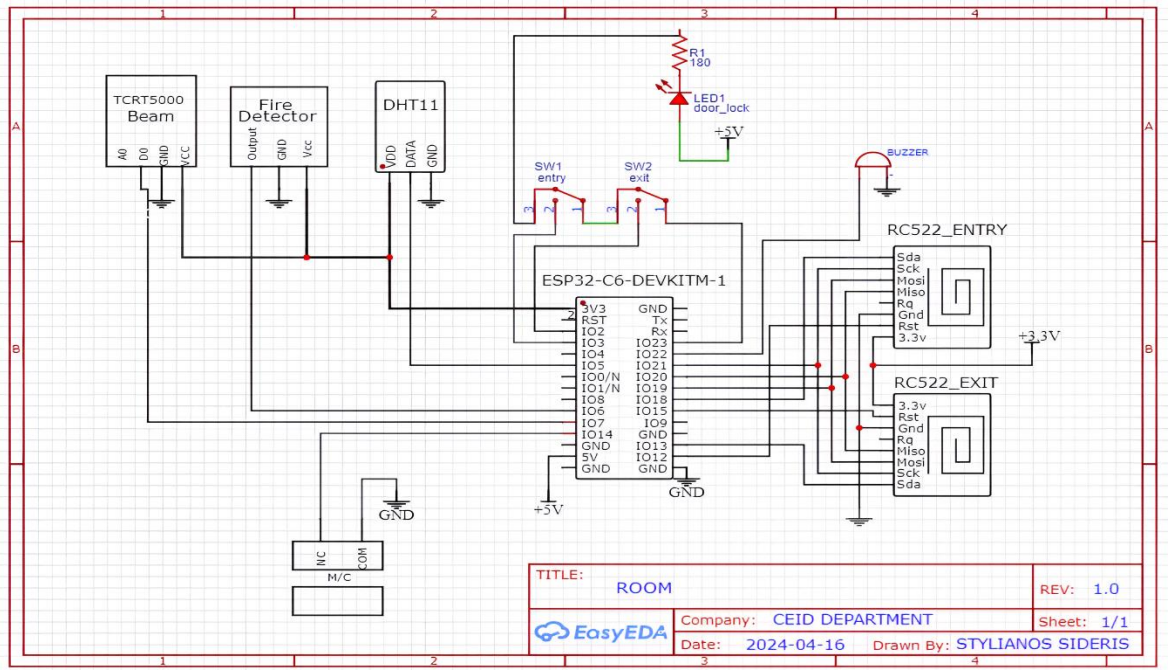

Figure 1 : Resource management system architecture proposal 1

So the two mechanisms emergency switches at the figure 2 that are visible above the EPS32-C6 microcontroller, in case the microcontroller incorrectly block the door due to failure of the electronics , cut the power supply voltage to the door locker and the door will unblock. Also in the design ,when the flame sensor detects a fire , the power supply voltage to the door locker is cut off again to avoid difficulties in cases such as emergency evacuation of the building.

When someone swipe his card on one of the two RFID readers ,he has 5 seconds to ender or exit the room and this will be evaluated by the TCRT5000 motion sensor to there is on the door. The same sensor prevents someone from entering the room as a second person without

swipe his card/tags after the door has been unlocked for someone by a first person. Also when a valid card is reading the buzzer sounds briefly to let the person that the card has been successfully recognized.

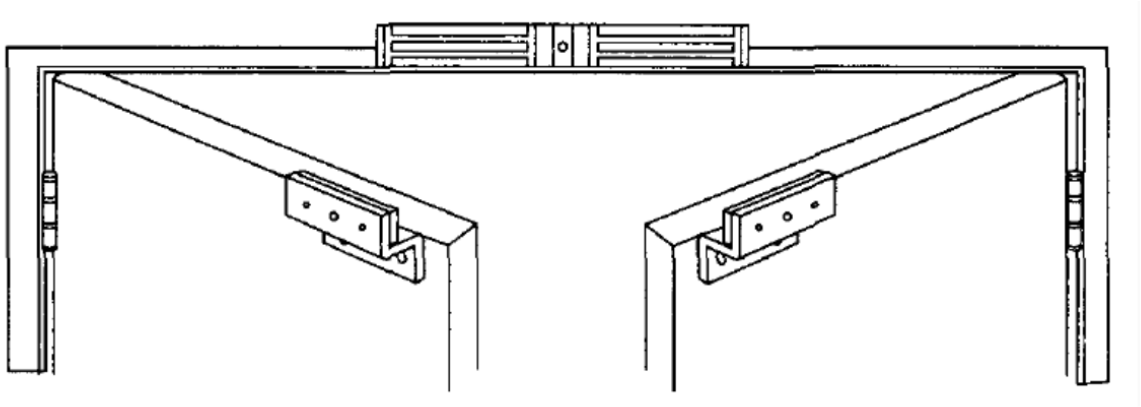

Figure 2 : electromagnetic door locker with failure safety property
Source : beaconcdl.com

Propose 2

In this design we replace the RFID readers to present in proposition 1 with an RFID carpet reader to show in figure 3 where in an elderly care home in Japan such device has been installed and through passive cards/tags on the slipper of the elderly and caregivers ,entry or exit from tooms is detective.

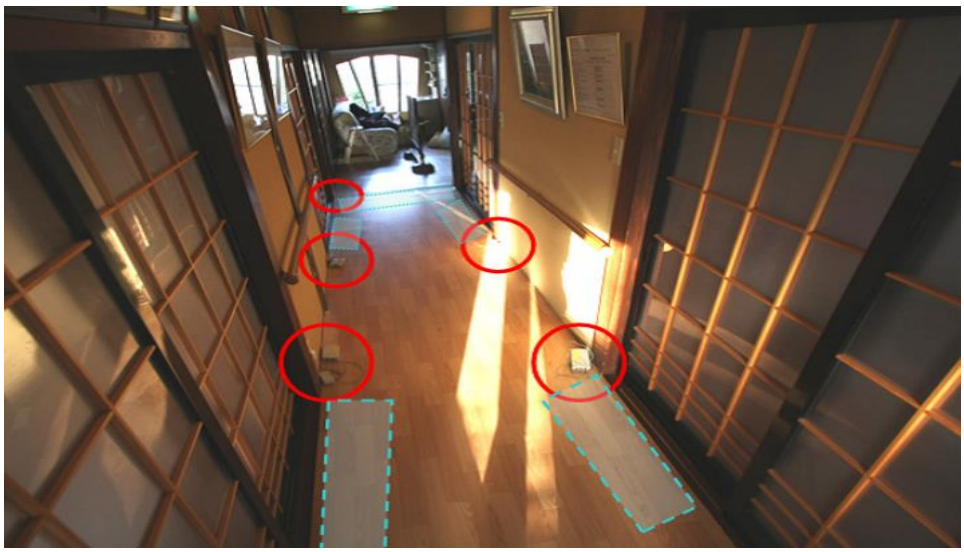

Figure 3 : RFID carpet placement in an elderly care home
Source : Miura, Motoki, et al. "An empirical study of an RFID mat sensor system in a group home." *Journal of Networks* (2009).

As can be seen in the figure 4 in comparison to proposal 1, the use of door locker and consequently emergency switches as well as the use of an alarm buzzer is omitted in the design since by using an RFID floor reader the entry and exit from a chamber is simplified. People are now tracked as they enter/exit the space via RFID reader to located at each chamber entrance and the passive RFID tags placed on their shoes.

With this proposal it is possible to record the entry/exit of medical equipment that is placed on special bases with wheels as shown in figure 5. The RFID tags should be places at a distance 5 to 10 cm to be within the range of RFID carpet readers. The plan view of the base is shown in figure 6.

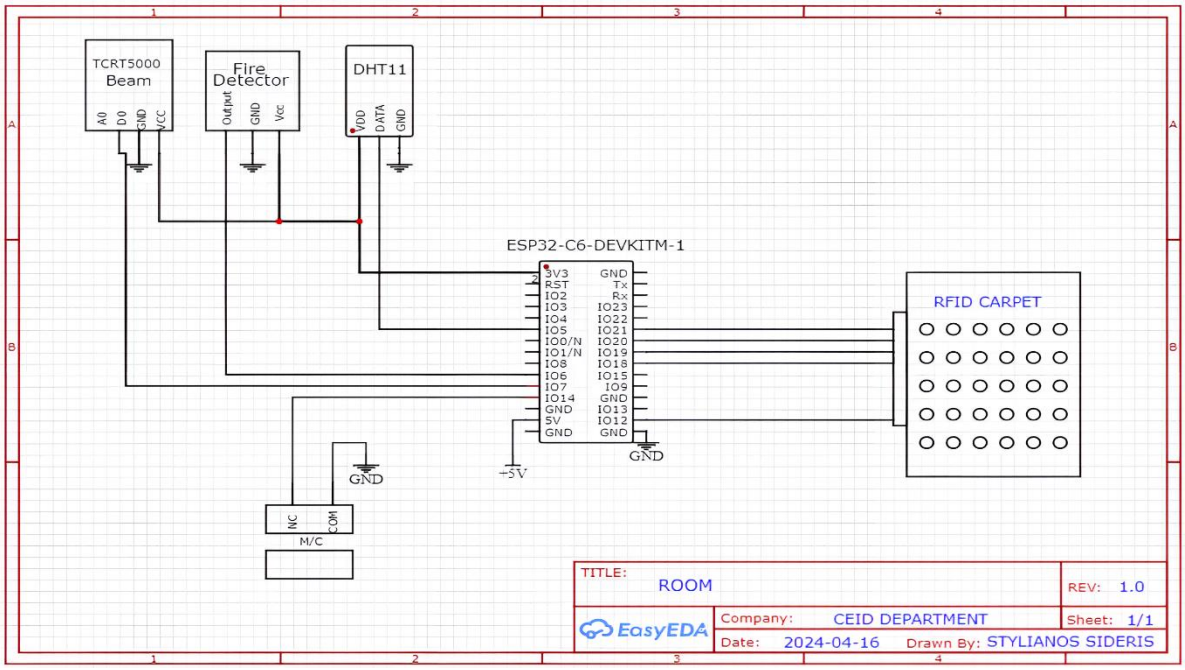

Figure 4 : Resource management system architecture proposal 2

Figure 5 : Hospital equipment on a wheeled base
Πηγή : medicalmeasurements.com

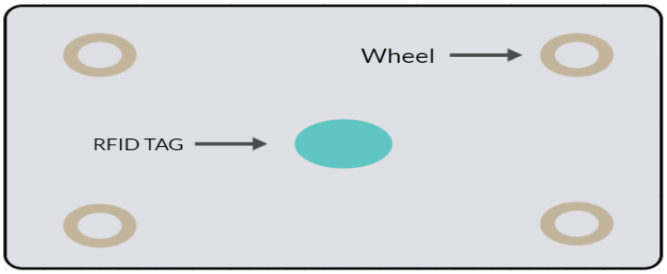

Figure 6 : Plan view of the hospital equipment base

Now that we have described both proposals for the design of the system at the chamber level ,figure 7 shown the block diagram at the higher level of abstraction of the system. Each microcontroller collects the information of each chamber, encrypts it and through wireless channel and especially with the ESP=NOW protocol, the data is transferred to the microcontroller to collects the data from all the chambers. This microcontroller when decrypts the data and via USB port send the data to the main computer where the system is managed through graphical display.

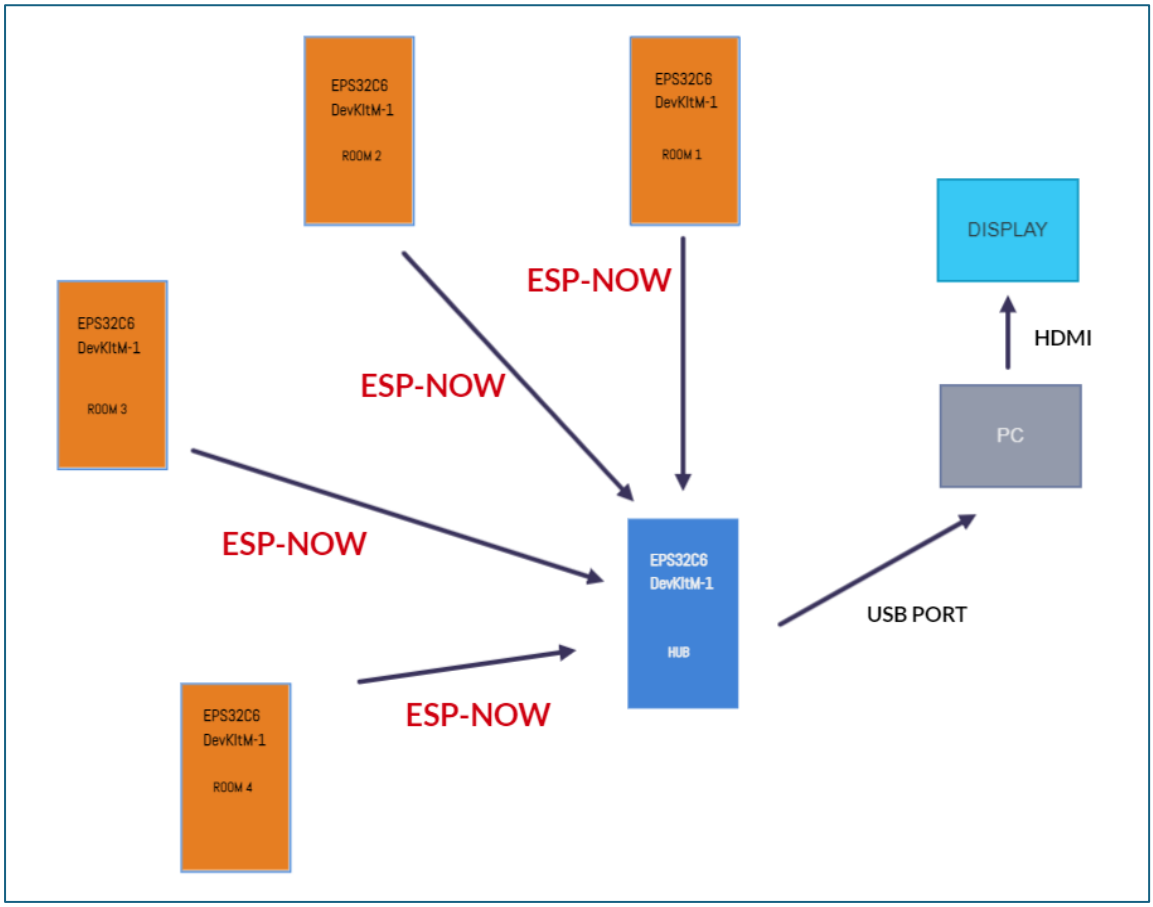

Figure 7 : Block diagram management system

4. Choice of equipment (hardware)

- ESP32-C6 Microcontroller on Devkit
- RFID passive cards RC522 13.56MHz
- Passive card MIFARE
- W/TCRT5000 object detection infrared sensor
- Fire detector sensor - Flame Sensor Module
- DHT11 digital temperature and humidity sensor
- Passive buzzer low level trigger
- Magnetic contact ALEPH DC 1561
- Two positions switches
- LED
- Resistors

5 Chamber microcontrollers-Firmware

At the startup of the microcontroller the initialization of variables for the connection to the local network of the system and the variable for the encryption of data. Then the system operation is started in which the following processes are controlled.

- Check for fire and, if there is a fire, unlock the doors. A special reset switch is required to reset the locking mechanism on the doors.
- Check if there is any RFID card to read and if there is , the ID of the card is read and stored.
- Starts counting a time to allow entry or exit to the room. If someone enters or exits, then the time is reset and no second person can enter or exit.
- If there is no card to read and the motion sensor is ON, then the escape variable is set to 1, which means that someone has entered a room illegally without using a card
- Data collection from the other sensors and from values of the system variables.
- After the collection of the status of the sensors, the price of escape variable and the ID cards of the people in the room, a message is generated.
- Check if this message is the same as the one in the last transmission and if it is the same, then it is not send again.
- If it is not same, then it is encrypted and is encoded in Base64 and send.
- If the mission is not successful, we have a retry mission for the specific attempts, according the specification of the memo mission protocol.

Figure 8 shows the diagram for the firmware of the microcontroller of each hospital room

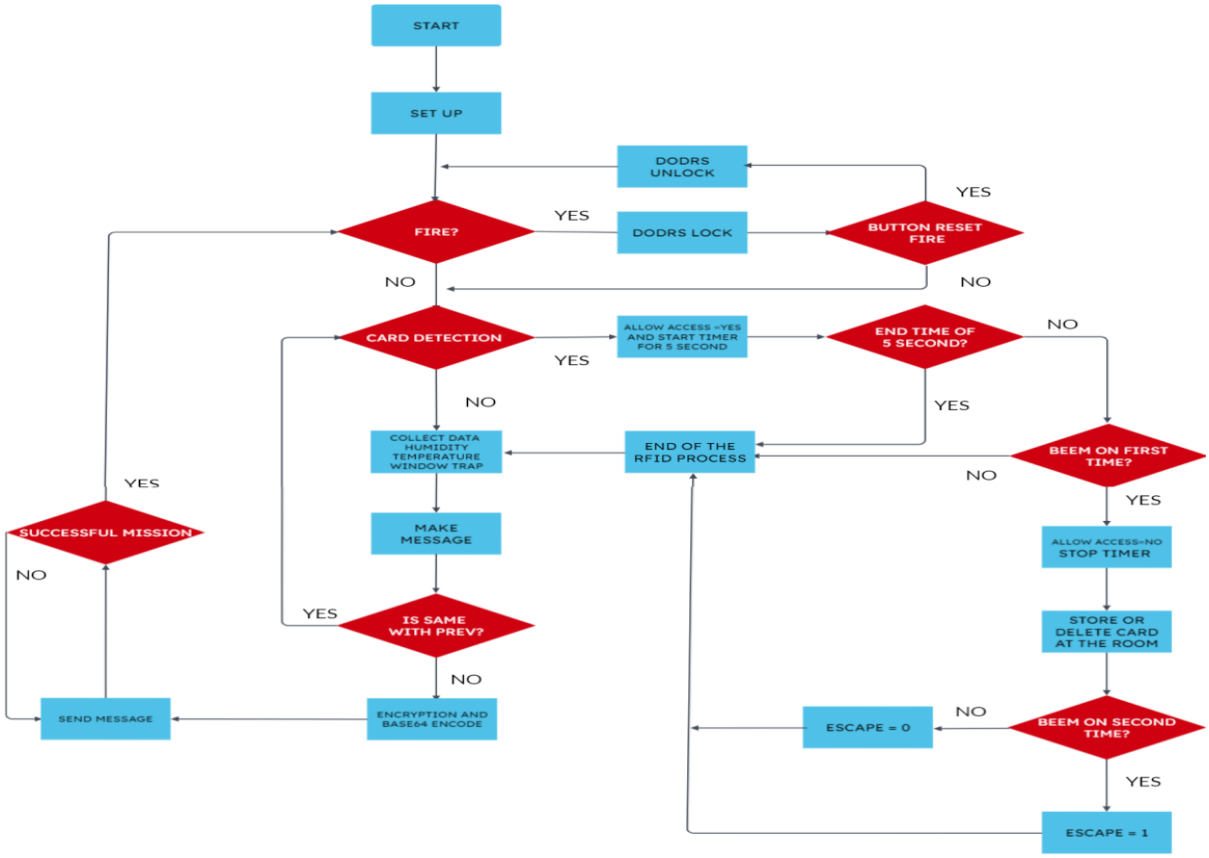

Figure 8 : Flowchart for microcontroller in the chambers

6 Data collector microcontrollers-Firmware

The shape of figure 9 shows the flowchart for the microcontroller that collects the data from all microprocessors in the room. Sender identification is done base on MAC addresses and any message received from a sender with unknown MAC address, is discarded. If the received packet belongs to one of the registered potential senders, then it is decrypted and decoded from Base64 to plain text and forwarded via a USB serial port to the computer running the resource management software. In addition the microcontroller has the ability, in addition to sending messages to the resource management software, to receive messages such as, for example, a message to activate a security personnel alert.

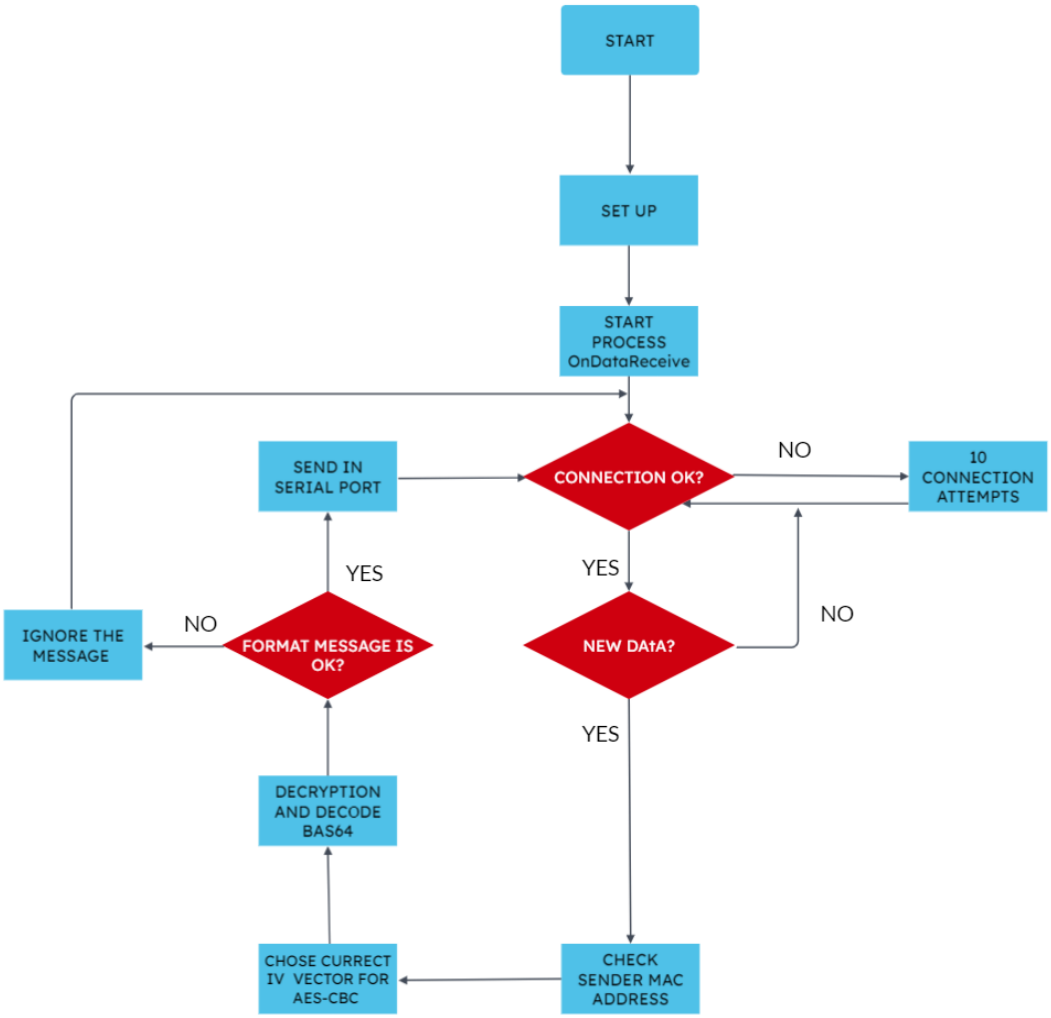

Figure 9 : Firmware flowchart for data aggregation microprocessor.