IJEMD-CSAI, 2 (1) (2023), 1 – 16 https://doi.org/10.54938/ijemdcsai.2023.02.1.172

International Journal of Emerging Multidisciplinaries:
Computer Science and Artificial Intelligence

Research Paper
Journal Homepage: www.ojs.ijemd.com
ISSN (print): 2791-0164 ISSN (online): 2957-5036

Integrating Smart Bag Technology and Mobile Apps for Seamless Travel and Beyond

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Abstract

The uses of bags, for travelers, have been an integral part of life. People face difficulties in securing their bags against theft during travel and luggage transit. The emerging Internet of Things technologies and IoT devices like sensors, microcontrollers, GPS/GSM modules, RFID tags/ readers, fingerprint scanner and many such components help immensely in automation and can be used to collate vast amounts of data, ranging from time- series data from sensors to spatial data. The objective of this project is to make travel bags smart by using the IoT devices and utilizing the captured data to thwart from robbery of personal belongings and to eliminate theft to great extent. The proposed smart bag with a mobile application keeps owner credentials like fingerprint, passcodes and other security components collected and endorsed using the IoT devices can be used to track the bag. And if the bag is stolen an emergency notification sent to the owner mobile and used the geographical data to track down to the culprit in precision time before the stolen bag is mutilated. These and other features elaborated in this article helps the law enforcement officers track criminals easily. The smart bag will also benefit banks in secure fund transfer among automatic teller machines and business enterprises in exchanging confidential documents.

Keywords: Bluetooth; Fingerprint sensor; GPS/GSM; Load sensor; Microcontroller; RFID.

1. Introduction

With the remarkable development witnessed by the world using technology in all areas of life, it was necessary to create something new that supports this development, helps people, and solves the problem they suffer from. Many bags have been made in different shapes, types, and sizes for all categories of people and satisfy everyone. The multiplicity of use of bags according to their forms, some of them are for daily use by women, some are used by children when they go to school, some are used by businessmen,

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and some are used by travelers. Despite the versatility of bags, its main goal is to help a person collect his needs and facilitate the process of carrying them from one place to another. Despite the benefits of the bag, many users of the bag suffer from many problems. Theft is one of the most problems that people suffered from and it is spreading at an accelerating pace in the world, the process of detecting the thief depends on the data collected manually and searching through crime records that could reveal the criminal may take a long period of time. Even though the collected data might be correct it might lead to incorrect conclusions, through overlapping the information from many people resulting in investigation with many people, to track down to the exact culprit [1]. Hence the idea of creating a smart bag that contains many features that will benefit the holder of this bag and protect him from the problems he is exposed to. The smart bag has features that the rest of the regular bags don't have. The smart bag is designed with help of the latest technology for solving the losing bags problems. The bag is working on Bluetooth interacting with a file controller, GPS / GSM modules, RFID cards, Ultrasound sensors, power unit, load cell, fingerprint, etc. The bag can be easily tracked for location by GPS technology and RFID cards which help in the unique definition of a bag and is also controlled by the user's smartphone. Furthermore, fingerprint technology helps in digital lock, tracking and locating along with many other specially designed features [2]. So, the smart bag will leave the owner with more confidence against robbery of personal belongings anywhere and anytime as this product is intended to eliminate the widespread theft by a large percentage. Smart bag has a fingerprint enabled locking system that helps to avoid theft and maintain a level of security and safety and send notifications to the application synchronized with the phone. In addition, this bag relies on the wireless network to quickly locate bags. If the bag is within the Bluetooth range the application can locate it as well [3].

Objectives

The objective of this project is to create a secure bag with sensors for fingerprint detection and luggage weight and equipped with fingerprint lock/unlock technology to increase the level of security. In addition, there is a mobile app for this bag to receive notifications sent from the sensors of the smart bag [4]. These notifications include fingerprints and smart bag location. This bag will provide more security for the community [4]. In addition, it will help law enforcement agents find criminals easier. Moreover, it provides a high transformation to the market because there is a demand for it, and it also saves effort and time while increasing the speed of response. This project will help us learn how sensors are used in different fields and can help people in different ways. The bag owner will know who is touching his/her bag and alert the owner if the bag is lost based on sensor values read by the microcontrollers [1]. Based on the fingerprint-enabled lock system, the application should be developed to help people avoid theft, maintain a level of security and safety, and send notifications application synchronized with the phone [1].

Purpose and Scope

Smart bags abound with many technical innovations, which facilitate people's travel and movements, and provide them with means of comfort and luxury, as bags can be opened by fingerprint, and provides tracking function via the Global Positioning System [GPS] and Global System for Mobile communication [GSM] [5]. In addition, for the purpose of providing high protection for confidential and important belongings, so that the bag is closed as soon as it moves away from a certain distance from its owner [9]. As well as recording the fingerprints of the bag and storing it in the storage cloud [6]. To sum up, there are

three main purposes of the smart bag, the purposes of comfort and luxury, the purposes of protection against theft, and the purposes of the accuracy of tracking the thief through the application linked to the bag. The project, when implemented, will save security, comfort, effort, and time to search for the thief, and thus reduce theft, leading to increased protection. Where we see the globe rapidly evolving and developing, the smart bag has a tremendous scope. When it comes to tracking the bearer's whereabouts, safety, luggage weight control, and convenient access through an application embedded in an Android based mobile with features adhering to 4G/5G network [10], as well as theft tracking, this smart bag has it all. Future preferences will lead to increased scope and competition for designing and manufacturing smart bags in large quantities, as well as the addition of performance and security features.

Need and Requirements of the new System

Oman is one of the countries that keeps pace with development and technology, and according to the Oman Vision 2040, it supports education and scientific research. This project uses the Internet of Things technology system and has many advantages. The bag contains a GPS system that helps to locate the bag in a very short time. In addition, it contains a fingerprint system that allows the owner of the bag to open it, and if anyone else tries to open it, an alert will be issued, and an SMS message will be sent to help the owner of the bag that there is a thief trying to steal the bag or open it. The bag is also linked to a mobile smart phone application that helps collect information related to the bag. All these features will help in solving the problem of thefts and all problems related to the bag. The use of Internet of Things technology in the bag is the best solution and a smart way to solve the restrictions found in regular bags that lack security [8].

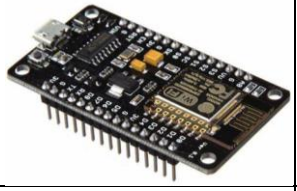
User Requirements

1. The system must have security features and addresses a persistent theft issue.
2. Must be able to save effort and time and increase the speed of response to address the problem.
3. Must be able to meet the acceptance and approval of the individual and society.
4. Must be able to provide a high transformation to the market because there is a demand for it.
5. Must help people avoid theft, maintain a level of security and safety, and send notifications application synchronized with the phone.

System Requirements

The hardware requirements include a computer laptop with a minimum configuration having Intel Core i3, Microsoft Windows 10 operating system, 4GB RAM, 500 GB HDD, 14" LED monitor with Network adaptor and WiFi connectivity. Besides the minimum software requirements include Arduino IDE, Blynk App and Blynk Cloud. The important IoT devices required are shown in the table below:

Table 1: IoT components

Arduino Uno 	Keystudio Uno R3 is a microcontroller board based on the ATmega328. It has 14 digital input/output pins, 6 of those pins can be used as PWM outputs, 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, and 2 ICSP headers, as well as a reset button.
NodeMCU ESP8266 	NodeMCU is based on ESP8266 which can connect objects and let data transfer using the Wi-Fi protocol and provides important features of microcontrollers which are GPIO, PWM, ADC, etc.
LCD display module 	The serial LCD (liquid crystal display) is used to analyze the sensor output. It is a high- quality 4-line 20-character LCD module that not only allows contrast through a rear-mounted potentiometer, but also has a backlit and I2C communication interface.
Load cell card 	PCB load cell sensor is used for all types of measuring and inspection machines. It is a highly reliable and accurate load cell sensor PCB.
Fingerprint reader module 	The fingerprint sensor module is used as a means of identity verification. It is widely applied to computers, mobile phones, electronic door locks, access control systems, security cabinets,etc. It can store and identify up to 3000 fingerprints. The built-in 32-bit microcontroller implements image signal processing using a unique algorithm to complete high-speed fingerprint sampling, template file generation, identification, and other operations
RFID Module (RFID-RC522) 	RFID, or Radio Frequency Identification, is a data collection method that uses low-energy radio waves to send and receive data between tags and readers. An RFID system consists of three components: an antenna, a

	transceiver, and a transceiver.
RFID Tags 	RFID tags have an inbuilt antenna that generates a magnetic field for communication between the RFID reader and the tag. RFID tags are usually of two types: an active tag and a passive tag. Active RF identifier and passive RF identifier are basically two distinct technologies but are often evaluated together. Passive RFID bank on radio frequency energy transmitted from the reader to the tag. Thus, stronger signals from the passive reader are needed. The signal strength returned from the tag is limited to very low levels.
GSM Module (SIM900) 	GSM is a network technology based on TDMA (Time Division Multiple Access). The digital system has the ability to transmit data rates from 64 Kbps to 120 Mbps. The main feature of GSM is a subscriber identification module known as a SIM card. It operates in the frequency bands 850MHz, 900MHz, 1800MHz and 1900MHz.

Functional and Non-Functional Requirements

The functional and non-functional requirements are important as meeting these requirements are obligatory, are essential for system operations and help understand the functions of the system and therefore summarized in the following table:

Table 2: Functional and Non-Functional requirements

Functional Requirements	Non-Functional Requirements
The system must be able to differentiate between the fingerprint of the owner of the bag and the fingerprint of the thief. When an attempt is made to steal the bag, it will issue an alert. This process will be done through the sensors and the Fingerprint locking system	Easy access: The user can access the data in the system at any time
The system must have the ability to send an alert such as a message to the phone ofthe owner of the bag that someone is trying to steal the bag or that it has been stolen	Maintainability, Backup: The system provides the productivity of information backup, Fatal Errors: The system will track each error and keep a log of it.
The system should have the geo-location feature of the actual bag location in the shortest possible time	Ease of use: The system is easy and easy to use, and the interface is uncomplicated

All data collected from the sensors and other devices in the bag must be available atany time for analysis and understanding	Extensibility/ flexibility: The system can be updated over time and add some new features in it
The information that was captured from the sensors and the rest of the devices mustbe saved in a safe place, such as clouds, to be obtained at the time of need	Correctness: The system gives the correct and accurate result, Security: The system allows access to authorized persons only, Reliability: The system can run the task without failure for a specified number of uses for different times

System Design

Use-Case and Activity Diagrams

Figure-5.1 shows the use-case diagram for the administrator of the system showing several activities including tracking a bag. Figure-5.2 shows the use-case diagram for a client or user of a smart bag.

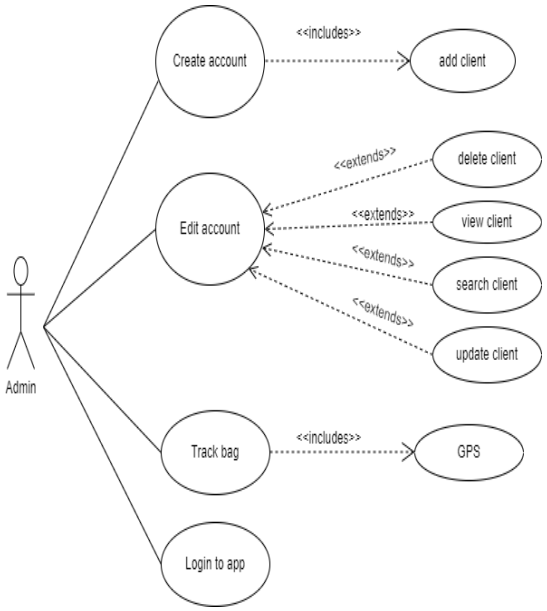


Figure 5.1 Admin Use-case diagram

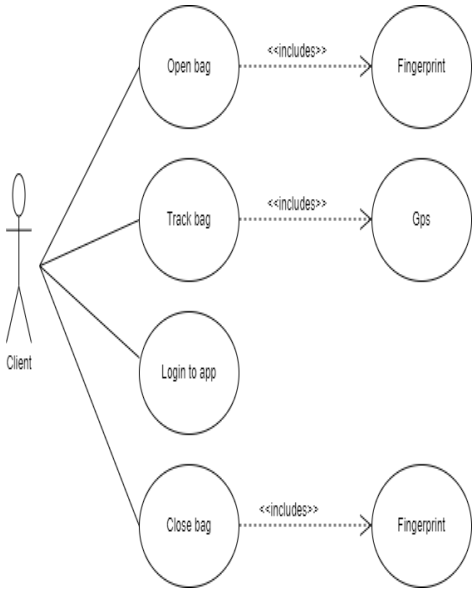


Figure 5.2 Client Use-case diagram

Figure-5.3 shows the activity diagram for creating an account for a user.
Figure-5.4 shows the activity diagram for tracking a bag and Figure-5.5 shows the activity when a bag is either opened or closed.

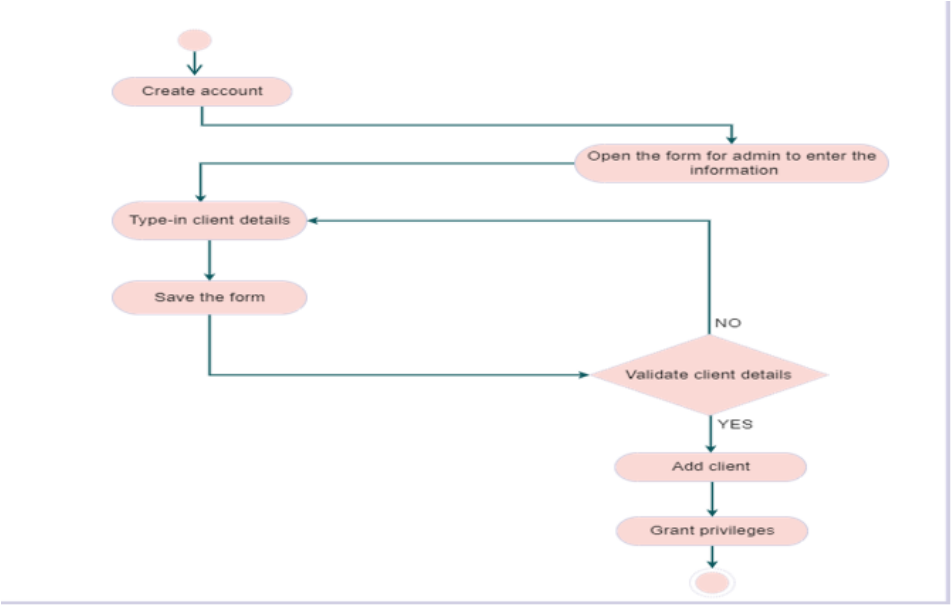


Figure 5.3 User Account Create

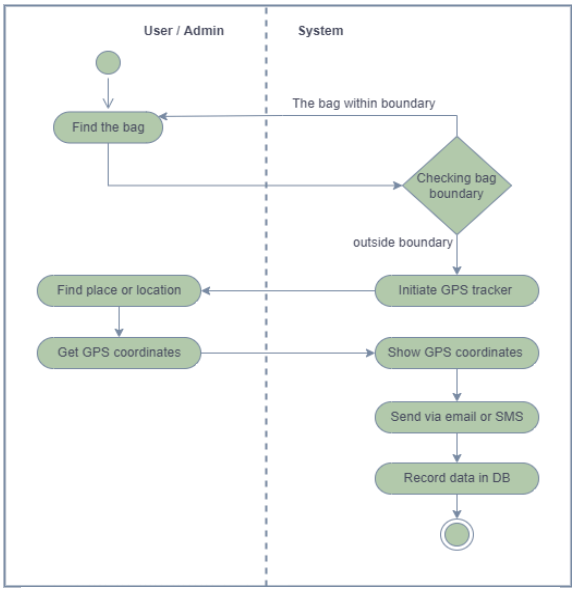


Figure 5.4 Activity diagram for Tracking bag

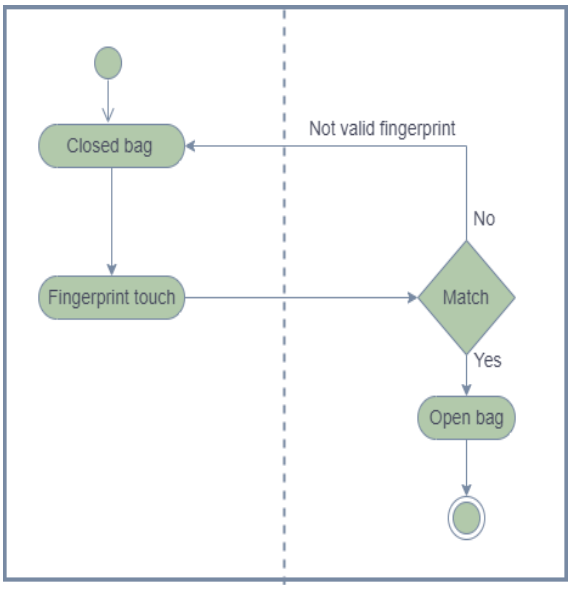


Figure 5.5 Activity diagram for Bag open/close

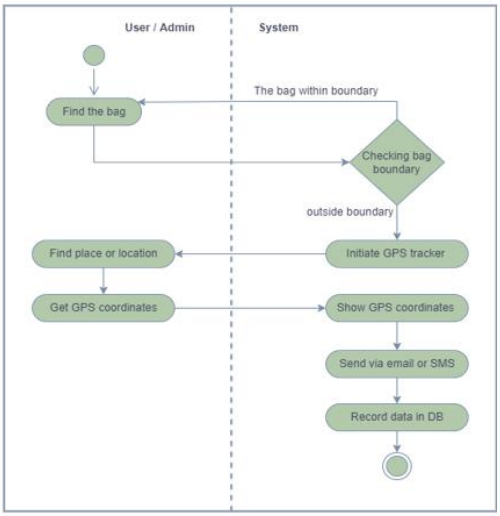


Figure 5.4 Activity diagram for Tracking bag

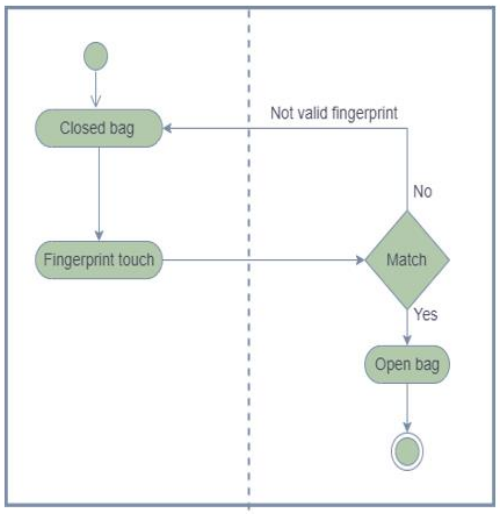


Figure 5.5 Activity diagram for Bag open/close

System Sequence Diagram

Figure 5.6 shows the sequence diagram for creating a user account. Figure 5.7 shows the sequence diagram for tracking a bag and Figure 5.8 shows the sequence diagram for opening or closing a bag.

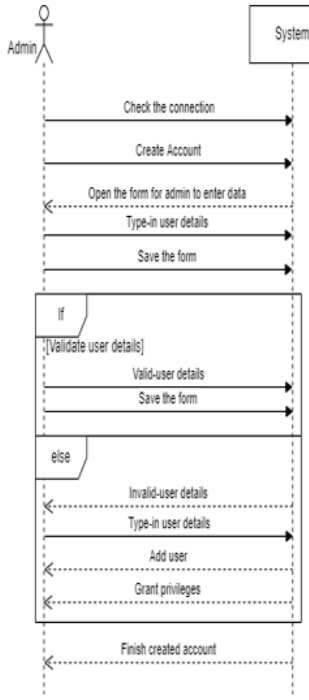


Figure 5.6 User account-sequence diagram

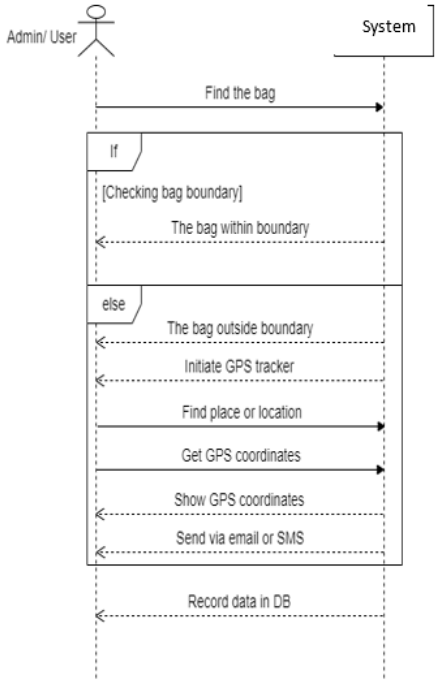


Figure 5.7 Track bag-sequence diagram

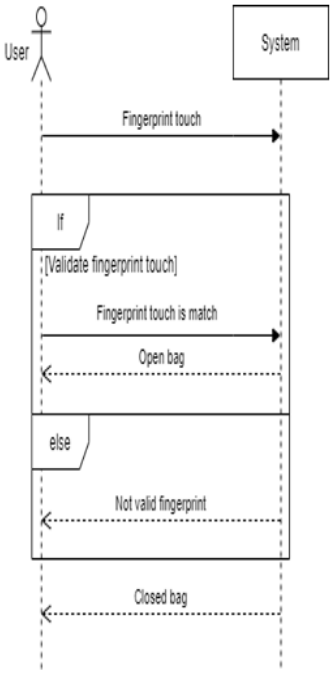


Figure 5.8 Open-close bag-sequence diagram

Entity Relationship and Class Design for the System

The Entity Relationship Diagram (ERD) is illustrated in Figure 5.9 that shows all the entities of the IoT based smart bag and its relationship. The entities are using two main types of association which are one-to-one and one-to-many relationship. The ERD is converted to classes that enables in designing and modeling software to describe classes and their relationships. The classes also indicate the names and attributes, connections between the classes, and the methods of the classes.

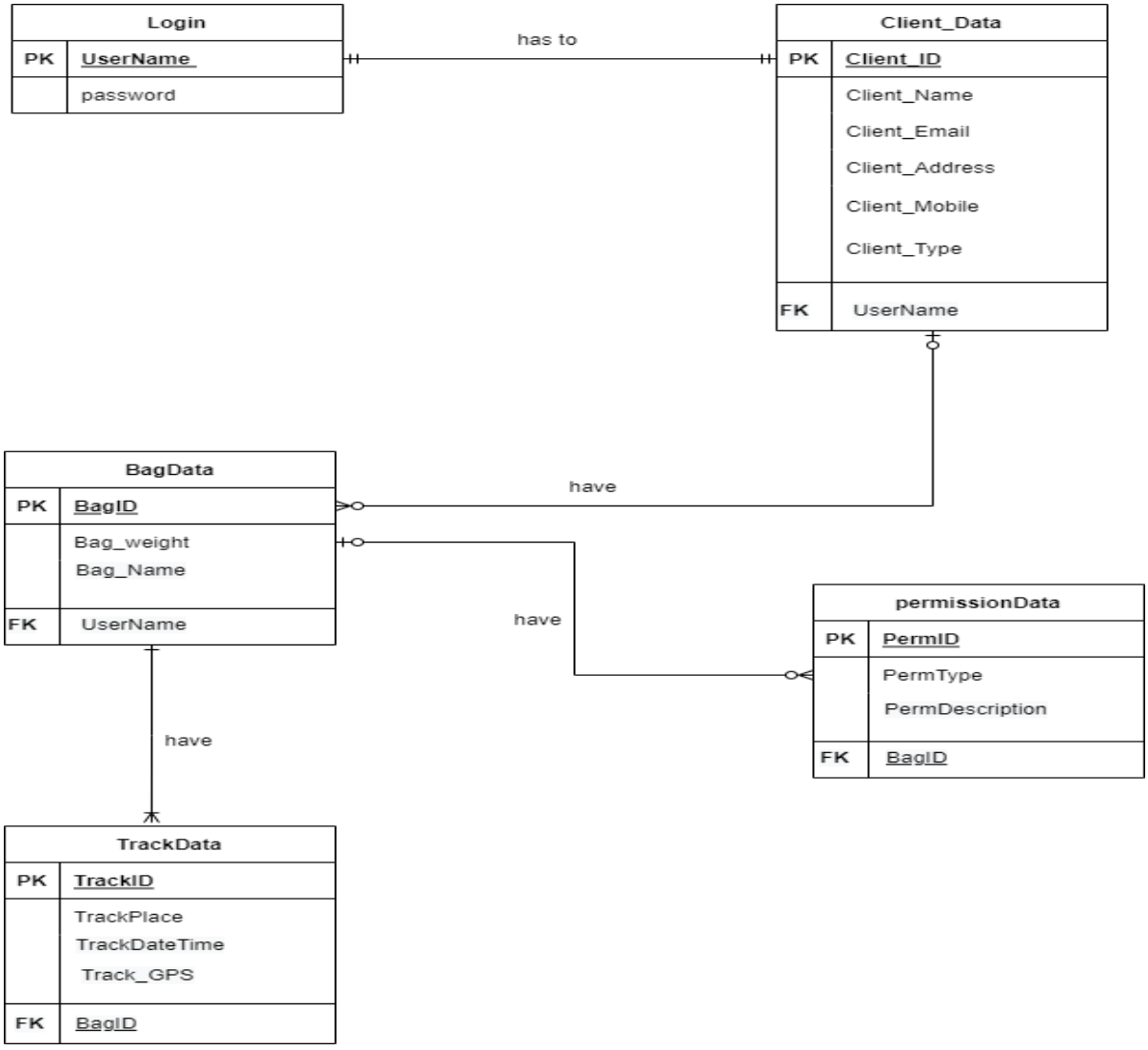


Figure 5.9 Entity Relationship diagram

Block Diagram of connections for IoT based Smart bag.

The following figure 5.11 shows the block diagram of the interconnections of IoT devices with microcontroller which in turn fixed on to a bag.

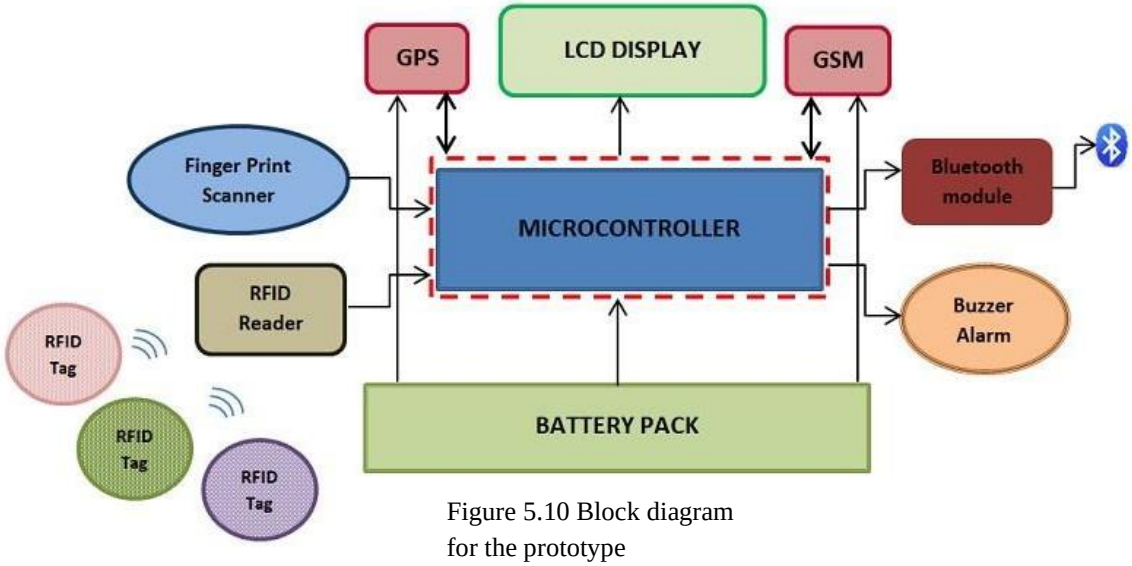


Figure 5.10 Block diagram for the prototype

Implementation and Testing

Figure 6.1 shows the first step in linking RFID and load cell. RFID will send the data from the box, and when we place the box on the bag on the load cell, the load cell will calculate the weight and show it on the LCD.

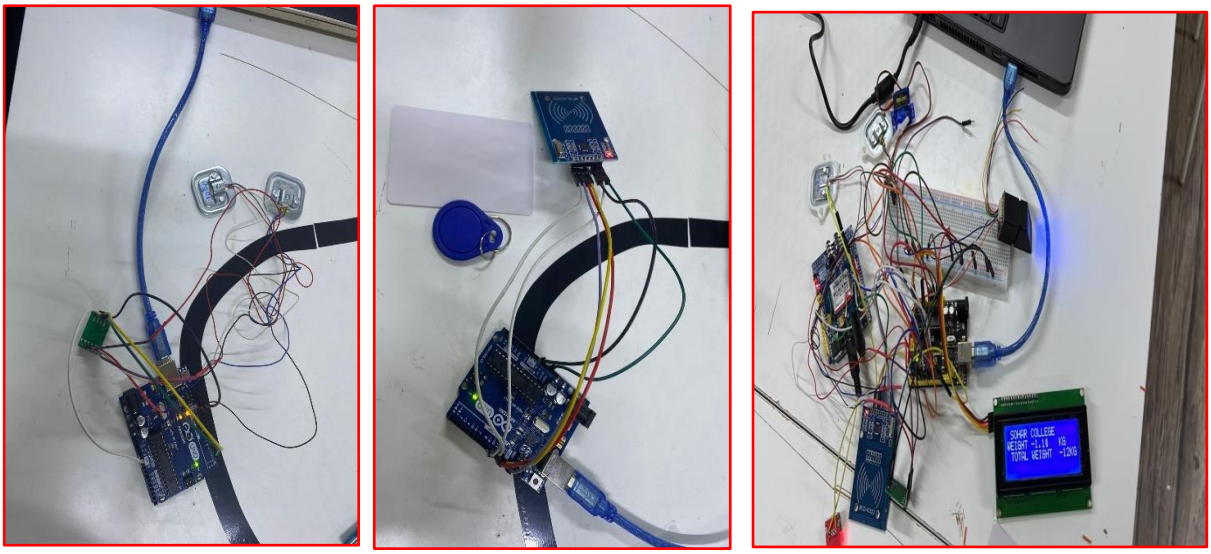


Figure 6.1 RFID linked with Load cell

Figure 6.2 Finger print linked with servo motor, GSM and buzzer

Figure 6.2 shows the fingerprint sensor which is used to verify identity is linked with the servo motor which is a rotary actuator that allows for precise control, so whenever there is an authorized fingerprint the servo motor will turn on and send a notification throughout the GSM module, as well as a buzzer which is a sounding device that can alter audio signals into sound signals. Then the output "Bag opened" will be shown on the LCD. Otherwise, "Bag closed" message will show on LCD.

Figure 6.3 shows GPS Module interfacing with NodeMCU ESP8266 and also the latitude and longitude on Blynk app. Here in this smart bag project, we will interface the GPS Module with NodeMCU ESP8266 and display the GPS data (latitude, longitude, speed, number of satellites that is getting to connect, and direction of the bag) on a Blynk app. And by forwarding the port in the router, these coordinates can be accessed to monitor the location of tracking bag where this system is installed. To connect this NodeMCU and GPS with Blynk, six virtual pins have been created. The virtual pin, V0, for showing the map and location of the bag, V1 and V2 for displaying latitude and longitude, V3 for displaying the speed of connections, V4 for displaying number of satellites that is getting to connect and V5 displaying the direction of movement of the bag.

We did the testing for hardware components to ensure that they are working correctly without any error. We run a full code for the GSM, GPS, RFID reader, RFID tag, load cell, fingerprint, servo motor and LCD display. In addition, we ensure that all components work properly. Furthermore, we test the NodeMCU that connect to the internet and get the satellite to find the specific GPS location in correct way. Figure 6.4 shows the complete connections of components for the smart bag.

Figure 6.5 shows the prototype of smart bag after assembling all the components together and tested each component and connections separately and satisfying with correct and expected results.

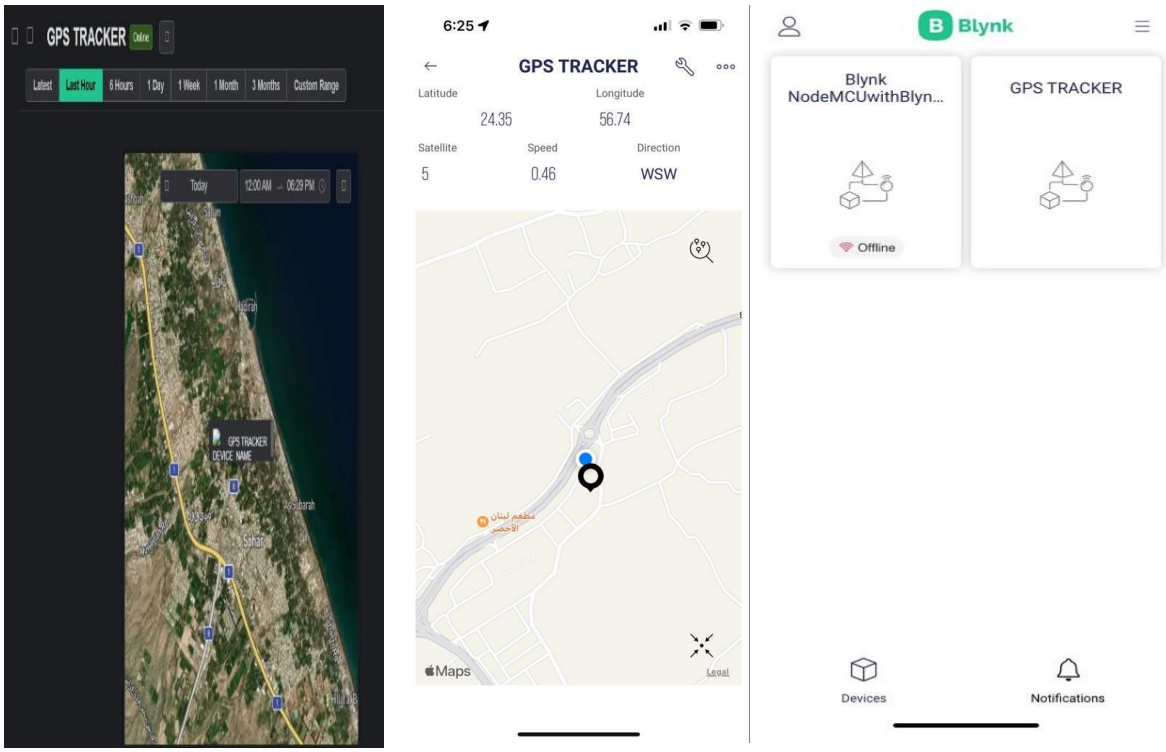


Figure 6.3 GPS Tracker linked with Blynk app

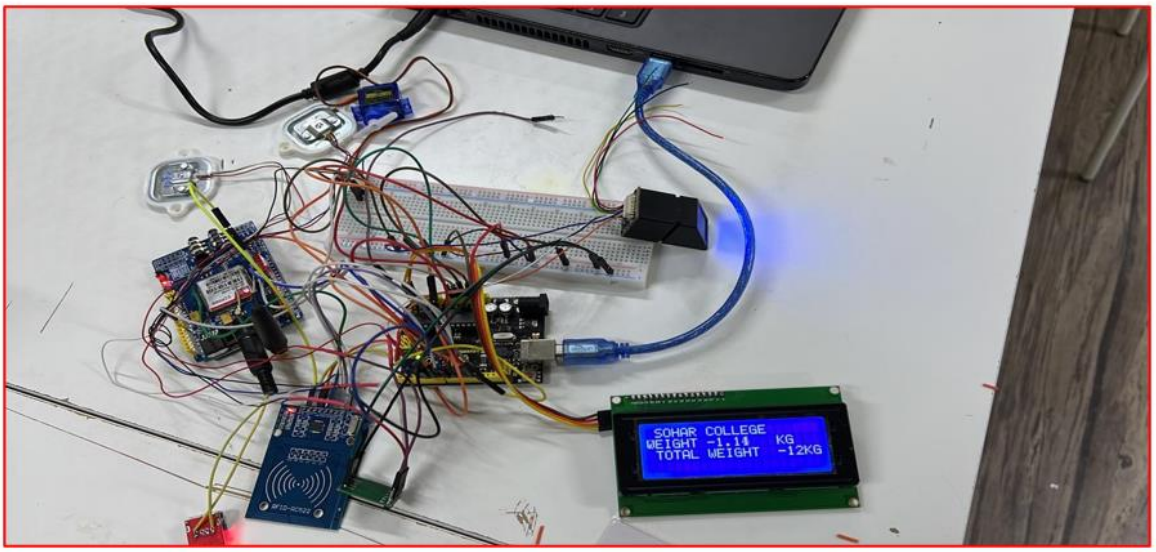


Figure 6.4 Complete connected hardware components for smart bag

Figure 6.5 Prototype of smart bag

Results

Smart bags expect that the owner of the bag put their finger in the fingerprint reader, once the fingerprint reader scans the fingerprint will check if the user is authorized or not. After that, in the Arduino serial monitor shows that the user is authorized. After few seconds, the servo motor will open the bag and it will show message (“Bag opened”) in the LCD display. Then, the notification message will be sent to the user’s mobile phone that the bag is opened, and the buzzer will make a sound. In addition, when the user put things in the bag, the load cell will measure the weight of them. The RFID reader will scan the RFID tag and will show the weight of the thing and the total weight in the LCD display. Furthermore, while the user does the previous steps, the servo motor will close the bag and it will show message (“Bag closed”) in the LCD

display. Then, the notification message will be sent to the user's mobile phone that the bag is closed, and the buzzer will make a sound. In addition, the user can track the location of the bag through the GPS tracker by using Blynk app. So, in the Blynk app the user can see the map and follow the bag's location to ensure that the bag either available or not and whether the bag is moving in the desired direction.

The following results we obtained when the codes run in the Arduino serial monitor as well as Blynk app. Figure 7.1 shows the GPS location, speed, satellite, direction, the latitude, and longitude will be shown in Blynk app. Figure 7.2 shows the latitude and longitude will be shown in the serial monitor. Figure 7.3 shows the LCD display that will show the weight and total weight of things in the bag. Figure 7.4 shows load cell output value will be shown in the serial monitor. Figure 7.5 shows the fingerprint reader that will store each authorized fingerprint of a person with unique number. Figure 7.6 shows the SMS message which received once the bag is opened and Figure 7.6 shows each RFID tag with specific unique id and message that show if it authorized access or the access denied.

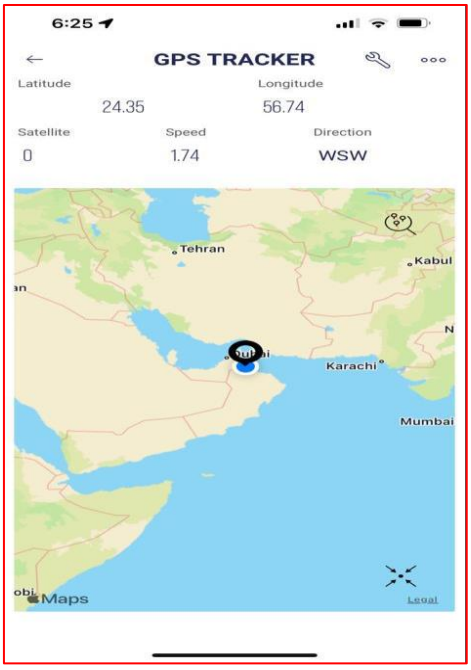


Figure 7.1 GPS location

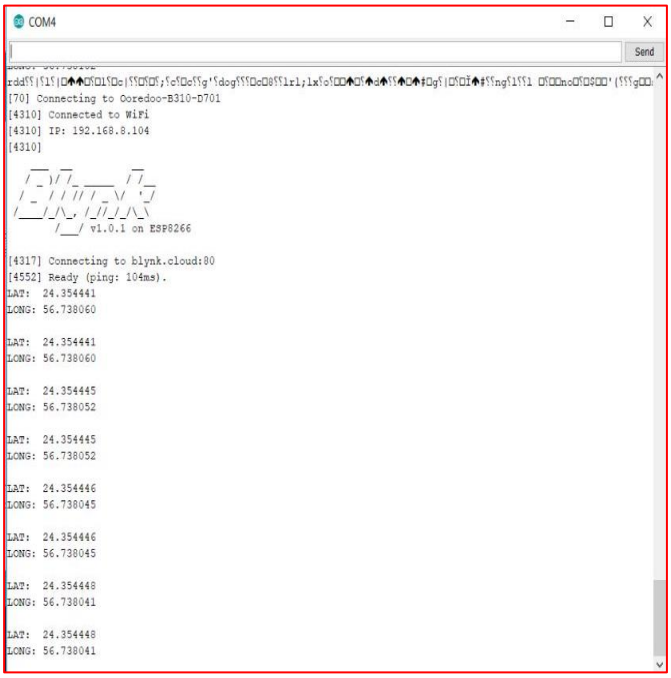


Figure 7.2 Latitude & Longitude

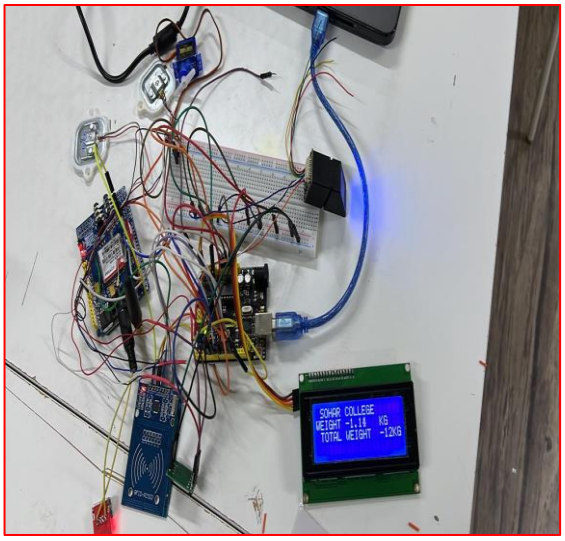


Figure 7.3 Load cell output in LCD

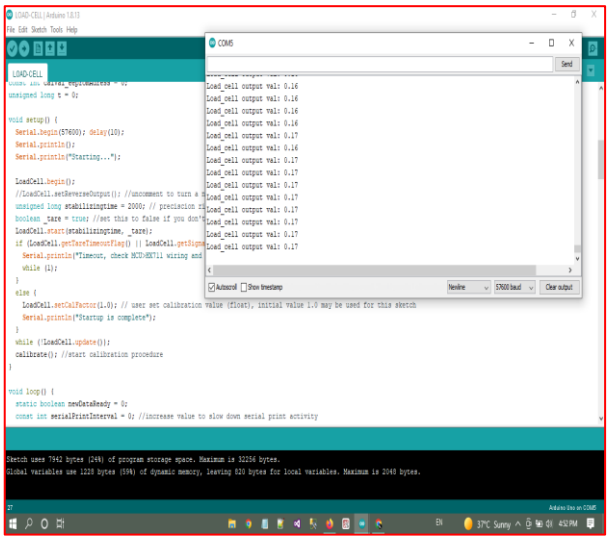


Figure 7.4 Load cell output from Arduino

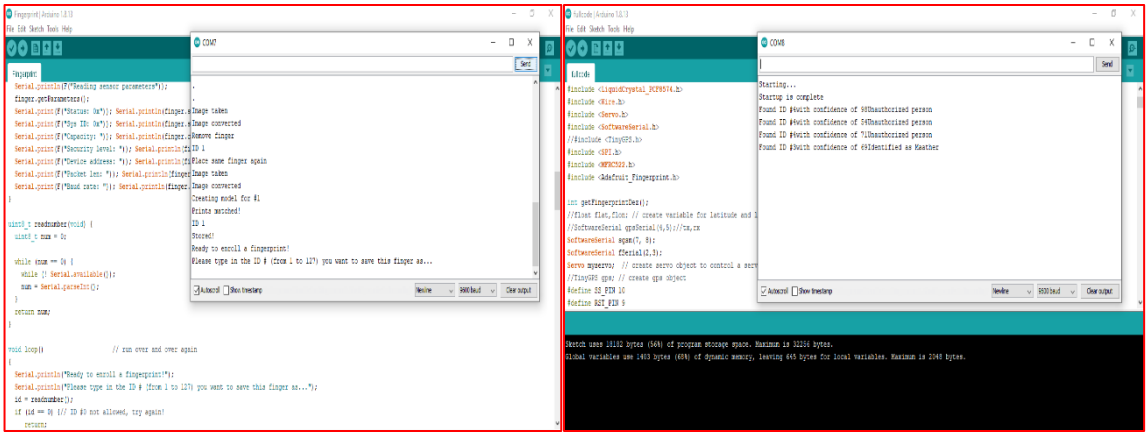


Figure 7.5 Finger print output from Arduino

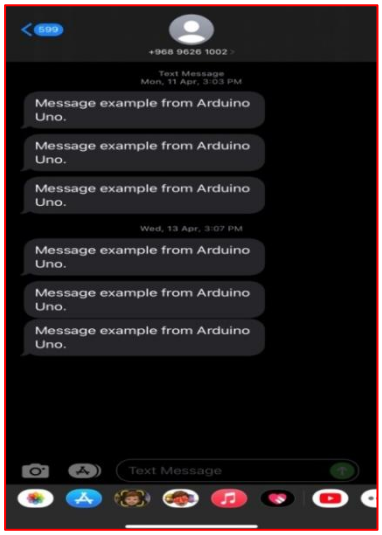


Figure 7.6 Outputs from GSM

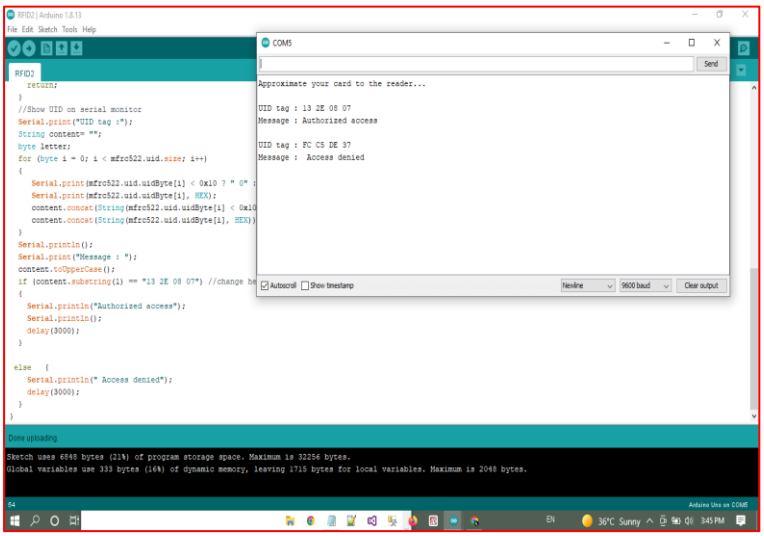


Figure 7.7 Output of RFID from Arduino

2. Conclusion and Future Work

A travel bag was automated with IoT components and is capable to be tracked. Tracking helps identify lost or stolen bags. Many procedures and techniques were required to be developed during the design and implementation phase. Also, experiments and testing were carried out using maps to track the location of the misplaced bags so that the route, directions, and location of the bag can be obtained. The testing included the use smart phones with rich features like Google maps, GPS, SMS, email, etc.

The project can be enhanced to be using Geo-fencing and emergency messaging services and also enable the use of universal connectivity so that the bag can be connected to internet worldwide avoiding the hurdles of connectivity in each country.

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