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Graduation Project 2

SmartConnect logistics system

Students:

Maysam Ja'far

Rua Huwari

Supervisor:

Dr. Abdallah Rashed

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Disclaimer Statement

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Abstract

Delivering items and packages securely and conveniently has always been an issue that have never found a suitable solution. What the user wants to find is a system, that is both secure, and user-friendly. Time convenience should also be taken into consideration; what will happen if my package arrived when no one is at home to take it?

The "SmartConnect Logistics System" project presents an innovative and comprehensive solution for secure, automated, and user-friendly package management. Integrating cutting-edge technologies such as ultrasonic sensors, smart locks, RFID, barcode scanners, and an autonomous pick-and-place arm, our system aims to revolutionize the logistics industry.

Users begin by placing packages in the first smart cupboard, initiating a seamless process involving barcode scanning, RFID payment, and password authentication. The autonomous car, equipped with advanced sensors, efficiently transfers packages between smart lockers. A user-friendly mobile app facilitates package retrieval, with real-time updates and secure access control, using this app, the user can order the package to get delivered to a suitable delivery point, at a convenient time; thus solving the time convenience issue.

The system's resilience is bolstered by the implementation of advanced security measures, careful consideration of energy efficiency, and a scalable design. This project not only demonstrates the exceptional technical expertise in computer engineering but also places significant emphasis on enhancing user experience and promoting environmental consciousness.

The SmartConnect Logistics System sets a new standard for smart logistics systems, offering a reliable, secure, and efficient solution for modern package management.

Chapter 1

Introduction

1.1 Project Rationale

The SmartConnect Logistics System initiative aims to tackle the deficiencies identified in conventional package management systems. These limitations encompass the absence of a comprehensive and secure method for tracking and retrieving packages, the lack of user-friendly interfaces, and the necessity for heightened security measures within the logistics sector.

1.2 project objectives:

The main aim of this project is to create and execute an advanced logistics solution that meets the changing requirements of both users and the industry. In particular, the objectives involve offering users a secure, efficient, and adaptable package management experience by incorporating smart locks, autonomous transportation, and user-friendly mobile applications. Furthermore, the project strives to establish a system that guarantees real-time monitoring and secure package access for end-users.

1.3 Work Scope

The project adopts a holistic strategy encompassing multiple stages. Commencing with the identification of the most suitable attributes, the team carefully chooses and incorporates elements like intelligent locks, ultrasonic sensors, RFID systems, and self-driving mechanisms. The project is partitioned into distinct units, comprising intelligent cabinets, lockers, and a self-driving vehicle, all of which undergo thorough examination prior to integration. An algorithm is devised to facilitate smooth communication and operation among the units, guaranteeing optimal efficiency.

1.4 Work significance

The demand for logistics solutions that are secure, customizable, and technologically advanced is increasing. Our SmartConnect Logistics System is well-positioned to fulfill these demands by offering a distinctive and user-friendly experience. In a time where security, efficiency, and convenience are prioritized by users, our project has the capability to transform package management systems, establishing fresh benchmarks for the industry.

1.5 Organization of the Report

This report is structured to provide a comprehensive understanding of the SmartConnect Logistics System project. Following this introduction, the second section defines the scope and boundaries of the project. The third section details the methodology employed in its design and development. The fourth section presents results, findings, and solutions to challenges encountered. The fifth section discusses the significance and potential impact of the project on the logistics industry. The conclusion summarizes key points, and recommendations for future work are provided. Appendices offer supplementary information and data relevant to the project.

Chapter 2

Constraints, Standards/ Codes and Earlier course work

2.1 Constraints

Through designing and building our machine, we faced multiple constraints:

1. **Power supply :**

Multiple components in the project needed different values of voltage and current, Such as the two locker that needed 5 volt adapter for each one, the DC motors of the automated car which need 12volt, the arm that is also in the car has servo motors that need 5 volt, the electromagnet, on top of the arm needs a power supply of 6 volt, we overcome this by using two 5volt adapters, one for each locker, 12volt chargeable battery for the car, power bank to give 5 volt to the Arduino and esp32 connected to the car, 12 to 5 voltage convertor to give power supply for the servos, 12 to 6volt voltage convertor for the electro magnet, 12 volt adapter to charge the battery when needed.

2. **Arduino**

We initially decided to use Arduino uno as the controller of the first locker, their was no enough pins on it to control all the components, so we replace it with Arduino mega. For the second locker the Arduino uno was also not enough, but we used esp32, to connect with the rest of the components.

3. **Robotic Arm**

We initially wanted to build a robotic arm with five degrees of freedom, but after printing it using 3D printers, and after building it step by step, we found that we were using servo motors that cannot handle the arm weight, and there was no time left for redesigning the arm so it can hold a stronger servo, so instead we replaced the arm picker with an electromagnet, and the arm went from having five degrees of freedom, to have two degrees only.

4. **Car design:**

At first, we built the car using wood, and we used wheels from children's cars. But when we reached the final stage, we found that we need to change the material of the car, because the wood is too heavy for the DC motors to control. The car was not able to go back or move to the left and right freely. So, we rebuilt the car, and changed the materials of the car body, and change the wheels to get a type of wheel that is easier to control.

5. **the correctness of the car:**

we face a problem with the correctness of the car to walk a specific path without losing its way. We worked hard to solve it and tried to get the best outcome possible.

2.2 Standards and Codes

The software components of the system include three Arduino programs written in C++, which incorporates several libraries and functions such as Keypad.h, LiquidCrystalI2C.h, wire.h, NewPing.h, WiFi.h, WiFiClient.h,, WebServer.h,ESPmDNS.h, SoftwareSerial.h, SPI.h, MFRC522.h, Arduino.h, firebase_ESP_client.h, addons/TokenHelper.h, addons/RTDBHelper.h and Servo.h. The user interface was developed using Flutter, while the backend and database were implemented using Firebase. The system adheres to relevant industry standards and codes in the design and implementation of its software components.

2.3 earlier coursework

Taking and completing the Microcontrollers course, and learning how to write codes and programs for the PIC based systems, was of great help in building our system, and writing the codes for the Arduino's used in it. The course provided us with the necessary knowledge to proficiently develop the code encompassing the essential algorithm for the System, which serves as the core component of the project.

The Networks 1&2 courses, along with the Wireless course, were crucial in deepening our comprehension of the complex interrelationships among various components. This understanding played a vital role in the advancement of our project, as wireless communication serves as a fundamental element of its operation. The knowledge acquired from these courses enabled us to proficiently design the codes for the two ESP32 modules that interface with the ESP8266, which is a pivotal aspect of implementing our project.

The Critical Thinking course played a vital role in our project, acting as a guiding principle in our methodical approach and decision-making procedures. With the necessary critical thinking abilities, we were skilled at recognizing possible problems, conducting comprehensive analyses, and formulating efficient resolutions. This expertise became especially important when faced with difficulties concerning design and power, enabling us to navigate and surmount such hurdles with a considerate and strategic mindset.

The Electronics course provided a strong basis by teaching necessary information on basic electronics principles. This basis was crucial in the development and resolution of the hardware elements of our project, such as sensors, motors, valves, and pumps. The skills we gained allowed us to successfully navigate the complexities of electronic systems, guaranteeing the efficient operation and functionality of vital machine components.

Chapter 3

Literature Review

The SmartConnect Logistics System initiative aims to provide an advanced package management experience through the seamless integration of contemporary technologies. In the literature review, we extensively examine pertinent research and projects that contribute to the comprehension and progress of intelligent logistics systems. This review encompasses an investigation into established automated locker systems, sensor networks for secure storage solutions, Internet of Things (IoT) applications in logistics, and innovative designs in autonomous transportation for package handling. By scrutinizing these crucial domains, our objective is to establish a comprehensive groundwork for our project, drawing inspiration from successful implementations and incorporating state-of-the-art concepts to enhance the efficiency, security, and user experience of our SmartConnect Logistics System.

“Automated Car Service Management System to Make Industry More Efficient”

General Sir John from Kotelawala Defense University, Built the Automated Car Service Management System which represents a pivotal advancement in the automobile service sector by transitioning from manual, paper-based operations to an automated, web-based framework. This system introduces an array of features including online booking and appointments, automated service scheduling, distinct dashboards for customers and administrators, feedback mechanisms, inventory management, and comprehensive reporting. Its strengths lie in enhancing operational efficiency, improving customer service through transparent and accessible service details, and enabling better data management for informed decision-making. Despite its benefits, the system's reliance on technology infrastructure, the potential learning curve for users, security vulnerabilities associated with online data handling, and the necessity for ongoing system maintenance emerge as notable weaknesses. These aspects make it an essential reference in discussions about technological interventions aimed at enhancing service efficiency and customer engagement in the automobile maintenance industry. [1]

“Robots at your doorstep: acceptance of near future technologies for automated parcel delivery”

Maher Said, Spencer Aeschliman, and Amanda Stathopoulos conducted a study on U.S. consumer preferences for automated parcel delivery methods, utilizing an Integrated Nested Choice and Correlated Latent Variable model. Their research highlighted the impact of demographic factors on the acceptance of innovations like autonomous vehicles, drones, sidewalk robots, and bipedal robots. The findings indicate a cautious but growing interest in automated delivery, with significant concerns about package security and handling. The study emphasizes the necessity for tailored strategies, considering consumer demographics and concerns, to facilitate the broader adoption of automated delivery technologies. It provides valuable insights for companies and policymakers navigating the shift towards automation in the logistics sector. [2]

“RFID BASED AUTOMATED BANK LOCKER SYSTEM”

The RFID-Based Automated Bank Locker System streamlines and secures locker access in banks, significantly reducing manual intervention and associated wait times for customers and bank employees. Through RFID technology, each customer receives a unique RFID card for automated locker access, improving security and operational efficiency. This system minimizes customer wait times and lightens the workload for bank employees, enabling them to focus on crucial tasks. The project exemplifies a successful application of RFID technology in enhancing banking services, proposing a scalable solution for broader implementation. This innovation signifies a promising approach to modernize traditional banking services, underscoring RFID's potential to enhance customer experience and operational efficiency in the banking sector. [3]

“Smart Locker Management System Using IoT”

Parth Parab, Manas Kulkarni, and Dr. Vinayak Shinde developed the Smart Locker Management System, leveraging Internet of Things (IoT) technology to revolutionize locker management for heightened efficiency and security compared to traditional systems. This innovative system seamlessly integrates IoT and cloud computing, utilizing microcontrollers and electronic devices for remote locker access and management. Key components include reed relays for door status detection, solenoid latches for secure locking, and a user-friendly mobile application for easy locker access. The system boasts advantages like remote accessibility, dual user and admin authentication for enhanced security, usage tracking, and energy efficiency. While dependent on electrical power, potential security risks are acknowledged in case of a lost smartphone. With significant potential for institutions, this scalable solution lays the foundation for secure locker management, with future improvements focused on enhanced security measures, offline access options, and user interface enhancements. [4]

“Automated Package Delivery Accepting System - Smart Freight Box”

The Smart Freight Box (SFB) project, presents a timely and innovative solution to cater to the shifting consumer preferences in favor of convenient and online shopping. The integration of an Internet of Things (IoT) interface, coupled with strategically placed dual doors accessible through this platform, ensures both accessibility and heightened security for clients and customers. By prioritizing security, convenience, and damage prevention, the SFB aligns well with contemporary trends in e-commerce and logistics. However, for a comprehensive understanding, further exploration into technical specifications, scalability, and potential challenges is recommended to gauge the project's broader implications and feasibility in the evolving landscape of package delivery.[5]

“Performance Evaluation of Automated Medicine Delivery Systems”

The Telelift Automated Medicine Delivery (AMD) system is a transformative solution in hospital logistics, automating the conventional medicine delivery process from warehouses to patients. Utilizing a specialized overhead conveying system, it has been successfully implemented in over 1300 hospitals across 40 countries, significantly improving health safety, reducing operational costs, and enhancing system efficiency. The study introduces a stochastic model, employing a two-moment approximation method and an aggregation approximation algorithm to evaluate the nested queuing model under various demand scenarios. Numerical experiments validate the model's accuracy, offering hospitals a tool to minimize patient waiting times and improve medicine response times. Beyond its impact on hospital logistics, this research establishes a scalable model with potential applications in other automated overhead material handling systems, signaling its capability to transform hospital operations and patient care delivery. [6]

The SmartConnect Logistics System embarks on an ambitious mission to revolutionize package management through cutting-edge technologies. Drawing insights from a comprehensive literature review, several projects share common themes that intersect with the envisioned SmartConnect initiative. The Automated Car Service Management System introduces automated, web-based operations, echoing the SmartConnect objective of seamless integration. Similarly, the RFID-Based Automated Bank Locker System aligns with SmartConnect's emphasis on security and operational efficiency through RFID technology. The Smart Locker Management System, utilizing IoT for enhanced security, resonates with the SmartConnect's IoT-driven approach. The Smart Freight Box project, prioritizing security and convenience in package delivery, provides valuable lessons for SmartConnect. Furthermore, the Telelift Automated Medicine Delivery system, focusing on efficiency and scalability in hospital logistics, shares parallels with the SmartConnect initiative.

The SmartConnect Logistics System distinguishes itself by amalgamating key attributes from renowned projects like the Automated Car Service Management System, RFID-Based Automated Bank Locker System, Smart Locker Management System Using IoT, Smart Freight Box, and the Telelift Automated Medicine Delivery system. While sharing the goal of enhancing efficiency, security, and user experience, SmartConnect goes beyond its predecessors by offering a comprehensive and adaptable logistics solution. In comparison to the Automated Car Service

Management System, it addresses user learning curves and technology infrastructure reliance, emphasizing a more user-friendly interface and robust security measures.

When juxtaposed with the RFID-Based Automated Bank Locker System and the Smart Locker Management System Using IoT, SmartConnect stands out by offering a holistic approach that integrates automated locker systems, sensor networks, and IoT applications. It not only minimizes customer wait times and reduces workload for administrators but also prioritizes scalability, enhanced security measures, offline access, and improved user interfaces. In relation to the Smart Freight Box, SmartConnect shares the goal of aligning with contemporary trends in e-commerce and logistics. However, it outshines by focusing on technical specifications, scalability, and potential challenges, ensuring a more comprehensive understanding and feasibility in the evolving landscape of package delivery.

Compared to the Telelift Automated Medicine Delivery system, SmartConnect goes beyond hospital logistics, positioning itself as a dynamic solution applicable across various industries. Its adaptability and versatility, coupled with an emphasis on advanced security measures and seamless integration, make SmartConnect a new standard in intelligent logistics.

Chapter 4

Methodology

This section will delve into the hardware components employed in constructing the system, their interconnections, and the holistic system design. Additionally, we will explore the operational processes of the system, along with insights into the software implementation, mobile application, and database utilized in the project.

4.1 Hardware Components

4.1.1 Microcontrollers

4.1.1.1 Arduino Mega 2560

The Arduino Mega 2560 serves as a microcontroller board, utilizing the ATmega2560. With an array of features, including 54 digital input/output pins (15 of which support PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, USB connection, power jack, ICSP header, and a reset button, it stands as a comprehensive microcontroller solution tailored to meet the requirements of our project. The decision to employ the Arduino Mega 2560 was driven by the necessity to accommodate a substantial number of connected devices, a demand that rendered the Arduino Uno unsuitable for our first locker , making the Mega 2560 the preferred choice.

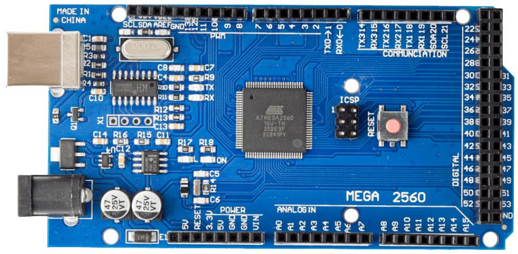


Figure 4.1.1. 1 Arduino Mega

4.1.1.2 Arduino uno:

The Arduino Uno, based on the ATmega328P microcontroller, is a versatile board equipped with 14 digital input/output pins (6 of which can function as PWM outputs), 6 analog inputs, a USB connection, a 16 MHz crystal oscillator, a power jack, and an ICSP header. While it offers a slightly more compact set of features compared to the Mega 2560, the Arduino Uno is well-suited for projects with less extensive hardware requirements. Its simplicity and ease of use make it an excellent choice for applications where a more streamlined microcontroller solution is preferred. In our deliberations, the Arduino Uno was considered when the project's hardware demands did not necessitate the extensive capabilities provided by the Mega 2560. It was used with the automated car and with the second locker, which serves as the delivery point in our project. Hence, two Arduino uno were used.

Figure 4.1.1. 2 Arduino Uno

4.1. 1.3ESP32-WROOM-32U Core Board

The ESP32, a powerful microcontroller and Wi-Fi/Bluetooth module combination, played a pivotal role in our project, serving distinct functions for the second locker and the car system. With its 34 GPIO pins, Wi-Fi and Bluetooth capabilities, dual-core processing, and compatibility with Arduino IDE, the ESP32 provided an efficient and flexible solution. For the second locker, the ESP32 facilitated seamless communication between the locker system and the central microcontroller, ensuring secure and responsive remote access. In the car system, the ESP32's integration allowed for real-time data exchange, enabling features such as remote monitoring, control, and feedback. Its versatility and connectivity options made the ESP32 an integral component, enhancing the overall functionality and connectivity of our project.

Figure 4.1.1. 3 ESP32

4.1.1.4ESP8266

The ESP8266 serves a crucial role in the project, acting as a communication interface between the first locker and Firebase, as well as facilitating communication with the ESP32 embedded in the autonomous car. Leveraging its Wi-Fi capabilities, the ESP8266 establishes a seamless connection with Firebase, enabling real-time data exchange and synchronization for efficient package tracking and management in the locker. Additionally, its role extends to coordinating with the ESP32 on the car, contributing to the overall intelligence of the autonomous vehicle. The ESP8266's versatility, coupled with its reliable wireless communication, makes it an integral component in ensuring the smooth operation and connectivity of the project's diverse elements.

Figure 4.1.1. 4 ESP8266

4.1.2 Motors and drivers

4.1.2.1Servo Motors:

The servo motor serves as a vital component within the project's robotic arm system. Selected for its precision and controlled movement capabilities, the servo motor is strategically integrated to manage various mechanical functions. In the context of the robotic arm, the servo motor facilitates accurate control of the arm's movements, allowing it to articulate and position itself precisely. This precision is crucial for tasks such as grabbing, lifting, and placing objects with the desired accuracy. The servo motor's ability to respond to specific control signals enables the robotic arm to perform intricate and controlled motions, enhancing the overall efficiency and functionality of the system.

Figure 4.1.2. 1 Servo Motor

4.1.2.2Geared DC Motor 12Volt

The 12-volt geared DC motor plays a pivotal role in powering the movement of the project's car system by driving its wheels. Selected for its robust design and power capabilities, this motor is well-suited for the dynamic requirements of the vehicular application. The gearing mechanism enhances torque and provides the necessary force to propel the car, ensuring smooth and controlled motion. The 12-volt power supply empowers the motor to deliver sufficient energy for driving the wheels, contributing to the overall mobility of the car. Through careful integration and control, this motor enables the project's car to navigate its environment effectively, showcasing a reliable and efficient solution for vehicular movement within the system.

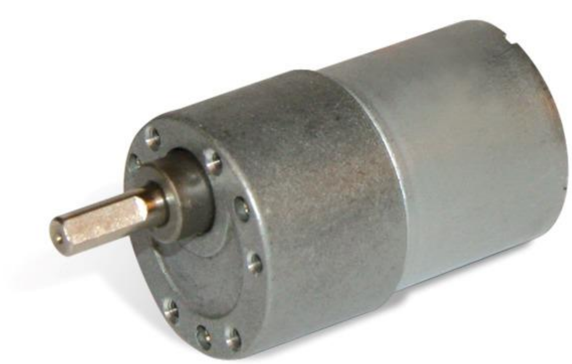


Figure 4.1.2. 2 DC Motor

4.1.2.3 H-Bridge

The H-bridge configuration serves as a critical component in the system, providing control and directionality to the 12-volt geared DC motors associated with the project's car. Each DC motor is paired with a dedicated H-bridge, ensuring independent control over the direction of rotation and enabling precise maneuvering of the car. The H-bridge facilitates seamless forward and reverse movements by managing the polarity of the voltage supplied to the DC motors. This modular setup enhances the flexibility and responsiveness of the car's motion, allowing for a diverse range of movements and maneuvers within the system. The implementation of H-bridges in conjunction with the DC motors exemplifies a sophisticated control mechanism, contributing to the overall efficiency and agility of the project's vehicular component.

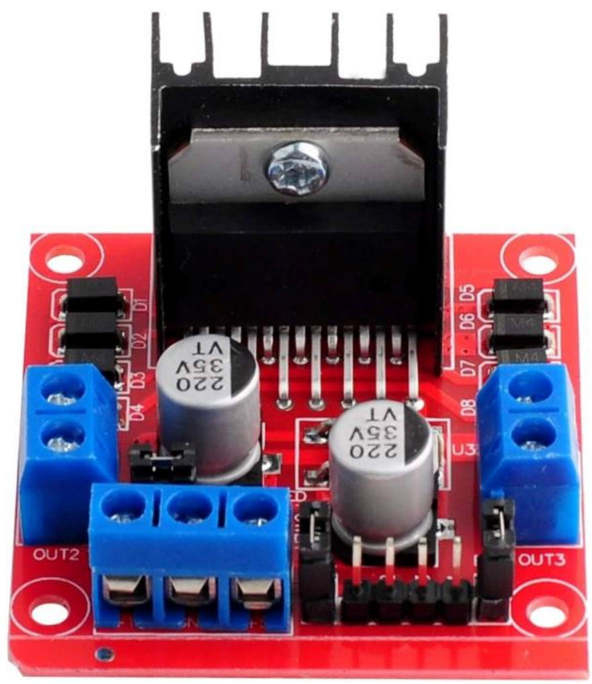


Figure 4.1.2. 3 H_Bridge

4.1.2.4 micro servo

The micro servo motor is a pivotal component in the project, contributing to dynamic and precise control within the system. Its compact size and lightweight design make it an ideal actuator for various applications, particularly in the context of the ultrasonic sensor for obstacle avoidance. The servo's ability to rotate within a specified range allows for controlled movements of attached sensors or mechanisms. In this project, the micro servo's role extends to steering the ultrasonic sensor, enabling it to sweep across the environment, detecting obstacles and ensuring a responsive avoidance system in the autonomous car. The micro servo's versatility, accuracy, and ease of integration make it an essential element in enhancing the overall functionality and adaptability of the project's robotic components.

Figure 4.1.2. 4 MicroServo

4.1.3 Sensors

4.1.3.1 Ultrasonic

In the project configuration, ultrasonic sensors play a pivotal role in enhancing the overall functionality and security. One ultrasonic sensor is strategically integrated into the autonomous car, utilizing its precise distance measurement capabilities to enable obstacle avoidance. This ensures the vehicle navigates its environment safely and efficiently. Meanwhile, the deployment of ultrasonic sensors in the lockers serves a dual purpose. In the second locker, two ultrasonic sensors are employed to detect the presence or absence of packages in each of its two compartments, enhancing the security and tracking capabilities of the storage unit. In the first locker, a more extensive setup of four ultrasonic sensors is utilized to monitor the status of packages across its four compartments. This comprehensive arrangement ensures effective and accurate monitoring, providing users with real-time information about the presence of packages in specific lockers. The strategic integration of ultrasonic sensors throughout the project underscores their versatility and efficiency in addressing various aspects of the system's operational requirements.

Figure 4.1.3. 1 ULTRASONIC

4.1.4 input/output devices

4.1.4.1 LCD& I2C device

The incorporation of two LCD displays with I2C communication protocol represents a user-centric enhancement in the project's design. Each LCD is dedicated to providing a user-friendly interface for its respective locker. The application of I2C simplifies the communication process, allowing seamless integration between the LCD displays and the microcontroller. This user interface serves to convey essential information about the status and contents of the lockers, ensuring an intuitive and efficient interaction for users. With a dedicated LCD for each locker, individuals can easily access real-time data, such as package status, locker availability, and other pertinent details. This approach not only contributes to the overall accessibility and convenience of the system but also aligns with the project's commitment to user-centric design principles.

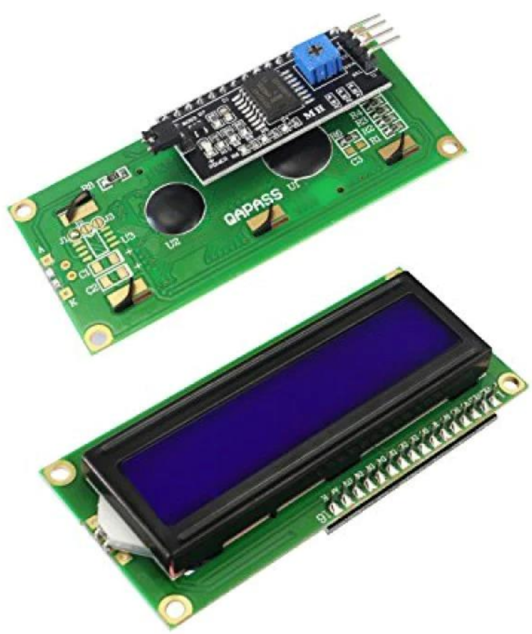


Figure 4.1.4. 1 LCD&I2C

4.1.4.2 Keypad

The integration of two keypads, each coupled with an LCD display, enhances the user interaction aspect of the project. These keypads are specifically assigned to their respective lockers, serving as user input devices for secure access. The combination of keypads and LCDs provides a comprehensive user interface, enabling individuals to input access codes securely and receive real-time feedback on the locking and unlocking process. This design choice not only ensures the security of the lockers but also contributes to the user-friendly nature of the system. Users can easily navigate through the interface, inputting codes and receiving prompt responses from the LCD displays, facilitating a smooth and secure experience in accessing the lockers.

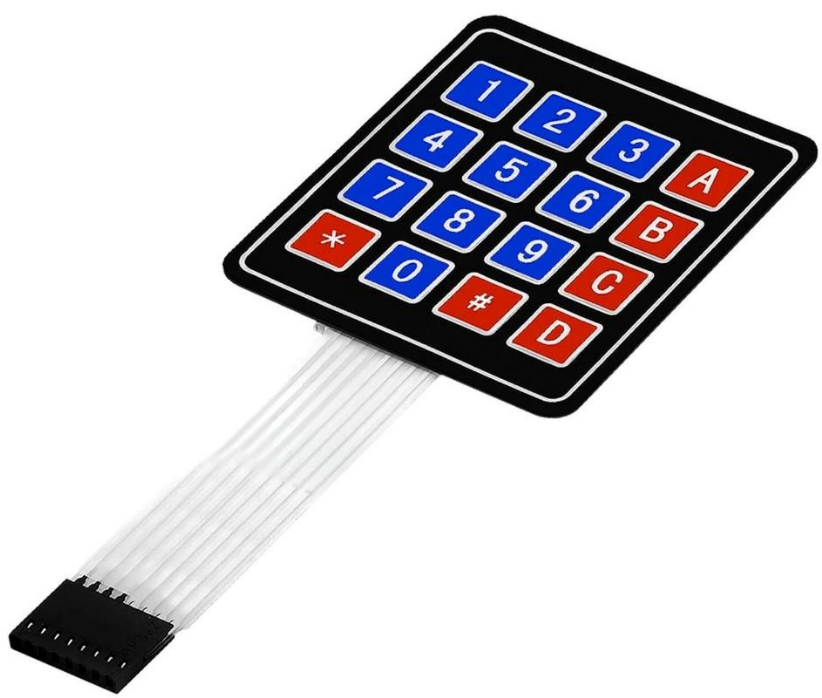


Figure 4.1.4. 2 KeyPad

4.1.4.3 Barcode Scanner

The incorporation of a barcode scanner in the project adds a streamlined method for registering packages. This technology allows for efficient and accurate identification of packages through scanning their barcodes. The barcode scanner, integrated seamlessly into the system, provides a quick and reliable way to input package information, reducing the likelihood of errors and enhancing the overall efficiency of the package management process. Users can easily register packages by scanning their barcodes, and the system can then process this information swiftly, updating the relevant databases and ensuring accurate tracking of package details. This addition not only simplifies the package registration process but also aligns with industry standards for effective and error-free package management.

Figure 4.1.4. 3 Barcode Scanner

4.1.4.4 RFID

In our project, RFID (Radio-Frequency Identification) technology plays a pivotal role in facilitating secure and efficient payment handling. Each user is provided with an RFID card that serves as a unique identifier linked to their account. When initiating a payment transaction, users can simply tap their RFID cards on the designated reader. This contactless method ensures a swift and hassle-free payment process. The RFID technology enables a secure and reliable authentication mechanism, reducing the reliance on traditional payment methods. By seamlessly integrating RFID for payment handling, our system enhances user convenience and security, providing a modern and efficient approach to financial transactions within the context of our package management system.

Figure 4.1.4. 4 RFID

4.1.5 Actuators

4.1.5.1 Solenoid Lock 6volt

The solenoid lock plays a pivotal role in the operational dynamics of the smart lockers within the project. This actuator, positioned strategically in each locker, functions as the mechanism responsible for both securing and releasing the locker doors. When activated, the solenoid lock exerts a mechanical force, either engaging or disengaging the locking mechanism, allowing seamless access to the contents within. Its integration ensures a secure and controlled environment for the stored packages. This component, housed within the lockers, exemplifies the project's commitment to advanced, technology-driven solutions for efficient and secure package management.

Figure 4.1.5. 1 Solenoid Lock

4.1.5.2 Electromagnet

The electromagnet serves a crucial role in the project's robotic arm system, specifically designed to facilitate the handling of packages. Functioning as an attractive force, the electromagnet effectively attracts and holds packages securely during the operational phases of the robotic arm. When activated, the electromagnetic field generated by the component ensures a stable grip on the packages, allowing for precise and controlled movements. This innovative application of electromagnet technology enhances the efficiency of the robotic arm, contributing to the overall seamless and automated package management system. The integration of electromagnets underscores the project's commitment to deploying advanced solutions for optimizing logistics processes.

Figure 4.1.5. 2 Electromagnet

4.1.6 Power devices

4.1.6.1 12 volt chargeable battery

The power supply for the car is facilitated by a 12-volt rechargeable battery, providing a reliable and portable energy source. This choice of power solution ensures the autonomy and mobility of the car within the project. The 12-volt battery offers sufficient voltage to drive the car's components, including the DC motors responsible for its movement. Additionally, the rechargeable nature of the battery allows for convenient and sustainable usage, supporting extended operational periods before requiring a recharge. This configuration aligns with the project's objective of creating a versatile and self-contained system, emphasizing efficiency and practicality in the implementation of its mobile components.

Figure 4.1.6. 1 Battery 12Volt

4.1.6.2 5volt adapter

Each locker in the system is powered by a dedicated 5-volt adapter, contributing to a stable and regulated power supply for these components. The use of individual adapters ensures that each locker operates independently and reliably, minimizing potential issues related to power fluctuations or sharing resources. This tailored power approach aligns with the project's focus on providing dedicated and optimized solutions for different subsystems, promoting efficiency and robust performance within each locker. The 5-volt adapters contribute to the overall system's reliability, ensuring consistent power delivery for the electronic components within each locker, including sensors, microcontrollers, and display modules.

Figure 4.1.6. 2 5Volt Adapter

4.1.6.3 power bank

To enhance the mobility and autonomy of the car subsystem, a power bank is employed to provide a portable and cable-free power source for the ESP32 and Arduino modules. This strategic use of a power bank aligns with the project's objective to optimize the car's functionality by eliminating the need for constant wired connections. The power bank ensures that the ESP32 and Arduino of the car can operate seamlessly, offering flexibility in movement and positioning. This approach caters to scenarios where the car needs to navigate freely, allowing it to reach various locations without being constrained by a wired power source. The integration of a power bank represents a practical solution to enhance the overall versatility and functionality of the car within the intelligent locker system.

Figure 4.1.6. 3 Powerbank

4.1.6.4 Voltage reducer

To ensure compatibility and optimal functionality, a 12 to 6V converter is implemented in the system. This converter plays a crucial role in adapting the power supply for the servo motors utilized in the robotic arm. By converting the 12V output from the car battery to a more suitable 6V, the converter allows the servo motors to operate efficiently within their specified voltage range. This thoughtful integration demonstrates a meticulous approach to power management, ensuring that each component receives the appropriate voltage to function effectively. The 12 to 6V converter contributes to the overall reliability and precision of the robotic arm, enabling precise and controlled movements without compromising the integrity of the system.

Figure 4.1.6. 4 Voltage reducer

4.1.7 Other Devices

4.1.7.1 3D printed arm

The project incorporates a 3D-printed robotic arm, strategically positioned above the car, to facilitate efficient package handling and movement. This innovative addition enhances the project's versatility, allowing it to extend beyond conventional automated locker systems. The 3D-printed robotic arm showcases a commitment to customization and adaptability, as it can be tailored to specific project requirements. Its placement atop the car underscores the integration of diverse technologies, such as 3D printing and robotics, to achieve a seamless and comprehensive solution. This feature adds a layer of sophistication to the project, elevating its capabilities and showcasing a forward-thinking approach to automated logistics and package management.

But during after connecting and building the arm, at the testing stage, we found that the gripper of the arm is not working properly because of the inconvenience of packages weight on the gripper. So we were in front of two options, the first one is to reprint the arm, which is not convenient to the tight time we have, and the other one is to find another way to handle the package, so we replace the gripper with electromagnet.

Here is the arm design we printed:

Figure 4.1.7.1. 1 robotic arm

And here is the are after we built it:

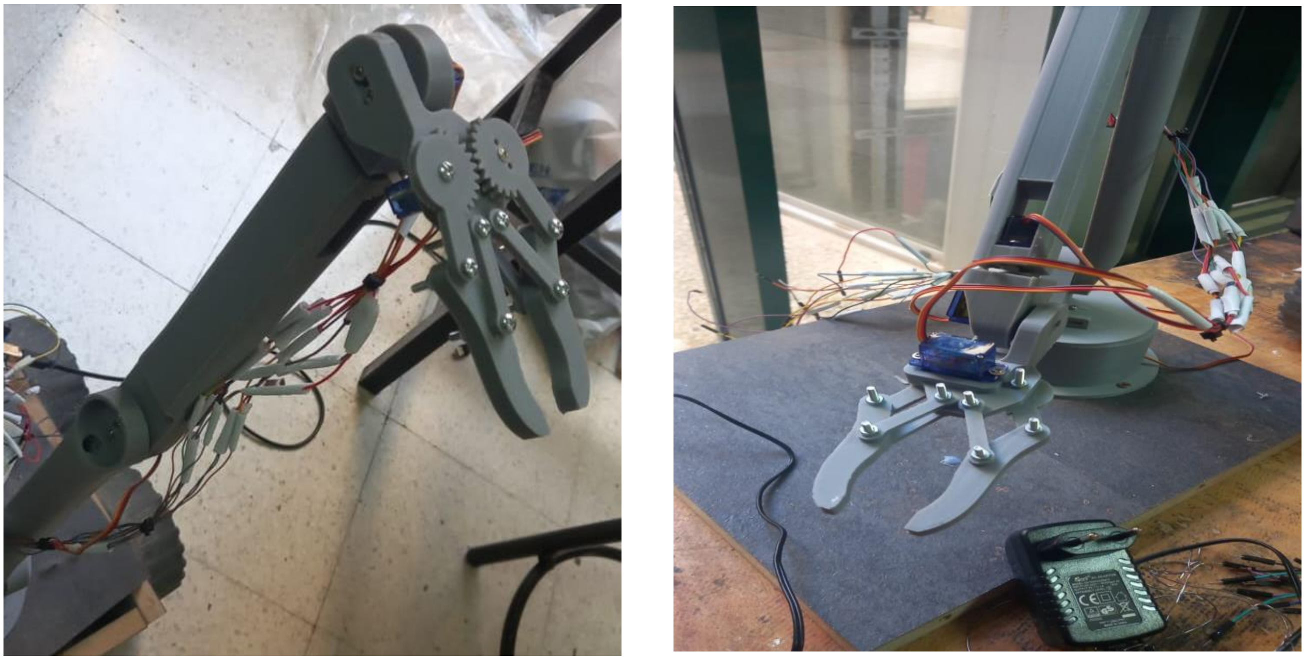


Figure 4.1.7.1. 2 Robotic Arm- first design

Then after we replaced the gripper with an electromagnet:

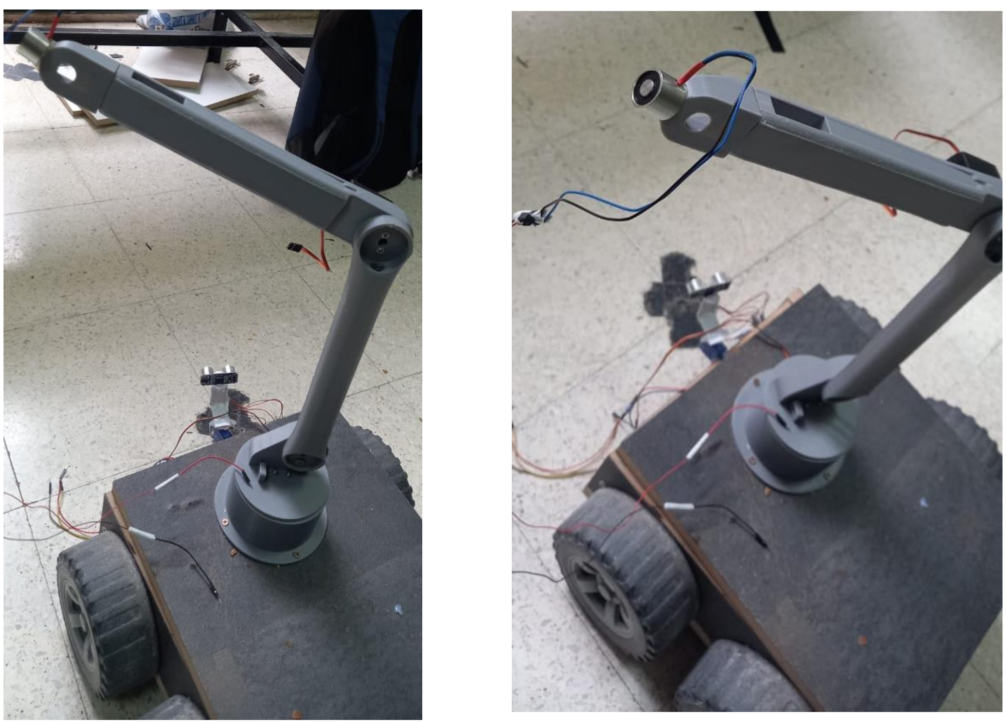


Figure 4.1.7.1. 3 Robotic Arm- final design

4.1.7.2 Lockers

The project incorporates two wooden lockers, serving as secure storage units for efficient package management. These lockers are designed to house and safeguard packages, integrating seamlessly with the advanced technological components of the overall system. The use of wood provides a robust and durable structure for the lockers, ensuring the safety of stored items. The combination of modern technology with traditional materials like wood showcases a balanced approach, merging reliability and innovation in the realm of automated package handling. This integration of wooden lockers aligns with the project's commitment to combining cutting-edge technology with practical, sturdy solutions for effective and secure package storage.

The first locker serves as the end point, or the storage place for all the packages, so the packages get delivers to this locker to get stored securely, until it is time for package delivering to so the package will be taken from the first locker to the second one (delivery point). While the admins can access the lockers and open them manually, the user need to wait on the delivery point.

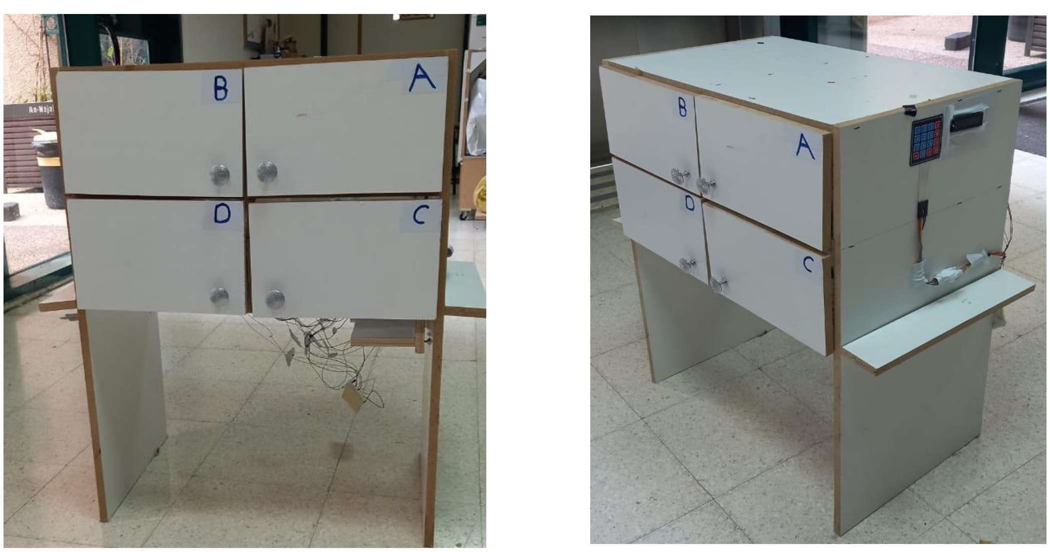


Figure 4.1.7.2.1 Storing locker

The second locker is the one the user will interact with. The user goes to this locker, scans the barcode of his package, then the user will set the password for his package, and pay using the RFID card. And when receiving the package the user will enter the barcode of his package into the mobile application, then the package will be delivered to this locker, so the user can enter the password and take his package.

Figure 4.1.7.2. 1 Delivery point locker

4.1.7.3 Car

A key element of the project is the utilization of a car to facilitate the movement of packages between the two lockers. This innovative approach introduces a dynamic and automated system for efficient package transfer. The car, equipped with various components such as DC motors, ESP32 microcontroller, and sensors, acts as a versatile and mobile entity within the project ecosystem. Its role in navigating the environment and transferring packages aligns with the project's objective of creating an intelligent and automated package management system. The incorporation of a car adds mobility to the system, enhancing its overall functionality and contributing to the seamless and automated transfer of packages between lockers.

Figure 4.1.7. 2 final design for the car

4.1.7.4 wires

Jumper wires played a crucial role in establishing the intricate connections among the various components of the project. Serving as the essential conduits for electrical signals, these wires ensured the seamless integration and communication between microcontrollers, sensors, motors, and other hardware elements. The judicious use of jumper wires facilitated a clean and organized wiring setup, contributing to the overall reliability and efficiency of the project. Their flexibility and ease of use allowed for precise connections, enabling the smooth flow of data and power throughout the system. In the intricate network of components, the jumper wires served as the backbone, underscoring their importance in ensuring the proper functioning and coordination of the diverse elements within the project.

Figure 4.1.7. 3 jumper wires

4.1.7.5 breadboard

The breadboard served as a vital component in the project's circuitry, particularly for connecting the solenoid locks with the LM2803APG and establishing connections with the ESP microcontrollers. This versatile platform provided a convenient and organized space for prototyping and testing various electrical configurations. The solenoid locks, crucial for securing and releasing the lockers, were efficiently connected through the LM2803APG driver on the breadboard, ensuring a reliable and controlled mechanism for locking and unlocking. Additionally, the breadboard facilitated the intricate connections with the ESP microcontrollers, offering a flexible environment for adjusting and refining the electrical layout. Its user-friendly design and modular structure enabled rapid prototyping and troubleshooting, contributing to the overall efficiency and success of the project's electronic configurations. The breadboard, as a dynamic tool in the development process, played a pivotal role in achieving the desired functionality and connectivity of the project's electronic components.

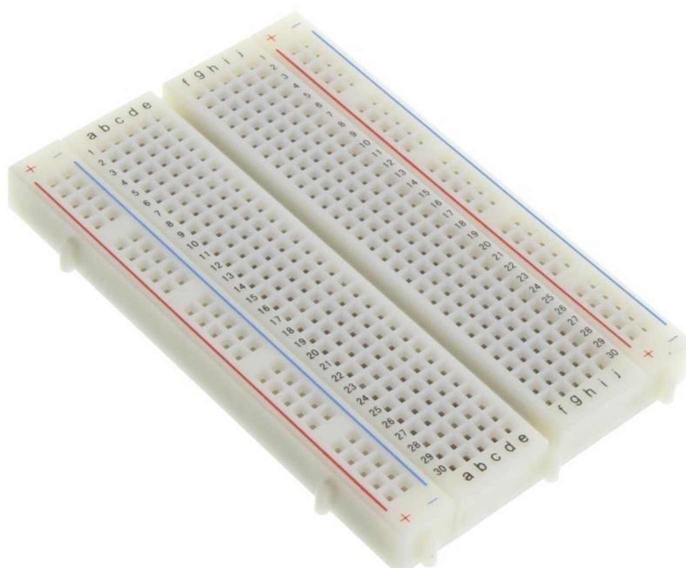


Figure 4.1.7. 4 breadboard

4.1.7.6 LM2803apg

The LM2803APG played a crucial role in the project by acting as an interface between the control signals from the microcontroller and the solenoid locks. This integrated circuit, designed for driving solenoids and relays, efficiently handled the high-current requirements of the solenoid locks. By interfacing with the LM2803APG, the microcontroller could provide precise and controlled signals to activate and deactivate the solenoids, ensuring secure and reliable locking and unlocking of the system's lockers. This integration of the LM2803APG contributed to the overall safety and functionality of the project, enabling a seamless interaction between the electronic components and the physical locking mechanisms. The LM2803APG's capability to manage high currents and interface with microcontrollers made it an essential component in achieving the project's objectives of secure and efficient locker management.

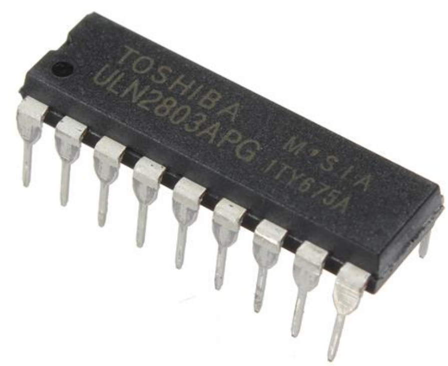


Figure 4.1.7. 5 LM2803apg

5.2 Software implementation

Our project has 6 microcontrollers, each one of them has a code that is independent from the others on some aspects, and dependent on another. The first locker in our project, the one the has four lockers, serves as a storing place for the packages, and it also has its own security measures. The second locker serves as the delivery point for the packages. And the car moves the packages in between these two lockers.

So, our project has the following scenario:

1. **Package registration**: The delivery point -the second locker- should be empty and ready to get a package at any time, the lock of its two lockers is closed until it becomes the right time for it to open. So the user who wants to deliver a package to someone else, will go to the delivery point that is the nearest to him, in our project we made each one of the two lockers of this cupboard as an independent delivery point (logically), so the user goes to the point, scans the barcode of his package to register it, then scan his RFID card to register his identity and pay for the service. After that the lock of the locker for the point he is at will open, so he can put the package inside, after closing the door the locks will be locked again, and the user will be asked to set a password for the package. The LCD is used to show help and instructions for the user, and the user will use the keypad to enter the password.

2. **Package Transfer**: after the user puts the package inside the locker and sets the password, the ultrasonic inside the sensor inside the locker will sense the presence of a package in the locker, so the esp32 connected with the locker, will send a command to the esp32 connected with the car, to tell it to come and transfer this package. So now the car will go to the delivery point, take the package and then move it to the storing locker. The cars esp32 will contact the

esp8266 connected with storing point, and ask it which lockers are empty and ready to get a package. After getting an answer the car will put the package inside the locker, and the following info will be registered in the firebase; the barcode of the package, its password, the user ID, and the locker it is stored in.

3. **Package retrieval**: now when the user who should receive the package is ready to get it, he goes to the mobile application, insert the barcode for his package, then he inserts the delivery point that is most convenient for him to go and his package from. Now the mobile application checks the database, looks for the package with this barcode, and sends a command to the esp32 connected with the car, to tell it to go to the specific locker that the package is registered in, and the car will start the delivery process.

4. **Package delivery**: now the package is on the way to the delivery point to get the package delivered to the user, when the package arrives, a notification will be sent to the user so he knows that the package is ready and he can now take it. The locker will set the password for the package as the first user set it. So now the user will go to the locker, insert say that he wants to take a package, and insert the password for it, so now he can take his package successfully.

5. **Admins Authorities**: the storing locker has a keypad and lcd, if some special occasion happened, the admin have the authority to go and open the lockers manually and get the package stored inside.

5.3 Hardware implementation

Completing and finishing this project went on three stages:

4.3.1building stage:

At first we started by building the first cupboard, which serves as the storing locker. We connected all its component and connected it to the database. Then we went on by building and connecting the second locker. So now we have two lockers, each one works successfully on it own. Then we built the car design and connected it with the robotic arm. So, at the end of this stage, we had each component working on its own.

4.3.2testing stage:

After we finished building each stage of the project, we started testing each stage on its own. Then we started testing the car ability to go from one locker to the other, and its ability to pick the packages and moving them.

4.3.3finishing stage:

Now, after all is said and done, came the time for connecting the components together using esp32 and esp8266, so now we can test the project all in one go and finish everything. So we wrote the codes for the esp's and tested the connectivity and finished the final stage.

4.4 Mobile application

In order for the user to be able to take the package and order it to be delivered, we built the mobile application using mit app inventor, it is a simple application with a simple design:

In the first page, the user chooses the delivery point he want to get the package delivered to.

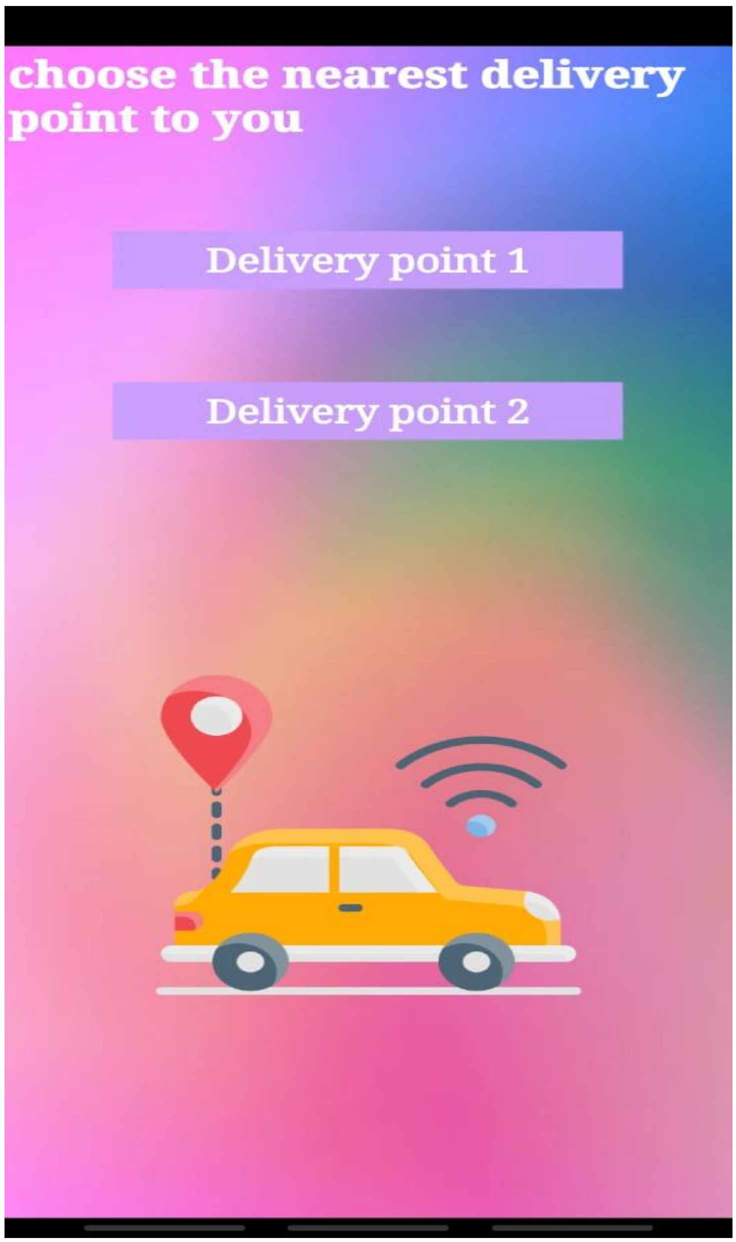


Figure 4.4. 1 Mobile application 1st page

In the second page, the user insert the barcode for his package and get it delivered.

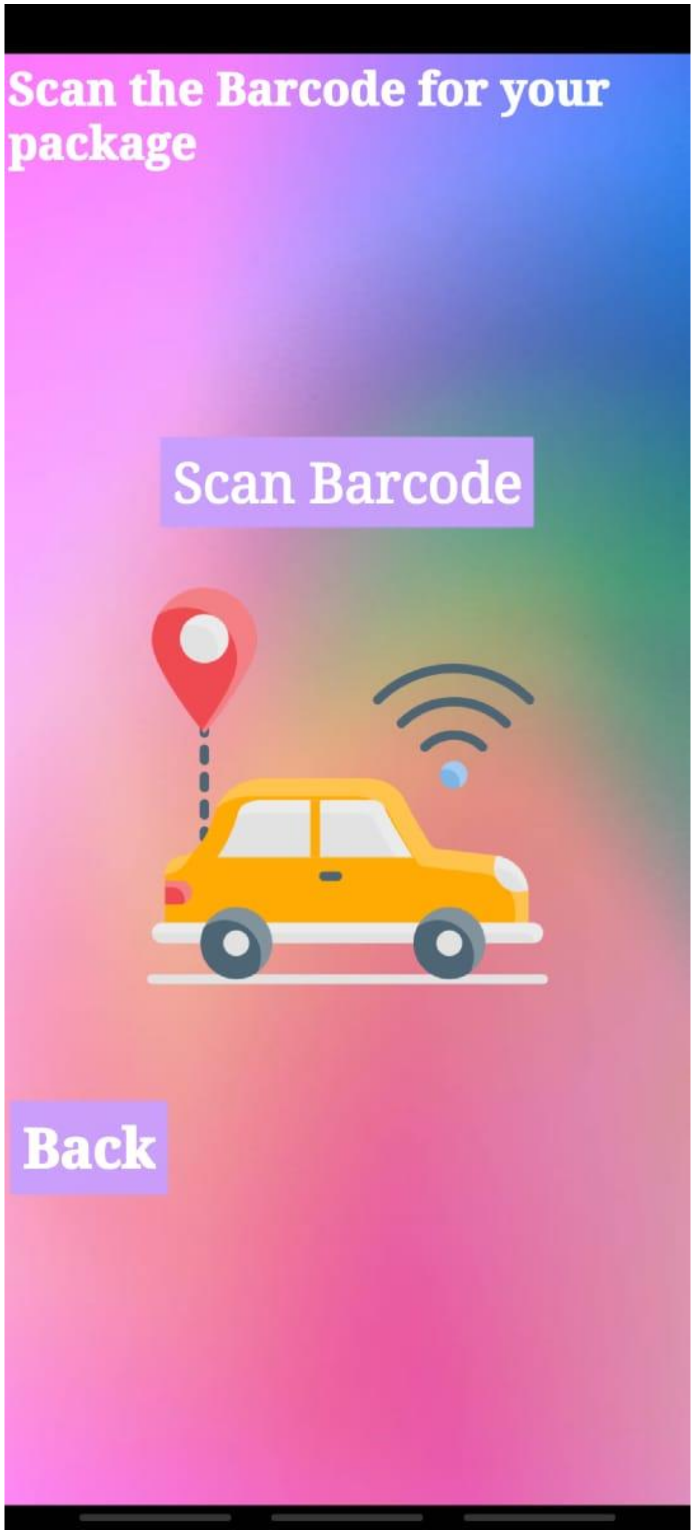
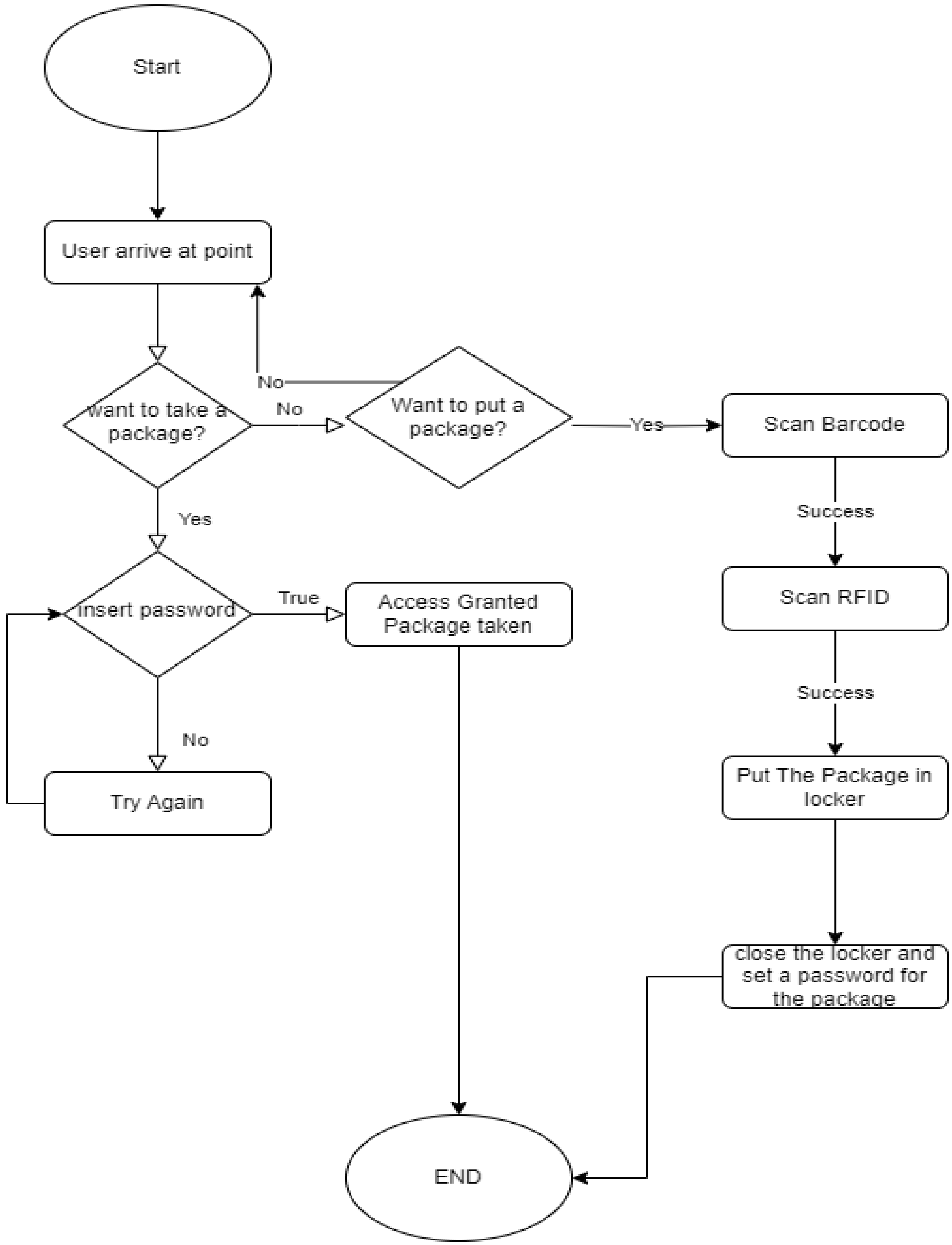


Figure 4.4. 2 Mobile application 2nd page

Flow Chart


Start
User arrive at point
want to take a package?
No
Want to put a package?
No
Yes
Scan Barcode
Success
Scan RFID
Success
Put The Package in locker
close the locker and set a password for the package
Yes
insert password
True
Access Granted Package taken
No
Try Again
END

Chapter 5

Results and discussion:

The SmartConnect project aimed to revolutionize logistics with an automated, secure, and user-friendly system, employing Arduino microcontrollers, ESP modules, and a variety of sensors.

Challenges Encountered: The project faced significant hardware challenges, particularly with the power supply and the limitations of microcontrollers. These issues were critical as they directly affected the system's reliability and efficiency. Mechanical difficulties with the robotic arm presented another significant hurdle, impacting the system's ability to handle packages effectively.

On the software front, the complexity of the system demanded a high level of synchronization between multiple microcontrollers, each responsible for different functions. This interdependency posed a significant challenge in ensuring a seamless operational flow, especially in scenarios involving real-time data processing and decision-making.

Innovative Solutions: The team employed innovative solutions to overcome these challenges. For hardware, modifications were made to the power supply system to enhance efficiency and reliability. The microcontroller's limitations were addressed by optimizing the code and incorporating additional processing units where necessary. The mechanical issues with the robotic arm were resolved through a series of design revisions and testing.

In terms of software, the team developed a robust framework that allowed efficient communication and coordination between the different microcontrollers. This involved creating a layered software architecture that could manage the complex interactions required for the system's functionality.

Chapter 6

Conclusion and Future work:

6.1 Conclusion

The SmartConnect Logistics System integrates RFID technology, barcode scanners, and a mobile application to enhance package management efficiency and security.

The system's real-time tracking capability ensures transparency and accountability in package handling. The secure access control mechanism, facilitated by RFID and barcode scanning, significantly enhances the system's security. The autonomous package transfer between lockers is a groundbreaking feature that reduces manual intervention and streamlines the logistics process.

The project has the potential to significantly impact the logistics industry by setting new standards in package management. However, it's important to acknowledge the limitations faced, such as the challenges in hardware reliability and software complexity. These limitations, while crucial, provide a roadmap for further improvement.

The project's journey from conception to realization highlights the importance of innovation, teamwork, and resilience in the face of technical challenges. It stands as a testament to the team's commitment to revolutionizing logistics through technology.

6.2 Future work

The next phase of the SmartConnect project involves scaling up the system for broader application and improving its security features.

Enhancing scalability involves both technical upgrades and logistical planning to ensure the system can handle increased loads without compromising efficiency. Addressing security vulnerabilities is crucial to protect against potential breaches and ensure user trust.

Improving the user interface for ease of use will be a focus, alongside the integration of advanced AI algorithms for smarter package handling. This involves not just technological advancements but also user-centric design principles.

Future iterations will explore sustainable power solutions, reflecting a commitment to environmental responsibility. The long-term vision for SmartConnect is to continually adapt to the evolving technological landscape and maintain its relevance in the logistics industry.

The future work outlined here emphasizes the project's ongoing commitment to innovation and improvement, ensuring that SmartConnect remains at the forefront of logistics technology.

Chapter 7

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