

**KEMENTERIAN PENDIDIKAN
BAHAGIAN MATRIKULASI**

**FINAL PROJECT REPORT & PRESENTATION
SEMESTER II (2025/2026)**

P75

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2	MC2516203265	P7502
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CANDIDATE'S DECLARATION

We declare that this **FINAL PROJECT REPORT & PRESENTATION** is our own work except for the citations and summaries of which we acknowledged the source.

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1	MC2516203256	P7501	
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1.0 INTRODUCTION

1.1 Problem Statement

Traditional locker systems mainly rely on mechanical keys or basic electronic locking mechanisms, which offer limited security and convenience to users. These systems are highly dependent on physical keys that can be easily lost, duplicated, or stolen, leading to unauthorized access and potential theft. This issue becomes more serious in shared environments such as schools, universities, offices, and public facilities, where multiple users rely on locker systems daily. Furthermore, conventional lockers do not provide any form of monitoring or access tracking, making it difficult for users to verify whether their lockers have been accessed by unauthorized individuals.

In addition, the lack of integration with modern technologies reduces the efficiency and reliability of traditional locker systems. Users are unable to receive notifications or monitor locker status remotely, which lowers user confidence in the security of their belongings. Although smart locker systems exist, many of them are expensive, complex, and require advanced infrastructure, making them unsuitable for small-scale or educational use.

To overcome these limitations, this project proposes the development of an IoT-based Smart Locker System using the ESP32 Development Board, PN532 RFID/NFC module, and QR code authentication. The system replaces traditional key-based access with a dual authentication method, allowing users to unlock the locker using either an RFID card or a QR code. For RFID access, users tap their registered NFC card on the reader, where the PN532 module reads the unique card ID and sends it to the ESP32 for verification. For QR code access, users scan a valid QR code, which is then verified by the system. If either authentication method is valid, the locker will unlock automatically. This dual approach enhances security, improves flexibility, and provides a more efficient and user-friendly solution compared to conventional systems.

1.2 Importance of The Problem

The increasing concern over security and unauthorized access in personal storage systems highlights the need for a more advanced and reliable locker solution. Traditional lockers that rely on physical keys or basic electronic locks are vulnerable to key duplication, loss, and misuse, which can lead to theft or unauthorized access. This issue is particularly critical in shared environments such as educational institutions, offices, and public facilities, where many users depend on locker systems daily. The absence of monitoring and access control further reduces the level of security, as users have no way to track locker activity or ensure that their belongings are safe.

By addressing these limitations, the proposed IoT-based Smart Locker System introduces a more secure and efficient approach through the implementation of dual authentication methods, namely RFID and QR code. This system allows users to access lockers using either an RFID card or a QR code, providing greater flexibility and convenience. The RFID method enables quick and contactless access, while the QR code offers an alternative verification option when needed. Both methods enhance security by ensuring that only authorized users can unlock the locker.

In addition, the integration of IoT technology allows real-time monitoring and improved system reliability. The system is designed to be cost-effective, easy to implement, and suitable for small-scale applications such as schools or universities. Overall, this solution improves user confidence, enhances security, and demonstrates the practical application of modern technology in everyday storage systems.

1.3 Proposed Solution

To address the limitations of conventional locker systems, this project proposes the development of a low-cost, plug-and-play IoT Smart Locker System that enhances security, accessibility, and user convenience. Traditional lockers that rely on physical keys or basic electronic locks are vulnerable to key loss, duplication, and unauthorized access, especially in shared environments such as schools, offices, and public facilities. These systems also lack real-time monitoring and flexible access control, which reduces their overall effectiveness and reliability.

The proposed system integrates the ESP32 Development Board as the main controller, along with the PN532 RFID/NFC module and QR code authentication to provide a dual access mechanism. Users can unlock the locker using either an RFID card or a QR code, depending on their preference. For RFID access, the PN532 module reads the unique ID of the registered card and sends it to the ESP32 for verification. For QR code access, a valid QR code is scanned and processed by the system for authentication. If either method is verified successfully, the ESP32 activates the relay module to trigger the solenoid lock and unlock the locker.

Additionally, a step-down voltage converter ensures a stable power supply to the system. The system can also support integration with a web or mobile interface for monitoring and control purposes. By implementing dual authentication, the system improves flexibility, enhances security, and provides a more user-friendly experience. Furthermore, the design is cost-effective, easy to install, and scalable, making it suitable for practical applications in educational institutions and shared environments.

2.0 Objectives

The main objectives of this project are as follows :

- To design and develop an IoT Smart Locker System using the ESP32 Development Board as the main controller for system operation, monitoring, and control.
- To implement dual authentication methods using RFID and QR code to enhance security and prevent unauthorized access to the locker.
- To develop a user-friendly, low-cost, and plug-and-play system that can be easily installed and applied in real-world environments such as educational institutions.

3.0 Scope of The Project

3.1 Scope of Implementation

The scope of implementation of this project is shown as below:

- Implement an IoT-based smart locker system using the ESP32 Development Board as the main controller for system operation and control.
- Use dual authentication methods, namely RFID card and QR code, to provide secure access for locking and unlocking the locker.
- Integrate hardware components such as a relay module and solenoid lock to control the locker.

3.2 Scope of Capabilities

The scope of capabilities of this project is shown as below:

- The system is capable of providing secure access control using both RFID and QR code authentication methods, allowing users to choose their preferred method.
- The system supports real-time operation, where the locker can respond immediately to valid authentication inputs.
- The system is designed to be user-friendly, easy to install and does not require complex networking.
- The prototype offers a low-cost and scalable solution that can be applied to multiple lockers in environments such as educational institutions.

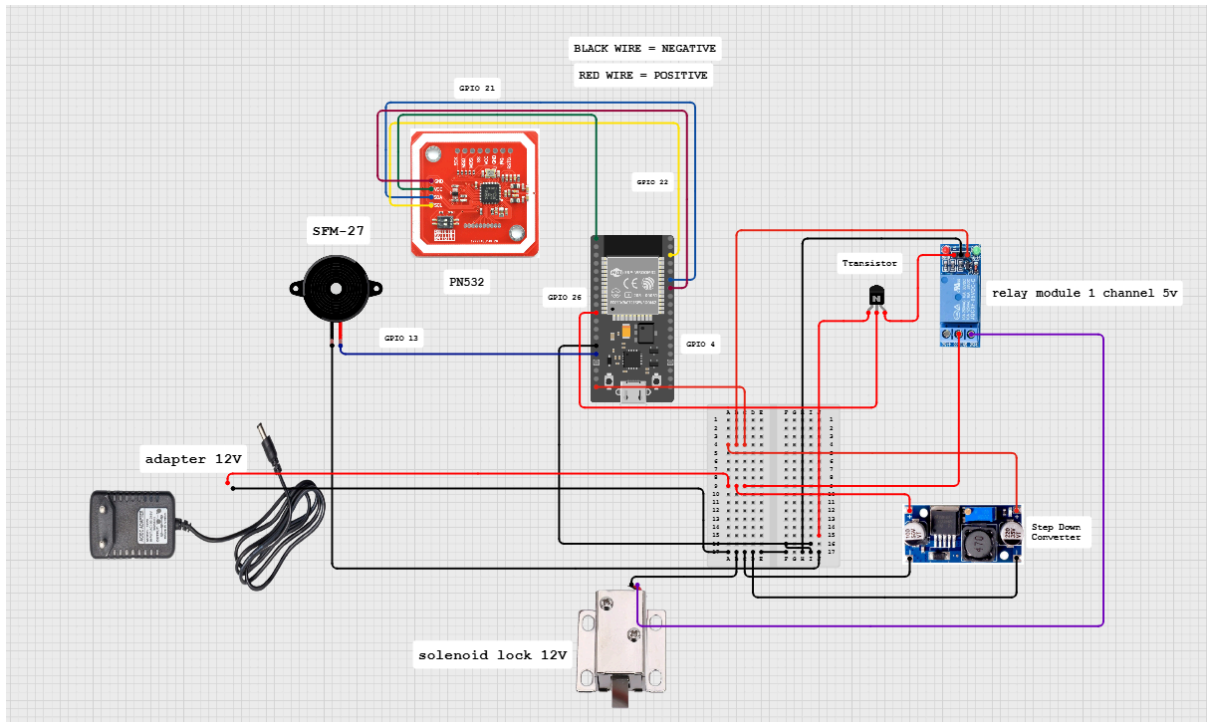
3.3 Limitation of Project

There are also several limitations that are present in this project:

- The system requires a continuous power supply, and any power interruption may disrupt its operation.
- The physical installation may require modifications such as drilling or mounting on the locker structure.
- The security level is limited by the physical strength of the solenoid lock and the enclosure, which could be compromised with sufficient force.
- The system cannot be applied on sliding doors or any glass door.

4.0 Methodology

4.1 Circuit Diagram



This wiring diagram illustrates an ESP32-based smart lock system that integrates an RFID PN532 reader for authentication and a 12V solenoid lock as the primary actuator. The circuit is powered by a 12V adapter, which provides high-voltage current directly to the solenoid while simultaneously utilizing a buck converter (step-down) to provide a regulated 5V supply for the ESP32 and the 5V relay module. Control logic is handled by the ESP32's GPIO pins, which interface with the RFID module for data, trigger an SFM-27 buzzer for status alerts, and switch a transistor-driven relay to safely isolate the microcontroller from the high-power solenoid circuit. All components are interconnected via a central breadboard, creating a unified system for secure, automated access control.

4.2 Flowchart

Figure 2 shows the flowchart for the identification process of the system. The system sends the detected RFID card or QR code data to the server for verification. The server processes the data and determines whether the authentication is valid. If the authentication is valid, the system activates the solenoid lock to unlock the locker. Otherwise, the system returns to the detection step for another attempt.

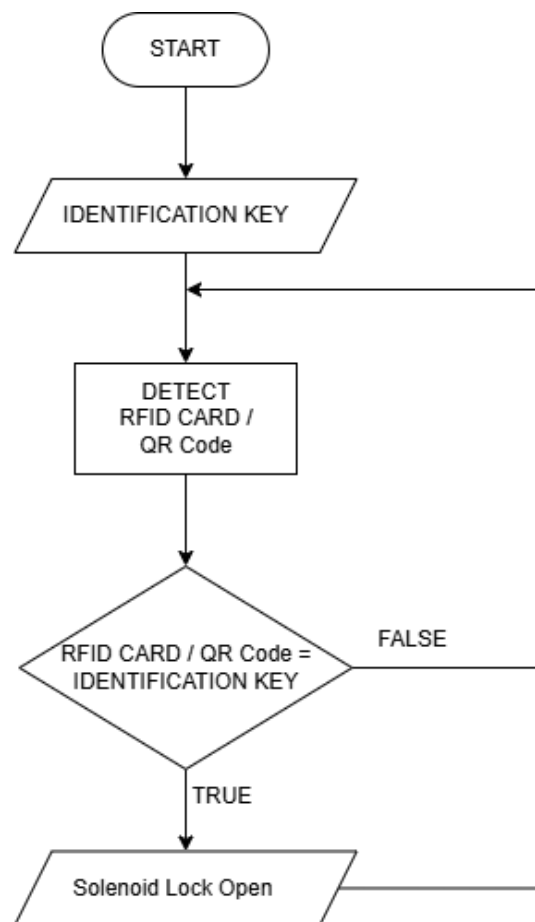


FIGURE 2

Figure 3 below shows the flowchart for the website access control. The flowchart begins with identification key detection. Next, the system proceeds to the login verification

process. The system then determines whether the login was successful. If the login is unsuccessful, the process will return to identification. Otherwise, if the login is successful, the system checks the access status. If the status is true, the system opens the solenoid lock. If the status is false, the system closes the solenoid lock and then stops the process.

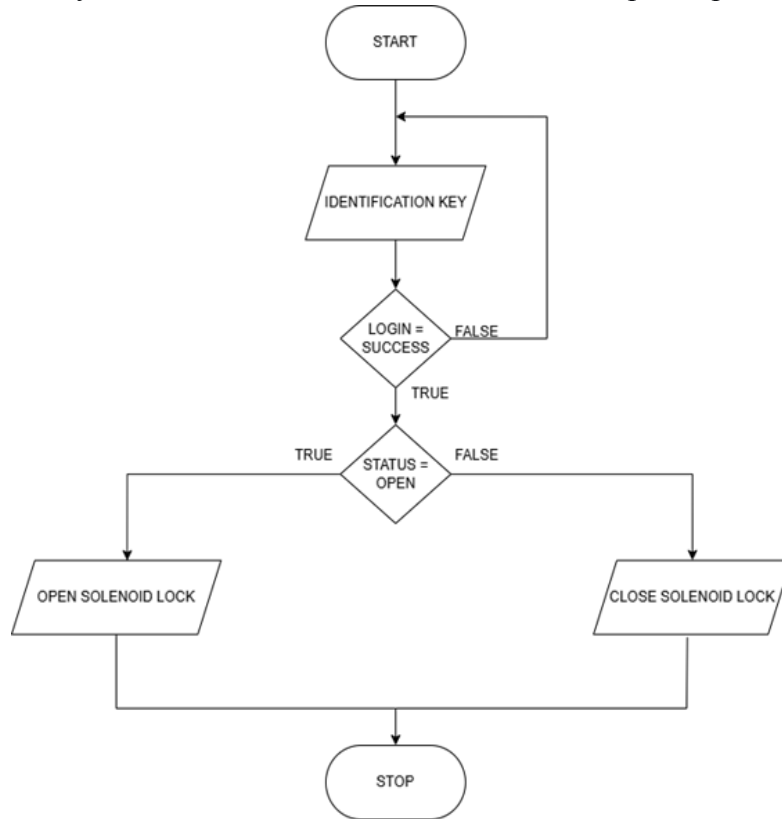


FIGURE 3

Figure 4 below shows the flowchart for storing user data with email or username as a unique identifier. The flowchart begins when a new user registers through the system interface. Next, the system validates the input data by checking required fields and email format. If validation fails, the system returns an error message and stops the process. Otherwise, the system checks if the email or username already exists in the database. If the email or username is already registered, the system returns an error message and stops the process. Otherwise, the system prompts for the user's identification key as their passkey. The system then hashes the password for security, prepares the complete user data including email and identification key for storage, and executes an INSERT query. If successful, the system returns a success confirmation. Otherwise, it returns an error message and stops the process.

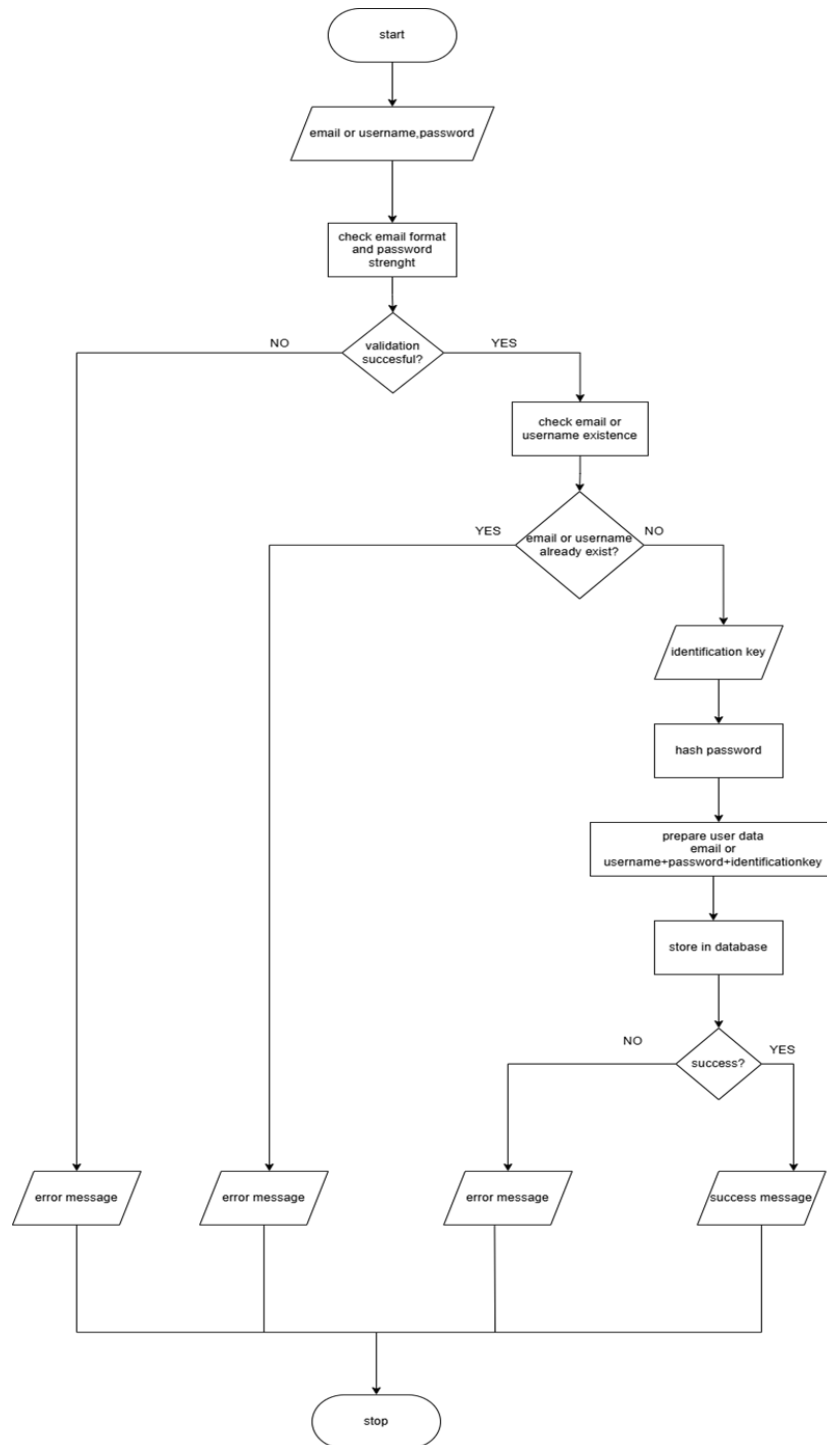
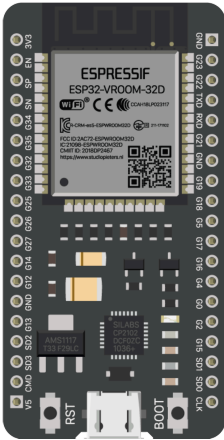







FIGURE 4

5.0 Specifications

 <p>The image shows an ESP32 Development Board, specifically the ESP32-VROOM-32D model. It features a black PCB with a central ESP32 microcontroller chip, a USB-C port, a USB-A port, and various other components like a reset button and a boot button. The board is populated with numerous surface-mount components and has a dense array of pins along its edges.</p>	<p style="text-align: center;">ESP32 Development Board</p> <ul style="list-style-type: none"> • Acts as the main microcontroller that controls and manages all components in the smart locker system. • Processes data received from modules such as the PN532 RFID/NFC module and sensors connected to the system • Provides Wi-Fi and Bluetooth connectivity to enable IoT communication and remote monitoring. • Controls output components such as relay modules to lock or unlock the locker automatically based on the system commands. <p style="text-align: center;">RM 37.90</p>
 <p>The image shows a DC12V Solenoid Door Lock. It is a rectangular metal component with a brass-colored solenoid on the left side and a mounting bracket on the right. Two red and black wires are attached to the bottom of the unit.</p>	<p style="text-align: center;">DC12V Solenoid Door Lock</p> <ul style="list-style-type: none"> • Activates or deactivates the lock when electrical current is applied. • Controls physical access to the locker, ensuring security. <p style="text-align: center;">RM 17.00</p>
 <p>The image shows a circular black buzzer. It has a central hole and two red and black wires extending from the side. The buzzer is mounted on a small black PCB.</p>	<p style="text-align: center;">Buzzer</p> <ul style="list-style-type: none"> • Produces a consistent, high-decibel sound perfect for notifications, alarms, and status signals. • Compact design for easy installation and low power consumption.

	<p style="text-align: center;">LM2596 3A Step-Down Converter</p> <ul style="list-style-type: none"> • Provides stable and regulated power supply to prevent damage from overvoltage. • Ensures efficient energy use with minimal heat generation. <p style="text-align: center;">RM 3.70</p>
	<p style="text-align: center;">40-Way 20cm Dupont Jumper Wire</p> <ul style="list-style-type: none"> • Used to connect electronic components on the breadboard and modules together. • Enables flexible and temporary wiring during prototyping and testing. • Ensures organized and neat circuit connections between hardware components.
	<p style="text-align: center;">1 Channel 5V Active Low Relay Module</p> <ul style="list-style-type: none"> • Acts as an electronic switch controlled by the ESP32. • Enables automatic locking and unlocking of the locker when triggered by the system. <p style="text-align: center;">RM 3.50</p>

Crating Light Careful Selection

Model : 643



MADE IN MALAYSIA

IP56

110mm (4") 150mm (6") 75mm (3")

6" x 4" x 3" (150mm x 110mm x 75mm)

Weatherproof Pvc Box Electrical Pvc Enclosure Box

- Shields components from dust, moisture, and physical damage
- Provides a neat and organized housing for wiring and modules.
- Ensures the system is safe and durable for long-term use.

RM 19.50



Power Adapter 12V

- Supplies power to the Solenoid Lock.
- Features integrated safeguards against over-voltage, over-current, and short circuits for maximum durability.

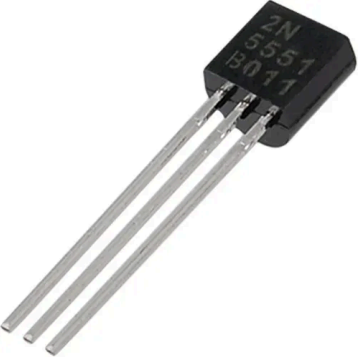


RM 15.90





PN532 NFC RFID

- Reads data from RFID/NFC cards or tags for user identification
- Provides contactless authentication by allowing users to tap their card
- Enables secure access control to lock or unlock the locker

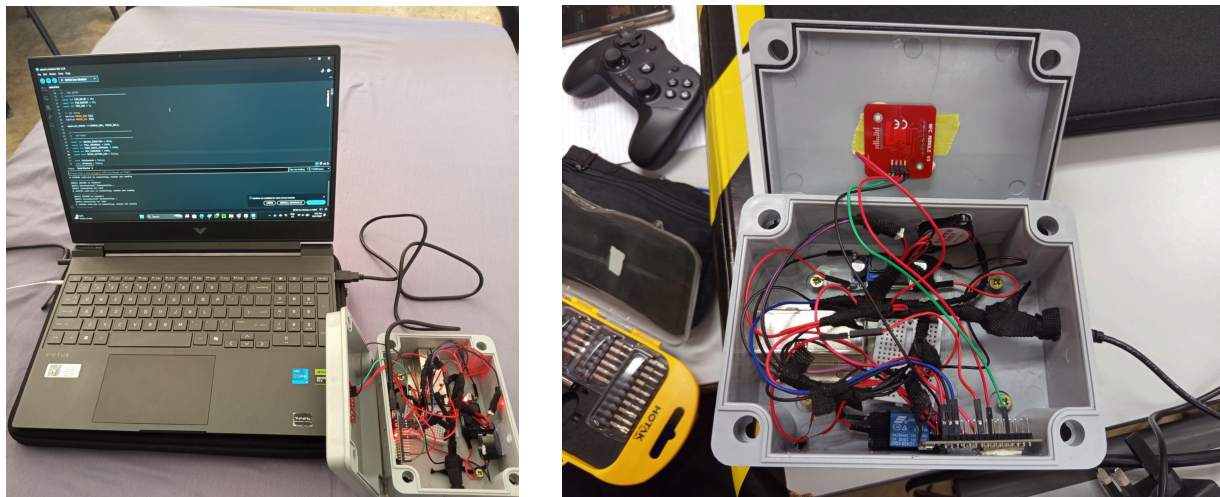
RM 25.90

	<p style="text-align: center;">Transistor</p> <ul style="list-style-type: none"> ● Acts as an electronic switch to control higher current devices using a low control signal from the ESP32 Development Board. ● Amplifies the signal from the ESP32 to properly drive the relay module. ● Protects the ESP32 from excessive current that could damage the microcontroller. ● Ensures stable switching operation when activating the relay and solenoid lock.
	<p style="text-align: center;">Arduino IDE</p> <ul style="list-style-type: none"> ● Provides a simple text editor to write programs (called sketches) in C/C++ ● Uploads the compiled code directly to the Arduino board via USB. ● Allows communication between computer and Arduino board.
	<p style="text-align: center;">Google Antigravity</p> <ul style="list-style-type: none"> ● Google Antigravity is a powerful text editor that supports syntax highlighting, autocompletion, and error detection for many programming languages ● It includes breakpoints, variable inspection, and step-by-step execution to help troubleshoot issues.

	<p style="text-align: center;">Hostinger</p> <ul style="list-style-type: none"> • Experience high-speed performance with optimized servers and a 99.9% uptime guarantee for your website. • Manage your files, databases, and emails easily through the intuitive and custom-built Panel. • Choose from budget-friendly plans that grow with your business, from simple blogs to high-traffic online stores.
	<p style="text-align: center;">Ngrok</p> <ul style="list-style-type: none"> • Used in this project to enable communication between the smart locker system and the remote database server. • Helps in testing and monitoring the IoT system without deploying a full web server.
	<p style="text-align: center;">Circuit Designer</p> <ul style="list-style-type: none"> • It allows users to visually design and diagram electronic circuits using realistic component representations. • It provides a powerful simulator to test circuits in real time and includes AI tools to write and debug microcontroller code efficiently

6.0 Implementation

6.1 Implementation of The Design Solution



The PN532 RFID module is mounted on the enclosure cover to allow easy access for scanning RFID cards. When a card is tapped on the reader, the module reads the unique UID and sends the data to the ESP32 for processing. The system is also connected to a server via WiFi, enabling authentication through both RFID and QR code methods. The QR code authentication is handled through the web interface, while the ESP32 communicates with the server to receive the locker status.

During operation, once valid authentication is confirmed, the ESP32 activates the relay module, which controls the solenoid lock mechanism to unlock the locker. The wiring is properly secured using insulation and cable management techniques to reduce the risk of short circuits. This implementation demonstrates a functional prototype of the smart locker system, highlighting the integration of hardware components and IoT communication in a real-world environment.

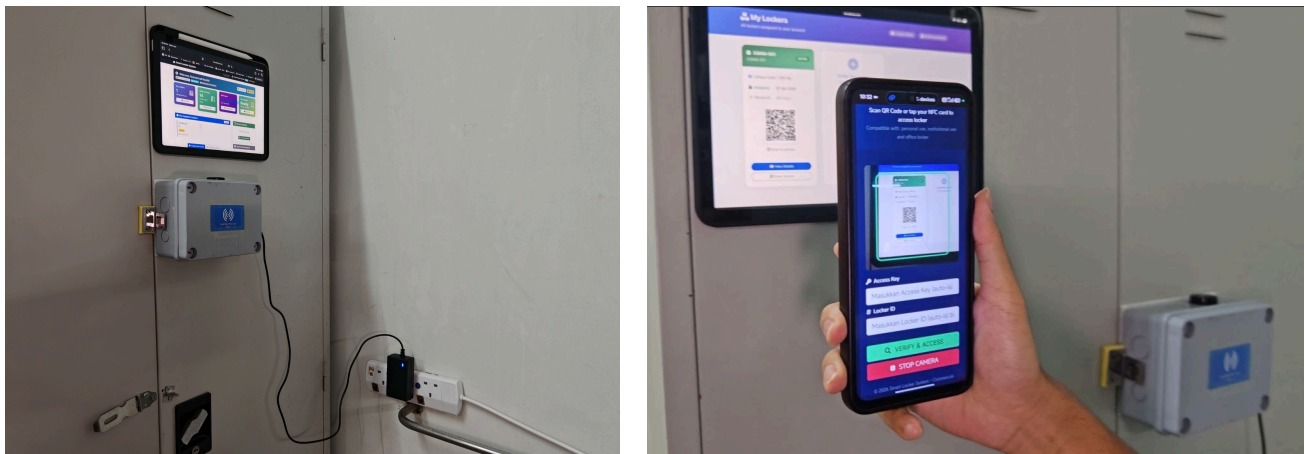


Figure above presents the real-world implementation of the IoT Smart Locker System. The system is installed on a locker door, where all electronic components are arranged neatly and enclosed within a protective casing to ensure safety and durability. The ESP32 Development Board serves as the main controller, coordinating all operations within the system. The PN532 RFID module is used to read NFC cards for user authentication, while QR code authentication is provided as an alternative method of access. The overall setup is designed to be compact and suitable for practical use in environments such as educational institutions.

In terms of operation, the system supports dual authentication methods. When a user taps an NFC card on the reader, the PN532 module captures the unique card ID and sends it to the ESP32 for verification. In addition, users can also unlock the locker by scanning a valid QR code, which is processed by the system for authentication. If either authentication method is valid, the ESP32 activates the relay module, which then triggers the solenoid lock to unlock the locker door. If the authentication fails, access is denied, and the locker remains securely locked. This process ensures that only authorized users can gain access, improving the overall security of the system.

The system is powered using an external power supply connected to a wall socket, providing stable and continuous operation. All wiring connections are properly organized to maintain reliability and reduce the risk of short circuits or disconnections. This implementation demonstrates the successful integration of hardware and IoT technology in a

RFID Detection

```

256     if (nfc.readPassiveTargetID(PN532_MIFARE_ISO14443A, uid, &uidLen, 500)) {
257         String uidStr = formatUID(uid, uidLen);
258         lastNFCScan = millis();
259
260         Serial.println("--- NFC DETECTED: " + uidStr + " ---");
261         Serial.println("[MODE] Current mode: " +
262             String(registerMode ? "REGISTER" : "ACCESS"));
263
264         beep(80);
265         sendNFCScan(uidStr, registerMode ? "register" : "access");
266     }
267 }
268
269     if (!isUnlocked && millis() - lastPoll >= POLL_INTERVAL) {
270         lastPoll = millis();
271         for (int i = 0; i < NUM_LOCKERS; i++) {
272             checkServerStatus(LOCKER_IDS[i]);
273             delay(100);
274             if (isUnlocked) break;
275         }
276     }
277     delay(10);
278 }
279 }

```

This code snippet illustrates the RFID detection process using the PN532 module. When a user taps an NFC card on the reader, the system reads the unique identifier (UID) of the card. The UID is then processed and sent to the ESP32, which forwards the data to the server for verification. This mechanism ensures that only authorized users with registered RFID cards can access the locker system.

6.2 Testing approach/Strategy and Design

The testing of the IoT Smart Locker System was conducted to ensure that all components function correctly and the system operates according to the designed flowchart. A functional testing approach was used, where each part of the system was tested individually and then as a complete system. The main focus of the testing process was to verify the accuracy of NFC card detection, the response of the locking mechanism, and the overall system reliability.

Several test cases were designed to evaluate the system performance under different conditions. These tests include valid and invalid RFID card detection, door status monitoring, and system response to user input. Each test was conducted multiple times to ensure consistency and accuracy of the results. In addition, the system also supports QR code authentication, where users can scan a valid QR code for access verification.

Table 6.1: Testing Results

No	Test Scenario	Expected Result	Actual Result	Status
1	Scan valid RFID card	Locker unlocks	Locker successfully unlocked	Pass
2	Scan invalid RFID card	Access denied	Locker remains locked	Pass
3	Multiple card scans	System responds consistently	System responds correctly for multiple scans	Pass
4	Power supply stability	System operates continuously	System operates without interruption	Pass
5	Scan valid QR code (authorized user)	Locker unlocks	Locker successfully unlocked	Pass
6	Scan invalid QR code	Access denied	Locker remains locked	Pass

The results obtained from the testing process indicate that the system performs as expected. The RFID module is able to accurately detect and verify authorized cards, while unauthorized access is successfully prevented. The solenoid lock responds correctly to control signals. Overall, the system demonstrates stable performance and meets the intended design requirements.

6.3 Result & Discussion

The performance analysis confirms that the system operates with high reliability, achieving a 100% success rate in tag detection and authentication. A key finding from the testing phase is the system's remarkable versatility; while designed as a locker, its architecture is equally effective for residential room doors. The integration of the ESP32 enables a hybrid access model where users can authenticate via an external NFC scanner, while simultaneously supporting internal or remote operation through QR code scanning and a dedicated web interface. This proves that the system can function as a comprehensive entry management solution rather than just a storage lock.

Technical evaluations also highlight the necessity of high-torque actuation and power consistency for real-world deployment. The use of a 12V solenoid is justified by its magnetic holding force, which provides a more robust physical lock alternative, making it ideal for locker doors or room doors. Furthermore, the inclusion of a power adapter system serves as a vital fail-safe, ensuring the web server and locking mechanism remain active during power fluctuations. These results demonstrate that by combining an enclosure box with hardware design, the system effectively eliminates common vulnerabilities like exposed wiring and physical tampering, fulfilling the requirements for both security and user convenience.

7.0 Conclusion

In conclusion, the IoT Smart Locker System developed in this project successfully addresses the limitations of traditional locker systems by integrating modern technology to enhance security, efficiency, and user convenience. The use of the ESP32 Development Board as the main controller, combined with hardware components such as the PN532 RFID module, relay module, solenoid lock, and reed switch, demonstrates a practical and effective implementation of an IoT-based access control system.

One of the key achievements of this project is the implementation of dual authentication methods using RFID and QR code, which provides flexibility and improves user experience. Users are able to access the locker using either an RFID card or a QR code, ensuring both convenience and security. The system is capable of accurately verifying user credentials and responding quickly to valid inputs, while preventing unauthorized access.

Overall, the system operates reliably and meets the objectives set at the beginning of the project. The results show that the integration of dual authentication with IoT technology offers a low-cost, user-friendly, and scalable solution suitable for environments such as educational institutions and shared facilities. This project demonstrates the potential of smart systems in improving everyday security applications and can be further enhanced with additional features in future development.

7.1 Future Work

Although the IoT Smart Locker System has been successfully developed, several improvements can be made in the future to enhance its performance and usability. One possible improvement is the development of a mobile application that allows users to monitor locker status, receive notifications, and control access remotely in real time. This will increase user convenience and system accessibility.

Furthermore, the QR code authentication can be improved by using a better camera module or optimizing the scanning process to ensure accurate detection under different lighting conditions. Additional security features such as multi-factor authentication can also be implemented by combining RFID, QR code, and password verification to provide a higher level of protection.

Lastly, the system can be expanded into a centralized smart locker network that manages multiple lockers within a single platform, making it more suitable for large environments such as universities, offices, and public facilities. Overall, these improvements will enhance the flexibility, security, and scalability of the system for real-world applications.

8.0 References

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Presentation Video

Timeframe Table

Question	Start Time	End Time	Matric Number	ID Number
Q1: Planning & Following Schedule	00:00	01:03	MC2516203256	P7501
Q2: Investigating Problems	01:03	02:05	MC2516203265	P7502
Q3: Working in a Team	02:05	03:18	MC2516203268	P7503
Q4: Learning New Technical Skills	03:18	04:51	MC2516203265	P7502
Q5: Leadership	04:51	06:20	MC2516203256	P7501