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Smart IoT Locker with QR Code Access

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Abstract: *As a modern application for everyday public storage services with QR code Access, we designed and implemented the Smart IoT Locker System, which is an advanced automation platform developed to improve security, accessibility, and operational efficiency. It is a cost-effective and scalable solution for automated locker management in smart environments. The system utilizes the ESP8266 for communication, control operations, and real-time monitoring. It integrates QR-code based locker access, OTP authentication, MQTT communication, and online payment processing for secure and contactless operation. Traditional locker systems in locations such as colleges, malls, railway stations, offices, and public areas require continuous manual supervision, often resulting in security risks, unauthorized access, management difficulties, and service delays. MQTT protocols are employed for real-time communication and remote monitoring, while relay modules and solenoid locks ensure accurate locking and unlocking operations. A QR-based authentication mechanism enhances security by allowing access only to authorized users. The proposed solution demonstrates the practical implementation of IoT and embedded technologies in real-world smart locker applications. The system also supports countdown timers, overtime handling, admin bypass control, and cloud-based session management functionalities for secure operations.*

Keywords: IoT, ESP8266, Smart Locker System, MQTT, QR Code Authentication, OTP Verification, Solenoid Lock,

I. INTRODUCTION

With the rapid growth of the Internet of Things (IoT), many everyday systems are becoming smarter, more secure, and easier to use. One such application is the smart locker system, which provides a convenient way to store personal belongings in places such as colleges, railway stations, shopping malls, offices, and other public areas. As more services move towards automation and contactless operation, there is a growing need for locker systems that are secure, reliable, and easy to manage.

Most traditional locker systems depend on physical keys or manual supervision. These methods often lead to problems such as lost keys, unauthorized access, difficulty in managing multiple lockers, and increased maintenance. In addition, users usually have to rely on staff for locker allocation and monitoring, making the process less efficient and time-consuming.

To overcome these limitations, this paper presents a Smart IoT Locker with QR Code Access that combines IoT technology with secure authentication and cloud-based management. In the proposed system, each locker is assigned a unique QR code that directs the user to a web application. The user verifies their identity using an email-based One-Time Password (OTP), selects the required storage duration, completes the payment through Razorpay, and gains access to the locker. The ESP8266 microcontroller communicates with the server through the MQTT protocol using the HiveMQ broker to control the locking and unlocking operations. MongoDB Atlas is used to store user information and locker session details securely, while the web application is developed using Next.js, React, and Tailwind CSS.

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The proposed system provides a secure, contactless, and user-friendly solution for automated locker management. Features such as real-time locker status monitoring, countdown timer management, overtime handling, and administrator override improve the overall reliability and efficiency of the system. By integrating embedded systems, cloud services, and modern web technologies, the proposed solution offers a practical and cost-effective approach for smart locker applications in educational institutions, commercial buildings, and other public environments..

II. LITERATURE REVIEW

Several researchers have worked on smart locker systems to improve the security and management of lockers using IoT technologies. Different authentication methods such as RFID, QR codes, OTP verification, and face recognition have been proposed to replace traditional key-based locker systems. This section discusses some of the existing research related to smart locker systems and highlights the need for the proposed solution.

Developed an IoT-based smart locker system that uses password authentication along with face recognition to improve security[1]. Their system allows only authorized users to access the locker and reduces the chances of unauthorized entry. However, the use of cameras and image processing increases the overall cost and makes the system more complex to implement.

Proposed a smart security locker system that uses OTP verification for user authentication. The system provides better security than conventional lockers by sending a One-Time Password before allowing access. Although the system improves authentication [2], it does not include features such as QR code access, online payment, or cloud-based session management.

Introduced a QR code-based smart locker system that allows users to unlock lockers by scanning a QR code. This approach removes the need for physical keys and makes the locker more convenient to use. However, the proposed system mainly focuses on QR code authentication and does not provide additional security features such as OTP verification or real-time cloud monitoring.Explained how IoT technologies are transforming traditional systems into smart and connected applications. Their survey discusses the importance of communication between devices, cloud services, and internet connectivity in developing secure and efficient IoT systems[4]. This work provides a strong foundation for the design of modern smart locker systems.

Different IoT architectures and communication protocols used in smart applications[5]. They explained that lightweight communication protocols such as MQTT are well suited for IoT devices because they provide fast, reliable, and efficient communication while consuming very little network bandwidth.

Introduced the MQTT Version 3.1.1 protocol, which is widely used in IoT applications for real-time communication between devices and servers [6]. MQTT follows a publish-subscribe communication model that enables fast and reliable message exchange, making it suitable for smart locker applications.

From the above studies, it can be observed that many existing smart locker systems focus on only one or two features, such as RFID, QR code access, OTP verification, or face recognition. Very few systems combine secure authentication, cloud-based session management, online payment, and real-time IoT communication in a single platform. To overcome these limitations, the proposed Smart IoT Locker System integrates QR code access, email-based OTP verification, MQTT communication, MongoDB Atlas for cloud storage, and Razorpay for online payment. This combination provides a secure, reliable, and user-friendly solution for smart locker management.

III. PROBLEM STATEMENT

Locker systems are commonly used in colleges, shopping malls, railway stations, offices, and other public places to store personal belongings safely. Most traditional locker systems use physical keys or require manual management, which can create several problems. Keys can be lost or duplicated, lockers may be accessed by unauthorized users, and maintaining locker records manually becomes difficult, especially when a large number of lockers are in use. These issues reduce security and make locker management less efficient.

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Many smart locker systems have been developed to improve security by using technologies such as RFID, QR codes, or OTP verification. However, most of these systems focus on only one or two features and do not provide a complete solution. Features such as cloud-based session management, real-time communication between the server and locker, online payment, and remote monitoring are often missing. As a result, users and administrators still face difficulties in managing lockers efficiently.

To overcome these challenges, this paper proposes a Smart IoT Locker with QR Code Access. The system combines QR code authentication, email-based OTP verification, MQTT communication, cloud-based session management using MongoDB Atlas, and online payment through Razorpay. By integrating these technologies into a single platform, the proposed system provides a secure, contactless, and easy-to-use locker management solution suitable for colleges, offices, shopping malls, and other public environments.

IV. PROPOSED SYSTEM

Locker systems are commonly used in colleges, shopping malls, railway stations, offices, and other public places to store personal belongings safely. Most traditional locker systems use physical keys or require manual management, which can create several problems. Keys can be lost or duplicated, lockers may be accessed by unauthorized users, and maintaining locker records manually becomes difficult, especially when a large number of lockers are in use. These issues reduce security and make locker management less efficient.

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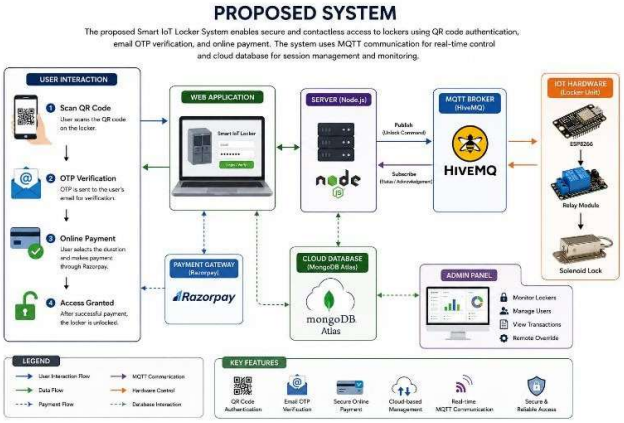

Fig. 1. Proposed System

V. METHODOLOGY

The Smart IoT Locker System is designed to provide a secure and automated way of managing lockers. The system combines a web application, cloud database, online payment gateway, MQTT communication, and IoT hardware to

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ensure a smooth user experience. The complete working process is divided into several stages, starting from QR code scanning and ending with automatic locker locking after the session is completed.

1) QR Code Scanning

Every locker is assigned a unique QR code that serves as its digital identity. The QR code is placed on the locker so that users can easily access it using the camera on their mobile phone. When the QR code is scanned, it automatically opens the web application in the browser. This eliminates the need to download a separate mobile application or manually search for the locker.

The QR code also helps the system identify which locker the user wants to access. By using QR code technology, the booking process becomes faster, contactless, and more convenient for users.

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3) Locker Booking and Payment

Once the user is verified, the application displays the available booking options. The user selects the amount of time for which the locker is required, such as one hour or several hours. Based on the selected duration, the system calculates the total amount that needs to be paid.

The payment is completed using the Razorpay payment gateway, which provides a secure and reliable online payment process. After the payment is successful, the server verifies the transaction and creates a new locker session. All important information, including user details, payment status, locker number, and booking duration, is securely stored in MongoDB Atlas.

4) MQTT Communication

After the booking process is completed, the server sends an unlock request to the locker hardware using the MQTT protocol. The unlock message is first published to the HiveMQ MQTT broker. The ESP8266 microcontroller is continuously connected to the broker and subscribes to the required MQTT topic.

Whenever a new message is published on that topic, the ESP8266 receives it immediately. MQTT is used because it is lightweight, fast, and suitable for IoT devices that require real-time communication with minimal network usage. This ensures quick communication between the web application and the locker hardware

5) Locker Unlocking Mechanism

When the ESP8266 receives the unlock command, it activates the relay module connected to the solenoid lock. The relay works as an electronic switch that controls the power supplied to the lock.

Once the relay is activated, the solenoid lock unlocks, allowing the user to open the locker and store their belongings. The unlocking process takes only a few seconds and does not require any physical key. This improves both convenience and security.

6) MSession Monitoring

As soon as the locker is unlocked, the storage session begins automatically. A countdown timer starts based on the duration selected by the user during booking. The remaining time is displayed on the web application so that the user can monitor how much time is left.

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At the same time, the server continuously updates the session information in MongoDB Atlas. This allows both the user and the administrator to view the current locker status, session duration, and booking details in real time.

7) Locker Retrieval and Automatic Locking

When the user returns to collect their belongings, the locker can be accessed according to the retrieval process provided by the system. After the user removes their belongings or when the selected storage time expires, the server publishes a lock command through the MQTT broker.

The ESP8266 receives this command and switches the relay module to lock the solenoid lock again. The locker status is updated in the database, and the locker becomes available for the next user. This automatic locking mechanism ensures that the locker remains secure even if the user forgets to lock it manually.

8) Administrator Module

The proposed system also includes an administrator dashboard for monitoring and managing the locker system. Through this dashboard, the administrator can view locker availability, monitor active user sessions, verify payment records, and check locker status in real time.

The administrator also has permission to manually lock or unlock lockers whenever required, making it easier to handle emergencies or maintenance activities. This centralized management system improves the overall efficiency and reliability of the locker system.

VI. SYSTEM ARCHITECTURE

The overall architecture of the system consists of four major modules: the user interface module, server module, communication module, and hardware control module.

The user interface is developed using Next.js, React, and Tailwind CSS, allowing users to interact with the locker system through QR scanning, OTP verification, locker booking, payment processing, and session monitoring.

The server module manages authentication, payment verification, session creation, and database operations using MongoDB Atlas. Email-based OTP verification is performed through secure server-side communication. The communication module uses MQTT protocol through the HiveMQ broker for real-time message exchange between the web application and locker hardware

The software flow of the Smart IoT Locker System begins when the user scans the locker QR code and opens the web application. The user enters an email address and completes OTP verification for secure authentication. After successful verification, the user selects the required storage duration and completes payment through Razorpay. The server verifies the payment and creates a session in MongoDB Atlas. An unlock command is then published through the HiveMQ MQTT broker. Finally, the Espressif Systems ESP8266 receives the command and unlocks the locker using the relay module and solenoid lock.

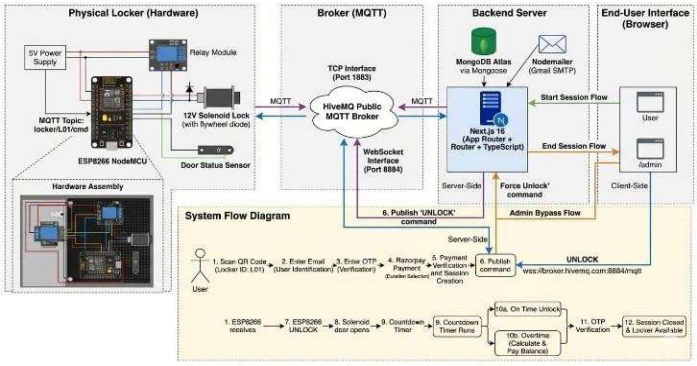

Fig. 2. System Architecture Working Flow of the System

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The working of the Smart IoT Locker System begins when the user scans the locker QR code attached to the physical locker :

QR Code Scanning:

The user scans the QR code attached to the locker, which directly opens the web application.

User Authentication: The user enters an email address and receives an OTP for identity verification.The system verifies the entered OTP and grants secure locker access.

Item Placement:

The locker unlocks automatically, allowing the user to place belongings inside safely.

Locker Locking:

After item placement, the locker closes and gets locked using the solenoid lock mechanism.

Duration Monitoring:

The system starts monitoring the locker session and selected storage duration.

Payment During Retrieval:

When the user wants to retrieve items, payment for the used duration is completed through Razorpay.

Locker Unlocking :

The Espressif Systems ESP8266 receives the unlock command through HiveMQ MQTT communication and opens the locker.

The system continuously monitors locker status, OTP authentication, and MQTT communication to ensure secure and accurate operation throughout the process. Error handling mechanisms are included to manage failed OTP verification, payment failures, and communication interruptions. The control logic ensures proper coordination between the web application, server, and Espressif Systems ESP8266 locker hardware. Communication between modules is optimized to provide fast response and minimal delay, improving the overall reliability and efficiency of the smart locker system. After completion, the locker session is closed and the system prepares for the next user operation cycle.

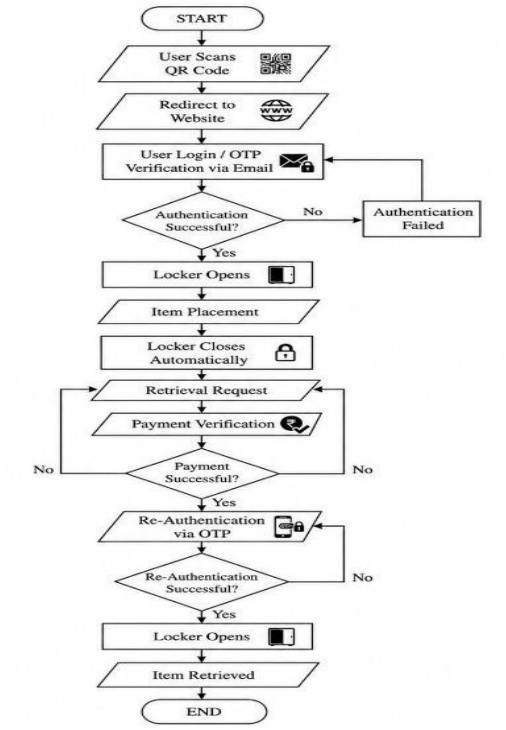

Fig. 3. Flowchart

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VII. HARDWARE SPECIFICATION

- Built-in Wi-Fi support
- Low power consumption
- Real-time MQTT communication
- Multiple GPIO pins for interfacing

Fig. 4. Esp8266 Microcontroller

B. Solenoid Lock

The solenoid lock is used to securely lock and unlock the locker door during storage and retrieval operation

Key Features:

- Fast locking mechanism
- High security operation
- Electromagnetic locking system
- Suitable for automated lockers

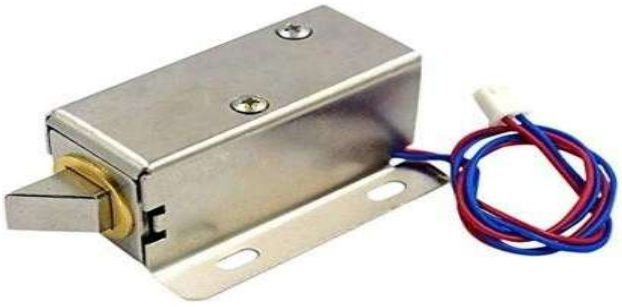

Fig. 5. Solenoid Lock

C. Relay Module

The relay module acts as an interface between the ESP8266 and the solenoid lock by controlling high-voltage switching operations.

Key Features:

- Supports high current switching
- Electrically isolated control
- Fast switching response
- Reliable operation

A. ESP82 Microcontroller and Wi-Fi Communication

The Espressif Systems ESP8266 acts as the main controller of the Smart IoT Locker System. It manages MQTT communication, authentication responses, and locker control operations.

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D. Power Supply

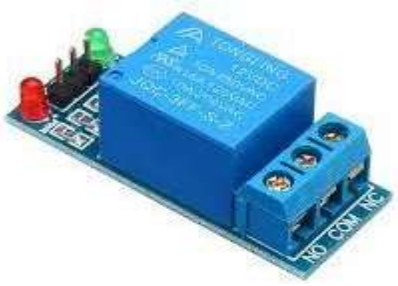

Fig. 6. Relay

Key Features:

The power supply provides a stable DC voltage to all electronic components in the smart locker system, ensuring reliable and continuous operation.

Key Features:

- Provides stable 3.3V and/or 5V DC output
- Protects against voltage fluctuations
- Ensures continuous power to the ESP8266 and peripherals
- Compact and energy-efficient design

Fig. 7. Power Supply

VIII. RESULTS AND DISCUSSION

The proposed Smart IoT Locker System was successfully designed and implemented using Espressif Systems ESP8266, MQTT communication, QR-based authentication, OTP verification, and online payment integration. The system was tested under real-time conditions to evaluate locker operation, communication reliability, authentication accuracy, and overall system performanceQR-based authentication mechanism to perform secure and contactless delivery operations.

1. QR Code Access and Authentication

The QR code scanning mechanism successfully redirected users to the web application interface. OTP verification through email authentication provided secure user validation before locker access. The authentication process reduced unauthorized access and improved overall system security.

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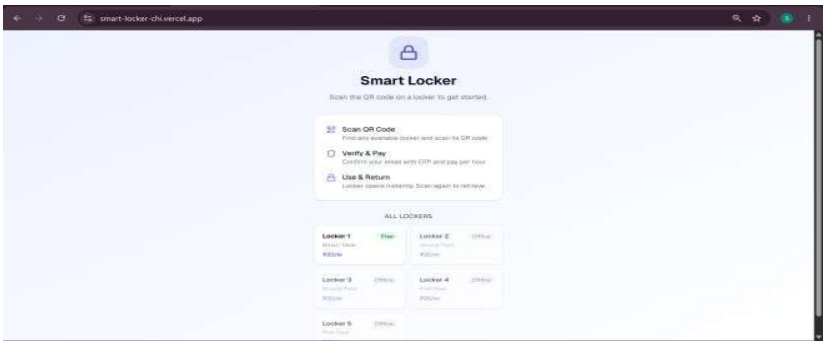


Fig 8: Login Page

2. Locker Locking and Unlocking Mechanism

The relay module and solenoid lock operated successfully with commands received from the ESP8266. The locker unlocked temporarily for item placement and retrieval operations. MQTT-based communication enabled reliable and low-latency command transmission between the server and locker hardware.

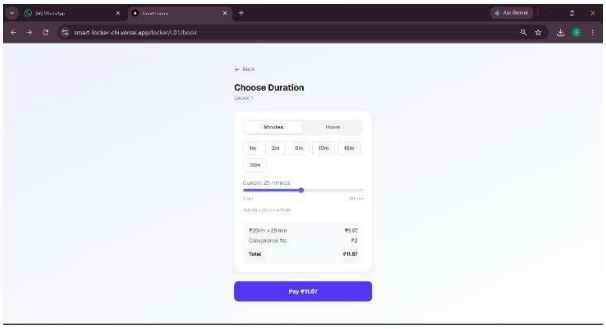
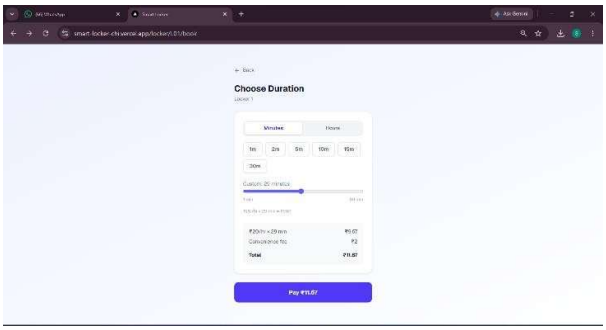


Fig 9:. Locker Availability

3. Real-Time Monitoring

The MQTT communication system using HiveMQ provided efficient real-time communication between the web application and hardware module. The system showed fast response during locking and unlocking operations with minimal communication delay



. Fig. 9. Time Allocation

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4. Payment and Session Management

The system successfully integrated Razorpay for duration-based payment processing. After successful payment verification, locker session details were stored securely in MongoDB Atlas. The session monitoring mechanism accurately tracked storage duration and updated locker status in real time.

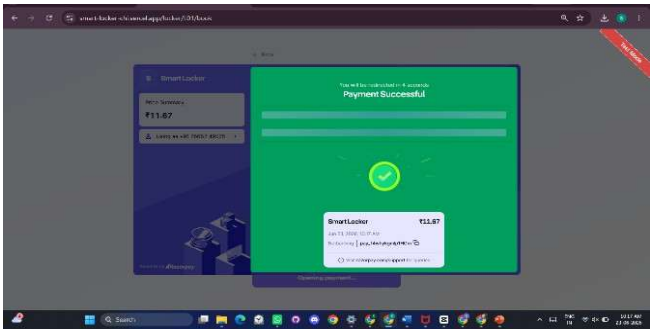

Fig 10: Payment Page

5. Security and Reliability

OTP reverification during item retrieval enhanced locker security and prevented unauthorized access. Error handling mechanisms successfully managed failed OTP verification, communication interruptions, and payment failures. Experimental testing demonstrated stable system performance and reliable operation under continuous usage conditions.

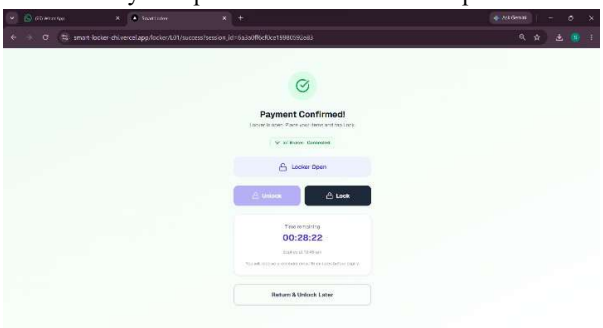

Fig 11: Final Page

6. Overall System Performance

The developed system provides a cost-effective, secure, and scalable smart locker solution for public and commercial applications. The integration of IoT communication, cloud database management, and automated locker control demonstrates the practical implementation of embedded and web technologies in real-world smart storage syste

Fig. 13. Locker Placement Mechanism

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VI. CONCLUSION

The proposed Smart IoT Locker System was successfully designed and implemented using Espressif Systems ESP8266, MQTT communication, OTP authentication, QR code access, and cloud database integration. The system provides a secure, reliable, and cost-effective solution for smart storage applications. The integration of HiveMQ MQTT communication and MongoDB Atlas enables real-time monitoring, fast response, and efficient session management. The use of OTP verification and duration-based payment through Razorpay improves security and user convenience during locker operations.

The developed system demonstrates the practical implementation of IoT, embedded systems, and web technologies in real-world smart locker applications. Experimental results confirmed stable communication, secure authentication, and reliable locker control with minimal delay. applications, multiple locker support, biometric authentication, and AI-based monitoring features for advanced smart storage management

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and debugging phases of the Smart IoT Locker System. The authors would also like to thank all tho

Special thanks go to the peer students who gave us their valuable ideas in terms of technical discussion sessions, testing,se who tested our proposed system and offered us their valuable feedback for improving the performance and functionality of the project.

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