Universiti Teknologi MARA
Cawangan Melaka

# PCMJ

## Progress in Computing and Mathematics Journal

## volume 1

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College of Computing, Informatics, and Mathematics
Universiti Teknologi MARA Cawangan Melaka, Kampus Jasin
77300, Merlimau, Melaka Bandaraya Bersejarah

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# EDITORS



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# PREFACE

Welcome to the inaugural volume of the **Progress in Computing and Mathematics Journal (PCMJ)**, a publication proudly presented by the College of Computing, Informatics, and Mathematics at UiTM Cawangan Melaka.

This journal represents a significant step in our commitment to fostering a vibrant research culture, initially providing a crucial platform for our undergraduate students to showcase their intellectual curiosity, dedication to scholarly pursuit, and potential to contribute to the broader academic discourse in the fields of computing and mathematics. However, we envision PCMJ evolving into a beacon for researchers both nationally and internationally. We aspire to cultivate a space where groundbreaking research and innovative ideas converge, fostering collaboration and intellectual exchange among established scholars and emerging talents alike.

The manuscripts featured in this first volume, predominantly authored by our undergraduate students, are a testament to the hard work and dedication of these budding researchers, as well as the guidance and support provided by their faculty mentors. They cover a diverse range of topics, reflecting the breadth and depth of research interests within our college, and set the stage for the high-quality scholarship we aim to attract in future volumes.

As editors, we are honored to have played a role in bringing this journal to fruition. We extend our sincere gratitude to all the authors, reviewers, and members of the editorial board for their invaluable contributions. We also acknowledge the unwavering support of the college administration in making this initiative possible.

We hope that PCMJ will inspire future generations of students and researchers to embrace research and innovation, to push the boundaries of knowledge, and to make their mark on the world of computing and mathematics.

**Editors**
**Progress in Computing and Mathematics Journal (PCMJ)**
**College of Computing, Informatics, and Mathematics**
**UiTM Cawangan Melaka**

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# DEVELOPMENT OF STORAGE BOX WITH AUTOMATED AND REMOTE LOCK CONTROL SYSTEM IN WLAN ENVIRONMENT

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**Abstract**

Traditional locks face challenges in security and efficiency, driving the demand for modern solutions like smart locks. This project addresses this need by developing a Storage Box with an Automated and Remote Lock Control System in a wireless local area network (WLAN) environment. To bolster security, the system implements MAC address filtering, restricting access to authorized devices. Users can securely control the ESP32 microcontroller and servo motors through a website, enabling remote lock/unlock functionality. Functionality, security, and performance testing were conducted, confirming the system's effectiveness in WLAN connectivity, website interactions, and microcontroller functionality. In performance testing, an unexpected result was observed, with the response time at 15 meters being less than that at 7 meters, possibly due to environmental and hardware-related factors. Latency variations were noted in different rooms within a home setting, influenced by obstacles such as walls and furniture. Future improvements could include exploring advanced encryption protocols or alternative authentication methods to enhance security against evolving threats like MAC address spoofing.

**Keywords**: Enter; Keywords; Storage Box, Lock Storage System, MAC Address Filtering, Smart Lock

## INTRODUCTION

The demand for secure and user-friendly storage solutions has grown significantly in recent years, driven by the need to protect valuable assets while ensuring convenient access. Traditional lock systems, while widely used, often present challenges in terms of security vulnerabilities and operational limitations. In response to these shortcomings, this project aims to develop a Storage Box with an Automated and Remote Lock Control System in a wireless local area network (WLAN) environment. By leveraging modern technologies such as microcontroller ESP32 and servo motors, the system offers advanced features including remote lock/unlock functionality and website-based control. This innovative solution addresses the shortcomings of traditional lock storage systems by enhancing security through measures such as MAC address filtering while providing users with convenient and secure access to their valuable items. Through this project, we aim to contribute to the advancement of secure storage practices, catering to the evolving needs of homes and small-scale environments.

## LITERATURE REVIEW

The landscape of property protection has evolved significantly over the years, with traditional lock systems facing increasing scrutiny due to their inherent limitations in terms of security and convenience. Research in this area has highlighted the vulnerabilities of conventional lock mechanisms, such as pin tumbler locks and sliding bolt locks, which are susceptible to techniques like lock picking (Krishna et al., 2023). Additionally, human error, such as forgetting to lock storage units, has been identified as a common risk factor contributing to unauthorized access and potential theft (Chakkaravarthy Sethuraman et al., 2022).

In response to these challenges, there has been a growing interest in the development of modern lock systems that leverage electromechanical devices and wireless technologies to enhance security and convenience. Smart locks, in particular, have gained traction for their ability to offer remote access control and advanced authentication methods (James, 2022). These systems typically utilize wireless communication protocols like Bluetooth or Wi-Fi to enable users to remotely lock, unlock, and monitor access to their storage units.

However, while smart locks represent a significant advancement in the field of property protection, there remains a need for tailored solutions that cater to specific use cases, such as

storage boxes for homes or small-scale environments. This gap in the literature underscores the importance of projects like ours, which aim to develop innovative storage solutions that combine the security of modern lock systems with the convenience of remote access control.

By integrating technologies such as microcontroller ESP32 and MAC address filtering, our project seeks to address the limitations of traditional lock storage systems while providing users with a secure and user-friendly storage solution. This approach aligns with the broader trend towards smart living, where technology plays a central role in enhancing the security and convenience of everyday tasks.

## METHODOLOGY

Project methodology is structured around the Waterfall Model, a sequential software development process with distinct phases. The methodology outlines a structured approach for system development, defining specific steps in creating a system. It provides a framework for organizing work activities during each development phase. This chapter describes the phases and workflows based on the chosen methodology, listing the activities to facilitate the development process.

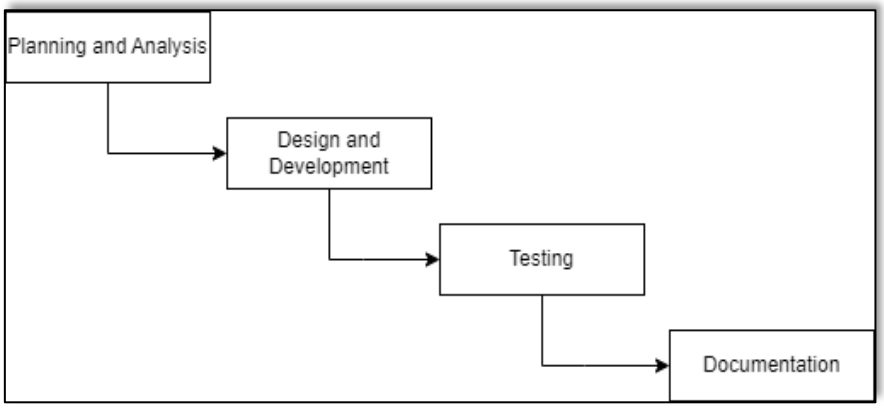


**Figure 1** Methodology Framework

The phases and activities undertaken are Planning and Analysis, this initial phase involves identifying available resources, estimating time periods, defining project goals and scope, and identifying project components. Activities include analyzing and collecting information from various sources such as journals, the internet, and surveys on shops and

online resources. The outcomes of this phase include the project proposal and identification of software and hardware requirements.

For the Design and Development phase, the system architecture is designed, and the web-application and connectivity between the microcontroller ESP32 and the web-application are developed. Techniques such as flow charts, use cases, ER diagrams, and system architecture diagrams are used. The outcomes include project architecture and flow chart system, and the system source code. Testing phase involves conducting functionality testing, security testing, and network performance testing. Functionality testing ensures that each functionality of the web-application works with the microcontroller ESP32. Security testing involves testing authorized and unauthorized devices' access to the network, while network performance testing measures the system's latency at various distances and locations.

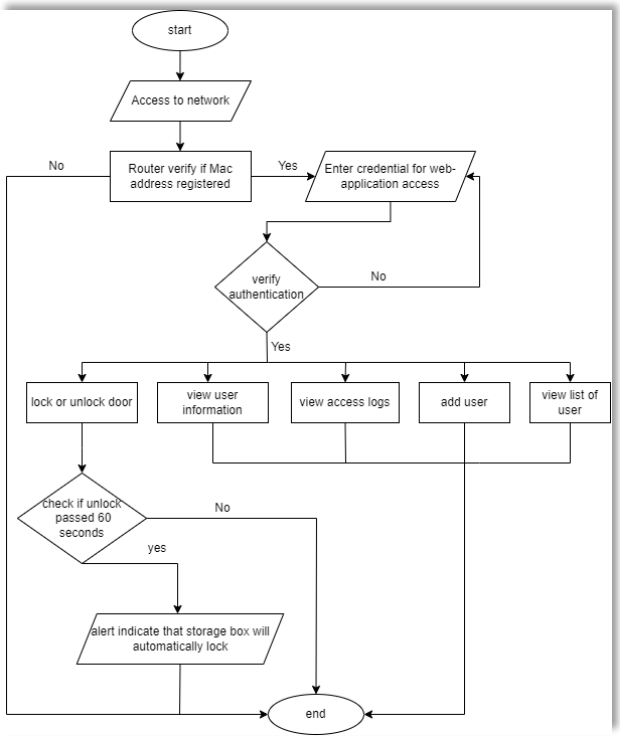


**Figure 2** Flowchart of Storage Box with Automated and Remote Lock Control System in WLAN Environment

The operation of the smart key storage box begins with the user's device attempting to connect to the WLAN network. The router then verifies the device's MAC address against the registered devices. Once successfully authorized to join the network, the user proceeds to access the web-

based application. Here, the user inputs credentials to interact with the system, such as enabling remote control functionalities for the storage box, view personal information, view access logs, add new user. The system also will be triggered automatically in certain time if user forgot to lock the storage box.

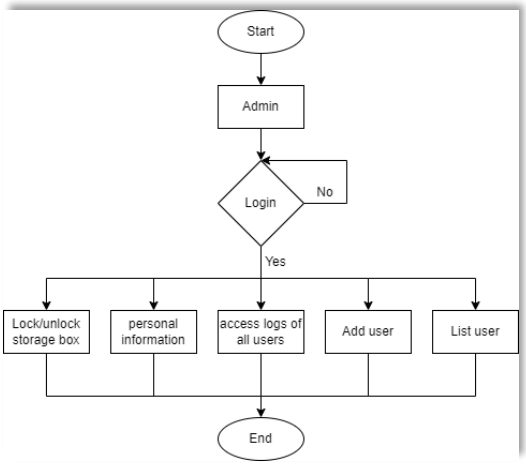


**Figure 3** Flowchart of storage box with automated and remote lock control system in WLAN environment for admin

The figure above shows flowchart for admin begins by connecting to the system through the web-based application, once inside, the admin can lock or unlock the storage box in real-time and view user details and access logs. If the admin forgets to lock the box, an automatic lock activates after a set time. Additionally, the admin can add new users to the system, expanding access to the smart key storage box, also admin be able to view list of users in the system.

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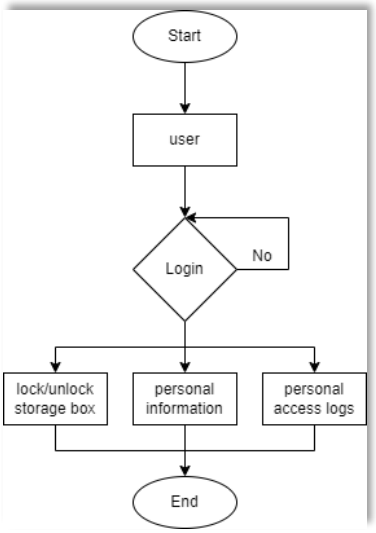


**Figure 4** Flowchart of Storage box with automated and remote lock control system in WLAN environment for user

Based on figure above, users can control the storage box, locking or unlocking it as needed. Users have the capability to view personal information and access logs for their accounts. Similar to the admin, an automatic lock feature activates if users forget to manually secure the storage box after a designated time, enhancing overall security and users do not have the ability to add new users to the system.

**Features Implemented for The Storage Box with Automated and Remote Lock Control System in WLAN Environment**

Several key components have been implemented to ensure the successful development of the Storage Box with Automated and Remote Lock Control System. One such component is MAC address filtering, which enhances security by restricting network access to authorized devices. By implementing MAC address filtering, only devices with recognized MAC addresses are allowed to connect to the network, preventing unauthorized access attempts. This security measure adds an extra layer of protection to the system, safeguarding valuable items stored within the storage box.

In addition to MAC address filtering, our project methodology incorporates the development of a web-based application to control the Storage Box with Automated and Remote Lock Control System. This website serves as the interface through which users can securely interact with the system, enabling functions such as locking and unlocking the storage

box remotely. The website facilitates seamless communication between users and the system, providing a user-friendly platform for managing valuable items.

Furthermore, the methodology involves integrating the ESP32 microcontroller with the web-based application and database. Through this integration, the ESP32 microcontroller can read status updates from the database. For example, when a user initiates a command on the website to lock or unlock the storage box, the corresponding status update is sent to the database. The ESP32 microcontroller then retrieves this status information from the database, allowing it to synchronize its actions with the user's commands in real-time. This bidirectional communication between the website, database, and ESP32 microcontroller ensures accurate and timely control of the storage box, enhancing overall system functionality and user experience.

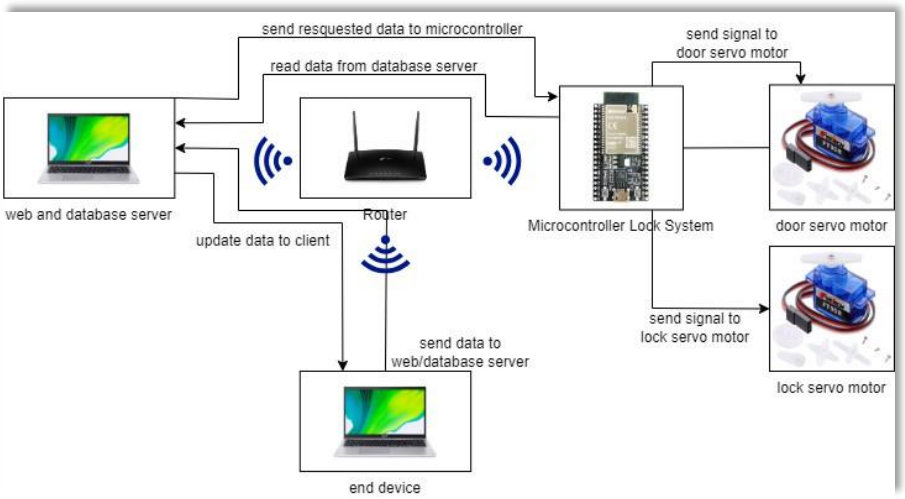


**Figure 5** Overview of System Architecture Diagram

The system architecture diagram, as detailed in section 3.4.4, offers an extensive insight into the structure and organization of the wireless web-app-controlled storage system. The illustration delineates key components of the system, encompassing the ESP32 microcontroller (control unit), router, servo motor, end device and lastly web and database server, which collaboratively facilitate secure wireless control and management of the storage unit.

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## RESULT AND DISCUSSION

### Functionality Testing Result

Testing functionality is a necessary process to ensure that each device in the system operates according to the specified requirements. It aims to identify and address any errors present. The table below displays the tested results.

**Table 1** Wireless Local Area Network Connectivity Result

| Name (IP address) | Description | Result |
|---|---|---|
| Database (192.168.1.100) | Be able to communicate with end host (192.168.1.100/102) | Pass |
| Web-server (192.168.1.100) | Be able to communicate with end host (192.168.1.100/102) | Pass |
| Microcontroller ESP32 (192.168.1.101) | Be able to communicate with end host (192.168.1.100/102) | Pass |

**Table 2** User System Response Result

| System Response | Description | Expected Result | Result |
|---|---|---|---|
| User login | Insert credentials | User can login. | Pass |
| Toggle to lock | User switches the toggle to indicate locking. | secure locking of the storage unit. | Pass |
| Toggle to unlock | User switches the toggle to indicate unlocking. | Secure unlocking of the storage unit. | Pass |
| Alert for automatic lock | System will display alert box after unlock action | System's respond by automatically lock storage in 60 seconds. | Pass |
| User personal information | User view personal information. | User be able to view personal information. | Pass |
| User access logs | User view personal access logs. | User be able to view personal access logs. | Pass |

**Table 3** Administrator System Response Result

| System Response | Description | Expected Result | Result |
|---|---|---|---|
| Admin login | Insert credentials | Admin can login. | Pass |
| Toggle to lock | User switches the toggle to indicate locking. | secure locking of the storage unit. | Pass |
| Toggle to unlock | User switches the toggle to indicate unlocking. | Secure unlocking of the storage unit. | Pass |
| Alert for automatic lock | System will display alert box after unlock action | System responds by automatically locking the storage in 60 seconds. | Pass |
| Admin personal information | Admin view personal information. | Admin is be able to view personal information. | Pass |
| Admin access logs | Admin view all users access logs. | Admin is be able to view list of user access logs. | Pass |
| Add User | Admin direct to add user page. | Admin can add a user from the admin side. | Pass |
| List Users | Admin view list of users. | Admin can view list of users in the system | Pass |

In the testing results for the system's response to user input in table 2 and table 3, all actions aligned with the expected outcomes, ensuring website functionality to user access and user input by secure locking and unlocking of the storage unit.

**Security Testing Result**

**Table 4** MAC Address Authentication Result

| Device | MAC Address | Description | Result |
|---|---|---|---|
| Device A | 04:e5:98:fe:2e:1c | Device with authorized MAC address | Authorized |
| Device B | 30:7f:10:80:17:25 | Device with unauthorized MAC address | Unauthorized |
| Device C | a8:4b:4d:6e:03:d3 | Device with unauthorized MAC address | Unauthorized |

The testing results indicate that devices with authorized MAC addresses (Device A) successfully passed the authentication process, validating the effectiveness of the MAC address

filtering. However, unauthorized devices (Device B and Device C) failed to pass the authentication, declare that the system's ability to distinguish and reject unauthorized connections.

**Performance Testing Result**

In the performance testing phase, the system's responsiveness and reliability were thoroughly evaluated to gauge its effectiveness in real-world scenarios. One aspect of performance testing focused on assessing the system's latency at different distances in an open space environment and at different rooms in home settings.

**Table 5** Latency at Different Distances in an Open Space

| Distance | Scenario | Expected Result | Result |
|---|---|---|---|
| 3 meters | Open space. | Response time within acceptable limits | 36 milli-seconds |
| 7 meters | Open space. | Response time within acceptable limits | 104 milli-seconds |
| 15 meters | Open space. | Response time within acceptable limits | 86 milli-seconds |

The result of testing network performance using the ping technique showed an unexpected result, where the response time at 15 meters was observed to be less than that at 7 meters. This inconsistency may be due to a combination of environmental and hardware-related factors affecting wireless signal.

**Table 6** Latency in Different Rooms

| Room | Scenario | Expected Result | Result |
|---|---|---|---|
| Room A | Different room within a home setting. | response times considering potential signal obstacles | 83 milli-seconds |
| Room B | Different room within a home setting. | response times considering potential signal obstacles | 76 milli-seconds |
| Room C | Different room within a home setting. | response times considering potential signal obstacles | 75 milli-seconds |

The result of testing latency in different rooms within a home setting exhibited variations in response times. In Room A, the observed response time was 83 milliseconds, while Room B showed a slightly lower response time of 76 milliseconds. Room C demonstrated the lowest response time at 75 milliseconds. These differences may arise due to several factors influencing wireless signal propagation in enclosed spaces.

## Conclusion

In conclusion, the Storage Box with Automated and Remote Lock Control System in a WLAN Environment stands as a significant advancement in secure storage management. The system prioritizes security, ensuring the protection of valuable items and user privacy through an effective and user-friendly authentication framework.

By implementing a system requiring unique login credentials, the Storage Box system mitigates the risk of unauthorized access and potential data breaches. This heightened security not only strengthens the overall safety of the system but also instils confidence and trust among users and administrators.

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