APPLIED INFORMATION TECHNOLOGY AND COMPUTER SCIENCE
e-ISSN: 2773-5141

AITCS

Vol. 6 No. 1 (2025) 401-414
https://publisher.uthm.edu.my/periodicals/index.php/aitcs

Bicycle Lock System Notification

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DOI: https://doi.org/10.30880/aitcs.2025.06.01.022

Article Info

Received: 20 July 2024
Accepted: 18 june 2025
Available online: 30 June 2025

Keywords

Bicycle lock, system, notification,

Abstract

Traditional bike locks are often insufficient, and students frequently lose keys or underestimate the risk of theft, leading to repeated purchases of similar locks. This project introduces an innovative Bicycle Lock System Notification, transforming conventional physical key locks into advanced, smartphone-operated locking devices integrated with secure bike parking facilities. Utilizing Arduino-based microcontrollers, language used are ReactJS and c++. The system enhances bike security, reduces costs, and organizes parking. Real-time notifications are crucial, alerting users instantly to any unauthorized access attempts, thereby providing an additional security layer. The project employs a prototyping methodology to ensure the system's functionality and performance. Our proposed solution offers a modern, cost-effective, and organized approach to bicycle security within university areas, effectively addressing current issues while enhancing overall safety and convenience for student cyclists.

1. Introduction

Having a bicycle without being properly locked is a real risk among students as it is easy to steal and sell. Moreover, many students don't even take a step to protect their bicycles thinking it was safe around university will park their bike at random places, some are near tree or in front of hostel room and not to specific place for bike to park due to less security[1]. This gives a roadblock for other students to walk through it and gives eyesore to people that saw it. This led to the invention of bicycle locks from lighter type to heavier type such as U-Lock the lighter type and chain lock the heavier type. The heavier the material to create the lock, the more secure the bicycle lock device to protect students bicycles when they are away[2]. RFID bicycle lock where to unlock the bike by simply using keychain or card to unlock the bike. However, there will be human errors when it's related to misplaces their main key to unlock the bike that sometimes result in unlocking the bike by force which breaks the lock and at the same time the cycle of buying the same bicycle lock security device will remain unchanged. Traditional security systems may not provide adequate protection against sophisticated theft techniques. Notifications help bridge this gap by offering real-time alerts and updates to students. Without notification systems, motorcycle owners face challenges in remotely monitoring their vehicles' security status[3]. Bicycle lock system notification will be an alternative solution to provide security device to lock the bicycle using a mobile app as the main key.

The use of the Bicycle Lock System Notification has potential to improve the current method of bicycle locking which requires physical key. The focus of the proposed system is to enhance the bicycle security device, from handheld security device to developing parking with locking device for bicycle. To offer more security and cost saving among students. Bicycle Lock System Notification will be using mobile keys to unlock via a smart phone. This eventually able to overcome human error that usually facing absentminded or intent to forget important things or distraction [4]. This proposed system will be built for smart phones, since each student has their own smart phone as their primary device compared to other devices. Overall, Bicycle Lock System Notification has the

potential to improve current bicycle security devices to protect student bicycles and at the same time better arrangement when it comes to finding a place to lock their bicycle.

To solve this problem mentioned above, the project proposes a system Bicycle Lock System Notification, and the main objectives of this project are as follows:

I. To design an application for bicycle lock system on android.
II. To develop lock system feature for bicycle lock system
III. To test the developed bicycle lock system on the students.

The system uses smart phone as a mobiles key to unlock the devices and will run the system in an Android smartphone, where it was more affordable. The system will include login modules, dashboard modules, navigation bar modules, profile modules and sign-out modules to make it easier for student to use the application.
While the devices hardware will be using Arduino to interact mobile apps with the lock device. The component include microcontroller, servo motor, breadboard and jumper wire.

Bicycle Lock System Notification is a system that aims to enhance bicycle security device from handheld and physical key to bike parking that implement security device lock and smart phone as mobile key. It uses mobile keys and microcontroller from arduino devices to control the lock process to secure their bike. The goal of this proposed system to make it more cost saving and more organized.

This paper will be divided into five parts. First section discusses the background of the project. The second section discusses related work. The third section outlines the methodology of the project. The fourth section is the result and discussion. The fifth section summarizes the conclusion

2. Related Work

This section will discuss the related system used currently. Each of the related works has different methods but the same goal is to develop better bike lock security for students to use its service.

2.1 Bicycle Lock

A bicycle lock is a security device lock used to deter bicycle theft by simply locking one of the wheels. It's a device in which each of the students who owns a bicycle will have it to prevent it from being stolen. It came in different sizes and material but still serves the same purpose which is to secure their bike. To properly secure the bike, always lock the frame to an immovable object such as tree, so it cannot be stolen. Next is to position the lock so that it is difficult to access and tamper with. Make sure there is no extra space inside it to prevent leverage attacks[5].

2.2 Internet of Things (IOT)

IoT allows these smart devices to communicate with one another and with other internet-connected devices. Like smartphones and gateways, this creates a vast network of interconnected devices that can exchange data and perform various tasks autonomously. Using IoT devices to automate and optimize processes may enhance efficiency and productivity for many tasks [4]. Using IOT in proposed project, helping on enhancing the security bike lock device such as from physical key to wireless key. Several IT tools will be used for the proposed system to develop the prototype for the proposed system, these tools will be used to build the prototype according to the plan and to meet the project's goal:

ESP-32 (Bluetooth + Wi-Fi):

- This microcontroller serves as the core of the system, enabling wireless communication and control of the lock.

Servo Motor SG90:

- This motor will be used to actuate the locking mechanism.

ADXL345:

- This motion sensor detects any movement or tampering with the bicycle, triggering alerts.

2.3 Comparison of The Existing System with the Proposed System

Table 1 shows the comparison of their existing systems together with the proposed system. The purpose it was chosen to make comparison to see either it can enhance the features or can be implemented with the proposed system. The comparison of the three systems including the proposed system is shown in Table 1. All the systems are all IOT- based. System 1 uses an Arduino Uno microcontroller, a U-shaped lock, and a passcode, but lacks a mobile app, notification feature, and database. System 2 uses an ATMega 328P microcontroller, an RFID card, and a portable lock, featuring a database but no app or notification. System 3 uses an Arduino microcontroller, a remote lock, and a phone-based key concept, with an Android app, notifications, and a database.

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Table 1 *Comparison System*

Function	Anti-Theft Bike Rack Research[6]	Portable RFID bicycle locks [7]	Bluetooth remote lock system for a smartphone[8]	Bicycle Lock System Notification
IOT Based	Yes	Yes	Yes	Yes
Microcontroller	Arduino Uno	ATMega 328P	Arduino	ESP32
Application	No	No	Android App	Android App
Lock Concept	U- Shaped	Portable Lock	Remote Lock	Parking Lock
Notification	No	No	Yes	Yes
Key Concept	Passcode	RFID Card	Phone	Phone
Database	No	Yes	Yes	Yes

3. Methodology/Framework

Prototyping Model is a methodology that involves creating prototypes of the proposed system. This methodology can be used to gather feedback and refine the design before the final product is developed. Next section will be a discussion about the prototype models[9].

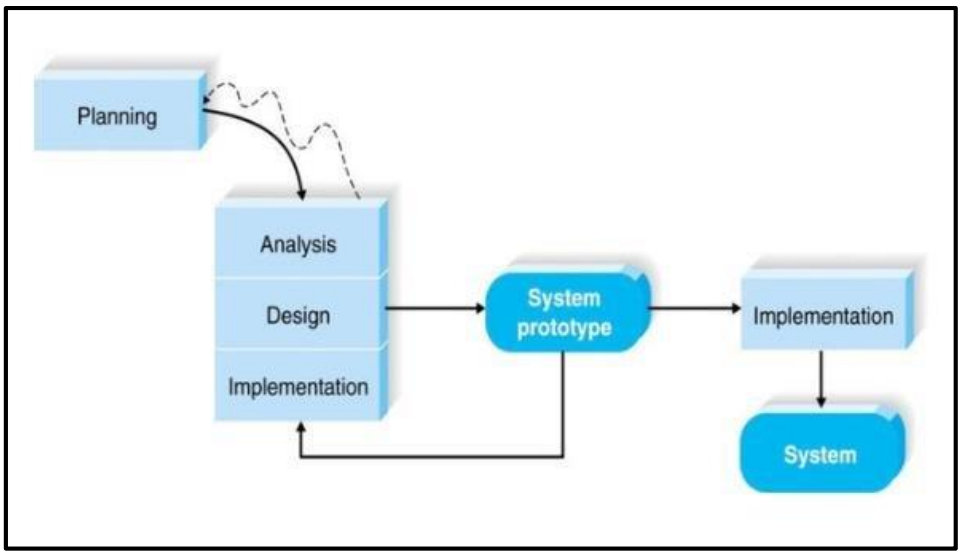

Fig. 1 *Methodology of Prototyping model*

Fig. 1 shows the methodology for the proposed project; prototyping methodology was chosen to ensure the proposed project functionality and performance. Prototyping was particularly suitable for this project given that it allows for iterative testing and refinement of the system, to make sure the final product meets user needs and works reliably in the real world.

3.1 Planning

At the beginning of Prototype model, planning phase is the basic root of bicycle lock system notification Project. This phase was to identify the project objective after identifying the problem. Next will make a preparation for the implementation of the structure to expedite the process development project timeline.

3.1.2 Analysis

The second phase is analysis. This phase will be focusing on gathering information for project development purposes and observations as an instrument for data collection. This phase will require the author to go to places where students use to park their bike in university such as library, study hall or faculty. This phase also identifies the requirements and specifications of hardware and software for project implementation purposes.

Table 2 *Hardware Requirement*

No.	Hardware Type	Description
1.	Laptop	Source to connect hardware and software
2.	ESP32	Module that enables wireless communication over the internet.
4.	ADXL3455	Type of sensors to detect movement
5.	Servo S90	Enable rotation

Table 2 shows several components in hardware requirement, a laptop serves place to coding where it connecting to An ESP32 module enables wireless internet communication, allowing for remote data exchange over Wi-Fi. The ADXL345 sensor detects movement and reports acceleration data. A Servo S90 motor also allows reliable pointed movements, which is useful for tasks that require accurate positioning control.

Table 3 *Software Requirements*

No.	Software Type	Description
1.	Arduino IDE	Tools to write, compile and upload programming language to almost all Arduino for communication.
2.	Notepad++	Source code editor that supports all languages. To check codes.
3.	Fritzing	For graphical representation of the circuit
4.	Blynk	To connect the project and the mobile phone.

Table 3 outlines the software requirements. First, the Arduino IDE is for writing, compiling, and uploading code to esp32 microcontrollers, allowing for communication servo and mobile. Notepad++ is used as code editor that supports programming languages while ensuring code accuracy and readability. Fritzing is used to create graphical representations of circuits, visualizing and designing the physical connections between components. Finally, Blynk plays an important role in connecting the project to mobile phones, allowing for remote monitoring and control via an easy-to-use interface. These software tools work together to provide the support required for efficient development, testing, and interfacing with the system's hardware components.

3.1.3 Design

Next, the design phase is to design the framework for user interface design. This phase is also determining the position for hardware module to make it functional based on decided scenario. Programming code that will be used for developing Android applications and the hardware component will be decided. As well as the configure the function to control and connect for both hardware and software to communicate will implement to make bike lock system notification working.

3.1.4 Prototype Phase

The prototype phase is where the system will be tested for the first time. It will be necessary to repeat the analysis step if there are any changes required for the improvements or errors that occurred. If there are no changes, this development process can be continued to the last step, which is the testing phase.

3.1.5 Implementation

The implementation phase, all the information gathers the inputs from the design phase. Then, programming code will be produced to run the application and ensure it is functional. Furthermore, this phase enabled the integration of Android application and microcontroller Esp32 for interaction purposes. The system will then start to develop in a small piece for programming.

3.1.6 Testing Phase

The final phase is testing. This type of testing will be done continuously to ensure the system fulfills its functionality. While the system is through testing, all systems will be observed to check for any flaws and failures. This is to ensure it operates without any problems. This phase will go through before being developed into a real system.

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3.2 System Analysis and Design

The section will go through the functional and non-functional requirements, the use of diagrams such as, flowchart including entity relationship diagram for the development of a Bike lock system notification. It will outline the actions the system must perform, and the characteristics such as security, reliability, operation and usability that the system needs to have. They will help identify potential issues and areas of improvement before implementation and allow us to gain a better understanding of the system's components and how they work together to make better decisions during the development process.

3.2.1 Use case Diagram

In a Use Case Diagram, relationships are essential for illustrating the interactions between actors and use cases. These relationships provide a comprehensive overview of the system's functionality and scenarios [10]. Fig. 2 shows the main components of the Bike Lock System The actors or users who carry out the various types of use cases are identified as admin and user.

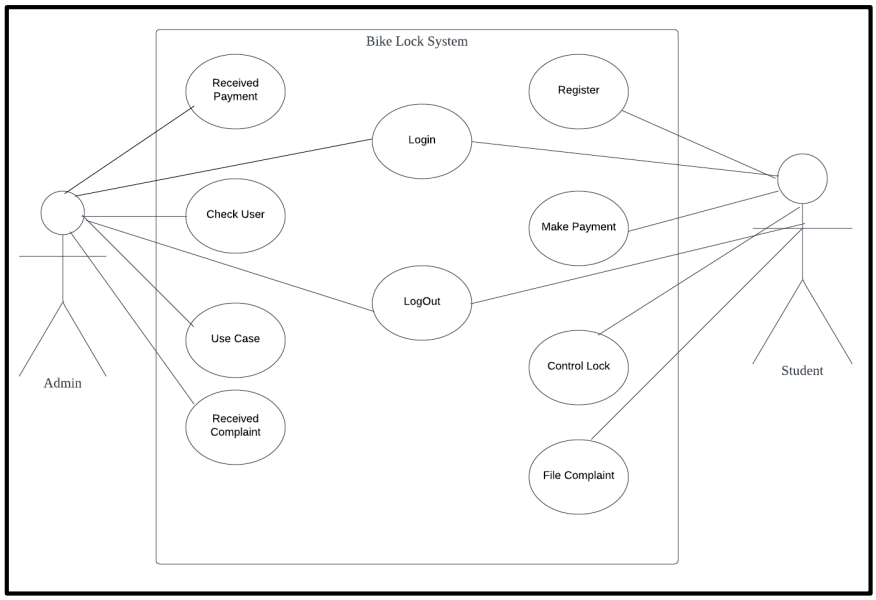

Fig. 2 *Use case of proposed project*

3.2.2 Sequence Diagram

Fig. 3 starts with a student registration in the device to use the service. The student will enter the details on the registration page. The system receives the student details and checks details if it meets requirements. This could involve validating the information or storing it in a database. If the details are valid, the system sends a message labelled display message back to the student. This message is for a confirmation message or a success notification.

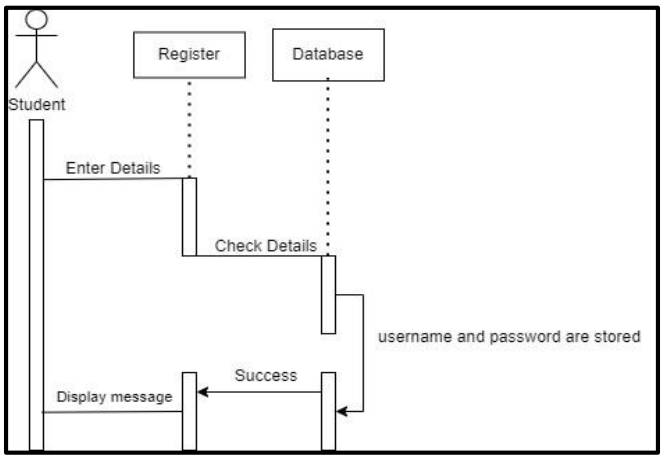

Fig. 3 *Sequence diagram for Student registration*

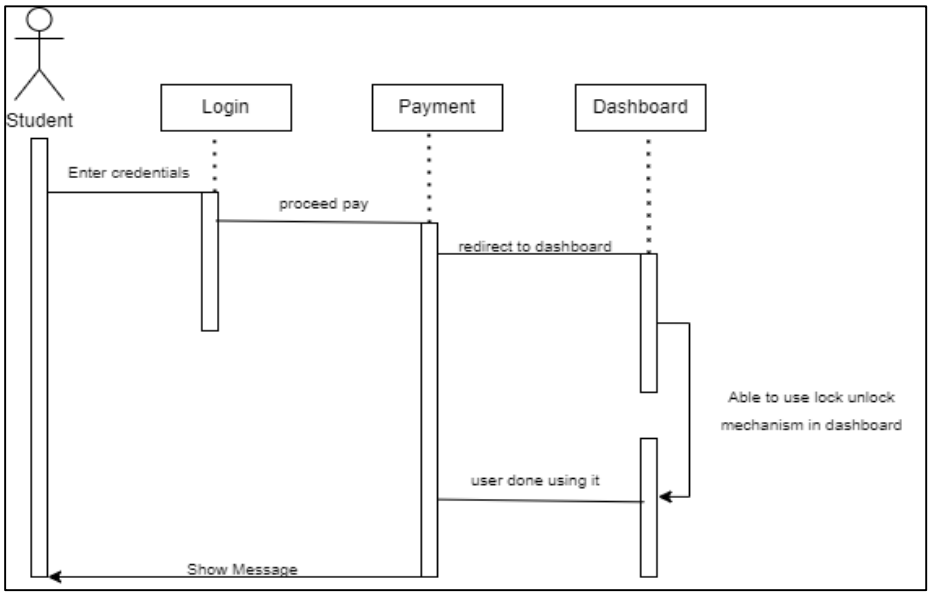

Fig. 4 *Sequence diagram Student Login*

Fig. 4 starts with a student login. The student will enter the details. Email and password in login page. The system will directly to payment page. Once payment is done will send to dashboard page where students able to use the lock mechanism to control the lock. Once students done using it, the page will redirect to payment page again since its one time use only. All success logins will be displayed back to user.

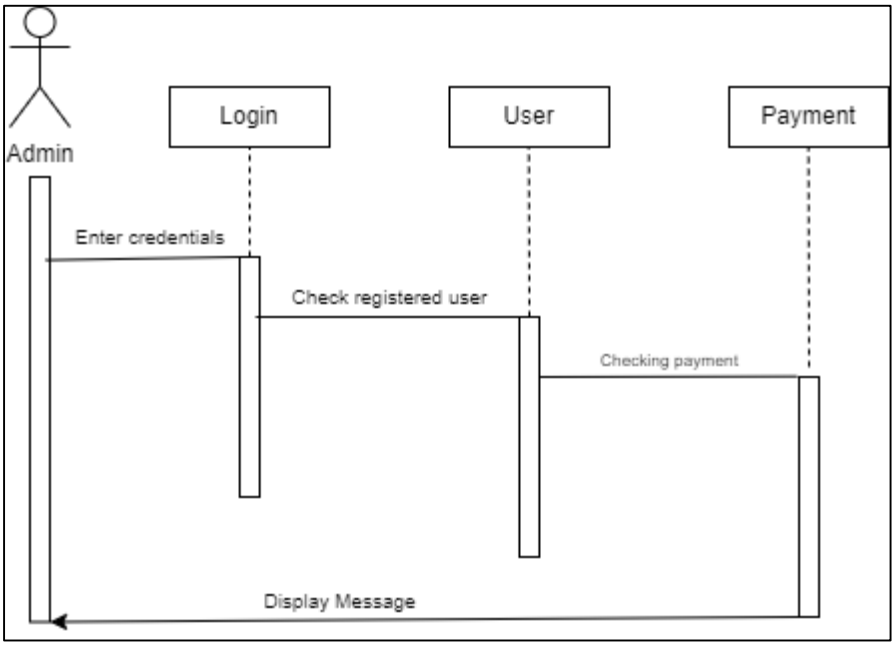

Fig. 5 *Sequence diagram for admin login*

Based on Fig. 5, the sequence diagram shows a simplified checkout process. Here's a breakdown of the interaction. The process starts with the admin entering their credentials (username and password) for login. The system receives the credentials and checks if the user is registered. Upon successful login, the system displays a message likely a success message or a transition to a different system state like a dashboard where their admin able to see total of registered user and check payment received based on service use by student.

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3.2.3 System Architecture

Fig. 6 shows system architecture for bike lock system. To use the services, students are required to register first. Once registered, students will be able to login. Before being able to use the services, students need to make payment first then they need to go to the bike car park and choose the parking numbers that are available. Once type the bike parking number, automatically students will be able to use the lock mechanism service.

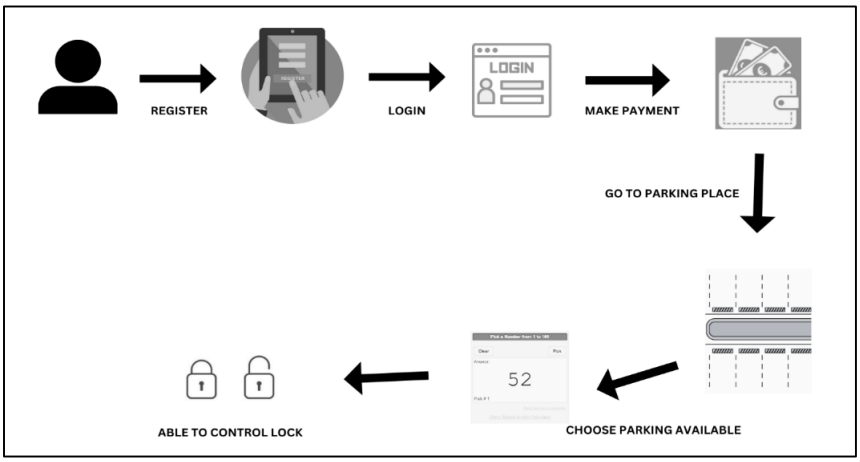

Fig. 6 *System architecture*

3.2.4 Activity Diagram

Activity Diagrams can be used to describe the flow of control within a system and are called steps as to how a use case will be executed. In an activity diagram, we can represent both sequential processing and concurrent processing of activities; that is, an activity diagram deals with the condition of flow and the order in which it is occurring.

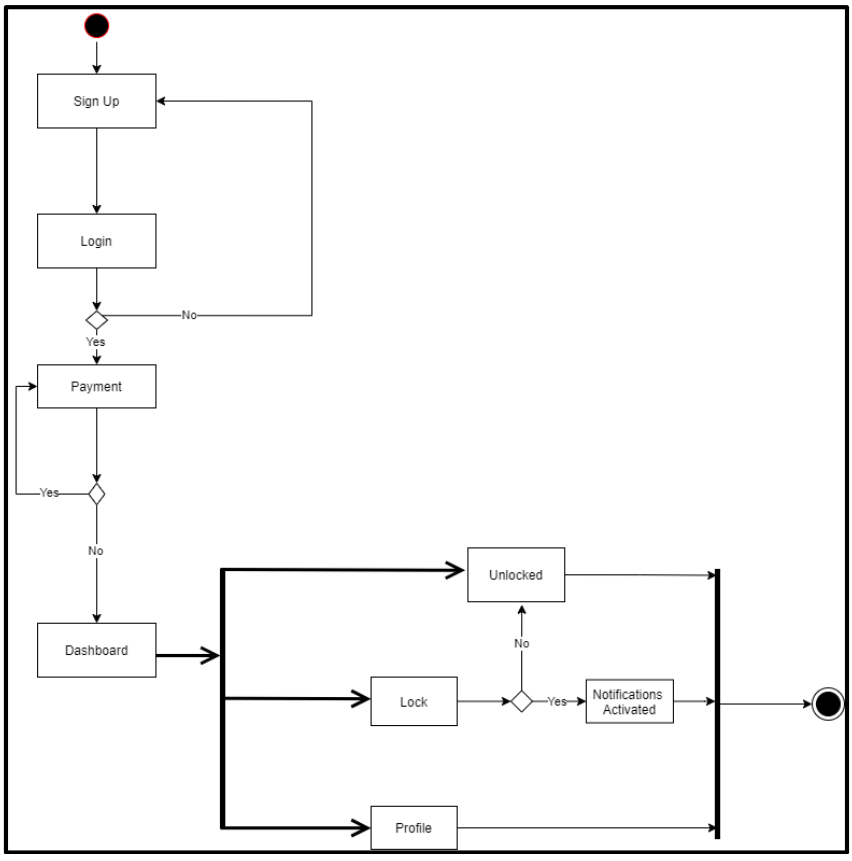

Fig. 7 *Activity diagram*

Fig. 7 shows an activity diagram for student registration or sign up and login, beginning with start node, represented by a solid circle, it initiates the process. Login action, the first step. If successful, it leads to the "Payment" action; otherwise, it loops back to the login. Payment action, two outcomes: "Yes" proceeds to the "Dashboard," while "No" loops back to login. Dashboard, an uninterrupted flow leads to the "Lock" action. Lock Action, two outgoing flows, one loops back to itself ("No"), the other leads to a decision point. Decision point, two options. "Notifications activated" (looping back) and a direct path to an end node.

3.3 Functional Requirements Analysis

The Functional requirements describe what the system should do. Table 4 summarizes the system's functional modules and key components. First, the Registration Account module allows students to securely log in and out of their accounts using their email and password credentials. Second, the Lock and Unlock Mechanism allows users to control bicycle access by locking and unlocking them as needed. The Help section provides a forum for students to report problems or request assistance with the system's functionality. Finally, the Notification feature keeps users informed by sending relevant information about services or updates.

Table 4 *Functional requirement*

No.	Modules	Description
1.	Registration Account	Student able to log in and logout of their account by email and password
2.	Lock and Unlock Mechanism	To allow users to unlock and lock bicycle
3.	Help section	To allow students make complaint when facing problem upon using the system
4.	Notification	To give user information regarding of service

3.4 Non- Functional Requirements Analysis

Non-functional requirements describe how the system should perform the functions that the system must satisfy based on the functional requirements. They elaborate on quality attributes, performance, and constraints the system should fulfill, for example, speed, security, reliability, and scalability.

Table 5 *Non- Functional Requirment*

No.	Non-Functional	Description
1.	Security	Can be only accessed with email and password
2.	Reliability	Ensuring the process of locking and unlocking system work accordingly.
3.	Operation	System can be used in Android operating system
4.	Usability	The system focusing on user friendly

Table 5 outlines the system's non-functional aspects, including key operational and user experience. To begin, the security parameter highlights the importance of access control, limiting access to users who have valid email and password credentials. Second, reliability points out the system's consistent performance in carrying out the lock and unlock processes for bicycles, ensuring dependable functionality. Third, Operation specifies connection with the Android operating system, which increases accessibility across a wide range of devices. Finally, Usability, focusing on easy access and ease of use to increase user satisfaction and adoption.

4. Results and Discussion

The React Native is used in development of the bike lock system notification system. The Java Script is used as programming language for developing android applications. While in Arduino ide using c++ language for programming language.

4.1 Module Implementation

This section discusses the connection module, login module, lock mechanism module.

4.1.1 Connection Module

The application needs a connection with the application from ESP32 to control the sg90 by lock and unlock. This module is about connection between mobile applications and the servo using esp32. The connection is by sending commands from the mobile application to Esp32 and Esp32 will send the message to servo s90 to start

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the lock process. Fig. 8 shows the connection flow between mobile applications, esp32 and servo90. Fig. 2 shows connection flows between mobile applications and hardware applications use for the project which are esp32, servo, adxl3455

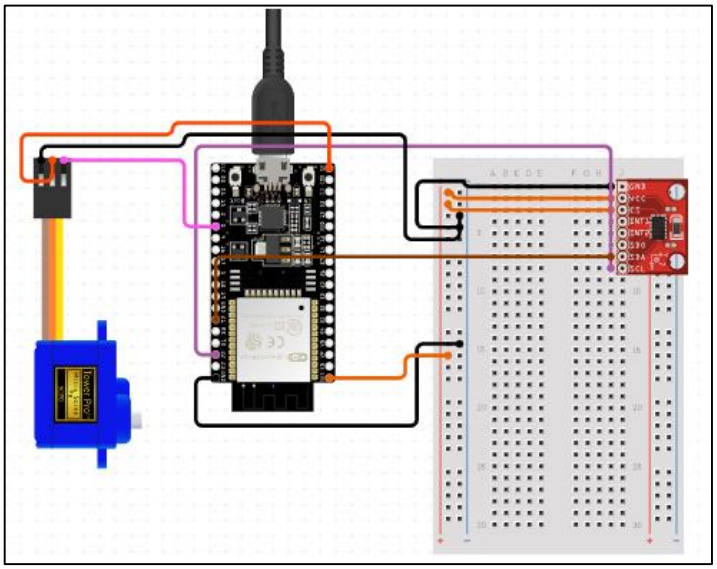

Fig. 8 *Connection module*

Based on Fig. 8, the wiring shows ESP32 microcontroller connected to a servo motor and ADXL 3455 sensor. The connections are as follows: for the ADXL BUS (if present), the CS (Chip Select) pin controls communication and is connected to a positive voltage line, the VCC pin provides power and is connected to a positive voltage line, and the GND pin connects to the common ground. For the SERVO BUS, the CS pin controls communication with the servo motor and is connected to a positive voltage line, the VCC pin provides power and is connected to a positive voltage line, and the GND pin connects to the common ground. The ESP32 BUS connections include the GND pin, which connects to the common ground, and the 3V3 pin, which provides 3.3 volts of power to the ESP32. Additionally, the SERVO ESP32 connections include the SIG pin, which carries the control signal from the ESP32 to the servo motor (connected to pin 0 of the ESP32), and the VIN pin, which provides power to the servo motor and is connected to a 5V line.

4.1.2 Login/Sign Out Module

The login method is developed based on the reacting Native Js. The method that the project uses is email and password Authentication only to access the application.

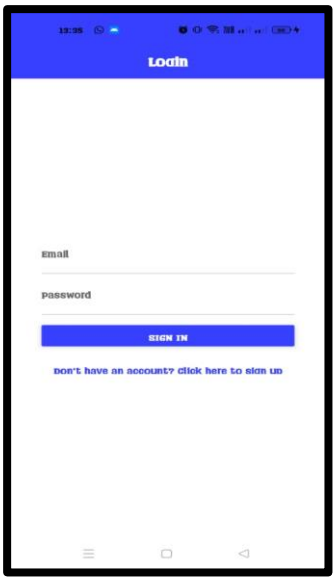

Fig. 9 *Sign In Module*

Fig. 9 shows the login screen features a blue background with a white login title. It prompts users to enter their email address and password in separate fields, followed by a "SIGN IN" button to initiate login. For new users, there's an option to "sign up" at the bottom, making it a standard way for users to identify themselves and gain access to the mobile application.

The sign-up method is also developed based on reacting to Native Js programming language. The sign-up is almost identical compared to the login for the users of the bike lock system notification. Fig. 4 shows the sign-up process. It involves the user entering their full name, email address, and creating a password (hidden for security) in designated fields. Once complete, a "Sign Up" button allows them to submit the registration form. Additionally, an option to log in to an existing account might be available for users who already have one.

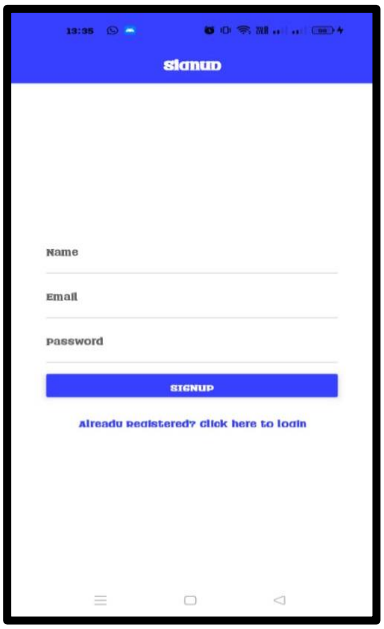

Fig. 10 *Sign Up Module*

4.1.3 Lock Mechanism Module

The lock mechanism will show the unlock lock position where it represents a picture in specific style as button. The design was put in dashboard after users are authorized to enter the application. Fig. 11, This interface is designed for intuitive use, focusing on clarity with straightforward icons and minimal textual information, ensuring users can easily monitor and control their lock remotely.

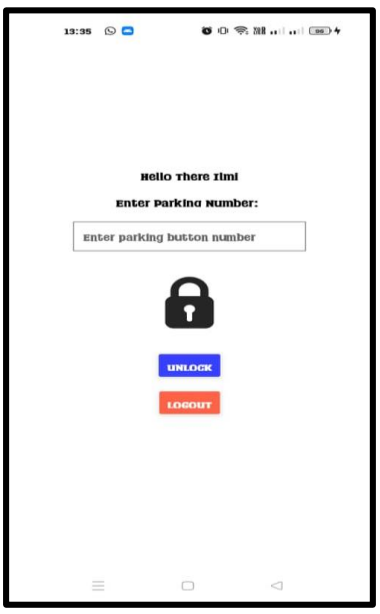

Fig. 11 *Lock Mechanism in Module*

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4.2 Testing Result from Test Plan

The testing was carried out once the project development was completed, following the previously developed test plan. The test was performed on a physical module depending on the category, and the result is shown after the module was tested.

Table 6 *Test plan result*

Category	Description	Expected Results
Application	Login	Able to verify user and enter the application
Application	Register user	Able to enter details
Application	Notification	Able to give notifications to users.
Sensor	Connection	Able to connect between sensors and application
Microcontroller	Connection	Able to connect between microcontroller and application
Motor	Connection	Able to connect between microcontroller and application

Table 6 is a series of tests conducted on various components of a mobile application, detailing each test category along with their descriptions, expected results, and actual outcomes. For the Login test, the application verified user credentials, allowing access to the application. In the Register User test, users were able to enter their details during the registration process without issues. The Notification test showed that the application should deliver notifications to users effectively. The Sensor Connection test confirmed that sensors could connect and communicate with the application. In the Microcontroller Connection test, the microcontroller established the expected connection with the application. Lastly, the Motor Connection, connect and control the motor via the microcontroller.

4.3 User Acceptance Test

Volunteers were accepted to be testers for this project's user testing. The tester was given an Android Package (APK) file to download onto his or her mobile phone. The functioning of the sensors and the design of the mobile application are being tested. The findings will be based on the tester's rating of 1 (poor) to 5 (outstanding). The results of this project's user acceptability testing are shown in Table 7.

Table 7 *User acceptance Test*

No	Aspect Tested	Scales				
		1	2	3	4	5
1	Login Functionality				/	
2	Registration functionality				/	
3	User activation functionality			/		
4	Operation functionality			/		
5	Prototype functionality				/	

The evaluation of the system's key functionalities reveals a generally positive user experience with some areas for improvement. Login and Registration scored a 4, indicating that these processes are relatively easy and successful for users, which is essential for a seamless user experience. User Activation, scoring a 3, suggests that while functional, there may be occasional complexities or issues that need addressing to streamline the process further. The Operation Functionality also scored a 3, showing that the core operations of the bike lock system are usable but have minor shortcomings that could benefit from additional testing or user feedback. Lastly, the Prototype Functionality scored a 4, indicating that the prototype meets user expectations in terms of features and usability, suggesting that the system is on the right track in its development.

Table 8 *Security Test Plan*

No.	Checklist	Actual Result
1	Ensure the error message does not inform which part of the validation is incorrect.	Pass
2	Password are covered	Pass
3	Ensure Password strength	Pass
4	Only authorized user can control lock mechanism	Pass
5	Ensure password strength	Pass

Table 8 summarizes successful test results for a system's security features. It verifies that error messages are vague to protect user information, passwords are hidden while typing, password strength is enforced, and only authorized users can control the lock mechanism. Overall, these tests confirm the system prioritizes security and protects user credentials.

5. Conclusion

Bike lock System notification comes with an improvement in terms of notifying compared to an existing product in the market. The application will be given to the students who own bikes so that the user can use the bicycle anytime by just registering and once they are able to login they can begin using the service without worrying about losing their bicycle.

After completing this project, it was found that some areas of study could be improved for future study. With further study and understanding, the lock itself may be better and stronger to make it more secure than before. The design can be improved to make it more convenient for users to use, especially bicycle design may be different. The interface in the application can be more user friendly such as the position to control the lock. The proposed design tends to confuse the user. Next is, microcontrollers need to be changed to adapt to long-range power as esp32 tends to be overheated for longer duration. Finally, to enhance the security, also with more and better interaction script that will ease the user. To counter the 0.01% possibility trial to open the password.

Acknowledgement

The authors would like to thank the Faculty of Computer Science and Information Technology, Universiti Tun Hussein Onn Malaysia for its support.

Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *N. I. N. Abdul Aziz, N. A. Abdullah;* ***data collection:*** *N. I. N. Abdul Aziz, N. A. Abdullah;* ***analysis and interpretation of results:*** *N. I. N. Abdul Aziz, N. A. Abdullah;* ***draft manuscript preparation:*** *N. I. N. Abdul Aziz, N. A. Abdullah. All authors reviewed the results and approved the final version of the manuscript.*

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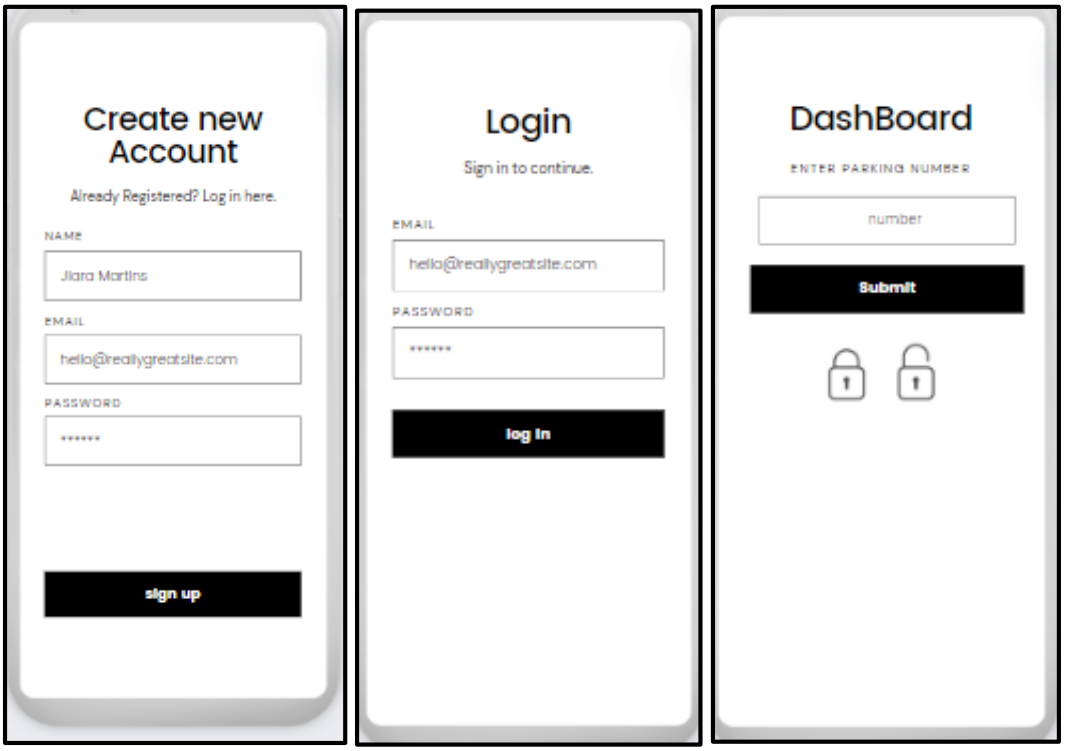
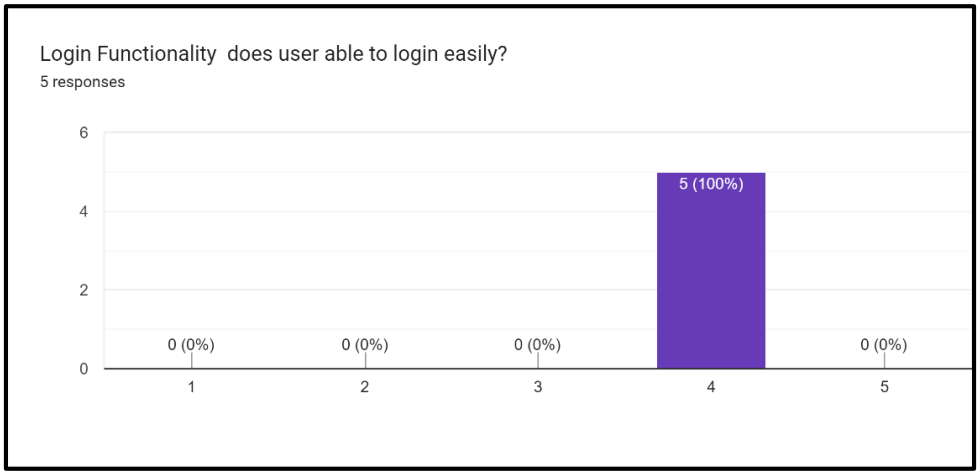
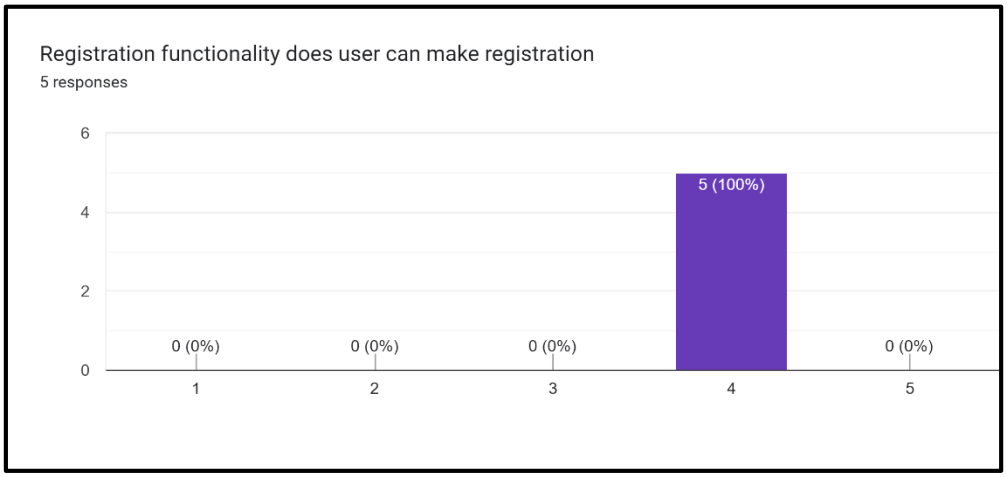
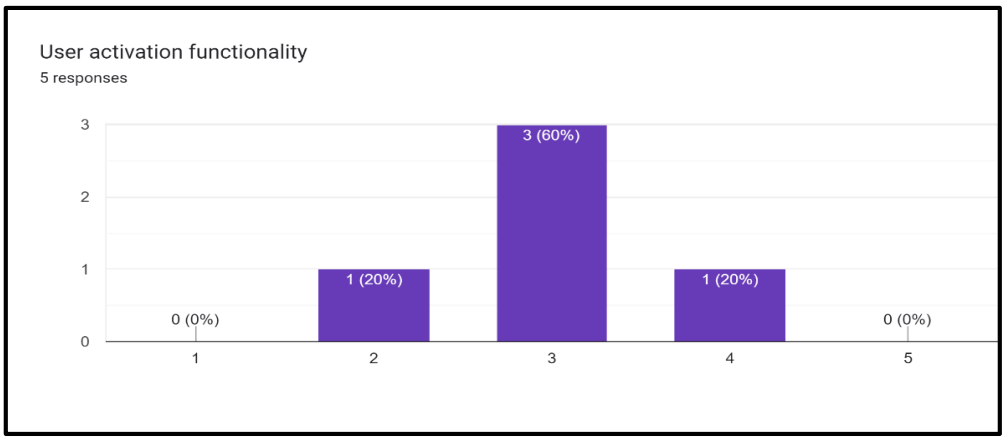
Appendix A: System Modules

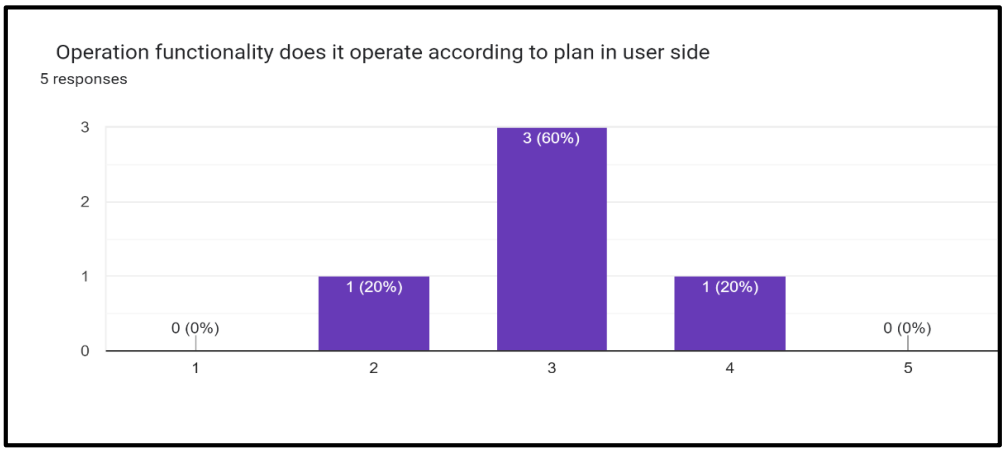


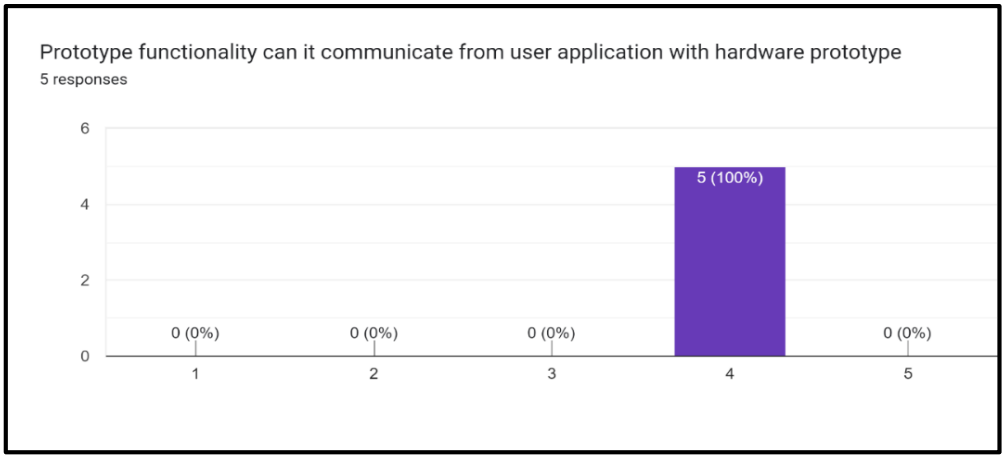
Appendix B: User Acceptance Test




Registration functionality does user can make registration
5 responses
6
4
2
0
0 (0%)
0 (0%)
0 (0%)
5 (100%)
0 (0%)
1
2
3
4
5


User activation functionality
5 responses
3
2
1
0
0 (0%)
1 (20%)
3 (60%)
1 (20%)
0 (0%)
1
2
3
4
5


Operation functionality does it operate according to plan in user side
5 responses
3
2
1
0
0 (0%)
1 (20%)
3 (60%)
1 (20%)
0 (0%)
1
2
3
4
5


Prototype functionality can it communicate from user application with hardware prototype
5 responses
6
4
2
0
0 (0%)
0 (0%)
0 (0%)
5 (100%)
0 (0%)
1
2
3
4
5