

# Integration of Web-Based Key Booking and Monitoring System with Smart Key Rack for University Application

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DOI: <https://doi.org/10.30880/eeee.2022.03.01.026>

Received 27 January 2022; Accepted 06 March 2022; Available online 30 June 2022

**Abstract:** This project introduces integration of the web-based key booking and monitoring system with smart key racks which have automated and real-time data collection that can vastly reduce key lost problems, and poor management systems. The key booking and monitoring system was developed by using IoT technology, which can be applied in the Faculty of Electrical and Electronic Engineering (FKEE) building. The webpage was developed using the Ionic Framework using Cloud Firestore to store the database. The smart key rack was developed by using Arduino IDE to program the NodeMCU ESP32, which controls the IR sensor, LCD, keypad, and solenoid lock to be integrated and work in parallel to the webpage. This key booking system allows the students and staff to book or cancel the reservation of the keys. The administrator can manage, monitor the keys, and verify the booking requests made by the users. This system will potentially minimise the inconvenience caused by manual key booking systems and improve the key management system at the university.

**Keywords:** Web-Based Key Booking, Monitoring System, Smart Key Rack

## 1. Introduction

Nowadays, human life is inseparable from the advancement of digital technology, considering it has developed rapidly over time [1]. The Internet of Things, or IoT technology is widely used to remote or monitor devices over the internet using a smartphone, laptop, or tablet [2]. The applications of the IoT consist of several parts, such as connectivity [3], small system devices [4], sensors [5], and active engagement such as cloud [6], microcontroller [7],[ 8]. IoT works by utilising a programming argument, where each command of these arguments can produce an interaction between machines that have been connected automatically without human intervention and without being limited to any distance [2]. Recently, IoT technology has been implemented in our daily life, such as for the smart key box [9], door gate [10], smart parking reservation system [11], and smart door [12]. However, the application of IoT based on booking and monitoring of the key system is still lacking, and people still use the manual

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way to manage their keys. In a normal condition, the university building will store a bunch of keys for different rooms. To borrow the desired key, traditionally, the user can just come to the administrator's office, inform the person in charge, and ask for the key, or if the user is a staff member in the same building, he or she can simply take the key manually from the key box.

This manual technique has its own advantages and disadvantages. The advantage of this manual technique is the person or user can easily take the key without any hassle if the key is available. But, if the key is unavailable, this will be the main problem, especially in monitoring the key. First, the person in charge needs to identify the last person that took the key. Sometimes, the user just informed but did not record any information about the key in the provided logbook. When this problem occurs, it will be difficult to find the key as well as to identify the person who borrowed the key. Thus, this inefficient key management system will result in the loss of keys and will also delay our daily activities.

In order to minimise and solve the key lost problem, the integration of an automated and real-time web-based facility key booking and monitoring system using IoT technology was designed and developed to improve the poor existing key management system. In this project, a web page for key booking and monitoring system, smart key rack with a sensing element that is equipped with mobile alert notification system have been developed using the IoT-based technology. This includes the integration of the key booking database, key sensing detector, and alert notification to the mobile phone. The users can easily book the keys that they want to use no matter where and when by using the web-based facility. This project will help the administrator to monitor the keys' whereabouts and how long they have been gone. It also equips with an alert notification that sends to the user via mobile phone as a reminder for returning the keys, thus, vastly reducing human error and effort as well as time-saving.

## 2. Methodology

The web-based key booking and monitoring system with a smart key rack was divided into two sections. The first section provides an overview of the hardware part which consists of the overall block diagrams and circuit and wiring connections of the smart key rack. The second section specifies the overall flowcharts for the web-based facility key booking and monitoring systems. In the software part, Arduino IDE [13], Ionic Framework [14], and Cloud Firestore [15] will be used for the development of an automated and real-time web-based facility key system. These software elements will work in parallel with hardware components such as the microcontroller NodeMCU ESP32, infrared (IR) sensor, keypad, motor, and liquid crystal display (LCD). These elements will integrate with the web-based database where it can store and monitor the data as well as send the notification to the user.

### 2.1 Block diagram and wiring connection of the circuit

The block diagram for the key booking and monitoring system that includes the integration of software and hardware components is shown in Figure 1. The main idea was to develop a web-based facility for key booking and monitoring systems in conjunction with the smart key rack. It can be monitored with the help of a database and the NodeMCU ESP32 microcontroller that can read the input data from the IR sensor to sense the presence of the key. The Light Emitting Diode (LED) on the sensor was to indicate the key availability together with the assistance of the sensor. The keypad was used by the user to enter the keypad unique number received from the administrator. The Liquid Crystal Display (LCD) screen near the keypad allowed the user to check and confirm during entering the keypad unique number. The solenoid lock that was in the smart key rack will function to open the box once the keypad unique number was entered correctly. The smart key rack itself was integrated with the booking and monitoring web-based facility system and the database was stored in the Cloud Firestore. The wiring and circuit connections of the smart key rack with the sensing element for this project are depicted in Figure 2. The circuit consisted of the NodeMCU ESP32, 16 x 2 LCD, IR sensors, 4 x 4 keypad, 5 V relay, Solenoid lock, and 12 V adapter.

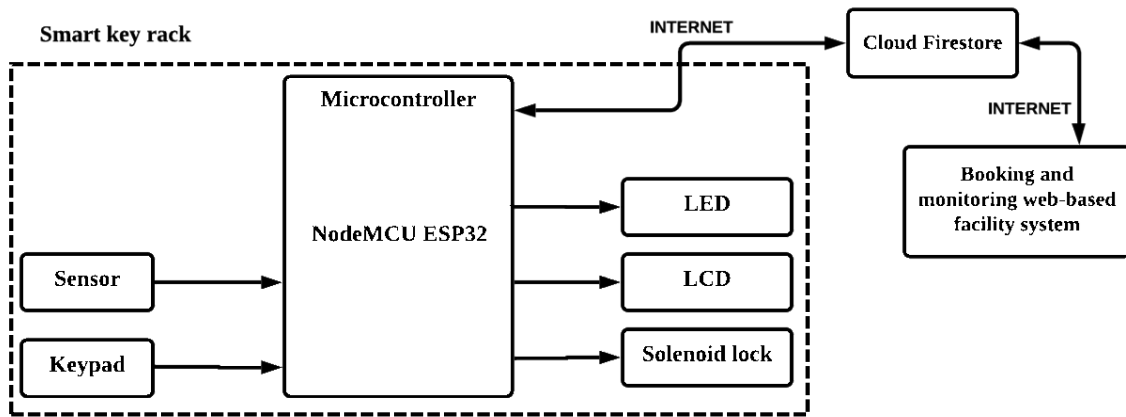


Figure 1: Overview of the block diagram web-based facility key booking and monitoring system integrated with smart key rack

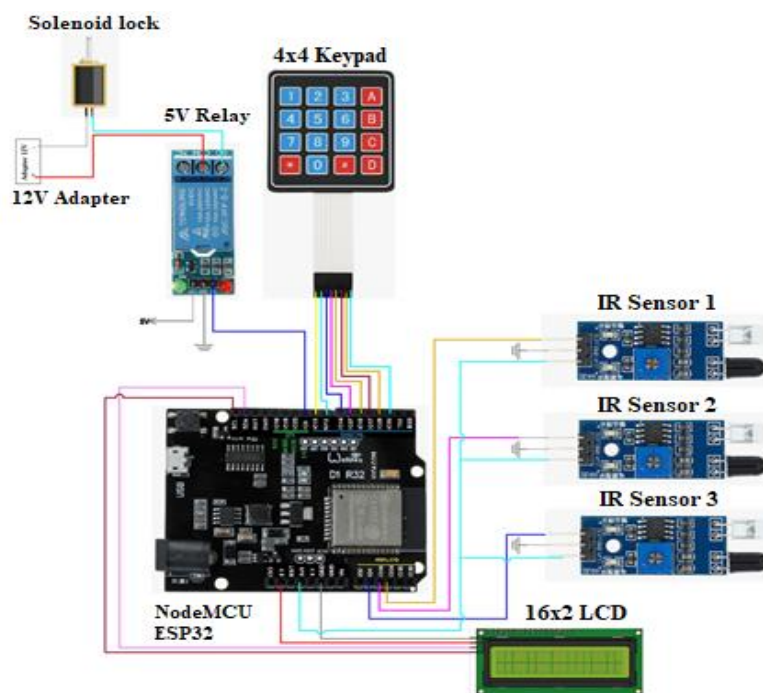


Figure 2: Wiring and circuit connections of the smart key rack

## 2.2 Key booking and monitoring systems flowchart

The overall flowchart of the key booking and monitoring system that was developed in this project is shown in Figure 3. It started with the user and administrator login to the webpage that was developed in this system. On the login page, users that were allowed to use the webpage, namely, the student, staff, and admin of the university. Once the log-in was successful, it directed the user to the main page, which depended on their login identification. The user can start the execution function; for example, if the user is a student or staff member, they can start to book the keys, check for the verification status, and cancel request. On the other hand, the admin had its own login webpage, where the admin could easily check, monitor, and approve the key bookings by the users. The webpage facility includes the users' booking details, approval or cancel the request, the booking history, and updated user status, either approval or cancellation. If the booking request is approved, the user will be notified by mobile phone along with a keypad number to be used by the user upon accessing the key at the office. However, if the previous user has not returned the key, the admin can send a notification reminder to the user to return the key.

In this system, all the information from the booking system will then be saved in the database for the admin to monitor and track the status of the key with ease.

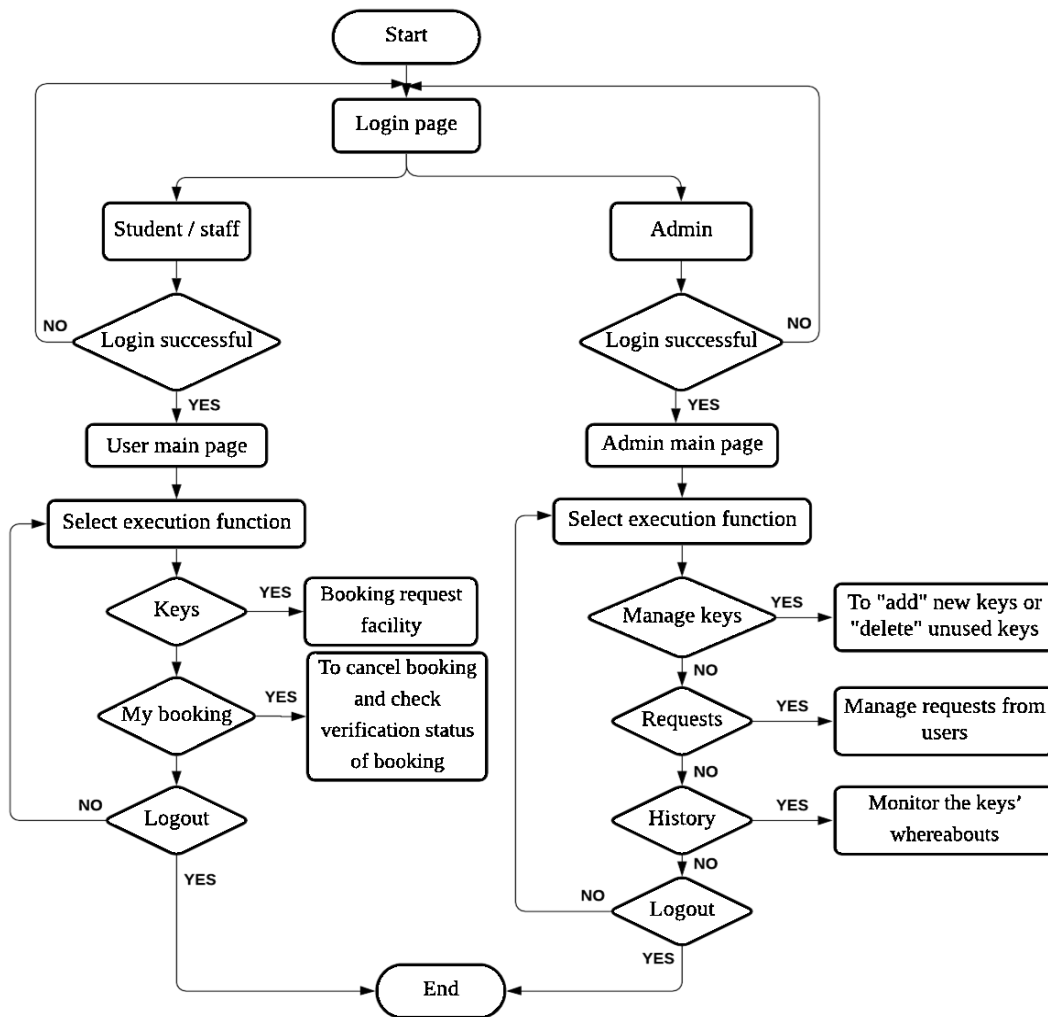


Figure 3: Overall flowchart of key booking and monitoring system

### 3. Results and Discussion

The key rack has been designed and developed as shown in Figure 4. In order for the key rack to fully operate, it must be connected to the power supply. The LCD will automatically display “Enter Code” when the whole circuit is on and it is used to display the passcode that the users have entered using the keypad. The IR sensors are used to detect the keys in the key rack and the green LED on the sensors acts as an indicator for the availability of the keys. If the entered passcode is correct, the solenoid lock will turn on by the relay and unlock the key rack.

Figure 5(a) shows all the green LEDs on the IR sensor light-up which indicate that the keys are all available and the availability status of the keys will be updated to the website in about 5 to 10 seconds. Meanwhile, Figure 5(b) shows that the green LED on sensor 2 turns off when the key is removed. The IR sensor has the detection range of objects from 2 cm until 10 cm, but in this key rack application, it was set to be 4 cm.

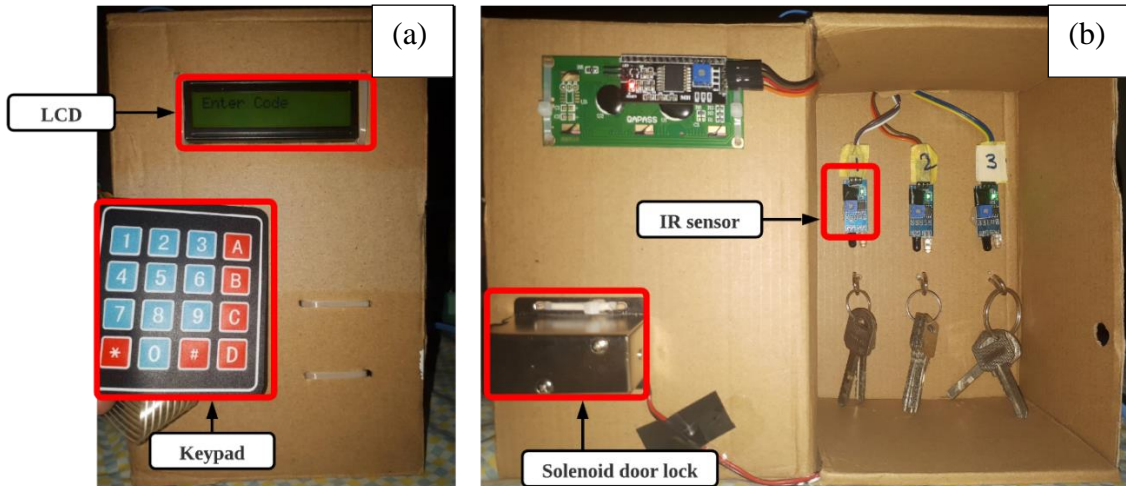


Figure 4: Image of (a) front door and (b) inside cabinet of the smart key rack.

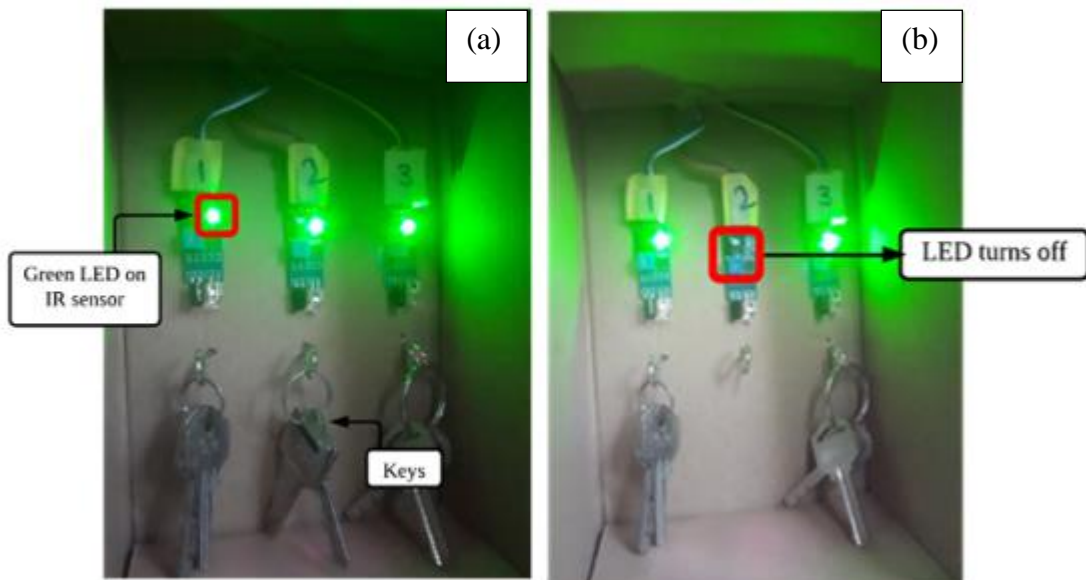
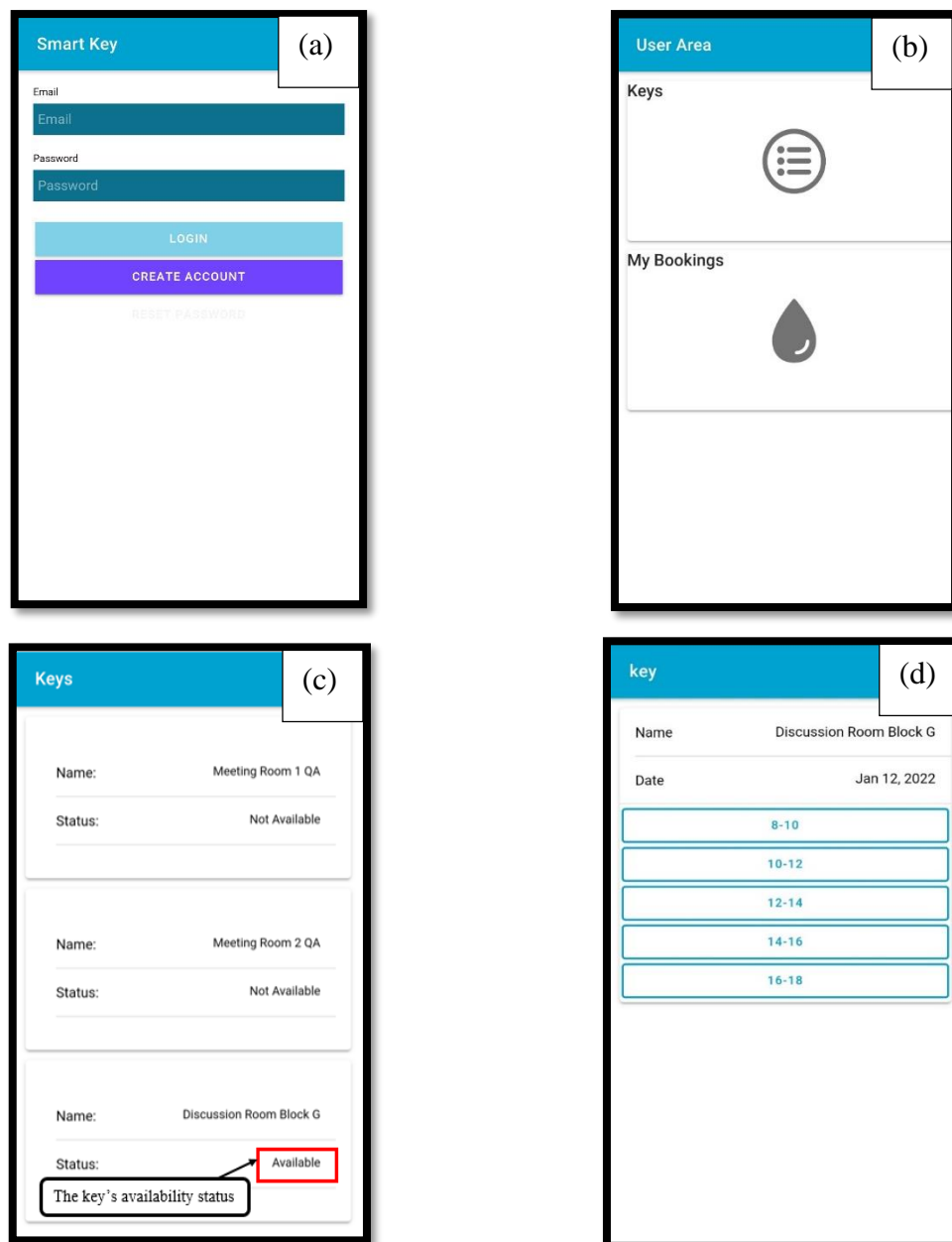


Figure 5: Image of (a) Green LED lights up when all the keys are available and (b) Green LED on sensor 2 turned off when the key is removed

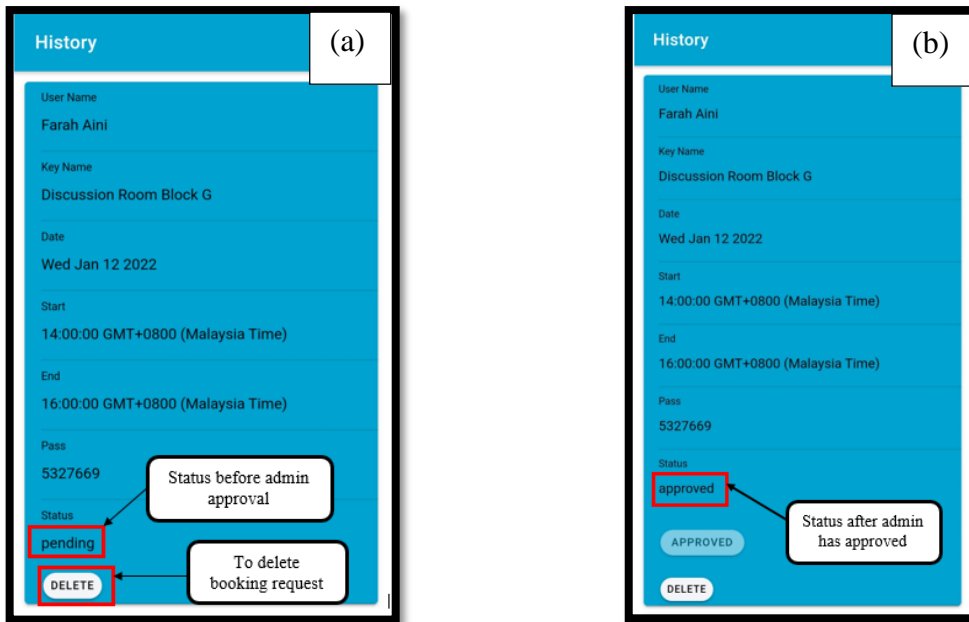
### 3.1 User interface for smart key booking application (for user)

The website and app require the users to log in at the login page as depicted in Figure 6 (a). After successfully logging in, users will be directed to the user main page as shown in Figure 6 (b). On the user main page, two tabs will appear once successfully logged in, namely 'Keys' and 'My Bookings'. The 'Keys' tab will direct the users to the keys list page as shown in Figure 6(c). Users can choose the desired keys they want to book as well as to see the availability status of the keys on the key list page. After selecting the room key, the users need to choose the desired time (using 24 hours format) and date for the key booking as shown in Figure 6(d). Their booking request will be automatically recorded after users have finished choosing the date and users can check up their request approval in the 'My Bookings' tab under the user main page as shown in Figure 6(b).

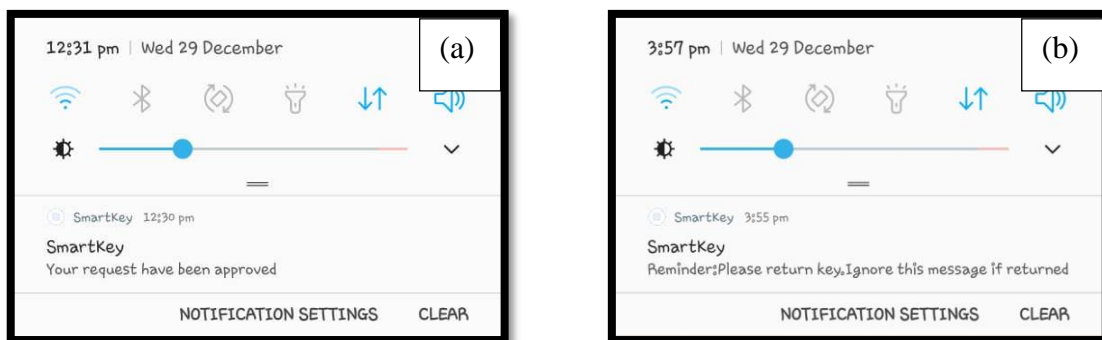


**Figure 6: Image of (a) login page, (b) user main page, (c) key list page, and (d) booking page.**

The 'My Bookings' tab will direct users to the booking history page that is shown in Figure 7(a). The user's name, the key's name that the user has booked, date, starting and ending time, passcode, and also the approval status before the admin approves the booking request are shown on the same page. If the users want to cancel their booking, they can simply click on the 'Delete' button. They can also find the passcode on the same page, but it can only be used after the admin has approved their request and within the booking time frame. Once the admin has approved the booking request, the user will be notified through mobile notification as depicted in Figure 8(a) and they will see that the request status has changed from 'Pending' to 'Approved' as can be seen in Figure 7(a) and Figure 7(b). Finally, 5 minutes before their time is up, the users will be reminded to return the keys by notification on the mobile app as shown in Figure 8(b).



**Figure 7: Image of booking history page (a) with pending status and (b) after the request had been approved.**



**Figure 8: Image of (a) mobile notification after user’s request have been approved and (b) reminder notification to return the key**

### 3.2 User interface for smart key booking application (for admin)

After successfully logging in, the admin will be directed to the admin main page as shown in Figure 9(a). On the admin main page, four tabs will appear, namely ‘Manage Keys’, ‘Requests’, ‘History’, and ‘Admins’. On the ‘Manage Keys’ tab, the admin can add new keys to the list or delete any keys. The page for managing the keys is shown in Figure 9(b). For the admin to add the keys, it can be done by clicking on the ‘Add keys’ button, and the key form which is shown in Figure 9(c) will appear. The admin needs to fill in the key name and submit it to add the keys to the list. Each of the keys in the list has the ‘Delete’ function below the keys’ status to delete any keys. The newly added key will be directly stored in the database.



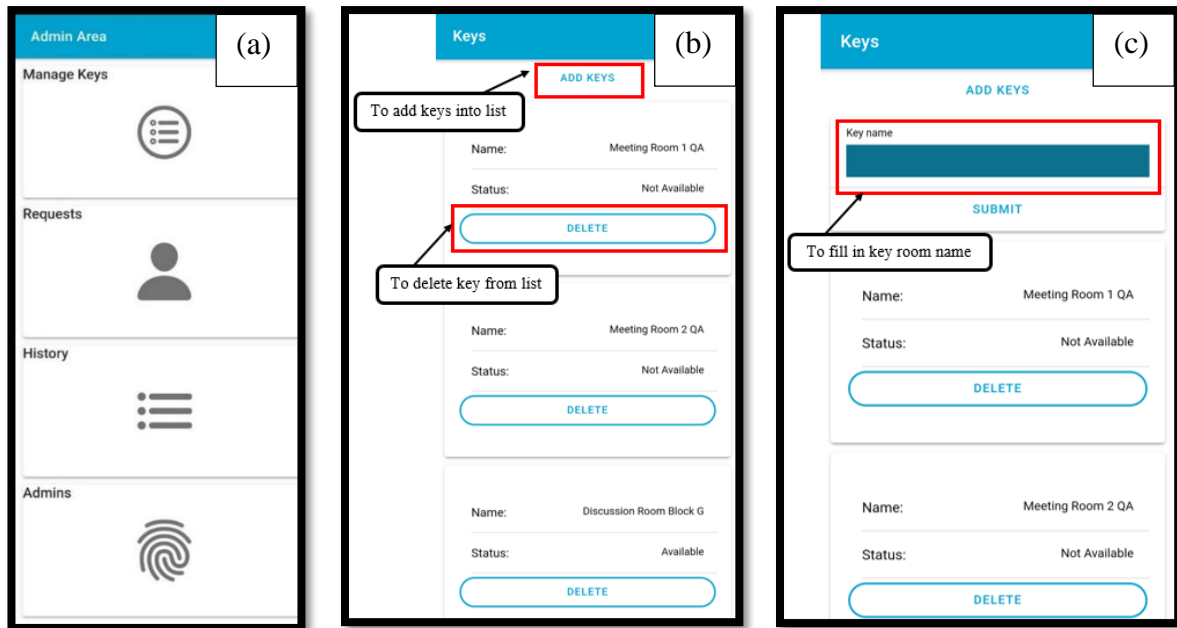


Figure 9: Image of (a) admin main page, (b) manage keys page, and (c) add new keys feature.

Next, the 'Requests' tab will direct the admin to the requests page as shown in Figure 10(a) which shows the booking request from the user with a pending status. The admin can decide whether to approve the request by clicking on the 'Approve' button or to cancel the request with the 'Delete' button. Once the admin has approved the request, it will go to the history page as depicted in Figure 10(b) that can be accessed through the 'History' tab.

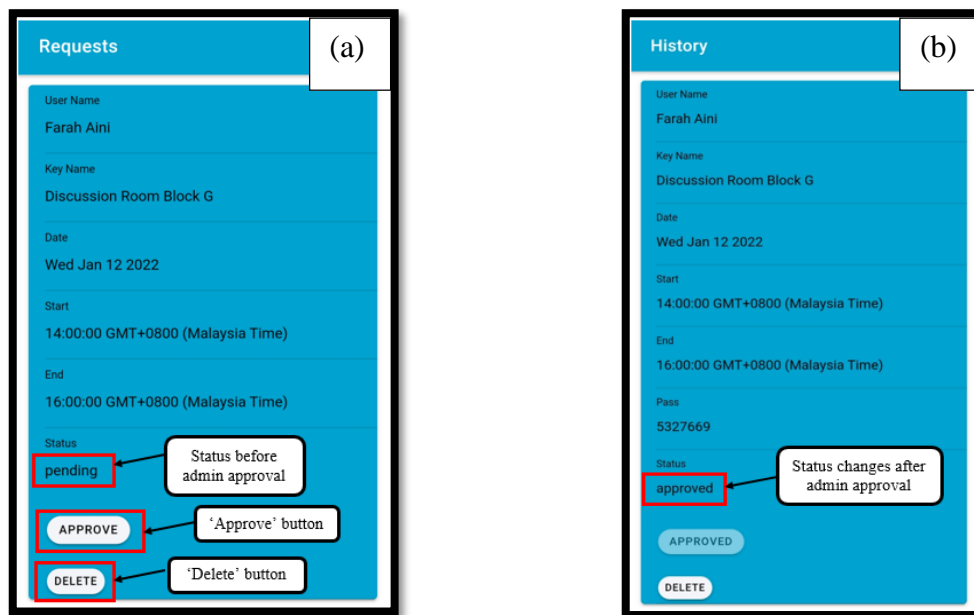


Figure 10: Image of (a) request page with pending status and (b) history page after the approval.

#### 4. Conclusion

The automated and real-time key facility booking and monitoring-based system using IoT has been successfully developed in this project. This web-based facility has been developed using Ionic Framework and Cloud Firestore database and it can be operated automatically without any manpower required. Hence, this system was able to improve efficiency and eliminate the inconvenience caused by manual key booking systems. Next, the IoT-based system was integrated with the smart key rack



sensing element that had been developed and programmed using HTML5 and Arduino IDE software. This integration system was able to work synchronously according to requests from users and approval or cancellation from the administrator. Results show that the smart key rack was able to sense the availability and non-availability of the keys room using the IR sensor by indicating it through the flashing LED. Lastly, the real-time online monitoring system via a mobile application that is integrated with the key detector has been developed and functioning well. Users can receive alert notifications via their mobile phone. For example, if the admin has approved the booking request, the user will be notified through a mobile alert notification. Thus, users can take the key room without any hassle. Users will also be reminded to return the keys by the mobile notification 5 minutes before the booking time is up; hence human error can be minimised and the university can work effectively.

### Acknowledgement

The authors would like to thank the Faculty of Electrical and Electronic Engineering, Universiti Tun Hussein Onn Malaysia for its support.

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