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Design and Development of an Affordable Smart Key Monitoring System with the Internet of Things

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Abstract: Every premises is protected by a lock, and a key is the element to be used to unlock to access the premises. Key management has become an essential agenda in an organisation to ensure the key can be managed well. Commercial key management can be found in two categories: the mechanical approach and the digital system approach. Overall, the digital system approach was more effective in key management, but the cost is far more expensive. In this project, an affordable and smart key management system was proposed and can benefit all types of organisations. This system is developed with two essential components: software and hardware. The software includes Google Sites, Google Forms, Google spreadsheets, Wi-Fi, and hardware, which consists of the ESP32 controller, servo motor, and ultrasonic. With minimal customisation, this new smart key management system could easily be installed on usual key boxes. This system is used for efficient key monitoring anytime and anywhere and can also be used for room booking through a personal handphone or PC. This key management system has been developed successfully and integrated well to fulfill all its digital key management system functions.

Keywords: *ESP32 controller, key management system, organisation, Internet of Things, google form*

1.0 Introduction

The usual locking mechanism was a regular lock with a key. The traditional locking system has some disadvantages, such as the key being easily copied and the lock is easily opened by an unauthorised person (Keriya, 2019). Nowadays, a security key is a tool that makes it easier to access other devices, internet systems, and apps or to do tighter authentication (Nandy et al., 2019). Security tokens are another name for security keys. Security keys are auxiliary devices that need a primary device to function. Similar to how a smart card functions, these hardware components collaborate with the workstation, application, or other system. Although an intelligent card also needs card-reading hardware linked to the primary device, the two are relatively comparable. Similar to smart cards, the authentication procedure for security tokens depends on software interaction with the primary system or device. Several methods for security solutions have been published in the literature, including radio-frequency identification (RFID) cards, keypads, pins, and passwords (Goyal et al., 2017; Hossain et al., 2019; Motwani et al., 2021; Mumtaz et al., 2020; Sobur et al., 2022; Wee, 2021). However, there still are some drawbacks, such as the possibility of passwords being hacked and a card being stolen or misplaced, and this system also lacks a warning mechanism in case of a break-in or an unauthorised person attempting to unlock the door.

Small/ medium non-profit organisations and learning institutions need an affordable, intelligent key monitoring system with the Internet of Things (IoT), which could be attached to the current key box. This is because most institutions are currently just using traditional ways to record the key users in a book, making it easy to monitor and trace the key and lack of security. The network of connected

devices known as the Internet of Things (IoT), connects to and exchanges data with other IoT devices as well as the cloud (Adiono et al., 2019; Shanthini & Vidya, 2021). IoT devices, which can include consumer goods and both digital and mechanical machinery, are often incorporated with technology such as sensors and software (Nagarajan & Arthi, 2017; Umadi et al., 2023; Zefi et al., 2022).

Therefore, an Affordable Smart Key Monitoring System with Internet of Things was designed and developed in this paper. This project aims to implement the developed affordable key management system in non-profit organisations and educational institutions and evaluate the benefit and performance of the developed key management system. This innovation project will increase the security and efficiency of key management at small/ medium organisations and learning institutions.

2.0 Method

2.1 Block Diagram

Block diagram is used to help visualize the components and their interactions in this proposed system. The simplified block diagram for an affordable Smart Key Monitoring System with IoT is shown as below:-

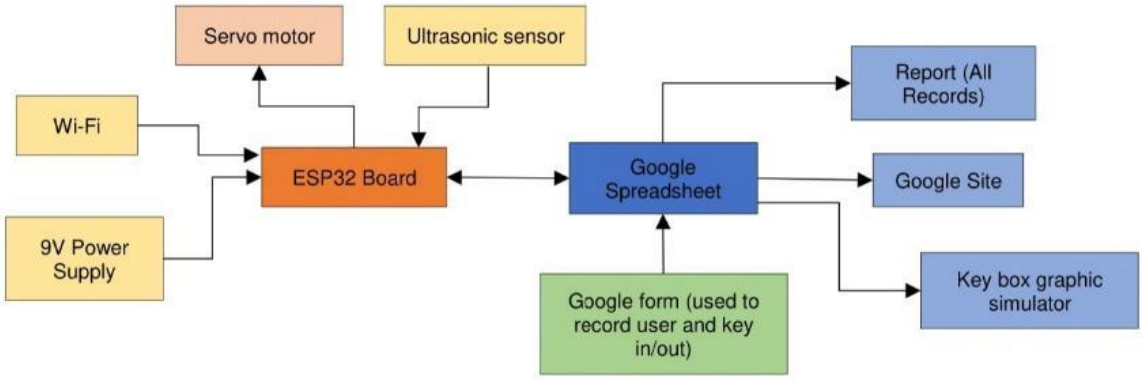

***Figure 1**: Block Diagram for an Affordable Smart Key Monitoring System with IoT*

Figure 1 shows the block diagram for an affordable smart key monitoring system with IoT. This proposed innovation project is developed by interfacing the software with hardware. Software are Google Site, Google Form, Google Spreadsheet, Key Box Simulator and Wi-Fi, while hardware includes ESP32 controller, servo motor and ultrasonic sensor. The Smart Key Monitoring System with IoT is installed into a typical key box locker, as shown in Figure 2.

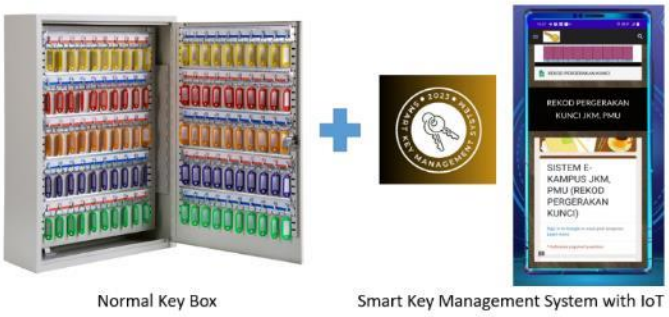

***Figure 2**: Normal Key Box with Smart Key Monitoring System*

2.2 Design of an Affordable Smart Key Monitoring System

Designing an affordable Smart Key Monitoring System involves considering the components, connectivity, power consumption, and overall cost-effectiveness. Below is a design for such a system:-

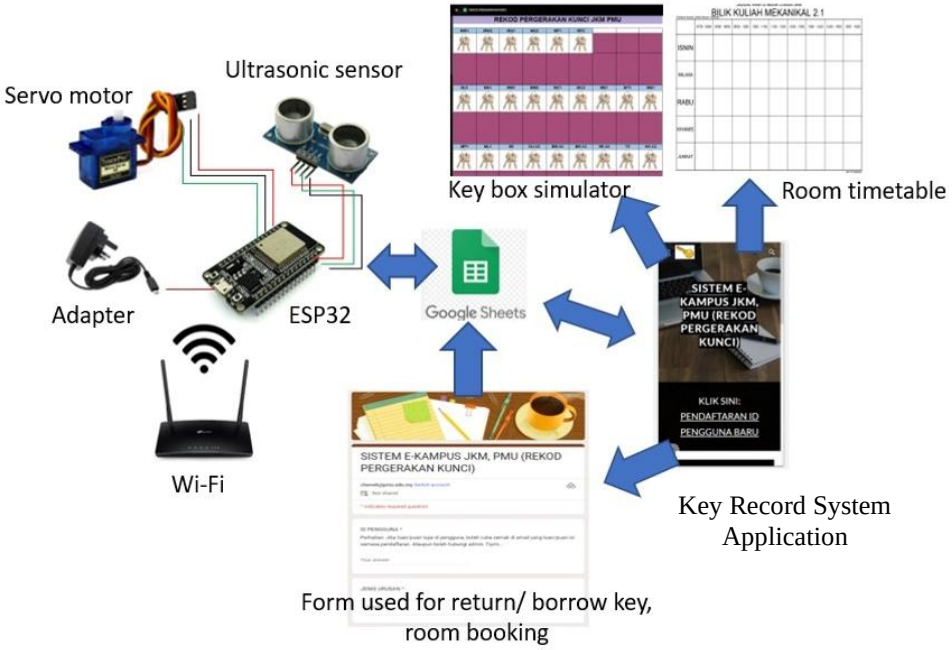

***Figure 3**: Design of circuit for an Affordable Smart Key Monitoring System with IoT*

Figure 3 shows the circuit design for an Affordable Smart Key Monitoring System with IoT. ESP32 is a single-microcontroller board-based open-source physical computing platform. With built-in Bluetooth and Wi-Fi connection, it is a potent System-on-a-Chip (SoC) microcontroller suitable for a range of applications. Antenna switches, RF baluns, power amplifiers, low-noise receive amplifiers, filters, and power management modules are all included into the ESP32 (Wee & Fang, 2021; Wee & Keong, 2022).

Sonar is used by the ultrasonic sensor to detect the distance to an item or object. This sensor has a reading range of 2cm to 400cm and an accuracy of 0.3cm. The ultrasonic transmitter (trig pin) produces a high-frequency (40 kHz) sound. The sound is carried by the air. If it discovers an item, it returns to

the module. The reflected sound (echo) is received by the ultrasound receiver (echo pin). A servo motor is one type of motor that possesses precise rotation. This motor often has a control circuit that provides feedback on the motor shaft's current location. This feedback allows the servo motors to spin with exceptional precision. The Key Record System application is the platform to display the Google form for users to log in and fill in the Google, demonstrate the key box simulator, and show the room timetable. The user will select the available classroom key from the selection in the form and submit the form. Then, the servo motor will unlock the key locker for the registered user to take out the key.

2.3 Software Development

Software development is the process of developing, creating, testing, and maintaining software systems to satisfy specific needs or address particular issues. It entails a sequence of actions and activities designed to produce a high-quality software product.

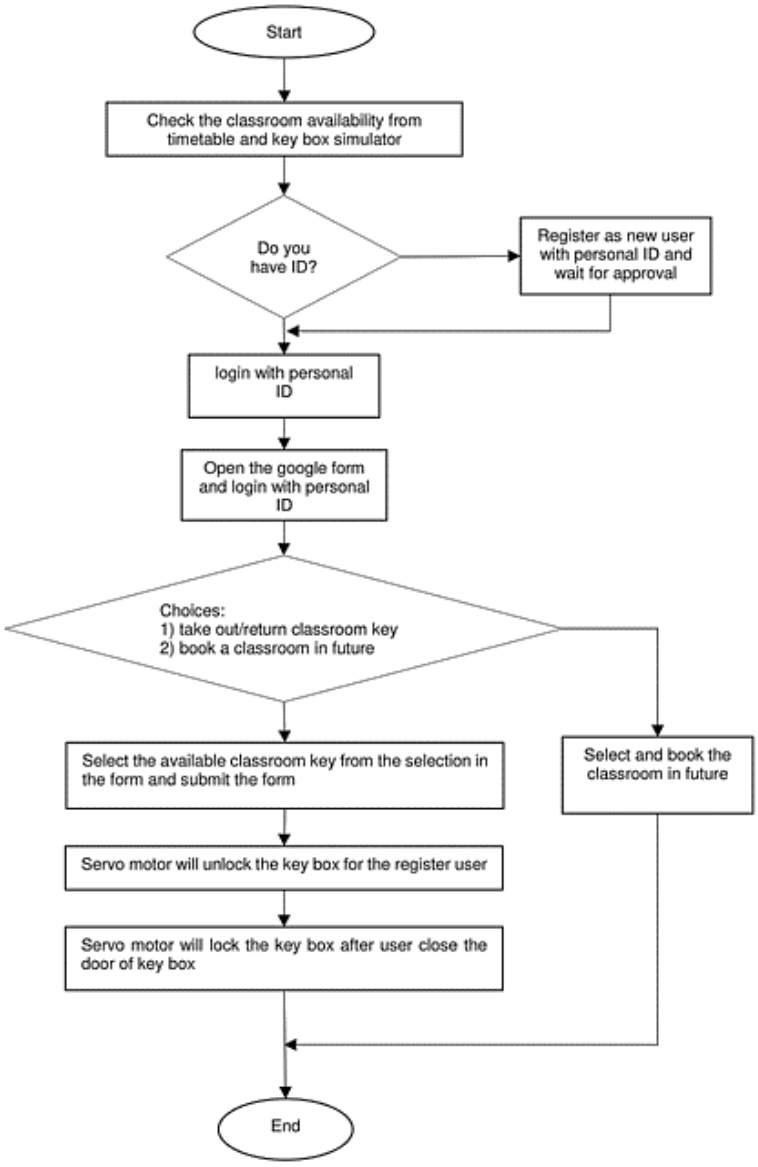

***Figure 4**: Flow chart for Proposed System*

Figure 4 shows the flow chart for an Affordable Smart Key Monitoring System with IoT. The user can check the classroom availability from the timetable and key box simulator. Firstly, the user must register as a new user with a personal ID and must be approved by the admin. Then, the user can log into this system's Google form by keying in the ID number. Users can choose whether to take out/return classroom keys or book a classroom in future. After selecting the available classroom key from the form selection and submitting the form, the servo motor will unlock the key locker for the registered user. Finally, the servo motor will lock the key locker after the user closes the key box door.

Figure 5 shows the Arduino Coding for the Proposed System. The Arduino platform is the most basic way to start creating code for the ESP32 platform. This open-source fast prototyping platform is built around Atmel microcontrollers. To write software for microcontrollers, the Arduino integrated development environment, written in Java, is utilised. This software was created in the learning environment and has been somewhat modified and expanded with features such as Wiring Language. Wiring is a programming language similar to the C ++ framework that is designed to programme a microcontroller without the need for specific hardware knowledge. The usage of a microcontroller with a boot programme is required for wiring.

***Figure 5**: Arduino Coding for Proposed System*

3.0 Results and Discussion

An affordable smart key monitoring system with IoT was designed and developed, as shown in Figure 6. The results indicate that the IoT-enabled Smart Key system is a viable and cost-effective solution for enhancing access control in residential buildings. While the system demonstrated high performance and user acceptance, ongoing improvements and security measures will be crucial for its long-term success.

***Figure 6**: An Affordable Smart Key Monitoring System with IoT*

This innovation project is used to attach to an existing traditional key box to ensure the ease of hardware and software system installation, increase security by making sure the door of the box is always closed, monitor who has opened the key box door in real time, increase the efficiency of room booking and easy to access the latest classroom timetable as well. Figure 7 illustrates this system's three (3) LEDs. When the Wi-Fi is connected, the LED Orange will be ON. When the key locker door is closed, the red LED will be ON, as shown in Figure 8(a). When the key locker door is open, the green LED will be ON, as shown in Figure 8(b).

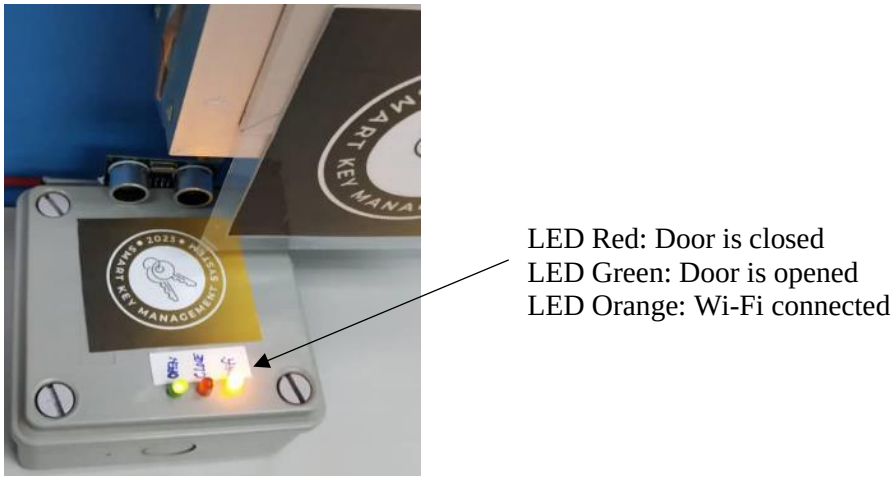

***Figure 7**: LED indicator*

(a) Key Box Door is closed (b) Key Box Door is open

***Figure 8**: Normal Key Box with Smart Key Monitoring System with IoT*

Figure 9 shows the Key Record System Application that used to control the door at the locker key. This system could always detect whether or not the key box door is closed. This Key Record system is easy to install and user-friendly. The user information for opening the key locker will be stored on Google Drive, as shown in Figure 10. The system could detect where and with whom the key is in real-time via phone, as shown in Figure 11. Besides, the system could be easily used by the user to book a room, as illustrated in Figure 12. The system is uploaded with an updated classroom timetable and is easy for the user to refer to, as shown in Figure 13. Hence, a Smart Key Monitoring System with IoT can increase the security and efficiency of managing the keys.

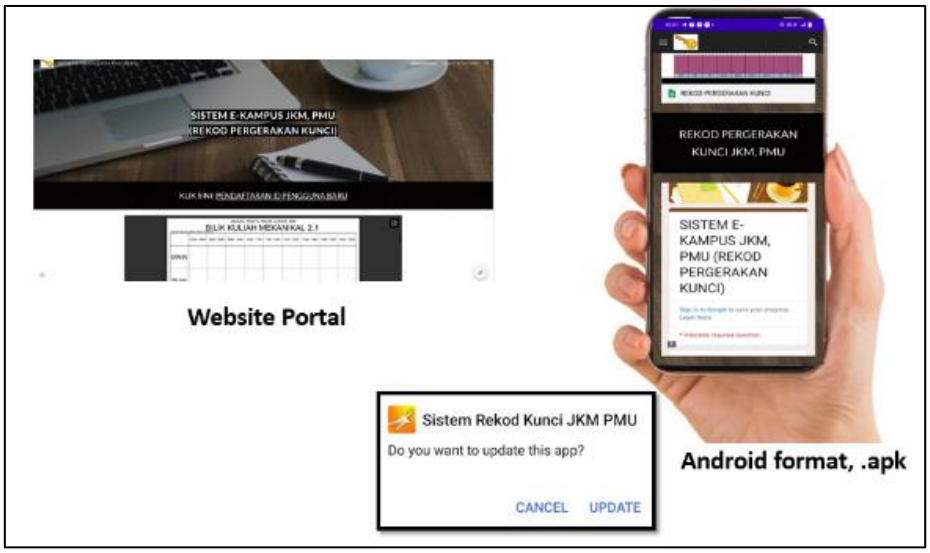

***Figure 9**: Application of Key Record System*

Timestamp	KUNCI YG DIPINJAM	KUNCI YG DIPULANG	NAMA PENGGUNA
11/27/2023 10:23:29			LEN BIN ANNUAR RIGOS
11/27/2023 12:28:46		BILIK KULIAH MEKANIKAL 2.3 (2.3)	CHEN WONG KEONG
11/27/2023 12:28:56		BILIK KULIAH MEKANIKAL 2.9 (2.9)	KHAIRULBADRI BIN AHMAD
11/27/2023 12:29:11		BILIK KULIAH MEKANIKAL 2.11 (2.11)	MOHAMAD AMIRUL BIN MD ALI
11/27/2023 12:29:24		BILIK KULIAH MEKANIKAL 2.14 (2.14)	BRENDA AK NORBERT RABAR
11/27/2023 13:42:20			CHEN WONG KEONG
11/27/2023 14:07:26		BENGKEL FONDRI (MF1)	KAMAL BIN JAMAL
11/27/2023 14:07:46		BENGKEL KIMPALAN & FABRIKASI LOGAM (MW1)	ALI BIN ABU
11/27/2023 14:09:38		BENGKEL KIMPALAN & FABRIKASI LOGAM (MW2)	ISMAIL BIN JAMAL
11/27/2023 14:11:54		MAKMAL MEKANIK MESIN (MM1)	FARIHANA BINTI A.RAHMAN
11/27/2023 20:10:14	BILIK KULIAH MEKANIKAL 2.1 (2.1)		CHEN WONG KEONG
11/28/2023 7:21:14	BILIK KULIAH MEKANIKAL 2.2 (2.2)		KHAIRULBADRI BIN AHMAD
11/28/2023 7:21:40	BILIK KULIAH MEKANIKAL 2.3 (2.3)		MOHAMAD AMIRUL BIN MD ALI
11/28/2023 7:22:20	BILIK KULIAH MEKANIKAL 2.4 (2.4)		BRENDA AK NORBERT RABAR
11/28/2023 7:23:19	BILIK KULIAH MEKANIKAL 2.5 (2.5)		CHEN WONG KEONG
11/28/2023 7:24:01		BILIK KULIAH MEKANIKAL 2.5 (2.5)	KAMAL BIN JAMAL
11/28/2023 7:24:13		BILIK KULIAH MEKANIKAL 2.4 (2.4)	ALI BIN ABU
11/28/2023 7:24:29		BILIK KULIAH MEKANIKAL 2.3 (2.3)	ISMAIL BIN JAMAL
11/28/2023 7:24:40		BILIK KULIAH MEKANIKAL 2.2 (2.2)	FARIHANA BINTI A.RAHMAN
11/28/2023 7:25:55		MAKMAL MEKANIK MESIN (MM2)	ALI BIN ABU
11/29/2023 10:39:19	BILIK KULIAH MEKANIKAL 2.2 (2.2)		ISMAIL BIN JAMAL
11/29/2023 10:39:57		BILIK KULIAH MEKANIKAL 2.2 (2.2)	FARIHANA BINTI A.RAHMAN
11/29/2023 10:40:25		BILIK KULIAH MEKANIKAL 2.1 (2.1)	CHEN WONG KEONG

***Figure 10**: User Records*

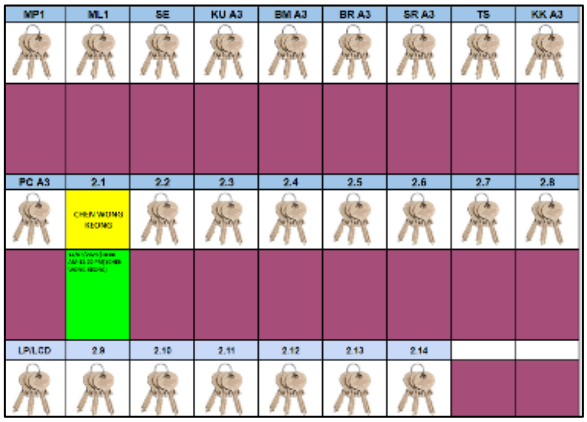

***Figure 11**: Key box simulator*

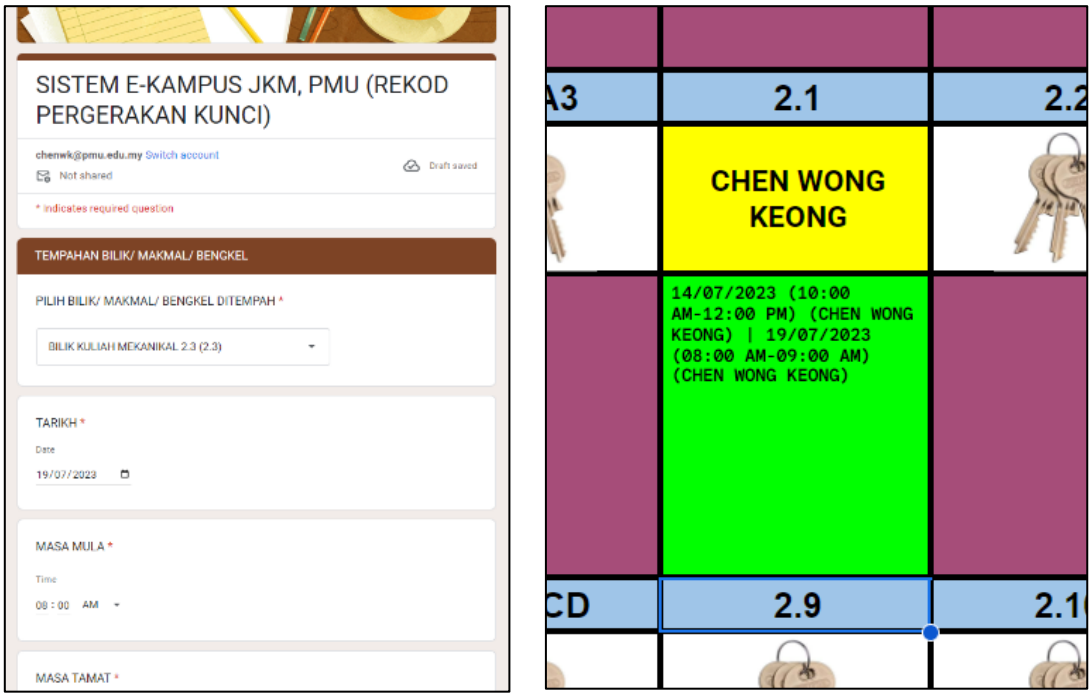

***Figure 12**: Booking a Laboratory/Workshop/Lecture Room*

***Figure 13**: Classroom Timetable*

4.0 Conclusion

An Affordable Smart Key Monitoring System with IoT for traditional key box has been created, which offers improved security, efficiency, and user convenience in many cases. This system could be applied to any traditional key box with the minimal starting cost of installation. This key management system has been developed successfully and integrated well to fulfil all its functions for a smart key monitoring system with IoT.

REFERENCES

Adiono, T., Fuada, S., Anindya, S. F., Purwanda, I. G., & Fathany, M. Y. (2019). IoT-enabled door lock system. *Int. J. Adv. Comput. Sci. Appl*, *10*(5), 445-449.

Goyal, S., Desai, P., & Swaminathan, V. (2017). Multi-level security embedded with surveillance system. *IEEE Sensors Journal*, *17*(22), 7497-7501.

Hossain, S., Ahmed, M. I., & Mostakim, M. N. (2019). A Prototype of Automated Vault Locker Solution for Industrial Application. 2019 1st International Conference on Advances in Science, Engineering and Robotics Technology (ICASERT),

Keriya, F. R. B. (2019). Development of IoT–based locking system.

Motwani, Y., Seth, S., Dixit, D., Bagubali, A., & Rajesh, R. (2021). Multifactor door locking systems: A review. *Materials Today: Proceedings*.

Mumtaz, Z., Ilyas, Z., Sohaib, A., Ullah, S., & Madni, H. A. (2020). Design and Implementation of User-Friendly and Low-Cost Multiple-Application System for Smart City Using Microcontrollers. *arXiv preprint arXiv:2010.07016*.

Nagarajan, L., & Arthi, A. (2017). Iot based low cost smart locker security system. *International Journal of Advance Research, Ideas and Innovations in Technology*, *3*(6), 510-515.

Nandy, T., Idris, M. Y. I. B., Noor, R. M., Kiah, L. M., Lun, L. S., Juma'at, N. B. A., Bhattacharyya, S. (2019). Review on security of internet of things authentication mechanism. *IEEE Access*, *7*, 151054-151089.

Shanthini, M., & Vidya, G. (2021). IoT-Based Smart Door Lock with Sanitizing System. In *Inventive Computation and Information Technologies* (pp. 63-79). Springer.

Sobur, M. A., Masud, M. A. A., Chowdhury, N. R., Gani, M. O., & Kader, M. A. (2022). Design and prototyping of a security locker system for public places using RFID technology. *International Journal of Information Technology*, 1-7.

Umadi, K. R., Aishwarya, A., Narendramath, J. E., Inchara, S., & Dharishini, P. P. P. (2023). Smart E-Locker System using IoT. 2023 International Conference on Intelligent Data Communication Technologies and Internet of Things (IDCIoT),

Wee, B. S. (2021). Design and Implementation of an Arduino Based Smart Fingerprint Authentication System for Key Security Locker. *International ABEC*, 155-160.

Wee, B. S., & Fang, K. S. (2021). Design and Implementation of an Arduino-Based Body Temperature and Pulse Rate Monitoring System. *International ABEC*, 161-166.

Wee, B. S., & Keong, C. W. (2022). Design and Fabrication of Smart Automated Shoes Sanitizing System Based on Arduino. *Borneo Engineering & Advanced Multidisciplinary International Journal*, *1*(2), 27-32.

Zefi, S., Susanti, E., Sholihin, S., Agung, M. Z., Halimahtussa'diyah, R., & Wee, B. S. (2022). Innovation Technology of Lekor Dough Mixer Based Internet of Thing. 5th FIRST T1 T2 2021 International Conference (FIRST-T1-T2 2021),