Library Locker Security System with Integrated RFID, Dual Camera Monitoring, and Telegram Notification

Mario Fazero Siregar
Teknik Elektro
Universitas Islam Negeri Sultan Syarif Kasim
Riau, Indonesia
12050512066@students.uin-suska.ac.id

Jufrizel
Teknik Elektro
Universitas Islam Negeri Sultan Syarif Kasim
Riau, Indonesia
Jufrizel@uin-suska.ac.id

Ahmad Faizal
Teknik Elektro
Universitas Islam Negeri Sultan Syarif Kasim
Riau, Indonesia
ahmad.faizal@uin-suska.ac.id

Hilman Zarory
Teknik Elektro
Universitas Islam Negeri Sultan Syarif Kasim
Riau, Indonesia
hilman.zarory@uin-suska.ac.id

Abstract- Libraries generally provide lockers for users to store their luggage. Lockers in general still use conventional security by using manual locks. Currently, UIN Suska Riau Central Library still uses conventional key security which is considered easy to duplicate, lose, and damage. The purpose of this research is to improve locker security for user convenience and security through a system integrated with RFID, dual camera monitoring, and telegram notification. This tool has a CRUD (Create, Read, Update, Delete) system embedded in the telegram application managed by the admin. Admin can register, delete, and monitor locker user activities. This tool can identify registered and unregistered RFID tags properly. When a registered user accesses the locker, the system will send a picture of the user and a message to the telegram. Meanwhile, when an unregistered user accesses the locker 3 times incorrectly, the device will send the user's picture and message to the telegram and an alarm will sound for 3 seconds as an indication of an attempted locker break-in. The speed of information notification from the Internet of Things system has a delay in sending images with stability in the range of 3 - 4 seconds with relatively strong internet provider speed stability.

Keywords— locker security, internet of things, RFID, dual camera monitoring, telegram

I. INTRODUCTION

A library is an educational facility that is one of the centers of information and knowledge [1]. Supporting learning requires good services for the convenience and safety of the users [2]. One of the services that need to be considered is storage, where storage places such as lockers are essential for library facilities. Along with current technological developments, some libraries in various universities in Indonesia have implemented locker security by utilizing Radio Frequency Identification (RFID) technology [3].

Lockers are facilities used to store items and are often found in public places such as libraries, tourist attractions, sports venues, and similar public locations [4]. In terms of its function, lockers should be equipped with a high level of security to provide adequate protection for its users [5]. Lockers in general still use conventional key security, where the security is considered to have relatively low security, its use is also less effective in ensuring the security of goods in the locker. This is evidenced by one the facts that conventional security using manual keys can be easily duplicated, easily damaged, and even there is a chance of losing the key [6].

RFID (Radio Frequency Identification) is an identification technology by utilizes radio wave frequency emission [7]. RFID consists of RFID tags and RFID readers [8]. RFID technology has unique data integrity so it is difficult to counterfeit [9]. Therefore, the utilization of RFID technology is suitable for use as a locker key security replacing conventional keys because it has high security and is easy to use [10].

Based on the results of observations and interviews with the Central Library Staff of Sultan Syarif Kasim Riau State Islamic University, the lockers in the Central Library of Uin Suska Riau still use manual key security, which is considered to have relatively low

security. The use of the manual key, allows students to be less careful in using the locker. Based on these problems, a manual key replacement system is needed to improve locker security at the Uin Suska Riau Central Library.

Several previous studies have been conducted on the use of digital-based locks. One of them is research on automatic lock systems using RFID conducted by researchers [11][12][13]. In this study, the lock will automatically open and close when the RFID tag detected by the RFID reader matches the registered one. Another related research is the Security System on Internet of Things-Based Lockers conducted by Researchers [14]. The lock can be opened automatically through an Android application with 4-digit PIN verification at a distance of 15 meters and the average notification delivery time for 23.52 seconds. Further research on the use of cameras as locker security was conducted by researchers [15][16][17]. Locker users must do face scanning to access the locker whose results are stored in the database, when the detected face is appropriate, the locker will open and if it is not appropriate locker access will be denied.

The following related research on the design of a safe security system using RFID with an e-ID card as a tag and monitoring with IOT-based ESP 32 Cam with Telegram notification conducted by researchers [18]. the working principle of the tool is that when the e-ID card detected by the RFID reader matches the one that has been registered, the selenoid door lock will retreat and the ESP 32 cam will take pictures and send notification messages to the telegram. When the e-KTP detected by the RFID reader is wrong, the alarm will sound and a notification message will be sent to the telegram. When an object is detected in front of the safe, the pir sensor will activate and the ES 32 cam will take a picture and send it directly to the telegram.

Based on the description of the problems above, a Library Locker Security System through an Integrated RFID system, Dual Camera Monitoring, and Telegram Notification is carried out. The goal is to increase locker security for the safety and comfort of the library users and develop the design results that have been done by previous researchers. This tool uses the CRUD (Create, Read, Update, and Delete) system, where users must request RFID tags from the library admin to use the lockers. The admin registers the RFID tag using the Telegram application so that users can use the lockers. When the registered RFID tag is read by the RFID reader. The LCD will display the RFID tag ID, and the number of the open locker, and the ESP 32 CAM takes a picture and sends a message to Telegram. When the RFID tag is detected incorrectly 3 times, the alarm will sound for 3 seconds and the ESP32 CAM takes a picture and sends a message to the telegram. Admin can delete registered RFID tag IDs and monitor empty lockers via Telegram. This tool uses Wemos D1 R32 as the main control of the system because it can be integrated with the Internet of Things so that the system can be integrated into the Telegram platform. Telegram is an open-source messaging platform centered on user security and confidentiality that provides an Application Programming Interface (API) to manage and monitor notifications on devices and computers [19].

II. RESEARCH METHODS

A. System Design

This design is carried out to describe the renewal of the security system for accessing lockers. The following is a design of the system design process.

Figure 1. System flow design

The picture above is a description of the solution offered to improve the security and comfort of locker users, where users borrow cards from the admin which are then registered by the admin through the telegram application. The registered card will be stored in the database to recognize the registered card. Once the card is registered, the user can access the locker with the card. When the card is scanned correctly the camera will take a picture and send it to the telegram. Conversely, if the card is scanned incorrectly 3 times, the camera will take a picture and send it to the telegram.

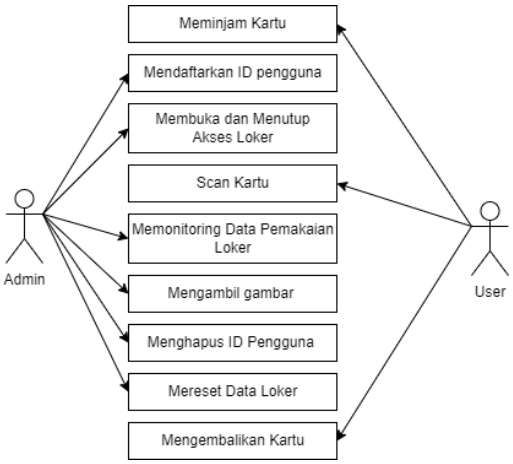


Figure 2. Locker loan diagram

Figure 2 shows the actors involved in the system, namely the admin and user. Admin access can register user IDs, open and close locker access, monitor locker usage, take pictures, delete user IDs, and reset locker data. The user access is to borrow a card from the admin, scan the card, and return the card.

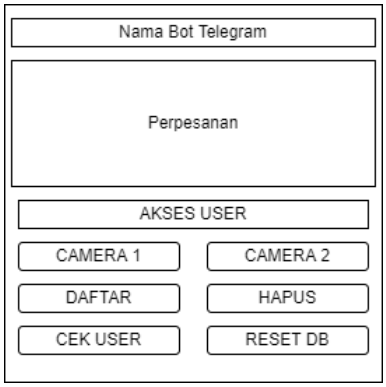


Figure 3. Locker loan display design

Telegram bot is built using the CRUD (Create, Read, Update, Delete) system so that the admin can add users, monitor locker usage, update usage data, and delete locker users. The uses of several menus designed in the telegram bot application include:

1. User Access serves to open and close locker access.
2. Camera 1 serves to monitor lockers by taking pictures from camera 1.
3. Camera 2 serves to monitor lockers by taking pictures from camera 2.
4. Register serves to register locker users into the database.
5. Delete is used to delete the registered locker user ID.
6. Check User is used to monitor lockers that have been filled.
7. Reset DB is used to restart the database and return to its original state without any registered ID.

B. Hardware Design

This design includes 3 main parts, namely input, process, and output, which represent the workings of the system and the relationship between devices made in the design diagram. The hardware design diagram is shown in Figure 4.

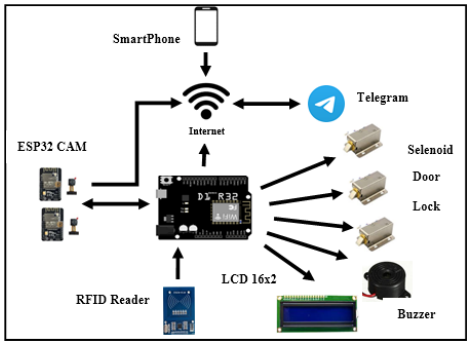


Figure 4. Tool system design

Based on the picture above, the way this tool works is the Wemos D1 R32 as the main control which has input from the RFID Reader in the form of an ID from an RFID card. The ID is processed and displayed on the 16x2 LCD in the form of ID and locker conditions. When the registered ID is correct, the Wemos D1 R32 requests data to ESP32 CAM 1 and 2 to take pictures and send images to Wemos D1 R32 via serial communication. Then one of the door lock selenoids opens, the buzzer sounds once and the message and image notification will be sent to the telegram.

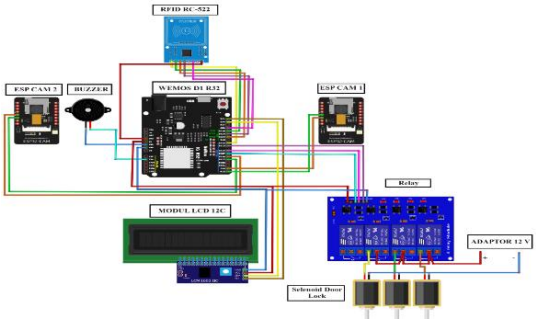


Figure 5. Schematic of the circuit

The picture above is a circuit scheme designed using the fritzing application. Fritzing is free software used to design electronic equipment [20]. Each component will be installed by the circuit scheme to work properly. The following is an explanation of the circuit scheme above:

1. Wemos D1 R32 is the brain of the system that can connect to the internet network.
2. RFID (Radio Frequency Identification) is the UID reader of the RFID card to access the locker.
3. ESP32 CAM as an image taker and sends images to Wemos D1 R32.
4. Relay as locking and opening the locker door.
5. Buzzer as an alarm when there is a locker break-in and a sign that the system is connected to the internet.
6. 16x2 I2C LCD module as an information display in the form of ID and locker condition.

C. Software Design

This design is made to design the performance of tools that will affect the operation of the system. The following is a software flow chart.

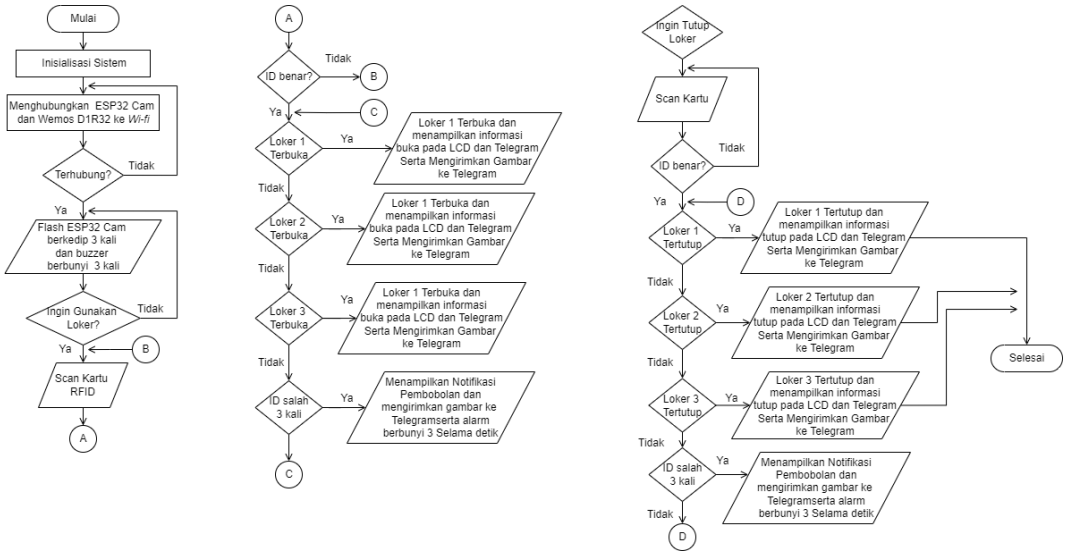


Figure 6. Software diagram

D. Mechanical Design

Mechanical design is needed in making a tool that aims to provide a design appearance and reference in designing prototypes. The results of the mechanical design include 3 lockers with each size 35x40x27.4 cm with a total height of 100 cm, 1 project

box measuring 20x10x10 cm, 1 ESP32 Cam support measuring 5x5x30 cm above the locker, and 1 ESP32 Cam support with a height of 1.7 m towards the side of the locker door. The application used in designing mechanics is SketchUp.

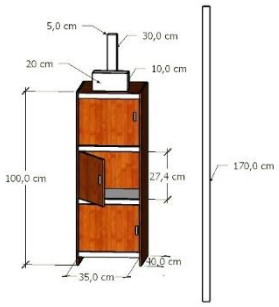


Figure 7. Tool design

III. RESULTS AND DISCUSSION

The results of the tests carried out by researchers are the development of the implementation of digitalization of locker access carried out by researchers [8], as well as tests carried out by researchers [12]. The tool development points of this research include:

1. The average delivery of notification time lag is faster than the researcher [8], which is shown in Table 2.
2. The use of the telegram application as a locker lending interface by using the CRUD system on the telegram bot is shown in Figure 9.
3. Changing the security system mode carried out by research [12], by adding a Dual Camera Monitoring system shown in Table 1.

All component needs such as Wemos D1 R32, RFID reader, buzzer, and 16x2 I2C LCD are installed in a project box so that the components are protected and can be implemented. The locker security prototype is shown in Figure 8.

Figure 8. Prototype locker security integrated with RFID, dual camera monitoring, and telegram notification

In Figure 8, it can be seen that at the top of the locker, there is a project box and a pole. The front of the project box has an RFID reader that functions to read RFID tags, a 16x2 I2C LCD as a viewer of locker user activity information, and a buzzer that functions as a sound notification. Behind the project box, there is a pole mounted with an ESP32 Cam that takes pictures from the front. Each locker has a selenoid door lock that functions as a locker lock. Beside the lockers, there is a pole with a height of 1.7 m installed with an ESP32 Cam which functions to take pictures from the side.

Figure 9. Locker loan display

The picture above is the result of the telegram bot implementation which consists of user access, camera 1, camera 2, list, delete, check user, and reset. The results of this telegram bot design are to improve access to the locker security system, where the admin can manage and monitor the locker usage process so that users get a sense of security and comfort for their luggage.

A. Admin Access Testing

This test is carried out to find out if the system design can run well. At this stage, testing the design that has been made is carried out, where the admin can register, monitor, and delete locker usage data through the Telegram application. The following is the configuration of the registration process in Telegram.

Figure 10. User card registration process

To operate the locker that has been created, the admin first connects the system installed in the locker with the modified telegram bot system by connecting to the internet and the admin sends a '/start' message to the telegram to start the system operation. After the '/start' message is sent, the admin can register users by clicking the 'register' icon on the menu provided. Where the admin sends the user ID to register the user's RFID tag card into the system. Then to make sure the ID is registered, the admin can click the 'Check User' icon and the telegram will automatically display the filled lockers along with the user ID.

Figure 11. User id deletion process

Figure 11 shows the process of deleting a user ID by sending a 'Delete' message. The delete message sent will give an automatic reply informing you to enter the user ID that you want to delete. Once the ID is entered correctly, the locker that was filled with the ID will return to an unfilled state, so that other users can use the locker. This delete message is used when the locker user has finished using the locker loan. While the 'Reset DB' message will delete the registered user ID without entering the user ID.

(a) Camera -1 (b) Camera -2

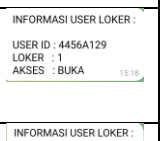
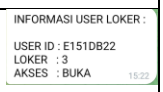
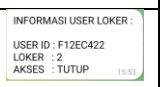
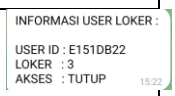
Figure 12. Admin access camera

Figure 12 shows the monitoring of lockers by taking pictures through the 'Camera 1' and 'Camera 2' features. The 'Camera 1' and 'Camera 2' commands are useful for admins to directly monitor lockers via telegram when there is a misuse of lockers used by users or there are processes that are not desired.

B. User Access Testing

This test is carried out to find out how the response of lockers that are integrated with the needs of the components used to the actions taken by users. This test includes users who use cards that are registered and not registered by the admin. Before using the locker, the user brings the RFID card given by the admin to be scanned to the RFID reader on the device. After the goods are put into the locker, the user closes the locker door again then the user brings the RFID tag back to be scanned again and the door is automatically closed. The test results of registered users are shown in Table 1.

Table 1. Registered User Testing Results

No	ID Kartu	Status ID	Status Loker	Notifikasi Gambar		Notifikasi Pesan
				ESP32 Cam -1	ESP32 Cam -2	
1	4456A129	Terdaftar	Loker 1 Terbuka			
2	F12EC422	Terdaftar	Loker 2 Terbuka			
3	E151DB22	Terdaftar	Loker 3 Terbuka			
4	4456A129	Terdaftar	Loker 1 Tertutup			
5	F12EC422	Terdaftar	Loker 2 Tertutup			
6	E151DB22	Terdaftar	Loker 3 Tertutup			

In Table 1, it can be seen that when the user scans the RFID tag with the ID registered by the admin, the locker door can be opened and the locker access notification is sent directly to the telegram in the form of image notifications and message notifications. The image notification sent to the telegram has 2 sides of the image, where one side points to the user's face and the other side points to the locker cabinet. The results of the unregistered user test can be seen in Figure 13.

(a) Camera -1 (b) Camera -2 (c) Break-in message

Figure 13. Unregistered users

Figure 13 shows the image and message notifications of locker break-ins. When a locker break-in occurs, where an unregistered ID is detected 3 times, the ESP32 Cam -1 and ESP32 Cam -2 will take a picture which is then sent to a telegram and send a break-in message. In addition, the buzzer will sound for 3 seconds indicating the locker break-in.

C. Internet of Things Notification Speed Testing

This test was conducted to find out how the response to sending image notifications received by telegram. Testing is done by bringing the RFID tag closer to the RFID reader for 10 trials. The results of the Internet of things notification speed test can be seen in Table 2.

Table 2. Testing the Speed of Internet of Things Notifications

Percobaan Ke-	**Unduh (Mbps)**	**Unggah (Mbps)**	**Delay (Detik)**		**Notifikasi Telegram**	
			Cam -1	**Cam -2**	**Cam -1**	**Cam -2**
1	29.4	10.8	4	4	√	√
2	29.4	10.8	4	3	√	√
3	29.4	10.8	3	4	√	√
4	29.4	10.8	4	4	√	√
5	29.4	10.8	3	4	√	√
6	29.4	10.8	3	3	√	√
7	29.4	10.8	3	3	√	√
8	29.4	10.8	4	3	√	√
9	29.4	10.8	4	4	√	√
10	29.4	10.8	3	4	√	√
Rata – Rata Delay			3.5	3.6		

Based on the above tests, the delay time required until the telegram receives the image notification is above 3 seconds for both camera 1 and camera 2. However, the door can be opened immediately when the correct RFID tag is detected by the RFID reader and also the message notification can be sent directly to the telegram application. The stability of the delay in sending image notifications is in the range of 3 to 4 seconds in each experiment. This is influenced by the stability of the internet access speed used. To maintain the stability of the delay in sending image notifications quickly, an internet connection with good speed and limited connections is needed.

IV. CONCLUSION

From the test results and analysis that has been done, the locker security system can work well. The reading of RFID tags that have been registered by the admin can be identified by the system properly, besides that when a registered user accesses the locker, the system will send a picture of the user and a message to the telegram. Locker break-in attempts can also be identified, when an unregistered ID is detected 3 times, the system will send a picture and message to the telegram and an alarm sounds for 3 seconds. The speed of notification of Internet of Things information in the telegram application also runs well as evidenced by several experiments. Image delivery delay has a stable time range of 3-4 seconds with relatively good internet provider speed. The CRUD (Create, Read, Delete, Update) system in the telegram application can work well, as evidenced by the admin registering and deleting user IDs and monitoring locker usage activities. Based on these results, the tool can be declared as one of the latest alternatives for managing locker security with a system that is integrated with RFID, Dual Camera Monitoring, and Telegram Notifications.

REFERENCES

[1] M. R. Adhitama and I. G. E. W. Putra, "Analisis Pembacaan dan Penulisan Data Buku Menggunakan RFID Mifare RC-522 untuk Perpustakaan," *Jurnal Sistem dan Informatika (JSI)*, vol. 14, no. 1, pp. 23–34, Nov. 2019, doi: 10.30864/jsi.v14i1.228.

[2] D. Nusyirwan and R. T. Putra, "Proses Desain Rekayasa Pada Perancangan Purwarupa Loper Id (Locker Penyimpanan Berbasis RFID) Dalam Menunjang Sistem Keamanan Perpustakaan," *Jurnal Teknologi dan Terapan Bisnis* , vol. 3, no. 1, pp. 1–12, 2020.

[3] R. Wulandari, V. Haristianti, and A. N. Syahida, "Elemen Smart Library pada Interior Perpustakaan Perguruan Tinggi," *Waca Cipta Ruang*, vol. 7, no. 1, pp. 27–37, May 2021, doi: 10.34010/wcr.v7i1.3999.

[4] Muhtar, "Prototipe Sistem Keamanan dan Pencegahan Virus Pada Loker dengan Menggunakan RFID Reader MCR522 Berbasis Arduino Mega2560," *Jurnal Ilmiah Sutet*, vol. 13, no. 1, pp. 60–71, Jul. 2023, doi: 10.33322/sutet.v13i1.1848.

[5] R. Sanjaya, "Sistem Keamanan Loker Menggunakan Biometrik Sidik Jari Berbasis Arduino," Universitas Islam Riau, Pekanbaru, 2019. [Online]. Available: https://repository.uir.ac.id/8659/%0Ahttps://repository.uir.ac.id/8659/1/133510079.pdf

[6] I. Komang, "Rancang Bangun Sistem Pengunci Loker Otomatis Dengan Kendali Akses Menggunakan Rfid Dan Sim 800L," *Jurnal Ilmiah Mahasiswa Kendali dan Listrik*, vol. 1, no. 1, pp. 33–41, 2020, doi: 10.33365/jimel.v1i1.187.

[7] M. Muthohir and Sendi Prayogi, "Prototype Sistem Keamanan Brankas Menggunakan Teknologi RFID Berbasis Arduino Uno," *Jurnal Manajemen Informatika & Teknologi* , vol. 1, no. 1, pp. 108–117, 2021, [Online]. Available: http://journal.stiestekom.ac.id/index.php/mifortekh

[8] Y. Tritularsih, Yohanes Sugiarto, Hizkia Urianto, and Aloysius Triyanto, "Purwarupa Sistem Keamanan Locker Laboratorium Berbasis Raspberry Pi Biometrik Dan RFID," *POLITEKNOSAINS*, vol. XIX, no. 1, pp. 28–35, 2020.

[9] Fauziah and Meta Meysawati, "Purwarupa Sistem Keamanan Portal Perumahan Menggunakan Rfid Berbasiskan Arduino Uno," *JUIT*, vol. 1, no. 2, pp. 23–40, 2022.

[10] A. Candra and F. Nurlaila, "Rancang Bangun Sistem Keamanan Loker Menggunakan RFID Berbasis Arduino Uno Pada Loker Karyawan SMK Yadika 2 Jakarta," *Bullet: Jurnal Multidisiplin Ilmu*, vol. 01, no. 4, pp. 713–720, 2022.

[11] G. Devira Ramady and R. Juliana, "Sistem Kunci Otomatis Menggunakan RFID Card Berbasis Mikrokontroler Arduino Uno R3," *Jurnal Isu Teknologi*, vol. 14, no. 1, pp. 28–32, 2019.

[12] F. Rozy and I. Fahruzi, "Sistem Pengaman Loker Menggunakan Smart Card PN532 RFID/NFC," *Jurnal Integrasi* , vol. 14, no. 2, pp. 114–121, 2022.

[13] R. H. Orbia, Raden Deiny Mardian, and Lydia Sari, "Rancang Bangun Kunci Loker Otomatis Berbasis Raspberry Pi Dan RFID Untuk Meningkatkan Efisiensi Waktu," *Jurnal Pendidikan Teknik Elektro Undiksha*, vol. 9, no. 3, pp. 151–160, 2020.

[14] F. Fajar Luthfi, D. Marisa Midyanti, and Suhardi, "Sistem Keamanan pada Loker Berbasis Internet of Things," *Jurnal Fokus Elektroda*, vol. 07, no. 03, pp. 200–206, 2022, [Online]. Available: https://elektroda.uho.ac.id/

[15] H. Agus Pradita and D. Durbin Hutagalung, "Sistem Pengenalan Wajah Sebagai Akses Loker Penyimpanan Barang Menggunakan ESP32-CAM (Studi Kasus: PT Bumi Nusantara Jaya)," *Jurnal Ilmu Komputer dan Science*, vol. 2, no. 5, pp. 1396–1404, 2023, [Online]. Available: https://journal.mediapublikasi.id/index.php/oktal

[16] W. Sulaeman, E. Alimudin, and A. Sumardiono, "Sistem Pengaman Loker Dengan Menggunakan Deteksi Wajah," *Journal Of Energy And Electrical Engineering (JEEE)*, vol. 3, no. 2, pp. 117–122, 2022.

[17] D. N. Diatma, Arif Sumardiono, and Erna Alimudin, "Sistem Keamanan Loker Arsip Menggunakan Metode Face Recognition," *Prosiding Seminar Nasional Wijayakusuma National Conference*, vol. 3, no. 1, pp. 116–123, 2022, [Online]. Available: https://proceeding.winco.cilacapkab.go.id/index.php/winco

[18] A. A. Ashar and Dwi Hadidjaja Rasjid Saputra, "Design and Build a Safe Security System Using RFID With e-KTP as a Tag and Monitoring With IoT-Based Esp32-

Cam With Telegram Notifications," *Indonesian Journal of Innovation Studies*, vol. 13, pp. 6–14, Jan. 2021, doi: 10.21070/ijins.v13i.527.

[19] F. Akbar, Putut Son Maria, Aulia Ullah, and Hilman Zarory, "Kunci Kelas Terjadwal Teknik Elektro UIN SUSKA Riau Berbasis RFID dan IoT," *Jurnal Sistem Cerdas*, vol. 06, no. 01, pp. 19–28, 2023.

[20] A. P. Ramadhan, Jufrizel, Putut Son Maria, and Hilman Zarory, "Prototipe Jemuran Pakaian Otomatis Menggunakan Wemos D1R2 Dengan Notifikasi Suara dan Email Dari Thinger.io," *Jurnal Sistem Cerdas*, vol. 05, no. 03, pp. 171–181, 2022.