Prototype of Cluster Housing Portal Security System Using Fingerprint and One Time Password Based on Internet of Things

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***Abstract*— Cluster housing is chosen by many people because of the security system is uses one gate system. However, the housing portal system that is often encountered still uses human labor and guest data recording is also still done manually. It often happens that the housing portal is always open, so that residents and non-residents can enter and exit the housing freely. Based on the existing problems, this research proposes an innovation, namely "Prototype of Cluster Housing Portal Security System Using Fingerprint and One Time Password Based on Internet of Things". Fingerprint is used for portal access by residents, while One Time Password (OTP) is used by guests to access the portal. The OTP is made through the citizen's website. The OTP will later be sent by residents to guests, so they can access the portal without having to have a security guard. All portal access data and guest data can be monitored through the security officer's website. The test parameters in this study are the accuracy of the fingerprint sensor, the suitability of the OTP code, the accuracy of the proximity sensor E18-D80NK, Quality of services (QoS), and the overall system test.**

***Keywords*—Portal Security Sistem, One Time Password (OTP), Fingerprint, Quality of Service.**

I. INTRODUCTION

Cluster Housing is chosen by many people because of the security system is using one gate system. However, the housing portal system that is often encountered still uses human labor and guest data recording is also still done manually [1]. Often happens that the housing portal is always open, so that residents and non-residents can enter and exit the housing freely.

Along with the development of technology, these problems can slowly be overcome. Currently, an automated housing portal system has been implemented using Radio Frequency Identification (RFID) technology such as [2] and [3]. Several studies have been carried out to improve housing security systems using RFID, including [2], [3] using fingerprints and [4] using QR Code.

However, the automated portal system that had been made before also still has a weakness because anyone who has a card, even if it is not a resident of a residential area, can access the portal. In addition, security officers are also still doing guest data collection manually [5].

Based on the existing problems, this research proposes an innovation, namely "Prototype of Cluster Housing Portal Security System Using Fingerprint and One Time Password Based on Internet of Things". Fingerprint is used for portal access by residents, while One Time Password (OTP) is used by guests to access the portal [6][7]. The OTP is made through the citizen's website. The OTP will later be sent by residents to guests, so they can access the portal without having to have a security guard. All portal access data and guest data can be monitored through the security officer's website [8]-[11].

This innovation is expected to be able to create a high-level security system in a residential environment as well as an effective step to ease the performance of security officers by implementing multifunctional technology [12][13].

II. METHOD

A. System Block Diagram

Systematically, the workings of the tools that the system runs are made in the form of a block diagram shown in Fig. 1. below:

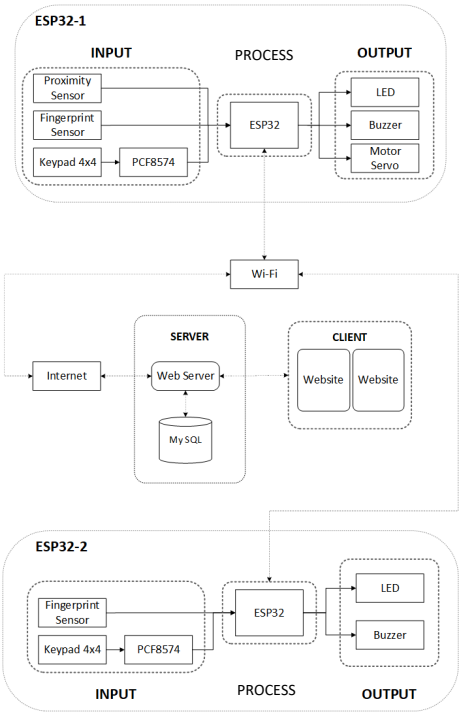


Figure. 1. System block diagram

In Fig. 1 the block diagram of the system will explain the work process of the system carried out during the study, the description of Fig. 1. is as follows: First is the input section. The input section consists of a fingerprint module, a 4x4 matrix keypad, and a proximity sensor. The fingerprint module is used for registration and fingerprint scanning of citizens. The 4x4 matrix keypad is used for guest OTP code input. Before connecting to the microcontroller, the 4x4 matrix keypad is first connected to PCF8574 which serves to summarize the 4x4 matrix keypad pins, so as to reduce the number of pins used on the microcontroller. Meanwhile, the proximity sensor is used to detect resident or guest vehicles passing through the housing portal. If the vehicle has passed through the portal, the portal will be closed again.

The second is part of the process. Data processing in this system uses an ESP32 microcontroller. ESP32 functions as the main component of the hardware to process input and output data coupled with the Wi-Fi communication that is already available in it that can connect to the internet network [14].

The third is the output section. The output section consists of a 16x2 LCD, servo motor, buzzer and LED. The 16x2 LCD is used as a display to display notifications to residents or guests of the results of fingerprint scanning and OTP code input. This system uses a servo motor as a portal driver. As an indicator, this system uses a buzzer and LED. The use of the buzzer is for a warning sound indicator if someone makes an error while scanning the fingerprint or inputting the OTP code three times. While the LED is used as an indicator of whether the housing portal is open or not.

B. *Mechanincal Design*

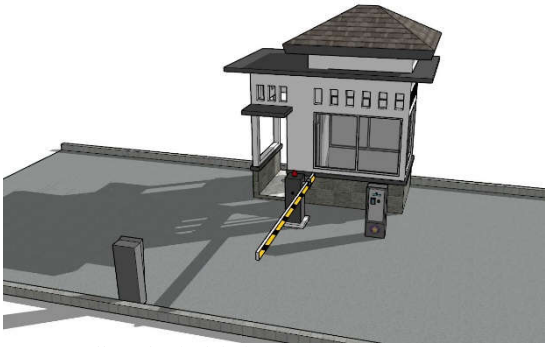


Figure. 2. Overall mechanical design

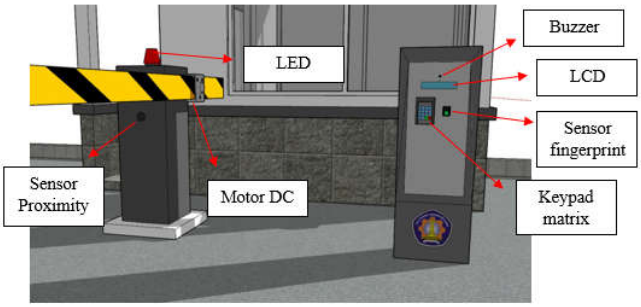


Figure. 3. Mechanical design close up

- Fingerprint sensor: Functions as a sensor to obtain scanning data in the form of fingerprints of residential residents.
- Keypad matrix: For push buttons in the form of numbers. In this study to input the OTP code by residential guests.
- Proximity sensor: Functions as a vehicle detection sensor that passes through the portal as well as a trigger to drive the servo motor.
- LCD: Serves as a display for the system.
- Servo motor: As an actuator for opening and closing the portal.
- Buzzer: As a warning when someone makes an error in inputting fingerprints and OTP 3 times.
- LED: As an indicator of opening and closing the portal

C. *Overall Scematic Design*

- Open Gate

The following is an overall electronic circuit of open gates that installed on ESP32 microcontroller.

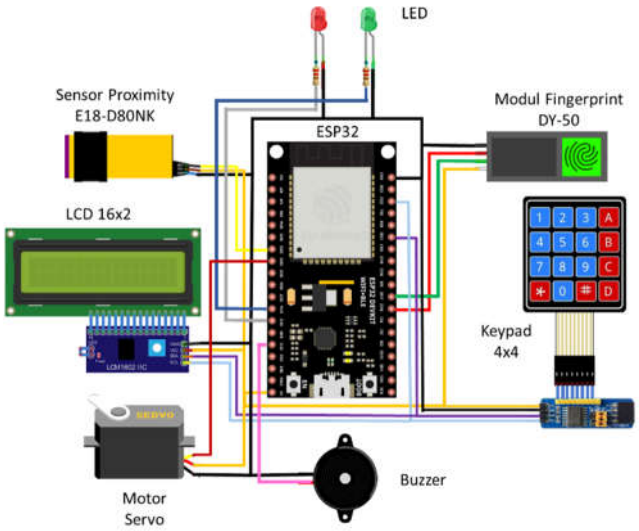


Figure. 4. Open gate circuit

Fig. 4. is an electrical design (open gate) that will be implemented. This open gate circuit is implemented for entry access. Servo motor portal and proximity sensor are connected with this open gate circuit.

TABLE I
CONNECTION PIN 1 OF ESP31 TO FINGERPRINT MODULE

ESP32 1 Pin	Modul Fingerprint Pin	Cable Color
GPIO16	TX	Red
GPIO17	RX	Green
VCC	VCC	Orange
GND	GND	Black

TABLE II
CONNECTION PIN 1 OF ESP31 TO PROXIMITY SENSOR MODULE

ESP32 1 Pin	Sensor Proximity Pin	Cable Color
GPIO32	DATA	Yellow
VCC	VCC	Orange
GND	GND	Black

TABLE III
CONNECTION PIN 1 OF ESP31 TO I2C PIN

ESP32 1 Pin	I2C Keypad Pin	Cable Color
GPIO21	SDA	Purple
GPIO22	SCL	Light blue
VCC	VCC	Orange
GND	GND	Black

TABLE IV
CONNECTION PIN 1 OF ESP31 TO MOTOR SERVO MODULE

ESP32 1 Pin	Motor Servo Pin	Cable Color
GPIO33	DATA	Brown
VCC	VCC	Orange
GND	GND	Black
GPIO21	SDA	Purple
GPIO22	SCL	Light blue
VCC	VCC	Orange
GND	GND	Black

TABLE V
CONNECTION PIN 1 OF ESP31 TO BUZZER MODULE

ESP32 1 Pin	Buzzer Pin	Cable Color
GPIO13	DATA	Pink
GND	GND	Black

TABLE VI
CONNECTION PIN 1 OF ESP31 TO RED LED MODULE

ESP32 1 Pin	Red LED Pin	Cable Color
GPIO12	DATA	Grey
GND	GND	Black

TABLE VII
CONNECTION ESP31 TO GREEN LED MODULE

ESP32 1 Pin	Green LED Pin	Cable Color
GPIO12	DATA	Dark blue
GND	GND	Black

- Close Gate

The following is a complete electronic circuit of close gates installed on the ESP32 microcontroller.

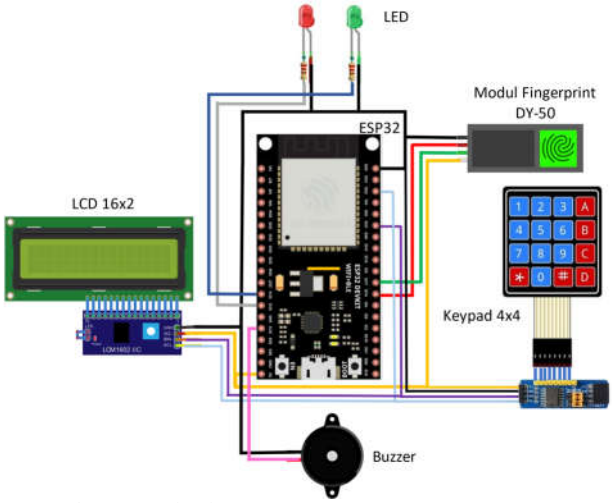


Figure. 5. Close Gate Circuit

Fig. 5. is an electrical design (close gate) that will be implemented. This close gate circuit is implemented for exit access. Servo motor portal and proximity sensor are not connected to close gate circuit.

TABLE VIII
CONNECTION PIN 2 OF ESP31 TO FINGERPRINT MODULE

ESP32 2 Pin	Modul Fingerprint Pin	Cable Color
GPIO16	TX	Red
GPIO17	RX	Green
VCC	VCC	Orange
GND	GND	Black

TABLE IX
CONNECTION PIN 2 OF ESP31 TO KEYPAD PIN

ESP32 2 Pin	I2C Keypad Pin	Cable Color
GPIO21	SDA	Purple
GPIO22	SCL	Light blue
VCC	VCC	Orange
GND	GND	Black

TABLE X
CONNECTION PIN 2 OF ESP31 TO LCD MODULE

ESP32 2 Pin	I2C LCD Pin	Cable Color
GPIO21	SDA	Purple
GPIO22	SCL	Light blue
VCC	VCC	Orange
GND	GND	Black

TABLE XI
CONNECTION PIN 2 OF ESP31 TO BUZZER MODULE

ESP32 2 Pin	Buzzer Pin	Cable Color
GPIO13	DATA	Pink
GND	GND	Black

TABLE XII
CONNECTION PIN 2 OF ESP31 TO RED LED MODULE

ESP32 2 Pin	Red LED Pin	Cable Color
GPIO12	DATA	Grey
GND	GND	Black

TABLE XIII
CONNECTION PIN 2 OF ESP31 TO GREEN LED MODULE

ESP32 2 Pin	Green LED Pin	Cable Color
GPIO12	DATA	Dark blue
GND	GND	Black

III. RESULT AND DISCUSSION

A. Result of Product

1. Mechanical Implementation Result

Figure. 6. Mechanical Implementation Result

The mechanical prototype uses solid wood and plywood with a thickness of 1.5 cm, a length of 100 cm, and a width of 50 cm as the main materials. For the portal access box, use a plastic box measuring 18 cm high, 11 cm wide, and 6 cm thick

2. Hardware Implementation Result

Fig. 7. shows the contents of the access box which is an implementation of Fig. 4. The circuit is an overall open gate circuit where the proximity sensor and servo motor are connected

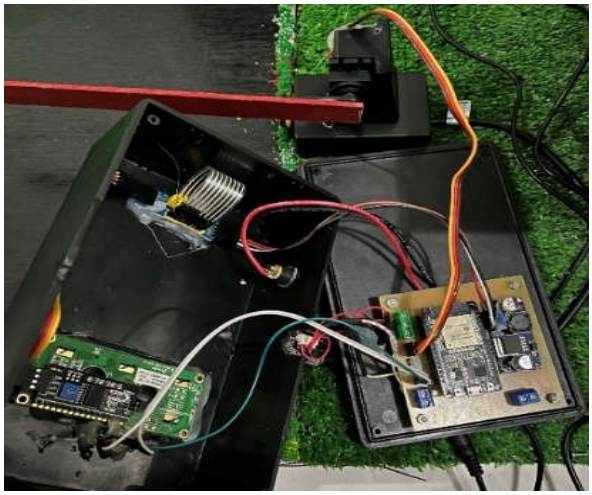


Figure. 7. Hardware Implementation Result

3. Software Implementation Result

Figure. 8. Software Implementation Result

The picture above is the result of the implementation of the website. There are 3 login options, there are Guest, Guard, and Resident.

B. Fingerprint Sensor Accuracy Test Result

The fingerprint module accuracy test aims to determine whether the fingerprint module used can record and read the user's fingerprint properly. The testing result is shows in the table XIV.

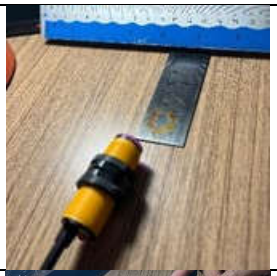
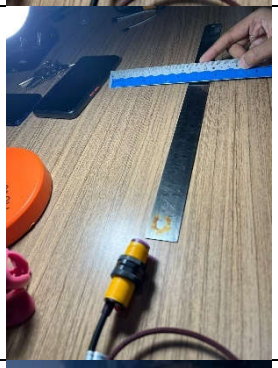
C. Proximity Sensor Accuracy Test Result

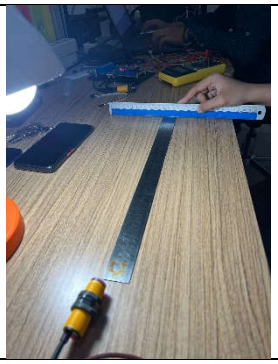
Proximity sensor accuracy testing aims to determine whether the proximity sensor is able to detect objects properly. This test is carried out with a comparison system between the proximity sensor and a ruler. The testing result is shows in the table XV:

TABLE XIV
ACCURACY TEST OF FINGERPRINT MODULE

No	Finger	Status	Detection	Description
1	Right thumb	Registered	Detected	Hand A
2	Right index finger	Registered	Detected	Hand A
3	Right middle finger	Registered	Detected	Hand A
4	Right ring finger	Registered	Detected	Hand A
5	Right pinky	Registered	Detected	Hand A
6	Right thumb	Not registered	Not detected	Hand B
7	Right index finger	Not registered	Not detected	Hand B
8	Right middle finger	Not registered	Not detected	Hand B
9	Right ring finger	Not registered	Not detected	Hand B
10	Right pinky	Not registered	Not detected	Hand B

TABLE XV
ACCURACY TEST OF PROXIMITY MODULE

No	Distance	Condition	Image
1	8 cm	Detected	
2	16 cm	Detected	
3	24 cm	Detected	
4	32 cm	Detected	

No	Distance	Condition	Image
5	40 cm	Detected	

D. OTP Conformity Test Results

Testing the suitability of the OTP aims to determine whether the process of sending the OTP is running well and whether the OTP inputted by the "guest user" via the 4x4 matrix keypad matches the OTP sent by the "citizen user". The testing result is shows in the table bellow:

TABLE XVI
ACCURACY TEST OF OTP

OTP	Result	Image
Enter: 232799 Exit: 709893	Succeed	The display of the citizen website when receiving a guest request.  The display of the guest website when it has been received by the citizen and gets the OTP.  Input OTP that has been received before on hardware (access box) 
		If the OTP is correct, the portal opens 

E. Quality of Service (QoS) Testing Result

- Throughput

Throughput testing is to test the effective data transfer rate, which is measured in bps (bits per second). Testing is done using the Wireshark application.

$$\text{Throughput} = \frac{Accepted\ Packet\ Data}{Lobservation\ time} \quad (1a)$$

$$\frac{208300\ \text{Bytes}}{11{,}582\ \text{s}} \quad (1b)$$

$$17.984{,}804\ \text{Bytes/s} \quad (1c)$$

$$17{,}984\ \text{KB/s} \quad (1d)$$

Because throughput is measured in bps (bits per second), then from KiloBytes/s it is converted into Kilobit/s units. The calculations are as follows:

$$\text{Throughput} = \frac{Accepted\ Packet\ Data}{Lobservation\ time} \quad (2a)$$

$$= 17{,}984\ \text{KB/s} \times 8 \quad (2b)$$

$$= 143{,}872\ \text{Kb/s} \quad (2c)$$

$$= 144\ \text{Kb/s} \quad (2d)$$

- Packet Loss

Packet loss testing aims to determine the percentage of the total number of lost packets that can occur due to collision and congestion on the network. Testing is carried out using the Wireshark application.

$$\text{Packet loss} = \frac{data\ packet\ sent - packet\ data\ accepted}{data\ packet\ sent} \times 100\% \quad (3a)$$

$$= \frac{7361 - (7361-2)}{7361} \times 100\% \quad (3b)$$

$$= \frac{7361 - 7359}{7361} \times 100\% \quad (3c)$$

$$= \frac{2}{7361} \times 100\% \quad (3d)$$

$$= 0.0002717 \times 100\% \quad (3e)$$

$$= 0.02717\% \quad (3f)$$

TABLE XVI
PACKET LOSS MEASUREMENT

No	Packet Send	Packet Received	Packet Loss	Packet Loss (%)
1	7361	7359	2	0.02717
2	289	288	1	0.34602
3	169	169	0	0
4	205	200	5	2.43902
5	390	383	7	1.79487
6	764	760	4	0.52356
7	923	915	8	0.86673
8	578	575	3	0.51903
9	432	428	4	0.92592
10	527	520	7	1.32827
Average				0.87705

Based on the calculations that have been carried out, it can be concluded that the packet loss of the network used is in the good category.

- Delay

Delay (latency) testing aims to determine the time it takes for data to travel the distance from origin to destination.

TABLE XVII
DELAY MEASUREMENT

No.	Source	Destination	Time 1 (s)	Time 2 (s)	Delay (s)
1.	172.20.10.13	172.20.10.9	0,000000	0,005986	0,005986
2.	172.20.10.13	172.20.10.9	0,005986	0,007519	0,001533
3	172.20.10.13	172.20.10.9	0,007519	0,013238	0,005719
4	172.20.10.13	172.20.10.9	0,013238	0,014328	0,00109
5	172.20.10.13	172.20.10.9	0,014328	0,017283	0,002955
6	172.20.10.13	172.20.10.9	0,017283	0,031334	0,014051
7	172.20.10.13	172.20.10.9	0,031334	0,038603	0,007269
8	172.20.10.13	172.20.10.9	0,038603	0,058516	0,019913
9	172.20.10.13	172.20.10.9	0,058516	0,068235	0,009719
10	172.20.10.13	172.20.10.9	0,068235	0,071232	0,002997
11	172.20.10.13	172.20.10.9	0,071232	0,095217	0,023985
12	172.20.10.13	172.20.10.9	0,095217	0,102090	0,006873
13	172.20.10.13	172.20.10.9	0,102090	0,104692	0,002602
14	172.20.10.13	172.20.10.9	0,104692	0,136396	0,031704
15	172.20.10.13	172.20.10.9	0,136396	0,142915	0,006519
16	172.20.10.13	172.20.10.9	0,142915	0,147922	0,005007
17	172.20.10.13	172.20.10.9	0,147922	0,149533	0,001611
18	172.20.10.13	172.20.10.9	0,149533	0,155394	0,005861
19	172.20.10.13	172.20.10.9	0,155394	0,156955	0,001561
20	172.20.10.13	172.20.10.9	0,156955	0,160414	0,003459
		Average			0.012521

From the results of these calculations, it is obtained that the average delay that occurs is 0.012521 s or 12.521 ms. Based on the results of calculations that have been carried out, it can be concluded that the quality of the network used is included in the very good latency category because <150ms.

IV. CONCLUSION

From the results of testing the accuracy of the fingerprint module, the implementation of fingerprint as a residential portal security system can run well because the fingerprint module used can record and detect user fingerprints properly. From the results of testing the suitability of the OTP, the implementation of the OTP as a housing portal security system can run well because the OTP in the software and hardware is well synchronized. From the results of testing the accuracy of the proximity sensor, the proximity sensor which functions as a vehicle detector can detect objects properly at a minimum distance of 0 cm and a maximum distance of 40 cm. Websites for residents, guests, and officers with different main functions can be implemented properly as a user interface according to the design. Overall, the designed system was successfully implemented in the form of a prototype housing portal security system. From the Quality of Service testing, it was found that the throughput of 144 Kb/s was included in the very good category, the average of packet loss is 0.87705, that was included in the good category, and the average of delay is 0.012521 s, that was included in the very good category. For the next research, use the android application as a user interface to make it more flexible, use a separate webcam camera so that CCTV monitoring can be more optimal, and use raspberry pi as a microcontroller for faster data processing.

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