Smart Security System for Housing Using Website-Based MQTT

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***Abstract*— The housing security system is one of the aspects of implementing a security system in several house buildings which have several functions that work to secure assets in the building. The high rate of theft at home while outside. Then in residential areas it is difficult to carry out intense security. The number of security officers is still limited compared to the residential areas which must be monitored regularly. This study designed a "Smart Security System in Housing Using Website-Based MQTT". This system is equipped with PIR sensors, LDR, ACS 712, and limit switches that are placed in each house. PIR sensors are used to detect human movement, limit switches are used to detect open doors, and LDR sensors are used to automate outside lights when homeowners activate outdoor mode. The ACS 712 sensor functions to give a warning of an anomaly in current usage. Using ESP8266 as a controller that sends data to the online MQTT broker "broker.mqtt-dashboard.com" which is equipped with the cloud. Home owners website programming using Node-RED installed on Raspi. Likewise with the security guard website using Node-RED as a website design. In monitoring at the security guard, you can monitor the security of the doors in each house. The results of the accuracy of the PIR sensor are only able to detect movement at a distance of less than 400 cm. The LDR sensor used in outdoor lighting automation with a voltage limit value above 2.56 V detects no light intensity. The accuracy of the ACS 712 current sensor in house 1 is 95% and house 2 is 94%.**

***Keywords*— Home, MQTT, Node-RED, Residential Security**

I. INTRODUCTION

The security system, including housing, is one aspect of implementing a security system in several residential buildings which have several functions that work to secure assets in the building. The high rate of theft in households can be anticipated by using a more modern home security system, one of which is a smart home [1]. It's difficult to check the lights on/off when traveling. Sometimes it's a hassle for neighbors to leave their house keys so they can turn on and off the lights when they leave the house. Of course, it can pose a security risk and social burden [2]. Then, in residential areas, it is difficult to carry out intensive security. The number of security officers who are still limited compared to the area of housing that must be monitored often shoots officers while carrying out their work [3].

Many obstacles are faced in being able to carry out home surveillance when not at home. This includes housing security, which is also difficult to monitor regularly. In addition, the use of IoT is growing in a short time. This causes the involvement of many devices that are interconnected with sensors installed in the environment. So that the presence of many devices causes interoperability of each tool [4]. That way, it requires a protocol to handle interoperability issues and be able to handle requests from every device profile from every connected sensor or device. A protocol capable of dealing with this problem is the Message Queue Telemetry Transport (MQTT).

MQTT is a messaging protocol based on the OASIS standard that is often used in IoT. The MQTT protocol operates by consuming less energy than the HTTP protocol, MQTT has lower latency and is more dynamic than HTTP, and the MQTT server operates at lower data traffic, compared to HTTP which operates and consumes high data traffic [5]. The broker used in this study is an online and free broker using mqtt-dashboard.com, where the broker's address is "broker.mqtt-dashboard.com". By using a free broker, there is no additional security to secure the data and topics that are created. However, using the MQTT protocol in the IoT without implementing adequate security measures opens up a number of cybersecurity threats [6]. Furthermore, MQTT also has better performance for IoT than CoAP which must be a stable transmission [7].

Research related to the implementation of smart home security systems has been carried out by several researchers, including Rikki, Ratna, Dhea [8] designing an early detection system for theft and house fires using Global System for Mobile (GSM) technology to send messages to related parties and use the Arduino module as a control center. Research by David and Subodh [9] designed a smart housing monitoring system using the Thingspeak IoT platform using the MQTT protocol. Research by Banu Santoso [10] designed control and monitoring of electrical equipment in the house using wireless sensor and actuator network technology based on the zigbee protocol. Research by Putri and Thamrin [11] designed a smartphone-based home security system. Research by Anwar and Laith [12] designed a smart home automation system using a cloud-based security enhancement.

From the several studies that have been described, a "Smart Security System in Housing Using Website-Based MQTT" was designed. In this system, it is built by installing a Passive Infra Red (PIR) sensor to detect movement outside the house and a limit switch as an open door detection when the home owner is not at home. ACS712 current sensor, functions as a measure of anomaly in the use of lamp current. The LDR sensor functions as an outside light automation based on light intensity. Limit switch, functions as a current link when pressed which will be installed on the doors and windows of the house. The camera
that functions to monitor the situation around the house uses the ESP32-CAM.

By using Raspberry Pi as a server from every home system. The output of this system is a buzzer as an alarm if there is an indication of theft. ESP8266 module as a tool for data communication with the internet via WiFi media. The website here functions as a display of data results from sensor exits that can be seen, can turn on and off lights, open/close automatic doors in every house. In housing security monitoring, use the website as a data display to monitor. The data is taken from the door security sensor nodes in each house via the MQTT protocol. The last component is the utilization of continuous communication between the device connection and sensing data which is capable of storing and performing data analysis and is used to help humans [13].

Node-RED is a programming tool for connecting hardware devices in new ways. Node-RED provides a browser-based editor that makes it easy for users to connect flows using a wide range of nodes in the palette that can be applied immediately with one click. Node-RED is used in conjunction with Antares, MQTT and other platforms or protocols [14]. Node-RED uses node.js so it can run on a network or in the cloud. Node-RED consists of a Node.js-based runtime that points to a web browser to access the flow editor. Through the web browser, applications can be created by dragging the available nodes in the palette to the workspace and then creating a series. The application is then run by deploying back to its runtime [15].

II. METHOD

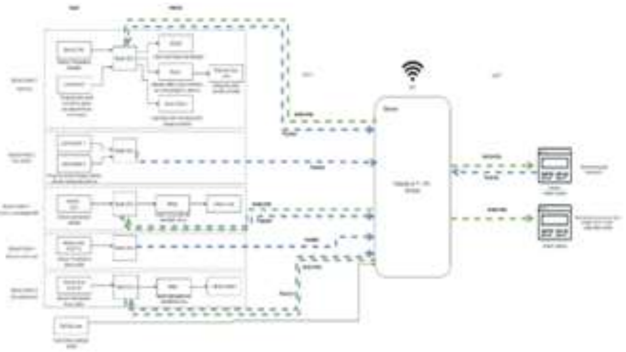

Figure 1. Smart Home Security System Block Diagram

A. *System Design (Hardware, Software, and Applications)*

Fig. 1 shows a block diagram of the system which is explained as follows: Raspberry Pi hardware that functions as a controlling system for processing data between input and output systems. PIR sensor: to detect the movement of people in front of doors and windows. ACS-712 Current Sensor: to detect an electric current. LDR sensor: to detect light. Camera: to monitor the situation around the house and catch suspicious objects. Limit Switch: as a current link when pressed which will be installed on the doors and windows of the house. Buzzer: as an alarm in case of theft and fire. Relay: as a switch that turns off and on the lights and door lock solenoid. Lights: as an indicator when there is a theft with flashing lights. Selenoid Door Lock: to lock and unlock the door. Servo Motor: as a door mover. MQTT Broker: managed cloud-native IoT data transmission platform makes IoT device connectivity.

B. *Smart Security System Architecture in Housing*

Fig. 2 show houses 1 and 2 have the same smart security system to monitor environmental conditions and house security through the website. In addition, it can control lights, door lock solenoids, and open, close doors. Published and subscribed data from each house is stored in a free online broker that is available in the cloud. In carrying out monitoring from security guards, receiving data (subscribe data) on door security at each house when the home owner is outside. Data obtained from the same online broker from houses 1 and 2. What is monitored by security guards is monitoring the detection of indications of theft from the door unit in each house.

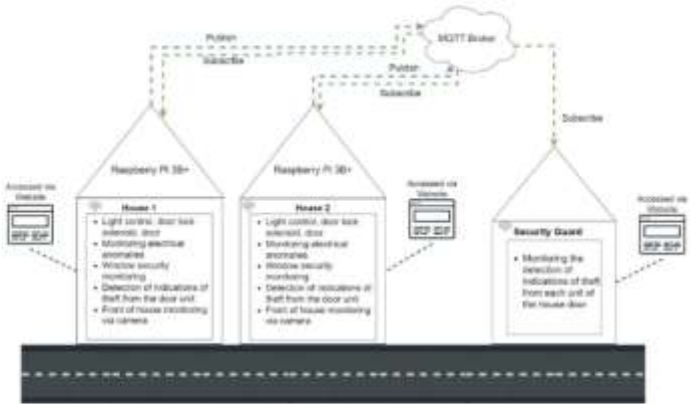

Figure 2. Smart Security System Architecture in Housing

C. *Security Website Software Flowchart*

The workings of this system are shown in Fig. 3, the following is an explanation of the system flowchart:

Prepare a laptop that has Node-RED installed and connected to WiFi. Run Node-RED on the laptop to access the Node-RED UI. Open in a browser by typing "http://localhost:1880/ui". Retrieves MQTT data in each home when enabling or disabling outdoor mode. If the home owner activates user mode outside the home, the security guard retrieves MQTT data from sensor node 1 (Door Unit) for each house that is activated, so the security guard can monitor each of these houses from the PIR sensor and limit switch. If the home owner does not activate the mode outside the home, the security guard cannot monitor the house. Finished.

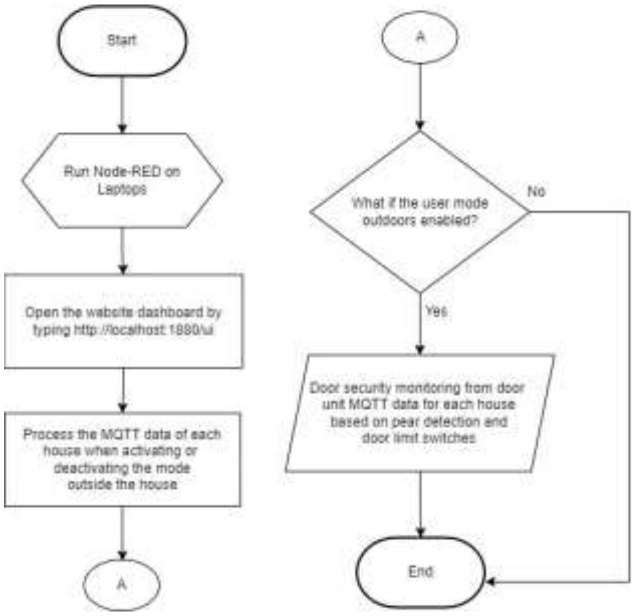

Figure 3. Security Website Software Flowchart

III. RESULTS AND DISCUSSION

The results of the system design are divided into two plans, namely hardware and software planning.

A. Hardware Design Results

The results of the hardware design include components in the box consisting of NodeMCU, ACS712 current sensor, relay, and DC power supply. While the components outside the box consist of limit switches, PIR sensors, LDR sensors, cameras, door lock solenoids, and servo motors as shown in Figure 4.

Figure 4. Components in the Box

Figure 5 depicts the component in the Cover Section Box. In addition, Figure 6 shows component in the house. Then, Figure 6 highlights Top View Component Layout.

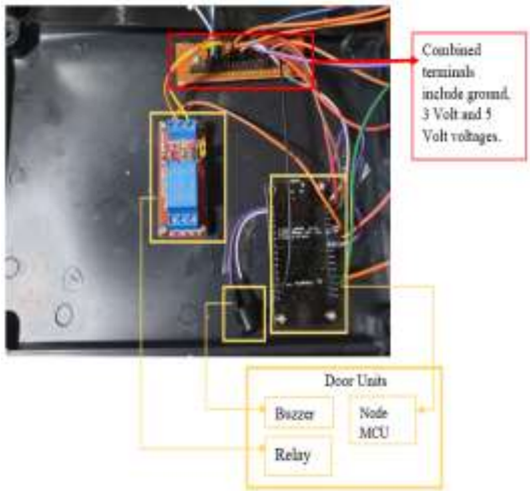

Figure 5. Components in the Cover Section Box

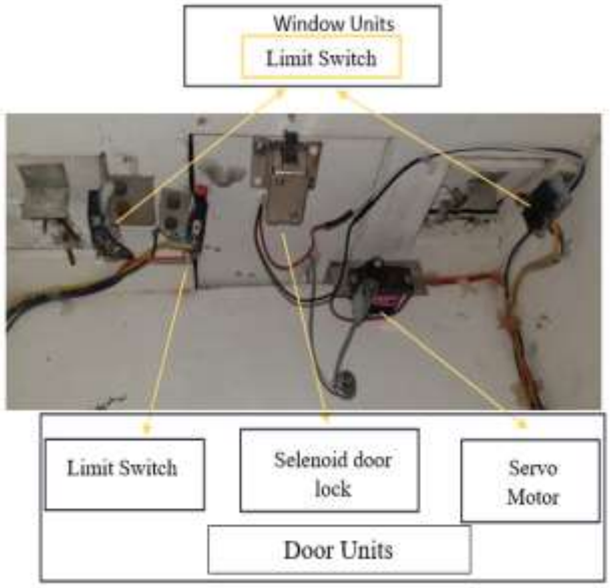

Figure 6. Components in the House

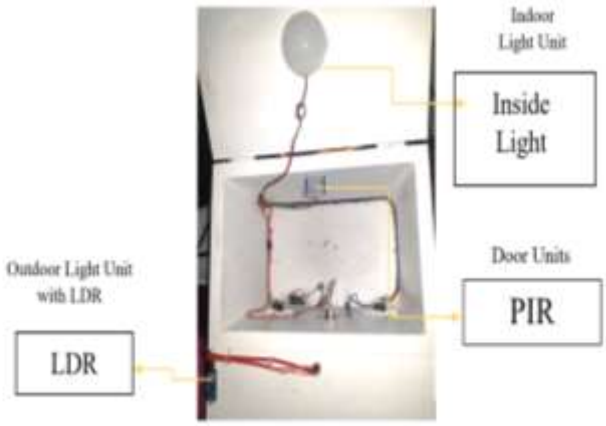

Figure 7. Top View Component Layout

The results of front vies component is depicted in Figure 8.

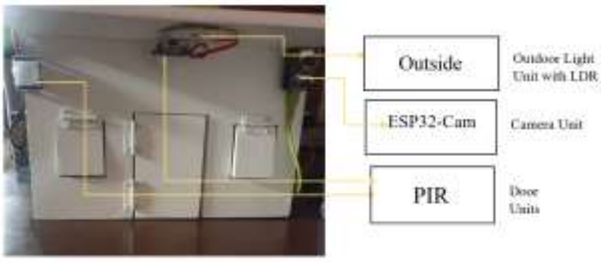

Figure 8. Front View Component Location

The result of the housing design consists of two houses of the same type. This housing concept is not fenced with a one-gate system, as shown in Figure 9.

Figure 9. Front View Housing Design Results

B. *Software Design Results*

The results of the software design for home users are shown in Fig. 10 and monitoring of security guards using Node-RED are shown in Fig. 12. Read MQTT data from NodeMCU and displayed on the Node-RED UI dashboard by adding the "mqtt in" node. Do the configuration, by writing the broker according to NodeMCU and the topic that will be displayed according to the subscribe section. Each "mqtt in" node is connected to a "debug" node to view the messages received.

Figure 10. Flow-Based Programming for Home Owner Websites

In house 2, the programming process at Node-RED is the same, but the difference is in the topics that are input on each "mqtt in" and "mqtt out" node. The results of the website interface design for each home user, as shown in the Figure 11.

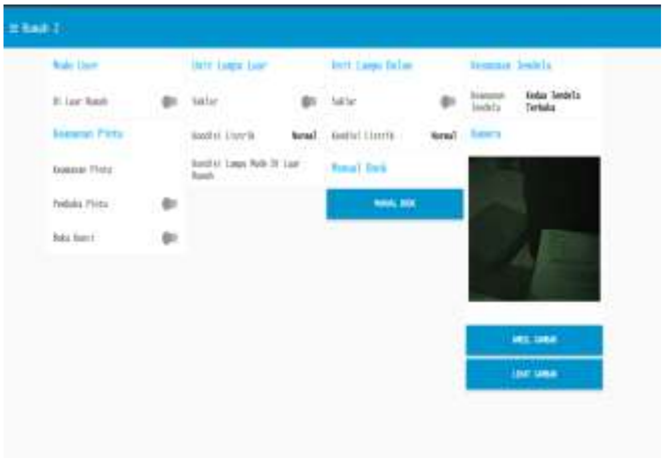

Figure 11. Website Views for Every Home

Programming flow for housing monitoring at security guards, by taking data from sensor node 1 for each house, namely the topic subscribed to "Unit Pintu" and "Unit Pintu_R2".

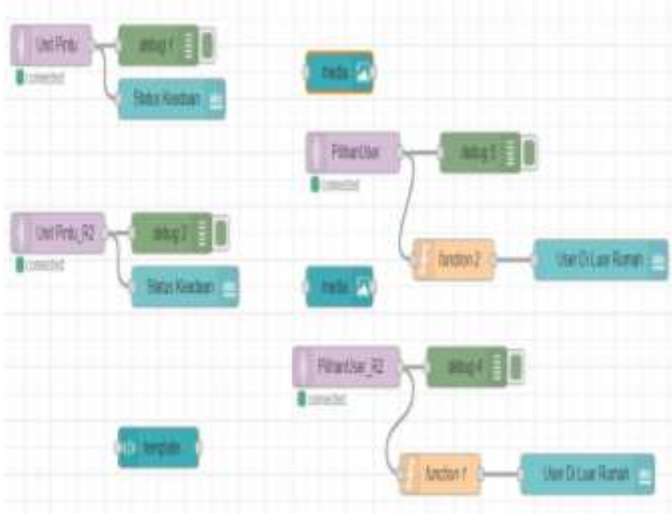

Figure 12. Flow-Based Programming for Security Websites

Monitoring for each house is taken from the detection of the PIR sensor or the door limit switch on the door unit when the user activates the mode outside the home. Then, create an "mqtt in" node for the topic subscribed to the Door Unit. Checking user mode is activated or not in each house, taken from the published topics "User Choice" and "User Choice_R2". The topic is inputted to the "mqtt in" node to find out whether the status of the home owner is active or not. If you activate outdoor mode, you can monitor the security of each house from PIR detection and door limit switches. The results of the website interface design on housing monitoring on security guards, as shown in the Figure 13.

Figure 13. Display Security Website

C. Component Testing

PIR sensor testing is used as a determinant of the maximum distance detected by motion. The pir testing procedure is to connect the pir sensor with NodeMCU. Next, use a ruler as a reference for the distance detected by the PIR if there is movement, as depicted in the Table I

TABLE I
PIR SENSOR TEST RESULTS

Measurement Manual (cm)	Testing to- 1	2	3
House 1			
5	Motion detected	Motion detected	Motion detected
50	Motion detected	Motion detected	Motion detected
100	Motion detected	Motion detected	Motion detected
150	Motion detected	Motion detected	Motion detected
200	Motion detected	Motion detected	Motion detected
250	Motion detected	Motion detected	Motion detected
300	Motion detected	Motion detected	Motion detected
350	Motion detected	Motion detected	Motion detected
400	Motion detected	Motion detected	Motion detected
450	Not detected	Not detected	Not detected
500	Not detected	Not detected	Not detected
House 2			
5	Motion detected	Motion detected	Motion detected
100	Motion detected	Motion detected	Motion detected
150	Motion detected	Motion detected	Motion detected
200	Motion detected	Motion detected	Motion detected
250	Motion detected	Motion detected	Motion detected
300	Motion detected	Motion detected	Motion detected
350	Motion detected	Motion detected	Motion detected
400	Motion detected	Motion detected	Motion detected
450	Not detected	Not detected	Not detected
500	Not detected	Not detected	Not detected

The results of the data obtained in Table 1 were obtained from testing the PIR circuit by themselves. The voltage that goes into the PIR is maximum, so the sensitivity of the PIR works well.

Testing the LDR sensor is used as a determinant of the minimum voltage limit to turn on the lamp. The LDR sensor testing procedure is based on morning, afternoon and night time. By changing the ADC value to the form of a voltage, it makes it easier to determine the intensity of the incoming light. Using a voltage scale of 0 – 3.3 Volts as a determinant of identifying light intensity, the greater the voltage, the smaller the light intensity, as shown in the Table II.

TABLE II
LDR SENSOR TEST RESULTS BASED ON TIME

Time	Testing to- 1 Voltage (volt)	Led	2 Voltage (volt)	Led	3 Voltage (volt)	Led
Home 1						
06.00	1.30	ON	1.18	ON	1.26	ON
07.00	0.81	ON	0.73	ON	0.79	ON
08.00	0.74	ON	0.62	ON	0.60	ON
09.00	0. 64	ON	0.58	ON	0.55	ON
10.00	0.50	ON	0.54	ON	0.48	ON
11.00	0.48	ON	0.35	ON	0.37	ON
12.00	0.36	ON	0.39	ON	0.25	ON
13.00	0.33	ON	0.37	ON	0.52	ON
14.00	0.53	ON	0.34	ON	0.51	ON
15.00	0.59	ON	0.44	ON	0.63	ON
16.00	0.83	ON	0.67	ON	0.70	ON
17.00	1.19	ON	1.07	ON	1.14	ON
18.00	2.85	OFF	2.56	ON	2.72	OFF
19.00	3.30	OFF	3.30	ON	3.30	OFF
Home 2						
06.00	1.33	ON	1.22	ON	1.25	ON
07.00	0.83	ON	0.75	ON	0.79	ON
08.00	0.74	ON	0.64	ON	0.59	ON
09.00	0. 67	ON	0.60	ON	0.55	ON
10.00	0.49	ON	0.52	ON	0.45	ON
11.00	0.48	ON	0.35	ON	0.37	ON
12.00	0.36	ON	0.39	ON	0.25	ON
13.00	0.33	ON	0.37	ON	0.52	ON
14.00	0.53	ON	0.34	ON	0.51	ON
15.00	0.59	ON	0.44	ON	0.63	ON

Time	Testing to-					
	1		2		3	
	Voltage (volt)	Led	Voltage (volt)	Led	Voltage (volt)	Led
16.00	0.83	ON	0.67	ON	0.70	ON
17.00	1.19	ON	1.07	ON	1.14	ON
18.00	2.90	OFF	2.66	OFF	2.70	OFF
19.00	3.30	OFF	3.30	OFF	3.30	OFF

Testing of house 1 and house 2 is measured based on the time from 06.00 – 19.00 WIB with a duration of three consecutive days and the voltage limit is above 2.5 Volts. The data above shows that at 06.00 - 17.00 WIB, the voltage value is less than 2.5 volts so the LED turns off. Conversely, at 18.00 and above, the voltage value is more than 2.5 volts, the LED lights up.

Testing the ACS 712 current sensor is used as an anomaly in the use of current. The procedure for testing the ACS 712 sensor using a 5 A current type. The tools used are a 12 V DC PSU, a digital avometer, a current sensor, a 5 watt and 15watt DC light bulb. When using 2 different light loads, the first light load is 5 watts and the second light load is 15 watts. When the program is run while the lights are off on both loads, the current value is 0A. From the experimental results, the ADC value and current at a load of 5 watts and 15 watts when the condition is on are shown in Table III.

TABLE III
ADC TEST RESULTS AT A LOAD OF 5 WATTS AND 15 WATTS

Light Load	Condition Lights On	
	ADC Value (x)	Current Value (y)
5 Watt	551,50	0,08A
15 Watt	562,50	0,30A

From the table above, a linear equation is made to determine the current value with the formula:

$$y = mx + c \quad (1)$$

The current value is for example the y value and the ADC value is for example the x value, enter it with the formula. Using the value when the condition of the lamp is on at 5 watts and 15 watts of light load.

$$y_1 = mx_1 + c$$
$$y_2 = mx_2 + c \quad -$$
$$y1 - y2 = mx1 - mx2$$
$$m = \frac{y1 - y2}{x1 - x2} \quad (2)$$
$$= \frac{0{,}08 - 0{,}30}{551{,}50 - 562{,}50}$$
$$= 0{,}02$$

The value of m, is entered in equation 1

$$y_1 = mx_1 + c$$
$$0{,}08 = 0{,}02(551{,}50) + c$$
$$c = -10{,}95$$

The current value equation is y = 0.02 – 10.95. This equation, for testing the DC current program.

The test results at home 1 are in accordance with Table IV showing the percentage of errors when the conditions are on and off at 5 and 15 watt light loads. This test is based on a series of lights individually.

TABLE IV
COMPARISON OF HOME CURRENT TESTING RESULTS 1

Testing to-	Lamp Condition	Test Results on Avometer Load 5 Watts	Test Results on Sensors Load 5 Watts	Error
1	OFF	0 A	0,00 A	0%
	ON	0,08 A	0,09A	12,5%
2	OFF	0 A	0 A	0%
	ON	0,08 A	0,06 A	25%
3	OFF	0 A	0 A	0%
	ON	0,08 A	0,08 A	0%
Testing to-	**Lamp Condition**	**Test Results on Avometer Load 15 Watts**	**Test Results on Sensors Load 15 Watts**	**Error**
1	OFF	0 A	0 A	0%
	ON	0,30 A	0,26 A	13,3%
2	OFF	0A	0 A	0%
	ON	0,32 A	0,34 A	6,25%
3	OFF	0 A	0 A	0%
	ON	0,30 A	0,30 A	0%

TABLE V
COMPARISON OF HOME CURRENT TESTING RESULTS 2

Testing to-	Lamp Condition	Test Results on Avometer Load 5 Watts	Test Results on Sensors Load 5 Watts	Difference	Error
1	OFF	0 A	0,00 A	0 A	0%
	ON	0,08 A	0,10A	0,02 A	25%
2	OFF	0 A	0 A	0 A	0%
	ON	0,08 A	0,07 A	0,01 A	12,5%
3	OFF	0 A	0 A	0 A	0%
	ON	0,08 A	0,08 A	0 A	0%
Testing to-	**Lamp Condition**	**Test Results on Avometer Load 15 Watts**	**Test Results on Sensors Load 15 Watts**	**Difference**	**Error**
1	OFF	0 A	0 A	0 A	0%
	ON	0,30 A	0,35 A	0,05 A	16,6%
2	OFF	0A	0 A	0 A	0%
	ON	0,30 A	0,36 A	0,4 A	13,3%
3	OFF	0 A	0 A	0 A	0%
	ON	0,30 A	0,30 A	0 A	0%

The average ACS 712 sensor error in house 1 is 5%, so that the sensor accuracy is 95%. Meanwhile, the average ACS 712 sensor error in house 2 is 6%, so the sensor accuracy is 94%, as shown in the Table V.

D. Publish/Subscribe Data Testing using MQTT

The following is the topic table on the mcu node as publisher and subscriber in house 1. The topic names used in house 1 and house 2 are different so as not to retrieve packet data from house 1 to house 2 or vice versa. By adding the character "_R2" to each topic in house 2 in Table VII. However, the function of each topic remains the same according to Table VI.

TABLE VI
TOPIC PUBLISHER AND SUBSCRIBER AT HOME 1

No	Publisher	Function	Subscriber	Function
1	User Choice	Activate door security through PIR detection or door limit switches with the buzzer on and turn on the outside light based on the LDR sensor when the message contains "1", namely user mode outside the home. The message contains "0" i.e. do not activate outdoor mode.	Door Units	Informs the door is open when movement is detected by the pear or triggers a limit switch to open the door when the user mode outside the home is activated
2	Light Relays 15 Watts	Controlling the outside light turns on when the message contains "1" and turns off when the message contains "0" with a note that the mode is not outside the home.	15Watt lamp LDR	Informs a message when the outside lights turn on based on the LDR sensor when the user mode outside the home is activated
3	Light Relays 5 Watts	Controlling the Inside light turns on when the message contains "1" and turns off when the message contains "0" with a note that the mode is not outside the home	Light Units Outside 15Watt	Informs the current on the outdoor lamp on or off condition.
4	RelayServo Door	Controlling the selenoid door lock to lock with a message containing "1" or not locking and controlling the servo to open the door with a message containing "3" and closing the door with a message containing "4" with a note that the mode is not outside the house.	Light Units Within 5 Watts	Informs the current on the lamp in the on or off condition.
5			UnitWindow	Informs the condition of the window open or closed based on the trigger from the limit switch

TABLE VII
TOPIC PUBLISHER AND SUBSCRIBER AT HOME 2

No	Publisher	Subscriber
1	User Choice_R2	Door Units _R2
2	Light Relays15 Watts _R2	15Watt lampLDR _R2
3	Light Relays5Watts2	Light Units Outside 15Watt _R2
4	RelayServoDoor_R2	LightUnitsWithin5Watts2
5		UnitWindow _R2

E. Test Results of Combined Hardware and Software Systems

Conduct tests on Houses 1 and 2 on hardware and software systems as well as monitoring systems for security guards.

1) The test scenario when the user mode outside the home is activated, serves to determine the door security function and the condition of the outside lights are on or not working properly. In this mode, it cannot control the indoor or outdoor lights, and cannot control the opening or closing of the door and locking or not locking the door. Test procedure when activating outdoor mode. In testing the PIR sensor by giving a hand movement in front of the door so that the buzzer sounds and on the website display the user informs the door security "Open Door". Then, test the LDR sensor by closing the ldr module by hand to turn on the outside lights automatically and inform the condition of the "Lamps On" light on the website.

TABLE VIII
HOME TESTING USER MODE OUTSIDE THE HOME

No	Test Scenario	Expected results	Result Status
1	Provides hand gestures on the PIR sensor from the front of the door	The website display on the door security shows the door is open and the buzzer sounds	Valid
2	Provides hand gestures on the PIR sensor from the front of the house	The website display on the door security shows the door is open and the buzzer sounds	Valid
3	Tidak memberikan gerakan tangan pada sensor PIR dari depan rumah atau depan pintu	The website display on the security door is empty and the buzzer does not ring	Valid
4	Covering the LDR module so that less light intensity is received	The condition of the external lights turns on automatically and provides information on the lights on the website	Valid
5	Provides a lot of light intensity on the LDR module	The external light condition turns off automatically and the	Valid

No	Test Scenario	Expected results	Result Status
6	Gives an order to turn on the light switch on the website	lamp condition information is blank. Cannot turn on indoor light when outdoors mode is activated	Valid

2) Furthermore, when the user mode outside the home is deactivated, the door opener test scenario when it is activated on the website, the solenoid opens and the servo actively moves the door open. The test results are shown in Table IX.

TABLE IX
HOME TESTING OPENS AND CLOSES DOORS

No	Test Scenario	Expected results	Result Status
1	Activate the door opener on the website	The door opens automatically	Valid
2	Did not activate the door opener on the website	The door closes automatically	Valid

3) Test scenario when activating the unlock, the selenoid door lock does not lock the door. The test results are shown in Table X.

TABLE X
HOME TEST OPENING AND CLOSING DOOR LOCKS

No	Test Scenario	Expected Results	Result Status
1	Enable unlock on the website	The relay is active and the selenoid does not lock the door	Valid
2	Disable unlock on websites	The relay is not active and the selenoid locks the door	Valid

4) Window unit test scenario by manually opening the window. The test results are shown in Table XI.

TABLE XI
HOUSE TESTING WINDOW UNIT

No	Test Scenario	Expected results	Result Status
1	The left and right windows are closed by window hinges	The window security information display on the website is "Window closed"	Valid
2	The left window opens and the right is closed by a window hinge	Window security information displays on the website, namely "Window opens"	Valid
3	The left and right windows open	Window security information displays on the website, namely "Window opens"	Valid

5) Scenario for testing the outdoor light unit by activating the switch, the outside light is on. The test results are shown in Table XII.

TABLE XII
HOME TESTING OUTSIDE LIGHT CONTROL

No	Test Scenario	Expected results	Result Status
1	Activate the switch	The relay is active and the outside light is on	Valid
2	Did not activate the switch	The relay is not active and the outside light is not on	Valid

6) Scenario of the electrical condition of outdoor lights when they are turned off and on. According to the ACS712 sensor accuracy test on the inside light, normal conditions are stated if the light is off, there is no incoming current or current = 0. Meanwhile, the normal condition for the light is on, when the current received is in accordance with the ACS712 sensor accuracy test, namely 0.30-0.40A. The test results are shown in Table XIII.

TABLE XIII
HOME TESTING OUTSIDE LIGHT CONTROL

No	Test Scenario	Expected results	Result Status
1	Activate the switch	The relay is active and the outside light is on	Valid
2	Activates the switch and publishes '0' message	The relay is active, the outside light is on, and the electrical condition is abnormal	Valid
3	Activates the switch and publishes message '1'	The relay is active, the outside light is on, and the electrical condition is abnormal	Valid
4	Did not activate the switch	The relay is off and the light is not on	Valid
5	Does not activate the switch and publishes message '0.3'	Does not activate the switch and publishes message '0.3'	Valid

7) Scenario for testing the inside light unit by activating the switch, the inside light is on. The test results are shown in Table XIV.

TABLE XIV
HOME TESTING INDOOR LIGHT CONTROL

No	Test Scenario	Expected results	Result Status
1	Activate the switch	The relay is active and the inside light is on	Valid
2	Did not activate the switch	The relay is not active and the interior light is off	Valid

8) Scenario of the electric condition of the inside light when it is turned off and on. According to the ACS712 sensor accuracy test on the inside light, normal conditions are stated if the light is off, there is no incoming current or current = 0. Meanwhile, the normal condition for the light is on, when the current received is in accordance with the ACS712 sensor accuracy test, namely 0.08-0.10A. The test results are shown in Table XV.

TABLE XV
HOUSE TESTING INSIDE LIGHT CURRENT ANOMALY

No	Test Scenario	Expected Results	Result Status
1	Activate the switch	The relay is active and the inside light is on	Valid
2	Activates the switch and publishes '0' message	The relay is active, the inside light is on, and the electrical condition is abnormal	Valid
3	Activates the switch and publishes the message '0.30'	The relay is active, the inside light is on, and the electrical condition is abnormal	Valid
4	Did not activate the switch	The relay is not active and the light is not on	Valid
5	Does not activate the switch and publishes message '1'	The relay is not active, the lamp is not lit, and the electrical condition is not normal	Valid

9) The camera test scenario, by checking the display on the website and the real one. The test results are shown in Table XVI.

TABLE XVI
HOME TESTING CAMERA

No	Test Scenario	Expected Results	Result Status
1	The camera streams	Streaming video results are in accordance with real	Valid

F. Residential Monitoring Test Results on Security Guards

Residential monitoring test results that match homeowner output. The test results are shown in Table XVII.

TABLE XVII
Residential Monitoring Test Results on Security Guards

No	Test Scenario	Expected Results	Result Status
1	Houses 1 and 2 activate outdoors mode. Haven't been given a move or opened the door.	The website display on the user's security guard outside the house shows that houses 1 and 2 are active. The status is empty because there is no motion detection from the pear or door opening detection from the limit switch.	Valid
2	Houses 1 and 2 activate outdoors mode. Then given the movement or opening the door in houses 1 and 2.	The website display on the user's security guard outside the house shows that houses 1 and 2 are active. The status when a motion is detected is "Movement", if the door is open is "Door Open".	Valid
3	House 1 does not activate outdoor mode and house 2 activates outdoor mode. Then given the movement or opening the door in houses 1 and 2.	The website display on the user's security guard outside the house shows that house 1 is not active and house 2 is active. The state of the state when a motion is detected or the door is open in house 1 is empty, while house 2 displays the status "Open Door" in house 2.	Valid
4	House 1 activates outdoor mode and house 2 does not activate outdoor mode. Then house 2 is given movement or opens the door and house 1 is not given movement or opens the door.	The appearance of the website on the user's security guard outside the house shows that house 1 is active and house 2 is not active. The state of the state when motion is detected or the door opens in house 2 is empty, while house 1 is not given movement or opens the door showing empty status.	Valid
5	Houses 1 and 2 do not have outdoor mode enabled. Then given a move or open the door.	The website display on the user's security guard outside the house shows that houses 1 and 2 are not active. The status is empty because the PIR and limit switches work when the outdoor mode is activated.	Valid

G. MQTT Test Results

The procedure for testing MQTT connectivity performance using the wireshark application in house 1 and house 2 three times. Each test at each house, the number of packets processed is 100 packets.

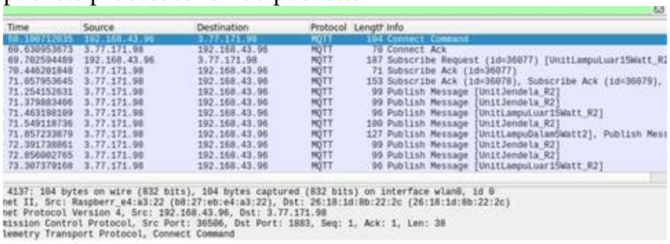

Figure 14. Delay Testing Results at Home Wireshark

Figure 14 shows the data display in wireshark. The easiest way to view MQTT data is to filter it by typing mqtt. The filtering results can be saved in .csv format which is then processed using the Microsoft Excel application. The results of the delay can be seen in the "Time delta from previous displayed frame" column. Then the 100 processed packets will be averaged. The test result for the house 1 is shown in Table XVIII

TABLE XVIII
Testing Delay on MQTT at Home 1

Testing to-	**IP Source**	**IP Destinantion**	**Delay (ms)**	**Category**
1	52.28.123.232	192.168.43.172	287	Good
2	52.28.123.232	192.168.43.172	248	Good
3	52.28.123.232	192.168.43.172	214	Good

The test results for the house 2 is shown in Table XIX.

TABLE XIX
Testing Delay on MQTT at Home 2

Testing to-	**IP Source**	**IP Destinantion**	**Delay (ms)**	**Category**
1	3.77.171.98	192.168.43.96	289	Good
2	3.77.171.98	192.168.43.96	236	Good

Testing to-	**IP Source**	**IP Destinantion**	**Delay (ms)**	**Category**
3	3.77.171.98	192.168.43.96	195	Good

The MQTT performance test results from Tables 9 and 10 are in the good category. In the application of the MQTT protocol, the smallest delay is obtained from house 2 of 195 ms due to the influence of a good internet network. While the biggest delay is in house 2 which is 289 ms. In addition, the delay parameter in this test can be affected by physical media distance and waiting time on the internet network.

IV. CONCLUSION

The conclusions of this study are as follows: The study presents a home security system with two modes: outdoor and at-home modes. In the outdoor mode, PIR sensors and limit switches on doors detect potential theft by sensing unusual movement or attempts to open doors, triggering a buzzer and lights. When deactivated, the homeowner can control lights, door opening/closing, and door locks, accessible solely through a website. A security monitoring website displays each house's outdoor mode activation status based on data from the door unit's online MQTT broker. Activation of outdoor mode triggers security information display on the security guard website. Each house has a dedicated website designed using Node-RED installed on Raspi, allowing homeowners to monitor sensor data sent from NodeMCU through MQTT subscription. The PIR sensor's accuracy is limited to detecting movement within 400 cm, while the LDR sensor controls outdoor lighting automation by detecting light intensity above 2.56 V. The ACS 712 current sensor's accuracy is 95% for house 1 and 94% for house 2. Communication performance between the controller and MQTT broker exhibits delays ranging from 195 to 289 ms, meeting TIPHON standards for good connectivity.

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