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To cite this article: Daniel Patricko Hutabarat *et al* 2018 *IOP Conf. Ser.: Earth Environ. Sci.* **195** 012065

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Development of home security system using ESP8266 and android smartphone as the monitoring tool

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Abstract. With the increasing number of homes being developed in Jakarta and surrounding area, a home security system is needed to prevent disruption to every home and residents especially when the number of crime increasing. With this system, residents are guaranteed security all the time either when residents are at home or outside the home. This paper demonstrates the implementation of home security system for homes using low cost and low power consumption wireless security systems. In this eco-friendly home security system, devices are installed in every home and will promptly notify residents and local security personnel during interruptions. The owner receives a Short Message Service (SMS) with a link to open the application installed in his /her android smartphone. The security guard also receives SMS with a link to open the map application to show the location of the house using its android smartphone. A 100% success rate of sending SMS and a 100% sensors functionality was proven through the experiment.

Keywords: Home security system, sensors, GSM module, android smartphone.

1. Introduction

The technology for home security system has evolved since the early 1900's and this technology are important features for modern home [1]. In the 1900s home security system was expensive and ineffective [2]. This was because the electronic devices still consume a lot of power and the price of the electronics was also expensive. In addition, communication system between devices was still using the cable so that the installation process was difficult and expensive. Today most home security systems use GSM [3-4] and Wi-Fi [5-6] technology for their communications systems. This technology benefits the home security system because it consumes less power, is low-cost and reliable [7]. In addition to wireless communication systems, home security systems are also developed using electronic devices such as smoke detector, sound detection, touch sensors, etc. [8]. This systems can also be used to secure banks, offices, residential areas, locker dan vehicles etc. [9-10]. In this paper, the research is focused to develop an eco-friendly home security system by using ESP8266. This ESP8266 module will reduce the cost and the power consumption of the system developed by reducing the use of wireless router as the connecting devices. This system also provides monitoring mechanism through android smartphone.



In this paper, the system was developed using wireless technology so that the system was safe, low-cost and easy to install. Each installed sensor will be connected to the local network via ESP8266 module that communicates with router. In areas near the main door are installed door system module using RFID, PIR sensor module, IP Camera and reed switch sensor module. Door sensor module aims to read the RFID card used by every occupant who will open the door of the house. Door can be opened when the RFID card attached to the RFID module is recognized by the system. If the RFID card is damaged, lost or left then residents will not be able to open the door. The PIR sensor module will detect the presence of a person standing or moving in front of the entrance. The system will then provide SMS notifications to other residents. The notification provided is an information requesting the user to access the application. Other residents can open the application and access the camera to see the person standing at the door of the house. If the person standing in front of the house is one of the residents of the house who does not have access to the RFID module then other residents who know it, can open the door remotely. If the entrance is broken the reed switch module installed on the door will ask the system to turn on the buzzer and provide SMS notification to the residents of the house and local security guard to open the monitoring system applications that have been installed on the android smartphone. Through the application, residents can find out the last position of the disturbance and see any camera installed inside or outside the house while the security officer can only access the map to find out the location of the house where the disturbance occurred.

Inside the house are placed some security modules and IP Cameras used to build home security system. In this research, the security modules are consist of controller module, door system module, PIR sensor module, reed switch module, gas sensor module, panic button module and IP camera. Controller module is placed on the wall near the entrance in the house. The purpose of this module is to receive input from each installed module and then provide output in the form of alarm, LED indicator, SMS notification and data to smartphone users in real time. In the controller module, there are keypad and LCD screen that is used to enter the password and choose the security mode. There are two security modes that can be chosen by the hosts, ON and Home mode. ON mode means that all security modules are active while Home mode means that all PIR sensor modules in the house are inactive. Door system module is a module used to handle security systems in the area around the entrance of the house. The PIR sensor module is a module designed to detect suspicious movements when no residents are at home. PIR sensor module is placed on the wall opposite the windows and doors to anticipate if there is an unauthorized person who made it into the house. Reed switch module is a module designed to detect unauthorized person trying to enter through windows or doors. This module is placed on every door and window of the house that can be opened. Gas sensor module is a module designed to detect gas leakage and placed on the kitchen wall close to the gas cylinder. Panic button module is a button module used by residents to turn alarms manually if the residents at home know there are unauthorized person who made it into the house. Panic button module is placed in each bedroom of its inhabitants.

2. Research Method

The proposed network design of the eco-friendly home security system is divided into two main parts, the home security system based on microcontrollers shown in Figure 1(a) and the monitoring system based on android smartphone shown in Figure 1(b). In the home security systems, there are six types of security modules connected to the controller module via Wi-Fi Router. The transmission of data from each security module to the controller module is done by using TCP and with different threads. While on the network monitoring system there are VPN Server, controller module and IP Camera that will communicate with android smartphone using VPN port forwarding method.

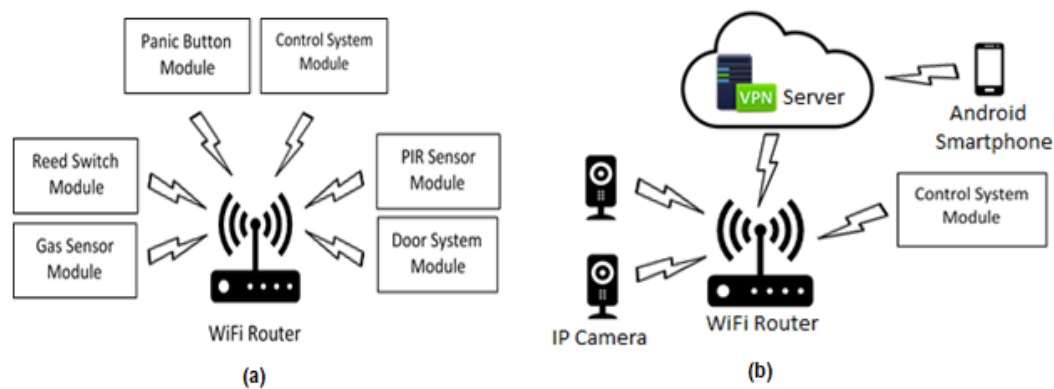


Figure1. (a) Local System, (b). Monitoring System

Block diagram of controller module can be seen in figure 2. Arduino Pro is used as microcontroller that process input and output. The keypad is used as input to enter a password or select the security mode to be activated. LCD, alarm 1 and alarm 2 are output from arduino pro. GSM module is a module connected serially with arduino pro and is also used as input / output to send or receive SMS. GSM module used is Simcom SIM900A while ESP8266 is used to connect wireless controller module to Wi-Fi router.

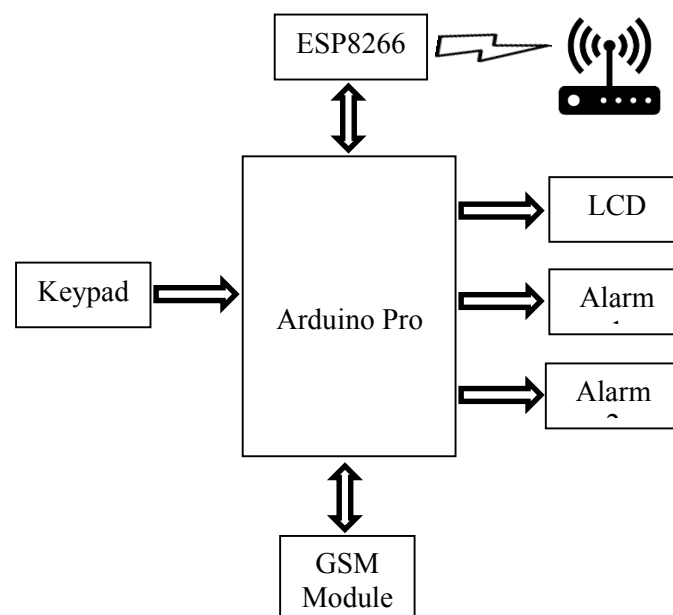


Figure 2. Block Diagram of Controller Module

Block diagram of door system module can be seen in figure 3. This module also uses arduino pro as microcontroller. There are three inputs in this module, namely PIR sensor module, reed switch module, and RFID reader. The outputs are a door strike that serves to open and lock the door, buzzer as an alarm when there is a breaking door and LED indicator uses to give a sign of a blinking light when the alarm sounds. In this module there is also Wi-Fi indicator that can be used to know the status of Wi-Fi connection.

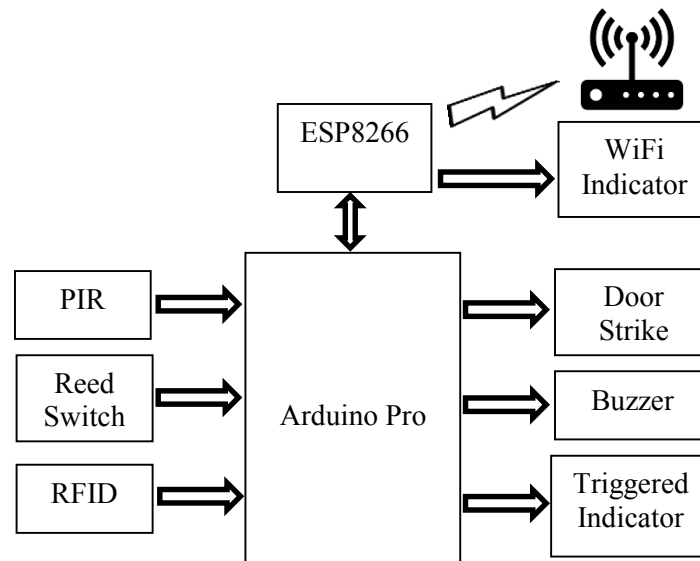


Figure 3. Block Diagram of Door System Module

The block diagram of PIR sensor module can be seen in figure 4(a). This module uses ATtiny85 as its microcontroller. In this module there is an input and two output. The input is PIR sensor while its output is LED indicator that will blink when PIR sensor detects suspicious movement at home and connection to EESP8266 which make this module connects wirelessly to controller module. In this module there is also WiFi indicator which is used to know the status of Wifi connection. Gas diagram block sensor sensor is almost the same as PIR sensor module, the difference is only in the sensor input. The input is MQ-6 gas sensor. Block diagrams gas sensor modules can be seen in figure 4(b).

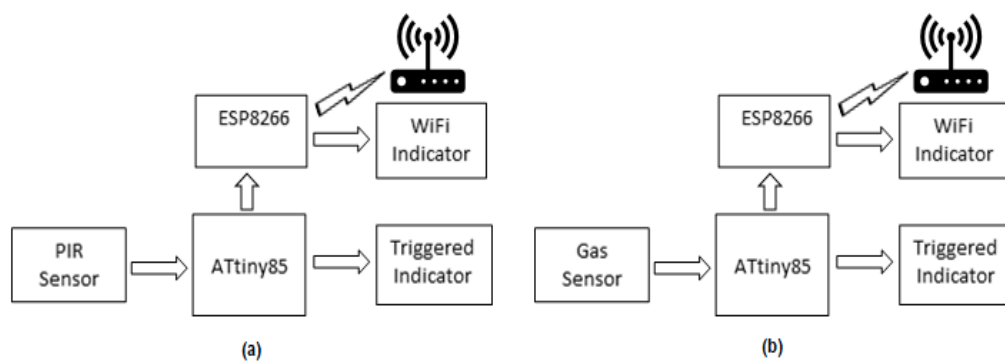


Figure 4. (a). Block Diagram of PIR Sensor Module, (b). Block Diagram of Gas Sensor Module

Block diagram of panic button module can be seen in figure 5(a). This module uses ESP8266 as microcontroller to process input / output. In this module, there is one input and two outputs. The input is a push button while the two outputs are the indicator LED indicating that the push button has been pressed and the Wi-Fi indicator to know the status of Wi-Fi connection. Block diagram of the reed switch module is almost the same as the panic button module, the difference is only in the sensor input is reed switch sensor. Block diagram of reed switch module can be seen in figure 5(b).

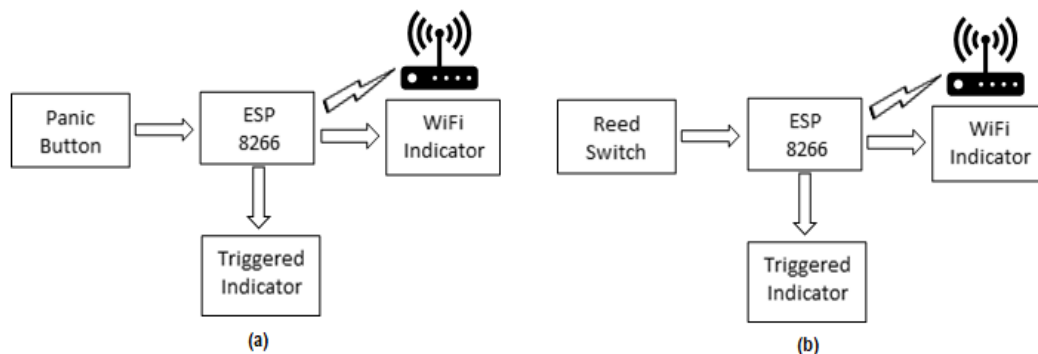


Figure 5. (a). Block Diagram of Panic Button Module, (b). Block Diagram of Reed Switch Module

IP camera used in this system is TP-Link Cloud NC200. Monitoring can be done live streaming or playback recorded and can be accessed remotely by VPN port forwarding method. In this research also developed two android based applications that can be used to monitor the condition of the house remotely. The first application is intended for residents who want to monitor their homes and the second application is intended for security guard in order to immediately find out the location of the house. Both residents and security personnel must first install the application to their smartphone android in order to use the application. Flowchart of the application can be seen in Figure 6 while the main menu of the application can be seen in Figure 7(a). Registration process should be done after the residents of the house install the application. In the registration process the user enters all the required information on the registration menu which can be seen in Figure 7(b). After user successfully register, user can login through login menu which can be seen in picture 8. If authentication process succeed, user can access user menu as seen in picture 9(a) and picture 9(b).

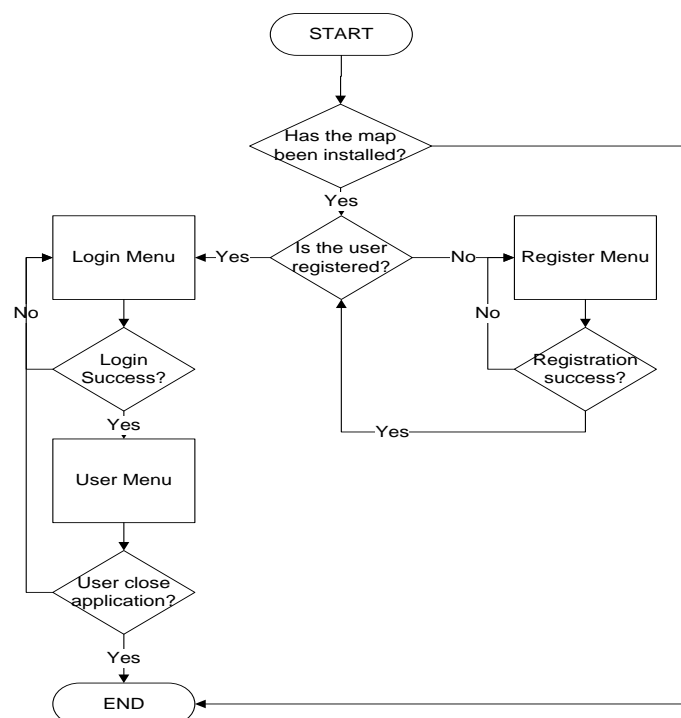


Figure 6. Application Flowchart

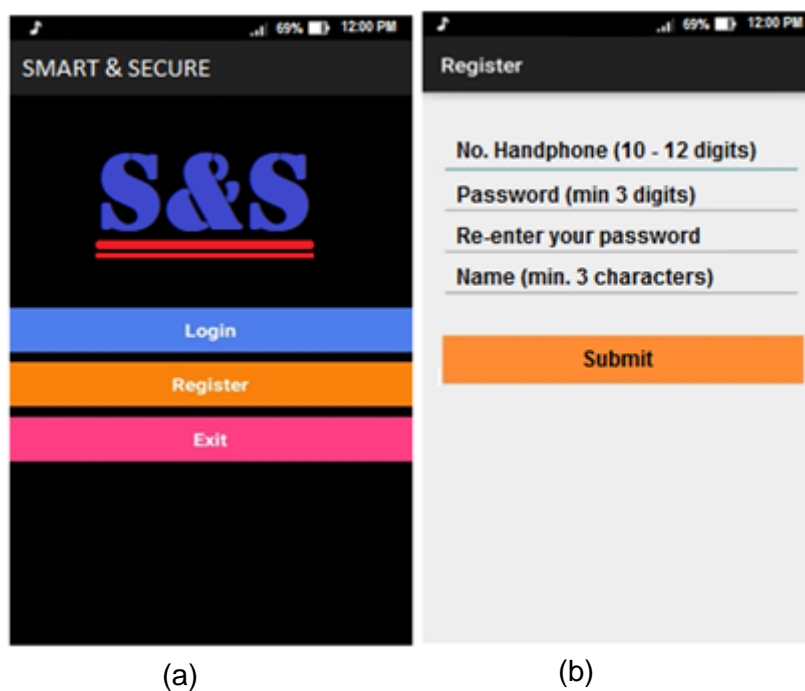


Figure 7. (a) The Main Menu, (b). Registration Menu

In user menu, residents can see security status through the room colors and monitor every rooms in their home by accessing the camera installed in each rooms. For security guard, the user menu can only be used to view location maps and access existing cameras outside the home.

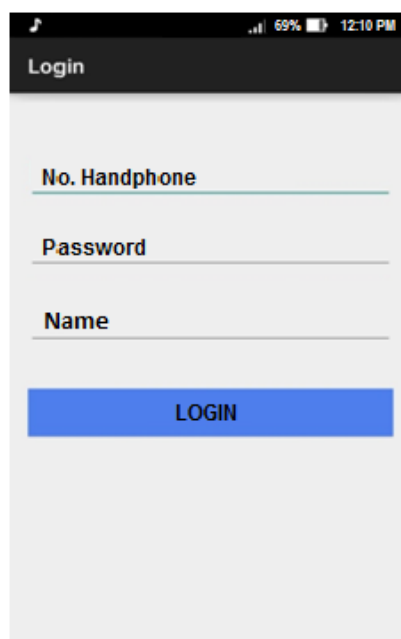


Figure 8. Login Menu

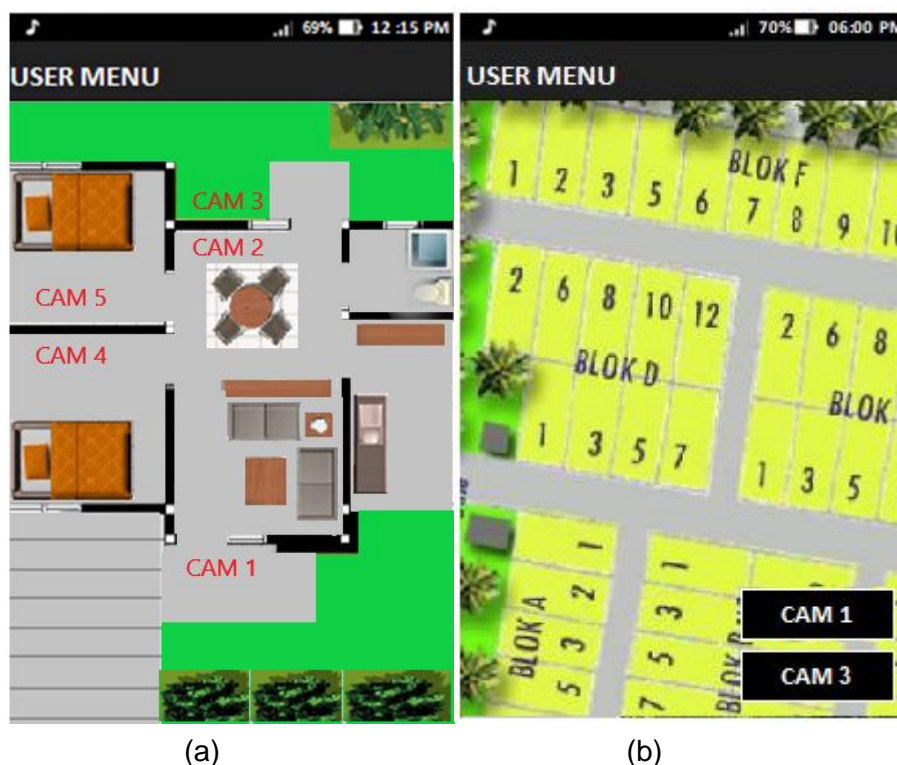


Figure 9. (a) Residents User Menu, (b) Security Guard User Menu

3. Result and Analysis

In this research, there are several tests conducted to measure the reliability of the developed system. The first test is the performance test. Each installed module is given input 20 times. The sensor of each module will respond to the input given by providing information to the controller module. Table 1 shows that all modules of the security system work very well. This is shown by the performance of each module that successfully detects any given input and then sends the information to the controller module without failing.

Table 1. The Result of Performance Test

No	Module	Experiment	Success Rate
1	Door System	20	100%
2	Reed Switch	20	100%
3	Gas Sensor	20	100%
4	Panic Button	20	100%
5	PIR Sensor	20	100%

In the second test is carried out network connectivity test. In this test, a ping packet is sent 20 times to each installed module. Ping packets are sent from a laptop connected wirelessly to each module through Wi-Fi router. Table 2 shows that the connection of the installed network is very good with 100% data transmission success rate.

Table 2. The Result of Connectivity Test

No	Module	Packets	Average	Minimum	Maximum	Success Rate
1	Controller	20	16 ms	1 ms	105 ms	100%
2	Door System	20	18 ms	1 ms	99 ms	100%
3	Reed Switch	20	14 ms	1 ms	96 ms	100%
4	Gas Sensor	20	19 ms	1 ms	116 ms	100%
5	Panic Button	20	17 ms	1 ms	114 ms	100%
6	PIR Sensor	20	16 ms	1 ms	104 ms	100%

In the third test, the performance test of GSM module is performed. In this test, the controller module will send 20 packet alerts to the GSM Module and then sent to three different people with a 3 second interval between recipients. Table 3 shows that sending alerts through the GSM module successfully performed at different acceptance speeds. This depends on the SMS network of the telecommunication provider used. From the results shown, the time of sending SMS to the user is still within the reasonable threshold.

Table 3. The Result of GSM Module Performance Test

Recipients	Average Time of Sending SMS	Minimum Time of Sending SMS	Maximum Time of Sending SMS
User1	9 seconds	4 seconds	11 seconds
User2	13 seconds	13 seconds	16 seconds
User3	19 seconds	18 seconds	23 seconds

View of monitoring results by residents can be seen in Figure 10(a). The red color shows the last location of the disturbance that occurred in the house. Users can select the camera they want to see by pressing the camera button available in the application. One of the monitoring results of the camera from one of the rooms can be seen in Figure 10(b). The display of monitoring results from the security officer can be seen in Figure 11(a). The security guard can identify the location of the disturbed homes from the star sign that is printed on the map in user menu. Security guard can also see the camera that is installed outside the home by pressing the camera button. Figure 11(b) shows us the monitoring result of the security guard. From the pictures, we see that the developed application can run well.

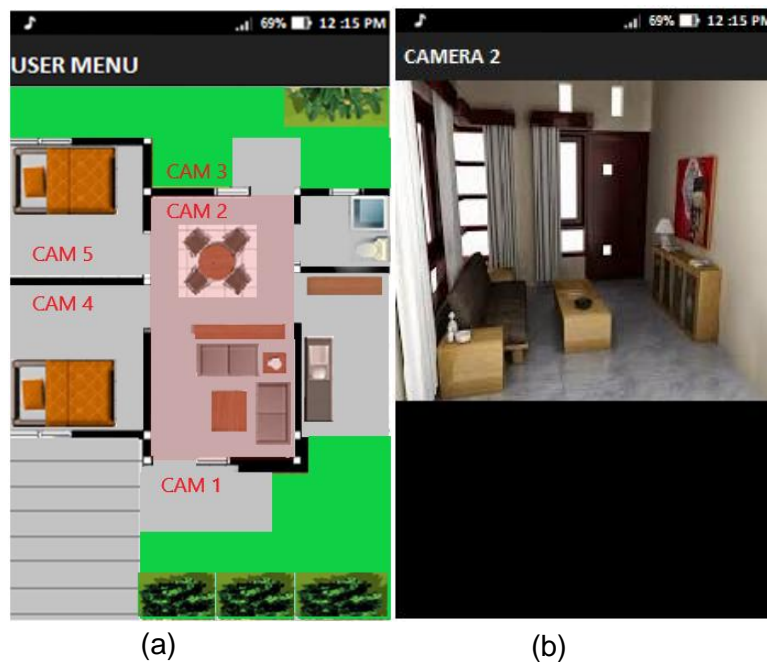


Figure 10. (a) Monitoring Result by Resident, (b) Camera View by Resident

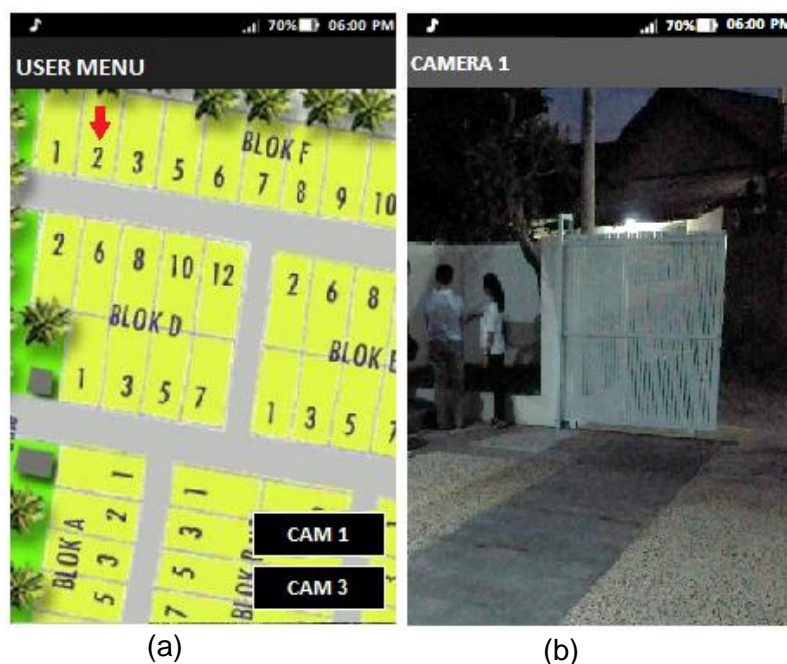


Figure 11. (a) Monitoring Result by Security, (b) Camera View by Security

4. Conclusion

Eco-friendly home security system developed by combining two systems, namely home- security system based on microcontrollers and monitoring system based on android smartphone. The home security system is developed by using six types of security modules while monitoring system is developed by

using IP camera, GSM module, VPN server and android smartphone. This integrated system can detect both internal and external disturbances with excellent performance. This is proven by the excellent results of security module performance test and network connectivity test. The monitoring system also works well which is indicated by the success rate of SMS sending and successful monitoring application run on android smartphone. The next system will be developed for home security systems on cluster housing using LoRaWAN technology.

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