The Design and Analysis of Home Automation Systems Based on MAC Address

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ABSTRACT

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Home Automation is one of the advances in technology and communication by automating the control of electrical devices at home. With this method, home electronic devices can be controlled using a remote control system without having to touch the home appliances themselves. The development of the operating system on mobile devices gives birth to innovation and creativity in line with the needs of its users, from mere communication tools to information centers. One of the innovations in daily life is Home Automation, which allows control of electrical devices to save electricity consumption at home. That can be done remotely both in the same location or in other rooms with sensors and user interface design from Android to simplify monitoring. The Home Automation application communicates via MAC addresses on Android registered in Wemos D1, which Android can be used to control automatically, in this study using the Wemos D1 module as a brain or control center that receives data from Android for later processing to the lamp output, the motion sensor (PIR), DHT22 sensor, fan, and door lock by using a solenoid that can be controlled automatically from any sensors connected to the Wemos D1 microcontroller.

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I. Introduction

The development of technology in a daily application makes it easy to turn on and off various electronic equipment such as lights, water heaters, and fans. The electronic devices can be controlled using a time-based program application, motion sensors, and automatic door locking. The technology that makes it easy for homeowners, who previously were electronic devices operated manually by everyone [1]. Home Automation can provide convenience, comfort, safety, savings, with technological sophistication. Automation using natural language, increasing interest in smart homes, improving the language, or collecting specific languages where input provided by the system allows users to interact with the system in various languages. The attraction of using this natural language is that smart home systems can understand the interaction and communication that humans use in everyday communication. This smart home can control electronic devices with only one central controller, Android, or control them when the user is not at home. Thus, it is vital to have a smart home automation system controlled with an Android device so that it significantly increase interest and develop technology for smart homes. Therefore, this research is inspired to design Home Automation by using event-driven methods to make it easier for humans to control these electronic devices. This electronic device can be controlled automatically in the room. The main objective is to realize savings in energy consumption and waste of excess operational costs.

The development of smartphones technology is not only used for communication. The smartphone makes it easy for all community activities, especially in terms of communication, not only limited to calling or sending messages, in this case, but many smartphones also use the Windows mobile operating system, Linux, RIM Blackberry, and Android. Many online or offline applications make it easier for developers to create Android [2]. One example of the current problem is in the room, there are electronic items such as lights, fans, and door locks are generally still controlled manually, and the user must move a lot to activate these items. Therefore, this is a consideration for making this tool easier for humans to control electronic devices.

II. The Proposed Method/Algorithm

A. Home Automation

Home Automation is a smart home that has a system that can help control electronic equipment in the household so that it can simplify household work. Home Automation (HA) is an activity in building automation in a residential building or house to get a variety of convenience, comfort, and high efficiency in activities in the house [3]. To create such automation, a device that can work in an organized manner is needed where each device performs its private functions and simultaneously communicates with other devices in the system. Building an Energy Management System (BEMS) has been developed to improve occupancy's energy efficiency, which is seen as a comparison between energy costs and overall comfort. A BEMS optimizes control of energy supply and demand according to data [4].

B. Wi-fi Technology

Wi-fi is a wireless communication technology that uses radio technology, so wi-fi is a wireless device that acts as a bridge between wireless devices. Wi-fi technology has 2 main topology types, namely infrastructure and Ad-hoc. Ad-hoc allows a wi-fi network to function without a wireless router or access point. Ad-hoc mode is a method that allows wireless devices within range of the signal to communicate with peers without involving an access point [5].

C. MAC Address

MAC Address (Media Access Control Address) adalah sebuah alamat jaringan yang diimplementasikan pada lapisan data-link dalam tujuh lapisan model OSI, yang merepresentasikan sebuah node tertentu dalam jaringan. Dalam sebuah jaringan berbasis Ethernet, MAC address merupakan alamat yang unik yang memiliki panjang 48-bit (6 byte) yang mengidentifikasi sebuah komputer, interface dalam sebuah router, atau node lainnya dalam jaringan. MAC Address juga sering disebut sebagai ethernet address, physical address, atau hardware address.

D. Algoritma

The subject of this research is the Wemos microcontroller-based automation system as a Home Automation controller, while the research object is an input variable, namely a digital signal (MAC Address) (X1), a temperature sensor (X2) and a motion sensor (X3), and an output variable in the form of a light dimmer (Y1), solenoid lock door (Y2) and fan (Y2). The following research objects are shown in Figure 1.

Fig 1. Object of research

The initial design of home automation systems, door lock controllers, lights and fans using Wemos D1 microcontroller based on ESP8266 is composed of several block diagrams, namely adapters as power supplies, Wemos D1 modules as communication intermediaries, incandescent lamps as room lighting, dimmers as regulators light intensity, a DC motor as a fan, and a door lock solenoid as a lock.

III. Method

A. Conceptual Design

The prototype design of Home Automation is a system designed with the help of Wemos D1 microcontroller to integrate and control a device or equipment such as a fan, dim lights and illuminate lights using an AC light dimmer module (Pulse Width Modulation) PWM control, open and lock the door using a solenoid, and PIR as a motion sensor that serves to capture the movement in a room so that the lights remain in a state of life, LCD to display the temperature in the room, using the DHT22 sensor to measure the temperature in the room, while communication from Android and the sensor uses Wemos D1, for more he explained pay attention to Figure 2 below.

Fig 2. System Conceptual Design

B. System Configuration

The home automation configuration scheme using Wemos D1 in the prototype design of the house can be seen in Figure 3. In this condition, the house is installed Wemos D1 with Access Point mode as well as server, while the smartphone is a client. When the client is connected to the access point, the system reads the MAC address of the device. If the MAC address is the same as that registered, the system permits to turn on the system, but if it is not registered, then the system does not give device permission to turn on the system. Furthermore, when the device is disconnected with an access point, the system stops and not be able to run until it is connected to the registered device.

Fig 3. MAC Address-based SmartHome Schema

Figure 4 is a wiring diagram of the SmartHome system. This system uses Wemos D1 as a microcontroller, with input in the form of a DHT22 sensor device as a temperature sensor and a PIR sensor as a motion sensor. At the output in the form of a fan device as a room temperature regulator, lights as lighting, solenoid door lock as a door lock, and LCD as a visualization of room temperature. While the 2 channel relay device as a switch setting and AC Light Dimmer as a lamp dimmer setting.

Fig 4. Home automation system series

The home automation configuration scheme above can be explained in Table 1 about the use of pins on Wemos and their information.

Table 1. Explanation of the use of a PIN on Wemos

No.	Pin Wemos	Sensor PIR	Sensor DHT22	AC Light Dimmer	I2C Serial LCD	Relay		
						Solenoid Door Lock	Kipas Angin	Stop Kontak
1.	D10	OUT	-	-	-	-	-	-
2.	D9	-	OUT	-	-	-	-	-
3.	D7	-	-	PWM	-	-	-	-
4.	D6	-	-	Z-C	-	-	-	-
5.	D5	-	-	-	-	IN1	-	IN1
6.	D4	-	-	-	SDA	-	-	-
7.	D3	-	-	-	SCL	-	-	-
8.	D2	-	-	-	-	-	IN2	-
9.	VCC	VCC	VCC	VCC	VCC	VCC	VCC	VCC
10	GND	GND	GND	GND	GND	GND	GND	GND

C. Working Mechanisms

Figure 5 is a flowchart of the SmartHome system. When the device is connected to Wemos D1, the system reads the MAC address of the device and then compares it with the registered MAC address. If the same, the system turns on and gives access to the user. When the user is given access, the system gives a command to the door lock solenoid to open the door lock. Then the user enters the house, causing movement. The movement can be detected by a PIR sensor (motion detector). When motion is detected, the lamp starts to turn on using the AC light dimmer. The temperature sensor then

reads the temperature in the room. If the temperature is more than 29°C, the fan is turned on. If the room temperature is less or equal to 29°C, then the fan is stopped.

Fig 5. Flowchart of SmartHome Systems

D. Program Structure

Based on Figure 6, the program's structure has three subsystems: the input subsystem, the processing subsystem, and the output subsystem. In the input subsystem, there are three functions, namely the MAC address function, the motion detector function, and the temperature sensor function. In the processing subsystem, there are three functions, namely, the function of comparing MAC addresses, the function of reading motion, and the function of comparing room temperature. Whereas in the output subsystem, there is a lock door function, light dimmer function, and fan function. Each input is responsible for each output. In the MAC address function for the lock door function, in the motion detector function for the light dimmer function, and the temperature sensor function for the fan function.

Fig 6. Program Structure

IV. Results and Discussion

A. Prototype Performance

After conducting several stages of testing on the sensor module using a digital multimeter, it can be obtained several results in which the test data on incandescent lamps using AC power such as Table 2.

Table 2. Data after installing SmartHome with a 450W lamp load

Time	Voltage (Volt)	Current (Ampere)	Power (Watt)	Energy (kWh)	Explanation
13:00	220	0,09	19,8	0,003366	There are no occupants
13:10	217,6	1,77	385,152	0,06884184	There are occupants
13:20	217,8	1,77	385,506	0,13437786	There are occupants
13:30	217,7	1,77	385,329	0,19988379	There are occupants
13:40	217,1	1,78	386,438	0,26557825	There are occupants
13:50	217,2	1,77	384,444	0,33093373	There are occupants
14:00	217,5	1,78	387,15	0,39674923	There are occupants
14:10	217,8	1,78	387,684	0,46265551	There are occupants
14:20	217,9	1,77	385,683	0,52822162	There are occupants
14:30	218,2	1,76	384,032	0,59350706	There are occupants
14:40	218,3	1,77	386,391	0,65919353	There are occupants
14:50	218,5	1,78	388,93	0,72531163	There are occupants
15:00	218,7	1,79	391,473	0,79186204	There are occupants
15:10	218,5	1,78	388,93	0,85798014	There are occupants
15:20	218,2	1,78	388,396	0,92400746	There are occupants
15:30	217,5	1,77	384,975	0,98945321	There are occupants
15:40	217,5	1,75	380,625	1,05415946	There are occupants
15:50	217,7	1,74	378,798	1,11855512	There are occupants

Time	Voltage (Volt)	Current (Ampere)	Power (Watt)	Energy (kWh)	Explanation
16:00	217,7	1,75	380,975	1,18332087	There are occupants
16:10	217,9	1,76	383,504	1,24851655	There are occupants
16:20	218,4	1,76	384,384	1,31386183	There are occupants
16:30	218,9	1,77	387,453	1,37972884	There are occupants
16:40	219,2	1,77	387,984	1,44568612	There are occupants
16:50	219,8	1,78	391,244	1,5121976	There are occupants
17:00	219,4	1,79	392,726	1,57896102	There are occupants

Based on Table 2, the test results are carried out for 4 hours with a 10-minute test interval, which is to obtain energy usage (kWh), the amount of power (Watts) 19.8 at 13.00 is converted to energy use (kWh) by calculating in Equation (1).

$$\left(\frac{19,8}{1000} \right) \times 0,17 = 0,003366 \quad (1)$$

A value of 0.17 is obtained from the sum by taking a 10-minute delay in which the data is taken for 4 hours, with 1 hour 60 minutes, then:

$$\frac{60}{10} = 0,1666667 \quad (2)$$

Then round up to 0.17. The calculation in the 2nd table row at 13.10 until 17.00 hours is the same for the sum.

Tabel 3. Data before install *SmartHome* with 450W

Time	Voltage (Volt)	Current (Ampere)	Power (Watt)	Energy (kWh)	Explanation
13:00	220	0,09	19,8	0,003366	There are no occupants
13:10	220	2	440	0,078166	There are occupants
13:20	220	2	440	0,152966	There are occupants
13:30	220	2	440	0,227766	There are occupants
13:40	220	2	440	0,302566	There are occupants
13:50	220	2	440	0,377366	There are occupants
14:00	220	2	440	0,452166	There are occupants
14:10	220	2	440	0,526966	There are occupants
14:20	220	2	440	0,601766	There are occupants
14:30	220	2	440	0,676566	There are occupants
14:40	220	2	440	0,751366	There are occupants
14:50	220	2	440	0,826166	There are occupants
15:00	220	2	440	0,900966	There are occupants
15:10	220	2	440	0,975766	There are occupants
15:20	220	2	440	1,050566	There are occupants
15:30	220	2	440	1,125366	There are occupants
15:40	220	2	440	1,200166	There are occupants

Time	Voltage (Volt)	Current (Ampere)	Power (Watt)	Energy (kWh)	Explanation
15:50	220	2	440	1,274966	There are occupants
16:00	220	2	440	1,349766	There are occupants
16:10	220	2	440	1,424566	There are occupants
16:20	220	2	440	1,499366	There are occupants
16:30	220	2	440	1,574166	There are occupants
16:40	220	2	440	1,648966	There are occupants
16:50	220	2	440	1,723766	There are occupants
17:00	220	2	440	1,798566	There are occupants

In Table 3, the data shows the usage of electric power before installing SmartHome. In this condition, there are two loads used, namely a lamp load of 100 Watts and an iron load of 350 Watts, so the total load used is 450 Watts. The use of power used starts at 13:00 with a power of 0.003366 kWh and ends at 17.00 with a total power usage of 1.798566 kWh. Data is collected every 10 minutes.

B. Energy Savings

After conducting several stages of testing on the sensor module using a digital multimeter, several results can be obtained in which the power saving data is tested on incandescent lamps by using AC power, as shown in Table 4.

Table 4. Energy-saving data

Time	Energy Used		Energy saving	
	Before Installation (kWh)	After Installation (kWh)	Difference (kWh)	(%)
13:00	0,003366	0,003366	0	0
13:10	0,078166	0,06884184	0,00932416	13,54
13:20	0,152966	0,13437786	0,01858814	13,83
13:30	0,227766	0,19988379	0,02788221	13,95
13:40	0,302566	0,26557825	0,03698775	13,93
13:50	0,377366	0,33093373	0,04643227	14,03
14:00	0,452166	0,39674923	0,05541677	13,97
14:10	0,526966	0,46265551	0,06431049	13,90
14:20	0,601766	0,52822162	0,07354438	13,92
14:30	0,676566	0,59350706	0,08305894	13,99
14:40	0,751366	0,65919353	0,09217247	13,98
14:50	0,826166	0,72531163	0,10085437	13,90
15:00	0,900966	0,79186204	0,10910396	13,78
15:10	0,975766	0,85798014	0,11778586	13,73
15:20	1,050566	0,92400746	0,12655854	13,70
15:30	1,125366	0,98945321	0,13591279	13,74
15:40	1,200166	1,05415946	0,14600654	13,85

Time	Energy Used		Energy saving	
	Before Installation (kWh)	After Installation (kWh)	Difference (kWh)	(%)
15:50	1,274966	1,11855512	0,15641088	13,98
16:00	1,349766	1,18332087	0,16644513	14,07
16:10	1,424566	1,24851655	0,17604945	14,10
16:20	1,499366	1,31386183	0,18550417	14,12
16:30	1,574166	1,37972884	0,19443716	14,09
16:40	1,648966	1,44568612	0,20327988	14,06
16:50	1,723766	1,5121976	0,2115684	13,99
17:00	1,798566	1,57896102	0,21960498	13,91
Total energy savings			2,75723969 kWh	
Percentage of Average Energy Savings			13,36 %	

Based on Table 4, we can take the difference from the calculation by subtracting from Table 3 before SmartHome installation and Table 2 after SmartHome installation, as shown in Equation (3).

$$\text{Before (kWh)} - \text{After (kWh)} = \text{Difference (kWh)} \quad (3)$$

Based on Table 3, the total power savings of 2.75723969 kWh are obtained. In calculating the percentage of energy savings using a formula like in Equation (4).

$$\left| \frac{\text{Before (kWh)} - \text{After (kWh)}}{\text{After (kWh)}} \right| \times 100\% = \% \text{ Savings} \quad (4)$$

Fig 7. Power comparison graph

Based on Figure 7 shows a graph of power comparison between SmartHome before being installed and after SmartHome installed. It can be seen that the power used before SmartHome was set at 440 Watt, while after SmartHome was installed, the power was less than 440 Watt. Power measurements are carried out for 4 hours, starting from 13:00 until 17:00. The power used before installing SmartHome looks linear because the power used is constant. In contrast, the power before installing SmartHome is unstable due to the effect of using AC Light Dimmer.

Fig 8. Energy usage comparison chart

Based on Figure 8 is a comparison graph between the use of power between before installation of SmartHome and after installation of SmartHome. The shape of the graph shows a linear increase. That is because the measured power usage by the kWh meter continues to increase from time to time. Although the data continues to increase, power usage after the installation of SmartHome is less than before the installation of SmartHome. The measurement data is carried out for 4 hours, starting from 13:00 until 17:00. Savings on SmartHome occur due to the effects of the AC Light Dimmer device. AC Light Dimmer functions as a regulator of dim or bright lights

V. Conclusion

Based on testing that has been done, the Home Automation system using Wemos as a MAC address-based control center can automatically turn off and turn off various devices. In the Home Automation system application, home load uses a power of 450 Watt to obtain energy savings of 2.75723969 kWh with an average percentage of energy savings of 13.36%.

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References

- [1] Akkaya, K., Guvenc, I., Aygun, R., Pala, N., & Kadri, A. (2017). "IoT-based occupancy monitoring techniques for energy-efficient smart buildings." In 2017 IEEE wireless.
- [2] R. Missaoui, G. Warkozek, S. Bacha, S.Ploix, "Real-time validation of an optimization building energy management strategy based on power hardware in the loop tool," in 2012 3rd IEEE PES International Conference and Exhibition on Innovative Smart Grid Technologies (ISGT Europe), IEEE, 2012.
- [3] E. Ahmed, and A. H. Karim, "Design and Implementation of a wi-fi Based Home Automation System," World Academy of Science, Engineering and Technology, vol. 6, pp. 1856-1862, 2012.
- [4] W. Kastner, G. Neugschwandtner, S. Soucek, H.M. Newman, "Communication systems for building automation and control," Proc.IEEE 93 (June (6)) (2005) 1178–1203.
- [5] E. Ahmed, and A. H. Karim, "Design and Implementation of a wi-fi Based Home Automation System," World Academy of Science, Engineering and Technology, vol. 6, pp. 1856-1862, 2012.