ESP 8266 FOR CONTROL AND MONITORING IN SMART HOME APPLICATION

by Artikel 4

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Lailis Syafa'ah
Informatics Engineering Faculty
Universitas Muhammadiyah Malang
Malang, Indonesia
lailis_tsd@yahoo.co.id

Agus Eko Minarno
Informatics Engineering Faculty
Universitas Muhammadiyah Malang
Malang, Indonesia
agoes.minarno@gmail.com

Fauzi Dwi Setiawan Sumadi
Informatics Engineering Faculty
Universitas Muhammadiyah Malang
Malang, Indonesia
fauzisumadi@umm.ac.id

Gayuh Widya Mukti
Informatics Engineering Faculty
Universitas Muhammadiyah Malang
Malang, Indonesia
gayuhwm@icloud.com

***Abstract*— A smart home system is commonly defined as an embedded system in the house which helps resident in carrying out routines at home. In this paper we propose to measuring maximum distance and response time of ESP8266 modules in smart home system which include online and real time controls of: door lock, lighting dimmer, automatic switches equipped with energy sensors, infrared furniture and camera systems. The system modules are based on an ESP8266 Wi-Fi microcontroller. The modules are connected to a central server via Wi-Fi media by using data communication based on JSON on HTTP protocol, using an IP camera. Programs in modules are designed to be as simple as possible to save resources and to achieve the shortest possible response time. Modules on this smart home system have been tested and have proved to operate intelligent-home systems in providing controls of: electricity, automatic door lock, electricity consumption statistics, infrared-based furniture, and cameras to monitor a room directly. Based on experiment the maximum distance between Wi-Fi access points and ESP8266 modules in LOS conditions is 190 meters, and the average response time of the module is 1.62 seconds.**

Keywords*—: *Smart home, IoT, wi-fi, Measuring, Response time, ESP8266

I. Introduction

A house is a building that serves as a place to live and a means of family development along with the other functions as: a gathering place for relieving fatigue with family. To build a comfortable house, it requires high costs, such as: the cost of maintenance, security and so forth. In general, the house has a patent or fixed electrical system [1]. Routines, such as turning on the lights in the afternoon, turning off lights at bedtime, even forgetting to turn off the lights in the bathroom, especially forgetting to lock the door at night, are among common things to do in a house with patent electricity system. Thus, an automation to replace the manual job of home owner is required [2]. The frequent solution commonly chosen by homeowners is usually by hiring a housemaid and house keeper to secure the house. This solution is however not cheap, which cannot even be applied by middle to lower-income families with small income. The second choice to solve this problem is to build an intelligent housekeeper-like device on the smart home [3].

Smart home has a technology and service integrated in a home network to easily be accessed remotely in supporting a better life quality [4,5]. Smart home is a system that can be used to monitor and can control various home electronic devices remotely by using a wireless control, such as a remote control or other devices [6-9]. Smart home generally has 2 subsystems, which are: the software system with the user interface and the hardware system. The software system with the user interface performs a computerized process from the user commands and forwards commands to the system hardware that has been planted in the home electrical system [10,11]. The hardware system works as a center of control points on furniture and electrical points at home [12].

Smart home technology is related to the Internet of Things (IoT). According to Cisco, the Internet of Things is the point in time when objects connected to the internet exceed those of people connected to the internet [13]. The Internet of Things is a view where internet extends to the real world that includes everyday objects. Thus, it accommodates physical objects to be controlled remotely and can act as physical access points to internet services [14,15]. If a smart home adopts this technology, the smart home can be controlled remotely, from places connected to the internet [16].

However, several of the smart home modules in [17-20] do not shown maximum distance of IoT modules and response time of modules. Based on this background, this study proposes measuring maximum distance and response time of ESP8266 in a smart home system consisting of several modules, such as: lamp control, door locks, electrical control and electrical energy consumption sensors (watt meters & electricity control), infrared control and a camera that is integrated with the server. With a number of smart home modules, this system is expected to operate intelligent home systems such as providing electrical control, automatic door lock control, electricity consumption statistics reports, infrared-based furniture controls, and cameras to monitor a room directly. All of these controls will be carried out remotely by using an internet connection.

II. Method

At this stage, data collection and analysis of component requirements are carried out in each module. Identifying the functions in each module plays a significant role to find out the required appropriate components. Data collection is conducted from paper, journals and other information media including surveys as a source of information. Therefore, such a comfort home security can be achieved. The system as proposed to be developed, has the following architecture:

1) Server Layer: serves as the core layer of this system, which functions as a whole processor system and stores all system data.

2) Communication Layer: serves as the second layer which functions as the communication media used among subsystems.
3) Media Layer: functions as the communication media used by modules in dealing with servers.
4) Modul Layer: functions as the most basic layer of the whole system. This layer relates directly to the sensors and / or tools to be controlled, including:
   a. Door Lock
   This module uses several components, such as: solenoid door lock module, solenoid driver circuit, and ESP8266 as a microcontroller as well as a medium of communication with the server. Figure 1 and Figure 2 illustrates system scheme and flowchart door lock module.
   b. Lamp Control
   This module is an additional module to adjust the light intensity on the lamp. Control of the light intensity produced by the lamp is operated through a dimmer circuit that regulates the amount of electrical voltage entering the lamp.
   c. Watt Meter & Electricity Control
   This module can calculate the amount of energy consumption in the form of watts charged to the module. This module can also connect / disconnect the electricity that is passed on the module.
   d. Camera
   This module is a product module as its popular market name of IP Camera. The function of this product is to monitor the room.
   e. Infrared Control
   This module is an infrared-based replacement remote control system to control devices that have been registered without using the remote control. The user must firstly register a button on the remote control into the system. After the remote control recording process is complete, the user can use the recorded button in the smart home system.

2.1 System Feature

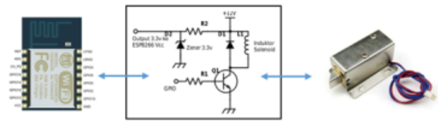
This system proposes several features, as follows:

1. All modules are designed in modular with automatic synchronization to enable the users for module installation and replacement without configuration.
2. The system will resume normaly after a power shut-down.
3. Control to all devices can be done manually or automatically scheduled.
4. Control the system does not have to use a local network, as this system can also be accessed by using public networks (the internet).

Programs on modules are designed to be as simple as possible to achieve the best response time.

2.2 Door Lock Control

Door lock module designed when module accepts an unlock command from the server, the key armature will be pulled in. Contrastingly, if this module is in standby-mode or if receives a key to close command from the server, the key armature will return to its original position. Solenoid door lock module shown in Figure 1 Figure 3.



(a) (b) (c)

Figure 1: System Scheme On Door Lock Module: (a) ESP8266, (b) Solenoid Driver Transistor, (c) Solenoid Door Lock

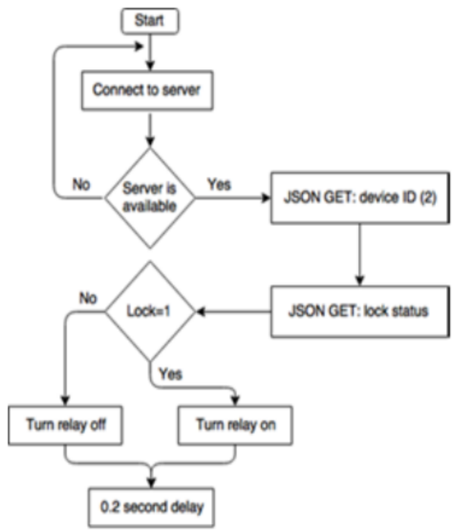
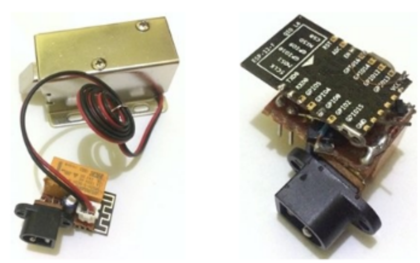


Figure 2: Flowchart System Of Door Lock Module



(a) (b)

Figure 3: (a) Top View Of The Door Lock Module With A Solenoid Door Lock, (b) Bottom View Of The Doorlock Module

2.3 Lamp Control

This module is a lamp dimmer which can be controlled by the server. The light intensity setting is operated by the triac as a regulator of the current to the lamp. This triac circuit is connected with photoisolator as a microcontroller electric bulkhead to triac. To add, the electricity supply on ESP8266 is obtained from the modification of the USB charger with a voltage output of 3.3 volts. Scheme and flowchart of lamp control shown in Figure 4 and Figure 5.

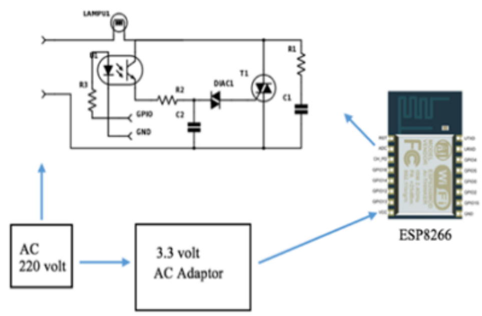


Figure 4: System Scheme On Lamp Control

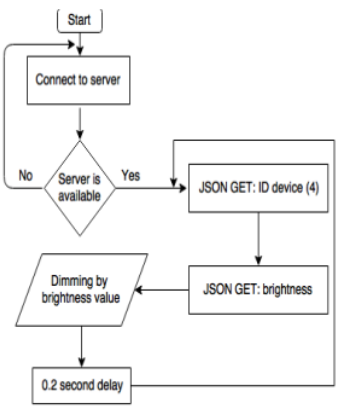


Figure 5: Flowchart System of Lamp Control

Setting the light intensity from the server is transmitted through the JSON line and is declared on the GPIO pin by using the PWM (Pulse Width Modulation) method. The distance of the PWM value is 0-255, in which "0" is the dimest outlook. Figure 6 shows the brightness value. The PWM output of the ESP8266 digital pin is then connected with photoisolator.

(a) (b) (c)

Figure 6: (a) The Light On The Brightness Value Of 10 (Dim), (b) The Light On The Brightness Value Of 50 (Medium), And (c) The Light On The Brightness Value Of 100 (Brightest)

2.4 Watt Meter & Electicity Control

This module records the amount of current passing through the sensor. The sensors used are: a 5A Non Invasive Current sensor and Current Transformer sensor with a maximum current of 5 amperes. This sensor emits an analog AC voltage as a result of current reading. This module can also disconnect and connect electricity through a relay with a maximum rating of 220 volts and 10 amperes. Watt meter flowchart shown in Figure 7.

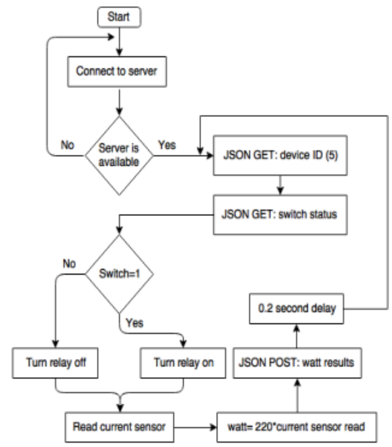


Figure 7: Flowchart Sistem on Watt Meter & Electricity Control

2.5 Infrared Control

This module serves to record and send infrared remote control signals. This module consists of Wi-Fi ESP-12F, infrared sensor, and infrared led. This module uses the Arduino library named irrecord. During the recording process, the data is obtained in the form of hexadecimal which can later be transmitted via infrared led to replace the remote control function. Scheme infrared control shown in Figure 8 and Figure 9.

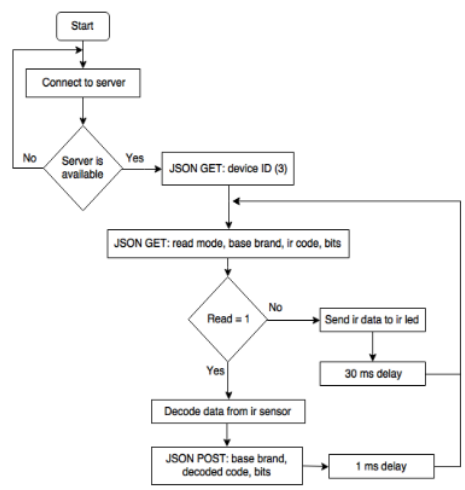


Figure 8: Flowchart System of Infrared Control

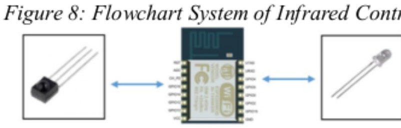


Figure 9: System Scheme On Infrared Control

III. RESULT AND DISCUSSION

Tests are carried out separately according to the functionality and features offered in each module. In general, modules have an equal performance in the ability to receive commands based on distance from the server. The distance testing in this module is carried out with the LOS (Line of Sight) condition, which means that the module's condition is not blocked in any way by sight with Wi-Fi router. Testing is done by giving a command to the module through the server at any time when the module is added from the Wi-Fi router. The following Table 1 presents data of success modules in receiving commands from the server:

TABLE 1: MODULE RELIABILITY BASED ON WI-FI DISTANCE

Distance (meter)	Success
20	Succeed
40	Succeed
80	Succeed
100	Succeed
120	Succeed
140	Succeed
180	Succeed
190	Succeed
200	Failed

3.1 Door Lock

The test on this module is performed by giving a command along with running the timer. The timer starts when the command button is pressed and is stopped when the module responds to a command. A stopwatch on a cellphone is utilized as a timer. This test takes 20 sample response times in the module. Table 2 shows the result of door lock testing.

TABLE 2: RESPONSE TIME TO ORDER

No	Order	Time (sec)	No	Order	Time (sec)	No	Order	Time (sec)
1	Open	3.4	11	Open	2.3	21	Open	2.1
2	Close	2.3	12	Close	3.1	22	Close	1.3
3	Open	3.5	13	Open	1.7	23	Open	2.5
4	Close	3.0	14	Close	2.5	24	Close	3.0
5	Open	2.4	15	Open	1.8	25	Open	2.0
6	Close	2.6	16	Close	2.3	26	Close	2.0
7	Open	1.7	17	Open	2.6	27	Open	1.7
8	Close	1.6	18	Close	2.7	28	Close	2.6
9	Open	2.2	19	Open	2.2	29	Open	1.2
10	Close	2.4	20	Close	3.1	30	Close	2.5
Average response time						2.34 seconds		

3.2 Lamp Control

This test is performed by giving a command along with running the timer. The timer starts when the command button is pressed and stopped when the module responds to a command. A stopwatch on a cellphone is utilized as a timer. This test takes 20 sample response times in the module. Table 3 shows the result of lamp control testing.

TABLE 3: RESPONSE TIME TO ORDER

No	Order	Time (sec)	No	Order	Time (sec)	No	Order	Time (sec)
1	Change brightness	2.6	11	Change brightness	1.9	21	Change brightness	1.4
2	Change brightness	2.9	12	Change brightness	2.2	22	Change brightness	2.1
3	Change brightness	3.1	13	Change brightness	2.7	23	Change brightness	1.8
4	Change brightness	2.4	14	Change brightness	2.5	24	Change brightness	2.9
5	Change brightness	2.4	15	Change brightness	1.4	25	Change brightness	2.4
6	Change brightness	2.9	16	Change brightness	2.3	26	Change brightness	2.2
7	Change brightness	1.8	17	Change brightness	2.3	27	Change brightness	1.1
8	Change brightness	2.9	18	Change brightness	2.7	28	Change brightness	2.2
9	Change brightness	2.3	19	Change brightness	2.8	29	Change brightness	2.1
10	Change brightness	3.2	20	Change brightness	3.1	30	Change brightness	1.1
Average time response						2.32 seconds		

3.3 Module Resistance to Different Loads

In this test, the module is given a load in the form of a filament bulb lamp that has a different wattage rating. This test starts after the module receives 1000 commands. Testing is performed by looking at performance changes such as the consistency of the output voltage, temperature and response time in the module. Temperature measurement is done by physically touching the TRIAC. Module resistance to different loads shown in Table 4.

TABLE 4: MODULE RESISTANCE TO DIFFERENT LOADS

Type of load	*Brightness value*	Voltage (*AC*)	*TRIAC* temperature
filament light bulb (5 watt)	100 (*max*)	200	Temperature not change
	50 (*mid*)	120	
	10 (*low*)	20	
	0 (*low/off*)	0	
filament light bulb (100watt)	100 (*max*)	196	Warm
	50 (*mid*)	115	
	10 (*low*)	20	
	0 (*low/off*)	0	
filament light bulb (2x100watt)	100 (*max*)	191	Hot
	50 (*mid*)	113	
	10 (*low*)	19	
	0 (*low/off*)	0	

TABLE 5: ENERGY RECORDING ACCURACY COMPARED TO MEASURING INSTRUMENTS

No.	Type of load	Watt value of module	Watt value of energy meter	Reading difference
1	filament light bulb (5 watt)	14	14	0
2	filament light bulb (100 watt)	94	95	1
3	TV *CRT* 14"	67	68	1
4	*LED* lamp (13 watt)	10	8	2
5	*LED* lamp (30 watt)	28	26	3
6	*Hair dryer* level 1	146	146	0
7	*Hair dryer* level 2	580	581	1
8	*LCD TV* 21"	22	23	1
9	Iron	234	236	2
10	30 watt solder	26	26	0
11	Rice cooker 1 – rice-cooking mode	231	232	1
12	Rice cooker 1 – rice-heating mode	44	45	1
13	Rice cooker 2 – rice-cooking mode	192	192	0
14	Rice cooker 2 – rice-heating mode	30	32	2
15	Filament bulb (3 watt)	8	8	0
16	Fan 1	6	6	0
17	Fan 2 – level 1	30	29	1
18	Fan 2 –level 2	32	31	1
19	Fan 2 – level 3	37	38	1
20	Fan 3	12	11	1
21	Water-pump 1	180	183	3
22	Water-pump 2	208	209	1
23	Water-pump 3	150	152	2
24	*USB adapter* 1	2	2	0
25	*USB adapter* 2	3	3	0
26	*USB adapter* 3	1	1	0
27	12 volt adapter – modem fiber optic	9	10	1
28	12 volt adapter – *ip set-top box*	6	6	0
29	Electric mosquito repellent	1	1	0
30	*LCD TV* 15"	18	17	1
Average reading difference		0.9 *watt*		

TABLE 6: TIME RESPONSE TO ORDER

No.	Order	Time (sec)	No.	Order	Time (sec)
1	Switch "*on*"	1.6	16	Switch "*off*"	1.9
2	Switch "*off*"	1.9	17	Switch "*on*"	2.2
3	Switch "*on*"	1.1	18	Switch "*off*"	1.7
4	Switch "*off*"	1.4	19	Switch "*on*"	1.5
5	Switch "*on*"	1.4	20	Switch "*off*"	1.4
6	Switch "*off*"	1.9	21	Switch "*on*"	2.3
7	Switch "*on*"	1.8	22	Switch "*off*"	2.3
8	Switch "*off*"	1.9	23	Switch "*on*"	1.7
9	Switch "*on*"	1.3	24	Switch "*off*"	1.8

10	Switch "*off*"	1.2	25	Switch "*on*"	1.4
11	Switch "*on*"	1.1	26	Switch "*off*"	1.3
12	Switch "*off*"	2.1	27	Switch "*on*"	1.7
13	Switch "*on*"	1.0	28	Switch "*off*"	1.7
14	Switch "*off*"	1.6	29	Switch "*on*"	1.2
15	Switch "*on*"	1.4	30	Switch "*off*"	1.9
Average time response				1.62 seconds	

TABLE 7: TIME RESPONSE TO EACH ORDER

No.	Order	Time (sec)	No.	order	Time (sec)
1	"Vol +"	1.3	16	"Vol -"	1.1
2	"Vol -"	[illegible]	17	"Vol +"	2.0
3	"Vol +"	1.2	18	"Vol -"	1.2
4	"Vol -"	1.4	19	"Vol +"	1.5
5	"Vol +"	1.5	20	"Vol -"	1.4
6	"Vol -"	1.4	21	"Vol +"	1.9
7	"Vol +"	1.2	22	"Vol -"	[illegible]
8	"Vol -"	1.7	21	"Vol +"	1.1
9	"Vol +"	1.3	24	"Vol -"	1.8
10	"Vol -"	1.2	25	"Vol +"	1.4
11	"Vol +"	[illegible]	26	"Vol -"	1.3
12	"Vol -"	1.5	27	"Vol +"	1.3
13	"Vol +"	1.7	28	"Vol -"	1.8
14	"Vol -"	1.2	29	"Vol +"	1.5
15	"Vol +"	1.4	30	"Vol -"	1.6
Average time response			1,48 seconds		

TABLE 8: NUMBER OF PUSH-BUTTON FOR CODE RECORDING

No	Remote Control button	Number of push-button (times)	No	Remote Control button	Number of push-button (times)
1	RC 1 - button vol+	4	16	RC 6 - button vol+	5
2	RC 1 - button vol-	6	17	RC 6 - button vol-	9
3	RC 1 - button ch+	4	18	RC 6 - button ch+	4
4	RC 2 - button vol+	5	19	RC 7 - button temp+	3
5	RC 2 - button vol-	6	20	RC 7 - button temp-	2
6	RC 2 - button ch+	7	21	RC 7 - button power	5
7	RC 3 - button vol+	10	22	RC 8 - button 1	5
8	RC 3 - button vol-	8	23	RC 8 - button 2	7
9	RC 3 - button ch+	5	24	RC 8 - button 3	5
10	RC 4 - button vol+	4	25	RC 9 - button menu	2
11	RC 4 - button vol-	2	26	RC 9 - button up	5
12	RC 4 - button ch+	2	27	RC 9 - button down	8
13	RC 5 - button vol+	3	28	RC 10 - button menu	14
14	RC 5 - button vol-	5	29	RC 10 - button up	12
15	RC 5 - button ch+	5	30	RC 10 - button down	5
Average push-button			5.5times		

3.4 Wattmeter & Electricity Control

This test is performed by comparing the results of energy recording by a module with a measuring device called as an energy meter. Table 5 shows the result of watt meter testing, and Table 6 shows the result of time response to order.

3.5 Infrared Control

In the next stage, testing of success in receiving code from a remote control based on different remote controls is done by pressing a button on the remote control several times until the code can be read and entered on the form on the web. Tests are carried out on remote controls on different types of furniture and brands. Each remote control provides 3 buttons to be recorded. The result of testing infrared control shows on Table 7 and Table 8 shows number of push-button for code recording.

3.6 Camera

The camera used in this test is the IP TP Link Model TL-SC3171G. The camera is connected to a network and to the server. The addition of this camera to the system is operated manually, by filling in the form. Some of these form fields are *IP Cam User Name*: Name of *username* to access *camera*, *IP Cam Password*: *Password* to access *camera*, *IP Cam URL*: As customized based on the brand and IP Cam model to be installed by selecting provided input above the box. If the settings are appropriate, then on the main page the device will display images taken by active CCTV.

After the camera is connected to the server, the next test is performed to take images, which will be saved on the "Photo" tab on the web. In this section, the user can see the results of the image along with capturing the image, and might delete it. Each saved image will be stored on every device that captures a picture, which cannot be be viewed when the camera device is removed.

4. DISCUSSION

The design and implementation of this smart home system applies JSON and is based on IoT networks. The maximum distance between Wi-Fi access points and modules in LOS conditions is about (±) 190 meters. Manual electric switches can be controlled automatically by replacing the switch with the Wattmeter & Electricity Control module. This Switch Control is carried out by the relays contained in the module. Energy recording is not always accurate, as an ESP8266 ESP-12F only has 1 ADC, which means it can only record currents, while the voltage is declared statically in the module program. The difference in energy readings compared to the energy meter is 0.9 watts, while the module average time response is 1.62 seconds.

Infrared-based furniture can be controlled by using the Infrared Control module through registering a remote control button with the system. Every brand of remote control on furniture has a different performance when sending infrared signals. When registering a remote control button on the Infrared Control module, the button must be pressed briefly (about ± 0.5 seconds) for successful code recording. This is due to the limited speed of the microcontroller in accepting data coding on the remote control. All types and brands of furniture remote controls can be recorded through this module. Each remote control has a different performance in sending infrared signals. The average response time for each command in the module is 1.48 seconds.

The door lock can be controlled automatically by replacing the manual door lock with the Door Lock module. If the door lock is open for more than 2 hours, the solenoid will become hot. The average time response for each command in the module is 2.34 seconds.

Lights that can be dimmed is controlled by using the Lamp Control module. This module can issue a 0-200 volt AC that can be used for various furniture. The maximum load for this module is 200 watts. If it exceeds the load, the module will heat but does not affect the performance and response time. The average response time for each command in the module is 2.32 seconds. By using the IP camera module, user can directly monitor a room and can take photos which will be stored on the system website.

IV. CONCLUSION

The maximum distance between Wi-Fi access points and modules in LOS conditions is 190 meters. The manual electric switch can be activated automatically by replacing the switch with the Wattmeter & Electric Control module. This switch control is carried out by the relay in the module. Energy recording is not always accurate, this is because ESP8266 ESP-12F only has 1 ADC, which means it can only use current, while the voltage is statistically declared in the program module. The difference in energy readings compared to the energy meter is 0.9 watts. While the average response time of the module is 1.62 seconds.

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ESP 8266 FOR CONTROL AND MONITORING IN SMART HOME APPLICATION

Lailis Syafa'ah
Informatics Engineering Faculty
Universitas Muhammadiyah Malang
Malang, Indonesia
lailis_tsd@yahoo.co.id

Agus Eko Minarno
Informatics Engineering Faculty
Universitas Muhammadiyah Malang
Malang, Indonesia
agoes.minarno@gmail.com

Fauzi Dwi Setiawan Sumadi
Informatics Engineering Faculty
Universitas Muhammadiyah Malang
Malang, Indonesia
fauzisumadi@umm.ac.id

Gayuh Widya Mukti
Informatics Engineering Faculty
Universitas Muhammadiyah Malang
Malang, Indonesia
gayuhwm@icloud.com

***Abstract*— A smart home system is commonly defined as an embedded system in the house which helps residents in carrying out routines at home. In this paper we propose to measuring maximum distance and response time of ESP8266 modules in smart home system which include online and real time controls of: door lock, lighting dimmer, automatic switches equipped with energy sensors, infrared furniture and camera systems. The system modules are based on an ESP8266** Wi-Fi **microcontroller. The modules are connected to a central server via** Wi-Fi **media by using data communication based on JSON on HTTP protocol, using an IP camera. Programs in modules are designed to be as simple as possible to save resources and to achieve the shortest possible response time. Modules on this smart home system have been tested and have proved to operate intelligent-home systems in providing controls of: electricity, automatic door lock, electricity consumption statistics, infrared-based furniture, and cameras to monitor a room directly. Based on experiment the maximum distance between** Wi-Fi **access points and ESP8266 modules in LOS conditions is 190 meters, and the average response time of the module is 1.62 seconds.**

Keywords—: Smart home, IoT, wi-fi, Measuring, Response time, ESP8266

I. Introduction

A house is a building that serves as a place to live and a means of family development along with the other functions as: a gathering place for relieving fatigue with family. To build a comfortable house, it requires high costs, such as: the cost of maintenance, security and so forth. In general, the house has a patent or fixed electrical system [1]. Routines, such as turning on the lights in the afternoon, turning off lights at bedtime, even forgetting to turn off the lights in the bathroom, especially forgetting to lock the door at night, are among common things to do in a house with patent electricity system. Thus, an automation to replace the manual job of home owner is required [2]. The frequent solution commonly chosen by homeowners is usually by hiring a housemaid and house keeper to secure the house. This solution is however not cheap, which cannot even be applied by middle to lower-income families with small income. The second choice to solve this problem is to build an intelligent housekeeper-like device on the smart home [3].

Smart home has a technology and service integrated in a home network to easily be accessed remotely in supporting a better life quality [4,5]. Smart home is a system that can be used to monitor and can control various home electronic devices remotely by using a wireless control, such as a remote control or other devices [6-9]. Smart home generally has 2 subsystems, which are: the software system with the user interface and the hardware system. The software system with the user interface performs a computerized process from the user commands and forwards commands to the system hardware that has been planted in the home electrical system [10,11]. The hardware system works as a center of control points on furniture and electrical points at home [12].

Smart home technology is related to the Internet of Things (IoT). According to Cisco, the Internet of Things is the point in time when objects connected to the internet exceed those of people connected to the internet [13]. The Internet of Things is a view where internet extends to the real world that includes everyday objects. Thus, it accommodates physical objects to be controlled remotely and can act as physical access points to internet services [14,15]. If a smart home adopts this technology, the smart home can be controlled remotely, from places connected to the internet [16].

However, several of the smart home modules in [17-20] do not shown maximum distance of IoT modules and response time of modules. Based on this background, this study proposes measuring maximum distance and response time of ESP8266 in a smart home system consisting of several modules, such as: lamp control, door locks, electrical control and electrical energy consumption sensors (watt meters & electricity control), infrared control and a camera that is integrated with the server. With a number of smart home modules, this system is expected to operate intelligent home systems such as providing electrical control, automatic door lock control, electricity consumption statistics reports, infrared-based furniture controls, and cameras to monitor a room directly. All of these controls will be carried out remotely by using an internet connection.

II. Method

At this stage, data collection and analysis of component requirements are carried out in each module. Identifying the functions in each module plays a significant role to find out the required appropriate components. Data collection is conducted from paper, journals and other information media including surveys as a source of information. Therefore, such a comfort home security can be achieved. The system as proposed to be developed, has the following architecture:

1) Server Layer: serves as the core layer of this system, which functions as a whole processor system and stores all system data.

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