Implementation and Analysis of Smart Lamp Using Android Application Based on Internet Of Things

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ABSTRACT
Internet of things (IoT) is technology that can make the devices communicate with each other and can be controlled from everywhere. Through this IoT technology, the smart lamp was made so the human can control the lamp in their house from everywhere and the lamp can work automatically based on the environment. This research was developed from the device was made before with three features, can control the lamp manually using a button on android application, can control the lamp automatically using ultrasonic sensor and light sensor connected to microcontroller ESP32. The sensors collect the data and storage to a cloud server, to control the lamp using an application in the smartphone with an android operating system. From the functional test light sensor, ultrasonic sensor, cloud server, and android application can work as its function. From end to end testing Ultrasonic Sensor mode from the lamp condition turn off to turn on has the lowest average delay 2.05 s. From network testing using fiber-optic wi-fi connection from ESP32 to ThingSpeak the On Button mode has the lowest average delay 0.35 s with throughput of 7.485 kbps. And from android application to ThingSpeak the Ultrasonic Sensor mode when the lamp condition is turned on has the lowest average delay 0.34 s with throughput of 7.127 kbps. From network testing using 4G wi-fi connection from ESP32 to ThingSpeak the Off Button mode has the lowest average delay 0.37 s with throughput of 8.151 kbps. And from android application to ThingSpeak the Off Button mode has the lowest average delay 0.19 s with throughput of 9.119 kbps.

Keywords: *IoT, HTTP, microcontroller ESP32, android, ultrasonic sensor, light sensor, lamp, ThingSpeak*

1. INTRODUCTION

In many countries energy efficiency is an important topic, because it can reduce the level of energy imports from foreign countries, and slow down the rate at which domestic energy resources are depleted[1]. Many people now using the Compact Fluorescent Lamp (FCL) than Light Emitting Diode lamp (LED), FCL lamp needs more electric power than LED[2]. Some previous research about this topic is using the temperature sensor, motion sensor [1], and button in android application [3]. The other research using a light sensor with Bluetooth connection as data transfer media[4]. But the Bluetooth connection has a maximum distance of around 100 meters[5]. Based on the previous research this system adding a new feature using an ultrasonic sensor to make the lamp turn on/off automatically based on the object in front of the sensor.

2. BACKGROUND

2.1 Internet of Things

Internet of Things (IoT) was first used in 1999 by Kevin Ashton to describe a system in which objects in the physical world could be connected to the Internet by sensors. IoT also can describe as intelligently connected devices and systems which be made up of smart machines, environments, objects and infrastructures and Radio Frequency Identification (RFID) and sensor network technologies[6].

2.2 ESP32

ESP32 is a microcontroller which has built-in 802.11 wi-fi module. ESP32 using Xtensa Dual-Core 32-bit LX 6 CPU, has 128 KB ROM, and 416 KB SRAM. ESP32 powered by 2.5 V to 3.6 V. EPS32 has 3.3 V and 5 V power inputs, 2 digital pins, and 15 analog pins[7].

2.3 Light Sensor

The light sensor generates an output signal indicating the intensity of light by measuring the radiant energy that exists in a very narrow range of frequencies basically called "light", and which ranges in frequency from "infra-red" to "visible" up to "ultraviolet" light spectrum[8].

2.4 HC-SR04

HC-SR04 is an ultrasonic sensor that provides a 2 cm to 400 cm non-contacts measurement function. It can be powered from a 5V power supply[9].

2.5 Relay

Relay is a programable electrical switch, which can be controlled by a microcontroller. It used to opening or closing the electrical circuit[10].

2.6 ThingSpeak

ThingSpeak is an IoT analytics platform service that allows to aggregate, visualize, and analyze live data streams in the cloud[11].

2.7 Android

Android is a Linux based operating system, it is designed primarily for touch screens mobile devices such as smartphones and tablet computers.

2.8 Hypertext Transfer Protocol

The Hypertext Transfer Protocol (HTTP) is an application-level protocol for distributed, collaborative, hypermedia information systems. The HTTP protocol is a request/response protocol. A client sends a request to the server in the form of request method, URI, and protocol version, followed by a MIME-like message containing request modifiers, client information, and possible body content over a connection with a server. The server responds with a status line, including the message's protocol version and a success or error code, followed by a MIME-like message containing server information, entry metainformation, and possibly entity-body content [12].

3. RESEARCH METHODOLOGY

This research used IoT in the smart home field to make a smart lamp system which can control from everywhere.

This smart lamp system used ESP32 microcontroller as the brain of the system, ultrasonic sensor and light sensor to control the lamp automatically. The smart lamp system also can control manually to turn on or turn off the bulb lamp using the button in the android application. All the smart lamp systems controlled by android applications. This system using a cloud server ThingSpeak to save the data sensors or used by the android application to get the sensors data, and the sensors data can be displayed in the android application. After build the system, this study also check the quality of service (QoS) of this system to known the delay and throughput in traffic data from a microcontroller to cloud server and from android application to cloud server. The smart lamp system uses the HTTP protocol as the transfer data protocol.

The system is tested using three kind of tests, first sensor testing. Sensor testing used to know the delay of the sensors and how the sensor reads the condition based on their function when connected to the internet. The second is an end to end testing, end to end testing is the time that happens from user giving a command in the android application until the bulb lamp responding the command. And the last testing is network testing, network testing is used to know the delay and throughput from microcontroller ESP32 to cloud server ThingSpeak and also from android application to cloud server ThingSpeak. The network testing divided into two wi-fi connection, first is using fiber optic wi-fi connection and second is using 4G wi-fi connection.

4. RESULT AND DISCUSSION

Table 1. Ultrasonic sensor testing result

Distance	Lamp status
25 Cm	On
75 Cm	Off
125 Cm	Off

The result of the sensor testing is the ultrasonic sensor can work well and read the object distance constantly at 25 cm, 75 cm, and 125 cm. In 25 cm the lamp is turned on, in 75 cm and 125 the lamp is turned off because this system set the distance threshold at 75cm.

Table 2. Light sensor testing result

Parameter	Lamp status
Above threshold	Off
Under threshold	On

The light sensor also can work well, this system set the light intensity threshold at 850, first testing in room condition with a low light intensity which is under the threshold and the sensor read the light intensity inconstantly but it is not a serious problem for this system because the sensor still read the light intensity under the threshold with the lamp condition is turn on; and the second testing in room condition with a bright light intensity which is above the threshold and the sensor read the light intensity inconstantly but it is not a

serious problem for this system because the sensor still read the light intensity above the threshold with the lamp condition is turn off.

Table 3. End to End testing result

Mode	Average Delay
On Button	2.16 s
Off Button	2.28 s
Light Sensor (on to off)	3.87 s
Light sensor (off to on)	2.71 s
Ultrasonic Sensor (on to off)	2.2 s
Ultrasonic Sensor (off to on)	2.05 s

This end to end testing set the maximum delay parameter at 26.5 s. The results of the end to end testing are in Button On mode the delay is 2.16 s; Button Off mode 2.28 s; Light Sensor mode (from the lamp condition from turn on to off) the delay is 3.87 s; Light Sensor mode (from the lamp condition from turned off to on) the delay is 2.71 s; Ultrasonic Sensor mode (from the lamp condition from turned on to off) the delay is 2.2 s; Ultrasonic Sensor mode (from the lamp condition from turned off to on) the delay is 2.05 s.

Table 4. Fiber optic wi-fi network testing result

Mode	ESP32 to ThingSpeak		Aplikasi Android to ThingSpeak	
	Delay	Throughput	Delay	Throughput
On Button	0.35 s	7.485 kbps	1.31 s	1.668 kbps
Off Button	0.36 s	7.401 kbps	0.69 s	2.691 kbps
Light Sensor On	0.47 s	4.631 kbps	0.61 s	4.462 kbps
Light Sensor Off	0.47 s	4.682 kbps	0.67 s	3.462 kbps
Ultrasonic Sensor On	0.49 s	4.463 kbps	0.34 s	7.127 kbps
Ultrasonic Sensor Off	0.49 s	4.488 kbps	0.54 s	5.280 kbps

The network testing set the maximum delay parameter at 3.24 s and set the maximum throughput parameter at 0.16 kbps. The result of network testing using wi-fi fiber-optic connection from ESP32 to ThingSpeak On Button mode has 0.35 s delay and 7.485 kbps throughput; Off Button mode has 0.36 s delay and 7.401 kbps throughput; Light Sensor mode (the lamp condition is turn on) has 0.47 s delay and 4.631 kbps throughput; Light Sensor mode (the lamp condition is turned off) has 0.47 s delay and 4.682 kbps throughput; Ultrasonic Sensor mode (the lamp condition is turned on) has 0.49 s delay and 4.463 kbps throughput; Ultrasonic Sensor mode (the lamp condition is turned off) has 0.49 s delay and 4.488 kbps throughput. And the result from android application to ThingSpeak On Button mode has 1.31 s delay and 1.688 kbps throughput; Off Button mode has 0.69 s delay and 2.691 kbps throughput; Light Sensor mode (the lamp condition is turned on) has 0.61 s delay and 4.462 kbps throughput; Light Sensor mode (the lamp condition is turn off) has 0.67 s delay and 3.462 kbps throughput; Ultrasonic Sensor mode (the lamp condition is turned on) has 0.34 s delay and 7.127 kbps throughput; Ultrasonic Sensor mode (the lamp condition is turned off) has 0.54 s delay and 5.28 kbps throughput.

Table 5. 4G wi-fi network testing result

Mode	ESP32 ke/dari ThingSpeak		Aplikasi Android ke/dari ThingSpeak	
	Delay	Throughput	Delay	Throughput
On Button	0.38 s	8.097 kbps	0.25 s	7.005 kbps
Off Button	0.37 s	8.151 kbps	0.19 s	9.119 kbps
Light Sensor On	0.51 s	6.474 kbps	0.6 s	4.362 kbps
Light Sensor Off	0.8 s	4.038 kbps	0.78 s	3.583 kbps
Ultrasonic Sensor On	0.55 s	4.558 kbps	1.24 s	2.402 kbps
Ultrasonic Sensor Off	0.55 s	4.691 kbps	1.03 s	2.606 kbps

The result of network testing using wi-fi 4G connection from ESP32 to ThingSpeak On Button mode has 0.38 s delay and 8.097 kbps throughput; Off Button mode has 0.37 s delay and 8.151 kbps throughput; Light Sensor mode (the lamp condition is turned on) has 0.51 s delay and 6.474 kbps throughput; Light Sensor mode (the lamp condition is turned off) has 0.8 s delay and 4.038 kbps throughput; Ultrasonic Sensor mode (the lamp condition is turned on) has 0.55 s delay and 4.558 kbps throughput; Ultrasonic Sensor mode (the lamp condition is turned off) has 0.55 s delay and 4.691 kbps throughput. And the result from android application to ThingSpeak On Button mode has 0.25 s delay and 7.005 kbps throughput; Off Button mode has 0.19 s delay and 9.119 kbps throughput; Light Sensor mode (the lamp condition is turned on) has 0.6 s delay and 4.362 kbps throughput; Light Sensor mode (the lamp condition is turned off) has 0.78 s delay and 3.583 kbps throughput; Ultrasonic Sensor mode (the lamp condition is turned on) has 1.24 s delay and 2.402 kbps throughput;

Ultrasonic Sensor mode (the lamp condition is turned off) has 1.03 s delay and 2.606 kbps throughput.

5. CONCLUSIONS

1. In this system plug, relay, and fitting connected each other using cable. The sensors and relay connect to microcontroller ESP32 using jumper wires. For data traffic from a microcontroller to cloud server and from android application to cloud server using the HTTP protocol.
2. Ultrasonic Sensor mode and Light Sensor mode in android application use to control the led lamp to an automatic mode so the lamp can turn on/off based on the environment condition. Button mode use to control the lamp manually. To control the lamp the data from the android application send to a cloud server and from cloud server data send to a microcontroller ESP32.
3. Ultrasonic sensor and light sensor can collect and send the data to the microcontroller. Android application can send the command to a microcontroller and display the sensors' data. The cloud server can save the data from the microcontroller. Average end to end delay in every mode under 26.5 s. Average network delays under 3.24 s and the throughput more than 160 bps in every mode.

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