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SMART LABORATORY SYSTEM USING RASPBERRY PI 2

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Abstract. *Smart Laboratory is an automation system to facilitate the control of the electronic appliances located in a laboratory. In the present study, we developed a Smart Laboratory system using Raspberry Pi 2, in which the lamps and air-conditioning (AC) are as its object. To control lights is to use relay 12VDC derived by GPIO of Raspberry Pi 2, while the AC control using a programming library LIRC (Linux Infrared Remote Control) is installed in the Raspberry Pi 2. To work the system in this study is based on the time delay control is based on two types of connection, i.e., Wi-Fi (1st scenario) and PLC adapter (2nd scenario). The results showed that the average time delay is obtained for the 1st scenario of AC 1 = 1.09s, AC 2 = 0.93s, Lamp 1 = 1.152s, Lamp 2 = 1.402s, while in the 2nd scenario of the AC button 1 = 1.34s, AC 2 = 1.81s, Lamp 1 = 1.28s, Lamp 2 = 1.483s. The better performance is shown when the connection uses Wi-Fi adapter.*

Keywords: Raspberry Pi 2, Smart Home, Smart Laboratory, Delay, LIRC

1. **Introduction.** Advancement in science and technology allows us to make a device and system that can assist all activities and resolve problems faced by themselves. One of the systems created by man to facilitate the work of the system is the Smart Home.

Smart Home is an automated system for a room or a building created to make our task managements easy to do. This system is needed to provide comfort, convenience and energy efficiency. Smart Home can combine multiple electronic devices and connect through the Internet to be controlled using a computer or *Smartphone*, allowing *remote* access from the Internet and creating a device that can communicate in an integrated and coordinated one. Among the two media controllers, PC and *Smartphone*, *Smartphone* device was the most appropriate to be used as an interface in the *Smart Home* system.

The laboratory has an important role in the field of engineering. A technology-based system that can simplify and streamline the activities of the laboratory is needed. Smart Home system is the most appropriate to be adapted in the laboratory system. Therefore, this study proposes a control system using the Raspberry Pi 2 where the air conditioning (AC) and lights are as managed object. This study is the first step to develop a smart laboratory.

2. **Related Work.** There are several related researches on *Smart Home* including *"Man Machine Interface (MMI) in Smart Home Prototype Based on Smartphone"* [1]. However, this research is still a *prototype* and has not been able to control the air conditioning. In another study, controlling is carried out by using the Web Server and the managed objects are lights [2]. Furthermore, in [3] the authors use the applications installed on the Smartphone for the controlling but its communication system is based on local host with the controlled object being relay. In other related researches, Smart Home is using Microcontroller and Webserver as interface [4].

3. **Design and Implementation System.** The proposed design system consists of designing hardware and software. Hardware design includes the control circuit of the Raspberry Pi 2, while software design includes software Raspberry Pi 2 and Android application. The aim of this design is to provide convenience to the user to control the electronic device in laboratory, in this case the air conditioning (AC) and lights (lamps), via the Internet using *Smartphone*. The diagram of the proposed system is shown in Figure 1.

Smart Application Laboratory is installed on smartphones that can access the web address on the Raspberry Pi 2 as a server, which is used to change the temperature of AC and lamps condition. Detail design is shown in Figure 2. Raspberry PI is the main part of our design. In this paper, Raspberry Pi 2 is as the control center and server; Wi-Fi and PLC adapters are to connect Raspberry Pi 2 from Internet via Virtual Private Network; Smartphone with Android OS is as media regulator in the Smart Laboratory system; Our Design makes use of two IR LEDs. *IR LED* serves as an infrared signal sender to set the AC; in addition there are three *Relays*. Two 12VDC relays are used as switches to control two lamps. The other relay is used to select control active data transmission from IR infrared LED 1 or 2. As interfaces to the relays, transistors are used. The transistor is protected from inductive current the relay by diode. In this experiment, Raspberry PI 2 is powered by USB power supply while the relays and their drivers are powered by additional regulated power supply (LM7805).

Figure 3 shows the user interface of android application on Smartphone. The first screen is logon screen to input username and password. The second screen is to input temperature settings (up/down button) and to control the light by setting the buttons on

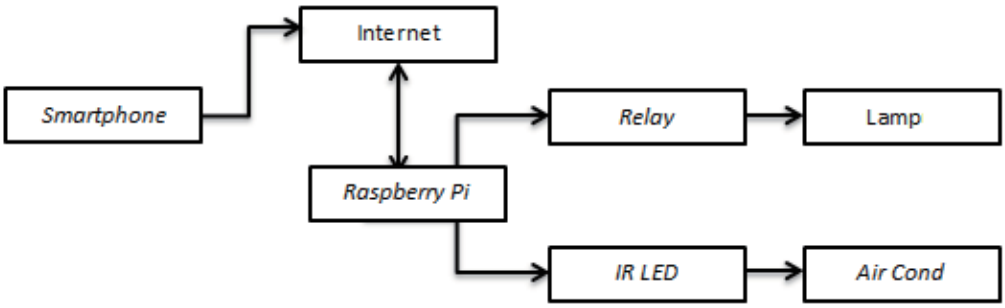


FIGURE 1. The proposed system

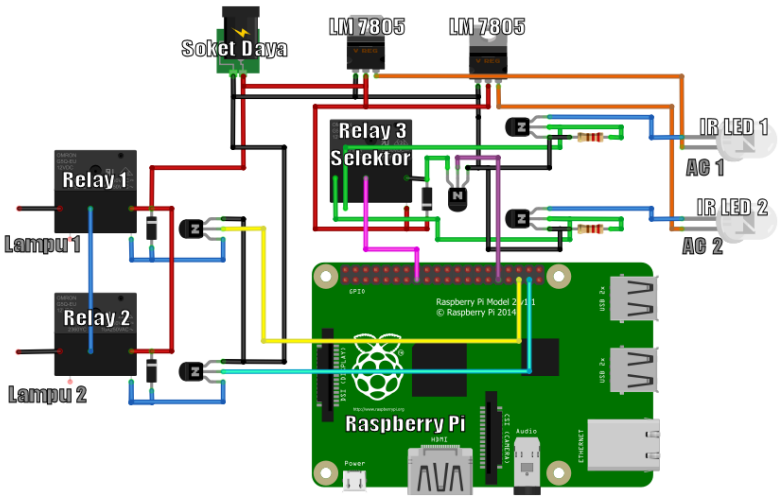


FIGURE 2. General schematic diagram of Smart Laboratory system

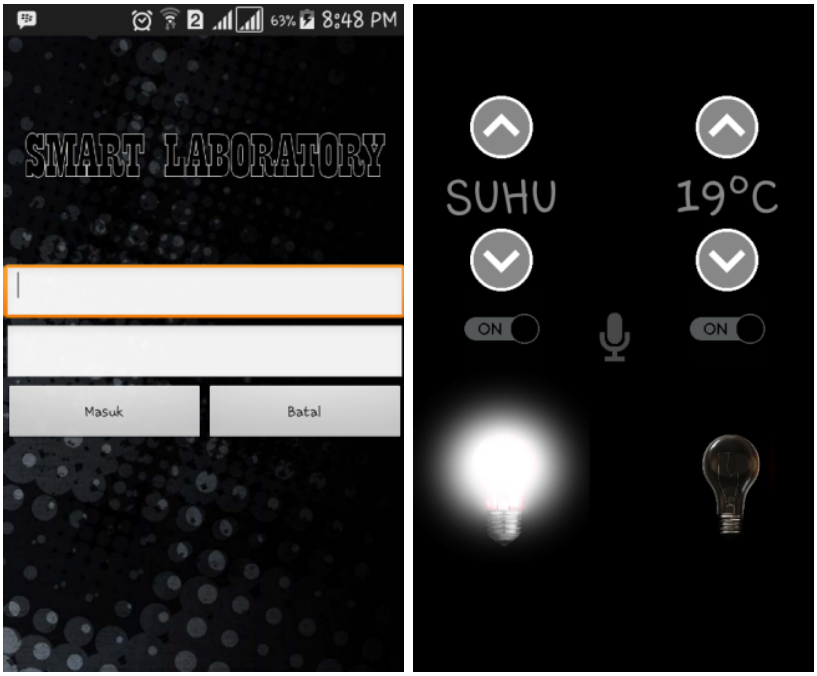


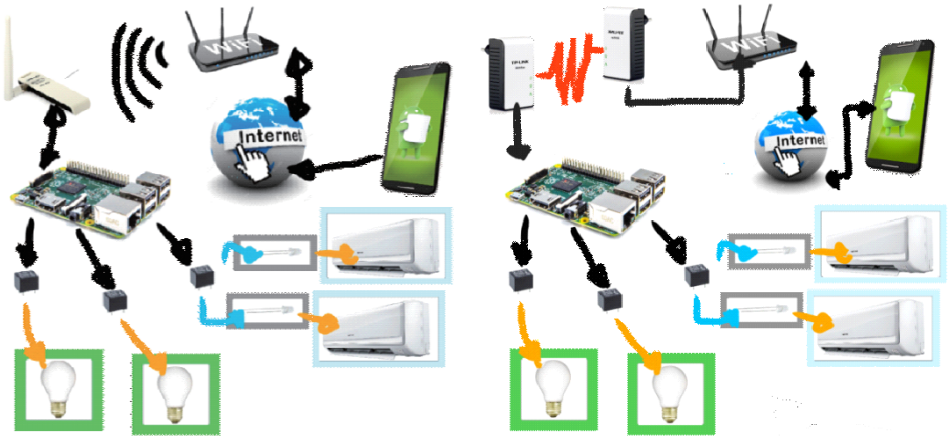
FIGURE 3. Smart Laboratory UI application on Smartphone

or off. At the same time when one button is switched on, timer is activated. The timer is used to perform delay measurements.

4. **Results.** This section presents testing scenarios of the system by measuring *the time delay* based on the illustration in Figure 4 below. To measure the time delay, we implement timer on android application. The application activates the timer at the same time when we set the button on. Finally the timer stops after the lights are on. The same scenarios are applied for the air conditioning system.

In this paper, Wi-Fi and PLC adapters are compared related to delay time access to the managed objects. From the AC and lamp control testing, the results of delay time measurements are presented as shown form Table 1 to Table 2.

Table 1 shows that the average delay time access via Wi-Fi adapter is smaller than that via PLC adapter for controlling AC 1 and AC 2. While controlling the lamps, the delay time is measured five times for the two conditions, namely ON-OFF and OFF-ON.



(a) Using Wi-Fi adapter (b) Using PLC adapter

FIGURE 4. The illustration of testing scenarios

TABLE 1. Delay time response of AC relative to command button

Temperature		**Delay time (*s*) using Wi-Fi adapter**		**Delay time (*s*) using PLC adapter**	
From	**To**	**AC 1**	**AC 2**	**AC 1**	**AC 2**
16	17	1.33	1.31	1.01	0.89
17	18	1.33	1.06	1.53	1.07
18	19	1.38	1.16	0.96	0.82
19	20	1.66	1.16	1.39	0.77
20	21	1.28	1.01	0.97	6.06
21	22	1.36	1.33	1.15	1.47
22	23	0	0	1.02	3.06
23	24	1.41	1.16	1.05	3.44
24	25	1.46	1.33	1.02	0.87
25	26	1.4	2.23	1.09	0.91
26	27	0	0	1.57	0.82
27	28	1.35	1.33	1.18	3.91
28	29	0	0	0.9	0.69
29	30	0	0	3.97	0.61
Average		**1.09**	**0.93**	**1.34**	**1.81**

TABLE 2. Lamp response time to tap button

Lamp condition		**Average delay time (*s*) using Wi-Fi adapter**		**Average delay time (*s*) using PLC adapter**	
From	**To**	**Lamp 1**	**Lamp 2**	**Lamp 1**	**Lamp 2**
ON	OFF	1.3	1.718	0.984	1.394
OFF	ON	1.004	1.086	1.272	1.572

Average response time of lamp 1 and lamp 2 are shown in Table 2. The results show that PLC adapter gives better performance in condition of ON-OFF. The amount of delay time in the proposed system is not only influenced by the hardware used, but also affected by the quality of Internet connection.

5. **Conclusion.** The implementation of electronic devices controlling in laboratory as the previous step toward Smart Laboratory was performed in this paper based on delay time access. Based on the results, controlling system through Wi-Fi adapter shows the better performance than PLC adapter. However, the delay time in the measurement is also influenced by the quality of the Internet connection from Smartphone to Raspberry Pi 2.

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