Web based Home Automation System Prototype using Raspberry Pi

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Abstract: Progress in the field of technology has grown very rapidly, especially related to Internet of Things (IoT) where the development of smart home automation system can be found in our daily life. Electronic devices such as lights in the house are generally controlled manually, which the homeowner often forget to turn off while going out and resulting in excessive use of electrical energy. The development of a web-based home automation system prototype using the raspberry pi can provide a solution to remotely control an electronic device. The method used to develop the system is prototyping model to built, tested and refined repeatedly until a final prototype is achieved. The result of this research is a prototype will simulate 4 electric outlets using 4 lamps, and the raspberry pi will work as the web server enabling the user to be able to remotely control the electronic device and minimize excessive use of electrical energy.

1 INTRODUCTION

The rapid development of technology has influence many aspect of daily activities and has become an integrated part of people's lives. Home Automation System (HAS) is growing faster and it requires extensive development to be implemented as a smart home. The purpose of home automation is to makes living in the house more enjoyable or productive by applying intelligence to make it happen. Home automation can be seen as a collection of open source software, consumer hardware and a few line of code that makes them interact. Different technologies and programming languages can be used to finish the tasks. The communication protocols will be essential in home automation and has been the first step toward true technology integration. Wide variety of options are available for HAS such as GSM based HAS, Bluetooth based HAS, Phone based HAS, Zigbee based HAS, Wireless Control System and Mixed Type (Satish et al., 2015). Data source will provide information and the software and process are necessary to combine everything into a unified technology. Typical sensor that's been used in HAS modelling involved infrared remote, Bluetooth and GSM. While infrared and Bluetooth has a range issue, the GSM can be used worldwide to control HAS from anywhere. The key advantage of system is if control circuit fails then manual switching option of traditional method is available (Shinde et al., 2017).

The priority for developing a HAS is to have an automatic or controlled appliances and equipment in the vicinity. Specialized system comes with higher price tag, while cheaper solution can be made based on mini computer system such as Raspberry Pi and Java ME 8 (Rostyslav et al., 2015). The Raspberry Pi provision of GPIO makes it capable of running several services at once, expanded easily, and better update. With a number of specific modules that are available for expansion to be implemented in a low of new projects (Goodwin, 2013).

Another development on the concept of smart home is by using PIC16F887 as the microcontroller and integrates it with GSM to provide the smart automated house system with the desired baud rate of 9600 bps. The proposed prototype then will be implemented and tested with maximum of four loads and shows the accuracy of ≥98% (Teymourzadeh et al., 2013). HAS was developed using open source software technology for computer based applications. The huge number of data collected needs efficient data storage mechanisms for continuous monitoring. (Suryadevara and Mukhopadhyay, 2015).

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The lack of monitoring in the use of electronic devices has an impact on excessive use of electrical energy and increasing electricity bills. The fundamental of building an automation system for an office or home is to acquire an efficient and economical use of the electricity. The use of wireless technologies provide several advantages such as reduced installation costs, internet connectivity, scalable and expandable (Gunge and Yalagi, 2016). HAS using Raspberry pi and Internet of Things technology are suitable for real time monitoring and for controlling the home appliances remotely. It also provide extra layer of security and protection, can be employed in many places. (Pavithra and Ranjith, 2015).

Most homeowner are not efficient in operating various electronic equipment in daily life. For example the lights in a room that are no longer used but still on and homeowners often forgot to turn off electronic devices that has not been used when leaving. To help reduce the negligence use of these electronic devices, this research will overview the implementation of a Raspberry Pi Mini PC as a controller through the PHP programming language to make it easier for homeowners to control electronic equipment.

2 PROPOSED SYSTEM

Prototyping model will be used to develop the system and it is a system development model that will assist developer and other stakeholder to better understand what is to be built when the requirement are fuzzy. The constructed prototype constructed is deployed and evaluated by stakeholders. Prototype serves as a mechanism to identify software requirements (Pressman, 2011) as shown in Figure 1.

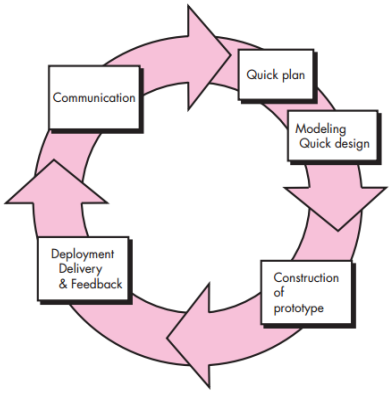

Figure 1: Prototyping paradigm (Pressman, 2010).

SWOT analysis (Strength, Weakness, Opportunities and Threats) is the process of formulating a strategy to find strategic solution between external opportunities and internal strengths while paying attention to external threats and internal weaknesses. One way to conclude the strategic factors is to combine external strategic factors with internal strategic factors into a summary analysis of strategic factors. Based on the SWOT analysis in Table 1, a Web-based Prototype Home Automation System using Raspberry Pi will be built. It will simulate the lights controlling as a solution in dealing with problems that occur in current situation of homeowner.

Table 1: SWOT analysis.

Internal / External	Strength: The configuration and ease of use of the control system.	Weakness: The existing control system is still less efficient because the control distance is limited.
Opportunity: Security is more trustworthy, still widely used by the community.	S-O Strategy: Develop a control system that is easy to use and safe, develop a system that can attract people's interest.	W-O Strategy: Develop an electrical control system that can be accessed anywhere and anytime.
Threat: The use of electrical energy is not controlled.	S-T Strategy: Building a control system that is easy to use and can minimize errors in controlling and using electrical energy.	W-T Strategy: Develop a control system that is not limited to distance that can minimize the use of uncontrolled electrical energy.

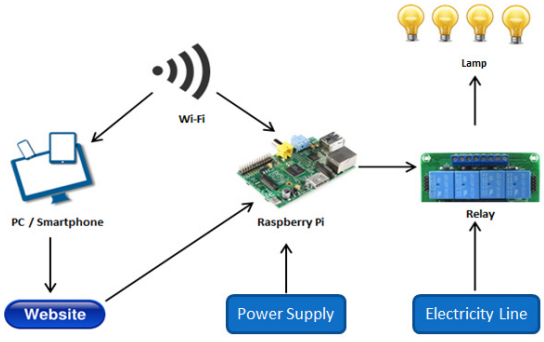

Figure 2: Architecture of proposed HAS.

From Figure 2, it can be seen that a PC or smartphone is the device that will be used to access the system website page so that it can control electricity on simulated devices with 4 lights via the internet. The power supply is a device that provides a voltage source to Raspberry Pi.

Raspberry Pi in this system is used as a Web Server and the controller for electrical devices through Relay Module. To enable the control of Relay Module on Raspberry Pi, there is a GPIO Pin that can be used for communication with other devices and on this system there are 4 pins that will be used as output pins, namely GPIO 18, GPIO 23, GPIO 24, and GPIO 25. Raspberry Pi used in this system is the Raspberry Pi B model.

Relay is an electronic switch that can be controlled by providing logic value 0 or 1 which in the construction of this system, the input is obtained from Raspberry Pi GPIO pins. The relay used in the design of this system is the DT-I / O Quad Relay Board from Innovative Electronics. Relay on this system is used to control electrical devices that can be directly connected via a jumper cable to the Raspberry Pi mini pc.

3 SYSTEM DESIGN

The work flow from the Home Automation Prototype will be described on system design. To be able to control the electrical devices in this system simulated with lights, first the user must log on the web page, after that the system will check the user's login data whether it is correct or not. If the login user data is not suitable then the user cannot enter the system to control the lights, so the user must re-login with the appropriate username and password. After logging in correctly, the user can choose the light mode such as ON or OFF mode on the web page. The system will then change the GPIO status value 1 or 0 on Raspberry Pi based on the light mode selected by the user on the web page, if the GPIO status is 1 then the system will turn on the light, and if the GPIO status is 0 then the system will turn off the light. The user will receive light status information on the web page, and then the user can logout to exit the system control web page.

Website interface design is designed to make it easier for users to interact with the system. The website created only has 2 pages, which is the login page and the control page. The website that will be created is also a responsive website that can adjust the size of the website based on the size of each screen that accesses this system. Figure 3 and 4 is the website design that will be created. The mock-up is created using the Balsamiq Mock-up 3 application.

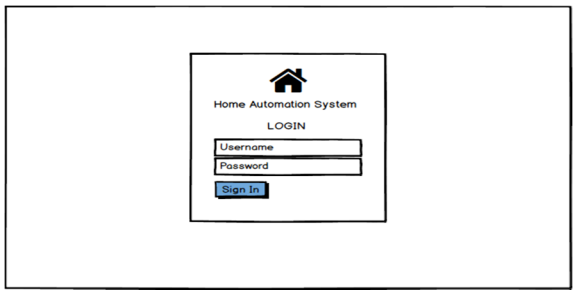

Figure 3: Login page design.

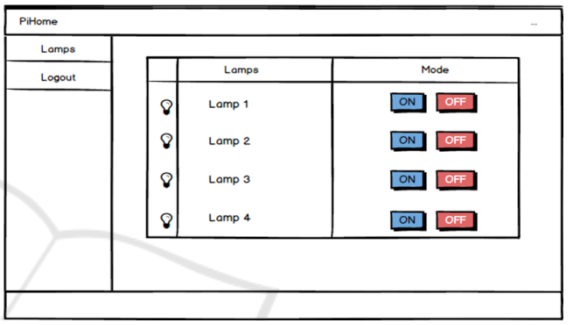

Figure 4: Control page design.

Figure 5 shows how the configuration of hardware and software components used in this system. Based on the system architecture design, there are 4 hardware components that are configured to be implemented in this system, namely pc/smartphone, raspberry pi, relays, and lights.

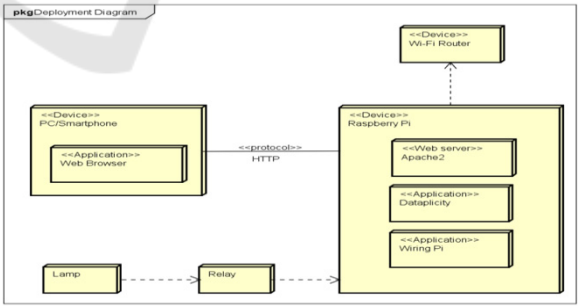

Figure 5: HAS Deployment diagram.

Users can access the Prototype Home Automation System interface by using a PC or smartphone that has a web browser application installed. Raspberry Pi is a tool that will be used as a server in this system, there are three applications installed on Raspberry Pi so that it can be used for controlling lights. The applications are Apache2,

Dataplicity, and WiringPi. A PC or smartphone can connect to Raspberry Pi via HTTP (Hypertext Transfer Protocol). Relay is a tool used as a magnetic switch to turn on or turn off the lights. Relay relies heavily on Raspberry Pi to run.

4 IMPLEMENTATION

Based on the design of the user interface prototype that has been designed, the next stage is to implement the web based application using PHP and HTML that can be accessed online where the devices can be controlled and monitored remotely. Rostylav et al., (2015) developed a HAS using Java ME with various sensors and only works offline.

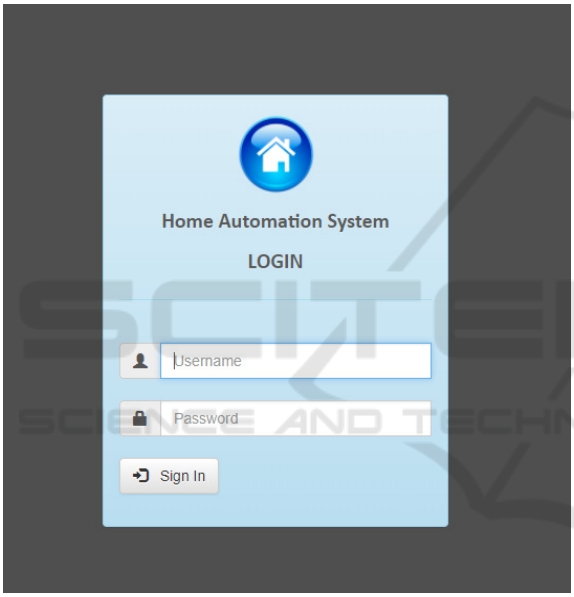

Figure 6: Login page (version 1).

The initial version of login page as shown in Figure 6 will require the users to enter a username and password to enter the next page. The status of all lights will be visible, showing whether it is turned On or Off as shown in control page Figure 7.

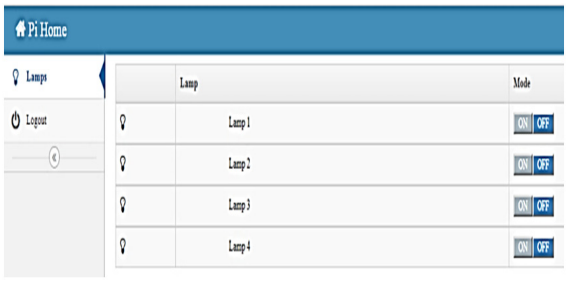

Figure 7: Control page (version 1).

When the user clicks the On/Off button, the button and icon will change colour, which indicates that the button is active. Options menu in the sidebar will be highlighted when the cursor is directed at each option for both elements. On control page the user can choose the light mode, which is On/Off as provided in the table, there are 4 lights that can be controlled. Users will be transferred to the login page when clicking on the logout button. The HAS website is accessible through a web browser and it will communicate with the Raspberry Pi mini pc using a number of supporting software namely WiringPi, PHP5, Apache, and Dataplicity which are configured on Raspberry Pi. Sweta and Dinesha (2016) implement HAS that support voice command but accessed by using an IP address and can only be used with android smartphone.

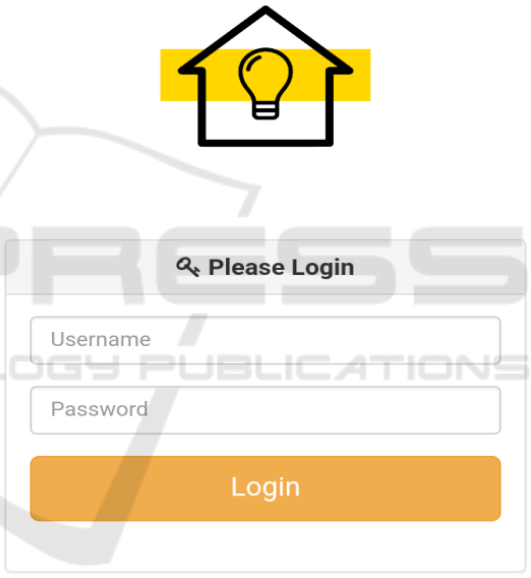

Figure 8: Login page (version 2).

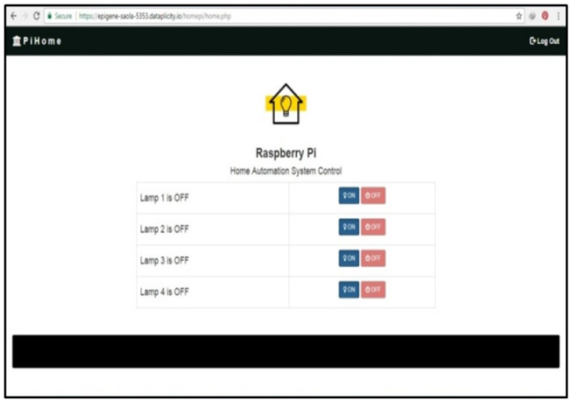

Figure 9: Control page (version 2).

Users then evaluate the website user interface and based on their feedback, some changes has been made in the interface design as shown in Figure 8 and Figure 9. The HAS consists of Raspberry Pi as the central control of all hardware that has been used in this system. The result of this research in the form of hardware is an electrical device control system using the Raspberry Pi as a control centre for electrical devices that receives commands from the website and forwards commands to the relay module to turn on or off the electrical device. Teymourzadeh et al., (2013) investigates the potential of HAS based on SMS technology and microcontroller.

Figure 10 shows the electronic circuit of raspberry pi home automation system hardware that is implemented in prototype form. Connected directly to the power source and forwarded to the relay module and electrical devices which in the system prototype is implemented in the form of a lamp so that it can be controlled through the system.

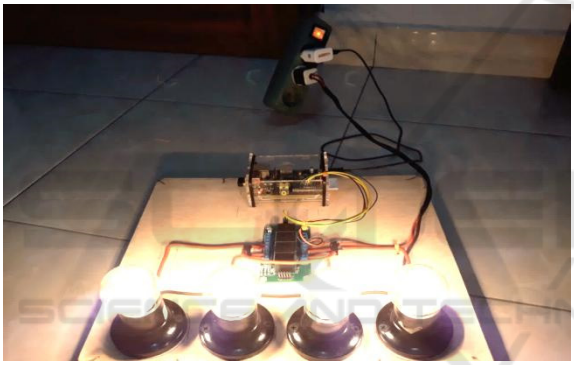

Figure 10: HAS hardware prototype.

Server response testing is to test the response speed of the server to process commands from user turning on a lamp, and the test process applied to all four lights using the internet network at different times, namely at night and morning. Based on the data in Table 2, the average response time from the server to be able to turn on a lamp is 1.7 seconds. So it can be concluded that the main factor that influences the performance of the system is the internet network, if the internet network is slow, the process carried out by the server to receive data becomes slow.

Table 2: Server response testing.

	Night	Morning
Lamp 1	02.15 sec	01.71 sec
Lamp 2	01.97 sec	01.25 sec
Lamp 3	01.71 sec	01.45 sec
Lamp 4	02.55 sec	01.25 sec

5 CONCLUSIONS

Based on the design and results of the tests that have been carried out, the proposed home automation system prototype is able to remotely control the electronic device and minimize excessive use of electrical energy. In this case, it is made using 4 lights as a simulation of electronic devices, raspberry pi which functions as a server, and a relay module that functions as a magnetic switch. The user interface in this system can be accessed using a PC or smartphone. Prototype of web-based home automation system using raspberry pi allows users to be able to control electronic devices without being limited by distance using the internet network.

For future works, it is expected to be developed and improved by adding various sensors in the system, using scheduling to turn on/off electronic devices, measuring the use of electrical energy, etc.

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