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Development of an IoT-based Smart Home System to support a Comfortable and Safe Work Environment

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Abstract. One of the important aspect in creating a comfortable and safety working or living environment is when all supporting electronic equipment can be controlled according to user desires and needs. Home, room or building can be a pleasant environment for doing activities by providing the comfort of the work environment beforehand. Therefore, a reliable IoT-based smart home system was designed to help users or managers to control the room or office so that the comfort and safety aspects was maintained. The IoT system built using a MCU Node Microcontroller allowed the room electronic equipment to be controlled. While the control interface was embedded in the smartphone. The research design used Research and Development (R&D) with Waterfall model. Meanwhile, the testing system used functionality testing and performance testing. The test results showed that all the functions of the system designed could run well. Meanwhile, the performance testing showed very effective result. Based on the test results, it can be concluded that the smart room system can be applied.

Key Words: Comfortable and Safe Work Environment, Smart Room, IoT System, Node MCU.

Background

A smart room is a room equipped with high technology that allows various systems and devices in the building to communicate with each other. Smart rooms contain various systems and devices such as central heating, fire alarms, televisions and lights that convey information and commands to one another. Smart room systems in work are assisted by computers to provide all the comfort, safety, security and energy saver that works automatically and is connected via a computer in a building. Smart room systems are used to control almost all electronic devices and equipments, such as controlling lights and air conditioners whose commands can be carried out only by using the internet network, infrared rays or remote control (Endra dkk., 2019).

Humans can make various kinds of tools as a tool in carrying out various activities in daily life to be used appropriately, effectively and efficiently. Technological devices that are created simply and properly managed will greatly assist the activities of everyday human life. One of these supporting tools is the application of Internet of Things (IoT) technology, which is part of information technology and can be applied to electronic devices.

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Picture 1. Concept of the Internet of Things (IoT) (Source : Endra et al., 2019)

Internet of Things plays an important role in people's lives. For example in smart rooms, IoT can connect various electronic devices that can be controlled both indoors and outdoors so that they can be controlled from anywhere with the help of an internet network connection. Furthermore, opportunities are formed to connect and incorporate the real world into the computer world by integrating with the internet network and sensors. Many of the connections of the tools came into being and resulted in a process that was automatic in all respects and allowed them to be used at an advanced level. And it can provide accuracy that provides efficiency for the economy which results in reduced direct human activity (Muhamad, 2019).

Smart room is an automation system that makes it easy to control electronic devices in a room or office (Rahmasari & Arrofiq, 2016) (Isnianto et al., 2017). Smart home or home automation can help in everyday life. Of course, the method is quite simple like flipping a switch to turn on a light and it is much easier than climbing a ladder to turn on a light (Endra et al., 2019). However, when you are in a place where you don't need to touch a light switch again, a computer or smart phone can automatically do it.

IoT applications can be built using the ESP 8266 module. This ESP 8266 module already has a microprocessor, memory, and input / output pins. This module can be used directly to communicate with the TCP / IP model (Wasista et al., 2019). The ESP-8266 module can also be used to control electronic equipment.

This research was conducted at the Department of Electronics Engineering, FT UNM. Electronic equipment in this department is in the form of lights, air conditioning (AC), computers and projectors. But in this research, only lights and AC will be controlled. In general, the operation of lights and air conditioners is only based on turning on and off the device using either a remote control or a switch. Campus and lecture services usually start at 7:30 a.m. so the time it takes to prepare the room including making sure the room is comfortable by turning of the AC. In addition, during after-office hours sometimes forget to turn off some equipments, especially lights and air conditioning. This is usually caused by human factors that sometimes forget.

RESEARCH METHODOLOGY

The research design used was Research and Development (R&D). This study aimed to produce a product, test the functionality and performance of the resulting

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product. The R&D cycle consists of several things, namely analyzing research needs related to the product wanted to develop, developing a product based on the results of a needs analysis, testing the end user, then making revisions to fix deficiencies found at the testing stage. The development model used was the Waterfall Model. This model is also known as "Linear Sequential Model", and is often referred to as "classic life cycle". This model first appeared around 1970 so it is sometimes considered outdated, but it is a model that is often used to build Software Engineering (SE).

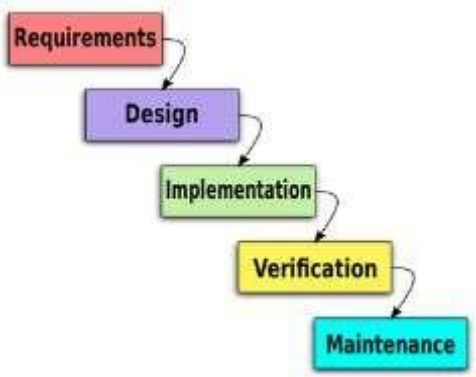

Figure 2. Water fall model (Source: Endra et al., 2019)

This model is implemented using a structured and sequential approach starting from the needs analysis, design, programming, testing, and maintenance stages. It is said to waterfall because each stage used must wait for the previous stage to finish and run systematically.

The needs analysis process was carried out intensively to specify device requirements so that it could be understood what kind of device was needed by the user. After the needs analysis, the next stage was the design stage. This stage of the architectural process was made in detail. The system design stage helped in determining the hardware. The design system really determined how the system architecture would be made. The next stage was the coding stage. At this stage, the system was first developed in small programs called integrated units in a later stage. Coding used the App Inventor to create applications and also the Arduino IDE software to control hardware. The two of them would then be connected using an internet connection. The coding process in a system started from the smallest unit. Each unit was developed and tested for functionality.

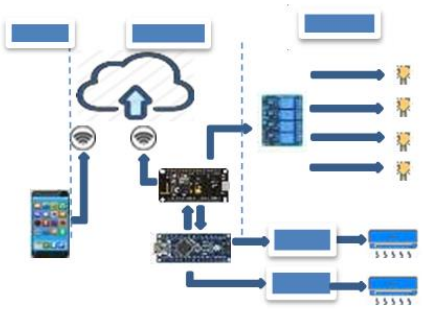

Figure 3. Desain of Diagram Block

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The resulting product was then tested on equipment (lamps and AC). Testing was done using functionality testing and system performance testing so that it was ensured that all components were functioning properly. To ensure the objectivity of the test, the test was carried out by several parties, namely operators, employees and colleagues.

RESULTS AND DISCUSSION

1. Results

In the needs analysis stage, the researcher conducted a direct interview with the Department of Electronic Engineering Education (employees, operators and managers) regarding the constraints experienced by electronic device control systems, in relation to the comfort and safety of the room. Information was obtained that –controlling the air conditioning and lighting devices in this department room was still done manually. This method did not allow officers to set room conditions as comfortable as possible before use. Likewise with the security aspect of the room, the use of room lights and air conditioning exceeded the usage time limit. Officers was sometimes negligent in turning off equipment even though working hours have ended. This would have the potential to cause equipment damage and fire. After collecting information, a needs analysis was carried out which functions to find out what was needed to produce a viable product based on the information that has been previously collected. An IoT-based controller was develop using a smartphone as the interface media.

The next stage was creating hardware design. Hardware selection considerations based on the type and number of equipment to be monitored and controlled. In this study, two air conditioners and four lights were the objects of control. Obtained several components used to build the system, among others;

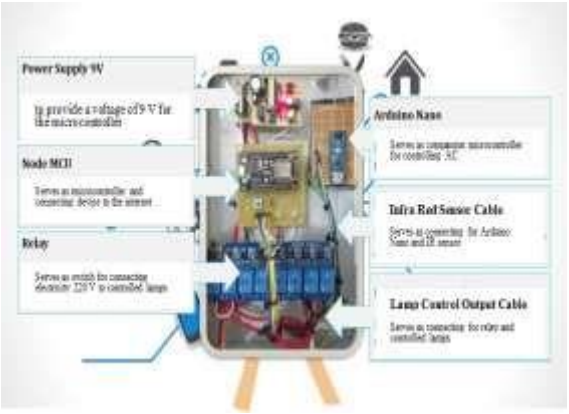

Figure 4. Smart Room Hardware Design

Explaination:

a. **The adapter** serves to provide a voltage supply of 9 volts DC to the microcontroller as a source of voltage.
b. Node MCU functions as a microcontroller and a connecting device to the internet.

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c. Arduino Nano functions as a companion microcontroller
d. Sensor infra red functions as an infrared ray emitter to control the air conditioner.
e. Modul functions as a switch to forward 220V electricity to the lights to be controlled.
f. The connecting cable serves as a link between the relay and the controlled light.

Next was the software design. As an interface on a smartphone, the application was made to function as input and output to control and read monitoring data for controlled equipment (lights and AC). This interface was built using an application that is connected to the internet network and connected to Firebase. Before the application was used, the application was first made using APP Inventor. In the smart home application there are four displays, namely:

Figure 5. Results of Smart Room Application Design

a. The initial display is the application view before entering the login. In this view there is a button that serves user to direct to the login view.
b. b. The login view is a display before entering the main menu. In this display, the login process is carried out by filling in the password that has been previously set so that it can enter the main menu.
c. c. The main menu is a display application to display monitoring and control of

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equipment (lights and air conditioning).

d. AC control is a display on the application to control the AC in the Department.
e. Lamp monitoring to see the current state of the lamp.

2. Testing Results

a. Data test results for functionality

After making a hardware design in the form of a tool, then combining each component so that it becomes a controller. In combining each part, first prepare a box to place each important part of the tool, such as the MCU node, Arduino Nano, relay modules and adapters. After placing the components in the box is complete, then connect the parts using fiber and cables. At this stage, component function testing is also carried out.

Testing on the functionality aspect is assessed based on the results of the ability of each component to perform its respective functions and the response to commands sent through the application which ultimately determines whether the device is able to control electrical equipment. If the tool is able to work as a whole, all aspects of the functionality of the tool are said to be functional (feasible to operate). If not, it is necessary to repair/revise it so that all aspects can run well. Testing was carried out in accordance with the hardware and software blocks of the application. The results of testing for functionality that are carried out get the results of all components functioning properly.

b. Data of Application testing result

Application testing is done by testing every action and response in the application, whether it can send, display data and control hardware / tools. The trial results get a score with a percentage of 100%.

Based on the results of the descriptive analysis above, they are converted to the value conversion table and the results of the application percentage are 100% and have very good interpretations. The results of testing functionality and testing the application tools can be seen in the following graph:

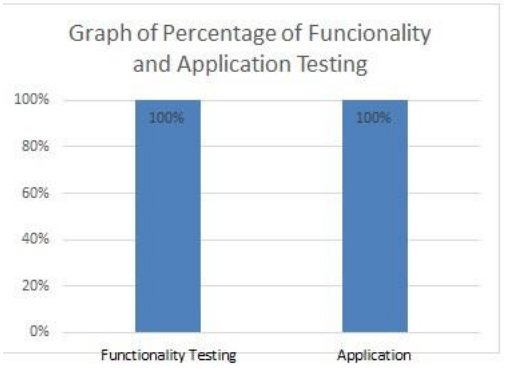

Figure 6.Graph of Functionality and Application Test Percentages

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c. Performance test data

After conducting the next trial, the controller was tested directly by the researcher and assisted by several observers. The test results from the researchers are used as a basis for seeing the level of effectiveness of controllers and applications that have been developed for the better. The following are the results of testing the controller and application.

Based on the test results of the controller and application, after testing 30 times in 3 days with results for lamp 1 with a 100% success percentage, lamp 2 with a 97% success percentage, lamp 3 with a 97% success percentage, lamp 4 with a success percentage 97%, AC 1 with a success percentage of 97%, AC 2 with a success percentage of 97%, which can be seen in the following graphic:

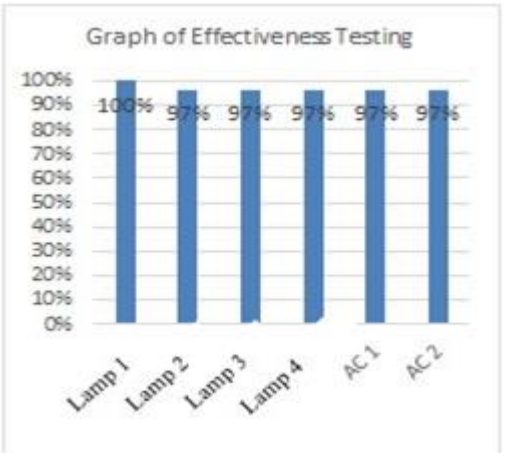

Figure 7. Percentage Graph of Successful Use of Tools

CONCLUSIONS AND RECOMENDATIONS

1. Conclutions

The conclusions of this study are as follows:

a. This research produces a product in the form of "Electronic Equipment Controller Using an Internet Connection". This study uses R&D research design, the waterfall model which has five stages, namely needs analysis, design, coding, testing and support and maintenance.
b. Based on the analysis of the results of the Functionality testing and the application, the percentage of tool and application functionality gets the overall results to function properly. Furthermore, for the analysis of the results of the effectiveness trial, the percentage of success in controlling all the devices as a whole was also very good.

2. Recomendations

The recomendations for this research are as follows:

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a. The developed controller tools and applications can be used as a learning resource to support the learning process in the field of control, microprocessors, IoT, and so on.
b. The developed controller tools and applications are made to be used more easily by the operator as the main user, but if there are still unfulfilled user needs, this system is still open for development.
c. The tools and controller applications developed can be further developed such as development in order to monitor, adjust with other electronic devices that will be added / applied in the future. The addition of animations and image designs that are more attractive in terms of applications to maximize their use and development of input applications or other sensors, such as voice recognition applications.

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