Energy Efficiency Use of Amount of Light in a Room Based on Number of People Based on IoT and Image Processing

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***Abstract*—A room with too humid conditions can cause mold and bacteria to multiply quickly. The humidity level of the room can be influenced by several factors such as the temperature level and the intensity of light entering the room. Even so, the use of lighting as a sterilizer is currently still lacking in reducing the level of humidity in the room. For this reason, it is necessary to develop technology in the form of a control system for the use of led and ultraviolet lamps in the study room by utilizing the IoT system, so that it can turn on the lights and utilize electrical energy. In this study, the Internet of Things system was applied as a control for Web cameras, Gyml 8511, DHT11, and BH1750 sensors. Data from the sensor will be sent from Arduino uno to a local server, namely raspberry pi 4 using NRF24L01. The communication system between nodes is designed with a mesh topology that can determine the fastest route in the process of sending information. The result of this research is monitoring on the web display that displays the condition of the class and the condition of the lights. From the experimental results, it is found that the mesh communication system can work well.**

Keywords*— *Ultraviolet, GYML 8511, Web Camera, Mesh topology.

I. INTRODUCTION

The sun is a source of free light needed by humans, the source of lighting in a room is very influential on the comfort and health of the people in it besides that sunlight can reduce the humidity level of the room, if a room has less lighting it is possible for humidity to exist in the room. According to the standards of the Meteorology, Climatology and Geophysics Agency and according to the regulation of the Minister of Health of the Republic of Indonesia number 1077/MENKES/PER/V/2011 that the regulatory standard for ultraviolet light in the room must be in the range of 0-0, 0-5 wm^2 [1]. Ultraviolet irradiation is a way that can be done to maintain air quality and control the number of airborne germs [2].

The condition of sunlight which has recently been covered by clouds has resulted in the presence of ultraviolet light entering the room less than optimal [3], so it is possible that it can cause the development of bacteria that is quite fast and viruses scattered in the air so that it is feared that it will be dangerous if offline learning is carried out. Thus, there needs to be an innovation that can ensure comfort and safety in the learning process in the classroom. The addition of LED lights as indoor lighting is not enough to eradicate bacteria and viruses [4], so a sterilization device that can utilize ultraviolet lights is needed.

At this time the lighting of the room with led lamps and sterilization of ultraviolet lamps is still carried out in full, even though the sunlight that enters the room can also be used as additional lighting and as room sterilization. From the above problems, we need a system that can regulate the LED [4] and ultraviolet lights so that the use of electric power will be lower and more efficient.

From the results of the above exposure, it can be done using technology that utilizes light from the sun, so that when using other sources, the use of UV lamps can be more efficient in energy use. The regulation of this energy use can be done using the IoT system, which is a concept or program where an object has the ability to transmit or transmit data over a network without using the help of computers and humans.

II. METHOD

This section describes the type of research, research design, system design, preparation of tools and materials, as well as the determination of procedures and parameters for using the facility from "Using Energy Efficiency Amount of Light in a Room Based on Number of People Based on IOT and Image Processing".

A. Type of Research

The type of research method used is research and development or research and development, in accordance with the objectives to be achieved. The purpose of research with the nature of development has the intention of expanding and also deepening knowledge with existing research. The research that will be conducted aims to design a system to monitor and improve indoor air quality. According to Borg and Gall (1983: 772), "educational research and development (R & D) is a process used to develop and validate educational production". will always be carried out referring to the results of the previous step until a new device system is finally obtained.

B. Research

Design The research design is carried out as an early stage in conducting research. Everything related to research must be planned in advance starting from finding references, designing

tool systems, and testing tools and also how the data obtained will be analyzed.Here is picture 1 which is the research

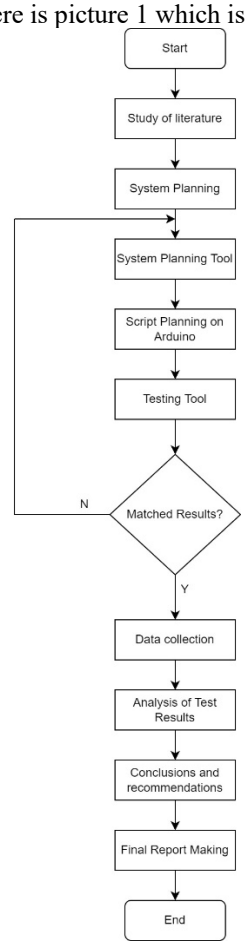

Figure 1. Research Stages

following is a description of Fig.1:

1. The first stage is a literature study on the Arduino Uno [5]-[7], DHT22 Sensor [8], BH1750 [9], C programming language [10], Gyml 8511 [11], Module nrF24l01 [12]. On stage, this study examines the use and characteristics of sensors, programming for system creation and data transmission [13]-[15].
2. The second stage is system planning, which is about the test parameters that will be obtained by the sensor.
3. The third stage is the design of the tool design, namely the device used, at this stage planning is carried out regarding sensors and relays that are connected to the Microcontroller and connectivity from the Microcontroller to the database.
4. The fourth stage is planning the script that is used to program all the tools that will be used.
5. The fifth stage is a system test that has been made in the third and fourth stages, this test is carried out to find out the results of the planned system testing.

C. *Design Sensor Node 1*

The components in node 1 are connected to Arduino uno as a microcontroller. So that it will be assembled according to Figure 2 on the sensor node outside the room. The implementation of the sensor nodes that have been assembled will be implemented as shown in Figure 7.

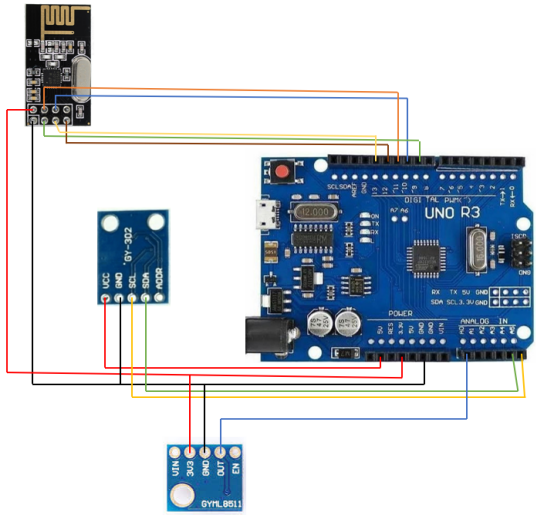

Figure 2. Node sensor 1

D. *Design Sensor Node 2*

At *node* 2, the main function is as a server, but there are also sensors connected to the Raspberry Pi 4. At node 2 this there are no sensors connected to the server but only the *wireless* and webcam as shown in Figure 3. Installing the sensor component on node 2, there is a NRF24L01 wireless module which is used to send and receive data from the server to the node. The web camera on node 2 is used to detect the presence of people in the room which can later be monitored via a Web page.

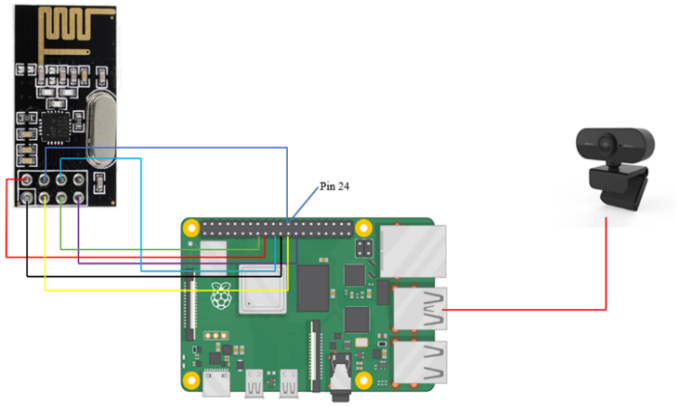

Figure 3. Node sensor 2

E. *Design Sensor Node 3*

The components at node 3 are connected to Arduino uno as a microcontroller. So that it will be assembled according to Figure 4 on the sensor node outside the room. The implementation of the sensor nodes that have been assembled will be implemented as shown in Figure 9.

Fig. 4 explains the diagram of sensor node installation in the room to measure lighting conditions at one point in the room. Where the sensor component is GYML 8511 connected

to the Arduino Uno board. The GYML 8511 sensor is used to measure UV levels and light levels in lux units from the sun.

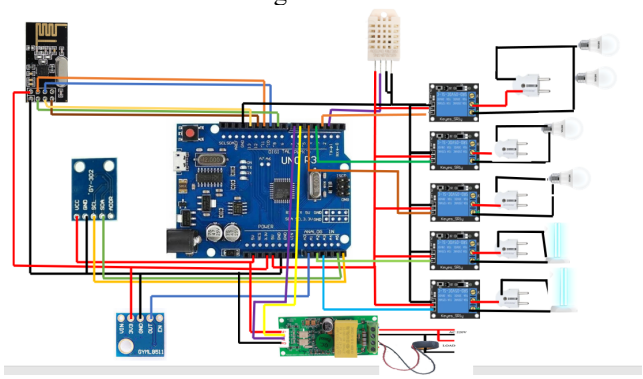

Figure 4. Node sensor 3

On the Arduino board there is also a NRF24L01 wireless module which is used to send and receive data from the sensor node to the server. In addition, there is also a relay component that is connected to the Arduino. The relay functions to turn on or turn off the UV lamp and led lamp automatically according to the data measured on the sensor. The output of the two sensors will affect the condition of the UV and led lamps.

F. Website Page Planning

In Figure 5 below is the design of the website page that was created. The information displayed on the main page includes temperature, humidity, number of people, total power usage and time. On this main page, a live video stream from the camera is also displayed, which is processed by the Raspberry Pi. In addition, the design of this website also displays historical information from monitoring that has been carried out on the history menu. Here is a view that can be seen for website design.

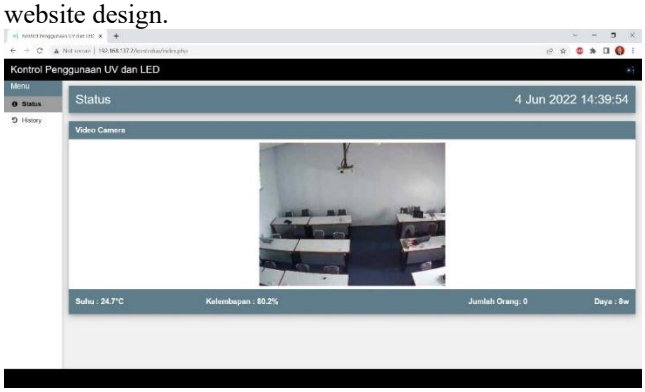

Figure 5. Website Design

G. Tools and Materials

The following are the tools and materials used in the system created.

TABLE 1.
TOOLS AND MATERIALS

Tool Name	Number of
Arduino R3	2
Raspberrry Pi 4	1
Sensor GY-ML 8511	2
Sensor BH 1750	2
NRF Module 24L01	3
Sensor PZEM-004T	1
Relay	5
Sensor DHT 22	1
LED Light	4
Web Camera	1
Ultraviolet Lamp	2

III. RESULTS AND DISCUSSION

The results of this study begin with a system flow chart display. The overall system flow diagram of this tool is shown in Fig 6.

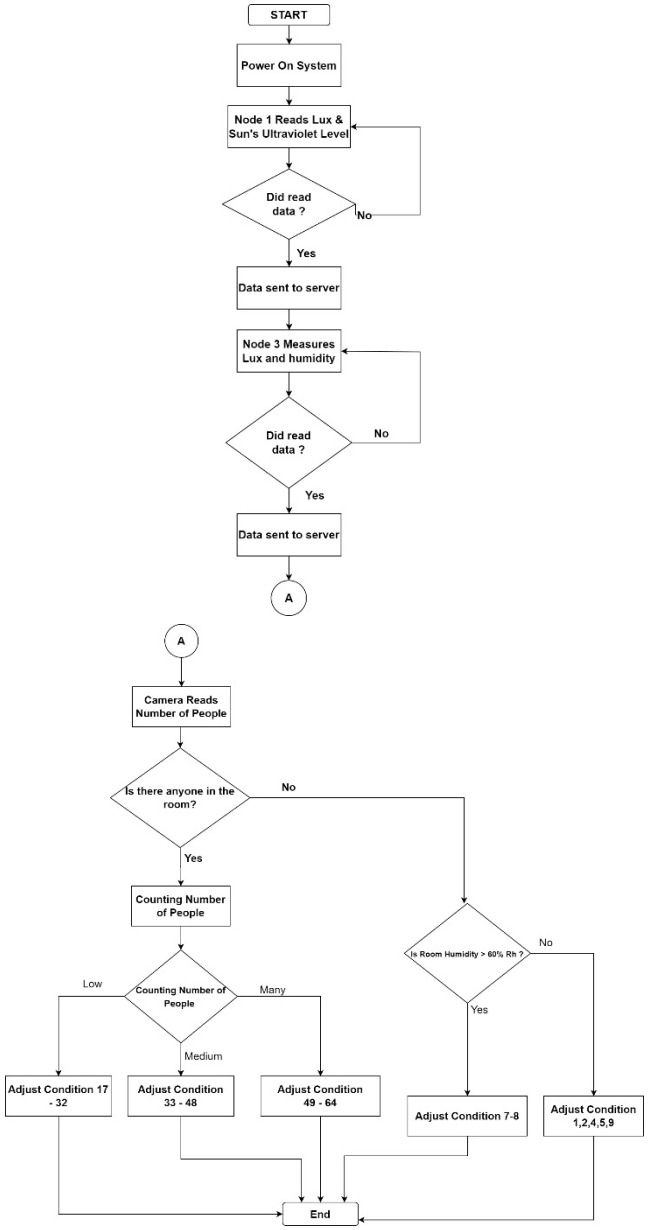

Figure 6 Flowchart of the work system

In Figure 6 is a working system as a whole. Condition selection is used to determine the type of lamp that is on and

the number of lights that are on. Like when the condition of people is in the low category the number of lights that are lit will adjust the rules that have been made by turning on 2 led lights and so is the next condition when the number of people is moderate then the led lights are 3 and the last is when the condition of the people is a lot of led lights 4.

A. Results of Hardware

1) Installation node 1

The implementation of the hardware installation plan on Node 1, the implementation itself is outside the room with components consisting of Arduino R3, GY-ML 8511 Sensor, NRF24l01 Sensor, and BH 1750 SensorInstallation, as shown in Figure 7.

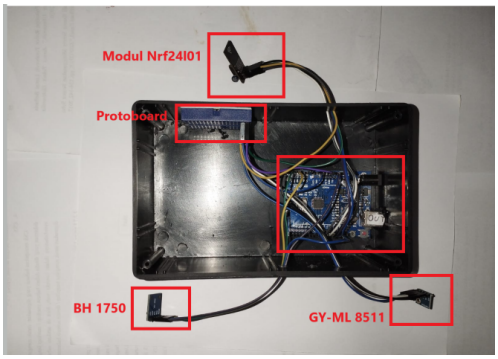

Figure 7 Implementation of Node 1

2) Installation node 2

For the next node is the implementation of node 2, this node is also referred to as the server node where the components in it contain Raspberry Pi 4, NRF 24L01 Module and Web camera. This server node will receive data information from nodes 1 and 2 to display information on the website display, as shown in Figure 8.

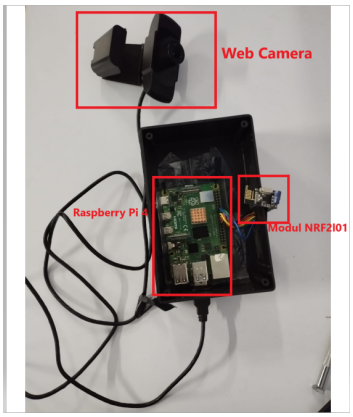

Figure 8. Implementation of Node 2

3) Installation node 3

Figure 9 shows the implementation of the installation of sensor nodes in the room to measure lighting conditions at one point of the room. Where the sensor component is GYML 8511 connected to the Arduino Uno board. The GYML 8511 sensor is used to measure UV levels and light levels in lux units from the sun. On the Arduino board there is also a NRF24L01 wireless module which is used to send and receive data from the sensor node to the server. In addition, there is also a relay component that is connected to the Arduino.

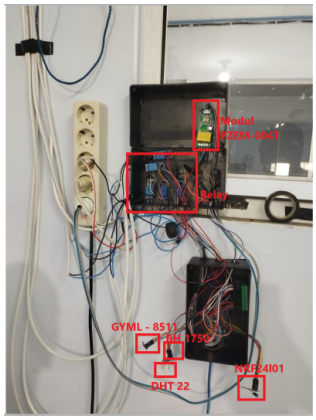

Figure 9. Implementation of Node 3

The relay functions to turn on or turn off the UV lamp and led lamp automatically according to the data measured on the sensor. The output of the two sensors will affect the condition of the UV and led lamps.

B. Result of Node Communication with Server

The following is a display of the result of communication between the node and the server where the information will be displayed on the server page by opening the PuTTY application as a tool. Displays that appear include the conditions of light outdoors and indoors and then information on the UV level inside and outside the room. For the output value issued from the server is processing information from nodes 1 and 2 as well as information on the number of people in the room so that it will determine the condition of the lights that are on.

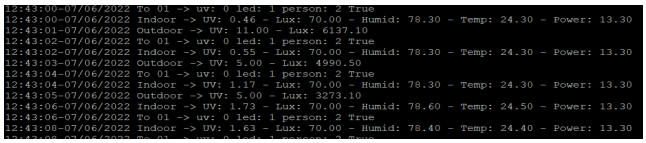

Figure 10. Result of node communication

C. Image Testing

In this sub-chapter, we will test the image system that was created where we try to detect people in a different number of rooms. This test is also carried out at different points to find the maximum point for reading the number of people in the room.

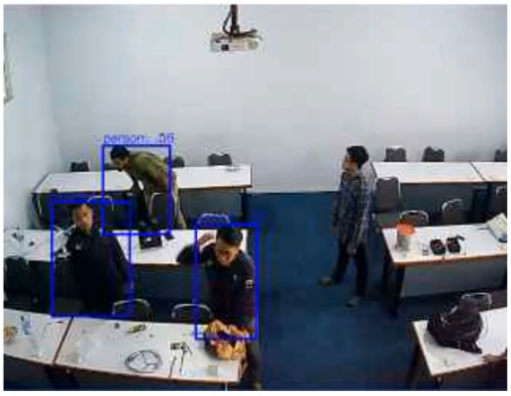

Figure 11. Image test results

The following is an image testing Table II:

TABLE II
IMAGE TESTING

Distance (cm)	The average value detected			
	Person 1	Person 2	Person 3	Person 4
550	62%	54%	51%	47%
450	73%	71%	68%	65%
350	98%	95%	90%	84%
250	85%	81%	77%	75%
150	65%	58%	42%	35%

From table II it can be seen that the closer the distance between humans detected by the camera, the more difficult the camera to identify. This is because the closer to the camera, the fewer elements of the human body that are caught. The lowest value for human detection is 40 percent and below it will not be detected as a human. The value above is the result of rounding the calculation value so that the table is not too long.

In addition to measuring based on the distance from the camera, several delay experiments were also carried out from the system successfully detecting and then sending commands to node 3 to turn on the targeted led lights according to the rules. In this study, 10 experiments were conducted where experiments 1-5 were in conditions where there were no people and then people were in the room, while experiments 6-10 were experiments where people were detected from conditions and then people left. For detection accuracy, it is only limited to 35% because if below it is considered not a human object, it aims to facilitate camera detection. The delay calculation is done using a stopwatch when seeing the detection of someone or not on the Raspberry Pi SSH display as in the test video.

D. QOS Testing

Parameters for testing the success rate of data transmission used are Qos (Quality Of Service), including Packet Loss and Delay. The test results for each QOS will be displayed in a table as below.

1) Packet Loss

In table 2 is the result of the Packet Loss measurement that has been carried out and Figure 12 is a graph of the measurement results, there are 3 samples shown in the following table.

TABLE 2
MEASUREMENT OF PACKET LOSS

Delivery of Packages to	Packet Loss					
	Package Condition 1 Person		Package Condition 5 Person		Package Condition 8 Person	
	Sent	Error	Sent	Error	Sent	Error
1	10	0	10	0	10	0
2	10	0	10	0	10	0
3	10	0	10	2	10	0
4	10	0	10	0	10	2
5	10	1	10	1	10	0
6	15	0	15	0	15	1
7	15	1	15	1	15	1
8	15	0	15	1	15	1
9	15	0	15	1	15	1
10	15	2	15	0	15	0
11	20	0	20	1	20	1
12	20	1	20	0	20	1
13	20	0	20	0	20	3
14	20	1	20	0	20	1
15	20	0	20	5	20	1
Total	225	6	225	12	225	13
Packet Loss	3 %		5%		6%	

From the results of the calculations that have been carried out in table 2, it is found that the Packet Loss value is different in each condition, when the condition of the room is 1 person, the Packet Loss value is 3%, then in the condition of 5 people the Packet Loss value is 5%. and when there are 8 people in the room, the Packet Loss value is 6%. The results obtained from the three test conditions, the packet loss values obtained are included in the medium category value range according to ITU-T G.114.

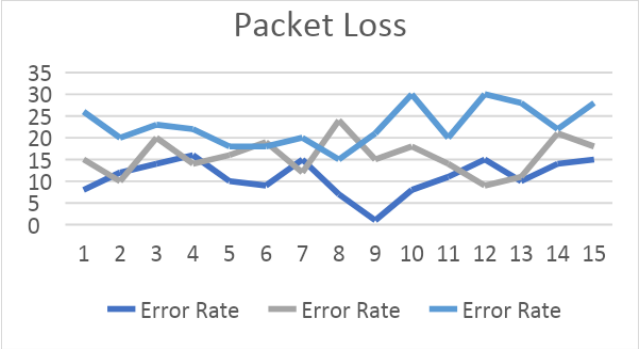

Figure 12. Graph of Package Loss

2) Delay

In table 2 is the result of the delay measurement that has been carried out and Figure 13 is a graph, there are 3 samples shown in the following table.

TABLE 2.
MEASUREMENT OF DELAY

Delivery of Packages	Delay Condition 1 Person(s)	Delay Condition 5 Person(s)	Condition 8 Persons (s)
1	0.291	0.245	0.717
2	0.276	0.219	0.494
3	0.182	0.384	0.265
4	0.229	0.399	0.619

Delivery of Packages	Condition 1 Person(s)	Delay Condition 5 Person(s)	Condition 8 Persons (s)
5	0.298	0.228	0.127
6	0.268	0.232	0.294
7	0.167	0.224	0.225
8	0.167	0.197	0.147
9	0.243	0.289	0.275
10	0.249	0.112	0.238
11	0.251	0.231	0.178
12	0.265	0.283	0.193
13	0.146	0.242	0.173
14	0.173	0.265	0.294
15	0.192	0.241	0.243
Average	0.226	0.252	0.298

Delay measurement in 3 conditions, namely during class conditions there are 1 person, 5 people and 8 people, the delay value obtained in each of these conditions is different. When there is 1 person in the classroom the delay value is 0.226 seconds, then when there is a change in the number of people in the room the delay value is 0.252 seconds with the number of people in the room as many as 5 people. For the last delay measurement value, when there are 8 people in the room, the delay value obtained is 0.298 seconds. The value of delay changes is increasing due to changes in the number of people in the class so that it affects the reading of objects by the camera and the process of sending data.

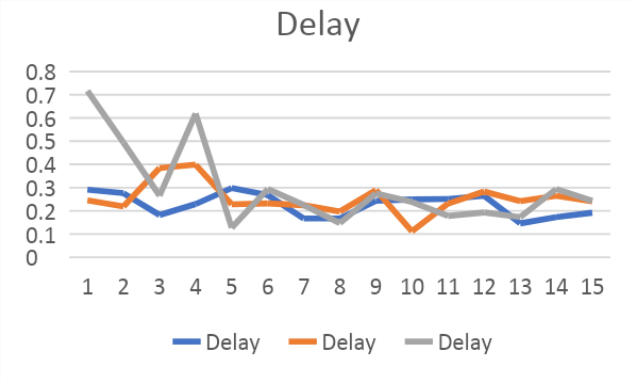

Figure 13. Delay

IV. CONCLUSION

Based on the background, problem formulation, planning and implementation, it can be concluded from this research that: (1) The design of the LED and UV light control system can be done using a raspberry pi mini pc which is connected to the BH 1750 and GYML 8511 sensors. The use of Led and Ultraviolet lights in the classroom can be regulated by taking into account the level of lighting in the room and the level of people in the room. The level of lighting in the room can be measured using the BH-1750 sensor and the number of people in the room can be identified using the BH-1750 sensor. camera that applies the SSD method and the method on this system is set by Fuzzy Logic. (2) The communication process that conveys some information, namely light levels, ultraviolet levels and the amount of power used can run using the nrf24l01 module by applying a mesh topology, where each measured data will be sent to the server for data processing and then the server will send information to node 3 for processing. perform the command to turn on the led or ultraviolet light. The process of sending data from the server to the web by retrieving information, among others, is delay, packet loss and throughput. (3) Testing of this energy efficiency control system by applying the system directly and comparing it when using the system and before using it. From the results that have been tested the use of this system is more efficient in the use of electrical power.

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