IOP Conference Series: Earth and Environmental Science

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Smart-Room Technology Implementation Based on Internet of Things Toward Smart Campus in Institut Teknologi Sumatera

Smart-Room Technology Implementation Based on Internet of Things Toward Smart Campus in Institut Teknologi Sumatera

Harry Yuliansyah[1*], Dean Corio[1], Rajif Agung Yunmar[2], and Muhammad Reza Kahar Aziz[1]

[1] Electrical Engineering Department, Institut Teknologi Sumatera, Lampung Selatan, INDONESIA
[2] Informatics Engineering Department, Institut Teknologi Sumatera, Lampung, Indonesia, INDONESIA
Email: {*harry, dean.corio, reza.kahar}@el.itera.ac.id, rajif @if.itera.ac.id, *corresponding author

Abstract. Institut Teknologi Sumatera (ITERA) has started the development of smart campus aiming to decrease the wastage of electricity energy. In our college, we observe that the lights or air conditioning are kept on even when there is nobody in the room. In this paper, the implementation of smart-room technology based on the Internet of Things is proposed to increase the energy efficiency. With the use of small chip of ESP8266, we develop a smart-switch to control on/off for the lights. The smart-switches are connected with another sensor node to adjust the intensity of sunlight by moving the curtain position. Another node has a role in controlling air conditioning without human interaction. In front of the door, we install the visitor counter to count the number of persons who are entering the room. This paper provides a model to manage a lot of sensor in the room to create a smart room that could be used in daily life. The implementation results show that the proposed smart-room technology is working with excellence.

1. Introduction

Institut Teknologi Sumatera (ITERA) is a new state university established by the government through Presidential Regulation number 124 of 2014. As a new institution, ITERA carries a mission to provide reliable human resources for Sumatera region. Taking the Smart, Friendly and Forest Campus slogan, ITERA confidently looks at the future to prepare the next generation human resources and technology of Sumatera in particular and Indonesia in general.

ITERA which is currently developing requires a variety of infrastructure and human resources to be able to achieve ITERA's vision and mission. The construction of infrastructure is in the form of lecture buildings, laboratories, and supporting facilities for educational activities. It is challenging to manage the lecture buildings where there are many rooms and electronic devices such as air conditioning (AC), projectors, lights which are almost impossible to manually control by a single operator. This condition increases the potential level of waste of electricity to be higher [1].

Through this research, the solutions are provided to create the smart-rooms that can construct their own decisions without special instructions from humans, hence the electronic equipment in a room can be automatically controlled. Therefore, the use of electrical energy for electronic equipment can be more effective and efficient [2][3]. This is because there are no lights on the empty lecture hall or AC that kept cooling the room when there is no teaching and learning activity in the room. The light control system provides benefits in ease, flexibility and reliability in its operation [4].

2. Research Roadmap

To obtain the ITERA Smart, Friendly and Forest Campus there are several related research topics as shown in Figure 1. In 2017, the overall research was initiated with the work on smart power meters funded by the ITERA smart mandiri research grant budget allocation in 2017. The study has produced a prototype for measuring the energy consumption based on Internet of Things (IoT). In IoT, there are four important elements: things, human, data and process [5]. Furthermore, in 2018, this research continues with the topic of implementing IoT-based smart-room technology in the ITERA environment presented in this paper. It is expected to produce a smart technology prototype that can be applied in the lecture room, hence it can reduce the level of waste of electricity use. For the next phase of research, it will be continued on smart building topics in 2019 and smart campus in 2020.

3. Design and Implementation

In implementing the smart-room, this research is conducted in the lecture room as a place for testing the system. Figure 2 shows the system diagram block. It is shown that in the classroom, there are several subsystems in the form of curtain control systems, light control, AC control, and visitor counters. In addition to the subsystem, a smart kWh meter is installed on the electrical panel of the building that monitors the use of electricity energy. Hence, it is able to observe whether there is an improvement in electricity energy consumption after the application of the smart room is activated. Each subsystem is connected to the local server with the use of the Message Queuing Telemetry Transport (MQTT) protocol. Therefore, the local server can be later connected to the cloud server via the internet network.

4. Research Outcome and result

In performing the testing, a system prototype using a smaller scale is assembled. The use of this prototype can minimize the losses due to the errors that may occur in constructing the system. This system prototype is built with the condition that it is created as closely as possible to the original one, however, in smaller dimensions.

4.1. Smart Switch

The main component of this smart switch is the Solid-State Relay (SSR) where the ESP8266 controls the element as a microcontroller and a Wi-Fi module is used to connect to the local server using the MQTT protocol. It should be noticed that the SSR components have the advantage of not causing sparks when the contact relays are on/off. The spark appears during a power surge (spike) at the beginning of the electrical equipment being turned on. This spike can emit a frequency signal of noise which causes the microcontroller equipment to hang or restart. However, the SSR has a disadvantage regarding the price where the SSR is slightly more expensive compared to the conventional Relays that utilize the electromagnetic induction.

Additionally, the Wi-Fi module used in the series as shown in Figure 3 is an ESP8266 module with the ESP-01 variant. This module only has two General-Purpose Input/Output (GPIO) pins, hence it can only control a maximum of two SSRs. To produce more SSR controllers, we can employ the WEMOS D1 Mini variant which has nine digital pins and one analog pin. Hence, it can control up to 9 SSRs in one module. For the need to control large amounts of electronic equipment, the ESP8266 module can be juxtaposed with the MCP23017 IC which can add as many as 16 digital pins with the I2C protocol. A maximum of 8 IC MCP23017 can be used together, hence a maximum of 128 SSRs can be controlled.

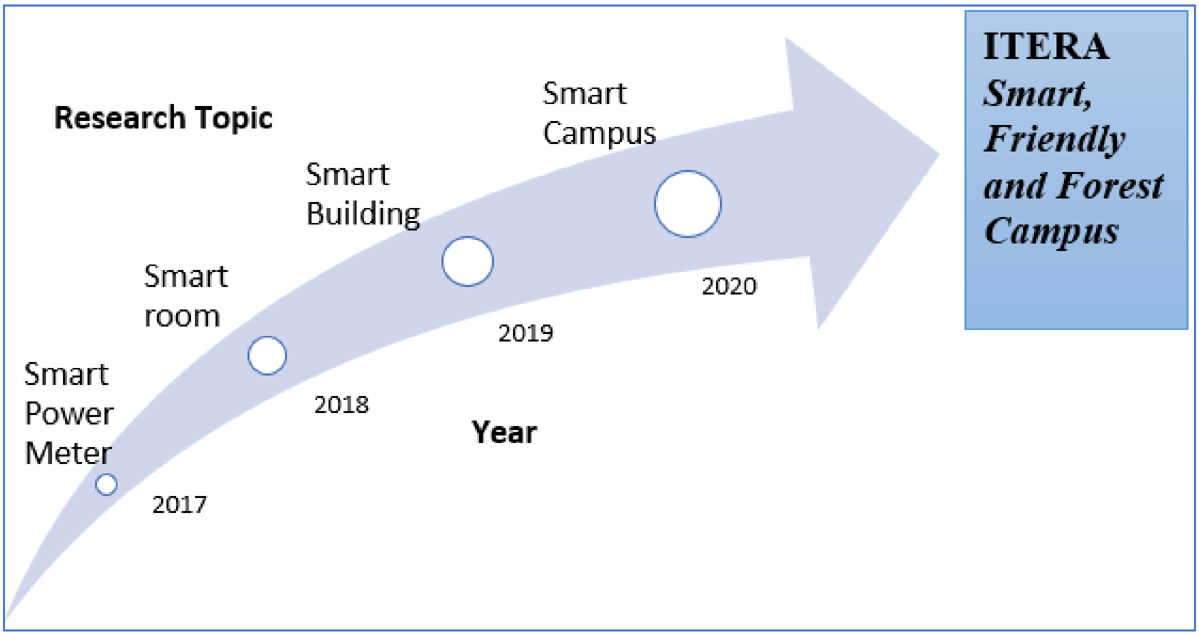

Figure 1. Research Roadmap.

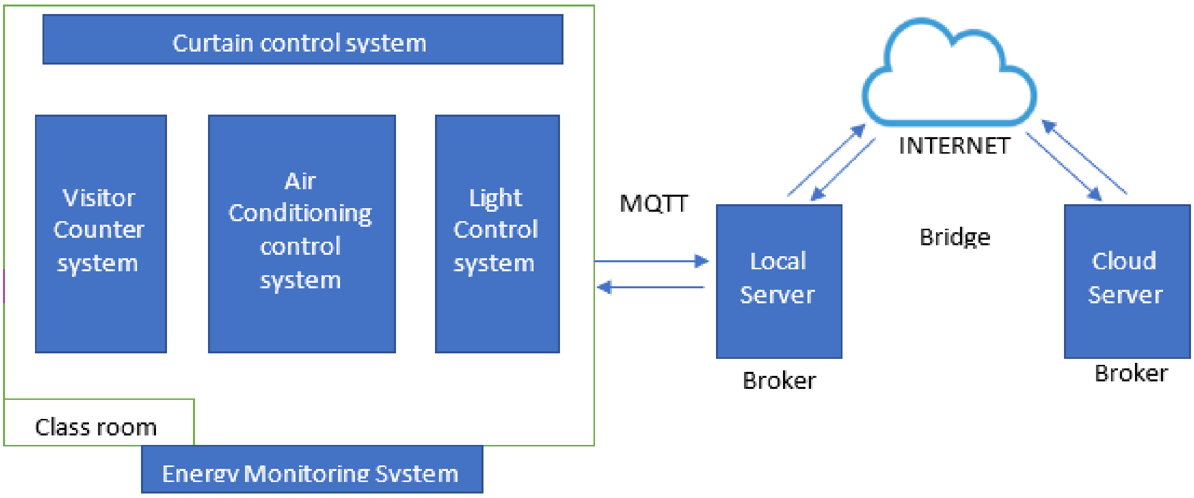

Figure 2. Block Diagram System.

4.2. Curtain Control

The curtain control system is an unstable system with great interference, inertia and non-linear [6]. A comfortable environment in the classroom can improve a better learning environment [7]. Curtain control is applied to control the light entering the class room as shown in Figure 4. If the sunlight is too bright, then the curtain is automatically closed adjusting the brightness in the room. Likewise, if the sunlight is lacking, then the system automatically turns on the light according to the level of light intensity needed in the room. In measuring the intensity of light, this study employs two types of sensors.

Figure 4. Curtain Control prototype.

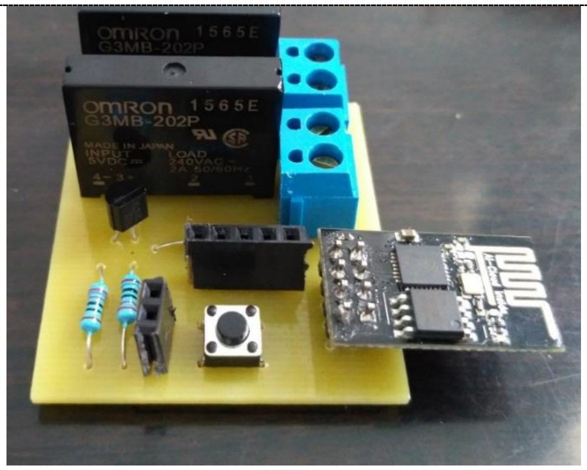

Figure 3. Smart Switch Prototype.

The first sensor utilizes the Light Dependent Resistor (LDR) component; the second sensor utilizes a BH1750 light intensity sensor. The following comparison of LDR and BH1750 sensors is shown in Table 1.

Table 1. Comparison of the LDR and BH1750 sensors,

No	Sensor Type	Advantages	Disadvantages
1	LDR	- Cheaper - Simple circuit	- Less Precision - calibration required - Output in the form of change of resistance value (ohms)
2	BH1750 sensor	- High Accuracy and Precision - Lux output Unit - No calibration needed	- Expensive

4.3. Visitor Counter

In calculating the number of visitors who enter and exit the room, we can apply the sequential detection techniques where there are more than one sensor that detect the visitor movements. In Figure 5, there are two ultrasonic distance sensors of A and B. If there is an object passing through in front of the sensor, there is a shift in length of distance from the previous. This distance variation is utilized to detect the incoming and outgoing visitors. The sensor sequences for visitor conditions are shown in Table 2.

Table 2. Sensor sequences for visitor conditions.

No	Visitor Conditions	Sensor sequential detection	Number of visitors
1	Incoming	Sensor A → Sensor B	Increment
2	Outgoing	Sensor B → Sensor A	Decrement

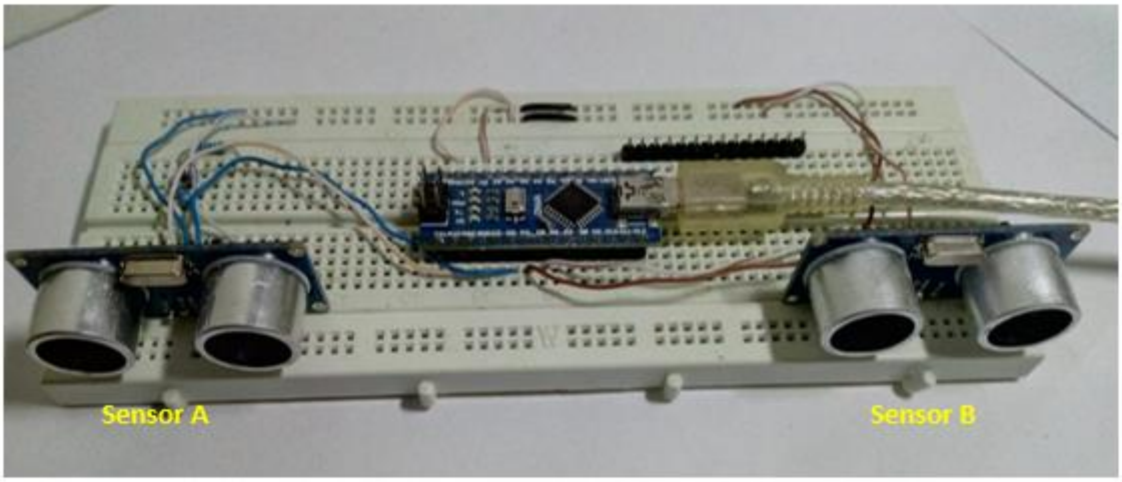

Figure 5. Curtain Control prototype.

In this study, the communication from each subsystem is carried out using the MQTT protocol where this protocol is a development of the WebSocket protocol. Two-way communication can be established shortly after the handshake between the server and the client. At MQTT, a broker is required to collect and distribute the data sent from the node. This research employs the Mosquitto as a broker. This application is an open source, hence it can be used more widely.

4.4. MQTT

The smart-room technology is built on realizing communication between the devices or machines. This scheme is widely known as machine-to-machine (M2M) communication. If the machine has been able to communicate with each other, the controller can make a decision how to respond according to the rules that have been made before without the need for interaction by humans. This research takes a class room at ITERA as a place for implementing the smart-room system. The next step in implementing this smart-room is to determine the rules to be used. The following rules are generated in this study:

- The intensity of light in the room is maintained in comfortable conditions for teaching and learning process when the light intensity is less than the setpoint. Henve, the Curtain remains open until the lumination in the room is appropriate.
- If the curtain has opened at the maximum, but the brightness in the room is still lacking, hence the light is turned on.
- The room temperature is maintained between the lower and upper limits. If the upper limit is exceeded, the AC system is turned on. However, if the lower limit has been exceeded, the AC system is turned off.
- It should be noticed that the above three rules work if there is a schedule of lecture activities in the classroom.

These rules become a reference in implementing the smart rooms in the ITERA environment. Also, the “Topic” format is essential considering that the devices are connected in large numbers. The following as shown in Figure 6 is an example of the coding Topic format in this study.

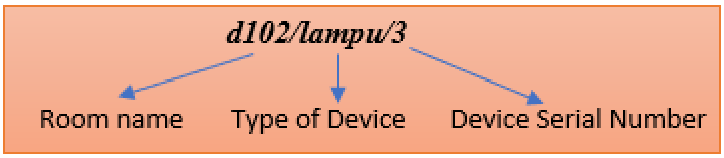

Figure 6. Topic Format.

In Figure 6, there are three parts of Topic format used in MQTT protocol. The first, second and third parts are the name of the room, the type of device and the serial number of the device, respectively. Hence, each device has a unique Topic. This format was chosen because in MQTT communication there is a retain message feature. This feature will be useful if there is a connection disruption between nodes and brokers. When the communication returns, the broker sends a retain message containing the message when the last connection was established. In MQTT, only one retain message is for each topic.

In this research, each node employs the ESP8266 WEMOS D1 module. This module has several advantages including having a large number of GPIO, saving energy and relatively lower prices. However, this module can only run unencrypted MQTT communications. Hence, it still allows other parties to do sniffing to read the messages on data traffic. On the other hand, the encrypted communication modules require higher specifications such as ESP32. Nevertheless, the price is high and the arrangement is more complicated. Therefore, to avoid the sniffing, the implementation of smart-rooms in ITERA requires an exclusive network that is separated from the internet data lines on campus. Thus, the individual access point is provided to connect the nodes with brokers.

Additionally, the predetermined rules can be compiled with the help of Node-Red software application. For more detailed, Figure 7 describes an example of the display of rules that have been defined previously in a classroom. By performing this, the system automatically determines the response taken if it meets the requirements of the rule that have been made. Finally, Figure 8 shows the page display of the website user interface to monitor all interactions between the subsystems or nodes. All electronic devices in the real world are represented in this virtual world, called the IoT.

5. Conclusion

This paper has presented the research to build a smart-room system made of several subsystems, hence the manufacturing process becomes faster. Between these subsystems, they can be interconnected with the MQTT protocol. Furthermore, the data communication using MQTT can run well and in accordance with what is expected when implemented in a smart-room system. Moreover, the users can create a custom rule to be applied to a smart-room system. Finally, the implementation of the rules that have been made can be helped by the use of Node-Red application showing excellence results in the display.

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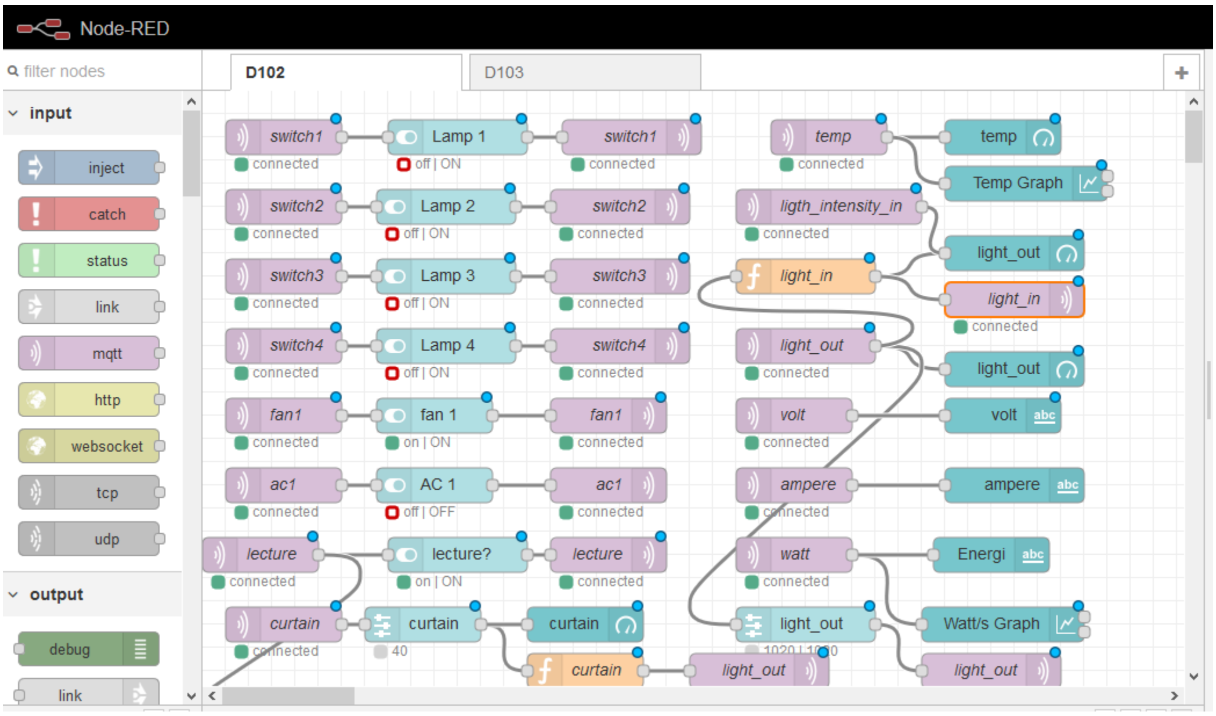

Figure 7. Node-RED flow.

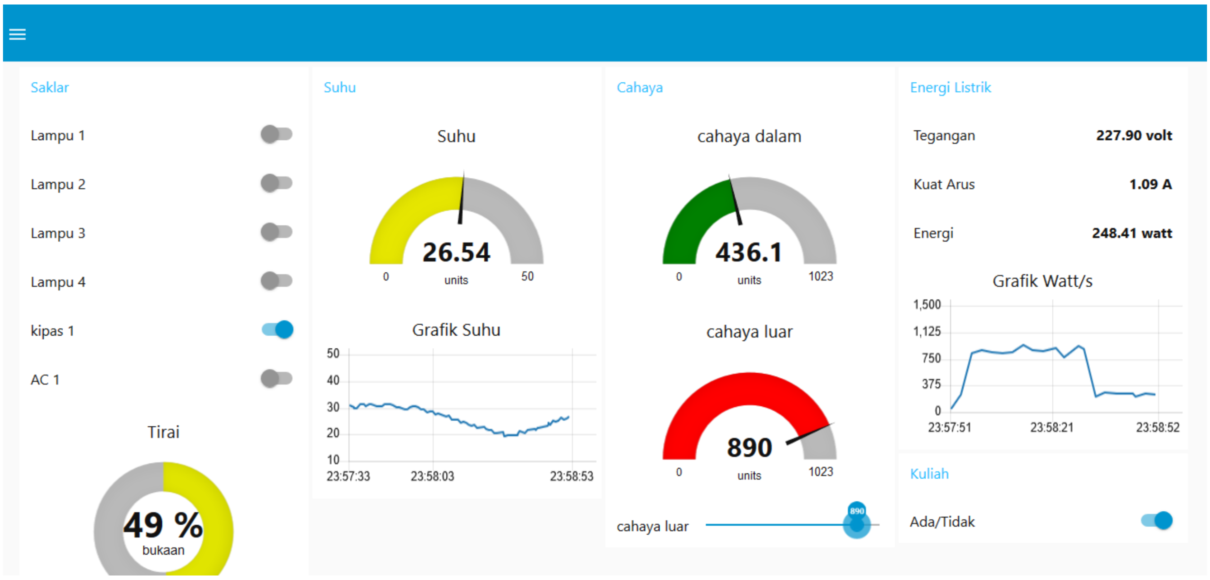

Figure 8. Node-RED User Interface.

Acknowledgments
This research was supported in part by research grant of Hibah Mandiri ITERA 134c/IT9.C1/PP/2018. We thank our student Muhammad Danofan Aryandanu who helped to make curtain control system.

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