Design and Implementation of Smart Class System Based on LoRa at Faculty of Science and Technology UIN Sunan Gunung Djati Bandung

by Eki 7

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***Abstract*—In this research a LoRa based smart class system was designed and implemented at the Faculty of Science and Technology UIN Sunan Gunung Djati Bandung. The system's purpose was to create effectiveness in the use of electronic devices in the classroom and ensure that they were only used when necessary, turning them off when not in use. By employing LoRa module device that has a long range and have ability to monitor the classroom's electronic equipment, such as air conditioners, projector and lights. Additionally, a device that uses a limit switch and a buzzer is created for the projector security system. The results of the distance test utilizing the LoRa communication module are 221 meter with an average response time 3.4 seconds.**

***Keywords*—smart class system, LoRa, AC, projector, lamp.**

I. Introduction

The development of technology is advancing very quickly, particularly in intelligent control systems that can be implemented anywhere, including in the classroom, which gave birth to the smart class concept. The smart class concept itself can be modified based on technology that can be applied through its infrastructure. The use of technology can solve a number of issues, one of which is when controlling electronic devices which are usually done by pressing the switch manually, now it can be done using a remote control [1]. The application of technology in the classroom by using smart class concept, controlling and monitoring electronic devices in the class room can be done remotely.

Some of the issues we frequently run into among others are managing control of electronic devices in educational institution buildings, such as lecture buildings, which occasionally create an obstacle, security staff usually must check one by one each room on each floor of the building manually. This causes the manual control system to be ineffective. Additionally, it frequently occurs for students to forget to turn off all electronic devices after class, which can damage some electronic devices if it happens repeatedly. The theft of electronic devices often occurs if a security system is not implemented. By utilizing the smart class concept the issues can be reduced and controlled. Smart class is an evolution of internet-based learning such as e-learning, m-learning and u-learning supported by various devices that interact through a network [2].

The smart class concept in this research focuses on the use of renewable communication technology called LoRa module. The LoRa module is used as a communication media for data transmission to connect systems one another, because LoRa module supports long-distance large enough data transmission [3]and LoRa module has advantages compared to other communication modules.

As for research on smart class that has been carried out using communication other than LoRa, such as Muhammad Rofiq, et al research regarding the control system and monitoring of lights in classrooms by utilizing bluetooth communication [4] and research by Theresia Gozalia, et al regarding monitoring the classroom temperature by utilizing XBee communication [5].

The advantages of using LoRa technology for communication are also explained in one of Richard Gilang Wisnudianto research, where the advantage is in the LoRa communication range that can reached sensor data acquisition systems on agricultural land as far as 400 meters [6]. Based on these advantages, the communication technology that will be used in this research uses LoRa as the latest technology for the smart class system with the addition of scheduling system and there is a security system on the projector device.

Based on above description which is the background of the research "Design and Implementation of Smart Class System at Faculty of Science and Technology UIN Sunan Gunung Djati Bandung", by using LoRa communication technology that have longer range ability, and being able to create a smart class system that is able to carry out control systems and electronic devices security systems and remote systems in the classroom.

II. Methode of Research

The research method used in this research is Research and Development (R&D), which entails creating new products by developing existing products. The steps taken in this study are represented in Fig. 1:

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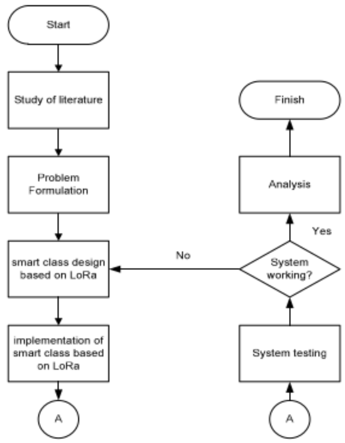

Fig. 1. Flowchart of research

The research method is shown in Figure 1 above, which begins with a literature review on the smart class system utilizing the LoRa communication module, identifying problems by looking at the condition of the class in the Faculty of Science and Technology that will be used as a smart class. The challenge in this research is to develop a smart classroom system as an effort to effectively use electronic devices in the classroom.

III. Result And Discussion

A. *Smart Class System Design*

This stage is carried out to provide a planning sketch of the smart class system design, which consists of integrated hardware and software. The smart class system design is displayed in the following Figure 2.

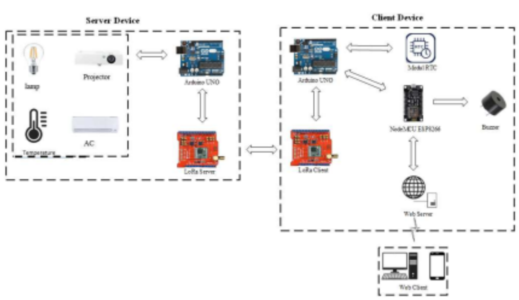

Fig. 2. Smart class design based on LoRa

The design and implementation of the LoRa-based smart class system in this research uses a design system as shown in Figure 2. The smart class system design consists of Server devices, Client devices and Web Clients. Server devices in this smart class system consist of Arduino UNO ATmega328 which serves as a microcontroller to process data obtained from the LM35 sensor, limit switch, relay module and infrared transmitter sensor module and LoRa Server module. Server devices can function as senders and recipients of information on the condition of electronic devices.

The second function is LoRa Server receiving data sent from LoRa Client. The data received by LoRa Server contains commands to control electronic devices and commands to read the LM35 sensor. Electronic device control is divided into two parts, first by using a scheduling system and second by using the ON/OFF button on the website page.

The timing of the RTC module functions as a simulation of the classroom scheduling system, which means that electronic devices can be controlled according to a predetermined schedule. While controlling electronic devices through the website page is enabled so that when the device is active when the class is empty, the user can turn it off manually through the website page.

The next device is the Client device. Client device consists of Arduino UNO microcontroller, LoRa Client, NodeMCU ESP8266, RTC module and buzzer. Client device functions as a sender and receiver of integer data in the form of information on the condition of electronic devices. The devices connected to the LoRa Client are the RTC module and the NodeMCU ESP8266. While the buzzer is connected to the NodeMCU ESP8266 pin.

The first function of LoRa Client is as a data receiver that is sent from NodeMCU ESP8266 to be sent back to LoRa Server. The data sent from the NodeMCU ESP8266 contains integer data to control electronic devices and retrieve temperature data.

The second function of LoRa Client is as a data sender that is received from LoRa Server. The data received by LoRa Client are temperature data, feedback data on electronic device control conditions and projector security data. The three data are sent to the NodeMCU ESP8266 and executed according to their part. Integer data limit switch serves to control the buzzer. Temperature data and electronic device condition feedback data will be temporarily stored before being sent to the web server.

Next is the user section, the user is in charge of controlling electronic devices and monitoring the temperature of the classroom. Users can control electronic devices by pressing the ON/OFF button and can refresh the room temperature data by pressing the refresh temperature data button.

B. *Working Principle of Smart Class Based on LoRa*

The following is the working principle of the smart class system based on LoRa which is shown in Figure 3.

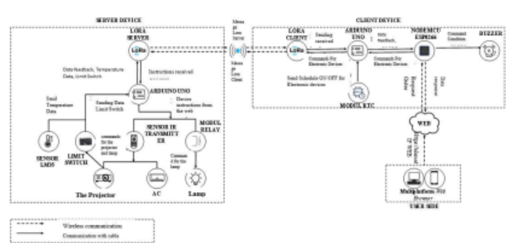

Fig. 3. Working principle of smart class based on LoRa

The working principle shown in Figure 3 consists of two parts, firtst is the Server device and second is the Client device. Server device consists of Arduino UNO microcontroller, LoRa Server, relay module, infrared transmitter sensor module, limit switch and LM35 sensor.

Server device functions as a sender and receiver of integer data in the form of information on the condition of electronic devices. The process of sending packets starts from determining the device's input output pins, determining the integer used and setting the LoRa Server so that it can send and receive packets. The packet sent from LoRa Server to LoRa Client contains data from the LM35 sensor input, limit switch input and feedback data from electronic device control.

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C. Smart Class Implementation Based on LoRa

Smart class design is carried out in one classroom. The following is the appearance of the classroom design along with the placement of the LoRa Server and LoRa Client devices and the direction of movement when carrying out the test as shown in Figure 4.

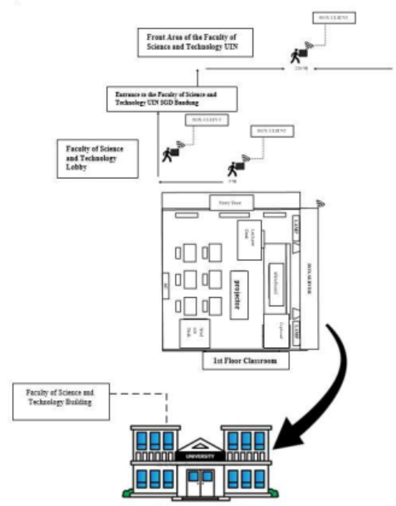

Fig. 4. Working principle smart class system besed on LoRa

The following are some tests using several test parameters for based on Figure 4, the visualization of the LoRa-based smart class system prototype includes the placement of Server devices and Client devices. Server equipment is placed in the classroom with placement on the wall area that is parallel to the projector and air conditioning equipment, and server equipment is placed between the classroom lights. After that the Client device is placed in the box to make it easier for the user when carrying it. The user functions as a giver of electronic device instructions in the classroom.

D. Smart Class Based on LoRa Testing

The LoRa-based smart class system testing was carried out in the UIN Sunan Gunung Djati Campus area, Bandung, West Java. The prototype of the smart class system using LoRa communication has been made correctly and in accordance with the design that has been designed, until the time of application. Sensors and device modules used such as the LM35 temperature sensor, IR infrared transmitter sensor, limit switch, relay module, RTC module and buzzer can work according to their functions. To ensure that the tools made can function properly, correctly and as expected, the testing phase is carried out.

The following are the device connection blocks used for testing and analyzing LoRa-based smart class systems, which are shown in Figure 5.

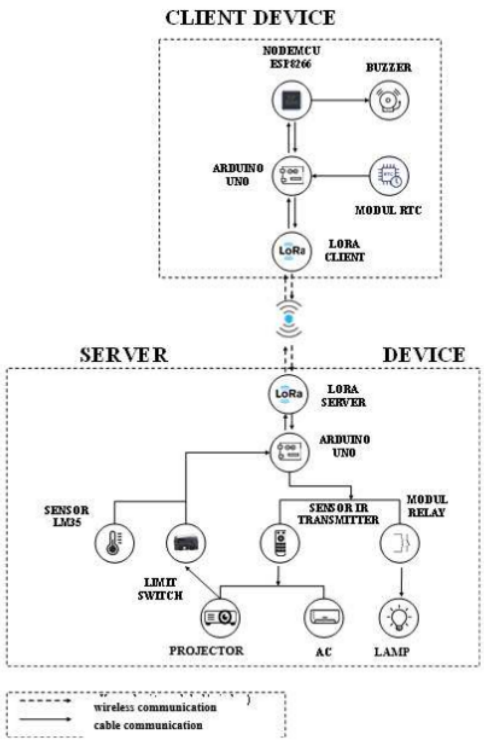

Fig. 5. Block communication device

The process of prototype testing and analysis of the LoRa-based smart class system prototype was carried out in several stages, which is:

- Hardware-to-electronic device communication testing.

Testing is done by looking at the results of sending and receiving integer data on each serial monitor on the Arduino IDE. The following table shows the results of testing the hardware to electronic communication system as shown in Table 1.

TABLE I. THE RESULTS OF THE HARDWARE TO ELECTRONIC COMMUNICATION SYSTEM TESTING RESULTS

Program Code	Function	Results of Receiving Data on The Serial Monitor
Integer 1	Light Control ON	Instruction accepted by Lora Server
Integer 2	Light Control OFF	Instruction accepted by Lora Server
Integer 3	Requesting Temperature Data	Instruction accepted by Lora Server
Integer 4	AC Control ON	Instruction accepted by Lora Server
Integer 5	AC Control OFF	Instruction accepted by Lora Server
Integer 6	Projector Control ON	Instruction accepted by Lora Server
Integer 7	Projector Control OFF	Instruction accepted by Lora Server
Feedback 21	Result of Light Control ON	Data received by NodeMCU ESP8266
Feedback 22	Result of Light Control OFF	Data received by NodeMCU ESP8266
Feedback 23	AC ON Control Result	Data received by NodeMCU ESP8266
Feedback 24	AC OFF Control Results	Data received by NodeMCU ESP8266
Feedback 25	Projector Control Results ON	Data received by NodeMCU ESP8266
Feedback 26	Projector Control Results OFF	Data received by NodeMCU ESP8266

Based on Table 1, the use of program code performed on hardware communication to control and receive control results from electronic devices on Server devices works according to the system functions that have been set. The use of program code in hardware to electronic communication consists of integer data sent from the NodeMCU ESP8266 to the Server device and feedback data sent from the Server device to the ESP8266 NodeMCU. The two program codes have an effect on the execution of electronic devices and the response results from the execution.

- Testing of the smart class electronic device scheduling system.

The scheduling system testing on electronic devices is carried out to find out the results of controlling electronic devices automatically according to the scheduling that has been arranged. Testing is done by sending integer data containing messages to control electronic devices from LoRa Client to Server devices according to the scheduling time that has been set in the RTC module scheduling program code. The following is a table from the results of the scheduling system testing on electronic devices as shown in Table 2.

TABLE II. TESTING THE SCHEDULING SYSTEM ON ELECTRONIC DEVICES

Electronic Device	Set ON/OFF Schedule of Devices	Sent Device Instruction	Device ON/OFF Results
Lamp	Thursday, 2020/07/02 16:00:00	ON	Lamp ON
	Thursday, 2020/07/02 19:00:00	OFF	Lamp OFF
AC	Thursday, 2020/07/02 07:00:00	ON	AC ON
	Thursday, 2020/07/02 09:30:00	OFF	AC OFF
	Thursday, 2020/07/02 10:00:00	ON	AC ON
	Thursday, 2020/07/02 12:00:00	OFF	AC OFF

Electronic Device	Set ON/OFF Schedule of Devices	Sent Device Instruction	Device ON/OFF Results
Projector	Thursday, 2020/07/02 07:00:05	ON	Projector ON
	Thursday, 2020/07/02 09:30:05	OFF	Projector OFF
	Thursday, 2020/07/02 10:00:05	ON	Projector ON
	Thursday, 2020/07/02 12:00:05	OFF	Projector OFF

Based on Table 2, the scheduling system testing on electronic devices works according to its function.

- LM35 temperature sensor testing for temperature monitoring.

The LM35 sensor testing for monitoring classroom temperature on a smart class system based on LoRa aims to determine whether the LM35 sensor can detect the temperature of the classroom or not. The LM35 sensor testing for monitoring the classroom temperature is carried out when the LoRa Server receives integer data 3 which contains instructions for the LM35 sensor to read the classroom temperature data and the temperature data will be sent back to the NodeMCU ESP8266 through the LoRa Client intermediary. The following are the results of testing the classroom temperature data using the LM35 sensor, which are shown in Table 3.

TABLE III. TEST RESULTS OF TEMPERATURE SENSOR DATA USING LM35 SENSOR AND DIGITAL THERMOMETER

Date	Time	LM35 (^{0}C)	Thermo meter (^{0}C)	Differen ce
03-08-2020	12:00:00	29.66	28.4	1.26
03-08-2020	13:00:00	28.48	28.2	0.28
03-08-2020	14:00:00	28.61	28.5	0.11
03-08-2020	15:00:00	27.86	27.7	0.16
03-08-2020	16:00:00	27.83	27.4	0.43
04-08-2020	12:00:00	29,02	28.5	0.52
04-08-2020	13:00:00	28.81	28.6	0.21
04-08-2020	14:00:00	28.47	28.3	0.17
04-08-2020	15:00:00	27.56	27.4	0.16
04-08-2020	16:00:00	27.66	27.1	0.56
Average difference				0.39

Based on Table 3, the LM35 temperature sensor testing to detect class room temperature has been carried out. The sensor can work according to its function, namely sending class room temperature value data. The test was carried out 10 times within two days.

- Smart class projector security system testing.

Projector security system testing is done by using a limit switch. If the limit switch lever is pressed, it is assumed that the load pressing the limit switch lever is the projector's load, while if the limit switch lever is not pressed, it is assumed that the projector has disappeared because there is no load pressing the limit switch lever. The following are the results of testing the data transmission program code from the limit switch for the projector security system as shown in Table 4.

TABLE IV. THE RESULTS OF PROGRAM CODE FOR SENDING DATA FROM LIMIT SWITCH FOR PROJECTOR SECURITY SYSTEM

Program Code	Function	Results of Receiving Data on The Serial Monitor
Integer 1	Buzzer ON	Instruction accepted by NodeMCU ESP8266
Integer 2	Buzzer OFF	Instruction accepted by NodeMCU ESP8266

Based on Table 4, the test code for sending data from the limit switch sent from the LoRa Client can be received by the NodeMCU ESP8266 to execute the buzzer.

- LoRa Server and LoRa Client Distance Testing

The executions of the buzzer testing when the limit switch lever is pressed or not by using distance variations. The following are the results of testing the projector security system using the distance variations shown in Table 5.

TABLE V. THE RESULTS OF TESTING THE PROJECTOR SECURITY SYSTEM BY USING DISTANCE VARIATIONS

Distance (m)	Buzzer's Condition
20	Stable Sounds
40	Stable Sounds
60	Stable Sounds
80	Stable Sounds
100	Stable Sounds
120-138	Stable Sounds
139	Sounds Less Stable
160	Sounds Less Stable
180	Sounds Less Stable
200 -220	Sounds Less Stable
221	No Sound
>221	No Sound

The test is carried out by placing a limit switch in the Server device group in the Faculty of Science and Technology Building, UIN Bandung, 1st floor, classroom/research lab. Meanwhile, the buzzer which is a group of Client devices will be brought by the user from inside the Faculty of Science and Technology Building, UIN Bandung, 1st floor to outside the building. Testing the distance of sending limit switch data from LoRa Server to Client devices is carried out until the maximum distance LoRa Client can receive limit switch data, where the maximum distance of limit switch data transmission that can be received by LoRa Client is up to a distance of 220 meters, right in front of the Al-Jamiah UIN Bandung.

IV. CONCLUSION

The conclusion of this research that has been carried out on the design and implementation of LoRa-based smart class systems, that is smart class systems using the LoRa module as a data communication tool can be designed and implemented according to the objectives and designs.

The LoRa-based smart class schedule system testing showed that the scheduling system can control electronic devices according to the ON/OFF schedule according to the lecture schedule at UIN Sunan Gunung Djati Bandung.

The projector security system testing using a limit switch and buzzer, the result is that the buzzer can function according to the system. If the data limit switch message received by the NodeMCU ESP8266 indicates that if the projector is lost, the buzzer will generate sound, if the projector is safe, the buzzer will not generate sound. The maximum distance for sending projector security system data and testing to control led devices on LoRa Client and Server that can be connected is as far as 220 meters with an average device system response of 3.4 seconds. The location for testing the maximum distance of sending data for the smart class system with LoRa communication is precisely at UIN Sunan Gunung Djati Bandung, starting from the Faculty of Science and Technology Building until the test distance is in front of the Rectorate Building.

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