Prototype Design of Smart Home System Base on LoRa

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***Abstract*—The smart home system is a system in which there are features for controlling and monitoring household electronic equipment. The smart home application system is a combination of technology and services specific to the home environment. The main purpose of applying LoRa-based smart home system technology in this study is to monitoring room temperature and controlling electronic devices. The communication module used in this research is the LoRa Dragino 915 MHz module. The LoRa Dragino 915 MHz module is used as a communication tool between the LoRa Client and LoRa Server. The LoRa-based smart home system prototype that has built can function properly according to specifications because it can monitoring room temperature in real-time and controlling electronic devices. Also, the range of communication signals between LoRa Client and LoRa Server which is the test in this research can work at a maximum distance of 183 meters in semi-open spaces while obstructed spaced the maximum distance is lower, which is only 63 meters.**

Keywords—Electronic Devices, LoRa Client, LoRa Dragino 915 MHz, LoRa Server, Smart Home.

I. INTRODUCTION

The smart home system is a system in which there are features for controlling and monitoring household electronic equipment and home security systems directly by the homeowner which is controlling remotely [1] using an application with one touch or click [2]. This application system is a combination of technology and services that are specific to the home environment [3] to conduct surveillance [4] around the home environment. A smart home system consists of several control devices, monitoring, and automation of several home devices or appliances that can be accessed via a computer [5].

There are currently developing smart home systems that use wired and wireless installations. In its utilization and implementation, the installation of a smart home with wireless communication can provide convenience because of the level of work frequency, effectiveness and several other benefits arising from the use of wireless communication, so that this wireless communication system can be the main choice as part of a smart home system [6]. On the other hand, the use of smart home technology offers an easier quality of life by introducing automation to electronic devices.

An automation system is based on context-aware that can receive data from the monitoring results of the home environment. Monitoring result data is sent via a wireless communication system. One of the wireless system technologies currently being developed is by utilizing the LoRa (long-range) module [7]. LoRa is a wireless communication technology that is currently developing because it has advantages compared to other communication modules, namely low power or low power consumption, and has a wider range [8] with a large enough data transmission [9].

LoRa is the latest communication technology, one of the low power wide area network (LPWAN) communication technologies [10]. LoRa technology emphasizes long-distance communication with the ability to receive high message sensitivity which allows it to work in areas that have a large amount of interference. The emergence of LoRa technology can correct the shortcomings of the smart home system because the previous technology lacked a limited number of nodes in several locations in one area, for example in WiFi technology which required more access points to increase the coverage area [10]. Platforms with long reach modules such as LoRa are rarely developed and published [11]. Several studies on LoRa in Indonesia include the collection of ambient RF energy at nodes [12] and the LoRa-WAN prototype for monitoring ship positions [13] as well as studies on the potential of LoRa for the development of rural areas in Indonesia [14].

The implementation of the LoRa module as a communication for the smart home system certainly has a high enough complexity, so it is necessary to calculate and use supporting components in its utilization. This research will discuss the design process of a LoRa-based smart home system prototype using the LoRa Dragino 915 MHz type and with other supporting components.

II. RESEARCH METHODE

This study describes the process of designing a LoRa-based smart home system by describing parts of the system design, work principle flow, and circuit simulation design used in room temperature monitoring systems and LoRa-based electronic device control. The system design includes the type of hardware used by the smart home system, while the system work principle flow describes the workflow of each hardware device from the data sending process and the

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data control process so that these parameters can display the results in a web-based application. The circuit system design describes the circuit structure used in the smart home system.

A. LoRa Based Smart Home System Design

The system design is carried out to sketch the design of a LoRa-based smart home system. This system design consists of an integrated client device and server device, to meet the performance of the smart home system tool in this study using a voltage of 5 V.

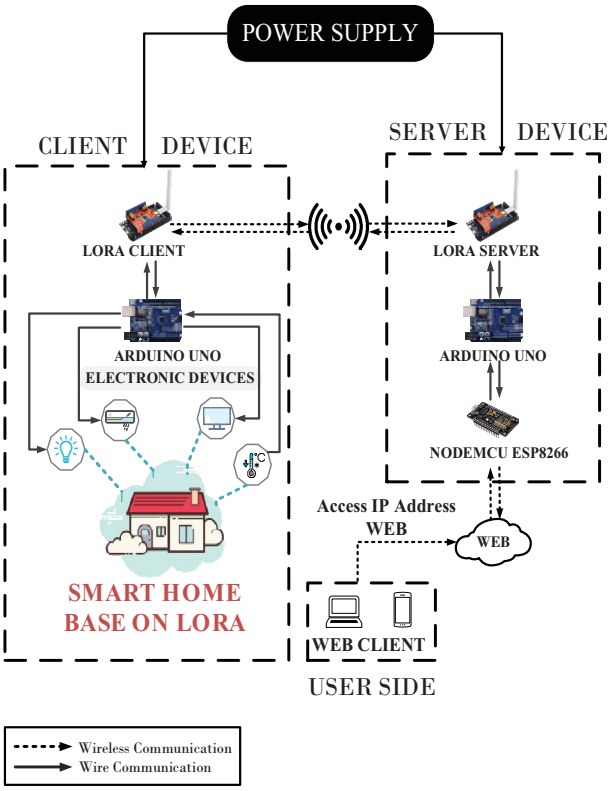

Fig. 1 LoRa Based Smart Home System Diagram

The client device consists of an Arduino UNO Atmega328 which functions as a microcontroller to control electronic lighting, TV, air conditioning, and monitoring of room temperature received from the LM35 temperature sensor through an interface application instructed by the user. Also, sending and receiving information on electronic device conditions and room temperature conditions is carried out through communication between LoRa Client and LoRa Server by sending an integer code to enable electronic devices and retrieving room temperature data from each integer code instructed.

The server device consists of LoRa Server, Arduino UNO Atmega328, and NodeMCU ESP8266. The LoRa-based smart home system server device functions as a data transfer from the client device and the ESP8266 NodeMCU which contains message information signals in the form of an integer code for room temperature conditions and an integer code for instructions for controlling electronic devices for lights, TV, and AC. Furthermore, the control and monitoring results will be displayed via a web page on the interface application, the process is carried out by sending an integer feedback code for room temperature monitoring instructions and an integer feedback code for electronic device control instructions via NodeMCU ESP8266 communication to LoRa Server and LoRa Server communication to LoRa Client by sending data integer code feedback. The feedback integer code will instruct the electronic device to turn ON / OFF and update the room temperature in real-time by retrieving room temperature data from the LM35 temperature sensor.

B. Working Principles of Smart Home Systems

The working principle of designing a prototype of a LoRa-based smart home system is divided into three main system parts, namely: client device, server device, and user side. The division of work principles can be seen in the flow diagram of the smart home working principle.

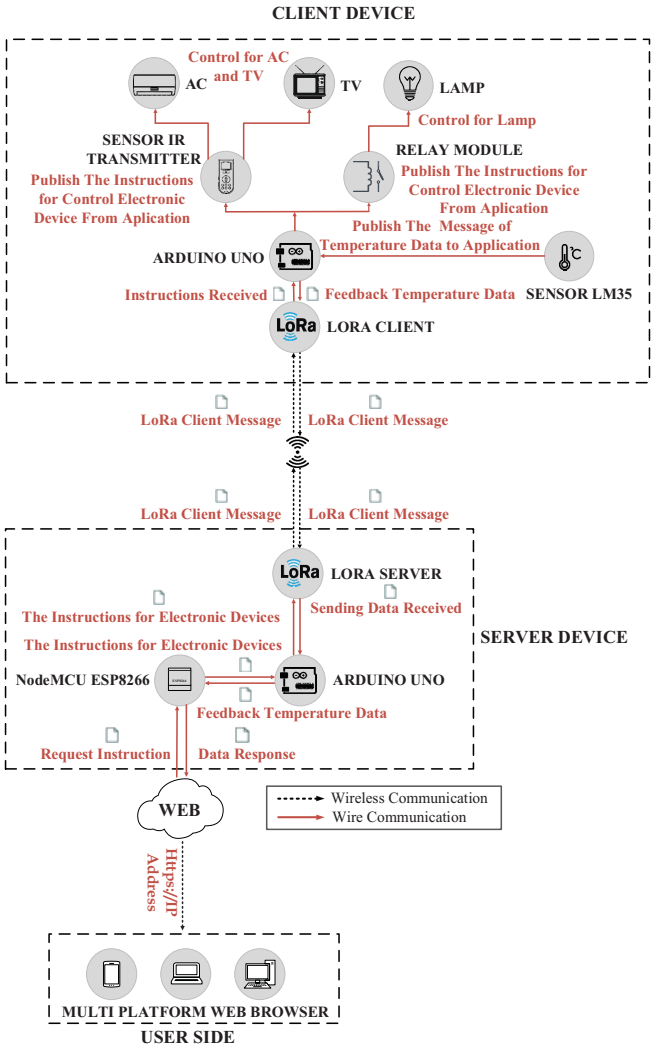

Fig. 2 Flow Chart of Smart Home Working Principles

C. Smart Home System Design

The design of the LoRa-based smart home system hardware has several stages. The first stage is needs analysis, needs analysis is carried out based on literature studies. In the second stage, a circuit design simulation is carried out using the Fritzing software. After designing using Fritzing software, in the third stage, a series of simulation software design results are carried out using a project board. Furthermore, the fourth stage is the assembly of the smart home system, this stage is carried out if the simulation carried out on the project board has been successful.

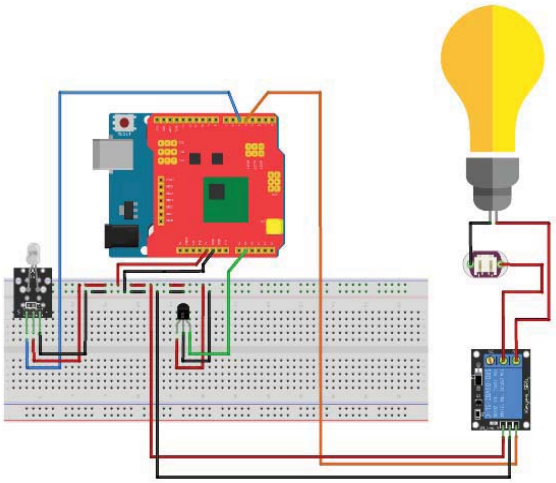

Fig. 3 Smart Home System Design

III. Result and Discussion

In this research, 3 aspects were tested, namely circuit testing, hardware communication testing, and distance testing. 5 data parameters are carried out by the sending process to monitor temperature and control electronic devices. The data sent and received serves to instruct each system to carry out the execution process of the data.

A. Smart Home System Series

The schematic of the system circuit flow diagram is made so that it can be analyzed for each component of the client device and server device, so that it is known that the system in each component of the client device and server device can function properly according to the specifications, namely connected between one system and another, by sending data sent from the access point client to the access point server using the LED as an indicator that the component is connected properly.

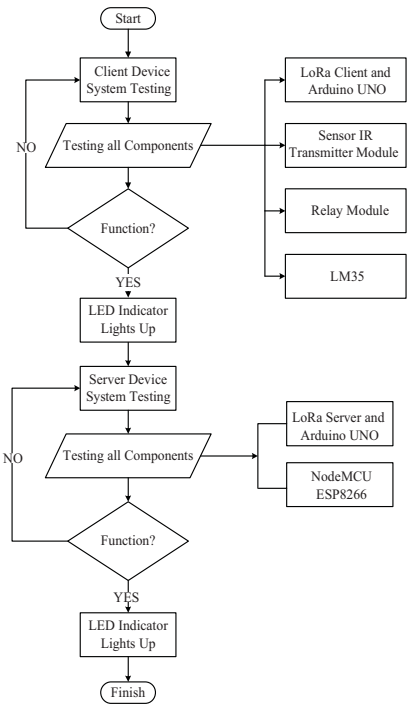

Fig. 4 Smart Home Schematic Flowchart of Smart Home System Circuit

After designing the circuit, the next step is implementing the circuit assembly for the client device and the server device. Then the test was carried out, and the results showed that the circuit was functioning under the specifications.

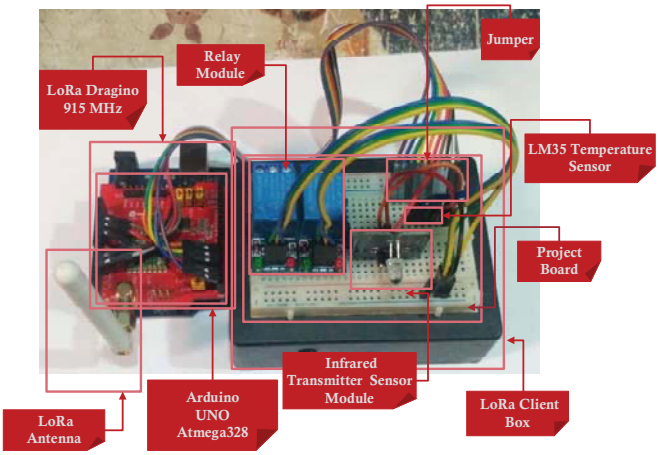

Fig. 5 Smart Home System Assembly

B. Client Device and Server Device Communication

Communication between client device and server device is done by sending and receiving information messages on room temperature conditions and electronic devices by LoRa Server to LoRa Client and vice versa with each integer code testing and integer feedback code. The data sent and received for each parameter is measured and instructed under the integer code and integer code feedback sent. The purpose of this test is to prove the communication relationship between the client device and the server device in the process of sending integer code instructions and sending integer feedback code execution for electronic devices and room temperature data. The following is a table display of test results for each component that is tested by displaying the test table obtained from the serial monitor on the Arduino IDE platform command.

TABLE I. Client Device and Server Device Communication

Program Code	***Function***	***Serial Monitor***
Integer 1	LED ON	Received by LoRa Server
Integer 2	LED OFF	Received by LoRa Server
Integer 3	LED ON	Received by LoRa Server
Integer 4	LED OFF	Received by LoRa Server
Integer 5	Temperature	Received by LoRa Server
Integer 6	TV ON	Received by LoRa Server
Integer 7	TV OFF	Received by LoRa Server
Integer 8	AC ON	Received by LoRa Server
Integer 9	AC OFF	Received by LoRa Server
Feedback 21	LED ON	Received by LoRa Client
Feedback 22	LED OFF	Received by LoRa Client
Feedback 23	LED ON	Received by LoRa Client
Feedback 24	LED OFF	Received by LoRa Client
Feedback 25	TV ON	Received by LoRa Client
Feedback 26	TV OFF	Received by LoRa Client

Program Code	*Function*	*Serial Monitor*
Feedback 27	AC ON	Received by LoRa Client
Feedback 28	AC OFF	Received by LoRa Client

C. *The Maximum Distance of Lora Server and Lora Client in Semi-Open Space*

Testing the maximum distance of LoRa Server and LoRa Client is carried out in a semi-open space, which is meant by semi-open space. In this study, it is an area outside the room or outdoor with a few obstacles, namely areas that still have obstacles in the process of sending information message signals. This test is carried out under the design concept, namely testing to control electronic devices and monitoring room temperature based on integer code instructions and integer feedback code sent by the user by pressing the push button on the interface application.

This testing process is carried out by testing several times at different distance positions. The following is a sketch of the location of testing the distance between LoRa Server and LoRa Client in a semi-open space which was tested on Jalan Karang Sari No. 126 RT 004 RW 001 Cimahi City.

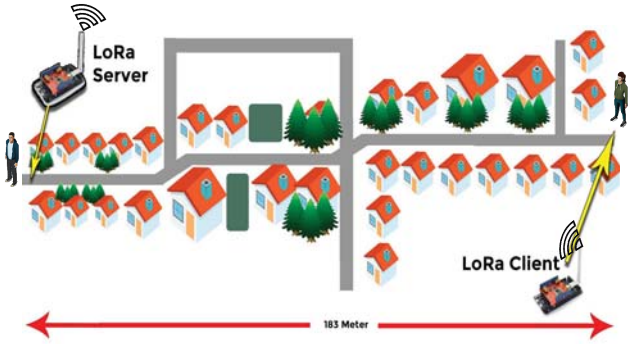

Fig. 6 Sketch of a Test Location in a Semi-Open Space

Testing in a semi-open space is carried out to obtain the maximum distance results obtained from the communication results of the LoRa Server and LoRa Client. The following are the results of an experiment for testing the maximum distance of LoRa Server and LoRa Client in a semi-open space.

TABLE II. RESULT OF DISTANCE TESTING IN SEMI OPEN SPACE

Distance (m)	*Device*
20	Connect
40	Connect
60	Connect
80	Connect
100	Connect
120-138	Connect
139	Unstable
160	Unstable
180	Unstable
200-220	Unstable
>221	Lost Connect

Based on the test results in Table II., The results of the test system conditions are connected conditions, unstable conditions, and disconnected conditions. The connected condition is the condition after testing 10 times at each varying distance, namely LoRa Server and LoRa Client receiving integer code data and integer code data feedback well by getting the results of instructions in the connected condition. Then for the unstable condition is the condition after testing 10 times at each varying distance, namely LoRa Server and LoRa Client receiving integer code data and integer code feedback data is unstable by obtaining the results of instructions in connected conditions 1 to 7 tests. And for the disconnected condition, it is a condition where after testing 10 times the results show that LoRa Server and LoRa Client do not receive the integer feedback code sent, so LoRa Server does not receive instruction messages properly.

The results of distance testing are obtained in Table II., By testing the closest point, namely at a distance of 20 meters, in a condition that LoRa Server and LoRa Client can be connected properly. The maximum distance from the connected condition between LoRa Server and LoRa Client in semi-open space obtained a distance of 183 meters, while in testing the distance of 184 - 201 meters the connection between LoRa Server and LoRa Client found unstable conditions. Also, for testing distances of 202 meters or more, the connection between LoRa Server and LoRa Client was found to be disconnected.

D. *The Maximum Distance of LoRa Server and LoRa Client in Obstructed Space*

Testing the maximum distance of LoRa Server and LoRa Client was carried out in an obstructed space, which is meant by blocked space in this study, which is an area indoors or indoors with closed walls on the concrete slats of each room. This test is carried out under the design, namely conducting tests to control electronic devices and monitoring room temperature based on integer code instructions and integer feedback code sent by the user by pressing the push button on the interface application.

This testing process is carried out by testing several times at different distance positions. The following is a sketch of the location of testing the distance between LoRa Server and LoRa Client in an obstructed space which is being tested on Jalan Karang Sari No. 126 RT 004 RW 001 Cimahi City.

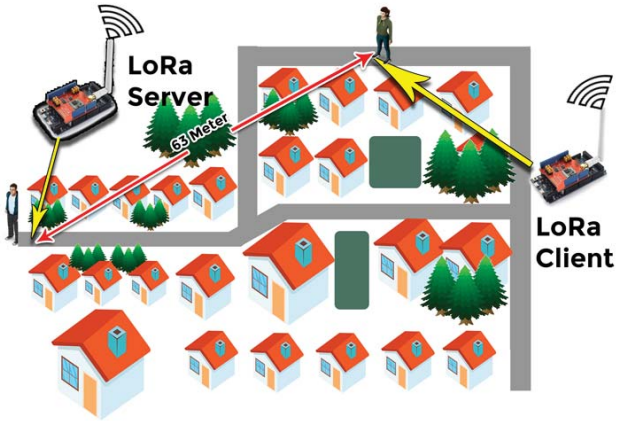

Fig. 7 Sketch of Test Locations in an Obstructed Space

Testing in an obstructed space is carried out to get the maximum distance results obtained from the communication results of the LoRa Server and LoRa Client. The following are the results of an experiment for testing the maximum distance of LoRa Server and LoRa Client in an obstructed space.

TABLE III. RESULT OF DISTANCE TESTING IN BARRIER ROOMS

Distance (m)	*Device*
10	Connect
20	Connect
30	Connect
40	Connect
50	Connect
60	Connect
61-63	Connect
64-81	Unstable
>82	Lost Connect

The test results in Table III, show the results of the test system conditions, namely connected conditions, unstable conditions, and disconnected conditions. The connected condition is the condition after testing 10 times at each varying distance, namely LoRa Server and LoRa Client receive integer code data and integer code data feedback properly and get the results of instructions, namely in a connected condition. Then for the unstable condition is the condition after testing 10 times at each varying distance, namely LoRa Server and LoRa Client receiving integer code data and integer code feedback data is unstable by obtaining the results of instructions in connected conditions 1 to 7 tests. And for the disconnected condition, it is a condition where after testing 10 times the results show that LoRa Server and LoRa Client do not receive the integer feedback code sent, so LoRa Server does not receive instruction messages properly.

The results obtained from the distance test at the closest point to a distance of 10 meters, namely the LoRa Server and LoRa Client conditions can be connected properly. The maximum connected condition distance between LoRa Server and LoRa Client in the blocked room is found at a distance of 63 meters, while in tests with a distance of 64 - 81 meters the connection between LoRa Server and LoRa Client is found to be unstable. Besides, for testing with a distance of 82 meters or more, the connection between LoRa Server and LoRa Client shows that the condition is not connected, this is because the communication signal range is blocked by interference from walls or house concrete.

IV. CONCLUSION

The conclusion from the research "Design of LoRa-Based Smart Home System Prototypes" that has carried out starting from data collection, design, circuit assembly, testing, and analysis, it can be concluded that:

1. The design and construction of a LoRa-based smart home system prototype can complete and function according to specifications because it can perform real-time room temperature monitoring and control electronic devices on lights, TV, and air conditioners.
2. The implementation of the LoRa-based smart home system using a smart home interface application can control electronic devices and monitor the temperature in a semi-open space with a maximum distance of 183 meters when in an obstructed space the maximum distance is 63 meters.

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