Monitoring System in Lora Network Architecture using Smart Gateway in Simple LoRa Protocol

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***Abstract*—LoRa is a low power wide area network communication that has ability to transmit data in a long range with a low power. Lora Alliance has designed a network architecture that usually used, called LoRaWan. The implementation of LoRaWan itself has not meet the requirement of LoRa as one of the LPWAN protocol because it still depend on the internet in processing and displaying data. To meet the purpose of Low Power Wide Area Network (LPWAN) such as simple implementation, low cost, and simple architecture, this research using Simple LoRa Protocol (SLP) with Raspberry Pi 3b+ as the smart gateway. The module used is Dragino LoRa that work in 868 MHz with Spreading Factor 7 and Arduino UNO for the client. The architecture build used in this research implemented to a monitoring system. The system build only to access a Local Area Network. Result showed that the smart gateway could handle the LoRa communication and the monitoring information system together. It also showed that the system average throughput is 489 bit/s and has packet loss 26% at 1-meter distance.**

Keywords*—*Dragino LoRa, Monitoring System. Raspberry Pi 3b+, Simple LoRa Protocol, Smart Gateway

I. Introduction

In this modern era, the growth of IoT (Internet of Thing) is very fast. There are numerous IoT application used in various sector such as industry, farming, livestock, security, transportation, and household [1]. The rapid growth of IoT also affecting the various offer of IoT transmission method, one of it is LoRa.

LoRa, which means "Long Range" is one of the LPWAN (low-power wide-area network) communication systems that has long-distance transmission capabilities, supported by the development of IBM, Semtech, Actility, etc., which are members of the LoRa Alliance [2]. The target of LoRa development is low-power (battery-powered) end-node transmission, which will transmit certain amount data packets in certain time.

In LoRa implementation, LoRa Alliance has designed a network architecture in LoRa communication called LoRaWan [3]. However, the implementation of LoRaWAN itself does not meet the main design objectives of LoRa as one of the LPWAN protocols because it still need an internet to process and display data [2]. It is not suitable with the purpose of LPWAN design, which are simple implementation, low cost, and simple architecture. Based on that, a new alternative protocol called SLP (Simple LoRa Protocol) is designed. The purpose of designing SLP are to optimize the purpose of LPWAN design in LoRa and to meet the development of monitoring system.

Widianto et al. made a research on LoRa QoS performance in Indonesia [4]. Rosmiati et al [5] discussed the use of LoRa using the Raspberry Pi 3 device. Hsieh, et al discussed the use of LoRa as a monitoring system communication method [6]. Prihatmoko [7] discusses the monitoring system using a web server using the Raspberry Pi device.

Based on previous studies from [5] and [6] still needed internet facilities to process and present data from the results of the LoRA communication. While [7] has successfully present data in the form of a web server without internet facilities, however the communication method used is not LoRa.

The purpose of this research is to develop what has been achieved by previous studies. Combine Raspberry's ability as a web server provider as in [7] and use LoRa as a communication tool as in [5]. Then, [4] is used as a reference to the QoS parameters to be assessed from the LoRa system. In this case, the focus of research is in LoRa communication and presentation of monitoring system data using a web server.

In this research, the development of SLP used to use Arduino board as the client and gateway. Arduino only had limited memory capacity, so it cannot save and display a large amount of data. So here the used of smart gateway that able to function not only as a gateway but also as a thing to save and display data.

Smart gateway particularly design to SLP protocol to meet the use of LoRa. In general, ordinary gateways only tasked to distribute data from client to server, the difference between smart gateway and ordinary gateway is its ability to combine the functions of a gateway and server on one device. This makes the SLP architecture simpler than LoRaWAN, and another difference is that the SLP architecture does not use an internet connection to send data to the server, but only the LoRa connection.

II. Literature Review

A. LoRa

LoRa specifically developed by Semtech to work in 433.868 or 915 MHz ISM Band (depend on the regional placement) with transmission rate between 0.25kbps-50kbps [8]. The parameters that possibly changed in LoRa modulation are Bandwidth, Spreading Factor and Code Rate. The spreading factors are - in short - the duration of the chirp. LoRa operates with spread factors from 7 to 12. SF7 is the shortest time on air and SF12 will be the longest. Each step up in spreading factor doubles the time on air to transmit the same amount of data [9] [10] [11].

LoRaWAN is the communication protocol and the system architecture for the network while the LoRa physical layer enables the long-range communication link. It has the most influence in determining the battery lifetime of a node, the network capacity, the quality of service, the security, and the variety of applications served by the network [12]. LoRaWAN network architecture is composed of four types of devices, namely End Nodes, Gateway, Network Server and Application Server. End-nodes communicate with the gateway with LoRa connection. The gateway works as the connecting bridge between end-nodes and network servers, where data saved and proceed by users. The gateway uses IP backhaul to send data to the network server with which has a large transfer capability. The typical LoRa architecture shown in Fig 1.

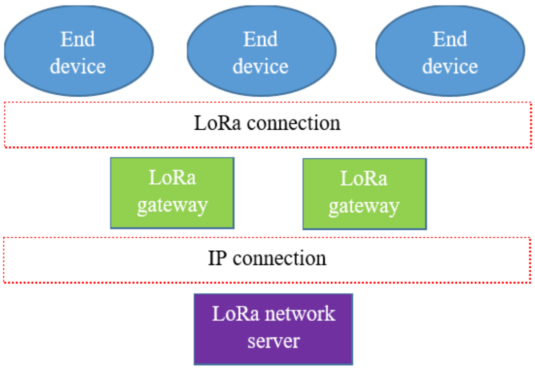


Fig. 1. Typical LoRa architecture

One kind of Lora shiel that can be used in LoRa communication is The Dragino Shield. It made with attention to the Arduino design, and can be mounted directly above the Arduino, minimizing the size. This shield can be used for several types of Arduino namely, Leonardo, Uno, Mega and DUE. Using SX1276 / SX1278 chips made by Semtech [13].

B. Raspberry Pi

Raspberry is a small computer (single board PC) that can be used to run computer programs that are relatively lightweight. The specifications of the Raspberry Pi are not as big as a PC in general because of their small size. It has various features like larger memory compare to controller boar, wireless and Ethernet communication, Extended 40-pin GPIO header, etc as in Fig. 2 [14].

Fig. 2. Raspberry Pi 3b+

The selection of Raspberry Pi 3B + as a device used in this research is because it will used as a Smart Gateway that requires a small computer size, to be installed in difficult environment. As stated in [15] Raspberry Pi can support various kind of Internet of Things application. It can be used as a new tool in embedded project.

III. Research Method

This research design a monitoring system using a network architecture for the SLP protocol in the form of creating a Smart Gateway, which includes writing a programming code, and designing information systems to process data from the client, and evaluate the QoS parameters in the communication system (packet loss and throughput). The result of the QoS parameter testing then compare with the previous research using LoRaWan [4] .The LoRa architecture using SLP designed in this research can be seen in Fig 3. The LoRa parameter used in this research shown in Table I.

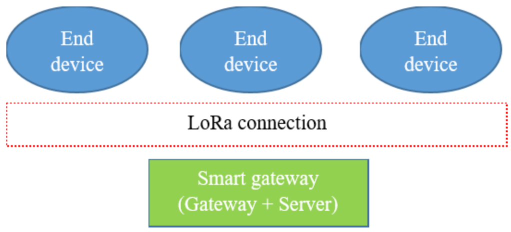


Fig. 3. LoRa architecture using SLP

The client used in this research is Arduino UNO with LoRa Shield with specification used are:

- The client is able to send dummy sensor data using the SLP format to the Gateway with 1-meter distance.
- Client programmed using Arduino IED in Windows 8 operating system.
- The gateway is able to receive and extract data sent by the client.
- Gateway is able to enter data into the database. The gateway is able to retrieve data from the database and present information on the web server.
- Gateway programmed with GNU compiler collection in Debian operating system.
- User can access the web server locally or using the user interface from the Raspberry directly.

TABLE I. LoRa Parameter

Parameter	Value
ISM Frequence	868.0 MHz (EU)
Spreading Factor	7
Bandwith	125 kHz
Code Rate	4/5

In SLP client requires 4 states to be able to communicate with the gateway. State 1 to 3 controls the communication set up and provides installed client and sensor information. State 4 used for polling, which is the process of taking sensor data from the client. Fig 4 show the client state diagram. Fig 5 show the gateway state diagram.

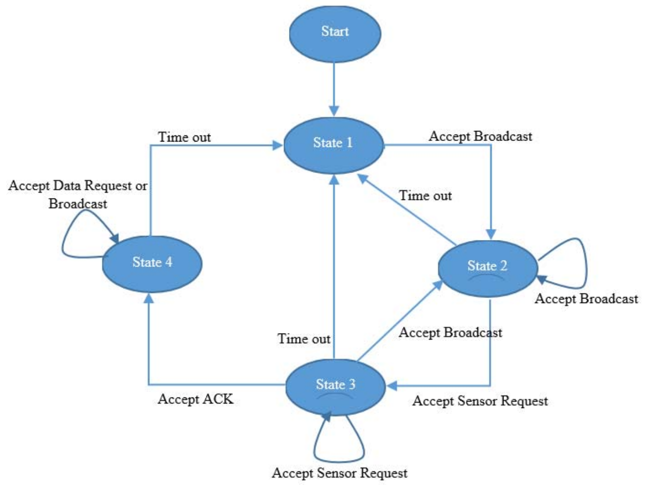


Fig. 4. Client State Diagram

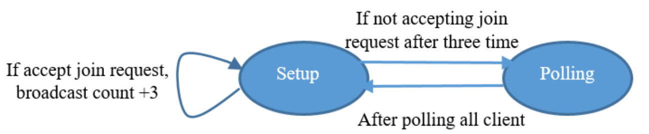


Fig. 5. Gateway State Diagram

The testing mechanism in this research using QoS parameter such as packet loss and throughput to be analyzed.

IV. Implementation

As the hardware, the system use dummy sensor as the end devices that connected to Arduino UNO with LoRa shield to transmit the dummy sensor data. The data transmitted then received by the Smart Gateway, which use a Raspberry Pi 3b+ to be gateway and a server. The monitoring system also developed to bridge the user with the hardware. The design of the monitoring system in this research can be seen in Fig 6. The hardware implementation can be seen in Fig 7. For the monitoring system in Fig 8.

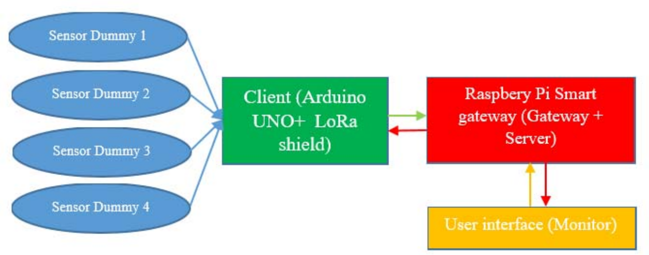
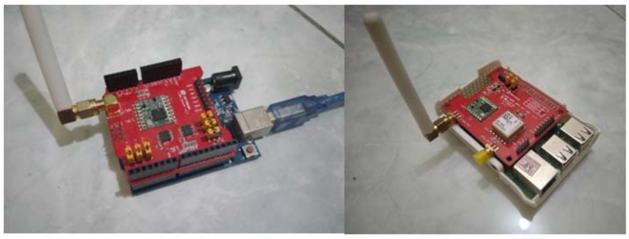
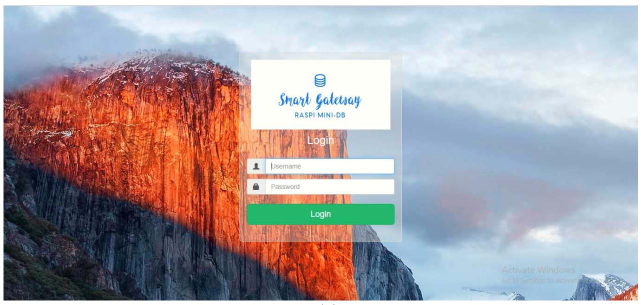


Fig. 6. System Design

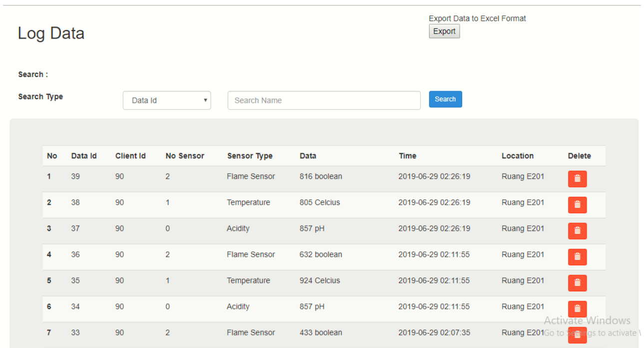


(a) (b)

Fig. 7. (a) Client Implementation
(b) Smart Gateway Implementation



(a)



(b)

Fig. 8. (a) Monitoring system landing page
(b) Log data page

The monitoring system is able to work together with LoRa communication. Before entering the system, user need to login to the system. After login, user can monitor the data sent by client in the log page.

V. Testing and Analysis

The testing mechanism done by checking the Throughput and Packet Loss of the system. Throughput is an effective data transfer rate. It can obtained as in (1) where T is throughput in bps, Dt is amount of arrived packet, and t is observing time. Packet Loss is parameter showed the amount of packet lost in transmission process. It can obtained as in (2), where PL is packet loss, Dk is amount of sent packet, Dt is amount of arrived packet.

$$T = \frac{Dt}{t} \tag{1}$$

$$PL = \frac{(Dk - Dt)}{Dk} \times 100\% \tag{2}$$

A. Throughput

The throughput testing done by dividing the amount of packet that successfully sent with the observed time. Values taken from the average of three polling for each of client variances. Every client polled, sent with 496-bit data. Fig 9 is a graphical representation of the connectivity of client amount with average data throughput. Table II is the average result of the testing done.

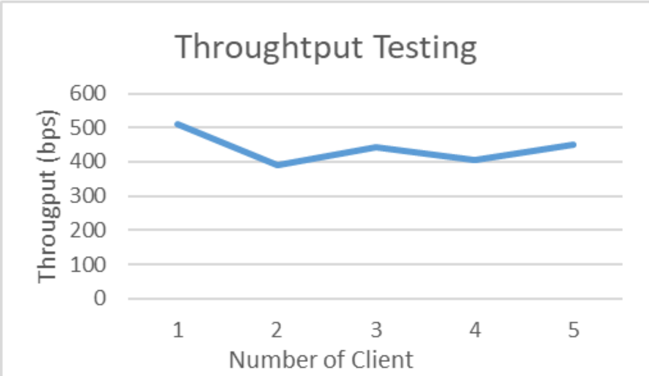


Fig. 9. Throughput testing

TABLE II. THROUGHPUT TESTING

Number of Client	Packet Size (bit)	Average Polling time (ms)	Average Throughput (bit/s)
1 Client	496	975	508.37
2 Client	992	2541	390.35
3 Client	1488	3368	441.72
4 Client	1984	4893	405.48
5 Client	2480	5518	449.38
Average Throughput of The System			489 bit/s

Based on the result of the throughput testing, there is a transfer rate decrease when the number of client is 2 and 4, and then it increase when the number of client is 3 and 5. The average throughput for the 1-meter range communication is 489 bit/s. The minimum throughput is 390 bit/s with 2 clients and the maximum throughput is 508 bit/s with 1 client. The system in this research only has 25% of the LoRa throughput compare to [4] which has 1927 bit/s for 1 client communication.

The throughput in this system has a stable result but smaller value. It occur because this system has data entry process into the database and provides web server services, which are not present in the LoRa gateway system in general. Another obstacle occur in the form of packet loss during the communication process.

B. Packet Loss

Packet loss testing done by divide the data arrived on the gateway with the data request from the gateway. If the client does not answer the request from the gateway, it considered as loss. The testing done with three polling for each of the client variance. Fig 10 show the graphical representative of the packet loss testing based on the number of the client. Table III is showing the average packet loss testing.

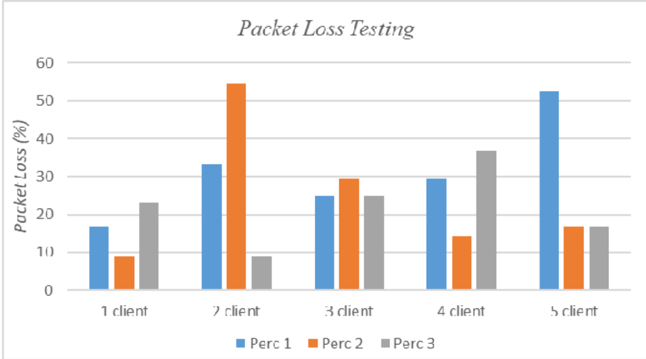


Fig. 10. Packet loss testing

TABLE III. PACKET LOSS TESTING

Number of Client	Packet Loss 1st Trial	Pcket Loss 2nd Trial	Packet Loss 3th Trial	Average Packet Loss
1 Client	16.66 %	9.09 %	23.07 %	16.27 %
2 Client	33.33 %	54.54 %	9.09 %	32.32 %
3 Client	25 %	29.41 %	25 %	26.47 %
4 Client	29.41 %	14.28 %	36.84 %	26.84 %
5 Client	52.38 %	16.66 %	16.66 %	28.57 %
Average Packet Loss of The System				26.09 %

Based on the packet loss testing result, there is a significant increase of packet loss when the system using 2 client. The average result of the packet loss is 26% in 1-meter communication range. The minimum packet loss is 16.27% with 1 client. The maximum packet loss is 32% with 2 client. This system has 22% bigger packet loss compare to [4], which has 4% packet loss for 1 client communication. It also showed that the variance result of the packet loss is too big and the number of the client used does not affect the result.

This result caused by the uncertainty of the many processes that must be done at a time in the gateway. Things that can make the value of packet loss become greater is the process of entering data into each client's database, providing web server services, and the possibility of interference when communicating.

VI. CONCLUSION

Based on the research done in the Smart Gateway network architecture, can be concluded that the system built able to serve 1 until 5 clients. The system can register and request the data automatically. The system also able to run the LoRa communication together with the information system used as the user interface. The system cannot be accessed from the outside of the local gateway. Based on the QoS testing, the average throughput is 489 bit/s and the average packet loss is 26% for 1-meter range communication.

Compare to the use of LoRaWan, the throughput in this system has a stable result but smaller value. It occur because this system has data entry process into the database and provides web server services, which are not present in the LoRa gateway system in general. However, it has a bigger packet lost for one client compare to the use of LoRaWan.

For further research, it is better to add communication mechanism in the gateways or add centralized network to gather several gateways, so that the network has bigger scale. The encryption and decryption format also can be added to make the security better. It is also better to build the system using a real sensor and test the LoRa parameter in the process.

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