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# Analysis of data exchange quality in LORA SX1262 Multipoint Telemetric Communication Network

## (CASE STUDY IN PDAM SMART DESIGN)

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**Abstract:** This study aims to determine the results of the analysis of Quality of Service (QoS) parameter testing using LoRa SX1262 telemetry with a certain distance on Smart PDAM and determine the effectiveness of using LoRa SX1262 telemetry on data exchange on multipoint communication networks. The data collection technique uses observation and documentation techniques to obtain valid test results data. This study uses an quantitative descriptive analytical approach with a standard assessment of the TIPHON QoS parameters on the throughput, delay, packet loss, and RSSI (Received Signal Strength Indicator) values. Based on the results of the analysis of this study, it was found that the data can be received well when the RSSI value is above -90 dBm, the average throughput and packet loss values resulting from data transmission on a digital water meter system is inversely proportional to the amount of bandwidth, the average delay of sending LoRa SX1262 telemetry data using a 115200 baud rate of 513 milliseconds. The conclusion of this study is that multipont communication on digital meter data transmission is effectively used at a maximum distance of 300 meters with a bandwidth of 500 kHz.

***Keywords:*** Analysis, Data Communication, LoRa SX1262 Telemetry QoS

## INTRODUCTION

Communication is a need that cannot be separated from human life. In this era of increasingly sophisticated technology, the need for a reliable and efficient communication system is increasing. One technology that can be used to meet these needs is Low Range Telemetry (LoRa). LoRa telemetry is a communication technology that has the ability to transmit data over long distances with low power consumption (Ghani and Zulkifflee, 2022) (Carvalho Silva et al., 2017). Data measurement systems using sensors can measure long distances with several devices without using cables, which are called telemetry systems. Telemetry has several advantages, one of which is lower maintenance costs compared to devices that use cables (Burton, 1987). Telemetry is expected to facilitate measurement, monitoring and reduce information barriers.

LoRa has advantages such as far-reaching communications such as cellular (Huo, Y., Dong, X., and Beatty, S.,2020) but low power usage like bluetooth (Z. Li and Y. Chen., 2020), therefore the implementation is very suitable for sensor devices that are used for the next few years in a wide area coverage using battery resources (Kombo et al., 2021). In addition, LoRa can also be applied to areas where there is no internet access (Andriana, Sutisna Abdul Rahman, 2020). As in the application of the use of digital PDAMs in rural areas (Kneese, 2013) .

Regional Drinking Water Company (PDAM) is a Regional Owned Enterprise (BUMD) that provides services and organizes benefits in the distribution of clean water for the community (Kneese, 2013). PDAM provides clean and healthy drinking water that meets the needs of local residents, which is also a form of service provided by the government to residents. However, the current PDAM system mostly uses a manual recording system which is prone to fraud, is inconsistent in measuring water use, lacks flexibility and lacks transparency in community water use. On research (Ramdhani *et al.*, 2020) has implemented the IoT on the Smart Meter System to monitor water usage in real time in households so that water use is more efficient. MQTT data communication on the system starts with the Water Flow Sensor sending (publishing) data obtained in the form of water discharge to the MQTT Broker via WeMos to be displayed on the web (Eridani *et al.* 2018). However, if this is applied to areas that do not have internet access, it will cause a lot of communication problems.

Therefore, the potential for implementing smart PDAM technology in this infrastructure is by using digital water meter devices, monitoring information systems and remote control using wireless network sensors.

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Smart PDAM is very suitable to be implemented because it can accommodate their needs. The digital PDAM program has integrated a digital water usage measurement system and a wireless remote monitoring and control system. Expandable functionality allows users to control water usage remotely. Availability of a system to monitor measurement data and remotely control digital PDAMs using telemetry technology. Telemetry is the process of measuring the parameters of an object (object, space, natural conditions) whose measurement results are sent to another place via cable or wirelessly (Harianto *et al.*, 2017). The type of telemetry used is LoRa SX1262. The LoRa SX1262 is designed for long battery life with 4.2 mA active receive data current. The LoRa SX1262 can transmit up to +22 dBm with its highly efficient integrated power amplifier (Semtech, 2017).

Implementation of the use of LoRa as a data communication medium on multipoint networks is very important to be analyzed to determine the reliability of data communication in digital PDAMs. A multipoint communication network uses several wireless devices, one of which functions as an access point and the other device acts as a wireless client (Yanziah, *et al.*, 2020). Data exchange analysis is certainly not a new thing for research. There have been many previous studies that have conducted research on the quality of network services such as research (Nurjannah *et al.* 2016) has conducted research on temperature telemetry which is more focused on analyzing the data rate and data distance parameters, these factors can affect the transmission of measurement data. According to some of these studies, radio data exchange using telemetry technology has several quality of service problems.

Implementation of smart PDAM is very important to know the quality of data exchange services that occur. So that research was raised about the effectiveness of using LoRa SX1262 telemetry in exchanging digital water meter data on multipoint communication networks. The network uses a point to multipoint topology which is a common network architecture for outdoor wireless networks connecting multiple locations to a central location (Bhakti *et al.*, 2017). To translate the data generated from the sensor in a digital water meter, a microcontroller is needed. Microcontroller is a chip in the form of an IC (Integrated Circuit) that can receive input signals, process them and provide output signals according to the program loaded into them (Destiarini and Kumara, 2019). This study utilizes the built-in WiFi module facility provided by ESP 8266 with low power consumption capability because it only requires 3.3V power, is easy to flash and remove firmware and is supported by USB (Kodali and Mahesh, 2019).

This study also uses a water flow sensor on a digital water meter, a water flow sensor is used to measure the flow of water flowing in the customer's pipe (Suharjono *et al.*, 2015). The pressure sensor or pressure sensor is a sensor that is used to measure the pressure of the water entering the digital water meter (Edwin and Kristiadjie, 2016). Meanwhile, the solenoid is used as an output in a system that regulates the discharge of water in a digital water meter (Putra et al., 2022).

With this research, it is expected that the final results aim to find out the results of the analysis of QoS parameter testing using LoRa SX1262 telemetry with a certain distance on Smart PDAM and 2, and find the effectiveness of using LoRa SX1262 telemetry for data exchange on communication networks. The communication network used in this study is multipoint communication consisting of several devices, one device as an access point and the other as a wireless client that is installed on each digital water meter. The test was carried out in an open room with various specified distances in the data exchange trial between the transmitter and several receiver devices. So that it can be seen whether the effective quality of data exchange using LoRa SX1262 telemetry is on a multipoint communication network at a certain distance. The results obtained in this study will be used as basic data to build a multipoint network-based smart PDAM system that will be developed in the future.

## LITERATURE REVIEW

LoRa has advantages such as far-reaching communications such as cellular (Huo, Y., Dong, X., and Beatty, S.,2020) but low power usage like bluetooth (Z. Li and Y. Chen., 2020), therefore the implementation is very suitable for sensor devices that are used for the next few years in a wide area coverage using battery resources (Kombo et al., 2021). In addition, LoRa can also be applied to areas where there is no internet access (Andriana, Sutisna Abdul Rahman, 2020). As in the application of the use of digital PDAMs in rural areas (Kneese, 2013) .

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## METHOD

The type of research used in this research is quantitative with a descriptive approach that focuses on explaining the relationship between the parameters used. This type of research is used to solve or answer the problems being faced. This research was carried out by taking the steps of testing, collecting, analyzing data processing, making conclusions with the main goal of making an objective picture of a situation.

In order to obtain complete information in accordance with the research focus, the data collection techniques used in this study are as follows:

### a. Observation

Observation is an intentional, systematic observation of social phenomena with psychic symptoms for later recording. This research was carried out directly in the field by conducting a range testing process. This process aims to see how far the LoRa SX1262 telemetry range is and the quality of service on a multipoint communication network.

### b. Documentation

Documentation techniques are used to obtain data sourced from research locations to support research results. The data analysis technique used in this study is descriptive quantitative analysis, which is a technique of describing and explaining changes in QoS parameters that occur in the test results using LoRa SX1262 with a frequency of 868 MHz for digital PDAM data transmission. It is said to be effective if it meets the parameters at what distance the data can still be sent without any data lost.

## RESULTS

The results of this study examine the QoS of the digital water meter data communication system. This system is divided into two, namely monitoring stations and digital water meters. Monitoring station as control and data recording of the use of digital water meters. In this study it was limited to testing the ability of the communication system on digital meters using the LoRa SX1262. QoS studied such as data transmission range, throughput, packet loss, delay.

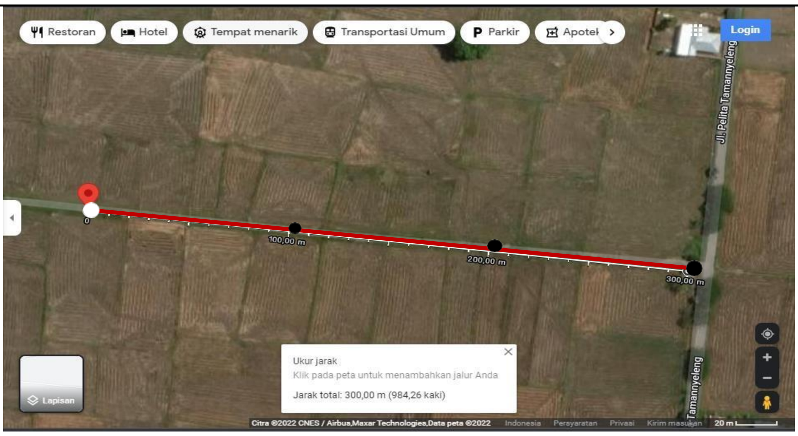
### a. Data Transmission Range

To get the range of wireless data communication, a distance test is carried out by placing a Monitoring Station (SM) device and a Digital Water Meter (M) device at several certain points. This is done to determine the performance of digital water meter data communication devices. In testing the performance of multipoint communication devices, a test scenario is created by placing SM and M at a certain distance. SM makes a data request to the digital water meter by sending a command code. The list of commands used in the monitoring station (SM) communication system to the digital water meter (M) can be shown in Table 1.

**Table 1.** Command List Description

| No. | Command List | Information |
|---|---|---|
| 1 | M;2<br>(3 byte) | M OFF |
| 2 | M;3<br>(3 byte) | M ON |
| 3 | M;1;1<br>(5 byte) | Request hourly debit |
| 4 | M;1;2<br>(5 byte) | Request debit per day |
| 5 | M;1;3<br>(5 byte) | Ask for a monthly debit |

Table 1. Shows the commands sent by SM to the digital water meter. The data requested is hourly, daily, and monthly debit data. Then there are also types of commands to turn off the water meter and turn on the water meter.



Ukur jarak
Klik pada peta untuk menambahkan jalur Anda
Jarak total: 300,00 m (984,26 kaki)

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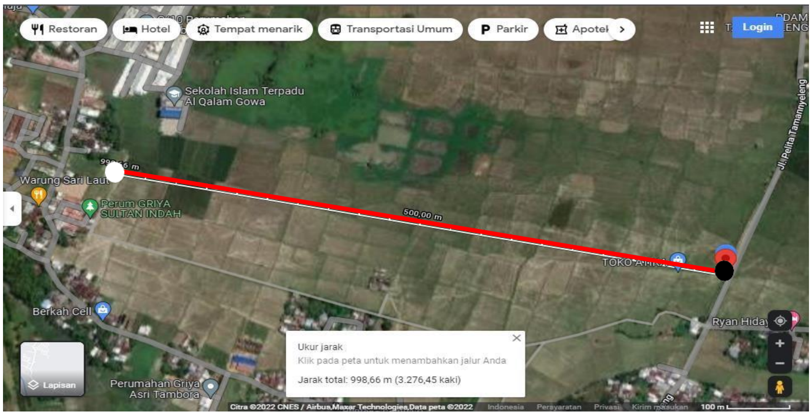
**Figure 1.** Data transmission at line of sight distances of 100 meters, 200 meters and 300 meters



Ukur jarak
Klik pada peta untuk menambahkan jalur Anda
Jarak total: 998,66 m (3.276,45 kaki)

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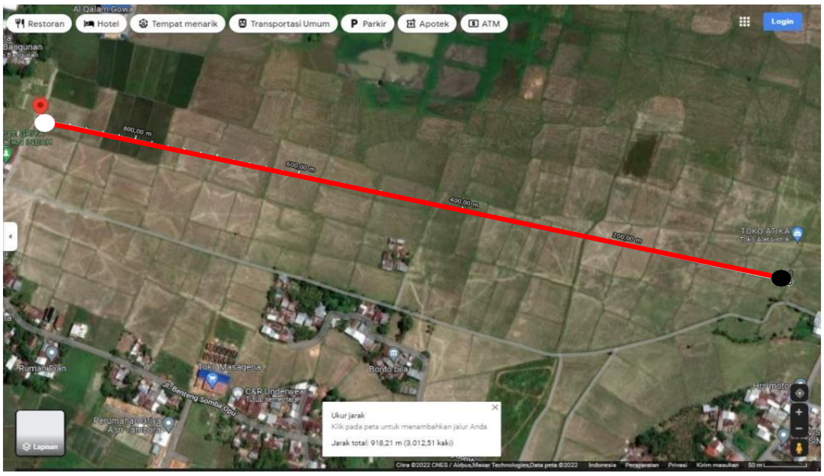
**Figure 2.** Data transmission at a line of sight distance of 998.66 meters



Ukur jarak
Klik pada peta untuk menambahkan jalur Anda
Jarak total: 918,21 m (3.012,51 kaki)

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**Figure 3.** Data transmission at a line of sight distance of 918.21 meters

The following Figure 4 shows the relationship between data transmission range and bandwidth usage in the digital water meter monitoring station communication system. From the test results it was found that the bandwidth value affects the distance of data transmission range in the digital water meter monitoring station communication system using LoRa SX1262 telemetry, for more details can be seen in Figure 4.

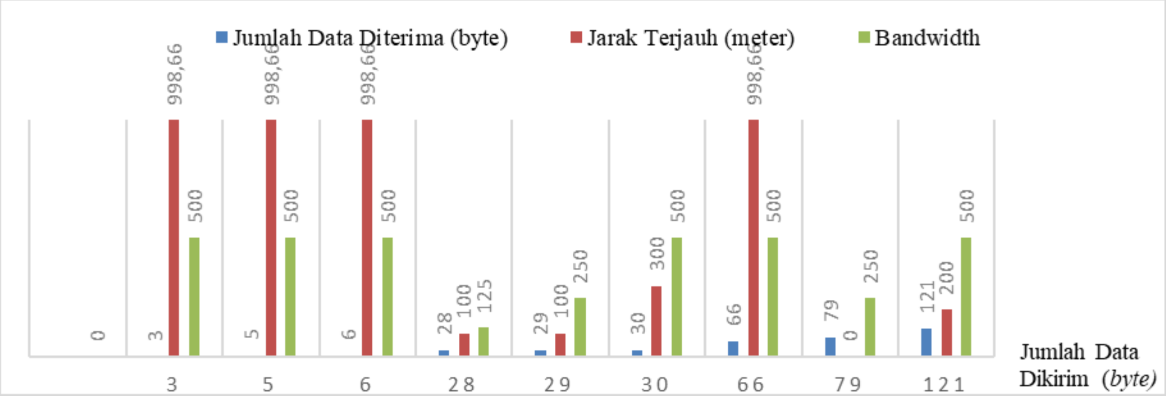


**Figure 4.** Graph of the Relationship between Range and Bandwidth

In Figure 4 it is clearer that if the bandwidth value is greater, the farther the data transmission range will be. LoRa SX1262 telemetry data transmission capability using a standard antenna is only able to reach a distance of 998.66 meters using a bandwidth of 500 kHz.

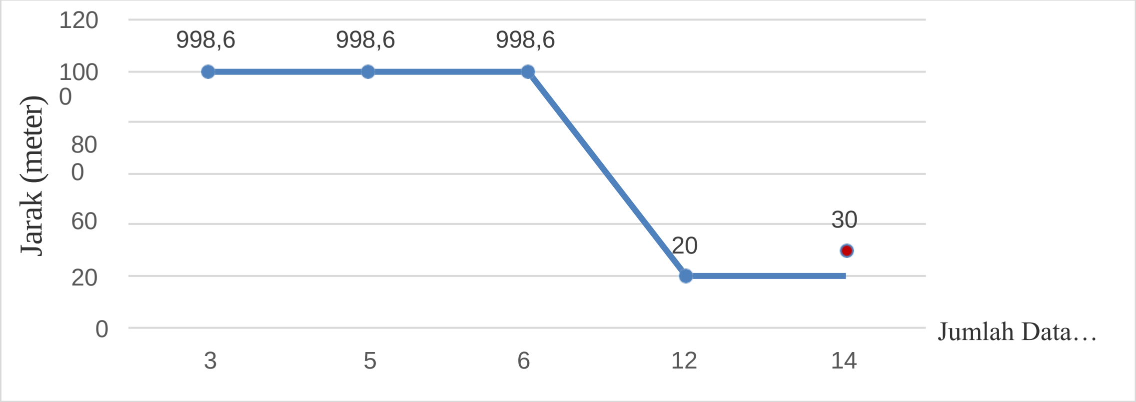


**Figure 5.** Graph of the Relationship between Distance and Total Data

Figure 5 shows that the test results show that data lengths above 121 bytes cannot be received by monitoring stations from a distance of 200 meters. However, with a data length of 66 bytes, the receiver can receive data sent from a distance of 998.66 meters. For more details, see Figure 5. Figure 5 shows a red dot on the amount of data 141 bytes, which means that the data did not arrive at the receiver at a distance 300 meters. While the blue dot indicates that the data has arrived at the recipient.

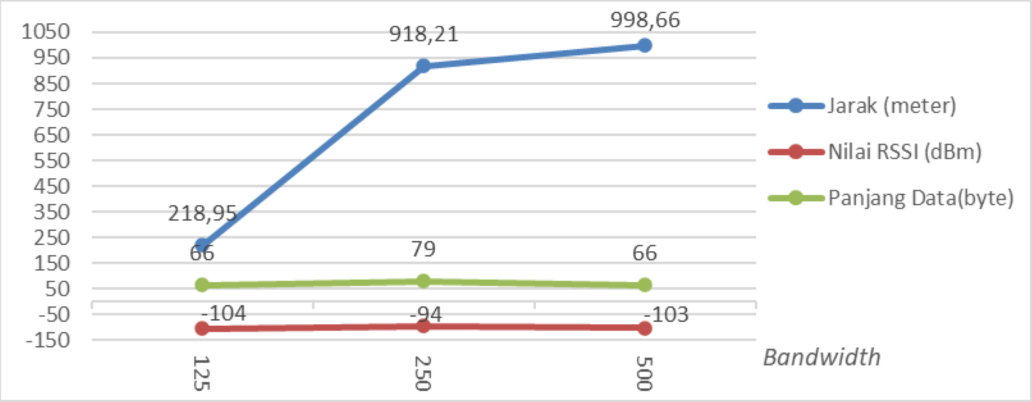


**Figure 6.** Graph of the Relationship between Distance and Total Data

### b. Value RSSI (*Received Signal Strength Indicator*)

**_Bandwidth_ 125 kHz**

The following Figure 7. is a graph of the range of RSSI values from the measurement results with a bandwidth value of 125 kHz at a distance of 100 meters to 300 meters.

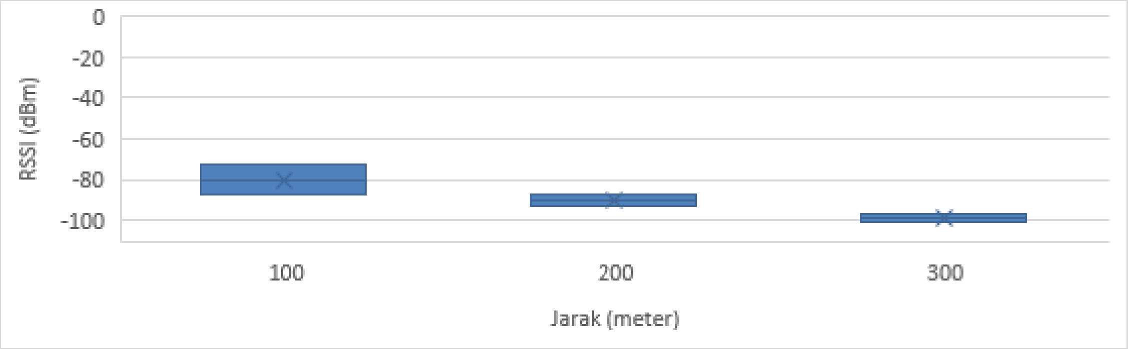


**Figure 7.** Graph of RSSI Value from 125 kHz Bandwidth Measurement Results

In Figure 7 it can be seen that in the use of 125 kHz bandwidth the best range of RSSI values is at a distance of 100 meters, because the RSSI value can be said to be good if the value is close to zero [11].

**_Bandwidth_ 250 kHz**

The following Figure 8 is a graph of the RSSI value from the measurement results with a bandwidth value of 250 kHz at a distance of 100 meters to 300 meters.

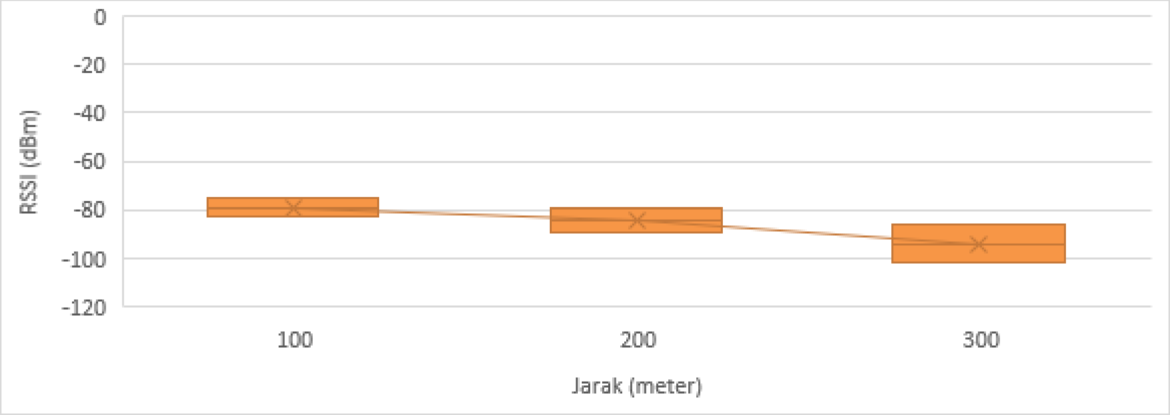


**Figure 8.** Graph of RSSI Values from 250 kHz Bandwidth Measurement Results

Figure 8 can be seen that in using 250 kHz bandwidth the best range of RSSI values is at a distance of 100 meters from -83 to -75 dBm. Meanwhile, at a distance of 200 meters, the RSSI value ranges from -79 to -89 dBm. And at a distance of 300 meters the RSSI value range starts from -86 to -102, with poor network quality which means it can receive data but often drops out.

**_Bandwidth_ 500 kHz**

The following below is a graph of the RSSI value from the measurement results with a bandwidth value of 500 kHz at a distance of 100 meters to 300 meters.

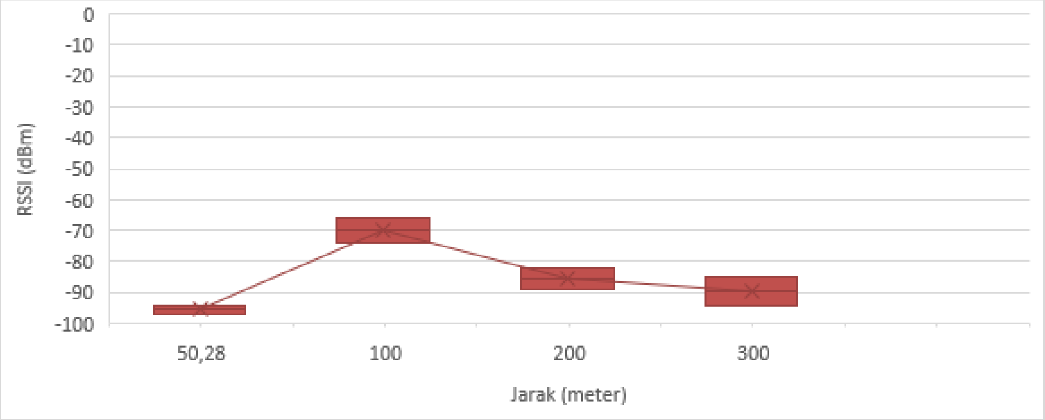


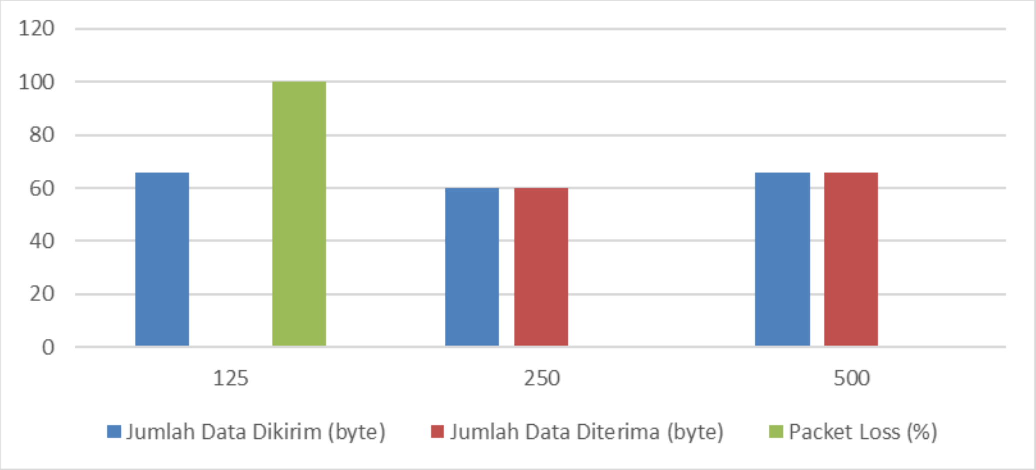
**Figure 9.** Graph of RSSI Value from 500 kHz Bandwidth Measurement Results

In Figure 9. it can be seen that in the use of 500 kHz bandwidth the range of RSSI values is best at a distance of 100 meters, because the RSSI value can be said to be good if the value is close to zero. And at a distance of 50.28 meters the RSSI value is low because measurements at that distance are carried out by placing a digital water meter inside the building and a monitoring station outside the building. So the farthest distance for data transmission if the digital water meter is placed inside the building is 50.28 meters and produces a low RSSI value.

### *c. Packet Loss*

The following is a graph of the relationship between the packet loss value on the measurement results and the bandwidth value namely 125 kHz, 250 kHz, and 500 kHz.

**Figure 10.** Graph of Packet Loss with Bandwidth



The picture above explains the relationship between packet loss and the bandwidth used at a distance of 300 meters. If the bandwidth value is 125 kHz with the amount of data sent is 66 bytes, the resulting packet loss is 100%, meaning that the data sent by the sender does not reach the recipient. However, if you use a bandwidth value of 250 or 500 kHz in sending data with a distance of 300 meters, the resulting packet loss is 0%, meaning that all data sent by the sender is received by the recipient and no data does not reach the recipient.

### *d. Delay* and *Troughput*

#### Bandwidth 125 kHz

The following graph explains the relationship between delay and throughput from the results of the response test from a digital water meter to a monitoring station with a bandwidth of 125 kHz.

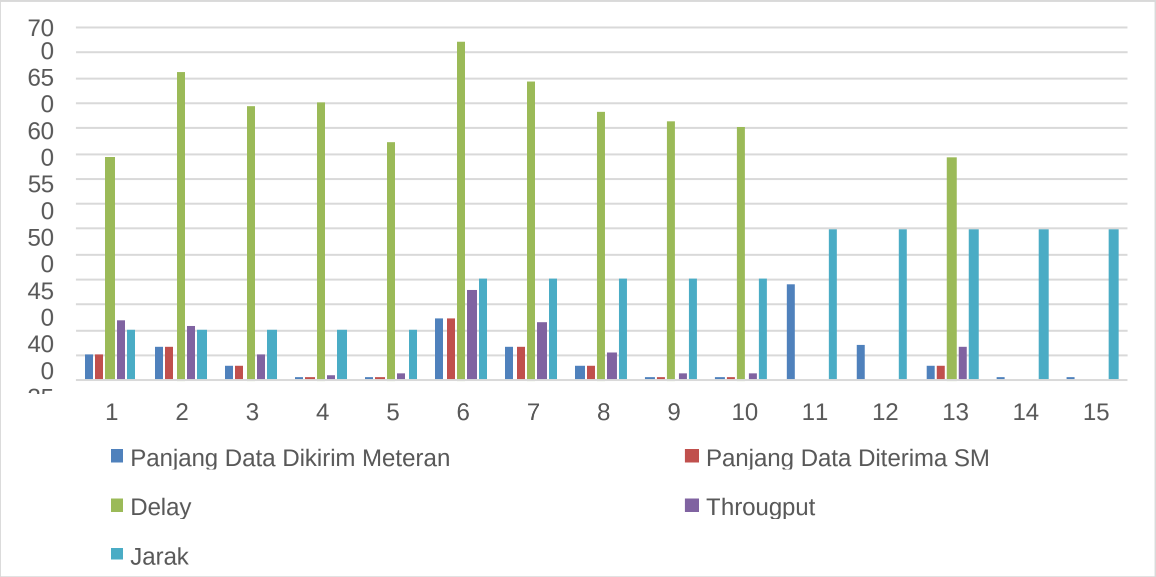


**Figure 11.** Graph of Delay and Troughput of Meter Response at 125 kHz Bandwidth

Figure 11. Is the result of data from tests that have been carried out using a bandwidth of 125 kHz with a measuring distance of 100 meters, 200 meters and 300 meters. From Figure 11. it can be concluded that the average throughput value is 67.6 bps. And the average delay value for measurements using a 125 kHz bandwidth is 535 ms.

**Bandwidth 250 kHz**

The following graph explains the relationship between delay and throughput from the results of the response test from a digital water meter to a monitoring station with a bandwidth of 250 kHz.

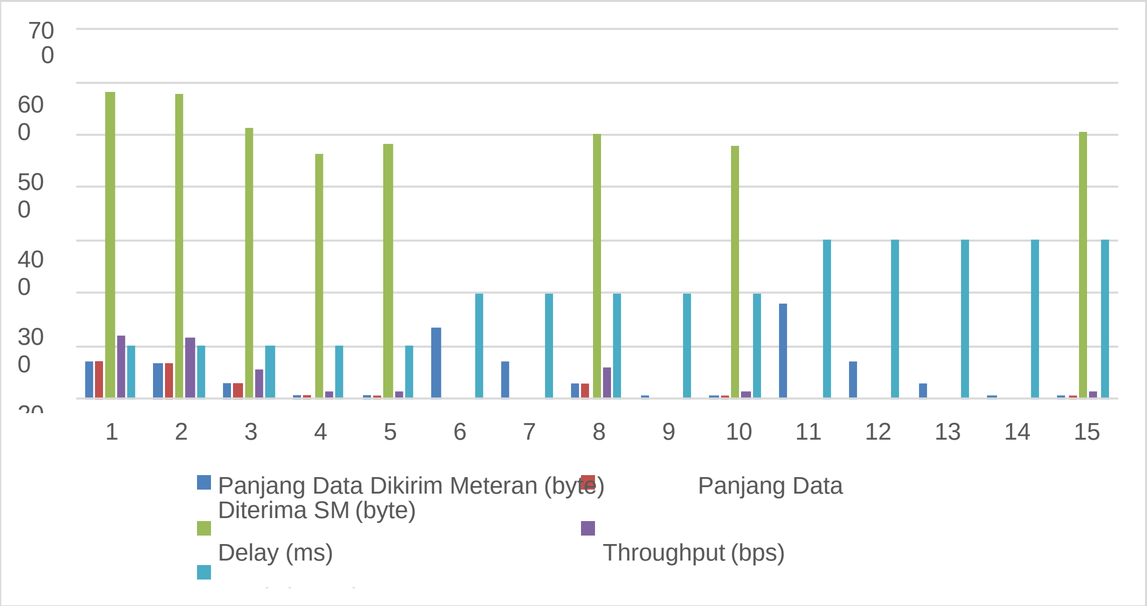


**Figure 12.** Graph of Delay and Throughput of Meter Response at 250 kHz Bandwidth

Figure 12. Is the result of data from tests that have been carried out using a 250 kHz bandwidth with a measurement distance of 100 meters, 200 meters and 300 meters. From Figure 12. it can be concluded that the throughput value is 50.3 bps. And the average delay value for measurements using a 250 kHz bandwidth is 514 ms.

**Bandwidth 500 kHz**

The following graph explains the relationship between delay and throughput from the results of the response test from a digital water meter to a monitoring station with a bandwidth of 500 kHz.

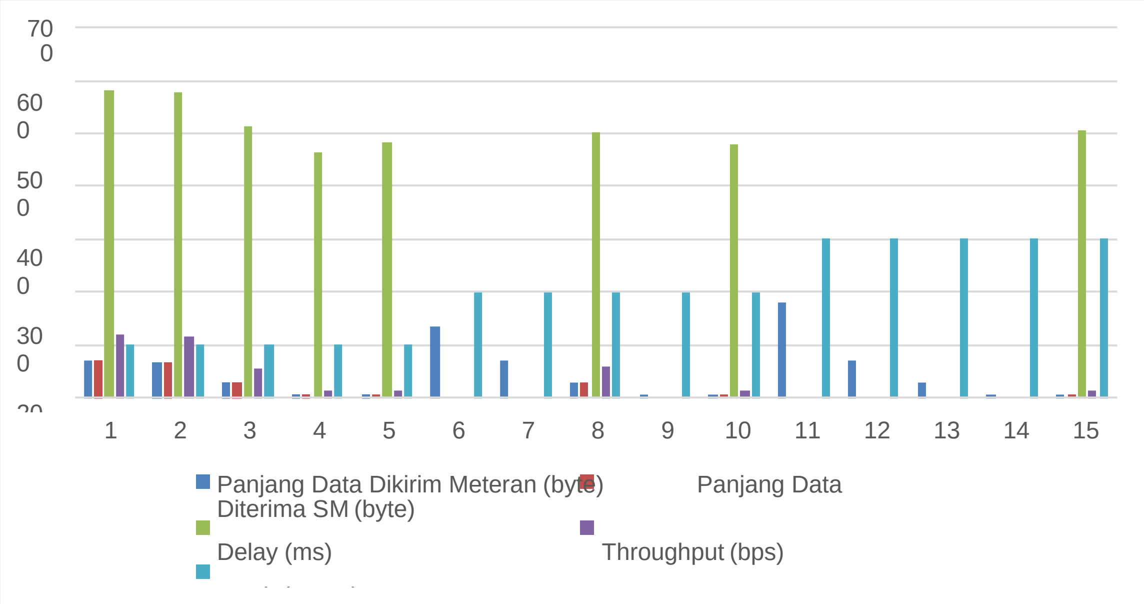


**Figure 13.** Graph of Delay and Throughput of Meter Response at 500 kHz Bandwidth

Figure 13. is the result of data from tests that have been carried out using a 500 kHz bandwidth with a measurement distance of 100 meters, 200 meters and 300 meters. From Figure 12. it can be concluded that the average throughput value is 48 bps. And the average delay value for measurements using a 500 kHz bandwidth is 490 ms.

## DISCUSSION

Tests carried out to determine whether there is a relationship between the distance of data transmission range with the value of the bandwidth used. And the results of the test show that there is a relationship between the distance of the data transmission range and the bandwidth, because the results obtained are that the value of the bandwidth can change the distance of the data transmission range. Likewise, the length of the data sent is very influential with the range of data transmission in the monitoring station communication system with a digital water meter. The results also show that if the number of bytes or length of data sent is equal to 3 or 5 bytes, then a distance of 998.66 meters in data transmission can work well with a Bandwidth value of 500 kHz but if the number of bytes or length of data sent is equal to one hundred and twentyone, then the farthest distance that can be received by the monitoring station is 200 meters with the same Bandwidth value of 500 kHz.

The RSSI value on the data transmission of the digital water meter monitoring station affects the range. In this study the range of RSSI values -66 dBm to -77 dBm at a distance of 100 meters with a bandwidth of 500 kHz is considered very good. The results of this test support the theory in Table 2.5 RSSI Signal Levels in Sallyna's research, et al. 2020. However, in this study the range of RSSI values was –75 dBm to -102 dBm, some data was not accepted, while in Sallyna et al.'s 2020 study it was stated that RSSI values from -90 dBm to -105 dBm were considered good, and there were some data which is not accepted.

## CONCLUSION

Based on the results of this study, it was found that data can be received properly when the RSSI value is above -90 dBm, the average throughput and packet loss values resulting from data transmission on a digital water meter system are inversely proportional to the amount of bandwidth, the average delay of transmission LoRa SX1262 telemetry data uses a baud rate of 115200 of 513 milliseconds. Based on the results of this study, the use of LoRa SX1262 telemetry for digital water meter data exchange in multipoint communication networks is effective at a maximum distance of 300 meters with a bandwidth of 500 kHz.

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