Design and Build Android-based LoRaWAN Mobile Drivetest Application for Network Planning in the Internet of Things (IoT) Network at PT. Telkom Indonesia

Ryan Arief Satrio[1], Ahmad Wilda Yulianto[2*], Putri Elfa Mas'udia[3]

[1,2]Digital Telecommunication Network Study Program, Department of Electrical Engineering, State Polytechnic of Malang, 65141, Indonesia.

[3]Telecommunication Engineering Study Program, Department of Electrical Engineering, State Polytechnic of Malang, 65141, Indonesia.

[1]aripsatrio45@gmail.com, [2]ahmadwildan@polinema.ac.id, [3]putri.elfa@polinema.ac.id

Abstract— **Technicians often have difficulty testing new sensors in LoRaWAN networks because they have to open many websites to see the parameters of the gateway, which is time-consuming. In addition, the creation of reports is done manually so that the data is not stored neatly. This research aims to create a drivetest application to optimize the installation of the gateway and measure the quality of the sensor signal from the gateway. The application allows technicians to see if a new installation area already has a LoRa gateway, as well as measure parameters such as Received Signal Strength Indicator (RSSI) and Signal-to-Noise Ratio (SNR). The app helps identify the optimal location for the installation of new gateways, ensures efficient network coverage, and avoids unnecessary installation costs. Development methods are used in the creation of these applications, with LoRaWAN parameter data collected through field testing. Data analysis is used to determine the optimal location for the installation of the new gateway, and the application is tested directly by technicians during the drivetest. The result of this study is an Android-based mobile drivetest application that can display color indicators based on the quality of the SNR signal from the sensor in the test area, namely Depok. The sensor can uplink well if the green indicator is 0 – 10 dB, while the sensor cannot uplink according to the time interval with a red indication with a value of < 10 dB. This drivetest application can also generate a report of drivetest results in the form of graphs and CSV files.**

Keywords— Drivetest, Gateway, LoRaWAN, RSSI, Sensors, and SNR.

I. INTRODUCTION

Internet of Things (IoT) is a paradigm that emerged with promising technology and tends to revolutionize the global world, where everyday objects are equipped with an internet connection so that each of these devices can collect and exchange information. The IoT concept has attracted the attention of the research community to ensure wearable devices, environmental sensors, smart appliances, smart phones, smart transportation, and other entities are connected to a common interface with the ability to communicate with each other [1].

In the period between 2015 and projected to 2025, the high growth and popularity of Internet of Things (IoT) is predicted to bring more than 30 billion connected devices around the world, of which a quarter will use technology Low Power Wide Area Network (LPWAN) such as Long Range Wide Area Network (LoRaWAN) [1]. LoRaWAN has been known for its ability to transmit data over long distances with low power consumption, enabling widely distributed device connectivity. However, the main challenge in building this IoT connectivity is to provide services for devices spread over a large geographical area, where some of them can communicate over significant distances exceeding 10 km under conditions Line of Sight (LOS) [1], but also face challenges Non Line of Sight (NLOS) which can affect the range Gateway LoRaWAN. To overcome this, LPWAN technology often relies on star topology to minimize complexity in network construction and maintenance [1].

In addition, IoT adoption also faces significant cost challenges in the construction and operation of communication infrastructure, especially when seeking to develop networks on a smaller scale. Nevertheless, this has prompted markets in developing countries to offer affordable IoT connectivity services. This challenge is a major focus for many organizations and companies that are trying to implement IoT technology, especially in terms of infrastructure development cost efficiency and increased accessibility to IoT connectivity across a wide geographical area [1]. Effective IoT adoption also depends on infrastructur

adequate and efficient communication, especially when it comes to providing connectivity for a large number of devices spread over a large geographical area. These challenges include not only the cost of building and maintaining infrastructure, but also focusing on the reliability of networks that are able to span a large geographical area with minimal power consumption, which is a key factor in the successful implementation of IoT in various environments [1].

*Corresponding author

In this case drivetest carried out by technicians from PT. Telkom Indonesia to detect LoRaWAN coverage on sensor installations in the region coverage area to find out how many gateway and LoRaWAN parameters in each gateway which includes RSSI and SNR values [2]. In doing drivetest technicians have difficulties such as too much to open website in view Gateway that reach in the area such as opening website network server to view mac address gatewayopen website radio access network to see the name Gateway from mac address, and look at Deveui devices carried by technicians on the Antares web platform. In making a report on the results drivetest is still done manually. It can be concluded based on these problems, lack of efficiency in doing drivetest so that it has an impact on network planning which will be done [2]. Network Planning to plan the LoRaWAN network in order to reach the sensors installed in the client such as smart water meter sensors installed in every house. The use of the LoRaWAN network in this smart water meter sensor has many advantages such as two-way communication support, low power, wider range, longer battery life, and the use of unlicensed frequencies making LoRaWAN have low deployment costs compared to other technologies [3]. Therefore, LoRaWAN networks are essential to reach those sensors.

LoRaWAN is a technology that provides a Low Power Wide Area Network (LPWAN) environment from LoRa where low-power devices can transmit data with a license-free modulated radio Chirp spread spectrum and licensed frequencies over very long ranges of up to tens of kilometers. The following is a Figure 1 of Telkom LoRaWAN utilization in Indonesia:

Figure 1. Telkom LoRaWAN Utilization in Indonesia

LoRaWAN networks are implemented in a star-of-star topology, i.e. a point-to-multipoint topology of communication from one point to many points. LoRaWAN networks generally consist of the following elements:

The following is an explanation of the LoRaWAN architecture: (1) End Nodes LoRaWAN can be sensors, actuators, or both. Often they are battery-operated. These end devices connect wirelessly to the LoRaWAN network via gateway using LoRa RF modulation [4]; (2) Gateway, every gateway registered (using configuration settings) to the LoRaWAN network server.Gateway receive LoRa messages from the end device and forward them to the LoRaWAN network server. Gateway Connect to a network server using backhaul such as Cellular (3G/4G/5G), wifi, ethernet, fiber optics, or 2.4 GHz radio links [4]; (3) Network Server Manage gateway, end devices, applications, and users across the LoRaWAN network [4]; (4) Application Server, processes application-specific data messages received from the end device. It also generates all the application layer downlink payloads and sends them to the end devices connected through the network server. A LoRaWAN network can have more than one application server [4]; (5) Join Server, Helps in secure device activation, root key storage, and session key generation. The merge procedure is initiated by the end device by sending a join request message to the join server through the network server. The join server processes the join request message, generates the session key, and transfers NwkSKey and AppSKey to the network server and application server. Merge servers were first introduced with LoRaWAN v1.1 [4]. The LoRaWAN network architecture is illustrated in Fig. 2.

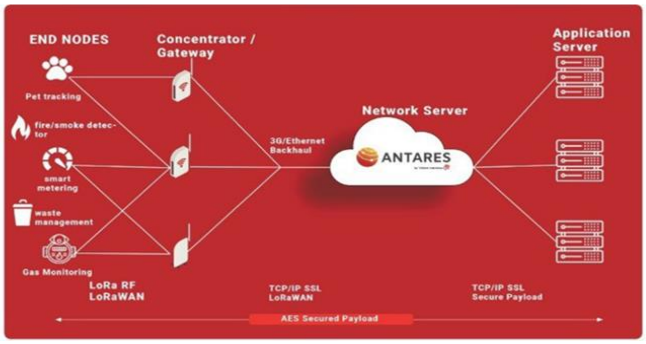


Figure 2. LoRaWAN Architecture

Modulation in LoRa is the process of changing a certain periodic wave so that it becomes a signal that is able to carry information. LoRa uses Chirp Spread Spectrum (CSS) modulation where the essence of processing is to generate sTable frequency values that use sinusoidal frequency signals that increase or decrease over time to encode information [5]. LoRa modulation has several parameters:

1) Received Signal Strength Indicator (RSSI),

The RSSI value is influenced by several parameters, one of which is the distance, the greater the distance between the sender and the receiver, the smaller the signal received. In addition, the environment between the sender and receiver also affects the received signal. Wave propagation in an unobstructed area (LOS) is different from wave propagation in an area with many obstacles, such as trees or buildings around, this will affect the RSSI value because it results in reflection, scattering, and signal deflection.

The minimum RSSI value of a LoRaWAN device is -123 dBm which means that at that value the signal received by the gateway is poor/weak [8]. The following is the calculation formula from RSSI using path loss, as shown in equation (1):

$$PL(d0)[db] = 3,44 + 10n\log f(MHZ) + 10n\log d0(Km) \quad (1)$$

Where, PL(d0) is path loss refrensi at the distance d0 by adjusting to n test environment conditions, namely path loss exponent. The path loss exponent values used in this research are shown in Table I.

TABLE I
PATH LOSS EXPONENT VALUE

Environment	Path Loss Exponent, n
Free space	2
Urban area cellular radio	2,7 – 3,55
Shadowed urban cellular radio	3 – 5
In building LOS	1,6 – 1,8
Obstructed in building	4 – 6
Obstructed in factories	2 – 3

2) Signal To Noise Ratio (SNR)

Race signal-to-noise (SNR) is the comparison between the actual signal level and the noise level. This ratio is usually represented on the scale decibel [1]. The higher the SNR value, the better the quality of the information signal sent. For LoRaWAN technology, the SNR value is between -20 dB and 13 dB where when the SNR value is close to 13 dB, it means that the received signal is not too experienced corrupt. The following is the formula for calculating the SNR value [4].

$$\frac{S}{N} = 10 \log \frac{Signal\ Power}{Noise\ Power} \quad (2)$$

Where Signal Power is the power received by the sensor and Noise power is the noise power that occurs in the field.

In this test, the noise reference power in urban areas is around -90 dBm to -100 dBm, which can be seen in the spectrum as shown in Fig. 3 [8].

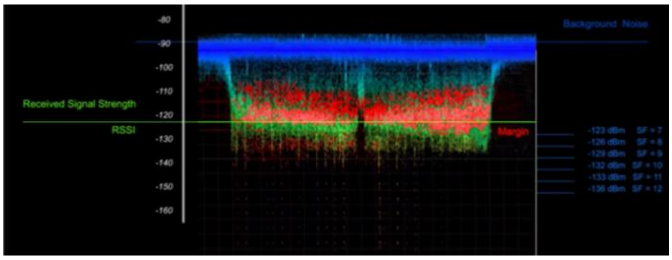


Figure 3. Power Spectrum Of Floor Noise In Urban Areas

At PT. Telkom Indonesia uses a LoRa gateway with the Wirnet brand Istation Kerlink. Wirnet iStation Kerlink is a LoRaWAN gateway that specifically meets the standard requirements of public operators, MVNOs, cable operators, private businesses or public authorities who want to scale their business with IoT and to deploy evolutive and reliable networks, connect large numbers of end devices, and manage millions of two-way messages every day [6]. This gateway uses a signal power of 27 dBm or 400 mw in accordance with LoRaWAN regulations in Indonesia, as shown in Fig. 4.

Figure 4. Kerlink Gateway

In this study, a sensor was used smart water meter to do drivetest. Smart Water Meter is a smart water meter that can transmit real-time water discharge consumption data via the internet and for certain types is able to control water flow (open/close water pipe valves) [7] , as shown in Fig. 5.

In this research to design an application drivetest uses a mysql database because the data used to hold data from network server structured data [8]. In this study, mqtt communication is also used for communication between the server and the Cloud used in the drivetest [9].

In this study, the process drivetest will be made easier to use the application. Apps are built using multiple apps, such as Android Studio for parts frontend and Visual Studio Code for backend [10]. Part backend will generate an API (application programming interface) menu of the application and the API will be deployed to the cloud [11]. To solve the drivetest problem carried out by PT. Telkom Indonesia has designed an android-based mobile drivetest application to make it easier for technicians to perform because the application is equipped with 2 features[12], namely a network test to find out which gateway reaches the sensor equipped with a map display and can see LoRaWAN parameters such as RSSI and SNR [13]. See the distance from the sensor to the gateway so that analysis of these parameters can be carried out including good or bad indications and can make it easier for network planning [14]. For the history menu to be used as a report on the results of the drivetest, this report will be created like a graph of each parameter in the gateway connection with the sensor [15].

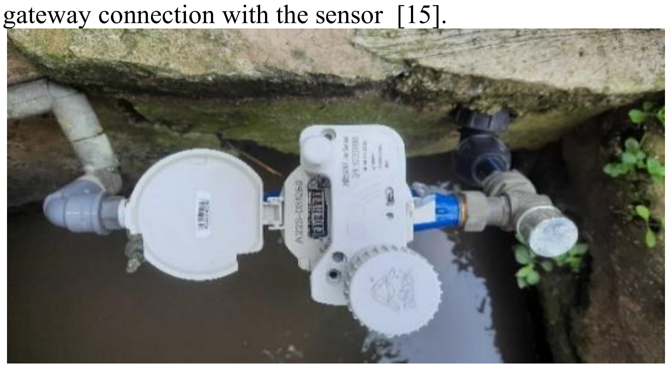


Figure 5. Smart Water Meter

II. METHOD

This research is a development research that focuses on making drivetest applications and collecting numerical data from drivetest results in the field. This research method is designed to identify the optimal location for the installation of new sensors in the JABODETABEK area, according to customer needs. To achieve this goal, the research involves comprehensive development and analysis steps of the new sensor installation site.

The first step is to determine the location of the new sensor installation according to the customer's needs and demands. Once the potential locations are determined, the technicians conduct tests using the mobile drivetest app. The drivetest method is the main approach in data collection, where technicians take the sensor to a predetermined location to conduct the test.

Drivetest allows the identification of LoRaWAN gateways that cover the area. During the test, technicians pay attention to various technical parameters such as Received Signal Strength Indicator (RSSI) and Signal-to-Noise Ratio (SNR). In addition, the technician also measured the distance between the gateway and the sensor under test .

The results of this analysis are a strong foundation for decision-making regarding the determination of the optimal gateway for the installation of new sensors. Taking into account all relevant technical parameters, the study ensures that the selected LoRaWAN infrastructure supports sensor operations with maximum efficiency, improving overall network performance.

A. *Research Stages*

The research stage in the design and development of an android-based LoRaWAN mobile drivetest application for network planning in IoT networks at PT. Telkom Indonesia can be explained as follows:

This research started from the stage of identifying problems that occurred at PT. Telkom Indonesia is in the process of drivetesting the installation of new sensors on the LoRaWAN network, especially related to the limitations of access and proper monitoring of gateways. Technicians have difficulty accessing comprehensive information about the location and details of the gateway such as MAC address and signal coverage, which slows down the identification of the exact gateway. Therefore, improving the efficiency and access of gateway information is the main focus to overcome this problem. The second stage involves studying the literature to understand the concepts, basic principles, and methodology of the LoRaWAN drivetest, as well as evaluating the success of previous methods and any obstacles that may arise [13]. Additionally, the exploration of the latest software, hardware, and technology is important to ensure research is at the cutting edge in LoRaWAN network testing, building a solid foundation before the next stage. The third stage, the planning and design phase of the LoRaWAN drivetest application, involves identifying the key features that engineers need as well as designing test steps. With careful planning and design, it is hoped that an efficient and relevant drivetest application can solve the technician's problems in installing new sensors in the LoRaWAN network. The fourth stage, namely the drivetest application development stage, begins with the creation of an Android-based application prototype that meets the needs of technicians. Once the prototype is complete, an initial test run is carried out to ensure the basic functionality is working well before being widely used in field testing. The fifth stage, the application implementation stage, involves the application of drivetest applications in the field by technicians at various locations where new sensors are installed, followed by the collection of parameter data such as RSSI, SNR, and LoRaWAN signal strength at each point. The final stage is data analysis and evaluation, where data from drivetest tests is analyzed to understand the performance and scope of the LoRaWAN gateway. The results of this analysis will determine the optimal gateway for the installation of new sensors and become the basis for IoT network planning, ensuring that the recommendations provided are accurate.

B. *System Planning*

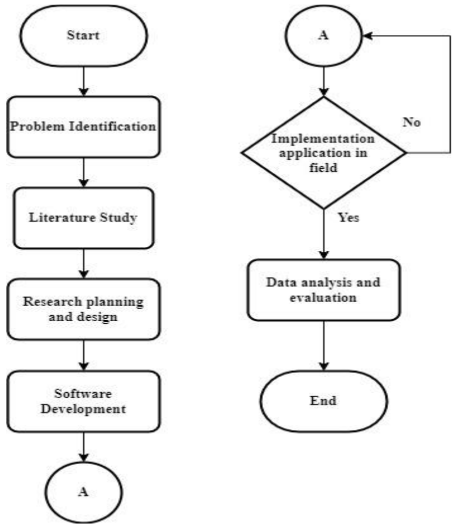


Figure 6. Research Stages

In Figure 6, the design of this system, it is divided into 2 sub-chapters, namely application design and database design.

1) *Application Design*

Drivetest app diagram blocks illustrate how the app works from backend to frontend. On the backend, data is retrieved from the LoRaWAN network server and the Antares web platform via APIs for gateway data and MQTT for real-time sensor data, and then stored in a MySQL database. The frontend implements the APIs that have been generated by the backend. In Figure 7 is a block diagram from the drivetest application:

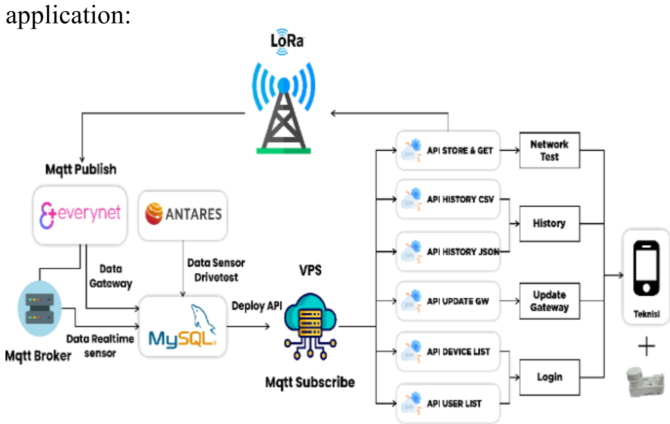


Figure 7. Diagram Block

In application design, a flowchart or flowchart is made that presents the algorithm or sequential instruction steps in the application. Follow the flowchart from the drivetest application:

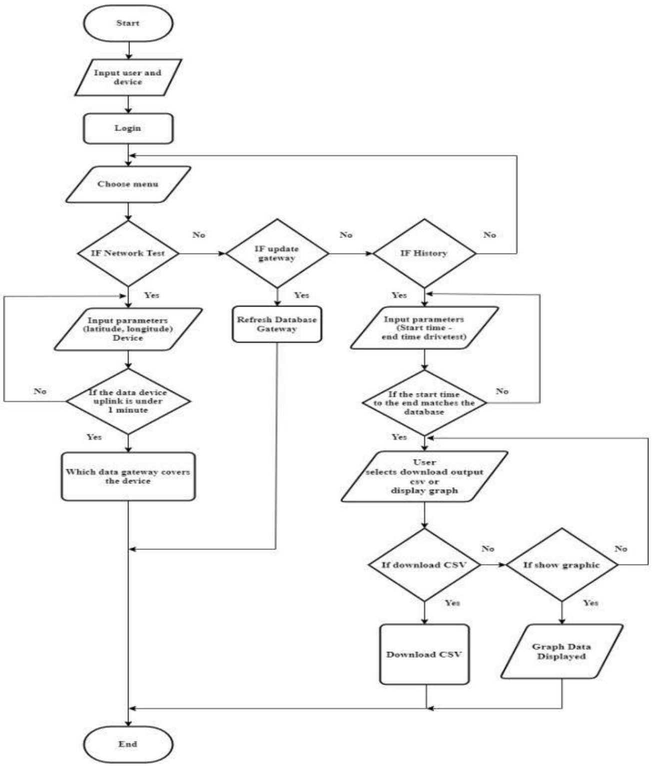


Figure 8. Application Flowchart

The flowchart of the drivetest application is shown in Fig. 8. The flowchart of the drivetest application, starting from login, after that enters the main menu consists of 3 menu network test, update gateway, and history. In the network test, enter the device location data based on the technician's cellphone, then if the device data is not updated for 1 minute, the process is not carried out, if the update is for 1 minute, the process will be carried out and the gateway data that reaches the sensor will be displayed. The gateway update feature is used to refresh the database of the newly installed gateway. The history feature, entering the start time of the drivetest and the end time of the drivetest to display historical data carried out by technicians in the form of .csv and graphic formats.

2) Database Design

The database design in this study is modeled in the form of Entitiy Relation Diagram (ERD). ERD is a modeling to explain between data in a data base based on basic data objects that have relationships between. Figure 9 is the diagram design of the mysql database.

The database in the drivetest application uses mysql, which is a relational database that uses a Table form consisting of rows and columns. There are several Tables in the mysql database of the drivetest application which are tb_user, tb_gateway, tb_data_gateway, tb_data_device, and tb_data_log.

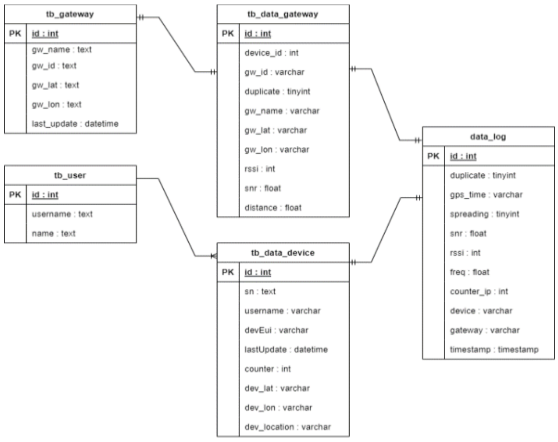


Figure 9. Entity Relationship Diagram

These Tables have relationships with each other, starting from tb_user to input user names, then user names are inputted into tb_data_device to obtain data on user names that use applications. This tb_data_device is to accommodate device data information consisting of serialnumber, devEui, longitude, and latitude from the device location. The data is then input into the data_log to read the device used by the driver test. In tb_gateway to accommodate data from the LoRaWAN server' s network API, then the data is connected to tb_data_gateway, namely the database to accommodate parameter data such as RSSI, SNR, and distance from the gateway to the sensor. Then the database is connected to the data_log to get real-time data from the sensor to get the network/can be uplinked from any gateway.

C. Application Implementation

In the application implementation section, it explains the API that will be used for the drivetest application. The backend uses the golang language to generate several APIs such as listdevice, listuser, historycsv, historyjson, networktest, and update gateway. From the results, the API is deployed to the cloud and the frontend uses the API to display the output. In Figures 10 is the application of the API to the get and post methods.

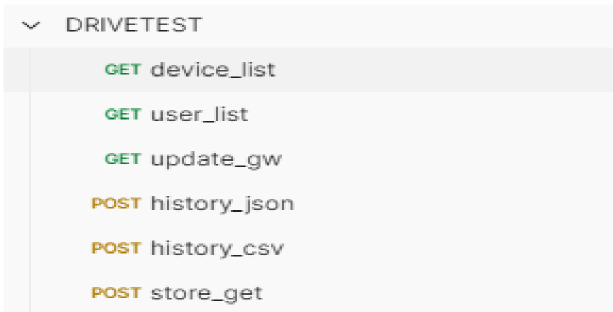


Figure 10. Drivetest Application API Display

III. RESULTS AND DISCUSSION

This chapter discusses the results of building and testing drivetest applications which includes testing the functionality of features in the application. The results of this study have 3 parts, namely frontend (application display), backend (API), and sensor uplink data.

A. Application View (frontend)

In the android-based drivetest application, it consists of a splashscreen page, login, main menu, network test, network test output, maps, input history, and output history. The following is the appearance of the application that has been designed.

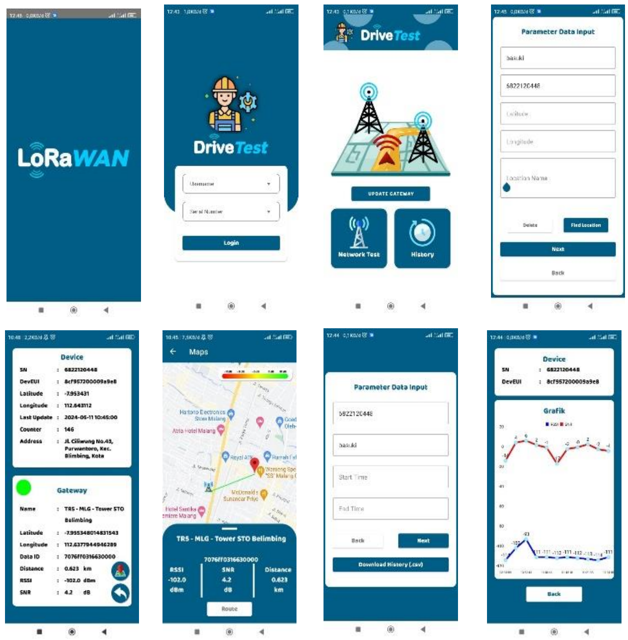


Figure 11. Drivetest Application Display

In Figure 11 is the display of the drivetest application consisting of a splashscreen page, a login page to get device and user data, a menu page displaying 3 buttons, namely update gateway, network test, and history, a network test data input page that enters longitude and latitude data from the sensor, a drivetest output page in the form of a list gateway, a drivetest output page in the form of maps, a history input page that enters start and end time data, and lastly, the output history page is in the form of a graph.

B. Drivetest App API Documentation

In this sub-chapter, we will explain some of the APIs that have been generated. Is the API:

1. http://localhost:8080/device/listdevice
   This API uses METHOD GET to get device data from the web platform antares in the application drivetest.
2. http://localhost:8080/user/listuser
   This API uses METHOD GET to get user list data from a mysql database.
3. http://localhost:8080/updategateway
   This API uses the GET METHOD to refresh the mysql database connected to the LoRa network server to get the gateway data.
4. http://localhost:8080/history/json
   This API uses METHOD POST to display the output results of the drivetest in json format.
5. http://localhost:8080/history/csv
   This API uses METHOD POST to display the output data of the drivetest results using the csv file format. The input form is the same as the endpoint.
6. http://localhost:8080/store/data
   This API uses METHOD POST to display the data from the drivetest, which is a list of gateways that cover the sensor used by the drivetest.

C. Data Sensor Uplink

In this sub-chapter, sensor data is generated in the interes database using the LoRa network. The sensor must be conFigured first. In this study, a smart water meter sensor was used to perform a drivtetest. The following is the configuration of the smart water meter sensor using an infrared cable. In Figure 12, how to join the LoRaWAN network using OTAA activation, then the antara database will be uplink.

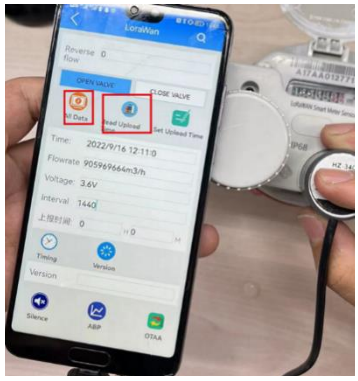


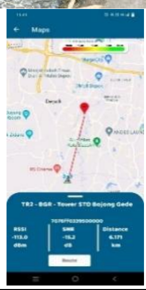
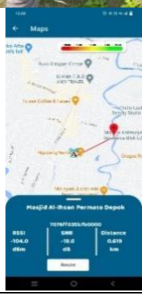
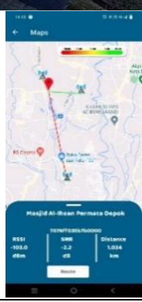
Figure 12. Sensor Configuration

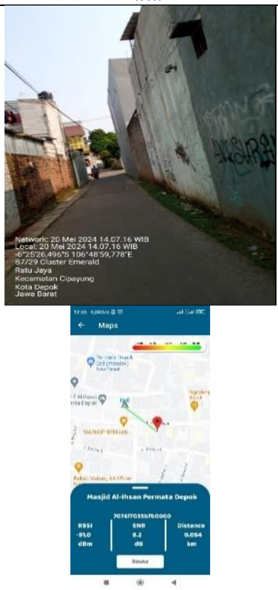
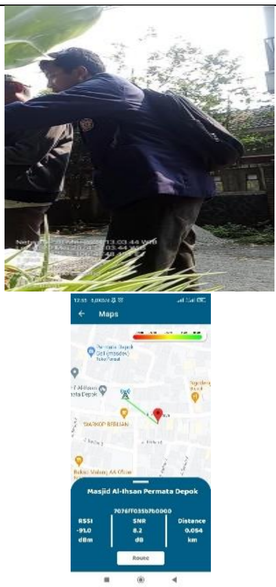
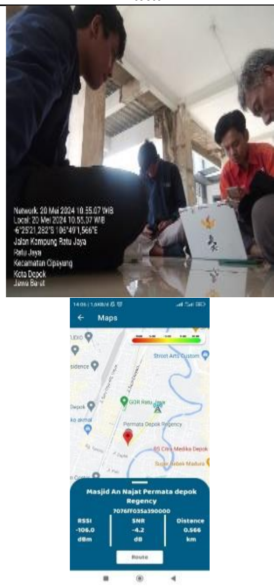
D. Data Discussion

This chapter will explain the results of the data obtained from the testing of the drivetest application. The drivetest application test was carried out by technicians in the Depok area because the integrated smart water meter sensor was installed in the area. In this test, it is carried out in several different environmental conditions such as in LOS and Non-LOS areas so that the SNR values obtained are different and can be seen in the application regarding the color indication of the signal quality including good, medium, or bad indicators. The following are the results of the discussion from the drivetest application testing. The results of the drivetest application testing are summarized in Table II.

TABLE II
DRIVETEST RESULT

NO	Data	Discussion
1		In the data, in addition to conducting a drivetest in the Depok area to survey the place of new installation of the sensor. From the results of the drivetest, the technician triggered the sensor, and the sensor was covered by 1 gateway with a distance of 0.979 km from the sensor, namely the gateway installed at the An Najat Permata Mosque

NO	Data	Discussion
		Depok Regency with an SNR value of -4.2 dB marked with a yellow line which means that the SNR obtained is at a normal indication, which is around 0 to -5
2	 	In the data next to the technician conducting a quality test of the sensors that have been installed on the customer's house, because he received a report, that in the area there are several sensors that are not uplinked. From the results of the drivetest, the technician triggered the sensor, and the sensor was covered by 1 gateway with a distance of 0.978 km from the sensor, namely the gateway installed at the An Najat Permata Mosque Depok Regency with an SNR value of -6.8 dB marked with a red line which means that the SNR obtained is in a bad indication, which is around -5dB to 10 dB.
3	 	In the next data, the technician conducted a test in the area to be newly installed. The sensor is placed because the water meter on the customer is at the bottom. From the results of the drivetest, the technician triggered the sensor, and the sensor was covered by 1 gateway with a distance of 0.978 km from the sensor, namely the gateway installed at the An Najat Permata Mosque Depok Regency with an SNR value of -6.8 dB marked with a red line which means that the SNR obtained is in a bad indication, which is around -5dB to 10 dB.
4	 	In the data next to it is an area where a drivetest is carried out to install a new sensor. In this data, the sensor is covered by 3 gateways, namely the Bojong Gede STO Tower which is the farthest away from the red indication, the Al Ihsan Permata Depok Mosque with a red indication even though it is close, and the An-Najat Permata Depok Regency mosque with a red indication even though it is close. From this data, this area is an area with many obstacles, so the gateway must be moved so that the sensor is well covered.
5	 	In the data, in addition to conducting a drivetest in the Depok area to survey the place of new installation of the sensor. From the results of the drivetest, the technician triggered the sensor, and the sensor was covered by 1 gateway with a distance of 0.619 km from the sensor, namely the gateway installed at the Al-Ihsan Permata Mosque in Depok with an SNR value of -18 dB marked with a red line which means that the SNR obtained is a very bad indication, which is more than -10 dB in the sense that the sensor is difficult to uplink to the gateway.
6	 	In the data next to the technician triggering the sensor in the Depok area where the new sensor will be installed. In the data obtained, the sensor is covered by 3 gateways, 2 gateways with red indications and 1 gateway with green indications. In the sense that it is safe to install sensors because there is 1 gateway that covers well, and it is better that the 2 gateways are relocated so that there are 2 gateways that cover the sensor.

NO	Data	Discussion
7		In the data next to it is an area where a drivetest is carried out to install a new sensor. In the data, an SNR value of 8.2 dB was obtained with a green indication which means that the area is well reached by the gateway with a good value indication, namely a value range of 0 – 10. The sensor data is covered by 1 gateway, namely the Al-Ihsan Permata Mosque in Depok.
8		In the data, the technician conducted a sensor signal quality test because there were several sensors that did not uplink because in the Figure there were 3 gateways that covered but with a red indication in the sense that the sensor could not be uplinked at the specified interval. From the gateway of the An Najat Permata Mosque Depok Regency, an SNR value of -13.8 was obtained, including a red indication because it was in a very bad value range, which was more than -10 dB.
9		In the next data, technicians conducted a signal quality test in the area. From the results of the drivetest, an SNR value of 6.2 dB was obtained from 1 gateway, namely the Al-Ihsan Permata Mosque in Depok with a green indication which means the value is in a good value range, namely 0 – 10 dB.
10		In this data, technicians are analyzing the signal obtained from the gateway of the An-Najat Permata Mosque Depok Regency with an SNR value of -4.2 dB with a yellow indication which is in the normal value range of 0 - -5 dB. In this case, the sensor can still uplink normally according to the specified interval, which is 1 day to send the uplink to the database.

In the data discussion, the drivetest was carried out by technicians in two stages, namely before and after. The previous stage is to survey the place where the new sensor will be installed to ensure the existence of the LoRa network. The next stage is to measure the quality of the sensor signal to ensure its suitability for uplink to the gateway. From the discussion of the drivetest data, in the test area, namely the Depok area, there are several areas that get a gateway signal but with a red indication, namely a bad and very bad indication with a value range of -5 to -10 dB and more than -10 dB, in the sense that there are several areas that must be relocated to install a gateway or add a new gateway, then there are also areas that have sensors installed but experience interference because the signal from the sensor does not reach the gateway. In this disturbance, the gateway is not high enough to be installed so that the signal is closed to the obstacle, namely the mosque dome. This must be raised back about 2 meters from the previous installation so that the sensor can be uplinked according to the predetermined interval.

IV. CONCLUSION

Technicians can see the gateway that covers the sensor by taking advantage of the Network Test application feature by triggering the sensor first to uplink to the Antares database. Then, the sensor data is entered into the MySQL database as log data to provide information about the gateway that covers the sensor. In the application section, the Network Test API is used to display the gateway that covers the sensor. Technicians can also see LoRaWAN parameters such as RSSI and SNR from the output network test results, where there are several RSSI and SNR values obtained from several gateways that cover sensors. The display also includes a color indication to determine the signal quality from the sensor in good, medium, or poor conditions based on the SNR value obtained. In addition, technicians can measure the distance between the sensor and the gateway by utilizing the network test feature that applies the haversine formula to obtain the distance from the location point of the sensor and the gateway. The distance is displayed on the network test output of multiple gateways in km. Technicians can also obtain data from drivetest results by utilizing the application history feature. To use this feature, technicians enter the start and end time data that they want to report. In this feature, technicians can view historical data in the form of graphs of SNR and RSSI values, then it can also be used as a report in CSV format.

REFERENCES

[1] R. Apriantoro, A. Suharjono, K. Kurnianingsih, and I. K. A. Enriko, “Investigation of Coverage and Signal Quality of LoRaWAN Network in Urban Area,” CENIM 2020 - Proceeding Int. Conf. Comput. Eng. Network, Intell. Multimed. 2020Pp. 326-331, 2020, doi: 10.1109/CENIM51130.2020.9297982.

[2] T. L. Digital, "Driving the business revolution with Telkom's IoT solution, Antares." Accessed: Nov. 26, 2023. [Online]. Available: https://leap.digitalbisa.id/article/how-to-boost-business-revolution-with-telkoms-iot-solutions-antares

[3] A. Yusri and M. I. Nashiruddin, “LORAWAN Internet of Things Network Planning for Smart Metering Services,” 2020 8th Int. Conf. Inf. Commun. Technol. ICoICT 2020, pp. 18–23, 2020, doi: 10.1109/ICoICT49345.2020.9166455.

[4] The Things Network, “LoraWAN.” Accessed: Nov. 26, 2023. [Online]. Available: https://www.thethingsnetwork.org/docs/lorawan/regional-parameters/

[5] N. Hanafi, A. W. Yulianto, and A. E. Rakhmania, “Implementation of Wireless Sensor Network on Smart Trash Bins Using LoRa With AES128 Algorithm (Case Study : Mentari Waste Bank Panceng Gresik),” vol. 14, no. 1, pp. 92–101, 2024.

[6] Kerlink.com, “Wirnet Istation Gateway Oudoor,” 2023. [Online]. Available: https://www.kerlink.com/iot-solutions/iot-gateways/wirnet-outdoor-lorawan-gateways/

[7] mokolora, "A full understanding of LoRa and LoRaWAN," August 17, 2021. Accessed: Nov. 26, 2023. [Online]. Available: https://www.mokolora.com/id/full-understanding-of-lora-and-lorawan/

[8] DQLAB, "Learning the Basic Theory of MySQL with DQLab," January 05, 2023. Accessed: Nov. 25, 2023. [Online]. Available: https://dqlab.id/belajar-teori-dasar-mysql-bersama-dqlab

[9] A. D. Djayali, Muhammad Muzammil, and Abjan Samad, "Implementation of Online Meeting Applications on Virtual Private Servers during the Pandemic," Simcom, vol. 6, no. 1, pp. 23–33, 2021, doi:10.51717/simkom.v6i1.52.

[10] “Bab 2, Tinjauan Pustaka API,” p. 9, [Online]. Available: http://library.binus.ac.id/eColls/eThesisdoc/Bab2/2013-1-00621-IF Bab2001.pdf

[11] I. G. Made, Y. Priyandana, A. Saputra, and P. K. Sudiarta, "Analysis Of Drive Test Results Using G-Net And Nemo Software In The Lte Network In The Denpasar Area," vol. 5, no. 2, pp. 216–223, 2018.

[12] A. Yanziah, S. Soim, and M. M. Rose, "Analysis of Lora's Range Distance with Rssi and Packet Loss Parameters in Urban Areas," J. Teknol. Technoscientia, vol. 13, no. 1, pp. 27–34, 2020.

[13] A. Osorio and M. Calle, “PLANNING LORAWAN NETWORKS INCLUDING NON-LINE-OF-SIGHT CONDITIONS,” 2020 Ieee Andescon, Andescon 2020, pp. 2–6, 2020, doi: 10.1109/ANDESCON50619.2020.9272159.

[14] D. Gutama, M. Junus, and P. E. Mas'udia, "Lecturer Attendance in Teaching and Learning Activities Using QR Codes in the AH Building of the JTD State Polytechnic of Malang," J. Jartel J. Jar. Telekomun., vol. 11, no. 2, pp. 107–111, 2021, doi: 10.33795/jartel.v11i2.76.

[15] J. Dipati, U. No, K. Bandung, and J. Barat, "KOMPUTA: Scientific Journal of Computer and Informatics Registration System For Task Warrants (Cst) At The Public Works Office, Spatial Planning And Computing: Journal of Computer Science and Informatics," vol. 10, no. 2, pp. 70–77, 2021.