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LORAWAN GATEWAY PLANNING USING AS923-2 FREQUENCY IN TASIKMALAYA FOR MONITORING ODC

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Abstract

This study aims to design a LoRaWAN network and find out how many gateways are needed to cover the research area and to design an IoT-based monitoring system for ODC devices on the FTTH network based on data at PT. Telkom Witel Tasikmalaya. The method used is a simulation using Atoll software version 3.40 and several calculation stages to predict the parameters of RSSI (Received Signal Strength Indicator) and SINR (Signal to Interference Noise Ratio) in a planning area of 358.66 km2. This study using AS923 frequency with a bandwidth of 125 kHz and a Spreading factor of 10. The results obtained are signal strength (RSSI) and signal quality (SINR) parameters. Based on the results of calculations and planning simulations, it produces 20 gateways using SF 10 with an RSSI parameter of -69.53 dBm and a SINR parameter of 20.21 dBm, each gateway can cover 4-5 km2 in the planning area.

Keywords: *Gateway, LoRaWAN, ODC, Planning.*

1. INTRODUCTION

In the current era of technological development, there are many common problems among the public, especially in big cities in Indonesia [1]. Network modernization continues to be carried out to increase bandwidth capacity in order to obtain increased multimedia video, voice and data services. The need for internet access with high broadband speed can be provided by fiber optic networks which also have many other advantages, making fiber optic networks currently have many enthusiasts. Fiber optic is an ideal transmission medium with little transmission loss, low interference and high bandwidth potential [2].

One of the communication technologies by utilizing fiber optics is Fiber to the Home (FTTH). FTTH is the construction of fiber optic network infrastructure to customers [3]. One of the devices on the FTTH network is the Optical Distribution Cabinet (ODC) which is a box-shaped room that functions as a place for the installation of optical network connections and terminations between feeder cables and distribution cables. Inside the Optical Distribution Cabinet (ODC) there are connectors, joints, and splitters [4].

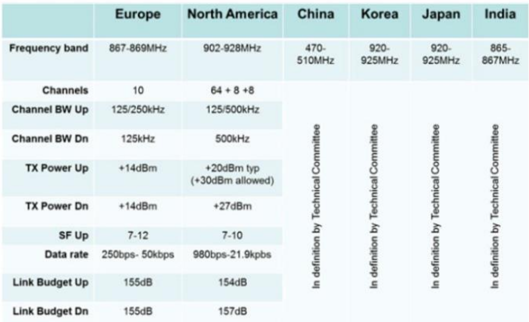
Now in the era of globalization, the internet will synergize with electronic devices to help human activities. This is called the Internet of Things (IoT) [5]. IoT is a technology where all the activities of the actors interact with each other via the internet. Applications to IoT can assist in identification, discovery, tracking, object monitoring and automatic and real time event triggers [6].

LoRaWAN which stands for Long Range Wide Area Network is a Low Power Wide Area Network (LPWAN) technology built on top of LoRa modulation. This technology allows a large number of devices to communicate wirelessly over long distances (in the order of 5-15 km, depending on the propagation environment) at low data rates. [7].

LoRaWAN is a communication protocol and system architecture for LoRa physical layer temporary networks that enable remote communication coverage. LoRa can send small data packets with a throughput of 0.3 kbps – 5.5 kbps over a considerable distance [8]. Throughput is the speed of data transfer which is measured in bps. Throughput see of the total length of packets successfully received during a certain time interval [9].

LoRa has a unique modulation format acquired by Semtech with Chirp Spread Spectrum (CSS) modulation with the option to add different Spreading Factors and bandwidths to optimize the modulation to meet the range and data requirements so that it can cover a wide area [10]. The data signal carrying data from the end device to the gateway is chipped off at higher data rates and modulated to the chirp carrier signal. LoRa modulation also includes a variable error correction scheme that increase the robustness of the transmitted signal. For every four bits information sent, the fifth bit of parity information is sent [11]

LoRaWAN frequency specifications differ from region/country to region/country. This depends on the spectrum allocation and the policies of each country. Globally, LoRaWAN frequency allocation is shown in the following figure [12].



	Europe	North America	China	Korea	Japan	India
Frequency band	867-869MHz	902-928MHz	470-510MHz	920-925MHz	920-925MHz	865-867MHz
Channels	10	64 + 8 +8	In definition by Technical Committee	In definition by Technical Committee	In definition by Technical Committee	In definition by Technical Committee
Channel BW Up	125/250kHz	125/500kHz				
Channel BW Dn	125kHz	500kHz				
TX Power Up	+14dBm	+20dBm typ (+30dBm allowed)				
TX Power Dn	+14dBm	+27dBm				
SF Up	7-12	7-10				
Data rate	250bps- 50kbps	980bps-21.9kpbs				
Link Budget Up	155dB	154dB				
Link Budget Dn	155dB	157dB				

Figure 1. LoRaWAN Frequency Allocation [12]

For the Asian region, the frequency allocation is set in the 923 MHz range with the AS923 allocation code. AS923 is classified as symmetric band where the frequency for the downlink is the same as the uplink plus the extra receive window (RX2). There are at least 8 communication channels provided with an average working in the range of 923–925 MHz [12].

Table 1 shows the LoRa received signal strength index (RSSI) standard, where practically the range of -90 to -110 dBm is acceptable.

Table 1. RSSI Signal Level [13]

RSSI (dBm)	Information
-30 s/d -60	Very strong. Transmitter and receiver distance is very close
-60 s/d -90.	Very good. Close coverage
-90 s/d -105	Good. There are some data that are not accepted.
-105 s/d -115	Bad. Can accept but often drop-out
-115 s/d -120	Very bad. Weak signal data is often lost

LoRa range is greatly affected by area conditions. Urban, suburban and rural areas have different LoRa ranges, so this also affects the Received Signal Strength Indicator (RSSI) [14].

This Research aims to monitor ODC devices in the PT. Telkom WITEL Tasikmalaya and to maximize its implementation, it is necessary to design a LoRaWAN network to find out how many gateways are needed to cover all ODCs in the research area as a means of communication between sensors and servers in the process of sending data [15]. This design uses Atoll software version 3.4.0 and several calculation stages to predict RSSI and SINR based on parameters such as frequency, bandwidth, and spreading factor.

2. RESEARCH METHOD

The method used in this study is a simulation using Atoll software version 3.4.0 to design coverage in analyzing the comparison of the parameters Spreading factor, SNR, RSSI, and the number of gateways. Before carrying out the simulation, data such as the size of the research area, link budget, and calculations are needed.

2.1. Flowchart and Research Areas

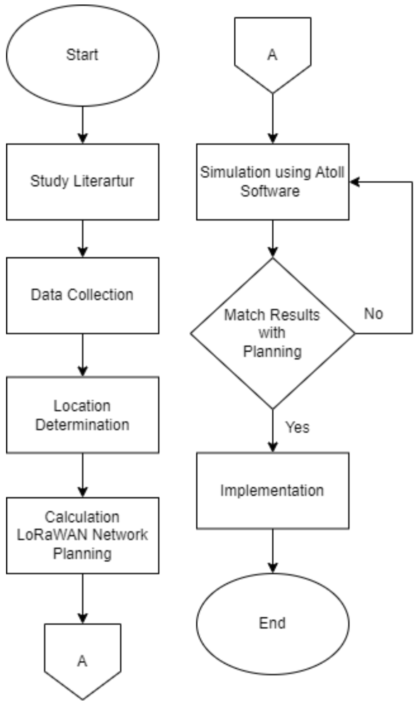


Figure 2. Flowchart LoRaWAN Network Planning

Flowchart is to provide an overview of the workflow or process. Process illustrated through a chart or symbol so that the information presented is easier to understand. This flowchart illustrates how the system process is offered.

Figure 3. Research Areas

Figure 3 is a research area to cover all ODC at Witel Tsikmalaya. The total area of this research area is 358.66 km^2

2.2. LoRaWAN Network Planning

To carry out the planning of the Lorawan network, a link budget and calculations are needed to find out the total gateways needed to cover all planning area is 358.66 km^2.

Table 2. Link Budget LoRa [16]

Parameter	UL	DL
Tx Power (dBm)	15	20
Tx Cable loss (dB)	-1	-3
T x Antenna Gain (dBi)	0	9
Tx Antenna Height (m)	30	
RX Antenna gain diversity (dBi)	10	0
Rx Antenna Height (m)	1,5	
Frequency (MHz)	920	
Bandwidth (kHz)	125	

The link budget calculation is needed to calculate the lost signal power between the gateway and the end device to get the maximum coverage area on the site [17].

LoRa sensitivity calculation is based on Spreading Factor and SNR, where the sensitivity calculation is as follows:

Table 3. LoRaWAN sensitivity

Sensitivity (dBm)					
SF 7	SF 8	SF 9	SF 10	SF 11	SF 12
-125	-127	-130	-132	-135	-137

$$Sensitivity = -174 + 10\,log(BW) + NF + (-\,SNR\ limit) \quad (1)$$

The value of the Noise Figure used in LoRaWAN technology is 6 dB [18].

MAPL is required to find out the highest value of attenuation allowed between the LoRa gateway and the end device [19]. The EIRP and MAPL calculation formulas are as follows:

$$EIRP = Tx\ Power + Gain\ Antenna\ Tx - Loss\ Cable \quad (2)$$

$$MAPL = EIRP - Sensitivity \quad (3)$$

Table 4. EIRP Value

EIRP	*Device*	Value (dBm)
EIRP Downlink	Gateway	26
EIRP Uplink	End Device	14

Table 5. MAPL Value

Spreading Factor	MAPL Downlink (dBm)
7	151,00
8	153,00
9	156,00
10	158,00
11	161,00
12	163,00

The calculation of the cell radius is used to calculate the coverage area or coverage in one site. In the propagation model used in planning the LoRaWAN network with a frequency band of 920 MHz is the Okkumura Hatta model. Using the MAPL value, you can find the LoRaWAN network radius cell value [20]. The equation used to calculate the pathloss is as follows:

$$PL = 69.55 + 6.16log(f) - 13.82log\,hb - a(hm) + 44.9 - 6.55loghb)\ log10\,d \quad (4)$$

$$a\,(hm) = (1.1\,log10(f) - 0.7)h - (1.56\,log10(f) - 0.8) \quad (5)$$

Table 6. Cell Radius

Spreading Factor	a(hm)	Cell Radius (km)
7	0,0167	4,91148
8		5,5975
9		6,8102
10		7,7603
11		9,4325
12		10,7499

After the cell radius calculation is obtained, the next step is to calculate the cell area that can be covered by one LoRa gateway site.Calculating the Number of Gateway [21]. The equation used to calculate the cell area is as follows:

$$LCell = \frac{3\sqrt{3d^2}}{2} \quad (6)$$

Table 7. Cell Area

Spreading Factor	Cell Area (km^2)
7	12,76040826
8	14,54262009
9	17,69333875
10	20,16192356
11	24,50641348
12	27,9291582

The formula for calculating the number of gateways is as follows:

$$Number\ of\ Gateways = \frac{Research\ Area}{Cell\ Area} \quad (7)$$

Table 8. Number of Gateway

Spreading Factor	Number of Gateway
7	28
8	25
9	20
10	18
11	15
12	13

3. RESULTS AND DISCUSSION

Planning this research using Atoll 3.4.0 software using SF 10 with a downlink scheme. Based on the calculation results, to cover all ODCs in Witel Tasikmalaya as many as 9 ODCs, using SF 10 requires 20 LoRa Gateways.

The analysis of this research uses 2 parameters, namely RSSI (Received Signal Strength Indicator) and SINR (Signal to Interference Noise Ratio). RSSI is a parameter used to measure the received signal strength indicator, while SINR is the ratio of the signal strength ratio between the main signal that is emitted and the interference compared to the background noise that arises.

Figure 4. ODC location

3.1. Received Signal Strength Indicator

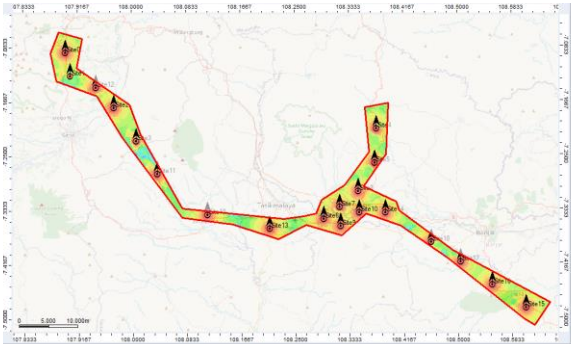


Figure 5. RSSI Prediction Result

Figure 5 shows the placement of the gateway and the simulations performed on the RSSI parameters. From the signal level prediction, the number of gateways used using SF 10 is 9. each gateway can cover 4-5 km2 in the planning area**.** With this prediction, the RSSI histogram value can be seen.

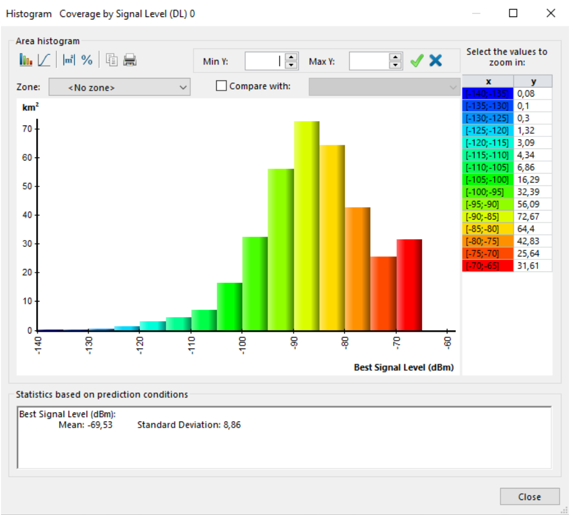


Figure 6. Histogram of RSSI

Figure 6 shows the values on the x-axis to indicate the signal strength are generated and on the y-axis to show the distance in square kilometers. The resulting RSSI is -69.53 dBm with a standard deviation of 8.86 dBm which means it is included in the good category.

3.2. Signal to Interference Noise Ratio

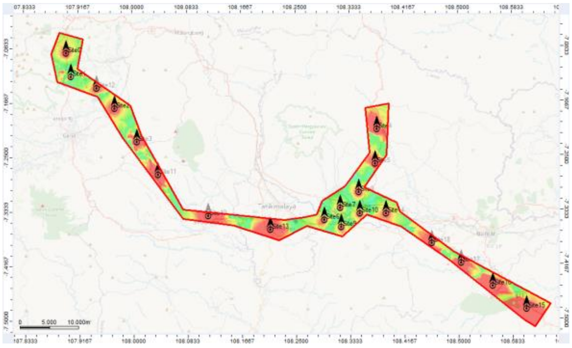


Figure 7. SINR Prediction Result

Figure 7 shows the placement of the gateway and the simulations performed on the SINR parameters. From the signal level prediction, the number of gateways used using SF 10 is 9. each gateway can cover 4-5 km2 in the planning area**.** With this prediction, the SINR histogram value can be seen.

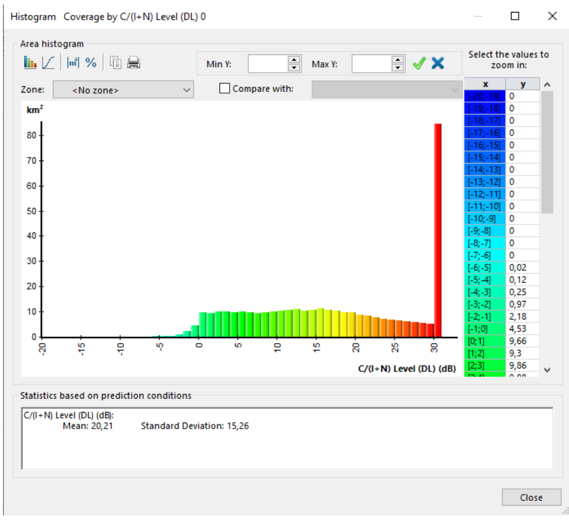


Figure 8. Histogram of SINR

Figure 8 the values on the x-axis to indicate the signal strength are generated and on the y-axis to show the distance in square kilometers. The resulting SINR is 20.21 dBm with a standard deviation of 15.26 dBm which means it is included in the good category.

4. DISCUSSION

Research in 2021 with the title "LoRaWAN Network Planning At Frequency 920-923 MHz for Electric Smart Meter: Study Case in Indonesia Industrial Estate" discusses the design of the LoRaWAN network for smart meters in the Karawang Industrial Area to measure and monitor electricity usage. This study aims to obtain the number of gateways needed to optimize gateway coverage for sending electrical monitoring data to the Karawang Estate Industry [16].

The difference between this research and previous research is that it is contained in the data used as an object for monitoring devices on the FTTH network, namely the ODC owned by PT Telkom Witel Tasikmalaya. The research area and the number of gateways used are different, the ODC locations are scattered in several places outside the city limits of Tasikmalaya but are still under the ownership of Witel Tasikmalaya.

The problem in this research is that errors often occur in the software, so it takes several simulations.

5. CONCLUSION

Based on the simulation results of the LoRaWan network design using AS923 frequency for ODC monitoring of PT. Telkom Witel Tasikmalaya with 9 ODCs with a planning area of 358.66 km2, meaning that LoRaWAN planning needs to use 20 LoRa gateways for the downlink scheme using a spread factor of 10. each gateway can cover 4-5 km2 in the planning area**.** With an average of -69.53 dBm for the RSSI parameter and an average of 20.21 dBm for the SINR parameter, this shows that the simulation results can be categorized as good. The use of Spreading Factor 10 is due to the fact that there are not too many gateways so that it can save on planning costs and also the results obtained are in good condition.

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