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Research Paper

The Influence of Physical Tuning Technology VoLTE

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A B S T R A C T

The Long-Term Evolution (LTE) technology is currently evolving in the cellular communication system. Currently, LTE technology is only used for faster internet data activities. Unfortunately, phone calls still rely on second-generation (2G) or third-generation (3G) networks. To improve the quality of voice calls, one of the ways is through the utilization of Voice Over LTE (VoLTE) technology. The reason for using VoLTE in fourth-generation (4G) networks includes the voice quality based on Internet Protocol (IP). This study analyzes the performance of VoLTE technology networks. Based on the data collected, the Reference Signal Received Power (RSRP) with a percentage of 37.73% falls into the Good category, Signal to Interference Noise Ratio (SINR) with a percentage of 55.32% falls into the Fair category, and Throughput with a percentage of 66.16% falls into the Poor category. In terms of delay, it has a score of 4, categorized as very good, jitter has a score of 3, categorized as good, and packet loss has a score of 4, categorized as very good. The optimization results using physical tuning show that the Reference Signal Received Power (RSRP) falls into the Good category with a percentage of 52.8%, Signal to Interference Noise Ratio (SINR) falls into the Good category with a percentage of 70%, and Throughput falls into the Very Good category with a percentage of 64.50%.

INTRODUCTION

The South Padang area is a district located in the city of Padang, with a latitude of 00°58'04" South and an east longitude of 100°21'11". This area is one of the regions frequently visited by foreign tourists. South Padang is a place with numerous tourist attractions, including Pantai Air Manis, Jembatan Siti Nurbaya, Batu Malin Kundang, Puncak Bukit Gado-gado, and Kelok View Teluk Bayur. The high level of activity in the vicinity of these tourist spots naturally leads to increased traffic, necessitating a good network and stable mobile communication services. Based on data from the Central Statistics Agency in 2022, the South Padang District is one of the areas with a relatively large population

Mobile telecommunications have experienced rapid development in recent times, evident in the increasing number of subscribers. In terms of mobile phone subscriber growth, it has shown significant progress compared to other industries. Good quality service must also keep pace with customer development. Telecommunications technology is advancing rapidly, and we are now in the era of 5G networks. In Indonesia, there is talk of discontinuing 3G networks, but compared to the older 2G networks, which are still needed by the community, especially for voice calls, 3G is still relevant. Additionally, the growth of 5G technology is not yet widespread, as 4G networks are still widely used, and 2G networks are used for voice calls, with 4G serving as an alternative network.

VoLTE on IP-based LTE networks, the implementation of VoLTE to support voice services over LTE networks relies entirely on the IP Multimedia Subsystem (IMS). IMS offers voice services with several additional features such as authentication, authorization server, call control, routing, interconnection with the Public Switched Telephone Network (PSTN), billing, and more. The VoLTE solution offered is not supported by the Evolved Packet Core (EPC), so the EPC cannot process voice calls without the presence of IMS in the LTE network [1],[2].

The network performance degradation has prompted the author to conduct research on improving network performance by implementing Physical Tuning, New Site, Soft Frequency Reuse (SFR), and bandwidth expansion. If left unaddressed, this can lead to the emergence of signal dead zones (bad spots) or a decline in network quality. The growth of LTE technology aligns with the increasing number of users year by year. Therefore, the increase in the number of users must be accompanied by improvements in the existing mobile network infrastructure. These improvement efforts are crucial to maintain optimal network quality. Service degradation is often caused by weak signals in a certain area and limited access, which can ultimately harm customers. Both of these issues are due to several factors, such as blocking, interference, minimal coverage, and other technical factors.

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The complaint of weak LTE signals, specifically on the Telkomsel operator in the South Padang area, serves as an indicator that Telkomsel's signal coverage is weak in the Pantai Air Manis area and its surroundings. Signal quality also affects the signal strength received by users, and the user experience is suboptimal for customers in the South Padang region. Based on these complaints, optimization efforts are carried out in this research to improve the signal quality of Telkomsel in the South Padang area.

METHOD

This research is conducted as a form of optimization process for a cellular system's performance, with the aim of achieving a much better network quality and performance compared to the previous conditions. This research is motivated by customer complaints stating that signal quality, especially 4G signals for Telkomsel operator in the South Padang area, is not as optimal as compared to other operators.

The process of optimizing cellular networks is generally divided into several stages, including initial problem analysis, preparation, data collection, analysis of the collected data, and report generation. Therefore, the first thing to ensure is the signal quality condition in the South Padang area. Hence, the common method typically used to measure and assess 4G signal quality is by conducting drive test activities. In general, the research methodology to be employed in this study is depicted in the flowchart. Can see in Figure 1

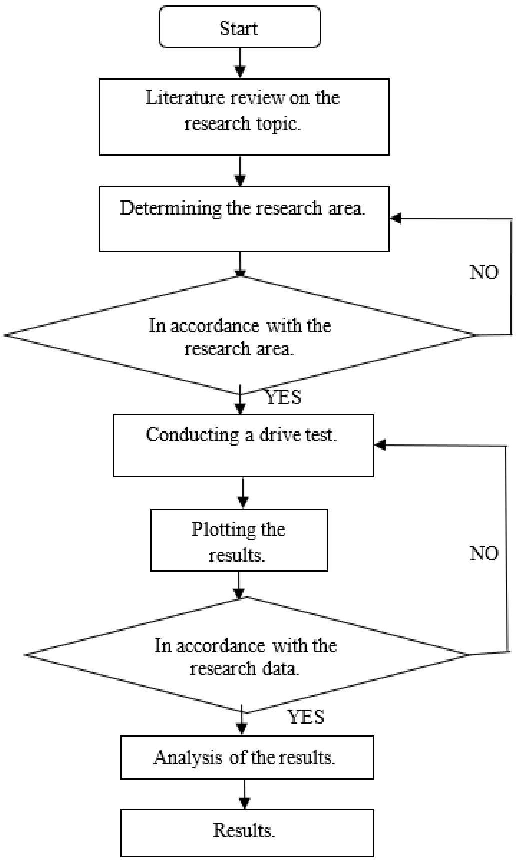

Figure 1. Research Data Flowchart

Figure 1 explains that research begins by looking for a topic or problem. After we get the topic of the problem, we research an area that has that problem and if the problem has been found, we will carry out testing using the drive test method. so that the data obtained can be analyzed and find solutions to the problem topic.

RESULTS AND DISCUSSION

RSRP (Reference Signal Received Power)

RSRP is the level of LTE signal strength received by users on a specific frequency. As the distance between the base station and the user increases, the RSRP value received by the user will decrease. RS refers to the Reference Signal or RSRP at each coverage area point. Users outside the coverage area will not receive LTE services [3],[4],[5]. It is evident that the signal strength in the southern Padang area is poor because it is predominantly yellow in color, with parameter values visible in the following categories. Very Poor Category (-110 dBm ≤ RSRP < -120 dBm) 221 data samples, accounting for 5.52%. Poor Category -110 dBm ≤ RSRP < -100 dBm) 483 data samples, accounting for 12.05%. Fairly Good Category (-100 dBm ≤ RSRP < -85 dBm) 1512 data samples, accounting for 37.73%. Good Category (85 dBm ≤ RSRP < -75 dBm) 1178 data samples, accounting for 29.40%. Very Good Category (≥ -75 dBm ≤ RSRP < 0 dBm) 613 data samples, accounting for 15.30%.

Based on these results and considering the KPI data, these areas fall into the 'fairly good' category. This indicates that the RSRP of the 4G VoLTE network by Telkomsel in the research area is still relatively weak, causing difficulties for user equipment to access signal services. Further improvements are necessary to meet the 'excellent' standard as per the KPI criteria, which is above -80 dBm. Can see it in Figure 2 and Table 1.

SINR (Signal to Interface Noise Ratio)

SINR It is the ratio comparing the main signal transmitted to the interference noise that arises (mixed with the main signal). SINR parameter is often used by vendors or operators to establish the relationship between radio frequency access conditions and the throughput received by the user[6],[4],[5],[7]. The quality of the SINR parameter can be seen in the 4024 samples obtained during the download process along the route. The measured data in Table 4.4 can be observed in the following categories. Very Poor Category (-20 dB ≤ SINR < 0 dB): 1065 data samples, accounting for 26.47%. Quite Poor Category (0 dB ≤ SINR < 13 dB): 2226 data samples, accounting for 55.32%. Good Category (13 dB ≤ SINR < 20 dB): 454 data samples, accounting for 11.28%. Very Good Category (20 dB ≤ SINR < 30 dB): 279 data samples, accounting for 6.93%. It can be seen that the SINR values for the 4G VoLTE network in the southern Padang area are quite poor because they are dominated by yellow-colored indicators. So, it can be concluded that the Telkomsel network in the southern Padang area has a ratio of the main signal strength transmitted with interference against background noise (which is mixed with the main signal) that shows less satisfactory results. In situations with SINR like this, optimization is required, especially in areas marked with yellow and red domains. Can see it in Figure 3 and Table 2.

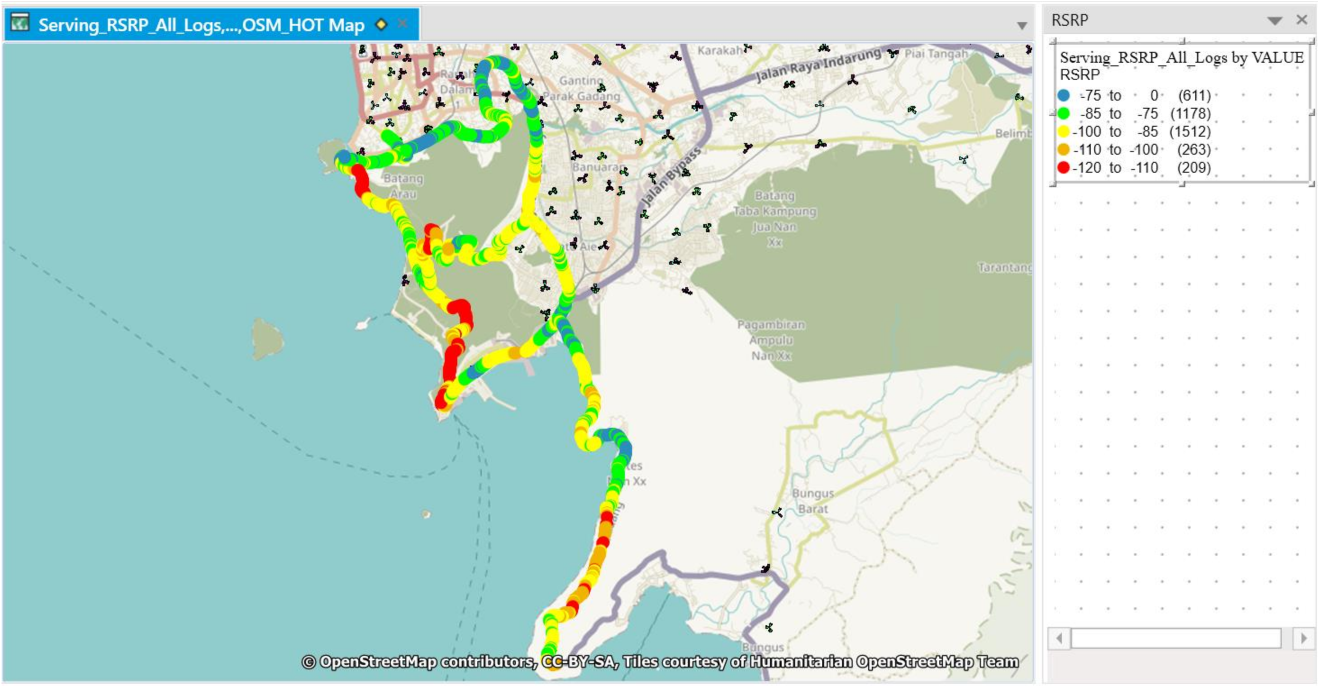

Figure 2. RSRP Measurement

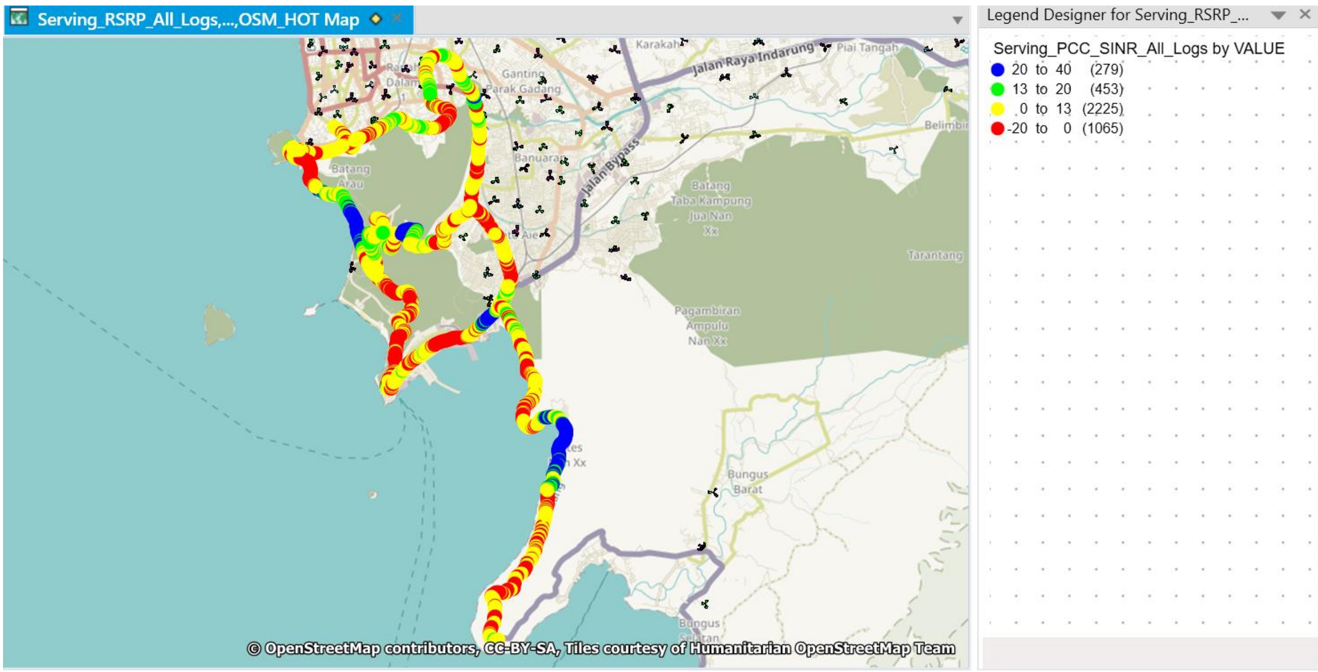

Figure 3. SINR Measurement

Table 11. RSRP Results

RSRP (dBm)	Category	Legend
-75 ≤ RSRP < 0	Excellent	
-85 ≤ RSRP < -75	Very Good	
-100 ≤ RSRP < -85	Good	
-110 ≤ RSRP < -100	Fair	
-110 ≤ RSRP < -120	Poor	

Table 12. SINR Results

SINR (dB)	Category	Legend
20 ≤ SINR < 30	Excellent	
13 ≤ SINR < 20	Good	
0 ≤ SINR < 13	Fair	
-20 ≤ SINR < 0	Poor	

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Measurement of VoLTE Quality

Delay or Latency refers to the time it takes for data to reach its destination after being sent. Factors such as the distance of the physical medium, traffic density, and even the time it takes play a role in influencing delay. TIPHON classifies network performance into four categories based on the value of delay.[8],[9],[10],[11] as in Table 3 and Table 4.

Table 13. Categories Based on Delay Values (source TIPHON)

Category	Delay	Index
Very good	< 150 ms	4
Good	150 ms to 300 ms	3
Currently	300 ms to 450 ms	2
Bad	> 450 ms	1

According to the delay specifications, when compared to the TIPHON standard for VoLTE network testing, the inbound delay values are very good, with a latency below 150 ms. This indicates that the delay time for packet transmission is shorter, resulting in smooth VoLTE network transmission and stable signals, with a percentage of 61.38%.

Table 14. Delay Specifications

Element	RTP Delay Avg (ms) _All Logs
Average	43.49
Maximum	1743
Minimum	0
Standard Deviation	66.99
[0,20]	8 (1.04%)
[20,40]	472 (61.38%)
[40,60]	231 (30.04%)
[60,100]	49 (6.37%)
[100,150]	5 (0.65%)
[150,300]	2 (0.26%)
[300,1000]	2 (0.26%)
Sum Total	769

Jitter, also known as delay variation, refers to the time difference between data packets occurring in a network, usually caused by queuing when processing data. The level of jitter is greatly influenced by traffic levels and the number of packet collisions (congestion) in the network. When traffic load increases in the network, the level of queuing will also increase, which will ultimately result in an increase in jitter values. This impacts the decrease in low QoS values [8], as in Table 5 and Table 6.

Table 15. Categories Based on Jitter Values (source TIPHON)

Category	Delay	Index
Very good	0 ms	4
Good	1 ms to 75 ms	3
Currently	76 ms to 125 ms	2
Bad	126 ms to 225 ms	1

When the Jitter specifications are compared to the TIPHON standard for VoLTE network testing, the Jitter values fall into the 'good' category. An index value of 3 indicates that the Jitter performance meets the standard and has a percentage of 81.04%.

Table 16. Jitter Specifications

Element	RTP Jitter Avg (ms) _All Logs
Average	14.85584
Maximum	32
Minimum	0
Standard Deviation	5.058693

The parameter packet loss, also referred to as packet loss, indicates how many data packets are lost during the data transmission process in a network. Packet loss can be caused by insufficient signal at the destination location, natural or human-made interference, excessive noise in the system, software failures, or excessive network load. Based on the packet loss value, TIPHON divides network performance into four categories.[8],[12],[13] as in Table 7 and Table 8.

Table 17. Categories Based on Packet Loss Values (source TIPHON)

Category	Packet Loss	Index
Very good	0%	4
Good	3%	3
Currently	15%	2
Bad	25%	1

Table 8. Packet loss spesifications

Element	RTP Lost Rate (%) (QCI1)All Logs
Average	0.86
Maximum	69.81
Minimum	0
Standard Deviation	5.36
[0,20)	757(98.31%)
[20,40)	8(1.04%)
[40,60)	3(0.39%)
[60,80)	2(0.26%)
[80,100]	0(0.00%)
Sum Total	770

Physical Tuning

Physical tuning is a technique for optimization. This technique is applied to the antennas located on Base Transceiver Station (BTS) towers by making physical adjustments to the antenna equipment. Some types of physical adjustments that can be made include adjusting the antenna height, adjusting the antenna's directional angle (tilting), and adjusting the antenna's azimuth direction. Tilting has two variations, namely mechanical tilt and electrical tilt. Mechanical tilting involves physically adjusting the antenna's tilt position. The effect of tilting is a change in the overall coverage area. In mechanical tilting, the change in antenna direction is achieved by altering the tilt angle of the rear part of the antenna [14],[15],[16],[17],[18].

a. Mechanical Tilt

   Implemented through the modification of the antenna azimuth position by physically changing the antenna's tilt angle. The effect resulting from this tilting is a change in the overall coverage area. Mechanical tilt involves adjusting the antenna direction by manipulating the tilt angle located on the bracket.[19],[20],[21] as in Figure 5. The calculation is performed using (1), (2), and (3).

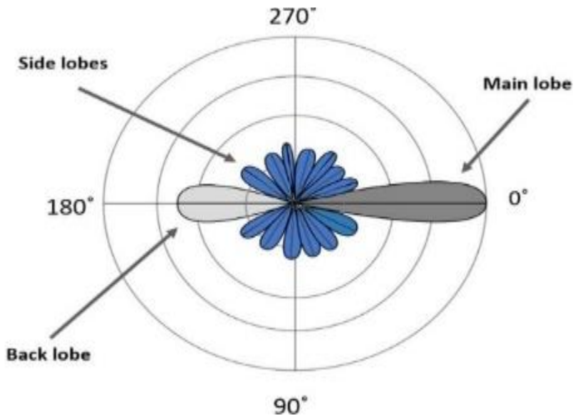

Figure 6. Antenna Radiation Pattern

$$A = Tan^{-1}\frac{(Hb)-(Hr)}{d} \quad (1)$$

$$Distance = \frac{(Hb)-(Hr)/tan\propto}{1000} \quad (2)$$

$$Corner = \frac{(Hb)-(Hr)}{d \times 1000} \quad (3)$$

While,
A : Antenna tilt angle
Hb : Antenna height above sea level (meters)
Hr : Height of the target location above sea level (meters)
d : Distance between BTS and the target location
∝ : Provided antenna tilt angle

b. Electrical Tilt

Electrical tilting involves changing the antenna coverage by manipulating the antenna's phase, resulting in modifications to the antenna beamwidth. Adjusting the antenna phase can be implemented through electrical tilt settings on the antenna, which can be adjusted at different levels such as 1, 2, 3, and so on. Electrical tilt adjustments are typically made at the base of the antenna. Electrical tilt refers to electronically controlled antenna polarization modifications. Electrical tilting alters the phase characteristics of the signal on each antenna element. The larger the electrical tilt value, the more limited the coverage provided.[22],[23] as in Table 9 and Figure 6, 7, 8. The calculation is performed using (4), (5), and (6).

$$mainbean\ distance = \frac{Hb-Hr/TanA}{1000} \quad (4)$$

$$Inner\ Radius = \frac{Hb-Hr}{\tan\left(A+\frac{BW}{2}\right)} \quad (5)$$

$$Outer\ Radius = \frac{H_b-H_r}{Tan\left(A-\frac{BW}{2}\right)} \quad (6)$$

While,
Hb : Transmitter antenna height (meters)
Hr : Receiver antenna height (meters)
A : Antenna tilt angle
Bw : Vertical beamwidth angle of the antenna

Table 18. Antenna Before Optimization

Antenna	Site Air Manis	Site Sei Beremas
Type Antenna	MOBI_MB4BQMf 651616DEINTSL	Rosenberger BA-B7B7W8W8W8x65 V-11
PCI	372	24
	373	25
	374	26
Mechanical Tilt	0	0
	0	0
	0	0
Electrical Antenna	2	0
	4	0
	6	0
Azimuth	20	60
	120	170
	180	330
High Antenna	72 m	40 m
Bandwidth Vertical	25	30

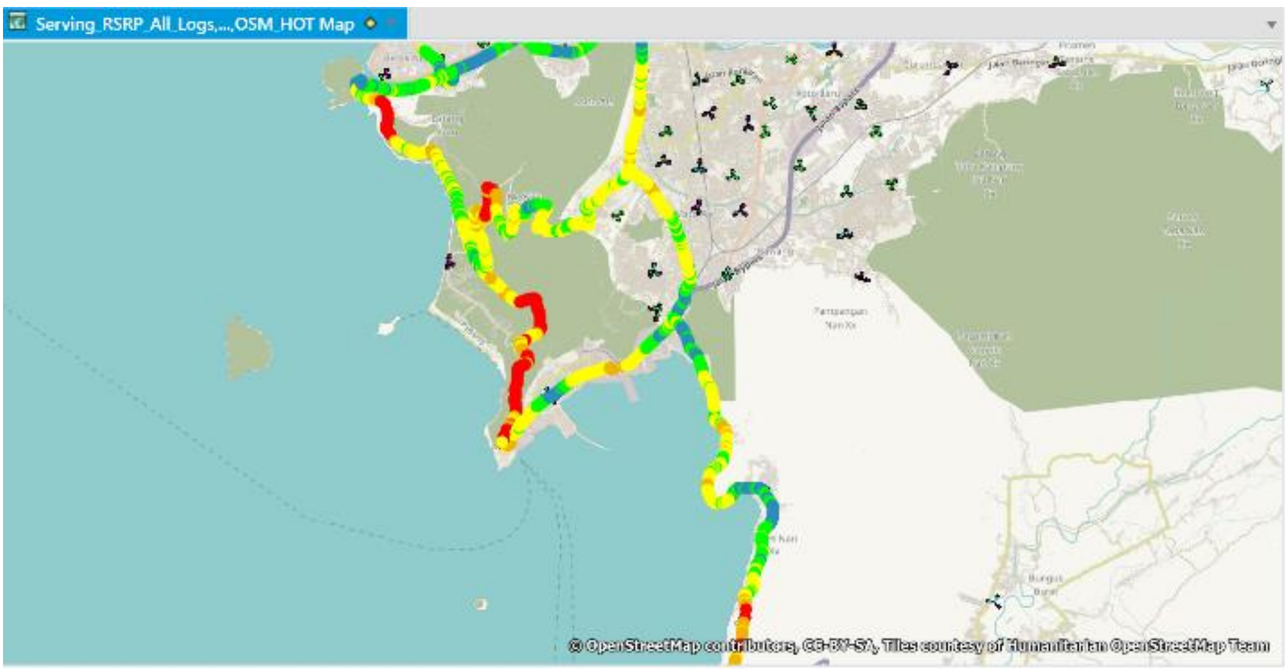

Figure 4. The Optimized Area

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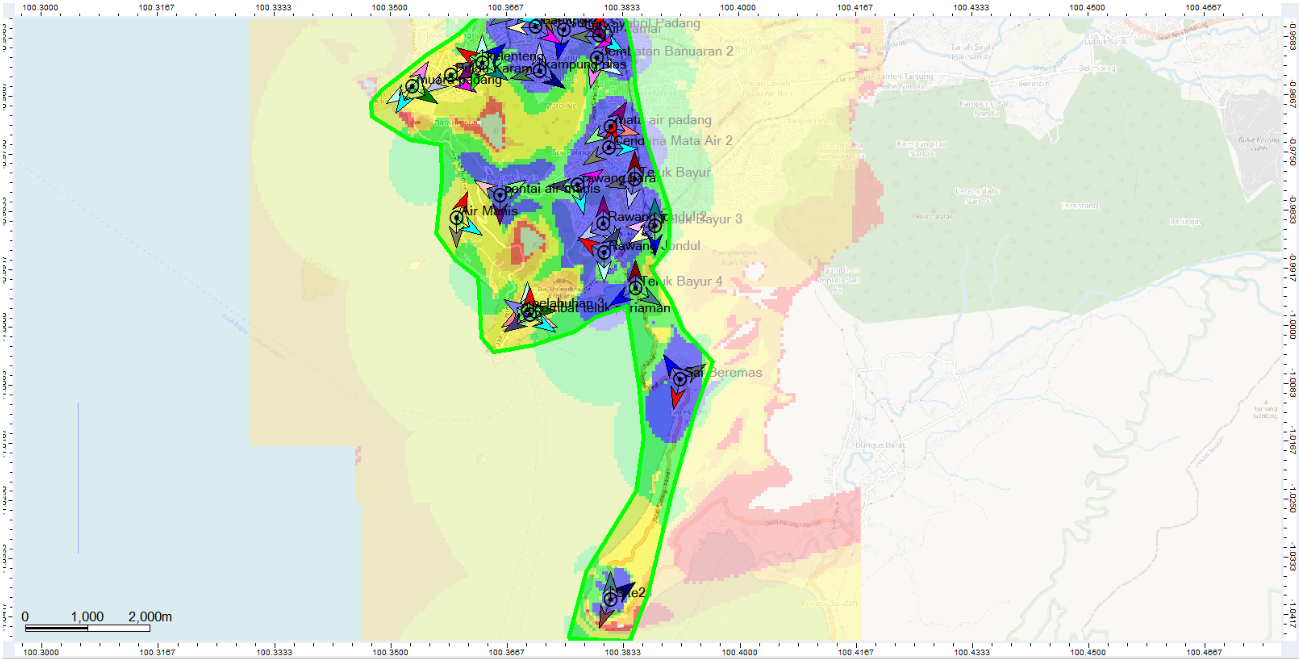

Figure 5. RSRP Before Optimization

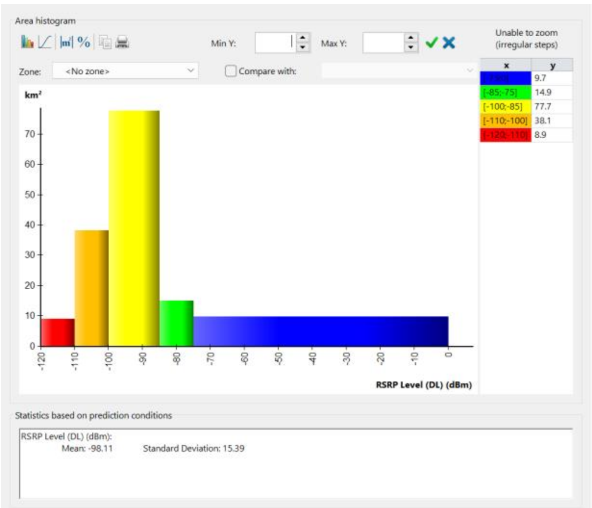

Figure 6. Histogram of RSRP Before Optimization

Figure 4,5 and 6 explain the results of an RSRP measurement in the southern Padang area with quite good quality with a percentage of 77.7%

The coverage range of the antenna site named 'Air Manis' at a frequency of 900 MHz.

$$mainbean\ distance = \frac{H_b - H_r/Tan\ A}{1000}$$

$$= \frac{72-2/0}{1000}$$

$$= \infty$$

$$Inner\ radius\ coverage = \frac{H_b - H_r}{Tan(A + \frac{BW}{2})}$$

$$= (\frac{72-2}{Tan\left(0+\frac{25}{2}\right)}$$

$$= 324.771\ m$$

$$Outer\ Radius\ Coverage = \frac{H_b - H_r}{Tan\ (A - \frac{BW}{2})}$$

$$= \frac{72-2}{Tan(0-\frac{25}{2})}$$

$$= \infty$$

Optimization, achieved by changing the azimuth direction, is carried out for areas experiencing interference and also to determine the serving direction that is suitable for potential areas. Below is a table showing the azimuth direction changes. Sectoral antennas are antennas that are similar to omni antennas that can accommodate clients and are also used in PtP (Point to Point) networks. If the omni antenna has polarization in all directions up to 360 degrees, this sectoral antenna has polarization in a certain direction, namely 180 degrees, can see it in Table 10.

Table 19. Re-Azimuth

Antenna	Before Site Air Manis	Before Site Sei Beremas	After Site Air Manis	After Site Sei Beremas
Type	MOBI_MB4BQMF 651616DEINTSL	Rosenberger BA-B7B7W8W8W8x65V-11	MOBI_MB4BQMF65161 6DEINTSL	Rosenberger BA-B7B7W8W8W8x65V-11
Azimuth	20	60	30	60
	120	170	145	190
	180	330	341	330

Optimizing by increasing the transmit power of the antenna also affects the coverage area in the covered region. So, in the antenna transmission at the Air Manis and Sei Beremas sites, it has not been maximized to cover the bad spot area. The formula for transmit power radiation is EIRP as follows:

a. Cost-231 Propagation Calculation

MAPL (*Downlink*) = 158.445 db

158,445 = 46.3 + 33.82 log f + 13.82 log h_{te}+ $a(h_{re})$ + 44.9 – 6.55 logh_{te}+ 6.55 log(h_{te})log d +cm

158.455 = 46.3 + 33.82 log 1800 + 13.82 log 72 + 3.2 + 44.9 – 6.55 log72 + 6.55 log 72 log d + cm

158.445 = 230 log d

Log d = 230 / 158.445

d = log(1,45)

d = 1.61 km

b. EIRP calculation

EIRP is the effective radiated power of a transmission system after experiencing signal loss due to connectors and connecting cables, which is then enhanced by antenna amplifiers. Can see it in figure 9 and 10.[19]

Known on the MAPL that:

TX power (Po) = 46 dBm

TX Antenna Gain (G) = 18 dBm

Loss system (Lt) = 3 dB

$$\mathrm{EIRP} = \mathrm{Po} + \mathrm{G} - \mathrm{Lt}$$

$$\mathrm{EIRP} = 46 + 18 - 3$$

$$EIRP = 61\ dBm$$

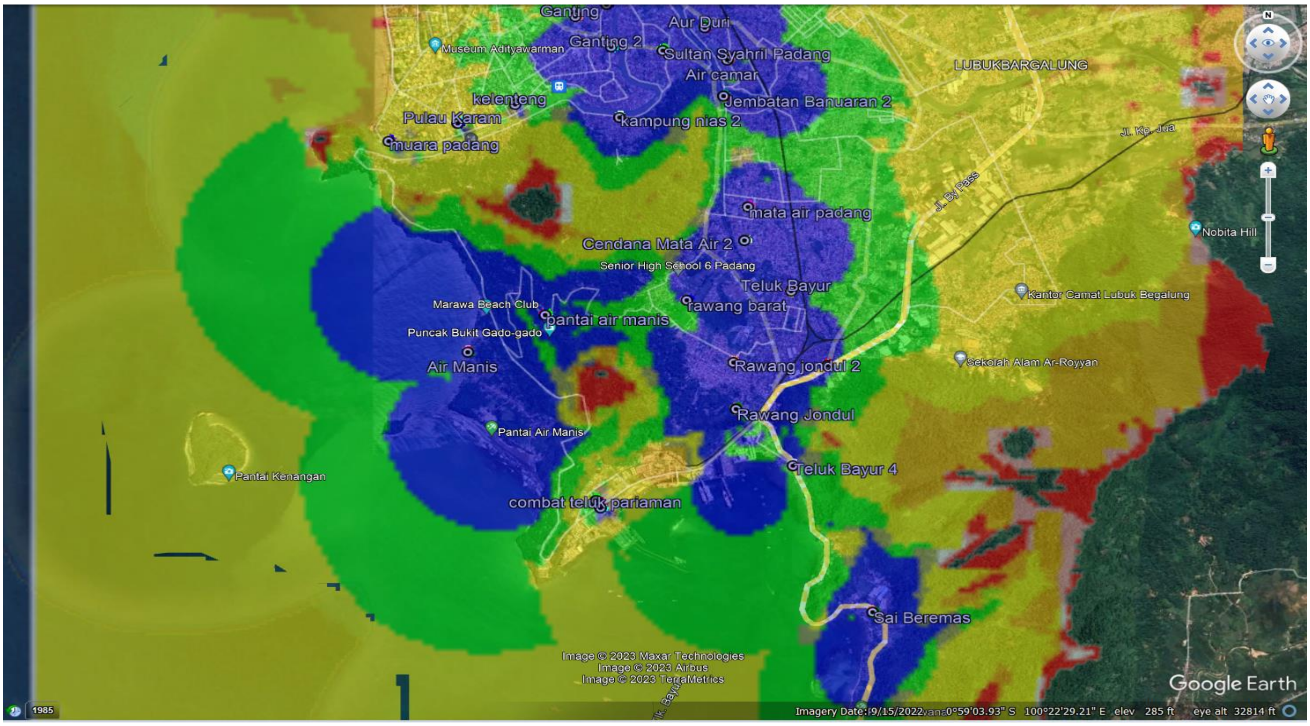

Figure 7. Results After Re-Azimuth and Power Addition to the Antenna

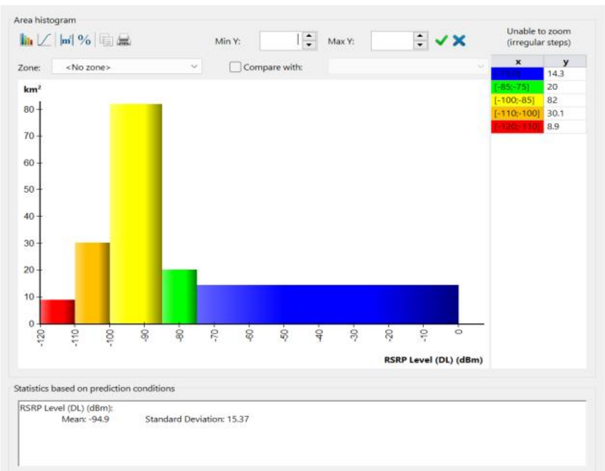

Figure 8. Results of RSRP Histogram After Optimization

CONCLUSIONS

Received Power Reference Signal RSRP is a type of RSSI measurement. This is the LTE Reference Signal strength spread across full bandwidth and narrowband. A minimum of -20 dB SINR (S-Synch channel) is required to detect RSRP. The percentage obtained in the South Padang area is considered quite good, namely 37.73%. SINR is commonly used in wireless communications as a way to measure the quality of a wireless connection. Typically, signal energy fades as distance increases, which is referred to as path-loss in wireless networks. On the other hand, in a cable network, the existence of a cable path between the sender or transmitter and the receiver determines the correct reception of data. In wireless networks we have to consider other factors (e.g. background interference, interfering power of other simultaneous transmissions). The SINR concept seeks to create a representation of this aspect. SINR The percentage obtained by the South Padang region is classified as

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poor at 55.32%. The quality of Telkomsel's VoLTE technology network in the South Padang area is classified as good, seen from three indicators, namely packet loss has a percentage of 98.31%, jitter has a percentage of 81.04%, and delay has a percentage of 61.38%. The results of the analysis after optimization using physical tuning show that RSRP is classified as good with a percentage of 52.8%, and SINR is classified as good with a percentage of 70%.

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