

4G LTE (Long Term Evolution) Network Optimization Using Physical Tuning Methods for the Kubu Gulai Bancah Area

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ABSTRACT

This study aims to optimize the 4G LTE network in the Kubu Gulai Bancah area, West Sumatra, which is a suburban area with weak signal and unstable internet speed challenges. The main problem identified is that the network quality is not yet optimal based on Telkomsel's Key Performance Indicator (KPI) parameters, as well as the need for an appropriate optimization method to improve this quality. The research methodology involves a drive test using the G-NetTrack Pro application on a Redmi Note 13 Pro 5G smartphone to collect RSRP, SINR, and Throughput data. The collected data is then processed using MapInfo for visualization and analysis, and simulated with Atoll software for optimization planning. Initial drive test results showed that while RSRP was mostly in the "very good" category (55%) and Throughput was predominantly 'good' (84%), SINR was still dominated by the "poor" category (56%). Optimization was performed using physical tuning, specifically adjusting the tilt and re-azimuth of the antenna at Site Campago Ipuh 2, Sector 1, with an azimuth change from 0° to 65°. After optimization, the bad spot area for RSRP decreased from 13.2% to 10.89%, and for SINR from 14.1% to 13.21%. The good category for Throughput also increased from 30.5% to 32%. This optimization successfully improved signal coverage quality and network performance significantly.

INTRODUCTION

Mobile network technology continues to improve in order to meet public demand for high-speed voice and data communication services. One technology that is currently widely used is 4G LTE (Long Term Evolution), which was developed by the 3rd Generation Partnership Project (3GPP) as a solution to increase the capacity, speed, and quality of mobile network services. As the number of users and demand for data access increases, network traffic loads also rise, potentially reducing network performance, especially in areas with limited signal coverage. A decline in service quality generally occurs in areas that are at the edge of eNodeB coverage, which are often categorized as bad spots. This condition is exacerbated by the uneven development of 4G LTE network infrastructure in Indonesia, especially in suburban and medium-sized cities[1]. As a result, users in these areas still often experience problems such as weak signals and unstable internet speeds. Kubu Gulai Bancah is a suburban area with hilly terrain, located at an altitude of approximately 930 meters above sea level. Based on 2023 data from the Central Statistics Agency (BPS), this area has a population of 7,058, with smartphone users predominantly in the productive age group. The high demand for data services in this area has not been fully matched by adequate network quality, even though the area is served by several eNodeBs with varying distances. To improve network quality, network optimization efforts based on actual conditions in the field are needed. One commonly used method is drive testing, which is a mobile network performance test to obtain signal quality parameter data such as signal strength and quality. The drive test data is then used as the basis for the network optimization process using the Physical Tuning method, specifically through readjusting the azimuth and tilt angle of the antenna to improve network coverage and service quality [2].

LITERATURE REVIEW

LTE (Long Term Evolution)

LTE (Long-Term Evolution), a wireless communication standard developed by 3GPP, is designed to overcome the limitations of 3G such as UMTS/HSPA with increased speed, capacity, and spectrum efficiency. This technology implements OFDMA on the downlink and SC-FDMA on the uplink, enabling download speeds of up to 300 Mbps, upload speeds of 75 Mbps, and latency below 20 ms—far exceeding HSPA+ (42 Mbps download, 22 Mbps upload).



LTE supports flexible bandwidths of 1.4-20 MHz on frequency bands such as 700 MHz to 2600 MHz, adjusted to national regulations [3]. The advantages of LTE include fast internet access for HD streaming, large downloads, and responsive gaming, driving mass adoption worldwide [4]. However, increased user traffic often degrades performance at the edge of coverage, requiring optimization such as drive tests and physical tuning (re-azimuth, tilting), as discussed in previous studies [2][1].

LTE Network Architecture

LTE adopts System Architecture Evolution (SAE) through Evolved Packet System (EPS), which integrates UE (User Equipment), E-UTRAN, and EPC for packet-based all-IP networks, replacing the separation of circuit and packet switches in 2G/3G. E-UTRAN simplifies radio access with a single eNodeB (combining Node B and RNC), deployed as a greenfield or rooftop BTS, for spectrum efficiency and high mobility. EPC handles end-to-end IP delivery, supporting new business models such as streaming content. Its main components include: Mobility Management Entity (MME), managing authentication, security, mobility, and control plane connectivity. Home Subscription Service (HSS), a permanent database of subscribers and UE locations. Serving Gateway (S-GW), a user plane bridge for switching and resource allocation based on MME/PCRF instructions. Packet Data Network Gateway (PDNGW) PDN termination with policy enforcement, filtering, and charging via service data flows (SDFs). Policy and Charging Rules Function (PCRF), real-time policies for QoS and charging, integrated with the operator's system [5].

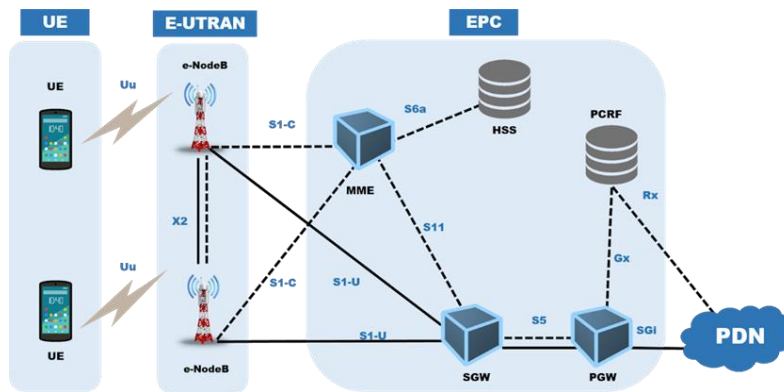







Figure 1. LTE Network Architecture [6]

4G LTE Network Performance Parameters

Mobile network optimization aims to maximize service quality by adjusting parameters based on drive test data, affecting handover, cell selection, and user throughput. Key parameters include RSRP for signal strength, SINR for interference, and throughput for actual data speed. [7][1].






Reference Signal Received Power (RSRP) measures the average linear power on LTE reference signal resource elements, which is crucial for handover and cell reselection based on path loss. Values are calculated only on cell-specific reference signals, which is efficient without full subcarrier measurements [8] [9]. The range of RSRP is shown in Table 1.

Table 1. RSRP Parameter Standards

RSRP (dBm)	Category	Legend
$-80 \leq \text{RSRP} < 0$	<i>Excellent</i>	
$-95 \leq \text{RSRP} < -80$	<i>Very Good</i>	
$-100 \leq \text{RSRP} < -95$	<i>Good</i>	
$-110 \leq \text{RSRP} < -100$	<i>Poor</i>	
$-150 \leq \text{RSRP} < -110$	<i>Bad</i>	






Signal to Noise Ratio (SINR) is the ratio of the main signal strength to interference and noise, directly correlated with throughput although not formally defined by 3GPP; used by vendors for radio access evaluation [7] [8]. The range of SINR is shown in Table 2.

Table 2. SINR Parameter Standard

SINR (dB)	Category	Legend
$20 \leq \text{SINR} < 30$	<i>Excellent</i>	
$10 \leq \text{SINR} < 20$	<i>Very Good</i>	
$0 \leq \text{SINR} < 10$	<i>Good</i>	
$-5 \leq \text{SINR} < 0$	<i>Poor</i>	
$-20 \leq \text{SINR} < -5$	<i>Bad</i>	

Throughput is the rate of successful data from the UE to the eNodeB per unit of time, reflecting the actual bandwidth and influenced by traffic and interference [10] [1]. The range of SINR is shown in Table 3.

Table 3. Standar Parameter Throughput

Throughput DL (kbps)	Category	Legend
$15.000 \leq \text{THP} < 100.000$	<i>Excellent</i>	
$8.000 \leq \text{THP} < 15.000$	<i>Very Good</i>	
$3.000 \leq \text{THP} < 8.000$	<i>Good</i>	
$2.000 \leq \text{THP} < 3.000$	<i>Poor</i>	
$0 \leq \text{THP} < 2.000$	<i>Bad</i>	

Key Performance Indicator (KPI)

Key Performance Indicator (KPI) serves as an operational target for telecommunications companies to measure RSRP, SINR, and LTE network throughput, calculated as a percentage of drive test data samples that meet the “Excellent” to “Good” categories according to operator standards [8] [11]. KPI targets are shown in Table 4. General formula:

$$\%Target\ Parameters = \frac{Number\ of\ samples\ that\ meet\ the\ target}{Total\ number\ of\ samples} \times 100\% \quad (1)$$

Table 4. KPI Target

N0	Parameter	KPI Target (percentage)	KPI Target
1	RSRP	90%	$\geq -100\ \text{dBm}$
2	SINR	80%	$\geq 0\ \text{dBm}$
3	Throughput	80%	$\geq 2000\ \text{kbps}$

Drive test

Drive testing involves mobile data collection using specialized devices, GPS, digital maps, and analysis software to measure signal coverage, service quality, throughput, and net success rate in the target area. Conducted during BTS/eNodeB troubleshooting or routine checks, this method reflects the real user experience in terms of interference, path loss, and bad spots [12] [7].

Re-Azimuth Method and Tilting Antennas

Network optimization aims to improve network quality in the research area. In this study, the optimization method used is Physical Tuning with tilting and re-azimuth. Antenna tilting is an adjustment of the antenna angle that serves to determine the area that will receive signal coverage. To change the coverage area served by eNodeB, tilting techniques can be used, namely tilting or changing the position of the antenna to adjust the antenna coverage.

To calculate the antenna tilting angle using the mechanical tilting approach as shown in the formula.

$$A = \tan^{-1} \frac{(Hb-Hr)}{d} \quad (2)$$

Where:

- A : antenna tilting angle
- Hb : antenna height above sea level (m)
- Hr : target location height above sea level (m)
- D : distance between the base station and the target location (m).



Re-azimuth antenna is a change in the direction of the antenna in one sector. Azimuth itself is defined as the angle of rotation from west to east. The north wind direction is used as the reference angle of zero. If the transmission power from the antenna is blocked by an obstacle so that it does not meet LOS (Line Of Sight), then to obtain the change in antenna height, it is calculated according to the formula.

$$H_b = (\text{distance } (m) \times \tan^{-1} A) + H_r \quad (3)$$

Changing the height of the antenna installation must be calculated based on the height of obstacles that block the antenna's transmission in an area so that there is no loss in signal reception. To obtain good results, it is necessary to have a condition where the transmitting and receiving antennas can “see” each other without any obstacles (line of sight) within certain limits, as shown in Figure 2 [13].

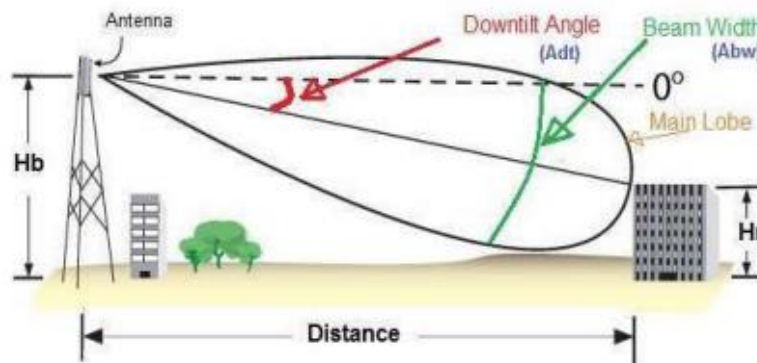


Figure 2. Tilting Antenna [13]

METHOD

This study uses a descriptive method with a comparative analysis approach to evaluate the improvement in the quality of the 4G LTE cellular network in the Kubu Gulai Bancah area, Bukittinggi City, West Sumatra Province. The descriptive method was chosen because this study aims to describe the network performance based on direct measurements in the field using the drive test technique. Comparative analysis was conducted by comparing network performance before and after the network optimization process [14].

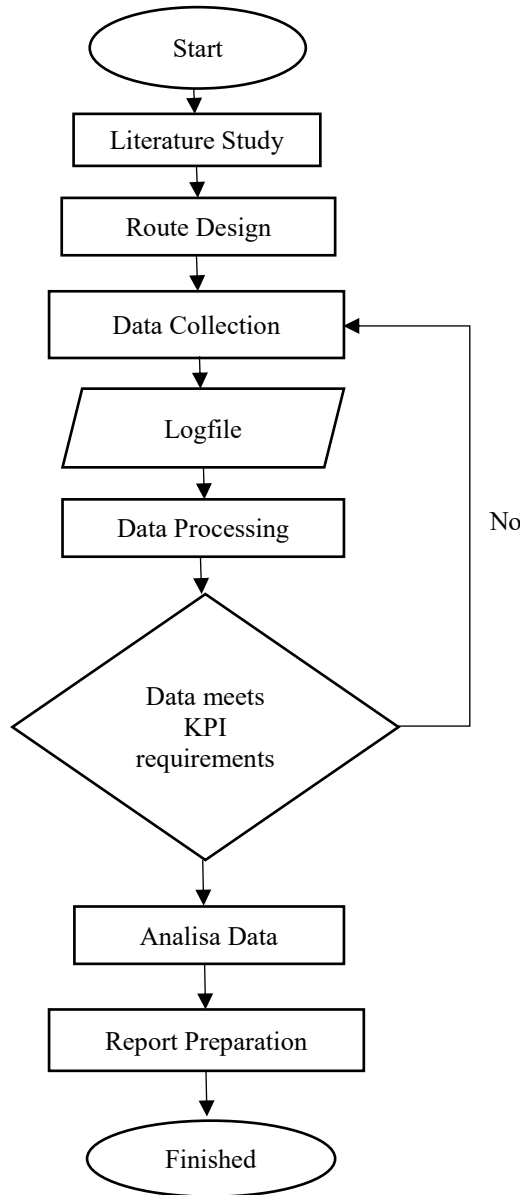


Figure 3. Research Flowchart

After the data was collected, network performance analysis was carried out by comparing network quality parameters before and after optimization. The parameters analyzed included Reference Signal Received Power (RSRP), Signal to Interference plus Noise Ratio (SINR), and Throughput [15]. The analysis of these parameters referred to the Key Performance Indicator (KPI) range set by Telkomsel as the standard for evaluating network quality.

RESULT

Data collection was conducted using the drive test method to obtain field information about network performance. Next, the measurement data was analyzed and used as the basis for network optimization using the Physical Tuning method in the area using the Atoll application. [16].

4G LTE Network Performance Measurement Results

The measurement data was obtained in the form of log files through the Gnet Track Pro application, then processed using MapInfo software. The main parameters observed and analyzed included RSRP (Reference Signal Received Power), SINR (Signal Interference to Noise Ratio), and Throughput.

RSRP (Reference Signal Received Power)

The RSRP plotting results obtained during the drive test can be seen in Figure 4. RSRP performance is classified into several categories, namely Excellent with a range of values from -80 dBm to 0 dBm, totaling 1786 samples or 34%; Very Good with a range of values from -95 dBm to -80 dBm, totaling 2862 samples or 55%; Good with a value range of -100 dBm to -95 dBm, amounting to 365 samples or 7%, Poor with a value range of -110 dBm to -100 dBm, amounting to 233 samples or 4%, and Bad with a value range of -150 dBm to -110 dBm, amounting to 2 samples or 0%.



Figure 4. RSRP coverage area and RSRP diagram

The RSRP parameters obtained from the data collection results are presented more clearly in Table 5. This table displays the RSRP values and their locations, which can be viewed and analyzed to provide an overview of the signal quality in the measurement area.

Table 5. View RSRP

Longitude	Latitude	RSRP (dBm)	Location
100.368224	-0.283506	-60	Gerbang kantor walikota
100.368178	-0.283637	-55	Simp. Pengadilan agama
100.370112	-0.283543	-56	Jl. Bypass
100.363481	-0.289089	-80	Jl. kinantan
100.364147	-0.286604	-81	Jl. kinantan Sablon cup Tilaw
100.36458	-0.284503	-83	Jl. kinantan Warkop ST. kayo
100.365118	-0.282969	-95	Gadut batas kota bukittinggi
100.365185	-0.282674	-97	Jl. Lintas barat sumatra
100.365339	-0.281858	-98	Jl. Veteran Lapau kik Ambacang
100.373053	-0.288344	-100	Jl irigasi
100.371806	-0.287897	-104	Jl. Kusuma bhakti
100.371722	-0.287826	-106	Jl. Kusuma bhakti Amanah laundry
100.371282	-0.286257	-112	Jl masjid nurul wathan

Table 6 shows the results of the analysis for the RSRP parameter obtained from data collection.

Table 6. Analysis of RSRP Parameter Results

RSRP (dBm)	Category	Sample	Percentage
-80 ≤ RSRP < 0	Excellent	1786	34%
-95 ≤ RSRP < -80	Very Good	2862	55%
-100 ≤ RSRP < -95	Good	365	7%
-110 ≤ RSRP < -100	Poor	233	4%
-150 ≤ RSRP < -110	Bad	2	0%
Total		5248	100%
	RSRP > -100 dBm		95.52%

The RSRP value that meets the operator's KPI standard with formula (1) is as follows:

$$\begin{aligned}
 \%Target\ Parameters &= \frac{\text{Number of samples that meet the target}}{\text{Total number of samples}} \times 100\% \\
 \%RSRP \geq -100\ dBm &= \frac{\text{Number of RSRP samples} \geq -100\ dBm}{\text{Total number of samples}} \times 100\% \\
 \%RSRP \geq -100\ dBm &= \frac{(1786 + 2862 + 365)\ \text{samples}}{5248} \times 100\% \\
 \%RSRP \geq -100\ dBm &= \frac{5.013\ \text{samples}}{5248} \times 100\% = 95.52\%
 \end{aligned}$$

Based on all measurement data, it was found that the percentage of RSRP parameters that met the KPI standard, namely with a value of ≥ -100 dBm, reached 95.52%.

Signal to Interference plus Noise Ratio (SINR)

The SINR plotting results obtained during the drive test process are shown in Figure 5. The performance of the Signal to Interference plus Noise Ratio (SINR) parameter in the test area can be classified into five categories. The Excellent category, with a value range of 20 dB to 30 dB, had no samples, or 0%. The Very Good category, with a range of 10 dB to 20 dB, was found in 594 samples, or 11%. The Good category, with a range of 0 dB to 10 dB, was found in 1696 samples, or 32%. The Poor category, with a value range of -5 dB to 0 dB, was the dominant category, with 2958 samples or 56%. Meanwhile, the Bad category, with a value range of -20 dB to -5 dB, recorded 0 samples or 0%. Based on this data, most measurement points (56%) fall into the weak signal (Poor) category, indicating that network performance in the test area tends to be suboptimal and may cause service disruptions.



Figure 5. SINR coverage area and SINR diagram

The SINR parameters obtained from the data collection results are presented more clearly in Table 7. This table displays the SINR values and their locations, which can be viewed and analyzed to provide an overview of the signal quality in the measurement area.

Table 7. View SINR

Longitude	Latitude	SINR (dB)	Location
		-	
100.374022	-0.286495	10	Jl. Banda Rajang
100.372101	-0.284153	11	Belakang RSUD Bukittinggi
100.370112	-0.283543	13	Jl. Lintas Sumatera
100.363481	-0.289089	0	Jl. kinantan
100.371273	-0.28755	2	Jl. Kusma bakti
100.371291	-0.286246	5	Gang Aster
100.371273	100.371273	-3	Jl. Kusuma Bhakti Balai pemuda RW 2
100.372377	-0.285718	-4	Gang mahoni
100.367685	100.367685	-5	Dinas Kominfo Bukittinggi
		-	

Table 8 shows the results of the analysis for the SINR parameter obtained from data collection.

Table 8. Analysis of SINR Parameter Results

SINR (dB)	Category	Sample	Percentage
$20 \leq \text{SINR} < 30$	Excellent	0	0%
$10 \leq \text{SINR} < 20$	Very Good	594	11%
$0 \leq \text{SINR} < 10$	Good	1696	32%
$-5 \leq \text{SINR} < 0$	Poor	2958	56%
$-20 \leq \text{SINR} < -5$	Bad	0	0%
Total		5248	100%
		SINR > 0 dB	43.63%

SINR values that meet operator KPI standards using formula (1) are as follows:

$$\%Target\ Parameters = \frac{Number\ of\ samples\ that\ meet\ the\ target}{Total\ number\ of\ samples} \times 100\%$$

$$\%SINR \geq 0\ dB = \frac{Number\ of\ SINR\ samples \geq 0\ dBm}{Total\ number\ of\ samples} \times 100\%$$

$$\%SINR \geq 0\ dB = \frac{(0 + 594 + 1696)\ samples}{5248} \times 100\%$$

$$\%SINR \geq 0\ dB = \frac{2.290\ samples}{5248} \times 100\% = 43.63\%$$

Based on all measurement data, it was found that the percentage of SINR parameters that met the KPI standard, namely with a value of ≥ 0 dB, only reached 43.63%. This achievement is still far below the KPI standard target of 80%, so it can be concluded that the signal quality of the SINR parameter in the measurement area is not yet optimal and requires improvement.

Throughput

The throughput results obtained during the drive test process are shown in Figure 6. The throughput parameter performance in the test area can be classified into five categories. The Excellent category, with a range of 15,000 kbps to 100,000 kbps, was found in 1 sample, equivalent to 0%. The Very Good category, with a range of 8,000 kbps to 15,000 kbps, was found in 133 samples or 3%. The Good category, with a range of 3,000 kbps to 8,000 kbps, was the dominant category with 4,432 samples or 84%. The Poor category, with a range of 2,000 kbps to 3,000 kbps, was found in 83 samples or 2%. Meanwhile, the Bad category, with a range of 0 kbps to 2,000 kbps, was recorded in 600 samples or 11%. Based on this data, most areas in the Kubu Gulai Bancah sub-district have internet speeds in the Good category (84%), indicating adequate network performance for everyday use. Approximately 13% of measurement points (combined Poor and Bad) show low speeds and require attention from operators to improve network quality.



Figure 6. Coverage Area Throughput and Throughput Diagram

The Throughput parameters obtained from the data collection results are presented more clearly in Table 9. This table displays the Throughput values and their locations, which can be viewed and analyzed to provide an overview of the signal quality in the measurement area.

Table 9. View Throughput

Longitude	Latitude	Throughput (kbps)	Location
		-	
100.365039	100.365039	9470	Jl. veteran
100.370221	-0.2864	8797	Jl. Kusuma bakti,MIN Kota Bukittinggi
100.369763	-0.287378	10664	Jl. Patanangan
100.363513	-0.288976	3173	Jl. Kinantan,Giwam Wash
100.364038	-0.287368	6222	Jl. Kinantan depot suci
100.370109	100.370109	7015	Jl. Kusuma bakti
100.370809	100.370809	2537	Jl. By pass
100.36227	100.36227	2786	Jl. Baru
100.372736	-0.285584	2215	Gang Gaharu
100.370547	-0.287041	100	Jl. Kinantan,Kazoku parfum
100.367127	100.367127	6	Pustaka bunghatta
100.372037	-0.28641	1980	Jl. Masjid nurul wathan

Table 10 shows the analysis results for the Throughput parameter obtained from data collection.

Table 10. Throughput Parameter Results Analysis

Throughput (kbps)	Category	Sample	Percentage
$15000 \leq THP < 100000$	Excellent	0	0%
$8000 \leq THP < 15000$	Very Good	133	3%
$3000 \leq THP < 8000$	Good	4432	84%
$2000 \leq THP < 3000$	Poor	83	2%
$0 \leq THP < 2000$	Bad	600	11%
Total		5248	100%
Throughput > 2000 kbps			88.56%

Throughput values that meet operator KPI standards using formula (1) as follows:

$$\begin{aligned} \%Target\ Parameters &= \frac{\text{Number of samples that meet the target}}{\text{Total number of samples}} \times 100\% \\ \%Throughput \geq 2000\ dB &= \frac{\text{Number of samples with throughput} \geq 0\ dBm}{\text{Total number of samples}} \times 100\% \\ \%Throughput \geq 2000\ dB &= \frac{(0 + 133 + 4432 + 83)\ \text{samples}}{5248} \times 100\% \\ \%Throughput \geq 2000\ dB &= \frac{4.468\ \text{samples}}{5248} \times 100\% = 88.56\% \end{aligned}$$

Based on all measurement data, it was found that the percentage of Throughput parameters that met the KPI standard, namely with a value of ≥ 2000 kbps, reached 88.56%.

Simulation at Atoll

After analyzing the drive test data and identifying problems in various site areas, such as handover failures and a decline in network quality as indicated by the high percentage of "poor" categories in the RSRP, SINR, and Throughput parameters, the next step was to perform a simulated optimization process using Atoll software. Atoll was chosen for its ability to facilitate network coverage mapping by utilizing existing eNodeB site data[17].

Existing Site

The existing site was developed with the aim of displaying data on BTS towers that are already operating in the field, which is then entered into Atoll software as a basis for network analysis, planning, and optimization.

RSRP (Reference Signal Received Power)

Figure 7 shows that most of the research area has medium to low signal quality. The Excellent category only covers about 3.4%, while Very Good dominates with 63.6%. Areas with Good quality reach 19.8% and Poor 13.2%, while the Bad category was not found. The average RSRP value of -92.6 dBm indicates that signal quality in the research area still needs to be improved to achieve optimal network performance.

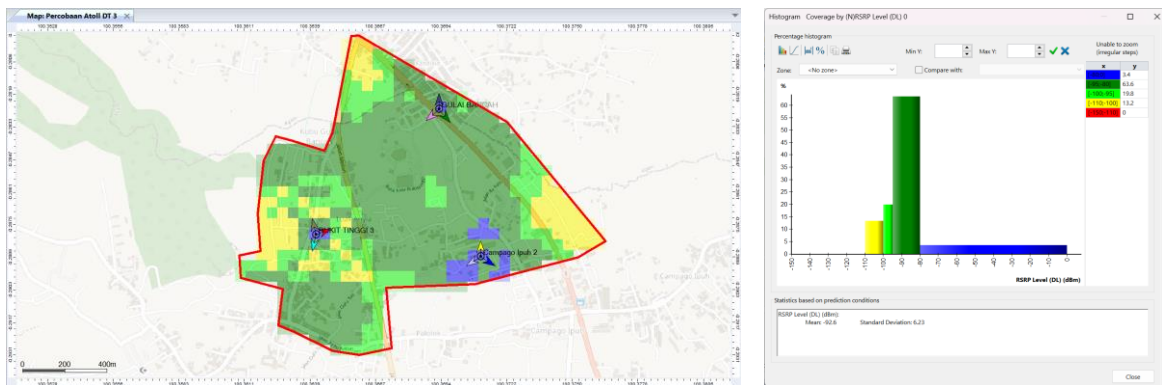


Figure 7. RSRP Coverage and Site Area Histogram

Signal to Interference plus Noise Ratio (SINR)

Figure 8 shows that the SINR signal quality in the study area was dominated by the Good category (0–10 dB) at 56.8%, followed by Very Good (10–20 dB) at 25%. The Excellent category (20–30 dB) only accounts for 4.1%, while the Poor category (–5 to 0 dB) accounts for 14.1% and Bad is not found. The average SINR value of 6.69 dB indicates that the overall signal quality is at a medium to low level.

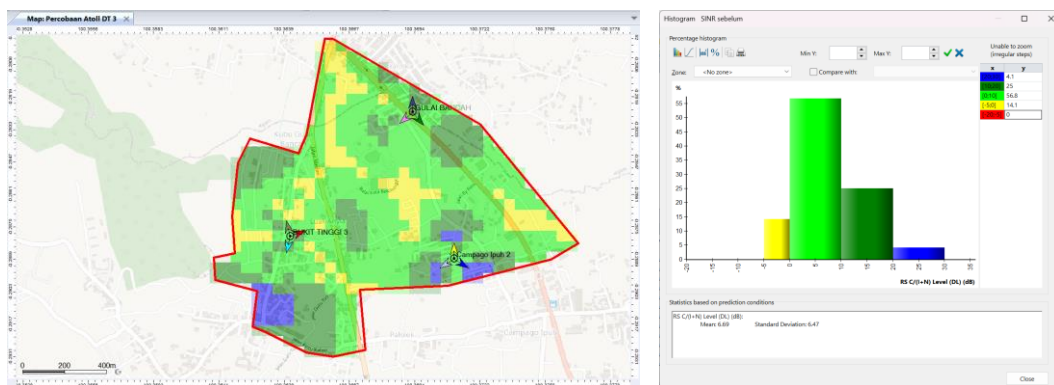


Figure 8. SINR Coverage and Site Area Histogram

Throughput

Figure 9. Most of the research areas have good throughput, with the Excellent category (15,000–100,000 kbps) covering 39% of the area. The Very Good and Good categories each cover 30.5%. No areas were found in the Poor or Bad categories. The average throughput value of 18,342 kbps indicates that the overall network data capacity is good, although there is still room for improvement in some areas.

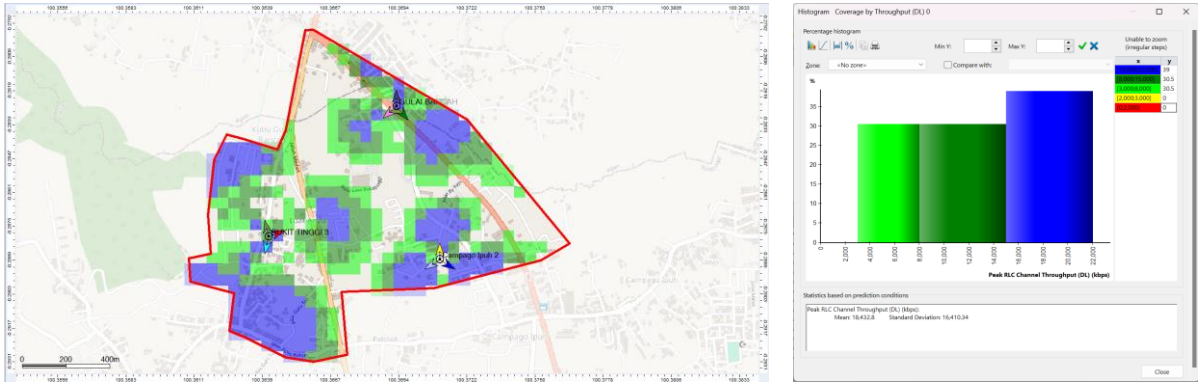


Figure 9. Throughput Coverage and Site Area Histogram

4G LTE network optimization

The optimization process using the antenna tilting method was carried out based on the drive test analysis data shown in Figure 10. The aim was to optimally improve network performance in terms of coverage and service quality in the test area.

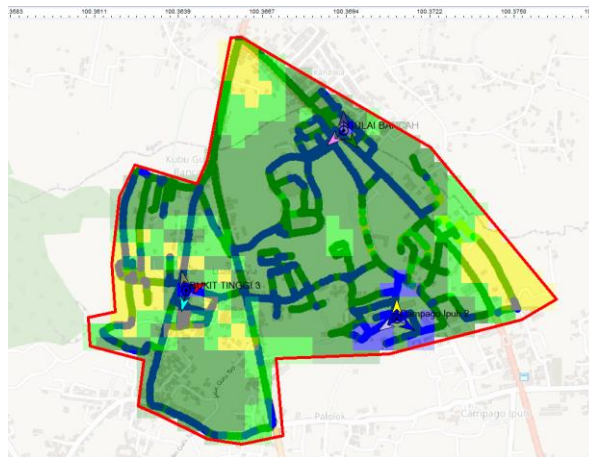


Figure 10. Area to be Optimized

Based on the results of drive tests and data analysis, two locations were identified as having poor network quality. Network optimization efforts were carried out using the Physical Tuning method, namely by applying tilting and re-azimuth techniques.

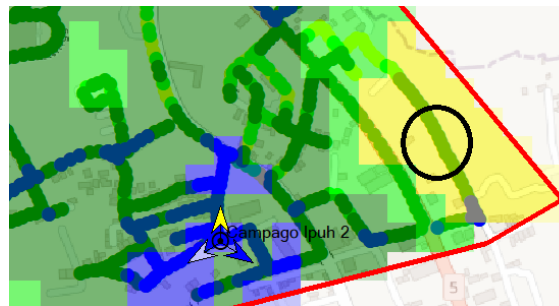


Figure 11. Area Bad Spot

The badspot area shows poor RSRP, SINR, and throughput values, resulting in weak signals and low access speeds. This location is covered by the Campago Ipuh 2 site, sector 1, which is approximately 423 meters away from the site. Detailed sector information is presented in Table 11.

Table 11. Site information Campago Ipuh 2

<i>Site Information</i>	
Site Name	Campago Ipuh 2
Site ID	BKT532
Long/Lat	100.3711/-0.28887
Azimuth	0
Jarak site ke badspot	423 m
Tilt (E/M)	(2/RET)
Antena Height + altitude (Hb)	17 + 896 (m)
Height mobile station (Hr)	2 (m)

Tilting calculation using equation (2)

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

$$A = \tan^{-1} \left(\frac{(17 + 913) - 2}{423} \right)$$

$$A = 65.495^\circ$$

$$A = 65^\circ$$

Optimization in the badspot area was carried out by adjusting the antenna direction (re-azimuth) with an angle change from 0° to 65°, in order to expand coverage and improve signal quality. The difference after optimization by changing the angle can be seen in Figure 12.

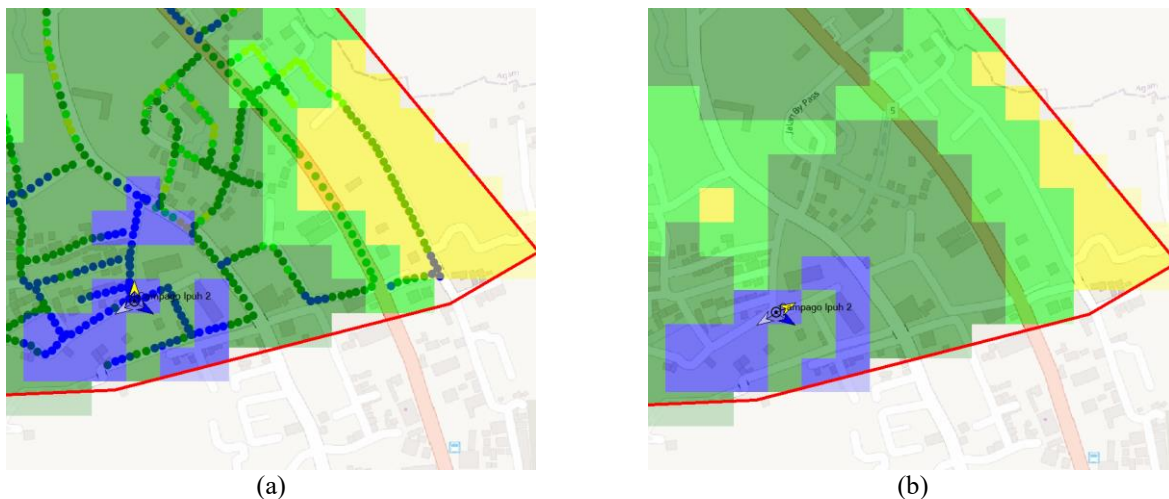


Figure 12. Comparison of (a) the site before optimization and (b) the site after optimization

Results after optimization

After performing optimization using the physical tuning method, which included adjusting antenna tilting and re-azimuth in several sectors identified as problematic, an improvement in network quality was achieved in the research area. This optimization was carried out with the aim of improving key cellular network parameters, namely RSRP (Reference Signal Received Power), SINR (Signal to Interference plus Noise Ratio), and Throughput.

RSRP (Reference Signal Received Power) after optimization

After optimization using the physical tuning method, the RSRP value increased, indicating an improvement in signal strength in the research area. The visualization of the improvement is shown in Figure 13.

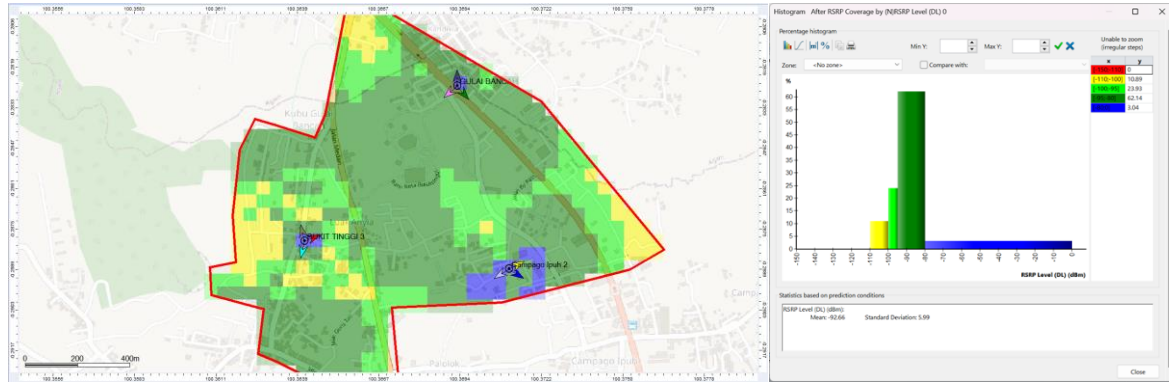


Figure 13. RSRP coverage area after optimization and histogram

Table 12 shows that the comparison before and after optimization indicates an increase in signal strength in the RSRP parameter.

Table 12. Comparison of RSRP Before and After Optimization

Reference Signal Received Power		Area Coverage		Optimization Percentage	
RSRP (dBm)	RSRP Level	Before	After	Before	After
$-80 \leq \text{RSRP} < 0$	<i>Excellent</i>	0.048 km ²	0.043 km ²	3.4%	3.04%
$-95 \leq \text{RSRP} < -80$	<i>Very Good</i>	0.89 km ²	0.87 km ²	63.6%	62.14%
$-100 \leq \text{RSRP} < -95$	<i>Good</i>	0.278 km ²	0.335 km ²	19.8%	23.93%
$-110 \leq \text{RSRP} < -100$	<i>Poor</i>	0.185 km ²	0.153 km ²	13.2%	10.89%
$-150 \leq \text{RSRP} < -110$	<i>Bad</i>	0 km ²	0 km ²	0%	0%

The comparison before and after optimization shows that the Bad category remains at 0%. The Poor area decreased from 0.185 km² (13.2%) to 0.153 km² (10.89%), while the Good category increased from 0.278 km² (19.8%) to 0.335 km² (23.93%). The Very Good and Excellent categories decreased slightly. Overall, RSRP optimization successfully reduced the bad spot area significantly.

SINR (Signal to Interference plus Noise Ratio) setelah optimasi

After optimization using the physical tuning method, the RSRP value increased, indicating an improvement in signal strength in the research area. The visualization of the improvement is shown in Figure 14.

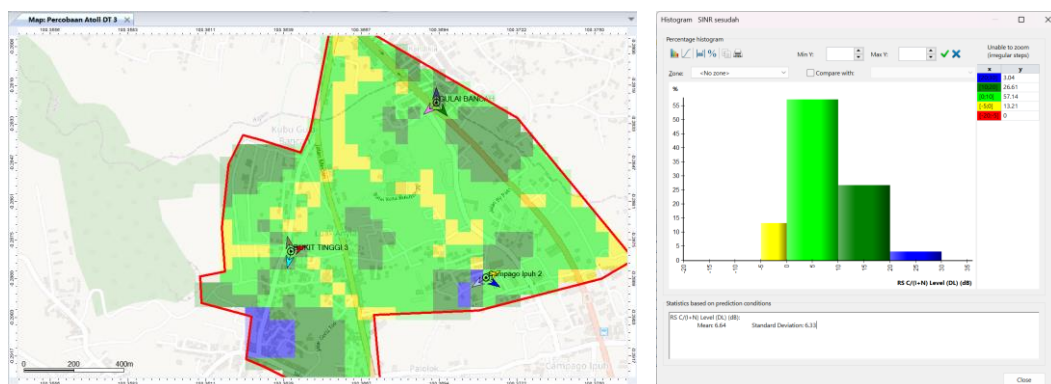


Figure 14. SINR coverage area after optimization and histogram

Table 13 shows that the results of the analysis comparing the conditions before and after optimization indicate an improvement in signal quality in terms of the Signal to Interference and Noise Ratio (SINR) parameter.

Table 13. Comparison of SINR Before and After Optimization

<i>Signal to Interference and Noise Ratio</i>		<i>Area Coverage</i>		<i>Optimization Percentage</i>	
SINR (dB)	SINR Level	Before	After	Before	After
$20 \leq SINR < 30$	<i>Excellent</i>	0.058 km ²	0.043 km ²	4.1%	3.04%
$10 \leq SINR < 20$	<i>Very Good</i>	0.35 km ²	0.373 km ²	25%	26.61%
$0 \leq SINR < 10$	<i>Good</i>	0.795 km ²	0.8 km ²	56.8%	57.14%
$-5 \leq SINR < 0$	<i>Poor</i>	0.198 km ²	0.185 km ²	14.1%	13.21%
$-20 \leq SINR < -5$	<i>Bad</i>	0 km ²	0 km ²	0%	0%

The comparison before and after optimization shows that the Bad category remains at 0%. The Poor area decreased from 0.198 km² (14.1%) to 0.185 km² (13.21%), while the Good category increased from 56.8% to 57.14%. The Very Good category increased slightly and the Excellent category decreased slightly. In general, SINR optimization successfully reduced the bad spot area.

Throughput setelah optimasi

After optimization using the physical tuning method, the RSRP value increased, indicating improved signal strength in the study area. A visualization of the improvement is shown in Figure 15.

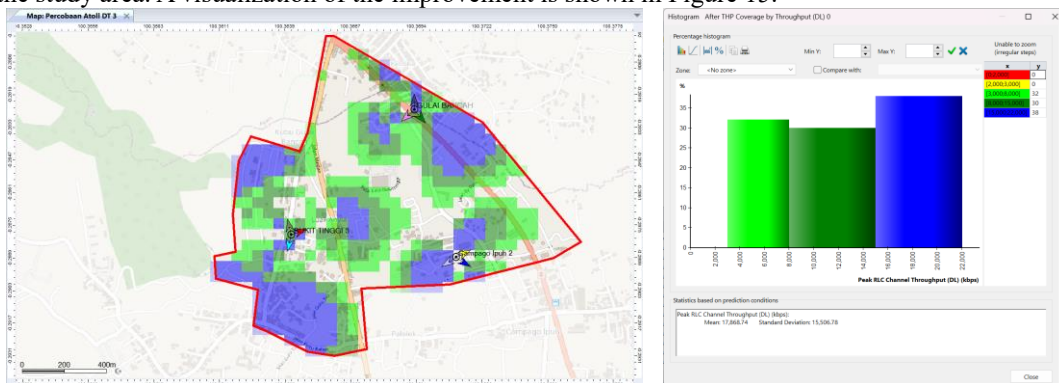


Figure 15. Coverage area Throughput after optimization and histogram

Table 14 shows that the results of the analysis comparing the conditions before and after optimization indicate an improvement in performance in terms of throughput.

Table 14. Comparison of Throughput Before and After Optimization

<i>Throughput</i>		<i>Area Coverage</i>		<i>Optimization Percentage</i>	
<i>Throughput (kbps)</i>	<i>Throughput Level</i>	Before	After	Before	After
$15000 \leq THP < 100000$	<i>Excellent</i>	0.37 km ²	0.37 km ²	39%	38%
$8000 \leq THP < 15000$	<i>Very Good</i>	0.29 km ²	0.29 km ²	30.5%	30%
$3000 \leq THP < 8000$	<i>Good</i>	0.29 km ²	0.31 km ²	30.5%	32%
$2000 \leq THP < 3000$	<i>Poor</i>	0 km ²	0 km ²	0%	0%
$0 \leq THP < 2000$	<i>Bad</i>	0 km ²	0 km ²	0%	0%

The comparison before and after optimization shows that the Bad and Poor categories remained at 0%. The Good category increased from 30.5% to 32%, while Very Good and Excellent decreased slightly. Overall, physical tuning optimization showed an improvement in service quality, marked by an increase in the Good category.

CONCLUSION

1. Evaluation of the quality of Telkomsel's 4G LTE network in the Kubu Gulai Bancah area through a drive test with G-NetTrack Pro and MapInfo analysis showed that RSRP met the standard of 95.52% (≥ -100 dBm), SINR was low at 43.63% (target ≥ 0 dB), and throughput was 88.56% (≥ 2000 kbps).
2. Optimization simulation on Atoll software using the physical tuning method in the form of re-azimuth antenna site Campago Ipuh 2 sector 1 from 0° to 65° . This resulted in an improvement in coverage distribution, namely poor RSRP decreased from 13.2% to 10.89%, poor SINR from 14.1% to 13.21%, and the good throughput category increased from 30.5% to 32%, thereby significantly reducing the poor service area.
3. The before-and-after comparison of optimization in Tables 12, 13, and 14 confirms an overall improvement in KPIs with a reduction in bad spots and an approach to the operator's targets (90% RSRP, 80% SINR, 80% throughput).

REFERENCES

- [1] M. H. Adwel and M. Mulyono, "Optimasi Jaringan 4G LTE Menggunakan Metode Automatic Cell Planning (ACP) di Wilayah Kubu Gulai Bancah," *remik*, vol. 7, no. 1, pp. 233–245, Jan. 2023, doi: 10.33395/remik.v7i1.12033.
- [2] A. Rahmi, J. P. Hapsari, B. P. Jati, T. Elektro, and F. T. Industri, "OPTIMALISASI JARINGAN 4G PADA FREKUENSI 1800MHZ DENGAN METODE RE-AZIMUTH DAN TILTING MENGGUNAKAN SOFTWARE SIMULASI ATOLL (STUDY KASUS: KOTA PEMALANG)," *Media Elektrika*, vol. 15, no. 1, 2022, [Online]. Available: <http://jurnal.unimus.ac.id>
- [3] H. Prasetyo, D. Putra Setiawanline, and S. Sa'idah, "Lte Network Optimization On Telkom University Area".
- [4] A. Hikmaturokhman, "Optimasi Jaringan LTE di Wilayah Sario, Kota Manado: Studi Kasus Pada Salah Satu Operator Telekomunikasi di Indonesia," *JIKO (Jurnal Informatika dan Komputer)*, vol. 8, no. 2, p. 329, Sep. 2024, doi: 10.26798/jiko.v8i2.1202.
- [5] N. Suroyya, "ANALISA PERFORMANSI JARINGA 4G DI WILAYAH MALANG," 2019.
- [6] I. Suandi, "PERANCANGAN JARINGAN LONG TERM EVOLUTION (LTE) PADA FREKUENSI 2100 MHZ DI KECAMATAN MUARA DUA KOTA LHOKSEUMAWE PADA TAHUN 2029 MENGGUNAKAN SOFTWARE ATOLL," 2024.
- [7] B. Hardiyanto *et al.*, "ANALISIS QUALITY OF SERVICE (QOS) JARINGAN 4G LTE MELALUI DRIVE TEST DI BBPLK BEKASI MENGGUNAKAN APLIKASI NETMONITOR CELL SIGNAL LOGGING," 2020.
- [8] H. Yulianto, M. Haryanti, and S. T. Mt, "Perbaikan Dan Peningkatan Coverage Jaringan 4G LTE."
- [9] Y. Ismemet and T. Purnamirza, "ANALISIS PERBANDINGAN KUALITAS SINYAL 4G LTE PADA BEBERAPA PROVIDER COMPARATIVE ANALYSIS OF 4G LTE SIGNAL QUALITY ON SEVERAL PROVIDERS," *Journal of Information Technology and Computer Science (INTECOMS)*, vol. 5, no. 1, 2022.
- [10] A. Budiman, M. Ficky Duskarnaen, and H. Ajie, "ANALISIS QUALITY OF SERVICE (QOS) PADA JARINGAN INTERNET SMK NEGERI 7 JAKARTA."
- [11] D. Putra Wenadri, A. Yuhaneef, and D. Chandra, "Comparative Analysis Of 4G LTE Network Quality At 900 Mhz And 2100 Mhz Frequencies."
- [12] H. Maafifa Nugraha, R. Rohmat Saedudin, and M. Fathinuddin, "Analisis Performansi Jaringan 4G LTE Dengan Metode Drive Test Pada Gedung Tokong Nanas Telkom University."
- [13] R. Sirait and I. Nurhidayanto, "Kajian Optimasi Jaringan Long Term Evolution (LTE) Menggunakan Metode Physical Tuning di Kelurahan Bojong Nangka," vol. 9, no. 2, doi: 10.33322/kilat.v9i2.1118.
- [14] Muhammad Harun Ashar and Dinda, "Analisis Performansi Jaringan 4G Telkomsel Menggunakan Metode Drive Test," *Bulletin of Computer Science Research*, vol. 3, no. 5, pp. 364–371, Aug. 2023, doi: 10.47065/bulletincsr.v3i5.273.
- [15] R. D. Ayuningtyas, M. P. K. Praja, S. Romadhona, and Z. H. Pradana, "Penerapan Skema Automatic Cell Planning (ACP) untuk Meningkatkan Coverage Area Jaringan 4G-LTE pada Perumahan Bukit Kalibagor Indah," *Journal of Telecommunication Electronics and Control Engineering (JTECE)*, vol. 6, no. 1, pp. 13–28, Jan. 2024, doi: 10.20895/jtece.v6i1.1188.
- [16] F. Tri Utari Angela, S. Aulia, P. Maria, and R. Dewi, "Analisa dan Optimasi Pengaruh Physical Tunning Terhadap Handover Failure Pada Jaringan 4G LTE," 2024, doi: 10.30630/eji.0.0.439.
- [17] C. D. Rahmadila, "Optimasi Kualitas Jaringan 4g Lte Menggunakan Metode Physical Tuning," *Telekontran : Jurnal Ilmiah Telekomunikasi, Kendali dan Elektronika Terapan*, vol. 12, no. 2, Apr. 2025, doi: 10.34010/telekontran.v12i2.12310.