Analysis of LTE Network Performance in Regional Surabaya City (Case Study of Telkomsel Company)

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***Abstract*—The rapid development of wireless technology in Indonesia necessitates reliable network performance, particularly for mobile users. This study analyzes the performance of the Telkomsel 4G LTE network in Surabaya, focusing on key radio frequency parameters critical for service quality. The primary objective is to evaluate and optimize signal quality by assessing Key Performance Indicators (KPIs) based on data from vendor PT Nexwave. The methodology employs a drive test utilizing the Single Site Verification (SSV) approach. Data collection and analysis for Reference Signal Received Power (RSRP) and Signal to Interference plus Noise Ratio (SINR) are conducted using Genex Probe and Genex Assistant software. Optimization efforts resulted in significant improvements: the RSRP distribution meeting the -90 dBm threshold increased from 71.8% to 96.54%. Similarly, the SINR parameter achieving above 12 dB improved from 81.45% to 90.77%, exceeding the 90% KPI target. The study concludes that the SSV-based drive test and optimization successfully enhanced network performance. The final results show RSRP and SINR conformance at 96.54% and 90.77%, respectively, closely approaching the 100% optimization success requirement set by the operator and vendor.**

***Keywords*—4G LTE, Network Performance, Drive Test, RSRP, SINR, Single Site Verification (SSV).**

I. INTRODUCTION

The proliferation of mobile data traffic and user demand for seamless connectivity has positioned 4G Long-Term Evolution (LTE) technology as a critical infrastructure worldwide, including in Indonesia [1]. Network performance optimization is essential for operators to maintain Quality of Service (QoS) and Quality of Experience (QoE), particularly in dense urban environments where user concentration and physical obstacles challenge signal propagation [2], [3]. Key Performance Indicators (KPIs) such as Reference Signal Received Power (RSRP), Signal to Interference plus Noise Ratio (SINR), and Handover Success Rate (HOSR) are fundamental metrics for quantitatively assessing radio network health and user-perceived quality [4], [5].

In LTE networks, mobility management through efficient handover (HO) is paramount for maintaining session continuity. Poor HO performance, often triggered by suboptimal RSRP or SINR, leads to call drops, reduced throughput, and degraded user experience [6], [7]. Consequently, extensive research focuses on analyzing and optimizing HO parameters and coverage to mitigate failures [8], [9]. Field measurement techniques, notably drive testing, provide ground-truth data for such analysis, enabling the validation of network planning models and the identification of specific problem areas like coverage holes or pilot pollution [10], [11].

Recent studies have employed drive tests to evaluate LTE performance in various urban settings, analyzing the impact of factors like frequency band, traffic load, and antenna configuration on KPIs [12], [13]. Furthermore, data-driven optimization strategies, including those based on Self-Organizing Network (SON) concepts, are increasingly leveraged to automate and improve network tuning processes [14], [15]. While benchmarks exist, performance is highly localized, necessitating region-specific evaluations [16], [17].

Despite the general understanding of LTE KPIs, a detailed, empirical analysis of Telkomsel's LTE network in the dense metropolitan area of Surabaya remains underrepresented in recent literature. Most prior local studies rely on older data or different geographical contexts [18], [19]. This study aims to fill this gap by conducting a comprehensive field-based performance analysis. Utilizing the Single Site Verification (SSV) drive test methodology, this research measures and evaluates critical KPIs—primarily RSRP and SINR—against operator-defined thresholds. The objective is to diagnose network issues, assess the effectiveness of subsequent optimization actions, and provide a validated case study on urban LTE performance enhancement in Indonesia, contributing practical insights to the field of network optimization.

II. METHOD

A. Research Stages

This study employs a quantitative, field-based approach to analyze and optimize the performance of Telkomsel's 4G LTE network in a selected urban cluster of Surabaya. The methodology is designed to systematically collect empirical radio frequency (RF) data, diagnose performance issues, implement corrective actions, and validate the improvements. The process follows a cyclic optimization framework common in network performance management [12], [15]. The research stages carried out are shown in Fig.1.

The research adopts a case study design focused on a single operator (Telkomsel) within a specific geographical area. The core methodology is the Single Site Verification (SSV) and Optimization cycle. SSV is a targeted drive test procedure used to validate the performance of a newly integrated or

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problematic cell site against predefined Key Performance Indicators (KPIs) [10], [18].

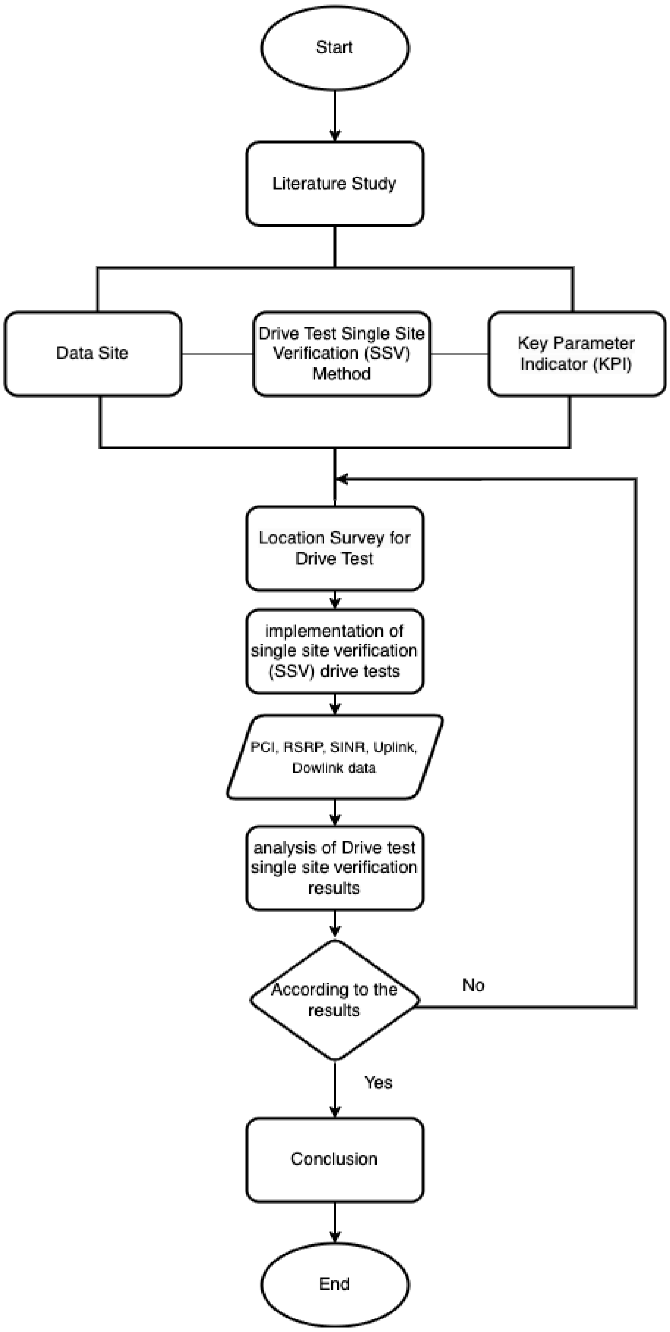

Figure 1. Flowchart of data collection design

B. Data Collection Using the SSV Drive Test Method

The stages of data collection using the single site verification method are arranged with the intention that the research is carried out in detail. The stages of the research carried out are shown in Fig.2.

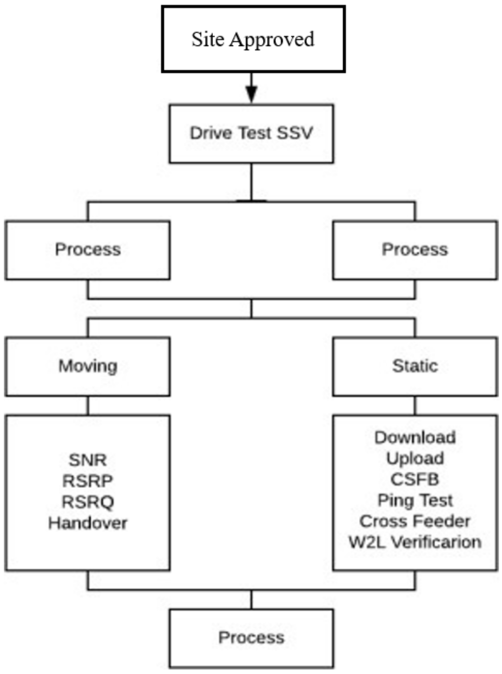

Figure 2. Data collection using the SSV drive test method

Description of Fig.2 as follows:

1) *Site Approved:* by Operator At this stage, what is done is to ask the vendor to give permission for the Telkomsel SBX364_BRONGGALANMC site to be approved for data collection so that it can be used as a report.

2) *SSV Drive Test:* Carrying out a drive test using the SSV method on the SBX364_BRONGGALAN site by referring to the parameters provided by the vendor and operator.

3) *Site Planning and Site Audit:* Where there are 2 types of sites that are drive tested, namely to distinguish which sites can be drive tested statically or movingly.

4) *Drive Test Moving:* From the results of the drive test moving site SBX364_BRONGGALAN, a log file was obtained with various parameters such as , RSRP, and Handover.

5) *Drive Test Static:* From the results of the drive test static site SBX364_BRONGGALAN, a log file was obtained from various parameters such as Download, Upload, Ping test, CSFB, W2L, Cross Feeder Verification.

6) *SSV Report:* After obtaining the data from the drive test, the next step can be carried out, namely reporting the results of the drive test log file.

C. Location and Route Data

Location and route data are determined after conducting a location survey. In this case study, the location chosen is the Pacarkembang Village Area, Tambaksari District, Surabaya City. The location was chosen because it has many bad spots and bad quality in several areas that can reduce the quality of the Telkomsel operator's LTE network in the area. Therefore, a drive test and optimization were carried out at the location to improve the quality of good cellular data services.

Figure 3. Location and route data

Based on Fig. 3, it can be seen that the Drive Test route used starts from the Bronggalan II - Ploso Baru highway, then passes through Ploso Timur road, continues to Kalijudan road, then ends by passing through Pacarkembang V road. The route taken is based on the direction of the Telkomsel project team in the Pacarkembang Village area.

III. RESULTS AND DISCUSSION

A. Calculation Results According to Site KPI Values

The following is an analysis of the calculation of RSRP and values in drive test measurements using bandwidth values and RSSI parameter values. The bandwidth at the SBX364_BRONGGALAN site has a value of 20 MHz with a block resource number of 100. The RSSI value at the SBX364_BRONGGALAN site is 58.81 dBm, as shown in Table I.

Where the above value was obtained from the KPI data of the SBX364_BRONGGALAN site before optimization was carried out and could not be used as the current reference value before direct measurement was carried out with a drive test.

TABLE I
VALUE PARAMETER RSSI

Serving RSSI Unlock	
Element	Serving RSSI UNLOCK
Average	-58.81
Maximum	-31.25
Minimum	-85.51
Standar Deviation	10.31
[-140,-120]	0 (0.00%)
[-120,-100]	0 (0.00%)
[-100,-80]	35 (1.28%)
[-80,-60]	1023 (40.21%)
[-60,-40]	1357 (53.34%)
[-40,-10]	129 (5.07%)
SUM TOTAL	2544

$$RSRP = RSSI - 10\,log\,(12 \times N)$$
$$RSRP = -58 - 10\,log\,(12 \times 100)$$
$$RSRP = -89\,dBm \tag{1}$$

TABLE II
VALUE PARAMETER

Serving SINR Unlock	
Element	Serving RSSI UNLOCK
Average	9.25
Maximum	30.25
Minimum	8.51
Standar Deviation	6.60
[-140,-120]	15 (0.46%)
[-120,-100]	261 (8.06%)
[-100,-80]	35 (1.28%)
[-80,-60]	1469 (43.35%)
[-60,-40]	1313 (40.54%)
[-40,-10]	181 (5.59%)
SUM TOTAL	3239

$$N(Watt) = k \times T \times B$$
$$n = k \times T$$
$$n = 1{,}38 \times 10 - 273(joule/K)300°K$$
$$n = 4{,}002\,E - 273(joule)$$
$$n(dBm/Hz) = \left(10 \times log10(4002E - 273)\right) + 27$$
$$n(dBm/Hz) = -173{,}977$$
$$N = n \times B$$
$$N = -173{,}997 + (10 \times log10(20\,E^{6}))$$
$$n(dBm/Hz) = -53{,}977\,dbm$$
$$SINR = \frac{P(rs\,powerconfig)}{1 + N}$$
$$SINR = \frac{15{,}2}{55{,}22 + (-53{,}97)}$$
$$SINR = \frac{15{,}2}{2{,}25}$$
$$SINR = 12{,}16\,dBm \tag{2}$$

B. Drive Test Parameter Measurement Results

RSRP and SINR parameter signal quality results After implementing the drive test with the Genex probe software, the next step is to report the logfile of the drive test results using the Genex Assistant software, which can be seen in Attachment 2, where the following results are obtained:

TABLE III
SINGLE SITE VERIFICATION

Parameter	Measured		
	Sector 1	Sector 2	Sector 3
PCI	341	340	349
RSRP	-88.56 dBm	-74.56 dBm	-89.35 dBm
SINR	12.39 dBm	19.58 dBm	11.15 dBm
LTE Band	1800 MHz	1800 MHz	1800 MHz

TABLE IV
STATIONARY TEST

Sector	Stationary	Target	Test Result	Remark
	DL Sigle User Throughput (Maximum)	16 Mbps	31.19	Pass

	DL Sigle User Throughput (Average)	6 Mbps	25.56	Pass
	DL Sigle User Throughput (Maximum)	6 Mbps	28.02	Pass
	DL Sigle User Throughput (Average)	2 Mbps	25.06	Pass
1	CSFB Session Setup Success Rate	10.s	3.415	Pass
	W2L (Fast Return)	5.s	0.66	Pass
	Cross Feeder Verification	Pass/Fail	Pass	Pass
	DL Sigle User Throughput (Maximum)	16 Mbps	58.13	Pass
	DL Sigle User Throughput (Average)	6 Mbps	54.55	Pass
	DL Sigle User Throughput (Maximum)	6 Mbps	23.32	Pass
	DL Sigle User Throughput (Average)	2 Mbps	16.70	Pass
2	CSFB Session Setup Success Rate	10.s	3.396	Pass
	W2L (Fast Return)	5.s	0.61	Pass
	Cross Feeder Verification	Pass/Fail	Pass	Pass
	DL Sigle User Throughput (Maximum)	16 Mbps	21.05	Pass
	DL Sigle User Throughput (Average)	6 Mbps	13.87	Pass
	DL Sigle User Throughput (Maximum)	6 Mbps	14.41	Pass
	DL Sigle User Throughput (Average)	2 Mbps	9.56	Pass
3	CSFB Session Setup Success Rate	10.s	4.635	Pass
	W2L (Fast Return)	5.s	0.608	Pass
	Cross Feeder Verification	Pass/Fail	Pass	Pass

TABLE V
DRIVE TEST

Drive Test	Measured		
	Target	Test Result	Remark
RSRP Distribution	90% > -90dBm	92,26%	Pass
SINR Distribution	90% .12dB	82,54%	Pass

From Table IV, the verification results are obtained by dividing 3 sectors, with each sector having an LTE band of 1800 MHz and PCI worth 341 for sector 1, 340 for sector 2, and 339 for sector 3. Then the RSRP value for each sector is 88.56. dBm in sector 1, -74.56 dBm for sector 2, and -89.35 dBm for sector 3, with an average RSRP value of the three sectors being -84.15 dBm. The SINR value in each sector is 12.39 dB in sector 1, 19.58 dB in sector 2, and 11.15 dBm in sector 3, with the average SINR value of the three sectors being 14.37dB. Where in the drive test results, the RSRP distribution test result value reached 92.26% of the target 90%> -90 dBm, and the SINR distribution value reached 82.54% in the test results with a target of 90%> 12 dB.

C. Existing Condition Measurement Results

After getting the drive test results, the next thing to do is to evaluate the drive test results for later analysis. The data obtained from the drive test is a combination of many parameters. So, if you want to observe a particular parameter, a selection process is needed to get the desired parameters. The evaluation of the drive test results is specifically for the optimization area. In this final project, there are three radio parameters that will be used as a reference for whether the network is in good or bad condition, namely RSRP, SINR, and throughput.

1) Reference Signal Received Power (RSRP):

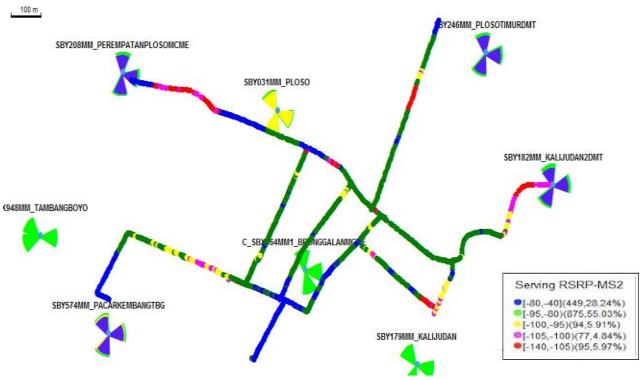

Figure 4. Distribution of existing network RSRP

TABLE VI
PRESENTATION OF EXISTING NETWORK RSRP VALUES

Range (-dBm)	Category	Colour	Sample	Percentage
-40 to -80	Excellent		449	28.24%
-80 to -95	Good		875	55.03%
-95 to -100	Fair		94	5.91%
-100 to -105	Poor		77	4.84%
-105 to -140	Bad		95	2.31%

Fig. 4 shows that the distribution of RSRP is uneven; there are even 5 areas that have poor RSRP values. In fact, these 5 areas have high traffic potential, so that optimization needs to be done. The following is a table of the RSRP category percentage of sample points taken during the drive test:

In Table VI, 13.06% of RSRP sample points are still below the Telkomsel operator KPI standard (RSRP ≥ -90 dBm). So, optimization needs to be done to solve this problem.

2) Signal Interference to Noise Ratio (SINR):

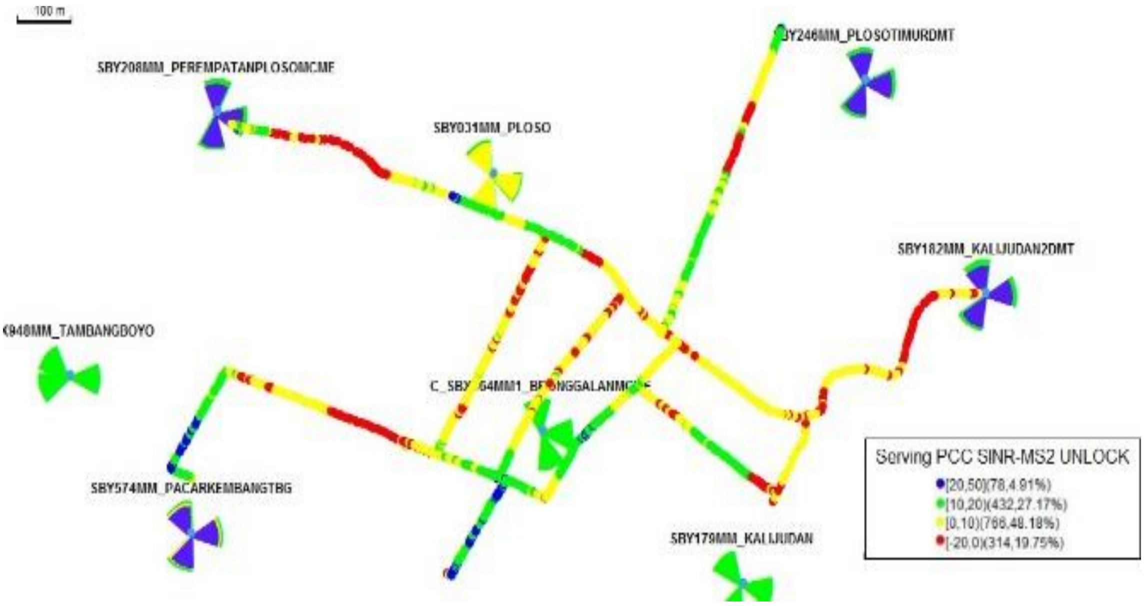

Figure 5. Distribution of existing network SINR

TABLE VII
PRESENTATION OF EXISTING NETWORK SINR VALUES

Range (dB)	Category	Colour	Sample	Percentage
20 to 50	Excellent		78	4.91%
10 to 25	Good		432	27.17%
0 to 10	Fair		766	48.18%
-20 to -10	Poor		314	19.75%

Based on Fig. 5, it can be seen that there are many bad spots that occur in SINR on the drive test route, so that optimization is needed. Percentage. In Table VII, 67.93% of SINR on the drive test route is in the bad category or still below the Telkomsel operator KPI standard (≥12 dB), so that optimization is needed.

3) Throughtput:

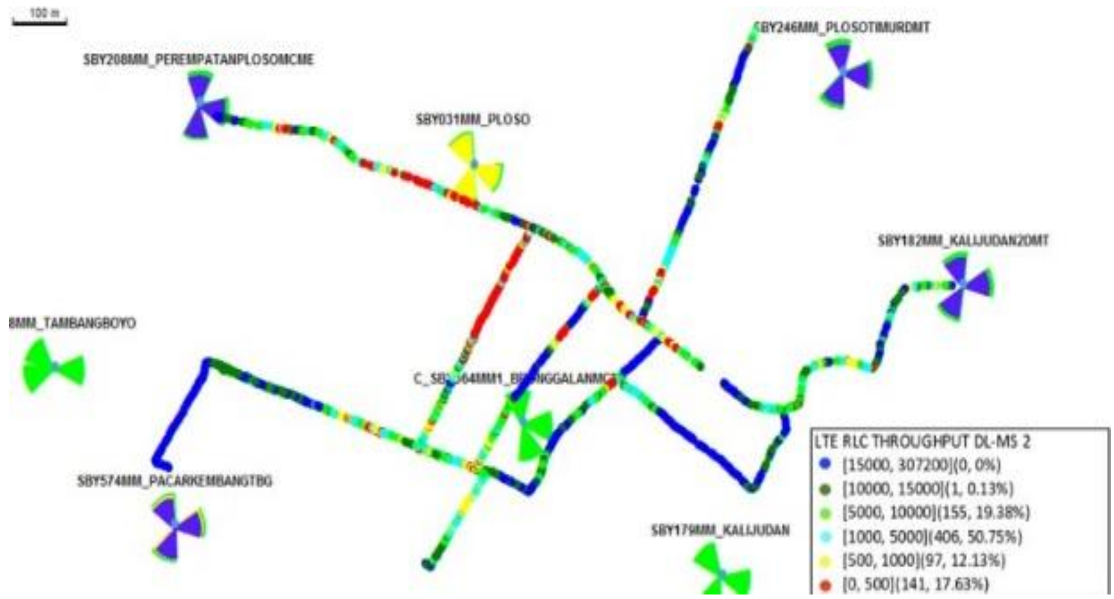

Figure 6. Distribution of existing network throughput

TABLE VIII
PRESENTATION OF EXISTING NETWORK RSRP VALUES

Range (Kbps)	Category	Colour	Sample	Percent age	Percentage By Category
10000 - 307200	Excellent		0	0%	0%
10000 - 10000	Good		1	0.13%	0.13%
5000 - 10000	Fair		155	19.3%	70.13%
1000 - 5000			406	50.75%	
500 - 1000	Bad		97	12.13%	29.75%
0 - 500			141	17.63%	

Based on Fig. 6, it can be seen that the distribution of Telkomsel operator's existing network throughput on the drive test route is uneven, so optimization is needed. In Table VIII, 80.51% of throughput sample points are still below the Telkomsel operator's KPI standard (throughput ≥ 6 Mbps). So optimization is needed to solve this problem.

D. Recapitulation of Existing Network Throughput

TABLE IX
RECAPITULATION OF AVERAGE VALUES OF OPTIMIZATION PARAMETERS

Parameter	Key Parameter Indicator (KPI)	Average Value
RSRP	> -90 dBm	-92.29 dBm
SINR	> 12 dB	9.01 dB
Throughput	> 6 Mbps	2674.47 Kbps

Based on the recapitulation of the average values of optimization parameters in table IX, it can be concluded that the cause of customer complaints in the area is because there are 3 optimization parameters that are still below the KPI standard of the Telkomsel operator. So, it is necessary to optimize so that the quality of the LTE network in Pacarkembang district is better and more evenly distributed.

E. Measurement Results and Analysis

Problem analysis based on drive test measurement results.

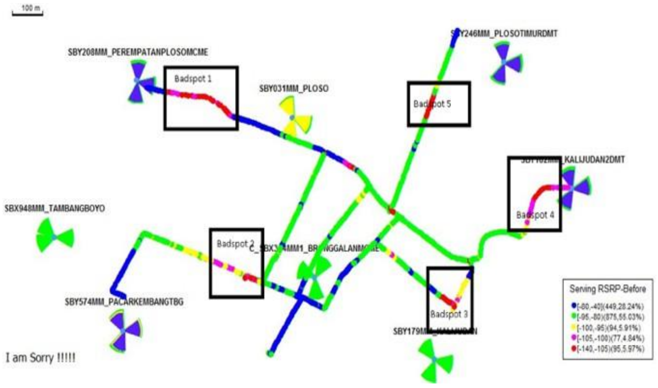

Figure 7. Optimization area based on bad spot coverage

After conducting a drive test, it was found that the performance of the Telkomsel operator network in the Pacarkembang Village area was in poor condition. Therefore, optimization needs to be carried out so that the network quality is good so that customers will not switch to other operators. To make it easier, the optimization area is divided into 5 parts along the drive test route in Pacarkembang Village.

The purpose of dividing the optimization area is to make it easier to classify problems that occur in the optimization area. In Fig.7, the RSRP value in areas 1 to 5 is still below -90 dBm, so optimization needs to be carried out in both areas.

1) Analysis Badspot Area 1:

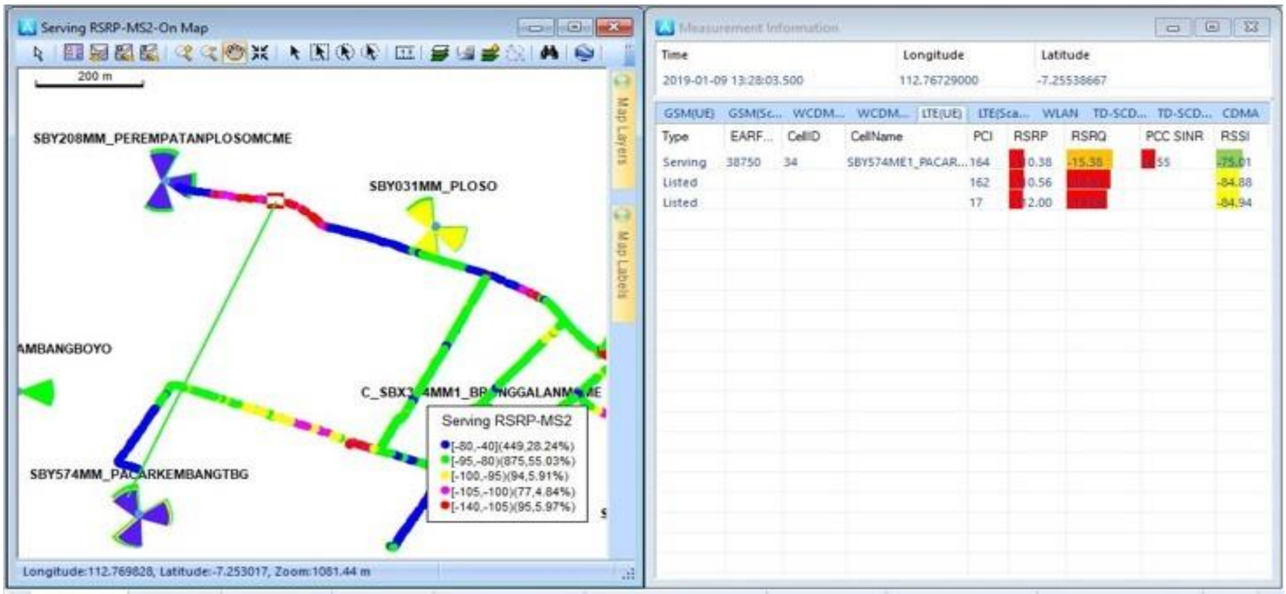

Figure 8. Spidergraph area 1

It can be seen that Bad Spot Area 1 has poor distribution, so optimization needs to be done in that area. To see the problems that occur in detail, a spidergraph plot is done on the bad spot, Area 1.

In Fig. 8, it can be seen that the SBY031_PLOSO- 3 site, which should serve Area 1, cannot reach it evenly. On the contrary, Area 1 is actually served more by the SBY574MM_PACARKEMBANGTBG-3 site, which is further away from the SBY031MM_PLOSO-3 site to Area 1. The potential distribution of traffic on the optimization route can be seen in Fig. 9.

Based on Fig. 9, it can be seen that bad coverage occurs because the SBX364_BRONGGALAN-3 site has an azimuth angle of 340°. While the 340° azimuth angle is more directed towards the residential area than the potential traffic area. The site SBY574_PACARKEMBANG-3 exceeded the range of

450 meters; the site was unable to reach the potential traffic area, resulting in overshoot by sidelobe sector 3 in area 1.

2) Analysis Badspot Area 2:

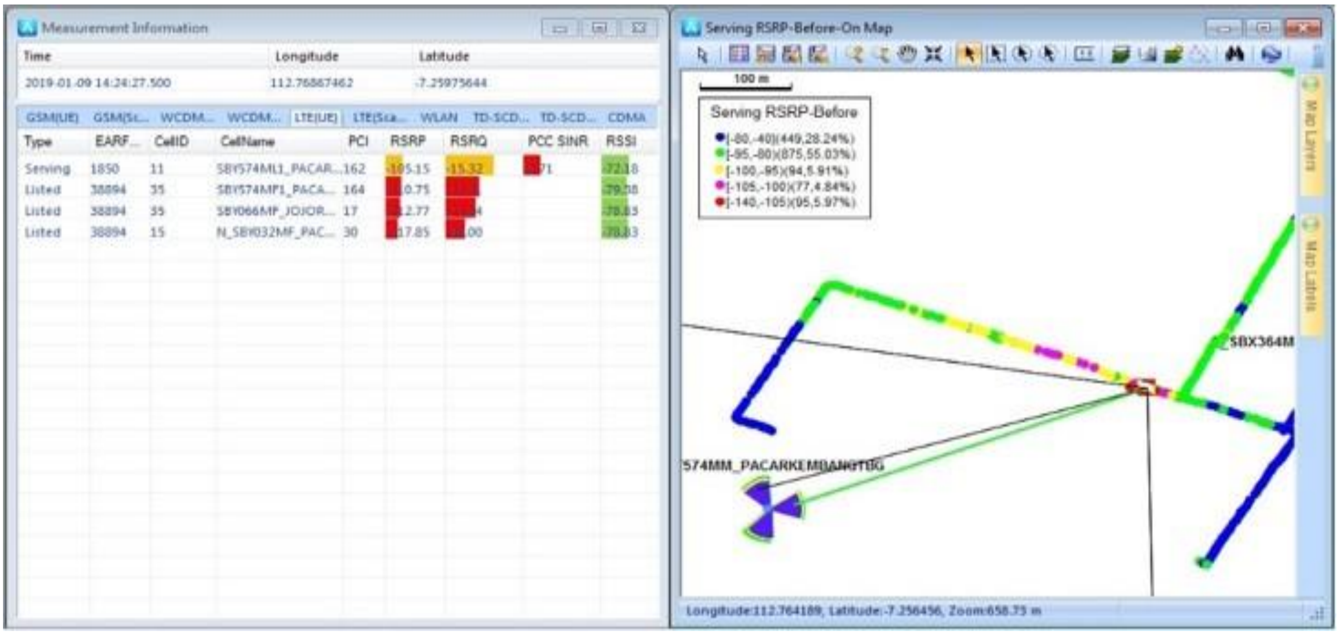

Figure 9. Spidergraph area 2

It can be seen that Bad spot Area 2 has a poor distribution, so optimization needs to be done in that area. In Fig. 9, it can be seen that site SBX364_BRONGGALAN- 3, which should serve area 2, cannot reach it. Even sites SBY574_PACARKEMBANG-1, SBY574_PACARKEMBANG-3, SBY032_PACARKELING 1, and SBY066_JOJORANME-3 also serve area 2, even though the distance is very far. Bad coverage occurs because there is no dominant serving pointing at bad spot area 2.

The distribution of potential traffic on the optimization route can be seen in Fig. 9. Based on Fig. 9, it can be seen that bad coverage occurs because there is no serving in cell SBX364_BRONGGALAN-3 that points directly at bad spot area 2. Even though Area 2 has high traffic potential. So that site SBY574_PACARKEMBANG-1 exceeded the range of 251 meters, the site was unable to reach the potential traffic area, resulting in no dominant serving, covered by sidelobe sector 1 in area 2.

3) Analysis Badspot Area 3:

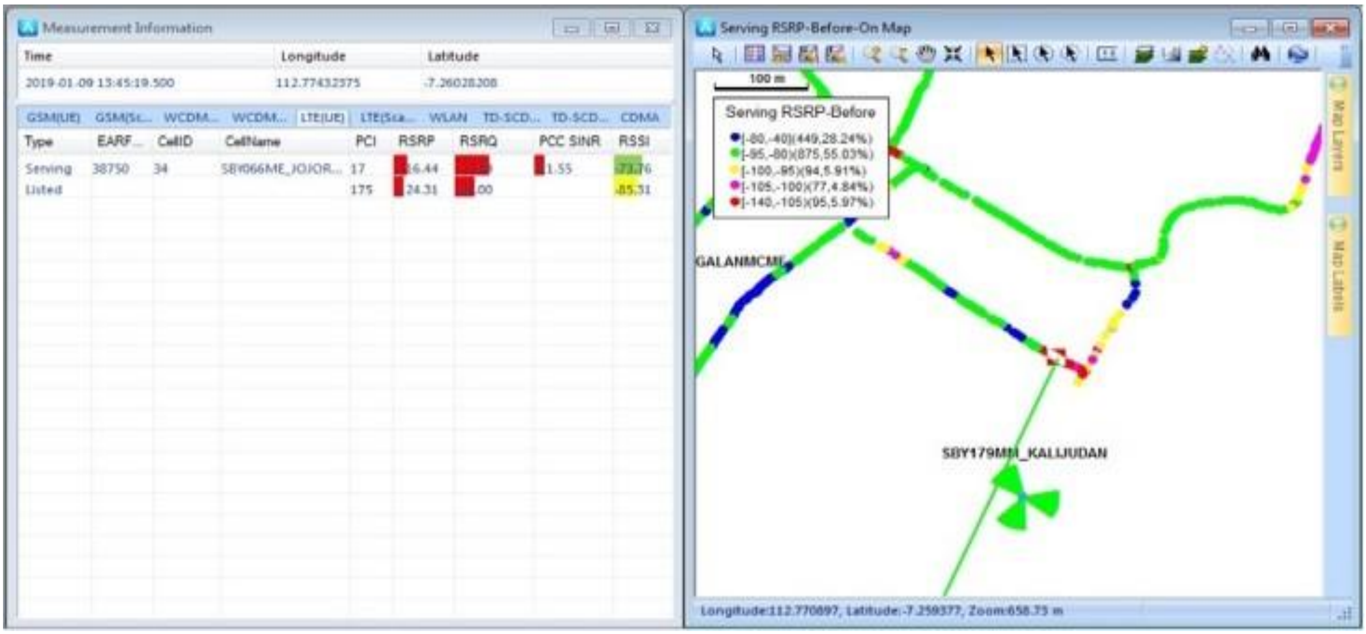

Figure 10. Spidergraph area 3

It can be seen that Bad spot Area 3 has a poor distribution, so optimization needs to be done in that area. In Fig. 10, it can be seen that site SBX364_BRONGGALAN- 2, which should serve area 3, cannot reach it evenly. Even site SBY066_JOJORAN-3 also serves area 3, even though the distance is very far. Bad coverage occurs because there is no serving cell to bad spot area 3. The distribution of potential traffic on the optimization route can be seen in Fig. 10.

Based on Fig. 10, it can be seen that bad coverage occurs because there is no serving in cell SBX364_BRONGGALAN-2 that points directly to bad spot area 3. Even though Area 3 has high traffic potential. So that site SBY066_JOJORAN-1, due to overshoot, is covered by sidelobe sector 1 with a distance around 345 m.

4) Analysis Badspot Area 4:

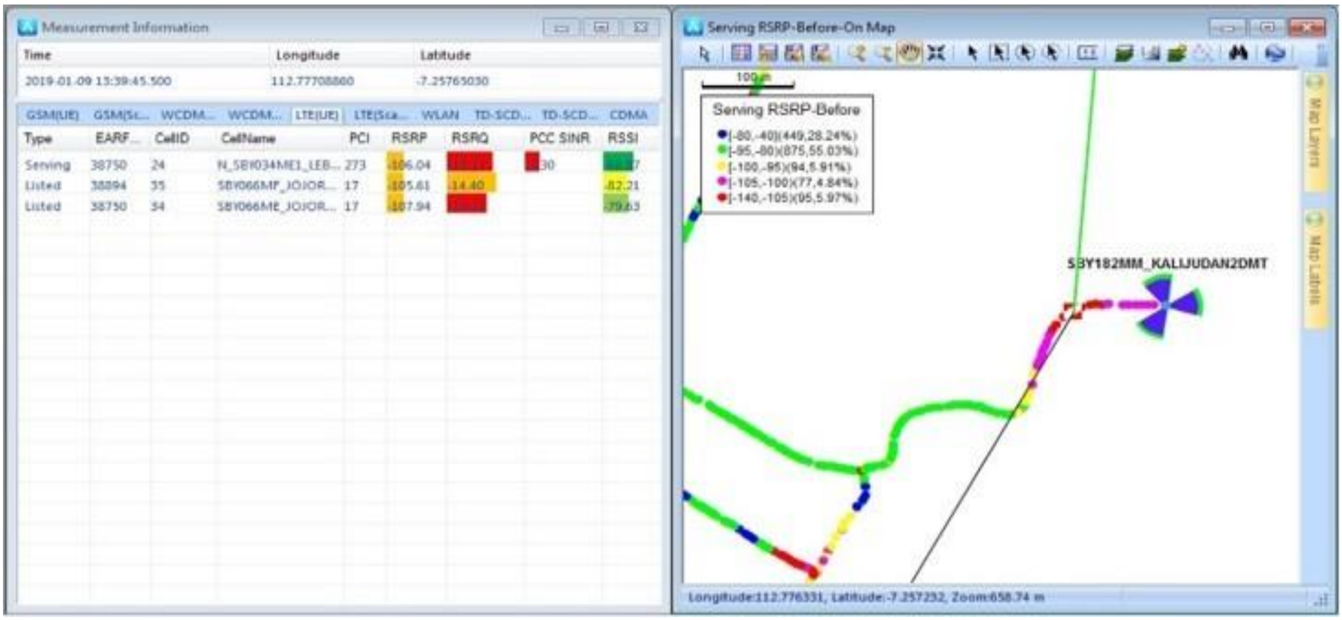

Figure 11. Spidergraph area 4

It can be seen that Bad spot Area 4 has a poor distribution, so optimization needs to be done in that area. In Fig. 11, it can be seen that site SBX364_BRONGGALAN- 2, which should serve area 4, cannot reach it evenly. Even sites SBY034_LEBAKJAYA-1 and SBY066ME_JOJORAN-3 also serve area 4, even though the distance is very far. Bad coverage occurs because there is no serving cell to bad spot area 4. The distribution of potential traffic on the optimization route can be seen in Fig. 11.

Based on Fig. 11, it can be seen that bad coverage occurs because there is no serving in cell site SBX364_BRONGGALAN-2 that points directly to bad spot area 4. Even though Area 4 has high traffic potential. So that site SBY034_LEBAKJAYA-1 No dominant serving, covered by sidelobe sector 1, with a distance of around 625 meters.

5) Analysis Badspot Area 5:

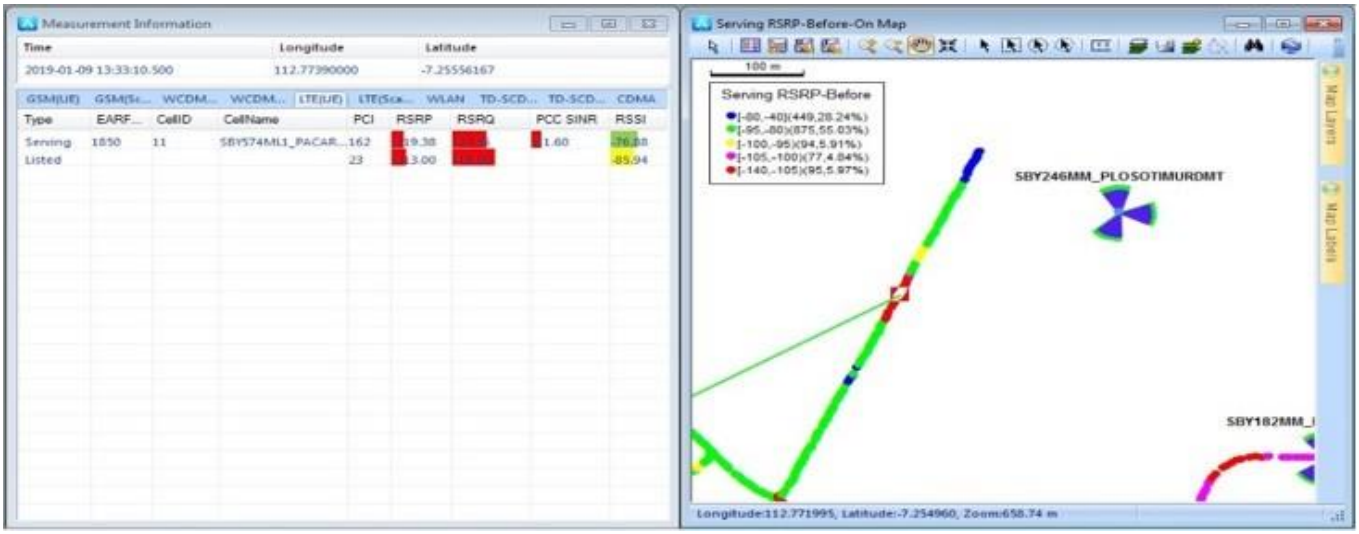

Figure 12. Spidergraph area 5

It can be seen that Bad spot Area 5 has poor distribution, so optimization needs to be done in that area.

In Fig. 12, it can be seen that site SBX364_BRONGGALAN- 1, which should serve area 5, cannot reach it evenly. Even site SBY574_PACARKEMBANG-1 also serves area 5, even though the distance is very far. Bad coverage occurs because there is no serving cell to bad spot area 5. The distribution of potential traffic on the optimization route can be seen in Fig.12.

Based on Fig. 12, it can be seen that bad coverage occurs because there is no serving in cell site SBX364_BRONGGALAN-1 that points directly to bad spot area 5. Even though Area 5 has high traffic potential. So that site SBY574_PACARKEMBANG-1 due to threshold is covered by sidelobe sector 1 with a distance around 442 m.

F. Drive Test Parameter Handover Measurement Results

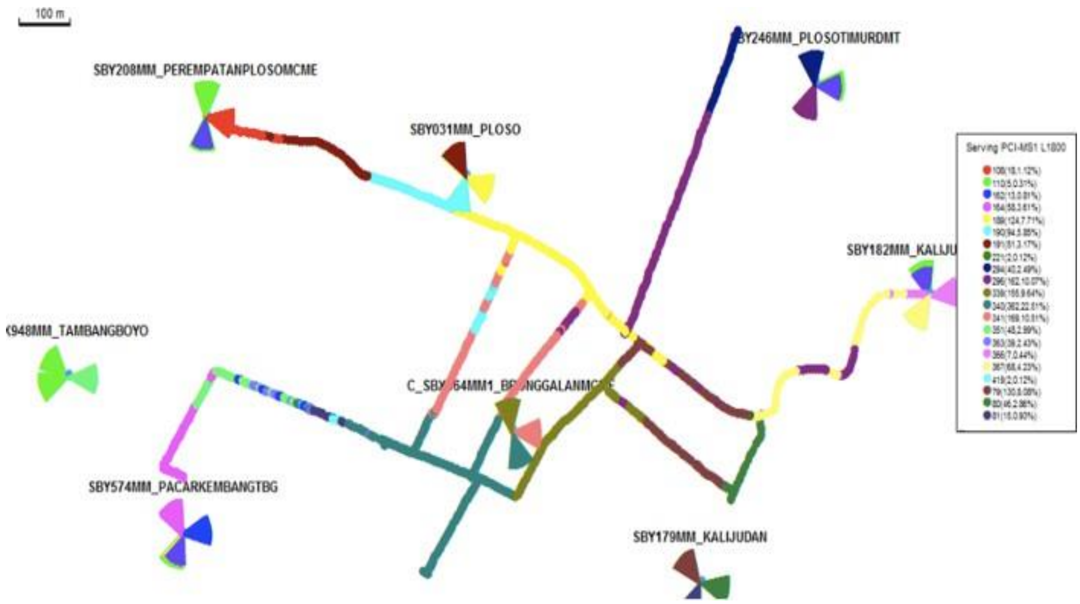

Figure 13. Drive test results handover parameters

TABLE X
DATASHEET LTE HANDOVER SUCCESS

NO	Longitude	Latitude	Date Time	LTEHandoverSucess_Lock
134	112.604.199	- 7.935505	2/15/19 13:25:05	LTEHandoverSucess
135	112.604.122	- 7.935528	2/15/19 13:25:06	LTEHandoverSucess
136	112.604.118	- 7.935579	2/15/19 13:25:08	LTEHandoverSucess
137	112.604.147	- 7.935575	2/15/19 13:25:13	LTEHandoverSucess
138	112.604.399	- 7.935550	2/15/19 13:25:23	LTEHandoverSucess
139	112.604.135	- 7.935542	2/15/19 13:25:29	LTEHandoverSucess
140	112.604.126	- 7.935589	2/15/19 13:25:31	LTEHandoverSucess
141	112.604.110	- 7.935575	2/15/19 13:25:40	LTEHandoverSucess
142	112.604.161	- 7.935596	2/15/19 13:25:05	LTEHandoverSucess
143	112.604.124	- 7.935568	2/15/19 13:25:06	LTEHandoverSucess
144	112.604.157	- 7.935541	2/15/19 13:25:08	LTEHandoverSucess
145	112.604.125	- 7.935542	2/15/19 13:25:13	LTEHandoverSucess
146	112.604.121	- 7.935530	2/15/19 13:25:23	LTEHandoverSucess
147	112.604.124	- 7.935510	2/15/19 13:25:29	LTEHandoverSucess
148	112.604.170	- 7.935550	2/15/19 13:25:31	LTEHandoverSucess
149	112.604.115	- 7.935507	2/15/19 13:25:40	LTEHandoverSucess
150	112.604.111	- 7.935528	2/15/19 13:25:05	LTEHandoverSucess
151	112.604.170	- 7.935553	2/15/19 13:25:06	LTEHandoverSucess
152	112.604.132	- 7.935506	2/15/19 13:25:08	LTEHandoverSucess
153	112.604.180	- 7.935513	2/15/19 13:25:13	LTEHandoverSucess
154	112.604.123	- 7.935549	2/15/19 13:25:23	LTEHandoverSucess
155	112.604.161	- 7.935509	2/15/19 13:25:29	LTEHandoverSucess
156	112.604.138	- 7.935545	2/15/19 13:25:31	LTEHandoverSucess
157	112.604.156	- 7.935507	2/15/19 13:25:40	LTEHandoverSucess
158	112.604.142	- 7.935520	2/15/19 13:25:05	LTEHandoverSucess

$$HOSR = \frac{\Sigma Handover\ success}{\Sigma Handover} \times 100\%$$
$$HOSR = \frac{158}{158} \times 100\%$$
$$HOSR = 1 \times 100\%$$
$$HOSR = 100\% \quad (3)$$

From the data obtained, because the quality of the RSRP and SINR that were measured were in very good condition and had a total percentage that met the KPI parameter requirements of the provider and vendor, it can be ascertained that the handover signal quality parameters also met the success requirements, which were 100% from the results of the drive test and calculations.

G. Optimization Recommendations and Execution

1) Recommendation and Execution of Optimization in Area 1:

Based on the analysis in area 1, it is known that bad coverage occurs because the distance of the SBX364_BRONGGALAN-3 site, which should serve area 1, is unable to reach more than 440 meters, resulting in no dominant service in area 1. Therefore, it is necessary to re- azimuth the SBX364_BRONGGALAN-3 site from azimuth 340 to 290 and downtilt from MT0 ET2 to MT1 ET2 so that the SBX364_BRONGGALAN-3 cell can reach area 1 more optimally.

2) Recommendation and Execution of Optimizing in Area 2:

Based on the analysis in area 2, it is known that bad coverage occurs because the distance of the SBX364_BRONGGALAN-2 site, which should serve area 2, is unable to reach more than 251 meters, resulting in no dominant service in area 2. Therefore, it is necessary to re- azimuth the SBX364_BRONGGALAN-2 site from azimuth 220 to 176 and downtilt from MT1 ET2 to MT2 ET2 so that the SBX364_BRONGGALAN-2 cell can reach area 2 more optimally.

3) Recommendation and Execution of Optimization in Area 3:

Based on the analysis in area 3, it is known that bad coverage occurs because the distance of the SBX364_BRONGGALAN-2 site, which should serve area 3, is unable to reach more than 345 meters, which results in no dominant service in area 3. So, it is necessary to re-azimuth the SBX364_BRONGGALAN-2 site from azimuth 220 to 176, downtilt from MT1 ET2 to MT2 ET2, and audit the SBY179_KALIJUDAN-2 site from azimuth 220 to 200, downtilt from MT2 ET2 to MT4 ET2. So that the SBX364_BRONGGALAN-2 cell can reach area 3 more optimally.

4) Recommendation and Execution of Optimization in Area 4:

Based on the analysis in area 4, it is known that bad coverage occurs because the distance of the SBX364_BRONGGALAN-1 site, which should serve area 4, is unable to reach more than 625 meters, resulting in no dominant service in area 4. Therefore, it is necessary to re-azimuth the SBX364_BRONGGALAN-1 site from azimuth 110 to 30. So that the SBX364_BRONGGALAN-1 cell can reach area 4 more optimally.

5) Recommendation and Execution of Optimization in Area 5:

Based on the analysis in area 5, it is known that bad coverage occurs because the distance of the SBX364_BRONGGALAN-1 site, which should serve area 5, is unable to reach more than 442 meters, resulting in no dominant service in area 5. Therefore, it is necessary so that the SBX364_BRONGGALAN-1 cell can reach area 5 more optimally. the SBX364_BRONGGALAN-1 site from azimuth 110 to 30. So that the SBX364_BRONGGALAN-1 cell can reach area 5 more optimally.

TABLE XI
IMPLEMENTATION CONFIGURATION ANTENNA SITE SBX364_BRONGGALAN_4G

Cell Name	Antenna Height	Antenna Direction (Before)	Antenna Direction (After)	Antenna Type	Mech Tilt (Before)	Mech Tilt (After)	Elect Tilt (Before)	Elect Tilt (After)	Total Tilt (Before)	Total Tilt (After)
SBX364_BRONGGALAN_1	20	110	30	AQUA4518R 21v06	2	2	2	2	4	4
SBX364_BRONGGALAN_2	20	220	176	AQUA4518R 21v06	1	2	2	2	3	4
SBX364_BRONGGALAN_3	20	340	290	AQUA4518R 21v06	0	1	2	2	2	3

In table XI, it can be seen that at the SBX364_BRONGGALAN site, sector 1, a re-azimuth of 80° was carried out from 110° to 30°; on mechanical tilting, it remains 2 to 2; on electrical tilting, it remains 2 to 2 so that the coverage area is wider. So that cell sector 1 can reach potential traffic areas 4 and 5.

In sector 2, a re-azimuth of 44° was carried out from 220° to 176° on mechanical tilting from 1 to 2, on electrical tilting it remains 2 to 2 so that the coverage area is wider. So that cell sector 2 can reach potential traffic areas 2 and 3.

In sector 3, a re-azimuth of 50° was carried out from 340° to 290° on mechanical tilting from 0 to 1, on electrical tilting it remains 2 to 2 so that the coverage area is wider. So that cell sector 3 can reach potential traffic area 1.

H. Final Results of Performance Analysis and Optimization

Based on table XII, it is known that the average RSRP value before optimization is -92.29 dBm, then after optimization it increases by 10.04% to -83.02 dBm. The SINR value before optimization is 8.86 dB, then after optimization it increases by 20.25% to 11.11dB. The throughput value has increased very significantly, where before optimization it was 2674.47 Kbps, then after optimization it increased by 251.01% to 6713 Kbps. Although the throughput is still below the KPI, it is still acceptable because the optimization is based on customer demand. This indicates that the optimization process has succeeded in improving the performance of the KPI parameters of the Telkomsel operator's LTE network in Pacarkembang village.

TABLE XII
AVERAGE VALUE OF KPI PARAMETERS BEFORE AND AFTER OPTIMIZATION

Parameter	KPI	Before	After	Improvement (%)
RSRP	≥ -90 dBm	-92.29 dBm	-83.02 dBm	10.04%
SINR	≥ 12 dB	8.86 dB	11.11 dB	20.25%
Throughput	≥ 6 Mbps	2674.47 Kbps	6713.13 Kbps	251.01%

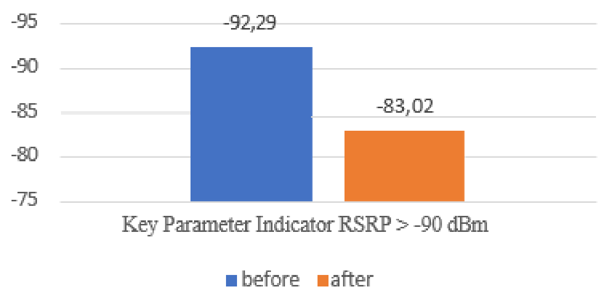

Figure 14. Comparison of RSRP before and after optimization

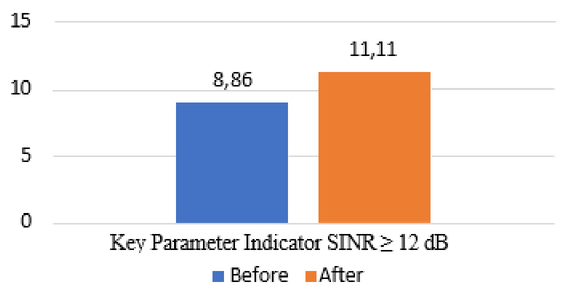

Figure 15. Comparison of SINR before and after optimization

IV. CONCLUSION

The distribution of RSRP 71.8% increased to 96.54% for the threshold value at -90 dB, while the SINR value also increased from 81.45% to 90.77% with the specified KPI target of at least 90% of SINR parameters above 12dB. Based on the calculation results using the KPI log sheet, the RSRP value was -89 dBm, while the drive test measurement results were -84 dBm at 100%, and the distribution of RSRP values was in the range of -92 dBm, which means very good. While the calculation results for the SINR parameters were 12 dB and the results during the drive test measurement obtained a value of 11.11 dB for a SINR value of 85% in the range of 10-15 dB, which means good. For handover measurements, it produces a HOSR of 100%, where in the range of 99%–100% it means very good. This difference is caused by site optimization and other unstable parameter activities that cause signal quality to increase compared to the site KPI value when the drive test is performed. Data retrieval with the Single Site Verification Method using Genex Probe software and logfile analysis with Genex Assistant software cannot display all complete handover parameters, but it can be concluded that if other signal parameters such as RSRP, SINR, Downlink, and Uplink are good, then the handover success rate will be high with a success rate exceeding 90%. Likewise with intra-frequency handover and inter-frequency handover. It can be concluded that the quality of the LTE network in the city of Surabaya, especially in the Bronggalan road area, is good, in accordance with the KPI standard obtained from the results of the drive test analysis, which has a value of -89 dBm. The percentage of power transmitted is 100%, with a download value of 33% more than 265 Mbps and an upload throughput value of 100% less than 265 Mbps.

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