Modeling and Analysis of Traffic Performance and Coverage of LTE Network with Automatic Cell Planning Method (Lowokwaru Subdistrict, Malang City)

Mohammad Miqdad Hasfhi A.[1], Aisah[2], Waluyo[3]
[1,2,3]Digital Telecommunication Network Study Program,
Department of Electrical Engineering, State Polytechnic of Malang, 65141, Indonesia
[1]hasfhi24@gmail.com,[2]aisah@polinema.ac.id,[3]waluyo@polinema.ac.id

***Abstract*— The growth of cellular network technology is very rapid, currently in generation 4 or Long Term Evolution (LTE), namely the development of the third generation. However, there is a problem in this case, namely that there are several cellular networks that are less than optimal considering the very high customer service needs from time to time. The purpose of this study was to improve the quality of performance of several cellular network parameters in the case study area in Lowokwaru District, Malang City. Based on the results that have been carried out by researchers, the results of the average RSRP value before optimization are -100.5 dBm after optimization to -85 dBm, for the average RSRP value before optimization is -10.67 dB after optimization to -6.78, for the SINR value before being optimized 7.6 after being optimized to 29.02 dB. The results value of traffic is 16 user points, the average value per user of downlink data before optimizing is 121 kbps to 128 kbps and the average value of uplink data throughput before optimization is 57.88 kbps 60, 93 kbps. The value of downlink voice throughput before being optimized was 7.16 kbps to 12.2 kbps and the average value of uplink voice throughput before being optimized was 6.43 kbps after being optimized to 12.8 kbps.**

Keywords—Automatic Cell Planning, Coverage, LTE traffic, Uplink and Downlink Throughput

I. INTRODUCTION

The growth of cellular technology is currently experiencing a very significant increase both in terms of the number of subscribers and traffic services since 2010 [1]. The current traffic growth is not accompanied by an increase in the increasingly limited frequency spectrum. To support customer demand for high Data Rate [2] as well as to maintain quality of service (QoS) [3] and quality of experience (QoE) [4] for customers as well as limited frequency spectrum, cellular operators need to improve network systems in order to serve The current increase in traffic is using 4G Long Term Evolution (LTE) technology [5].

Long Term Evolution (LTE) [5] is a name given to a project and the Third Generation Partnership Project (3GPP) to improve the 3rd generation (3G) mobile phone standard, namely UMTS WCDMA [6]. LTE is a development and previous technology, namely UMTS (3G) and HSPA (3.5G) where LTE is referred to as the 4th generation (4G) [7]. At UMTS the maximum data transfer speed is 2 Mbps [8], in HSPA the data transfer speed reaches 14 Mbps on the downlink side and 5.6 Mbps on the uplink side [9], in LTE this ability to provide speed in terms of data transfer can reach 100 Mbps on the downlink side and 50 Mbps on the uplink side. In addition, LTE is able to support all existing applications, both voice, data, video, and IPTV [10]. Determination of the coverage area of the 4G LTE network is very necessary so that users (users) can be served and for the telecommunication operator side, they can continue to improve their network quality [11].

On the other hand, the even distribution of signal coverage and traffic stability at several providers in several areas has not been maximized, for example on the Telkomsel network in the Lowokwaru District, Malang City. Many factors affect the poor quality of the network, including interference between cells that can affect other transmitters with different frequencies [12], the lack of a number of eNodeB sites [13] in the area which results in the area not being properly covered by the LTE network at the provider. Telkomsel [14]. According to data compiled by the Malangkota.bps.go.id page, the total population density reaches 17,084 [15] people due to several factors, one of which is the number of campuses. This study uses the Automatic Cell Planning approach to predict and analyze the performance of traffic and coverage on Long Term Evolution networks.

II. METHOD

A. Research Variable

1. Independent Variable

The independent variables in this study are coverage and traffic from the area to be studied. The research area is the District of Lowokwaru, Malang City with an average population per village of more than 1000 people.

2. Dependent variable

The dependent variables in this study are RSRP, RSRQ, SINR, Throughput.

3. Controlled Variable

The controlled variable in this study is the operator Telkomsel. How maximal is the quality of the network and data and voice traffic in the area under study.

B. Research Diagram Coverage Modelling with Automatic Cell Planning Method

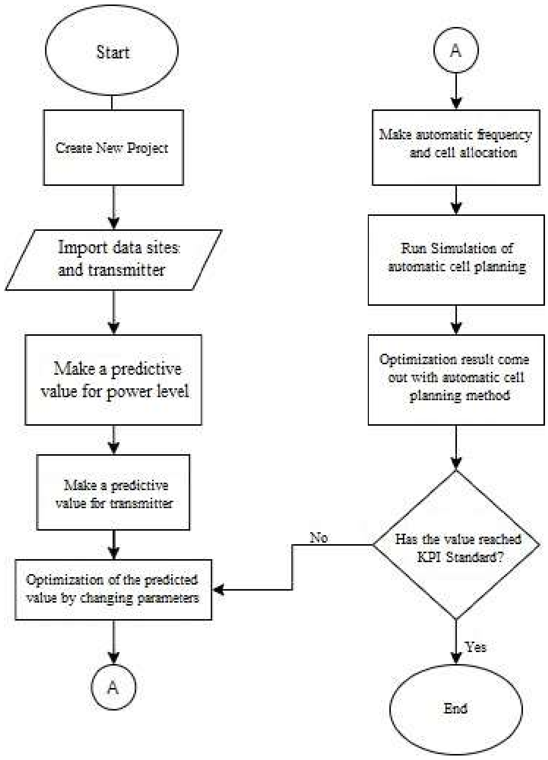


Figure 1. Coverage Modelling Diagram with Automatic Cell Planning Method

Fig. 1 is the modeling and coverage stages, with the following explanation:

1. Create a new project to start modeling the software.
2. Network configuration by adding several sites according to existing data in excel format that has been converted to txt format.
3. Make prediction values for coverage by transmitter and coverage by signal level before and after optimization.
4. Optimizing by adding sites and changing the azimuth angle on the transmitter tab.
5. Sets neighbor cell allocation automatically.
6. Plan to set the frequency manually or automatically.
7. Set up Automatic Cell Planning

C. Research Diagram Modelling and Traffic Simulation Modelling

Fig. 2 is a stage diagram of Traffic Modeling, with the following explanation:

1. Create a new project to start modeling the software.
2. Network configuration by adding several sites according to existing data in excel format that has been converted to txt format.
3. Make prediction values for coverage by transmitter and coverage by signal level before and after optimization.
4. Input tab by adding site and changing azimuth angle on transmitter tab.
5. Sets neighbor cell allocation automatically.
6. Input traffic parameters.
7. Select the predicted band and frequency.
8. Select a model from the pre-set smart antenna models.
9. Create a new simulation file for traffic.
10. Select the simulation file based on the type of traffic maps that have been set.
11. Analysis of the value results after running the simulation, if the value has not reached the specified KPI standard, the researcher repeats the modeling process.

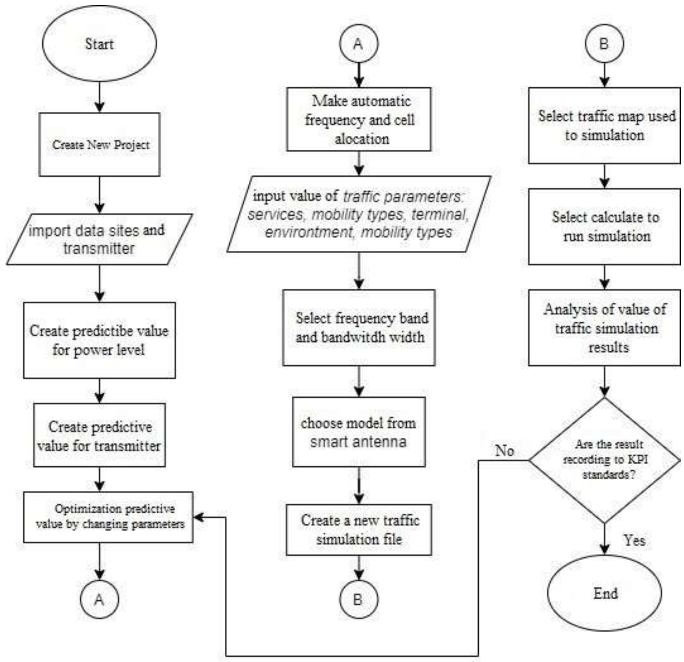


Figure 2. Modeling Flowchart and Traffic Simulation Modeling

III. RESULTS AND DISCUSSION

A. Results of Coverage Simulation Analysis and Optimization

This sub-chapter describes the value of the results that appear in the coverage optimization simulation on the Atoll software. With KPI standard reference values (SINR, RSRQ, RSRP, RS Coverage).

Zone	Prediction	Legend	Zone surface (km^2)	% of Covered Area	Surface (km^2)
-	**sebelum by Signal Level (DL) 0**		**-**	**100**	**2.295**
		Best Signal Level (dBm) >=-70	-	0.131	0.003
		Best Signal Level (dBm) >=-75	-	2.179	0.05
		Best Signal Level (dBm) >=-80	-	7.19	0.165
		Best Signal Level (dBm) >=-85	-	17.124	0.393
		Best Signal Level (dBm) >=-90	-	32.244	0.74
		Best Signal Level (dBm) >=-95	-	50.763	1.165
		Best Signal Level (dBm) >=-100	-	77.342	1.775
		Best Signal Level (dBm) >=-105	-	100	2.295

Figure 3. Reference Signal Coverage Before Optimization

1. Reference Signal Coverage

The Reference signal coverage value in the Lowokwaru area after the drive test shows results that are less than optimal, so optimization will be carried out with parameters according to Automatic Cell Planning. Fig. 3 explains that the area of the Lowokwaru zone under study is 2,295 km^2. From the signal coverage optimization data, the initial initial value is 86% after optimization to 91% as shown in Fig. 4.

Objective *LTE RS Coverage* (Coverage >= 90.0%)

	Evaluation Zone
Initial	86.39%
Final	91.92%
Improvement	***5.54%***
Objective	**ACHIEVED**

Figure 4. Optimization of Reference Signal Coverage

Change Order	Enable	Change Type	Name (Site/Tx/Cell)	Initial	Final	Quality Improvement
1	☑	Mechanical Tilt	Lowokwaru_5_1	3.00	0.00	71.01
2	☑	Mechanical Tilt	Lowokwaru_4_2	4.00	0.00	78.26
3	☑	Azimuth	Lowokwaru_6_3	270.00	290.00	84.30
4	☑	Mechanical Tilt	Lowokwaru_5_2	3.00	1.00	90.34
5	☑	Azimuth	Lowokwaru_7_3	240.00	225.00	95.17
6	☑	Mechanical Tilt	Lowokwaru_6_3	2.00	1.00	98.79
7	☑	Mechanical Tilt	Lowokwaru_4_1	4.00	0.00	100.00

Figure 5. Optimization Parameters by Automatic Cell Planning

Fig. 5 describes the parameters optimized by the Automatic Cell Planning site Lowokwaru_5_1 where there is a change in the mechanical tilt value from 3 to 0 and the quality improvement percentage value is 71%. The following is the result of the reference signal coverage value after being optimized.

Zone	Prediction	Legend	Zone surface (km²)	% of Covered Area	Surface (km²)
-	sesudah Coverage by Signal Level (DL) 0		-	100	2.325
		Best Signal Level (dBm) >=-70	-	8.731	0.203
		Best Signal Level (dBm) >=-75	-	48.387	1.125
		Best Signal Level (dBm) >=-80	-	82.796	1.925
		Best Signal Level (dBm) >=-85	-	92.602	2.153
		Best Signal Level (dBm) >=-90	-	98.925	2.3
		Best Signal Level (dBm) >=-95	-	100	2.325
		Best Signal Level (dBm) >=-100	-	100	2.325
		Best Signal Level (dBm) >=-105	-	100	2.325

Figure 6. General Report Coverage Signal Level

TABLE I
REFERENCE SIGNAL COVERAGE BEFORE AND AFTER OPTIMIZATION

Level signal value	Area before optimization (%)	Area before optimization (km2)	Area after optimization (%)	Area after optimization (km2)
Amount	100	2.295	100	2.325
-70	0.131	0.131	8,731	0.203
-75	2.179	2.179	48,387	1.125
-80	7.19	7.19	82.796	1,925
-85	17,124	17,124	92.602	2,153
-90	32.244	32.244	98.925	2.3
-95	50,763	50,763	100	2.325
-100	77.342	77.342	100	2.325
-105	100	100	100	2.325

Fig. 6 shows that after optimization with the addition of the site and the Automatic Cell Planning system, the area becomes 2,325 km^2. This means that there is an additional coverage area of 300 meters^2 in the Lowokwaru area. The value of the signal level coverage is also getting better, for example for the best value, which is -70 dBm before optimizing the area of 0.030 km^2 after being optimized to 0.203 km^2. This proves that the addition of sites and changes in parameters by Automatic Cell Planning have quite an effect on coverage. The results of the reference signal coverage before and after optimization are described in Table 1.

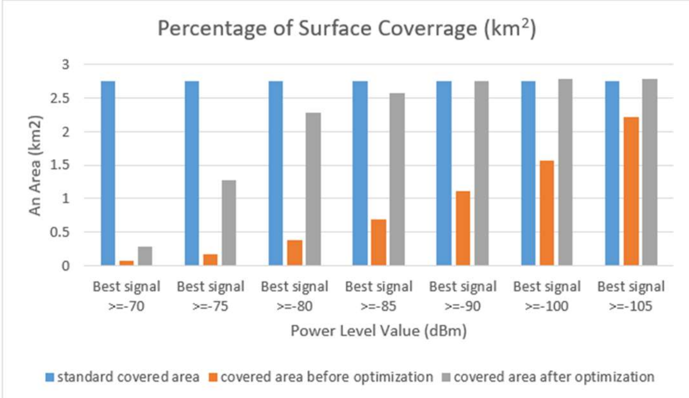


Figure 7. Graph of Surface LTE Network Coverage Percentage Before and After Optimization

Fig. 7 is a comparison graph of the total area value covered by the signal. The comparison of the before and after image values can be seen from the surface value and the percentage covered area (covered area).

2. RSRP

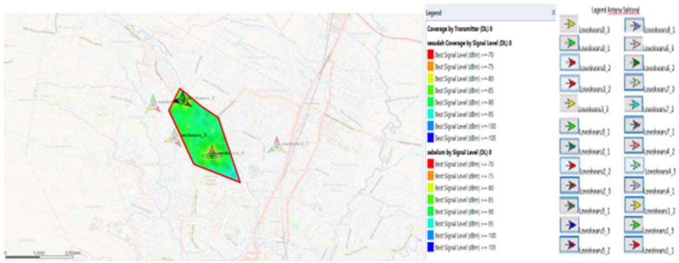


Figure 8. Result of the existing Telkomsel site RSRP value

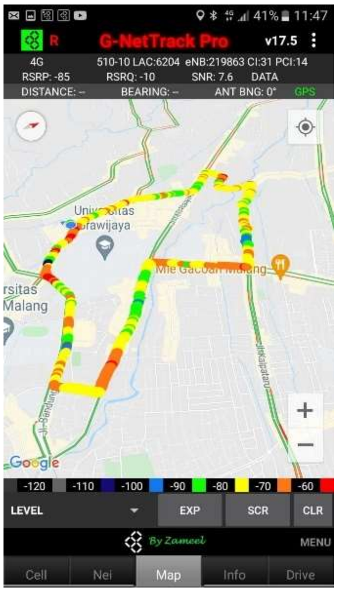


Figure 9. RSRP results display on G-NetTrack Pro application

Fig. 8 displays the results of the RSRP site for the existing eNodeB operator Telkomsel in the Lowokwaru area which is still active, and the coverage point for the Lowokwaru area. Fig. 9 displays the RSRP results on the G-NetTrack Pro test drive software, where red is worth -60 which means very good, green is worth -90 means pretty good and dark color is worth it -100 to -120 means very poor RSRP quality. Therefore, the researcher aims to optimize the RSRP value with the Automatic Cell Planning method.

Fig. 10 shows the optimized parameters, at the Lowokwaru_6_3 site there is a change in the azimuth angle at the transmitter, from 270 degrees to 290 degrees and the quality improvement or percentage of optimization quality is 84.30%.

Change Order	Enable	Change Type	Name (Site/Tx/Cell)	Initial	Final	Quality Improvement
1	☑	Mechanical Tilt	Lowokwaru_5_1	3.00	0.00	71.01
2	☑	Mechanical Tilt	Lowokwaru_4_2	4.00	0.00	78.26
3	☑	Azimuth	Lowokwaru_6_3	270.00	290.00	84.30
4	☑	Mechanical Tilt	Lowokwaru_5_2	3.00	1.00	90.34
5	☑	Azimuth	Lowokwaru_7_3	240.00	225.00	95.17
6	☑	Mechanical Tilt	Lowokwaru_6_3	2.00	1.00	98.79
7	☑	Mechanical Tilt	Lowokwaru_4_1	4.00	0.00	100.00

Figure 10. Automatic Cell Planning Optimization Parameters

Duration of optimisation: 0.75 s

Objective *LTE RSRP* (Coverage >= 90.0%)

	Evaluation Zone
Initial	90.86%
Final	96.65%
Improvement	***5.79%***
Objective	**ACHIEVED**

Figure 11. Optimization Percentage Value of RSRP

Fig. 11 shows the percentage value of RSRP's objectivity to coverage, before being optimized it was 90.86%, after being optimized it was 96.65%. There is a change of ±6% the better the coverage of the RSRQ value in the Lowokwaru area.

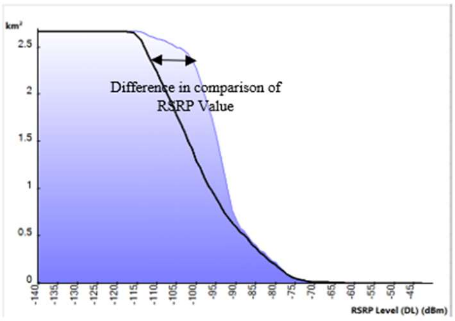


Figure 12. Histogram Graph of Comparison of RSRP Values Before and After Optimization

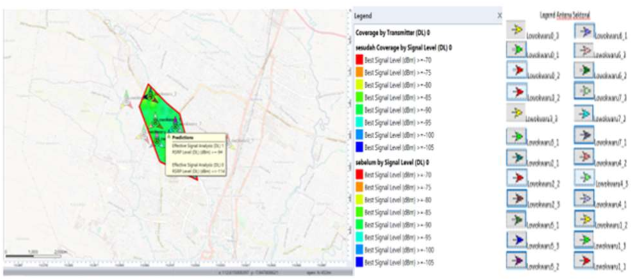


Figure 13. Result of RSRP Value After Optimization

Fig. 13 shows the results of optimizing the signal level above in the Automatic Cell Planning method to expand LTE signal coverage in the Lowokwaru area. The Automatic Cell Planning method automatically shows the optimal sample value from the previous RSRP value of -101 to -95. This shows the effect of adding sites and the Automatic Cell Planning Technique which is quite effective in optimizing.

TABLE II
RSRP OPTIMIZATION VALUE

No. User	Longitude	Latitude	RSRP Before Optimization (dBm)	RSRP After Optimization (dBm)
*User*1	112.617430037	-7.950123018	-105	-90
*User*2	112.616455832	-7.946853573	-105	-85
*User*3	112.61676361	-7.944383885	-100	-75
*User*4	112.61412435	-7.944394141	-95	-80
*User*5	112.618066762	-7.950590727	-95	-70
*User*6	112.616791362	-7.951472775	-100	-80
*User*7	112.615916302	-7.952678779	-100	-75
*User*8	112.619835694	-7.952979982	-95	-75
*User*9	112.621186752	-7.950578562	-95	-75
*User*10	112.621112972	-7.952577147	-105	-80
User 11	112.62177825	-7.9579999789	-100	-80
User 12	112.619136389	-7.957368117	-95	-75
User 13	112.618255368	-7.95705508	-105	-80
User 14	112.62257857	-7.958548226	-95	-75
User 15	112.623629156	-7.960461033	-100	-80
User 16	112.615615711	-7.956983984	-95	-75

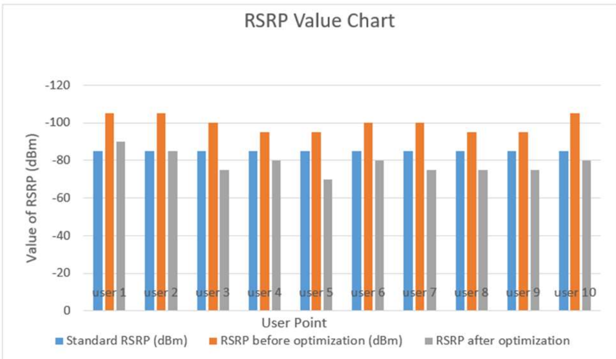


Figure 14. RSRP Graph Before and After Optimization

Fig. 14 is a graph of the RSRP value optimized by the Automatic Cell Planning method. The 10 users who are actively connected to perform network service activities, the results reach an average value of -100.5 dBm while the standard KPI value for the RSRP value is -85 dBm. This means that the RSRP value in optimization with the Automatic Cell Planning method is better than the average value obtained from the drive test after optimization by adding sites and changing azimuth.

3. RSRQ

Fig. 15 shows which parameters are optimized, for example on the Lowokwaru_4_1 site there is a change in the mechanical tilt value at the transmitter, originally 2 degrees to 1 degree and quality improvement or optimization quality percentage is 100%.

Change Order	Enable	Change Type	Name (Site/Tx/Cell)	Initial	Final	Quality Improvement
1	☑	Mechanical Tilt	Lowokwaru_5_1	3.00	0.00	71.01
2	☑	Mechanical Tilt	Lowokwaru_4_2	4.00	0.00	78.26
3	☑	Azimuth	Lowokwaru_6_3	270.00	290.00	84.30
4	☑	Mechanical Tilt	Lowokwaru_5_2	3.00	1.00	90.34
5	☑	Azimuth	Lowokwaru_7_3	240.00	225.00	95.17
6	☑	Mechanical Tilt	Lowokwaru_6_3	2.00	1.00	98.79
7	☑	Mechanical Tilt	Lowokwaru_4_1	4.00	0.00	100.00

Figure 15. Optimization Parameters by Automatic Cell Planning

Objective *LTE RSRQ* (Coverage >= 95.0%)

	Evaluation Zone
Initial	99.67%
Final	100.00%
Improvement	*0.33%*
Objective	ACHIEVED

Figure 16. Optimization Percentage Value of RSRQ

Fig. 16 is the result of optimizing the RSRQ value using Automatic Cell Planning (ACP) on Atoll. The difference between the two values does not change much, in the initial it explains the percentage of objectivity of the RSRQ value before optimization with the ACP method, in the final explains the results after optimization, and improvement explains the percentage of improvement. Figure 4. 13 produces objectivity of 99.67% which has not changed before. Then after being optimized, it has a percentage of 100% with a percentage improvement of 0.38%. This shows that changes in the antenna tilting value, the addition of new sectors and changing the azimuth angle affect the percentage of RSRQ objectivity values.

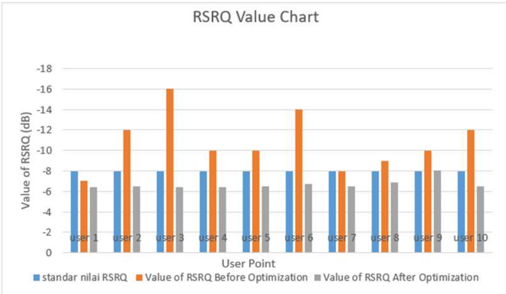


Figure 17. Graph of RSRQ Value

Fig. 17 shows a comparison of the percentage of RSRQ values. From the results of the driving test that has been optimized with the Atoll software. Referring to the KPI standard, a good RSRQ value is -15 dbm to 0 dbm and the average result before optimization is -10.67 after optimization which is -6.78 dbm. This is because the situation outside the power interference and the serving cell power is more real. While the comparison of site data simulation with site data that has gone through optimization in the form of site additions, tilting changes and azimuth angles has a difference of -0.22%.

4. SINR

Objective *LTE RS CINR* (Max)

	Evaluation Zone
Initial	96.10%
Final	100.00%
Improvement	*3.90%*

Figure 18. Percentage of Optimization of SINR Value

Fig. 18 shows the comparison of the results of the Noise to Ratio Signal values above between the existing data and after being optimized with the Automatic Cell Planning method, it is 3.90% different. The percentage value before being optimized is 91.58% and the value after being optimized is 100%. The average SINR value before optimization was 7.6 dB, after being optimized it became 29.02 dB. Changes in this value indicate the effect of adding sites and some parameter changes by the Automatic Cell Planning method greatly affect the quality of SINR.

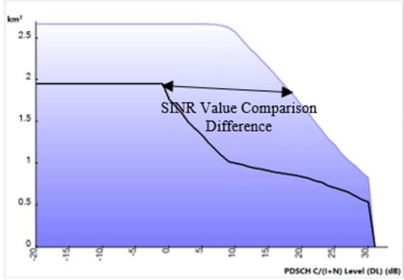


Figure 19. Histogram Graph of Comparison of SINR Values Before and After Optimization

B. Traffic Analysis and Modelling Results

This sub-chapter describes the result values that appear in the traffic simulation on the Atoll software. With KPI values taken according to standards from the Atoll software.

1. Statistics tab

The cumulative value before and after throughput optimization of each type of service. The following explains the value of mobile internet access throughput. This indicates a change from the ACP optimization method.

Mobile Internet Access:
Users: 16 (100%)
Active: Downlink: 0 Uplink: 0 Downlink + Uplink: 16
Inactive: 0
DL:
Peak RLC Cumulated Throughput (DL): 2.05 Mbps
Effective RLC Cumulated Throughput (DL): 2.05 Mbps
Cumulated Application Throughput (DL): 1.95 Mbps
UL:
Peak RLC Cumulated Throughput (UL): 988.01 kbps
Effective RLC Cumulated Throughput (UL): 974.87 kbps
Cumulated Application Throughput (UL): 926.12 kbps

Figure 20. Mobile Internet Access Statistics Tab Graph

Fig. 20 shows the results of the modeling values in the traffic simulation. The accumulated throughput value of mobile internet access downlink users is 1.95 Mbps, while after optimization it is 2.05 Mbps. The throughput value of mobile internet access uplink users before being optimized was 926.12 kbps, after being optimized it became 974.87 kbps.

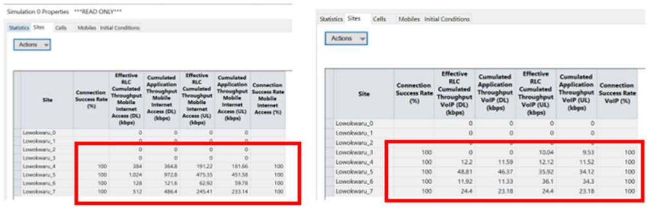
VoIP:
Users: 16 (100%)
Active: Downlink: 4 Uplink: 6 Downlink + Uplink: 4
Inactive: 2
DL:
Peak RLC Cumulated Throughput (DL): 97.6 kbps
Effective RLC Cumulated Throughput (DL): 97.32 kbps
Cumulated Application Throughput (DL): 92.46 kbps
UL:
Peak RLC Cumulated Throughput (UL): 122 kbps
Effective RLC Cumulated Throughput (UL): 118.56 kbps
Cumulated Application Throughput (UL): 112.65 kbps

Figure 21. Statistics Tab Display on Atoll

Fig. 21 shows the cumulative value of VoIP uplink user throughput before being optimized at 112.65 kbps, after being optimized to 118.65 kbps. The cumulative value of VoIP downlink user throughput before optimization is 92.46 kbps, after optimization is 97.32 kbps. Users who are active on uplink, downlink, uplink, and downlink are 100%.

2. Site Tab

The throughput value at each site is modeled using the automatic cell planning method.



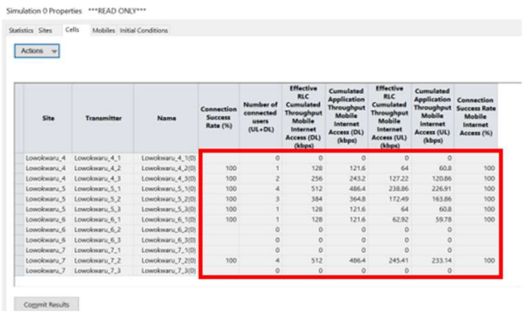
(a) (b)

Figure 22. Mobile Internet Access (a) VoIP (b) Site Tab Display on Atoll

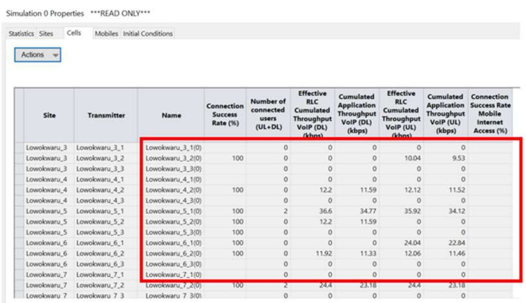
Fig. 22 explains the throughput value at each site connected to the user, for example on the Lowokwaru_5 site the throughput value of mobile internet access downlink is 972.8 kbps, after optimization it becomes 1024 kbps, while the throughput of mobile internet access uplink before optimization is 451.58 kbps after being optimized to 475.35 kbps. The throughput value of VoIP uplink before being optimized is 34.12 kbps after being optimized to 36 kbps, while the throughput value of VoIP downlink before being optimized is 46.37 kbps, after being optimized it becomes 48.81 kbps. This happens because of the influence of the addition of the site and changes in the azimuth angle. For outside the red mark is a value of 0 which means it is not included in the test drive zone.

3. Cells tab

The cells tab explains the throughput value for each cell in the modeling using the automatic cell planning method.



(a)



(b)

Figure 23. Cells Mobiles Internet Access Tab Display (a) VoIP (b) In Software Atoll

Fig. 23 (a) describes the display of the throughput value of each cell or transmitter and the number of users connected to the transmitter. For example, at the Lowokwaru_5 site at transmitter 5_2, the throughput value of mobile internet access downlink before optimization is 364 kbps, after optimization the effective value becomes 384 kbps, the throughput value of mobile internet access uplink before optimization is 163.86 kbps after being optimized to 172.49 kbps. Figure 4. 25 (b) describes the throughput value of VoIP downlink before optimization of 34.77 after being optimized to 36.6 kbps. This is due to the addition of sites and changes in the azimuth angle. The number of users connected to the Lowokwaru 5_2 transmitter is 1 user, and the connection success rate is 100%.

4. Traffic Simulation

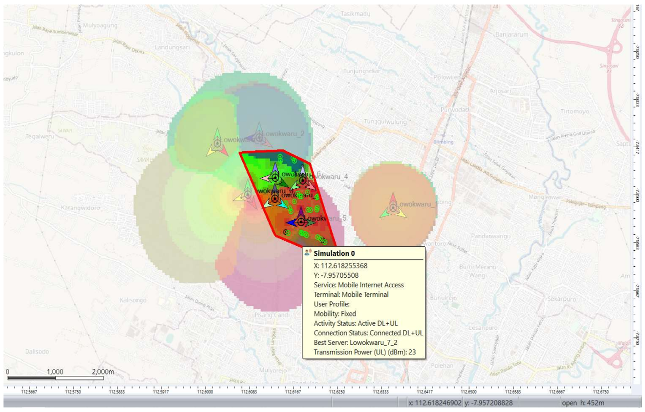


Figure 24. Traffic Simulation Display

Fig. 24 shows the traffic simulation after it is calculated or executed. The output values include information on the coordinates of the user's longitude and latitude, type of service, type of terminal, type of mobility types, activity status on downlink and uplink, connection status on downlink and uplink, best server information for transmitter connected to the user, and transmission power.

IV. CONCLUSION

The use of automatic cell planning methods is very effective for modeling and optimizing traffic and coverage. Based on the results that have been carried out by researchers, the value of the reference signal coverage as a whole before being optimized is 2,295 km^2, after being optimized to 2,325 km^2, it means that there is an additional coverage of 30 m2 and there is additional coverage at the best signal level value, namely -70 from 0.3 km^2 to 8 ,7 km^2 means that there is an increase in signal coverage of 8.4 km2. The results of the average RSRP value before optimization are -100.5 dBm after optimization to -85 dBm, for the average RSRQ value before optimization is -10.67 dB after optimization to -6.78, for the SINR value before optimization is 7, 6 after being optimized to 29.02 dB. The traffic simulation value after modeling with Atoll software shows quite effective results. Two types of throughput optimization values are taken, namely data and voice. Of the 16 user points, the average value per user of downlink data throughput before optimization was 121 kbps to 128 kbps and the average value of uplink data throughput before optimization was 57.88 kbps from the standard 60.93 kbps. The value of downlink voice throughput before being optimized was 7.16 kbps to 12.2 kbps and the average value of uplink voice throughput before being optimized was 6.43 kbps after being optimized to 12.8 kbps. The average value per user of downlink data throughput before optimization was 121 kbps to 128 kbps and the average value of uplink data throughput before optimization was 57.88 kbps from the standard 60, 93 kbps. The value of downlink voice throughput before being optimized was 7.16 kbps to 12.2 kbps and the average value of uplink voice throughput before being optimized was 6.43 kbps after being optimized to 12.8 kbps. The average value per user of downlink data throughput before optimization was 121 kbps to 128 kbps and the average value of uplink data throughput before optimization was 57.88 kbps from the standard 60, 93 kbps. The value of downlink voice throughput before being optimized was 7.16 kbps to 12.2 kbps and the average value of uplink voice throughput before being optimized was 6.43 kbps after being optimized to 12.8 kbps.

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Suggestions for further research can be to conduct research on a wider coverage area, perform network analysis with other methods, conduct traffic optimization and coverage modeling with other software.

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