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Automatic Cell Planning Method for Radio Network Optimization

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***Abstract*— As the first step in building a wireless communication network, wireless network optimization is crucial since it determines how the network will be built scientifically. Numerous challenges remain in the way of the Radio Network's deployment in Indonesia, not the least of which is the still-uneven coverage region. The Kiaracondong region in Bandung is one of the numerous areas in Indonesia that are still considered to be "bad spot areas" as a result. Based on the findings of the driving test conducted in the Kiaracondong sub-district, the KPI target was not fulfilled for the RSRP, SINR, and Throughput parameters. Therefore, this study primarily focuses on the physical tuning optimization using the Automatic Cell Planning (ACP) method for the LTE wireless network optimization. To assess the quality of the LTE network before and after optimization, the results of the ACP optimization simulation will be compared with the results of the existing or non-ACP site simulation and the results of the operator's ACP implementation. As a result, Area 1 has an average RSRP of -72.79 dBm, area 2 -73.17 dBm, and area 3 -68.22 dBm. Additionally, the average SINR in areas 1,2 and 3 is 8 dB, 6.58 dB, and 8.17 dB, respectively. The average downlink throughput in area 1 is 42652.66 Kbps, area 2 is 34420.88 Kbps, and area 3 is 43882.92 Kbps. Finally, the average throughput uplink for areas 1 to 3 is 51651.24 Kbps, 47895.99 Kbps, and 49648.84 Kbps, respectively.**

***Keywords*— LTE network; optimization; ACP; KPI parameter; Bandung.**

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I. INTRODUCTION

Wireless information transmission networks are currently one of the primary directions of information and communication growth. Long Term Evolution (LTE) is a universal city network standard that provides cellular broadband access to various applications [1], from classic voice transmission to current multimedia applications. Through the IP protocol, the LTE network connects users to multiple services and internet access [2]. All LTE network nodes are often classified into two types: the radio access network is tied to the nodes, and the nodes form the core network [3]. The algorithms and procedures utilized to transport data between base stations (eNB) and mobile user terminals (UE) are critical components that define the efficacy of any radio network [4].

According to [5], wireless network optimization is crucial in building a wireless communication network and determines if it will be a scientific activity. This paper focuses on the method and content of the LTE wireless network optimization, mainly involved in the planning process and critical technologies of the LTE wireless network. The study by [6] included PCI, Cells, RS, CN, and RSCRSRP. Then, use Automatic Cell Planning (ACP) to validate the method scientifically.

Automatic Cell Planning is an Atoll feature used to simplify the planning and optimization process. Atoll incorporates multi-technology on the ACP module; this ACP module is implemented as a function integrated into the Atoll interface. ACP modules are available for GSM, UMTS, LTE, CDMA WIMAX, and Wi-Fi. The ACP module also supports a mix of technologies to optimize GSM/UMTS/LTE and CDMA/LTE networks and supports HetNets and small cells [7]. The ACP module can be used in existing networks or at the start of planning. In existing networks, it is very efficient to focus on tuning parameters that are easy to do remotely [8].

A driving test has been conducted using the Covmo platform, which Telkomsel operators utilize to execute a virtual drive test while monitoring the RSRP, SINR, and metrics Throughput. The operator's KPI target for coverage, which is a minimum of 95%⩾ - 100 dBm, was not met by the RSRP value of 90.84%, the SINR value of 77.24%, which did not satisfy the KPI target for quality of 85% ⩾ 0 dB, and the throughput value of 86.81%, which did not satisfy the KPI target of 90%⩾ 3 Mbps. The Radio Frequency parameter value derived from these data is still unfavorable for Telkomsel services. Poor coverage and inconsistent signal quality are the reasons for this [9]. This low coverage can be attributed to overshot because of obstructions like the tall buildings in the Kiaracondong subdistrict. Still, it can also be the consequence of incorrect antenna direction, a cell's beam direction being too broad, and other factors [10]. In addition, the distance between sites is adjacent, resulting in the occurrence of pollutants that cause the quality of receiving power subscribers to decrease, resulting in a decrease in the value of RSRP, SINR, and Throughput. Telkomsel operator, as one of the network service providers in the region, is expected to be able to provide maximum service to users. Service providers can take several steps to improve network quality, one of which is to optimize physical tuning. Physical tuning can improve quality caused by coverage problems. Method the optimization used is the Automatic Cell Planning (ACP) method by changing antenna parameters such as altitude, tilting, and azimuth of the antenna to improve and increase the range of coverage in the region [11].

In earlier studies by [12], optimization is explored to increase the coverage area and enhance the UMTS network. Optimization is done by changing the azimuth and tilting of sectoral antennas to improve the network quality of UMTS. The optimization method uses the ACP method and Unautomated Planning [13]. Then, 4G LTE microcell network planning is optimized using the ACP method where the optimization results obtained are better using the ACP method than with non-ACP [14]. These two studies show that the ACP method can increase the coverage and quality of LTE networks.

Therefore, this article presents the optimization stage begins by conducting a virtual test drive on the area that has been determined using the Covmo platform and drive tests on an ongoing basis in place using the Nemo Handy software using all carrier LTE frequencies Telkomsel namely 900 MHz, 1800 MHz, 2100 MHz, and 2300 MHz. Then, the optimization results using the ACP technique and the outcomes of ACP implementation will be compared with the data collection from the existing site, which is the simulation result of the existing site data or non-ACP. Non-ACP simulations and physical tuning optimizations were performed using Forsk Atoll 3.3.0 Software. The observed parameter optimization is RSRP, SINR, and Throughput using 1800 MHz frequency. This optimization can improve performance in the observation area.

The remaining part of the paper is arranged accordingly: section 2 discusses the role and stages of the ACP method for optimizing LTE networks. Section 3 discusses the results and discussion obtained. Section 4 discusses the conclusions and future scope.

II. Materials and Method

In this article, a case study is conducted in Kiaracondong, Bandung, Indonesia. This area is the district with the third largest population in the city of Bandung, with a population of 130,347 people consisting of six sub-districts [15]. Kiaracondong District is located at an altitude of 488 – 685 meters above sea level with an area of 613.03 Ha. Kiaracondong District is where optimization is carried out using existing site data and the ACP method with Forsk Atoll 3.3.0 software. The operator will carry out the optimization. The specification for this case study is shown in Table 1. Primary optimization targets are to increase traffic penetration by observing throughput parameters and improving coverage by observing RSRP and SINR parameters.

TABLE I
Case Study Resume

Region	Technology	Vendor	Service
Bandung, Indonesia	4G LTE	Telkomsel	Voice and data

Every cellular operator could check the state of the quality-of-service performance received from the client regularly. The operator will perform network optimization immediately if there are issues or complaints regarding the signal quality as experienced by clients. There are eight optimization solutions [16], [17] that can be performed by operators, as shown in Figure 1.

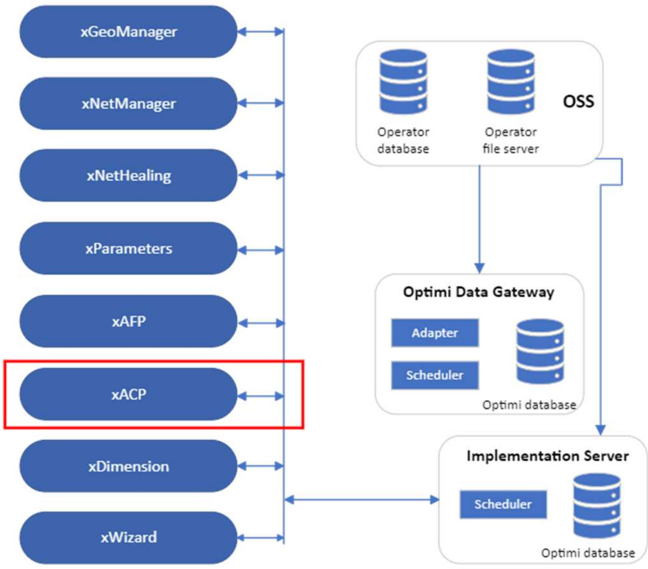

Fig. 1 Optimization solutions architecture [16], [18]

ACP is a multi-technology RF parameter optimization solution for GSM, UMTS, WiMAX, and LTE. ACP cost function allows the user to effectively balance coverage, quality, and capacity for uplink and downlink. Coverage and quality or dominance issues can be solved at the expense of creating boomers, reducing the capacity of 2G and 3G systems. Specific service quality targets are also taken into consideration. ACP produces the best network design to improve the coverage, quality, and capacity [19]. Several optimization mechanisms using the ACP method include the Transmitted power, Antenna model, Mechanical and electrical tilt, Antenna height and azimuth, and Site selection [20]. After fulfilling the antenna selection process, ACP chooses the optimum antenna from the range of installed antennas on this transmitter. As the antenna's azimuth is changed, the ACP modifies it using the specified distance [21]. The ACP changes the mechanical tilt of the antenna by measuring it over a predetermined distance [22]. ACP adjusts the antenna height and uses a predetermined distance to get the ideal height [23]. ACP makes site selections, adding or removing locations designated as candidates for new or upgraded networks. ACP can automatically add a list of candidate sites based on user-defined parameters [24]. Both mechanical and electrical tilt mechanisms will be used in this study. The decision was made since this mechanism can address the issues discovered through observation and measurement.

A process known as mechanical tilting involves altering the antenna's tilt to alter the antenna's coverage. The idea behind mechanical tilting is to position the antenna vertically or both upward and downward so that the lower the antenna is, the larger the mechanical degree, which results in a narrower primary lobe coverage but a more comprehensive side lobe coverage [25]. The impact produced by mechanical tilting changes the overall coverage area. Changes in tilting angle can be analyzed using a mechanical tilting approach by (1) [26], and the illustration can be seen in Figure 2.

$$Antenna\ heigh = (distance * \tan\alpha) + H_m \qquad (1)$$

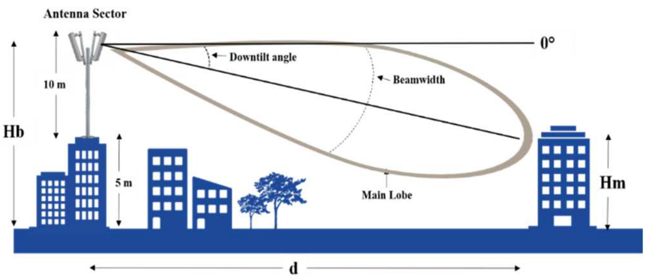

Fig. 2 Mechanical tilt [27]

Antenna height adjustment is also necessary because if obstacles block the transmit power from the antenna, it does not meet the LOS (Line of Sight) conditions. This approach uses the (2).

$$Tilt\ Angle = \tan^{-1}\left(\frac{Hb-Hm}{distance(m)}\right) \qquad (2)$$

Where Hm is height of transmitter antenna (mdpl), Hb is height of receiver antenna (mdpl), and α is tilt angle of antenna. Besides mechanical tilt, this research is also suing an electrical tilt. Electrical tilting is a tilting method that is done by changing the transmit power of the antenna by adjusting its electrical parameters. Changes in the shape of the antenna polarization are regulated electronically. Electrical tilt changes the signal phase characteristics of each antenna element so that the greater the electrical value, the smaller the coverage provided. However, not all antennas can be changed by the electrical tilt value. The changes in electrical tilt will only impact the size of the main lobe that the antenna will emit. Antenna re-azimuth is a change in the direction of the antenna in one sector [28]. Azimuth is the angle of rotation from west to east. The north wind direction is used as a zero-angle reference. If there is azimuth data from a 3-sector site with a value of 80, 150, or 300, then it can be interpreted that these numbers are the azimuth of each sector of the site. Figure 2 presents the flow of optimizing using ACP for LTE networks.

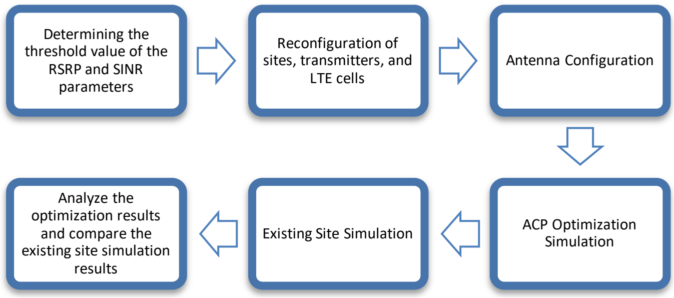

Fig. 3 Flow of optimization using the ACP method [29]

III. RESULT AND DISCUSSION

A. Measurement Results Using CovMo

Figure 4 shows the results of the drive test, which was carried out directly using the Nemo Handy. The data from the drive test results were processed using the Nemo Analyzer. From the results of the drive test, the problems with low coverage and low quality were discovered. 3 sites have bad spots: the JLKAMPUS-DMT, TRSNSTATION, and KELCICAHEUM-STP sites.

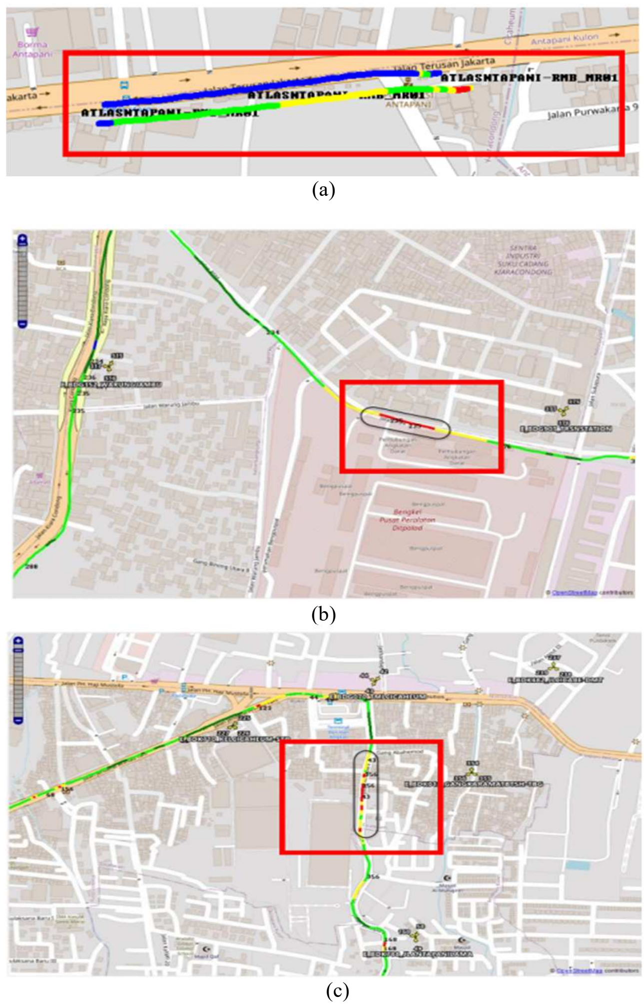

Fig. 4 (a) JLKAMPUS-DMT site (b) TRSNSTATION site and (c) KELCICAHEUM-STP site

The measurement results using Covmo can be seen in Tables 2 to 4. Covmo software could perform a remote test drive for network quality monitoring [30].

TABLE III
RESULT OF RSRP DRIVE TEST MEASUREMENT

Range (dBm)		Category	Color indicator	Value	Percentage
-85	-50	Excellent		15	2.90%
-90	-85	Good		34	6.56%
-100	-90	Medium		218	42.08%
-105	-100	Weak		178	34.36%
-115	-105	Bad		73	14.09%
-150	-115	No Signal		0	0.00%
		Total		518	100%
		Decent percentage			51.54%

TABLE IIII
RESULT OF SINR DRIVETEST MEASUREMENT

Range (dBm)		Category	Color Indicator	Value	Percentage
-85	-50	Excellent		25	4.83%
-90	-85	Good		51	9.85%
-100	-90	Medium		153	29.54%
-105	-100	Weak		216	41.70%
-115	-105	Bad		73	14.09%
-150	-115	No Signal		0	0.00%
		Total		518	100%
		Decent percentage			44.21%

TABLE IVV
RESULT OF THROUGHPUT DRIVETEST MEASUREMENT

Range (dBm)		Category	Color Indicator	Uplink		Downlink	
				Value	Percentage	Value	Percentage
30.000	100.000	Excellent		11	2.12%	0	0.0%
10.000	30.000	Good		36	6.95%	69	13.3%
5.000	10.000	Medium		40	7.72%	108	20.8%
3.000	5.000	Weak		71	13.71%	242	46.7%
0	3.000	Bad		360	69.50%	99	19.1%
		Total		518	100%	518	100%
		Decent percentage			9.07%		13.32%

Based on the results of this measurement in Tables II to IV, the percentage of each parameter is still below the operator's target. It Shows that the RSRP is only 51.54%, the SINR is only 44.21%, and the Throughput is only 9.07% in the uplink direction and 13.32% in the downlink direction.

B. Tilt Adjustment Process

One of the stages of the self-optimization process is tilt adjustments. The modifications entail steps of down-tilting for the congested cell and uptilting for the neighboring cell. The initial procedure is to tilt the congested cell down, then tilt the neighbors up. Remote Electrical Tilt (RET) will be employed because adjustments should be performed automatically. This means that each base station antenna has its own RET modulus. The number of tilt adjustments required will vary depending on the optimization goal, such as the FR threshold, user location within the crowded cell, and the granularity of tilt variations. A trade-off must also be made between the duration and accuracy of the optimization process. Tilt variation at a lower granularity, employing one-degree increments instead of two, will increase optimization time while improving accuracy. Higher granularities will accelerate the process, but some tilt configurations will be ignored. When there are numerous neighbors, the uptilt adjustments can be made concurrently by uptilting every neighboring cell at once or individually by uptilting one cell at a time. As with the granularity of tilt adjustments, a trade-off must be made. Individual or simultaneous uptilting is the trade-off. Simultaneous uptilting will shorten the optimization time but increase the likelihood of missing an optimal configuration. This likelihood increases as the number of neighbors increases. The time between two tilt changes should be proportional to the traffic variance causing congestion. Where traffic varies over a 24-hour period, one tilt change should be done every 24 hours until the optimization target is attained or no meaningful gains can be detected. The electrical tilt adjustment range of the antenna is the fundamental constraint for the tilt adjustment process. The normal range is between 0 and 10 degrees. In addition, the antennas will be down-tilted with a particular value in the initial configuration, reducing the usable range even further, particularly for down-tilting.

C. The Results of Optimization Using the ACP

This section describes the results of optimization using the ACP method. As explained in the previous chapter, ACP is carried out using Atoll. The first step is to create boundaries for the three lousy spot areas, as shown in Figure 5 below.

Fig. 5 Create boundaries for the three lousy spot areas

1) System Level Simulation

On the reconfiguration tab, three menus must be configured, namely: sites, transmitters, and LTE cells. The Sites menu is used to select a site to be optimized, and the transmitter menu is used to configure parameters to be optimized, such as antenna height, azimuth, and tilting of the antenna. The LTE Cell menu is related to the power used for each site. The antenna tab is used to select the most suitable antenna type with the antenna specifications for such simulation's suitability of the frequency range, gain, and beam width. When the ACP selects the best antenna, the ACP will also choose the electrical tilt of the antenna group if optimization is needed. Otherwise, ACP can also maintain electrical tilt like initial conditions. The system model and parameter with the proposed value are shown in Table V.

TABLE V
SYSTEM MODEL AND PARAMETERS

Parameter	Variable	Value
Propagation model	-	Cost-231
Region classification	-	Urban
Region-wide	L	6.13 km^2
Carrier frequency	f	1800 MHz
BS antenna height	h_b	34 m
MS antenna height	H_m	1.5 m
MAPL 1800	PL	Uplink: 120.11 dB Downlink: 129.41 dB
Power correction factor	cm	0 dB
Antenna model	-	Kathrein 742 215
Antenna gain	-	18 dBi
Antenna horizontal HPBW	-	65°
Electrical tilt	-	Adjustable : 0° - 10°
Tx Power	-	43 dBm

2) Simulation

The second step is to do the optimization configuration by filling in the number of iterations' values as recommended by the ACP. The third stage is Objective Configuration, in which the threshold values for the RSRP and RSRQ parameters, namely > = 80%, must be filled. In the fourth stage, the RSRP and SINR parameters will be configured. Next, reconfiguration of the antenna type, electrical tilt, azimuth, mechanical tilt, and antenna height will be implemented. Figure 6 shows the simulation method by Atoll.

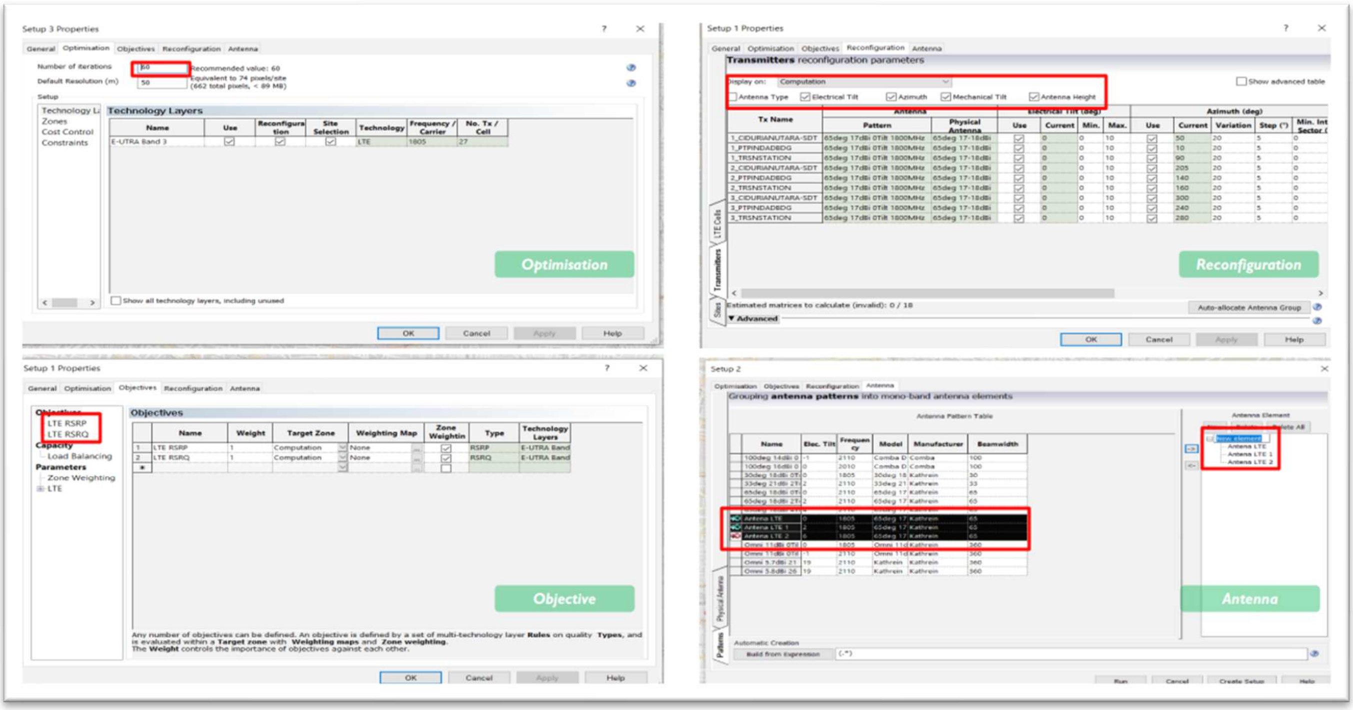

Fig. 6 Simulation method

Table 6 shows the increase in RSRP parameters after ACP optimization. Table 7 shows the rise in SINR parameters after ACP optimization. Tables 8 and 9 show the increase in the Throughput parameter after ACP optimization.

TABLE VI
COMPARISON OF RSRP VALUES BEFORE AND AFTER OPTIMIZATION

Condition	Area 1	Area 2	Area 3
	RSRP (dBm)		
Before	-72.94	-73.94	-69.23
After (Operator)	-72.84	-73.68	-69.16
After (ACP)	-72.79	-73.17	-68.22
Improvement (%)			
Before - After (Operator)	-0.14%	-0.35%	-0.10%
Before - After (ACP)	-0.21%	-1.04%	-1.46%
After (Operator)-After (ACP)	-0.07%	-0.69%	-1.36%

TABLE VII
COMPARISON OF SINR VALUES BEFORE AND AFTER OPTIMIZATION

Condition	Area 1	Area 2	Area 3
	SINR (dB)		
Before	6.7	5.38	6.28
After (Operator)	6.83	5.42	6.78
After (ACP)	8	6.58	8.17
Improvement (%)			

Condition	Area 1	Area 2	Area 3
Before - After (Operator)	1.94%	0.74%	7.96%
Before - After (ACP)	19.40%	22.30%	30.10%
After (Operator)-After (ACP)	17.13%	21.40%	20.50%

TABLE VIII
COMPARISON OF THROUGHPUT DOWNLINK VALUES BEFORE AND AFTER OPTIMIZATION

Condition	Area 1	Area 2	Area 3
	Throughput Downlink (Kbps)		
Before	34,480.50	28,154.98	31,350.45
After (Operator)	35,126.28	28,458.69	34,251.99
After (ACP)	42,652.66	34,420.88	43,882.92
Improvement (%)			
Condition	**Area 1**	**Area 2**	**Area 3**
Before - After (Operator)	1.87%	1.08%	9.26%
Before - After (ACP)	23.70%	22.26%	39.98%
After (Operator)-After (ACP)	21.43%	20.95%	28.12%

TABLE IX
COMPARISON OF THROUGHPUT UPLINK VALUES BEFORE AND AFTER OPTIMIZATION

Condition	Area 1	Area 2	Area 3
	Throughput Uplink (Kbps)		
Before	49,979.91	42,386.48	47,869.26
After (Operator)	49,991.77	42,562.21	47,950.01
After (ACP)	51,651.24	47,895.99	49,648.84
Improvement (%)			
Condition	**Area 1**	**Area 2**	**Area 3**
Before - After (Operator)	0.02%	0.41%	0.17%
Before - After (ACP)	3.34%	13.00%	3.72%
After (Operator)-After (ACP)	3.32%	12.53%	3.54%

Based on the results of the ACP optimization that has been carried out, optimization using the ACP method can increase the value average RSRP, SINR and Throughput as shown in Tables VI to IX. The average RSRP in area 1 is -72.79 dBm, while area 2 is -73.17 dBm and area 3 is -68.22 dBm. The average SINR in area 1 is 8 dB, area 2 is 6.58 dB, and area 3 is 8.17 dB. Meanwhile, the average downlink throughput in area 1 is 42652.66 Kbps, area 2 is 34420.88 Kbps, and area 3 is 43882.92 Kbps. Finally, the average throughput uplink area 1 is 51651.24 Kbps, area 2 is 47895.99 Kbps, and area 3 is 49648.84 Kbps. The simulation findings for the three metrics, RSRP, SINR, and Throughput, have all fulfilled the Key Performance Indicator requirement.

IV. CONCLUSION

In conclusion, this study underscores the critical importance of wireless network optimization as the initial phase in establishing a robust communication network. The challenges facing the deployment of Radio Networks in Indonesia, particularly the persistent issue of uneven coverage areas like the Kiaracondong region in Bandung, emphasize the need for focused attention. The driving test conducted in the Kiaracondong sub-district revealed that key KPI targets for RSRP, SINR, and Throughput parameters were not met. Consequently, our research centers on optimizing physical tuning through the application of the Automatic Cell Planning (ACP) method for LTE wireless network enhancement.

Through extensive simulations and comparisons with non-ACP site simulations and operator-implemented ACP results, we have observed significant improvements. Specifically, in Area 1, the average RSRP improved to -72.79 dBm, in Area 2, it reached -73.17 dBm, and in Area 3, it stood at -68.22 dBm. Furthermore, the average SINR values for Areas 1, 2, and 3 improved to 8 dB, 6.58 dB, and 8.17 dB, respectively. In terms of downlink throughput, Area 1 exhibited an average of 42652.66 Kbps, Area 2 had 34420.88 Kbps, and Area 3 achieved 43882.92 Kbps. For uplink throughput, the average rates for Areas 1 to 3 were 51651.24 Kbps, 47895.99 Kbps, and 49648.84 Kbps, respectively.

These findings highlight the potential of the ACP method for enhancing LTE network performance and addressing coverage challenges. The results obtained from this research pave the way for further improvements in wireless communication networks, providing valuable insights for future developments in this field.

We believe that these satisfying simulation results can be applied on a broader scale to the development of 4G LTE networks. In the future, we see the potential for further integrating ACP technology with other technologies, such as 5G and the next generation of cellular networks. We also believe that additional research can be conducted to optimize other parameters in wireless networks and address specific challenges that may arise in different regions. Therefore, our research opens the door for further exploration in this field, and we are eagerly anticipating how these developments will shape the future of wireless communication networks.

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