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Optimizing Telkomsel's 4G LTE Network Performance in Serpong District South Tangerang

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***Abstract*— Serpong District, South Tangerang City, is a densely populated urban area that requires reliable, high-performance 4G LTE network services. However, field measurements indicate that several areas still experience poor signal quality (bad spots), which affect user experience and network reliability. This study aims to analyze and optimize Telkomsel's 4G LTE network using the Automatic Cell Planning (ACP) method. The optimization is conducted using drive test measurements with G-NetTrack Pro to identify bad spots, followed by network simulation using Atoll based on existing site data. Optimization is performed through antenna parameter adjustment, namely tilt and azimuth, and evaluated using a before-and-after comparison. Network performance is assessed using Key Performance Indicators (KPIs), including Reference Signal Received Power (RSRP), Signal-to-Interference plus Noise Ratio (SINR), Download Throughput, and Shannon-based Cell Capacity. The results show improvements in RSRP, SINR, and cell capacity after optimization, while throughput remains stable and meets KPI requirements. This study contributes an integrated LTE optimization approach based on ACP that combines antenna parameter optimization and multi-KPI evaluation, including cell capacity using the Shannon model, in dense urban environments.**

***Keywords*— 4G LTE, ACP, Network Performance, Optimization, Serpong District, South Tangerang, Telkomsel.**

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I. Introduction

The development of telecommunications technology in Indonesia has increased the need for reliable and high-performance cellular communication services. The 4G Long Term Evolution (LTE) network plays a crucial role in providing high-speed data services with better quality than previous generations [1]

Serpong District, South Tangerang City, is a densely populated urban area with a population of 163,451 people by 2025 [2]. This high population density increases the need for a stable, high-quality cellular network. However, some areas still experience suboptimal LTE performance, particularly in terms of coverage quality and signal stability.

Various studies have proposed LTE network optimization methods, such as Automatic Cell Planning (ACP), antenna parameter adjustment, and electrical tilt, to improve KPIs, including RSRP, SINR, and Throughput [3], [4], [5], [6]. Other studies have also shown that ACP is effective in addressing bad spots and improving overall LTE network quality [7], [8]. Furthermore, the combination of ACP with Carrier Aggregation has been shown to improve network performance, including RSRP, SINR, and Throughput [9]

However, most research still focuses on improving signal quality without integrating ACP with antenna parameter optimization, such as tilt and azimuth, within a systematic framework. Furthermore, network performance evaluation is typically limited to conventional KPIs, whereas cell-capacity-based approaches using the Shannon model are rarely integrated into LTE performance analysis in dense urban environments.

This research proposes LTE network optimization based on Automatic Cell Planning (ACP), integrated with antenna parameter settings (tilt and azimuth) and multi-Key Performance Indicator (KPI) evaluation (RSRP, SINR, Throughput, and cell capacity) using the Shannon model, in dense urban environments.

II. The Materials and Method

A. Drive Test

A drive test is a field measurement activity conducted to collect signal quality data on a network [4]. In this study, the drive test was performed using the G-NetTrack Pro application.

B. Network Optimization Parameters

Network optimization is performed to improve cellular network performance and enhance service quality for users [1]. Several parameters are commonly used to evaluate LTE network performance, including Reference Signal Received Power (RSRP), Signal-to-Interference-Noise Ratio (SINR), Reference Signal Received Quality (RSRQ), and Throughput. The LTE parameter classifications used in this study are shown in Table I.

TABLE I
LTE Network Parameters

	RSRP	
Value (dBm)	Category	Color
-75 ≤ RSRP < 0	Excellent	
-85 ≤ RSRP < -75	Good	
-100 ≤ RSRP < -85	Fair	
-110 ≤ RSRP < -100	Poor	
< -110	Very Poor	
	SINR	
Value (dB)	Category	Color
≥ 20	Excellent	
13 ≤ SINR < 20	Fair	
0 ≤ SINR < 13	Poor	
< 0	Very Poor	
	RSRQ	
Value (dB)	Category	Color
≥ -9	Excellent	
-10 ≤ RSRQ < -9	Good	
-15 ≤ RSRQ < -10	Fair	
-19 ≤ RSRQ < -15	Poor	
< -19	Very Poor	
	Download Throughput	
Value (Kbps)	Category	Color
≥ 12.000	Excellent	
7.200 ≤ THP < 12.000	Good	
1.500 ≤ THP < 7.200	Fair	
324 ≤ THP < 1.500	Poor	
0 ≤ THP < 324	Very Poor	

To determine the percentage of network quality achievement based on the measured parameters, Key Performance Indicator (KPI) calculations are carried out using the following equation [10]

% Target Parameter = (Number of samples meeting the target x 100%) / Total number of samples (1)

C. Key Performance Indicator

KPI targets used in this study are based on Telkomsel standards, as presented in Table II

TABLE II
Telkomsel's KPI Targets

Parameter	KPI Targets
RSRP	90% ≥ -100 dBm
SINR	80% ≥ 0 dB
RSRQ	85% ≥ -15 dB
Download Throughput	80% ≥ 7.200 Kbps

D. Antenna Tilting

Antenna tilting is used to optimize signal coverage by adjusting the antenna beam direction according to service area requirements. Generally, antenna tilting falls into two types: mechanical tilt, which physically changes the antenna angle, and electrical tilt, which electronically adjusts the signal beam without changing the antenna's physical position [11]. In this study, electrical tilt was applied for the network optimization process.

E. Cell Capacity

Cell capacity refers to the maximum data transmission rate that a cell in a cellular communication system can support from transmitter to receiver without error. The theoretical information capacity of a communication channel is determined using the Shannon Capacity Formula [12]

$$C_{cell} = B \log_2 (1 + SINR) \quad (2)$$

F. Methode

A quantitative approach was used to analyze the performance of the 4G LTE network based on Reference Signal Received Power (RSRP), Signal-to-Interference-plus-Noise Ratio (SINR), Reference Signal Received Quality (RSRQ), and Download Throughput. Data collection was conducted through drive tests using the G-NetTrack Pro application in Serpong District, South Tangerang City. The collected data were processed in MapInfo Pro to identify areas with inadequate coverage and to visualize the current network conditions.

Network optimization was conducted using the Automatic Cell Planning (ACP) method within Atoll software. Antenna parameters were modified to enhance network coverage and signal quality. The optimization's effectiveness was assessed by comparing network performance metrics before and after the intervention. As the RSRQ parameter had already achieved the target value prior to optimization, subsequent efforts concentrated on improving RSRP, SINR, and Download Throughput. Figure 1 presents an overview of the research methodology.

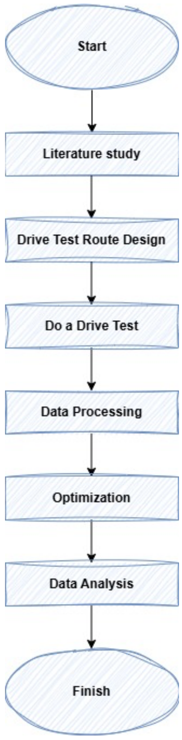

Fig. 1 Research Flow

III. Results and Discussion

Network performance was evaluated through drive tests utilizing the G-Net Track Pro application. The collected data were processed in MapInfo and simulated in Atoll to facilitate network optimization. Parameters analyzed included Reference Signal Received Power (RSRP), Signal to Interference plus Noise Ratio (SINR), and Download Throughput. The results indicate the distribution of LTE signal quality in the Serpong District, South Tangerang City. Field test findings identified two areas with low signal quality as priorities for network optimization.

A. Optimized Parameter Results for Bad Spot 1 Using ACP

The results of the ACP-based optimization simulation for bad spot 1, showing the RSRP, are shown in Figures 2 and 3.

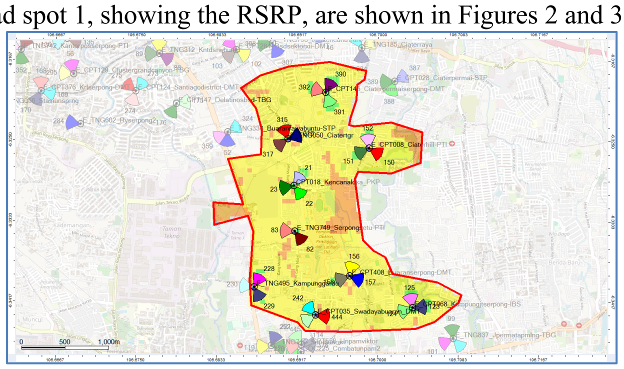

Fig. 2 Plotting ACP RSRP

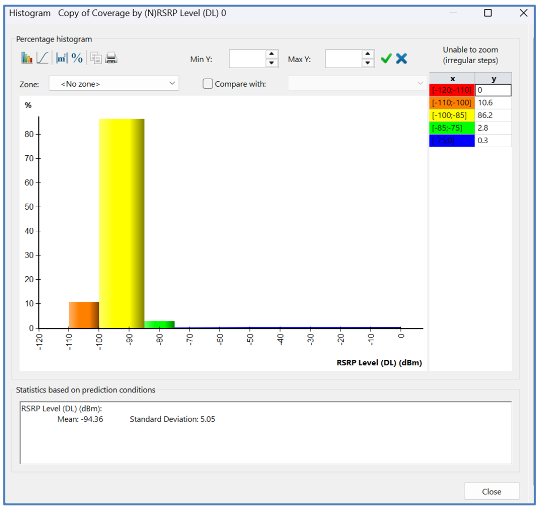

Fig. 3 ACP RSRP Histogram

A comparison of RSRP parameters before and after ACP optimization shows a decrease in poor signal levels and an increase in KPI achievement from 86,9% to 89,3%, as shown in Table III. The improvement indicates that antenna tilt and azimuth adjustments improved signal distribution, reduced coverage overlap, and strengthened signal levels in the bad-spot area.

TABLE III
Comparison of RSRP Bad Spot 1

RSRP (dBm)	Before	After
	Percentage	
-75 ≤ RSRP < 0 (Excellent)	0,3%	0,3%
-85 ≤ RSRP < -75 (Good)	1,1%	2,8%
-100 ≤ RSRP < -85 (Fair)	85,5%	86,2%
-110 ≤ RSRP < -100 (Poor)	13,1%	10,6%
< -110 (Very Poor)	0%	0%
KPI Target	86,9%	89,3%

Figures 4 and 5 present the results of the ACP optimization simulation for the SINR parameters.

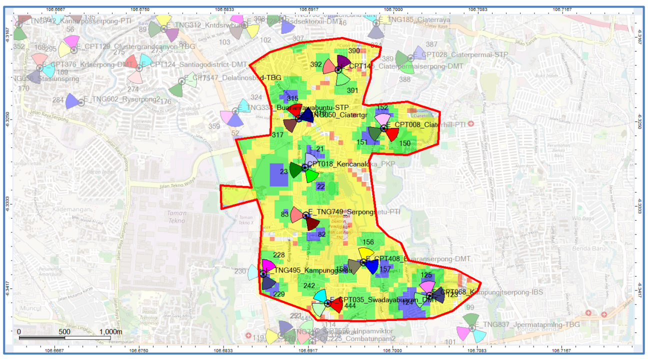

Fig. 4 Plotting ACP SINR

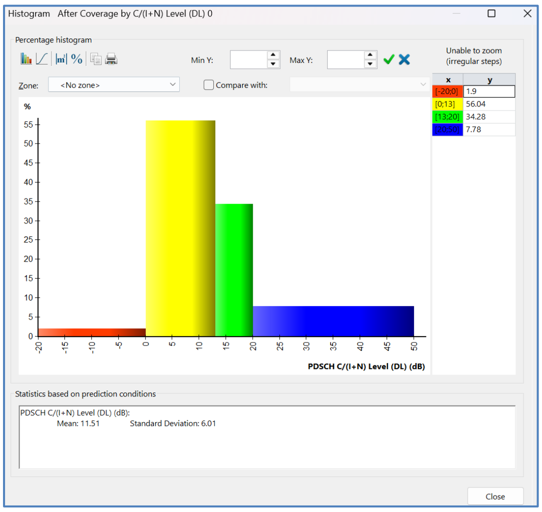

Fig. 5 ACP SINR Histogram

Table IV shows that the SINR KPI achievement increased from 96,7% to 98,1% after ACP optimization. This improvement indicates that antenna tilt and azimuth adjustments reduced inter-cell interference by optimizing antenna coverage direction and minimizing overlapping signals from neighboring cells.

TABLE IV
COMPARISON OF SINR BAD SPOT 1

SINR (dB)	Before	After
	Percentage	
≥ 20 (Excellent)	4,58%	7,78%
13 ≤ SINR < 20 (Fair)	23,28%	34,28%
0 ≤ SINR < 13 (Poor)	68,84%	56,04%
< 0 (Very Poor)	3,29%	1,9%
KPI Target	96,7%	98,1%

Figures 6 and 7 display the outcomes of the ACP optimization simulation for the Download Throughput parameters.

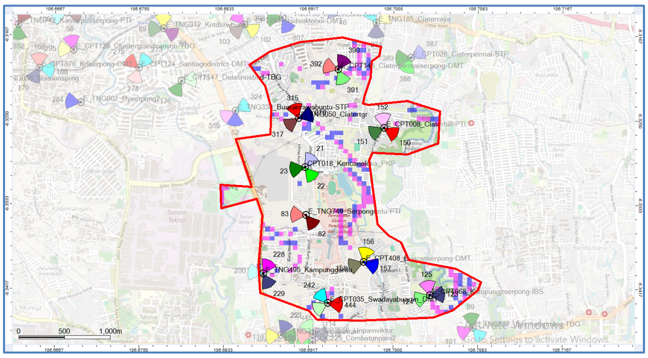

Fig. 6 ACP Download Throughput Histogram

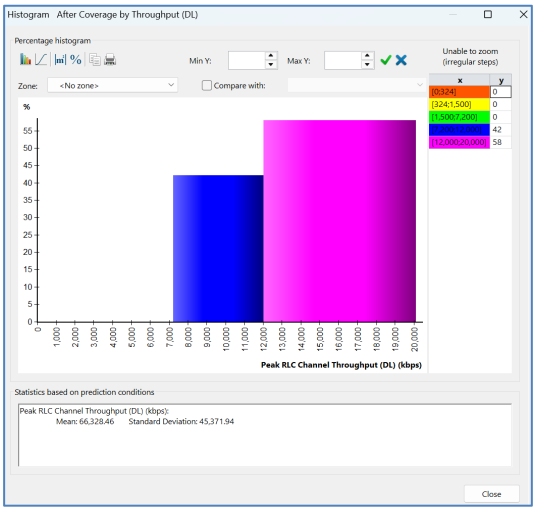

Fig. 7 ACP Download Throughput Histogram

As presented in Table V, the percentage of excellent Download Throughput values increased after ACP optimization, while the KPI achievement remained stable at 100%. This indicates that throughput performance had already met the operator's target before optimization. In addition, throughput performance is also influenced by traffic load, radio resource allocation, and network scheduling mechanisms, which limit significant throughput improvement after optimization.

TABLE V
COMPARISON OF DOWNLOAD THROUGHPUT BAD SPOT 1

Download Throughput (Kbps)	Before	After
	Percentage	
≥ 12,000 (Excellent)	53,5%	58%
7,200 ≤ THP < 12,000 (Good)	46,5%	42%
1,500 ≤ THP < 7,200 (Fair)	0%	0%
324 ≤ THP < 1,500 (Poor)	0%	0%
0 ≤ THP < 324 (Very Poor)	0%	0%
KPI Target	100%	100%

Subsequently, network performance analysis focused on cell capacity to evaluate the impact of ACP implementation on the network's user-serving capability. As shown in Table VI, cell capacity increased from 66,21 Mbps to 75,813 Mbps after ACP optimization. This improvement indicates that the increase in SINR performance contributed to higher theoretical channel capacity under the Shannon capacity model, while antenna tilt and azimuth optimization helped reduce interference and improve network performance in the bad-spot area.

TABLE VI
COMPARISON OF CELL CAPACITY BAD SPOT 1

Cell Capacity	Before	After
	Value	
	66,21 Mbps	75,813 Mbps

B. Optimized Parameter Result for Bad Spot 2 Using ACP

Figures 8 and 9 present the results of the ACP-based optimization simulation for bad spot 1, illustrating the RSRP.

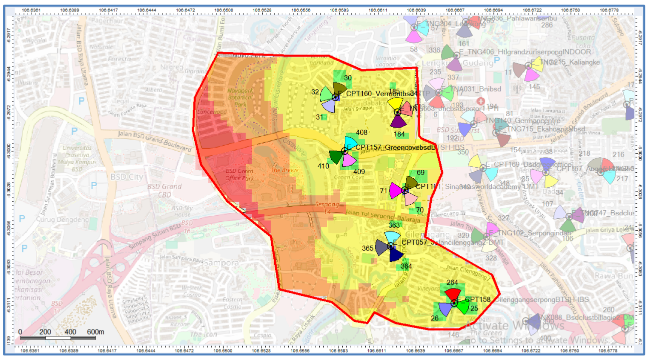

Fig. 8 Plotting ACP RSRP

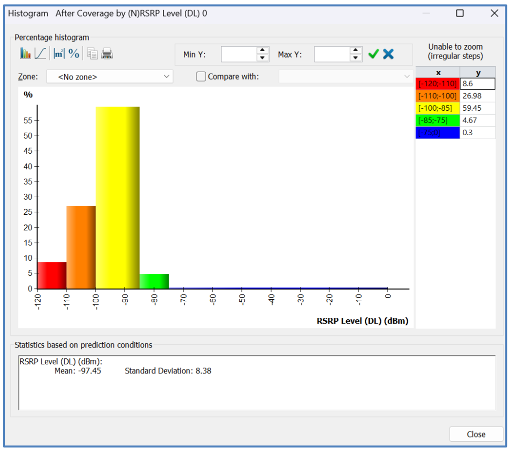

Fig. 9 ACP RSRP Histogram

A comparison of RSRP parameters before and after ACP optimization demonstrates a reduction in poor signal levels and an increase in KPI achievement from 58.49% to 64.42%, as presented in Table VII. These results suggest that adjustments to antenna tilt and azimuth enhanced signal distribution, minimized coverage overlap, and increased signal strength in previously identified low-coverage areas.

TABLE VII
COMPARISON OF RSRP BAD SPOT 2

RSRP (dBm)	Before	After
	Percentage	
-75 ≤ RSRP < 0 (Excellent)	0,15%	0,3%
-85 ≤ RSRP < -75 (Good)	4,52%	4,67%
-100 ≤ RSRP < -85 (Fair)	53,82%	59,45%
-110 ≤ RSRP < -100 (Poor)	24,17%	26,98%
< -110 (Very Poor)	17,35%	8,6%
KPI Target	58,49%	64,42%

Figures 10 and 11 present the results of the ACP optimization simulation for the SINR parameters.

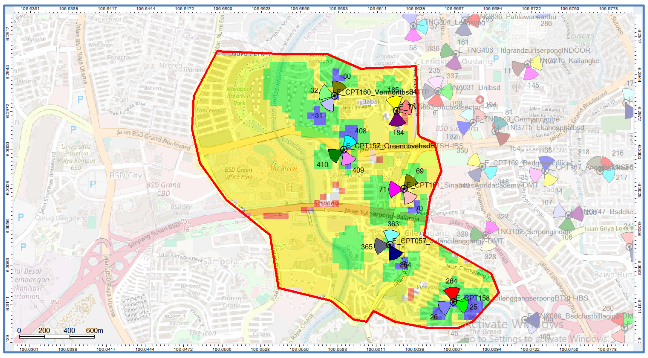

Fig. 10 Plotting ACP SINR

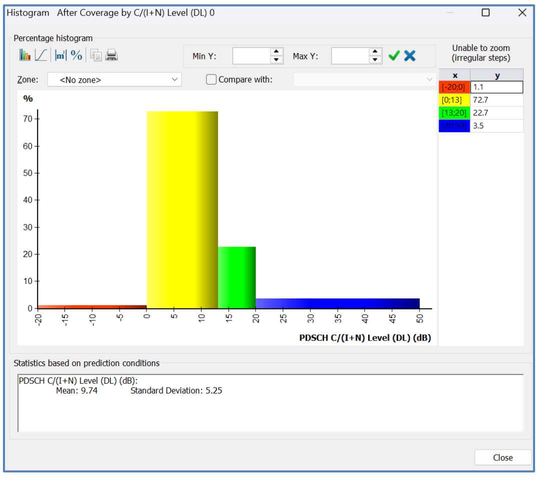

Fig. 11 ACP RSRP Histogram

Table VIII demonstrates that the SINR KPI achievement increased from 97.7% to 98.9% following ACP optimization. This improvement suggests that adjustments to antenna tilt and azimuth effectively reduced inter-cell interference by optimizing antenna coverage direction and minimizing overlapping signals from adjacent cells.

TABLE VIII
COMPARISON OF SINR BAD SPOT 2

SINR (dB)	Before	After
	Percentage	
≥ 20 (Excellent)	2,5%	3,5%
13 ≤ SINR < 20 (Fair)	14,8%	22,7%
0 ≤ SINR < 13 (Poor)	80,4%	72,7%
< 0 (Very Poor)	2,3%	1,1%
Target KPI	97,7%	98,9%

Figures 12 and 13 display the outcomes of the ACP optimization simulation for the Download Throughput parameters.

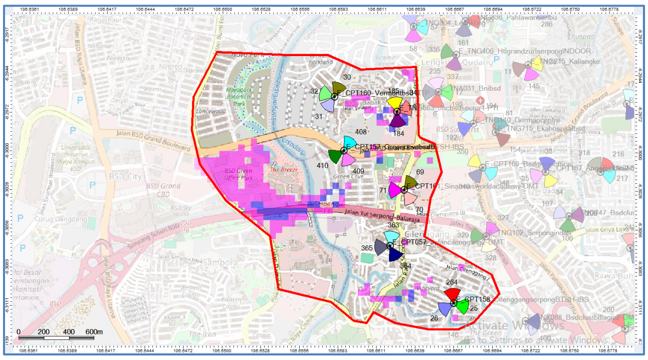

Fig. 12 ACP Download Throughput Histogram

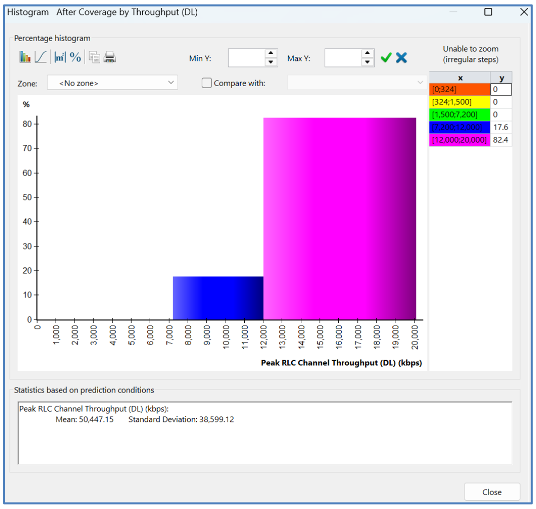

Fig. 13 ACP Download Throughput Histogram

Table IX shows that the percentage of excellent Download Throughput values increased following ACP optimization, while KPI achievement remained stable at 100%. This result suggests that throughput performance had already satisfied the operator's target prior to optimization. Furthermore, throughput performance is affected by factors such as traffic load, radio resource allocation, and network scheduling mechanisms, which constrain the extent of throughput improvement after optimization.

TABLE IX
COMPARISON OF DOWNLOAD THROUGHPUT BAD SPOT 2

Download Throughput (Kbps)	Before	After
	Percentage	
≥ 12,000 (Excellent)	79,5%	82,4%
7,200 ≤ THP < 12,000 (Good)	20,5%	17,6%
1,500 ≤ THP < 7,200 (Fair)	0%	0%
324 ≤ THP < 1,500 (Poor)	0%	0%
0 ≤ THP < 324 (Very Poor)	0%	0%
KPI Target	100%	100%

Subsequent network performance analysis focused on cell capacity to assess the impact of ACP implementation on the network's ability to serve users. As shown in Table X, cell capacity increased from 59,542 Mbps to 65,55 Mbps following ACP optimization. This improvement suggests that enhanced SINR performance contributed to higher theoretical channel capacity according to the Shannon capacity model. Additionally, optimization of antenna tilt and azimuth reduced interference and improved network performance in previously underperforming areas.

TABLE X
COMPARISON OF CELL CAPACITY BAD SPOT 2

	Before	After
Cell Capacity	Value	
	59,542 Mbps	65,55 Mbps

IV. CONCLUSION

The implementation of the Automatic Cell Planning (ACP) method in Atoll successfully improved LTE network performance in the identified bad spot areas by increasing RSRP, SINR, and cell capacity after antenna tilt and azimuth optimization. Cell capacity improved from 66.21 Mbps to 75.813 Mbps in Bad Spot 1 and from 59.542 Mbps to 65.55 Mbps in Bad Spot 2, indicating that ACP optimization effectively enhanced signal coverage, reduced interference, and improved network capacity in dense urban environments.

Practically, the proposed optimization approach can support cellular operators in improving LTE network quality and coverage performance through ACP-based antenna parameter adjustment.

This study is limited to downlink performance analysis and focuses on LTE network parameters, including RSRP, SINR, RSRQ, Download Throughput, and cell capacity. Although RSRQ was measured during the drive test, further optimization was not performed because the parameter had already met the required KPI target before optimization. Further research is expected to compare the ACP method with other optimization techniques and include uplink performance analysis to provide a more comprehensive evaluation of LTE network optimization.

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