Improving 4G LTE network quality using the automatic cell planning

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ABSTRACT

The growing demand for network services leads to an increase in traffic load on eNodeB, resulting in decreased network quality and performance, necessitating optimization. This research analyses the results of optimising 4G reference signal received power (RSRP), signal to interference noise ratio (SINR) and throughput parameters using the automatic cell planning (ACP) method. ACP has been shown to significantly improve the performance and quality of 4G LTE networks compared to traditional cell planning methods. Based on the standard parameter RSRP, increased after ACP optimisation which is dominant in the range ≥ -100 s.d > -85 dBm and obtained an average value of -98.59 dBm with good category. The average SINR has increased by 18.23 dB with a good category. The dominant throughput is in the 14,000 Kbps range with an average value of 50,241.08 Kbps with the excellent category. The ACP method can enhance the performance of 4G LTE networks, potentially addressing operator issues of unstable network quality due to poor coverage. The ACP method significantly enhances 4G LTE network performance, coverage, and user experience, potentially addressing unstable network quality due to poor coverage. This research is crucial for both users and the telecoms industry.

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1. INTRODUCTION

In today's fast-paced digital world, staying connected is no longer a luxury, but a necessity [1]. With the widespread adoption of smartphones and other mobile devices, the demand for high-speed and reliable mobile communications has skyrocketed. This surge in demand has fuelled the development of advanced network technologies, with 4G LTE (Long-term evolution) being at the forefront [2]. 4G LTE is the fourth generation of wireless communication technology, which offers significant improvements over its predecessor, 3G. LTE uses orthogonal frequency division multiplexing (OFDM) for the downlink and single-carrier frequency division multiplexing (SC-FDMA) for the uplink. This technology provides faster data transfer rates, lower latency, and better overall network performance. But to fully utilize the benefits of 4G LTE, network quality plays a critical role [3].

Network planning and optimization are key aspects for optimal performance and user experience [1]. Planning involves designing network layouts, estimating cell throughput, reducing equipment, and addressing traffic analysis needs. Optimization focuses on fine-tuning parameters like reference signal received power (RSRP), and signal to interference noise ratio (SINR) to improve performance and efficiency, ensuring cost-effective and optimized network deployment. The increasing need for network services causes the traffic load on the eNodeB to increase [4]. The increase in traffic load greatly affects the speed and performance of the network [5] This increase causes the quality and performance of the network to decrease and the effect is seen at the ends of eNodeB coverage, where the area becomes a new bad spot. Due to the growing number of customers and diverse needs, cellular network conditions must always be optimised. The increase requires the availability of competent network coverage, capacity, and quality [6].

Managing a 4G LTE network is not an easy task. Network operators face many challenges in maintaining and optimizing their networks [7]. One of the main challenges is the ever-increasing data demand. As more devices connect to the network, the load on the network infrastructure will increase, leading to congestion and degradation of network performance. In addition, network operators also have to deal with issues such as interference, signal propagation, and network capacity limitations.

Several case studies have demonstrated the successful implementation of ACP in 4G LTE networks, resulting in significant improvements in network performance, reduced congestion, and improved overall user satisfaction. Multiobjective genetic algorithm optimisation is one of these research' methods for maximising BTS location in 4G LTE networks [8], Optimising Mobile Broadband Network Service Quality for Dense Urban Environments [9], ACP of 1800 MHz FDD LTE networks in Klaten, Central Java [10], and evaluation of 4G/LTE cellular network performance based on experimental data [11]. Researchers took this research area in Korong Gadang and Gunung Sarik villages, Kuranji District, Padang City, West Sumatra Province. From the data of the central bureau of statistics (BPS) in 2022, it is known that the area in the village is 18.13 km2 and the population is 40,377 [12].

Parameters that become a reference for 4G LTE network measurements are RSRP, SINR, and Throughput parameters [13], [14]. Methods that can be used to solve the problem of bad spot 4G LTE network area is using physical method [15], the results of RSRP parameter optimization of 70.08% and SINR parameter of 78.13%. Using the Electrical Tilt method, the coverage area on RSRP parameters above -100 dBm decreased from 83.379% to 83.066%, and the RSRP signal below -100 dBm decreased from 17.621% to 13.934%. The automatic cell planning (ACP) technique is used, the optimization results meet the operator's KPI standards for RSRP of 90.037% ≥-100 dBm and SINR of 94.8% ≥ 0 dBm [10].

In general, network optimization using the ACP method can extend the range of the antenna and can maximize network performance in the coverage area of each eNodeB [16], [17]. The ACP method is the most effective method to overcome the problem of bad coverage [18] in this case study area. The advantages of this method are detailed calculations to get the best combination of sectoral antenna reconfiguration calculations (tilting, azimuth, and antenna height) [19]. Indirectly, network optimization with the ACP method can extend antenna coverage and maximize network performance in the coverage area of each eNodeB [16], [20]. With ACP, operators can optimize network parameters dynamically, based on traffic patterns and user demand. This ensures that the network always operates at its peak efficiency, minimizing signal interference, coverage gaps, and congestion.

Implementing ACP in 4G LTE networks provides many benefits, including increasing efficiency However, it is important to recognise the challenges and limitations associated with ACP and endeavour to overcome them through technological advancements in the future. Maintaining high network performance is critical for network operators to retain customers and remain competitive in the rapidly evolving digital landscape. However, it is important to recognize the challenges and limitations associated with ACP and work towards addressing them through future technological advancements.

As 4G LTE networks continue to expand and accommodate growing data demands, the future outlook for ACP is promising. With the advent of 5G technology in the future, ACP algorithms can be further improved to optimize the coexistence of 4G and 5G networks. The future of ACP in 4G LTE is undoubtedly to deliver outstanding network performance.

2. RESEARCH METHOD

Drive test is data collection with signal measurements carried out using a vehicle in a relatively large area (outdoor) [21], [22], used to collect data on the quality of a network in real-time in the field, measuring radio signals received by users in real-time such as uploading and downloading which aims to determine the performance of cellular networks and improve the quality of a network. Drive tests are carried out using TEMS Pocket software and logfile data analysis software, namely TEMS discovery [23]. The parameter used, namely RSRP, is a parameter that shows the signal strength received by users at a certain frequency [24], [25]. Furthermore, the ratio of received signal power to interference power or noise by service consumers is known as the Signal Interference to Noise Ratio, or SINR [26], [27]. Then the Throughput parameter is the bit rate or the amount of data transmitted on a network with a unit of time [28], [29]. ACP is a network optimization method with the working principle of searching algorithms to maximize eNodeB performance [30], [31]. The ACP module in Atoll 3.3.0 allows for network design and optimization of network settings to increase network coverage and capacity.

3. RESULTS AND DISCUSSION

3.1. Drive test data processing results before optimisation

The results of the driving test obtained several parameters that will be analyzed and optimised, namely RSRP, SINR, and Throughput. To determine whether the three parameters have met the KPI standards. The KPI target data for each parameter needed to be used as a reference for achievement targets as in Table 1.

RSRP is a power received by the user from the eNodeB [32]. The closer the user's position to the eNodeB, the better the signal will be received and the greater the RSRP value [33]. Vice versa, if the user's position is far from the eNodeB, the RSRP value received will be smaller. Based on Figure 1. the Korong Gadang and Gunung Sarik areas are dominated by the good yellow category (-100 to -85 dBm) as many as 777 samples with a percentage of 46.61%. Category very good green color (-85 s.d -75 dBm) as many as 455 samples with a percentage of 27.29%. Category excellent blue color (-75 s.d 0 dBm) as many as 123 samples with a percentage of 7.38%. The orange color bad category (-110 s.d -100 dBm) has as many as 288 samples with a percentage of 17.28%. Very bad category in red color (-120 s.d -110 dBm) as many as 24 samples with a percentage of 1.44%.

Table 1. Target KPI [27]

No	Parameter	Target KPI
1	RSRP	80% > -100 dBm
2	SINR	90% > 5 dB
3	THROUGHPUT	> 12Mbps

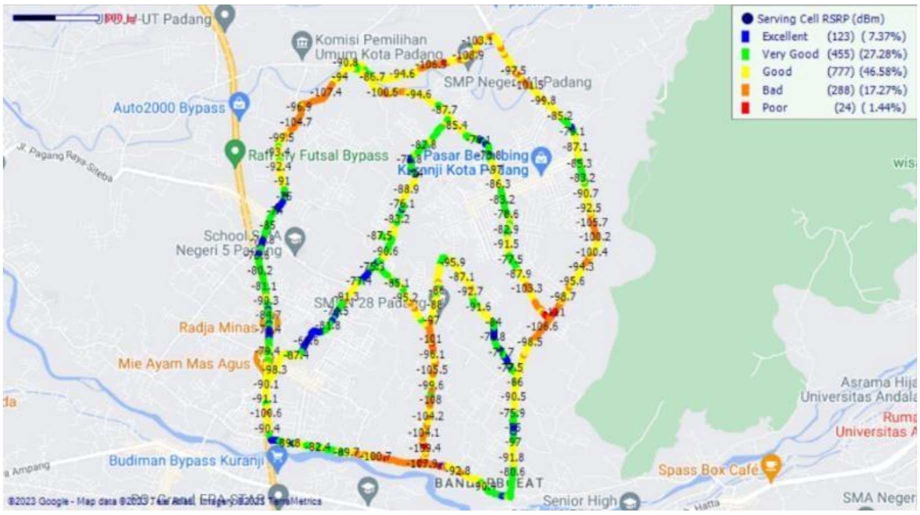


Figure 1. RSRP parameters

The ratio of noise interference to signal is displayed by the KPI parameter SINR, which indicates the quality of the signal on the 4G LTE network [13], [34], The signal quality is positively correlated with the SINR value, which indicates minimal noise and low levels of interference to the signal, the obstacle or latency will shrink, causing an increase in signal quality and speed on the 4G network. Based on Figure 2, the SINR parameter value in the Korong Gadang and Gunung Sarik areas is dominated by the yellow fair category (0 to 13 dB) with a total of 972 samples and a percentage of 58.27%. The good category of green color (13 to 20 dB) obtained a total of 349 samples with a percentage of 20.92%. The excellent category of blue color (20 s.d 30 dB) obtained 68 samples with a percentage of 4.08%. Poor category of red color (-15 s.d 0 dB) as many as 279 samples with a percentage of 16.73%.

Throughput on the LTE drive test is the value of data rate (Kbit/s) from UE to eNodeB [35], [36]. Based on Figure 3, it is known that the throughput in the Korong Gadang and Gunung Sarik area is dominated by the very good category in blue (7,000 to 14,000Kbps) with as many as 1068 samples with a percentage of 64.18%. The excellent category of purple color (≥14,000 Kbps) was 28 samples with a percentage of 1.68%. Category good green color (1,000 to 7,000) with 508 samples with a percentage of 30.53%. The fair category in yellow (512 to 1,000 Kbps) was 10 samples with a percentage of 0.60%. Poor category in red color (<512 Kbps) were 50 samples with a percentage of 3%.

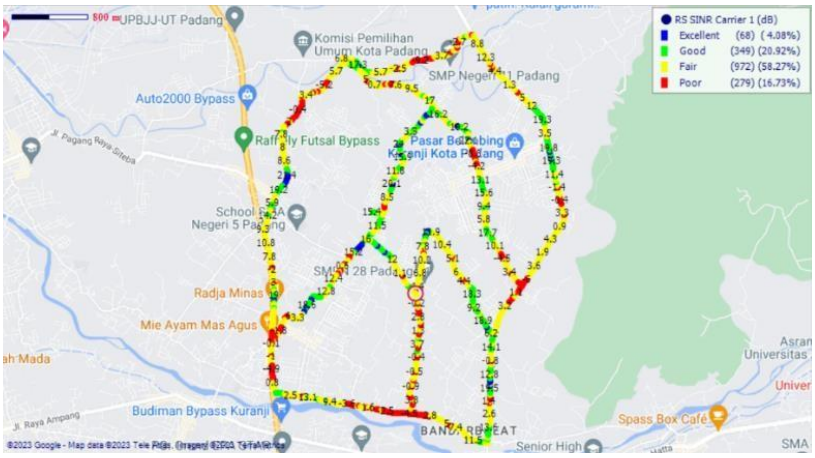


Figure 2. SINR parameters

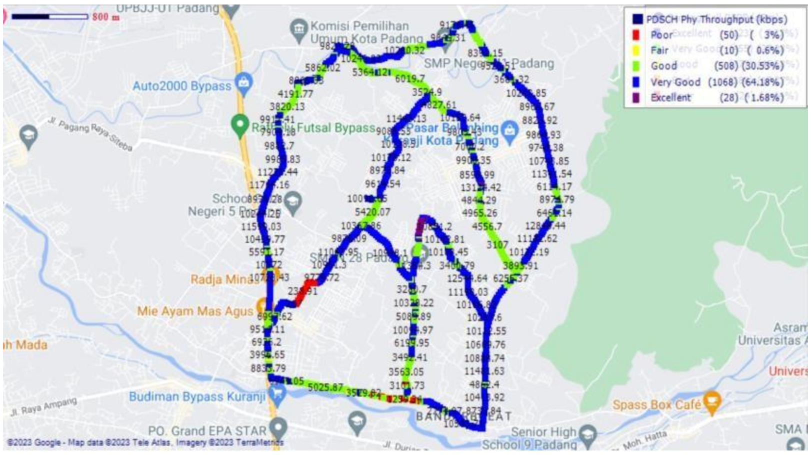
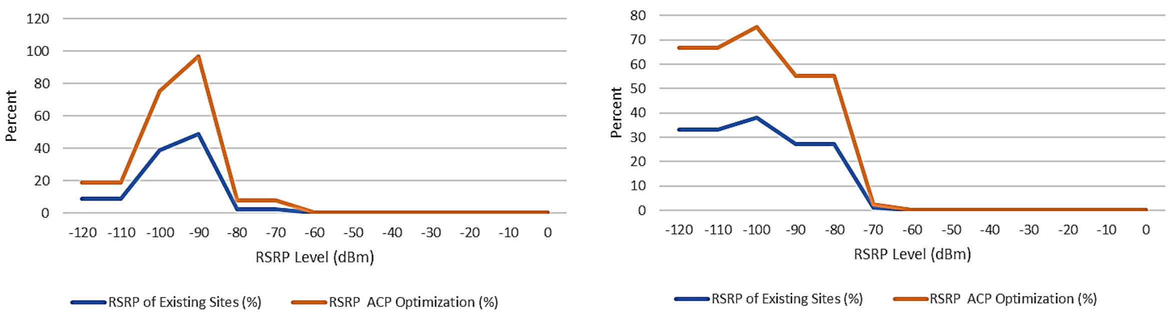


Figure 3. Throughput parameters

3.2. ACP optimisation results

3.2.1. RSRP parameter

Figure 4 is the result of the simulation of RSRP parameter prediction, Figure 4(a) shows the range of values -120 to -110 dBm obtained 9.88%, in the range of values -110 s.d -100 dBm obtained 36.68%, in the range of values -100 s.d -85 dBm obtained 48.08%, in the range of values -85 s.d -75 dBm obtained 5.1%, and in the range of values -75 s.d 0 dBm obtained 0.23%. With an average RSRP value of ACP optimization results of -98.59% is show in Figure 4(b). obtained a value of 37.03%. The average value in the computation zone after ACP optimization is 8.23 dB.



(a) (b)

Figure 4. RSRP ACP optimization results (a) bad spot area 1 and (b) bad spot area 2

3.2.2. SINR parameter

Figure 5 is the result of SINR parameter prediction simulation. Figure 5(a) shows the range of values -20 to 0 dB obtained 2.08%, in the range of values 0 to 13 dB obtained 38.75%, in the range of values 13 to 20 dB obtained 28.86%, and in the range of values 20 to 30 dB obtained a value of 30.29%. The average value in the computing zone after ACP optimization is 17.03 dB as shown in Figure 4(b). This distribution of SINR values indicates that the majority of the predicted SINR values fall within the 0 to 30 dB range, with a significant portion concentrated in the 0 to 13 dB and 20 to 30 dB ranges, demonstrating the effectiveness of the ACP optimization in improving the overall SINR performance within the specified computing zone. Figure 5(b) further illustrates the cumulative distribution function (CDF) of the SINR values, highlighting the probability that the SINR will be below a certain threshold. This CDF analysis confirms that after ACP optimization, the SINR values consistently achieve higher levels, reducing the instances of low SINR which could adversely affect system performance.

The improvement in SINR due to ACP optimization can be attributed to several factors. Firstly, the optimization process effectively manages interference and allocates resources more efficiently, leading to an increase in signal quality. Secondly, the deployment of advanced algorithms within the ACP framework ensures that SINR is maximized by dynamically adjusting parameters in response to real-time network conditions.

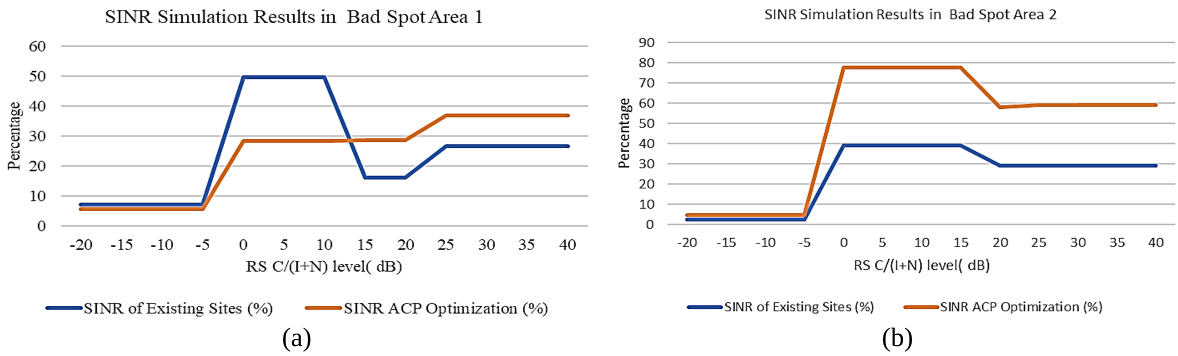


Figure 5. SINR ACP optimization results (a) bad spot area 1 and (b) bad spot area 2

3.2.3. Throughput parameter

Figure 6 is the result of the simulation prediction of Throughput parameters. Figure 6(a) shows the value range < 512 Kbps obtained 0%, in the value range 512 to 1,000 Kbps obtained 0%, in the value range 1,000 to 7,000 Kbps obtained 2.32%, in the value range 7,000 to 14,000 Kbps obtained 10.43%, and in the value range ≥ 14,000 Kbps obtained a value of 37.03%. The average value in the computation zone after ACP optimization is 18.23 dB, with 87.23% of the values falling within this optimized range. The average throughput value in the computation zone after ACP optimization is 50,241.08 Kbps as shown in Figure 6(b).

This data suggests that the ACP optimization has significantly improved the throughput performance, with the majority of throughput values exceeding 14,000 Kbps. The negligible percentages in the lower throughput ranges indicate that the network experiences very few instances of low throughput, thus ensuring high efficiency and performance. The considerable average throughput value of 50,241.08 Kbps further underscores the effectiveness of the ACP optimization in enhancing network capacity and data transmission rates.

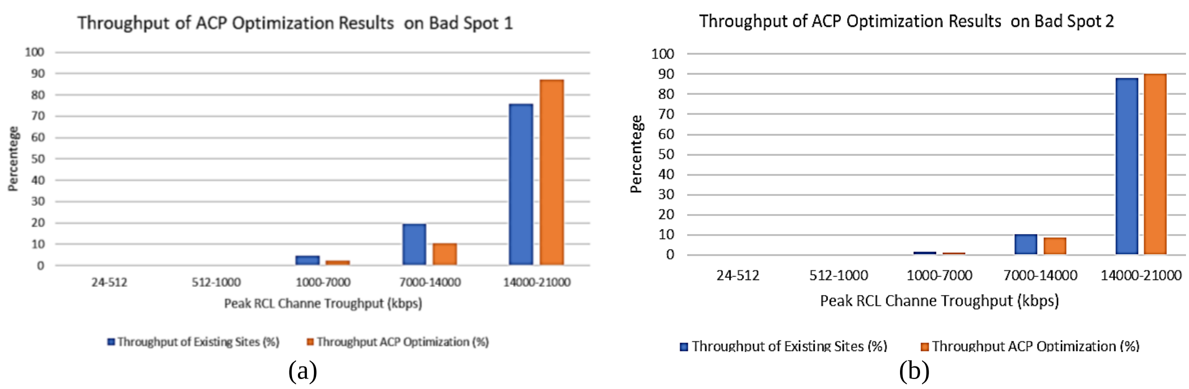


Figure 6. Throughput of ACP optimization results (a) bad spot area 1 and (b) bad spot area 2

3.3. Comparison of simulation results

Based on the operator's RSRP parameter standards, Table 2 shows a comparison of the existing site simulation results and ACP, where the RSRP value at bad spot 1 before the ACP optimization simulation is obtained on average of -99.24 dBm, the value has increased after ACP optimization which is dominant in the range of -100 s.d -85 dBm and obtained an average value of -98.59 dBm with the good category. The RSRP value in bad spot 2 before the ACP optimization simulation was obtained at an average of 14.58 dB, the value increased after optimization with the dominant ACP simulation results in the range of -110 s.d -100 dBm with the fair category. Based on the operator's SINR parameter standards, Table 3 shows a comparison of the existing site simulation results and ACP, where the SINR value in bad spot 1 before the ACP optimization simulation was obtained an average of 14.58 dB, the value increased after ACP optimization which is dominant in the range of 20 to 30 dBm and obtained an average value of 18.23 dB with the good category. The SINR value at bad spot 2 before the ACP optimization simulation was obtained at on average of 16.77 dB, the value increased after optimization with the dominant ACP simulation results in the range of 0 to 13 dBm with an average of 17.03 dB in the good category.

Based on the operator Throughput parameter standard, Table 4 shows a comparison of the existing site simulation results and ACP, where the Throughput value at bad spot 1 before the ACP optimization simulation was obtained an average of 39,801 Kbps. The value has increased after ACP optimization which is dominant in the range ≥ 14,000 Kbps and obtained an average value of 50,241.08 Kbps with an excellent category. The throughput value in bad spot 2 before the ACP optimization simulation was obtained at an average of 47,239.47 Kbps, the value has increased after optimization with the dominant ACP simulation results in the range ≥ 14,000 with an average of 47,952.91 Kbps in the excellent category.

Table 2. Comparison of RSRP site existing and ACP optimization

RSRP (dBm)	Category	Legend	Bad spot 1 site existing	ACP	Bad spot 2 site existing	ACP
-75 ≤ RSRP < 0	Excellent		0,31%	0,23%	0,11%	0,11%
-85 ≤ RSRP < -75	Very Good		2,63%	5,10%	1,24%	1,28%
-100 ≤ RSRP < -85	Good		48,96%	48,08%	27,33%	27,76%
-110 ≤ RSRP < -100	Fair		38,99%	36,68%	38,19%	37,10%
-110 ≤ RSRP < -120	Poor		9,09%	9,88%	33,11%	33,73%

Table 3. Comparison of SINR site existing and ACP optimization

SINR (dB)	Category	Legend	Bad spot 1 site existing	ACP	Bad spot 2 site existing	ACP
20 ≤ SINR < 30	Excellent		26,75%	37,03%	2,63%	30,29%
13 ≤ SINR < 20	Good		16,22%	28,66%	29,26%	28,86%
0 ≤ SINR < 13	Fair		49,82%	28,48%	39,16%	38,75%
-20 ≤ SINR < 0	Poor		7,19%	5,82%	2,50%	2,08%

Table 4. Comparison of existing site throughput and ACP optimization

Throughput (Kbps)	Category	Legend	Bad spot 1 site existing	ACP	Bad spot 2 site existing	ACP
>= 14000	Excellent		75,74%	87,23%	88,24%	90,30%
>= 7000 THP < 14000	Very Good		19,71%	10,43%	10,18%	8,53%
>= 1000 THP < 7000	Good		4,53%	2,32%	1,57%	1,16%
>= 512 THP < 1000	Fair		0,00%	0,00%	0,00%	0,00%
< 512	Poor		0,00%	0,00%	0,00%	0,00%

4. CONCLUSION

Based on the results of ACP optimization simulations that have been carried out, the average value of RSRP in bad spot 1 is 98.59 dBm in the good category, and RSRP in the excellent category with a percentage increase of 2.47%, bad spot 2 in the good category 27.76%. The average SINR value in bad spot 1 is 18.23 dB with a percentage of 12.44% in the good category, and bad spot 2 is 17.03 dB with an increase of 0.26% in the good category. The average Throughput value in bad spot 1 is 50,241.08 Kbps with a percentage increase of 11.49% in the excellent category, bad spot 2 obtained an average value of 47,952.91%.

Network optimization with the ACP method can expand antenna coverage and maximize network performance in the coverage area of each eNodeB. Based on the results of simulations that have been carried out on Atoll 3.3.0 software, it is found that the ACP method optimization is able to improve the performance of 4G LTE networks so that the ACP method can be a solution to the problem of unstable 4G LTE network quality in operators due to bad coverage. Several case studies have shown the successful implementation of ACP in 4G LTE networks, which resulted in significant improvements in network performance, reduced congestion, and improved overall user satisfaction.

In the future, ACP is expected to continue to evolve with new technologies and algorithm improvements. With 5G technology on the rise, ACP may become an even more important method of optimizing mobile networks. By keeping abreast of technological developments and implementing best practices, network operators can remain competitive and provide the best user experience in the 4G LTE era. The application of the ACP method in information and communication technology (ICT) can provide many benefits for telecommunications operators and users in improving service quality, optimizing resource usage, and increasing data transfer rates.

When designing a 4G LTE network, the ACP technique has a significant positive effect on network quality. By performing accurate analysis and modeling, ACP can identify and address problems in the network to improve signal quality and internet speed. This method can optimize the use of network resources and reduce operational costs associated with network planning and management.

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