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Optimization of 4G LTE Network with Automatic Cell Planning and Carrier Aggregation Methods

Sutoyo[1], Aulia Ulhamdi[2], Teddy Purnamirza[3], Mulyono[4], Ahmad Faizal[5]
[1,2,3,4,5] Universitas Islam Negeri Sultan Syarif Kasim Riau, Jl. HR. Soebrantas No. Km 15, Riau, 28923

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ABSTRACT

The implementation of 4G Long-Term Evolution (LTE) in Indonesia still faces numerous challenges, particularly in terms of coverage areas that are less than optimal, causing many areas to be classified as bad spots. One of them is Koto Baru Payobasung area, Payakumbuh. Network optimization is one method for overcoming this problem. In this study, we will use optimization techniques such as *Automatic Cell Planning* (ACP) and *Carrier Aggregation* (CA) with Received Signal Reference Power (RSRP), Signal to Interference and Noise Ratio (SINR), and Throughput parameters. Through existing simulations, the results of the initial research revealed that two of the three parameters, namely RSRP and Throughput, were classified as very bad conditions. Based on the results of optimization using the ACP technique, it was discovered that there was an increase in the RSRP value of = -103 dBm, SINR of = 2 dB, and Throughput = 15 Mbps. The RSRP value for the CA technique is -90 dBm, the SINR is 7 dB, and the throughput is 50 Mbps. Because of the value of the optimization parameter results, the CA technique is better than the ACP technique in these two optimization techniques.

Corresponding Author:

Sutoyo
Universitas Islam Negeri Sultan Syarif Kasim Riau, 28129, Pekanbaru
Email: sutoyo@uin-suska.ac.id

1. INTRODUCTION

Human needs for telecommunications networks are increasing in this era, and these needs can now be said to be their daily basic needs, especially when combined with work-from-home (WFH) policies for office workers and online schools for students/students. Both professions prove how important telecommunications networks are for human life today. 4G LTE is a telecommunications network technology that is widely used and provided by today's operators. At the time of its initial release, this 4G technology was expected to have a downlink speed of 100 Mbps and an uplink speed of 50 Mbps. However, the implementation of this 4G technology still faces numerous challenges and flaws. As a result, the estimated speed by experts is not met, and there are still many bad spot problems for this technology [1, 2]. Many factors can contribute to this bad spot problem, but with the current pandemic situation, the WFH situation for office workers and online schools for students causes an increase in traffic load. Due to the increased traffic load, eNodeB is unable to respond to user service requests. As a result, the service provided by eNodeB becomes congested, lowering network quality.

In addition, the lockdown situation, combined with students returning to their respective villages, has overburdened eNodeB in this area, causing network quality to deteriorate. Furthermore, in rural/suburban areas, the distance between eNodeBs is quite long, so users will notice a decrease in signal quality right away. Parit Putus a bad spot area in the Koto Baru area of Payakumbuh, West Sumatra. And there are 4 ENodeBs near this area, with a distance of about 1.5 – 3 Km between ENodeB

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and this area. According to the current simulation, the Received Signal Reference Power (RSRP) value is -110 dBm, the SINR value is -1 dB, and the Throughput value is 2400 kbps. As a result, it is possible to conclude that the network conditions in this area are deplorable. Particularly concerning the RSRP parameters and throughput. RSRP is the signal range provided by the nearest ENodeB, meaning that by looking at the RSRP value we can find out the range of the ENodeB. besides that we can also indirectly infer the condition of network performance in the region.

Meanwhile, according to data obtained from the Payakumbuh Central Statistics Agency (BPS), the population in this region is 2,037 people. And the estimated age of the population actively using smartphones is 10-50 years old, with a percentage of 65 percent. Several previous researchers have conducted studies on performance analysis and network optimization, one of which is a study titled "Analysis of 4G Network Performance in the Malang area" conducted by [3] This study examines the quality of the RAN to determine how the LTE network performs in Jln. General Basuki and Malang City Station areas (Radio Access Network). The findings revealed that the network conditions and performance in these two locations were excellent.

Furthermore, the ACP scheme has been carried out by [4] with the research title "Application of the ACP Method for Optimizing Physical Tunning of Sectoral Antennas on the 4G LTE Network in Purwokerto City". From the results of the study, it was found that the use of the ACP method was quite effective in increasing eNodeB coverage. The difference between this research and previous studies, such as research [5], is in the features of the use of carrier aggregation (CA). Which in previous studies used the Inter-band Non-Contiguous Carrier Aggregation feature, meaning that the frequencies used for the 2 carrier components have different frequencies. As for the research that the author himself did in this study using the Intra-band Continuous Carrier Aggregation feature, it means that the frequency used for the 2 carrier components has a continuous and adjacent frequency value. Meanwhile, the CA scheme that was conducted by [6] with the research title "Comparative Analysis of LTE-Advanced Carrier Aggregation Deployment Scenario 2 and 5 in Central Semarang" found that the use of the CADS5 scenario was more effective than the CADS2 scenario and the scenario without CA. From the problems identified in the existing simulation, researchers will try to overcome these problems by optimizing the network. For the optimization scheme itself, the researcher will apply 2 optimization schemes from previous studies that have been previously mentioned, among others The Automatic Cell Planning (ACP) and Carrier Aggregation (CA). The use of these two methods is intended to determine the most effective method for dealing with problems that arise.

2. RESEARCH METHOD

2.1. Research Design

This research was carried out computerized using the software network simulator Atoll.

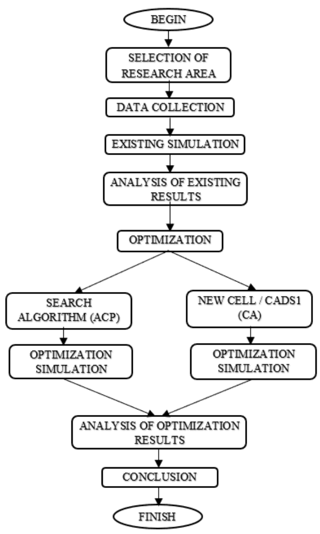

Figure 1. Research Flowchart

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2.2. LTE-Advanced

LTE Release 10 allows for heterogeneous deployment of pico-cells, femtocells, relays, remote radio heads, and various macrocell settings on each low-power eNodeB. LTE Release 10 enhancements include carrier aggregation, advanced uplink (Ul) and downlink (Dl) spatial multiplexing, Multipoint coordinated DL transmission (CoMP), and heterogeneous networking with an emphasis on type 1 and type 2 relays [1, 6].

2.3. Automatic Cell Planning

Automatic Cell Planning (ACP) is a network optimization method that automates the calculation of each optimization parameter. This method will tune the parameters to improve the coverage and direction of the antenna beam. This optimization is accomplished by calculating the antenna height, azimuth, and antenna tilting. Calculations will be performed several times to obtain optimal conditions; this calculation/iteration will be performed automatically by the network simulator system [4,7].

This ACP optimization technique can be concluded as a method of increasing signal coverage and service quality without adding new ENodeBs. The range was extended as a result of changes in the antenna tilting parameters obtained through several iterations [4,8]. The image below depicts the iteration setting dialog for the ACP technique.

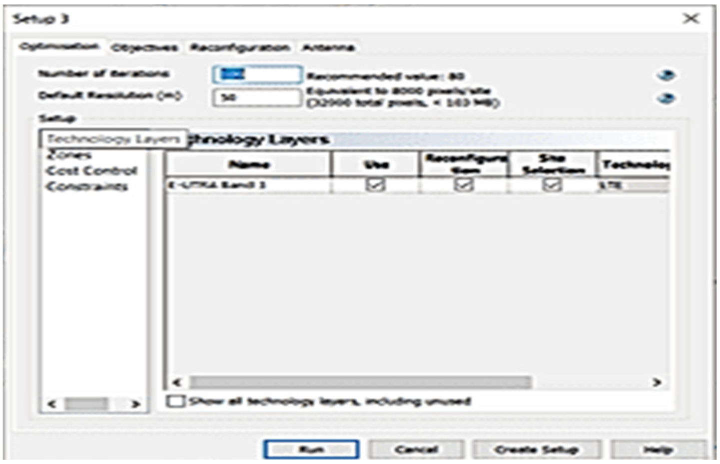

Figure 2. ACP iteration Settings

The results of the calculations will change the azimuth/direction of the antenna as well as its tilting. As a result, the mechanical tilt, electrical tilt, and antenna height values of each ENodeB will change. [9,10]. With this change, it is expected that ENodeB's performance will be more leveraged than the previous one, particularly in the given coverage area.

2.4. Carrier Aggregation (CA)

Carrier Aggregation is a method/technique of using two carrier frequencies simultaneously using the same or different frequencies to increase bandwidth. The maximum number of CC additions allowed is five (1 PCC and 4 SCC) [5]. There are several types of implemented scenarios, namely; [5, 6, 11].

1. Carrier aggregation deployment scenario 1 (CADS 1)

In the first scenario, both operator components are operating in the same frequency band, with the same antenna response and coverage area. As a result, carrier aggregation is feasible in all areas.

2. Carrier aggregation deployment scenario 2 (CADS 2)

The scopes of the scenarios for these two components differ. The coverage of the F2 component is less than that of the F1 component because it is derived from widely separated bands. They overlap each other in a small area for aggregation.

3. Carrier aggregation deployment scenario (CADS 3)

In this scenario, one carrier component's response is shifted to improve user performance at the cell's edge. Aggregation operators can also operate at the cell's edge.

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The CADS1 scheme will be used by the researcher in this study. Based on the previous explanation in this scheme, the researcher introduces a new carrier signal in the same band, as well as a continuous working frequency from the previous frequency [5]. As a result, once this CA is implemented, it will be generated as shown in Figure 3.

Figure 3. CADS 1

As shown in Figure 3, the added carrier component signal has the same coverage and response as the main carrier component in the implementation of this CADS1 scheme. As a result, the possibility of aggregation that occurs between the main carrier signal and the additional carrier signal following the implementation of this optimization scheme will overlap in all eNodeB coverage areas. [12,13].

2.5. Network Design

This design is carried out by taking into account each technical parameter, such as path loss, acceptability sensitivity, and others [14,12].

1. Link Budget Calculation

Table 1. Link Budget Calculation and MAPL

MAPL & Link Budget calculation			
Morfologi	UL	DL	Formula
Frekuensi	1800 MHz		
Transmitter	UE	eNB	
Tx power	23	43	A
RB to distributed power	3	100	C
Subcarriers to distribute power	36	1200	D=12*C
Subcarriers power	7,44	12,2	E=A-10log(D)
Tx antenna gain	0	17	G
Tx cable loss	0	0.5	H
EIRP	7,44	28,7	J=E+G-H
Receiver	UE	eNB	
SINR	-1	-1	K
Rx niose figure	2	3	L
Receive Sensitifity	-131,3	-130,3	M=K+L-174+ 10*log(15000)
Rx antenna gain	17	0	N
Rx body loss	2	2	P
Interface margin	2	3.13	Q
Min signal reception strength	-127,3	-125,17	R=M+P+Q
Pathloss & Shadow fading margin			
Penetration loss	10	11	S
Shadow fading margin	4	5	T
MAPL	137,74	137,87	U=J+N-R-S-T

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2. Propagation Model

This propagation model is a calculation that is used to determine how many path losses occur. [15, 5, 16]. The mathematical equations for this calculation are as follows:

$$PL = 46{,}3 + 33{,}9\log(fc) - 13{,}82\log(hte) - a(hre) + (44{,}9 - 6{,}55\log(hte))\log d + CM$$

Remark:
CM = 0 (suburban) and 3 (metropolitan)
F = working frequency
hte = 30 – 200 m
hre = 1 – 10 m
d = 1 – 20 Km

2.6. Parameter Engineer

1. RSRP (Reference Signal Received Power)

RSRP is a signal strength level parameter received by the user from a nearby eNodeB. [9, 4, 11].

Table 2. RSRP Mark

Mark	Remark
>= -71 dBm	Very good
<-71 dBm up to <=	Good
<-81 dBm up to <=	Normal
<-91dBm up to <=	Bad
<-101 dBm	Very bad

2. SINR (Signal Interference to Noice Ratio)

SINR is defined as the ratio of the main signal emitted by eNodeB to the *interference* and *noise* that occurs. [9, 17, 6].

Table 3. SINR Mark

Nilai	Keterangan
16 dB up to 30 dB	Very good
1 dB up to 15 dB	Good
0 dB up to -5 dB	Normal
-11dB up to -6 dB	Bad
-12 dB up to -20 dB	Very Bad

3. Throughput

Throughput is the actual data rate of a transmitted carrier signal [18, 9, 6].

Table 4. Throughput Mark

Mark (kbps)	Remark
Greater than 40.000	Very good
30.000 up to 40.000	Good
20.000 up to 30.000	Normal
10.000 up to 20.000	Bad
0 up to 10.000	Very Bad

3. RESULTS AND DISCUSSION

The ACP optimization technique is used to obtain changes in the condition of the sectoral antenna tilting at each site. Changes are obtained from this application, as shown in the Figure 4.

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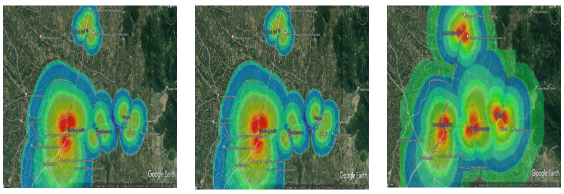
Figure 4. Reconfiguration improvement

Figure 4 shows the changes in several antenna parameters such as the tilt and direction of the antenna, these changes were made with the aim of finding the best combination of antenna parameters to be able to overcome the problem of bad spot areas that occur in the Ditto Ditch area. Changes in the slope of the antenna will affect the coverage area provided by an ENodeB, the smaller the slope value, the smaller the ENodeB coverage area and the greater the slope value, the farther the coverage area. However, this value change also affects the quality of the signal provided by ENodeB, the smaller the slope value and the smaller the ENodeB coverage area, the better the network quality, but the greater the slope value and the farther the coverage area provided by ENodeB, the signal quality will be better. decrease. Meanwhile, changing the value of the antenna direction will affect the direction of the emission from an ENodeB to the surrounding area.

The simulation results from these two scenarios can be seen in the Figure 5.



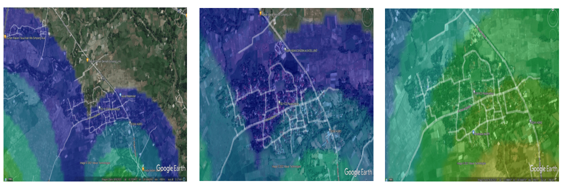
(a) Eksisting (b) ACP (c) CA

Figure 5. Optimization simulation results

Figure 5 shows the results of three optimization simulations: (a) for the existing simulation, (b) for the ACP technique, and (c) for the CA technique. The figure depicts all of the engineering parameters used in this study. We can also conclude from the image that there are differences between these two optimization technique schemes, particularly in terms of the *coverage area* they provide.

More information about the performance of each site on each parameter can be found in the figure and explanation below.

1. RSRP



(a) Eksisting (b) ACP (c) CA

Figure 6. RSRP Parameters Result

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The color of the visible zone in Figures 7(a) and 7(b) indicates differences in network quality. According to (a) the ACP optimization technique simulation results, the Koto Baru area is in the dark blue (very bad) and light blue (poor) zones. In terms of (b), the Koto Baru area is in the light blue (bad), green (normal), and yellowish green (normal) zones, according to the simulation results of CA optimization techniques. The table below provides a numerical representation of the network strength of dBm in the Koto Baru area.

Table 5. Analysis Points of Case Study Area

Cell	Distance (m)	Eksisting (dBm)	CA (dBm)	ACP (dBm)
PAYOBASUNG_1(0)	1.242	- 131,61	- 106,66	- 103,35
PAYOBASUNG_1(1)	1.242		-88,61	
KANIANGBUKIT_1(0)	2.726	- 135,3	- 112,85	- 109,54
TARAM_3(0)	2.715		- 139,04	- 122,97

Table 5 shows that the best RSRP value using the ACP optimization technique is -103.35 dBm, but this figure is still in the poor category. In terms of the CA optimization technique, the best RSRP value is -88.61 dBm, which is already in the normal range. The results of the two optimization schemes used for the RSRP parameters show that for the ACP technique, the RSRP condition is still in the bad category, whereas for the CA technique, the RSRP condition is already in the normal category.

2. SINR

(a) eksisting (b) ACP (c) CA

Figure 8. SINR Parameters Result

Figure 8(a) depicts the outcome of the optimization simulation using the ACP optimization technique, while Figure 8(b) depicts the outcome of the optimization simulation using the CA technique. At a glance, it is clear that the two optimization schemes used have different zones. The Koto Baru area is in the green zone in the ACP optimization simulation (normal). In the CA optimization simulation, Koto Baru area is in the slightly greenish-yellow zone (good). The numerical version of the SINR parameter value is shown in the Table 6.

Table 6. Analysis Point of SINR

Cell	Distance (m)	Eksisting (dB)	ACP (dB)	CA (dB)
PAYOBASUNG_1(1)	1.242			7,84
PAYOBASUNG_1(0)	1.242	-3	4,32	
KANIANGBUKIT_1(0)	2.726		1	1

The table shows that the best SINR value for using the optimization method with the ACP technique is 2.64 dB, which is generated or provided by the PAYOBASUNG coverage site cell 1. Meanwhile, the best SINR value for the application of the CA optimization technique is found to be 7 dB, which is generated from the coverage area of the PAYOBASUNG site in cell 1. (1). The PAYOBASUNG 1(1)

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cell is an addition to the CA optimization technique's implementation. The SINR parameter simulation results show that the SINR value is already in the good category, but the SINR value with the CA scheme is better than the ACP scheme.

3. Throughput

This network throughput is also known as the network speed that the user receives and enjoys. As a result, this parameter is critical in determining the provider's level of service satisfaction (QoS).

(a) Eksisting (b)ACP (b) CA

Figure 9. Network Throughput

Figure 9 shows the current state of the network throughput value in the research case study area (Koto Baru). According to the graph, the network throughput conditions in the Koto Baru area after the CA optimization technique were at 15,000 kbps or 15 Mbps (bad). Meanwhile, the throughput value following the CA optimization technique is greater than 50,000 kbps or 50 Mbps (very good). Figures 9 (a) and 9 (b) show that the images are nearly identical; this is because the ACP technique used in this study has not resolved the network throughput value or is still in poor condition. And, as shown in Figure 9 (c), the throughput value is already in excellent condition as a result of the CA scheme.

4. CONCLUSION

In this study, two issues were discovered in the case study area based on the existing simulation, namely very low RSRP and Throughput values. ACP (Automatic Cell Planning) and CA are the optimization schemes proposed to solve this problem (Carrier Aggregation). The use of the ACP scheme this provides several changes in the values of several antenna parameters such as the slope value and direction of the sectoral antenna direction for several sites, after the simulation is run again to see the results of using this ACP scheme, the results are still in bad condition. And the results obtained from using this ACP scheme for network performance parameter values are RSRP = -103 dBm, SINR = 2 dB, and throughput = 15 Mbps. Meanwhile, the use of the CA scheme using the intra-band feature with the CADS1 scheme provides quite a good change, and all the problems that arose at the beginning in the case study area can be resolved by using this CA scheme. After the CA scheme is implemented and simulated, the results obtained for each network performance parameter are as follows; the RSRP value is -90 dBm, the SINR is 7 dB, and the throughput is 50 Mbps. From the simulation results for the two optimization schemes carried out, it can be concluded that the use of the Carrier Aggregation (CA) optimization scheme is better than the Automatic Cell Planning (ACP) scheme in the case study area in this research.

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