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Planning of LTE-Apro Network using Licensed Assisted Access combining Spectrum Licensed 1800MHz and Unlicensed 5GHz

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ABSTRACT

Abstract: The number of activities in the room results in an increase in the amount of traffic which means a large surge in cellular users. As large data traffic increases, limited spectrum is available and high spectrum costs, wireless service providers respond by making adjustments to LTE technology. With the presence of LTE-AP supported by an unlicensed spectrum, Telkomsel operators can enjoy the unlicensed spectrum to increase capacity and throughput.

Cellular network planning uses 2 scenarios to get the best solution, Scenario 1 is planning the LTE Network with a bandwidth of 20 MHz in band 3 and using a 4x4 MIMO antenna. , scenario 2 planning the LTE-Advanced Pro network uses the LAA method by combining the unlicensed 20 MHz spectrum in band 36 and a licensed 20 MHz sprectrum in band 3 and using a 2x2 MIMO antenna. analysis and simulation using U-Net V500 software.

The results of the LTE network planning simulation obtained the average value of RSRP 77 -77.71 dBm, SINR ≥ 11.88 dB, Throughput ≥ 37.079 Mbps and User connected = 98.00%, while the LTE-AP average value of RSRP ≥ -73.51 dBm, SINR ≥ 17.02 dB , Throughput ≥ 49,739 Mbps and User connected = 100.00%. Based on the simulation results, the LTE-AP network planning is very good to be implemented in the city of Bandung, the best solution choice to overcome the limitations of Telkomsel spectrum with the network performance that is very good in terms of coverage and capacity.

1. Introduction

Current technological developments are increasingly rapid, so that the needs of users are increasing, especially wireless-based cellular technology. The more needs and number of users, the more data traffic is. Until the end of 2014, there were at least 7.2 billion mobile users worldwide. Meanwhile, the number of users of mobile services has grown every year. It is estimated that by 2022 there will be 9 billion mobile internet users in the world. That figure exceeds the current population of the earth which is only around 7.5 billion people. Indonesia itself contributes significantly in supporting the growth of mobile internet users in the world. During the first quarter of 2017, there were more than 10 million new mobile internet users from the country. That number makes Indonesia the third country with the largest growth of mobile internet users. One that drives

the massive consumption of the internet is video. According to Ericsson's report, currently 50 percent of mobile internet consumption flows to video. The percentage is predicted to increase to 75 percent by 2022. Consequently, the average data needs of mobile internet users, currently only 2.1 GB per month, are forecast to increase to 12 GB per month. Therefore cellular technology is required to increase user capacity and service quality with a high standard, large bandwidth and wide coverage.

The use of spectrum frequency is a major problem in the implementation of 4G, the government is encouraging cellular operators to provide 1800 MHz frequencies for slots for 4G. However, the bandwidth of each operator in this frequency is quite limited because some of it has been used for 3G networks. To overcome this problem 3GPP released the latest technology, namely LTE-Advanced pro release 13 that supports the unlicensed spectrum feature or License Assisted Access. License Assisted Access is an LTE feature that utilizes a 5 GHz unlicensed band combined with a licensed spectrum to provide performance boosts for mobile device users.

With features that support License Assisted Access, LTE-Advanced pro technology is increasingly optimized with unlicensed spectrum usage at 5GHz for indoor and combined with a licensed 1800 MHz outdoor spectrum.

LTE-Advanced pro network planning using the License Assisted Access feature is based on the calculation of coverage and capacity. The parameters used for analysis are RSRP, RSSI, SINR, Throughput and user connected.

2. Theoratical Advance Pro (LTE-AP)

ASK Telecom has just finished forming an evolution of LTE that is 4.5G. The 3GPP standard is managed as Releases. The LTE series, which is classified as LTE, LTE-Advanced (LTE-A) and LTE-Advanced Pro (LTE-APro), is defined in Release 8 to Release 14, and the 5G standard starts from Release 15. LTE-Advanced Pro, which also known as 4.5G, is the most evolved phase of all LTE series.

3GPP developed the following capabilities for LTE-Advanced Pro with specifications in Release 13 and is considered the most important feature for LTE-Advanced Pro. The features owned by LTE-Advanced with Release 10 specifications are bandwidth support reaching 640 MHz, Enhanced MIMO, and Interworking with WiFi and such as D2D and licensed assisted access.

2.1 LAA (Licensed Asisted Acces).

LAA is a feature introduced by 3GPP release 13, as shown below LAA connectivity is divided into 3 categories:

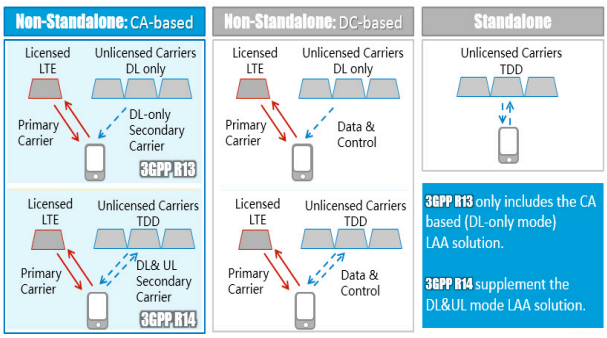

Fig. 1 - LAA conditions.

1. Standalone: Device only uses one connectivity, namely unlicensed frequency (TDD).

2. Non-Standalone DC-Based: Devices using dual connectivity namely unlicensed frequency (TDD) and licensed frequency.
3. Non-Standalone CA-Based: Device uses Carrier aggregation namely unlicensed frequency (TDD) and licensed frequency.

The basic principle of LAA is that LTE-Advanced Pro services continue to use licensed spectrum, with unlicensed frequencies used opportunistically to increase throughput and capacity.

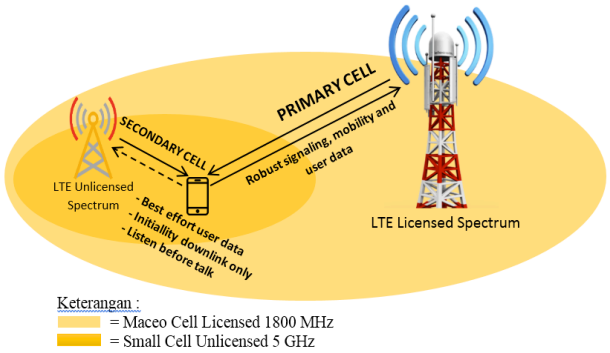

Fig. 2 - Concept LAA conditions.

First the device uses CA, both devices choose the connectivity mode between SDL or UL & DL, all three devices use the frequency provided between FDD or TDD then use LBT to avoid conflict or contention between 5 GHz wifi and 5 GHz LTE small cell.

3. System Planning.

3.1. Planning Process.

To achieve the goal, systematic and structured steps are needed in order to achieve optimal planning results. In general, the workflow is illustrated in Figure 3.1 which includes the stages of work carried out in this research. The flow chart in the work of this research can be described as follows.

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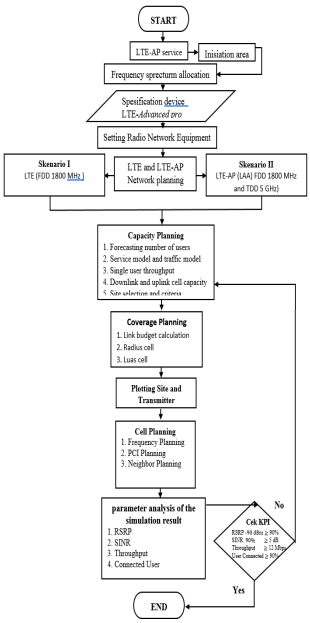

Fig. 3 - Flow Diagram

1. Service model parameters.

The traffic model table below is a traffic model parameter whose value is determined by the operator and vendor with consideration of service development and marketing strategies.

Table 1 - Service Model.

Traffic parameters	UL	DL
	Throughput / Session (Kbps)	Throughput / Session (Kbps)
VoIP	869.49	869,49
Video Phone	4421.31	4421.31
Video Conference	113690.91	113690.91
Real Time Gaming	11367.27	90952.73
Streaming Media	5683.64	864016.36
IMS Signaling	22.10	22.10
Web Browser	5684.55	22737.27
File Transfer	85266.67	454751.52
Email	7105.55	37895.96
P2P File Sharing	303151.52	909503.03

2. Network Throughput.

Network throughput is the amount of throughput needed for the total number of users planned in accessing all services.

Table 2 - Network Throughput.

ITEM	LTE(FDD)		LTE-*Advanced pro* (LAA)	
	Uplink (kbps)	Donwlink (kbps)	Uplink (kbps)	Donwlink (kbps)
Total target user	94.062		45.149	
Single User Throughput (kbps)	9.5088	36.3770	9.5088	36.3770
Network Throughput (ip) (kbps)	894,416.74	3,421,693.37	429,312.81	1,642,385.17
Network Throughput (ip) (Mbps)	894.41	3,421.69	429.31	1,642.38

3. Calculation of Total Site.

After all the data collected, then to determine the number of sites used several criteria such as the table below with the aim of selecting sites for the application of LTE and LTE-Advanced pro can be very accurate or in accordance with the standard operator. The following is the number of sites needed based on Telkomsel operator standard criteria.

Table 3 - Number site of LTE and LTE-AP.

Criteria LTE	No of Site	
Payload > 30 GB+4G Handset > 150	62	
POI + VIP	24	
Payload > 30 GB+4G Handset > 150+Transport Readiness	9	
POI + Payload > 30 GB	35	
POI+Payload < 30 GB+4G Handset < 150+Transport Readiness	17	
POI+Payload > 30 GB+4G Handset >150+Transport Readiness	8	
Total Site	156	
Criteria LTE-AP (LAA)	No of Site	New cell
Payload > 50 GB+4G Handset > 250	10	9
POI + VIP	24	23
Payload > 50 GB+4G Handset > 250+Transport Readiness	3	3
POI + Payload > 50 GB	4	4
POI+Payload < 50 GB+4G Handset < 250+Transport Readiness	9	9
POI+Payload > 50 GB+4G Handset >250+Transport Readiness	6	6
Total	56 Site	54 Cell

The first step to get the number of sites is to collect data for each site based on 4 methods: first each 3G payload site> 30 GB, second each site has a number of mobile phones that support LTE> 150, thirdly review the area from the POI and VIP side, the fourth transport readiness. You can see in Table 3.10 that the most sites for deploying LTE networks are 156 sites while for LTE-Advanced pro there are only 56 sites with the addition of 54 new cell devices for small cells. This is because there are several criteria that do not meet the LTE-Advanced pro deployment standard. especially the criteria for smartphone and 3G payload usage, after reviewing the use of smartphones with 4G LTE category 12 support only slightly compared to smartphones with 4G LTE category 5 support down then based on POI and VIP.

3.2. LTE-AP Network Planning Based on Coverage

Coverage dimensioning is planning that is carried out based on a review of area, that is, by calculating the value of MAPL (Maximum Allowed Path Loss) to get the coverage / radius of the cell from a site so that the entire review area can be covered properly.

1. MAPL Frequency 1800 MHz

The next step calculates the pathloss value of Tx and Rx for frequency 1800 MHz. Here are the MAPL uplink and downlink values:

Table 4 - MAPL Frequency 1800 MHz

Tx	UL	DL	Formula
Max Total Tx Power (dBm)	23.00	43.00	A
RB to Distribute Power	10	100	C
Subcarriers to Distribute Power	120	1200	D = 12*C
Subcarrier Power (dBm)	2.20	12.2	E = A-10*Log10(D)
Tx Antenna Gain (dBi)	0.00	17.00	G
Tx Cable Loss (dB)	0.00	0.50	H
Tx Body loss (dB)	0.00	0.00	I
EIRP per Subcarrier (dBm)	2.20	28.7	J = E+G-H-I
Rx	UL	DL	Formula
SINR (dB)	-1.50	-1.68	K
Rx Noise Figure (dB)	2.90	7.00	L
Receiver Sensitivity (dBm)	-130.8	-126.92	M = K+L-174+10*Log10(15000)
Rx Antenna Gain (dBi)	17.00	0.00	N
Rx Cable Loss (dB)	0.50	0.00	O
Rx Body loss (dB)	0.00	0.00	P
Neighbor Load	50.00%	70.00%	
Interference Margin (dB)	0.80	8.11	Q
Min Signal Reception Strength (dBm)	-145.7	-118.81	R = M-N+O+P+Q

2. MAPL Frequency 5 GHz

The next step calculates the path loss value Tx and Rx for the 5 GHz frequency. Here are the MAPL uplink and downlink values:

Table 5 - MAPL Frequency 5 GHz

Tx	UL	DL	Formula
Max Total Tx Power (dBm)	23.00	43.00	A
RB to Distribute Power	10	100	C
Subcarriers to Distribute Power	120	1200	D = 12*C
Tx	UL	DL	Formula
Subcarrier Power (dBm)	2.20	12.2	E = A-10*Log10(D)
Tx Antenna Gain (dBi)	0.00	11.00	G
Tx Cable Loss (dB)	0.00	0.50	H
Tx Body loss (dB)	0.00	0.00	I
EIRP per Subcarrier (dBm)	2.20	22.7	J = E+G-H-I
Rx	UL	DL	Formula
SINR (dB)	-1.50	-1.68	K
Rx Noise Figure (dB)	2.90	7.00	L
Receiver Sensitivity (dBm)	-130.8	-126.92	M = K+L-174+10*Log10(15000)
Rx Antenna Gain (dBi)	11.00	0.00	N
Rx Cable Loss (dB)	0.50	0.00	O
Rx Body loss (dB)	0.00	0.00	P
Neighbor Load	50.00%	70.00%	
Interference Margin (dB)	0.20	3.10	Q
Min Signal Reception Strength (dBm)	-141.1	-123.82	R = M-N+O+P+Q

This MAPL is used to calculate the radius value of a cell. After obtaining the radius value of a cell from a site, it can obtain the number of sites needed to cover the entire area of the review. The thing that is the top priority in this coverage planning is, the whole side of the review area can be covered by the signal, but regardless of the throughput value obtained by each user. Get MAPL values for links and uplinks like Table 6 below:

Tabel 6 - Pathloss Value

Path Loss & Cell Radius	1800 MHz		5 GHz		
	UL	DL	UL	DL	Formula
Penetration Loss (dB)	20.00	20.00	14.00	14.00	S
Std.of Shadow Fading (dB)	9.40	9.40	9.40	9.40	
Area Coverage Probability	90.00%	90.00%	90.00%	90.00%	
Shadow Fading Margin (dB)	4.24	4.24	2.00	2.00	T
Path Loss (dB)	119.06	122.2	127.3	130.52	U = J-R-S-T

Table 7: Cell Radius

Cell Radius-	URBAN			
	UL	DL	UL	DL
Propagation Model	Cost231-Hata		Erceg-Greenstein(SUI)	
eNodeB/UE Antenna Height (m)	30.00	1.50	3.00	1.50
Frequency (MHz)	1800		5150	
Cell Radius (m)	894	912	82.4	164.4

Obtained cell radius for urban areas with the use of 2 propagation models, the use of 2 propagation models is intended to use carrier aggregation method.

4. Simulation and Analysis

1. Coverage Prediction LTE (Scenario I)

The following are the results of the coverage prediction simulation for planning LTE networks using 20 MHz bandwidth and mimo 4x4 antennas and the use of several parameters to improve network quality. Here are the results of the simulation:

Table 8 - Coverage prediction LTE

Parameter			Scenario I		
			LTE	LTE with using PCI	LTE with using SFR
Signal Level	DL RSRP (dBm)	Average	-77.71	-77.71	-77.71
		Edge	-93.61	-93.61	-93.61
	DL Bandwidth RSRP >-65 (dBm)		89.44%	89.44%	89.44%
	RSSI >-50 (dBm)		70.61%	70.61%	70.61%
	DL PDSCH Signal Level >-80 (dBm)		73.31%	73.31%	73.31%
C/(I+N)	DL RS SINR (dB)	Average	1.9	0.17	11.88
		edge	-6.27	-7.95	-1.52
	DL PDSCH SINR >20 (dB)		1.38%	1.47%	30.75%
	RS Interference Margin >-80 (dBm)		37.43%	48.54%	2.23%
Throughput	DL MAC Peak Throughput (Kbps)	Average	15513.50	13793.02	38210.30
		Edge	3454.18	2645.72	8691.19

2. Coverage Prediction LTE-AP (Skenario II)

The following are coverage prediction simulation results for planning LTE-Advanced Pro networks by utilizing Licensed Assisted Access features by combining 2 frequency bands using 20 MHz macro cell bandwidth and 20 MHz small cell by using 2x2 mimo along with the use of several parameters to improve network quality. Here are the results of the simulation:

Table 9 - Coverage prediction LTE-AP

Parameter			Scenario II		
			LTE-AP	LTE-AP with using PCI	LTE-AP with using SFR
Signal Level	DL RSRP (dBm)	Average	-73.49	-73.49	-73.49
		edge	-87.35	-87.35	-87.35
	DL Bandwidth RSRP >-65 (dBm)		93.13%	93.13%	93.13%
	RSSI >-50 (dBm)		83.89%	83.89%	83.89%
Signal Level	DL PDSCH Signal Level >-80 (dBm)		78.66%	78.66%	78.66%
C/(I+N)	DL RS SINR (dB)	Average	6.35	6.89	16.77
		edge	-4.62	-4.05	2.3
	DL PDSCH SINR >20 (dB)		14.09%	14.02%	46.06%
	RS Interference Margin >-80 (dBm)		42.77%	39.29%	1.53%
Throughput	DL MAC Peak Throughput (Kbps)	Average	30942.33	31144.54	49569.61
		Edge	2893.981	3057	11263.64

3. Comparison of prediction LTE and LTE-AP Coverage

To see the performance of the use of licensed assisted acceess by using carrier aggregation in the planning of LTE-AP networks, in Table 4.3 a comparison is made between the planning of LTE-AP and LTE networks, here are the results of the simulation:

Tabel 10 - Comparison of LTE and LTE-AP Coverage

Parameter			Scenario I	Scenario II
			LTE with using PCI and SFR	LTE-AP with using PCI and SFR
Signal Level	DL RSRP (dBm)	Average	-77.71	-73.51
		edge	-93.61	-87.53
	DL Bandwidth RSRP >-65 (dBm)		89.44%	92.97%
	RSSI >-50 (dBm)		62.68%	78.81%
	DL PDSCH Signal Level >-80 (dBm)		73.03%	78.59%
C/(I+N)	DL RS SINR (dB)	Average	11.88	17.02
		edge	-1.52	2.79
	DL PDSCH SINR >20 (dB)		30.75%	45.88%
	RS Interference Margin >-80 (dBm)		2.23%	1.26%
Throughput	DL MAC Peak Throughput (Kbps)	Average	37079.66	49739.90
		Edge	7879.90	11507.95

A. Capacity Simulation

Capacity simulation here presents the distribution of users in the area of planning for LTE and LTE-AP networks as well as struggling to measure the capacity of a site and review the number of users who are using several services such as VoIP services, Email, FTP, Video Phone etc. Like the picture below:

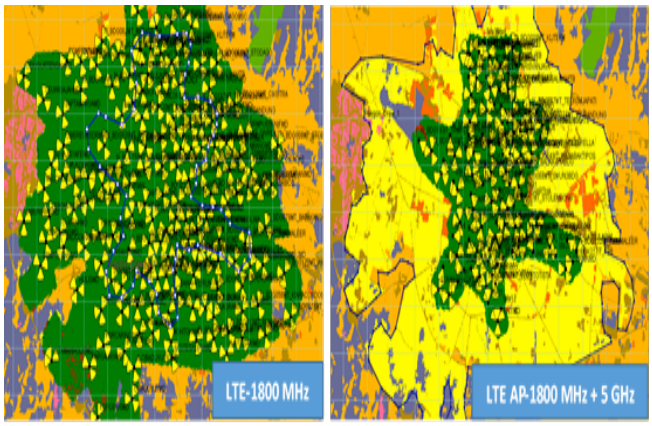

Fig. 4 - Coverage Prediction

The picture above is an EU distribution which is used to measure the capacity and quality of a network. Users get one of the 10 services provided by getting different rsrp and throughput values based on user conditions. Then the user also gets the type of modulation that is used along with the code rate based on the user 's condition.

1. Capacity simulation of LTE results (Scenario I)

After doing coverage prediction to see parameters such as RSRP, SINR and Throughput, in this final project capacity simulation analysis is performed to see the capacity and quality of LTE network planning such as reviewing user rejected and DL RS SINR distribution as shown below, as follows:

A. Analysis User Rejected

To find out how good the LTE network planning results are, it is necessary to spread the user. User rejected consists of 3 categories: rejected in no access, no coverage and offline status, as shown below

Tabel 11 - User Rejected LTE

Scenario I	Demand	Number of Site	Rejected			Presentase User Rejected	Presentase User Connected
			No Access	No Coverage	Offline		
LTE	94000	156	0	0	2817	2.91%	97.09 %
LTE+PCI	94000	156	0	0	2492	2.58%	97.42 %
LTE+SFR	94000	156	0	0	1932	2.00%	98.00 %

2.Capacity LTE-AP result simulation (Scenario II)

After doing coverage prediction to see parameters such as SINR, RSRP and Throughput, this final project analyzes capacity simulation to see the capacity and quality of LTE-AP network planning such as user rejected and DL RS SINR distribution, as follows:

A. Analysis User Rejected

To find out how good the LTE-AP network planning results are, it is necessary to spread the user. User rejected consists of 3 categories: rejected in no access, no coverage and offline status, as shown below:

Table 12 - User Rejected LTE-AP

Scenario II	Demand	Number of Site	Rejected			Presentase User Rejected	Presentase User Connected
			No Access	No Coverage	Offline		
LTE-AP	45000	74	0	0	0	0%	100 %
LTE-AP +PCI	45000	74	0	0	0	0%	100 %
LTE-AP +SFR	45000	74	0	0	0	0%	100 %

B. Final results of simulation analysis

Comparison of coverage between LTE using 4x4 mimo with LTE-AP uses mimo 2x2 and LAA, along with the use of several features such as PCI as cell identification by synchronizing time and frequency and SFR as interference management. From the simulation analysis that has been done, a summary of the final results is as follows:

1. Final Result of LTE mimo 4x4 and LTE-AP Simulation :

Table 13 - Final Simulation Results

	LTE (Scenario I)			LTE-AP (Scenario II)		
Parameter	Not using PCi and SFR	Using PCI	Using SFR	Not using PCi and SFR	Using PCI	Using SFR
	Using with mimo 4x4			Usingwith mimo 2x2 and LAA		
Number of user	94000			45000		
Number of site	156			74		
Number of user/site	602			608		
Average RSRP (dBm)	- 77.71			- 73.49		
Average SINR (dB)	1.9	0.17	11.88	6.35	6.89	16.77
RS Interferensi for SINR > -80 dBm	37.43%	48.54%	2.23%	42.77%	39.29%	1.53%
Average Throughput (Mbps)	15.513	13.793	38.210	30.942	31.144	49.569
25 < RS SINR Distribution (dB) <=60	0.12%	0.33%	13.72%	13.02%	20.61%	35.27%
User Connected	97.09%	97.42%	98.00%	100%		

Table 14 - Result of simulation coverage and capacity

Parameter	LTE (Scenario I)	LTE-AP (Scenario II)	KPI TELKOMSEL
	Using with PCI and SFR		
Average RSRP (dBm)	- 77.71	- 73.51	-90 dBm > 90%
Avegare SINR (dB)	11,88	17,02	90% > 5 dB
Avegare Throughput (Mbps)	37,079	49,739	> 15 dBm
User Connected	98.05%	100 %	90%

5 CONCLUSION

1. Based on the explanation described in previous chapters, conclusions can be drawn regarding the planning of LTE and LTE-AP networks in the area of Bandung, namely.

2. Site selection methods based on criteria are divided into 4, namely based on 3G payload> 30GB / day, handset> 150 / Site, POI and VIP, Transport Readiness. Based on this method, the number of sites LTE = 156 Site is obtained, while for LTE-AP there are 74 sites.

3. The results of the LTE network planning simulation in the area of Bandung using LTE (FDD), obtained an average RSRP parameter value of -77.71 dBm, SINR on average 1.09 dB, average throughput of 15.513 Mbps, and user connected 97.09%. While the results of the LTE-AP network planning simulation in Bandung area using LAA obtained an average RSRP parameter value of -73.49 dBm, SINR averaged 6.35 dB, average throughput was 30.942 Mbps, and user connected 100%.

4. The results of LTE and LTE-AP network planning simulations using PCI also improve several parameters such as SINR, Throughput and User connected. SINR for LTE-AP with mimo 2x2 non PCI obtained an average of 6.35 dB after using PCI increased to 6.89, the average value of throughput also increased from 30,942 Mbps after using PCI obtained 31,144 Mbps and user connected 100%. It is different when applying PCI on the 4x4 mimo antenna has a negative impact because of the allocation between signal references and PCI allocation, so much so that inter-symbol interference on each port is more common so SINR decreases and throughput also decreases, as has been done with SINR non PCI is an average of 1.9 dB when using PCI decreases to 0.17 dB, the average throughput also decreases from 15.13 Mbps after PCI is applied to 13,793 Mbps but for user connected it increases from 97.09% to 97.42%.

5. The results of the LTE and LTE-AP network planning simulation using SRF also improved several parameters, especially SINR and Throughput. As the simulation results that have been done for the SINR value on non SFR LTE on average 1.9 dB increased after using SFR to 11.88 dB, the average throughput also increased from 15.513 Mbps after using SFR to 38.210 Mbps and user connected also increased from 97.09% to 98.00%. Likewise the non SFR LTE-AP SINR is an average of 6.35 dB after using SFR to 16.77 dB, the average throughput also increased from 30,942 Mbps after using SFR increased to 49,569 Mbps and user connected remained 100%.

6. Network planning between LTE and LTE-AP that is better to be implemented in the Bandung area is planning the LTE-AP network using PCI and SFR. This is because the consideration of cost efficiency for the number of sites built is less, as many as 74 sites and is effective in utilizing 20 MHz unlicensed bandwidth in band 36 (5180 MHz) so as to be able to efficiency limited frequency spectrum and better network performance in terms of coverage with RSRP. on average -73.49 dBm, and better network quality with SINR averaging 17.02 dB, average throughput of 49.739 Mbps, and user connected 100%.

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