Analysis Simulation of LTE Network Capacity in Pekanbaru

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Abstract— **In Indonesia, LTE technology is appropriately to be applied by telecommunication operators in improving cellular communication services. In 2018, the number of LTE network users in Pekanbaru continues to increase. Increasing number of customers need increasing service capacity. To fulfill the capacity needs of LTE network services with better signal level in 2018, then in this study has been analyzed the simulation of LTE network capacity in Pekanbaru City. In this research, we use Monte Carlo simulation for analyze capacity. Frequency Division Duplex method with 1800 MHz frequency and COST-231 Hata propagation model were used in the simulation. The results of simulation capacity in Pekanbaru show that the urban area needs 143 number of BTSs for 20MHz bandwidth, BTSs coverage reaches 84.4% of covered area and highest focus zone covered at -100 dbm signal, and for 5MHz Bandwidth, the total number of subscribers is 47.375, with 39.158 connected subscribers and 8.216 unsuccessful subscribers.**

Keywords: LTE, Capacity, FDD

I. INTRODUCTION

Today, the information technology, multimedia and mobile Communication are growing rapidly. Mobile and wireless communication are moving towards a new era that will be characterized by the seamless collaboration of heterogeneous system, the need for high speed communication while on the move and for advanced services with quality guarantees. At the same time, Consumer's need for multimedia and mobile information is also increasing. Therefore, Improvement of wireless communication services are needed which can support consumer's need for multimedia information and mobile broadband network, with low cost but can work with more optimal result. At this time, technology of wireless communication has been developed for the fourth generation (4G), better known as with LTE (Long Term Evolution) technology.

Planning and performance improvement in cellular networks form a very active line of research in wireless communications. There are many works on LTE network planning. Planning coverage of LTE network in Khartoun City has been done in [1]. In [2] had analyzing of LTE coverage and capacity considering Dhaka City. In [3], Radio link budget is ivestigated for coverage planning. Coverage and capacity estimation is carried out in radio network dimensioning. The final product gives the number of sites needed in order to support a certain subscriber population with a given capacity. The Planning LTE frequency and investigation of LTE system capacity and coverage has been studied in [4], The study give result the interference limited coverage calculation, the traffic capacity calculation and radio frequency assignment. The implementation is achieved on the WRAP software platform for the LTE Radio Planning.

In [5], Mapping downlink SNR to CQI in LTE for different multiple antenna technique. Optimization capacity and coverage in LTE by self-tuning of remote electrical tilts based on call traces has been done in [6]. In [7], Comparison and planning LTE coverage network with different propagation model had been studied. In [8,9], using sofware atoll, the reserach had planning LTE network in 1800 MHz in Semarang City. While in [10,11], planning LTE network, using 2300 MHz ferquency has been done. Simulation of physical layer in LTE network has been studied in [12]. Another research in [13], has modeling 4G wireless system and compare propagation of radio channel. In [14], The LTE planning was performed as case study in selected area of Addis Ababa, then commence LTE implementation in the area with initial radio planning to properly reduce the number of basestation to less than ten BTSs at the same time improve the capacity.

4G LTE telecommunication technology has become the standard in mobile services in Indonesia in 2017. In Indonesia, LTE technology is appropriately to be applied by telecommunication operators in improving cellular communication services, because it can be implemented on GSM and CDMA networks. In addition, the application of LTE is considered easier and does not require major changes to the network infrastructure.

Initially, The LTE services in Pekanbaru city was launched by the biggest operator cellular in December 2015. At that time, the coverage of LTE services in Pekanbaru reached half of the Pekanbaru City included in the strategic area.

Since its launch in December 2015, LTE user in Pekanbaru continues to increase, both the number of customers, as well as traffics. There are 38 eNodeB/BTSs capable of serving 4G

in Pekanbaru. The densest area is around the Lumba-Lumba region with 16 percent coverage of the customers and the slow signal area at Sultan Syarif Qasim II Airport with penetration of about 1.3 percent. The coverage of LTE services in Pekanbaru city has only fulfilled some urban areas with low penetration, and has not fulfilled the needs of LTE capacity in Pekanbaru city.

To fullfill the capacity needs of 4G network services in 2018 that are evenly distributed with increased signal level throughout Pekanbaru City, then in this study has been analyzed the simulation of the LTE network capacity in Pekanbaru city. In this research, we use monte carlo simultion for analyze capacity. The eNodeB mapping was conducted in 12 sub-districts in Pekanbaru city including urban, suburban and rural areas using Frequency Division Duplex (FDD) method with frequency of 1800 MHz and COST-231 Hata propagation model.

The remainder of the paper is organized as follows. The methodology in simulation LTE network for mapping eNodeB/BTSs including link budget explained in Section 2. The analysis of results and conclusion are explained in Section 3 and Section 4 respectively.

II. METODHOLOGY

In the LTE network to map the location of BTSs there are several steps that must be followed. The stages of LTE network simulation as follows:
1. Determine the frequency and duplex method to be implemented.
2. Link Budget Calculation for finding MAPL (Maximum Allowable Path Loss) and cell radius.
3. Input city map as the basic parameter for software atoll.
4. The division of the morphological area.

A. Determine Frequency and Duplex Method

In LTE network simulation firstly, it should be specified frequency to be used. In this research, LTE's working frequency is 1800 MHz, which is in many countries this frequency will replace the 2G network frequency spectrum that works at 1800 MHz frequency [15].

According to 3GPP standards and E-UTRAN standards, these frequencies work on 1710-1782 MHz for Uplink and 1805-1880 MHz for Downlink. This planning using FDD (frequency division duplex) method as duplexing. This planning was conducted on bandwidth 5 MHz.

B. Link Budget and Cell Radius Calculation

In Table 1 describes the basic parameters of link budget calculation for 5 MHz bandwidth scenario. The first is to define the general parameters, the general parameters consisting of an operating band of 1800 MHz, the data rate that is assumed to be 256 kbps for downlink and 128 kbps for uplink. Assumption of data rate based on minimum data rate requirement on cell edge by customer. The value of Resource Block (RB) is obtained based on the data rate in the transport block size according to 3GPP TS 36.213 version 10.1.0 release 10, and Allocated Subcarriers are generated based on RB, where for 1 RB is equal to 12 Subcarriers.

The Calculation for the transmitter link budget is showed in Table 2. The value of feeder loss and feeder length based on the type of feeder. The result of EIRP transmitter are 61 dBm for downlink and 23 dBm for uplink.

In Table 3, it is explained about the calculation of Receiver. The kT is the multiplier of the boltzman constant (1.38x10-23J / K) with temperature (290oK), where the result is -174 (dBm / Hz). For the Thermal noise per subcarrier and Aggregate thermal noise value depends on the number of subcarriers used for downlink and uplink.

Table 1: General Parameter Link budget

| | Link budget | Formula | FDD 5MHz | |
			Down link	Up link
General Parameter	Operating Band (MHz)	a	1800	
	Data Rate (Kbps)	b	256	128
	Allocated RB	c	6	3
	Allocated Subcarriers	d	72	36

Table 2: Transmiter Link Budget

| | Link budget | Formula | FDD 5MHz | |
			Down link	Up link
Transmitter End	Tx RF Power (dBm)	e	46	23
	Tx Antenna Gain (dBi)	f	18	0
	Feeder Loss per m (dB/m)	g	0,06	0
	Feeder llength (m)	h	50	0
	Feeder Loss/Line Loss (dB)	i = g x h	3	0
	EIRP (dBm)	j= e + f- i	61	23

Table 3: Receiver Link Budget

| | Link budget | Formula | FDD 5MHz | |
			Down link	Up link
Receiver End	kT (dBm/Hz)	k = 10 log (k x T)	-174	
	Thermal noise per Subcarrier (dBm)	l = k + 10 log (15Khz)	-132,2	-132,2
	Aggregate Thermal noise (dBm)	m = l + 10 log(d)	-113,7	-116,7
	Noise Figure (dB)	n	7	4,5
	Required SINR at Cell Edge (dB)	o	-4,13	-5,11
	Fast Fade Margin (dB)	p	0	0
	Rx Sensitivity (dBm)	q = m + n + o + p	-110,8	-117,3
	Rx Antenna Gain (dBi)	R	0	18
	Rx RF Line Loss (dB)	S	0	3
	Effective Rx Sensitivity (dBm)	t = q – r +s	-110,8	-132,3
	Geometry Factor (dB)	U	0	0
	Cell load (%)	V	50%	50%
	Interference Margin (dB)	w = -10 log (1– SINR.v/u)	0,93	0,73
	Body Loss (dB)	X	0	0

The noise figure values use Nokia Siemens operator standard. The required value of Signal to Interference-Noise Ratio (SINR) at cell edge is determined based on the minimum data rate used, so it can be known the type of TBS index and MCS used. For the downlink side, the minimum data rate is 256 Kbps with 6 RB. According to standard 3GPP TS 36.213 version 10.1.0 release, for 256 bits obtained, TBS index used is 2 with modulation order is 2, so that SINR is used -4.13 dBm for uplink and -5,11 dBm for downlink. LTE does not use fast power control. Fast fading margin is not required, so the value of fast fading margin is 0 dB [16]. The cell load value is assumed to be 50%, this value is recommended value by Nokia Siemens. For the calculation of MAPL (Maximum Allow Path loss) use equation (1) as follow

APL = EIRP - Receiver Sensitivity - Margin Interference + Rx Antenna Gain-Cable Loss (1)

Table 4: The Calculation of Cell Radius

Parameter	Urban	Suburban	Rural
Min MAPL	154,57	154,57	154,57
Building Penetration Loss (dB)	17	12	10
Standard Deviation Outdoor (dB)	8	8	7
Cell Edge Probability	75%	75%	75%
Shadowing Margin (dB)	5,36	5,36	4,69
MAPL per clutter type (dB)	132,21	137,21	139,88
Operating Band (MHz)	1800	1800	1800
eNodeB Height (m)	30	30	30
UE Height (m)	1,5	1,5	1,5
Log d	-0,1	0,38	0,88
cell radius/d (km)	0,797	2,411	7,639
Hexagon radius (km)	0,398	1,205	3,819

Based on the obtained MAPL value, then the lowest MAPL value is selected to find the cell radius of the 5 MHz frequency. This value will be calculated using the COST-231 Hata equation. The Table 4 show the calculation of Cell Radius.

C. Input City Map

In simulation of LTE network with software atoll, digital map is needed as the basic of a plan, it is intended that the results obtained in accordance with the conditions in the field. The map used is showed in Figure 1. From the map can be seen the overall boundary of Pekanbaru city.
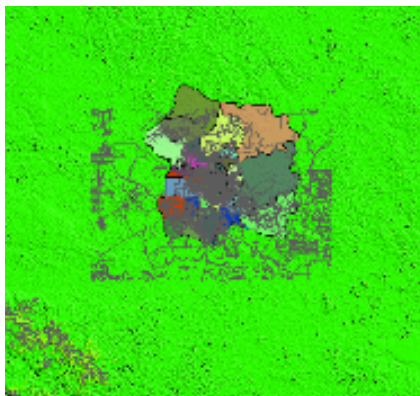

Figure 1: Digital Map of Pekanbaru City

D. The Division of Morphology Area

Before mapping eNodeB, it is necessary to divide the morphology and the contour of the earth from the region pekanbaru city, it is aimed to get maximum result in the simulation. Each region has different losses. The urban area is the area with the highest loss because this area is a densely populated area with more high buildings. Suburban areas has medium losses which is less densely populated area and not many high buildings, and the last is a rural area which is flat area with low losses.

Prior to eNodeB mapping, the digital maps were grouped by their morphology area with a specific color, the dark blue for the urban area, the light blue for the sub-urban area, and the yellow color for the rural area. The results can be seen in Figure 2.

After grouping the map based on the morphological type, then the next laying eNodeB in accordance with the morphology area. An eNodeB is a 3-square-sector hexagonal design. The first step in laying eNodeB is to put eNodeB in the urban area, because this area is the area that has the largest losses. Next is the sub-urban area, because this area has a more moderate loss. And the last is the rural area that has the smallest loss. The results can be seen in Figure 4.
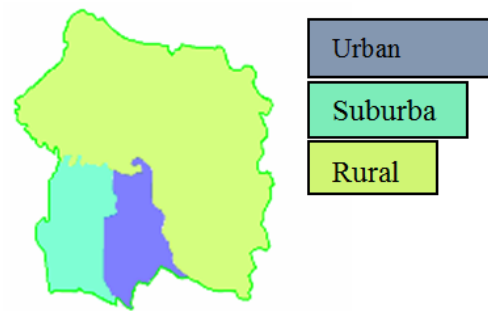
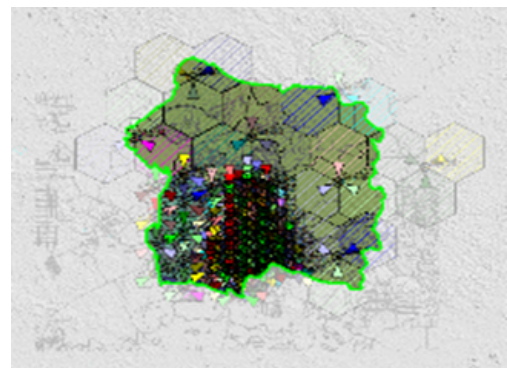

Figure 2: Pekanbaru Morphology Area

Figure 3: Mapping eNodeB Base on Morphology.

III. RESULTS AND DISCUSSION

A. BTS Mapping

In this sub section, the results of this work are presented. The LTE planning for BTSs mapping has been done with software Atoll on digital map of city of Pekanbaru. The result of BTSs mapping at urban, suburban and rural area could be seen in Table 5.

The LTE simulation in Pekanbaru resulting different number BTSs to fulfill coverage needed in 2018, where the urban area needs more number of BTSs, is about 143 BTSs for 20 MHz bandwidth. While suburban areas it takes about 13 BTSs for 5 MHz Bandwitdh. Rural areas need less number of base stations that is 7 BTSs for 5 MHz Bandwidth. Compared with research conducted by [8], where the research was conducted in Semarang city with frequency of 1800Mz, this city needs 152 BTSs and research on [11] with frequency 2300 MHz needs 161 BTSs. In the Semarang City requires BTSs more than the Pekanbaru City because Semarang city has denser population and larger urban areas than Pekanbaru.

Table 5: BTS Mapping Results

Bandwidth	Total eNodeB	Number of eNodeB		
		Urban	Suburban	Rural
5 Mhz	99	79	13	7
10 MHz	111	89	14	8
15 Mhz	130	104	17	9
20 Mhz	143	116	17	10

B. Coverage by Signal Level

After obtaining number of the BTSs mapping in the previous section, in this section the coverage of BTSs is generated based on signal level. Figure 4 show simulation of signal level based on 99 BTS that have been spread to 12 sub-district in Pekanbaru. From the figure 4 can be seen the signal level coverage area displayed by different colors according to the classification of the area and the distance to
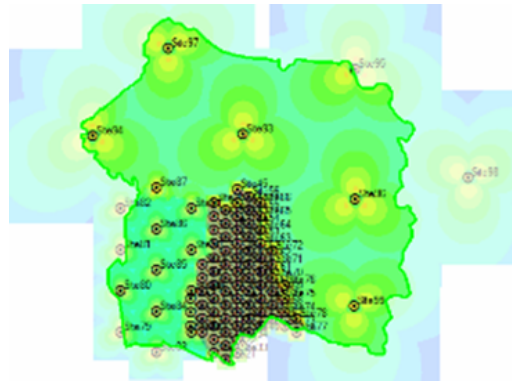

Figure 4: Simulation of Signal Level.

In Table 6 show the list of BTSs coverage by signal level. The Predicted signal level based on the estimated number of LTE subscribers in 2018 with a penetration of 25% in the city of Pekanbaru.

Table 6: Coverage BTSs Based on Signal Level

Signal level	% Focus Zone covered	% of covered area	focus zone surface (km²)	Surface (km²)
Best Signal Level (dBm) >= -70	0,34	0,3	2,133	2,133
Best Signal Level (dBm) >= -75	1,5	1,8	9,257	11,39
Best Signal Level (dBm) >= -80	6,2	8	38,49	49,88
Best Signal Level (dBm) >= -85	13,1	21,1	82,78	132,66
Best Signal Level (dBm) >= -90	11,8	32,9	73,79	206,45
Best Signal Level (dBm) >= -95	19	51,9	118,885	325,335
Best Signal Level (dBm) >= -100	32,5	84,4	204,217	529,552
Best Signal Level (dBm) >= -105	15,6	99,9	97,755	627,307
Best Signal Level (dBm) >= -110	0	100	0,031	627,338
Best Signal Level (dBm) >= -115	0	100	0	627,338
Best Signal Level (dBm) >= -120	0	100	0	627,338

The Prediction BTSs coverage depends on the number of base stations placed in that area. The normal signal level are in the range -91 dBm to -110 dBm [15]. LTE network planning that has been done in this research result BTSs coverage reaches 84.4 % of covered area and higest focus zone covered at -100 dBm signal level. So that, By increasing the number of BTS to 99, the coverage area in pekabaru increases with normal signal level. Compared with the research in [11], where its BTS coverage reached 86.4% at the same level.

C. Capacity Network

To analyze the capacity of LTE network in Pekanbaru, this research used the montecarlo simulation. In this simulation, calculated the average of 10 simulations of the design in Pekanbaru city. Here in figure 5 is the result of simulation of

Pekanbaru city for 5 MHz bandwidth. By the same simulation for all bandwidth scenarios, we get the result of data in the form of an average subscriber (Subs) connected to the network and subscriber who failed to connect. For more details can be seen in table 7 below.

Tabel 7: Number of Customers Served Based on Monte Carlo Simulation

Bandwidth	Total Num. Customer	Num. Subs Conn	Persentation (%)	Num. Subs Not Conn	Pesentation (%)
5 MHz	47.375	39.158	82,7	8.216	17,3
10 MHz	47.200	40.778	86,4	6.411	13,6
15 MHz	47.311	40.895	86,4	6.416	13,6
20 MHz	47.312	31.235	66,0	16.077	34,0

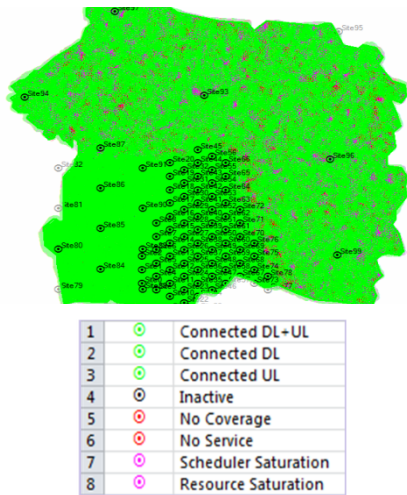| 1 | | Connected DL+UL |
2		Connected DL
3		Connected UL
4		Inactive
5		No Coverage
6		No Service
7		Scheduler Saturation
8		Resource Saturation

Figure 5: Result MonteCarlo Simulation for 5MHz.

From the results of Table 7, the total number of subscribers for each scenario is different, it is based on total customer estimation of 25% in 2018 Pekanbaru city. For 5 MHz Bandwidth, the total number of subscribers is 47,375, with 39,158 connected subscribers and 8,216 unsuccessful subscribers. Distribution of services to customers for bandwidth of 5 MHz, 10 MHz, and 15 MHz reaches 80% of LTE service users who have received the network. Bandwidth 20 MHz has the lowest percentage of 66% of subscribers.

IV. CONCLUSION

In this work, Simulation of LTE network for mapping BTS in Pekanbaru city has been presented. Increasing coverage BTSs with better signal levels need to increase the number of BTSs. By increase the number of BTS, the capacity user will also increase. . The results of simulation capacity in Pekanbaru show that the urban area needs 143 number of BTSs for 20MHz bandwidth, BTSs coverage reaches 84.4% of covered area and highest focus zone covered at -100 dBm signal, and for 5MHz Bandwidth, the total number of subscribers is 47.375, with 39.158 connected subscribers and 8.216 unsuccessful subscribers.

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