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Coverage and Capacity Planning of LTE Network for-Taizz City

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Abstract- This paper is based on the newly advanced cellular technology called Long Term Evolution (LTE). It is intended to give a good understanding of Radio Network planning of LTE and perform a case study onTaizz City, one of the highest populated cities in Yemen with a selected area of about 118.09km^2.

The LTE Radio network planning involves coverage estimation, capacity evaluation. In this paper the coverage estimation is done with regards to the real environment dataat its nominal stage to obtain better estimations. Propagation modeling is done using COST HATA W/I model with inclusion of additional parameters obtained from the real environment/terrain what improves the coverage estimation.This in turn, results in a wide coverage, introducing high quality services and excellent mobility support.

The simulation is performed using Atoll program to evaluate the traffic demand for all services and to calculate the average throughput of each service.

General Terms: *Telecommunications , Wireless Networks*

Keywords*: LTE,Radio Network planning , coverage , capacity , link budget*

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I. INTRODUCTION

The rapid growth of mobile communication and technologies made an outstanding development not only to ease our daily life but also to make an important contribution to the persistent computing environments. Starting from the first Generation of cellular network, which is analog communication totheones thatare being developednow like LTE, LTE advanced and WIMAX 802.16m, the technology is expanding in higher quality and accessibility [1]. Besides the end user expectations have grown from conventional mobile voice traffic to additional simple text communication and even to live streaming services and internet access which greatly affecting the traffic demands. All these requirements motivated the need for new emerging system architectures and management with issues related to quality of service, capacity and coverage. For this reason, the 3rd Generation Partnership Project (3GPP), which is currently the dominant specifications development group for mobile radio systems in the world, started to work on the upcoming new standard called, the Long-Term Evolution (LTE).

LTE is the evolution of the Third-generation of mobile communications to the Fourth-generation technology that is essentially an all IP broadband Internet system with voice and other services built to ensure 3GPP"s competitive edge over other cellular technologies. On the contrary to the circuit-switched technologies like GSM and WCDMA, which are currently serving nearly 85% of the global mobile subscribers, LTE has been designed to be a high data rate and low latency system supporting only packet switched services. It aims to provide seamless connectivity between two end user equipment (UE) without any disruption of the services in use during mobility. Based on the LTE Rel."8 standardization document of 3GPP, the technology enables flexible transmission bandwidth selection between 1.4 MHz and 20 MHz depending on the available spectrum which significantly enhances the service capacity compared to previous cellular technologies.

These and other significant performance achievements rely on recently introduced physical layer technologies, such as Orthogonal Frequency Division Multiplexing (OFDM), Multiple-Input Multiple-Output (MIMO) systems and Smart Antennas. Furthermore, as a result of these technologies minimization to the system and UE complexities; its coexistence with other 3GPP and non- 3GPP Radio Access Technologies (RATs) and straightforward planning and deployment approaches were basically achieved [2] , [3] .

LTE is a recently launched technology with improved performance in service delivery and systemsimplicity.Thus,books, literatures anddocumentation are available describing the technological advancement,technical standardizations and basic planning and deployment specifications. The planning approach of LTE is divided depending upon the system architecture of LTE as Radio access network and core network planning. LTE Radio access network planning refers to analytical approach which is based on algorithmic formulation and focuses on the radio engineering aspect of the planning process, i.e., on determining the locations, estimated capacity and size of the cell sites (coverage and capacity planning), and assigning frequencies to them by examining the radio-wave propagation environment and interferences among the cells.

II. Radio Network Planning Process

Radio network planning is a very vital step for a wireless communication technology. As standardization work of LTE is approaching the end line, it's high time to go for efficient radio network planning guideline for LTE. For the same reason, along with the fact that LTE radio network planning work just like other cellular technologies, initial stage plan is normally guided by various industries and vendors at their own discretion. They aren't likely to disclose their advancements and findings. That makes the job even more challenging. Whenever new cellular technology is considered for mass deployment hundreds of its RF parameters go through tuning process with a view to find out optimum value. But this phase is time consuming and very costly. So, before commercial deployment if extensive simulation can be run this tuning phase can be facilitated in numerous ways. Cost can also be greatly minimized. That is the benefit of running simulation before mass commercial deployment. All these aim at proper radio network planning of LTE.So, looking for optimizing the vital parameters in the least possible time is a very challenging issue which will obviously help network operators in a greater extent [4] .

LTE Radio access network planning refers to analytical approach which is based on algorithmic formulation and focuses on the radio engineering aspect of the planning process, i.e., on determining the locations, estimated capacity and size of the cell sites (coverage and capacity planning), and examining the radio-wave propagation environment and interferences among the cells [5].

2.1 Network Dimensioning

Dimensioning provides the first estimation of the network elements count as well as the capacity of those elements. The purpose of dimensioning is to estimate the required number of radio base stations needed to support a specified traffic load in an area and the specific service to the cell edge users

- Coverage estimation is used to determine the required base station must be used to fulfill coverage of area under study.
- Capacity planning deals with the ability of the network to provide services to the users with a desired level of quality. After the site coverage area is calculated using coverage estimation, capacity related issues are analyzed.

Once the number of sites according to the traffic forecast is determined, the interfaces of the network are dimensioned. Number of interfaces can vary from a few in some systems to many in others. The objective of this step is to perform the allocation of traffic in such a way that no bottle neck is created in the wireless network. All the quality of service requirements are to be met and cost has to be minimized .Good interface dimensioning is very important for smooth performance of the network [6] , [7].

Network dimensioning provides the following results

- Number of sites and their locations
- Cell Range and Cell area
- Site throughput and sector throughput

Also, it shows the expected variation of these results with time. And also help make Decision about few parameters in dimensioning phase. For example, BS configuration, e.g. 3-sector/omni, antenna types, MIMO type etc. The results of dimensioning help in estimation of core network and backhaul requirement and the cost of initial implementation. Thus, it helps in calculation of estimated return,make the tariff plan strategy, overall business planning, etc.

2.2 link budget

Link budget helpsin estimating the maximum allowed signal attenuation called path loss. The maximum path loss is calculated based on service throughput defined by the cell edge user that required SINR level at the receiver. The minimum of the maximum path losses in UL and DL directions is converted into cell radius, by using a propagation model appropriate to the deployment area. Radio Link Budget is the most prominent component of coverage planning exercise [8] .

Link budget uses various parameters some of them are listed bellow

Transmitter side

- Cell edge user throughput
- Tx power
- Tx antenna gain
- Cable loss
- TMA insertion loss
- Body loss

Receiver side

- UE noise figure
- Thermal noise
- Required SINR
- Receiver sensitivity

III. Radio Planning for Taizz City

3.1 Site Survey

Taiz is one of the biggest governorates in Yemen it laysdown in the southern part of Yemen, it includes the largest number of population which is about 3.6 million it has a variety of terrains its contains a lot of mountains ,flat places and also coasts .The area of planning is the capital of Taiz(Taiz City)", which includes the most urban part of the governorate. The chosen area is about 118,09km^2 with a population of 556900 which is distributed into three regions with different densities as illustrated in the following **Table3.1.**

Region Name	Region 1	Region 2	Region 3
Area Type	Urban	Suburban	Rural
Area Size (km^2)	8,058	36,965	49,877
Populations	267312	189346	100242
Subscribers	37423.68	26508.44	14033.88
No of Sites *	14	16	13
Site Range (km) *	0.543	1.0969	1.403
Intersites Distance(km) *	0.8145	1.6454	2.104
Cell Area (km^2) *	0.192	0.770	1.279

Table 3.1 Regions of planning

*Information from [9] .

3.2 Coverage and Capacity Planning

After collecting the information about the area of planning and by using Excel based tool from NSN to calculate link budget using the following parameters **.**

3.2.1 Planning Parameters

The parameters listed in the **Table 3.2** are the input to the NSN Excel based tool and was chosen carefully according to the type of terrain and city type i.e.urban , suburban etc..

Parameter	DL	UL
Frequency	2100 MHZ	
Bandwidth	20 MHZ	
Duplex	FDD	
Propagation Model	Cost-Hata	
Frequency reuse	1	
Scheduling	Proportional Fair	
MIMO Configuration	2x2 MIMO	1x2 MIMO
Tx Power	43 dB	23 dBm
Rx Antenna Gain	18 dBi	0 dB
Body loss	0 dB	0 dB
Feeder Loss	0.5	2.4 dB
Noise Figure	7 dB	
Throughput	1 Mbps	384 kbps

Table 3.2 Planning Parameters

3.2.2 Propagation Model

propagation model is very important for calculating cell range .There are many types of propagation models with different properties but *Cost231/ 2 slope (Cost Hata) model was chosen because it can be applied in Taiz and can be used for frequency band that will be worked on. The parameters related to the model is listed in**Table 3.3**

eNB Antenna Height (m)	30
UE Height (m)	1,5
Frequency (MHZ)	2100
Penetration Loss (dB)	17 (Urban) , 12 (Suburban) , 10 (Rural)

Table 3.3 Propagation Model Inputs

*2-slope mean that cell range is higher than slope 1

3.2.3 Dimensioning Tool (v 2.3.1)

Dimensioning tool is an Excel based tool which is designed by Nokia Simense Network (NSN) Dimensioning tool comprises of two main parts presented as 'Link Budget' and 'Site Count' sheets. The Dimensioning Tool (methods and parameters) follows RL10 and RL15TD Releases. The tool consist of nine excel workbooks as shown in **Figure 3.1.**

Figure 3.1 : Dimensioning Tool Sheets

3.2.4 Link Budget Calculation

After entering input parameters into the sheet of link budget itgavesthe results shown in the **Figure 3.2** as an outputs which include maximum path loss and Coverage parameters like cell range and number of sites and cells..

Figure 3.2 sites counts as resulted from Link budget sheet

3.2.5 Traffic Model

Traffic Model includes some standard parameters about the services i.e.Voip , Streaming , High Speed Internet , Mobile Internet Access and Circuit switching .The main output of this sheet is the total data volumes for downlink and uplink . **Figure 3.3** illustrates these parameters.

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Format	Link	Traffic Model for Long Term Evolution *Provided by NWS LTE RA E2E Mgmt SA NE*	2014
		Downlink Data Volume (MB)	[illegible]
		Uplink Data Volume (MB)	[illegible]
Format	Link	Quantity (per Busy Hour)	
Flat Rate	off	Subscription Rate (kbps)	1024
		Overbooking Factor	25
		do not remove this row	*off*
		Avg. Data Volume (MB)	**18.4320**
Flat Rate	off	Subscription Rate (kbps)	256
		Overbooking Factor	25
		do not remove this row	*off*
		Avg. Data Volume (MB)	**4.6080**
VoIP	both	Call Attemps	1
		Call Duration (s)	90
		Data Rate (kbps)	30.4
		Service Activity	0.5
		do not remove this row	*both*
		Avg. Data Volume (MB)	**0.1710**
Streaming	both	Call Duration (s)	500
		Data Rate (kbps)	200.00
		do not remove this row	*both*
		Avg. Data Volume (MB)	**12.5000**
Www +Email+VPN	both	Data Volume (MB)	7.727
		Protocol Overhead	10%
		do not remove this row	*both*
		Avg. Data Volume (MB)	**8.4997**
Www +Email+VPN	both	Data Volume (MB)	2.36
		Protocol Overhead	10%
		do not remove this row	*both*
		Avg. Data Volume (MB)	**2.5960**
CS-like format	both	Traffic (Erl)	1
		Data Rate (kbps)	12.2
		Service Activity	0.5
		do not remove this row	*both*
		Avg. Data Volume (MB)	**2.7450**

Figure 3.3 Traffic Model Sheet results

3.2.6 Sites Count (Capacity planning)

In this sheet Capacity planning is performed using the input parameters which are total number of population and expected subscribers as percentage from the total population-number .It's also includes the distribution of users into three regions of working area.

The main output of this sheet is number of sites according to the capacity planning process and after that it compares the number of sites in both capacity and coverage planning and chooses the maximum one and also predicated DL and UL throughput per eNB for the three regions of working area as shown in **Figure 3.4**.

#Sites (Coverage)	Dense Urban	0
	Urban	13
	Suburban	8
	Rural	1
#Sites	coverage limited	
	capacity limited	
	Urban	14
	Suburban	15
	Rural	13
DL Throughput per eNB (Mbps/site)	**Urban**	51.948
	Suburban	34.343
	Rural	20.970
UL Throughput per eNB (Mbps/site)	**Urban**	12.081
	Suburban	7.987
	Rural	4.879

Figure 3.4 Site Count as resulted from Capacity Planning

3.2.7 Summary of obtained results

From the coverage planning calculation the resulted sites number are 14 , 8 and 1 for region 1, region 2 and region 3 respectively on the other hand the resulted sites number from capacity planning are 14 , 15 and 13 for region 1 , region 2 and region 3 respectively. So it is necessary to choose the largest number as it will satisfy the requirements of both types of planning .So the sites will be distributed among regions as determined before and the location of each was set using Hexagonal tool that exist in Atoll for each region and considering intersites distance for each region.

According to output of the tool the expected throughput for DL for region 1 is 52 Mbps / site , for region 2 is 35 Mbps /site and for region 3 is 21 Mbps /site . While the expected throughput for UL for region 1 is 12 Mbps , for region 2 is 8 Mbps and for region 3 is 4.8 Mbps.

IV. Conclusion and Future Work

The main objective of this study of LTE network planning is to introduce the main features of this technology. Among others, toshow the procedure of planning process, estimate the coverage and capacity planning parameters using planning standard, to calculate the link budget and the rest of dimensioning processes that can help in the development of many tools used in radio network planning.Obtained results in this paper are expected to be used in detailed radio planning stage, where Atoll program will be used for the radio planning process involving Taizz Digital Map. The results of the coverage and capacity planning step will be used in atoll to obtain a detailed traffic map and also detailed coverage and capacity of eNodeBs.

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