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Coverage Planning for LTE system Case Study

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Abstract: Long Term Evolution (LTE) that provides higher throughputs and lower latencies. LTE brings many technical benefits to cellular networks and improves the spectral efficiency in previous networks, allowing carriers to provide more services. In this paper a through dimensioning analysis has been done through calculation of link budget in order to calculate the coverage for the city of Tripoli in Libya , where a COST321 propagation model was used to do the coverage planning in order to find out the required number of sites for the various parts of the city based on population distribution. From the analysis it was found that the dense urban area needed 48 sites, urban area requires 81 sites and the suburban area sits were found to be 46 sites.

KeyWords **:** Urban LTE, coverage, link budget, propagation model, sepectral efficiency.

I. Introduction

LTE framework basic objectives is to build up a system that meets high data rate demands , low latency and optimization for packet-domain traffic. LTE system is intended to have a peak data rate of 100 Mbps in DL and up to 50 Mbps in the UL[1]. To improve service provisioning and reduce user/operator costs, LTE must fulfill some key requirements and capability targets which are [2]:

· Low latency : for both user plane and control plane, with a 5MHz spectrum allocation the latency target is below 5 ms
· Bandwidth Scalability : different bandwidths can be used depending upon the requirements (1.25 to 20 MHz)
· Peak Data Rates : 100 Mbps for DL , 50 Mbps for UL
· 2 to 3 times capacity over existing Release 6 scenarios with HSUPA
· 2 to 4 times capacity over existing Release 6 scenarios with HSDPA
· Only Packet Switched Domain support
· Improved Cell edge performance
· Inter-working with the existing 2G and 3G systems and non-3GPP systems
· Optimized for low mobile speed but also support high mobile speeds
· Reduction of complexity in both system and terminals
· Ease of migration from existing networks
· Simplification and minimization of the number of interfaces

Network planning requires initially a dimensioning phase that provides the first estimate of the network element 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 [3].

Dimensioning provides the first, quick assessment of the probable wireless network configuration [4]. Dimensioning is a part of the whole planning process, which also includes, detailed planning and optimization of the wireless cellular network. Wireless cellular network dimensioning follows these basic steps:

· Data/Traffic Analysis that gives an estimate of the traffic to be carried by the system.
· Coverage estimation is used to determine the coverage area of each base station
· Capacity evaluation Capacity planning deals with the ability of the network to provide services to the users with a desired level of quality
· Transport dimensioning Transport dimensioning deals with the dimensioning of interfaces between different network elements.[5]

II. Link Budget

The main purpose of link budget in LTE network planning is to use such factors as building penetration loss, feeder loss, antenna gain, and the interference , margin of radio links to calculate all gains and losses that will affect the final cell coverage, To estimate the maximum link loss allowed based on the maximum transmit power of the terminal and eNodeB transmit power allocation and coverage radius of a base station can be obtained according to the maximum link loss allowance under a certain propagation model. The radius can be used in subsequent design. The link budget parameters are grouped as follows:-

- Propagation transmission related parameters, such as the penetration loss which indicates the fading of radio signals from an indoor terminal to a base station due to obstruction by a building, where the building penetration loss ranges from 5 dB to 40 dB, body loss indicates the loss generated due to signal blocking and absorption when a terminal antenna is close to the body, feeder loss indicates the signal loss caused by various devices that are located on the path of the antenna to the receiver, and background noise[6].
- Equipment dependent parameters, such as the transmit power, receiver sensitivity, and antenna gain.
- LTE specific parameters, such as the pilot power boosting gain, (MIMO) gain, edge coverage rate, repeated coding gain, interference margin, and fast fading margin.
- System reliability parameters, such as slow fading margin.
- Specific features that will affect the final path gain [7].

III. Propagation Model

The radio propagation model plays a key role in the link budget. Propagation models according to the area and frequency band should be selected and modified if needed. This is necessary for coverage estimation. Every propagation model is different. Some offer conservative high path loss predictions for a section of the spectrum, some offer optimistic low path loss predictions for most of the spectrum. Some extend a previous model to work at higher frequencies. COST231 Hata extends Hata to work beyond 100 to 2000MHz. Figure (1) shows the most common models, by representing the modes as relation between frequency and dB. Especially COST231

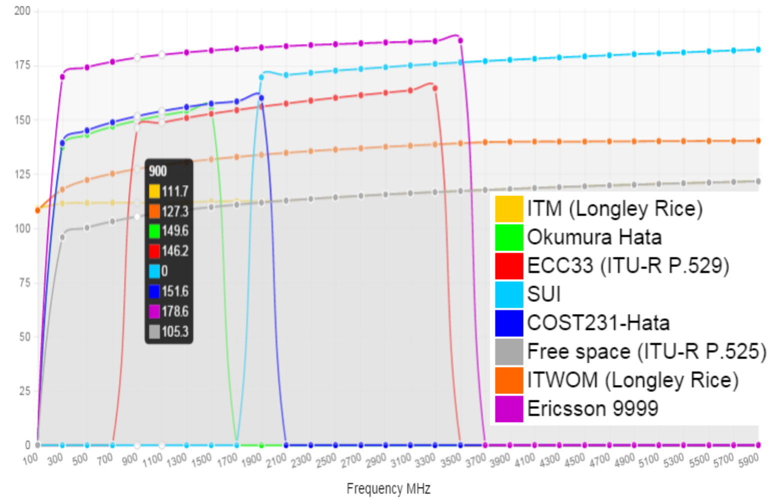

Figure (1) The most common models.

Hata where it appears in blue line. That Cost231-Hata model can be used in macro cells as the propagation model.

The basic path loss equation for this COST-231 Hata Model can be expressed as [8]:-

$$\textbf{PL}= [46.3 + 33.9 \times log(f) + 13.82 \times log(H_{BS}) + (44.9 - 6.55\ log\ (H_{SS})) \times\ log\ (d)] - \alpha(H_{SS}) + Cm \qquad 1$$

Where

(f) indicates the working frequency of the system, in MHz.

$(\boldsymbol{H_{BS}})$ indicates the height of the base station antenna, in m.

$(\boldsymbol{H_{SS}})$ indicates the height of the terminal antenna, in m.

(d) indicates the distance between the terminal and the base station, in km.

$\boldsymbol{\alpha(H_{SS})}$ indicates the terminal gain function. This function is related to the antenna height, working frequency of the terminal and the environment.

Parameters equipment affecting the quality of the path include the base station antenna and terminal, transmit power, receiver sensitivity, noise figure, gains MIMO antenna In addition to link budget parameters vary with the base stations antennas and terminals of different vendors. These parameters affect the link budget results and also on the path.

IV.Coverage Planning Analysis

Tripoli is the capital of Libya and it is considered an over population city compared to the rest of most of the country. Efficient radio network planning is obviously a big challenge here with the optimal utilization of limited resources. In this part of the work, coverage analysis along with link budget preparation and capacity analysis will be performed. Calculations will be made specifically for Tripoli city. As a result, it will be included for a complete Tripoli city radio network planning, the link budget calculations estimate the maximum allowed signal attenuation, called path loss between the mobile and the base station antenna. The maximum path loss allows the maximum cell range to be estimated with a suitable propagation model, such as Cost231–Hata model. The cell range gives the number of base station sites required to cover all Tripoli geographical area. The link budget calculation can also be used to compare the relative coverage of the different systems depending on the assumptions and considerations planning system and less trouble with procedure as these coverage planning and described briefly in the following points. In this point, the spectrum is managed; the available frequency band is chosen to be the frequency band for (LTE) network, the bandwidth, duplex mode SFR and Cyclic Prefix (CP) are specified as:-

- System bandwidth is 20 MHz.
- Cyclic prefix is chosen to be normal.
- Frequency band number 11 and therefore duplex mode is (FDD).
- Soft frequency reuse using (SFR 1*3*1).

Table (1) Input parameters for each case

Statement	Dense urban		Urban		Suburban	
Ch. Type	UL	DL	UL	DL	UL	DL
MIMO	1 × 2	2 × 2	1 × 2	2 × 2	1 × 2	2 × 2
Cell Edge Rate (kbps)	256	1024	256	1024	256	1024
MCS	QPSK 3/4	QPSK 1/2	QPSK 3/4	QPSK 1/2	QPSK 3/4	QPSK 1/2

System bandwidth, channel model, (MIMO) scheme, cell edge rate, and the modulation coding scheme are shown in Table (1) for each case the coverage planning, and link budget is calculated for each scenario separately, for both cases, upload and download, these planning procedure steps are:-

1. Calculate Maximum Allowed Path Loss (MAPL) for DL and UL.
2. Calculate the DL and UL cell radiuses by the propagation model equation and the MAPL.
3. Determine the appropriate cell radius by balancing the DL and UL radiuses.
4. Calculate the site coverage area and the required sites number.

Maximum Allowed Path Loss has different values for dense urban, urban and suburban UL and DL. So the calculation must be done to every condition and case apart, and from these results the cell radius can be calculated for each case. At the end, the minimum cell radius from UL and DL cell radiuses is chosen for each case. There are three different cell radiuses based on the capacity of area cases, each regions from cases has own cell radius [9].

Calculations Effective Isotropic Radiated Power (EIRP).
The following equation is used to calculate the transmit EIRP:-

$$T_x \text{ EIRP} = \text{Max } T_x \text{ Power} + \text{Total } T_x \text{ Gain} - \text{Total } T_x \text{ Loss}$$

The following equation is used to calculate the minimum required receiver signal strength (MRRSS)

$$\text{MRRSS} = R_x \text{ Sensitivity} - \text{Total } R_x \text{Gain} + \text{Total } R_x \text{Loss}$$

Total R_x Gain = Antenna Gain + Other Gains

Total R_x Loss = Cable loss + Body Loss + Interference Margin + Other Gains and Losses

The following equation is used to calculate the Extra Gain:

Extra Gain =Hard Handoff gain + MIMO Gain + Other Gain

The following equation is used to calculate the extra margin and loss:

Extra margin and Loss = Shadow Fading Margin + Penetration Loss + Other Loss.

The following equation is used to calculate the Maximum Allowed Path Loss:

MAPL = T_x EIRP - MRRSS + Extra Gain - Extra Margin and Loss

Balancing cell radius by using cost231-Hata model equations, with choosing the minimum distance between the terminal and the base station for Both types cell radius uplink and downlink.
Cell radius is calculated by using equation 1
Balancing the cell radiuses is to choose the smallest cell radius from UL and DL cell radius calculations to ensure the UL and DL power coverage to the required area.
The results of the cell radius calculation can be seen in fig. (2)

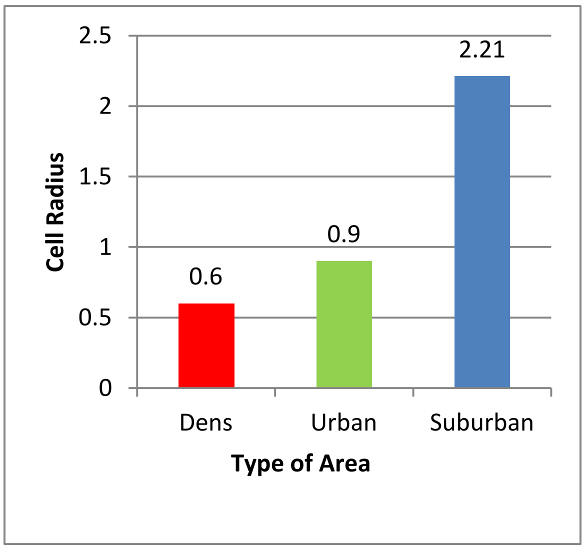

Fig. (2) Cell Radius distribution for Tripoli city

The classification of Tripoli city and its suburbs areas are:-

- dense urban 35.6 km^2.
- urban 127.4 km^2.
- suburban 407.9 km^2.

After determining the cell radius for different cases, sites number and sites coverage areas are calculated by the following equations:

$$\text{Site coverage area} = \frac{9}{8} \times \sqrt{3} \times R^2$$

$$\text{Required sites number} = \frac{\text{Area to be covered}}{\text{Site coverage area}}$$

The number of calculated site for the different area in the city can be seen in fig. (3)

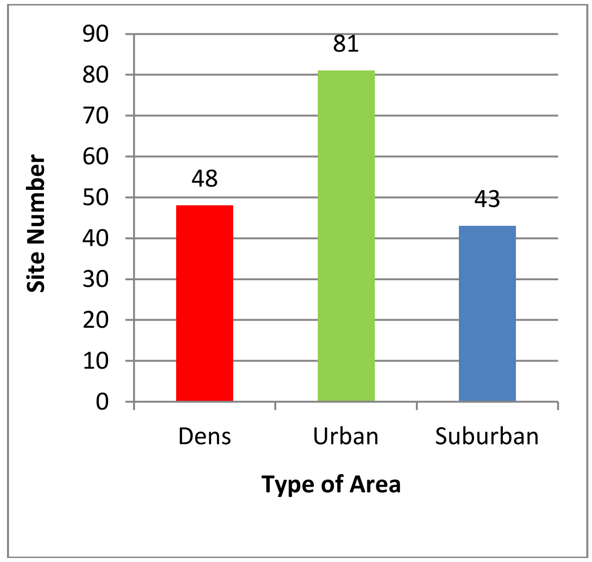

Fig (3) Site Number distribution

V. Conclusion

In this paper the coverage range for proposed LTE network for the city of Tripoli was calculated based on the COST 321 Hata propagation model since this model is used the frequency range 100 to 2000 MHz, which includes the frequency band 11 which used for calculation. From the obtained results it can be seen that base station cell radius for the three selected areas were 0.6 km for dense urban , 0.9 km for urban and 2.21 km for suburban. Also the number of needed sites to cover this proposed networks found to be 48 for the dense area, 81 for the urban area and 43 for the suburban area.   .

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