LTE Radio Planning Using Atoll Radio Planning and Optimization Software

Marwa Elbagir Mohammed[1], Khalid Hamid Bilal[2]

[1, 2] Faculty of Engineering, EL- Neelain University, Khartoum, Sudan

Abstract: ***Long Term Evolution (LTE) is most enhanced Broadband Wireless Access (BWA) technology. LTE is the standard in the mobile network technology tree that previously realized the GSM/EDGE and UMTS/HSPA technologies. LTE is expected to ensure 3GPP's competitive edge over other cellular technologies. As standardization work of LTE is approaching the end line, it's high time to go for efficient radio network planning guideline for LTE. In LTE just like other cellular technologies, initial planning is normally guided by various industries and operators at their own discretion. They aren't likely to open their advancements and findings. As a result, going on with LTE radio network planning perspective is a well-chosen challenge and a certain hot topic in the current research area. In this work, a detailed LTE radio network planning i.e. capacity and coverage analysis has been performed in order to prepare a radio planning guideline considering possible network implementation in the density in Khartoum city.***

Keywords: LTE, Radio Network Planning, Planning Tool, Coverage Prediction, Traffic Map.

1. Introduction

Long Term Evolution (LTE) has engaged the attention of wireless operators, investors, and industry watchers around the world in the late years. LTE was initiated by 3GPP, to maintain its competitive edge in the world of mobile networks in the future; it represents the first generation of cellular networks to be based on a flat IP architecture. The essential part of any system to be deployed is the planning operation, because the existence of all activities is related to its existence. The radio network planning process is designed to maximize the network coverage, whilst at the same time providing the desired capacity [1].

2. Problem Statement

The cellular industry is growing. Rapid increase in the demand for data services has pushed wireless operators to invest in new technologies. Operators capitalize a major portion of their money in their network infrastructure to be able to offer new services with high quality and lower rates. To survive in such a competitive market, they look for network planning tools which can design an optimized network with low cost. Furthermore, an optimized network requires less maintenance cost, meaning more saving. The primary goal of LTE network planning tools is to provide an optimum topology for the network.

3. Research Objectives

The main objective of this thesis is to develop automatic planning tools based on Exact and approximate algorithms in order to solve the planning problem of 4G with high coverage and high Quality of Service.

4. Literature Review

In [2], coverage planning in GSM networks as well as capacity and frequency planning has been studied. Various signal interruptions and the necessary steps to remove those interruptions in order to maintain signal quality in mobile communication have been studied. The success of GSM network depends on its three factors: coverage, capacity and quality. Capacity is based on an assessment of dropped calls and congestion that has been removed by proper optimization. Quality has been improved by eliminating interference from both external and internal sources.

A drive test was performed to asses capacity and coverage. The quality of the radio network depends on its coverage, capacity and frequency allocation. Most severe problems in a radio network can be attributed to signal interference, dropped calls and the amount of congestion that optimization has removed. The criteria that were discussed in the radio planning procedure were met and the needed KPI values were attained on completion of the process. As a result, dropped calls, handover, interference and RX levels were all improved.

In [3] Macro-cellular (outdoor) to indoor coverage is a natural inexpensive way of providing network coverage inside the buildings. However, it does not guarantee sufficient link quality required for optimal HSDPA operation. On the contrary, deploying a dedicated indoor system may be far too expensive from an operator's point of view. In this thesis, the concept is laid for the understanding of indoor radio wave propagation in a campus building environment which could be used to plan and improve outdoor-to-indoor UMTS/HSDPA radio propagation performance. It will be shown that indoor range Performance depends not only on the transmit power of an indoor antenna, but also on the product's response to multipath and obstructions in the environment along the radio propagation path. An extensive measurement campaign will be executed in different indoor environments analogous to easy, medium and hard radio conditions. However The number of mobile broadband users are increasing at an accelerated pace and in the current competitive cellular market, extensive coverage, capacity and quality of service have become key factors in increasing end-user base.

In [4] focuses on designing automatic planning tools for the planning problem of 3rd Generation (3G) Universal Mobile Telecommunication System (UMTS) all-IP Release 4 networks. and A new mathematical model for the design problem of such architecture was proposed. The main advantage of the proposed model is to incorporate a realistic traffic profile taken from real live networks. Two approximate algorithms based on the local search and tabu search principles are adopted to solve the problem. Numerical results show that “good” solutions are found with the proposed heuristics. Results demonstrate that the local search algorithm produces solutions that are, on average, at 4.98% of the optimal solution, and in the worst case at 11.31% of the optimal solution. Better solutions are obtained using the tabu search algorithm. Indeed, tabu search is able to provide solutions with an average gap of 2.82% and a maximum gap of 7.51% from the optimal solution.

In [5] the LTE system capacity and coverage are investigated and a model is proposed on the base of the Release 8 of 3GPP LTE standards. After that, the frequency planning of LTE is also studied. The results cover 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. the capacity of the LTE network is depicted with the indicators of average transmission data rate, peak transmission data rate and the subscriber’s numbers supported by the system. The coverage of the LTE system is also calculated on the base of Base Station parameters and different propagation models. One of the frequency allocation schemes of LTE, SFR, is also described to mitigate the inter-carrier interference (ICI). This work gives a macroscopic dimension and valuable estimation of the LTE system. The theoretical work will later be implemented in WRAP software and by using WRAP’s capacity calculation and evaluation tools the estimation and optimization of an LTE network can be performed.

5. Methodology

Dimensioning is the initial phase of network planning. It provides the first estimate of the radio network element count as well as the capacity of those elements. Dimensioning tool should be accurate enough to provide results with an acceptable level of accuracy, when loaded with expected traffic profile and subscriber base [6][7]. Dimensioning has two phases; coverage planning phase and capacity planning phase. In this paper using Atoll radio planning and optimaization software to provide the number of sites required in the capacity planning phase.

After choosing the network deployment parameters, dimensioning has two phases capacity planning and coverage planning to estimate the number of sites needed, the two phases are independent from each other. This paper focuses on capacity planning phase. The below flow chart shows the methodology followed during this project

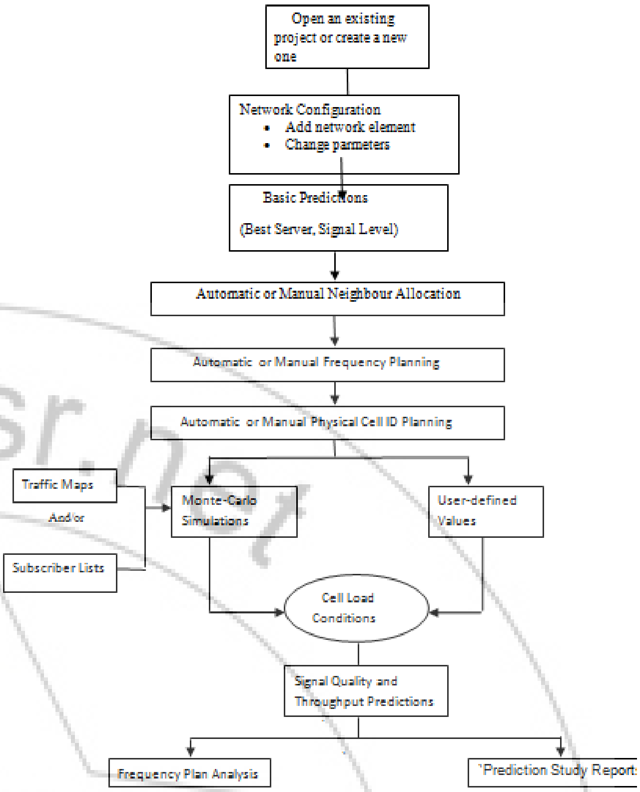

Figure 1: Flow chart of Project Work

6. Radio Network Planning

Network planning is a complicated process consisting of several phases. The final target for the network planning process is to define the network design, which is then built as a cellular network. The network design can be an extension of the existing LTE network or a new network to be launched. Environmental factors also greatly affect network planning. Radio Network Planning contains number of phases:

- Initial phase-which includes collection of pre-planning information and starting network dimensioning i.e. Link Budget preparation, coverage and capacity calculation by running simulations.
- Nominal and detailed planning- which includes selection and use of radio planning tool. This step involves propagation model tuning, defining thresholds from Link budget, creating detailed radio plan based on the thresholds, checking network capacity against more detailed traffic estimates, Configuration planning, Site surveys, Site pre-validation and validation, eNode B parameter planning.
- Defining KPIs and Parameter Planning- using eNode B system parameters and counters, defining performance KPIs and its target values based on vendor’s promise, verification of the KPIs and target values using planning and dimensioning tools nominally along with pre and post-launch optimization[8]. But defining KPI and parameter planning has been considered out of the scope of this paper.

6.1 Atoll planning tool

Atoll Planning Tool was used in this research; Atoll is an open, scalable, and flexible multi-technology network design and optimization platform that supports. Wireless operators throughout the network lifecycle, from initial design to densification and optimization.

6.2 Atoll General Features

1) Multi technology tool
   Dedicated Project Templates & Propagation Models for all supported technology
2) User friendly GUI
   - Windows based tools
   - Easy to export/ import all required data
   - Simply support copy/paste all data
3) Flexibility in data management
   Display, Sorts & Filter
4) Working systems
   Stand Alone .atl documents. [9]

7. Simulation Steps and Results Disscusion

Khartoum is the capital of Sudan. 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-link level simulation result along with link budget preparation and capacity analysis-system level simulation have been performed . As a result, it can be included for the complete part of Khartoum city radio planning performing the simulations with planning tool like Atoll.

- Open project or create a new one Import Map (Khartoum City)

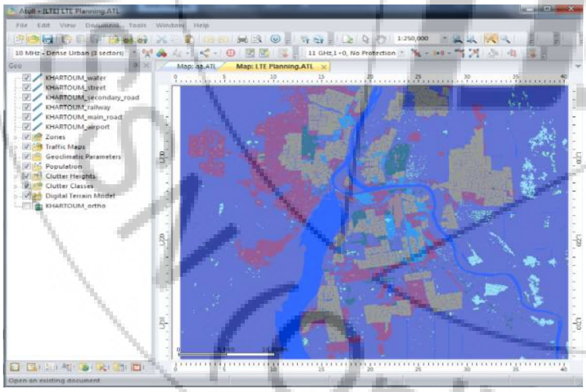

Figure 2: Import map in atoll planning tool

- **Selected zone Statistical**

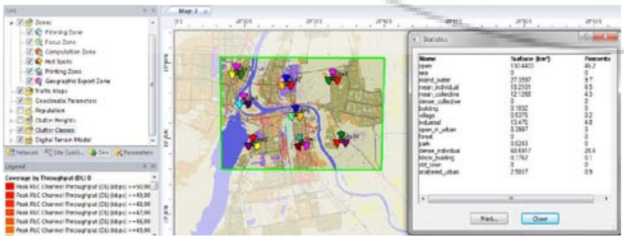

Figure 3: zone statistical

Statistical for Selected Zone
• Total Surface 14.000 $km2$
• Population (inhab)/$km2$3,819,996,75
• Hexagon radius (m) R = 350

LTE Planning Parameters
• Propagation Model : Okumura –Hata
• Antenna : 65deg 18dBi 4Tilt 2100MHz
• Hight(m) = 30
• Hexagon Area = 2.6 R
Propagation Model
Okumura – Hata was used in this planning
Name : Urban (medium-small city)
• Lu = 69.55 + 26.16 log f -13.82 log Hb+ (44.9-6.55 log Hb–0 Hb)log d
• A(Hr) = (1.1 log f –0.7)Hr–(1.56 log f –0.8)
• Total = Lu –a(Hr)
Where:
Lu = Median path loss. Unit: Decibel (dB)
f = Frequency of Transmission. Unit: Megahertz (MHz)
Hb= Base Station Antenna effective height. Unit: Meter (m)
d = Link distance. Unit: Kilometer (km)
Hr= Mobile Station Antenna effective height. Unit: Meter (m)
a(Hr) = Mobile station Antenna height correction factor as described in the Hata Model for Urban Areas. Shown in figure 4 below:

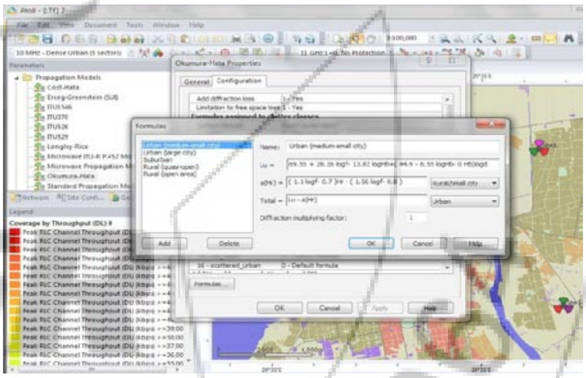

Figure 4: Okumura – Hata formulas

- **LTE Predication**

Coverage predictions have been performed by: transmitter, signal level, downlink throughput and Channel to Interference plus Noise Ratio (CINR). Coverage prediction properties: fig7 by signal level, fig 8 channel throughput (DL), coverage prediction results have been shown in Fig 5 to Fig 9.

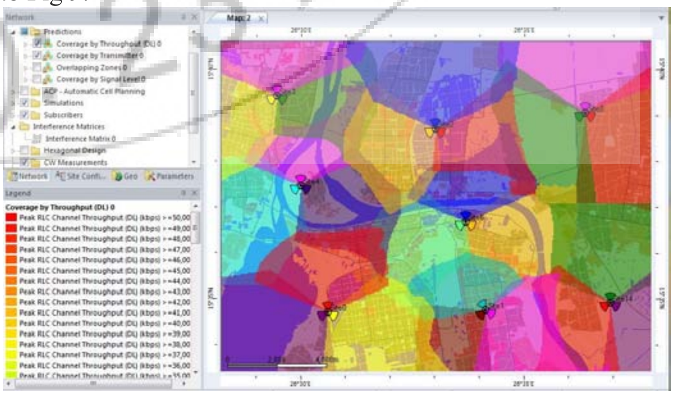

Figure 5: coverage by transmitter

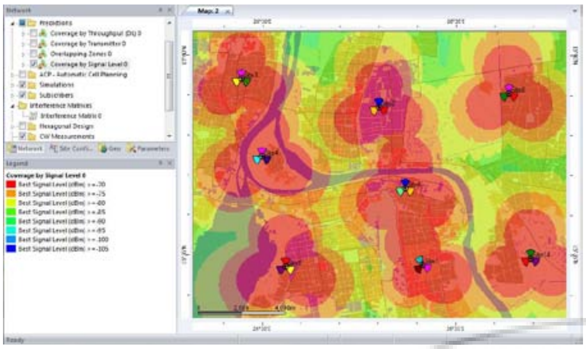

Figure 6: coverage by signal levels.

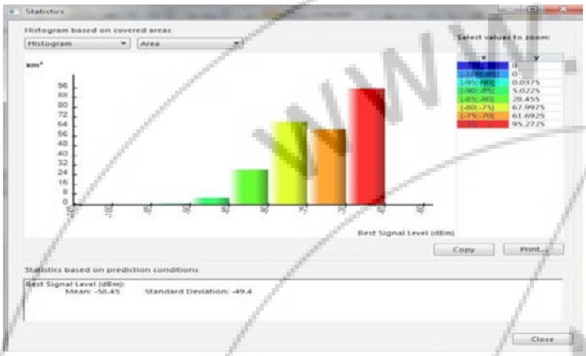

Figure7: histogram based on covered areas

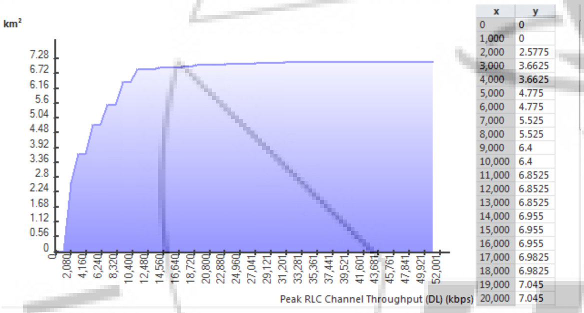

Figure 8: coverage by throughput DL

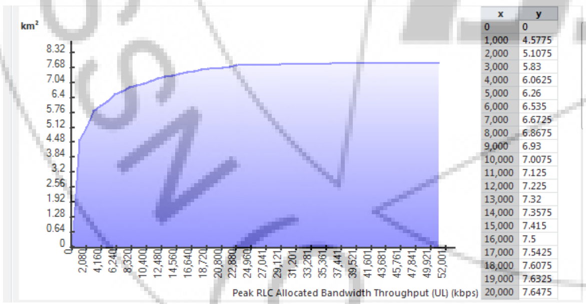

Figure 9: coverage by throughput UL

8. Performance Analysis of the Planned Network

Using point analysis tool of Atoll site 6-1 was chosen from the Khartoum map along with a receiver to analyze the cell edge throughput scenario and all other uplink and downlink parameters. The point analysis results appeared as the following shown in Fig 10(a). Fig.10 (b): shows the geographic profile of the site 6 - 1, fig 10(c): gives the signal analysis involving PBCH, Downlink and Uplink parameters of the adjacent.

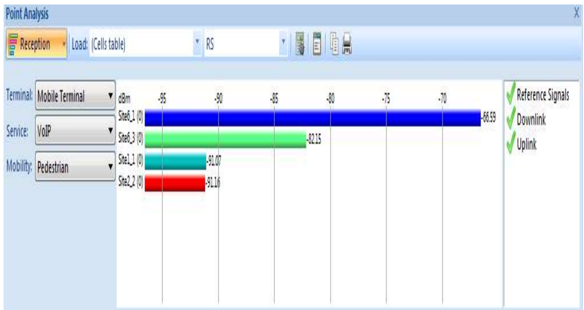

Figure 10 (a): The point analysis of sit 6-1

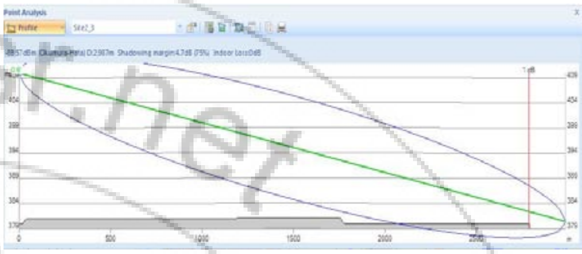

Figure 10 (b): The geographic profile of the site 6 – 1

Figure 10 (c): the signal analysis involving PBCH, Downlink and Uplink parameters

Analyzing the coverage prediction results with the placed eNodeB with respect to [10] it is quite evident that the planned network provides a satisfactory coverage. Again, evaluation of traffic map after simulation makes it clear that subscribers mostly remain connected at both UL & DL which also indicates a very positive sign for the planned network. Performance analysis with point analysis tool strengthens the base behind the planned network as an effective one.

9. Conclusion and Future Work

The success of LTE network depends on its three factors: coverage, capacity and quality. Capacity is based on an assessment of dropped calls and congestion that has been removed by proper optimization. Quality has been improved by eliminating interference from both external and internal sources. Radio planning stage with Atoll taking Khartoum digital map as input. In detail Atoll simulations have been run on Khartoum digital map containing both coverage predictions and traffic simulations. Again, performance evaluation has been done using point analysis tool. In future work must be provided research for improvement of LTE planning uses software and compare between some places.

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