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Long Term Evolution (LTE) Radio Network Planning Using Atoll

Gullipalli S.D. Rohit Gagan, Kondamuri N. Nikhitha, Electronics and Communication Department, Baba Institute of Technology and Sciences - Vizag

Abstract: *A rapid increase of mobile data usage and advent of new applications such as MMOG (Multimedia Online Gaming), mobile TV, Web 2.0, streaming contents have motivated the 3rd Generation Partnership Project (3GPP) to work on the Long-Term Evolution (LTE) on the way towards fourth-generation mobile. This project involves a detailed LTE radio network planning i.e. capacity and coverage using Atoll in order to formulate a radio planning guideline in view of possible network implementation in the Gachibowli area.*

Index terms: *LTE, 3GPP, Atoll, Radio Network Planning.*

I. INTRODUCTION

LTE evolved from an earlier 3GPP system known as the Universal Mobile Telecommunication System (UMTS), which in turn evolved from the Global System for Mobile Communications (GSM). Even related specifications were formally known as the evolved UMTS terrestrial radio access (E-UTRA) and evolved UMTS terrestrial radio access network (E-UTRAN). First version of LTE was documented in Release 8 of the 3GPP specifications.

- LTE is the successor technology not only of UMTS but also of CDMA 2000. LTE is important because it will bring up to 50 times performance improvement and much better spectral efficiency to cellular networks.
- LTE is introduced to get higher data rates, 300Mbps peak downlink and 75 Mbps peak uplink. In a 20MHz carrier, data rates beyond 300Mbps can be achieved under very good signal conditions.
- LTE is an ideal technology to support high date rates for the services such as voice over IP (VOIP), streaming multimedia video conferencing or even a high-speed cellular modem.
- LTE uses both Time Division Duplex (TDD) and Frequency Division Duplex (FDD) mode. In FDD uplink and downlink transmission used different frequency, while in TDD both uplink and downlink use the same carrier and are separated in Time.
- LTE supports flexible carrier bandwidths, from 1.4 MHz up to 20 MHz as well as both FDD and TDD. LTE designed with a scalable carrier bandwidth from 1.4 MHz up to 20 MHz which bandwidth is used depends on the frequency band and the amount of spectrum available with a network operator. All LTE devices have to support (MIMO) Multiple Input Multiple Output transmissions, which allow the base station to transmit several data streams over the same carrier simultaneously.

- All interfaces between network nodes in LTE are now IP based, including the backhaul connection to the radio base stations. This is great simplification compared to earlier technologies that were initially based on E1/T1, ATM and frame relay links, with most of them being narrowband and expensive.

- Quality of Service (QoS) mechanism have been standardized on all interfaces to ensure that the requirement of voice calls for a constant delay and bandwidth, can still be met when capacity limits are reached. Works with GSM/EDGE/UMTS systems utilizing existing 2G and 3G spectrum and new spectrum. Supports hand-over and roaming to existing mobile networks.

Advantages of LTE:

- **High throughput:** High data rates can be achieved in both downlink as well as uplink. This causes high throughput.**Low latency:** Time required to connect to the network is in range of a few hundred milliseconds and power saving states can now be entered and exited very quickly.

- **FDD and TDD in the same platform:** Frequency Division Duplex (FDD) and Time Division Duplex (TDD), both schemes can be used on same platform.

- **Superior end-user experience:** Optimized signalling for connection establishment and other air interface and mobility management procedures have further improved the user experience. Reduced latency (to 10 ms) for better user experience.

- **Seamless Connection:** LTE will also support seamless connection to existing networks such as GSM, CDMA and WCDMA.

- **Plug and play:** The user does not have to manually install drivers for the device. Instead system automatically recognizes the device, loads new drivers for the hardware if needed, and begins to work with the newly connected device.

- **Simple architecture:** Because of Simple architecture low operating expenditure (OPEX).

II. RADIO NETWORK PLANNING

Network planning is an intricate process consisting of numerous stages. The final goal 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 radio network or a new network to be launched. Environmental factors also significantly affect network planning.

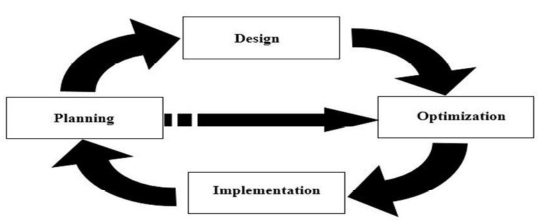

Figure 1. Radio Network Life Cycle

[4] RF Planning is the process of assigning frequencies, transmitter locations and parameters of a wireless communications system to provide sufficient coverage and capacity for the services required. The RF plan of a cellular communication system has two objectives: coverage and capacity. Coverage relates to the geographical footprint within the system that has sufficient RF signal strength to provide for a call/data session. Capacity relates to the capability of the system to sustain a given number of subscribers. Capacity and coverage are interrelated. To improve coverage, capacity has to be sacrificed, while to improve capacity, coverage will have to be sacrificed

The RF Planning process consists of four major stages.

1. Initial Radio Link Budgeting
2. Detailed RF Propagation Modelling
3. Fine Tuning and Optimization
4. Continuous Optimization

Phase 1: Initial Radio Link Budgeting

The first level of the RF planning process is a budgetary level. It uses the RF Link Budget along with a statistical propagation model (e.g. Hata, COST-231 Hata or Erceg-Greenstein) to approximate the coverage area of the planned sites and to eventually determine how many sites are required for the particular RF communication system. The statistical propagation model does not include terrain effects and has a slope and intercept value for each type of environment (Rural, Urban, Suburban, etc.). This fairly simplistic approach allows for a quick analysis of the number of sites that may be required to cover a certain area. Following is a typical list of outputs produced at this stage:

- Estimated Number of Sites

Phase 2: Detailed RF Propagation Modelling

The second level of the RF Planning process relies on a more detailed propagation model. Automatic planning tools are often employed in this phase to perform detailed predictions. The propagation model takes into account the characteristics of the selected antenna, the terrain, and the land use and land clutter surrounding each site. Since these factors are considered, this propagation model provides a better estimate of the coverage of the sites than the initial statistical propagation model. Thus, its use, in conjunction with the RF link budget, produces a more accurate determination of the number of sites required. Following is a typical list of outputs produced at this stage:

- Number of Sites and Site Locations (and Height)
- Antenna Directions and Down tilts
- Neighbor Cell Lists for each site
- Mobility (Handover and Cell Reselection) Parameters for each site.
- Frequency Plan
- Detailed Coverage Predictions (e.g. Signal Strength (RSRP), Signal Quality (RSRQ) Best CINR, Best Server Areas, Uplink and Downlink Throughput)

Phase 3: Fine Tuning and Optimization: The third phase of the RF planning process incorporates further detail into the RF plan. This stage includes items such as collecting drive data to be used to tune or calibrate the propagation prediction model, predicting the available data throughput at each site, fine tuning of parameter settings (e.g. antenna orientation, down tilting, frequency plan). This process is required in the deployment of the system or in determining service contract based coverage. Following is a typical list of outputs produced at this stage:

- A final List of Sites and Site Locations (and Height)
- Optimized Antenna Directions and Down tilts
- An optimized Neighbor Cell Lists for each site
- Mobility (Handover and Cell Reselection) Parameters for each site.
- An optimized Frequency Plan
- Detailed Coverage Predictions (e.g. Signal Strength (RSRP), Signal Quality (RSRQ) Best CINR, Best Server Areas, Uplink and Downlink Throughput)

Phase 4: Continuous Optimization

The final phase of the RF planning process involves continuous optimization of the RF plan to accommodate for changes in the environment or additional service requirements (e.g. additional coverage or capacity). This phase starts from initial network deployment and involves collecting measurement data on a regular basis that could be via drive testing or centralized collection. The data is then used to plan new sites or to optimize the parameter settings (e.g. antenna orientation, down tilting, frequency plan) of existing sites.

III. ATOLL PLANNING TOOL

[3], [5], [6] Atoll planning tool was used in this project; Atoll is a multi-technology wireless network design and optimization software tool suitable for many standards including GSM, UMTS and LTE. It supports multi-technology simulation suitable for planning LTE networks along with other standards. It includes various adjustable propagation models both empirical and deterministic. Atoll also supports various sources of geographical data including popular web map services.

3.1 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

3.2 Atoll configuration, Predictions and Simulation

Creating a new file and importing DTM, Clutter, Vectors, Places. Analysing the coverage predictions and simulation results it is evident that the planned network provides sufficient services to the users.

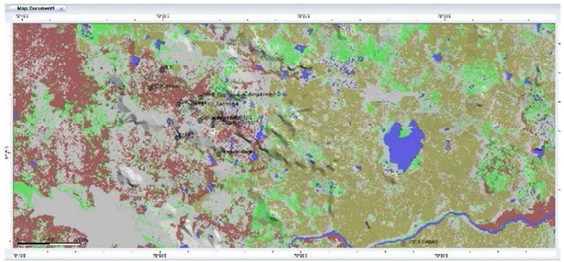

Figure 1. Map of Gachibowli area with Clutter

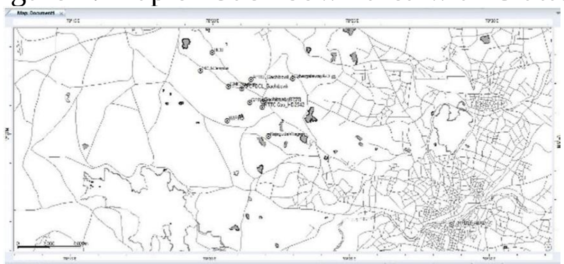

Figure 2. Map of Gachibowli area with Vectors

Predictions of coverage by Transmitter and Signal Level are performed.

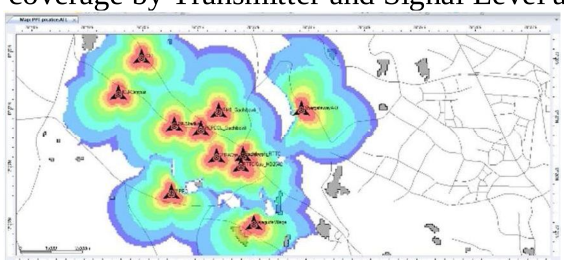

Figure 3. Coverage by Transmitter

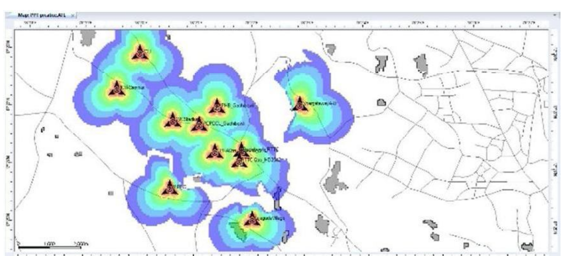

Figure 4. Coverage by Signal Level

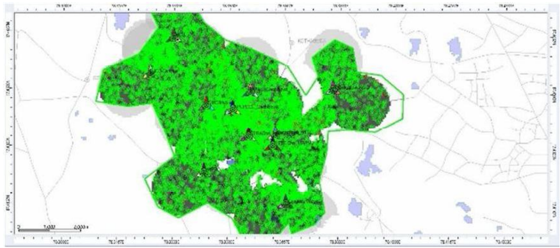

Figure 5. Monte Carlo simulation for Capacity

IV. CONCLUSION

LTE networks are very complex and their planning

needs many factors to be considered. All of the tasks of planning (capacity planning, coverage planning, frequency planning) are interconnected and cannot be carried out separately. 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. Atoll simulations have been run on Gachibowli area digital map containing both coverage predictions and traffic simulations.

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