International Journal of Innovation and Applied Studies
ISSN 2028-9324 Vol. 6 No. 1 May 2014, pp. 68-75

http://www.ijias.issr-journals.org/

Robust Physical Optimization for LTE Network

Ekta Gujral and Jitendra Singh Jadon

Amity Institute of Telecommunication and Mgmt.,
Amity University,
Noida, India

ABSTRACT: Initial tuning complements the Radio Network Design. It is performed when all nodes in a cluster are operational but not yet in commercial use. The analysis of the log files from drive - and stationary tests improve both network coverage and capacity. When the radio network has been tuned and there are sufficient subscribers generating traffic, the live network can be optimized in order to identify and solve possible issues. The Drive test is performed to find the effectiveness of RF conditions in wireless and mobile environment. In real "drive-test" these conditions are more appropriate with focus on different environment. This helps to check the actual coverage and quality of the network for the user. Through this paper we will learn that what effective etilt of antenna we needs to consider during the initial tuning optimization and what the effects are of Etilt changes on bad coverage, Reference Signal quality, Signal to Interference Noise Ratio, Channel Quality Indicator, Modulation Coding Scheme and bad throughput area. So that before commercial launch at least 90% of the coverage has been met. Also we are ensuring that every antenna has the most optimal combination of mechanical and electrical down tilt which is one of the most essential objectives of entire initial tuning.

KEYWORDS: LTE, Initial tuning, Coverage issues, Etilt, Optimization.

1 INTRODUCTION

It is very important to understand the LTE RAN tuning and optimization process in order to improve the radio network performance and the perceived end user quality. This paper is aimed at network engineer who need to resolve the coverage and quality issues in initial tuning of LTE radio network. It explained the different steps and tools needed to achieve this from an engineer prospective. Common radio related problems are presented and analyzed and purpose is to create a deeper understanding of radio performance and network tuning, resulting in improvement in radio network performance

The main purpose of initial tuning is to ensure that any service affecting faults related to radio planning, remaining in the network after integration process, are corrected [1]. Target of tuning is to prepare the air interface and troubleshoot system issues to achieve the best end user experience. It includes:

- Resolve hardware installation issues.
- Resolve parameter integrity issues.
- Improve design and end user experience. This includes:
  - Availability of service(coverage)
  - Mobility
  - Throughput
  - Latency and bottlenecks in the system
  - Reliability (BLER)
- Improve cell capacity. The aim is to maximize SINR and highest modulation in order to achieve the best throughput per resources block

Corresponding Author: Ekta Gujral (ekta12gujral@gmail.com)

Section 2 describes the Concept of RAN tuning and RAN optimization for LTE network. The Initial tuning methodology is explained in Sector 3.The experimental results and analysis using physical parameter changes will be discussed in Section 4.Conclustion and future scope is in section 5.

2 RAN Tuning and RAN Optimization

It is very important to understand the LTE RAN tuning and optimization process in order to improve the radio network performance and the perceived end user quality. This paper is aimed at network engineer who need to understand the main issues in initial tuning of LTE radio network. It explained the different steps and tools needed to achieve this from an engineer prospective. Common radio related problems are presented and analyzed and purpose is to create a deeper understanding of radio performance and network tuning, resulting in improvement in radio network performance.

LTE RAN is the Radio Access Network for LTE that provides the connection between the Core network and the user. The LTE Radio Access Network, called EUTRAN consists of

- Radio Base Station
- Operation Support System for Radio and Core
- TEMS Tools-TEMS Cell planner for LTE

There are two service which help to improve the RAN:

- RAN Tuning
- RAN Optimization

RAN tuning is done to provide operators with a detailed understanding of the underlying problems to address, such as network design, UEs and system. It is performed when all eNodeB in the area are installed and operational and when the network is stable and not yet commercially used. It is also performed when new sites are installed in already commercially launched areas. [2] RAN tuning is required to ensure good network quality and identifiers and solves radio network problems after network has been deployed.

RAN Optimization is performed after the radio network has been tuned and it identifies and solved radio network problem in live networks. When there are sufficient subscribers generating traffic, data from various system sources can be collected. [16]RAN Optimization can results in changes in parameter setting for the different functionalities such as idle mode, radio connection supervision, power control, capacity management and handover.

3 Initial Tuning Methodology

The first phase of LTE Tuning includes making necessary preparations and perform specific checks of the network. Many errors are found during the preparation phase so you are advised to perform these tasks very thoroughly. The next tuning phase is Mobility (drive test) and Hot Spot (stationary) Testing.Once the drive routes and the hot spots are been defined and the drive test tools are set up, it’s time to start testing! You should do both drive tests and stationary tests. TEMS investigation is the most commonly used tool for this purpose.

The next phase is to post process the log files you collected and create plots to identify problem areas. It is recommended to treat each problem area separately, and identify area specific problems such as lack of coverage, high interference problems and missing neighbors. Proposed changes such as antenna tilt, azimuth, or parameter changes are documented in the tuning report.

Normally the suggested changes are included in simulations, and if they bring the wanted result they are implemented in the network.

The major measurement from the equipment is to verify the signal strength and the quality of the signal. The second part is to verify the code planning and the handover areas, it is crucial to minimize the cell overlap even more than in WCDMA, as in LTE there is no soft handover. This means that inter-cell interference will occur even from the second best cell.

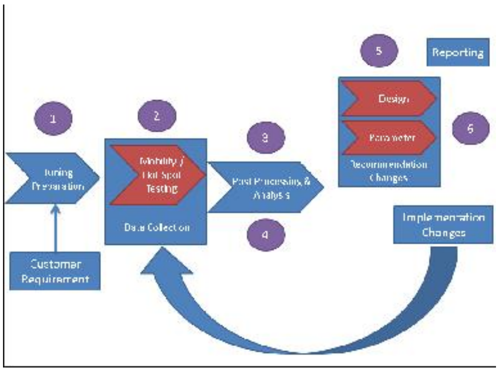

Figure 1. Initial Tuning process

The measurement made for the verification of the network is: RSRP, RSRQ and RSSI.

RSRP = Reference signal received power(RSRP), is defined as the linear average over the power contribution (in [W]) of the resource elements that carry the cell specific reference signals within the considered measurement frequency bandwidth. [3]

RSSI = EUTRAN Carrier Received Signal Strength Indicator, comprises the linear average of the total received power observed only in OFDM symbols containing reference symbols for antenna port 0, in the measurement bandwidth, over N number of resource blocks by the UE from all sources, interference, thermal noise etc. [3]

RSRQ = Reference Signal Received Quality is defined as

RSRQ = 10 Log (N) +10 Log RSRP-10 Log RSSI [dB] [3]

Where N is the number of resources blocks of the EUTRAN carrier RSSI measurement bandwidth. The measurements in the [10] ,[11] numerator and denominator shall make over the same set of resources blocks. It is used only in RRC Connected mode, along with RSRP for function such as handover.

The RSRP and RSRQ are supported to have a minimum value that is decided in collaboration with the operator and in accordance with the SINR expected from the cell plan. The better the SINR is, the better the rates that could be achieved in the network

For cell planning and dimensioning we need:

SINR: the signal to noise and interference ratio. Signal is the power of the wanted signal, and the interference is the sum of all intercell interference power and any external interference. [4]The noise is the thermal noise power. The power levels are the average levels of the resource elements over which user data is transmitted.

Interference ratio (F): Interference ratio is cell isolation measure defined as ratio of interference from all cells except the best over the best cell signal. It can be calculated on path gains

$$F = \sum g_i / g_{best\_cell}$$ [3]

It is independent of access technology, bandwidth, receiver performance and capability. In interference limited radio network, at full load, I/F will be equal to SINR before antenna combining. In contrast to pure SINR, this gives a measure independent of actual load and interference levels at the time of measurement and thus provides excellent measure of inter-cell interference.

This measure was introduced because it was noticed that all existing measure for inter cell interference RSRQ, CINR and number if inter-cell interferers has serious drawback

- RSRQ was sensitive to own cell load
- CINR measurement is empty network do not capture potential interference problems
- Number of inter-cell interferers did not explain much about the problem

These are the actions that should be taken for coverage verification:

- **Analyze coverage per cluster**
  - Use RSRP, F Interference, Best Server PCI plot etc.
  - Compare expected to actual coverage
- **Identify problem areas**
  - Poor coverage
  - High interference

Once a cluster drive test is complete, it is recommended to use the measurements to analyze the coverage in a cluster and to identify the [3],[17] problematic areas in it. For each problematic area the cause of the radio problem needs to be identified and corrective action should be proposed.

In order to identify the critical areas within the cluster, it is needed to define the following threshold:

- RSRP threshold value
- F Intercell Interference

Suggested plots for this task are:

Coverage Plots: Cell Coverage Plot, RSRP Plot, Best Server PCI Plot, TX power, 3 dB, 6dB and F Ratio plots.

Quality Plots: RSRQ plots, SINR plots and BLER plot.

Throughput plots: DL throughput plot, UL throughput plot, CQI, MCS, RI and Modulation.

An area where the signal level is below the threshold to achieve the bit rate requirements of the services as defined by the operator is s coverage hole. There are two causes for the coverage holes :

- Lack of signal power
- High interference

Also each cell will have two feeders, [12] [15] TX/RX to each antenna. A very common problem will be swapped feeders. During the installation, the feeders have been by mistake connected to wrong antenna port on the eNodeB.

Overshooting happens when a cell has coverage beyond the intended coverage area. This leads to interference problems especially if the signal strength of the overshooting cell is high. [8] ,[9] To identify areas where overshooting appears, a schematic map could be created where the problem areas are depicted (LTE Interferer plot). Then the coverage plot of one PCI should be examined and the interferers could be identified

These plots give indication of coverage holes, PCI-clashes, swapped feeders, cell not transmitting, or overshooting cells etc. The result of this analysis should lead to suggestion for corrective action like physical or parameter changes that will improve cell performance.

4 EXPERIMENTAL ANALYSIS AND RESULTS

For Initial tuning the experiment has been conducted on nearly 5-6 clusters. Each cluster have 12-15 sites on Air. The solution coverage hole due to lack of coverage is to increase the received signal level. This can be done with the folllowing ways :

- Change antenna down tilt and antenna azimuth.This can improve the coverage for both uplink and downlink
- Increase the antenna tower height, this process increase the cost.So not effective in paractice.
- Increase the reference power.

So to remove coverage holes in cluster we will recommend to change the electric tilt. [12] [14] Implementation of this is very cheep if RET is installed on site.

In order to find swapped feeders, a test should be performed by walking/driving round the site. This is to secure that the planned physical cell identity is in the right cell..

Usually for overshooting cell, solution is to change the antenna configuration e.g. tilting down the antenna, redirecting the antenna orientation. With this solution, uplink/downlink [5], [6], [7] coverage imbalance problem will not occur in the interferer because both uplink/downlink pathloss is modified simultaneously.

Using the Etilt recommendation as shown below we have improved the network.

Table 1. Etilt recommendation for Dense Area

Urban/Dense	**Electrical tilt**		
Antenna Height (m)	**800/900 MHz**	**1800/1900 MHz**	**2100/2300 MHz**
15-20	1.5-4.0	0.5-2.5	0.0-1.5
20-25	4.0-6.5	2.5-5.0	1.5-4
25-30	6.5-9.0	5.0-7.5	4.0-6.5
30-35	9-11.5	7.5-10.0	6.5-9.0
35-40	11.5-14.0	10.0-12.5	9.0-11.5
40-45	14.0-16.5	12.5-15	11.5-14

Table 2. Etilt recommendation for suburban Area

Suburban	**Electrical tilt**		
Antenna Height (m)	**800/900 MHz**	**1800/1900 MHz**	**2100/2300 MHz**
15-20	0.5-3.0	0.0-1.5	0.0-0.5
20-25	3.0-5.5	1.5-4.0	0.5-3
25-30	5.5-8.0	4.0-6.5	3.0-5.5
30-35	8-10.5	6.5-9.0	5.5-8.0
35-40	10.5-130	9.0-11.5	8.0-10.5
40-45	13.0-15.5	11.5-14	10.5-13

Table 3. Etilt recommendation for Rural Area

Rural Area	**Electrical tilt**		
Antenna Height (m)	**800/900 MHz**	**1800/1900 MHz**	**2100/2300 MHz**
15-20	0.0-2.5	0.0-1.0	0.0-0.0
20-25	2.5-5.0	1.0-3.5	0.5-2.5
25-30	5.0-7.5	3.5-6.0	2.5-5.0
30-35	7.5-10.0	6.0-8.5	5.0-7.5
35-40	10.0-12.5	8.5-11.0	7.5-10.0
40-45	12.5-15.0	11.0-13.5	10.0-12.5

The Pre-Post analysis of the cluster is as shown in following plots, which validates the result.

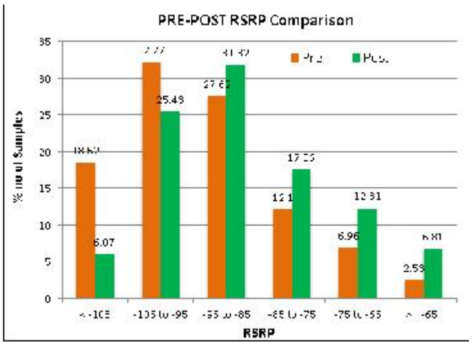

Figure 2: Comparision of RSRP

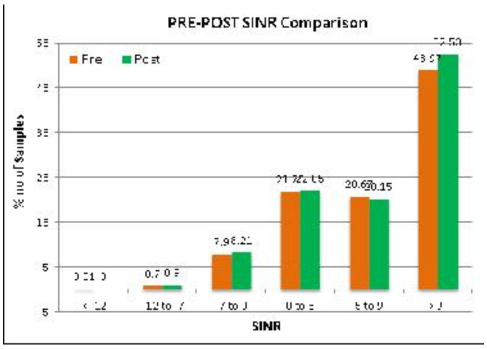

Figure 3. Comparision of SINR

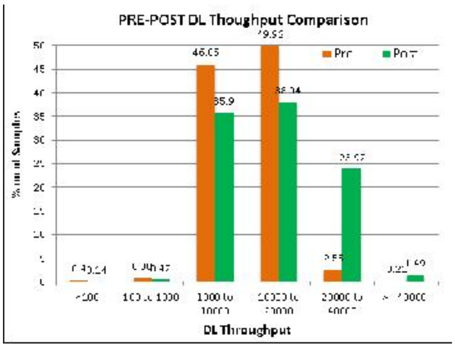

Figure 4. Comparision of DL PHY Throughput

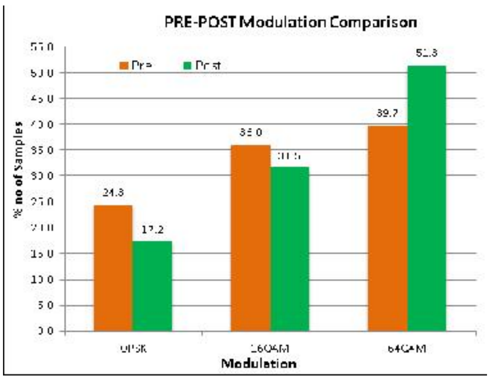

Figure5. Comparision of Modulation

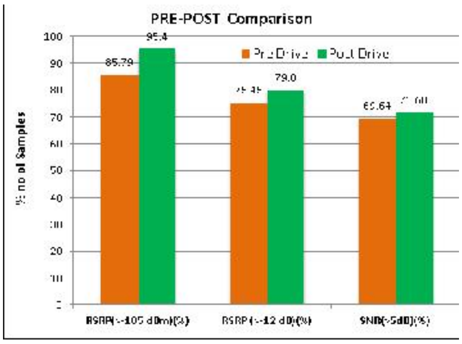

Figure 6a. Pre Post Comparison

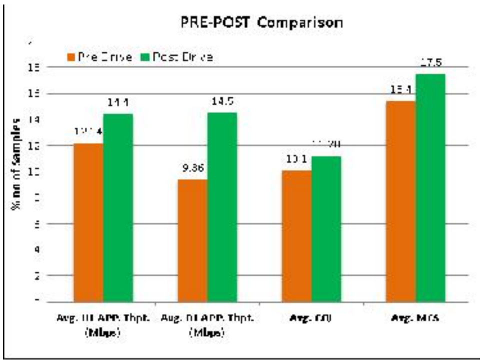

Figure 6b. Pre Post Comparison

From above results we can see that with the right tilt, the improvement in Coverage, Quality, SINR,MCS ,CQI and DL throughput can be seen. The results are validated for multifrequency and multi operator. But Before recommending the changes it is necessary to study the following points :

- Site photos
- Elevations of area
- Clutter information
- Antenna patterens

So one of the following possible solutions for overshooting and other coverage issues is :

Antenna Tilt: Antennas cab be tilted in two different ways:

- **Mechanical Tilt:** When an antenna is mechanically tilted, the gain in the main direction is reduced, whereas the gain in other direction might be less affected.
- **Electrical Tilt:** When an antenna is electricallt tilted , the gain is reduced in all direction.

When tilting the antenna , the antenna patteren will change as shown above. Ensuring that every antenna has the most optimal combination of mechanical and electrical down tilt, is one of the most essential objective of entore initial tuning.The Remote electric tilt allows remote antenna electric down tilt by means of phase shifting the antenna elements. The RET unit contains a communication interface and step motor to engage the antenna’s tilt mechanism. It is controlled ny antenna system controller.

5 CONCLUSION

When tilting the antenna , the antenna patteren will change result in change in coverage of node. Ensuring that every antenna has the most optimal combination of mechanical and electrical down tilt, is one of the most essential objective of entore initial tuning.The Remote electric tilt allows remote antenna electric down tilt by means of phase shifting the antenna elements. So optimal etilt result in in increasing the coverage, quality, SINR, MCS, CQI and DL throughput.

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