LTE INDOOR RADIO COVERAGE OPTIMIZATION STUDY IN MODERN CITY ENVIRONMENTS

Marian ALEXANDRU, Raluca URECHIATU

"Transilvania" University, Brasov, Romania

Abstract: *The goal of this paper is to illustrate an optimization study based on real cellular networks in modern city environments, where many types of obstacles for the radio waves can be found. The studied network is LTE 800 and the overall aim is to identify LTE optimization opportunities, to reduce cell overlapping and to evaluate effectiveness of design changes. It is shown the improvement of the indoor radio coverage after antenna tilt changing or height modification. Also, it is highlighted that the cell throughput depends on how many neighbors has the site that is analyzed, this one being a key factor in LTE cell planning. For these purposes tools like Atoll, ACP (Automatic Cell Planning) and Pace4G SRV were used to check the quality of the transmitter data.*

Keywords: *LTE, antenna tilt, antenna heights, overlapping, cell throughput*

1. INTRODUCTION

LTE (Long Term Evolution) is the fourth generation cellular technology that has the potential to offer significantly faster mobile broadband services and it is described in a set of open specifications published by 3GPP (The 3rd Generation Partnership Project).

The main objectives include significantly improved spectrum efficiency, a significant reduced latency for control-plane and user-plane and support for interworking with existing 3G systems.

As air interfaces technologies for LTE OFDMA (Orthogonal Frequency Division Multiple Access) and SC-FDMA (Single Carrier FDMA) have been chosen.

OFDMA is used on the LTE downlink and it is providing data rates approaching 360 Mbit/s in a 20 MHz channel.

SC-FDMA is used on the LTE uplink and it provides rates up to 86 Mbit/s.

LTE is an all-IP environment, meaning that all interfaces will carry only IP - based traffic. The evolution of this network is known as LTE Advanced, which provides data rates of 1 GBit/s or more (fig. 1).

The main purpose of the tools that were used in this study is to monitor the performance of the LTE network and to identify the possibilities to optimize it.

ACP (Automatic cell planning) software is strongly recommended to generate the traffic map and by read into this map it is ensured best customer experience.

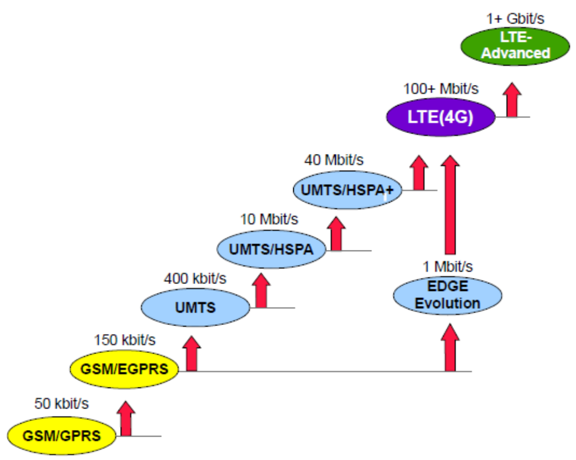

Fig. 1. Evolution of the GSM network [1]

Pace4G SRV software is used for checking the quality of site and transmitter data (there are situations when the antennas are not correctly aligned).

Atoll is a tool that allows network planning and analyzing. It is used by the largest operators for optimization of the network by traffic modelling, simulation, neighbor planning and other available options.

2. THE OPTIMIZATION PROCESS

2.1 Antenna tilts. Optimization was focused on looking for performance improvement through the application of electrical tilt or a combination of electrical and mechanical tilt.

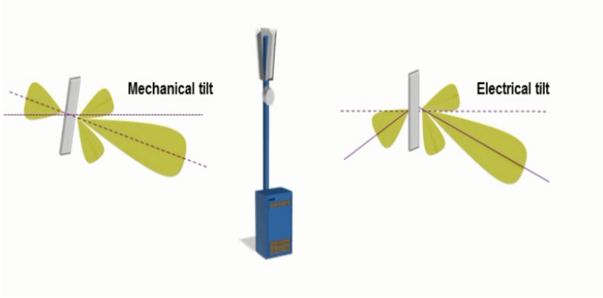

Fig. 2. Mechanical and electrical tilt

The tilt represents the inclination of the antenna; using it the antenna radiation direction can be changed [5].

The mechanical tilt doesn't change the phase of the input signal. The eletrical tilt changes the characteristics of signal phase and it is a built-in function.

2.2 The impact of 'boomer' sites. A key LTE planning guideline is that LTE sites should have relatively low antenna heights (below 30m). A boomer site is a site with antennas that are higher than 30m.

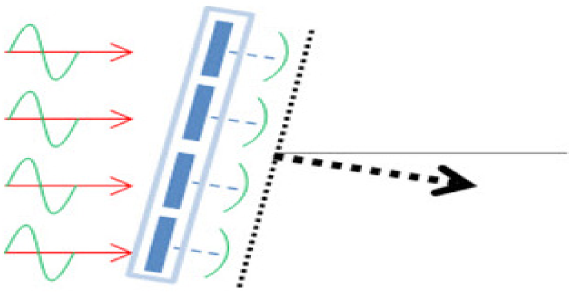

Fig. 3. Mechanical tilt

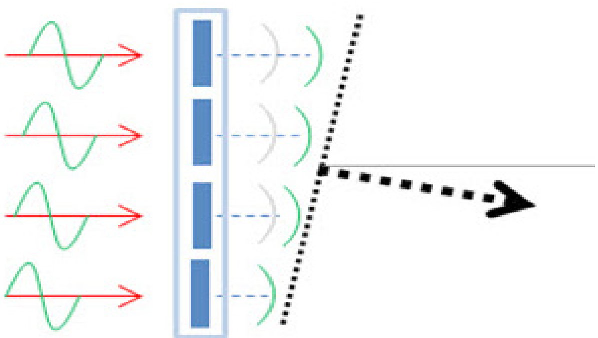

Fig. 4. Electrical tilt

One of the issues that will be faced in many operating markets is that the significant proportions of the available 2G and 3G site locations are very high. This high boomer sites should be avoided.

This view of drive test data (Fig. 5) shows the potential impact of using a high site location of this type. The drive test was performed monitoring an LTE 800 site having antennas of 51m.

The effect of the 'boomer' site is pointed out in the figure below; it can be seen that the site is measured as 'best server' at a distance of about 4.5 km (marked area) from the main station. This is about 2 km outside the nominal coverage area for the site. Long range overshooting is typical for a boomer site and will cause interference in LTE.

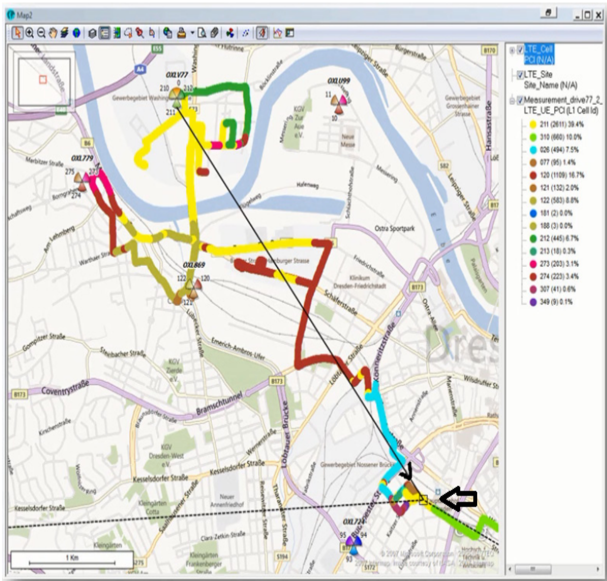

Fig. 5. The effect of the boomer site

2.3 Height optimization. In addition to notice the effectiveness of antenna tilt optimization the study has been extended to test the benefits of antenna height optimization.

The study was based on the same geographical region as used for the antenna tilt study and the frequency band considered was LTE 800. The aim was to identify neighbor relationship with height differentials and tries to improve overlapping by reducing heights to maximum 40 m and then applying antenna tilt optimization.

The screenshot (Fig. 6) shows all the sites from the study. The sites have been colored to indicate the heights. The majority of sites are in the range of 25 to 40 m. In the second screenshot (Fig.7) the result of the height adjustment are shown. These are real sites, but the changes are simulated.

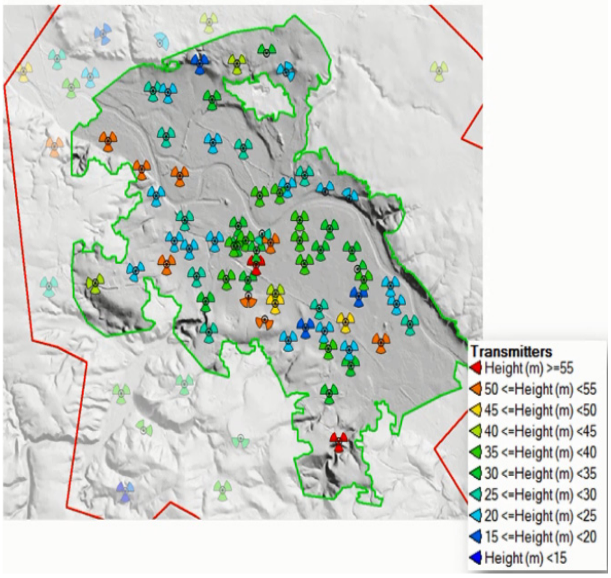

Fig. 6. Antenna heights before optimization

Following the antenna height adjustments, antenna tilt optimization based on a combination of mechanical and electrical tilt has been performed.

The indoor coverage signal level before and after the changes have been made is shown in the Fig. 8. The graph has been obtained by generating a coverage map and representing the area (%) in relationship with RSRP.

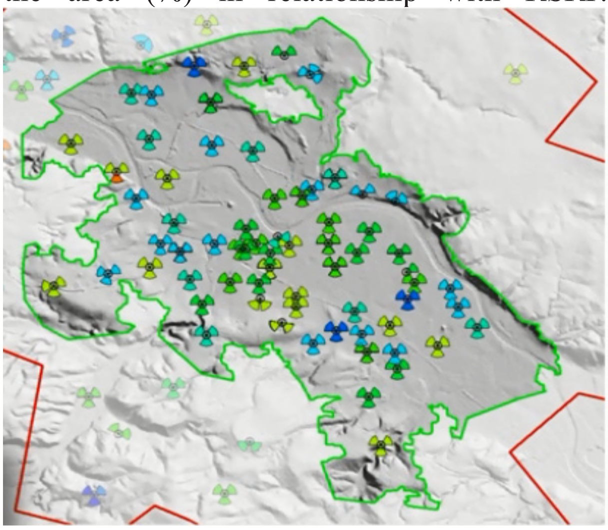

Fig. 7. Antenna heights after optimization

RSRP (Reference Signal Received Power) (dBm) is a parameter used to measure signal strength/quality of cells when cell selection takes place. RSRP threshold is -108 dBm.

The overall coverage is not degraded and there is a small improvement at the edge-cell.

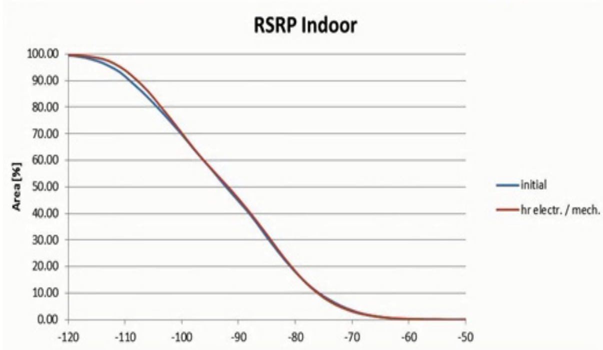

Fig. 8. Indoor coverage area related to RSRP [dBm]

This second graph (Fig. 9) is a histogram showing the distribution by area of the number of cells.

The results are shown before (in red) and after the adjustments have been made (green) and it can be seen that is a very significant shift toward fewer neighbors.

The difference is especially noticeable in the regions with 10 cells. This is certainly because the height reduction significantly reduced the instances of overshooting from the boomer sites.

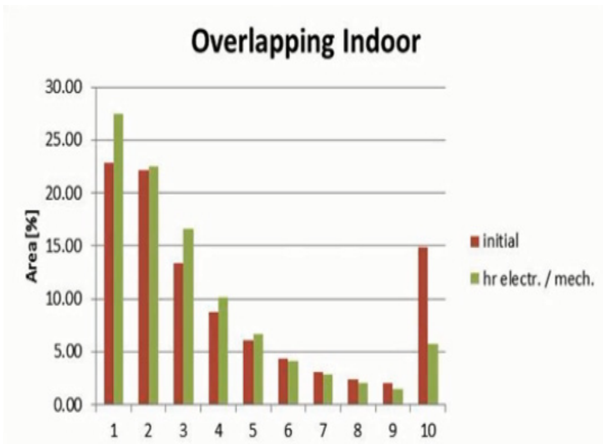

Fig. 9. Overlapping indoor results, area[%] in relationship with number of neighbors

1.4

1.4 Cell throughput. A key factor that will impact the cell throughput is the number of sites that are neighbors with the one that is analyzed, having closed signal levels.

This is an issue in urban areas because the inter site distance is smaller. This effect of too many neighbors is illustrated in Fig. 12.

The graph represents the PDSCH (Physical Downlink Shared Channel) throughput in relationship with SINR (Signal to Interference plus Noise Radio) and it was performed using Atoll software.

It is plotted for several scenarios with different numbers of neighbors. It can be seen that for the curves representing 3, 4 and 5 neighbors, throughput is limited to about 15 Mbit/s.

The red curve shows better performance with 2 neighbors.

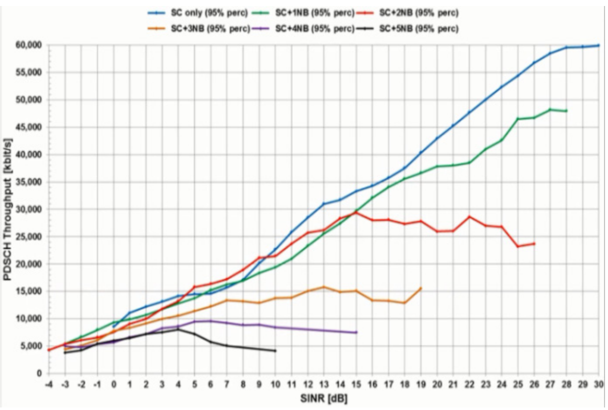

Fig. 12. PDSCH throughput related to SINR and the number of neighbors

The best performance is achieved only when there are just one or no neighbors (represented by the blue and green curves).

Overall it is recommended that the design of the network should be targeted in the maximum of 2 neighbors [1].

CONCLUSIONS & FUTURE WORK

The existing LTE sites have a large variation in height and the site distance differs very much from recommended distances. Overlapping can be further reduced by electrical tilt changing without loss in coverage.

For the overall LTE 800 indoor radio coverage optimization, several conditions should be met:

- Focus in more homogeneous network grid regarding site to site distance and antenna heights (avoid overshooting sites);
- Avoid overlapping areas close to the site;
- Sites with huge tilt close to upper electrical tilt limit should be avoided due to almost no further optimization potential;
- Check for dominant server to avoid overlapping;
- Use the full electrical tilt range especially for sectors pointing to rising terrain to ensure proper SINR conditions.

As future work, we'll focus our efforts to build outdoor radio coverage maps and to apply the same procedures for optimization, using also the software tools mentioned at the beginning.

BIBLIOGRAPHY

1. *** Automatic Neighbor Relation in LTE, LteWorld, Source. [online]. Available: http://lteworld.org [2014 February 10].
2. Vadada, H., LTE PCI Planning, Source. [online]. Available:http://www.telecom-cloud.net/wpcontent/uploads/2010/09/PCI-Planning-for-LTE.pdf [2014 January 22].
3. *** Cell planning for LTE networks, UK, 2011.
4. *** Huawei Technologies, Performance Monitoring Reference eNodeB, China, 2012
5. *** Antenna Electrical and Mechanical Tilt, Source. [online]. Available:http://www.telecomhall.com/ [2014 March 18].
6. Erik Dahlman, E., Parkvall, S., Sköld, J., Beming, P., 3G Evolution. HSPA and LTE for Mobile Broadband, Elsevier, 2008.