Analysis of handover based on the use of femtocells in LTE networks

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***Abstract*— One of the key elements in the networks LTE (Long Term Evolution) is the possibility of deploying multiple femtocells for the improvement of coverage and data rate. However, arbitrary overlapping coverage of these cells makes the handover mechanism complex and challenging. In this paper, simulations of deploying LTE femtocells in a scenario were evaluated. With this objective, measure impact and correlation of the use of femtocell parameters of QoS (Quality of Service) and handover. Possible limitations of this integration are discussed. Will be the integration of LTE femtocell a panacea? Despite this promising alternative estimates are fraught with uncertainty. The results show that the use of femtocell got worse on indicators of handover, impact on indicators of QoS.**

Keywords—LTE, handover, femtocell, simulation, OPNET.

I. INTRODUCTION

Currently, the Internet and mobile communications converge to a new paradigm, the Mobile Internet. The ability to access information and services anytime and anywhere has been shaping not only new user profiles but also demands for new applications.

With the popularization of the third and fourth generation technologies, mobile communication systems suffer from the addition of new services and functionalities, which also involve critical problems, such as interference, limited coverage, restrictions on the use of triple play applications, among others.

The multimedia services are becoming increasingly popular. These services generate intense traffic on the network, that demand for higher data rates and are sensitive to delay and delay variation, experienced in the network.

In indoor environments, the channel quality between the cellular base station and the mobile node may be affected by walls and obstacles. The wireless communication for indoor wireless requires more resources, including time, bandwidth, transmission power so that they can ensure the quality of service required by customers. However, the lack of resources in wireless cellular networks will be accelerated, since over 60% of the voice traffic and 90% of data traffic is generated indoors [1].

Thus, it is necessary to investigate access technologies to ensure satisfactory levels of quality of service, taking into consideration the growing demand for data services. In this respect, for a wireless operator femtocells are attractive since they are cost-effective way to significantly increase the user data rates of their wireless networks at the customer premises.[2]

This growing demand for indoor wireless multimedia and ongoing trends of mobile convergence are paving the way for the deployment of femtocells entire industry. These femtocells may be open access or closed access. [3] Open access allows an arbitrary user to use the femtocell, whereas in closed access, the use is restricted to users that are explicitly approved by the owner. While the ultimate goal of femtocell is to improve the efficiency, coverage and services at a reduced cost of operation, the possibility of arbitrary handovers between the existing eNodeB (enhanced NodeB) and HeNB (Home eNodeB), poses new challenges [4].

LTE (Long Term Evolution) is a technology for wireless broadband 4G (4th Generation) mobile networks for voice and data that ensures greater data speeds, better performance and more efficient use of spectrum. In this context, LTE networks have gained much attention, mainly because this technology can be used to improve voice services where there is a limited local coverage [5].

However, even supporting high data rate, LTE frequency can result in poor indoor coverage in some areas. In this case, an LTE femtocell network could be an alternative to improve the indoor signal and avoid overloading the macrocell. It is still too early to predict the success of LTE femtocell. Factors such as safety, interference and management still need to be studied.

The integration of femtocell LTE network appears to be a promising approach due to its homogeneous nature and characteristics. However, for the mobile unit to provide transparent communication in a change of radio resources, it is necessary to handover the network capacity. The handover is the process that characterizes a cellular network and assures its mobility feature.

From a technology point of view, a femtocell is not only characterized by short communication range and high throughput, but also by its ability to seamlessly interact with the traditional cellular network at all layers of the network stack, performing tasks like handovers, interference management, billing and authentication. This necessitates substantial support by the appropriate standards bodies.[6]

Therefore, this paper aims to conduct a handover from the use of femocells and evaluate the correlation between the indicators of handover and QoS is intended with this, study the effectiveness of using LTE femtocell and especially on what impacts, earnings and disadvantages that this combination of technologies offers.

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The following sections are organized as follows: section II will discuss some concepts of technologies in which this work is based. In section III related work will be presented. The description of the methodology used and the results are discussed in section IV. Finally, in Section V are final remarks.

II. Theoretical Fundaments

A. LTE (Long Term Evolution)

Searching solutions to make more efficient data transmission, while the volume of such traffic is on the rise, LTE has been proposed as the next step in the 4G mobile system, preceded by 2G and 3G . Its development is intended to provide performance improvements, while reducing the cost per bit, allowing for a greater spread of mobile services. Its standardization is the responsibility of 3GPP [7].

In LTE networks have a new architecture, totally different from what had been used in previous technologies, and an example of this is the base station, called eNodeB that the LTE starts to perform processing tasks previously performed in RNC (Radio Network Controller).

Note that the eNodeB will also be responsible for handover decisions through communication between the elements by using the X2 interface. However it is possible that the lack of communication over X2 (optional interface), communication between the eNodeB will be accomplished through other via the Access Gateway. Figure 1 illustrates the components of network architecture of LTE femtocell integration.

Over the next years, billions of devices will be connected to the Internet and cloud-based applications using mobile wireless 3G and LTE networks, will create a huge demand for capacity mobile wireless and ubiquitous coverage. Global mobile data traffic will increase 26 times between 2010 and 2015. This has been called "mobile data tsunami" [8].

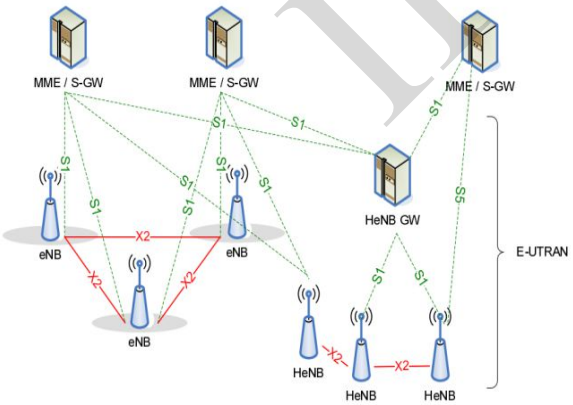


Figure 1. Overall E-UTRAN Architecture with deployed HeNB GW[9].

B. OPNET

The OPNET Modeler accelerates the process of research and development enabling the analysis and design of communication networks, devices, protocols and applications. It is widely used as a simulator Instrument for modeling telecommunications networks [10].

Have a work environment that allows you to create a network from a library of templates and define parameters not only the environment, but also of each object that makes up, and the impacts of its variations. In education their use is guaranteed, since one of its major advantages is the graphical interface provided to the user to configure settings and view results.

C. Handover

The handover is a difficult procedure because it involves several tasks that can cause interruptions in service delivery and performance degradation of applications. This fact becomes worse as you increase the frequency of migration and transition, as a result, the greater the number of occurrences of handover.

Recently, the concept of handover has not only been linked to continuity of a phone call, but also the continuity of streaming sessions, maintaining QoS and access the Internet. One of the research challenges for cellular systems is to improve the call admission system that controls and reduces blocking probability and improves the quality of service.

This extension of the concept of handover occurs due to the popularity of tablets and smartphones, which have allowed the collective experience of users sharing the same coverage area. Recently, the scenario of mobility at different speeds with applications in use has been increasingly common.

In LTE network, the decisions to take between two eNodeB are made by the entity without consulting eNodeB to MME: the source eNodeB decides to change the EU's target EU based on the measurement report eNodeB. The target eNodeB prepares radio resources before accepting the handover, after a successful passage, the target eNodeB indicates the source eNodeB to release the funds and sends a message to the MME path switching. The latter sends Plan Update for S-GW to eNodeB packages for the user on the route.

Control messages are exchanged across the interface between the two X2 eNodeBs and downlink data packet is also forwarded from the source to the target eNodeB via the same X2 [11],[12] interface. The figure below illustrates the process described here.

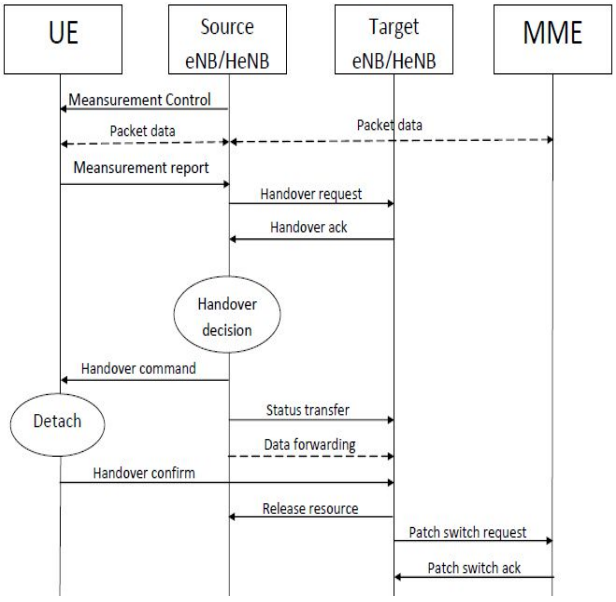


Figure 2 Handover procedure in LTE [13].

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D. Femtocell

The femtocell concept is part of the effort of telecommunication industry to provide communication of high performance, high-quality services for home users. In contrast to conventional types of cells, which are well planned by the operators, the femtocell base stations must be installed by customers themselves, similar to a wireless access point. [14]

The Femtocells are small base stations on the same functionality as the macrocells, but they have power to meet only a restricted environment (10-20 meters), are low cost, supporting a small number of users and installed by the user to best reception of voice and data in closed environments. [15]

It is estimated that 2/3 of the calls and over 90% of data traffic in a cellular network, occur in indoor environment. Some research shows that 45% of households and 45% of companies have a bad experience regarding indoor coverage [16]. Provide good indoor coverage for consumers, has become a major challenge for operators, because simply not offer a good voice service, but also high data transfers and video.

A factor to be taken into consideration, is that the process of installing these femtocells would be up to the user or in other words plug and play, without much consideration when planning, relying only on the skills of self-configuration built to minimize impact on the macrocell through self- provisioning parameters.

In this paper, simulations of deploying femtocells in an indoor environment have been carried out to study its effects on the handover and evaluation of quality of service experienced by users.

III. Related Works

Some works analyzed are intended to establish the best way of balancing the factors involved in mobile communication and manage users make better use of network resources and thus get a higher efficiency. Itself reviews the mechanism for handover in LTE networks has been intensively studied in academia and industry.

Some examples are [17], where the performance is evaluated TCP and UDP when the handover is executed in an LTE system, the TCP throughput is improved by using a small amount of A3-offset, because it effectively suppresses the interference from neighboring cells. Decreasing the value of A3 offset induces more "ping-pong" handover, but this does not affect the performance of TCP significantly.

Into [18] is proposed a strategy for handover between macrocell and femtocell for LTE networks, the paper presents a strategy that tries to avoid the failures of handover and the occurrence of unnecessary handovers. In many works [19, 20] if analyzes raise challenging problems on their potential for use in LTE femtocell networks as an alternative for coverage.

Into [21] the handover procedure in LTE femtocells is discussed focusing on the significant increase in the number of femtocells in certain environments. Simulations for the handover between macro and femto between femto were performed and an optimization algorithm was proposed and compared to conventional algorithm.

In other studies, the process of handover between HeNB and LTE eNodeB so modified [22] has been proposed. A new handover algorithm based on the speed of the UE and the QoS three different speed settings were considered in the algorithm, or low mobility (0-15 km/h), medium (15-30 km/h) and high mobility (>30 km/h). The analysis showed that the proposed algorithm has the best performance, and then the algorithm is compared with the traditional algorithm.

Next generation applications require seamless handover. The small coverage individual APs (Access Point) has increased the number of handover occurred. Thus reduce the handover latency has become a burning issue and much work has been done to achieve this goal.

IV. Methodology

The handover process is related to access, radio resource and network control, having a significant impact on the capacity and performance of the system. In this paper, the modeling of scenarios of interest was performed using the Opnet Modeler 17.5 (release 8). Figure 3 shows the modeling of the simulation scenario.

In the analysis conducted for this study, two identical scenarios were created, but one without the use of femtocell and the other with the insertion of 9 femtocells per cell. The configuration and parameterization of femtocell radios are contained in Table III.

In both scenarios, the network consists of 5 eNodeB, parameterized according to Table I. Concerning mobility, it was assumed for all 100 network users the random waypoint mobility model [23]. The structure also includes elements EPC (Evolved Packet Core) and gateway that will communicate with the application server.

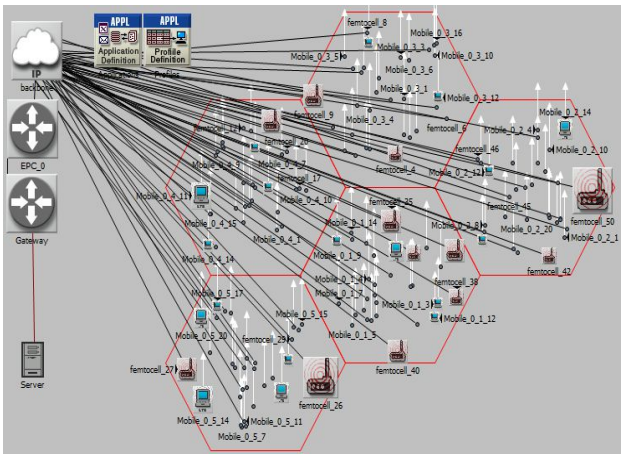


Figure 3.Scenario modeled in OPNET tool.

A. The simulation Parameters

The parameters and settings of the antennas are described in Table II. To generate traffic on the network, made use of a VoIP (Voice over Internet Protocol) application.

The VoIP application is used to represent the class of inelastic applications, real-time, interactive, which is sensitive to delay end-to-end, but can tolerate packet loss. Today, the emergence of real-time application requires more resources, so it is necessary ensure rapid and reliable

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voice communication for a large number of users on the network.

All users have been configured to establish a VoIP call to an external server. In Table I, we list the most relevant parameters used for configuring the application.

TABLE I. CONFIGURATION OF VOIP APPLICATION

Silence Length (s)	Exponentially distributed, mean 0.65
Talk Spurt Length (s)	Exponentially distributed, mean 0.352
Encoder Scheme	GSM FR
Voice Frames per Packet	1
Type of Service	Best effort (0)
De-Compression Delay (s)	0.02

TABLE II. CONFIGURATION OF LTE ANTENNAS

Parameter	Value
Transmission Power	26 dBm
SC-FDMA (UL) Frequency	1920 MHz
OFDMA (DL) Frequency	2110 MHz
Bandwidth	10 MHz
Gain Antenna	17 dBi
Antenna Height	40m
Radius Coverage	7 Km
Propagation Model	Urban Macrocell
Duration of simulation	900s

TABLE III. CONFIGURATION OF FEMTOCELLS

Parameter	Value
Transmission Power	23 dBm
Gain Antenna	2 dBi
Propagation Model	Indoor Environment
Antenna Height	1m

B. Handover Performance Indicator (HPI)

In this section the main evaluation metrics used as performance indicators handover will be described. The metrics are described below.

Handover Delay: From this statistic is possible to identify the number of handover performed, as well as the position in time where the delay for the handover is successfully occurred.

Handover Failure: The ratio of handover failure (HF) is the ratio between the number of failed handovers (NHfail) on the number of attempts made. Where the number of handover attempts is given by the sum of the number of failed handover (NHfail) plus the number of successful handovers (NHsuc).

$$HPI_{HF} = \frac{NHfail}{(NHfail + NHsuc)} \quad (1)$$

Blocking Probability: The blocking probability is the ratio of the number of failures (Nfail) on the total number of failures (failure of handover + failures radio) added to the total number of handover (TH).

$$HPI_{BP} = \frac{Nfail}{((RadioFail - NHfail) + TH)} \quad (2)$$

C. Simulation Results

The simulation was conducted through a survey of the initial configurations carried out in OPNET. The simulation time was 900 seconds, long enough for the environment present a stable behavior and test users could navigate the trajectory established.

In Figure 4, the graph extracted directly from OPNET. This chart expresses a joint display of two key metrics for analyzing the handover performance indicators. Membership lets you view the eNodeB in that moment of time and in which eNodeB, the user has joined.

In the same figure and the same instant of time, the handover delay is reported, identifying delays in handovers performed successfully.

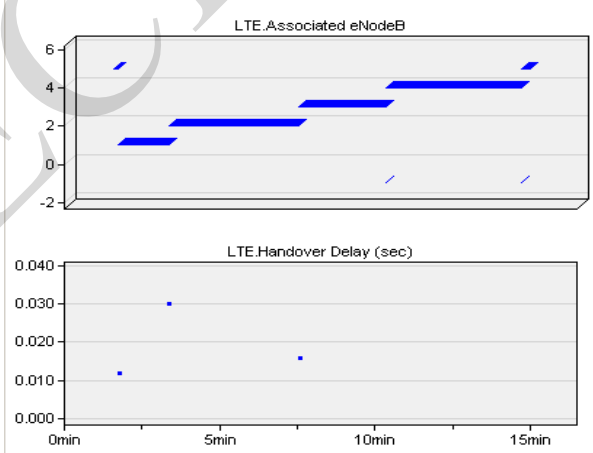


Figure 4. Associated eNodeb e Handover delay.

The results and trends are indicative of the mechanisms that actually impact on system performance. Some of the variable parameters include the speed of the user, the type of traffic, application, etc.

In the analysis, the 100 mobile users were initially observed individually, since each user traveled a random trajectory, which guaranteed numbers of failures and specific to each handovers.

The results presented here demonstrate a comparison of both simulated environments, ie with and without setting femtocell. The analysis allows us to infer that since deployment of femtocells in the network, users are conducting a much larger number of unnecessary handovers, which impacts heavily on indicators of handover performance. The comparison can be seen in Table IV.

The rate of handover failure suffers an additional 61%. Have the blocking probability increased by rejecting

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approximately 50% more using femtocells.

TABLE IV. INDICATORS OF HANDOVER PERFORMANCE

Statistic	LTE scenario	LTE scenario + *Femtocell*
Handover Failure	0.1	0.71
Blocking Probability	0.259	0.764

Some indicators were collected to evaluate QoS experienced by the users behavior. We notice that the deployment of femtocells did not represent a significant improvement over the parameters of QoS. An assessment of the general behavior of 100 users was carried out. The figure below shows the delay in both scenarios. We notice that there was not great variation, both had behavior around 200 milliseconds.

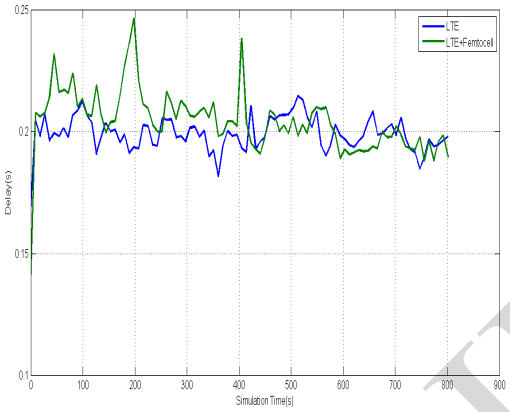


Figure 5. Delay of VoIP application.

Figures 6 and 7 show the values of MOS (Mean Opinion Score) and jitter obtained. The MOS is rated at calculate the mean of results of the test subjects. Using a scale from 1 to 5, where a score of average equal to or greater than 4 is considered toll-quality. The MOS achieved was considered poor, as had average behavior around 1.5 even after the addition of femtocells.

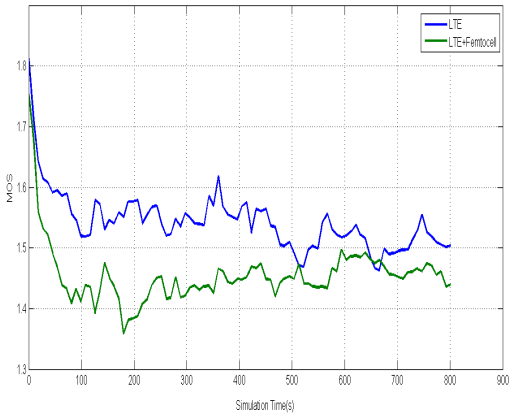


Figure 6. MOS of the VoIP application.

Have watched the last graph obtained, but not the least important, the jitter is illustrated below. The graph shows the maximum difference in one way delay of packets over a particular time interval. As shown in fig. 7, time average of jitters rate for voice in both scenarios are similar.

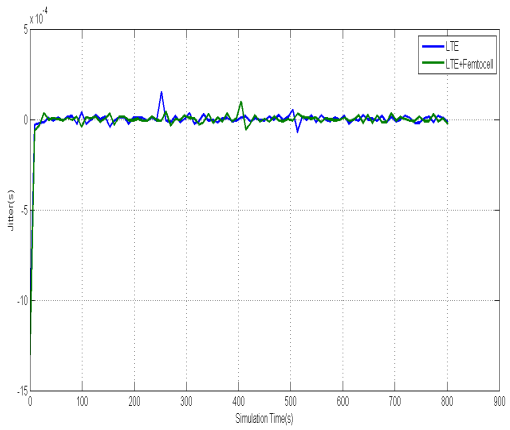


Figure 7. Jitter of VoIP application.

V. CONCLUSIONS

With the evolution of mobile communications and the emergence of new applications, more demanding in terms of bandwidth, become necessary studies on the parameters of quality of service and influence the mobility of users.

So, with preliminary analyzes obtained in this paper, one realizes that the integration of LTE femtocell and were not as favorable as expected. Despite predicates, using these femtocells is not a panacea. The management of the handover, interference and self-organization mechanism are still challenges of great relevance for the failure of this integration.

Finally it is concluded that in spite of adding a number of advantages of use, unfavorable experience of this solution is directly related to technical challenges still under discussion. In this sense, and in order to obtain more definitive conclusions new scenarios are being structured and analyzed.

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