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Improvement of LTE Coverage in the City of Yaoundé: Case of CAMTEL

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Abstract:- Mobile and wireless networks have experienced unprecedented growth in recent years. It involves the deployment of several successive generations of Telecommunications networks essentially dedicated to telephony (2G: Second Generation), then more oriented towards multimedia (3G: Third Generation), 4G/LTE (Long Term Evolution) designed to meet high speed and 5G (Fifth Generation) is aiming much higher and operators around the world are currently preparing for the arrival of this new generation. 4G (Fourth Generation) brings a real increase in terms of speed and allows interoperability with other mobile networks. This is how the historic operator of Telecommunications in Cameroon, CAMTEL (Cameroon Telecommunications) in order to meet the ever-increasing demand of users, undertakes to implement a new technology capable of responding to the continuous growth of traffic, with a low latency, better reliability and better spectral efficiency compared to the initial technology which was not successful. This article is about proposing solutions to optimize areas with low coverage of the LTE (Long Term Evolution) network in the city of Yaoundé, the capital of Cameroon. For that, we have to analyse the data collected in order to see the network status and subsequently identify the areas not covered that will require intervention.

Keywords:- *4G, LTE, Coverage, Drive-test, KPI.*

I. INTRODUCTION

For several years, the field of Telecommunications and new technologies has experienced real evolution and continues to innovate, despite a difficult economic situation. Today, we are witnessing an unprecedented craze among the public for the new applications and services offered by these new technologies, which was reserved a few years ago for specialized customers. Whether the mode of use is nomadic or sedentary, we are witnessing an important development of wireless radio technologies (Bluetooth, Wi-Fi (Wireless Fidelity); GPRS (General Packet Radio Service); CDMA, UMTS (Universal Mobile Telecommunications System), WiMAX (Worldwide Interoperability for Microwave Access), LTE) as evidenced by the increase in the number of mobile terminals or modems and wireless access points at home or in public places. In addition, whether for remote research or exchange of information, or even for the use of multimedia communication applications (Data, Voice, Photos, and Videos), the demand is growing for a high-speed transfer between mobile communicating equipment and compact. To meet these growing needs for wireless broadband communication, the various telecoms operators will very quickly put steps to be taken to improve the quality of service. This new technology, known as LTE (Long Term Evolution). LTE is able to reduce the cost of investment and improve the quality of service.

To do so the operator must go through phases key issues: planning, deployment, sizing and optimizing. This process helps to meet coverage constraints while minimizing the resources used; this ensures a reliable study of the network before it is operated. It is in this perspective that we asked the question, how to optimize and improve the coverage and quality of transmissions?

In order to provide a solution to this problem, we will articulate our study in different parts, the context and the problem, then the specific analysis of the problems posed and finally we will present the results and comments.

II. CONTEXT

Telephone operators in Cameroon (CAMTEL, Orange, MTN and Nexttel) have the major concern of ensuring good quality of service and meeting the needs of users, as they become more and more demanding in terms of quality and in services. These services are greedy in capacity, that is to say they need a lot more resources.

The 3G, which has just been installed in Cameroon, cannot solve this problem because it is limited.

This is why CAMTEL, to better meet the requirements and expectations of users, is embarking on the establishment of a high-speed and more reliable telecommunications network according to developments and needs, namely LTE. Indeed, LTE technology is the highest standard for mobile communication fast, the most advanced. It will be useful if you want to watch a video in high definition, establish a video conference offering better image quality and practically no waiting, or download very quickly large files and applications at high speed. All this is done with your tablet or mobile phone.

After conducting a full analysis its overalls, with adequate tools from the LTE network in the city of Yaoundé, we found that there are areas with low coverage and areas out of service (not covered). Therefore, it is important to make the service of good quality so that it cannot meet the difficulties of previous generations. That is why CAMTEL is embarking on optimization to improve the efficiency of the network in the city of Yaoundé and to know the uncovered areas of the city.

III. PROBLEM

The Telecommunications market has grown considerably; the number of mobile phone and Internet Of things users have grown exponentially. The demand for resources such as bandwidth has increased sharply. Thus, we note the presence of three mobile operators and the incumbent operator CAMTEL, which shares this vast mobile phone market in Cameroon. To catch up and better meet user expectations, CAMTEL is embarking on the deployment of its LTE network, including improving the same network, which will be the subject of our study in this article.

In order to allow CAMTEL to increase its performance, it would be wise for us to find a solution to the following questions:

- How can CAMTEL be helped to improve coverage in the city of Yaoundé?
- How can radio Engineers be helped to improve areas with low coverage of the LTE network in the city of Yaoundé?

Answering these questions is the procedure to follow to improve the LTE network in order to offer customers overall satisfaction.

IV. OBJECTIVES

The objective aimed at the end of our work is to propose improvement solutions to cover the LTE network in the city of Yaoundé allowing to:

- Improve the coverage of the CAMTEL LTE network in the city of Yaoundé;
- Improve the quality of service so that it cannot meet the difficulties of previous generations.

All of these goals can only be achieved through the establishment of a research methodology based on theoretical and practical concepts.

V. METHODOLOGY

To carry out the optimization of the LTE network of CAMTEL in order to increase the output of its customers, it would be wise for us to adopt the following methodology:

- The context and problematic of our work;
- The specific analysis of the problems raised;
- The presentation of the results in order to propose solutions followed by interpretations.

VI. SPECIFICATIONS

Optimizing LTE coverage is not a new concern, it is a logical consequence of improving the quality of service offered and reducing the risk of outages. In order to make our modest contribution to CAMTEL, we opted for the use of performance indications and the analysis of electromagnetic radiation, taking into account the specific characteristics of the antenna used. Thus the elements expected after the elaboration of the specifications which reached us, are the following:

- To have very large coverage over wider and more remote areas;
- To present the results of the Key Performance Indicator (KPI) in order to propose solutions to optimize the LTE network;

For our work, it will be a question of responding to the different annuities questions.

- ***What is it about?***

It is a technique for improving the coverage of the LTE network;

- ***Who is affected by this?***

All technicians working in the field of radio access network;

- ***When do we need it?***

During the completion of the Survey by the technicians;

- ***How do you feel the need?***

When there is a poor performance of the work and a verification of the conformity of the information in the installation folder of site;

- ***Why this technic?***

For better planning, good sizing, good coverage and better execution of works leading to an improvement in the quality of service and a reduction in the risk of cuts.

VII. ANALYSIS AND CONFIGURATION

1.1. Drives-Tests [3]

Several software programs allow performance evaluation and a network data analysis interface. Measurements on the LTE network will make it possible to determine the quality of the radio signals. For this therefore, we will study a drive-test measurement method, which consists in giving precise characteristics of the state of the network. This analysis technique allows the recovery of a trace of the measurements made by the mobile at different times.

1.2. The different types of drive test [4]

The nature of the drive test depends on the information that we want to extract. The main types of drive-tests are:

- **Performance analysis**

The drive test oriented performance analysis is the most common, and generally carried out in clusters (grouping of cells), that is to say, an area with sites. It can also be carried out in specific situations, such as responding to a customer complaint or monitoring the evolution of the network.

- **Integration of new sites**

It is recommended to carry out two tests: one with the site blocked on the basic frequencies, thus obtaining a total visualization of the coverage area. The other, later, with the authorization of the Handover intercellular, which is the final state of the site.

- **Modification of the parameters of existing sites**

This type of drive-test can be compared to the two preceding depending on the degree of modification of the parameters.

- **Benchmarking**

Comparative analysis of tests to compare competing networks. If the result is better, it can be used as an argument in favour of new promotions. It would show the points where the network needs to be improved.

1.3. MEASURING CHAIN

The drive-tests consists, as the name suggests, in field trips by car during which scenarios are carried out in order to test different aspects of mobile communication. In the case of our study, we used as a drive-test type the analysis of the performance of the LTE network in the city of Yaoundé, for this we used:

- A vehicle for travel;
- A mobile terminal compatible with the drive test for radio measurements. It is connected to the acquisition computer, which makes it possible to use commands to control the mobile, but its real usefulness lies in the fact that it can calculate all the radio parameters (signal level, quality of the signal…) and communicate them to the computer;
- A laptop with specialized software for data acquisition and recording. The software we used **is *Huawei Probe (Probe V300R015).*** The computer processes and records the measurements retrieved from the mobile terminal and the measurements are made readable, via software, and allow the Engineer to observe the state of the network on site ;
- A GPS (Geographical Position System) for the exact location of the geographic position of each measurement point (longitude and latitude). It is essential to identify measurement points that present radio problems.

Fig.1 Drive-test equipment [12]

VIII. RESULTS AND COMMENTS

It is a question here of commenting on the results of the data analyses (these different data are obtained during measurements carried out in the city of Yaoundé) and subsequently providing solutions to the uncovered areas. After all these, we will show a simulation of the coverage and quality of service compared to the proposed solution.

1.4. ANALYSIS RESULTS

- **Network coverage [12]**

CAMTEL has **58 eNodeB base stations** in the city of Yaoundé. The frequencies used are in the **1800 MHz** band. However, the measures carried out allowed us to have:

- **Total SINR COVERAGE**

The **SINR (Signal Interference Noise Radio)** allows us to measure the signal to noise to interference ratio.

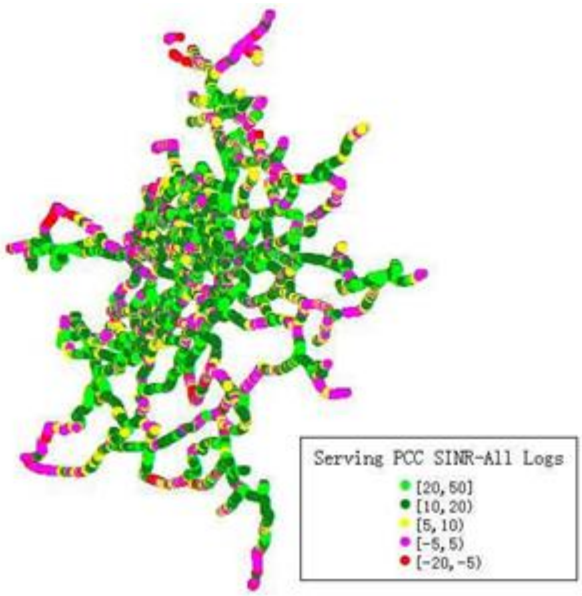

Fig.2 Quality of service during radio measurements [1]

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From **Fig.2,** we can observe a SINR plot with an acceptable rate of **91.7%.** We also note that in remote areas the signal is of poor quality due to transmission problems and distance.

- **RSRP COVERAGE [2]**

In **Fig.3,** we have the **RSRP (Reference Signal Receive Power)** coverage, which represents the power received from the reference signal in the entire network band transmitted by the base station and received from the terminal. Its value varies between **-140dBm** to **-44dBm**. In fact, it can be seen that in the remote areas, the basic signal transmitted is very weak, on the other hand, there is a concentration of the signal in urban areas because the demand is high. From this figure, we observe an acceptable opening point of **93.77%.**

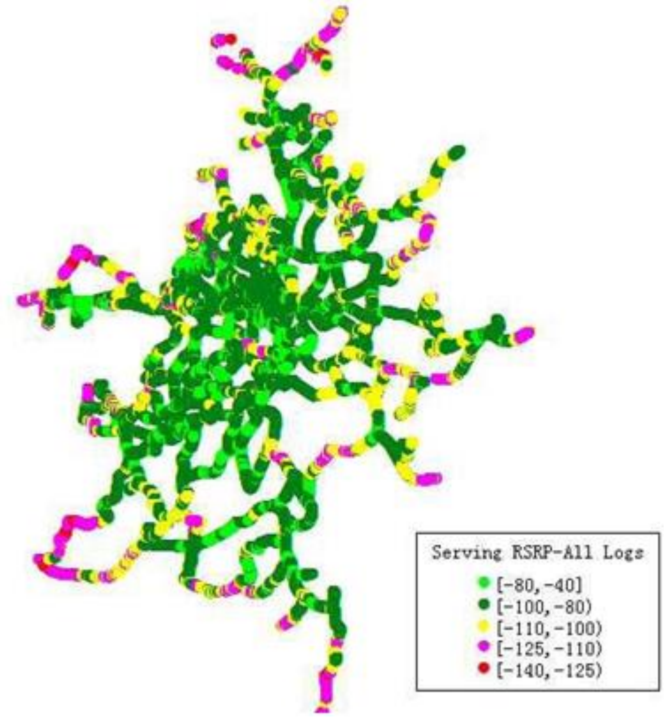

Fig.3 Cover pads during radio measurements [1]

1.5. INTERPRETATIONS

The analysis of the coverage allows us to identify the sites of the areas not covered. The **Fig.4** below we can see the cover of the signal received by the mobile from the base station. We have numbered the circled areas with weak signals. We find that in most of these areas the signal does not arrive which is due to the bad setting of the tilt angle of the main antenna lobe, to the high interference, which resulted in the impossibility of maintaining the signaling links and the distance (the reception signal is extremely weak).

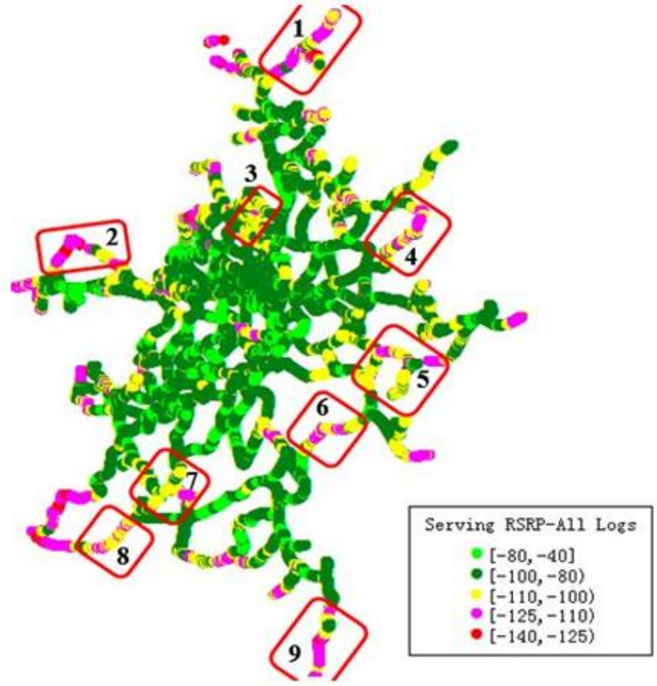

Fig.4 Areas with low coverage [1]

Table 1: Measurement statistics after the Drive-Test

KEY PERFORMANCE INDICATOR (KPI)	***YDE LTE***
Coverage Rate $(SINR >= 0\,dB)(\%)$	91,7
RSRP And SINR Coverage Rate $(>= -105\,dBm\ and\ >= 0\,dB)\ (\%)$	83,78
RSRP And SINR Coverage Rate $(>= -110\,dBm\ and\ >= 0\,dB)\ (\%)$	88,82
RSRP Coverage Rate $(RSRP >= -105\,dBm)\ (\%)$	87,58
RSRP Coverage Rate $(RSRP >= -110\,dBm)\ (\%)$	93,77
Drive Test Distance (Km)	461
Number Of Sites On Air	39
Number Of Sites Down during Drive-Test	5

1.6. MEASUREMENT RESULTS

- **Quality of service level [15]**

The assessment is based on the values defined in the table below:

Table 2: Level of quality of service [5]

Detection level	**Appreciation**
Between 50 and 20 dB	Well
Between 20 and 10 dB	Way
Between 10 and 5 dB	Acceptable
Between 5 and -5 dB	Bad
Between -5 and -20 dB	Very bad

- **Assessment of the quality of service**

We can deduct from ***Table 2*** that the reception is good in the city centre (reception above **5 dB**) from **Fig.4,** and starts to be bad when we head out of the city **[14]**.

- **Coverage level**

Coverage is defined by the power received from the base station reference signal. The assessment is based on the values defined in the table below:

Table 3: Coverage level

Detection level	Appreciation
Between $-80\ et\ -\ 40\ dBm$	Well
Between $-100\ et\ -80\ dBm$	Way
Between $-110\ et\ -100\ dBm$	Acceptable
Between $-125\ et\ -110\ dBm$	Bad
Between $-140\ et\ -125\ dBm$	Very bad

- **Assessment of the level of coverage**

We can deduct from the above table that the reception and emission of the signal is good in the city centre (reception above **-110dBm**), and begins to be poor in the end areas of the city. It can therefore be seen that the signal from the base station when it is transmitted when arriving in remote areas of the city will be attenuated during the journey because of the distance.

- **Level Low coverage area**

In **Fig.4,** we have circled the areas with low coverage; we have identified these areas on **Google Map** based on the city map; we have established a dominant coverage rate in each zone as well as the neighbourhoods present. We then obtain the following table:

- **Appreciation**

In all these areas, the reference signal sent by the base station does not arrive at the different locations, which is why the coverage is not of good quality in these areas.

Table 4: Identification of areas not covered

Zones low coverage	Coverage rate	Neighbourhoods
Zones 1	$-125\ to -110\ dBm$	NKOLDA (NSIMALEN)
Zone 2	$-110\ to -100\ dBm$	AHALA (Direction of Douala) SIMBOCK VILLAGE,
Zone 3	$-110\ to -100\ dBm$	MVAN
Zone 4	$-110\ to -100\ dBm$	EKIE
Zone 5	$-110\ to -100\ dBm$	BITENG, MINBOMAN NKOABANG
Zone 6	$-110\ to -100\ dBm$	NKOLMESSENG, NGOUSSO-SOA
Zone 7	$-110\ to -100\ dBm$	BASTOS COMMISSARIAT, QUARTIER GOLF, MONT FEBE, CARREFOUR MBANKOLO
Zone 8	$-125\ to -110\ dBm$	OYOMABANG, BEATITUDES NKOLBISSONG
Zone 9	$-125\ to -110\ dBm$	NKOZOA
Zone 10	$-125\ to -110\ dBm$	ELIG-ESSONO, DJOUNGOLO

1.7. IMPROVEMENT SOLUTIONS [10]

The careful evaluation of measurement data allows us to propose solutions to improve network performance by modifying network parameters or by modifying system parameters. As a result, the various information extracted from the drive-tests and the main performance indicators enabled us to provide solutions.

In this article, the improvement solutions provided to overcome the poor coverage of the CAMTEL LTE access network are as follows:

- **The choice of good performance indicators [7]**

During the Drive-test, we made a choice of two Key Performance Indicators (RSRP and SINR**)**. However, in order to have a precise idea on the cover, we offer the following indicator:

RSRQ (**Reference Signal Receive Quality).** This indicator ensures the quality of reception of the reference signal.

The measurement of the **RSRQ** is particularly interesting at the cell boundaries, positions for which decisions must be made to complete Handovers and change cell references; it provides additional information when

RSRP is not enough to make a reliable cell transfer or selection decision. **[8].**

- **Action on antennas**

This action can be:

- A Tilt: which is to change the angle of inclination from the upward vertical. The tilt allows you to vary the coverage area while keeping the same direction of radiation;

- A reorientation: It is the change of the direction and the direction of radiation of the antenna;

- A change: This action makes it possible to increase several parameters of the antenna such as for example the transmission power received by the users.

- **Addition of new base stations (eNodeB)**

This is the most important solution, in the case where there is no coverage and the emission of the nearest eNodeB antennas cannot reach the detected area with sufficient power. **[12]**

CAMTEL had installed **58 eNodeB** for LTE in the city of Yaoundé, but, after carrying out drive tests, we noticed uncovered areas where it was necessary to provide solutions. For this, we have added **33** new LTE base stations (**eNodeB)** and the frequencies used are in the **1800MHz** band. The following figure shows the position of the sites on **Google MAP.**

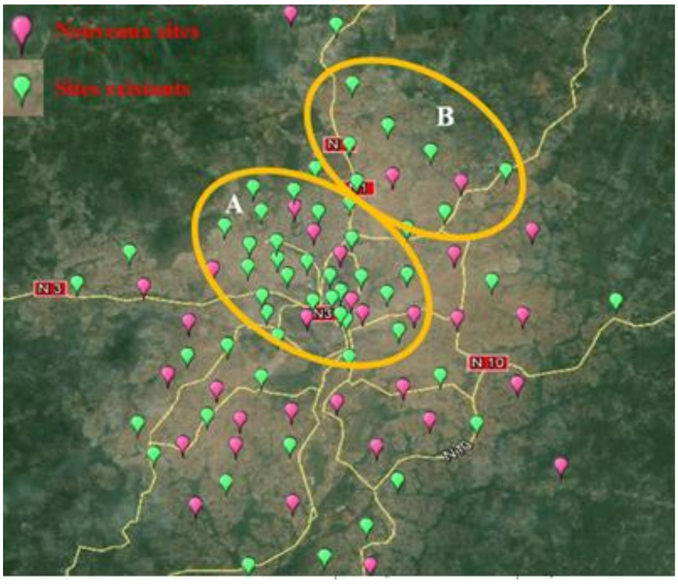

Fig.5 Positions of current sites on Google Map [1]

- **Appreciation**

From this figure, we see that the majority of existing sites are present in **zone A,** we can therefore say that the signal is highly concentrated in this part because the demand is high, however, in **zone B** we notice the presence of few sites due to lack of population and interference problems.

The analysis of the drive tests carried out allowed us to propose neighbourhoods for the addition of new sites and the present characteristics will be done using the **HUAWEI UNET software.** This is therefore distributed in ***Table 5.***

After installing the various base stations in the city of Yaoundé, the simulations were carried out with **HUAWEI UNET software** in order to plan coverage and quality of service. We therefore have the following plots:

- **Network coverage**

In the part where we interpret the results of the measurements after the drive-tests, we concluded that the signal was good from **-110dBm.** The addition of new base stations allows planning the network coverage we therefore see that each antenna of the base station has three sectors emitting signals in three specific directions; the figure below shows the cover simulation.

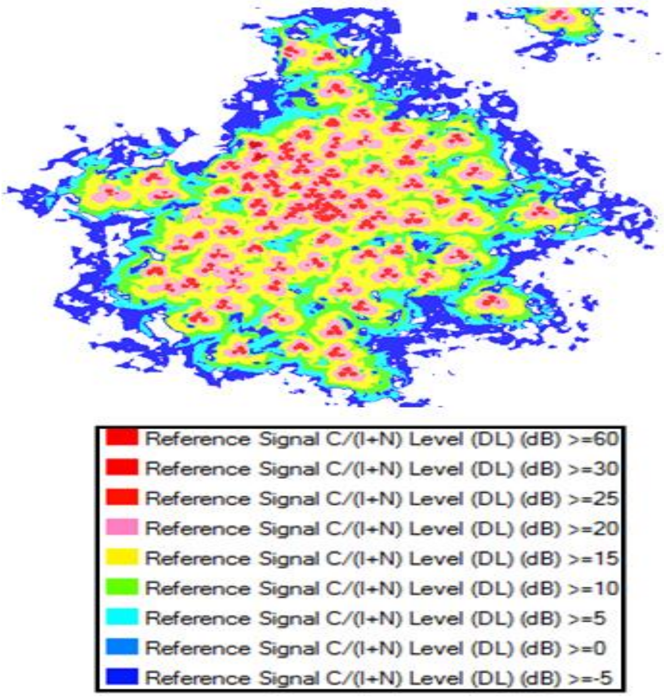

Fig.6 Network coverage plans [1]

According to this figure, we can deduce the following table:

Table 5: Assessment of the cover simulation

Detection level	Appreciation
> 20	Excellent
> 13	Well
≥ 5	Acceptable
< 5	Poor

- **SINR [9]**

Likewise, in the part where we interpreted the results of the measurements after the drive tests we concluded that the signal was good up to **5dB**. The addition of new base stations makes it possible to plan the quality of service of the network. It can therefore be seen that each antenna of the base station has three sectors emitting signals in three very specific directions; the figure below shows the simulation.

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Site names	Longitude	Latitude
ACCACIA IHS	11,488	3,841901
Ahala_Bloc3	11,50567	3,80933
ANGUISSA IHS	11,537375	3,861263
BITENG	11,56210	3,84092
CHAPELLE NSIMEYONG	11,493467	3,833207
CITE VERTE IHS	11,488256	3,875572
COMPLEXE BEAC IHS	11,526874	3,824411
ETOA-MEKI	11,519726	3,878967
OLEZOA IHS	11,506251	3,835179
NKOMO IHS	11,54019	3,83149
EKIE	11,533338	3,900386
ESSOS_800	11,56406	3,86021
ECOLE NORMAL IHS	11,479141	3,826691
CENTRE	11,524693	3,862204
TERMINUS	11,51750	3,83720
IMM-OLYMPIQUE IHS	11,550182	3,898032
AMBASSADE DE CHINE	11,57211	3,81754
MANGUIERS CHAPELLE	11,492203	3,825904
MIMBOMAN_ FEICOM	11,56718	3,88392
MONTEEJOUVENCE IHS	11,50989	3,94654
MONTESQUIEUX IHS	11,5134	3,88533
Mvan_800	11,52419	3,791027
NGOUSSO IHS	11,47104	3,87133
NKOLANGA_800	11,481835	3,861017
NKOL-MBANDA IHS	11,48169	3,80929
NKOLMESSENG_800	11,594946	3,988653
NKOLONDOM	11,533978	3,840986
NR-BASTOS IHS	11,54795	3,85984
ODZA BORNE 10 IHS	11,510969	3,861298
OYOMABANG NKOLSO	11,47616	3,84635
SCIENCE IHS	11,547821	3,877935
SIMBOCK _Village	11,522124	3,865809
SOA_800	11,509004	3,892201

Table 6: New sites installed

Table 7: Assessment of the quality of service

Detection level	Appreciation
$\geq -80\ dBm$	Excellent
$\geq -90\ dBm$	Well
$\geq -100\ dBm$	Way
$\geq -110\ dBm$	Acceptable
$\geq -120 dBm$	Bad
$\geq -140\ dBm$	Very Bad

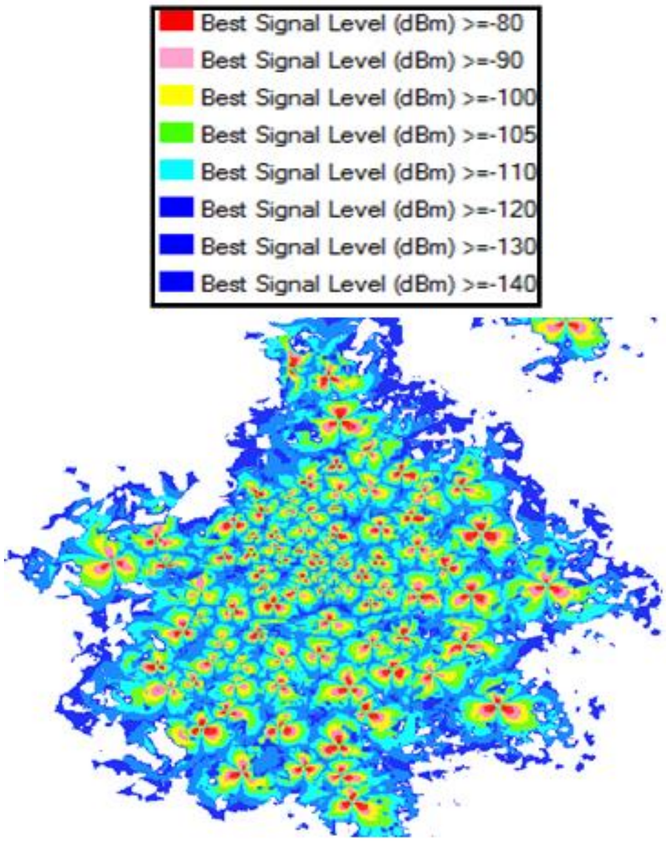

Fig.7 Quality of service planning [1]

In this part, after having presented all the data and the solutions proposed for the optimization of the coverage of the LTE network in the city of Yaoundé, we were able to present the position of the current sites on **Google Map** and we brought out the simulation of the cover.

In this study, we concentrated our analysis, our interpretations and our simulations in the access part of the system with a particular attention on the network coverage.

It has been deduced that the quality of service indicates the reliability of the network by implying good coverage for data transmission.

IX. CONCLUSION AND PERSPECTIVES

The work entrusted to us consisted in providing solutions to improve the coverage of the LTE network in the city of Yaoundé compared to the areas, which presented coverage problems; for this, we analysed the drive-test data in order to propose solutions.

To achieve this, we have brought out the methodology of our work based on the data collected during the drive-tests and this thanks to the key performance indicators; this information helped us to carry out an analysis on the network. In addition, it is thanks to the data collected that we have analysed the performance of network coverage and provide solutions proper to improve the network.

As a result, we have seen that the company has taken the solutions mentioned into consideration. We were therefore able to help the company in its project to improve LTE radio network access coverage by offering them the fruit of our study.

Given that we have worked on the LTE network coverage aspect, we therefore think that it is possible to extend this work to other regions of the country by taking into account:

- The capacity because later we have to be interested in the period during which the traffic is important ;
- Connection success rate through the availability of resources. It is calculated by the probability that all resources are occupied during a channel request ;
- The connection cut rate, which will be evaluated in order to make future improvements.

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