Increasing the performance of mobile networks by planning and dimensioning

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Abstract. The telecommunications systems are very widely present in our recent smart lifestyles. The key element of these systems is to ensure the high quality of service. For this purpose, the operators integrated new services and technologies. To evaluate these services, the operators have adapted their planning methods. This will allow an ample range and exemplary service to keep the latent augmentation in traffic. For this reason, the need for a crucial and inevitable tool for increasing the performance of mobile networks is essential. The main objective of this work is the amelioration of the network's performance by planning, optimization and dimensioning techniques of a mobile network. To achieve this objective, this study is based on real measurements of the different data (Received Signal Received Quality (RSRQ), Reference Signal Received Power (RSRP), and Signal to Interference & Noise Ratio (SINR)).

Keywords: Mobile networks Planning, mobile networks dimensioning, RSRP, RSRQ, SINR.

1 Introduction

Conventionally, in current and future mobile networks, mobile networks are proposed as the next generation of 3G. These mobile networks allow "very high mobile speed", i.e., data transmissions at theoretical speeds of the order of 100 Mb/s. This need for high-speed has developed the mobile network generations from the first generation (1G) to progressively reach the sixth generation (6G).

This rapid development allows integration of new services and has prompted operators to adapt their planning methods to new technologies that increase complexity at the network level. This complexity becomes more critical when these networks combine several different access technologies into a heterogeneous network (like 5G networks). The planning phase corresponds to ensuring the best radio coverage, compatibility with current networks, managing users' intercellular mobility, the anticipation of interference, cell size, and supported load. This will allow adequate coverage and exemplary service to keep the potential increase in traffic.

The project idea for developing mobile networks, led by the 3GPP standardization body, aims to draft the future generations' technical standards in mobile telephony. The purpose of this technology is to allow very high-speed data transfer, with a more excellent range, a higher number of calls per cell (area in which a mobile transmitter can enter into contact with terminals), and a weaker latency time. In theory, it allows a debit of around 50 Mb/s in the uplink and 100 Mb/s in the downlink shared between mobile users within the same cell. For operators (who have the most essential part to support this technology), this development involves modifying the core of the network and the radio transmitters. Adapted mobile terminals must also be developed.

Planning and dimensioning mobile networks are mainly considered to ameliorate and give adequate coverage and good service to support the potential increase in traffic. The authors in [1] presented a study based on designing wireless local networks to planning and optimization process cover the service area and to guarantee enough capacity to users. Machine learning-based methods have been used over the last years to plan and dimension the mobile networks [2, 3]. Based on comparison study between data-driven and image-driven estimations, the work of [3], uses deep learning as a tool for radio propagation modeling and path loss prediction. Based on PSO (Particle Swarm Optimization) algorithm and GWO (Grey Wolf Optimizer) to find the optimal Base Station position, the authors in [4] investigate the planning and optimization problem to satisfying coverage constraints and cell capacity constraint. The meta-heuristic algorithms are used in [5] for the cell planning problem for the cellular networks. The aim is to satisfy cell coverage and capacity constraints by formulating an optimization problem that captures practical planning aspects.

A combination of calculations of RSRP (Reference Signal Received Power) and RSRQ (Received Signal Received Quality) is very essential. They are used to facilitate a decision-making process of handover mode at the Inter-Cell mobility [6]. These two physical parameters are used in [7] to demonstrate how these parameters are affected by different levels of interference and give a solution to detect UEs that are being affected by hidden nodes.

The aim of this work is to ameliorate the performance of the network by planning and dimensional mobile network in the base of real measurements of the different data by the available tools (Drive Tests, TEMS…). Firstly, the theoretical background on the basic concepts of mobile networks and the study of dimensioning and coverage are introduced. Also, we will introduce the basic concepts and the mathematical calculations necessary for dimensioning. In the last part, we will validate our study by real measurements of the different data: Received Signal Received Quality (RSRQ), Reference Signal Received Power (RSRP), Signal to Interference & Noise Ratio (SINR).

2 Setups and processes of the approach used

Planning a mobile network is a very critical phase. Therefore, the mobile networks operators must focus on planning before any implementation of their networks to guarantee a minimum cost of radio links and network infrastructure. this task is allowed by considering the radio coverage and the size of the cells to QoS (Quality of Service) constraints to estimate the approximate number of sites required and the number of base stations to facilitate the work of manufacturers and operators of mobile networks. Planning in mobile networks, like any other cellular network, is a complex task and has several consecutive steps where a particular step's output provides the next step input. Mobile network coverage and capacity planning are done jointly in a single task, called dimensions. The steps of the used method are summarized in Fig. 1.

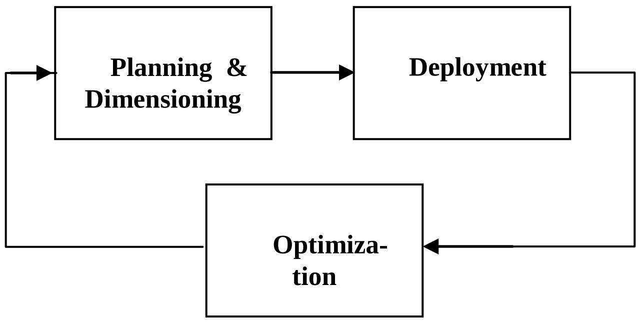


Fig. 1. Steps of the used method

In mobile networks, planning and dimensioning is an essential task. Indeed, this fundamental task is a result of the optimization task. Moreover, the optimization task is based on the network's deployment and maintenance (Fig. 1). Planning requires the collection of information about the deployment area. This information is the depth investigations results, for example, detailed information on the eNodeB and the UE (User equipment), information on the deployment area (area, the density of subscribers, the penetration rate), information on subscribers in the area (services requested, traffic offered, etc.).

The dimensioning of eNodeBs is the most advanced and delicate part of the dimensioning process. The dimensioning process a mutual connection between capacity and coverage. Therefore, two methodologies must be implemented to dimension this node: capacity-oriented dimensioning and a coverage-oriented dimensioning. The first considers the capacity and traffic requirements that must be absorbed and transported by the network, and the second takes into account the coverage requirements. Finally, the number of eNodeBs would be the maximum of the number from the two methods.

The last task is optimization. It is an iterative process for controlling and monitoring to maintain the pre-established QoS (Quality of Service) requirements.

In this work, we will be interested in the dimensioning phase, which determines the number of eNodeBs required. For mobile operators, the step of dimensioning the equipment and interfaces of its network is preliminary. It makes it possible to determine the volume of equipment and software to acquire and deploy to satisfy its subscribers. This fundamental step mainly consists in:

• Find a better cellular architecture capable of guaranteeing the QoS required for each service.

• Fully absorb the load: the network must provide the necessary channels to ensure that the traffic associated with each cell is absorbed and transported.

• Guarantee coverage and mobility throughout the deployment area.

3 Radio link account

The radio link account gives the maximum authorized path loss and from which the cell size is calculated using an appropriate propagation model. The radio link account takes into account: the transmission powers, the gains, the antenna losses, the diversity gains, the interference margins. For mobile networks, the basic radio link account is determined by the parameter MAPL (Maximum Allowable Path Loss). This parameter is given by the following equation (in dB):

$$MAPL = EIRP - IM + R_{xg} - k - R_x \quad (1)$$

With:

MA (Maximum Allowable Path Loss) (in dB): This is the parameter that we want to determine by establishing a link account.

EI (Equivalent Isotropy Radiated Power): is the radiated power equivalent to an isotropic antenna.

IM: Interference margin.

R_{xg} : Reception antenna gain.

k : Cable loss.

R_x: Reception sensitivity.

In the radio link, the radio propagation models are used to estimate the path attenuation value. There are several types of models:

• Empirical models: a mathematical formula used to predict a transmitter's impact on a reception area.

• Physical models: predict the propagation of radio waves and calculate radio waves' paths by taking into account reflection and diffraction phenomena.

These models do not accurately predict the behavior of the radio link, but the most likely action. They are used to indicate the radius of the cell from the maximum allowable path loss.

In the literature, Okumura-Hata's model is one of the most commonly used [8-10]. This model is developed to cover a wide range of frequencies between (0.5–2 GHz). It is based on Okumura measurements taken in the Tokyo area of Japan. This model considers several factors, essentially the nature of the environment, by specifying its degree of urbanization (urban, suburban, rural). The Okumura-Hata model operates only for a frequency range, which is less than 1000 MHz. The COST 231 group proposed to modify this model to create another serving in the 1500-2000 MHz band in urban areas, then adjust it, adding corrective terms for all the other environments (suburban, dense urban, and rural).

The parameters of two models (Okumura-Hata and COST-231 Hata) model are given in Table1.

Table 1. Parameters of Okumura-Hata and COST-231 Hata models

Parameters	**Okumura Hata model**	**COST-231 Hata model**
Frequency range (f)	150 to 1000 MHz	500 to 2000 MHz
Transmitter height (Th)	10 to 200 m	30 to 100 m
Height of mobile station (Hm)	1 to 10 m	1 m to 10 m
Distance (d)	1 to 20 km	up to 20 km

In this study, the range of variation of the distance separating the transmitter and the receiver in km is: [0.01 km, 10 km]. The other parameters are set as follows: Th = 80 m. Hm: = 2 m. f = 1000 Mhz.

The influence of distance and type of environment on propagation is given in the following figure:

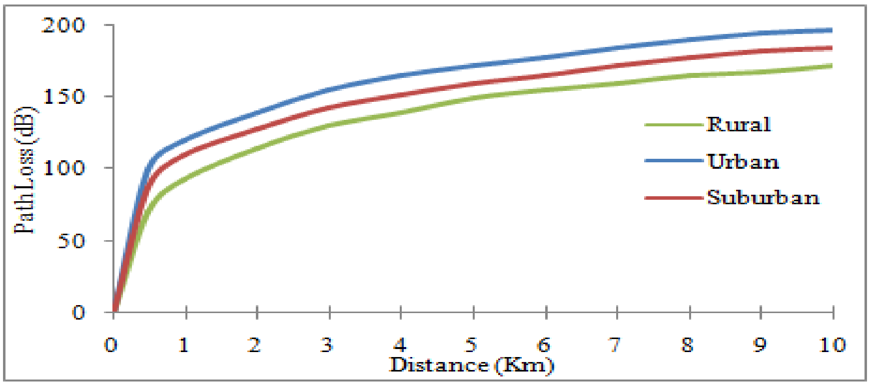


Fig. 2. Influence of distance and type of environment on the propagation for the Okumura-Hata model

From the Figure, We observe a proportional relationship between separation distance and attenuation (that attenuation increases with increasing distance between the emitter and receiver in both environments). For the influence of the height of the eNodeB, the range of variation of the height of the eNodeB is: [20 m, 200 m].

The other parameters are set as follows: Hm = 2 m. d = 2 km. f: 1000 MHz. The influence of the height of the eNodeB on propagation is shown in Fig.3.

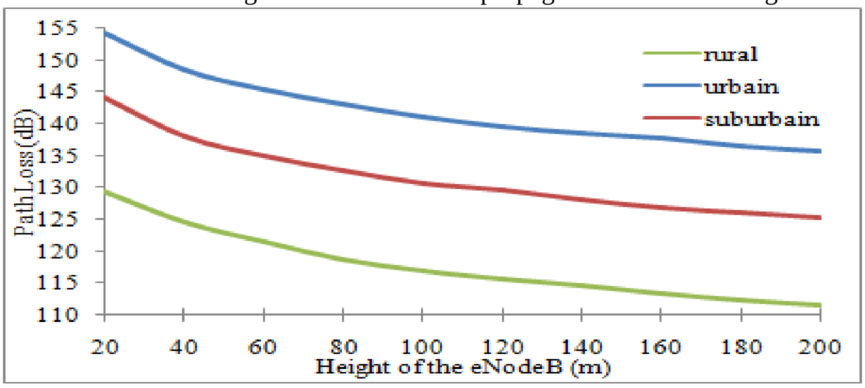


Fig. 3. Influence of the height of the eNodeB on the propagation for the Okumura-Hata model

We observe that the relationship between the height of the eNodeB and the attenuation is not proportional, i.e, If Hb increases, Lx decreases. Therefore, it is better to increase the size of the eNodeB to ameliorate the coverage.

4 Study with Drive Test & TEMS

Generally, planning is a systematic process and an essential step in designing a cellular network. The success of this phase is conditioned by the achievement of a good dimensioning of the network. In this study, we will present the optimization, planning and dimensioning techniques of access network. This will be based on real measurements of the different data such as Reference Signal Received Power (RSRP), Reference Signal Received Quality (RSRQ), and Signal to Interference & noise Ratio (SINR). The analysis of the obtained results is doing according to the steps summarized in Fig. 1.

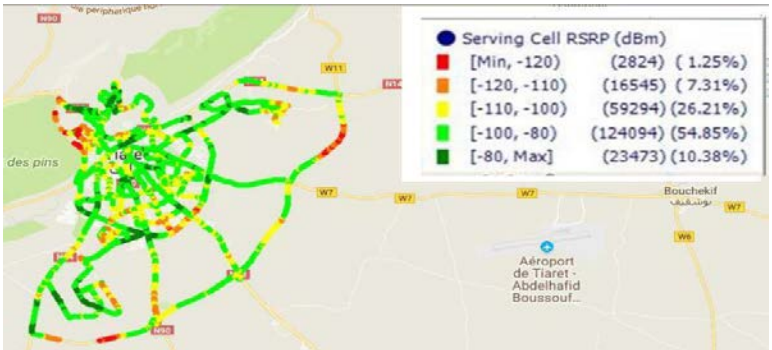
4.1 Reference Signal Received Power (RSRP)

RSRP is defined as the linear average received power. It is the most basic measure of the UEs (Users Equipments) physical layer and represents the linear average power (in watts) of downlink reference signals (RS) across the channel bandwidth. Knowledge of absolute RSRP provides UE essential information about cell strength from which path loss can be calculated and used in algorithms to determine optimal power settings for network operation. The RSRP is given by the following equation [6, 7]:

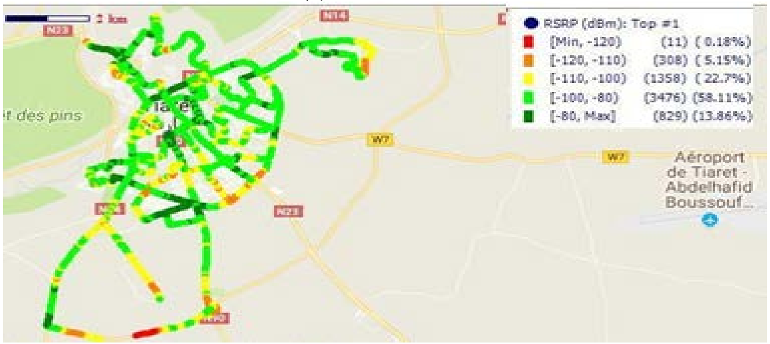
$$\mathrm{RSRP} = \frac{1}{K}\sum_{k=1}^{K} P_l \quad (2)$$

Where: (P_l) is the estimated power (in Watts) of kth Reference Signal (RS).

RSRP is the most basic measure of the UEs physical layer and represents the linear average power (in watts) of downlink reference signals (RS) across the channel bandwidth. Knowledge of absolute RSRP provides UE essential information about cell strength from which path loss can be calculated and used in algorithms to determine optimal power settings for network operation. The most studied area problems are: his area suffers from very poor coverage due to the profile of this area and due to very poor uplink due to the distance of the UEs. Also, we have inadequate coverage in this area due to the absence of a dominant cell. The RSRP distribution before and after treatment are given in Fig. 4.



(a) Before treatment



(b) After treatment

Fig. 4. RSRP distribution

Under the normal state, when the received signal is not affected by noise and interference, RSRP varies between [-100, -80] dBm. In good condition, RSRP is higher than -80dBm. For these two states, no action will be done. If the value of RSRP is less than -100 dBm, an activities of optimization is necessary. Several actions are possible: boost the power transmission, increase the height of the transmitter, and implementation of new eNodeB if necessary. The obtained RSRP before and after treatment are given in the table 2:

Table 2. RSRP before and after treatment

Range	**RSRP (dBm)**		**State**
	Before treatment	**After treatment**	
[min, -120]	2824 (1.25 %)	11 (0.18 %)	Very weak
[-120, -110]	16545 (7.31 %)	308 (5.15 %)	Weak
[-110, -100]	59294 (26.21 %)	1358 (22.7 %)	Low
[-100, -80]	124094 (54.85 %)	3476 (58.11 %)	Normal
[-80, Max]	23473 (10.38 %)	829 (13.86 %)	Good

The aim of this section is amelioration (ensuring maximum possible coverage) of the received RSRP in the area where the power is low (three first case in table 2). According to Fig. 6 and Table 2, there is an amelioration of 06.74 % in RSRP distribution. These ameliorations are distribution as follow: amelioration of 01.07 % in the range of [min, -120]dBm; amelioration of 02.16 % in the range of [-120, -110] dBm and amelioration of 03.51 % in the range of [-110, -100] dBm.

4.2 Reference Signal Received Quality (RSRQ)

RSRQ indicates the quality of the received signal. Measuring the RSRQ becomes particularly crucial near the cell's edge when decisions must be made, independent of the absolute RSRP, to transfer to the next cell. The reception quality of the reference signal is used only during the connected states. The RSRQ can be measured with the following equation [6,7]:

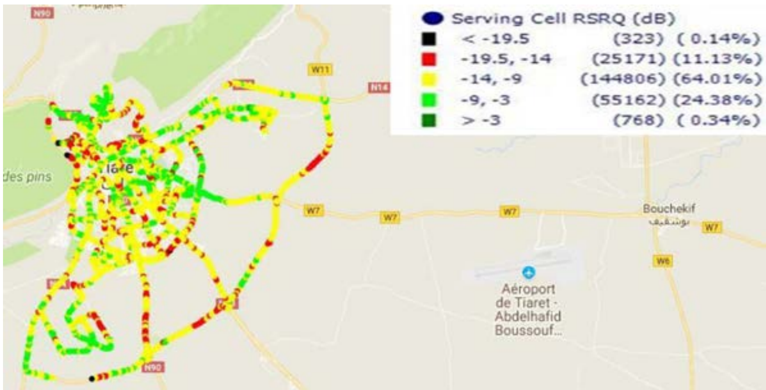
$$RSRQ = N_{RB}\,RSRP/RSII \tag{3}$$

Where: N_{RB} is the number of resource blocks on which the RSSI is measured.

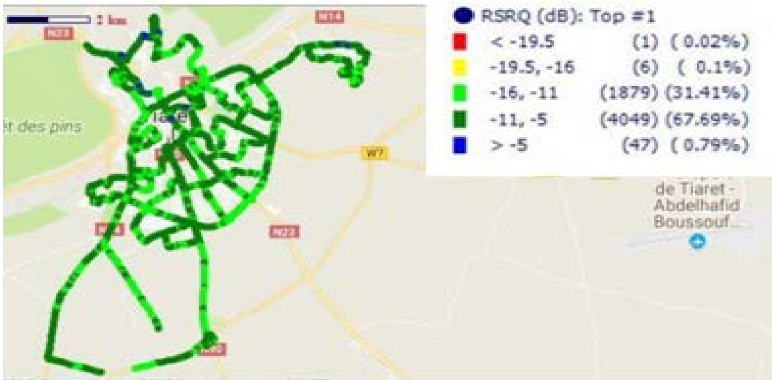
RSRP: Reference Signal Received Power

RSSI: Received Signal Strength Indication (linear average of the total received power).

The RSRQ distribution before and after treatment are given in Fig. 5.



(a) Before treatment



(b) After treatment

Fig. 5. RSRQ distribution

In this case, the value of RSRQ under the normal state is [-9, -3] dB. In good condition, RSRQ is higher than -3 dB. For these two states, no action will be done.

When the value of RSRQ is less than -9 dB, an action of optimization is necessary. The action is possible : handover management (the process of transferring intercellular of UE), increase the height of the transmitter, optimization of antenna tilt parameters, and implementation of new eNodeB if necessary. The obtained RSRQ before and after treatment are given in Table 3:

Table 3. RSRQ (dB) rang before and after treatment

Range	RSRQ (dB)		State
	Before treatment	After treatment	
[min, -19.5]	323 (00.14%)	1 (00.02 %)	Very weak
[-19.5, -14]	25171 (11.13 %)	6 (00.10 %)	Weak
[-14, -9]	144806 (64.01 %)	1879 (31.41 %)	Low
[-9, -3]	55162 (24.38 %)	4049 (67.69 %)	Normal
[-3, Max]	768 (00.34 %)	47 (00.79 %)	Good

According to the Fig.5 and Table 3, the amelioration in RSRQ is 43.76 %. The amelioration is distributed as follow: amelioration of 00.12 % in the range of [min, -19.5]dB; amelioration of 11.03 % in the range of [-19.5, -14] dB and amelioration of 32.6 % in the range of [-14, -9] dB. In this case, the amelioration is very significant.

4.3 Signal to Interference & noise Ratio (SINR)

SINR is a tool to measure the quality of mobile network wireless connections when the signal energy decreases with distance, i.e., the loss of path due to environmental parameters (for example, background noise, the interference force of another simultaneous transmission).

The signal-to-noise ratio SINR is given by the following equation:

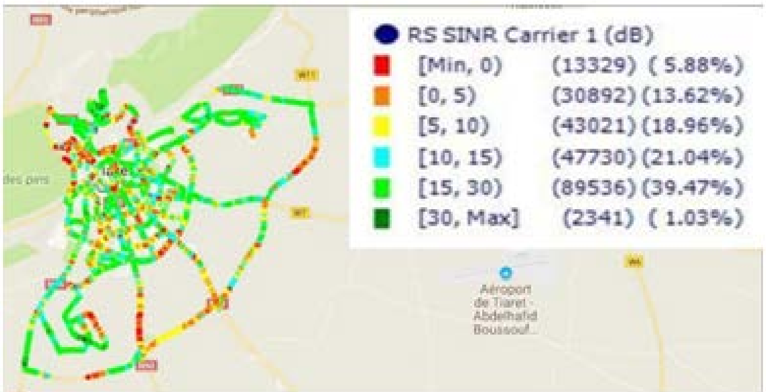
$$SINR=s/I+N \quad (4)$$

S: Average power of the received signal.

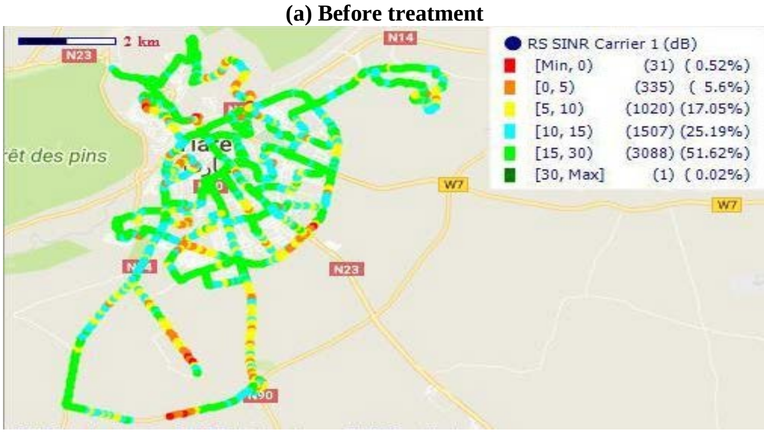
I: Average interference power.

N: Noise power.

The SINR distribution before and after treatment are given in Fig. 6.



(a) Before treatment



(b) After treatment

Fig. 6. SINR distribution

In the case of SINR, the values in the normal state are [15, 30] dB. In good condition, the values are higher than 30 dB. When the value of SINR is less than

15 dB, an action of optimization is necessary. The action is possible: boost the power transmission, handover management, increase the height of the transmitter, optimization of antenna tilt parameters, and implementation of new eNodeB if necessary. The obtained SINR before and after treatment are given in Table 4:

Table 4. SINR before and after treatment

Range	RSRQ (dB)		State
	Before treatment	After treatment	
[min, 0]	13329 (5.88 %)	31 (00.52 %)	Very poor
[0, 5]	30892 (13.62 %)	335 (05.60 %)	Very weak
[5, 10]	43021 (18.96 %)	1020 (17.05 %)	Weak
[10, 15]	47730 (21.04 %)	1507 (25.19 %)	Low
[15, 30]	89536 (39.47 %)	3088 (51.62 %)	Normal
[30, Max]	2341 (01.03 %)	1 (00.02 %)	Good

The amelioration in SINR is 16.30 %. The important ameliorations are 08.02% in the range of [0, 5]dB, and 05.36 % in the range of [min, 0] dB.

5 CONCLUSIONS

In this work, we have presented the need for planning and dimensioning to be considered a crucial and inevitable tool to increase mobile network performance. This study is based on the experimental evaluation. The parameters used in the assessment are Received Signal Received Quality, Reference Signal Received Power (RSRP) and Signal to Interference & Noise Ratio (SINR). Based on the obtained results, the planning, dimensioning, and optimization phases are very important phases for operators to increase their networks' performances. The obtained results indicate an amelioration of: 06.74 % in RSRP, 43.76 % in RSRQ, and 16.30 % in SINR. In perspective, several parameters can be measured and tested to enrich this study.

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