

Evaluation of the quality of service of MTN and ORANGE based on RSRP and RSRQ collected in the rural and urban localities of Maroua and Ngaoundere in Cameroon

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Abstract

The evaluation of the quality of service of mobile networks is as necessary as the need to improve the quality of service. It necessarily involves measuring, collecting and analyzing performance indicators. In the case of LTE mobile networks, it can be done using several tools and methods. Objectively and even subjectively, data science turns out to be an adequate and elegant method for managing the multitude of data that can be used to make the results credible. The objective of this study is initially to collect, using the CELL INFO application, the power levels of certain performance indicators of mobile network operators in Cameroon. It mainly involves collecting RSRP and RSRQ and other related parameters like operator id, mobility speed, geographic location and analyzing through tools used in data sciences these parameters to assess the quality of service of mobile telephone operators. The study focused on the collection and analysis of data from the LTE mobile networks of Orange and MTN in urban and rural areas, in simple mobility during the period June-October 2023.

Keywords: *Evaluation, Quality of service, Data sciences, performance indicator.*

1- Introduction

The appearance of mobile phones since the 1980s has aroused great interest among populations. The occurrence of the COVID 19 pandemic which led to teleworking pushed users to devote themselves more to the use of mobile networks and to question the real quality of service offered by operators.

In Africa particularly, the number of subscribers could reach 670 million by 2025 for an adoption rate of 65%. [1] The trend is focused much more on data services than voice services.

Alongside this strong and ever-increasing demand, the deployment of operators' infrastructures should also follow to provide a quality service with the entry of competition.

According to studies by FRATEL and GSMA, only 47% of the Sub-Saharan population is covered and Cameroon is not left behind in this rate despite the rapid increase in the number of subscribers. [2]

In the northern part of this country, we note the presence of all operators installed in Cameroon and all provide LTE except NEXTTEL which is visibly losing speed. From the Regulator ART, it appears that Orange Cameroon with around 3 million subscribers and MTN around 2.5 million are the dominant operators and provide their subscribers with LTE in addition to 3G and 2G.

In different circles, most people are users of mobile networks. The uses of these mobile networks are multiple. Get information, trade, connect to download a file for professional purposes, make an appointment with a

partner, have fun on the multiple applications, the needs are innumerable especially since communicating on the move is one of the characteristics of the numerical revolution.

Despite these needs, we wonder about the real infrastructural deployment of these operators which would respond to a quality service, the subject of this study when we know that the number of users is linked by the formula as (2)

$$N = \frac{W}{B} X \frac{m}{n} \quad [2]$$

With **N**: number of users;
n: Number of cells per Cluster;
W: bandwidth width;
B: Bandwidth
m: Total number of cells

To assess the quality of service which also depends on the investments of operators, the State of Cameroon through the regulator ART must control this quality of service. However, the collection of data turns out to be irregular because it is costly according to the regulator and the data from operators lack credibility and reach the regulator late and the analysis requires prior collection, hence the devolvement for this task through the tools of Data Sciences which are capable of serving the operation of mobile networks [3]

It being understood that data is the result of an observation made on a sample, the indicators which respond to requests from users to ensure a quality of service corresponding to the metrics chosen for 3G are for LTE:

- the Received Signal Received Power (**RSRP**) fundamental metric for coverage and for the classification of different candidate cells according to the strength of their signal,
- The Received Signal Received Quality (**RSRQ**) used for Handover and support parameter of the RSRP [4].

From the values of these parameters, we can determine the quality of connectivity according to the table 1 below [5].

RSRP	RSRQ	Conditions	Connectivité
≥ -80	≥ -9	Excellent	fast without loss
-80 à -90	-9 à -10	Good	fast without loss
-90 à -100	-10 à -15	Normal	Normally a little longer latency
-100 à -120	-15 à -20	Bad	Long latency, low data speed
≤ -120	≤ -20	Very Bad	May not connect

Table 1: Comparison table of performance parameter values

Overall, this study, which draws on data sciences through the measurement, collection and quantitative statistical analysis of data from the LTE networks of the two operators Orange and MTN, has two contributions; the first, software, consists of using the application to measure and collect the data of the operators selected for their strong deployment compared to other operators and the second algorithm which will allow us to analyze the data collected thanks to Python and its library composed of Pandas, Numpy and Matplotlib.

For this work, the different parts are structured around the following sections: After the introduction, a section is dedicated to the literature review, another which talks about the method and the tools used, another section presents the results and comments before exit through the outlook.

2- Literature review

In Cameroon, alongside the subjective judgment of the quality of service related to the evaluation of the quality of experience (QoE), the professional scanner remains the tool used by the regulator to assess the quality of service. Elsewhere where it is also used, this method, considered expensive with its harmful ecological effects, is not regular.

Alongside, operators have their servers which store data relating to the performance of their network. The inaccessibility of this data, deemed not sufficiently credible by the regulator and consumer defense associations, pushed players to develop intelligent agents in user terminals in order to evaluate the quality of service [6] Very quickly this advance was showed its limits due to the low memory of the phone which could not store data and technological progress with the transition to more advanced generations (up to 5G). Through random collection and

statistical analysis a study was carried out on the evaluation of the quality of service of mobile networks in Afghanistan [7]. This study was limited to collecting from users through questionnaires giving the subjective meaning to this study. While remaining in GSM, researchers wanted to agree on the possibility of measuring certain metrics by comparisons between the Professional Scanner and the terminal. These measurements were found to be different [8] which did not prevent researchers from evaluating the quality of service of certain GSM networks in Nigeria by testing Tukey ranges [9] and later by network statistics [10] With the arrival of smartphones and the possibility to develop Android applications capable of measuring and collecting metrics from the EU, there has been the establishment of a new form of evaluation [11] [12] [13] [14] Despite this technological progress the difference in measurements between the professional scanner and the terminal has shown itself to be a limit to this progress [15]. Still, with the entry on the scene of LTE considered as 4G, and the adoption of smartphones as a measurement tool it was first necessary to compare the measurements of certain KPIs made with the professional scanner and those made with the terminal of the user [16]. Later, verification of the accuracy of other network parameters demonstrated the possibility of measuring and collecting with the user's terminal [17] but the test having been limited to certain parameters such as RSRP it was necessary to extend to other KPIs deemed essential for assessing the quality of service in order to confirm the result Continuing the research, we arrived at the possibility of collecting other metrics such as CQI and CI but the difficulty was that of collecting all this data at a high frequency and the impossibility of displaying the speed of upload and download [18] Despite these results, which are considered laudatory, research has continued in the field to verify the precision of metric measurements from smartphones manufactured by different designers. The results showed the limits of certain terminals during measurements and the requirement for validation of the results before any measurements because the OS depends on each terminal designer [17] [19]. To complete his work, an article is published [20]. For this experiment carried out around the Polish capital, Warsaw, the professional measurement working group is working on two operators and is interested in the evaluation of voice calls, video streaming and web page downloading. Of the two operators, one uses UMTS and LTE and the second only LTE. The collection campaign took place in urban areas and rural areas in several scenarios

The Samsung Galaxy M20 with the application was used to measure parameters such as RSRP, SINR and RSRQ while the professional scanner was used to assess the quality and reference intensity of the signal and the quality of the radio channel of the different networks.

Overall, this study made it possible to compare the two networks in terms of quality of service Analysis of the network comprising several standards, such as UMTS and LTE, shows low collection compared to that which uses LTE.

For this network, UMTS resources are sometimes used by LTE. In this case the analysis shows that the quality of service of this operator is better because during the DT when the handover is carried out between two base stations which provide the two standards, the number of failed or interrupted calls is high compared to the one who has a single standard.

The analysis of the results obtained also shows that the evaluation of the quality of service is very important for the service provider and the development of mobile networks.

If a network with several standards (UMTS and LTE) experiences some difficulties during Handovers, why not evaluate only the UMTS network, especially since other studies have been carried out on LTE. Which led to the publication of [21] [22]. In these studies which relate to the evaluation of four UMTS networks (MTN, Globacom, Aitel and 9Mobile in Calabar in Nigeria, the equipment used is not very different from that of the predecessors. Four phones containing the four Sims cards of the four operators, a Laptop to store the collected data in which the TEMS discovery software is installed which is used to analyze this data and present the results in the form of tables and figures.

At the end the results are compared to those of the NCC to deduce the network which has the best KPIs. From this comparison, it appears that the parameters are consistent with those of the NCC but there is however a need to increase the base stations to optimize the network. There is reason to say that new generations of mobile networks offer more capacity but also more security and quality control mechanisms. However, this does not exempt these new generations from the evaluation of their performance parameters because the complaints remain.

In this other article published in 2023 [23], the aim was to evaluate the quality of service based on the performance indicators of three LTE operators (1, 2 and 3) in Najaf city in Iraq. Using the collection method with a DT, the study focused on the evaluation of the KPIs of three operators on the 1800 Mhz band with a bandwidth of 20Mhz. This involved the collection of RSSI, SINR, RSRP, RSRQ and DL in 377 cells located around a 19 km road, and the car with the DT drives at around 30 km/h. To obtain the results, the analysis of KPIs was made possible thanks to SPSS, Matlab and PYTHON. The results obtained show that the KPIs of the three operators are good with one of the operators standing out compared to the others.

Despite this desire to advance science, the study was limited to certain operators, at a single time of day and in mobility without also taking density into account.

In the logic of correcting this failure appears in 2023 [24]. The objective is to understand the MBB without comparing the different networks evaluated. The study is carried out in the city of Cyberaya in Malaysia, considered a smart city because it has high-tech facilities and infrastructure.

The evaluation concerns five operators namely Maxis, Celcom, Digi, Umobile and Unifi labeled A, B, C, D and E and use 3G and 4G. The performance measured in the driving tests are signal quality, throughput, forwarding, ping and the parameters measured are RSRP, RSRQ, SNR. After several comparison tests, the Android application marketed by Gyokov Solutions was used for the measurements. This application was installed in an OPPO F1 handset. The file to download weighs 1 GB.

Outdoor measurements were collected at two important times of the day. In the morning between 7 a.m. and 8 a.m. and in the evening between 2 p.m. and 4 p.m. with a vehicle traveling at 70 km/h. while inside the measurements were collected on several floors of a building which happens to be the central commercial center of the city. There, the study also considered 3 positions.

Indoors, the results of performance measurements for the five ORMs studied show that they offer good coverage with an acceptable throughput which can be improved by increasing the access sites. However, it is difficult for the high frequencies used by 5G to pass through buildings like 4G frequencies. They suffer more propagation loss through building materials.

Outdoors, there is a need to improve SNR by reducing background noise and improving signal strength. Most MNOs reach up to 20 Mb with acceptable SNR and ping. Of the five operators, four have 4G along the route where the test took place.

Beyond the positive aspect regarding accessibility to broadband service, it should be noted that this study did not focus on video streaming, web browsing, customer service and billing;

It also covered a single study area and could extend to many other areas. Dynamic sharing has not been taken into account.

As progress has made networks more complex, data sciences are being used to exploit them [3] and also to allow us to analyze them. If elsewhere these network tests are carried out with acuity and we take advantage of all these advances to exploit the networks, it is the subject of doubts in Cameroon where the evaluation of the quality of service sometimes remains subjective and makes the subject of several complaints from users which led to meetings between the different parties.

The contribution of this study is to use the user's terminal and through the CELLInfo application developed to objectively measure and collect certain metrics such as RSRP, RSRQ and many others which can help in the evaluation and to analyze the behavior of the networks of the dominant operators in Cameroon, Orange Cameroon and MTN, taking into account other parameters.

3- Method and tools

3.1. Location

The collection sample in an urban area is the Ngaoundere Regional Hospital in the Adamaoua region located at a latitude of 7.31438° and a longitude of 13.58322°

The rural area is the locality of Kongola located in the outskirts of Maroua in the Far North of Cameroon located at a latitude of 10.60892° and a longitude of 14.36945° .

The hardware used for collection and evaluation consists of a TECNO-CD6j brand user terminal, version of Android 10, 2G.0GHz processor, 4GB of Ram and 128GB of HDD in which is installed a CellInfo application which measures and stores not only certain performance indicators such as RSRP, RSRQ and RSSI but several others such as data relating to network types, the serving cell, data linked to position, time, mobility speed, data from the neighboring cell and many others, an HP Dual Core I5 brand Laptop with 8GB of Ram and 1TB of HDD, in which the Python software and its library are installed, a scanner professional, regulator measurement tool to validate by comparison the data collected by the terminal.

Data collection covered five months. The data collected at a frequency of one data/s is stored directly in a csv file in the user's terminal before exporting it to the Laptop for use.

The collected indicators are first cleaned before being explored. The algorithm written in Python and its library generates statistics and graphs. These results are the subject of an analysis. We focused on the quantitative statistical analysis of metrics such as Received Signal Received Power (RSRP) capable of allowing us to assess the quality of service of the two operators.

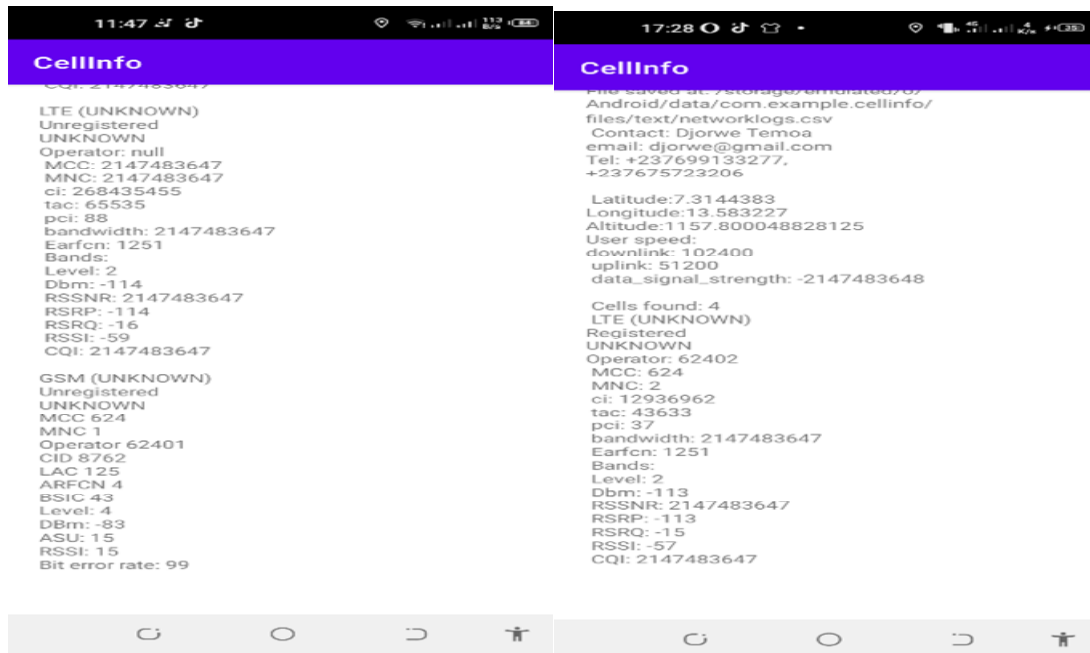


Figure 1: Interface of the CellInfo collection application

The choice of these metrics (RSRP and RSRQ) arises from the fact that they are the LTE correspondents of the metrics chosen for 3G and which fall within the operators' specifications.

4- Results and comments

The statistical analysis of performance indicators is one of the essential parts of this work. The algorithm is written in Python using its pandas, numpy and matplotlib library to display statistics and generate figures. We obtained the following results depending on the Operator, the period (day or night), the collection location, the mobility speed and the service cell.

Month	June	July	August	September	October
Data collected	0 - 2229	2230 - 6932	6933 - 7544	7545 - 8067	8068 - 17748

Table 2: Data month correspondence table.

4.1. Depending on the operator and the locality

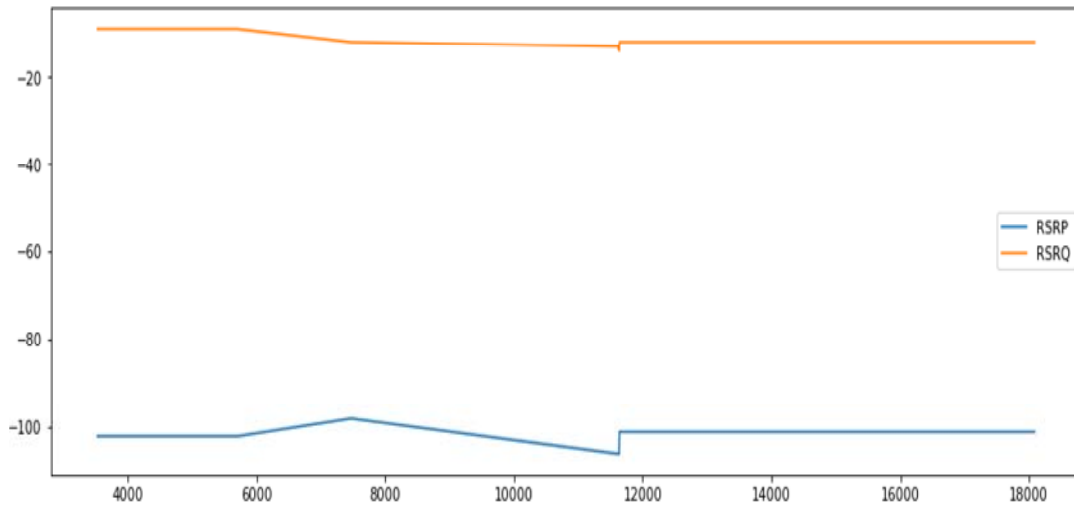


Figure 2: Average RSRP and RSRQ MTN recorded at the Ngaoundéré Hospital
RSRP: -101.142656 **RSRQ:** -11.543570

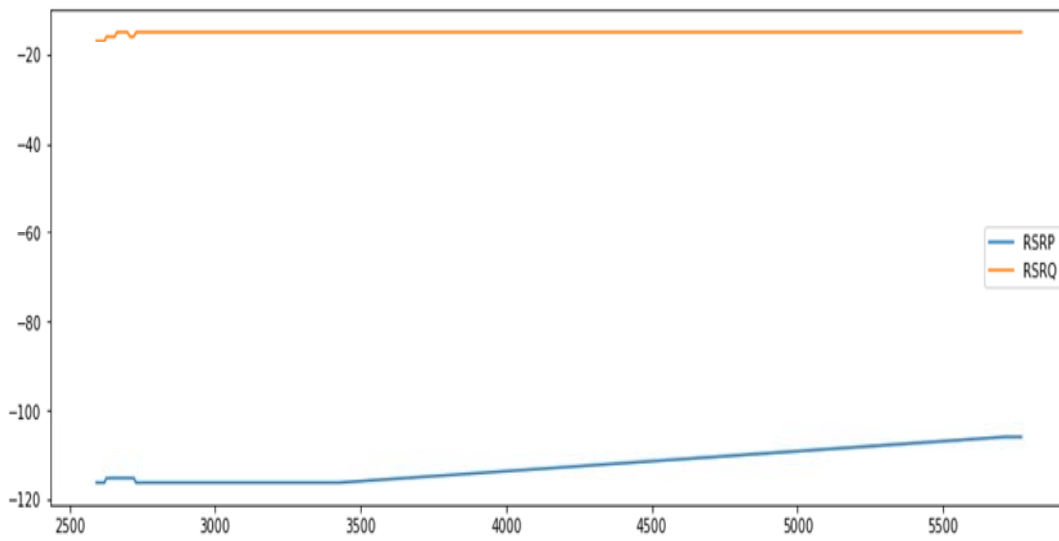


Figure 3: Average RSRP and RSRQ MTN recorded in Kongola-Maroua
RSRP: -114.096774 **RSRQ:** -15.135484

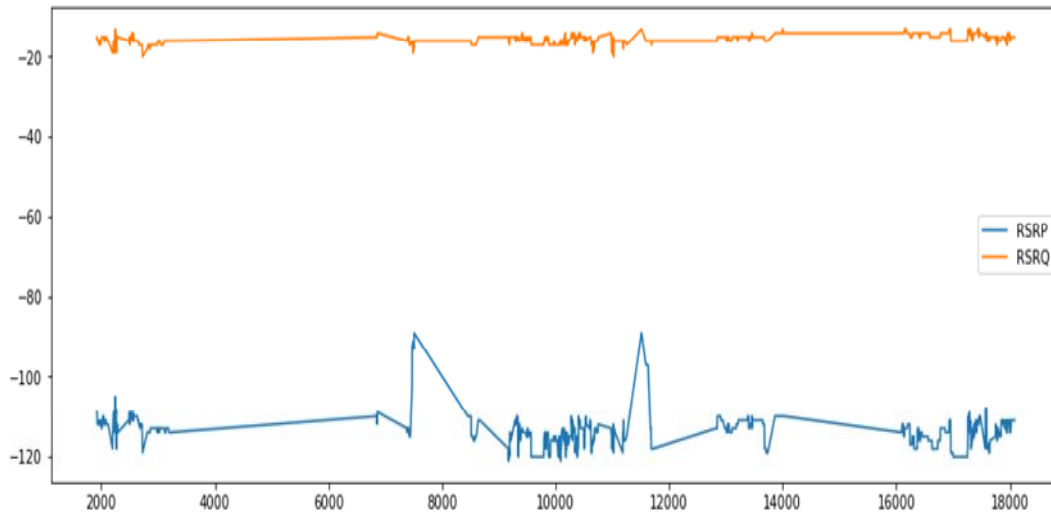


Figure 4: Average RSRP and RSRQ ORANGE recorded at the Ngaoundéré Hospital
RSRP: -113.453712 **RSRQ: -15.303930**

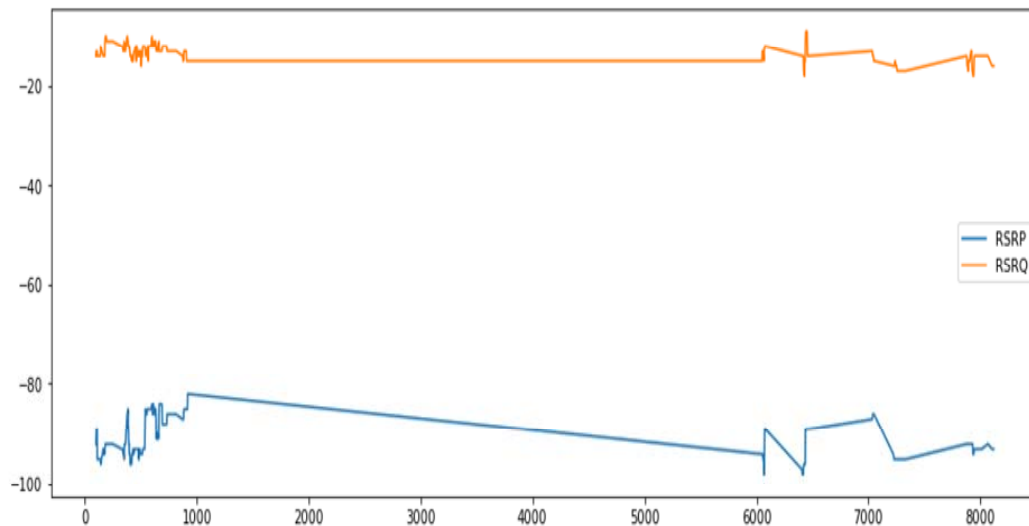


Figure. 5: Average RSRP and ORANGE RSRQ recorded in Kongola-Maroua
RSRP: -90.362637 **RSRQ: -13.302198**

Depending on the location of the subscriber, we took into account the metrics recorded in the rural area in Kongola Maroua and in the urban area at the Ngaoundéré Hospital located in the heart of the city frequented by hundreds of people every day.

Considering the results on the graphs by operator, the observation is that in urban areas the RSRP and RSRQ of MTN are bad and normal while those of ORANGE are all bad. In rural areas the RSRP and RSRQ of ORANGE are normal and those of MTN poor so ORANGE provides a significantly improved service compared to MTN in rural areas and MTN provides good service in urban areas than in rural areas unlike ORANGE.

4.2. Depending on the operator and the period in urban areas

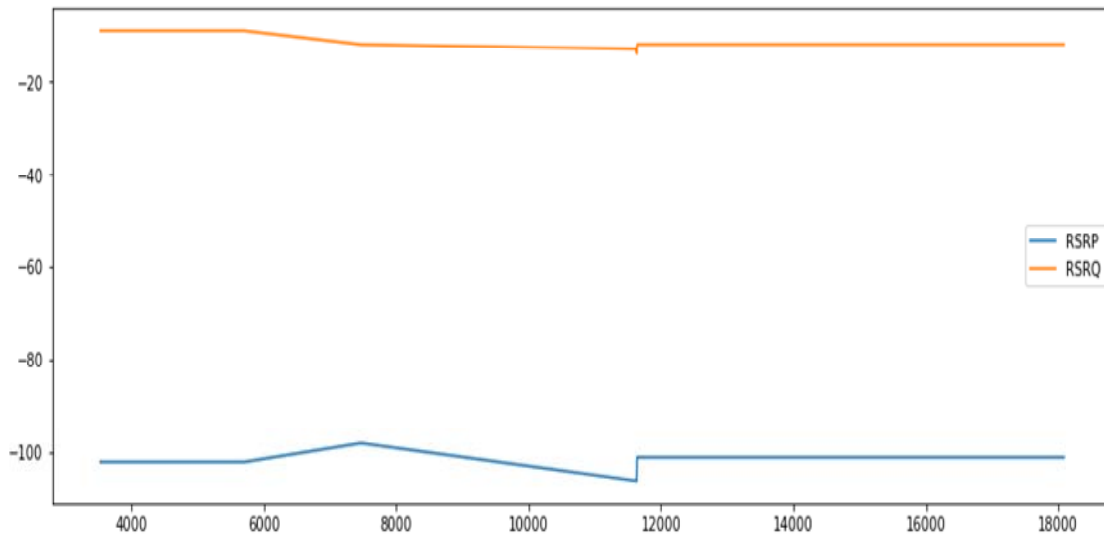


Figure 6: Average RSRP and RSRQ from MTN to Ngaoundéré during the day
RSRP: -101.142656 **RSRQ:** -11.543570

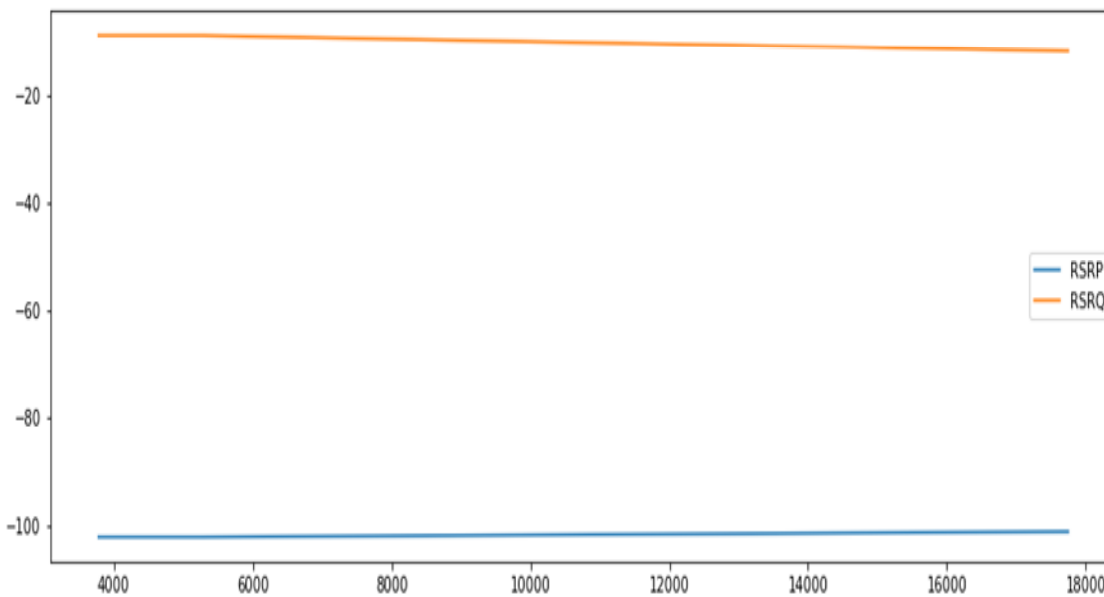


Figure 7: Average RSRP and RSRQ from MTN to Ngaoundéré at night
RSRP: -101.734940 **RSRQ:** -9.795181

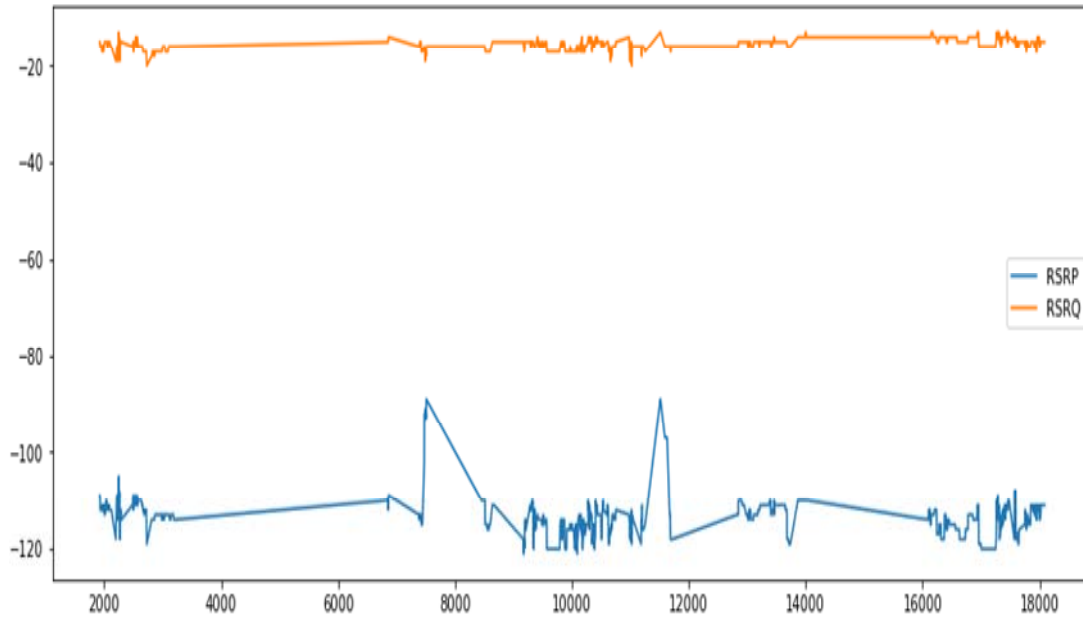


Figure 8: Average RSRP and RSRQ from ORANGE to Ngaoundéré during the day
RSRP: -113.453712 **RSRQ: -15.303930**

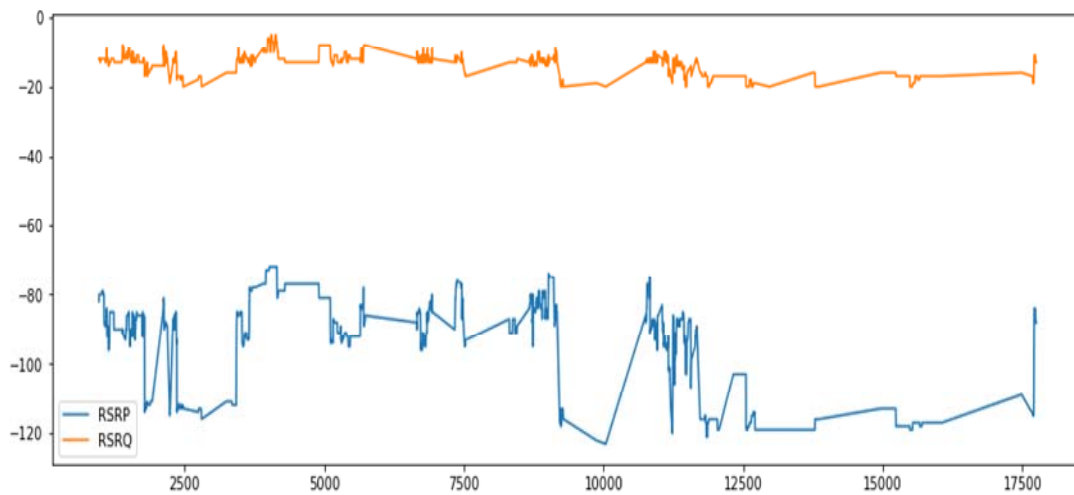


Figure 9: Average RSRP and RSRQ from ORANGE to Ngaoundéré at night
RSRP: -95.339709 **RSRQ: -13.855011**

Analyzing the data and graphs, the RSRP and RSRQ of MTN are bad and normal and those of ORANGE are all bad for daytime collection in urban areas. At night the MTN indicators are poor and excellent and those of ORANGE have normal average values.

Although MTN maintains its consistency during the day and at night in terms of RSRP, this operator in our sample provides an improved service during the day compared to ORANGE and improves it at night just like ORANGE. The best call time is between 6 a.m. and 8 a.m. in the morning and after 10 p.m. in the evening. The peak is between 1 p.m. and 2:30 p.m.

4.3. Statistics of collected data

	RSRP	RSRQ		RSRP	RSRQ
count	3144.000000	3144.000000	count	5841.000000	5841.000000
mean	-101.739504	-11.661578	mean	-101.904126	-14.305256
std	3.386901	1.440949	std	14.251594	2.340484
min	-116.000000	-17.000000	min	-123.000000	-20.000000
25%	-101.000000	-12.000000	25%	-114.000000	-16.000000
50%	-101.000000	-12.000000	50%	-110.000000	-14.000000
75%	-101.000000	-12.000000	75%	-88.000000	-13.000000
max	-96.000000	-8.000000	max	-65.000000	-5.000000

ORANGE
MTN

Table 3: MTN and ORANGE performance statistics

This table shows the total number of values (RSRP and RSRQ) collected for each operator. On observation, we see that the average values of the RSRPs are close but the RSRQ of MTN is better compared to that of Orange. Less than 25% of RSRP and RSRQ are good and at least 75% are bad for RSRP and very bad for RSRQ for the Orange network while those of MTN as a whole are bad with latencies that last.

For the specific case of RSRP, the minimum and maximum limits of ORANGE vary from excellent to very poor while those of MTN remain close and vary from normal to poor.

As for the RSRQ, ORANGE has the best limit value (-5.0000) and the highest (-20.000). Intermediaries are constant for MTN while in ORANGE we see a lot of variation.

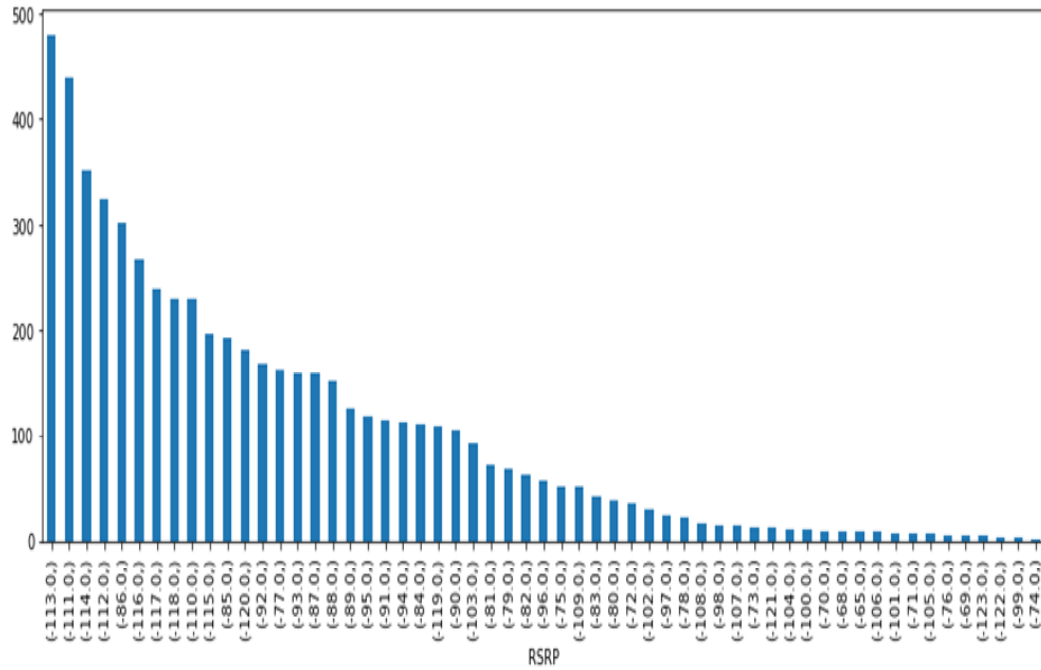


Figure 10: Value count RSRP ORANGE

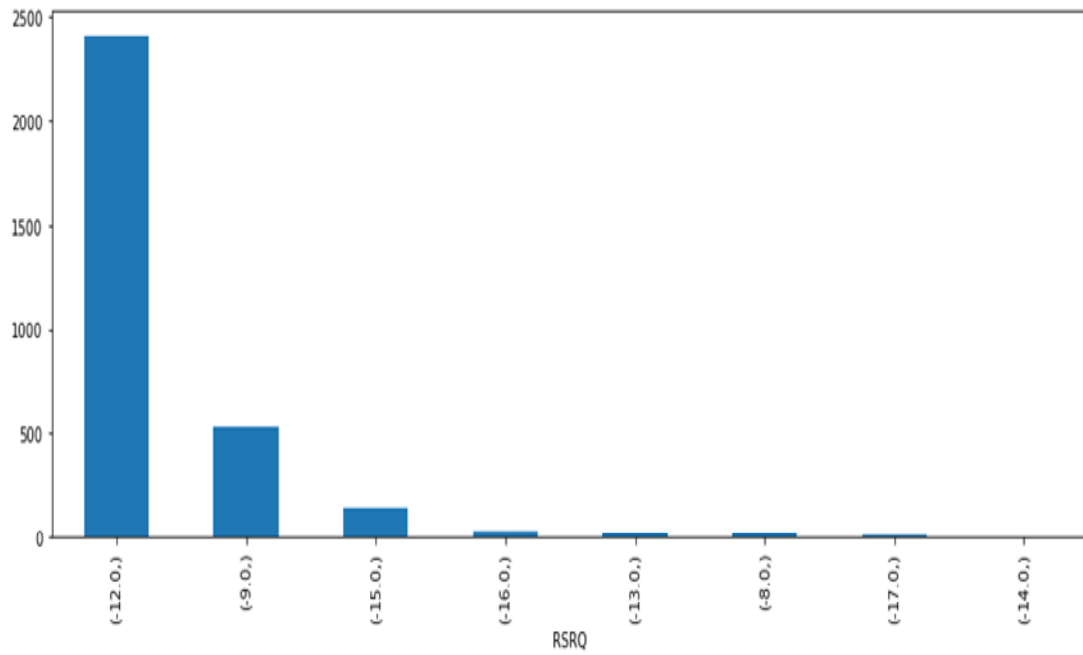


Figure 11 : Value count RSRQ MTN

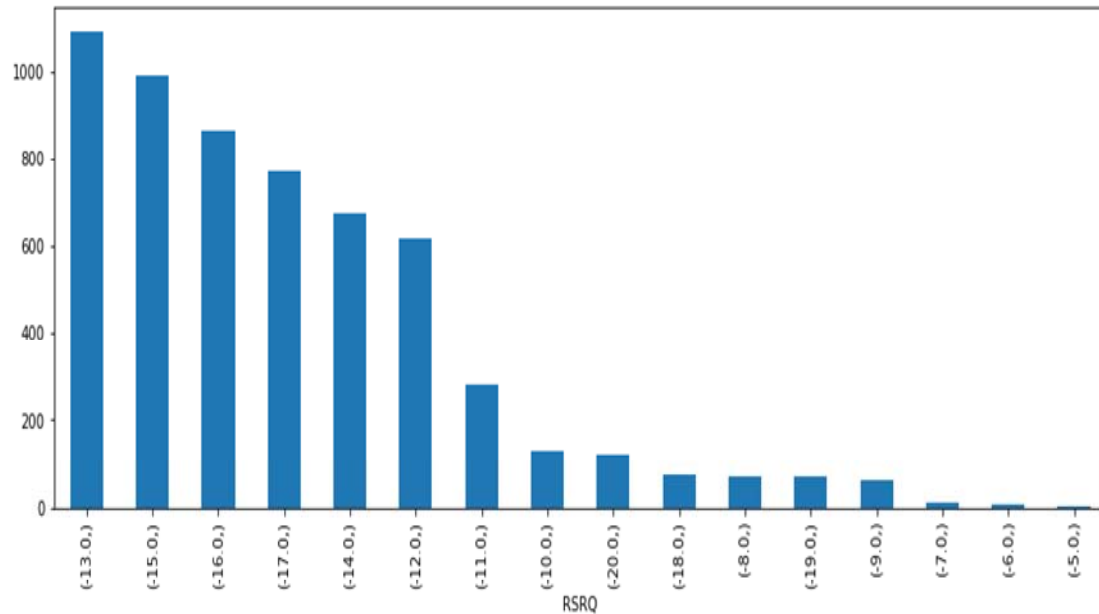


Fig 12: Value count RSRQ ORANGE

Analyzing the data and diagrams we observe that during the entire collection period the RSRP and RSRQ of MTN vary very little compared to those of ORANGE. Although the averages are poor and close in terms of quality as previously indicated for the RSRP, they are normal for the RSRQ with the MTN value which is improved and constant.

Which means in view of the statistics and graphs that when it is good it is ORANGE, when it is very bad it is also ORANGE, MTN generally having a bad network like ORANGE but constant.

The results show after simple and mobility measurements that the average levels of the RSRP signals are:

- 101.904126 DBm for ORANGE Cameroon.
- 101.739504 DBm for MTN Cameroon

For the RSRQ, the average levels are:

- 14.305256 DBm for ORANGE Cameroon;
- 11.661578 DBm for MTN Cameroon.

These close and quantifiable results as poor for these two parameters show that the quality of service evaluated with the values of RSRP and RSRQ which always tend towards mediocrity, must be improved to allow real user satisfaction which increases considerably.

5- Conclusion and perspectives

Thanks to data sciences we were able to measure and collect some fundamental metrics for coverage and analyze the quality of service provided by the mobile operators Orange and MTN in two localities in the northern part of Cameroon located in rural and urban areas, in day, at night, in simple mobility.

The results of the collection and statistical analysis of the data and graphs enabled allowed us to assess the quality of service provided to customers during the period JUNE-October 2023.

In perspective, we can consider evaluating the quality of high mobility on our roads, in border areas and or predicting the performance of these networks at the same time continuing the collection and comparing the results of the new collection and the predicted data.

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