

Evaluation of the Performance of 3G/4G Networks in Guinea According to Regulatory Standards

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Abstract

In Guinea, as in many sub-Saharan African countries, ensuring that mobile networks comply with regulatory standards is a major challenge to providing high-quality service. Despite these regulatory standards, coverage and service quality remain uneven across different parts of the country. This article evaluates the performance of 3G/4G mobile networks in the country's eight administrative regions using field measurements conducted with the Atlas Guinée and nPerf apps. Atlas Guinée collects indicators such as network coverage rate, call reception rate, SMS reception rate, and download speed. Meanwhile, nPerf measures network coverage speed. The data is then analyzed using Excel and compared to regulatory thresholds. The results show that, in terms of 3G coverage, Orange meets these benchmarks only in Conakry (85%), Labé (98%), and Nzérékoré (80%), while Cellcom's coverage rates fall well below the benchmark in all eight regions. As for MTN, it meets the set threshold only in the Conakry region. For 4G, Orange is the only provider to meet the threshold in Conakry, with 76% coverage. In terms of call and SMS quality, all operators meet the thresholds in all regions. For 3G download speeds, Orange reaches nearly 2 Mbit/s, while MTN and Cellcom range from 700 Kbit/s to 1.9 Mbit/s. For 4G, Orange offers speeds between 16.16 and 22.57 Mbit/s, while Cellcom and MTN show limited performance. Overall, Orange offers better performance, but coverage remains uneven across regions.

Keywords

Telecommunications, Network Performance, 3G/4G, Guinea, Regulatory

1. Introduction

The mobile economy in Sub-Saharan Africa (SSA) has experienced significant growth over the past two decades. Despite this progress, in 2022, the usage gap stood at 61% and the coverage gap at 17% [1]. Governments have an important role to play in developing policies and regulations that eliminate unnecessary costs, improve flexibility, and boost investor confidence. Existing regulatory requirements should be reviewed periodically (every five years) to adapt them to technological and market developments and to ensure that they remain consistent with the intended objectives [2]. In Guinea, assessing whether mobile networks comply with regulatory standards is a key challenge in ensuring service quality and user satisfaction. The mobile operator MTN launched its 4G network in December 2022, while Orange, in the same year, expanded its network coverage by deploying new sites: 164 for 2G/3G and 748 for 4G [3]. Despite these numerous assessments, coverage and service quality remain inconsistent across different regions of the country. The challenge is to verify compliance with performance indicators using drive-test measurement methodologies or mobile apps. These measurements are compared to the reference thresholds specified in the specifications attached to the operating licenses of mobile network operators in order to ensure reliable coverage and optimal quality of service.

Several studies in the literature have addressed this issue, highlighting various methodological approaches and findings. The work of Abdulwaheed Musa and Samad Adeniran, which utilized a survey questionnaire and the TEMS software (Testing Equipment for Mobile System), demonstrated the performance of 3G and 4G cellular networks using key performance indicators (KPIs) such as call setup success rate (CSSR), call drop rate (CDR), network coverage, and call quality, which did not meet the required thresholds [4]. Next, FASIL HAILU assessed the impact of customer satisfaction and wait times on the performance evaluation of 3G and 4G networks in Ethiopia. He conducted a survey of 40 organizations in Addis Ababa using SPSS software. The results show that 3G and 4G technologies have a positive impact on company performance and productivity, with an average score of 3.85, followed by awareness of 3G and 4G technologies and customer satisfaction, with average scores of 3.83 and 3.46, respectively [5]. GSMA (2020) used the method for assessing mobile network quality of service (QoS) in sub-Saharan Africa, employing standardized key performance indicator (KPI) tools. The results reveal significant variations in QoS over time and across operators. To ensure compliance with standards, financial penalties and the threat of license suspension are imposed in the event of non-compliance [6]. In 2019, the Fratel network surveyed its members on mobile service coverage and quality. The 25 responses received, based on an assessment of 2G, 3G, and 4G coverage as well as

measurements of voice, SMS, and data quality, show that regulators must monitor regulatory compliance, assess actual performance in different regions, and encourage operators to invest in order to improve national competitiveness [7]. As part of the study conducted by Garba S.A., the G-NetTrack Pro Android app was used over a three-week period (morning and evening) to collect radio performance metrics (RSRP, RSRQ, CQI, SNR, data rate). Analysis of the results revealed variations in performance as well as the impact of signal quality on data throughput, demonstrating the value of these measurements for optimizing coverage and quality of service (QoS) [8]. In the same vein, P. Elechi used MET's discovery software, which is based on a statistical approach. The results indicate that the measured key performance indicators (KPIs) ranged from -90 to -49.7 dBm for RSSI, -117.7 to -68.6 dBm for RSRP, and -14.2 to -22.8 dB for RSRQ. The probability distribution revealed that the optimal signal ranges were 38.21%, 69.63%, and 65.63% for RSSI, RSRP, and RSRQ, respectively. Although the indicators generally fall within acceptable ranges, they still need to be optimized to ensure better service quality for a larger population [9]. Next, E.T. Tchao, J.D. Gadze, and J.O. Agyapong used the Genex Unet simulator to evaluate the coverage and throughput performance of 2×2 , 4×4 , and 8×8 MIMO configurations. The results show that 4×4 MIMO offers a higher average throughput per sector than 2×2 MIMO. However, user coverage is higher with 2×2 MIMO (60.41% between 1 and 40 Mbit/s) compared to 55.87% for 4×4 MIMO in the study area [10]. Finally, in Papua New Guinea, Shafrida S. and Serah M., using the MST207T spectrum analyzer, demonstrated that Digicel experiences a decline in downlink signal strength and quality in areas with poor coverage. For Bmobile and Telikom, signal strength ranges from moderate to poor. The analysis of signal attenuation also reveals an increase in signal fading. The poor performance is attributed to congestion and base stations [11].

The objective of this research study is to evaluate the performance of several indicators, namely: network coverage, the rate of incoming calls and text messages, download speeds, and 3G/4G network coverage speeds in Guinea, in accordance with regulatory standards.

- Network coverage represents the percentage of a geographic area where a mobile network signal is available.
- Call delivery rate represents the percentage of incoming calls successfully received by users compared to the total number of calls attempted on the network.
- The SMS delivery rate represents the percentage of SMS messages successfully received relative to the total number of SMS messages sent or attempted on the network.
- Download speed represents the amount of data a user can receive from the Internet or a network over a given period of time.
- Network coverage speed refers to a mobile network's ability to provide a certain data transmission speed across a given geographic area.

To conduct this study, we used the digital tools Atlas Guinée and nPerf, in addition to Excel software for processing and analyzing the collected data.

2. Materials and Methods

2.1. Overview of the Study Site

Guinea is divided into four natural regions that are fairly distinct and homogeneous from a geo-ecological perspective. The country owes this uniqueness to its natural environment, which is characterized by climatic contrasts, mountain ranges, and the orientation of the terrain all of which combine to give each region its own distinct characteristics in terms of climate, soil, vegetation, and the way of life of its people [12]. It is divided into eight administrative regions: Conakry (the capital), Boké, Kindia, Mamou, Labé, Faranah, Kankan, and Nzérékoré. The Guinean population lives mainly in rural areas (70%), and more than half of the urban population (51%) resides in the capital. The urban population is growing at a faster rate 4.1% which is typical of most countries in the subregion. There are significant disparities in the level of urbanization across the various prefectures and regions. Aside from Conakry, which is home to more than one million people, the two largest urban centers are Nzérékoré and Kankan, each with a population of over 100,000 [13].

Figure 1 shows a map of Guinea's eight administrative regions.

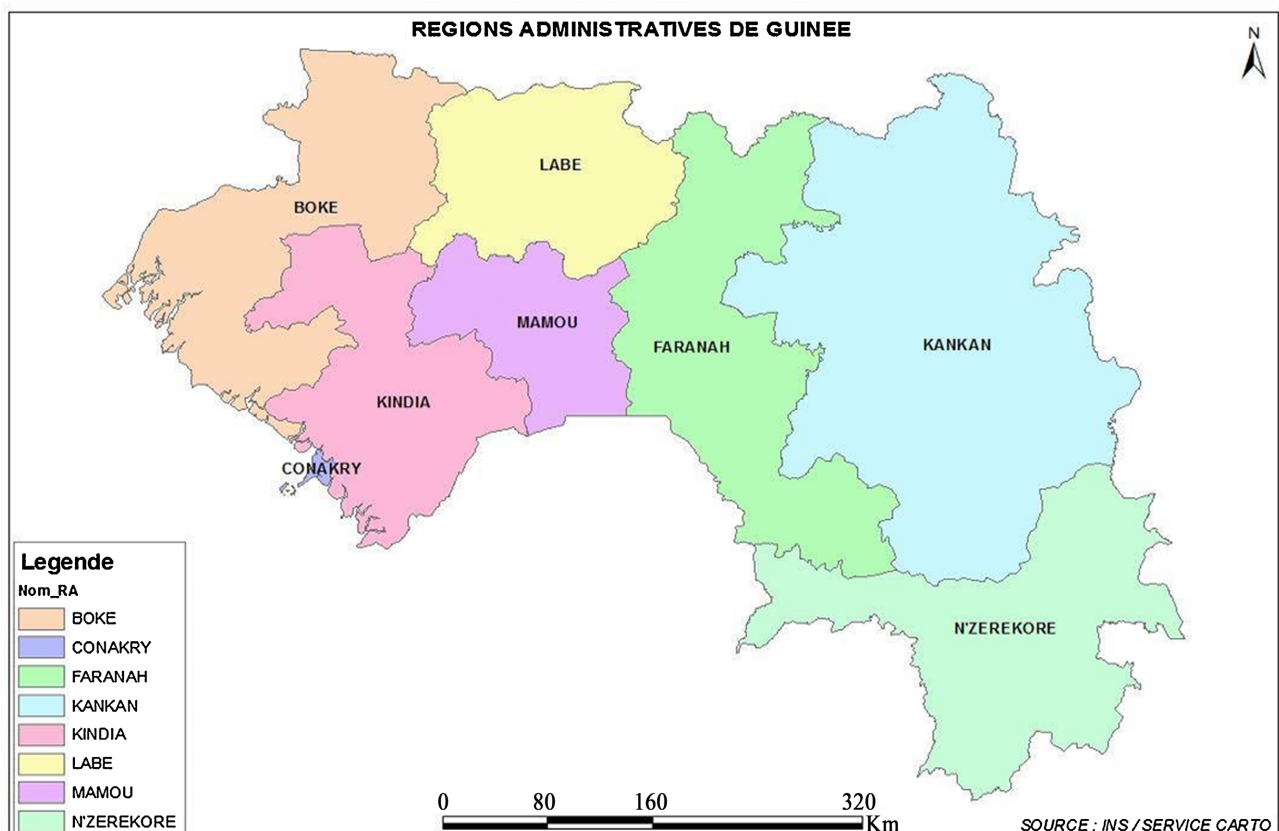


Figure 1. Map of the eight administrative regions [14].

This study is based on technical analyses compared with current regulatory standards. It focuses on 3G and 4G mobile network operators in the Republic of Guinea, by focusing on these eight administrative regions, which constitute the main areas of analysis and are distinguished by their high population density, their sociocultural diversity, and the significant concentration of the country's economic, administrative, and educational activities.

2.2. Tools and Methods

To gain a more comprehensive understanding of 3G and 4G mobile networks, field measurements were conducted in the eight administrative regions for each mobile operator using the Atlas Guinée and nPerf tools. The Atlas Guinée tool was used to collect data on network coverage rates, the rates of incoming calls and text messages, and download speeds. In addition, nPerf was used to measure network coverage throughput, while Excel was used to analyze the collected data and compare it to the reference thresholds defined in the specifications. The data collected by operator and by region are average and dynamic values. Data collection and analysis were conducted over a three-month period, from October 3, 2024, to January 26, 2025, at a rate of one campaign per week. Measurements were taken every Monday at 2:00 p.m., with 17 stationary tests conducted for each of the three mobile phone operators in each region.

The Regulatory Authority for Post and Telecommunications (ARPT) has established, in the operators' specifications, reference thresholds for field strength levels, differentiated by network technology. These thresholds vary depending on when the licenses were signed. For example, for Cellcom, whose license was signed in 2013, the benchmark threshold is set at 90% for 3G/4G. For Orange, which has held a license since 2019, the thresholds are set at 80% for 3G and 70% for 4G. Finally, for MTN, whose license expires in 2022, the threshold is set at 65% for 3G/4G. To meet the study's objectives, certain reference thresholds have been listed in **Tables 1-4** [3].

1) Network coverage

The purpose of examining the geographic coverage indicator is to describe the availability of services offered by mobile networks by area. It reflects the geographic availability of mobile networks by technology type (2G/3G/4G). Coverage can be verified through drive tests designed to measure field strength levels.

2) Voice service

Voice service quality metrics are designed to assess a subscriber's ability to establish a voice connection on the first attempt and to maintain that connection for two minutes while clearly hearing the other party.

3) SMS service

The purpose of SMS service quality measurements is to assess the ability to send an SMS and to ensure that the recipient receives the entire message within a specified time frame. Thus, an SMS measurement involves sending an SMS either dynamically or statically from the mobile teams to the fixed reference point and

Table 1. Shows the reference thresholds and coverage requirements for 2G/3G/4G mobile networks.

Technologies	Meters	Reference power level (dbm)	Obligations
2G	Rxlevel	Rxlev ≥ -72 , Excellent Level	<ul style="list-style-type: none"> • Rate of (RxLev ≥ -82 dbm) $> 85\%$ in cities (Indoor). • Rate of (RSCP ≥ -94 dbm) $> 80\%$ on major roads (Incar). • Rate of (RSCP ≥ -84 dbm) $> 85\%$ in cities. • Rate of (RSCP ≥ -94 dbm) $> 80\%$ on major roads.
		$-82 \leq \text{Rxlev} < -72$, Good Level	
		$-94 \leq \text{Rxlev} < -82$, Acceptable level	
3G	RSCP	Rxlev < -94 , Poor level	
		RSCP ≥ -74 , Excellent Level	
		$-84 \leq \text{RSCP} \leq -74$, Good Level	
4G	RSRP	$-94 \leq \text{RSCP} \leq -84$, Acceptable level	
		RSCP < -94 , Poor level	
		RSRP ≥ -66 , Excellent Level	
4G	RSRP	$-94 \leq \text{RSRP} \leq -66$, Good Level	
		$-122 \leq \text{RSRP} \leq -94$, Acceptable level	
		RSCP < -122 , Poor level	

Table 2. Shows the reference thresholds and requirements for 2G/3G voice services.

Indicator	Measurement method	Definitions	Obligations
Accessibility rate		Ratio of the number of samples of calls established in less than 7 seconds to the total number of samples	$\geq 98\%$ in urban areas $\geq 95\%$ along road and rail routes
Rate of good vocal quality	Locked mode (2G/3G)	Number of samples from calls lasting 2 minutes with a MOS greater than 2.5, out of the total number of samples.	$\geq 98\%$
Call drop rate		Ratio of the number of calls disconnected within 2 minutes to the total number of calls connected	$\leq 1.5\%$ in cities $\leq 5\%$ on the main roads

Table 3. Shows the reference thresholds and requirements for the SMS service.

Indicator	Measurement method	Definitions	Obligations
Accessibility rate		Number of SMS messages sent in less than 5 seconds out of the total number of SMS messages sent	$\geq 98\%$
Rate of SMS messages received without errors	Locked mode (2G/3G)	Number of SMS messages received without error out of the total number of SMS messages sent	$\geq 98\%$
Rate of received text messages		Ratio of the number of text messages received in less than 30 seconds to the total number of text messages sent	$\geq 98\%$

recording the metrics used to assess the quality of the SMS service (delivery rate, rate of error-free messages received, and overall message delivery rate). The interval between two consecutive SMS messages must be at least 15 seconds.

4) Data Services

For data, three types of services are evaluated: web browsing, file uploads and

downloads, and video streaming.

Web browsing: Web browsing metrics are collected via the HTTP service and are used to assess the accessibility of the web service, display quality, and page load speed. The websites in question are:

Google: <https://www.google.com/>

Uploading/downloading files: FTP service quality measurements involve connecting to FTP servers hosted on the internet and then downloading and uploading files (2 MB/1 MB for 3G and 10 MB/5 MB for 4G) at each measurement point.

Streaming: One way to measure streaming performance is to connect to a standard streaming server for one minute and establish a connection with the media server (YouTube).

Table 4. Shows the reference thresholds and requirements for 3G/4G data services.

Indicator	Measurement method	Definitions	Obligations
Accessibility rate	3G Locked Mode	Number of successful DATA connections within 15 seconds divided by the number of DATA connection attempts	≥98% in cities
	4G Locked Mode	Number of successful DATA connections completed in less than 7 seconds divided by the number of DATA connection attempts	≥95% on major roads
Percentage of successful DATA operations of acceptable quality	3G Locked Mode	Number of successful 3G downlink downloads with an average data rate exceeding 1 Mbit/s and successful uplink uploads with an average data rate exceeding 300 Kbit/s, out of the total number of samples	>90%
	4G Locked Mode	Number of successful 4G downlink downloads with an average speed exceeding 4 Mbit/s and successful uplink uploads with an average speed exceeding 512 Kbit/s out of the total number of samples	

3. Results and Discussion

3.1. Analysis of 3G/4G Mobile Network Coverage in the Eight Administrative Regions

The analysis of 3G/4G mobile network coverage aims to determine the coverage of the eight administrative regions using the Atlas Guinée tool [15].

3.1.1. Analysis of 3G Mobile Network Coverage

The figure below shows the 3G network coverage rates in the eight regions identified by the Atlas Guinée tool. The ARPT has established that the benchmark threshold in urban areas must be ≥90% for Cellcom, 80% for Orange, and 65% for MTN for 3G (see **Table 1**).

An analysis of **Figure 2** shows that Orange's 3G coverage rate meets the threshold in the administrative regions of Conakry, Labé, and Nzérékoré, with coverage rates of 85%, 98%, and 80%, respectively. However, Orange does not meet this criterion in the other five regions (Boké, Kindia, Mamou, Faranah, and Kankan). For its part, the operator Cellcom has coverage rates that are significantly below the benchmark threshold in all eight regions. As for MTN, it meets the threshold

only in the Conakry region. In terms of coverage, Orange ranks first, followed by MTN and then Cellcom.

3.1.2. Analysis of 4G Mobile Network Coverage

Figure 3 shows the 4G network coverage rate. The ARPT has set the benchmark threshold in urban areas at $\geq 90\%$ for Cellcom, 70% for Orange, and 65% for MTN (see **Table 1**).

An analysis of **Figure 3** shows that Orange is the only operator to meet the benchmark thresholds in the Conakry region, with a coverage rate of 76% . Furthermore, it is the only operator to have deployed 4G technology in all eight administrative regions, with the lowest coverage rate in Kankan (7%). In contrast, MTN has deployed 4G only in the Conakry region, with a coverage rate of 59.80% , while Cellcom has not yet deployed 4G in Guinea. In the Conakry region, where Orange meets the standards, users enjoy reliable 4G access, allowing them to download files, browse the Internet, or receive multimedia content. Outside of Conakry, access to data services remains limited for Orange. In terms of coverage rates, Orange leads the pack, followed by MTN.

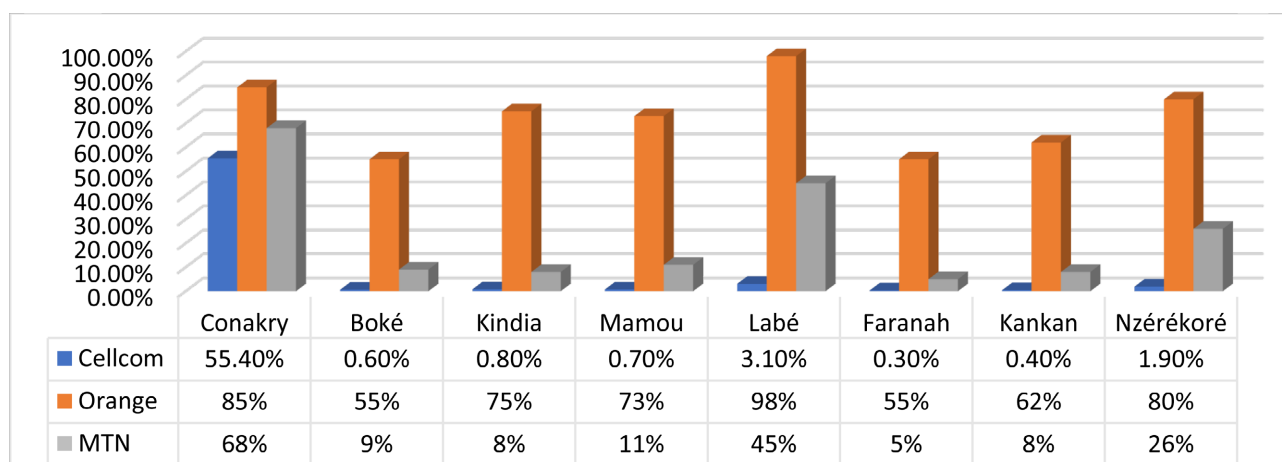


Figure 2. 3G coverage rates in the 8 administrative regions.

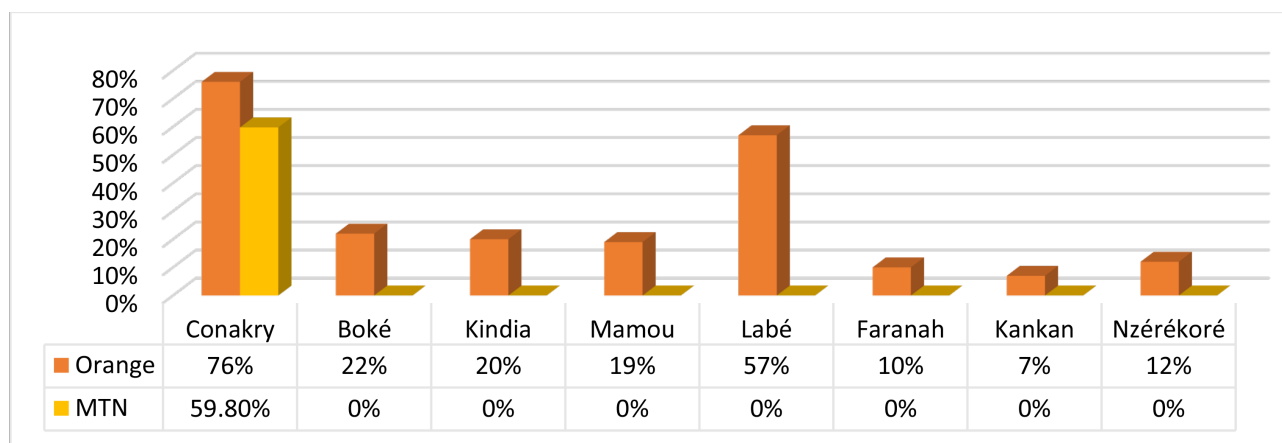


Figure 3. 4G coverage rates in the 8 administrative regions.

The quality of service of 3G/4G mobile networks in the eight administrative regions

For the service quality analysis, the objective is to use the Atlas Guinea tool to assess the compliance of call and SMS reception rates, as well as download speeds, across the eight regions.

3.1.3. Percentage of Calls Received from the 3G Network

Figure 4 shows the call pickup rate for the 3G network. The ARPT has specified that this rate must be $\geq 98\%$ (see Table 2).

The results shown in Figure 4 reveal that Orange and MTN meet the benchmark for incoming call rates in all eight administrative regions. Cellcom, however, fails to meet this benchmark only in the Kindia region.

Overall, Orange leads the pack with an incoming call rate of nearly 100%, followed by MTN, while Cellcom ranks third.

3.1.4. Percentage of Text Messages Received via the 3G Network

Figure 5 shows the SMS delivery rate for the 3G mobile network. The ARPT has specified that this rate must be $\geq 98\%$ (see Table 3).

The results in Figure 5 show that all three operators meet the benchmark

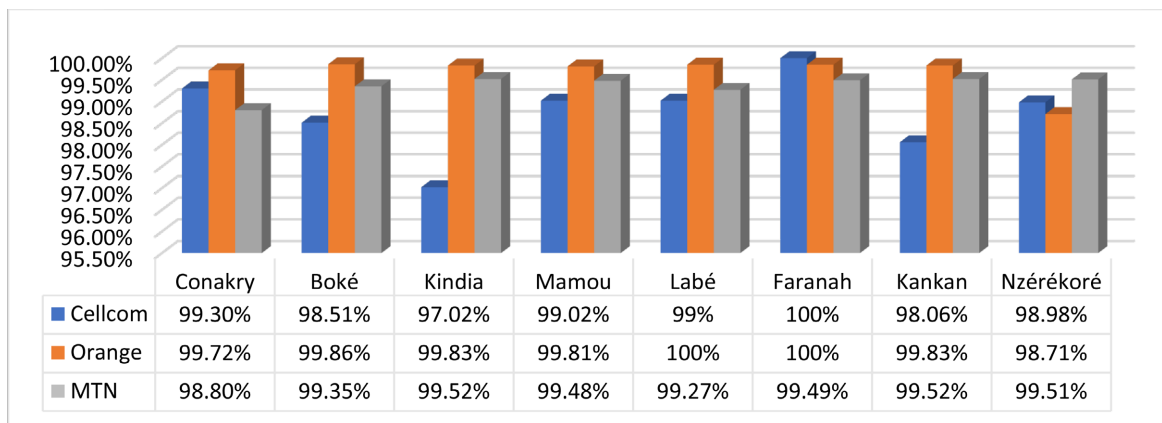


Figure 4. Percentage of calls received from the 3G mobile network in the 8 regions.

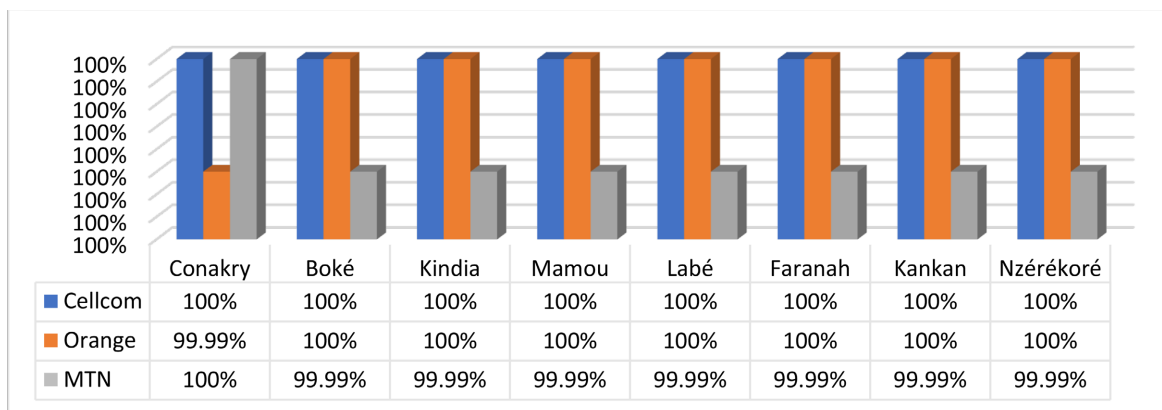


Figure 5. Percentage of text messages received via the 3G mobile network in the 8 regions.

threshold for SMS delivery rates in all eight administrative regions. Users have no issues sending or receiving SMS messages. In terms of 100% SMS delivery rates, Cellcom ranks first, followed by Orange, while MTN ranks third.

3.1.5. 3G Network Download Speed

Figure 6 shows the download speeds of the 3G network, which are ≥ 1 Mbps on the downlink and 300 kbps on the uplink (see Table 4). The data presented in this figure are in kbps.

The results in Figure 6 show that only Orange meets the benchmark for 3G download speeds across all eight administrative regions. Orange achieves speeds of around 2 Mbit/s in all regions, while Cellcom fails to meet this benchmark in Faranah. As for MTN, it does not meet this threshold in Kindia, Mamou, and Nzérékoré. These results indicate that Orange offers a higher-quality data service to users than its competitors. Consequently, Orange ranks first, followed by Cellcom, while MTN comes in third place.

3.1.6. 4G Network Download Speed

Figure 7 shows the 4G network download speeds of ≥ 4 Mbps on the downlink

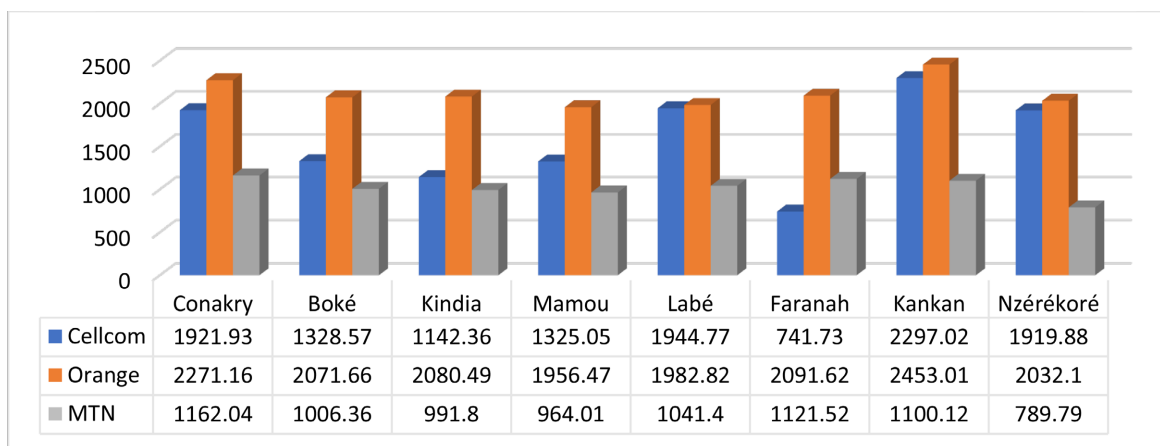


Figure 6. 3G network download speeds across the 8 regions.

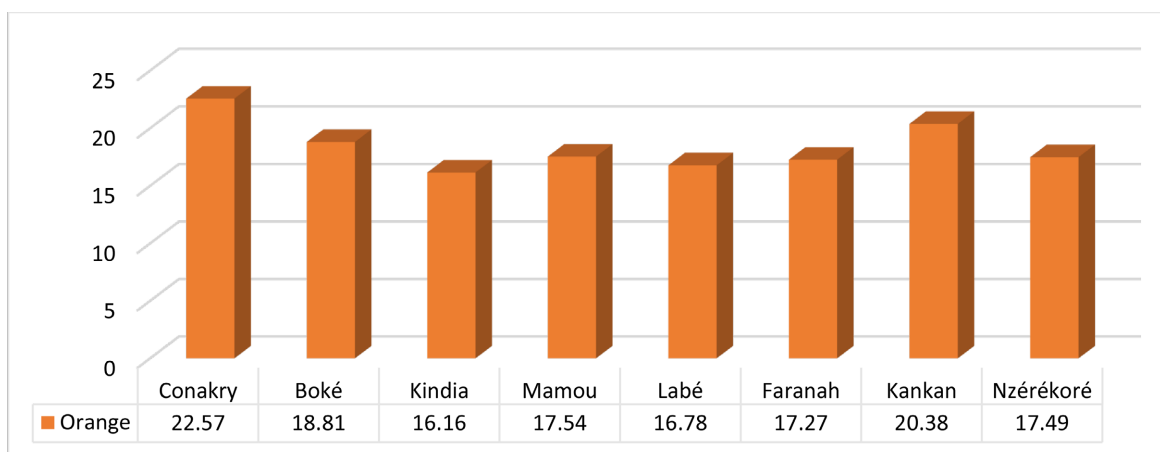


Figure 7. 4G network download speeds across the 8 regions.

and 512 kbps on the uplink (see **Table 4**). The data presented in this figure are in Mbps.

The results in **Figure 7** show that the operator Orange not only meets the benchmark for download speeds in all eight administrative regions, but also delivers strong performance, with speeds ranging from 16.16 to 22.57 Mbit/s. However, although the operator MTN has deployed 4G in Conakry, data on download speeds in this area are not available.

3.2. Network Coverage in Guinea

The analysis of 3G/4G network coverage speeds aims to identify the rate at which data is transmitted and received in areas covered by these mobile networks. **Figures 8-10** illustrate the 3G/4G network coverage speeds in Guinea for the three mobile operators.

Figure 8 shows the network coverage rate for the operator Cellcom.

Figure 8 shows that the operator Cellcom provides network coverage speeds ranging from 0 to 1 Mbit/s, primarily in Conakry. These results indicate that Cellcom's performance remains poor in Guinea.

Figure 9 shows the network coverage rate for the operator Orange.

An analysis of **Figure 9** reveals that Orange offers acceptable coverage speeds, ranging from 0 to 80 Mbit/s, particularly from 20 to 80 Mbit/s in city centers. This result shows that Orange combines 3G and 4G technologies to ensure good coverage.

Figure 10 shows the network coverage rate for the operator MTN.

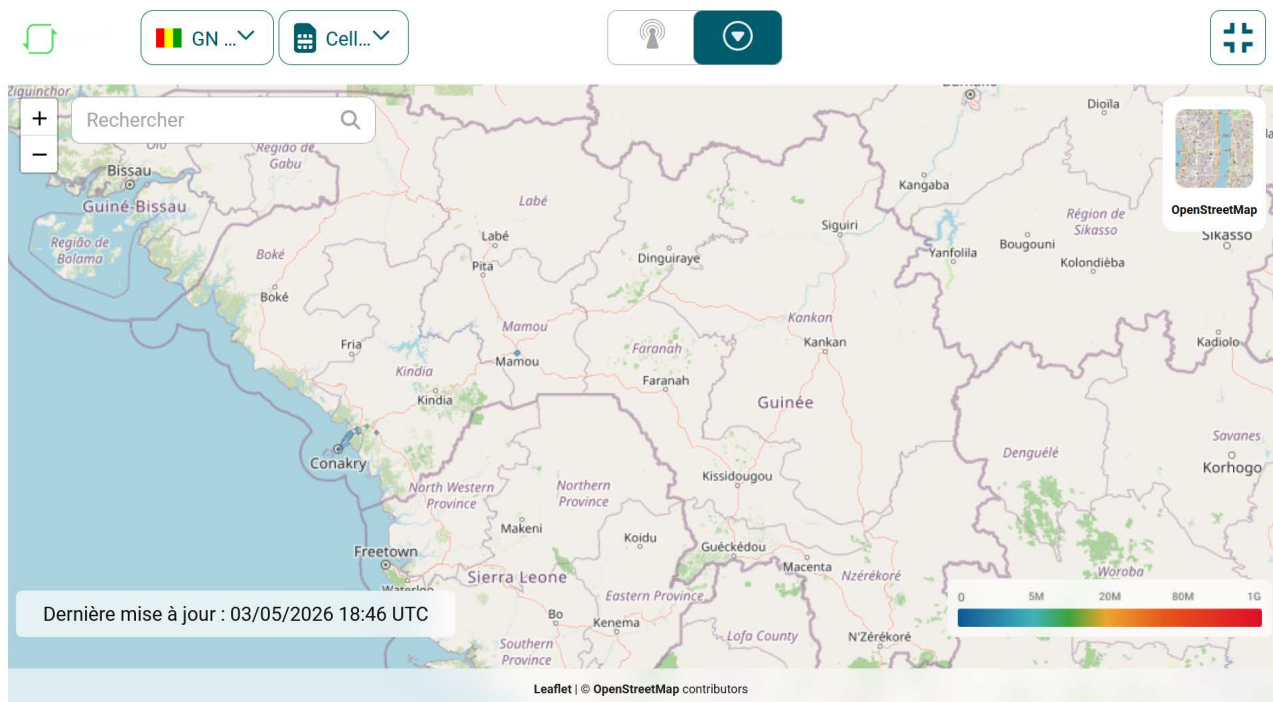


Figure 8. Network coverage speed for the operator Cellcom [16].

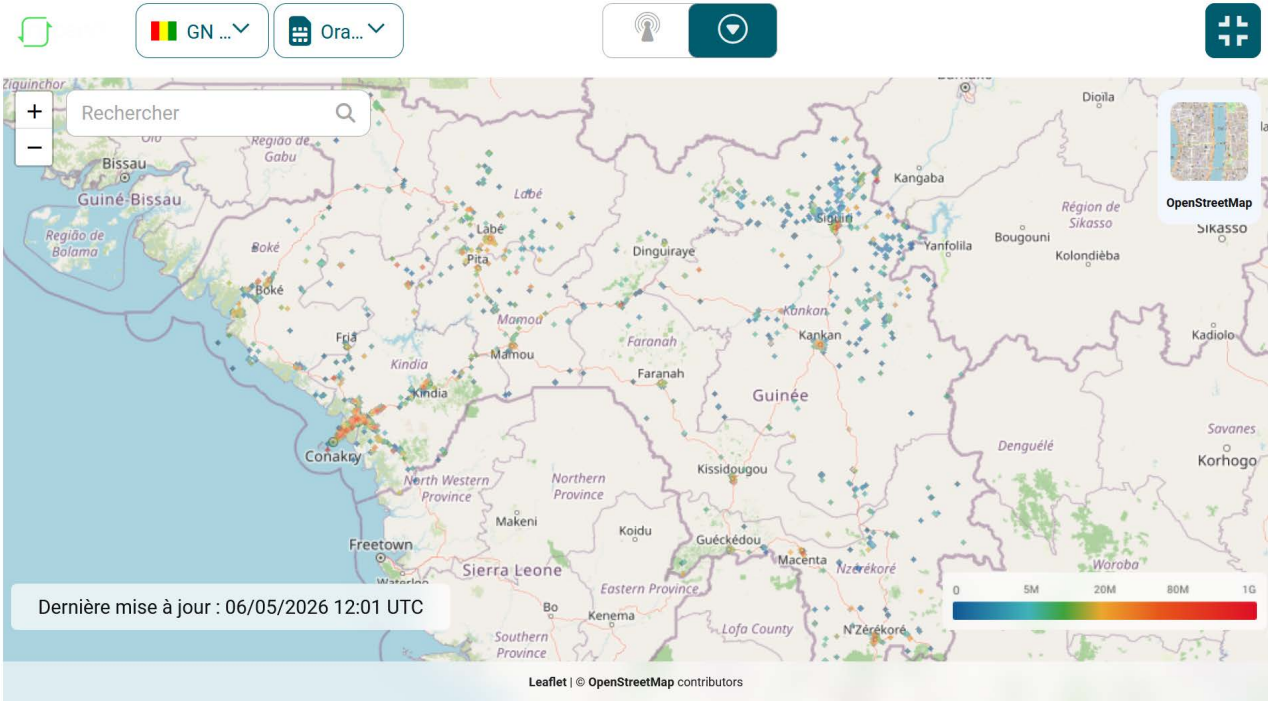


Figure 9. Network coverage speed for the operator Orange [16].

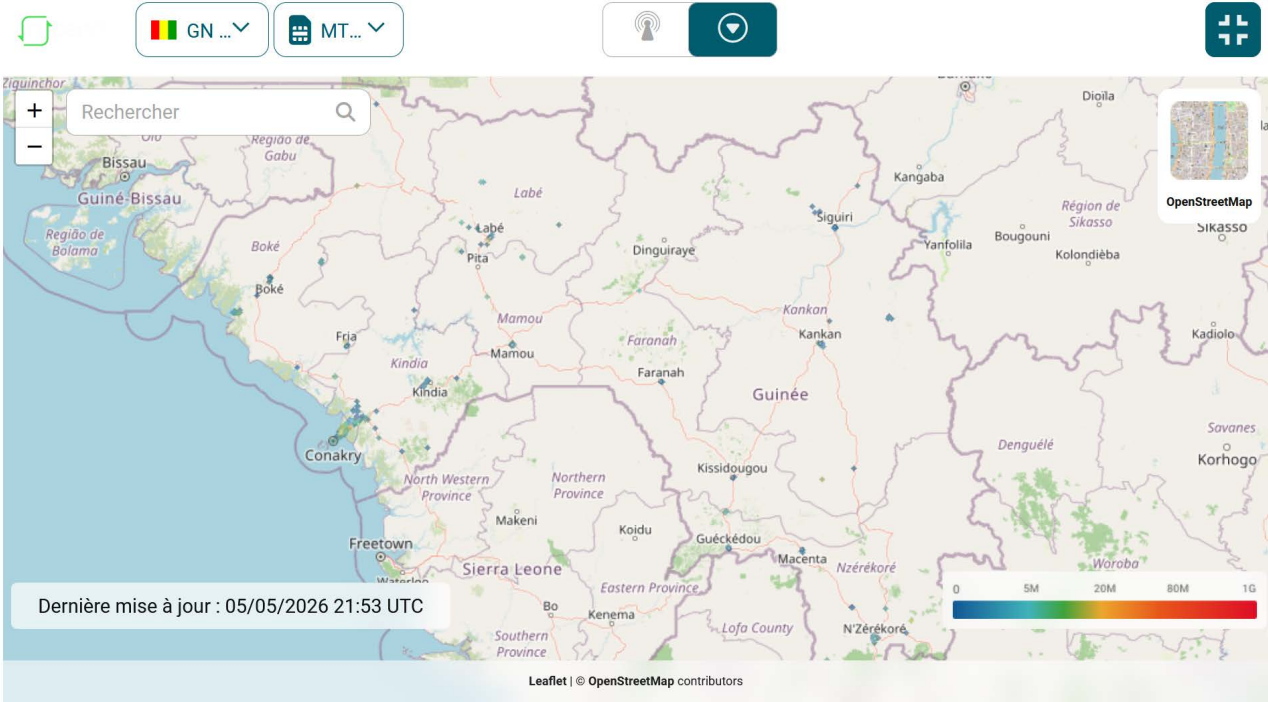


Figure 10. Network coverage speed for the operator MTN [16].

A look at **Figure 10** shows that MTN’s network coverage throughput remains limited, ranging from 0 to 20 Mbit/s, and specifically from 5 to 20 Mbit/s in the Conakry area.

These results indicate that Cellcom relies solely on 3G technology, while Orange combines 3G and 4G technologies. For its part, MTN also uses both 3G and 4G (4G only in the Conakry area).

In terms of mobile internet coverage and user experience—characterized by fast and seamless browsing for users—Orange ranks first, followed by MTN, while Cellcom comes in third. These results are consistent with the data published by Atlas Guinea.

4. Conclusions

The objective of this study is to evaluate the performance of 3G and 4G mobile networks in the Republic of Guinea in accordance with regulatory standards. It provides a detailed analysis of network coverage as well as the quality of service (QoS) offered to subscribers. This study also makes it possible to verify whether operators are meeting the commitments outlined in their service specifications. The measurements were taken using the Atlas and nPerf tools and then analyzed using Excel.

The results show that, for 3G technology, the operator Orange meets the benchmark in the regions of Conakry (85%), Labé (98%), and Nzérékoré (80%). In the other five regions, this criterion is not met. In contrast, the operator Cellcom has coverage rates significantly below the benchmark in all eight regions. As for MTN, it meets the benchmark only in the Conakry region. For 4G, Orange is the only operator to meet the benchmark in the Conakry region, with a coverage rate of 76%. It is also the only one to have deployed this technology in all eight administrative regions.

With regard to the quality of voice and SMS services, all three carriers meet the benchmark in all eight regions. In terms of 3G download speeds, they all meet the benchmark, but with varying levels of performance: Orange reaches nearly 2 Mbit/s, while MTN and Cellcom range from 700 Kbit/s to 1.9 Mbit/s. On 4G, only Orange meets the download speed threshold in all regions, with speeds ranging from 16.16 to 22.57 Mbit/s.

In terms of network coverage speeds, Cellcom remains limited to between 0 and 1 Mbit/s, mainly in Conakry. MTN reaches speeds of between 0 and 20 Mbit/s, while Orange delivers significantly higher performance, ranging from 0 to 80 Mbit/s. These findings reveal a significant imbalance in the market among mobile operators. Such a situation can only lead to a decline in quality of service (QoS). To address this, the Regulatory Authority for Post and Telecommunications (ARPT) must take strong measures to restore competitive balance and drive overall service improvements.

The focus of this research is on the monitoring and automatic optimization of 4G mobile network performance in preparation for the future transition to 5G.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Abbreviations

ASS	Africa Sub-Saharan
ARPT	Postal and Telecommunications Regulatory Authority
CQI	Channel Quality Indicator
CSSR	Call Setup Success Rate
CDR	Call Drop Rate
FTP	File Transfer Protocol
GSMA	Global System for Mobile Communications Association
HTTP	Hypertext Transfer Protocol
KPI	Key Performance Indicator
MIMO	Multiple Input Multiple Output
QoS	Quality of Service
RSRP	Reference Signal Received Power
RSRQ	Reference Signal Received Quality
SNR	Signal-to-Noise Ratio