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Analysis of Dropped Call Rate for Long Term Evolution Networks in Bayelsa State, Nigeria

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***Abstract*—**This work attempts to effectively compare Dropped Call Rate (DCR) against industry benchmarks and competitor networks to identify areas for improvement and sets performance targets. Four mobile telecommunication networks operational in Bayelsa State Nigeria were considered. Results obtained shows that MTN and Airtel performed well within the regulator's benchmark of ≤ 1% in all cases, while Globacom and 9moblie had instances where their performance fell outside the benchmark. The maximum values obtained within the period in view was 18.52% and it was in March 2016 for Globacom while the least value recorded is 0.00% and it was in September 2018 for 9mobile. In the seven years period under review, MTN and Airtel performed within the Nigerian Communication Commission's (NCC) benchmark all through. This affirms that it is possible for the networks to perform optimally if adequate measures are put in place for improved Quality of Service (QoS).

***Keywords*—**Attempted calls, data, dropped call rate, handover failure rate, key performance indicator, mobile network.

I. Introduction

DCR is one of the numerous indexes used in measuring QoS in mobile telecommunication networks. It is a crucial metric in mobile telecommunication networks, representing the percentage of calls that get prematurely terminated or dropped before completion [1]. It is a key indicator of network quality and customer satisfaction. High DCR can lead to a poor user experience, impacting the reputation of the telecom operator [2]. Understanding the factors influencing DCR and implementing effective strategies to minimize it are critical for maintaining a reliable and efficient mobile network. Mathematically, DCR is calculated using the formula:

$$DCR = \left(\frac{Dropped\ Calls}{Total\ Attempted\ Calls}\right) \times 100 \quad (1)$$

From (1), it is seen that DCR is primarily made of two components; Dropped Calls and Total Attempted Calls:

1. Dropped Calls: Dropped calls in mobile telecommunication networks occur when a phone call is terminated prematurely, causing inconvenience to users and reflecting negatively on the network's QoS [3]. Understanding the causes, impact, and potential solutions for dropped calls is crucial for telecommunication operators to maintain a reliable and efficient network [2], [4]. There are various factors that cause Dropped Calls and they include poor signal quality, handover failures, network congestion, high network traffic, equipment or software failures, malfunctioning network equipment, call setup issues, roaming and interconnect issues [5]. Dropped Calls have far reaching impacts on the networks performance which includes customer dissatisfaction, financial loss, reduced network efficiency, and negative perception [6], [8]. However, there are viable avenues to reducing Dropped calls, these avenues include network optimization, handover optimization, capacity planning, advanced technologies, regular maintenance, QoS monitoring etc. [7], [9].
2. In mobile networks, the term "total attempted calls" refers to the total number of user-initiated call setup attempts made during a given period of time. This measure offers important information about the capability, effectiveness, and efficiency of the network in managing voice communication services [10]. Call setup is a multi-step process that begins with the caller placing the first call. In addition to allocating resources and processing the call request, the network also creates a communication channel between the calling and receiving parties. If it is successful, the call is connected; if not, there could be a call failure for a number of reasons [11], [12]. Total Attempted Calls is influenced by a number of factors, including roaming, handovers, equipment problems, signal strength, and network congestion [10].

In general, there are various factors that can influence DCR in a mobile telecommunication network and they include Coverage Issues, Handover Failures, Interference and Signal Quality, Capacity Constraints, Equipment and Network Failures, Call Setup Failures etc [9], [13].

II. Previous Related Studies

Nigeria's mobile phone industry has seen significant growth over the years in terms of improved coverage and accessibility. More fascinating is the exponential increase in the numbers of internet users in Nigeria, in 2015 there were about 42.84 million internet users but in 2020 the number has grown to 96.84 million which is above 100% growth [14], [15]. Despite the obvious expansion, QoS is still a problem. According to [16], increased Handover Failure Rate (HOFR) and inadequate network availability both within the communities and even when relocating were the main causes of the poor QoS. Reference [17] stated that the Call Setup Success Rate, Call Setup Failure Rate (CSFR), DCR and

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HOFR were the most important Key Performance Indicators (KPIs) used in ascertaining the efficiency of LTE network in terms of the QoS rendered. One of the most significant KPIs used by all mobile operators is the Drop Call Rate; however, since there is no standard way to measure this parameter, different operators may use different approaches [18]. According to [19], most network issues arise from growing subscriber numbers and changing environmental conditions because of subscriber mobility and the intricacy of radio wave propagation. With the evolution of the network, RF optimization is an ongoing process that is necessary. Using the resources that are currently available, RF optimization is done to increase network performance. The authors of [20] described the calculation of DCR as the result of the division of Call Attempt data (number of calls entered during the observation period) divided by Call Drop during the observation and multiplied by 100 so that the data collected in the form of percentage refer to the KPI. The authors of [21] described Dropped Call as the inability of a mobile user's call to connect through the network successfully. It is also the abrupt disconnection of a call after the allocation of a channel [22]. Over the years, the number of subscribers has greatly improved but the QoS did not improve as many subscribers were not happy with the services provided [23]

III. Materials and Method

This study examines the DCR of four mobile network providers in Bayelsa State, Nigeria and conducts a comparative assessment to determine which network has the least DCR. Cellular networks analysed include MTN, Airtel, Globacom, and 9mobile. Materials used are:

1. Manager M2000 File Transfer Protocol (FTP): This distributed network file system standardizes file access and management through the use of an OSI application Layer 7 protocol. It defines and unifies the data file into a single protocol standard for both file transfer and remote file access. It served as a tool for network data collection.
2. Microsoft (MS) Excel tool box: This was employed to plot the data values to make the investigation's findings easier to comprehend and interpret.

The study employs a methodology that entails a systematic approach to gather data from the Management Centres of the four operational mobile networks. The steps are as follows:

a. Data Analysis: Primary data from all the Base Station Controllers (BSCs) in the State served as the basis for the analysis. Following that, a data set analysis was done to look into the QoS performance for every place under study. The Manager M2000 File Transfer Protocol was deployed at the Network Management Switching (NMS) to pull data from the network.
b. Determination of Average DCR: The average variable used in this study was previously assessed using the unprocessed data set that was acquired from the NMS. Using the MS-Excel toolbox, the monthly total average of DCR was determined on a daily basis for a month. A high DCR could have several causes [22], some of which include the following:

i. Network Congestion: A higher drop call rate may result from network congestion, which can happen during peak hours or in densely populated areas. Dropped connections could occur from the network's inability to handle the volume of calls [24].
ii. Low Signal Strength: One of the main causes of missed calls is a weak signal. This may occur as a result of things like physical barriers (buildings, mountains, etc.), interference from other electronic devices, and the distance from the cell tower [21].
iii. Handover Failures: When a user moves, mobile devices frequently switch between various cell towers. The call might be dropped if there is a problem with the handover between the towers. This may occur as a result of problems with the handover algorithms or insufficient communication between adjacent cells [25].
iv. Interference and Noise: Dropped calls can result from signal disruption caused by radio frequency interference, other electronic devices, or ambient environmental factors [26]. Electrical equipment, power lines, and even air conditions can cause interference.
v. Problems with Network Equipment: A high drop call rate may be caused by malfunctions or incorrect configurations in network equipment, including switches, routers, and base stations [26]. It takes routine upkeep and observation to spot and quickly fix such problems.
vi. Capacity Limitations: Dropped calls may occur if the mobile network infrastructure is unable to manage the volume of data traffic or concurrent calls [21]. It might be required to increase network capacity by installing more cell towers or modernizing existing equipment.
vii. Software Bugs and Glitches: Dropped calls may result from software problems with mobile devices or network components. In order to fix bugs and glitches that could affect call stability, regular software updates and maintenance are essential.
viii. Subscriber Overload: A high drop call rate may result from a specific cell tower serving more users than it was intended to. This overload may occur during events where a large number of people are concurrently using the network or in densely populated urban areas [25].
ix. Inadequate Backhaul Capacity: In order to support the traffic, the backhaul links that connect cell towers to the core network must be large enough. Inadequate backhaul capacity may lead to missed calls and deteriorated service quality [12].
x. Device-related Issues: Dropped calls may be caused in part by the mobile device itself. This covers problems with the hardware, software, or network compatibility of the phone. Call drops may occur as a result of outdated firmware, malfunctioning parts, or incompatible settings [3].

The QoS results from this paper's study were evaluated through performance analysis, with DCR serving as an index. For every one of the four network operators under examination, the performance index values were plotted on graphs for the months of January through December in the

following years: 2015, 2016, 2017, 2018, 2019, 2020, and 2021. The benchmark value set by the NCC was used to compare these measured values. The NCC has the authority to set minimum QoS requirements for the telecom sector's service delivery. Because all operators must meet these fundamental minimum quality standards in order to continue operating, these QoS standards guarantee that customers will always have access to high-quality telecommunications services [4]. Table I shows the KPI benchmarks in Nigeria in accordance with NCC´s regulation.

TABLE I
KPI BENCHMARKS IN NIGERIA

KPI	Benchmark Value
CSSR	≥ 98%
DCR	≤ 1%
SDCCH	≤ 0.2%
TCCH	≤ 2%

IV. Result Analysis

Bayelsa`s DCR has been Calculated for the four network operators under review (Airtel, 9mobile, Globacom, and MTN), the values obtained are as shown in Table II for 2015. Fig. 1 compares the values obtained for the four network operators in 2015.

TABLE II
2015 YENAGOA'S DCR VALUES

Month	Airtel	9mobile	Globacom	MTN
Jan'15	0.64	0	0.97	0.3
Feb'15	0.78	0.79	0.98	0.33
Mar'15	0.67	0.68	1.12	0.36
Apr'15	0.39	0.88	0.73	0.37
May'15	0.37	0.98	0.74	0.39
Jun'15	0.38	1.07	0.43	0.4
Jul'15	0.33	1.08	0.11	0.42
Aug'15	0.35	0.96	0.13	0.39
Sep'15	0.39	1.16	0.12	0.39
Oct'15	0.46	0.96	0.12	0.39
Nov'15	0.43	0.9	5.18	0.38
Dec'15	0.45	1.2	8.74	0.35

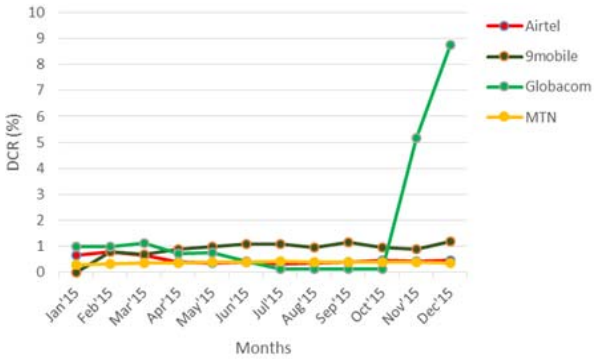

Fig. 1 Plot of DCR against Months in 2015

In 2015, Globacom had the highest DCR with its average values well above NCC's benchmark of 1% in the months of November and December. The other three networks under consideration had their average values within the NCC's benchmark except in few months where 9mobile's DCR values exceeded 1%. MTN and Airtel had their values while below the benchmark all through the year while MTN had the most stable average values. Table III shows the average values obtained in 2016 while Fig. 2 is a plot of DCR against months in 2016.

TABLE III
2016 YENAGOA'S DCR VALUES

Month	Airtel	9mobile	Globacom	MTN
Jan'16	0.42	0.98	16.99	0.43
Feb'16	0.32	0.72	10.27	0.46
Mar'16	0.3	0.85	18.52	0.21
Apr'16	0.29	0.64	5.87	0.24
May'16	0.33	0.77	5.51	0.19
Jun'16	0.33	0.69	5.63	0.18
Jul'16	0.34	0.68	2.59	0.19
Aug'16	0.5	0.76	1.05	0.22
Sep'16	0.33	0.68	0.95	0.18
Oct'16	0.29	0.74	0.97	0.2
Nov'16	0.3	0.69	0.87	0.24
Dec'16	0.29	0.74	1.05	0.15

Fig. 2 Plot of DCR against months in 2016

In 2016, Globacom's average DCR values were so high above the NCC's benchmark value of 1% in the first six months of the year, however it was below the benchmark from August to December even though it still remained the least performing network. The other three networks, Airtel, 9mobile and MTN, were very stable and performed within the allowed threshold though MTN was the most stable of them. Table IV shows the average values obtained in 2017 while Fig. 3 is a plot of DCR against months in the same year.

MTN and Airtel had their values well below the NCC's benchmark in 2017 while 9mobile and Globacom had instances where their values exceeded the benchmark. Globacom however had the most erratic values with December well out of control. While Airtel showed an impressive improvement, MTN maintains the best values across board. Table V shows the average values obtained in 2018 while Fig. 4 is a plot of DCR against months in 2018.

TABLE IV
2017 YENAGOA'S DCR VALUES

Month	Airtel	9mobile	Globacom	MTN
Jan'17	0.3	0.56	1.06	0.12
Feb'17	0.42	0.58	0.85	0.13
Mar'17	0.3	0.64	0.95	0.13
Apr'17	0.37	0.71	0.94	0.15
May'17	0.36	0.78	1.05	0.16
Jun'17	0.35	1.12	0.95	0.17
Jul'17	0.33	1.31	0.88	0.29
Aug'17	0.36	0.92	0.88	0.28
Sep'17	0.3	0.82	0.81	0.19
Oct'17	0.38	0.76	0.88	0.17
Nov'17	0.43	1.2	1.05	0.2
Dec'17	0.46	2.2	1.14	0.16

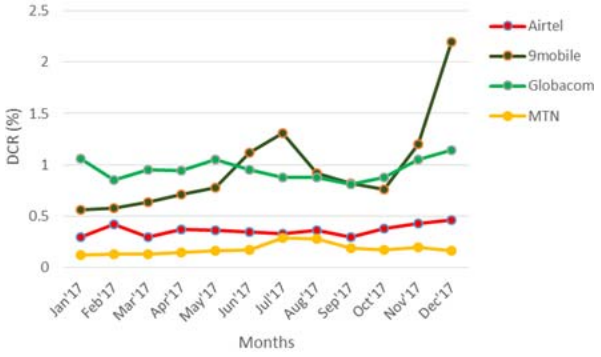

Fig. 3 Plot of DCR against Months in 2017

TABLE V
2018 YENAGOA'S DCR VALUES

Month	Airtel	9mobile	Globacom	MTN
Jan'18	0.39	0.67	1.41	0.17
Feb'18	0.31	1.31	1.44	0.14
Mar'18	0.31	0.89	0.21	0.12
Apr'18	0.39	1.86	0.8	0.13
May'18	0.32	1.43	0.84	0.12
Jun'18	0.21	3.02	1.03	0.19
Jul'18	0.37	2.27	0.77	0.15
Aug'18	0.27	0.5	1	0.04
Sep'18	0.31	0	0.65	0.14
Oct'18	0.34	1.03	1.25	0.14
Nov'18	0.32	0.94	1.14	0.13
Dec'18	0.33	0.76	1.63	0.12

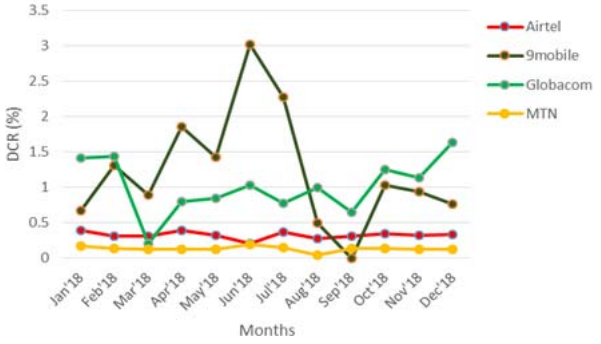

Fig. 4 Plot of DCR against Months in 2018

In 2018, the DCR values for MTN and Airtel maintained consistency and were well within the NCC's benchmark but Globacom and 9mobile values continue to be erratic and very inconsistent. 9mobile performed outside the threshold consistently from April to July with a worst-case value of 3%. MTN continued to maintain best average and most stable values. Table VI shows the average values obtained in 2019 while Fig. 5 is a plot of DCR against months in the same year.

TABLE VI
2019 YENAGOA'S DCR VALUES

Month	Airtel	9mobile	Globacom	MTN
Jan'19	0.31	1.37	1.27	0.12
Feb'19	0.35	1	1.1	0.1
Mar'19	0.33	1.58	0.91	0.09
Apr'19	0.31	1.05	0.99	0.1
May'19	0.34	1.02	0.96	0.12
Jun'19	0.35	0.52	0.91	0.09
Jul'19	0.36	1.97	0.93	0.09
Aug'19	0.34	0.81	0.86	0.08
Sep'19	0.24	0.64	0.87	0.09
Oct'19	0.29	0.76	0.89	0.09
Nov'19	0.28	1.04	0.97	0.11
Dec'19	0.25	0.87	0.85	0.09

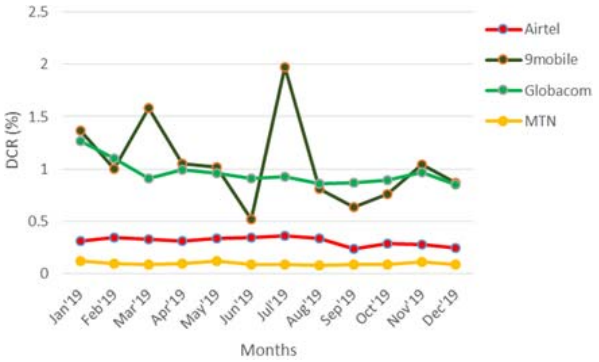

Fig. 5 Plot of DCR against Months in 2019

TABLE VII
2020 YENAGOA'S DCR VALUES

Month	Airtel	9mobile	Globacom	MTN
Jan'20	0.43	0.42	0.47	0.41
Feb'20	0.6	0.62	0.41	0.39
Mar'20	0.5	0.48	0.37	0.42
Apr'20	0.48	0.44	0.39	0.44
May'20	0.53	0.49	0.39	0.46
Jun'20	0.27	0.62	0.31	0.11
Jul'20	0.31	1.01	0.29	0.11
Aug'20	0.25	0.78	0.27	0.1
Sep'20	0.25	1.01	0.26	0.1
Oct'20	0.32	0.81	0.27	0.11
Nov'20	0.25	1.04	0.27	0.11
Dec'20	0.27	1.13	0.29	0.10

In 2019, MTN had superior average values with a maximum of 0.12% throughout the year while 9mobile recoded the highest value of 1.97% in July. 9mobile and Globacom showed a wide margin of data variation while MTN showed a slight variation in data values all through the year. Table VII shows the average values obtained in 2020 while

Fig. 6 is a plot of DCR against months in the same year.

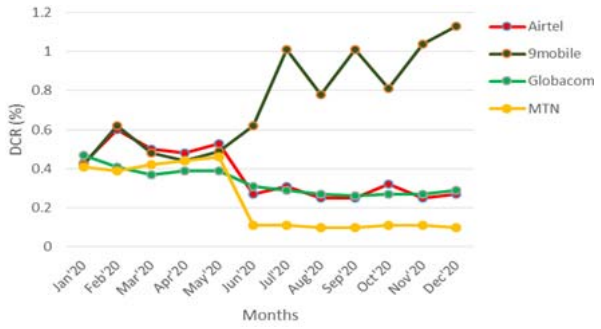

Fig. 6 Plot of DCR against Months in 2020

In 2020, the four networks performed very well with average values below the NCC's benchmark except in November and December where 9mobile' values exceeded 1%. However, a wide margin of data variation was noticed as compared to other years. MTN had the best values of 0.10 % while 9mobile has the worst value of 1.13%. Table VIII shows the average values obtained in 2021 while Fig. 7 is a plot of DCR against months in the same year.

TABLE VIII
2021 YENAGOA'S DCR VALUES

Month	Airtel	9mobile	Globacom	MTN
Jan'21	0.21	0.89	0.25	0.09
Feb'21	0.21	0.66	0.43	0.09
Mar'21	0.21	0.7	0.23	0.08
Apr'21	0.11	1.17	0.27	0.11
May'21	0.11	1.17	0.27	0.11
Jun'21	0.22	0.95	0.29	0.09
Jul'21	0.15	1.54	0.25	0.09
Aug'21	0.15	0.64	0.27	0.08
Sep'21	0.25	1.53	0.23	0.08
Oct'21	0.27	0.98	0.2	0.09
Nov'21	0.16	1.04	0.25	0.08
Dec'21	0.1	0.92	0.27	0.09

Fig. 7 Plot of DCR against Months in 2021

In 2021, 9mobile despite having the most erratic average values was also the only network which performed outside the threshold. MTN, Airtel and Globacom showed a high level of stability though MTN was the most stable of them.

V. CONCLUSION

This study deals with comparing DCR against industry benchmarks and competitor networks for the purpose of identifying areas for improvement and sets performance targets. Four mobile networks operational in Bayelsa State Nigeria were investigated. From the data obtained, the four networks performed well with the benchmark set by the regulating body, Nigeria Communication Commission, however there is room for improvement as some of the networks had instances where their performance fell outside the benchmark. Data from MTN were superior among the four networks and had the least variation within the period of investigation (2015-2021). Airtel's data were well within the benchmark all through the period under review and its variation was relatively small. The data from Globacome and 9mobile had wide ranges of variations and had instances where it fell outside the benchmark, which call for improvement in order to maintain good QoS and customer satisfaction. The maximum value of DCR recorded in the 7 years period under review is 18.52% and it was in March 2016 for Globacom while the least value recorded is 0.00% and it was in September 2018 for 9mobile. In the seven years period under review, MTN and Airtel performed within the NCC's benchmark all through. This affirms that it is possible for the networks to perform optimally if adequate measures are put in place for improved QoS.

VI. RECOMMENDATIONS

Enhancing the DCR in mobile networks is essential to guaranteeing users a dependable and smooth communication experience. It is imperative to put into practice the following recommendations, which address various facets of network performance, in order to guarantee optimal DCR:

1. Network Optimization: To find and fix coverage gaps and signal interference, regularly audit your network. For improved coverage and signal strength, adjust the location of cell sites and the orientation of antennas. Use advanced radio frequency (RF) planning to cut down on interference and traffic.
2. Capacity Planning: Examine network traffic patterns to predict locations and times of peak usage. Expand the network's capacity in regions with high demand by adding new cells or modernizing the current infrastructure. Employ load balancing techniques to ensure that traffic is distributed uniformly among cells.
3. Spectrum management: To expand the bandwidth and support more users, purchase more spectrum if it becomes available. To increase data capacity, use carrier aggregation to merge several frequency bands.
4. Policies for QoS: Give voice traffic priority over data traffic to guarantee a higher QoS for voice calls. Adopt regulations that give essential voice services more funding during peak hours.
5. Handover Optimization: To guarantee seamless cell transitions and lower the possibility of dropped calls during handovers, optimize handover protocols. Put in

place algorithms that make intelligent handover choices according to user mobility, load, and signal quality.

6. Interference Management: Locate and eliminate interference sources, such as adjacent networks or other electronic devices. For better signal quality, apply cutting-edge interference cancellation techniques.
7. Fault Detection and Resolution: Put proactive monitoring systems in place to instantly identify abnormalities and faults in the network. Create quick response teams to handle problems quickly and reduce missed calls and downtime.
8. Equipment Maintenance: Keep base stations, antennas, and backhaul connections up to date and maintain them on a regular basis. Use predictive maintenance techniques to find possible problems early on and fix them before they affect service quality.
9. Roaming Agreements: To ensure that users' service is uninterrupted when they switch between networks, establish strong roaming agreements with other operators.
10. User Education and Feedback: Inform users about the best ways to keep a steady connection, like avoiding crowded places at rush hour. To pinpoint specific issue areas, ask users to report concerns about poor call quality, dropped calls, or areas with poor reception.
11. Emergency Services Priority: Establish systems to give emergency calls top priority and guarantee the best possible care in order to improve public safety.
12. Constant Monitoring and Analysis: Use cutting-edge analytics software to keep an eye on network performance and spot patterns. Make proactive use of machine learning algorithms to anticipate and resolve possible problems.

Implementing a combination of these recommendations can significantly enhance DCR and improve overall network reliability. Regular testing, monitoring, and optimization are essential for maintaining a high-quality mobile telecommunication network.

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