



Performance Analysis of Packet-switched Services in Cellular Networks

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Abstract This study provides an in-depth analysis of the Call Setup Success Rate (CSSR) for packet-switched services across Nigeria's four major mobile networks: MTN, Airtel, Globacom, and 9mobile. By examining 36 months of CSSR data, from January 2021 to December 2023, sourced from the Nigerian Communications Commission (NCC), the research explores both monthly and yearly network performance trends throughout Nigeria. The analysis, which utilizes graphs and bar charts, compares each network's performance to the NCC's established benchmarks. The findings reveal that while Airtel, MTN and Glo networks consistently met the NCC's standards, 9mobile occasionally fell below the benchmark, particularly in November 2021 and in April, June, and September 2022. This research also highlights the specific periods when each network recorded its highest performance, offering valuable insights into the consistency and reliability of packet-switched services across the country. These findings emphasize the need for ongoing monitoring and optimization of network performance to meet the growing demand for data services and to improve the overall quality of mobile communications in Nigeria. The outcomes of this study will be beneficial to mobile network operators, the NCC, and researchers alike.

Keywords Call Setup Success Rate, Packet Switch services, Cellular Networks, Key Performance Indicator

Introduction

In Nigeria, the cellular network industry has witnessed exponential growth and has become a cornerstone of the nation's economic and social fabric. As one of the largest and most dynamic markets in Africa, Nigeria boasts a subscriber base of over 200 million, with mobile communication serving as a primary mode of connectivity to both voice and data services [1]. The importance of reliable cellular network services cannot be overemphasized, particularly in a country characterized by a growing reliance on mobile technology for essential services, including education, healthcare and banking [2].

Among the various technologies underpinning mobile communication, packet-switched services play a critical role, especially in the context of cellular data transmission. Unlike circuit-switched networks, where a dedicated communication path is established for the duration of a call [3], packet-switched networks break down data into packets that are transmitted independently across the network and reassembled at the destination. This method of data transmission, which is fundamental to the operation of modern cellular networks, offers several advantages, including greater efficiency, flexibility, and scalability. However, the performance of packet-switched services can vary significantly based on several factors, such as network infrastructure, geographic location, and the time of day [4-5].

Given the rapid adoption of mobile internet and the increasing demand for data-intensive applications, there is an urgent need to continuously monitor and evaluate the performance of packet-switched services across the major



cellular networks in Nigeria. Key performance indicators (KPIs) such as Call Setup Success Rate (CSSR) are particularly useful metrics for assessing the reliability of these services [6]. The CSSR measures the efficiency of the network in establishing connections, reflecting the overall reliability of the network in handling call attempts [7]. It refers to the percentage of successfully established packet-switched connections for data services, such as internet browsing or multimedia content, out of the total attempted connections. This KPI assesses the network's effectiveness in initiating data connections using packet-switching technology [8-10].

Several researchers have made several attempts to evaluate packet-switched services. The authors in [11] introduced the architecture of Universal Mobile Telecommunications System (UMTS) packet switched (PS) network and then applied multivariate statistical analysis to the Key Performance Indicators (KPI) monitored from network entities to guide the long term capacity planning of the network. The approach proposed in this paper was helpful to mobile operators in operating and maintaining their 3G packet switched networks. In [12], the research aimed at analyzing the network output on 3G network that uses packet switching. The performance indices observed were the Received Signal Code Power (RSCP), the energy per chip to spectral noise density ratio, handover success rate, and throughput. These indices were used to examine the coverage, accessibility, and data throughput of the network. The researchers in [13] carried out an analysis on KPIs in 3G and 4G networks. Measurement campaign was carried out through drive test on three sites using a TEMS Pocket, by analyzing the RSRP and SINR on 4G networks as well as the RSCP and Ec/No on the 3G network. Average values of the RSRP and SINR on the 4G network were -102dBm and 8dB, respectively. The average values on the 3G network for the RSCP and Ec/No were -98dBm and -11dB, respectively. From the results obtained, the signal qualities on the 3G and 4G networks were bad owing to obstacles in the form of hills and trees.

This research focuses on the performance analysis of CSSR packet-switched services provided by the four largest cellular networks in Nigeria: MTN, Airtel, Globacom, and 9Mobile. By analyzing the collected data, this research aims to uncover trends, identify areas of strength and weakness within each network, and provide actionable insights that can be used to enhance the overall quality of mobile services in Nigeria.

Methodology

This study evaluates the CSSR performance of packet-switched services across four major mobile networks in Nigeria: MTN, Airtel, Glo, and 9mobile. The analysis is based on CSSR data collected from base stations across Nigeria's 36 states and the Federal Capital Territory (FCT) over a 36-month period, from January 2021 to December 2023.

Data Collection

The CSSR data was collected from NCC, which provided a comprehensive overview of network performance across Nigeria. This dataset includes monthly CSSR values for each of the four networks, allowing for a detailed examination of trends over time.

Data Analysis

The collected data was analyzed using graphical and statistical methods. Graphs and bar charts were plotted to visualize the monthly and yearly trends in CSSR for each network. These visual tools facilitated a clear comparison of network performance over the three-year study period. Additionally, the CSSR values were assessed against the NCC's benchmark to determine compliance and identify instances of underperformance.

Comparative Analysis

A comparative analysis was conducted to identify the strengths and weaknesses of each network. This involved comparing the CSSR performance across the four networks to determine which network provided the most reliable packet-switched services over the study period. The analysis also highlighted periods when networks exceeded or fell below the NCC benchmark, offering insights into the factors influencing network performance.

Results and Discussion

The performance analysis of CSSR packet switched services for UMTS networks for the four major networks in Nigeria has been carried out. This research was conducted based on their CSSR packet switched services. Results of this study are displayed in the form of graphs and bar charts below.



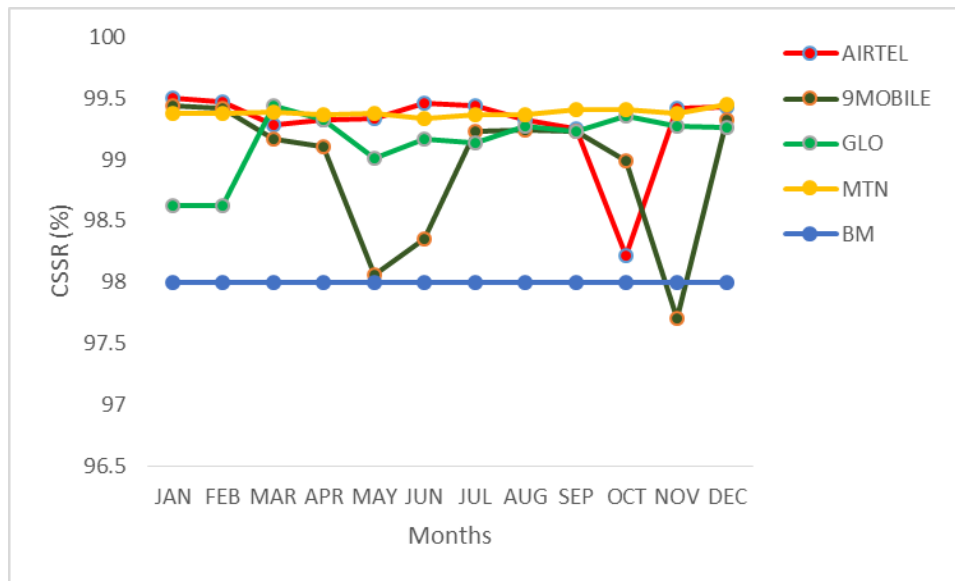


Figure 1: Monthly Call Setup Success Rate (CSSR) for Packet-Switched Services in 2021

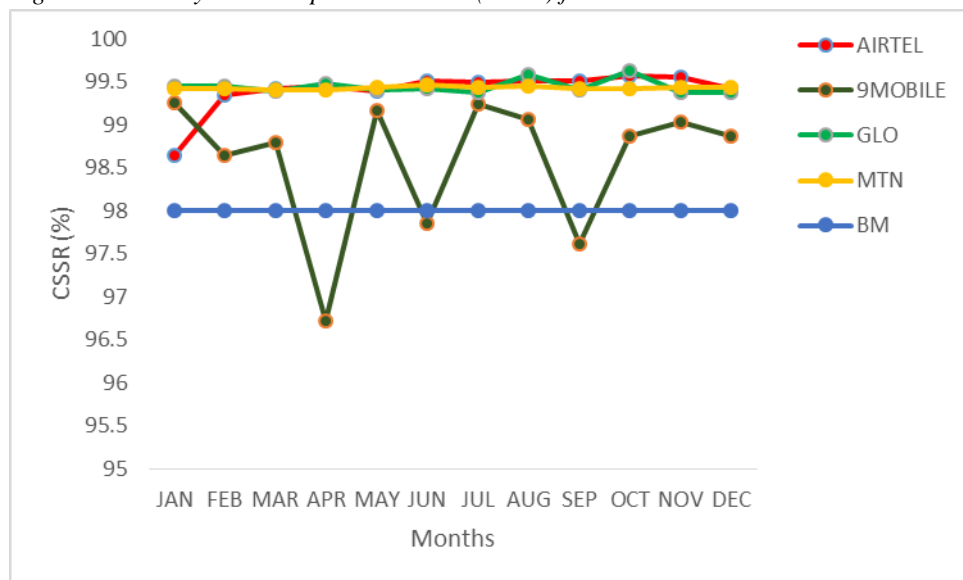


Figure 2: Monthly Call Setup Success Rate (CSSR) for Packet-Switched Services in 2022

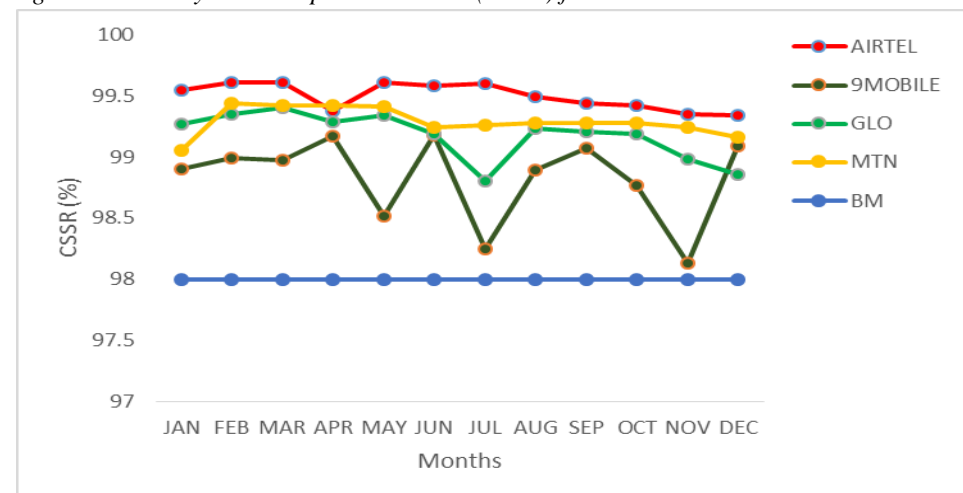


Figure 3: Monthly Call Setup Success Rate (CSSR) for Packet-Switched Services in 2023

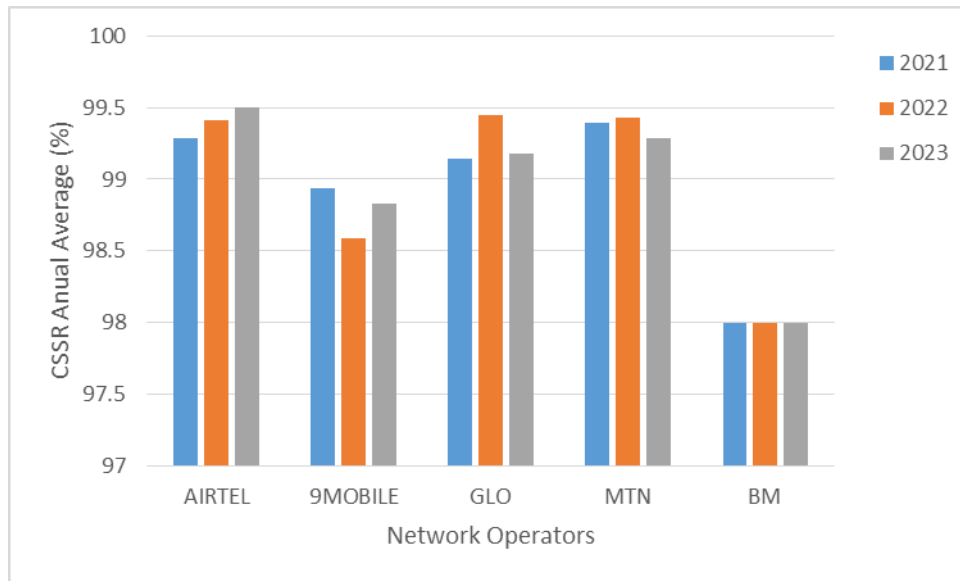


Figure 4: Yearly Call Setup Success Rate (CSSR) for Packet-Switched Services over the Study Duration

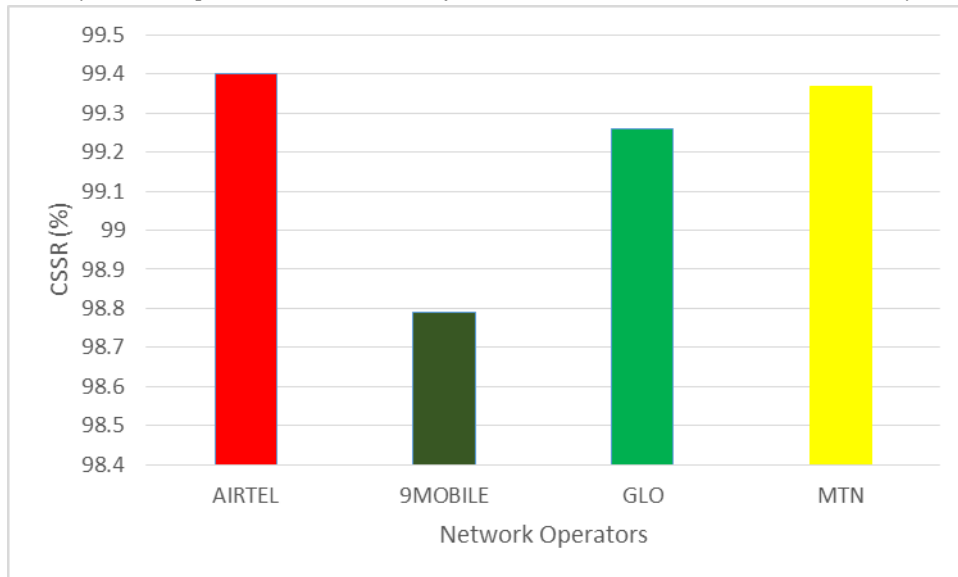


Figure 5: Average Call Setup Success Rate (CSSR) for Packet-Switched Services over the Study Duration

Figure 1 illustrates the monthly trend of the Call Setup Success Rate (CSSR) for packet-switched services in 2021. The graph indicates that 9mobile fell below the NCC benchmark in the month of November with the value 97.7%. Additionally, the best service performance for Airtel, 9mobile, Glo, and MTN occurred in January, February, March, and December, respectively, with values 99.5%, 99.42%, 99.44% and 99.45%.

Figure 2 depicts the monthly CSSR trend for packet-switched services in 2022. It shows that 9mobile did not meet the NCC benchmark in April, June, and September with values 96.72%, 97.86% and 97.62%, respectively. The peak performance for Airtel and Glo were recorded in October with the values 99.58% and 99.64%, respectively, while that of 9mobile and MTN were recorded in the months of January and June with values 99.26% and 99.47%, respectively.

Figure 3 presents the monthly CSSR trend for packet-switched services in 2023. According to the graph, all networks maintained services within the NCC recommended benchmark throughout the year. In 2023, 9mobile, Glo, and MTN achieved their best service in June, March, and February with values 99.18%, 99.4% and 99.44%, respectively. However, Airtel delivered its highest service quality in February, March, and May, with a CSSR value of 99.61%.



Figure 4 presents the yearly average CSSR for packet-switched services in a bar chart. The results indicate that in 2021, MTN provided the best packet-switched services, with Airtel, Glo, and 9mobile following in that order. In 2022, Glo led in packet-switched services, followed by MTN, Airtel, and then 9mobile. For 2023, Airtel delivered the highest quality packet-switched services, with MTN, Glo, and 9mobile ranking next, respectively.

Finally, Figure 5 presents a bar chart summarizing the average network performance from 2021 to 2023. The analysis concludes that over the study period, Airtel provided the best CSSR for packet-switched services, followed by MTN, Glo, and then 9mobile.

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