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Statistical analysis of call setup success rate for 4 g networks in yenagoa-southern Nigeria

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Abstract

This work attempts to effectively compare Call Setup Success Rate CSSR against industry benchmarks and competitor networks to identify areas for improvement and sets performance targets. Four mobile telecommunication networks operational in Yenagoa – Southern Nigeria were considered. Results obtained shows that MTN and Airtel performed above the regulator's benchmark of 98% in all cases, while Globacom and 9moblie had instances where their performance fell below the benchmark. The maximum values obtained within the period in view was 99.79% and it was gotten from 9mobile while the minimum value obtained was 94.07% and it was from Globacom. In the years 2017, 2019 and 2020 all the networks had values exceeding the NCC's benchmark, this affirms that it is possible for the networks to perform optimally if adequate measures are put in place for improved QoS.

Keywords- Call Setup Success Rate; Key Performance Indicator; Call Setup Failure Rate; Handover Failure Rate; Data; Mobile Network

1. Introduction

In the telecommunications sector, the Call Set-Up Success Rate (CSSR) is a key performance indicator (KPI) that gauges how well voice or data calls are connected to networks [1]. It is an essential metric for evaluating a telecom network's acceptability. In mobile communication networks, such as GSM (Global System for Mobile Communications), CDMA (Code Division Multiple Access), and other cellular technologies, CSSR is pertinent [2,4].

CSSR is the percentage of successfully established calls compared to the total number of attempted call setups [3]. It is expressed as a ratio and is calculated using the following formula:

$$\text{CSSR} = \left(\frac{\text{Successful Call Setups}}{\text{Total Attempted Call Setups}}\right) \times 100 \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Call Set-Up Success Rate is composed of two components

- Successful Call Setups: In order to connect two parties for a voice call, video call, or data transfer, a number of complex procedures must be followed for call setups in mobile telecommunications networks to be successful [4,5]. Positive user experiences and effective communication are guaranteed by these procedures. There are multiple steps in the call setup process, such as registration, location updating, call establishment, and handovers [6]. Key elements and steps involved in Successful Call Setups in Mobile Telecommunication Networks are Network Registration, Location Updating, Call Establishment, Resource Allocation, Call Routing, Connection Establishment, Handovers, Call Termination, Security Measures, Error Handling/Redundancy and Continuous Optimization [6,7,8]. The intricate interplay of registration, authentication, resource allocation,

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routing, and security measures is necessary for successful call setups in mobile telecommunications networks. In order to offer consumers dependable, superior communication services, network operators continuously improve and streamline these procedures. The efficiency and efficacy of call setups in mobile telecommunications will continue to be enhanced by the integration of cutting-edge technologies like 5G and the continuous optimization of network architectures [9].

- Total Attempted Call Setups: In mobile networks, the total number of attempts made by mobile subscribers to initiate voice, video, or data calls is known as the "Total Attempted Call Setups" [7]. In order to optimize their infrastructure, control network congestion, and guarantee a satisfactory user experience, network operators must comprehend and analyze these attempted call setups. Factors, Processes and Considerations related to Total Attempted Call Setups in mobile telecommunication networks are Initiation Process, Call Request Handling, Resource Allocation, Network Capacity Planning, Congestion Management, Call Setup Success Rate, Quality of Service (QoS) Monitoring, Load Balancing, Error Handling and Retries, Network Optimization, User Experience Enhancement and Security Measures [7,10,11,12]. One important indicator of a network's effectiveness and health in mobile telecommunications is the total number of attempted call setups [13]. Network managers use this information to put strategies into place for managing congestion, planning capacity, and general optimization. Operators can make sure that the telecommunications infrastructure is strong and dependable and can accommodate the changing demands of mobile subscribers by closely observing and evaluating attempted call setups [14].

2. Previous related studies

Nigeria's mobile phone industry has seen significant growth over the years in terms of improved coverage and accessibility, but not with the expected high quality of service (QoS) [11]. According to [15] 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. [16] in their studies stated that the Call Setup Success Rate, Call Setup Failure Rate (CSFR) and Handover Failure Rate were the most important Key Performance Indicators (KPIs) used in ascertaining the efficiency of GSM network in terms of the quality of services rendered. One of the most significant KPIs used by all mobile operators is the Call Setup Success Rate; however, since there is no standard way to measure this parameter, different operators may use different approaches. The real challenge lies in successfully optimizing the BTS coverage area in addition to providing better service [13,17]. According to [18] most networks 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 in [19] described the calculation of CSSR as ratio of the assigned Evolved Packet System (EPS) bearers to the random access preamble requests related to data calls with excluded ghosts, signaling radio bearer drops during call setup caused by Evolved Packet Core (EPC) network problems. The data means that the LTE is only packet switched based network, i.e. there are not any circuit switched services as it is typical for example for GSM. The proposed modeling can help mobile operators to measure the data CSSR properly. The authors in [20] described the successful Call Setup to consist of two procedures. The first procedure is Random Access (RA) and connection establishment procedure which is used to create a signaling connection between the UE and the EUTRAN while the second procedure is initial context set up procedure to establish a radio resource connection and a connection to the core. In similar manner [21] in their studies showed that depending on the number of nearest neighbors (k value) used, the percentage of successful CSSR optimization with real data varies, when the value of k fluctuates, there is no tendency for it to go down or up.

3. Materials and method

This study examines the Call Setup Success Rate of four mobile network providers in Yenagoa, Bayelsa State -Nigeria and conducts comparative assessments to determine which network has the best Call Setup Success Rate. Cellular networks analyzed include MTN, Airtel, Globacom, and 9mobile. Materials used are

- 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, into a single protocol, standards for both file transfer and remote file access. It served as a tool for network data collection.
- 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 present study employs a methodology that entails a systematic approach to gather data from the Management Centers of the four operational mobile networks. The steps are as follows:

- Data Analysis: Base Stations BY0101G, BY0124O, BY0122P, BY0121O, BY0042U, BY01109U, BY2670G, BY0105G, BY0082G, BY0083U, BY0096G, BY0097O, BY0091U, BY0214G, BY2217G, and BY0108U were the Base Station Controllers (BSCs) that 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.
- Determination of Average CSSR: 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 CSSR was determined on a daily basis for a month. A low CSSR could have several causes [10, 22], some of which include the following:
    - Network Congestion: This is an important factor that greatly affects the call setup success rate. This phenomenon, which results in delays, packet loss, and a decline in service quality, happens when the demand for network resources exceeds the capacity that is available [23]. Network congestion can significantly impact the start and end of voice calls in the context of mobile telecommunication, thereby affecting the call setup success rate. Noticeable effects of network congestion includes Increased Call Setup Time, Call Drops and Disconnections, Resource Allocation Challenges, Increased Handover Failures etc [8,24].
    - Radio Interference: Understanding how radio interference affects call setup success rate is crucial for designing reliable mobile communication systems [25]. Radio interference occurs when unwanted signals disrupt or degrade the quality of the communication channel, leading to a variety of issues that can affect the establishment of calls, these issues include Signal Degradation and Quality Challenges, Increased Bit Error Rate (BER), Call Drops and Interruptions, Frequency Band Congestions etc.
    - Equipment Failure: This is a significant factor that can affect the call setup success rate. In a mobile network, "equipment" refers to a broad range of hardware components such as base stations, switches, routers, transceivers, and other components [24, 26]. Failure of any one of these parts may cause network disruptions that impact the start and end of voice conversations. Examples of equipment failures include Base Station Failures, Switching System Failures, Transmission System Failures, Power Supply Issues, Backhaul Network Failures, Transceiver and Antenna Failures, Faculty Software or Firmware, Network Element Overload etc.
    - Routing Issues: Routing problems are a major factor in determining the success rate of call setup. In order to create a connection between the calling and receiving parties, voice and data traffic must be directed through the network during the routing process [27]. Any problems or inadequacies in the routing infrastructure can result in dropped calls, unsuccessful call setups, and a general deterioration of the communication experience. Examples of routing issues includes Call Routing Errors, Network Congestion and Overload, Incomplete or inefficient routing tables, Path Inconsistencies, Dynamic Routing Protocol Issues, Load Balancing Challenges, Interconnection and Peering Problems, Redundancy and Failover Mechanism etc.
- Evaluation of Data Values: The QoS results from this paper's study were evaluated through performance analysis, with Call Setup Success Rate (CSSR) 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: 2016, 2017, 2018, 2019, 2020, and 2021. The benchmark set by the Nigerian Communication Commission (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 (NCC technical standard, 2016). Table 1 shows the KPI benchmarks in Nigeria in accordance with NCC´s regulation

Table 1 KPI Benchmarks in Nigeria

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

4. Result analysis

Yenagoa`s Call Setup Success Rate has been Calculated for the four network operators under review (MTN, Airtel, Globacom, and 9mobile), the values obtained are as shown in Figure 1 which compares the values obtained for the four network operators in the years 2015.

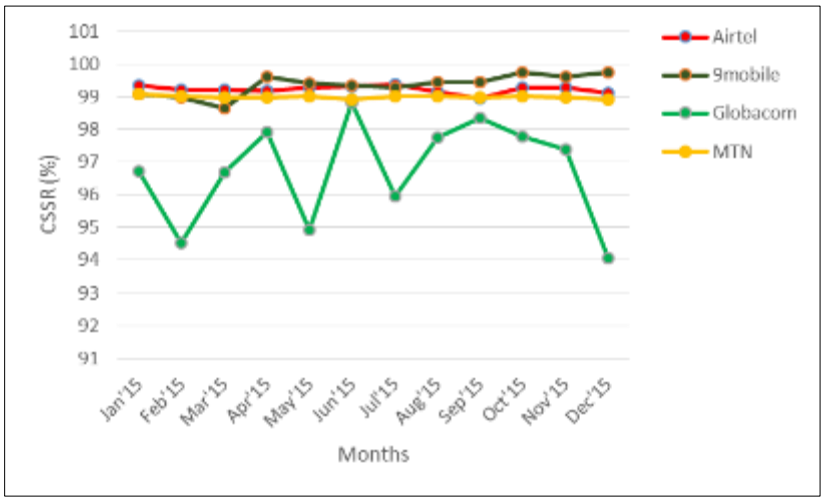

Figure 1 CSSR against Months for year 2015

In the year 2015, Globacom had the most erratic CSSR with its average values below NCC's benchmark of 98% in most of the months. The other three networks under consideration had their average values above the NCC's benchmark. 9mobile had the best average values while MTN had the most stable average values. Figure 2 below is a plot of CSSR against months in the year 2016.

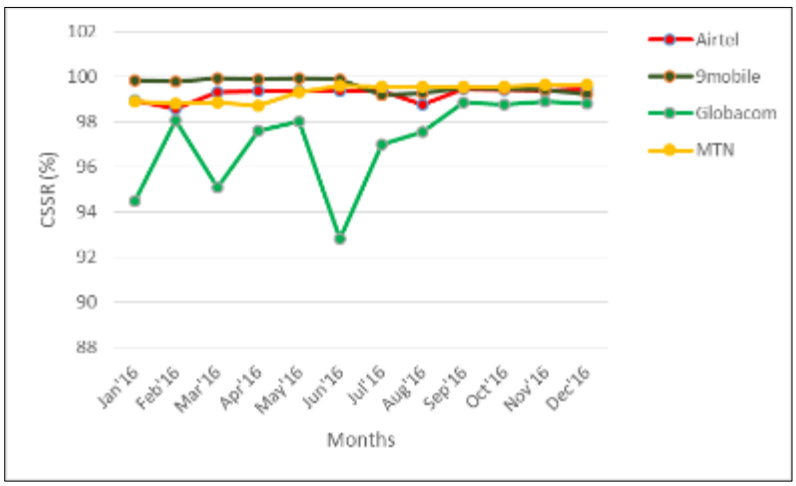

Figure 2 CSSR against Months for year 2016

In 2016, Globacom's average CSSR values improved as compared to the previous year, here its values exceeded NCC's benchmark in many months of the year however it remained the least performing network. 9mobile had the best values in the first half of the year while MTN's values were the best in the second half of the year and also the most stable of them. Figure 3 below is a plot of CSSR against months in the same year 2017.

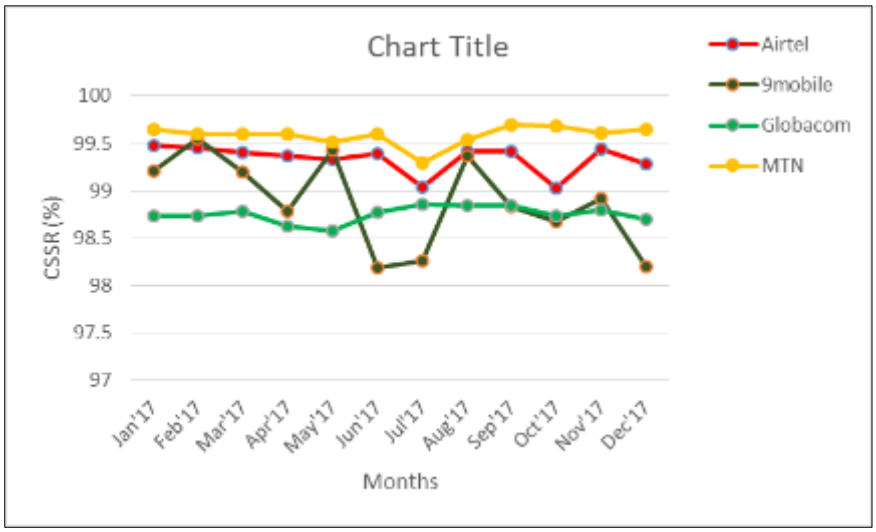

Figure 3 CSSR against Months for year 2017

The four networks under consideration had their values above the NCC's benchmark in the year 2017 except for 9mobile whose values in three months fell below NCC's benchmark. While Globacom showed an impressive improvement, her values still remained the least except for the months of June, July and December where 9mobile had the least values. Airtel had all her average values above 99% while MTN maintains the best values across board. Figure 4 below is a plot of CSSR against months in the year 2018.

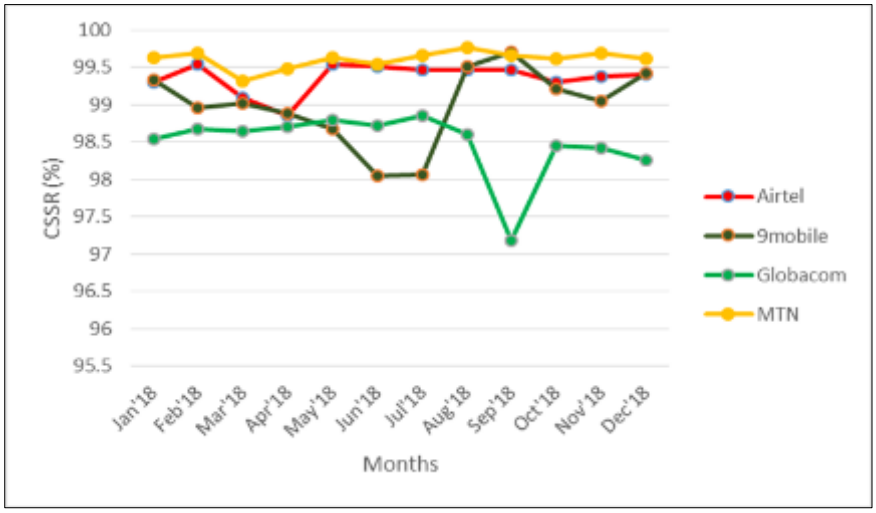

Figure 4 CSSR against Months for year 2018

In the year 2018, the CSSR average values for the four networks are more erratic when compared to the previous years though the values where above NCC's benchmark except for the month of September where the value for Globacom fell below the NCC's benchmark. MTN continues to maintain best average and most stable values. Figure 5 below is a plot of CSSR against months in the year 2019.

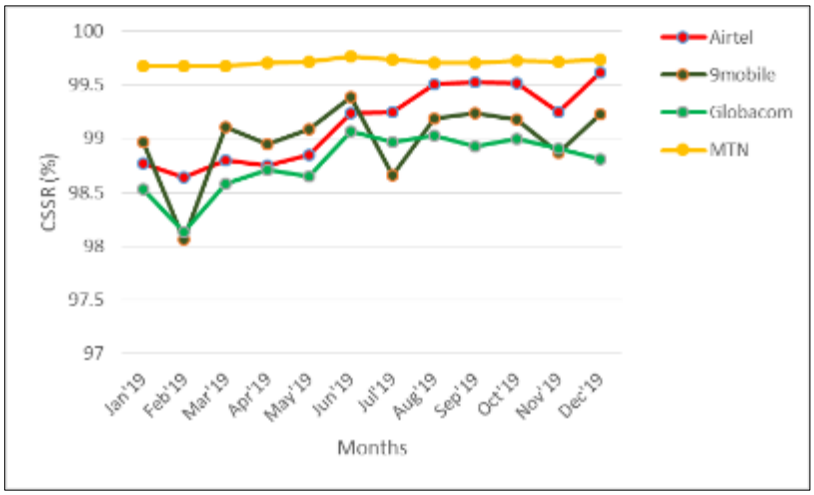

Figure 5 CSSR against Months for year 2019

In the year 2019, the four networks under consideration exceeded the NCC's benchmark at every point in time. MTN had superior average values exceeding 99.6% throughout the year while 9mobile recoded the least value of 98.06% in the month of February. 9mobile, Globacom and Airtle showed a wide margin of data variation while MTN showed a slight variation in data values all through the year. Figure 6 below is a plot of CSSR against months in the year 2020.

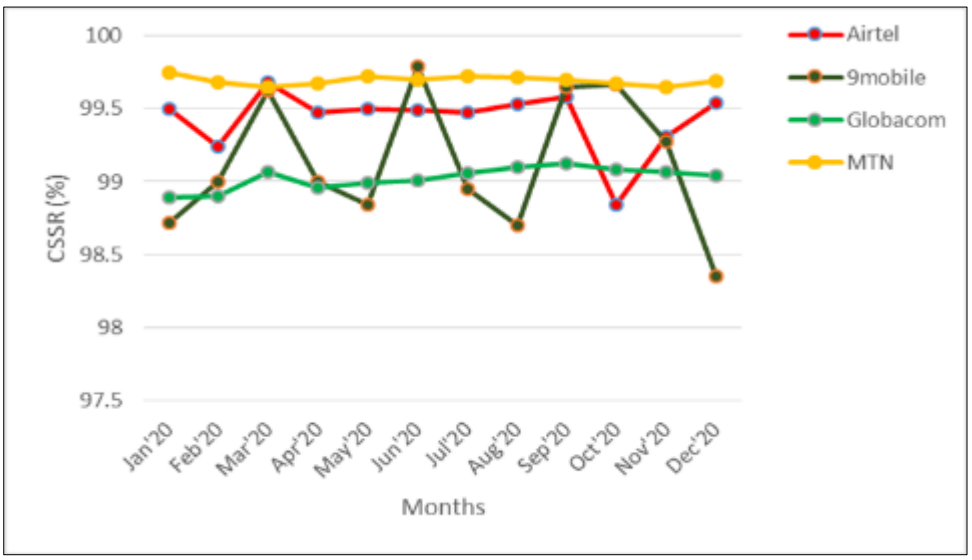

Figure 6 CSSR against Months for year 2020

In the year 2020, the four networks performed very well with average values above the NCC's benchmark, however a wide margin of data variation was notice as compared to other years. Here, 9mobile had the best values of 99.79% as well as the least value of 98.35%. MTN however maintained the best stability in value followed closely by Globacom. Figure 7 below is a plot of CSSR against months in the year 2021.

In 2021, 9mobile despite having the least average value of 96.16% also was the most erratic of the four networks under consideration. MTN, Airtel and Globacom showed a high level of stability though MTN was the most stable of them.

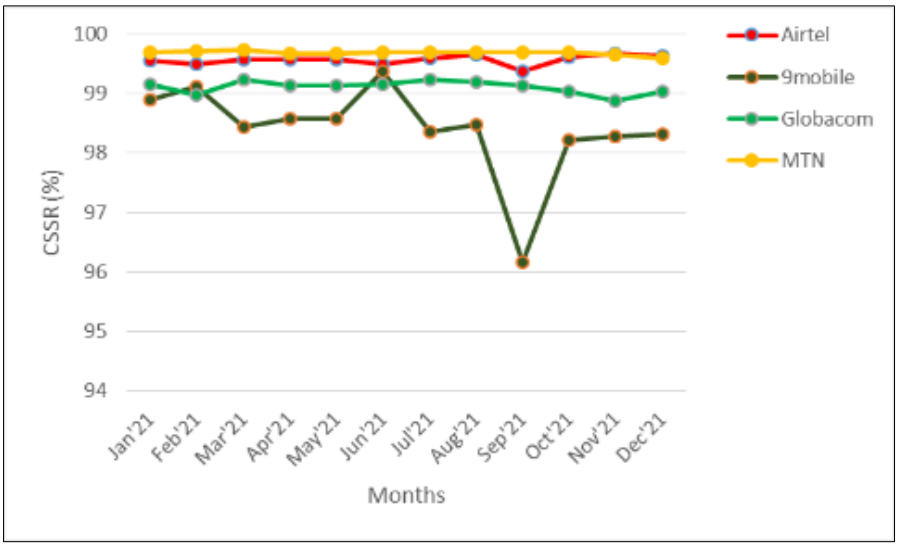

Figure 7 CSSR against Months for year 2021

5. Conclusion

This study deals with Comparing CSSR against industry benchmarks and competitor networks for the purpose of identifying areas for improvement and sets performance targets. Four mobile networks operational in Yenagoa the capital city of Bayelsa State Nigeria were investigated. From the data obtained, the four networks performed well above 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 below the benchmark. Data from MTN was superior among the four networks and had the least variation within the period of investigation (2015 – 2021). Airtel's data was well above the benchmark all through the period under review and its variation was relatively small. The data from Globacom and 9mobile had wide ranges of variations and had instances where it fell below the benchmark, which call for improvement in order to maintain good Quality of Service and customer satisfaction. The maximum value of CSSR recorded in the 7 years period under review is 99.79% and it was in 9mobile while the least value recorded is 94.07% and it was in Globacom. In the years 2017, 2019 and 2020 all the networks had values exceeding 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.

Recommendation

To ensure optimal Call Setup Success Rate (CSSR) in mobile telecommunication networks, it's essential to implement the following recommendations addressing different aspects of network performance:

- Network Capacity Planning: Regularly assess and adjust network capacity to accommodate increasing subscriber numbers and usage patterns, particularly during peak hours. Utilize predictive modeling and traffic analysis to anticipate future demands and scale network resources accordingly.
- Radio Resource Management (RRM) Optimization: Fine-tune RRM algorithms and parameters to ensure efficient allocation and management of radio resources, minimizing interference and enhancing call setup reliability. Implement dynamic resource allocation strategies to adapt to changing network conditions and traffic patterns.
- Handover Optimization: Optimize handover algorithms and parameters to facilitate seamless transitions between cell sites. Minimize handover failure rates by improving algorithms for better decision-making during handover scenarios.
- Cell Planning and Optimization: Conduct regular drive tests and site surveys to identify coverage gaps and optimize cell configurations. Adjust antenna tilt, power levels, and sectorization to enhance coverage and reduce interference, improving CSSR.
- Quality of Service (QoS) Monitoring: Implement robust QoS monitoring systems to track CSSR alongside other relevant metrics, providing a comprehensive view of network performance. Set and regularly review QoS targets to maintain a high level of service quality.

- Dynamic Spectrum Management: Utilize dynamic spectrum management techniques to efficiently allocate and adapt frequency bands based on real-time network conditions. Implement interference mitigation strategies to reduce the impact of co-channel and adjacent channel interference on CSSR.
- Load Balancing Strategies: Implement intelligent load balancing mechanisms to distribute traffic evenly across different cells and sectors. Utilize predictive analytics to identify potential congestion points and proactively balance network load.
- Fault Detection and Rapid Response: Implement advanced fault detection mechanisms to identify and address network issues promptly. Develop automated response systems to mitigate the impact of faults on CSSR and overall network performance.
- Continuous Performance Monitoring: Deploy comprehensive monitoring tools and conduct regular network audits to identify performance bottlenecks. Establish Key Performance Indicators (KPIs) for CSSR and regularly assess against benchmarks.
- User Equipment and Protocol Optimization: Ensure compatibility with a wide range of user devices and optimize protocols to enhance the efficiency of call setup procedures. Regularly update network elements and user equipment to support the latest technologies and standards.
- Capacity Headroom Provisioning: Provision additional capacity beyond current demands to provide headroom for sudden spikes in traffic. Employ predictive analytics to anticipate capacity needs and proactively scale resources.
- Employee Training and Skill Development: Ensure that network operators and maintenance personnel are well-trained to troubleshoot and address issues promptly. Provide ongoing training to keep staff updated on the latest technologies and best practices.

By implementing these recommendations, mobile telecommunication operators can enhance their network's resilience, efficiency, and overall CSSR, leading to improved user satisfaction and a positive impact on the quality of service.

Compliance with ethical standards

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Disclosure of conflict of interest

The author declare that there was no conflict of interest as this work is only serving academic purpose and not for litigation.

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