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Evaluation and Empirical Modeling of Call setup success rate and Call Completion Rate

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ABSTRACT

The Quality of Service (QoS) rendered by mobile communication network is pivotal to the economic development of any country. Therefore, considering the quality of service in Nigeria mobile communication network is not out of place. This study focuses on the evaluation and empirical modeling of the Call Setup Success Rate (CSSR). The research method is divided into three unique sections: evaluation of Call Setup Success Rate (CSSR), measurement of Call Setup Success Rate (CSSR) using the old Engineering Faculty and medical college area in Ekpoma town. Additionally, modeling of Call Setup Success Rate (CSSR) is based on the obtained data from the area under investigation. Measurement was carried out from two basic points, considering the attitudes and longitudes of two points respectively. Three mobile network operators were considered for this study, MTN NG, GLO NG and AIRTEL NG, six different mobile phones were deployed, along with ten stopwatches. Calls are initiated from MTN to GLO and Airtel, to determine the respective CSSR using a stopwatch. Additionally, the process was repeated from GLO to MTN and Airtel, and lastly from Airtel to MTN and GLO. This procedure is of subjective nature, where ten (10) evaluators with their stopwatches are made to record CSSR time independently. The corresponding results are averaged, and the outputs are presented in graphical format. It was observed that the CSSR obtained is not deterministic in nature due to poor signal strength level, and the CSSR flow pattern can best be described as a logarithmic distribution pattern based on the developed empirical model. Furthermore, it was observed that the call setup success rate is at a minimum when calls are setup within the same mobile network operator compared to inter-mobile network operator calls.

1. INTRODUCTION

As the world awaits the full implementation of both 5G and 6G, which come with interesting features such as wide broadband and robust internet of things (IoTs), the hope is that this 5G implementation will reduce the larger values obtained with Quality of Service (QoS) in mobile communication systems. The QoS keys Performance Indicators (KPIs) are divided into two sectors, these include Calls related KPIs parameters such as Block call rate, Call

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Completion Rate, Busy Hour Call Attempt, Call Setup Success Rate (CSSR) and Grade of Service, among others. Meanwhile, the data-related KPIs parameters include packet loss, throughput and latency, among others.
The focus of this study is on the Call Setup Success Rate (CSSR) and the Call Completion Rate (CCR), which is also known as call setup time and calls completion time. Those are major parameters considered in Quality of Service. This research work covers some basic objective areas such as highlighting the functionality procedure of both the Call Setup Success Rate (CSSR) and the Call Completion Rate (CCR). There are technical differences, measurements, evaluations of both the Call setup success Rate (CSSR) and Call Completion Rate (CCR) and lastly modeling of both Call Setup Success Rate (CSSR) and Call Completion Rate (CCR).

Both ITU and NCC have set benchmarks for high efficiency in both Call Setup Success Rate (CSSR) and Call Completion Rate (CCR) in mobile communication systems.
Nigeria Communication Commission (NCC) is an institution established by the government and empowered by law to oversee and regulate the communication industry. In Nigeria communication act of 2003, Quality of Service (QOS) regulations 2008 is presented in Table: 1 (http//www ncc.gov.ng).

Table 1: NCC QOS Indicator for Mobile Service Technical Parameters

S/No	Parameter	Value
1.	Call Setup Success Rate (CSSR)	≥ 90% (0.9)
2.	Call Completion Rate (CCR)	≥ 90% (0.9)
3.	Busy Hour Erlang Utilization/Cell	≤ 60%
4.	Grade of Service (GOS)	≥ 2%

Source: (Osahenvemwen, 2012)

Call Setup Time, or Voice Service Access Time, is the period of time elapsing from the sending of a complete destination address (target telephone number) to the setting up of a call to the receiving terminal (Osahenvemwen, 2015; Osahenvemwen 2012). It is also defined as the period of time that the network takes to establish the communication after the correct sending of the request (target telephone number). Call set up time is the period of time elapsing from the sending of a complete destination address (target telephone number) to the setting up of a call.

$$Call\ \ set\ up\ time(s) = t_{Calling\ \ Signal} - t_{\ Address\ Sending} \quad (1)$$

$t_{\text{address sending}}$ – moment when the user presses the send button

$t_{\text{calling signal}}$ – moment one hears the call signal on the caller terminal

The Call Completion Rate refers to the total number of calls that are initiated and connected successfully, compared to the number of calls that fail. A call failure can occur when there is an incorrect phone number, a non-answer, or when a customer declines the call. Call Completion Rate or Voice Service Retainability Ratio is defined as the probability that a call, after being successfully set up, to be maintained for a period of time and end normally, i.e., according to the user's will (Osahenvemwen, 2015).
Voice Call Completion Rate is referred as the probability that a call has, after being successfully set up, will be maintained for a period of time and end normally, according to the user's will

Formula

Successfully connected calls [within the hour, day]/Total number of attempted calls [within the hour, day]

$$Call\ completion\ [\%] = \frac{number\ of\ \ normally\ \ ended\ calls}{total\ number\ of\ call\ attempts}\ \ x\ \% \quad (2)$$

Today's 3G specifications call for 144 kb/s while the user is moving quickly, 384 kb/s for pedestrians, and up to 2 Mb/s for stationary users. This is a big step up from 2G bandwidth using 8 to 13 kb/s per channel to transport speech signals. The second key issue for 3G wireless is that users will want to roam worldwide and stay connected. Today, GSM leads with almost global roaming. Because of the pervasiveness of GSM, users can get comprehensive coverage in Europe, parts of Asia and some U.S. coverage. A key goal of 3G is to make this roaming capacity universal. A third issue for 3G systems is capacity. As wireless usage continues to expand, existing systems are reaching their limits. Cells can be made smaller, permitting frequency reuse, but only to a point. The next step requires new technology and new bandwidth.

Please note, that if a call is connected successfully but the dialed number is busy then the call is counted as successful

1.1 Related Study

The Quality of Service (QoS) remain one of flexible aspect of mobile communication system, QoS is used to access the performance of mobile communication network. In the study, the call setup success rates Key Performance Indicators (KPIs) aspects are considered and various studies from different authors have highlighted as follows.

Vandana & Sudhakar (2019), carried out a research on Quality of Service (QoS) represents the quality measure in cellular service to users to provide an error free service with defined voice quality, minimum acceptable signal strength, limited call blocking and dropping probability even at high data transmission rates. Osahenvemwen & Emagbetere (2012), presents a study on determination of traffic load and traffic performance parameters (indicators) in mobile communication network, using Nigeria (Lagos) as a case study. The operation and maintenance unit which is in-built with the mobile communication network was used as a measuring device. The traffic data obtained from the mobile network are; number of complete call, number of calls attempts and service time (calls duration) for the period of one year. They are Calls Completion Rate (CCR), Busy Hour Call Attempt (BHCA), Grade of Service (GOS) and Channels Utilization Percentage (CUP). It was discovered that route 9 and 10 Call Completion Rate (CCR) was not in accordance with Nigeria Communication Commission (NCC, 2008) regulation. Bello, (2015) one essential Key Performance Indicator (KPI) for mobile network performance assessment is Call setup time (CST). However, there is no standard measurement possible for this parameter; therefore the different operators can measure it differently. In this paper, the possibility of implementing an algorithm for CST measurement using citizen sensing techniques where individual GSM users' can quantify CST from their cell telephone without the utilization of Drive Test is been proposed. Consequently, examination of GSM ringing tone, call time and the sound nature of the ringing tone is analyzed using a Labview and Matlab. Ramesh (2009). In this paper, it proposed a higher order Markov chain based performance model for call admission control in a heterogeneous wireless network environment. In the

proposed algorithm we have considered three classes of traffic having different QoS requirements and we have considered the heterogeneous network environment which includes the Technologies (RATs) that can effectively handle applications like voice calls, Web browsing and file transfer applications which are with varied QoS parameters. The paper presents the call blocking probabilities for all the three types of traffic both for fixed and varied traffic scenario.

In this study is on the evaluation and empirical modeling of call setup time and calls completion time in communication system. Consideration is on the function procedures between Call setup success Rate (CSSR) and Call Completion Rate (CCR) and technical differences, measurement, evaluation of Call setup success Rate (CSSR) and Call Completion Rate (CCR). In addition, modeling of Call setup success Rate (CSSR) and Call Completion Rate (CCR)

2 RESEARCH METHODOLOGY

The study focuses on the evaluation and empirical modeling of Call Setup Success Rate (CSSR) in a communication system. The research method is divided into three unique sections: evaluation of Call Setup Success Rate (CSSR), measurement of Call Setup Success Rate (CSSR) in the Old Engineering Faculty and college area in Ekpoma town, and modeling of Call Setup Success Rate (CSSR) based on the obtained data from the area under investigation. Additionally, data were obtained from the network B OMC for further analysis of the mobile network under investigation. The mobile communication network operators considered for this study in Nigeria include:

1) MTN NG
2) GLO NG
3) AIRTEL NG

Six mobile phones were deployed alongside with 10 (ten) stopwatches and ten (10) evaluators using subjective method.

Two different locations were used they are;

(a) Old Engineering Faculty with lat. and long. 6.73698 N, 6.08072 E
(b) G2 close to college with lat. and long. 6.74533 N, 6.11100 E

The corresponding Google maps for the two different locations are presented in Fig. 1 and Fig.2.

2.1 Experimental Setup and Data Collection Procedure

Call Setup Success Rate (CSSR) was determined from the three network operators mentioned above. Six different mobile phones were deployed along with ten stopwatches for timing. Calls were initiated from MTN to GLO and Airtel, alongside ten stopwatches and ten evaluators, 50 times each day for three months. Thereafter, the process was repeated with calls initiated from GLO to MTN and Airtel, and finally, repeated for calls initiated from Airtel to MTN and GLO. The same experiment was repeated at two different locations: the Old Engineering Faculty and G2 close to the college. The obtained data were tabulated and averaged using Microsoft Excel, and the results are presented in graphical format from Fig. 3 to Fig. 11.

Fig. 1: Google Map for Old Faculty of Engineering

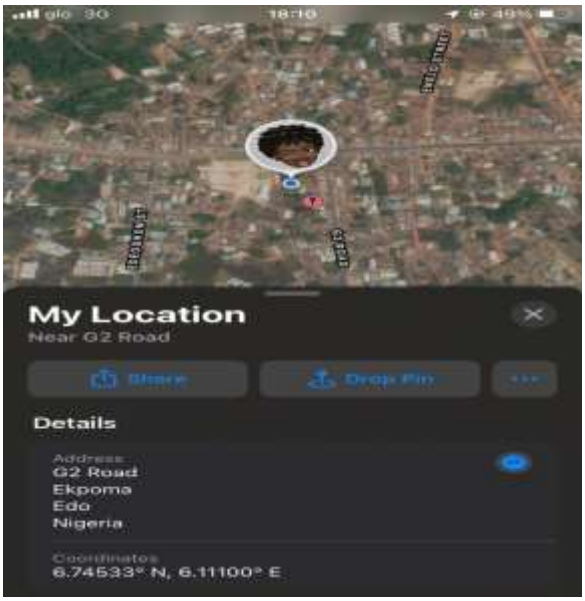

Fig.3: Google Map of the Area under investigation at G2 Road close to College at Ekpoma Town

Fig 2: the Screen Shot of the Correspond Time from the Stopwatch

Fig.4: the Screen Shot of the Time on the Stopwatch

3. RESULT AND DISCUSSION

Analysis of the data obtained from the field

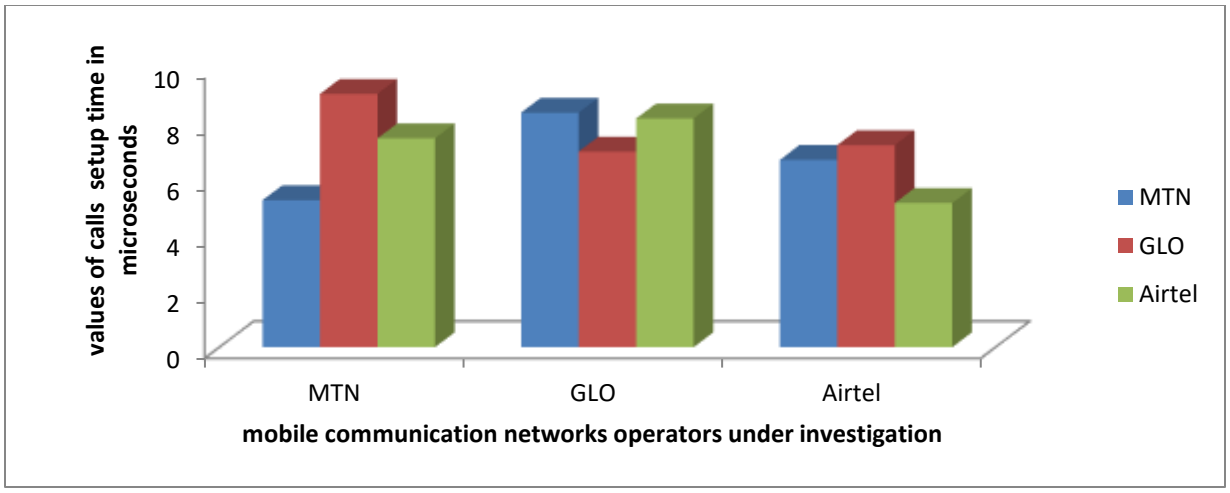

Fig. 5: Average value in Microsecond the Call Setup Time in Three Mobile Communication Network Operators in Nigeria

Fig 5 presents the average values for call setup time or call setup success rate, considering three mobile communication networks. Data were obtained using a subjective method for a period of one month, during which evaluators were tasked with recording the call setup success rate when calls were initiated from one mobile communication network to another. It was observed that Airtel has the lowest value when calls are made within the same Airtel mobile network, followed by the MTN network. Additionally, it was observed that the call setup success rate is minimum when calls are set up within the same mobile network operator compared to inter-mobile network operator calls. The bar chart for easy comparison is presented in Fig 5, while the line graph with the corresponding call setup success rate values is presented in Fig 6

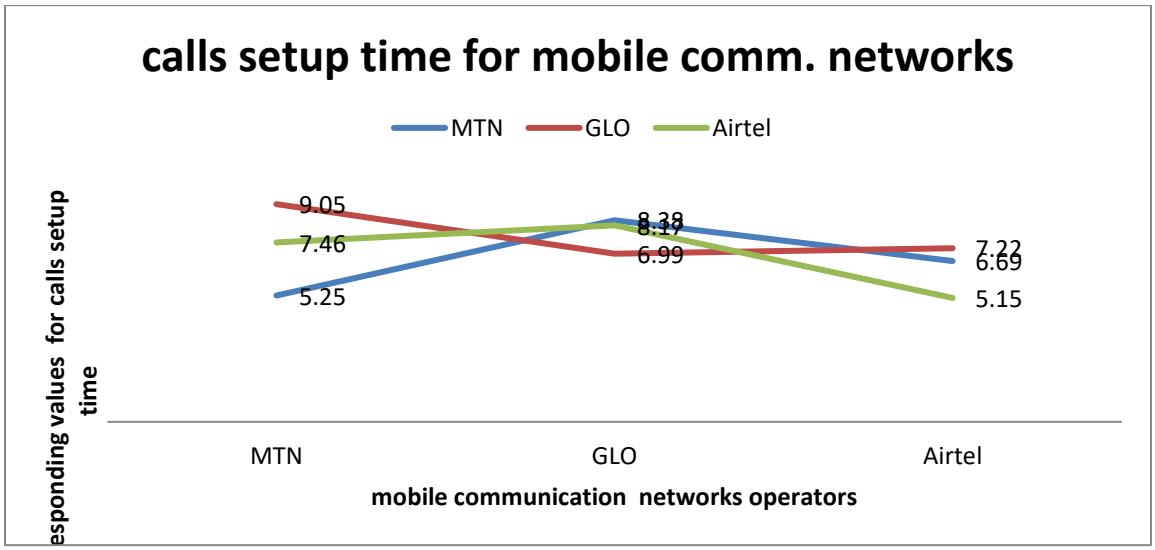

Fig. 6; a Line Graph of Average Value for Call Setup Time or in Three Mobile Communication Network Operators in Nigeria

A set of data was obtained from Network B, a mobile communication operator, from the Mobile Switching Center (MSC). The six-month average data included: cell ID, CS Call Drop Rate_HW 2020(%), CS CSSR_HW 2020(%), SHO Success Rate_HW 2020(%), CS Traffic (Erlang), PS Traffic (MByte), PS DL Traffic (MByte), and PS UL Traffic (MByte). This data was analyzed using Microsoft Excel, and the results are presented in graphical format from Fig. 7 to Fig. 8

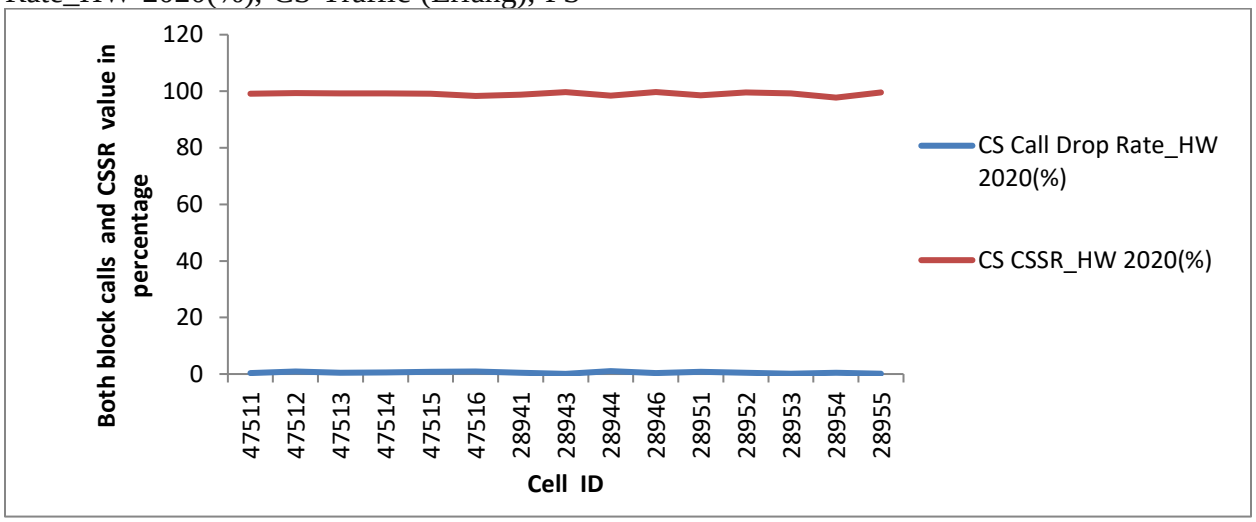

Fig. 5: Block Calls and Call Setup Success Rate

Based on the data obtained from Network B, it was observed that 15 different cells were considered. The block call percentage and call setup success rate were obtained for circuit switching. It was noted that the block call percentage obtained from Network B is very minimal, averaging at 0.5176%, which is lower than the recommended standard of two percent (2%) set by the NCC. The data for call setup success rate was obtained based on the success of the call setup, but the associated time was not captured. The efficiency of the call setup success rate depends on two major factors: the duration taken to complete the call setup process and the probability of completing the call setup process by seizing traffic channels. It was observed from Fig. 5 that 99.1% of call setup success rate was achieved, surpassing the NCC standard of 90%. Therefore, both the block calls and call setup success rate considered from Network B, a mobile communication network operator in Nigeria, adhere to international standards and practices.

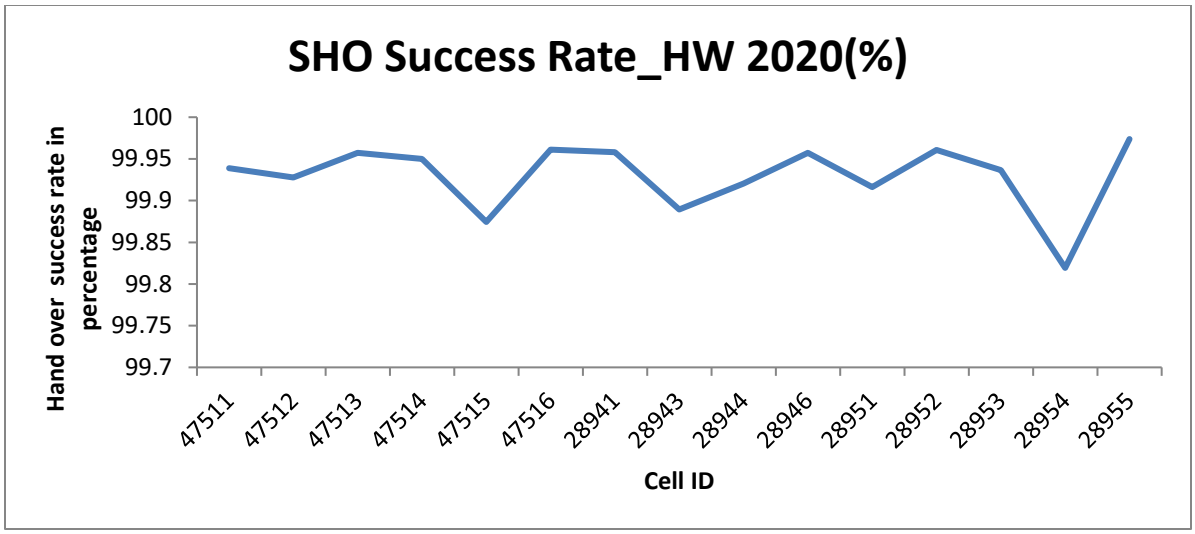

Fig. 6: Handover Success Rate in Percentage

The handover success rate in percentage was obtained, reflecting the process involving the movement of subscribers from one cell to another. It was observed that the handover success rate obtained is 99.929%. This implies that a high volume of dropped calls is reduced across the 15 cells investigated in this study. However, despite this improvement, some cells with identities such as 28954 and 47515 still experience failed handover processes in Network B.

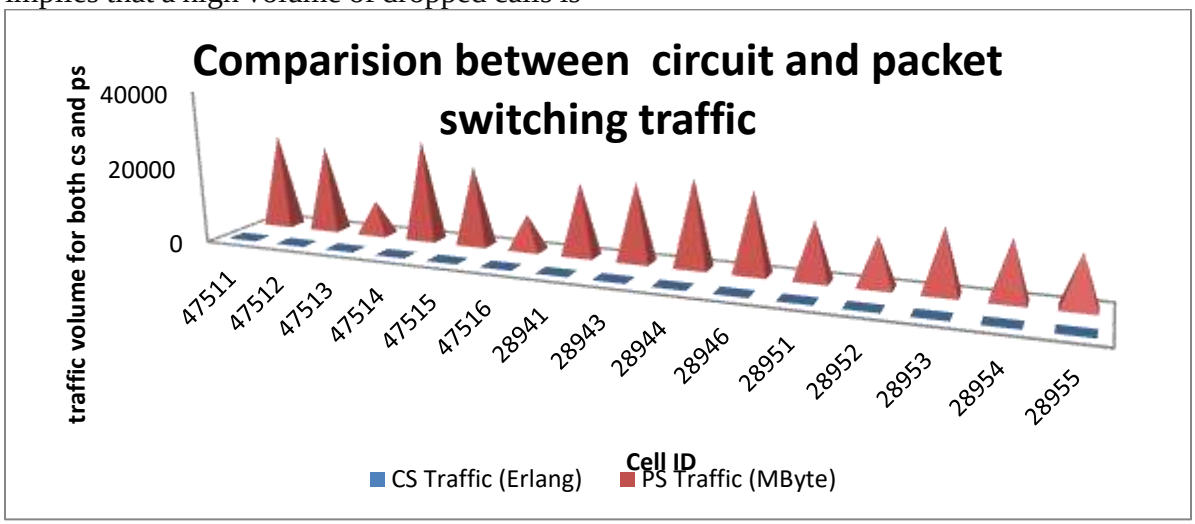

Fig 7: Comparison between Circuit Switching and Packet Switching Traffic

In Fig. 7, a comparison between circuit switching and packet switching traffic is presented. It was observed that with emerging new technologies, data usage and packet switching are on the rise compared to circuit switching technology. Most social media platforms are based on packet switching technology. It is observed that the traffic volume in packet switching is greater than in circuit switching traffic. The respective traffic percentages are presented in Fig. 7."

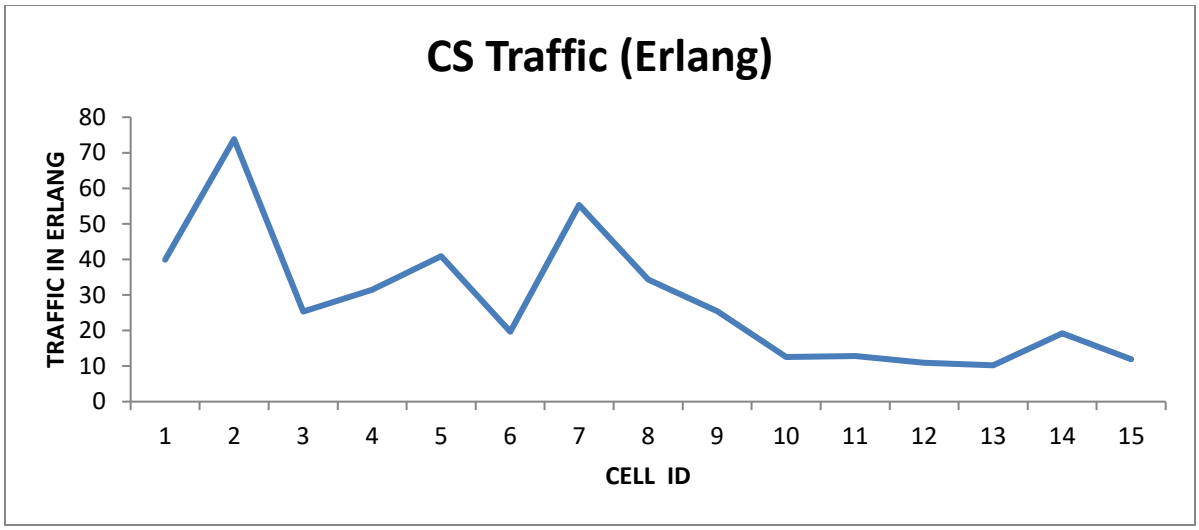

Fig.7: Circuit Switching Traffic in Erlang

It was observed that the traffic volume experienced in mobile communication is not linear but rather stochastic (random) in nature, as depicted in Fig. 7. Therefore, there is a need to develop a robust traffic channel admission system to cater for the non-deterministic traffic generated by mobile subscribers. The traffic associated with circuit switching is measured in Erlangs.

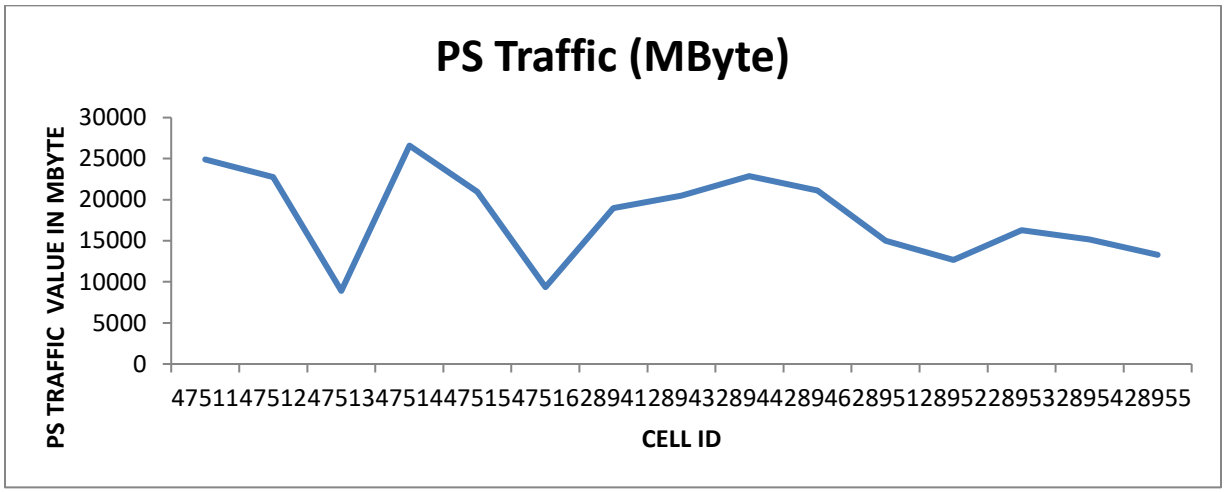

Fig.8: Packet Switching Traffic in MByte

The traffic generated from packet switching technology is of high volume and non-constant or nonlinear. This implies that packet switching is an emerging technology with more features and subscribers. The usage of subscribers can be best modeled using stochastic characteristics (Osahenvemwen, 2012). Traffic generated from packet switching is measured in MBytes. However, there are some basic drawbacks associated with packet switching such as delay, latency, packet loss, etc.

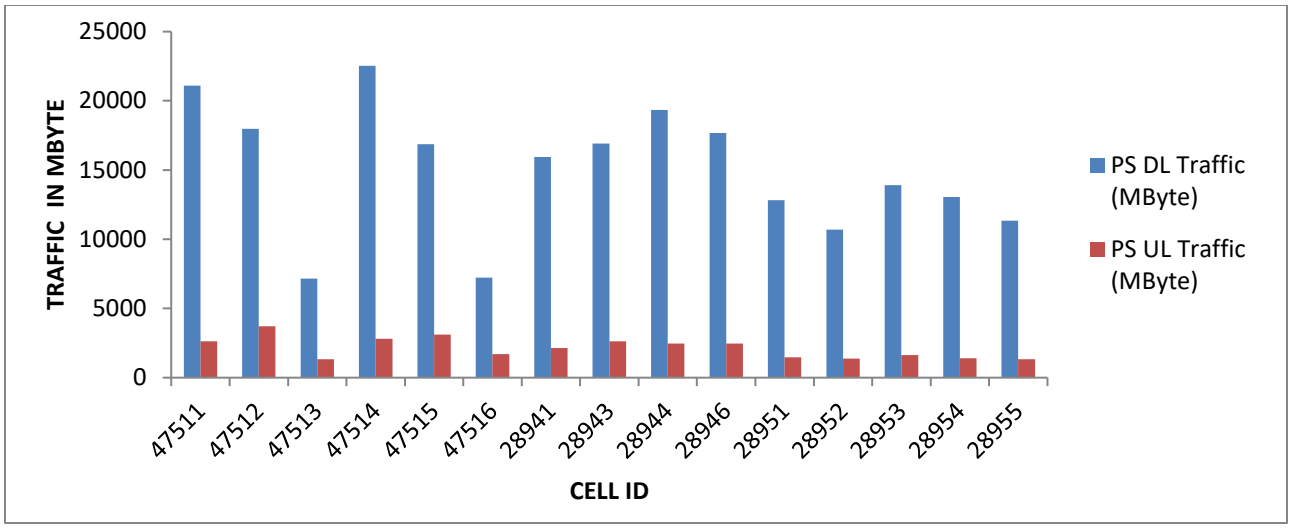

Fig. 9: the Comparison between Down Link and Up Link Traffic

In Fig. 9, a comparison between downlink and uplink traffic in a packet switching traffic system is presented. It was observed that downlink traffic in MBytes is greater than the uplink traffic. This is represented in both the figure, percentage, and pie chart in Fig. 10. This implies that more information in the form of MBytes is downloaded compared to what is uploaded. Additionally, this reveals the demand for information from the internet by mobile subscribers.

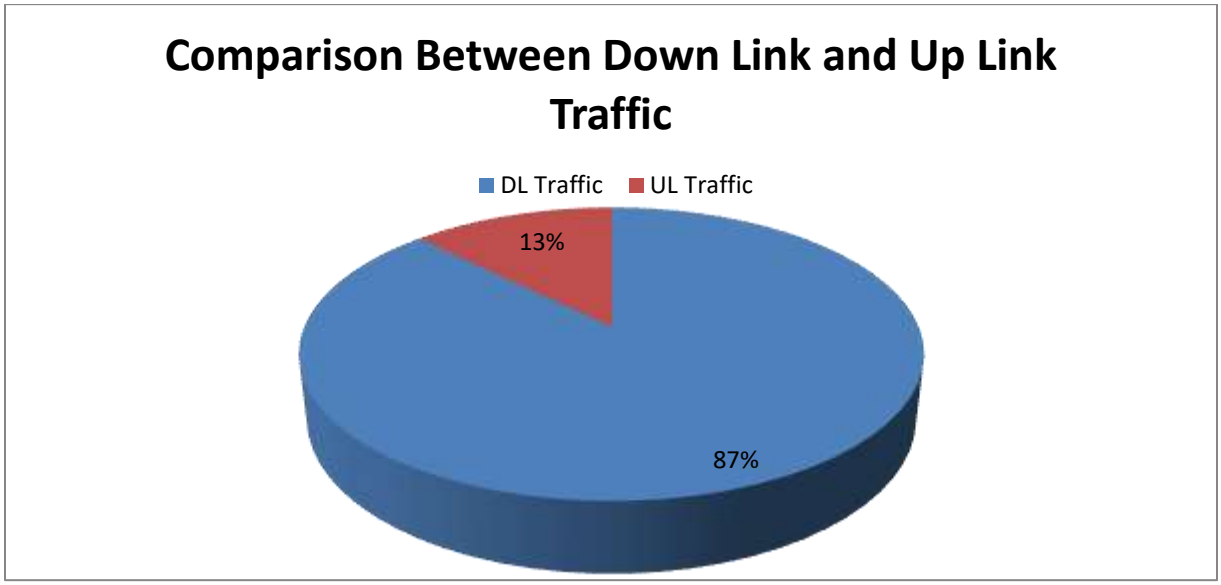

Fig.10: the comparison using pie chart between Down Link and Up Link Traffic with corresponding Percentages

Call setup failure reasons

There could be so many reasons for a poor CSSR. Some are described as follows:

1. Low Signal Strength
2. SDCCH Congestion
3. CM Service Reject

4. TCH Failure Assignment
5. Hardware Problem

The obtained Call Setup Success Rate (CSSR) from measurement from the old Faculty of Engineering, are presents in Fig 10.

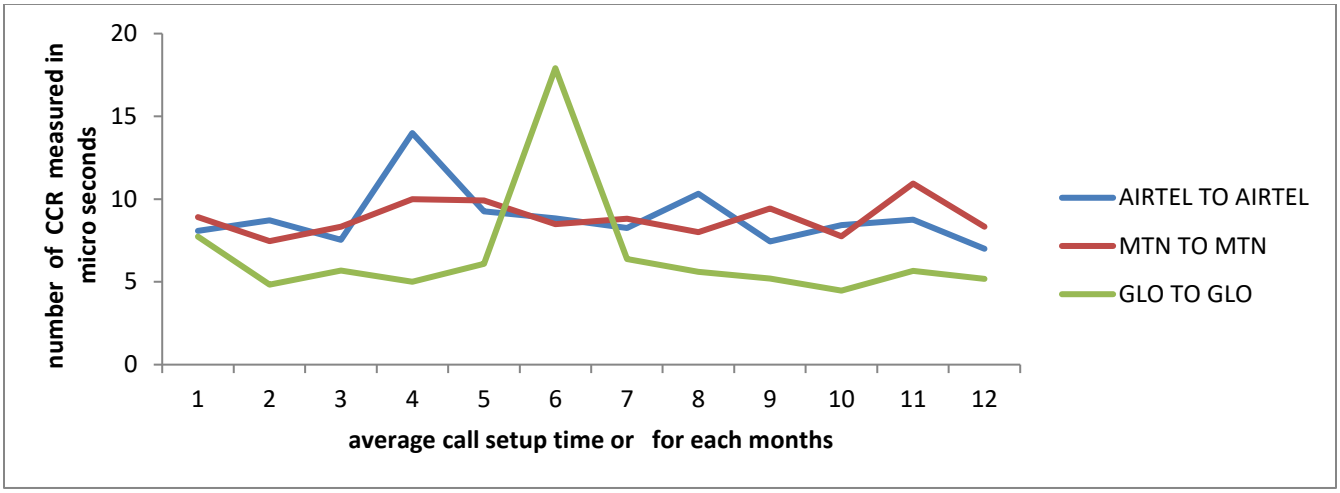

Fig. 11: Call Setup Success Rate (CSSR)

It was observed from three different mobile networks that the Call Setup Success Rates (CSSR) were not the same. Some instances of poor signal strength were witnessed during the investigation period, resulting in sharp upward movements observed in both the Glo and Airtel networks in Fig 11. Additionally, a high number of Call Setup Success Rate (CSSR) increases dissatisfaction with the quality of service provided by mobile communication networks in Nigeria. Ideally, the Call Setup Success Rate (CSSR) should follow a linear graph rather than an undulating one. Therefore, Call Setup Success Rate (CSSR) is expected to be deterministic rather than random in nature, as depicted in Fig. 11

The Empirical Modeling of Call Setup Success Rate (CSSR)

In Fig. 12, the presentation of the Call Setup Success Rate (CSSR) shows that the MTN network experienced the highest CSSR value during the investigated period. Therefore, the flow pattern of MTN's Call Setup Success Rate was modeled, considering the best distribution pattern for CSSR as shown in Fig. 12, along with the corresponding equation and values presented in Table 2.

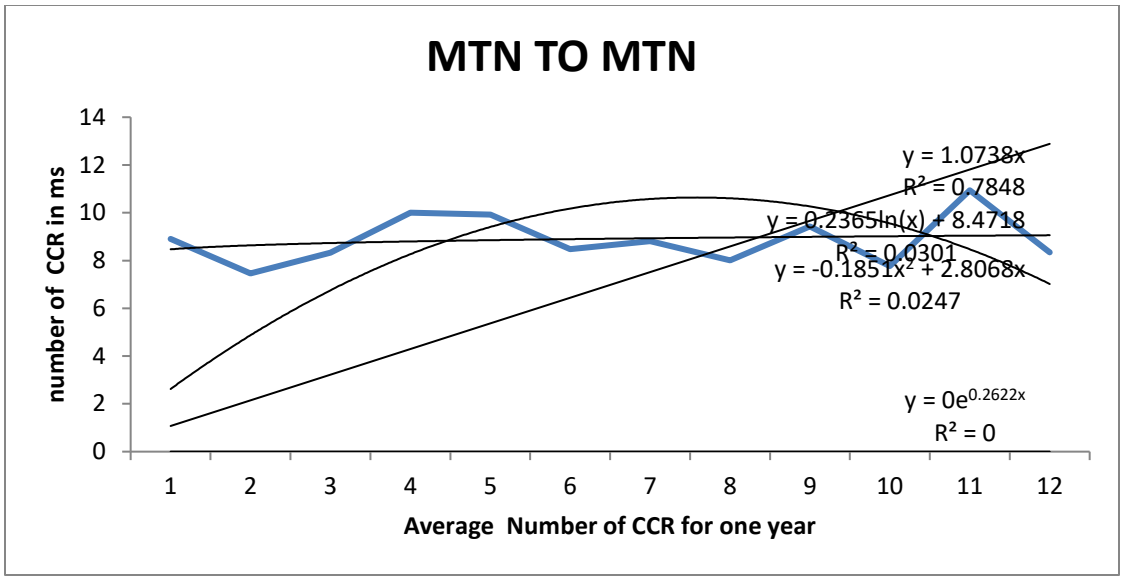

Fig. 12: Distribution Pattern of Call Setup Success Rate

Table 2: The Distribution Pattern of Call Setup Success Rate (CSSR)

S/No	Distribution Pattern	Resultant Equation	Root Mean Square (RMS) values
1	logarithmic	Y= 0.2365ln(x) + 8.4718	-16.01
2	linear	y = 1.0738x	0.0301
3	Polynomial	$y = -0.1851x^2 + 2.8068x$	-5.554

It was observed that the Call Setup Success Rate (CSSR) follows a logarithmic distribution pattern among the three distribution patterns considered. Additionally, it possesses the lowest Root Mean Square (RMS) value of -16.01, as shown in Table 2

4. CONCLUSION

The study focuses on the evaluation and empirical modeling of Call Setup Success Rate (CSSR). The aim is to determine the flow pattern and level of CSSR. Three different networks were considered: MTN, GLO, and Airtel. Data were obtained using a subjective method over a period of one month, during which evaluators were tasked with recording the CSSR when calls were initiated from one mobile communication network to another. It was observed that Airtel had the lowest value when calls were made within the same Airtel mobile network, followed by the MTN network. Additionally, it was observed that the call setup success rate is lower when calls are set up within the same mobile network operator compared to inter-mobile network operator calls. It was noted across the three different mobile networks that the CSSRs are not the same. A few instances of poor signal strength were witnessed during the investigation period, resulting in sharp upward movements observed in both the Glo and Airtel networks. Moreover, a high number of CSSR increases the level of dissatisfaction in the quality of service provided by mobile communication networks in Nigeria. Ideally, the CSSR should exhibit a linear graph rather than an undulating one. Furthermore, the CSSR follows a logarithmic distribution pattern.

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