

Appraisal of Quality of Service of Major Mobile Communication Networks Service Provider in Osogbo Metropolis, Osun State

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Abstract

Due to upsurge increase in the rate at which mobile communication services are being accessed by the users, such as voice and data services, the challenges of traffic congestion has been in the increase in recent time. This work presents the analysis of traffic congestion as an index of quality of service among the leading telecommunication service providers in Nigeria around Osogbo metropolis. A drive test was conducted to obtain the various key performance parameters that were used for the analysis. The key performance indicators (KPIs) evaluated were the Call Setup Success Rate (CSSR), Call Drop Rate (CDR), Handover Success Rate (HOSR), Traffic Channel (TCH) Congestion and Standalone Dedicated Control Channel (SDCCH) Congestion. The result showed that one of the operator (GLO) was able to provide a better quality of service (QoS) over other mobile communication service providers. Though other networks too performed credibly well based on KPIs bench mark provided by Nigerian Communication Commission, (NCC)

Keywords: Key Performance Indicators, Mobile communication, Network parameter, Traffic Congestion.

1. Introduction

Cellular systems began in the United States with the advent of the advanced mobile phone service (AMPS) system in late 1983 (Lee, 2006), Total Access Communication Systems (TACS) in 1985 and Nordic Mobile Telephone (NMT- 900) in 1986. Asia, Latin America, and Oceanic countries embraced the AMPS standard, causing an expanded potential market in the world for cellular network (Mehrotra, 1997). However, the networks had a low traffic capacity, unreliable handover, poor voice quality, and poor security. Due to the deployment of analogue technology, the transceiver cannot handle more than a call at a time. These restrictions led to the convergence of the European counties and International applications on a uniform standard for the development of a new cellular system that employs digital technology, called Global System for Mobile Communication (GSM, originally Groupe Spécial Mobile) which was firstly launched in Finland in December 1991 (Anton, 2003).

Network is said to be in a state of congestion when the number of subscribers that are attempting to access the network simultaneously is more than the carrying capacity of the network at a particular

time. Also, congestion was defined by Kuboye (2010), as unavailability of network to the subscriber at the time of making a call. The unavailability of network depends on switch facilities, exchange equipment and transmission link. Traffic congestion mainly arises due to inadequate capacity of equipment and improper network management. Some of the effects of congestion on the network systems are queuing, slow speed, poor throughput and poor network among the mobile wireless communication (Habibur, 2015).

2. Literature Review

In the early 1980s, most mobile telephone systems were analogue rather than digital. The advantages of digital systems over analogue systems include ease of signalling, lower levels of interference, integration of transmission and switching, and increased ability to meet capacity demands (Scourias, 1997). The limitations of analogue system became clear as the number of subscribers increased. This gave way to the Global system for mobile communications (GSM). While experimenting on a dynamic channel allocation model with one-level buffering for controlling congestion in mobile cellular networks, Ojesanmi, et al., (2011) realized that the use of one-level buffering in the dynamic channel allocation model reduces call loss due to network congestion hence leading to better network performance. Mughele, et al., (2012) attributed the causes of congestion in GSM network in some countries like Nigeria to factors such as exceeding the carrying capacity of network facilities, use of mobile phones for data transfer and multimedia activities, vandalization of network equipment and unfavourable weather conditions. Alimi O.A et al., (2015) attributed the network congestion to managerial issue and over-utilization of node in a network which can lead to short span of resources or malfunctioning. The author suggested call admission control techniques to control the network congestion and improve the system performance generally.

Ofomaja, et al., (2015) analysed the percentage traffic congestion in the different sectors/cells of a well-established network around the metropolitan area of Asaba, Nigeria. A Network Management Software (NMS) was used for data collection based on three GSM traffic cells with three sectors each for a total of about one million monitored calls. Considering three cells, traffic was measured at every hour of the day for 2 months, so as to obtain numerically substantial data. The cells were chosen as representative of the whole network taking into account cell extension, number of served subscribers in the area, and traffic load. The parameter used was the percentage traffic congestion. In their analysis, they were able to conclude that the sectors cannot perform optimally when the amount of traffic unusually increases and then suggested that the network operator should carry out further optimization on all the sectors/cells as this will ultimately improve the QoS of the network provider. They further concluded that traffic analysis should not be based on cells alone, but especially on sectors.

Emuoyibofarhe, et al., (2015) employed interviews and data logging software as the major instruments to collect data, explored the use of Erlang-B and critically analysed the call data for a period of busy hour for a week for over 60 minutes between the hours of 8.00am and 9.00am. The number of calls the network receives daily, number of calls congested, calls connected, and maximum number of calls the system could sustain at the peak or busy periods were observed, collected and analysed. With the use of correlation analysis hypothesis, the total load per call setup attempts, the effective load or successful call setup (times), the available channels or successful TCH assignments and also the blocking rate or TCH congestion ratio (%) were determined. It was discovered that a lot of available channels were being underutilized especially in areas with low blocking ratio where the available channels exceeded the required channels for transmitting the effective load. Furthermore, the cells with very high traffic will reduce the quality of calls made bringing about poor QoS and grade of service (GoS). It was then recommended that the network provider should restructure and re-plan the cells in those particular

geographical regions with high traffic intensity by increasing the number of channels in those cells (stations), and also by providing more cell sites in order to ensure proper caution in the frequency re-use factor so as to prevent other transmission challenges that can affect the GoS rendered to the subscribers resulting into congestion in the traffic.

Surajo, (2016) carried out traffic congestion audit of MTN cells located within Dutse metropolis, by following routes between the cells and assessing the QoS. Drive test was conducted to collect traffic data, the base transceiver station (BTS) power throughput was measured and the maximum carrying capacity of mobile stations (MSs) was identified which allowed the determination of the amount of deviation from the expected power. He identified the channels and/or interface(s) that mostly contributed to this traffic congestion by comparing his findings with the KPIs. In his analysis, he discovered that the channels that are significantly involved in call setup are at the same time played a vital role toward congestion effect. He then offered conceivable solutions for improvement.

In this work, the performance of the traffic congestion as index of QoS of leading mobile communication networks in Nigeria around Osogbo metropolis were analysed and the network performance was evaluated based on five major KPIs which are; call setup success rate, call drop rate, handover success rate, traffic channel congestion rate and standalone dedicated control channel congestion rate. Every KPI was explored and the results were likened to the standard threshold values recommended by NCC and based on the observation, some suggestions were offered for performance improvement.

3. Methodology

A Drive Test, using a drive test software called TEMS (Test Mobile Systems), was adopted to collect data. The test was carried out as a benchmarking on three leading mobile network operators for the months of March, July and August 2017. Fig. 1 shows the Google map of the study area.

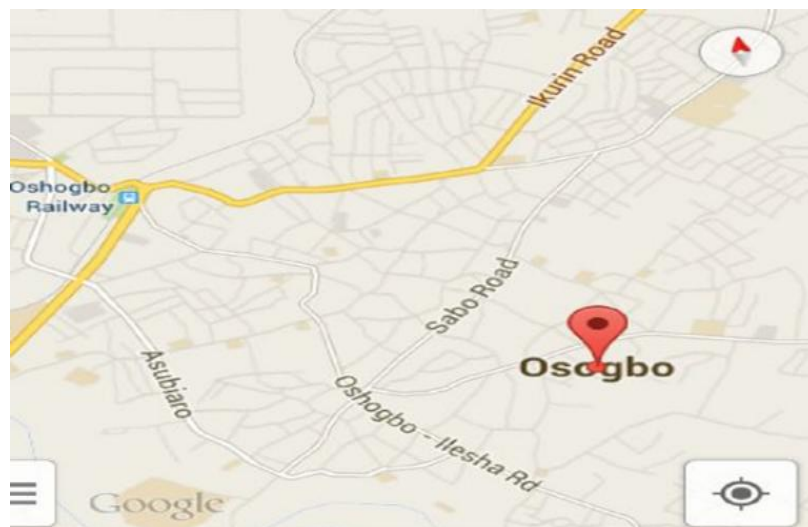


Fig. 1. The study area, Osogbo Google map.

3.1 Drive Test

Drive test could be performed on any cellular network regardless of technology e.g. GSM, CDMA, UMTS, LTE, etc. The required wares for Drive Test setup are:

- Laptop computer (RAM $\geq$ 4GB)
- Drive Test Software (TEMS 10.0.4 in this case)
- Dongle Key (Serve as security for unlocking the software)
- Mobile Phones
- GPS (Global Positioning System)
- A Scanner (Optional).

The main goal of drive test is to collect test data which can be viewed or analysed in real time during the test, allowing a view of network performance on the field. As such, the data were collected for benchmarking of the services of these mobile operators.

3.2 Key Performance Indicator Parameters

The KPIs serve as a measure of network performance and quality of service on a daily, weekly or monthly basis. Due to ever increasing number of mobile users and corresponding requirement for capacity improvement, continuous monitoring of the KPIs is necessary for the operators to ensure optimal performance. A network system is at the optimal performance when the parameters are measured to be within the set thresholds. The KPIs considered are: Call setup success rate (CSSR), Call drop rate (CDR), Handover success rate (HOSR), Traffic channel (TCH) congestion rate and Standalone dedicated control channel (SDCCH) congestion rate.

3.2.1 Call Setup Success Rate

Call Setup Success Rate (CSSR) indicates the probability of successful calls initiated by the mobile station. CSSR is used to measure the impact of congestion during a call attempt. It is an essential KPI parameter for appraising the network performance. A low CSSR dictates a poor QoS. It is expressed in percentage as given by (Agyekum, 2014).

$$\text{CSSR} = \frac{\text{Number of call setup}}{\text{Number of call attempt}} \times 100\% \quad (1)$$

3.2.2 Call Drop Rate

This is a fraction of the telephone calls which, due to technical reasons, were cut off before the speaking parties had finished their conversation and before one of them had hung up (Huawei, 2008). In other words, it is a prematurely terminated call before either the caller or the called party normally

released the call. Equation (2) shows the mathematical expression of call drop rate in percentage. A too high call drop rate adversely affects the user's experience.

$$CDR = \frac{\text{Number of dropped call}}{\text{Number of Successfully Completed call attempt}} \times 100\% \quad (2)$$

3.2.3 Handover Success Rate

Handover success rate (HOSR) is the ratio of the number of successfully completed handovers to the total number of initiated handovers. HOSR is used to measure the impact of congestion at movement during a call. Equation (3) gives the mathematical representation of HOSR (NCC, 2012).

$$HOSR = \frac{\text{Successful handover}}{\text{Total handover requests}} \times 100\% \quad (3)$$

HOSR is inversely associated with CDR. Hence, a high HOSR portrays a low CDR and an improved QoS.

3.2.4 Traffic Channel Congestion

Traffic channel (TCH) congestion is defined as the probability of failure in accessing traffic channel(s) or radio access bearer during call connections. It is used to measure the demand for services and channels utilization in the network. Traffic channel congestion rate is expressed in percentage as given in Eq. (4) (NCC, 2012). A high TCH congestion rate in a network gives a deteriorated network service quality.

$$TCH \text{ Congestion} = \frac{\text{Number of unavailable (blocked) TCH requests}}{\text{Total number TCH request}} \times 100\% \quad (4)$$

3.2.5 Standalone Dedicated Control Channel Congestion Rate

This is the probability of failure of accessing a standalone dedicated control channel during call set up. Standalone Dedicated Control Channel (SDCCH) is used in the GSM system to provide a reliable connection for signalling and short message services (SMS). SDCCH congestion rate is as given in Eq. (5)

$$SDCCH \text{ Congestion} = \frac{\text{Number of failed connection due to assignment failure}}{\text{Number of call attempt}} \times 100\% \quad (5)$$

SDCCH and TCH congestions are used to locate where exactly congestion appears in terms of logical channels as these channels are the ones most affected in a congestion situation.

4. Result and Discussion

Tables 1 to 5 show the value of each of the KPIs accountable for traffic congestion in the network with their corresponding graphical analysis when compared to each other is as depicted in Figs. 2 to Figs. 6.

4.1 Result of Call Setup Success Rate

Table 1 shows the values of the call setup success rate recorded during the period of the investigation while Fig. 2 shows the plot of this call setup success rate for the three networks.

Table 1. Call Setup Success Rate

DATE	MTN	GLO	AIRTEL
MARCH 21/03/2017	98.31	99.84	98.84
22/03/2017	98.37	99.86	99.32
23/07/2017	98.33	99.76	99.32
JULY 16/07/2017	92.50	94.78	87.59
17/07/2017	92.86	94.82	89.13
18/07/2017	92.90	94.84	91.74
19/07/2017	92.94	94.85	91.86
20/07/2017	93.10	94.88	92.56
AUGUST 03/08/2017	94.51	95.67	95.13
04/08/2017	94.51	95.74	95.73
05/08/2017	94.83	95.77	95.71
06/08/2017	95.10	95.82	96.02
07/08/2017	95.26	95.85	95.88

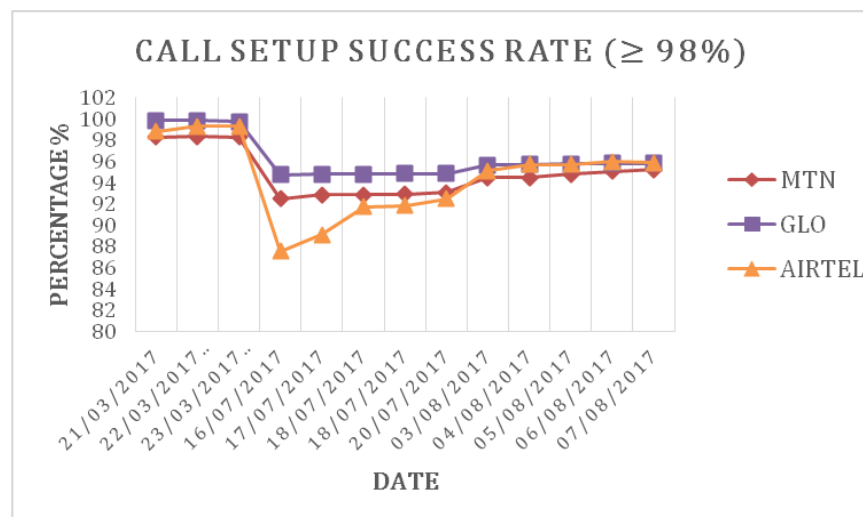


Fig. 2. Call Setup Success Rate

From Fig. 2, it can be seen that during the period under consideration in the month of March, the CSSR of all networks falls within the NCC standard threshold of $\geq 98\%$. However, in July, the CSSR of all the networks were less than the threshold with Airtel having lowest value amongst them. Also in August, the three networks have almost the same values recorded which is also lower than the NCC threshold value which implies that the subscribers were not likely to make call successfully during these periods, thereby experienced congestion during call attempt, this results in an unpleasant experience by the network subscribers in the period under review (i.e. July and August). The anomalies in CSSR values in the months of July and August for the considered networks occurred as a result of technical issues with power supply units in the base station and influx of more subscribers since that period is a festive session (not planned for by the operators) into the region of the case study. Moreover, the low CSSR may be caused by the problems of Immediate Assignment Success Rate, SDCCH drop rate or that of the Assignment Success Rate.

4.2 Result of Call Drop Rate

Table 2 depicts the value of the call drop rate recorded for the networks during the period and the corresponding graphical analysis of the call drop rate of the networks as compared to the acceptable threshold is shown in Fig. 3.

Table 2. Result of Call drop rate

DATE	MTN	GLO	AIRTEL
MARCH 21/03/2017	1.14	0.09	1.05
22/03/2017	1.11	0.07	0.85
23/07/2017	1.09	0.21	0.97
JULY 16/07/2017	2.42	1.53	1.32
17/07/2017	2.40	1.51	1.31
18/07/2017	2.32	1.50	1.31
19/07/2017	2.31	1.48	1.30
20/07/2017	2.31	1.47	1.28
AUGUST 03/08/2017	2.16	1.35	2.52
04/08/2017	2.16	1.35	2.51
05/08/2017	2.13	1.34	2.51
06/08/2017	2.12	1.34	2.50
07/08/2017	2.10	1.33	2.48

It can be seen in Fig. 3 that Glo recorded no deviation at all throughout the period of investigation as all its CDR values fall within the NCC standard threshold of $\leq 2\%$. Nevertheless, AIRTEL had values for CDR that are within the threshold value, except in the month of August where a slight deviation was experienced. MTN, on the other hand experienced deviation from this standard throughout the period in July and August. CDR deviation can be caused by network factors such as: poor coverage, network interference, hardware and transmission fault, improper parameter configuration and transceiver imbalance of Uplink and Downlink path.

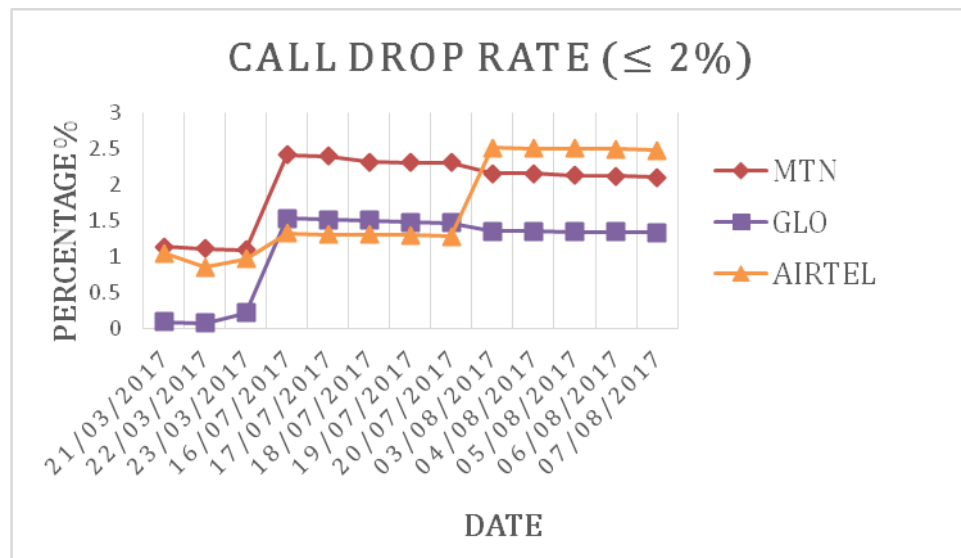


Fig. 3. Graph showing Call Drop Rate

4.3 Result of Handover Success Rate

A handover is a process in mobile communications in which a connected cellular call or a data session is transferred from one cell site (base station) to another without disconnecting the session. The results of the handover success rate recorded during the period of the investigation is presented in Table 3. Depicted in Fig. 4 is the plot of the analysis of the handover success rate of the network operators in comparison with the acceptable standards. The table shows that, although, the handing over rate is high but not meet the requirement, there is a need to for the operator to comply with threshold set by the industry regulator.

Table 3. Result of Handover Success Rate

Vertical (Value) Axis Title		MTN	GLO	AIRTEL
MARCH	21/03/2017	98.19	80.12	86.78
	22/03/2017	98.31	82.23	86.88
	23/07/2017	98.24	84.25	86.90
JULY	16/07/2017	93.72	95.98	94.86
	17/07/2017	93.76	96.01	94.84
	18/07/2017	93.76	96.01	94.82
	19/07/2017	93.80	96.06	94.80
	20/07/2017	93.82	96.07	96.10
AUGUST	03/08/2017	94.17	96.32	96.12
	04/08/2017	94.19	96.36	96.22
	05/08/2017	94.24	96.37	96.22
	06/08/2017	94.24	96.37	96.24
	07/08/2017	94.32	96.38	96.20

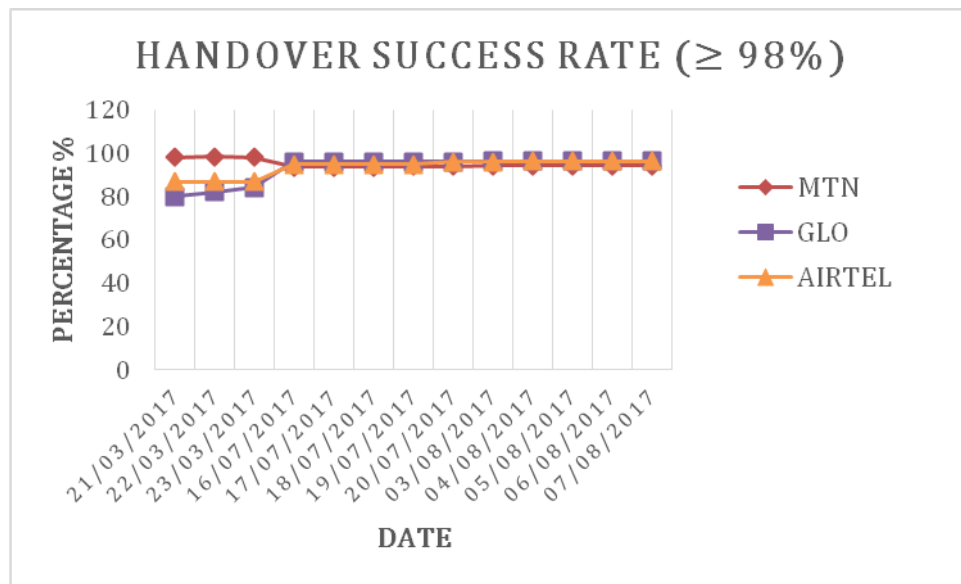


Fig. 4. Graphs of Handover Success Rate

As shown in Fig. 3, the handover success rate of MTN in the month of March was within the threshold value of $\geq 98\%$. However, GLO and AIRTEL experienced a severe deviation within the same period. Moreover, slight deviation in HOSR were experienced in all the networks throughout the months of July and August. This slight deviation in HOSR could dictate some handover failure during the period under consideration and as such, subscribers would experience dropped call and a deteriorated QoS at these periods. Degraded HOSR may be caused by, Improper Neighbour planning, Hopping Sequence Number (HSN) clash, DAC value and Sync mismatch, Overshoot and Low Coverage.

4.4 Result of Traffic Channel Congestion Rate

Table 4 shows the traffic channel congestion rate recorded for all the networks during the period of the findings. The graphical analysis of the traffic channel congestion values for the networks in comparison with one another is delineated by Fig. 5.

Figure 5 shows that the traffic channel congestion rate during the test period in the month of March and August for the three networks fall within the NCC standard. In July, Glo still upheld its value of TCH congestion rate threshold of $\leq 2\%$, while MTN and AIRTEL had their TCH values outside the threshold. This deviation in TCH congestion rate may be caused by network factors such as; poor coverage, network interference, hardware and transmission fault and improper parameter configuration. A poor TCH congestion rate means poor traffic channel assignment, thereby leading to low QoS.

Table 4. Result of Traffic Channel (TCH) Congestion of both networks

DATE	MTN	GLO	AIRTEL
MARCH 21/03/2017	0.03	0.03	0.02
22/03/2017	0.02	0.00	0.01
23/07/2017	0.04	0.06	0.02
JULY 16/07/2017	4.63	1.52	4.83
17/07/2017	4.51	1.51	4.82
18/07/2017	4.26	1.42	3.89
19/07/2017	3.97	1.37	3.86
20/07/2017	3.13	1.36	3.45
AUGUST 03/08/2017	0.59	0.93	1.95
04/08/2017	0.59	0.91	1.94
05/08/2017	0.55	0.89	1.86
06/08/2017	0.54	0.89	1.84
07/08/2017	0.54	0.89	1.84

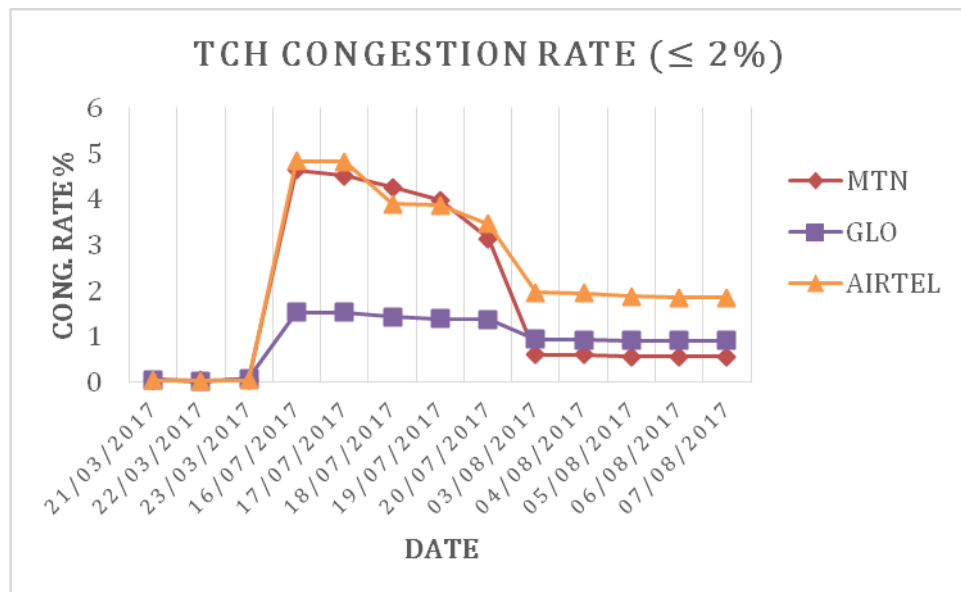


Fig. 5. Graphs of Traffic channel congestion

4.5 Result of Standalone Dedicated Control Channel Congestion Rate

The results obtained for the standalone dedicated control channel (SDCCH) congestion for the networks under consideration during the test periods is as outlined in Table 5 while Fig. 6 shows the plots for its graphical analysis.

Table 5. Result of SDCCH Congestion Rate

DATE	MTN	GLO	AIRTEL
MARCH 21/03/2017	0.10	0.00	0.04
22/03/2017	0.90	0.00	0.04
23/07/2017	0.80	0.02	0.02
JULY 16/07/2017	2.31	1.10	4.51
17/07/2017	2.10	1.08	3.69
18/07/2017	1.98	0.97	2.94
19/07/2017	1.86	0.96	2.25
20/07/2017	1.76	0.84	2.25
AUGUST 03/08/2017	1.17	0.58	0.77
04/08/2017	1.13	0.58	0.76
05/08/2017	1.11	0.57	0.74
06/08/2017	1.08	0.55	0.72
07/08/2017	1.03	0.55	0.68

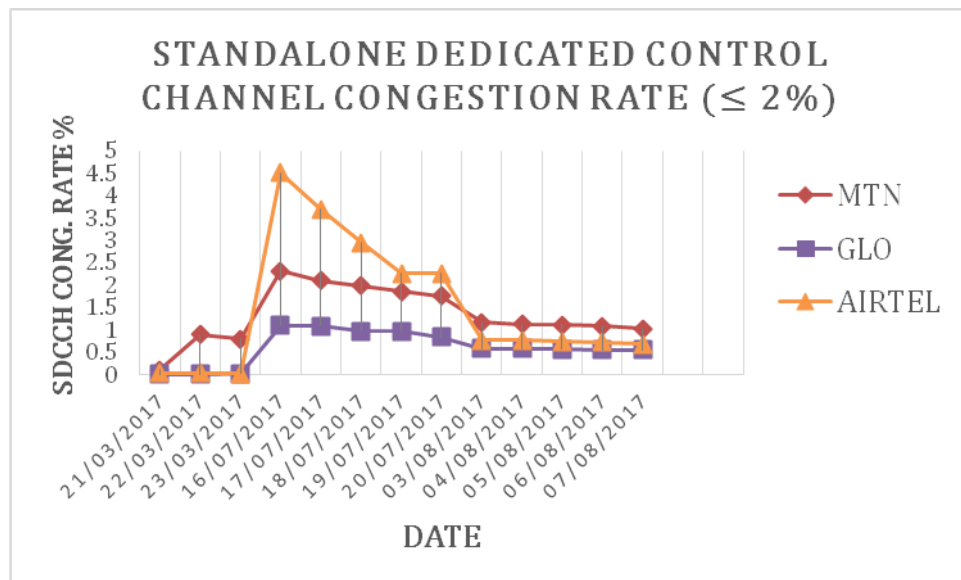
**Fig. 6. Graph showing SDCCH congestion rate**

Figure 6 shows that the SDCCH congestion of all the considered networks maintained the NCC standard thresholds of $\leq 2\%$ in the months of March and August. More so, while MTN and Glo still sustained this standard value during the period under consideration in the month of July, AIRTEL however experienced a great deviation from the NCC standard thresholds i.e. $>2\%$. This as a results of some factors such as network interference, insufficient signalling resources and improper parameter configuration may be responsible for poor SDCCH congestion rate.

5. Conclusions

The result revealed that during the period under investigation by the research team, it was observed that Glo network exhibit a mean traffic congestion values considerably within the NCC acceptable standards. However, the other performance index parameter, TCH and SDCCH congestion values recorded by AIRTEL in July exceeded the maximum NCC standard. Considering the values recorded by MTN and AIRTEL networks in the month of July for most of the KPIs, it is consequently concluded that Glo network delivered superior QoS during the period of investigation than all other networks. This may be attached to the influx of subscribers to the other networks at this period. It is therefore recommended that the network operator should perform routine network optimization, reset their network parameters as well as other cells and function parameters to ensure traffic congestion values that are within the stipulated threshold. Hence, it is of great importance for the regulator to keep monitoring the performance of the network provider regularly so that the network user will experience good services

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