JEMT 6 (2018) 25-32 ISSN 2053-3535

Journal of Engineering and Manufacturing Technology
www.bluepenjournals.org/jemt

Comparative analysis of traffic congestion of mobile communication networks in Osogbo, Nigeria

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Article History
Received 22 February, 2018
Received in revised form 27 March, 2018
Accepted 03 April, 2018

Keywords:
Key performance indicators, Parameters, Threshold, Telecommunication.

Article Type :
Full Length Research Article

ABSTRACT

Traffic congestion in mobile communication networks has been the major challenge to both the service providers and subscribers. It could be due to increased subscriber numbers along with introduction of new services by service providers. This research work comparatively analysed the traffic congestion of two leading telecommunication network providers, MTN and GLOBALCOM, around Osogbo metropolis, Osun State, Nigeria. Drive test techniques was adopted to obtain the traffic congestion audit used for benchmarking of these network providers and the various parameters involved in congestion were established. 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 MTN had a mean value of 93.34% CSSR, 1.95% CDR, 95.28% HOSR, 2.74% TCH and 1.62% SDCCH while GLOBALCOM had mean value of 95.53% CSSR, 1.11% CDR, 92.66% HOSR, 1.40% TCH and 0.78% SDCCH, respectively. The CSSR, TCH and SDCCH of MTN and the HOSR of GLO deviates greatly from the acceptable thresholds of ≥98% CSSR, ≤2% TCH, <2% SDCCH and ≥98% HOSR recommended by the Nigerian Communication Commission. Conclusively, MTN had mean traffic congestion values slightly higher than what were experienced in GLOBALCOM.

INTRODUCTION

Cellular telephone, commonly referred to as the cell phone or mobile phone, is the most recent telephone technology. A mobile phone is a movable telephone which receives or makes calls via a cell site (base station), or transmitting tower. A cellular telephone is designed to provide user maximum degree of freedom of movement and as a result, the number of mobile users increases rapidly. The role of cellular phones has risen with the improvement in services, reduction in service cost, and the ever-increasing range of services available through cell phones. 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, resulting in a broadened potential market in the world for cellular telephone. However, the networks had a low traffic capacity, unreliable handover, poor voice quality, and poor security. More so, the systems used an analogue system and analogue transceivers cannot handle more than one call at a time. All these limitations led to the convergence of the European counties and International applications on a

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uniform standard for the development of a new cellular system that uses digital technology, called Global System for Mobile Communication (GSM, originally Groupe Spécial Mobile) which was firstly launched in Finland in December 1991 (Anton, 2003).

GSM technology increased the number of subscribers beyond expectations. GSM uses digital modulation to improve voice quality and is therefore, the most popular standard for mobile phones in the world. The universality of the GSM standard has been an advantage to both consumers and network operators. GSM communication revolution in Nigeria started in August 2001 and this has brought a great change in the face of information and communication technology (ICT) (Adegoke et al., 2008). Nigeria, with the population of 182 million people (Bello, 2017) are presently being serviced majorly by four mobile telecommunication operators which are MTN, AIRTEL, GLOBACOM, and 9-MOBILE formerly called ETISALAT, with each operator competing for the same potential subscribers. The mobility features of GSM, improvements in services, reduction in service costs as well as the ever-increasing range of services (such as mobile internet, multimedia, e-mails, etc.) make the demand for GSM services ever increasing (Mughele et al., 2012). This ecstasy of owning a mobile phone has led to complaints of dropped calls and congestion among subscribers.

According to Kuboye (2010), congestion is the unavailability of network to the subscriber at the time of making a call. Congestion was described as a situation that arises when the number of calls emanating or terminating from a particular network is more than the capacity the network is able to cater for at a time (Mughele et al., 2012). There are various reasons for which traffic congestion can occur, depending on switch facilities, exchange equipment and transmission link. Traffic congestion mainly occurs 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. Consequently, efforts are made by various researchers on the congestion analysis of mobile network providers.

Kuboye et al. (2009) established a current congestion and call-drop state in Lagos through the administering of questionnaires. The respondents, living in different locations within Lagos, were queried on how many times they experienced congestion and call-drop (or call-break) for the last thirty days. The questionnaire was administered in Lagos between July 25 and August 9, 2005 with the expectations that there would be minimal congestion problems with the conception that Lagos has the largest population of subscribers, and all the four operators namely; GLO, MTEL, MTN and CELTEL (now Airtel) concentrate their efforts mostly on Lagos and Abuja. The results, however, showed that Lagos experienced heavy congestion problems. However, this kind of data cannot bode well for more rural or isolated locations in Nigeria. Mbachu and Usiade (2015) carried out comparative analysis of network congestion. In their research, they proposed a combine and non – combined model for managing the congestion control. The research proposed a new scheme that can control congestion in GSM network. The network performance evaluation was based on four major key performance indicators (KPIs) which include call setup success rate, CDR, handover success rate and traffic channel congestion rate. The KPIs were explored and the performance of the new model was compared with that of the non-combined (existing) model. Finally, improvement methodologies were suggested. Surajo (2016) carried out traffic congestion audit of MTN cells located within Dutse metropolis, which involves following routes between the cells and assessing the quality of service (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 enabled him to determine the amount of deviation from the expected power. He identified the channels and/or interface(s) that habitually contributed to this traffic congestion by comparing the outcomes with the KPIs. Conclusively, he found out that the channels that are greatly involved in call setup are simultaneously played a vital role toward congestion effect.

In this research, the traffic congestion of two leading telecommunication companies in the metropolitan areas of Osogbo were comparatively analysed and the performance evaluation was based on five major KPIs namely; 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. All these KPI were explored and the results were compared with the standard threshold values recommended by the Nigerian Communication Commission (NCC) and based on these, possible solutions for improvement to reduce congestion in GSM network were proffered.

MATERIALS AND METHODS

The methodology adopted for data collection in the research was drive test using drive test software called Test Mobile Systems (TEMS). The test was carried out as a benchmarking on two leading mobile network operators for the months of March, July and August, 2017. The drive tests were conducted to extract the parameters needed for the traffic audit of the considered mobile network operators. The extracted traffic congestion parameters were analysed and then compared with the threshold values stipulated by NCC. Figure 1 shows the Google map of the study area.

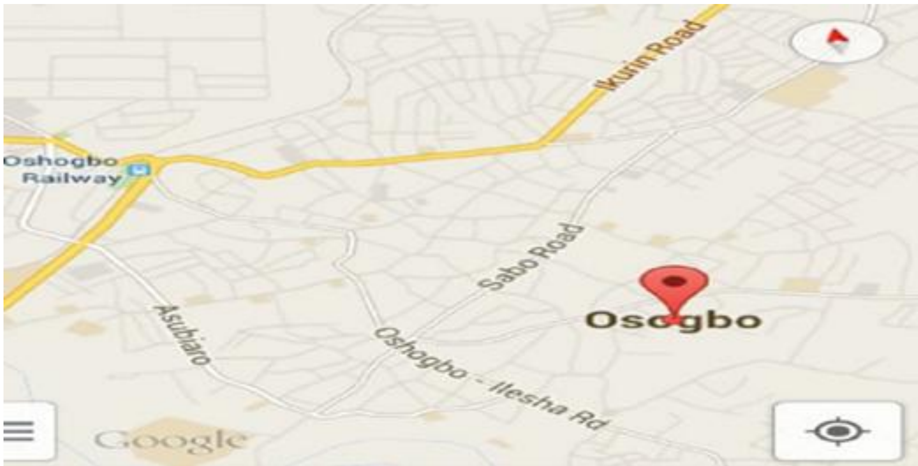

Figure 1. The study area, Osogbo Google map.

Figure 2. Drive test setup.

Drive test could be performed on any cellular network regardless of technology, for example, GSM, CDMA, UMTS, LTE, etc. In this research, the drive test was performed on GSM, and the required wares for the drive test setup are:

- Laptop computer (RAM ≥ 4GB)
- Drive test Software (TEMS 10.0.4 in this case)
- Dongle Key (Serve as security for unlocking the software)
- Mobile Phones (two mobile phones for benchmarking)
- GPS (Global Positioning System)
- A Scanner (Optional)

The setup for drive test is as depicted in Figure 2. The drive test was performed according to the need, the purpose of the test and depending on the technology. The main types of drive test were:

- Performance Analysis
- Integration of new sites and change parameters of existing sites
- Marketing
- Benchmarking

Drive test conducted in this research work was actually for benchmarking of the services of mobile operators. However, in each of the test type, the main goal 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. Figure 3 shows the screen shot of the KPIs captured during the test.

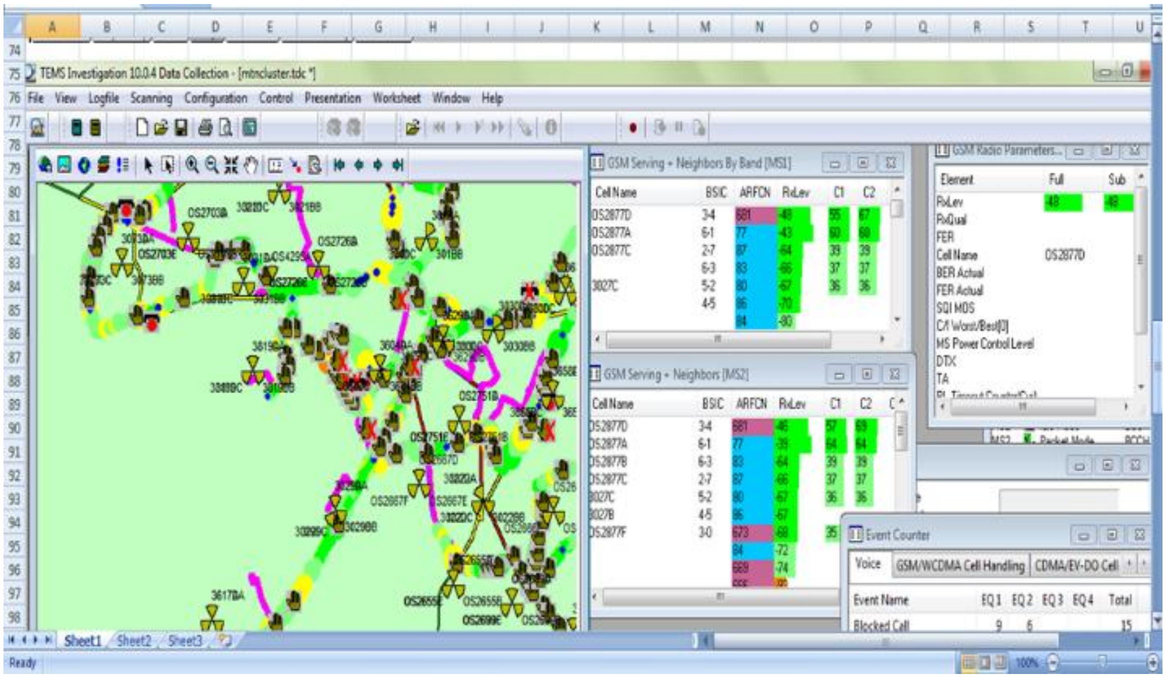

Figure 3. Screen shot of the KPIs.

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 ensuring optimal performance. A network system is at the optimal performance when the parameters are measured to be within the set thresholds. The KPIs evaluated in this paper are: CSSR, CDR, HOSR, TCH congestion rate and SDCCH congestion rate.

Call setup success rate

CSSR is used to measure the impact of congestion during a call attempt. It indicates the probability of successful calls initiated by the mobile station. It is expressed in percentage as in Equation 1 (Agyekum, 2014).

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

The CSSR is an important KPI parameter for evaluating the network performance. A low CSSR dictates a poor QoS.

Call drop rate

A dropped call is a call that is prematurely terminated before being released normally by either the caller or called party (NCC, 2012). Equation 2 depicts the mathematical expression of CDR expressed in percentage.

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

Handover success rate

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 is inversely related to CDR. Thus, a high HOSR depicts a low CDR and a better QoS.

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

Traffic channel congestion

TCH congestion is defined as the probability of failure in accessing traffic channel(s) or radio access bearer during call connections. TCH congestion is used to measure the demand for services and channels utilization in the

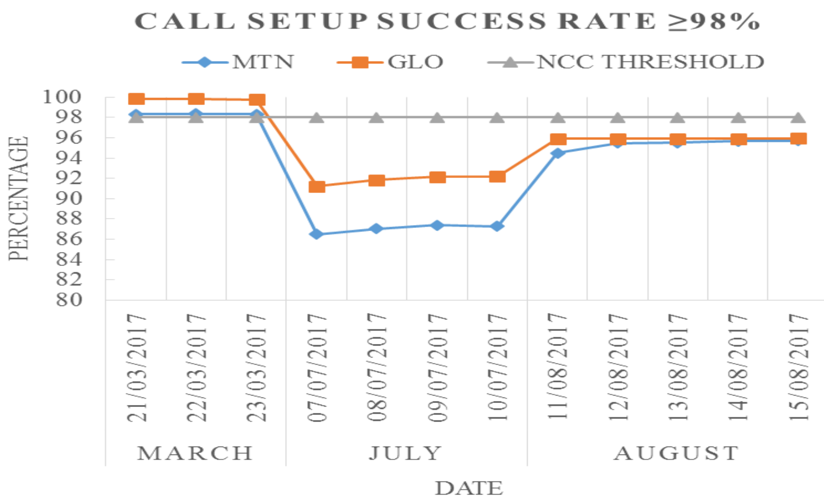

Figure 4. Graphs of CSSR.

Table 1. The NCC KPI threshold for cell and BSC metrics.

KPI parameter	NCC Target
CSSR	≥ 98%
CDR	≤ 2%
HOSR	≥ 98%
TCH CONG	≤ 2%
SDCCH CONG	≤ 0.2%

network. TCH congestion rate is expressed in percentage as given in Equation 4 (NCC, 2012). A high TCH congestion rate in a network gives a poor QoS.

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

Standalone dedicated control channel congestion rate

This is the probability of failure of accessing SDCCH during call set up. SDCCH is used in the GSM system to provide a reliable connection for signalling and short message services (SMS). 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. SDCCH congestion rate is as given in Equation 5.

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

SDCCH congestion is a useful index in measuring the QoS of a network. A SDCCH congestion value outside the threshold limits may lead to loss of revenue by the network operators, and poor network service to the subscribers.

Meeting the metric target set for these KPIs by the Nigerian Communication Commission remained the greatest challenge to service providers in Nigeria. The NCC threshold values (for KPIs parameters) for the base station controller (BSC) and the cell metric is shown in Table 1.

RESULTS AND DISCUSSION

This section of the journal discussed the results of considered mobile traffic congestion parameters when compared and analysed in line with their respective threshold values. Figures 4 to 8 present graphical representation of the congestion parameters.

Result of call setup success rate

Figure 4 shows the graphical representation of the CSSR

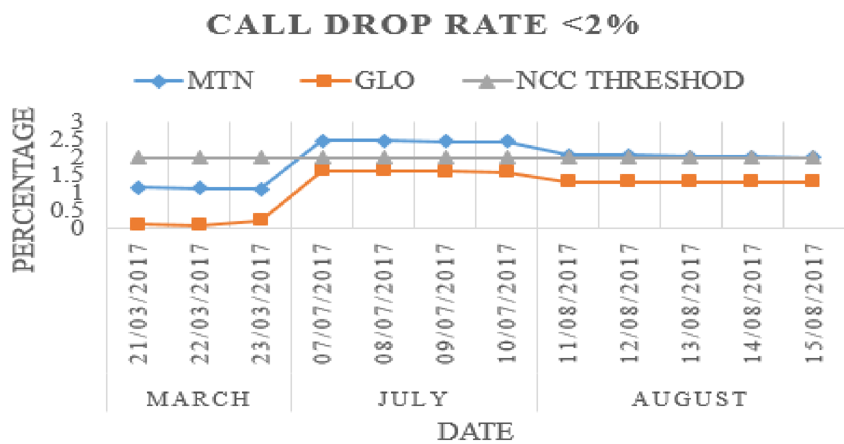

Figure 5. Graphs of CDR.

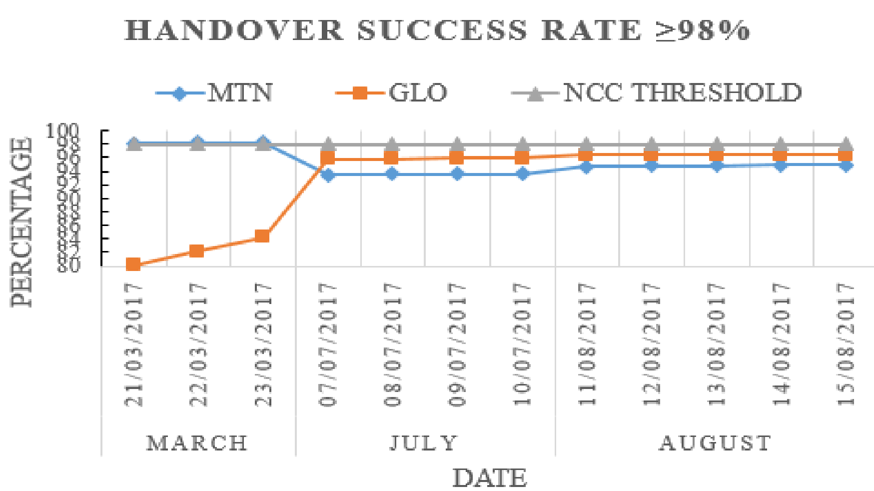

Figure 6. Graphs of HOSR.

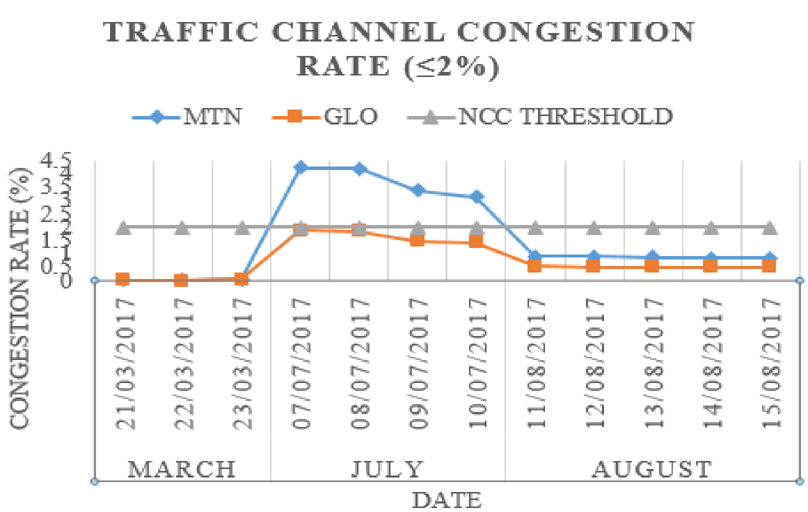

Figure 7. Graphs of TCH congestion rate.

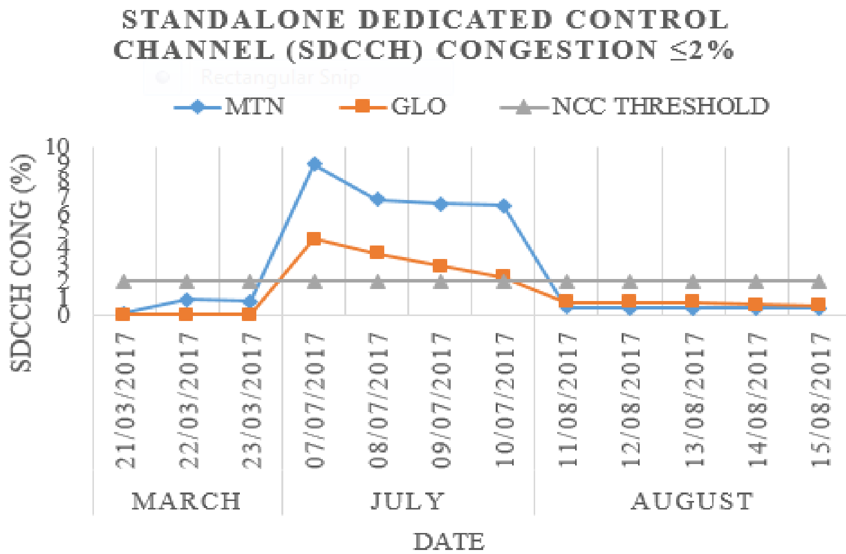

Figure 8. Graphs of SDCCH congestion.

for MTN and GLO evaluated during the drive test for the period under consideration in comparison with the NCC acceptable threshold. It can be seen from the figure that during the period under consideration, in the month of March, the CSSR of both networks falls within the acceptable threshold of ≥98%. However, in July, the CSSR for the two networks were less than the threshold. Also in August, both networks have almost the same values recorded which are also lower than the NCC threshold value. The anomalies in CSSR in the month of July and August for the considered networks might be as a result of technical issues or influx of more consumers (not planned for by the operators) into the region of the case study. Moreover, the low CSSR may be caused by immediate assignment success rate problems, SDCCH drop rate problems, or assignment success rate problems. By implication, mobile subscribers in the region were bound to have more call success in the month of March, while call drop and call failure were bound to characterise the month of July and August.

Result of call drop rate

The graphical analysis of the values of the CDR recorded during the test, for the considered networks in line with the NCC standard threshold is as shown in Figure 5.

It can be seen in Figure 5 that GLO recorded no deviation at all throughout the period of investigation as all its CDR values fall within the NCC threshold value of ≤ 2%. However, MTN had values for CDR that are within the threshold, except in the month of July where a slight deviation was experienced. The implication is that, GLO subscribers would have experienced minimal call drop in the period under consideration, however, MTN subscribers mighty have experience better service in the month of March and August, but a terrible call drop and mobile service in the month of July. Poor CDR can be caused by poor coverage, network interference, hardware and transmission fault, improper parameter configuration and transceiver imbalance of uplink and downlink path.

Result of handover success rate

The results of the HOSR recorded during the period of the investigation in accordance with NCC threshold are presented in Figure 6.

As shown in Figure 6, the handover success rate of MTN in the month of March was within the threshold value of ≥98%. However, GLO experienced a severe deviation within the same period. Moreover, slight deviation in HOSR was experienced in both networks in the month of July and August. Consequently, it was only MTN network that had a better handover procedure in the month of March throughout the entire period under consideration. Poor HOSR could dictate some handover failure in a mobile network. HOSR may be affected by improper neighbour planning, hopping sequence number (HSN) clash, DAC value mismatch, sync mismatch, overshoot and low coverage.

Result of traffic channel congestion rate

The graphical analysis of the traffic channel congestion values for both networks when compared with the NCC standard is delineated by Figure 7. It can be seen in the figure that the TCH congestion rate during the test period in the month of March and August for MTN and GLO fall within the acceptable standards of ≤2%. However in July, while GLO still maintained a TCH congestion rate that is within the threshold, MTN had TCH congestion values far outside the threshold. Consequently, MTN subscribers were bound to experience poor traffic channel assignment, thus traffic congestion in the month of July. Impaired TCH congestion may be caused by, poor coverage, network interference, hardware and transmission fault and improper parameter configuration.

Result of standalone dedicated control channel congestion rate

The results obtained for the SDCCH congestion for the two networks under consideration during the test periods in comparison with the NCC threshold is as outlined in Figure 8.

Figure 8 show that the SDCCH congestion of both networks maintained the threshold of ≤ 2% in the months of March and August. Nonetheless, both networks experienced deviation from the threshold in July. However, the deviation was more severe in MTN than in GLO. Thus, both networks were bound to experience call failure in the month of July. Factors such as network interference, insufficient signalling resources and improper parameter configuration may be responsible for poor SDCCH congestion rate.

CONCLUSION AND RECOMMENDATIONS

The result revealed that during the period under review especially in the month of July, MTN has mean traffic congestion values greater to some extent than those experienced in GLO. This may not be unconnected with higher number of subscribers, though none of the two network operators examined performed too badly. Based on the findings of the research, the following optimization methods, which when implemented will reduce the congestion problem or eradicate it entirely, are thus recommended:

- There is need for proper setting of the number of SDCCHs, TCHs and the SDCCH dynamic conversion function in order to relieve congestion.
- There is the need to upgrade and expand the site’s capacity.
- Frequency hopping needs to be incorporated (where absent) to minimize interference effects.
- Reset correctly, the network parameters such as handover, channel assignment and other cell and function parameters.
- Trace Abis-interface signalling.
- Check and solve hardware problems and clear alarms.
- Enable SDCCH dynamic allocation function or increase the number SDCCH channels.

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