CONGESTION CONTROL IN GLOBAL SYSTEM FOR MOBILE COMMUNICATION (GSM) NETWORK USING HYBRID MODEL ALGORITHM

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ABSTRACT
Global System for Mobile Communication (GSM) is a telecommunication network that is used globally for communication services such as voice communication, data connection for fax, short message service (SMS) and full dial-up connection to the internet for e-mail and web browsing. This network especially in Nigeria is faced with serious challenge of traffic congestion, leading to call drops, incomplete calls, cross-talks, distorted or faint talks and other undesirable effects. It is necessary that a means of managing this congestion so that subscribers can get desired satisfaction from GSM available services is taken into consideration. In this paper therefore a hybrid model algorithm for managing signal traffic congestion is developed. Based on the algorithm, the performance of the GSM network is extensively evaluated using the key parameter indicators which include call set-up success rate (CSSR), call drop rate (CDR), call completion success rate (CCSR) and traffic channel congestion rate (TCHCR). In this research work, a hybrid model for managing signal traffic congestion is developed. Based on the hybrid model, the performance of the GSM network is extensively evaluated using the key parameter indicators which include; Call Set-up Success Rate (CSSR), Call Drop Rate (CDR), Call Completion Success Rate (CCSR), Traffic Channel Congestion Rate (TCHCR). The paper discusses different schemes like block time sharing, dynamic allocation without time slicing, dynamic allocation with time slicing with signal sensing, frequently recent call allocation and priority allocation models for providing good Quality of Service (QoS) in GSM networks. A comparison of the performance of the hybrid model with other examined models in congestion centres reveals that the hybrid model has an improved performance (Quality of Service) over the other examined models (non-hybrid models).

Keyword: GSM, Mobile Network Evaluation, Drive Test, KPIs, QoS.

1. INTRODUCTION

In the past decade, the mobile telephone network in Nigeria has witnessed tremendous growth and this growth rate is likely to be sustained in the near future, and considering the ever increasing number of subscribers, more demanding applications have been developed and implemented which is consequential to greater resources requirement [1]. The analog system of telecommunication was associated with lots of setbacks or limitations which made it impossible for subscribers to get the desired satisfaction for its available services. The two major inherent limitations of the analog cellular systems are severe confined spectrum allocation and incompatibility among the various analog services available [2]. This consequently led to the convergence of the Europeans on a uniform standard for second generation digital system called global system for mobile telecommunication (GSM).

The GSM network is more advanced and handles more subscribers than the analog systems. It is a mobile telecommunication technology system that uses the Time Division Multiple Access (TDMA) to divide the channel into time slots. It offers high quality voice communication and low bandwidth (9.6kb/sec) data connection for fax, short message service (SMS) and full dial-up connection to the internet for e-mail and web browsing, usually requiring a mobile computer or intelligent handset. Nevertheless, as the number of services and subscribers of GSM in Nigeria keep increasing daily, the demand for good quality of service (QoS) has become an issue for national concern. This agitation has become a national issue which was been brought before the national assembly (House of Representative) in July 18, 2007 and the Nigeria communication Commission [3].

One of the major causes of poor QoS is signal traffic congestion. In digital communication congestion occurs when the number of subscribers attempting to simultaneously access the network is more than the capacity the network can handle or sustain. In [4], the author described congestion as unavailability of network to the subscriber at the time of making a call. Congestion can also be defined as a situation when a subscriber cannot obtain a connection to the wanted subscriber immediately [5]. In another related publication, [6] described congestion 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.

As at December 2012, the estimated number of GSM subscribers in Nigeria was stated to be over 80 million making the country one of the fastest growing GSM, market in the world [7]. The major operators of GSM network in Nigeria include MTN, Airtel, Globacom and Etisalat. MTN enjoys the highest patronage with over 80 million active lines (subscribers). In Nigeria the causes of congestion have been identified to include [6, 8, 9, 13, and 14] the following:

1. Inadequacy of base transceiver stations (BTS)
2. Limited bandwidth
3. Using radio waves for the transmission of speech (voice), data and video from base stations to mobile switching centres and these radio waves are subject to interference from other electromagnetic waves generating systems such as radio and television stations
4. Competition for subscribers among the operators
5. Lack of end-to-end system
6. Lack of good quality phones
7. Lack of good quality terms between different networks
8. Marketing strategies and pricing schemes
9. Use of mobile phones for data transfer and multimedia activities
10. Vandalisation of network equipment
11. Unfavorable weather conditions

Many researchers have worked on signal traffic congestion control in GSM in Nigeria. In [1] Oyebisi and Ojesanmi developed a congestion control scheme for wireless mobile network. In their publication, they presented a model which had a combination of call admission control with buffer management to prevent congestion in wireless mobile network. In [3, 10] the authors recommended upgrading of existing facilities, installation of additional base stations and switching centers and improving power supply as a congestion control technique. Popoola et al [11] proposed that the coverage area should be improved (increased) by GSM operators in order to improve their performance. They further stressed that Nigeria communication commission (NCC) should inspect the GSM network facilities in Nigeria regularly and more base stations should be built as a means of congestion control. In a related study, Alorape et al [12] developed a combined scheme which incorporated the Adaptive Call Admission (ACA) scheme and load balancing strategy. The scheme has the ability to minimize the New Call Blocking Probability (NCBP) and the Hand off Call Dropping Probability (HCDP). In this this paper a hybrid model algorithm for controlling control is developed. The developed algorithm is applied on an existing GSM hardware and the performance is extensively evaluated by simulation.

2. COMPONENTS OF GSM NETWORK SYSTEM

The GSM network is classified into three major systems as shown in fig 1. Each of these systems comprises a number of fundamental functional units which constitute the individual operational components of the mobile network. The three systems are the switching system (SS), the Base station system (BSS) and the mobile station (MS). In addition as with all digital telecommunication networks, GSM networks are operated, maintained and managed from computerized centres.

2.1 Mobile Station

The mobile station is made up of the mobile equipment and a smart card Subscriber Identity Module (SIM). The SIM provides personal mobility that enables the user have access to subscribe services irrespective of the type of mobile equipment being used. In other words, it enables the user to make and receive calls. The mobile equipment is uniquely identified by the International Equipment Identity (IMEI) and the SIM card has the International Subscriber Identity (IMSI) which is used to identify the subscriber to the system.

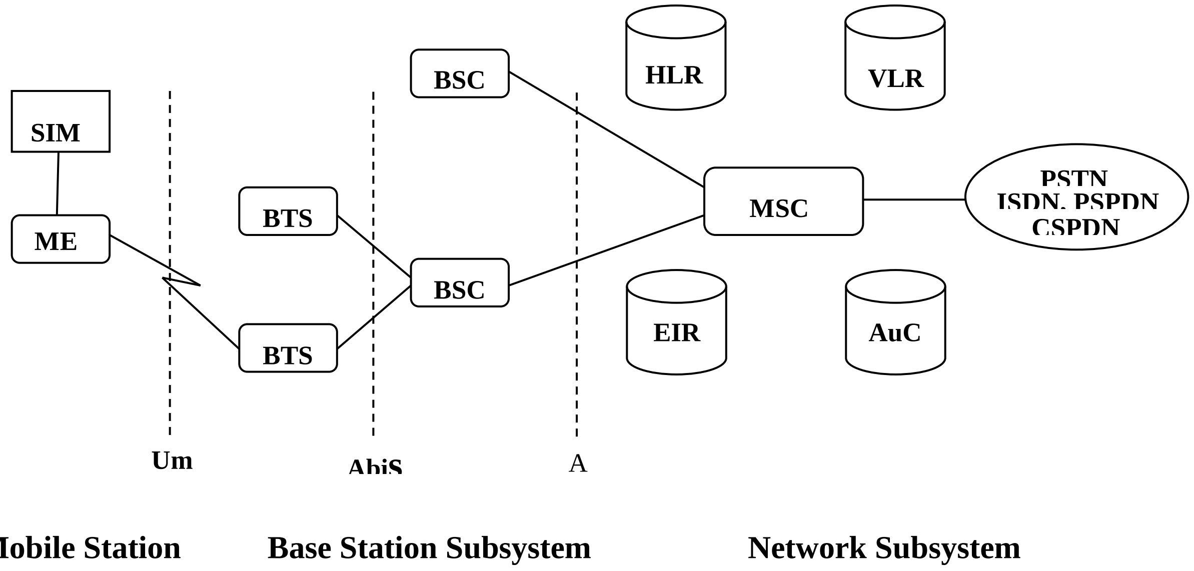

Figure 1: General Architecture of GSM Network

SIM: Subscriber Identity Module ME: Mobile Equipment BSC: Base Station Controller

2.2 Base Station System

All radio related functions are performed in the Base Station System. This system is made up of the Base Station Controller (BSC) and the Base Transceiver Station (BTS) as shown in fig 2. It is the section of a traditional cellular telephone network which is responsible for handling traffic and signaling between a mobile phone and the network switching sub-system.

The base station system carries out trans-coding of speech channels, and allocation of radio channels to mobile phones, paging transmission and reception over the air interface and many other tasks that is associated with radio network.

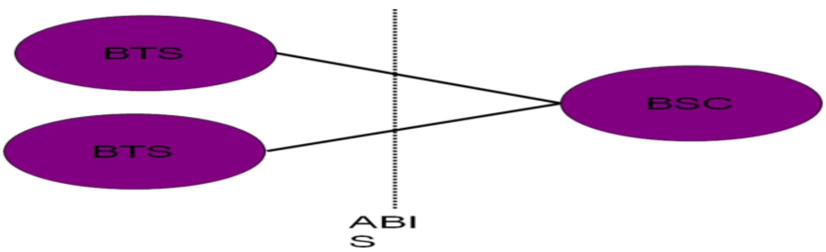

Figure 2: Two BTS System controlled by a BSC in the GSM Network

2.3 Switching System

The switching system is the GSM connection to other networks and allows calls to be set up to and from the mobile station. The switching system performs the function of call processing and other subscriber related functions. This system is made up of the following functional unit.

- Home Location Register (HLR)
- Mobile Service Switching Centre (MSC)
- Visitor Location Register (VLR)
- Authentication Centre (AUC) et cetera.

2.4 Key Performance Indicators for GSM Network

The key performance indicators as specified here simply describe the parameters that are used to assess or determine the quality of service (QoS) on the GSM network.

There are many network parameters that evaluate the quality of network service and this paper will be limited to the following areas:

Call Success Setup Rate (CSSR): This parameter measures the ease in which calls are established or setup. The higher the value of CSSR, the easier it is to setup a call.

Call Drop Rate (CDR): This indicator measures the network ability to retain call conversation when it has been established or setup.

Call Completion Success Rate (CCSR): It is a good parameter for evaluating the network accessibility and retainability performance as seen by the subscriber.

Traffic Channel Congestion Rate (TCHC): This congestion measures the relative ease by which the customer seizes a traffic channel to set up a call after a signaling seizure has been successful. The higher the value, the relative difficulty it is in making a call.

3. THE PROPOSED HYBRID MODEL

The proposed congestion control hybrid model is designed to incorporate three basic fundamental models which include call priority allocation, frequently recent call and handoff call buffer.

The handoff buffer scheme deals with the management of handoff/handover calls. This basic model is designed to buffer handoff calls if no free channel is available rather than rejecting them. These buffers are created in the base station controller and mobile switching substation controller unit of the network depending on the type of handoff operation. The handoff call will be allocated a channel when the channel if free (user completes its call) or the caller moves to another cell before the call is completed where it is assigned a free channel. However, handoff call of higher priority is preferentially assigned a channel in this system.

The frequently recent call allocation scheme allows subscribers who could not access the network but immediately redial within the pre-defined time frame to be given access to the network. This is made possible in this design by creating small memory unit that can register calls which were denied access initially and higher preference given to caller with higher numbers present in the memory unit. This memory is created in the base station controller unit.

The call priority allocation scheme enables every subscriber to be assigned a level of priority which has been integrated into the SIM card. Upon the activation of the SIM card, the network provider automatically registers the priority level of the subscriber. This level of priority helps to determine the nature of the subscriber service. In this model, the subscriber with a higher level of priority will gain access to the channel before the lower priority caller/subscriber.

The advantages of this hybrid control operation are:

- It gives priority to highly essential duties calls that need immediate attention. This will thereby forestall any casualties that may occur if such attention is not given.
- It gives priority to the most denied calls to grab the channel when they appear within a specified time.
- It does not allow any call to occupy the channel more than necessary when they are calls waiting to grab the channel.
- It allows dynamic allocation of channel when there is equal priority calls.

The flow chart of the hybrid congestion control scheme is depicted in fig 3 below.

4. DATA COLLECTION AND ANALYSIS

There are two approaches to evaluate the performance of a live GSM network, namely KPIs and drive tests. On one hand, KPIs give us detailed statistics for many events in GSM cells. On the other hand, drive tests show the realistic experience of the customer. Customer's point of view is more important since it reflects the real life scenarios. The drive test system consists of the following:

1. Software for data collection, such as TEMs (Ericsson professional tool used for drive test data Collection) and investigation, installed on a laptop.
2. A global positioning system (GPS) receiver to place the collected samples on their corresponding co-ordinates on a digital map [15].

Two laptop units with Microsoft Word package installed are used in the data analysis. One unit is used in connected mode (dedicated mode) to measure the QoS, handover and other serving cell parameters during the call. The other unit is used as scanner (idle mode) to scan all the available GSM900 band frequencies. The scanner unit is useful to detect the interfering cells on the serving cell.

A drive test was carried-out in the streets of Port Harcourt from January to April 2014. The distributions of the collected signal samples are shown in Table 1 below.

This data collection was made possible via the assistance of Airtel Nigeria (GSM service provider) and the data contained the Call Set-Up Success Rate (CSSR), Call Drop Rate (CDR), Call Completion Success Rate (CCSR) and Traffic Channel Congestion Rate (TCHCR) as showed in the table below. These data were analyzed using Excel to examine the performance of the two systems. The characteristics obtained for the two systems are presented in the result and discussion portion of this paper.

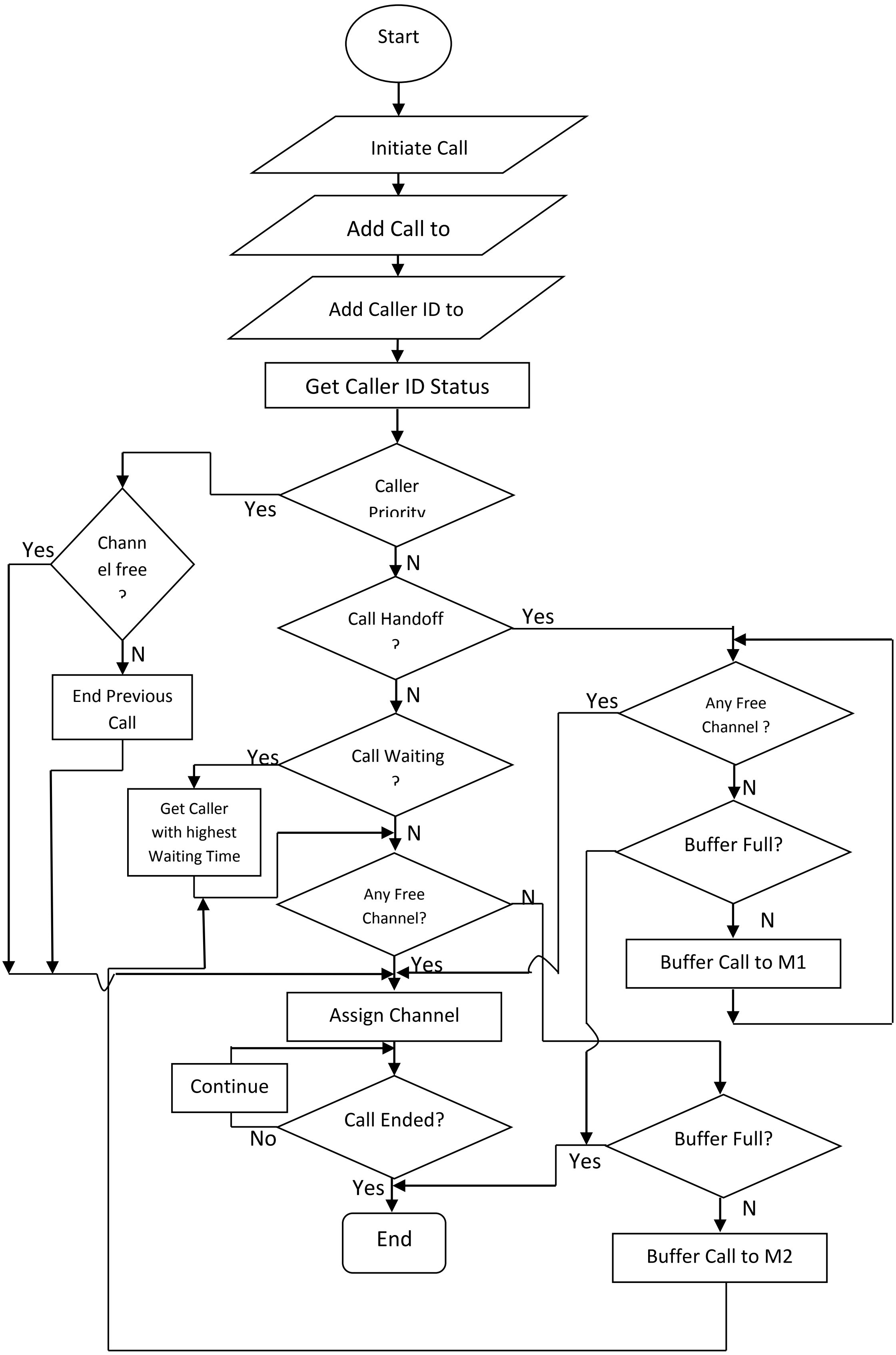

Figure 3: The Hybrid Model

5. SYSTEM RESULTS AND DISCUSSION

Table 1 below shows the results of a drive test carried out in the field on an existing model, which is the non-hybrid model, and the proposed hybrid model from January, 2014 to April, 2014 in the streets of Port Harcourt.

Table 1: Field Data for Hybrid and Non Hybrid Model

DATE	CALL SET-UP SUCCESS RATE (CSSR)		CALL DROP RATE (CDR)		CALL COMPLETION SUCCESS RATE (CCSR)		TRAFFIC CHANNEL CONGESTION RATE (TCHCR)	
	HM	N-HM	HM	N-HM	HM	N-HM	HM	N-HM
27/01/2014	98	95	1.2	2.0	99	97	1.6	1.8
03/02/2014	99	95	1.4	2.0	99	98	1.8	2.0
17/02/2014	98	93	1.4	2.2	99	96	1.4	2.0
03/03/2014	99	94	1.6	2.0	99	96	1.4	2.0
17/03/2014	99	93	1.4	2.2	98	97	1.6	1.8
31/03/2014	98	95	1.2	2.0	98	97	1.4	1.8
07/04/2014	98	94	1.2	2.0	99	96	1.4	1.8

Source: Drive Test Result, 2014.

NOTE: HM = Hybrid Model N-HM = Non Hybrid (Existing) Model

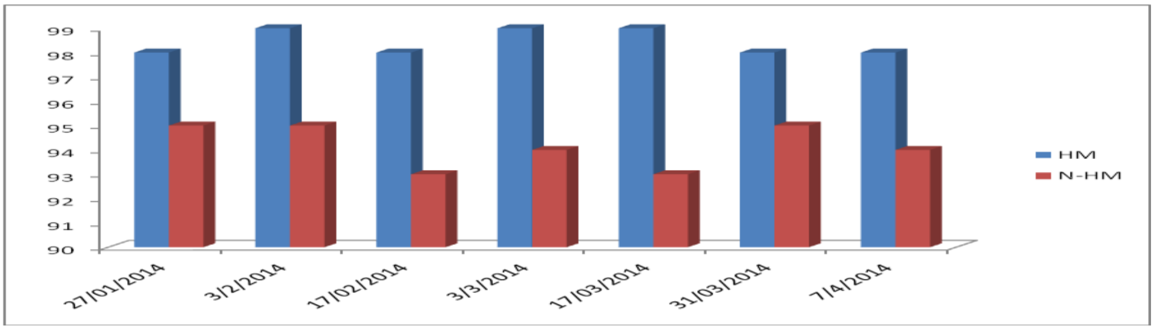

Figure 4: Call Set-Up Success Rate for Hybrid and Non Hybrid Model

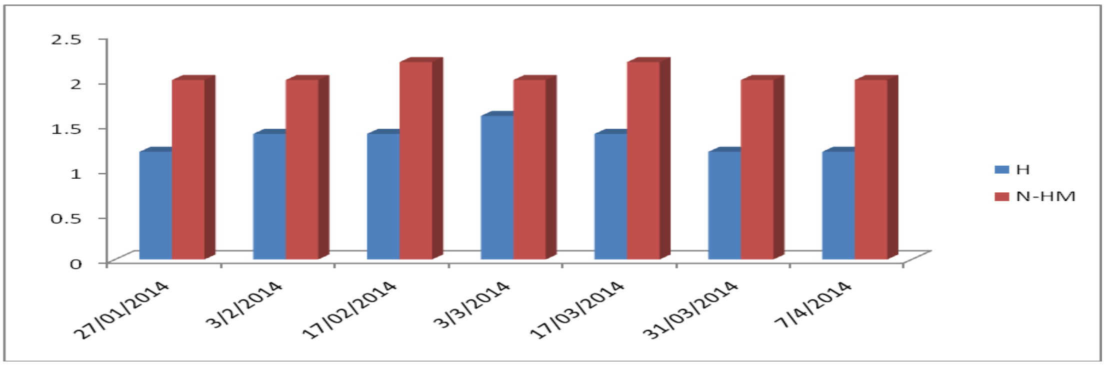

Figure 5: Call Drop Rate for Hybrid and Non Hybrid Model

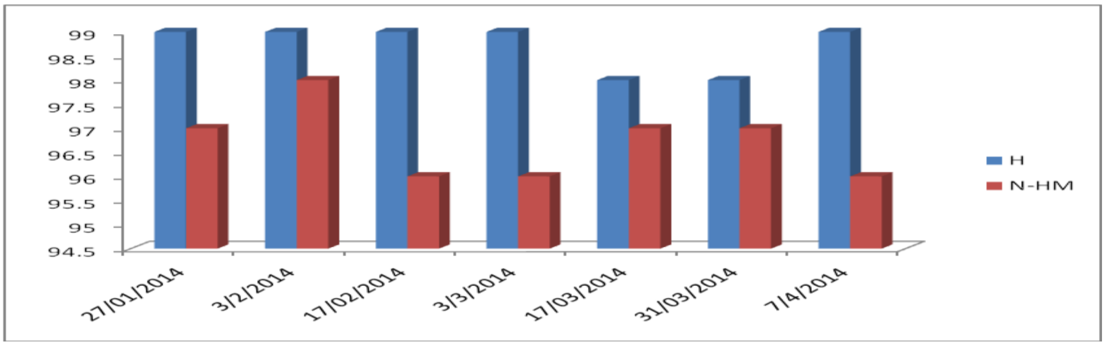

Figure 6: Call Completion Success Rate for Hybrid and Non Hybrid Model

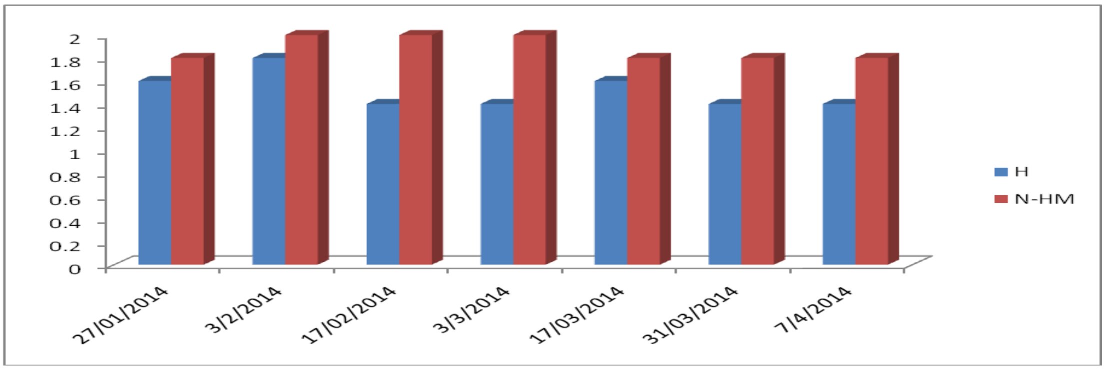

Figure 7: Traffic Channel Congestion Rate for Hybrid and Non Hybrid Model

Figure 4 shows the Call Set-Up Success Rate (CSSR) of the two systems (both hybrid and the existing system) during the test period.
Figure 5 shows the Call Drop Rate (CDR) of the two systems (both hybrid and the existing system) during the test period.
Figure 6 shows the Call Completion Success Rate (CCSR) of the two systems (both hybrid and the existing system) during the test period.
Figure 7 shows the Traffic Channel Congestion Rate (TCHCR) of the two systems (both hybrid and the existing system) during the test period.
From the plotted graphs, it can be seen that the proposed hybrid model has the best of all compared to non-hybrid model.

CONCLUSION

This research work presents the development of a Hybrid model for congestion management in GSM network in Nigeria. Although previous research effort have been trying to address this problem, most if not all of them have not put into consideration the concept of call prioritization and buffering of handover/handoff calls as a resourceful means of preventing congestion in GSM network. In this regard, the adoption of priority calls for the purpose of security, health and other related emergency matters makes this study outstanding. In addition to the inherent advantages mentioned above, the introduction of buffers in this design plays a vital role to ensure that the handoff and waiting calls are not deteriorated and the quality of service is generally improved.

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